AODV and DSR Routing Protocols in WSN: A Simulated Comparison

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Abstract: Wireless Sensor Networks (WSN) emerged as an essential area in wireless technology. Wireless Sensor Networks are one of the most important technologies for the twenty-first century. WSN consists of numerous sensor nodes which are connected to form a network. Data is collected from the source node and is sent to the sink node via multi-hop routing algorithms. The primary objective of any routing algorithm in WSN is to make the network more and more energy efficient to increase the network lifetime. Routing is one of the main challenging features because there exists no infrastructure which manages how the information is exchanged between the nodes. Routing protocols might differ depending on the application and network architecture in WSNs. The primary objective of this paper is to simulate two reactive routing protocols, i.e. AODV and DSR and compare their performance on parameters such as average throughput, packet delivery ratio, loss packet ratio and residual energy of the nodes via network simulator NS2.35 for the wireless sensor network. It is concluded that DSR performs better than AODV in terms of average throughput, packet delivery ratio and loss packet ratio but AODV is more energy efficient as compared to DSR and therefore, performs better regarding residual energy.

Keywords: WSN, AODV, DSR, PDR, LPR.

I. INTRODUCTION

A Wireless Sensor Network (WSN) consists of a large number of small, low-powered and low-cost sensor nodes which are deployed in the limited area of interest for a specific application field like monitoring the remote environment, tracking of the target, etc. These sensor nodes are then used to collect and send the sensed data to the sink node. The sensor nodes that form the Wireless Sensor Networks have a limitation regarding low memory, less processing speed [2] and limited power source. Batteries are the only primary power source for the nodes. Once the nodes are deployed in the sensing region, it is difficult to either replace or charge the batteries. Due to the dynamic behavior of wireless sensor networks, routing protocols have some significant challenges in designing. The biggest obstacle for researchers is to enhance the energy efficiency of sensor nodes so that network lifetime can be increased.

The rest of the paper is organized as follows- Section II will be discussing the routing protocols in WSN with various routing challenges and design issues. Section III will be providing an outline of AODV and DSR routing protocols. Section IV highlights the Simulation parameters and simulation results of the comparison of AODV and DSR. Finally, the conclusion of this paper is laid out in Section V.

II. ROUTING IN WIRELESS SENSOR NETWORK

Routing is a process of deciding a path between source and destination for data transmission [1] and the routing algorithms are used to provide a strategy that ensures a connection between any two sensor nodes in a network. The routing protocols in WSN are application specific and data-centric [3]. These routing protocols are also capable of aggregating the data and optimizing energy consumption [4]. A suitable routing protocol for WSN should be simple, energy efficient, adaptable and scalable due to limited energy supply, computation power, memory and limited bandwidth of WSN [5][6][7]. The preliminary design goal of WSNs is to continue the data communication while trying to prolong the network lifetime. Various challenging factors that influence the design of routing protocol in WSNs are [1]:

- **Node deployment:** Nodes are deployed in two ways: one is the deterministic (manual) way, where nodes are placed manually and the path is pre-determined for data routing and other is self-organizing (random) way, where nodes are scattered randomly in an application specific area. Placement of sink is most important regarding the energy efficiency of the network.
- **Energy Conservation:** The process of setting up the routes plays a significant role in energy conservation. As in most of the cases, the nodes are deployed randomly in a specific area; multi-hop routing algorithms prove to be more energy efficient than direct communication.

- **Fault Tolerance:** Routing protocols should have capability to form new links, if any sensor node fails in the network, so that overall network should not get affect.

- **Hardware Constraint:** The size and volume of a sensor node should be small and all the units like sensing, processing, power, positioning system and mobilizer should consume low power so as to be more energy efficient.

- **Environment:** Generally nodes are operated in locations that are inaccessible because of the hostile environment.

- **Transmission Media:** In WSN, transmission media is wireless either RF or infrared. Wireless media is affected by adding and high error rate that will further affect the operation of WSNs.

- **Node capabilities:** Each sensor node is capable of performing three main functions that are relaying, sensing and aggregation, one at a time. But if a node is engaged to perform all the functions at the same time then node's energy may exhaust quickly.

III. CLASSIFICATION OF ROUTING PROTOCOLS IN WSN

Routing protocols are classified into three categories [8]: Flat based routing, hierarchical routing and location based routing. Two methods are used for finding the route in these routing protocols: Distance vector and State link.

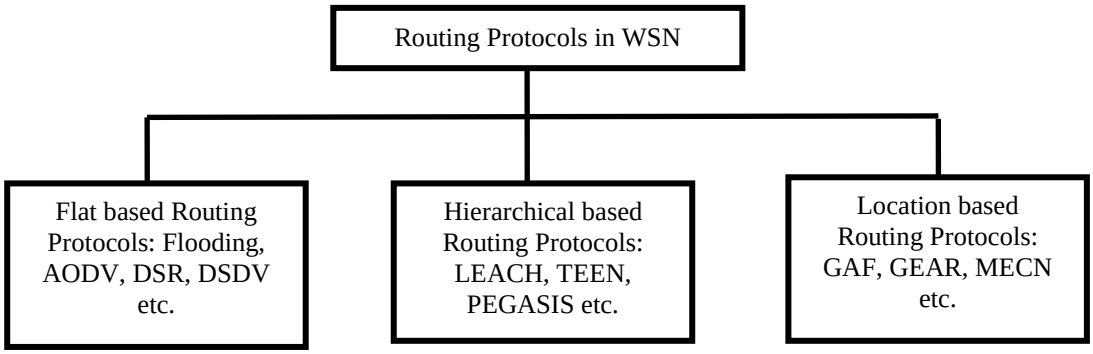

Figure1: Classification of Routing Protocols in WSN

Flat based routing protocols are further categorized into proactive and reactive routing protocols. In *proactive routing protocols*, the routing path and their states are set up before any actual communication between the nodes. Nodes broadcasts routing tables to all neighboring nodes and these routing tables are updated whenever the topology of network changes. Example of proactive routing protocols is: DSDV, OLSR. In *reactive routing protocols*, routing path is set up on demand only when query is initiated i.e. whenever any node has data to be sent to the other node; only then route is set up to the destination node. Example of reactive routing protocols is: AODV, DSR.

Routing protocols are designed and proposed to provide better data delivery and higher throughput. The main objective of routing protocols is to send data packets from source to destination efficiently. In this paper, two reactive routing protocols (AODV and DSR) are discussed and compared on various performance parameters.

1. **AODV (Ad-hoc On Demand Distance Vector) Routing Protocol:-**
   AODV is based on the reactive mechanism in WSN. The routing method used in this protocol is distance vector routing. AODV supports both unicast and multicast routing. Whenever source node wants to send some data to the destination only then a route from source to destination is set up. Nodes which are in process of communication will maintain the route information in their routing tables. In AODV [9] routing protocol, a routing table is maintained by each node with one entry per destination and a timer is also maintained in routing table when data is being routed. AODV also uses sequence number for loop free routing and for route maintenance. AODV uses 3 types of control messages:
   - **RREQ-** A route request packet is sent by source to entire network to establish a temporary route from source to destination. It maintains two counters: request id and sequence number.

- **RREP-** A route reply packet is sent by destination to source in response to RREQ message, to set up a route path.
- **RERR-** A route error packet is sent to nearest neighbour if route data is lost during any broadcast.

Algorithm:-

i. Is route available in routing table (Check using RREQ)? If yes refer to step iii else refer to iv.
ii. Broadcast (nodes send signal to find other nodes within the range).
iii. Update routing table.
iv. Transfer a message to the destination node.
v. Is the node ready? If yes go to step x else follow step vi.
vi. Route Maintenance using RERR.
vii. Activate local route repair
viii. Is an alternate route available in neighboring nodes? If yes go to step v else follow step ix.
ix. Activate local route repair and go to step i.
x. Receiving node sends back ready signal (RREP)
xi. Is this the destination node? If yes follow step xii else go to step v.
xii. Transmission begins, if transmission is successful end the process else go to step i.

2. DSR (Dynamic Source Routing) protocol:-

Dynamic Source Routing protocol (DSR) is an efficient reactive routing protocol designed specifically to use in multi-hop wireless ad hoc networks of mobile nodes [10]. DSR uses source routing to send the data packets. Source routing means that the source node is fully aware of the route to destination or the sequence of hops to the destination. The networks using DSR are assumed to be completely self-organizing and self-configuring. The protocol is consists of the two main mechanisms that are: Route Discovery and Route Maintenance. Both the mechanisms work together to allow nodes to discover and maintain routes from source to destination. DSR also uses three control messages: RREQ, RREP and RERR.

RREQ and RREP messages are used by the Route Discovery mechanism to discover a route from source to destination whereas RERR control message is used by the Route Maintenance mechanism to maintain the failed routes, if any.

Algorithm:-

i. Is route available in route cache (Check using RREQ)? If yes refer to step iii else go to iv.
ii. Broadcast (nodes send signal to find other nodes within the range).
iii. Update routing table.
iv. Transfer a message to the destination node.
v. Is the node ready? If yes go to step vii else follow step vi.
vi. Route Maintenance using RERR and go to step i.
vii. Receiving node sends back ready signal (RREP).
viii. Is this the destination node? If yes refer to step ix else go to step v
ix. Transmissions begin, if the transmission is successful then end the process else go to step vi.

IV. SIMULATION PARAMETERS AND RESULTS

A. About Simulator :

NS2.35 Network Simulator is used for the simulation of routing algorithms in Wireless Sensor network. NS2 is an open-source network simulator tool and simulation is performed under linux (Ubuntu18.0.1) environment. NS2 is mainly used to provide educational support for research in networking. It uses two languages: Object oriented Tool Command Language (OTcl) and object oriented language C++.

B. Performance Parameters Used :

The four parameters are used to compare the AODV and DSR routing protocols, which are:

- **Average Throughput:** Average throughput of a network is defined as the average rate of successful messages (packets) delivered over a communication channel. It is calculated as follows :

  Average Throughput = (No. of received packets / (Finish time- Start time)) *(8 /1000) kbps

- **Packet Delivery Ratio (PDR):** It is defined as the ratio of the total number of packets received by destination to the total number of packets sent by the source node. It is calculated as:

PDR = (Received packets / Sent packets) *100

- **Loss Packet Ratio (LPR):** It is defined as the ratio of the packets that are not received by the destination, which are sent by the source to the total number of packets sent by the source. It is calculated as:

LPR = ((Sent packets-Received packets)/Sent packets)*100

- **Residual Energy:** When nodes perform various network operations such as: sensing, processing and transmission of data, some amount of energy gets dissipated. So with the time, remaining energy or residual energy of nodes keep on decreasing.

energy_avail[i] = energy_avail[i]-(energy_avail[i] - energy_value)

C. Simulation Parameters :

Simulations were performed using NS2.35 Network Simulator. Simulation scenario consists of 50 nodes in a rectangular area of 800m x 800m. The different parameters used for our simulation are summarized in Table 1.

Table 1: Simulation Parameters

Parameters	Value
Protocols Studied	AODV and DSR
Channel Type	Wireless
Propagation Model	Two Ray Ground
Antenna Type	Omni Directional Antenna
Simulation Time	60,120,180,240…….600 sec
Simulation Area	800m x 800m
Traffic Type	FTP
No. of Nodes	50
Packet size	500,1000,1500,2000……8500 bytes

D. Simulation Results :

Network simulator version NS2.35 is used to carry out simulations. Varying packet size like 500, 1000, 1500… 8500 (in bytes) with fixed simulation time of 600 seconds is used to evaluate the performance metrics average throughput, PDR and LPR. Varying simulation time like 60, 120, 180… 600 (in sec) with packet size of 1000 bytes is used to evaluate the variation in residual energy of the nodes.

- ***Average Throughput-*** Fig. 2 shows the average throughput of both the routing algorithms decreases as the packet size increases. When the packet size is large i.e. 8000 or 8500 bytes then less packets are sent from source to destination and therefore, throughput increases suddenly. It is clearly shown that DSR perform better than AODV.

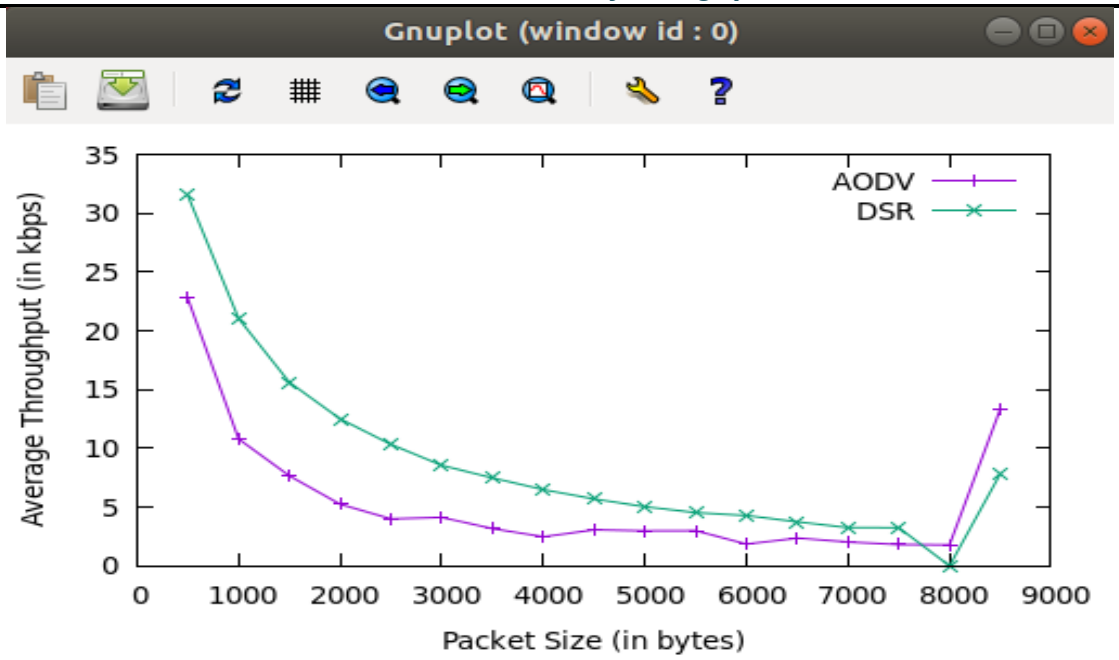

Figure 2: Throughput vs Packet size

- ***Packet Delivery Ratio***- Fig. 3 shows that with increase in packet size the packet delivery ratio also decreases gradually. But at packet size 8000 and 8500 there is a abrupt decrease in packet delivery ratio of DSR and AODV respectively. It is clear that DSR outperforms AODV.

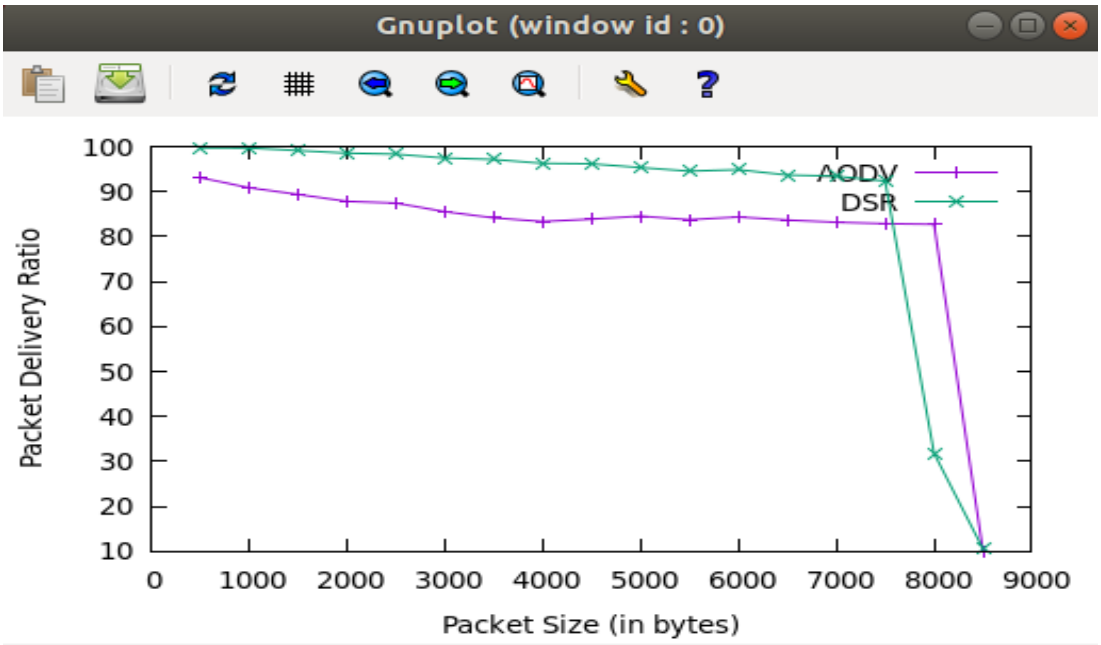

Figure 3: Packet Delivery Ratio vs Packet Size

- ***Loss Packet Ratio***- In Fig. 4, it is observed that as packet size is increased the network becomes incapable of handling such large packets and therefore packets are not delivered to destination node. Still, DSR handles large packet size better than AODV.

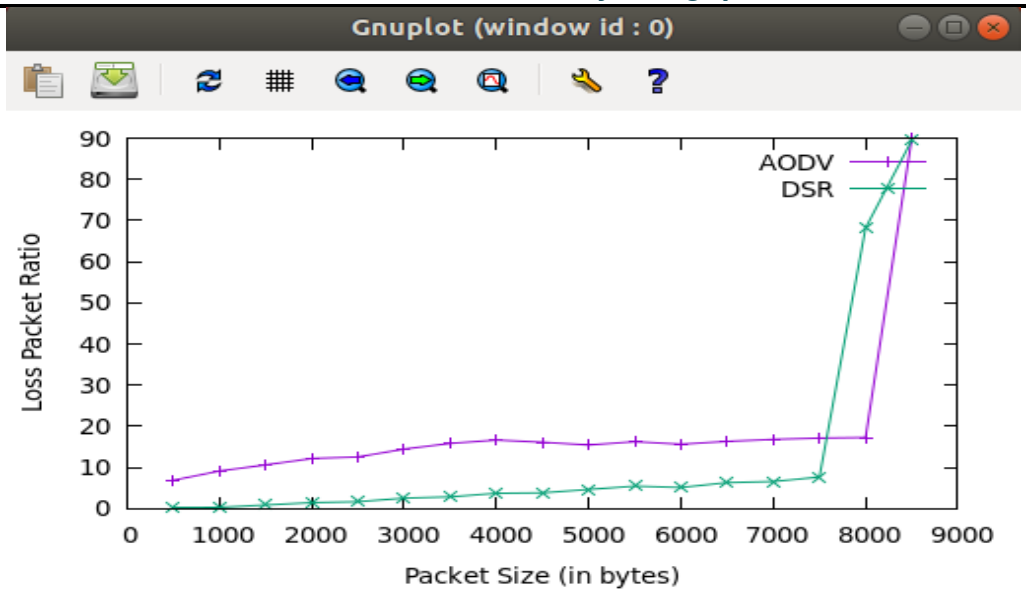

Figure 4: Loss Packet Ratio vs Packet Size

- ***Residual energy***- It is observed that with every simulation whether a node takes part in communication process or not, if it is in active state some amount of energy is being dissipated. Fig.5 and Fig.6 shows the residual energy of nodes in AODV and DSR algorithms respectively with varying simulation times.

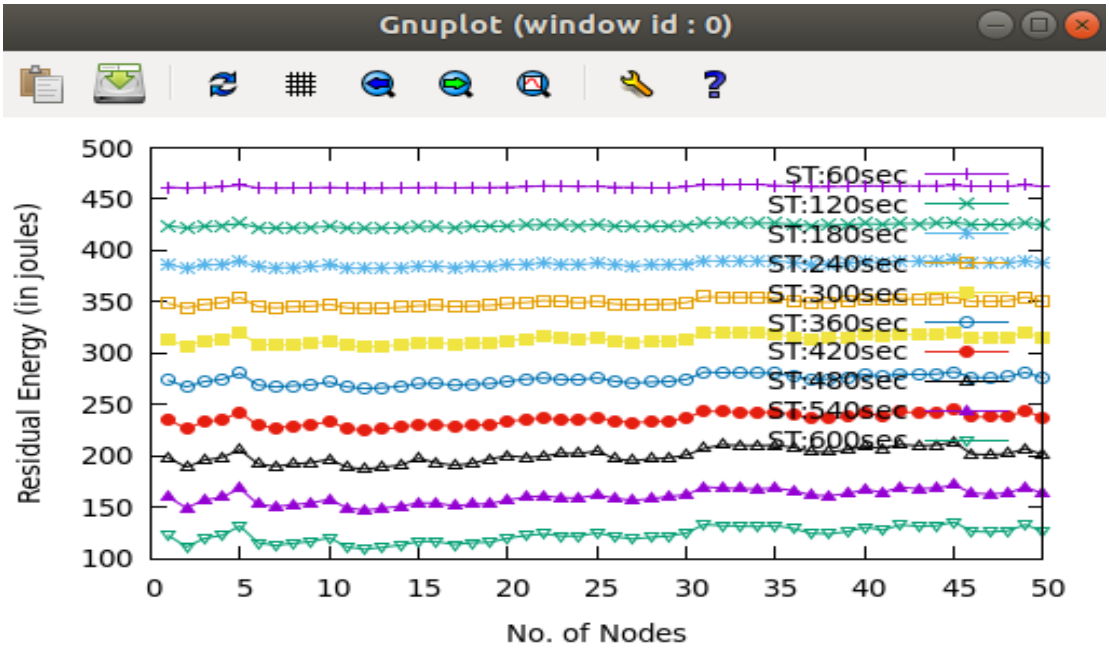

Figure 5: Residual energy of nodes in AODV routing algorithm

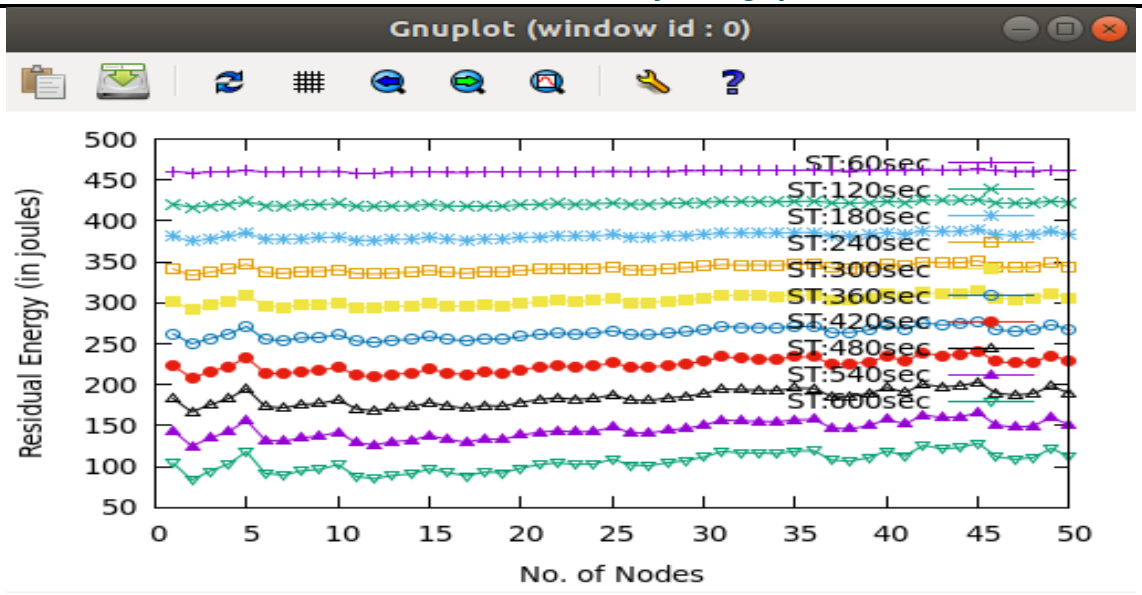

Figure 6: Residual energy of nodes in DSR routing algorithm

From the above figures it is concluded that AODV requires lesser amount of energy during routing as compared to DSR which uses REQUEST/ REPLY mechanism in routing that results in more energy consumption.

V. CONCLUSION

Wireless sensor networks play a vital role in many real life applications. Routing mechanism plays an important role in order to deliver the data from source to destination node. Two common flat routing protocols are overviewed and compared in terms of average throughput, packet delivery ratio, loss packet ratio and residual energy of nodes. The results concludes that DSR performs better than AODV in terms of average throughput, packet delivery ratio and loss packet ratio but AODV is more energy efficient as compared to DSR and therefore, performs better in terms of residual energy.

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