Performance Analysis of DSDV, AODV AND AOMDV Routing Protocols based on Fixed and Mobility Network Model in Wireless Sensor Network

Ashrafi Arobi [1], Romana Rahman Ema[2] and Subrata Kumar Das[3]

[1] JESSORE UNIVERSITY OF SCIENCE AND TECHNOLOGY, JESSORE-7408, BANGLADESH

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Abstract

Wireless sensor networks (WSN) is capable of autonomously forming a network without human interaction. Each node in a WSN acts as a router, forwarding data packets to other nodes. Without routing protocols, these routers cannot work together in phase. A central challenge in the design of WSN is the development of routing protocols that can efficiently find routes in a network. The question is which criteria should be considered when selecting a routing protocol, for instance, energy consumption (battery life), bandwidth, or security? We selected energy consumption as this is the most important criterion in WSN. To find out the best routing protocol, we analyzed three routing protocols namely AODV (Ad-hoc On Demand Distance Vector), AOMDV (Ad-hoc On Demand Multiple Distance Vector), and DSDV (Destination Sequence Distance Vector). Overall performance of these protocols was analyzed by comparing end-to-end delay, throughput, normalized routing load, and energy consumption of the network. This was accomplished by using the Network Simulator, NS-2.34 over IEEE 802.11. The analysis shows that AOMDV is the best routing protocol in terms of energy consumption.

Index terms— AODV, AOMDV, DSDV, end-to-end delay, throughput, normalized routing load, energy consumption, wireless sensor networks.

1 Introduction

wireless Sensor Network (WSN) is a spatially distributed autonomous system which is a collection of many power-conscious sensor nodes, having wireless channel to communicate with each other ??21]. Wireless networks are characterized by infrastructure-less, random and quickly changing network topology. This makes the traditional routing algorithms fail to perform correctly since they are not strong enough to accommodate such a changing environment [7].Efficient routing protocols can provide significant benefits in terms of both performance and reliability. Since latency, reliability and energy consumption are inter-related with each other, the proper selection of the routing protocol to achieve maximum effi-ciency is a challenging task [2]. Due to this fact, a detailed analysis becomes necessary and useful at this stage.

The application of wireless sensors in our real life such as controlling temperature and acceleration sensor is shown below. [2] studied and compared performance evaluation of Wireless Sensor Network with different Routing Protocols, Adel. S. Elashheb [3] evaluated the performance of AODV and DSDV Routing Protocol in wireless sensor network environment but our simulation results are based on different simulation environment (fixed and mobility) and simulation parameters. Simulation result shows that the performance of AOMDV routing protocol is better than AODV and DSDV in terms of throughput, energy consumption, normalized routing load and end-to-end delay.

2 II.

3 Related Work

Charles E. Perkins, Elizabeth M. Royer, Samir R. Das and Mahesh K. Marina compared the performance of DSR and AODV, two prominent on-demand routing protocols for ad hoc networks [1]. The general observation from the simulation these is that for application-oriented metrics such as delay and throughput, DSR outperforms AODV in less "stressful?" situations (i.e. smaller number of nodes and lower load and/or mobility). AODV, however, outperforms DSR in more stressful situations, widening performance gaps with increasing stress (e.g., more load, higher mobility). DSR, however, consistently generates less routing load than AODV.

Adel. S. Elashheb [4] evaluated the performance of AODV and DSDV Routing Protocol in wireless sensor network environment. In this paper two protocols AODV and DSDV had been simulated using NS-2 package and compared in terms of packet delivery fraction, end to end delay and throughput in different environment; varying period of pause time and the number of expired nodes. Simulation results show that AODV routing protocol had better performance in terms of packet delivery fraction and throughput but, AODV suffers from delay.

4 III.

5 Description of The Routing Protocols a) DSDV

DSDV is a proactive routing protocol and is based on the idea of the Bellman-Ford Routing Algorithm with certain improvements [2]. In DSDV, each node maintains a routing table, which lists all available destinations, next hop to each destination and a sequence number generated by the destination node to provide loop freshness [11] [12] [20]. The sequence numbers are generally even if a link is present; else, an odd number is used. Using such routing table stored in each node, the packets are transmitted throughout the network [20]. The routing table is updated at each node either with advertisement periodically or when significant new information is available to maintain the consistency of the routing table with the dynamically changing topology of the network [20]. If there is a failure of a route to the next node, the node immediately updates the sequence number and broadcasts the information to its neighbors. After receiving routing information the node checks its routing table. If it does not find such entry into its routing table then it updates the routing table with routing information it has found. If the node finds that it has already entry into its routing table then it compares the routing table entry with the sequence number of the received information with and updates the information. When a node receives a new route update packet; it compares it to the information available in the routing table and the routing table is updated based on the following criteria [13] [19]

? If the destination sequence number of receiving packets is greater, then the routing table

information is replaced with the information in the new route update packet. ? When the destination sequence numbers are the same, the routing table is updated by selecting the route with better metric. Thus, DSDV is not suitable for highly dynamic networks.

Figure 2 shown below represents the implementation of DSDV protocol. Table 3.1 illustrates the routing information stored in node 6 of Figure 2. The Destination column represents the destination nodes throughout network. Next hop field column represents the neighbor node which can forward data to the destination node. Metric column represents the number of hops the destination is away from node. Sequence number column represents the destination sequence number [9]. 1A 4A 3 S213_1 2A 4A 2 S899_2 3A 4A 3 S343_3 4A 4A 1 S441_4 5A 5A 1 S155_5 6A 6A 0 S067_6 7A 7A 1 S717_7 8A 5A/7A 2 S582_8 b) AODV

AODV is a development on the DSDV algorithm because it decreases the number of broadcasts by creating paths on-demand. AODV discovers routes as and when necessary. For inactive communication, it is not necessary to establish routes to destination. Whenever desired routes are not getting within the expected time, time to live (TTL) of AODV get expired. The nodes of every valid route employ routing tables to store routing information. The route table stores: <destination addr, next-hop addr, hop count, routing flags, destination sequence number, network interface, life_time> [15]. Sequence numbers are used to provide up-to-date routing information for route freshness criteria and for loop prevention. Life-time is updated every time the route is used. Whenever a node wishes to send a packet to some destination, it checks its routing table to determine if it has a current route to the destination. If it has found current route, then it forwards the packet to the next node, otherwise it initiates a route discovery process [15].

AODV uses different control messages for the discovery and maintenance of routes. They are Route Request Message (RREQ), Route Reply Message (RREP), Route Error Message (RERR), HELLO Messages [7] [14]. By creating a Route Request (RREQ) message, AODV initiates Route discovery process to reach from source to destination. Every time when the source node sends a new RREQ, broadcast ID gets incremented. After receiving of request message, each node checks the request ID and source address pair. The new RREQ is rejected if there is already RREQ packet having the same pair of parameters. If a node has no route entry for the destination, it rebroadcasts the RREQ with incremented hop count parameter. RREP contains the route information about the destination which is mentioned in RREQ and it is transmitted to the sender of the RREQ If there is a link failure of a valid route, a RERR message is generated by the node upstream of a link breakage to inform other nodes about the link failure. In AODV, Hello messages are broadcasted in order to know neighborhood nodes and to notify the neighbors about the activation of the link. Absence of hello message is defined as an indication of link failure [7] [14].

6 c) AOMDV

The motivation for designing AOMDV is to compute multiple loop free and link disjoint paths in highly dynamic ad hoc networks where the link breakage occurs repeatedly [17]. It is the extension of AODV routing protocol [2] [10] [16]. AOMDV maintains a routing table for each node containing a list of the next-hops and its associated hop counts. Every next hop has similar sequence number for maintaining of a route. To send route advertisements, each node maintains the advertised hop count of the destination. If any node's hop count is less than the advertised hop count, then loop freshness is guaranteed for that node by receiving alternate paths to destination. In the case of a route failure, AOMDV uses alternate routes [2]. In AODV routing protocol, a route discovery procedure is needed for each link failure. Performing such procedure causes more overhead and latency also [17]. In the case of AOMDV, new route discovery process is required only when all the routes fail [10] [16]. In AOMDV, a source initiates a route discovery process if it needs a communication route to a destination. The source broadcasts a route request (RREQ) along a unique sequence number so that duplicate requests can be discarded. After receiving the request, an intermediate node record previous hop. If it has a valid and fresh route entry to the destination in its routing table, then it sends a reply (RREP) back to the source. If it has no valid and fresh route entry, it rebroadcast the RREQ. The nodes on reverse route towards source update their routing information by establishing multiple reverse paths. Duplicate RREP on reverse path is only forwarded if it contains either a larger destination sequence number or a shorter route found **??**10] [16]. Figure 4 shows the route discovery process of AOMDV and in table 3.4, it is shown that each entry in the routing table consists of all available destinations, next hop towards each destination (i.e. B, C and J), number of hops required to reach destination and a destination sequence number.

IV.

7 Simulation Model

To configure both of the network models, we used the following simulation parameters which we have discussed in table 4.1.

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Performance Results

9 a) Performance Metrics i. Average end-to-end delay

Average end-to-end delay is the average time from the transmission of a data packet at a source node until packet delivery to a destination which includes all possible delays caused by buffering during route discovery latency, queuing at the interface queue, retransmission delays at the MAC, propagation delay for propagation and transfer times and carrier sense delay for carrier sensors [7] [18].

ii. Average Throughput Throughput is the total number of packets that have been successfully delivered from source node to destination node and it can be improved with increasing node density [7] [18].

iii. Normalized Routing Load It is the number of routing packets transmitted per data packet delivered at the destination [18].

10 iv. Energy Consumption

?Percentage Energy Consumed by all nodes [18] Number of all nodes v. Remaining Energy Remaining Energy is defined as Initial Energy -Energy Used [18] b) Result and Analysis number of packets delivery also increase. That's why queue is getting full. DSDV routing protocol tries to drop the packets if it is not possible to deliver them. This cause less delay and most dropping packets are retransmitted over again that causes retransmission delay. On the other hand, AODV and AOMDV both routing protocol allow packets to stay in the send buffer for 30 seconds for route discovery and once the route is discovered, data packets are forwarded on that route to be delivered at the destination. In this graph, result shows that AOMDV performs significant more delay than AODV after 24 connections. Due to multi paths in AOMDV there can be many stale routes which may contribute to more delay than AODV. As the number of connections increases, the end-to-end delay also increases in a fixed scenario.

To analyze the effects of mobility, figure 6 (c) shows that end-to-end delay of AODV is comparatively higher than AOMDV and DSDV at high density. When queue is getting free from 16-20 numbers of connections, the delay of DSDV is decreased because it consumes less time to deliver packets. AOMDV loses fewer packets than AODV (1-2% less) at high density in mobility cases. From 30-32 numbers of connections, the delay is almost similar in AODV and AOMDV because of less queuing delay. When a links failure is occurred in mobility scenario, the route discovery process of AODV causes very long delays for large scale networks due to the amount of control packets transmitted. These delays result in deliver packets waiting in the queues being dropped .The average end-to-end delay is 3% higher than fixed scenario because of high mobility environment, topology change rapidly.

Figure 6 (b, d) respectively shows the average end-to-end delay versus pause time by taking the each time delay which we considered as simulation time for AODV, AOMDV, DSDV routing protocol. Figure 6 (b) shows that DSDV performs less delay than AODV and AOMDV with 36 connections and with pause time varying from 0-60 second's when simulation is started. As the simulation time increases, the average end-toend delay increases because of number of packets generates by each source increases. If there is no alternate path or unable to deliver packets from source to destination, both AODV and AOMDV allow packets to stay in buffer for 30 sec. This causes the data packets waiting to be routed. The packets are dropped if the time the packets have been in buffer exceeds the limit (30s). In the case of a link failure at a node, AOMDV can find an alternate route whereas AODV is caused to be ineffective at that point. Being a proactive routing protocol the packet drop of DSDV is maximum than the other two protocol when its fails to find a route. So delay of DSDV is less than AODV and AOMDV.

Figure 6 (d) shows the effects of mobility, each node chooses a random destination and moves there at a high speed on expiry of its pause time. The observation is that the AOMDV routing protocol outperforms AODV when the pause times varies from 10 to 20 sec .But AODV outperforms AOMDV when the pause time is high that is varying from 26 to 50 sec. Figure 7(a, d) illustrates a comparison among AODV, DSDV, and AOMDV in terms of average throughput based on fixed and mobility scenario by varying maximum number of connections (number of nodes). The numbers of connections were varied as 12,16,20,24,28,32,36 nodes respectively. It can be observed from the figure 7 (a) that the average throughput of AODV and AOMDV routing protocol increases at low density in between the number of connections from 12 to 28 and AOMDV outperforms AODV. This is because whenever the packets are dropped, most of the missing packets are retransmitted again over multiple reliable routes from source or intermediate node to destination. At high density like from 32 numbers of connections, the average throughput decreases because of packet lost. Packets loss is minimum in both AOMDV and AODV than DSDV.DSDV provides much packets drop at high density from 28 number of connections. That's why its throughput is comparatively less than AODV and AOMDV.

Figure 7(d) shows that mobility affects the throughput of AODV, AOMDV and DSDV differently. For randomly changing topology, at low density from 12 to 20 numbers of connections, the throughput of AODV and AOMDV is almost similar. But at high density from 28 connections, the possibility of link failures increases. This causes the average throughput decreases of AODV, AOMDV, and DSDV routing protocol. AOMDV is able to select multiple paths to achieve more loads balancing in a high mobility to delivery packets than AODV and DSDV respectively.

As seen in figure 7 Figure 7(c) shows that the mobility affects the throughput of AODV, AOMDV and DSDV differently varying the pause time. AODV outperforms AOMDV when pause time increases from 5 to 15 sec. The reason behind this is when mobility is low, the occurrence of link failure is less and packets drop is less than AOMDV. As the pause time increase from 16 sec AOMDV outperforms AODV. This is because if the node mobility is high, then occurrence of link failure increases and as we said before in AOMDV as if one path fails or congested, an alternate path is utilized to deliver packets and it maximizes the throughput than AODV. With respect to varied pause time as from 5 to 20 sec, throughput increases because of less periodic updates of routing table. DSDV shows more variation of throughput if the node mobility is high. Thus its throughput decreases quicker as pause time increases from 25 sec and throughput increases again when pause time is 30 sec. AOMDV provides more data packets delivery than AODV and DSDV respectively. Figure 8 (a, c) illustrates a comparison among AODV, DSDV, and AOMDV in terms of normalized routing load based on fixed and mobility scenario by varying maximum number of connections (number of nodes). The numbers of connections were varied as 12,16,20,24,28,32,36 nodes respectively. In figure 8 (a), it is observed that AOMDV has more normalized routing load as compared to the DSDV and AODV .For both AOMDV and AODV, the NRL increases as number of connections increases except number of connections 20, 30 respectively. This is because for fixed scenario with smaller number of connections, a link failure is very rare and there is less control packets to route discovery such as hello message, RREQ, RREP, and RERR. DSDV has the least NRL which remain stable than AOMDV and AODV in case of low and high numbers of connections density by varying 12,16,20,24,28,32,36. DSDV does not adapt to increase so much because the difference of routing update interval at every 15 seconds in the network is not very noticeable. AOMDV is a multipath routing protocol and if the current route breaks it searches for alternate paths by flooding the network with RREQ packets. AODV being a unipath routing protocol, the packet delivery along that route stops in the case of link breakage. So NRL of AODV is less than AOMDV.

Figure 8(c) shows the performance of NRL as a function of mobility. DSDV gives the lowest NRL, except at initially the NRL is slightly increased than AODV and AOMDV, when numbers of connections are in between 12 to 16 numbers of connections. This means DSDV sends periodic updates which increase routing load in the mobility network. In case of mobility by varying high density from 17 numbers of connections, more link failures occur than fixed scenario .To detect and handle the pressure of routing load with large number of connection, AOMDV sends HELLO packets periodically which gives higher routing packet overload than AODV.

Figure 8 (b, d) illustrates a comparison among AODV, DSDV, and AOMDV in terms of NRL based on fixed and mobility scenario by variations of pause time from 5 to 60 sec which we consider for simulation time. In figure 8 (b), AOMDV outperforms AODV and DSDV. It is clear from the figure that the NRL of AOMDV and

AODV increases linearly with varying pause time 5 to 60 sec and this is because for a static network, max. Speed is of 0 m/s. That's why in the case of less link failure, DSDV's NRL is quite stable with an increasing number of pause time from 15 sec even though its delivery get increasingly worse. The effects of mobility are particularly visible in figure 8 (d). AOMDV outperforms AODV except pause time at 5 to 15 sec. Because in this case, the routing packets travel through more hops to reach the destination that increase the frequency rate of route discovery which is less than AOMDV. For DSDV the NRL remains almost unaffected by variations in pause time from 10 to 20 sec and with the increases of pause time from 20 sec, the routing load increases.

AOMDV being a multipath routing protocol and it searches for alternate paths if the current route breaks by flooding the network with RREQ packets. Hence AOMDV has more normalized routing load than AODV in both fixed and mobility scenario due to AODV being a unipath routing protocol. shows protocol energy, remaining energy and the maximum number of connections energy consumption respectively. Figure 9.1 (a) and 9.2 (a) shows that DSDV protocol consumes more energy compared to AOMDV and AODV. It is clear from the figure 9.2(a) that in mobility scenario, all the protocol consumes more energy than fixed scenario. The life time (battery) of the node for AOMDV is higher than other protocol. To utilize the same path for route discovery process of DSDV, the node life time expires (battery power) which consumes more bandwidth and energy than reactive protocols like AOMDV and AODV. In the case of a link failure, AOMDV has the ability to make longer battery and node's life time because of the proper utilization in choosing a path. Figure 9.1 (b) and 9.2(b) shows the overall residual energy of each route in the route discovery process. The overall residual energy of AOMDV and AODV in both cases higher than DSDV because of proper utilization stale routes and choosing alternate paths when it's needed. DSDV routing protocol is updated its all routing protocols if its need to be changed. For this reason residuals energy is less than AODV and AOMDV. Figure 9.1 (c) and 9.2(c) depicts that the maximum number of connection energy consumption. The number of sources of DSDV consumes more energy because its routing table updated at every 15 seconds in the network. For mobility cases in DSDV lots of link failure occurs and mostly drop packets are needed to retransmit on a same path which expires a sensor node battery life time than on-demand routing protocols (AODV and AOMDV). Both on-demand protocols have the ability to choose alternative path if link failure occur. 10 (a) shows average end-to-end delay vs. speed. End-to-End delay increases as speed increases. AODV outperforms AOMDV and DSDV respectively except as the speed of nodes is varied from 2 to 10 m/s. In case of a link failure at a node, AOMDV can find an alternate route whereas AODV is caused to be ineffective at that point. DSDV shows less delay because it immediately drops the packets when there is a link failure. The results show that in "low mobility" situation, AODV protocol gives approximately same end-to-end delay as that of AOMDV protocol but in "high mobility" situation, AODV outperforms AOMDV protocol. Figure 10 (b) shows Normalized routing load vs. speed. AOMDV has the highest normalized routing load than AODV and DSDV. As we seen from the figure, the NRL value for AOMDV and DSDV increases very less (the difference is unnoticeable) till 2 to 14 m/s. If any route fails in AOMDV, AOMDV tries to find alternate multiple routes which tend to incur greater routing packets. While a node moves at a high speed, a source node generate more RREQs to find an alternate route. For DSDV protocol as node speed increases, the topology changes occur quickly, and thus DSDV has fewer chances to make available routes at once. packets delivery and causes more packets drop. This is because it has gone out of packets transmission ranges since finding the route requires more and more routing traffic as speed increases. AOMDV outperforms AODV and DSDV. As AOMDV and AODV both are on demand routing protocols, they have the ability to deal with high mobility speed for delivering good numbers of packets.

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12 VI.

13 Conclusion and Future Work

This paper evaluated the performance of the well-known routing protocols in wireless sensor network on the basis of fixed and mobility network model in terms of average throughput, average end-to-end delay, normalized routing load, energy consumption, protocols residual energy, total energy consumption of each nodes, speed vs. throughput, speed Vs. end-toend delay, speed vs. normalized routing load with different simulation period and maximum number of connections. Being a proactive routing protocol, DSDV immediately drops the packets in the case of a link failure. Therefore, it has less delay than AOMDV and AODV in both fixed and mobility scenario. In mobility network scenario, the average end-to-end delay is 3% higher than fixed scenario because of high mobility environment and frequent topology changes. DSDV is not suitable for larger networks. In terms of average throughput and normalized routing load, both reactive protocols (AODV, AOMDV) performs better than DSDV. This is because AODV and AOMDV both chooses the alternate path if link failure occurs. Therefore, packet loss ratio of AODV and AOMDV protocols is lower than DSDV. The number of received packets for fixed scenario is 87-90% whereas the number of received packets for mobility scenario is 70-75%. In mobility scenario, received packets ratio is always less than fixed scenario due to the repeated update of the position of the sensor nodes and frequent link failures. AOMDV and AODV have higher normalized routing load than DSDV, because of maintaining stale routes and alternate paths. In both fixed and mobility scenario, AOMDV is energy efficient routing protocol than AODV and DSDV respectively. AOMDV has much residual energy along with the hop count. To utilize the same path for route discovery process of DSDV, the node life time expires (battery power) which consumes more bandwidth and energy than reactive protocols like AOMDV and AODV. In the case of a link failure, AOMDV has the ability to make longer battery and node's lifetime because of the proper utilization in choosing a path. So our performance analysis among DSDV, AODV and AOMDV routing protocol depicts that the applications where throughput, residual energy are important and delay can be tolerated; then the AOMDV routing protocol can be the best solution. We also observed that in a high speed movement of nodes, AOMDV can be the best choice. Though AOMDV routing protocol performs better in our simulation environment considering energy consumption and throughput, still it has some limitations like more delay, more routing load in the network. The future work would be to improve AOMDV routing algorithm so that these limitations can be removed. [1]

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Figure 1: Figure 1 :

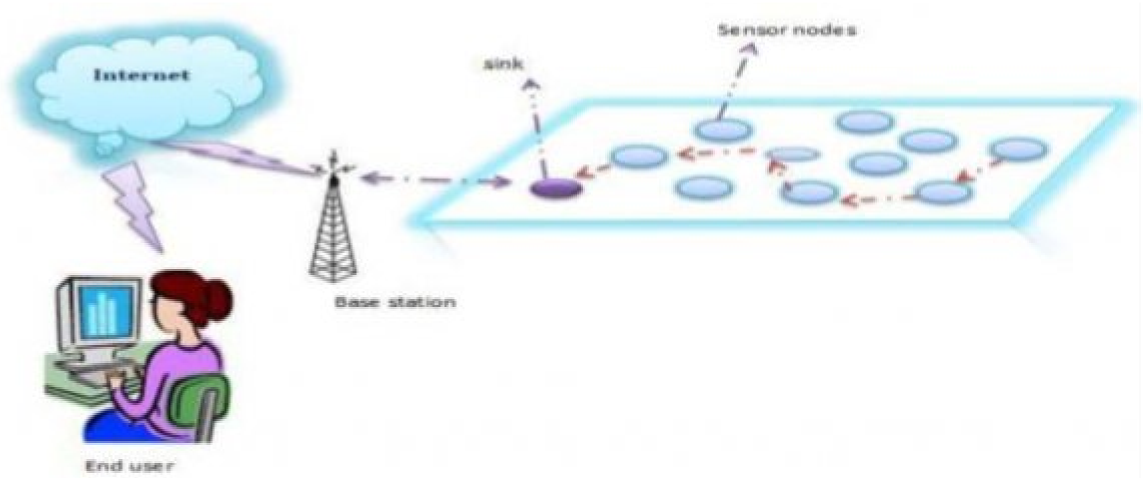

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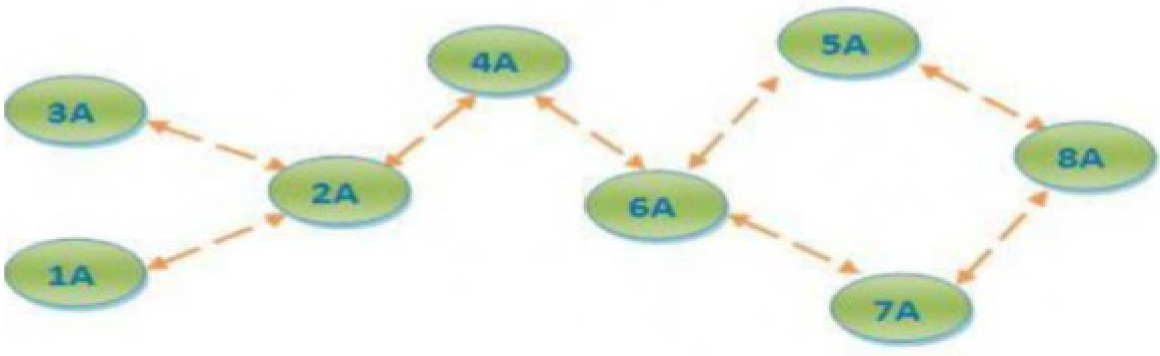
Figure 2: Figure 2 :



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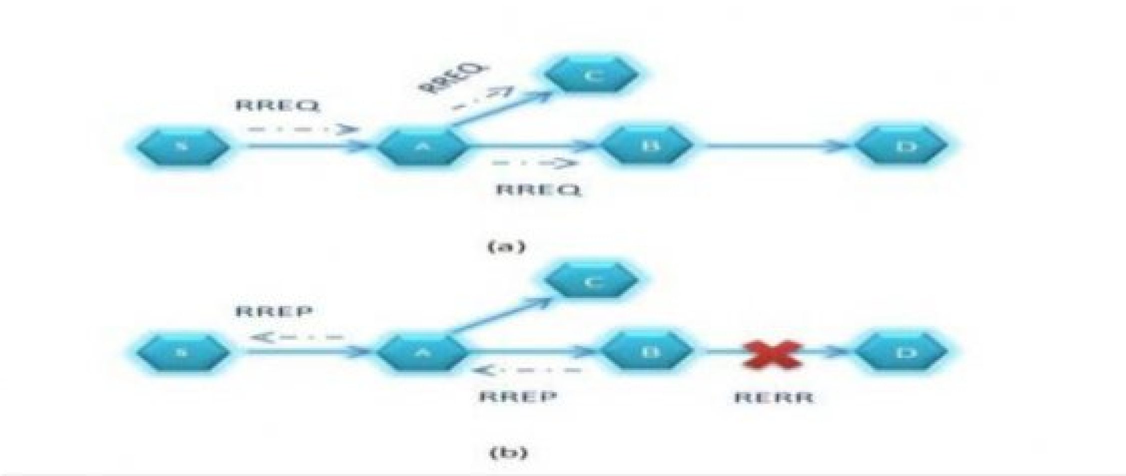

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Figure 4: Figure 4 :

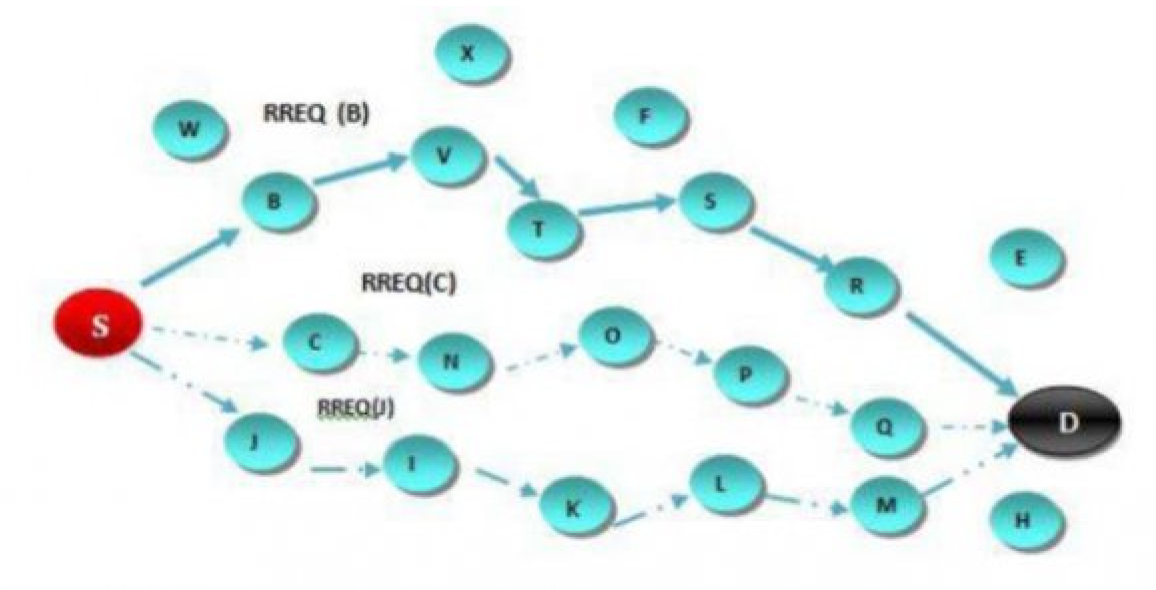

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Figure 5: Figure 6 :

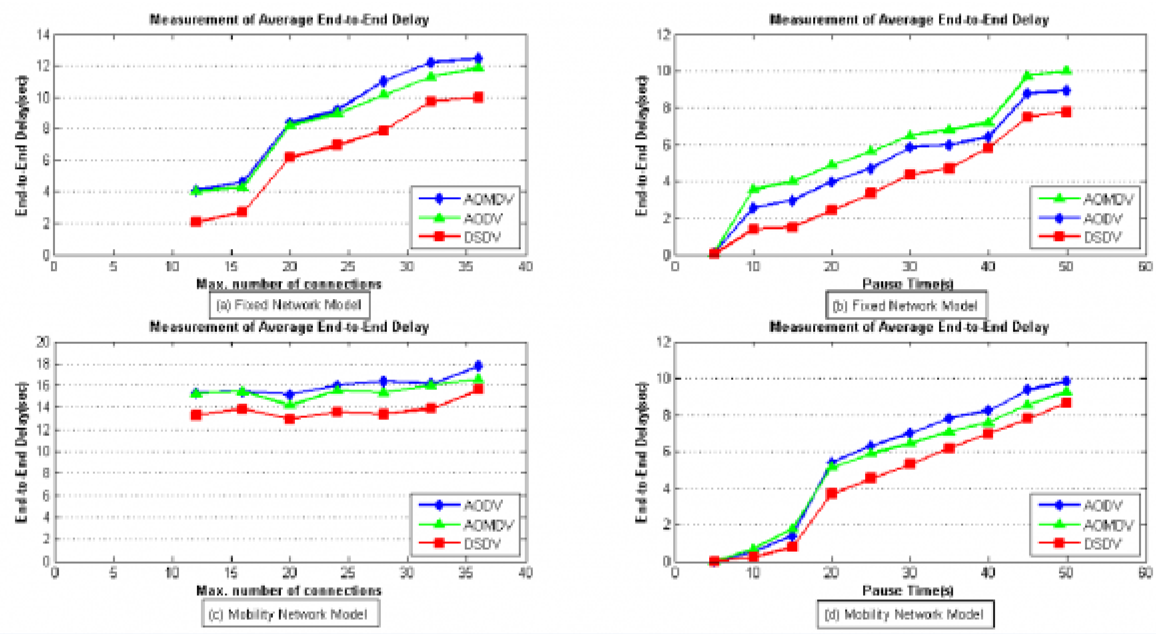

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Figure 6: Figure 7 :

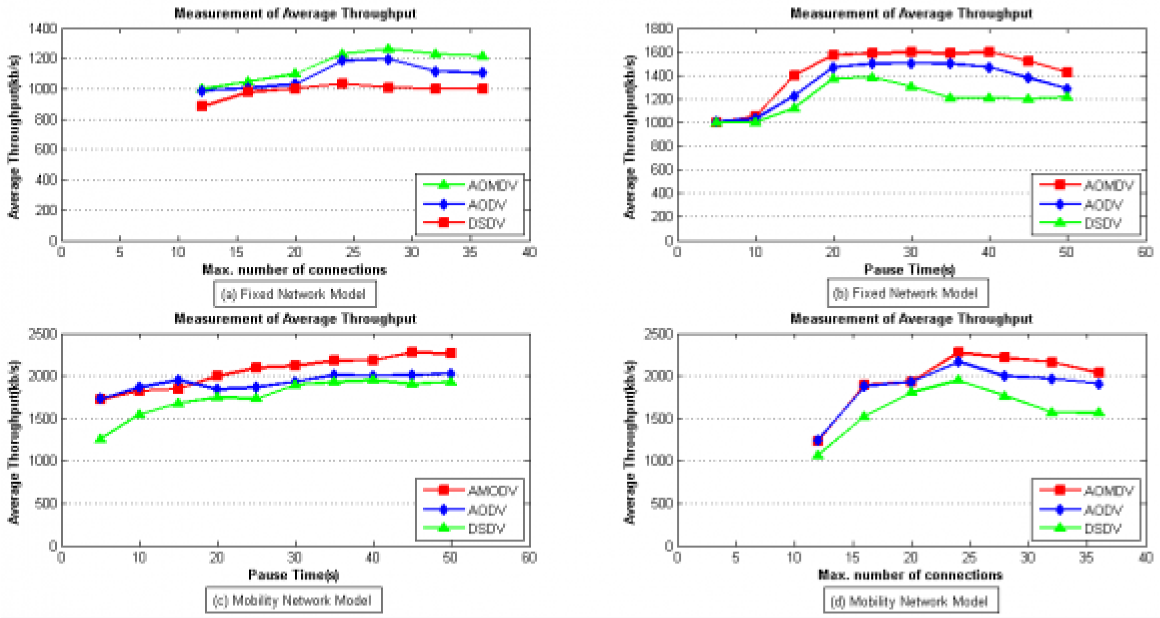

Figure 7:

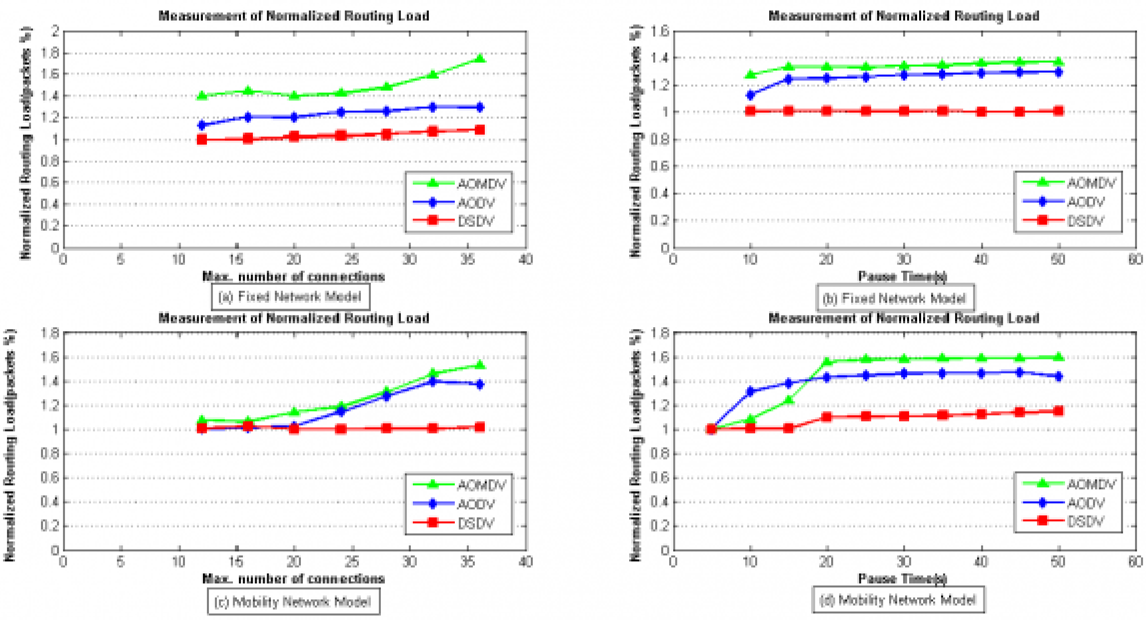

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Figure 8: Figure 8 :

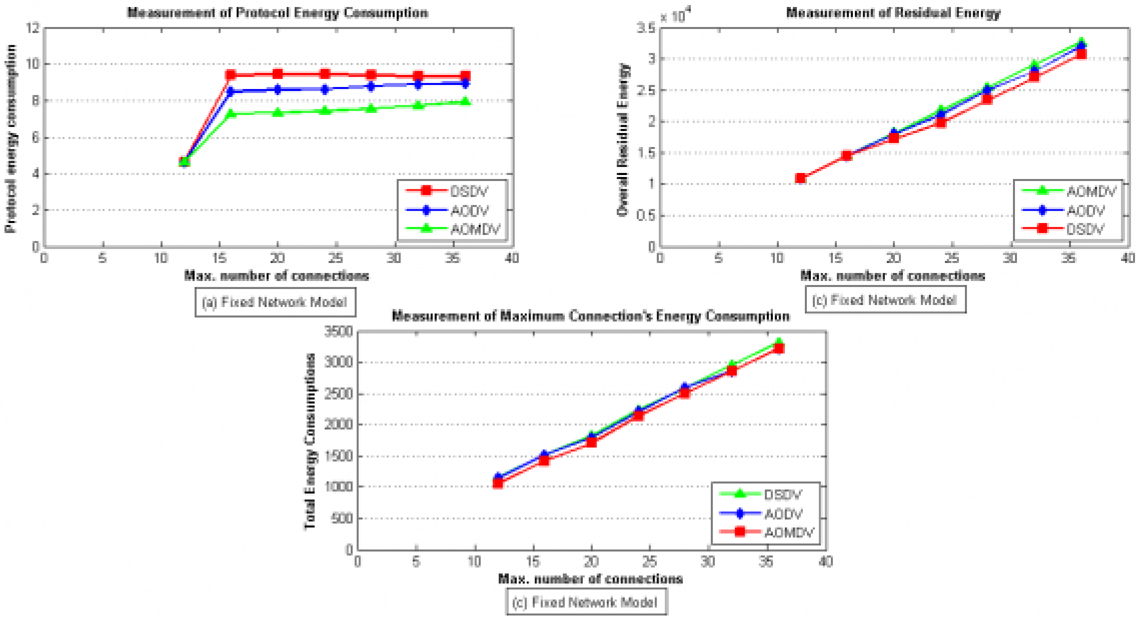

Figure 9:

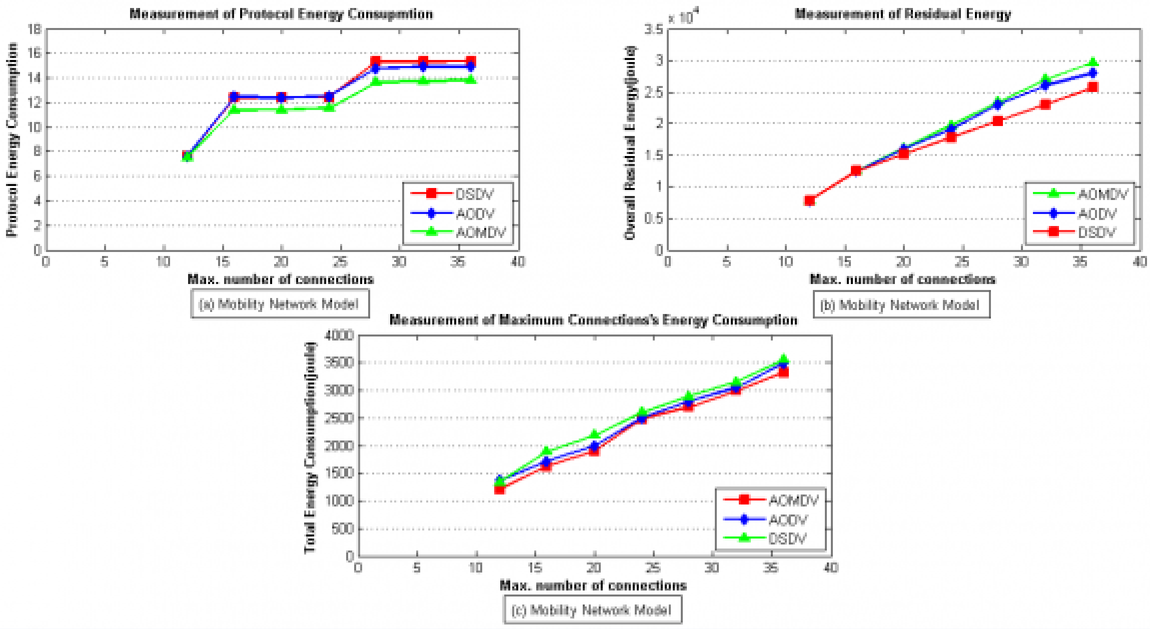

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Figure 10: Figure 9 .

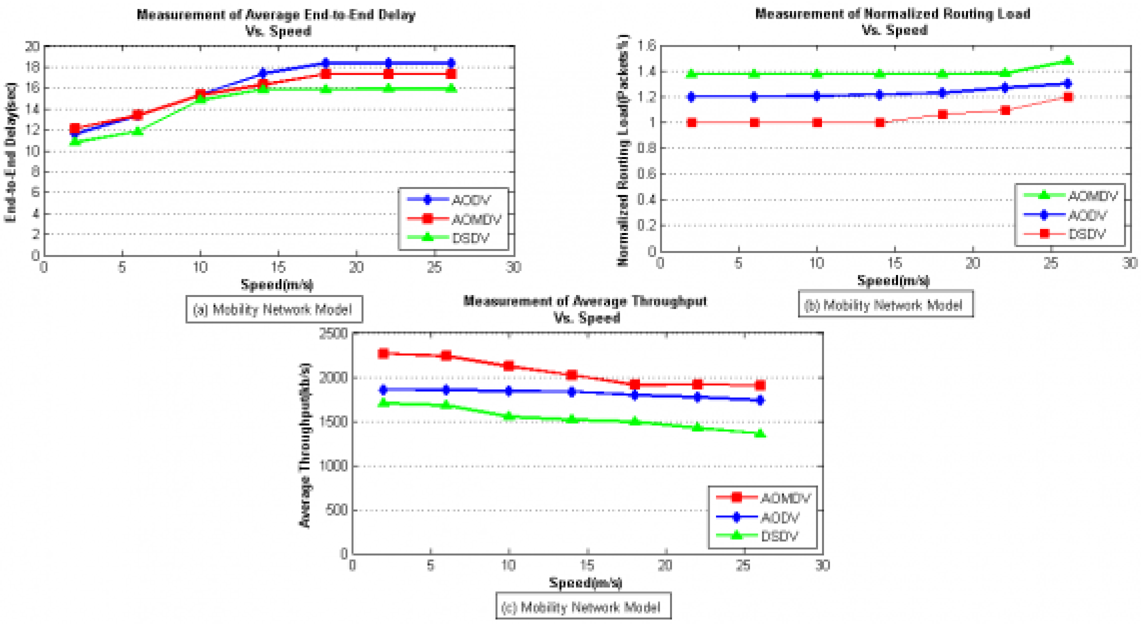

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Figure 11: Figure 10 :Figure 9 . 1 :Figure 9 . 2 :Figure 10

3

Figure 12: Table 3 .1 : Routing Table of Node 6 Destination Next Hop Metric Sequence Number

32

Destination	Next hop	Number of hops	Destination Sequence Number
D	B	5	S1
D	C	5	S2
D	J	5	S3

Figure 13: Table 3 . 2 :

4

1 : Simulation Parameters

Parameters	Details
Simulator	NS-2.34
Node Placement	Random, Fixed
No. of Nodes	12,16,20,24,28,32,36
No. of sink (destination)	One(Node 0)
No. of sources	35 (Node 1 to 35)
Area of simulation	2500 m *1000m
Packets generated by each source 1000	
Total packets generated in N/W	36*1000=36000
Size of each packet	1000 bytes
Model	Energy Model
Initial energy	1000J
Transmission Range	250m
Radio model	Two Ray Ground
Protocols	AODV,DSDV,AOMDV
Max speed	28m/s
Traffic type	FTP
MAC	Mac/802_11
Bandwidth	11mb
Simulation time(in sec)	1000 sec
Antenna Type	Omni directional
Link Layer Type	LL
Interface queue type	Queue/Drop tail
Channel type	Channel/Wireless channel
Network interface type	Phy/WirelesssPhy

Figure 14: Table 4 .

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