Performance Comparison Of Routing Protocols For Zigbee Wpan

Mrs. A. Narmada[1], Dr. P. Sudhakara Rao[2]

[1]Department of Electronics and communication Engineering, Jawaharlal Nehru Technological Univetsity, Vignan Institute of Technology and Science, Deshmukhi, Andhra Pradesh, India,-508284

[21]Department of Electronics and communication Engineering, Jawaharlal Nehru Technological Univetsity, Vignan Institute of Technology and Science, Deshmukhi, Andhra Pradesh, India,-508284

Abstract

A wireless sensor network (WSN) is adhoc network. Each node in WSN will participate in routing process, based on the dynamic activity of the network connectivity. The peer- to-peer nature of wireless ad hoc networks makes them suitable for a variety of applications where coordinator can't be relied on, and may improve the scalability of wireless ad hoc networks. The WSN consists of few nodes to several hundred nodes, where each node is connected to one or more sensors. The topology of the WSNs can vary from a simple star network to an advanced multi-hop wireless mesh network. The propagation technique between the hops of the network can be routing or flooding. In *on-demand* (or reactive) routing protocols for ad hoc networks, a node attempts to discover a route to some destination only when it has a packet to send to that destination.

While many routing protocols are competent for using them in Wireless Sensor Networks, it is commonly found that AODV (Ad hoc On-demand distance Vector) routing protocol is often used in IEEE standard 802.15.4 ZigBee protocol stack. As there are many protocols reported in literature, it is required to revisit all the suitable protocols to find, if any, more suitable protocol especially for on demand routing (reactive) protocols. In this paper reactive protocols AODV, DSR and DYMO are surveyed and the summary of the characteristics of all these protocols are presented. Qualnet 5.0.2 network simulator is employed to analyse the important characteristics like throughput, average end-to- end delay, average jitter and total packets received by varying the number of hops under low, medium and heavy loads.

Keywords: Adhoc Networks, WSN, CBR, STAR, AODV, DYMO, IEEE 802.15.4, and Simulation.

1. Introduction

Wireless network is a network-set-up by using radio signal frequency to communicate among computers and other network devices. As the name suggests sensor networks are primarily meant for carrying sensors data remote locations to the data acquiring node but relatively at low data rate. As it is an upcoming technology, it offers lot of scope for research. Sensor networks are usually designed, for specific applications.

The sensor nodes of Wireless sensor networks are designed around a microcontroller powered from battery. They microcontroller monitors, a radio transceiver for generating radio waves and different type of wireless communicating devices. The entire network works simultaneously by using different dimensions of sensors and on the phenomenon of multi routing algorithm, which is also termed as wireless ad hoc networking.

The IEEE 802.11 standards specify two wireless operating modes: infrastructure mode and ad hoc mode. Infrastructure mode is used to connect computers with wireless network adapters, to an existing wired network with the help from wireless router or access point. Operating in ad hoc mode allows all wireless devices within range of each other to discover and communicate in peer-to-peer fashion. In addition to the classic routing, ad hoc networks [1] can use flooding for forwarding the data. Due to the mobility of the nodes, mobile Ad-hoc networks are self-organizing and self-configuring multi-hop wireless networks where, the structure of the network may change dynamically. The nodes in the network not only act as hosts but also as routers/end devices that route data to/from other nodes in network.

A host of protocols that may be a candidate for use with WSN are AODV, DSR DYMO, ZRP and IERP. However WSN is implemented with AODV. This paper explores using other protocols for WSN. The paper details the merits and demerits of each of these protocols. This study is done using Qualnet network simulator software version 5.0.2.[5]

2 Routing Protocols Classification:

There are many routing algorithms that could be used for WSNs. They can be classified in many different ways based on sensor network architecture**.** These three protocols are briefly described below. The characteristic summary of **Reactive protocol [1]** like AODV, DSR and DYMO routing protocols are presented in this paper.

2.1 Classification-1:

Routing protocols may be classified as node centric, data-centric, or location-aware (geo-centric) and Quality of service (QoS) based routing protocols [2]. In node-centric, the destinations are specified based on the numerical addresses of nodes. In data-centric routing, the sink sends queries to certain regions and waits for data from the sensors in that region. In QoS based routing protocols the quality parameters Average Jitter, First Packet received, Total Bytes Received, Total Packets Received, Last Packet Received, Average End-to-End Delay, Throughput (bits/s) are mainly considered. To get a good QoS, the routing protocols must possess more throughput, less average end-to-end delay and less average jitter. Data-centric or geocentric is common with WSN and not Node centric communication.

2.2 Classification-2**:**

Routing protocols are also classified based on whether they are destination-initiated (DST-initiated) or source-initiated (SRC-initiated). A source-initiated protocol sets up the routing paths upon the demand of the source node. A destination initiated protocol, on the other hand, initiates path setup from a destination node [1].

2.3 Classification-3:

Some WSNs consist of homogenous nodes whereas some consist of heterogeneous nodes. Based on this concept we can classify the protocols whether they are operating on a flat topology or on a hierarchical topology. In Flat routing protocols [1] all nodes in the network are treated equally. When node needs to send data, it May find a route consisting of several hops to the sink. Some of the nodes in the heterogeneous networks may have more resources. However the hierarchy does not always depend on the resources. In Hierarchical (Clustering) protocols different nodes are grouped to form clusters and data from nodes belonging to a single cluster can be combined.

2.4 Classfication-4:

Several routing protocols have been developed for ad hoc mobile networks to deal with typical limitations including high power consumption, low bandwidth and high error rates. Figure 1 shows the categorization of these routing protocols [2]

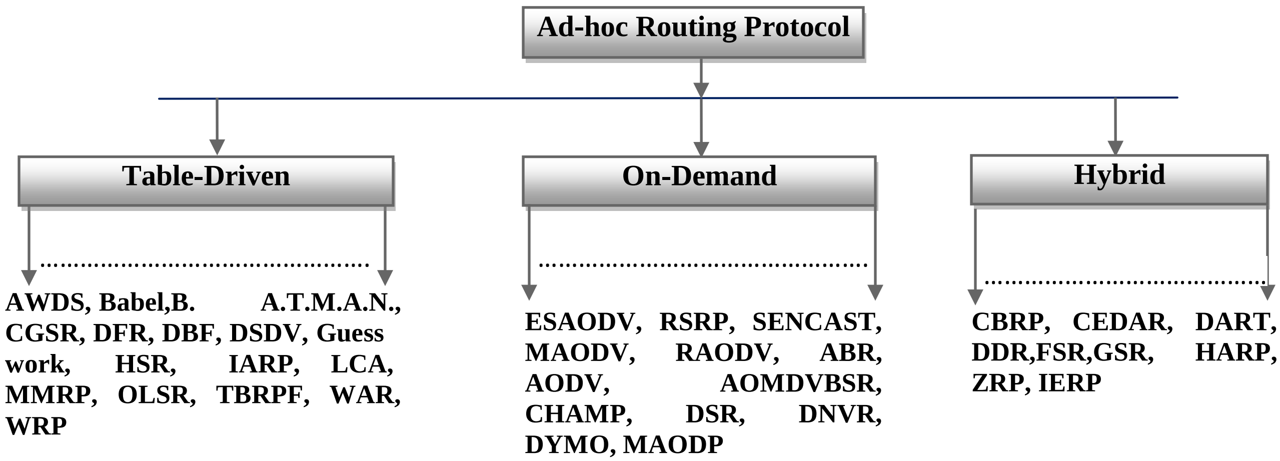

Figure 1: categorization of Ad-hoc routing

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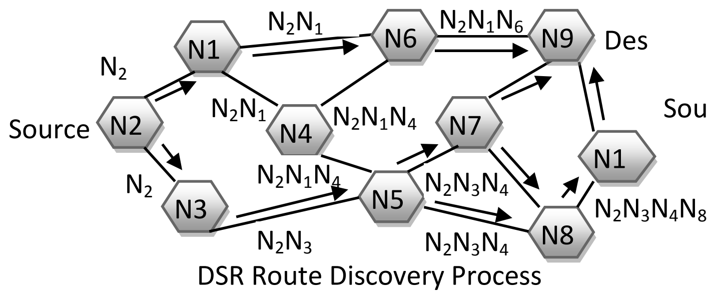


Figure2. DSR Process

2.4.1 Proactive Or Table-Driven Routing Protocol

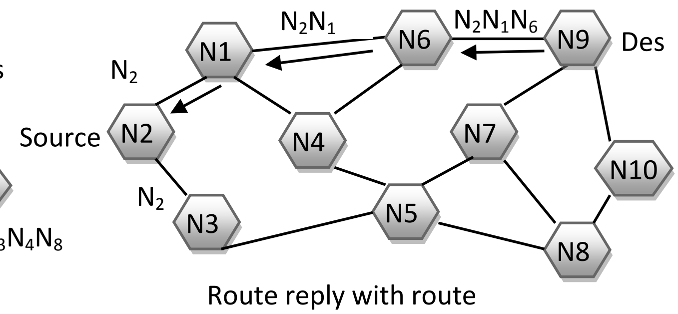
Proactive routing protocols, also called table-driven methods, maintain routes to all nodes, including nodes to which no packets are sent. Such methods react to topology changes. Examples are 1. Destination sequenced distance vector routing (DSDV) [2] 2. Source Tree Adaptive Routing (STAR) [2]. Table-driven routing protocol attempt to maintain consistent, up-to-date routing information from each node to every other node in the network. These protocols require each node to maintain one or more tables to store routing information, and they respond to changes in network topology by propagating updated routes throughout the network in order to maintain a consistent network view.

2.4.2 Reactive Or On-Demand Routing Protocol

This routing creates routes only when desired by source node. The node initiates a route discovery process. Once a route is found or all possible routes permutations have been examined, it is maintained by a route maintenance procedure until either the destination becomes inaccessible along every path from the source or until the route is no longer desired. On-demand routing protocols reduce control overhead, thus increasing bandwidth and conserving power at the mobile stations. Some examples of this approach are AODV [3], DSR, TORA [6] and ZRP[6] . All the on-demand routing protocols use flood search messages that either: (a) give sources the entire paths to destinations, which are then used in source routed data packets (e.g., DSR); or (b) provide only the distances and next hops to destinations, validating them with sequence numbers (e.g., AODV) or time stamps (e.g., TORA) [6].

2.4.3 **Hybrid Protocols**

These classes of routing protocols are reported that



choosing best among them is very difficult as one may be performing well in one type of scenario while the other may work in other type of scenario. Examples are 1. Temporally ordered routing algorithm (TORA)[6] 2. Zone Routing Protocol (ZRP)[6].

3 Dynamic Source Routing Protocol [Dsr]

The key feature of DSR is the use of source routing. The source knows the complete hop-by-hop route to the destination. These routes are stored in a route cache. The data packets carry the source route in the packet header. It allows the network to be completely self-organizing and self-configuring and does not need any existing network infrastructure or administration. It is an on-demand routing protocol and composed of two parts: The examples are i). Route Discovery ii). Route Maintenance [2].

3.1 Route Discovery

When a node in the ad hoc network attempts to send a data packet to a destination for which route is not known, it uses a route discovery process to find a route. Route discovery uses flooding technique in the network with route request (RREQ) packets. Each node receiving an RREQ rebroadcasts it further, unless it is the destination or it has a route to the destination in its route cache. Such a node replies to the RREQ with a route reply (RREP) packet that is routed back to the source. The RREQ builds up the path traversed so far. The RREP routes itself back to the source by traversing this path backward, the route carried back by the RREP packet is cached at the source for future use.

3.2 Route Maintenance

The periodic routing updates are sent to all the nodes. If any link on a source route is broken, the source node is notified using a route error (RERR) packet. The source removes any route using this link from its cache. A new route discovery process must be initiated by the source if this route is still needed.

4 Ad Hoc On-Demand Distance-Vector Routing Protocol (Aodv)

Ad hoc on-demand distance vector (AODV) is another variant of classic distance vector routing algorithm. It shares DSR on-demand characteristics, discovers routes on an as needed basis via a similar route discovery process. However, AODV [3] adopts traditional routing tables; one entry per destination which is in contrast to DSR that preserves multiple route cache entries for each destination. AODV provides loop free routes in case of link breakage. It doesn't need global periodic routing advertisement. AODV uses a broadcast route discovery algorithm and then the unicast route reply massage. The protocol consists of two phases i) Route Discovery ii) Route Maintenance

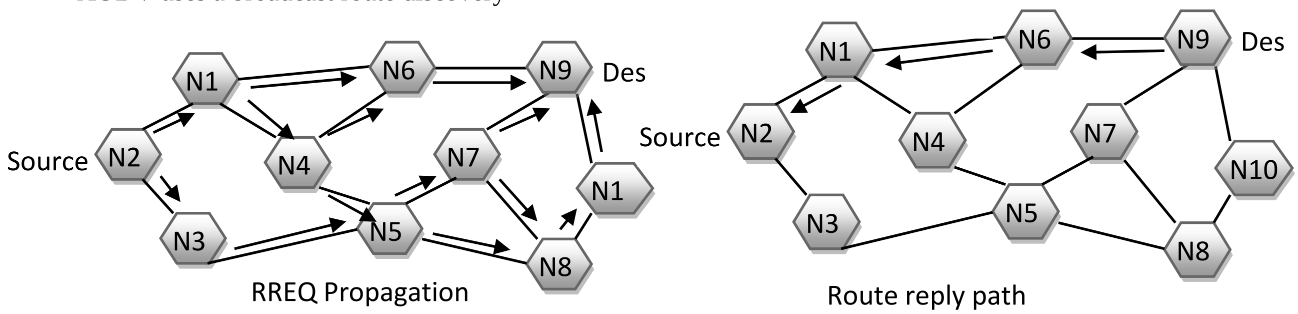


Figure 3. AODV Process

4.1 Route Discovery:

When a node wants to send a packet to some destination and does not have a valid route in its routing table for that destination, initiates a route discovery. Source node broadcasts a route request (RREQ) packet to its neighbours, which then forwards the request to their neighbours and so on shown in figure 3. To control network-wide broadcasts of RREQ packets, the source node uses an expanding ring search technique. In this technique, source node starts searching the destination using some initial time to live (TTL) value. If no reply is received within the discovery period, TTL value incremented by an increment value. This process will continue until the threshold value is reached. When an intermediate node forwards the RREQ, it records the address of the neighbours from which first packet of the broadcast is received, thereby establishing a reverse path. When the RREQ reaches a node that is either the destination node or an intermediate node with a fresh enough route to the destination, replies by unicasting the route reply (RREP) towards the source node. As the RREP is routed back along the reverse path shown figure 3, intermediate nodes along this path set up forward path entries to the destination in its route table and when the RREP reaches the source node, a route from source to the destination establish

4.2 Route Maintenance

A route established between source and destination pair is maintained as long as needed by the source. If the source node moves during an active session, it can reinitiate route discovery to find out a new route to destination. However, if the destination or some intermediate node moves, the node upstream of the break remove the routing entry and send route error (RERR) message to the affected active upstream neighbours. These nodes in turn propagate the RERR to their precursor nodes, and so on until the source node is reached.
The affected source node may then choose to either stop sending data or reinitiate route discovery for that destination by sending out a new RREQ message

5 DYMO

The Dynamic MANET On-demand (DYMO) routing protocol discovers unicast routes among DYMO routers within the network in an on-demand fashion, offering improved convergence in dynamic topologies. To ensure the correctness of this protocol, digital signatures and hash chains are used. The basic operations of the DYMO protocol are i) Route discovery and ii) Route maintenance.

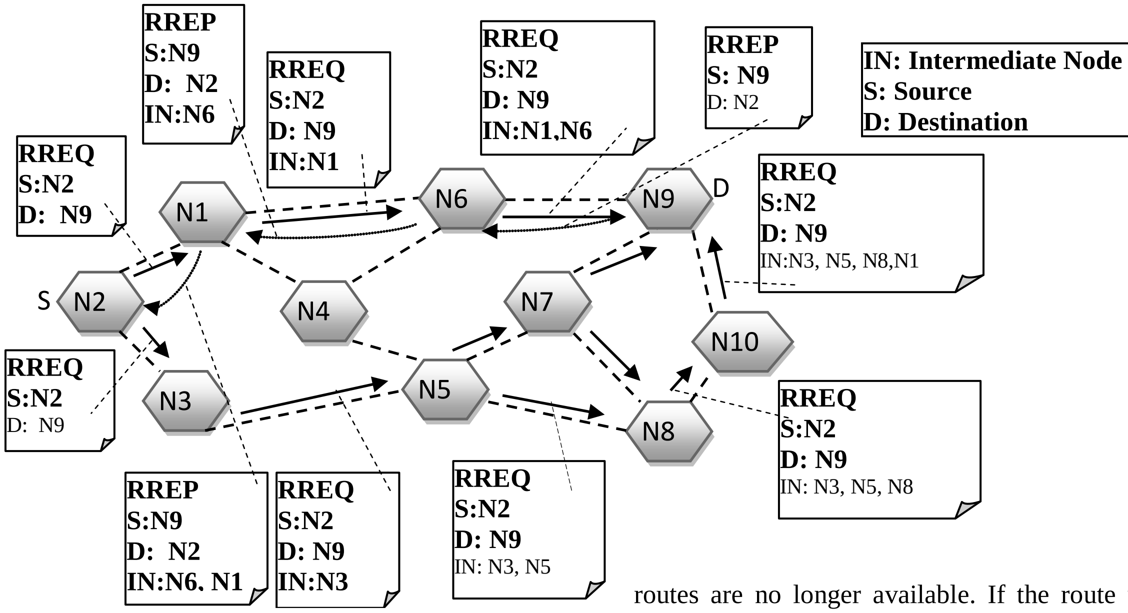


Figure 5. DYMO Route Discovery and Route

5.1 Route Discovery

When a source needs to send a data packet, it sends an RREQ to discover a route to that particular destination as shown in figure 5. After issuing an RREQ, the origin DYMO [2] router waits for a route to be discovered. If a route is not obtained within RREQ waiting time, it may again try to discover a route by issuing another RREQ. To reduce congestion in a network, repeated attempts at route discovery for a particular target node should utilize an exponential backoff. Data packets awaiting a route should be buffered by the source's DYMO router. If a route discovery has been attempted maximum times without receiving a route to the target node, all data packets intended for the corresponding target node are dropped from the buffer and a Destination Unreachable ICMP message is delivered to the source.

5.2 Route Maintenance

When a data packet is to be forwarded and it cannot be delivered to the next-hop because no forwarding route for the destination address exists; an RERR is issued shown in figure 6. Based on this condition, an ICMP destination unreachable message must not be generated unless this router is responsible for the destination address and that destination address is known to be unreachable. Moreover, an RERR should be issued after detecting a broken link of a forwarding route and quickly notify DYMO routers that a link break occurred and that certain routes are no longer available. If the route with the broken link has not been used recently, the RERR should not be generated.

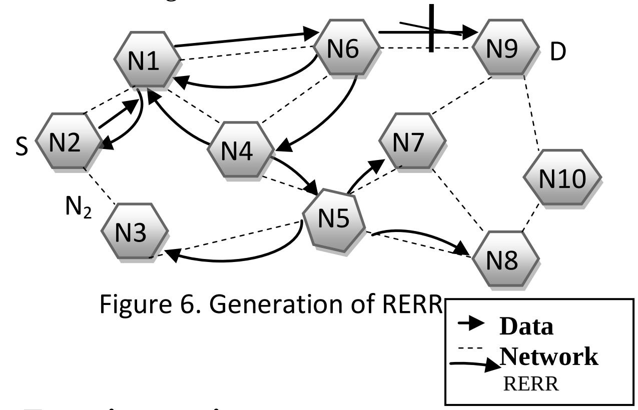


Figure 6. Generation of RERR

6 Experimentation:

All the simulation work is performed in QualNet network simulator version 5.0.2 [6]. The simulation was done using two scenarios one with 50 nodes and other with 100 nodes. In both cases the **seed** is set at one (one packet per one sec.). Both the scenarios are tested for near (1-hop), medium (3-hops) and far (6 to 7 hops) using low (100 packets), medium (500 packets) and high (800 packets) traffic loads (CBR data Rate) and using three different protocols AODV, DSR and DYMO in each case. The time set for simulation is 800 sec. Hence the maximum number packets chosen for transmission are 800. All the scenarios have been designed in a terrain size of 100m x 100m area. Mobility model used is Random Way Point [4] (RWP). In RWP a mobile node is initially placed in a random location in the simulation area. Network traffic load is provided by constant bit rate (CBR) application. A CBR traffic source provides a constant stream of packets throughout the simulation, thus providing further stress on the routing task. It is important to note that MAC layer protocol 802.15.4 is kept unchanged. The four measurements in our experiments were defined as follows:

i. *Throughput (bits/s):-* Throughput is the measure of the number of packets successfully transmitted to their final destination per unit time.
ii. *Total Packets Received:-* Packet delivery ratio [2] is calculated by dividing the number of packets received by the destination through the number of packets originated by the application layer of the source (i.e. CBR source).
iii. *End-To-End Delay:-* Average End to End Delay signifies the average time taken by packets to reach one end to another end (Source to Destination).
iv. *Average Jitter Effect [2]:-* Signifies the Packets from the source will reach the destination with different delays. A packet's delay varies with its position in the queues of the routers along the path between source and destination and this position can vary unpredictably

7 SIMULATION RESULTS And ANALYSIS

The simulation for on-demand routing protocols is based on simulation time, number of nodes, area of network and routing protocols. In experimental methodologies performance matrix can be measured with variation in number of hops and network traffic load, while rest of all other parameters like simulation time, seed and area of network are kept constant. Effects of different parameters on performance of on-demand protocols are studied and the results are published below. From simulation results of scenario for 50 nodes and that of 100 nodes as tabulated in Table-1 and Table-2, it is observed that the performance of DSR protocol is better than other on-demand routing protocols (AODV, DYMO), because of the better throughput. For comprehending easily, the results are also shown in figures 7(a) to 7(d) for 50 nodes and 8(a) to 8(d) for 100 nodes. However due to simulation results of End to End Delay and average jitter with variation in network traffic load and number of hops in figures 7(a) to 7(d) and 8(a) to 8(d), it is observed that the performance of DYMO protocol is superior to DSR and AODV in medium and far cases and even when more number of nodes are added to the scenario.

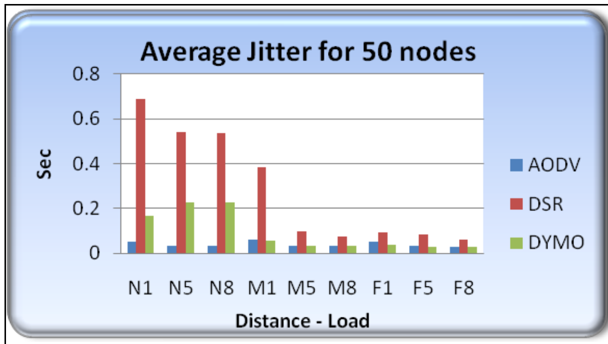


Figure 7(a) Average jitter for 50 nodes

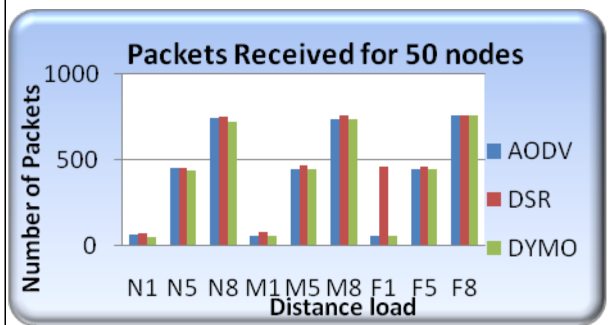


Figure 7(b) Tota l packets received for 50 nodes

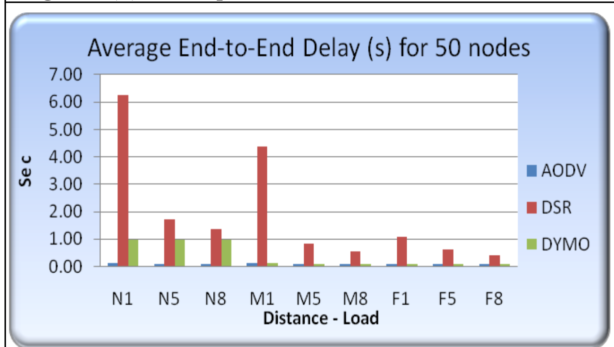


Figure 7(c) Average End-End delay for 50 nodes

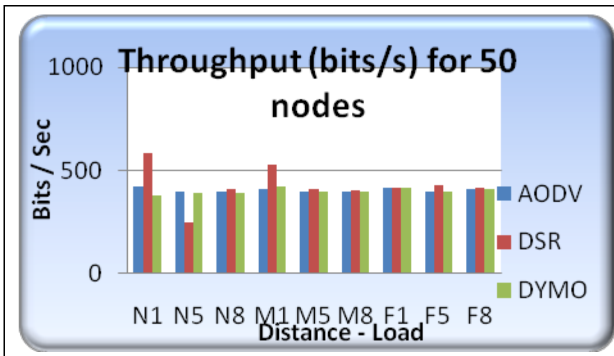


Figure 7(d) Throughput for 50 nodes

Scenario with 50 nodes													
		Near				Medium				Far			
Protocol	No. Of Packets	Avg Jitter [Sec]	Total Packets Received	Avg End-to-end-delay[Sec]	Throughput [bps]	Avg Jitter [Sec]	Total Packets Received	Avg End-to-end-delay[Sec]	Throughput [bps]	Avg Jitter [Sec]	Total Packets Received	Avg End-to-end-delay[Sec]	Throughput [bps]
AOD V	100	0.051	69	0.125	420	0.062	58	0.110	408	0.050	59	0.103	415
	500	0.033	456	0.086	398	0.034	447	0.084	398	0.033	446	0.083	397
	800	0.032	750	0.083	399	0.033	738	0.083	397	0.030	760	0.087	409
DSR	100	0.686	76	6.241	585	0.384	59	4.387	530	0.092	59	1.065	419
	500	0.540	458	1.732	248	0.096	447	0.836	413	0.085	447	0.633	427
	800	0.534	751	1.379	407	0.073	738	0.548	406	0.063	759	0.419	418
DYMO	100	0.166	53	0.990	381	0.055	59	0.134	422	0.038	59	0.100	415
	500	0.227	440	0.972	393	0.033	447	0.087	399	0.031	447	0.083	398
	800	0.229	727	0.972	392	0.032	738	0.085	397	0.031	759	0.089	409

Table 1: Parameters of Scenario with 50 Nodes

8 Conclusion

This paper presents simulation analysis of on-demand routing protocols like DSR, AODV and DYMO for ad hoc mobile networks along with

Scenario with 100 nodes													
		Near				Medium				Far			
Protocol	No. Of Packets	Avg Jitter [Sec]	Total Packets Received	Avg End-to-end-delay[Sec]	Throughput [bps]	Avg Jitter [Sec]	Total Packets Received	Avg End-to-end-delay[Sec]	Throughput [bps]	Avg Jitter [Sec]	Total Packets Received	Avg End-to-end-delay[Sec]	Throughput [bps]
AODV	100	0.149	18	0.252	409	0.050	19	0.136	432	0.079	14	0.195	7
	500	0.042	413	0.088	403	0.031	410	0.082	400	0.048	180	0.088	99
	800	0.037	707	0.085	401	0.031	701	0.081	398	0.046	296	0.086	163
DSR	100	0.565	50	7.846	887	0.616	39	10.990	1348	0.599	33	13.781	4765
	500	0.101	444	0.957	428	0.103	426	1.080	422	0.103	423	1.150	428
	800	0.075	739	0.609	417	0.076	718	0.675	411	0.076	713	0.716	413
DYMO	100	0.086	19	0.238	457	0.101	19	0.259	457	0.050	19	0.132	432
	500	0.033	414	0.087	405	0.035	410	0.087	401	0.031	407	0.081	397
	800	0.032	709	0.084	403	0.033	701	0.084	398	0.031	697	0.081	396

Table 2: Parameters of Scenario with 100 Nodes

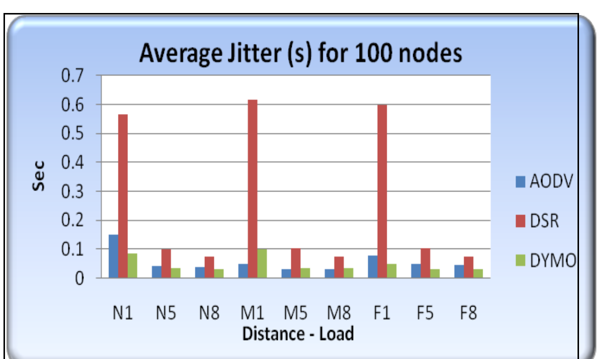


Figure 8(a) Average jitter for 50 nodes

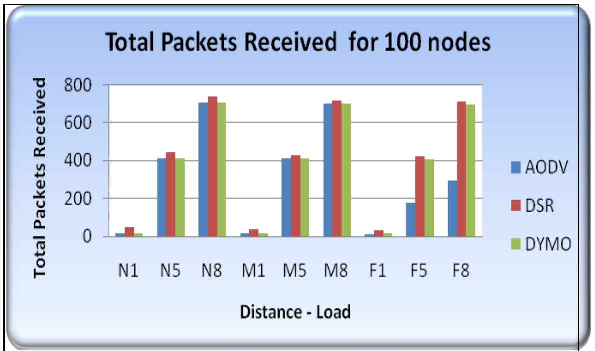


Figure 8(b) Total packets received for 100 nodes

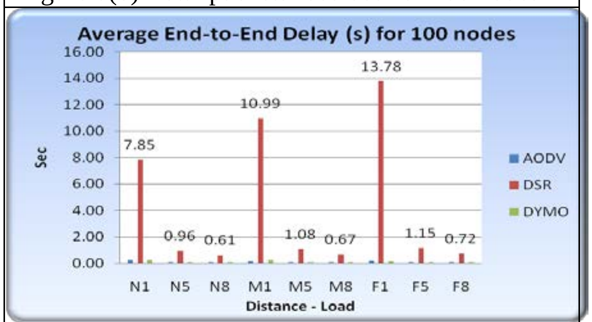


Figure 8(c) Average End-End delay for 100 nodes

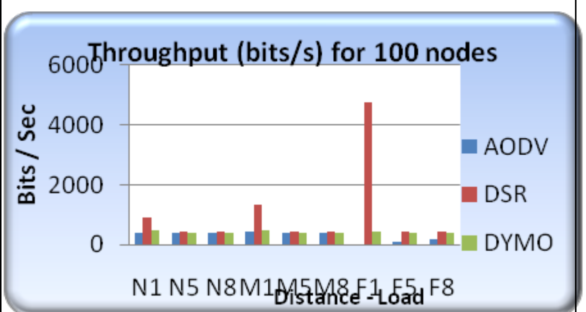


Figure 8(d) Throughput for 100 nodes

analysis is also presented under variation of network traffic load and number of hops, simultaneously measured various performance metrics including throughput, total packets received, average jitter and average end to end delay. From the tabulated results and graphs, it can

classification of these protocols according to the routing strategies. The results of comparison and be concluded that DSR performs better than AODV and DYMO under variation in network traffic load and number of hops when throughput is considered as performance metric. In majority of the performance metrics DYMO is found to be having better performances when compared to AODV. DYMO is better than DSR in performance metrics like average end to end delay and average jitter. The authors are continuing their research with the help of Qualnet simulator to consider Hybrid protocols like ZRP IERP and also modifying the MAC layer protocols.

9 References

[1] Imrich Chlamtac, Marco Conti, Jennifer J.-N. Liu. Mobile ad hoc networking: imperatives and challenges, School of Engineering, University of Texas at Dallas, Dallas, TX, USA ,bIstituto IIT, Consiglio Nazionale delle Ricerche, Pisa, Italy ,cDepartment of Computer Science, University of Texas at Dallas, Dallas, TX, USA. Ad Hoc Networks 1 (2003).

[2] J. Broch et al. A Performance Comparison of Multi-Hop Wireless Ad Hoc Network Routing Protocols. In Proc. ACM MOBICOM 98, Dallas, TX, October 1998. [3] Ian D. Chakeres and Charles E. Perkins. Dynamic MANET ondemand (DYMO) routing protocol. Internet-Draft Version 6, IETF, October 2006. [4] David B. Johnson, David A. Maltz, Yih-Chun Hu, The Dynamic Source Routing Protocol for Mobile Ad Hoc Networks, Internet-Draft, draft-ietf- manet-dsr-10.txt, July 2004.

[3] Charles E. Perkins, Elizabeth M. Belding-Royer, S. Das, “AdHoc on Demand Distance Vector (AODV) routing, Mobile Ad Hoc Networking Working Group” July 2003, Internet-Draft. [6] Qi Biao, He Jian-hua, Yang Zong-kai, Simulation of wireless Ad hoc routing protocols and its evaluation, Huazhong University of Science and Technology (Nature Science Edition) 32 (8) (2004) 66–69.

[4] Guolong Lin, Guevara Noubir, and Rajmohan Rajaraman, College of Computer & Information Science. Mobility Models for Ad hoc Network Simulation 0-7803-8356-7/04, 2004 IEEE. [8] E. Ahvar, and M. Fathy, Performance Evaluation of Routing Protocols For High Density Ad Hoc Networks based on Qos by Glomosim Simulator. 23 AUGUST 2007 ISSN 1307-6884. [9] S. Azad, A. Rahman and F. Anwar, “A Performance Comparison of Proactive and Reactive Routing Protocols of Mobile Ad-hoc NETwork (MANET),” Journal of Engineering and Applied Sciences 2(5), 2007, pp 891-896.

[5] Md. Arafatur Rahman, Md. Saiful Azad, Farhat Anwar and Aisha Hassan Abdalla, A Simulation Based Performance Analysis of Reactive Routing Protocols in Wireless Mesh Networks, 2009 IEEE DOI 10.1109/ICFN.2009.64 [11] Scalable Network Technology, “QualNet4.0 simulator” tutorial and QualNet Forum,http://www.scalablenetworks. com/forums/.....

[6] Zygmunt J. Haas, Cornell University Marc R. Pearlman, Cornell University the Zone Routing Protocol (ZRP) for Ad Hoc

Networks draft-ietf-manet-zone-zrp-02.txt> 2001. [13] Elizabeth M. Royer, University of California, Santa Barbara Chai-Keong Toh, Georgia Institute of Technology, A Review of Current Routing Protocols for Ad Hoc Mobile Wireless Networks. Ad Hoc Networks 2 (2004) 1–22.

[7] J N.Al-Karaki, A E.Kamal: Routing Techniques in Wireless Sensor Networks: A Survey, in the proceeding of in IEEE Wireless Communications(Dec. 2004).

First Author Completed **Bachelor** of Technology from SVH college of Engineering, Nagarjuna University, Machilipatnam, A.P, Indiain the year 1998, completed **Master** of Engineering from University College of Engineering, Osmania University, Hyderabad, AP, INDIA and Now pursuing the **Doctor of philosophy** from Jawaharlal Nehru technological University, Hyderabad, AP, INDIA. She is employed with Vignan Institute of Technology and Science , Nalgonda District, AP, INDIA as Associate professor. She had achieved National merit scholar ship and one gold medal. She is currently contributing her research for the project which is funded by Department of science and Technology. She has got 2 IEEE conference papers, 1 international conference paper, I international journal paper to her credit

Second Author Completed **Ph.D.,** Information and Communication Engineering from Anna University, India, **Masters** in Electronics and Communication Engineering from Anna University, India, **Bachelors** in Electronics and Communication Engineering from Mysore University, India. Worked as deputy **Director, "Central Electronics Engineering Research Institute center, India"** for over 25 years**, 2 years** as **Vice-president, "Sieger Spintech Equipments Ltd., India",** established an electronic department for the development of electronic systems for nearly 2 years**.** Presently working with Vignan Institute of Technology and Science, Nalgonda District, AP, INDIA as DEAN R&D, HOD ECE. He has one patent and 55 technical publications/ conference papers to his credit. Conducted many international and national conferences as chairman.