Extensive Simulation Performance Analysis of Variable Transmission Power on Routing Protocols in Mobile Sensor Networks

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Abstract A wireless mobile sensor network is a group of independent wireless mobile sensor nodes which forms a temporary network without the use of any centralized management or fixed infrastructure. Communication protocols are responsible for maintaining the routes in the network and guarantee reliable communication. On the other hand, appropriately adjusting the sensors transmission power is crucial for reducing network energy consumption. This paper proposes a comparison of routing strategies and the impact of variable transmission power for each mobile sensor node on the performance of these communication techniques for mobile wireless sensor networks with the aim of outlining design considerations of protocols for mobile environments. We analyze the performance of both reactive routing protocols Ad hoc On Demand Distance Vector protocol (AODV), Dynamic Source Routing (DSR) protocol and proactive protocol Destination-Sequenced Distance Vector routing protocol (DSDV) in different scenarios. The selected protocols are compared on the basis of various parameters, which include packet delivery ratio, total packet loss, network lifetime, and control overhead using variable number of nodes and speeds.

Keywords Mobile node · Wireless sensor networks · AODV · DSDV · DSR · Transmission power · NS2

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1 Introduction

A wireless sensor network is composed of a large number of node sensors. Nodes mobility is the main added value of WSNs due to their locomotion capability in addition to their ability to collecting data, computation and communication. These networks are characterized by dynamic topology. Indeed, mobile node can joint or leave the network as well as being able to change of their transmission. The information is transmitted hop by hop through the network to a collector node. On the other hand, sensor nodes are likely to operate on limited battery life, so power conservation is a crucial issue. Due to their small size, these sensors can be widely used in structural health monitoring, environmental protection or military support, as well as in many other applications. Sensor nodes consist of processing capability, containing a transceiver block, memory and a power source. Due to the finite power available to each wireless node, increasing the network lifetime has been of a great interest to developers. On the other hand, routing protocols in wireless sensor networks has also attracted a lot of attention in the recent years. Therefore, different routing techniques have been developed for wireless sensor networks and each one has its own unique characteristics. The authors of [1] compared the performance of three protocols AODV, DSR and DSDV based on PDR, end-to-end delay and throughput metrics. The simulations are performed under various situations (when packet size changes and when time interval between packet sending changes). This work concludes that AODV and DSR protocols perform better at less packet size. Performance analyses of three communication protocols are analyzed and compared in [2], under high mobility case and in high density scenario. The study concludes that AODV protocol is a viable choice for MANETs.

In this paper, we continue in same trend and we concentrate on evaluating the performance of AODV, DSR and DSDV in MANET environment with varying the transmission range and density. We investigate the impact of variable transmission power for mobile nodes on different communication protocols considered. Then, we analyze the effect on the total energy consumption of the network. Protocols were examined based on throughput, energy consumption, packet delivery fraction, end-to-end delay and packet lost.

2 Overview of Routing Protocol

A routing technique [3] in WSN presents many challenges compared to data routing in wired network. These protocols are classified according to many parameters and to the strategies of discovering and maintaining routes. Protocols can be classified as reactive, proactive and hybrid, depending on their operation and type of requests. Proactive protocols control peer connectivity to ensure the availability of any path between the active nodes. On the other hand, reactive protocols establish paths only on request. Meanwhile, the sensors are inactive in terms of routing behavior [4].

2.1 DSDV Routing Protocol

Destination Sequenced Distance Vector (DSDV) [5] is a hop-to-hop distance vector routing protocol. It is characterized by each host maintaining a table consisting of the next-hop neighbor and the distance to the destination in terms of number of hops. In order to obtain the optimal path, the protocol DSDV guarantees loop free routes to each destination node, this is based on an average settling delay, which is a delay before advertising a route. All the hosts periodically broadcast their tables to their neighboring nodes in order to maintain an updated view of the network.

2.2 DSR Routing Protocol

The DSR protocol [6] is a reactive protocol that aims to limit the bandwidth consumed by packet routing in wireless ad hoc wireless networks. Dynamic source routing protocol is based on the concept of a routing algorithm from the source node to discover routes. This means that every node needs only forward the packet to its next hop specified in the header and need not check its routing table as in a table-driven algorithm. Determining source routes requires accumulating the address of each device between the source and destination during the route discovery.

2.3 AODV Routing Protocol

The ad hoc on demand distance vector is an on demand algorithm [7, 8], meaning that it builds routes between nodes only as desired by source nodes. It maintains these routes as long as they are needed by the sources. AODV uses sequence numbers to ensure the freshness of routes. This routing protocol builds routes using a route request on a route reply query cycle. AODV uses a reactive approach for finding routes and a proactive approach for identifying the most recent path. This protocol uses the same route discovery process to DSR protocol for finding fresh routes [1, 4].

3 Performance Metrics

3.1 Energy Consumption

The energetic consumption is the average of the total energy consumption of the entire network to transmit data packets. We obtain the energy consumption by calculating the ratio of the sum of the total energy consumed by each node to the total number of nodes. So a protocol that uses less energy during the simulation is considered more effective [9].

3.2 Packet Delivery Fraction (PDF)

The packet delivery fraction represents the number of arriving data packets successfully delivered over the total number of packets from all sources on the network. Using this value as analysis of ad hoc network on the different parameters involves the accuracy and completeness of the routing technique.

$$PDF = \frac{\sum Number\_of\_Packets\_received}{\sum Number\_of\_Packets\_sent} \quad (1)$$

3.3 End-to-End Delay (EED)

The parameter end to end delay is the average time taken by a data packet from a source node to arrive at a destination node. It also contains the delay caused by the route discovery process, the queue in data packet transmission and retransmissions times at the MAC layer.

$$EED = \frac{\sum (receiveTime - SendTime)}{\sum Number\_of\_Packets\_receive} \quad (2)$$

3.4 Throughput

This value represents the ratio of the total number of data packets provided to the total duration of simulation time. This metric measures how the network can continuously provide data to the sink.

$$Thrgh = \frac{\sum Number\_of\_Bit\_received}{Simulation\_Time} \quad (3)$$

3.5 Packet Lost

It represents the total number of data packets dropped during the simulation. The loss of a packet may be due to a collision during transmission process.

$$Pkt\_Lost = Nb\_Packet\_send - Nb\_Packet\_received \tag{4}$$

4 Mobility Model

Several mobility models (MM) can be considered to simulate the movement of mobile sensors in WSN e.g. Manhattan model, Random Way Point model, Gauss Markov mobility model. Broadly, the Random Way Point mobility approach is used to model the node movement in the NS-2. This model is a variation of Random walk model with spatial dependence. It includes pause times between changes in direction and/or speed. When the pause time expires, the node chooses a random destination in the simulation field with some metric such as pause time between T_{min} and T_{max}, speed value between 0 and Sp_{max}. The values of these parameters are uniformly distributed [10].

5 Simulation and Comparative Results

The simulations were done using network simulator NS-2 version 2.34 under Linux environment [11]. In realistic scenarios, all mobile sensor nodes can send information to a chosen destination for this reason; we assume in our simulation that we have a single sink. All other nodes are considered as sources (Table 1).

In Table 2, we showed the correspondence between the transmission power and the transmission range.

In this study, we consider a sensor network based on 50 mobiles nodes randomly placed in a 1000 m × 1000 m field as represented in Fig. 1, using the DSR routing protocol. The packet size is set to 512 bytes. The initial battery energy level of each sensor is 30 J.

5.1 Energy Consumption

For the energy consumption, we note that the more transmission range increases the more the energy consumption is important. We also see that for the envisaged routing techniques, total energy consumption increases with the number of sensor nodes. On the other hand, simulation results show that AODV and DSDV protocols permits better energy consumption compared to DSR protocol (Fig. 2).

Table 1 Simulation parameters

Parameters	Values
Routing protocols	AODV, DSR, DSDV
Number of nodes deployed	50, 70 and 90
Environment size	1000 m x 1000 m
Nodes placement strategy	Random
Transmission range	100, 200, 300 m and variable
Initial node energy	30 J
Rx power	0.1 mw
Idle power	0.05 mw
Sleep power	0.03 mw
Simulation time	150 s
Node speed (m/s)	[1.0, 3.0]
Antenna model	Omni antenna
Propagation model	Two ray ground
Transport protocol	TCP

Table 2 Transmission power needed for each distance

Distance (m)	Transmission power required
100	0.0072
200	0.115
300	0.584
Variable	In [0.0072, 0.584]

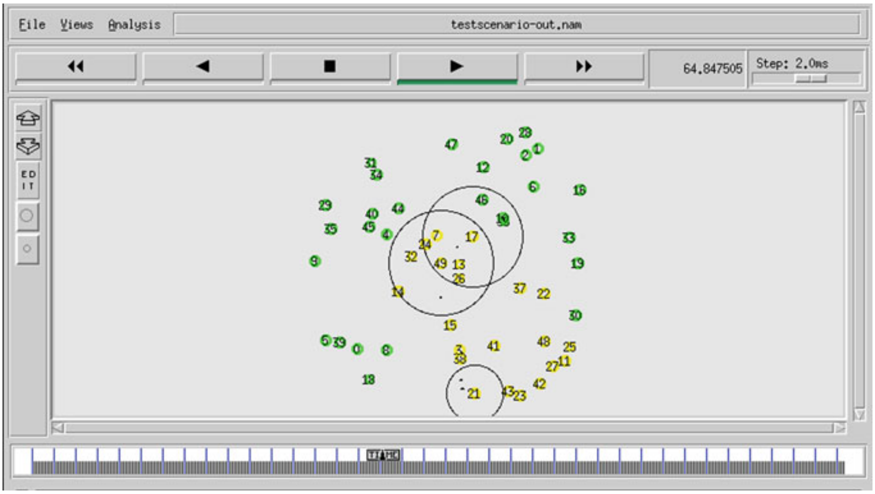

Fig. 1 Example of wireless sensor network with NS2

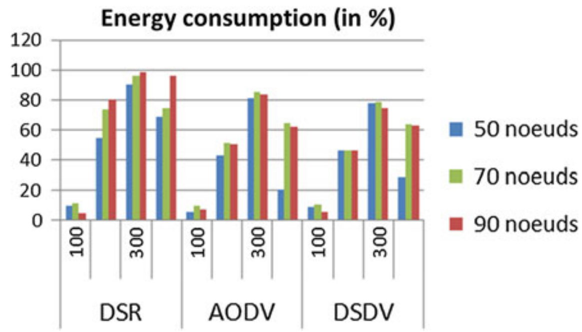

Fig. 2 Total energy consumption as a function of transmission range

5.2 Packet Delivery Ratio

It is clear that the greater value of PDF means the better performance of the routing technique. Therefore, we deduce from Fig. 3 that for short transmission range (100 m) the packet delivery fraction is better than 200 and 300 m transmission range. Compared to the 200 and 300 m communication range, the variable transmission range has good results.

5.3 End-to-End Delay

The following graph shows the impact of different transmission range on the end-to-end delay metric with DSR, AODV and DSDV routing strategies. The variable transmission range remains low at almost all communication ranges in different nodes scenarios (Fig. 4).

5.4 Throughput

The throughput by the three routing techniques with 100, 200, 300 m and variable communication ranges in 50 nodes, 70 nodes and 90 nodes scenario.

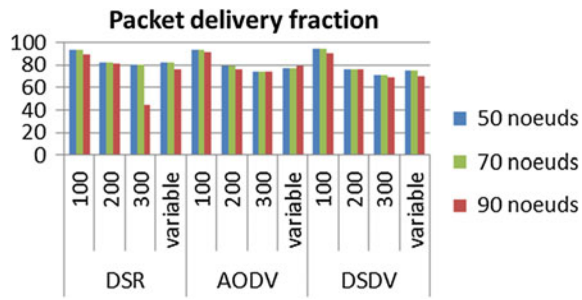

Fig. 3 Packet delivery fraction as a function of transmission range

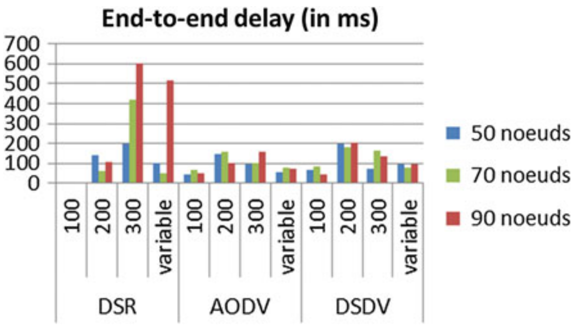

Fig. 4 End-to-end delay versus transmission range

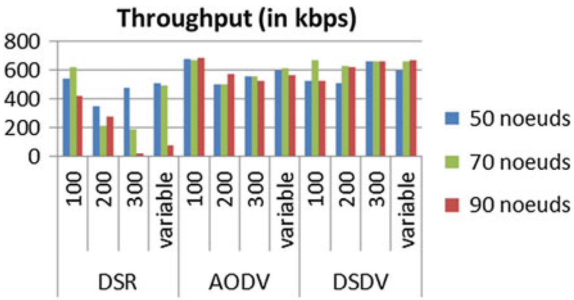

Fig. 5 Average throughput as a function of sensor nodes number and transmission range

All routing protocols have good results for short range (100 m) and also for a variable communication range. In addition, we note that for the DSDV technique, it is even preferable to use a variable transmission range that provides better throughput compared to the other transmission ranges used (Fig. 5).

5.5 Packet Lost

The performance of the three routing strategy in terms of total packet lost during the simulation time. It is clear that the DSDV is better in terms of total packet lost for

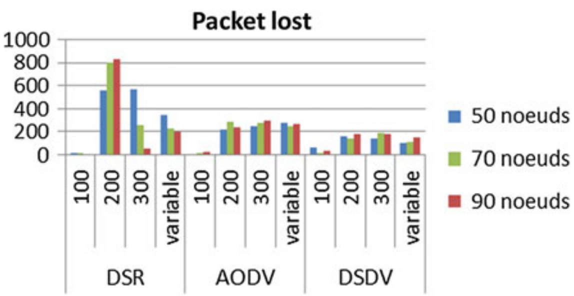

Fig. 6 Total number of packets lost during simulation

all different transmission range scenarios. In the case of variable transmission range, the number of packets lost is lower than the 200 m and 300 m communication range for all routing protocols used (Fig. 6).

6 Conclusion

The communication range of the sensor node is a very important metric which can influence network connectivity. This paper has offered a comprehensive analysis of extensive simulation analyses of DSDV, DSR and AODV MANET routing protocols under various traffic scenarios when the size of the network, the transmission range and node mobility are varied. By comparing these routing mechanisms on the basis of various performance metrics, we conclude that the variable transmission range offers a good performance for all metrics and is more preferable especially for high communication range. The results also disclose that AODV routing technique becomes more effective in providing better performance when the studied metrics are simulated.

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