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Investigation of different Adhoc routing topologies DSR, AODV and DSDV using IEEE 802.11 for WSNs using ns-2 for varying terrain areas by varying pause time (Node Mobility)

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Abstract
The micro-electro-mechanical systems (MEMS) based Wireless Sensor Network (WSN) are new in communications. A comparison of various Adhoc Routing Protocols viz. Dynamic Source Routing (DSR), Adhoc On-Demand Distance Vector Routing (AODV) and Destination-Sequenced Distance-Vector (DSDV)using IEEE 802.11 standards using Network Simulator 2 (ns-2) for WSNs is made. The parameters of a particular routing are affected by the choice of size, node mobility, etc. which has been extensively studied. This paper discuss and evaluate the performance of different network parameters like Packet Delivery Fraction (PDF), Average End-to-End Delay, Average Throughput, Normalized Routing Load **(**NRL) and Packet loss on different routing protocols by varying varying pause timein different terrain areas which is small (1000 m. x 1000 m.), large (2000 m. x 1000 m.) and very large (2000 m. x 2000 m.) keeping maximum node speed constant andmonitoring critical conditions with the help of these parameters. The actual Network designer can make use of such analysis before design of an actual WSNs system.

Keywords: Adhoc Routing, AODV, Average End-to-End Delay, Average Throughput, DSDV, DSR, IEEE 802.11, Maximum Node Speed, MEMS, Network Design, NRL, ns-2, Packet Loss, Pause Time, PDF, WSN

1. Introduction

Recent advancement in micro-electro-mechanical systems (MEMS) led to Wireless Sensor Network (WSN) which are wireless network with numerous spatially distributed tiny immobile autonomous devices or sensors with sensing, computation, and wireless communications capabilities envisioned to be deployed in the physical environment to monitor a wide variety of real-world phenomena [1].

The routing protocols designs used in the WSNs is of huge concern for efficient communication of data between sensor nodes. Sensors can perform their computations and transmission of information in a wireless environment by using their limited supply of energy [2, 14].

The Dynamic source routing protocol is an efficient reactive and simple routing protocol specifically used for multi-hop wireless adhoc networks of mobile nodes and wireless sensor networks. It has no need for any existing network infrastructure or administration. Dynamic source routing allows the network to be completely self- organizing and configuring. Dynamic source routing uses source routing to send packet which means the complete hop sequence to the destination is well known by the source. DSR protocol uses two mechanisms for sending packet from source to destination which are “Route Discovery” and “Route maintenance” which works together to allow nodes to discover and maintain routes [3, 4]. AODV is a routing protocol used for data transmission between sensor nodes. AODV finds the routes only when it requires. This routing protocol allows message passing across the sensor nodes. It sends HELLO message to track neighbour node. It uses sequence number generated by each node to check accuracy of updated information of route [2]. Destination-Sequenced Distance-Vector (DSDV) Routing Algorithm is based on idea of the classical Bellman-Ford routing algorithm designed for adhoc networks with improvements [5].

The experimental study is to measure the ability of the the above protocol to react to the network topology change while continuing to successfully deliver data packets to their destinations. To measure this, different scenarios were generated by varying pause time(node mobility) in the network that over different terrain areas [2, 3, 4] while keeping constant the maximum speed of nodes (node speed).

In this paper we describe in Simulation Tools, Simulation parameters, Related Work, Simulation Setup, Results and Analysis and Conclusion.

2. Tools and methodology

To work on the WSNs routing protocol and to evaluate performance of routing protocol metrics, Network simulator 2 (ns-2) was used [6]. This is most popular simulator for the researchers [9]. Even though newer tools like ns3 are used nowadays because of the simplicity in programming in simple English like Tool Command Language (TCL) to write front-end of the program [7]. It uses C++ as back end of the program. When TCL is compiled a trace file.tr and nam file is created. These files indicate movement pattern of the nodes and it keeps the number of hops between two nodes, connection type and number of packets sent etc. at each instance [8]. The connection pattern file (CBR file) specifies the connection pattern, topology and packet type. These files are also used to create the trace file and nam file which are further used to simulate the network [9].

3. Performance parameters

1. **Packet Delivery Fraction (PDF):** Packet Delivery Fraction = (number of data packets delivered to the destination nodes) / (number of data packets produced by source nodes) [10, 11].

2. **End-to-End Delay:** The term End-to-End delay refers to the time taken by a packet to be transmitted across a network from source node to destination node which includes retransmission delays at the MAC, transfer and propagation times and all possible delays at route discovery and route maintenance [10, 12]. The queuing time can be caused by the network congestion or unavailability of valid routes [10].
3. **Throughput:** The term throughput refers the number of packet arriving at the sink per ms. Throughput is also refers to the amount of data transfer from source mode to destination in a specified amount of time [10, 13].
4. **Normalized Routing Load [%] (NRL):** It is the number of routing packet required to be send per data packet delivered. NRL = (Number of Routing Packet) / (Number of Packet Received)
5. **Packet Loss [%]:** It is the number of dropped packet to the total packets. Packet Loss [%] = (dropped Packets/ (total packets)) *100) [10].

4. Simulation setup

There are many research papers on routing protocols in wireless sensor network and all are used for evaluating performance of different parameters in different scenario. In this work, a total of 54 simulations were carried out asshown in Figure I below (i.e. 3 Protocols x 3 terrain areas x 6 pause times).

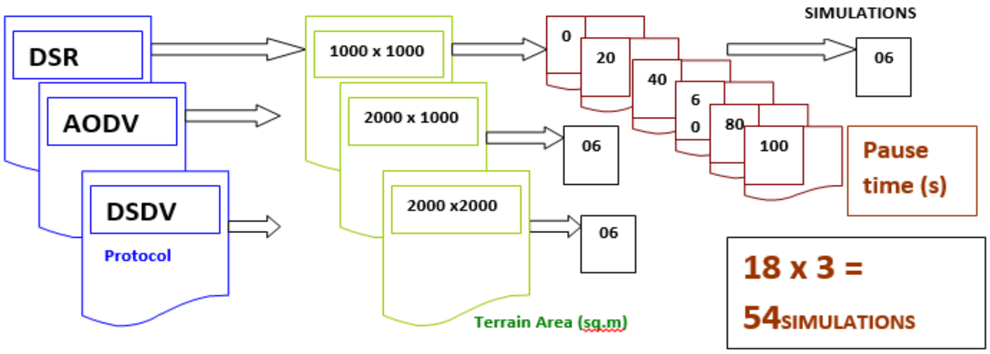

Fig 1: 54 Simulations i.e. 3 Protocols x 3 terrain areas x 6 pause times.

In this paper, an attempt was made to investigate all the three routing protocols under the same simulation environment wherein, the same movement models were used, for different terrain topologies, the maximum speed of the nodes was set to 10 m/s and the pause time was varied as 0 – 100s in intervals of 20s. A total of 100 nodes are used with the maximum connection number 10; CBR connection; transfer rate is taken as 4 packets per second i.e. the send rate of 0.25, implemented respectively on a terrain area of 1000 m. x 1000 m., 2000 m. x 1000 m. and 2000 m. x 2000 m. The simulation time was taken as 100 seconds. The details of general simulation parameter used are depicted in Table I.

Table 1: Simulation Parameter Values

S. No.	Parameters	Values
1	Transmitter range	250m
2	Bandwidth	2 Mbps
3	Simulation time	100 s
4	Number of nodes	100
5	Max Speed	10 m/s
6	Pause time	00, 20, 40, 60, 80, 100 s
7	Environment size	1000m x 1000m, 2000m x 1000m, 2000m x 2000m
8	Traffic type	Constant Bit Rate
9	Packet size	512 bytes data
10	MAC type	IEEE 802.11b Large Preamble
11	Antenna type	Omni-Antenna
12	Radio propagation method	Two Ray Ground

5. Result and analysis

The investigations were performed on different routing protocol on different parameters. The choice for large and medium terrain area WSNs and the experimental summary of results are depicted in Table II and their respective relative performance of the three routing protocols being shown in Figure II to VI respectively by Varying Pause Time the and keeping the Speed Constant = 10m/s.

Table 2: Varying the Pause Time and keeping the Speed Constant = 10 m/s

Parameters ↓	Protocol			Choice for large and medium terrain area WSNs	
	DSR	AODV	DSDV	Terrain Area	Choice
Packet Delivery Fraction	α 1/Terrain Areas α 1/ Pause time	α 1/Terrain Areas α 1/ Pause time	α 1/Terrain Areas α Pause time	Medium	PDF AODV> PDF DSR> PDF DSDV
				Large	PDF DSR> PDF AODV> PDF DSDV
Average End- to-End Delay	α Terrain Areas	α Terrain Areas	α 1/Terrain Areas	Medium and Large	Av E2E Delay DSDV< Av E2E Delay DSR< Av E2E Delay AODV

Average Throughput [kbps]	α 1/Terrain Areas α 1/ Pause time	α 1/Terrain Areas α 1/ Pause time	α 1/Terrain Areas α Pause time	Medium	Avg Throughput $_{AODV}$ >Avg Throughput$_{DSR}$> Avg Throughput$_{DSDV}$
				Large	Avg Throughput$_{DSR}$> Avg Throughput$_{AODV}$> Avg Throughput$_{DSDV}$
NRL	α Terrain Areas α 1/ Pause time	α Terrain Areas α 1/ Pause time	α Terrain Areas α 1/ Pause time	Medium and Large	NRL $_{DSR}$< NRL $_{AODV}$< NRL $_{DSDV}$
Packet Loss [%]	α Terrain Areas α Pause time (large area)	α Terrain Areas α Pause time (large area)	α Terrain Areas α 1/ Pause time (large area)	Medium and Large	PacketL oss[%] $_{AODV}$<PacketL oss[%] $_{DSR}$<Packet Loss[%] $_{DSDV}$

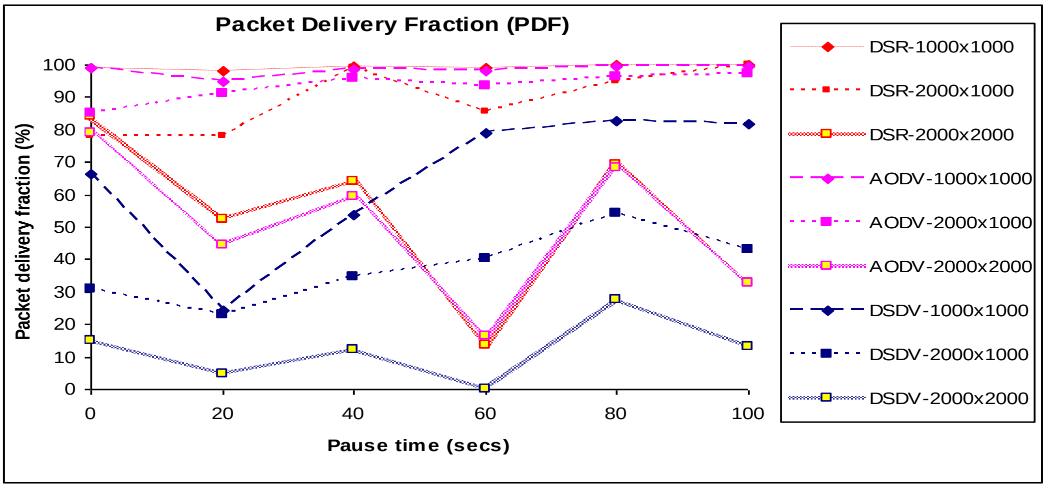

Fig 2: Pause Time vs PDF for terrain area 1000 m. x 1000 m., 2000 m. x 1000 m. and 2000 m. x 2000 m.

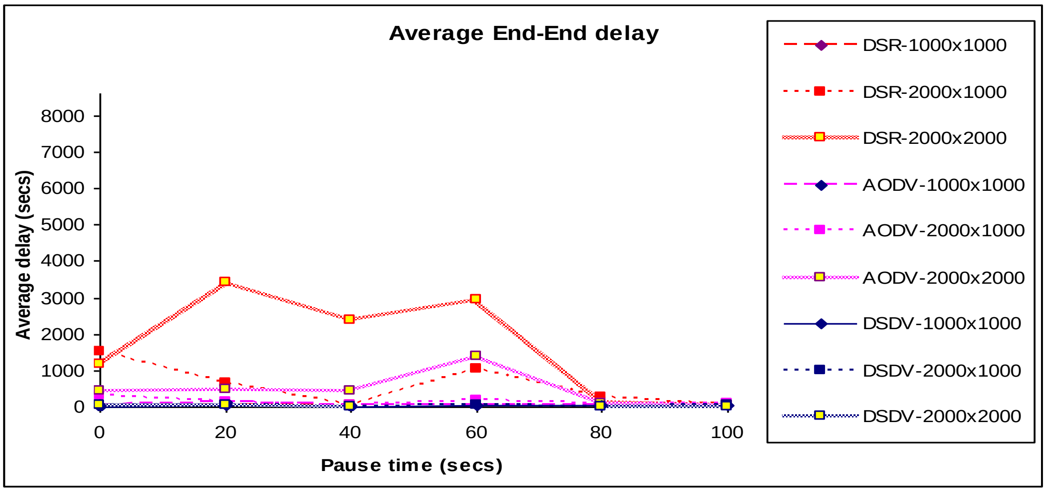

Fig 3: Pause Time vsAverage End-to-End Delay [in ms]for terrain area 1000 m. x 1000 m., 2000 m. x 1000 m. and 2000 m. x 2000 m.

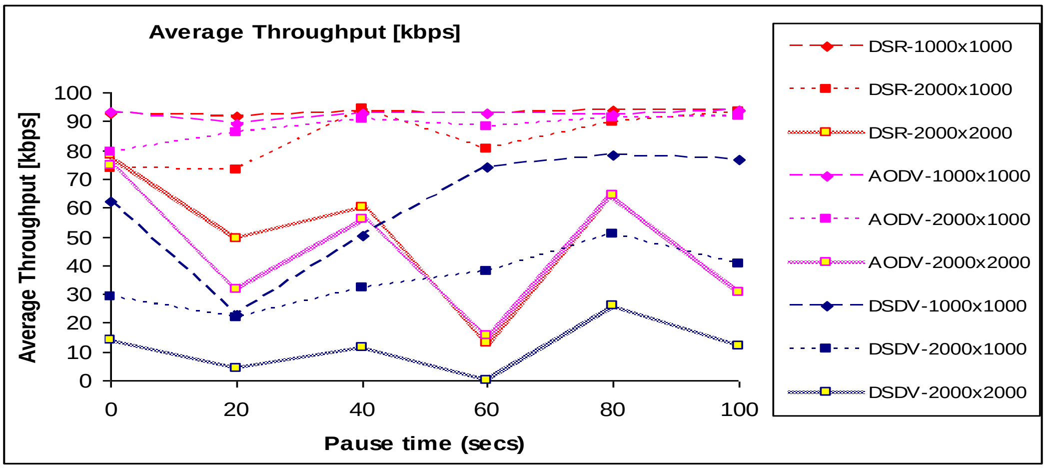

Fig 4: Pause Time vsAverage Throughput for terrain area 1000 m. x 1000 m., 2000 m. x 1000 m. and 2000 m. x 2000 m.

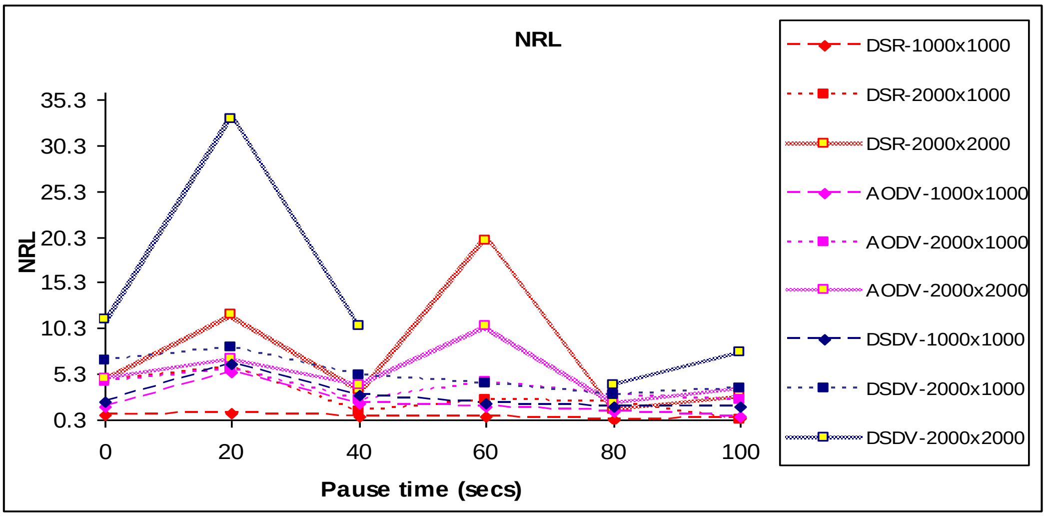

Fig 5: Pause Time vsNRL for terrain area 1000 m. x 1000 m., 2000 m. x 1000 m. and 2000 m. x 2000 m.

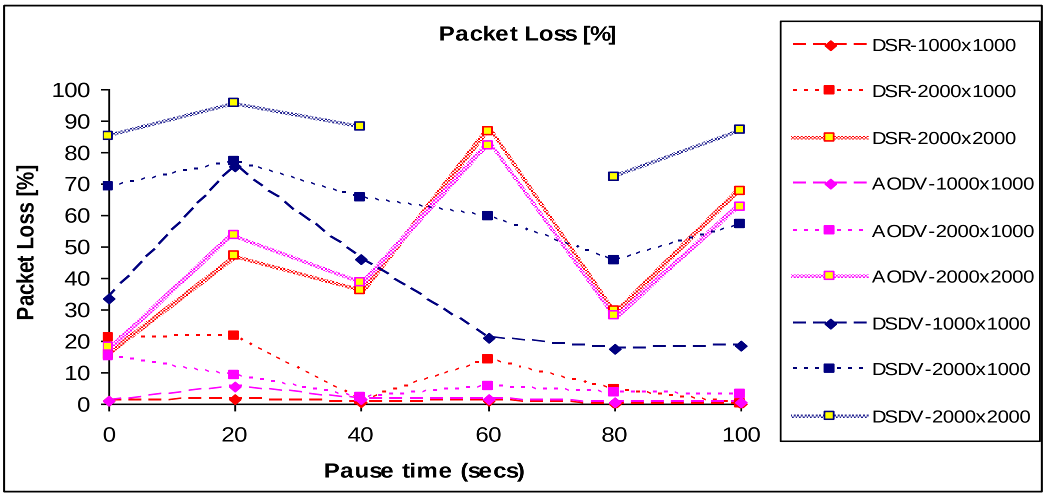

Fig 6: Pause Time vs Packet Loss for terrain area 1000 m. x 1000 m., 2000 m. x 1000 m. and 2000 m. x 2000

6. Conclusion

1. **Packet Delivery Fraction [%] (PDF):** The graph for the On-demand protocols, DSR and AODV protocol lies above than that of DSDV for most cases and performed particularly well, delivering over 87% of the data packets regardless of mobility rate. However in certain cases the DSDV protocols is also better.
   It is more likely for the mobile nodes to have fresher and shorter routes to a gateway and thereby minimizing the risk for link breaks. Link breaks can result in lost data packets since the source continues to send data packets until it receives a RERR message from the mobile node that has a broken link. The longer the route is (in number of hops), the longer time it can take before the source receive a RERR and hence, more data packets can be lost.
   When the pause time interval increases, a mobile node receives less gateway information and consequently it does not update the route to the gateway as often as for short advertisement intervals. Therefore, the positive effect of periodic gateway information is decreased as the advertisement interval increases.
   In all three simulations the PDF decreases with increase in terrain areas.In DSDV, the PDF increases as one increases the pause time unlike DSR and AODV where PDF decreases with pause time. By looking carefully at the graphs, we observe that the on demand protocols DSR and AODV gave better PDF than DSDV.
2. **Average End-to-End Delay [in ms] Comparison:** The Average End-to-End Delay [in ms] of packet delivery was lesser in DSDV as compared to both DSR and AODV. The reason is that the periodic gateway information sent by the gateways allows the mobile nodes to update their route entries for the gateways more often, resulting in fresher and shorter routes. With the DSR (reactive approach) a mobile node continues to use a route to a gateway until it is broken. In some cases this route can be pretty long (in number of hops) and even if the mobile node is much closer to another gateway it does not use this gateway, but continues to send the data packets along the long route to the gateway further away until the route is broken. Therefore, the Average End-to-End Delay [in ms] increases for these data packets, resulting in increased Average End-to-End Delay [in ms] for all data packets.
   The Average End-to-End Delay [in ms] is decreased slightly for short pause time intervals when the advertisement interval is increased. At the first thought this might seem unexpected. However, it can be explained by the fact that very short advertisement intervals result in a lot of control traffic which lead to higher processing times for data packets at each node.

Unlike DSR and AODV, in DSDV Average End-to-End Delay [in ms] decreases with larger terrain areas. The on demand protocols DSR and AODV gave higher delays then DSDV.

3. **Average Throughput [in kbps]:** In all three simulations the Average Throughput decreases with increase in terrain areas. The Average Throughput for DSDV increases as one increases the pause time unlike DSR and AODV where the Average Throughput decreases with pause time.The on demand protocols DSR and AODV gave better Average Throughput of packet delivery than DSDV.
4. **Normalized Routing Load [%] (NRL):** In all three simulations the NRL decreases with increase in terrain areas and pause time. The on demand protocols DSR and AODV are preferred choices as NRL is lesser than DSDV. In summary, both the On-demand routing protocols, DSR and AODV outperformed the Table-driven routing protocol; DSDV and the reasons are discussed later.
5. **Packet Loss [%]:** In all three simulations the Packet Loss increases with increase in terrain areas. In DSDV, the Packet Loss for large terrain areas decreases with increase in pause time, while in DSR and AODV it increases with increase in pause time. The on demand protocols DSR and AODV are preferred choices as Packet Loss is lesser than DSDV.
   In summary, when the number of sources is low, the performance of DSR and AODV is similar regardless of mobility. With large numbers of sources, AODV starts outperforming DSR for high-mobility scenarios. As the data from the varying sources demonstrate, AODV starts outperforming DSR at a lower load with a larger number of nodes. DSR always demonstrates a lower routing load than AODV. The major contribution to AODV's routing over-head is from route requests, while route replies constitute a large fraction of DSR's routing overhead. Furthermore, AODV has more route requests than DSR, and the converse is true for route replies.
   1. **Packet Delivery Fraction [%] (PDF):** In all three routing protocols, the PDF decreases with increase in terrain areas. The PDF for DSR, AODV and DSDV decreases as one increases the speed. The PDF is least for DSDV compared to DSR and AODV.
   2. **Average End-to-End Delay [in ms]:** Unlike DSR and AODV, in DSDV Average End-to-End Delay [in ms] decreases with larger terrain areas. The on demand protocols AODV and DSR gave higher delays then DSDV. In all three simulations the Average Throughput decreases with increase in terrain areas.
   3. **Average Throughput:** The Average Throughput for DSR, AODV and DSDV decreases as one increases the speed. The on demand protocols DSR and AODV gave better Average Throughput than DSDV.
   4. **Normalized Routing Load [%] (NRL):** NRL increases with increase in terrain areas as well as increases in speed. The on demand protocols DSR and AODV are preferred choices as NRL is lesser than DSDV.
   5. **Packet Loss [%] Comparison:** The Packet Loss increases with increase in terrain areas. The Packet Loss in general increases as the speed increases. The on demand protocols DSR and AODV are preferred choices as Packet Loss is lesser than DSDV.

All protocols deliver a greater percentage of the originated data packets when there is little node mobility (i.e., at large pause time), converging to 100% delivery when there is no node motion. Researchers specify the difference between routing protocols and its performance for different parameters and then the Network designer chose the best for the case of an actual practically deployable WSN.

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