Performance Analysis of Routing for Wireless Sensor Network

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Abstract. Wireless Sensor Network (WSN) consists of static or mobile sensor nodes by self-configuring. The nodes get in touch with each other via a special wireless that is utilized to send information between the source and destination nodes. Each sensor node is very cheap and has limited resources such as limited battery power, low bandwidth and so on during the delivery of message from one node to another. In this paper, we used NS-2 to simulate and implemented routing protocols like DSDV protocol, AODV protocol and DSR protocol for many numbers of nodes. We compared network parameters, analyzed and evaluated the performance with comparing the end-to-end delay, packet delivery fraction (PDF), throughput and packet loss rate. As the number of nodes increases and the network expands, the performance of the DSDV protocol will decline. When the number of nodes is more than three hundred, the DSDV protocol will lose efficacy.

Keywords: wireless sensor network, DSDV, AODV, DSR, NS-2.

1. Introduction

Wireless Sensor Network(WSN) is used to perceive the objective physical world and obtain the amount of information in the physical world. It has been used widely in recent years such as monitoring data, monitoring environmental variables, traffic monitoring, air traffic control, robotics, automotive, home health monitoring and industrial automation and so on. Wireless Sensor Network consists of static or mobile sensor nodes by self-configuring. The nodes get in touch with each other via a special wireless that is utilized to send information between the source and destination nodes. Each sensor node is very cheap and has limited resources such as limited battery power, low bandwidth, fusion and so on during the delivery of message from one node to other. So it is seen that routing protocols are needed to be studied effectively in wireless sensor networks[1-4].

in[5], the authors simulate and compare the performance of AODV, DSDV, DSR and so on in network size, packet delivery ratio, average delay and average throughput. The conclusion is that AODV is best in the average throughput and improved in case of average packet deliver ratio. DSR performs with the least delay in the network.

In[6], the authors compare the performance of AODV and DSDV using the NS-2 simulator. The result shows that AODV achieves higher efficiency and performance under high mobility scenario than DSDV.

In[7], the authors simulate the protocols of DSR, DSDV and AODV using dissimilar setting in terms of nodes density variation and nodes speed along with various traffic types. They evaluate the performance parameters which are energy usage, throughput, small packet delivery ratio and total packets dropped. Simulation results show that DSR behaves to be more consistent for throughput and PDF for different approaches. DSDV outperform the other two protocols in term of energy utilization when using constant rate. The behavior of AODV seemed to vary according to the traffic type used but on average it shows a high throughput regardless of the scenario examined.

Although many researchers compared the performance of routing protocols, the experimental environment is different and the experimental results are different. This paper contains two aspects. For one thing, it focuses on studying three routing protocols which are commonly used in wireless sensor network to measure the reliability and performance routing protocols of DSDV, AODV and DSR by using wireless sensor network in static conditions. For another, it analyze network expand with DSDV protocol. We study four parameters to calculate the performance of these routing protocols: average end-to end delay, Packet Delivery Fraction(PDF), loss packet rate and throughput. The performance of DSDV, AODV and DSR is simulated by NS-2 with different number of nodes.

The paper is organized as follows. Section 2 briefly describes three routing protocols. Section 3 details the simulation scenario and the evaluation parameters. Section 4 shows and analyzes the simulation results for three routing protocols. Expanding network with DSDV protocol is studied in section 5. The conclusions of this paper are finally presented in section 6.

2. Routing Protocols

2.1 DSDV (Destination-Sequenced Distance-Vector) Protocol)

A proactive type protocol DSDV is a routing protocol based on the improved routing algorithm. In this routing mechanism each wireless node must store and continue to update a routing table in which the destination address, the next hop, hop count, the sequence number, and the first time to connect are recorded. The sequence numbers are contained in each record in the routing table , which can be used to determine whether some paths are old, so as]   to avoid the generation of loop routing.

Each node transmits its routing table to the neighbor periodically to maintain a complete path for all nodes. When the network topology changes so greatly that the routing table has a great change, the node will also transmit the new routing table to the neighbors actively, so the update of the routing table has the characteristics by time-driven and by event-driven. The update of the routing table has two kinds of full dump and incremental update. If the routing table changes most, the node transmits full dump to neighbors. If not incremental update.[8-11]

2.2 AODV (Ad hoc On-Demand Distance Vector Routing) Protocol

AODV protocol is a reactive routing protocol. When a wireless node wants to send packets to the destination node, it checks its routing table. If there is no route entry that can reach the destination node, the node will broadcast the route requests(RREQs) packet to find a new path. The node receiving the RREQ checks first whether the destination address of the packet is for itself, if not, then checks if the intermediate point has an available path to the destination node. If so, the routing table is modified according to the information in the packet, and then it is broadcast. When the relay point receives RREQ information, and the destination address recorded in RREQ is itself, then the routing table will be changed according to the routing information recorded in RREQ.

Each RREQ has an identification (ID). When a node receives a RREQ, it confirms first whether it has been received before. If it is received, the packet is discarded to ensure that the path of all nodes is Loop-free.[8-12]

2.3 DSR (Dynamic Source Routing) Protocol

DSR protocol is a reactive routing protocol too. In this routing mechanism each wireless node has route buffer. Route information is directly recorded in the header of each packet. DSR protocol also uses route discovery process to find routes dynamically when a route is needed. The routing discovery process in DSR protocol is similar to the AODV protocol. When a node wants to transmit a packet to destination node, it checks its routing table first. If it can't find the route entry to the destination node, the source node send route request(RREQ) to each node by broadcast. The node receiving the RREQ will reply route reply(RREP) to the intermediate point or original source, in order to generate the route. Unlike AODV protocol, when the route record goes through a hop, the hop ID is recorded in the route record of RREQ. In this way, when route is recorded to the destination node, there will be information on Hop-By-Hop Route . The destination node selects an optimal route in a number of RREQs, and sends a RREP to the source node based on the route record. The source node store the route records in the RREP in the route table. So the source node knows Hop-By-Hop Route to the destination node.[9,13]

3. Simulation Environment

Simulator NS2 in the WSN provides us with the idea of its output performance in real time situations. 2 different scenarios are evaluated where the number of nodes are varies. Three routing

protocols like DSDV, AODV and DSR are compared in First scenario with diverse numbers of nodes from 10 to 500. But the DSDV protocol lose efficacy when the number of nodes is more than 300. In second scenario we evaluate network expansion with DSDV protocol. The number of nodes reaches to 345 at most, then DSDV protocol lose efficacy. The descriptions for the other parameters taken in simulation are shown in the table 1 as follows:

Table 1. Simulation Parameters

Parameters	Description
Simulator	NS-2
Network Size	500m*500m
Node Placement	Fixed
MAC Protocol	802.11
Routing Protocol	DSDV,AODV,DSR
Simulation Time	100 seconds
Packet Size	512 Bytes
Transmission Rate	10 Packet/sec
Traffic Type	CBR

4. Performance Evaluation

In this section, the performance is evaluated through simulation results using NS-2. For evaluating the performance we have analyzed the following metrics:

4.1 Average End-to-End Delay

End-to-end delay is the delay occurred during packet transmission from the source node to the destination node in application layer[1].But the delay from each source node to correspondent destination node is not equal. So we evaluated the average end-to-end delay. The lower the average end-to-end delay is , the better the protocol performance will be.

Based on the results in Fig.1,it can be concluded that the AODV protocol has the higher average end-to-end delay than DSDV and DSR when the number of nodes is less than 200. When the number of nodes is more than 250, the delay of the DSDV protocol is the highest. The delay of the DSR protocol is the lowest in all scenarios. As the number of nodes increases, the DSR protocol performance is better than DSDV and AODV.

4.2 Packet Delivery Fraction (PDF)

The packet delivery fraction(PDF) is calculated by number of packets the destination nodes receive by number of packets the source nodes send to destination. The higher the PDF,s value is, the better the protocol performance will be.

Based on Fig.2, the simulated results show that DSR overcome AODV and DSDV has the highest packet delivery fraction. The higher packet delivery fraction was achieved using DSDV protocol when the number of nodes is no more than 300. AODV doesn't store full route. If the incumbent link is failure, AODV will need establish link again. So, the packet delivery fraction for AODV is fluctuant and a downtrend.
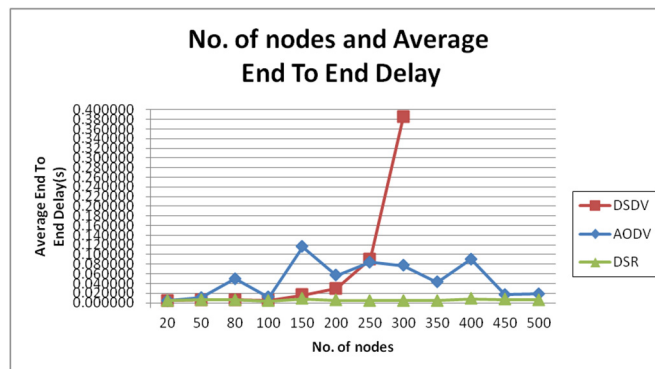
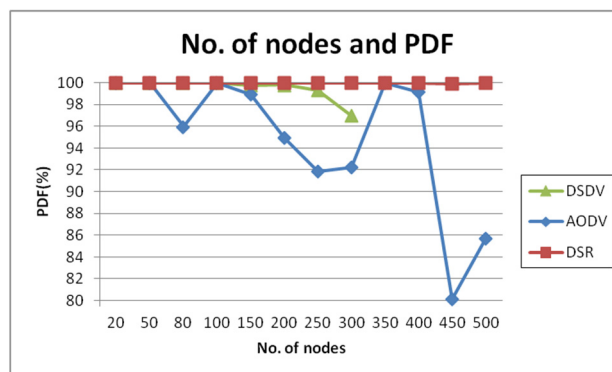Fig 1. No. of nodes and Average End-to-End Delay

Fig 2. No. of nodes and PDF

4.3 Loss Packet Rate

The loss packet rate is calculated by dividing the total lost packet for routing by total packet sent[13]. The lower the loss packet rate is, the better the performance will be.

Based on Fig.3, the simulated results show that DSR has the lowest loss packet rate. Loss packet rate is lower for DSDV as compared to AODV when the number of nodes is less than 300. The loss packet rate for AODV is fluctuant and a uptrend.

4.4 Throughput

Throughput in a network can be defined as amount of information transferred from a node to another during a certain interval. It is found to be the total packet size received at the destination to the total simulation time[1]. In this paper, the max throughput is used. It is measured in bits/sec or Bytes/sec. It can be said to have better performance for higher throughput.

Based on Fig 4, the simulate results show that the throughputs of DSR and DSDV are relatively stable with the number of nodes increasing but no more than 300. When the number of nodes is more than 300, DSDV decreases rapidly. This is stated in next section. It is relatively large fluctuations for AODV, and it is a downward trend. So DSR has stable and higher throughput.
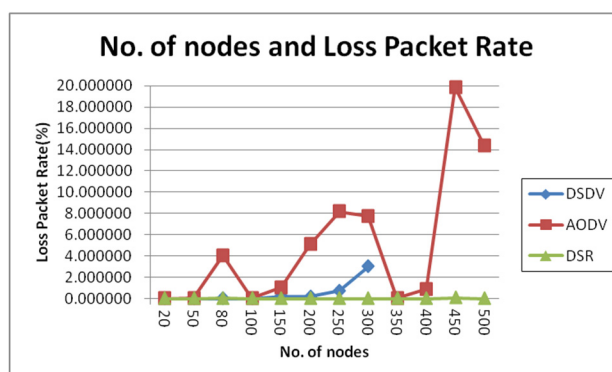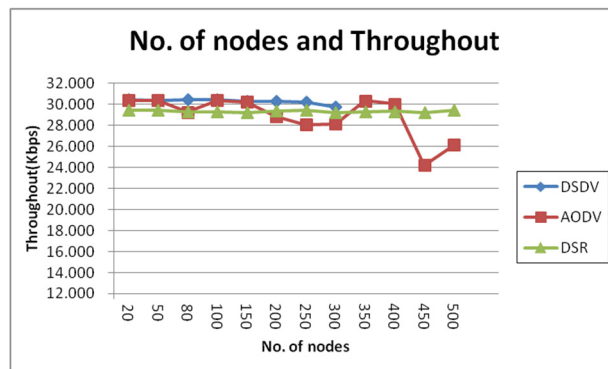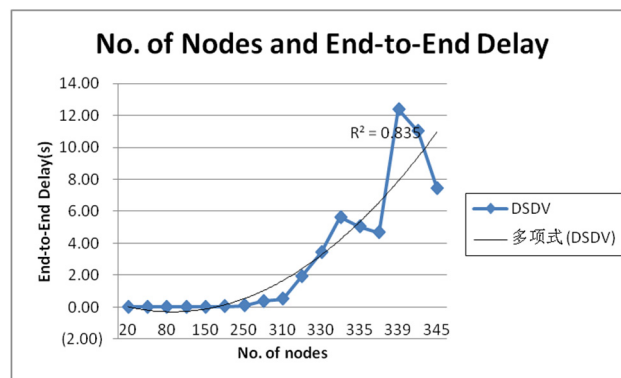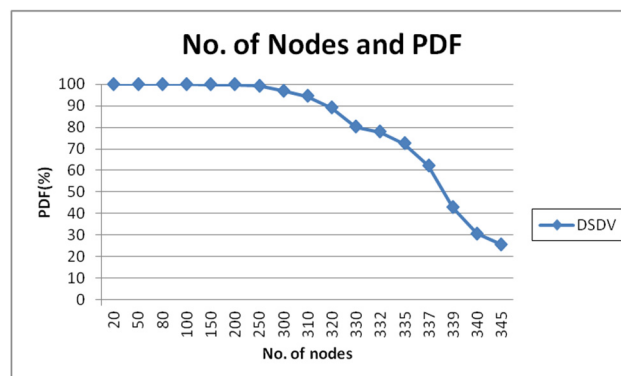

Fig 3. No. of nodes and Loss Packet Rate

Fig 4. No. of nodes and Max Throughput

5. Network Expand Analysis

In this section, DSDV protocol is analyzed that network expand which is discussed in the average end-to-end delay, PDF, loss packet rate and throughput. In DSDV protocol mechanism ,each node periodically transmits its routing table to the neighbors. When network expand and the number of nodes is more and more, each node transmits messages to the neighbors more frequently to update routing table all the time , so that the packets don't reach to destination nodes in the end, and the whole network can't converge. Based on Fig 5 (a) and (c), the simulate results show that when the network expand, end-to-end delay and loss packet rate are more and more high. Based on Fig 5 (b) and (d), PDF and throughput are lower and lower. This shows that the performance of DSDV protocol is decline and when the number of nodes is more than 345, the network can't converge. When the number of nodes is more than 300, the performance of DSDV protocol declines rapidly. So, 300 is a point of inflection.
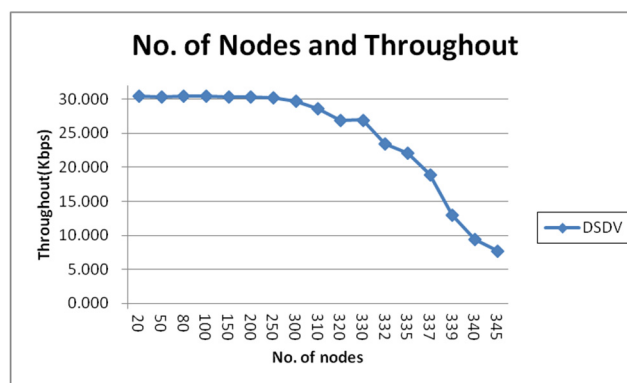

(a)

(b)
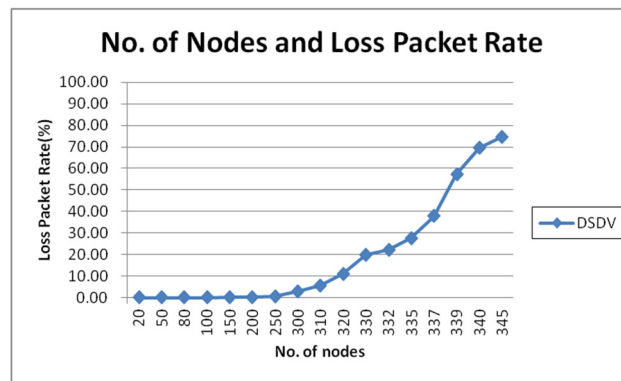
(c)

(d)

Fig 5. (a) No. of Nodes and average E-To-E Delay
(b) No. of Nodes and PDF
(c) No. of Nodes and Loss Packet Rate
(d) No. of Nodes and Throughout

6. Conclusion

In this paper we evaluate the performance of three routing protocols like DSDV, AODV and DSR by simulation in WSN. We analyze them over four metrics named the average end-to-end delay, PDF, loss packet rate and throughout. We also analyze DSDV protocol on network expand. We get the conclusions as follows. First, DSR has the best performance over four metrics in three routing protocols. The performance of DSR protocol is relatively stable though the number of nodes increases constantly. The performance of AODV protocol is instable when the number of nodes is more and more, and has a downtrend. The performance of DSDV protocol is close to DSR when the number of nodes is less. Second, When the network expand, the performance of DSDV protocol will decline and lose efficacy in the end. So DSDV is suitable for small networks.

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