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Simulation and Proportional Evaluation of AODV and DSR in Different Environment of WSN

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Abstract - ***Simulation and comparison of the routing protocols for network topology hold a significant position in the performance evaluation of wireless networks. This paper, discusses performance evaluation of Ad-hoc on demand Distance Vector (AODV) and Dynamic Source Routing (DSR), routing protocols for static WSN using NS-2. Energy efficiency, latency, throughput and fairness characteristics in different conditions are investigated under different load conditions on two-hop and multi-hop network. The comparison results reveal that AODV performs better in the network with strict requirement on time, whereas DSR is more adaptable in the networks with high throughputs and energy constraints.***

Index Terms - Wireless Sensor Network (WSN), Dynamic Source Routing (DSR), Ad-Hoc On-demand Distance Vector (AODV), energy efficiency, latency, throughput, fairness, NS-2 (network simulator-2)

1.0 INTRODUCTION

Wireless sensor networking is an emerging technology that has a wide range of potential applications including environment monitoring, smart spaces, medical systems and robotic exploration [6].

Such networks will consist of large numbers of distributed nodes that organize themselves into a multi-hop wireless network. Each node has one or more sensors, embedded processors and low-power radios, and is normally battery operated. Typically, these nodes coordinate to perform a common task. Due to the energy constraints wireless sensor networks have to take energy consumption factor in to consideration while performing various tasks [6]. Hence these are Energy-Aware Wireless Sensor Networks.

While many aspects of WSN have already been investigated, this paper concentrates on the performance characteristics of the routing protocols, in particular on the AODV and DSR protocols.

AODV is a distance vector type routing [3]. It does not require nodes to maintain routes to destinations that are not actively used. The protocol uses different messages to discover and maintain links: Route Requests (RREQs), Route Replies(RREPs), and Route Errors (RERRs). These message types are received via UDP, and normal IP header processing applies. DSR protocol works "ON Demand", i.e. without any periodic updates. Packets carry along the complete path they should take. This reduces overhead for large routing updates at the network. The nodes store in their cache all known routes. The protocol is composed of route discovery and route maintenance [3].

Both the protocols are implemented in the network layer and the MAC layer protocol used is 802.11. The IEEE 802.11 Standard is by far the most widely deployed wireless LAN protocol. This standard specifies the physical, MAC and link layer operation. Multiple physical layer encoding schemes are defined, each with a different data rate. At the MAC layer IEEE 802.11 uses both carrier sensing and virtual carrier sensing prior to sending data to avoid collisions.

The scope of the paper is to simulate the AODV and DSR protocols and analyse their performance based on specific traffic load conditions and scenarios of wireless sensor network and reveal the fundamental tradeoffs of energy, latency, throughput and fairness under steady state simulations by using Network Simulator – 2 (NS-2).

The remainder of the paper is organized as follows: Section 2 and Section 3 recalls the main features of AODV and DSR. Section 4 describes the simulation in multiple environments and result of energy consumption, latency, throughput and fairness.

2.0 THE DSR PROTOCOL

The DSR protocol is composed of two mechanisms that work together to allow the discovery and maintenance of source routes in the ad hoc network: Route Discovery is the mechanism by which a source node (S) sending a packet to a destination node (D) obtains a route to D [3]. It is used only when the route to D is not known. Route Maintenance is the mechanism by which node S is able to detect, while using a source route to D, if the network topology has changed such that it can no longer use its route to D. Route Discovery and Route Maintenance each operate entirely on demand.

When source node S originates a new packet destined to some other node D, it will obtain a suitable source route by searching its Route Cache of routes previously learned, but if no route is found in its cache, it will initiate the Route Discovery process to dynamically find a new route. S transmits a ROUTE REQUEST message as a single local broadcast packet, which is received by all nodes currently within its range. Each ROUTE

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REQUEST message identifies the initiator and target of the Route Discovery, and also contains a unique request id, determined by the initiator of the REQUEST. Each ROUTE REQUEST also contains a record listing the address of each intermediate node through which this particular copy of the ROUTE REQUEST message has been forwarded. This route record is initialized to an empty list. When a node receives a ROUTE REQUEST, it will add it's ID to the discovered route field and forward the request or if it is the target of the Route Discovery, it returns a ROUTE REPLY message to the source, containing the entire route; when the nodes in the discovered route receive this ROUTE REPLY, they cache this route in their Route Cache for use in sending subsequent packets to this destination. Thus the entire route is stored in the cache of all the intermediate nodes in that route along with the source node [3].

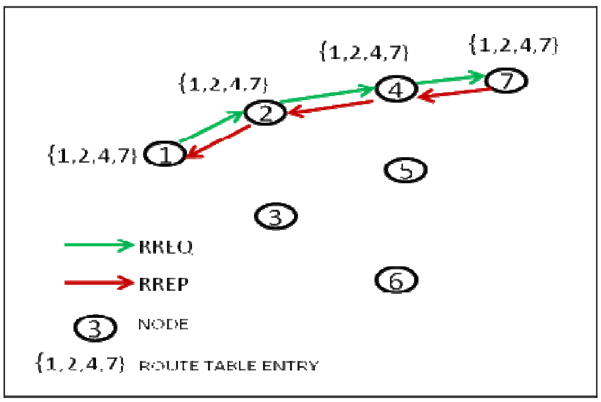

Figure1: DSR Route Discovery Mechanism

3.0 THE AODV PROTOCOL

The AODV routing protocol is designed for use in ad-hoc mobile networks. AODV is a reactive protocol: the routes are created and maintained on demand i.e. only when they are needed. It uses traditional routing tables, one entry per destination, and sequence numbers to determine whether routing information is up-to-date and to prevent routing loops. The distance-vector routing algorithm is used in AODV that keeps the information only about next hops to adjacent neighbors. An important feature of AODV is the maintenance of time-based states in each node: a routing entry not recently used is expired. In case of a route is broken the neighbors can be notified.

Hello messages may be sent to detect and monitor links to neighbors. Because nodes periodically send Hello messages, if a node fails to receive several Hello messages from a neighbor, a link break is detected [4]. When a source has data to transmit to an unknown destination, it broadcasts a RREQ to that destination. The number of RREQ messages that a node can send per second is limited. At each intermediate node, when a RREQ is received a route to the source is created. If the receiving node has not received this RREQ before, is not the destination and does not have a current route to the destination, it rebroadcasts the RREQ [4].

If the receiving node is the destination or has a current route to the destination, it generates a RREP. The RREP is unicast in a hop-by hop fashion to the source. As the RREP propagates, each intermediate node creates a route to the destination. When the source receives the RREP, it records the route to the destination and can begin sending data. If multiple RREPs are received by the source, the route with the shortest hop count is chosen. Unlike DSR the route table entry in the intermediate nodes on the established path contain only the record of next hop along the route instead of complete route [3].

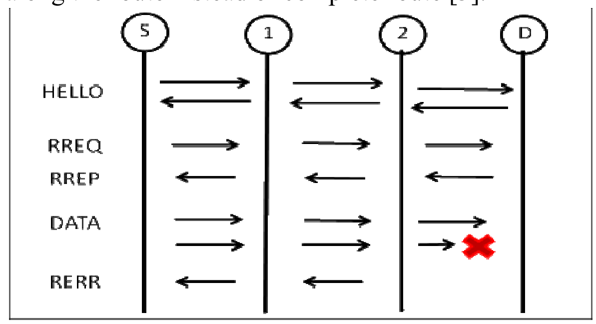

Figure 2: AODV Protocol Messaging.

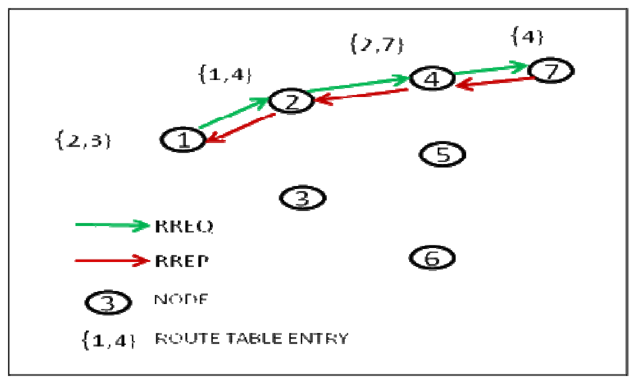

Figure 3: AODV Route Discovery Mechanism.

4.0 RESULTS AND ANALYSIS

The goal of the experimentation is to reveal the fundamental tradeoffs of energy, latency, throughput and fairness in AODV and DSR. All simulations are done using NS-2.27. The radio power values used to compute energy consumption in idle, transmitting, receiving, and sleeping state are in accordance with the RFM TR3000 radio transceiver [7] on Mica Motes.
Simulation parameter and node configuration parameter sets are given in Table 1 and Table 2 respectively.

Simulation Area	2500mx500m
Energy Model	Energy Model
Initial energy	1000J
Transmitting Power	36.00Mw
Receiving Power	14.4mW
Transmission Range	250m

Table 1: Simulation Parameters

Channel Type	**WirelessChannel**
Radio Propagation Model	TwoRayGround
Antenna Model	OmniAntenna
Network interface type	WirelessPhy
MAC Type	802.11
Interface Queue Type	PriQueue/CMUPriQueue
Buffer size of IFq	50

Table 2: Node Configuration Parameters

4.1. TWO-HOP SCENARIO

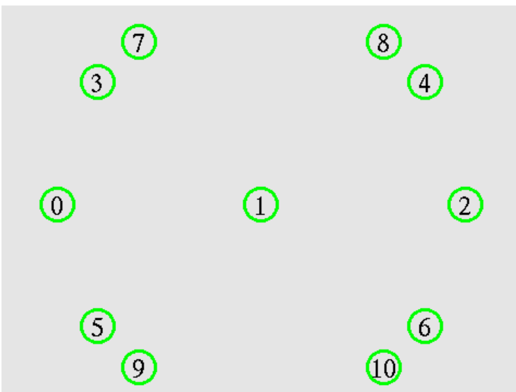

Figure 4: Two-hop Scenario of 11 nodes

The two-hop topology is useful to measure the performance of protocol when hidden terminals are present [8]. As shown in Fig 4, source and sink pairs are arranged around a single intermediate node i.e. node 1. The two-hop topology is of 2500m*500m area.

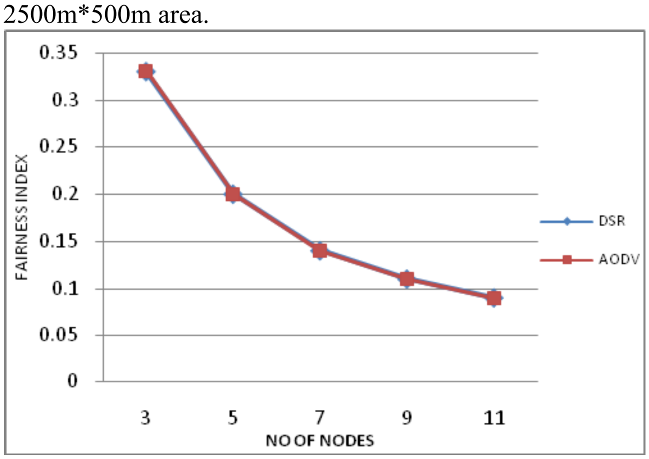

Figure 5: Measurement of Fairness in 2-hop Topology

The Fig 5 shows the measurement of fairness in two hop scenario. The measurement is done by varying the number of nodes. The fairness index values for both the protocols coincide exactly over the entire range. The fairness index reduces significantly with the increase in number of nodes. With increase on network congestion the channel sharing between the nodes becomes unequal, resulting into a drop in fairness index of the network. It is observed that both the protocols respond identically to increasing congestion in the network which gives overlapping graphs.

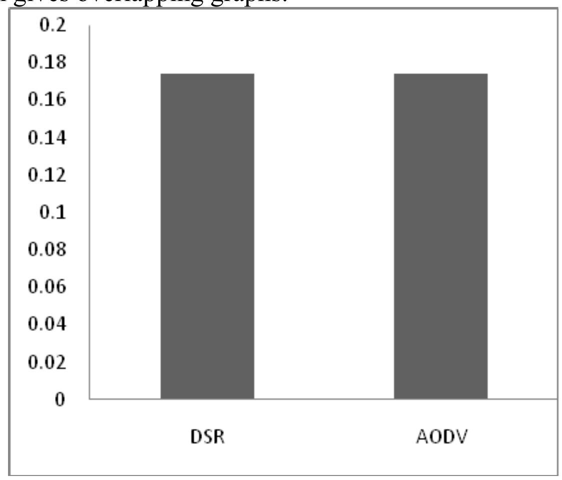

Figure 6: Comparison of average value fairness in 2hop Topology

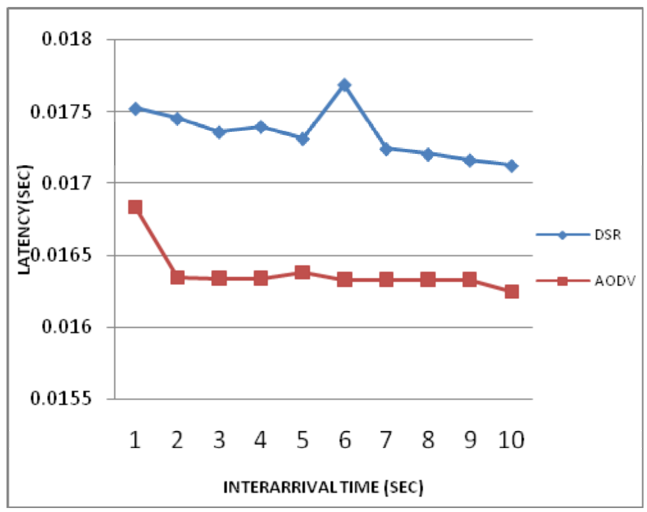

Figure 7: Measurement of Latency in 2-hop Topology

DSR shows higher latency for all values of inter-arrival-time with the respective latency values showing an overall decrease. AODV exhibits a drop at the second value and thereafter remains fairly constant. This may be because in AODV the node replies to the first arrived RREQ packet and discards all those received later thus automatically favoring the least congested path whereas in DSR the node accepts all the RREQ packets and then chooses the shortest path which is comparatively more time consuming [3]. Also DSR requires more time for obtaining routing information, as each node consumes more time for processing any control data it receives, even if it is not the intended receiver.
Throughput for both AODV and DSR reduces with increase in inter arrival time as seen in Fig 7. DSR gives better throughput than AODV over the range. The decrease in throughput is rapid

initially and then becomes gradual. As the inter arrival time increases the time for which the network remains idle increases thus throughput drops in both the cases.

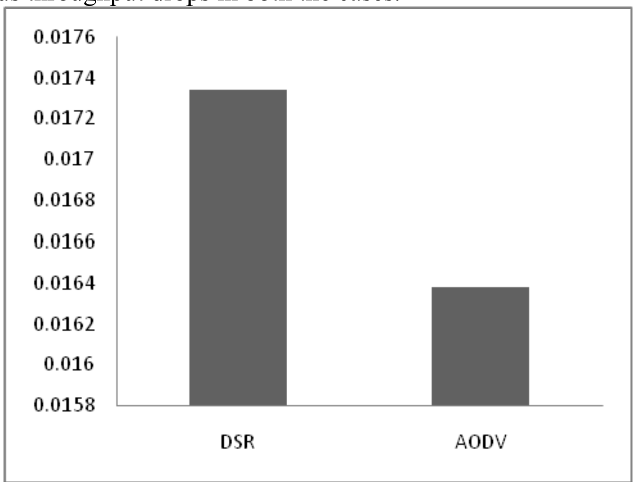

Figure 8: Comparison of Average Latency for 2hop Topology

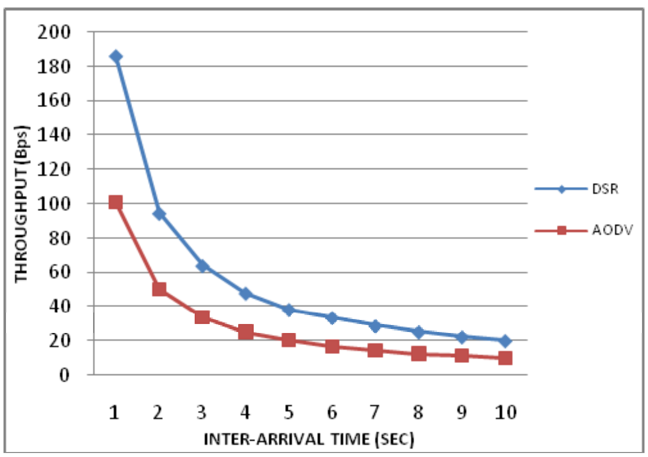

Figure 9: Measurement of Throughput in 2-hop topology.

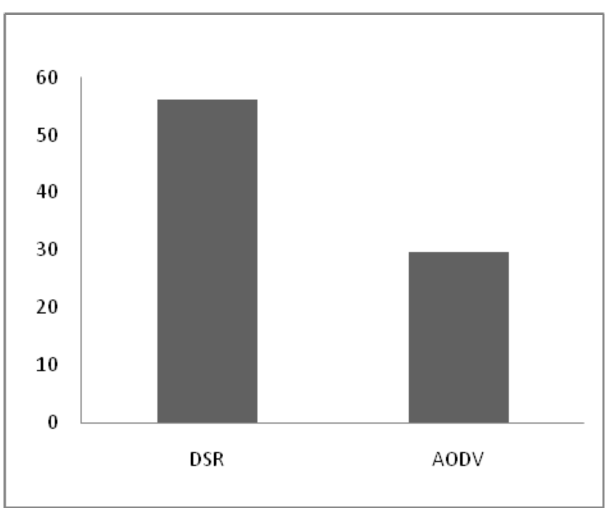

Figure 10: Comparison of Average Throughput for 2hop Topology

This is probably due to the fact that DSR applies the principles of promiscuous listening and caching aggressively which reduces the routing load, thus obtaining higher throughput [5].

4.2. MULTI-HOP CHAIN SCENARIO

The multi-hop scenarios allow the simulations of the complex interactions that more closely approximate the nature of real world WSNs [8]. The multi-hop chain topology can view the system when the sensor nodes are placed equidistant for example on the railway track. [4] The multi-hop chain topology of 11 nodes is as shown in Fig 7. Here, the node 0 is source and node 10 is sink node.

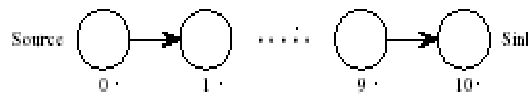

Figure 11: Multi-hop chain (10-hop) Scenario

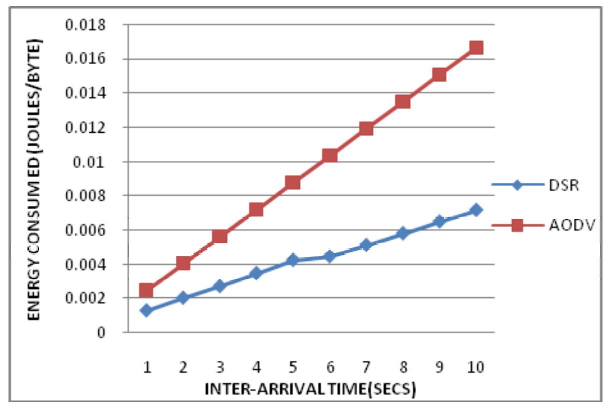

Figure 12: Measurement of Energy Consumption in multi-hop chain topology

Energy consumption in AODV & DSR varies linearly with inter arrival time & is directly proportional to it. It is consistently higher in AODV over the range of inter arrival times and increases at a higher rate than that of DSR. DSR out performs AODV in energy consumption. This may be due to its aggressive approach in promiscuous listening and caching. Because of this the nodes can save a lot of routing procedure as discussed earlier thus saving power [5]. In AODV hello packets are flooded regularly throughout the network. This leads to higher power consumption.

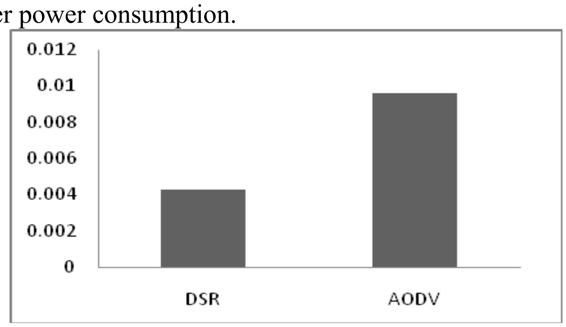

Figure 13: Comparison of Average Energy Consumption for Multi-hop Topology

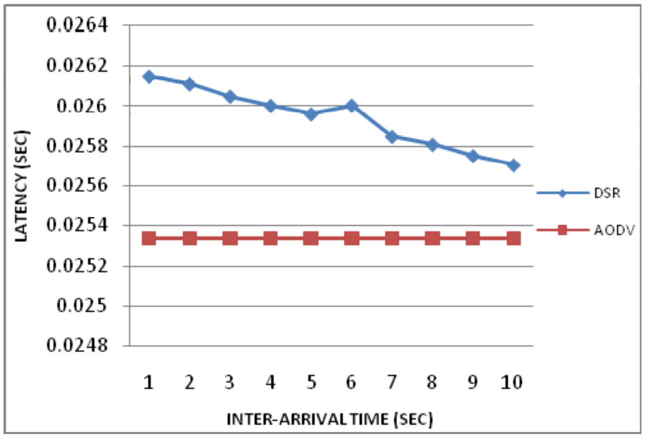

Figure 14: Measurement of Latency in multi-hop chain topology

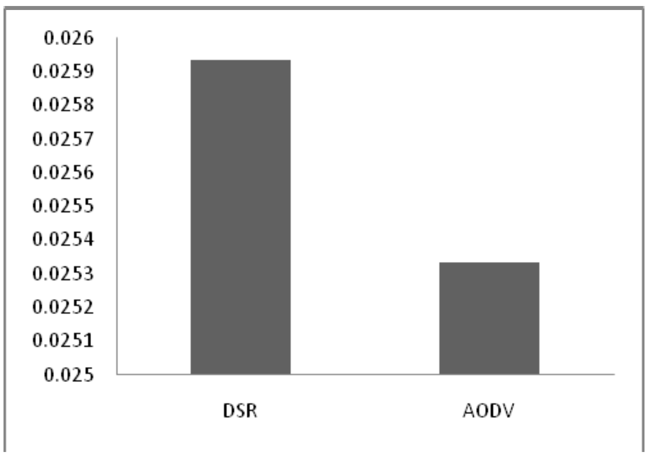

Figure 15: Comparison of Average Latency for Multi-hop Topology

In case of Multi-hop topology also DSR gives higher latency than AODV. This may happen for similar reasons as discussed while considering 2hop topology.

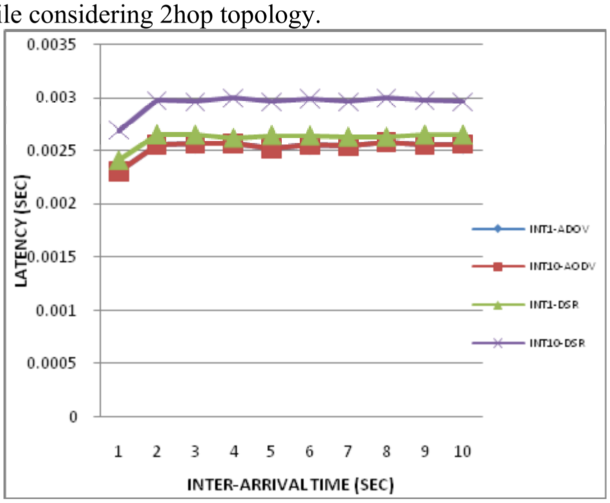

Figure 16: Measurement of Hop-Hop Latency in multi-hop chain topology

Hop to hop latency is the delay required for every hop. It is found to be lesser for the first hop than the rest for whom it is constant. This can be because the source node directly sends the packet to the next node where as the remaining intermediate nodes have to receive the packet, process it, determine the next destination before forwarding.

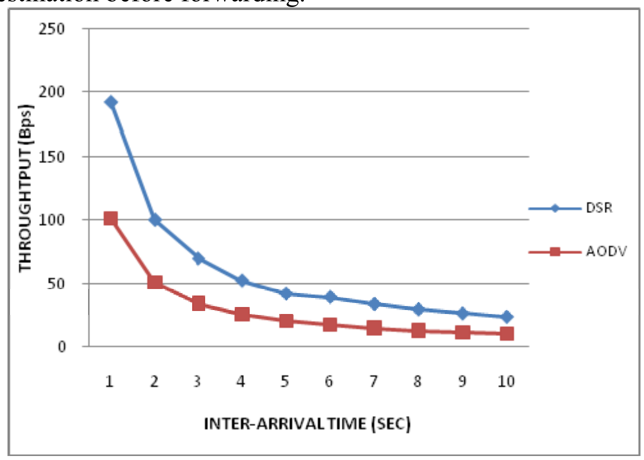

Figure 17: Throughput versus Inter-arrival time for AODV and DSR in multi hop scenario.

The throughput in case of multi-hop topology goes on decreasing in what appears to be an exponential curve, the reasons being same as those mentioned in case of 2hop topology.

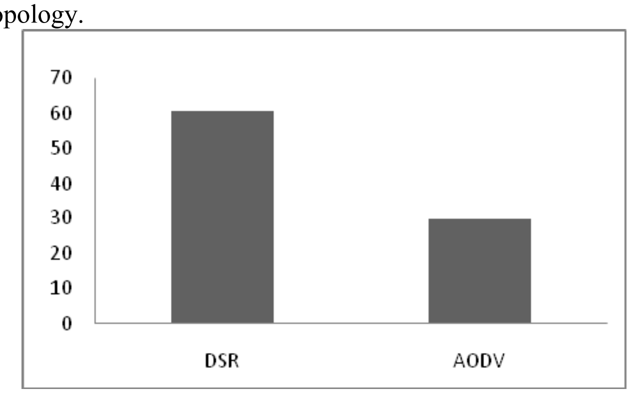

Figure 18: Comparison of Average Throughput for Multi-hop Topology

5.0 CONCLUSIONS

5.1. From the results obtained, DSR proves advantageous with respect to energy consumption with 55.12% lesser average power consumption. Thus DSR is the better choice in networks deployed in remote or inaccessible areas where changing the batteries or replacing the nodes is not practically or economically feasible. Such applications include environment monitoring, animal tracking etc.

5.2. DSR has poor latency as compared to AODV in both multi-hop and 2-hop scenarios. Hence the delay in packet delivery is higher for DSR, thus for time critical applications in which on time delivery of data is of utmost importance AODV is preferable over DSR. Such applications include various military, disaster warning, health care etc. based applications.

5.3. DSR exhibits nearly 51% higher throughput than AODV. Higher throughput is desirable in case of data intensive applications like industrial process monitoring, urban pollution and traffic monitoring networks etc, which generate a large amount of data that must reach the destination. DSR protocol gives better performance in such cases.

5.4. Both AODV and DSR protocols give identical results with respect to fairness.Thus in topologies with changing node density both protocols behave identically.

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Plain Text	A	S	K	S
Conversion to alpha numeric value	10	28	20	28
Sub key	9	7	2	5
Total	19	35	22	33
Mod 36	19	35	22	33
Cipher Text	j	z	M	x

Table 2: Encryption

Cipher Text	j	z	M	x
Conversion to alpha numeric value	19	35	22	33
Add 36 if less than 9	19	35	22	33
Sub key	9	7	2	5
Subtract	10	28	20	28
Plain Text	A	S	K	S

Table 3: Decryption