International Journal of Advanced Science and Technology
Vol.69 (2014), pp.1-12
http://dx.doi.org/10.14257/ijast.2014.69.01

Comparative Analysis of Routing Protocols in Ad-hoc Networks

Kalpana Sharma, Neha Mittal[1] and Priyanka Rathi[2]

Associate Professor, Department of Computer Science and Engineering
Sikkim Manipal Institute of Technology
Sikkim-737136, India
[1,2]Department of Computer Science and Engineering
Sikkim Manipal Institute of Technology
Sikkim-737136, India
kalpanaiitkgp@yahoo.com, [1]nehamittal135@gmail.com,
[2]priyanka.rathi7792@gmail.com

Abstract

An ad hoc wireless network consists of a set of hosts (mobile nodes) which are connected together by wireless links. The nodes can communicate with each other using different routing protocols. The routing protocols perform well when the nodes are stationary but degrade drastically when the nodes are mobile. A variety of routing protocols have been proposed for ad hoc networks in the past. Based on update mechanisms, they are classified into reactive, proactive and hybrid routing protocols. The performance of these protocols varies depending on the simulation environment. Many researchers have been working in this direction to evaluate the performance of these protocols in different simulation environments. The simulations can be done on Qualnet, NS2, and Omnet++ etc. The main aim of this project is to explore this fact and compare the performance of three different protocols-AODV, STAR and ZRP which constitutes a good combination of on-demand (reactive), table-driven (proactive) and hybrid protocols respectively. It is taken into account that these protocols are the best protocols in their respective domains due to their low overhead. The performance of these protocols will be analyzed by keeping the nodes static, dynamic and then semi dynamic. The pause time of each node is varied so as to depict a real world scenario in case of semi dynamic. The evaluation is done by considering the performance metrics - throughput, jitter, average end to end delay and packet delivery ratio. The simulator used is Qualnet 7.1.

Keywords: *Ad-hoc, routing, jitter, Qualnet, reactive, proactive, hybrid*

1. Introduction

Wireless networks are an emerging technology that allows users to access services and information electronically irrespective of their geographic position. Wireless networks can be classified in two types:

1. Cellular Wireless Networks
2. Ad Hoc Wireless Networks

The Cellular Wireless Networks are infrastructure dependent networks. Here the node communicates through a base station. Whereas Ad Hoc wireless networks utilize multi hop radio relaying and are capable of operating without any fixed infrastructures. Here the

ISSN: 2005-4238 IJAST

absence of a central coordinator makes the routing a complex one as compared to cellular networks. In order to standardize the protocols and functionalities of Ad Hoc Wireless Networks, Mobile Ad hoc Networks (MANET) was formed. It is a self –configuring network of mobile nodes connected using wireless links forming a random topology. The nodes move freely and randomly. The range of the MANETs applications can be static small area networks to highly dynamic area networks. The main challenge of designing MANETs is to develop scalable routing protocol which can help to communicate between mobile nodes. The role of routing protocols is to find a path which data packets can follow to transfer data from source to destination. It works effectively in case of traditional wired networks but it cannot be applied directly in ad hoc networks. The reason being their highly dynamic topology, absence of established infrastructure for centralized administration (*e.g.,* base stations), bandwidth-constrained wireless links, and resource energy constrained nodes. A variety of routing protocols for ad-hoc networks has been proposed in the recent past. The routing protocols for Ad Hoc wireless networks can be broadly classified into four categories- Routing information update mechanism, use of temporal information for routing, routing topology, and utilization of specific resources. Based on routing information update mechanism the routing protocols can be reactive, proactive and table driven. There are many proactive routing protocols available for Ad-hoc networks such as DSDV, OLSR, FSR, GSR, CGSR and IARP *etc*. There are also a variety of reactive routing protocols such as AODV, DSR, LAR, DYMO and IERP *etc.*, ZRP and TORA are hybrid routing protocols.

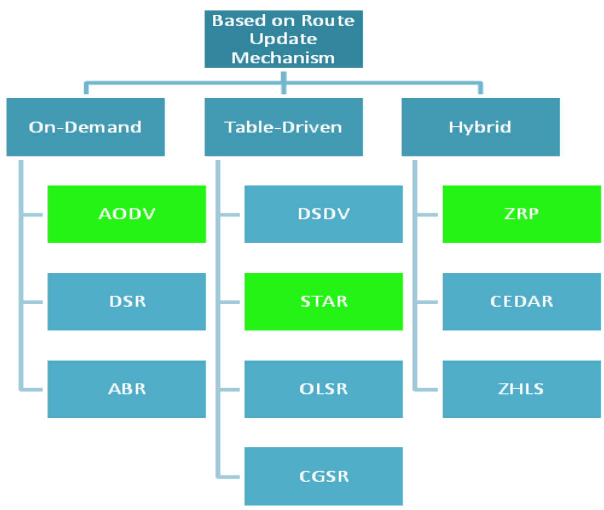


Figure 1. Routing Protocols

There are many challenges that a routing protocol designed for ad hoc wireless networks faces. Some of them are mobility of nodes, resource constraints, error-prone channel state, and hidden and exposed terminal problems. Mobility is a major challenge since the network topology is highly dynamic due to the movement of nodes and thereby suffers frequent path breaks. The disruption may occur due to the movement of the intermediate nodes or due to the movement of the end nodes. Hence the routing protocols must perform efficient and effective mobility management. In this project the three different routing protocols AODV, STAR and ZRP which comprise a good mix of On-Demand, Reactive and Hybrid protocols have been compared first by keeping the nodes stationary and then making it mobile using Random Waypoint mobility model. The pause time of each node is varied so as to depict a real world scenario. The performance metrics used are throughput, packet delivery ratio, average end to end delay and jitter. The simulation is done on Qualnet 7.1.

2. Brief Discussion about Routing and Various Routing Protocols

Routing is a method to choose the best path from source to destination to send data packets in a network. There are a huge number of routing protocols based on different criteria's. Based on the routing information update mechanism, there are three different types of routing protocols namely- Proactive or table driven routing protocol, Reactive or on-demand routing protocol and Hybrid routing protocol.

Proactive Protocol: Here each node maintains a routing table for keeping the updated route information of others nodes [17]. This routing information is flooded in the whole network. Whenever the network topology changes, the corresponding update needs to be done throughout the network. This category of protocols has large bandwidth and more memory requirements making them more suitable for wired networks only. Destination Sequenced Distance-Vector Routing protocol (DSDV), Wireless Routing protocol (WRP), Cluster-Head Gateway Switch Routing protocol (CGSR) and Source- Tree Adaptive Routing protocol (STAR) are some examples of proactive protocols. The chosen protocol in this category is STAR.

Source tree adaptive Routing (STAR)

The STAR [4] protocol is based on the link state algorithm. Each node maintains a source tree, which is a set of links containing the paths to destination. It uses a least overhead routing approach (LORA) to exchange routing information and to reduce control overhead. The Link State [21] updates are exchanged only when some event occurs. When there is no path from a node to the destination and it wants to send data packets, it sends an update message to all its neighbours. Hence a path is formed from that node to the destination with the help of the source-tree. The data packet also contains information about the path to be followed, to prevent loop formation. In case a data packet being sent through a node already has that node in the packet's traversed path, the packet is discarded. A Route Repair message is sent to the head of that path. It contains the entire source tree information of the path of that packet.

STAR [17] is efficient for large network as it reduces the bandwidth consumption for the routing updates and at the same time reducing latency by using predetermined routes. It has low communication overhead. However, this protocol may have significant memory overheads in large and highly mobile networks, because each node has to maintain a partial topology graph of the network.

Reactive protocol: In this case protocols do not maintain network topology information. When a source wants to send data to the destination, it invokes the route discovery mechanisms to find a path to the destination. Hence the routes are created on demand and table updating is not required here. This type of protocols is more suitable for ad hoc network as they do not have large memory and bandwidth. In comparison to Table Driven routing protocols the routing delay in this case is quite high since the routes are created when required. Some examples of reactive protocol are Dynamic State Routing protocol (DSR), Ad hoc On-Demand Distance Vector Routing protocol (AODV) and Temporally Ordered Routing Algorithm (TORA). The protocol taken into consideration is AODV.

Ad hoc On-Demand Distance Vector Routing Protocol (AODV)

The AODV protocol [3] uses on-demand approach [17]. Periodic exchange of routing information does not take place in this protocol. Here neighbour nodes store the route information of its next hop neighbour only. This protocol is based on two mechanisms i.e. route discovery and maintenance. AODV nodes use four types of messages to communicate among each other. Route Request (RREQ) and Route Reply (RREP) messages are used for route discovery. Route Error (RERR) messages and HELLO messages are used for route maintenance. The destination sequence number is used to make this routing protocol loop free [11] and identify the most recent path. When route for destination is not available, the source floods the Route Request packet in the network. It consists of source identifier, destination identifier, source and destination sequence number, broadcast identifier and time to live field. When a node has to send data and wants a path to the destination, it sends Route Request message to the next neighbour node. The node which receives this message either forwards it to the next node or sends a Route Reply message if it has a path to the destination. AODV does not repair the broken links locally. When a link breaks between any two nodes, they send a Route Error message to inform the end nodes about the link break and this link is removed from the table of the end nodes. Once again the source starts the path finding process with a new broadcast ID and old destination number.

The main advantage of AODV protocol is route is discovered and identified on demand. The count- to-infinity and loop problem is solved with sequence numbers. The disadvantage of AODV is poor scalability and unnecessary bandwidth consumption, due to periodic beaconing [7].

Hybrid Routing Protocol: These protocols use the best features of both the reactive and proactive routing protocols. Here the network is divided into small clusters or zones [15]. Within a particular zone the proactive routing scheme is used whereas the reactive routing scheme is used outside the zone. Some examples of this protocol are Zone Routing protocol (ZRP) and Zone-Based Hierarchical Link State Routing Protocol (ZHLS). ZRP is chosen in this category.

Zone Routing Protocol (ZRP)

ZRP combines the best features of both Table driven and on-demand routing protocol. The Zone Routing Protocol (ZRP) [10] divides the network into zones. A zone of a node has all the nodes lying within a certain zone radius which is defined in hops. ZRP [11] consists of two sub-protocols [14], a proactive routing *i.e.*, the intra zone routing protocol (IARP) is used inside the zone; while the reactive routing protocol *i.e.*, inter-zone routing protocol (IERP) is used outside the zone.

Each node, using IARP, maintains the information about routes to all nodes within the routing zone by exchanging route update packets periodically. Larger the zone, higher is the update control traffic. The IERP finds path for nodes not within the routing zone by using information of every node’s routing zone. If a packet has to be sent from a source to destination where both belong to the same zone, the packet can be sent directly. Else if the destination is not inside the zone, then the source bordercasts Route Request message to the peripheral nodes. If the destination is within the zone of the peripheral nodes, they add their address to it and send back the Route Reply packet to the source. Otherwise they resent Route Request packet to the peripheral nodes of their zone. This process continues till the destination node is not found. Once the source receives the Route Reply packet along with the path given, it uses this path to send the data to the destination.

Hence ZRP reduces control overhead by avoiding unnecessary flooding of Route Request packets. The disadvantage is the lack of route optimization. Decision of zone radius is also an important factor for efficiency.

3. Related Work

Many researchers have studied and performed experiments on the routing protocols so as to analyse which perform best in what condition. The authors of [11] performed comparison and analysis of DYMO, AODV, and DSR on-demand routing protocol based on IEEE 802.11. They have concluded that AODV performs best in all situations. DSR has worst packet delivery ratio while DYMO has huge jitter and more number of dropped packets. Hence DSR performs the poorest followed by DYMO. The authors of [4] have considered three routing Protocols DSR, ZRP & STAR for simulation and the energy performance metrics, routing power and residual energy have been considered in three modes (transmitting, receiving, and idle). According to the results DSR has maximum jitter, least energy consumption and throughput performance is very high. DSR gives better data packet delivery ratio and end to end delay performance compared to ZRP when more number of nodes is applied for simulation. STAR has minimum jitter and lowest memory consumption. After the simulation it is observed that DSR is better than STAR and ZRP. The authors of [12] have done simulation based on the performance evaluation of different Ad hoc routing protocols like AODV, DYMO, FSR, LANMAR, RIP and ZRP in Wireless Sensor Networks. They have seen that the average Jitter of AODV is least while it is highest for FSR. In case of end to end delay, FSR and LANMAR faces heavy delay.FSR, LANMAR and RIP have very low packet delivery ratio. Hence after the simulation was performed for all metrics it was seen that AODV and DYMO performs better than FSR, LANMAR and RIP.

4. Simulation Setup

The analysis and comparison of protocols can be done by testbed, real world experiments or simulation. Since simulation is cheaper and feasible so most research work of ad hoc networks is conducted using simulation software. It eliminates the need for time consuming and costly real world experiments. The simulator used is Qualnet 7.1 that predicts wireless, wired and mixed platform network and networking device performance. The reason for choosing this software is its accuracy, speed and portability.

The main motive of the project was to compare the performance of AODV, STAR and ZRP in different simulation environments. The comparison was made by varying the node density and the simulation environment one at a time and keeping all the factors to be constant. Three conditions were considered. In the first condition, *i.e.*, static, the nodes were kept stationary. Then all the nodes were made dynamic and the pause time of each node was almost negligible. The mobility model used was Random Way Point Mobility. A third condition was defined where the pause time of each and every node was set randomly. Some nodes were kept static while the other nodes were allowed to move randomly with varying pause time. This condition was assumed to be semi-dynamic. The simulation was carried on an area of size 1500*1500 sq units. The node density was varied from 25, 50, 75, and 100, 125 in each case. The number of rounds for each condition was 10. In the scenario UDP (User Datagram Protocol) connection was used and data traffic of Constant bit rate (CBR) was applied between source and destination. The multiple CBR applications were applied over 6 different source nodes – 17, 8, 14, 10, 16, 19 and destinations nodes -22, 25, 11, 13, 6, 15 respectively. Each simulation was carried out for 300 seconds. The performance metrics used for comparison were throughput, end- to-end delay, packet delivery ratio and jitter. The values for the different parameters is summarised in the table given below.

Table 1. Scenario Properties

Parameter	Description
Network Simulator	Qualnet 7.1
Routing Protocols	AODV, STAR,ZRP
Size of Region	1500*1500 Sq. Units
Shape of Region	Square
Mobility Model	Random Way Point
Number of Nodes	25, 50, 75, 100
Placement of Node	Random
Number of rounds	10
Antenna Model	Omni directional
Traffic Source	Constant Bit Rate
Packet Size	512 bytes
Simulation Time	300 seconds
MAC protocol	802 .11
Radio Type	802.11b
Data Rate	2 Mbps
Channel Frequency	2.4 GHZ
Path loss Model	Two Ray
Simulation Environment	Static, Dynamic, Semi dynamic

The snapshot of the simulation keeping 125 nodes is shown below.

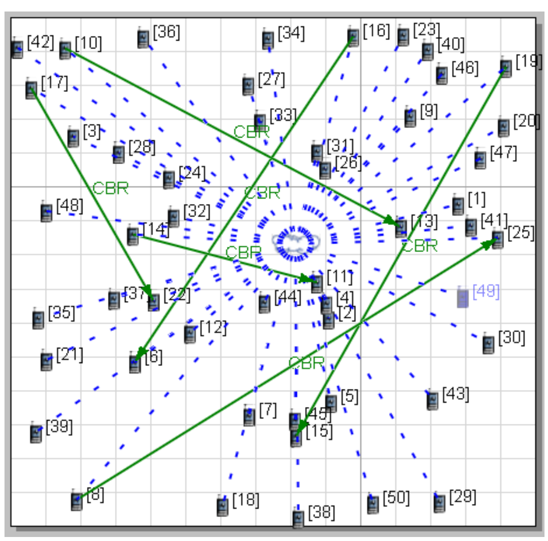


Figure 2. Simulation Scenario

5. Performance Metrics

Throughput: Throughput is the average rate of successful message delivery over a communication channel. The throughput is usually measured in bits per second (bit/sec), and sometimes in data packets per second or data packets per time slot. High throughput is always desirable in a communication system.

Jitter: Jitter is the variation in delay by different data packets that reached the destination and can seriously affect the quality of audio/video and thus an unwanted parameter. Jitter should be small for a routing protocol to perform better.

End-to-end Delay: End-to-end delay refers to the time taken for a packet to be transmitted across a network from source to destination**.** A data packet may take longer time to reach to the destination due to queuing and different routing paths.

Packet Delivery Ratio: It is defined as the ratio of total packet received by the destination to the total packet send by the source. If packet delivery ratio is high then it shows that it can receive maximum packet.

6. Results and Discussion

The Qualnet 7.1 network simulator [2] is used to analyze the performance of AODV, STAR, and ZRP. The animation of nodes mobility and transmission of data of one of the scenario is shown in Figure 2.

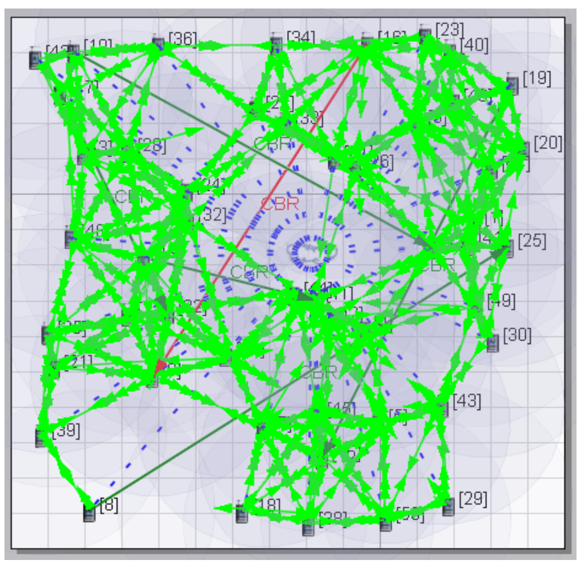
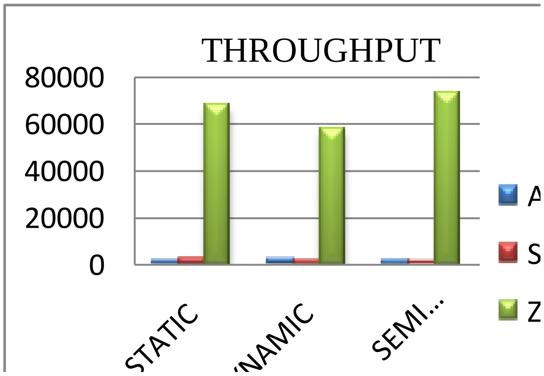
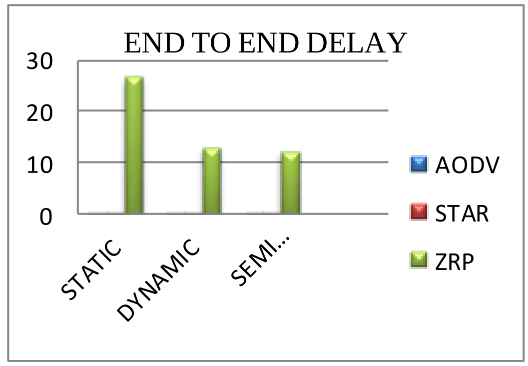


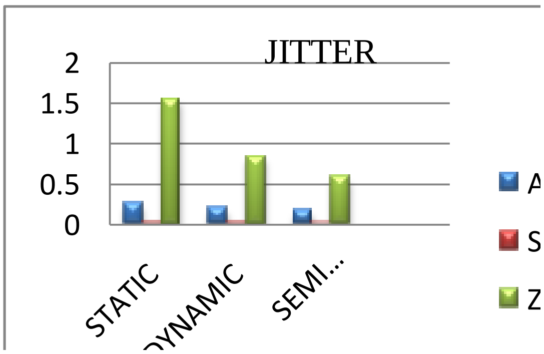
Figure 3. Running Simulation Scenario

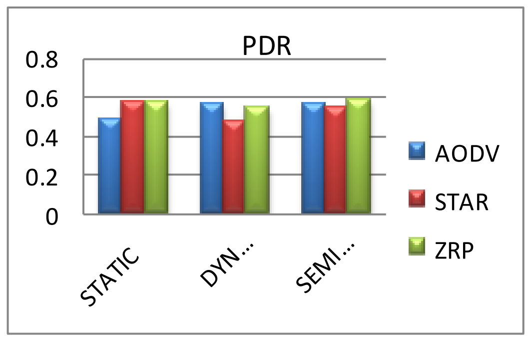
The performance metrics used for the comparison was throughput, end to end delay, jitter and packet delivery ratio (PDR). The following are the graphs obtained for 25, 50, 75 and 100 nodes.

For 25 nodes

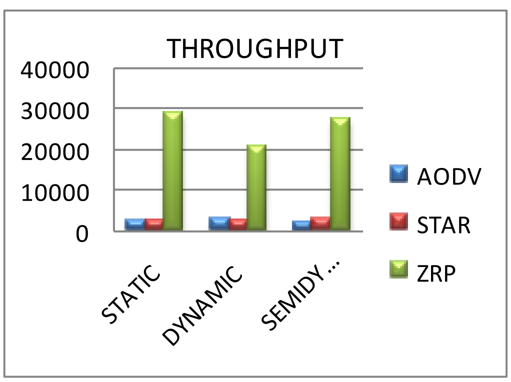


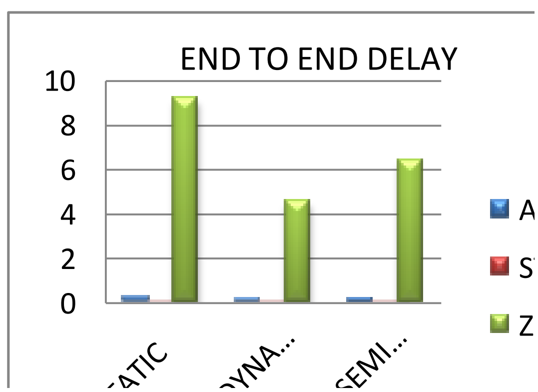


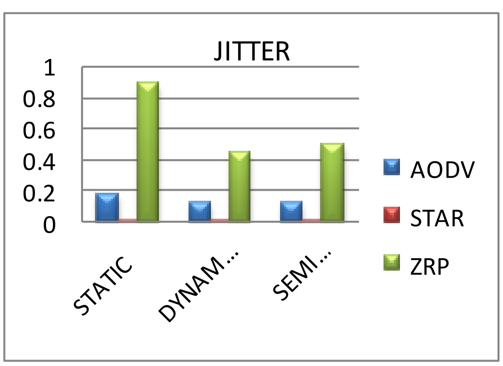


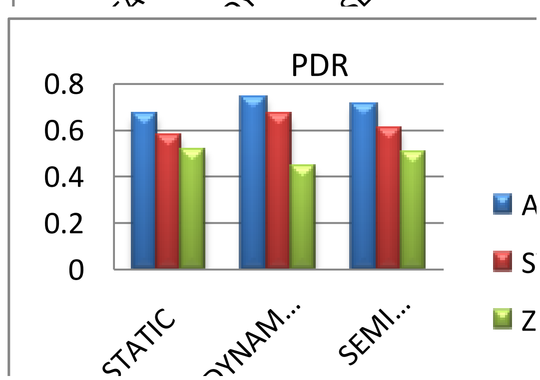


The graphs obtained for a node density of 50 and 75 resembles for each metrics obtained.

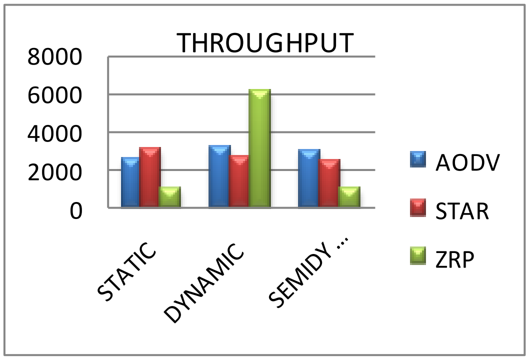


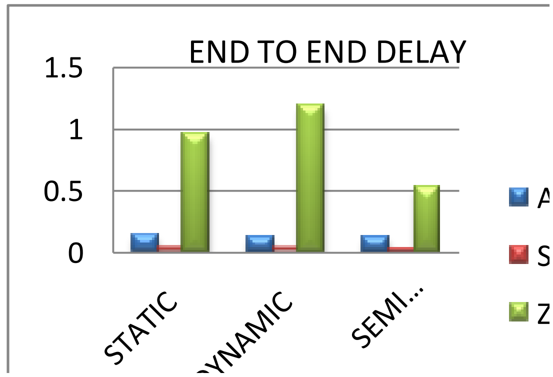


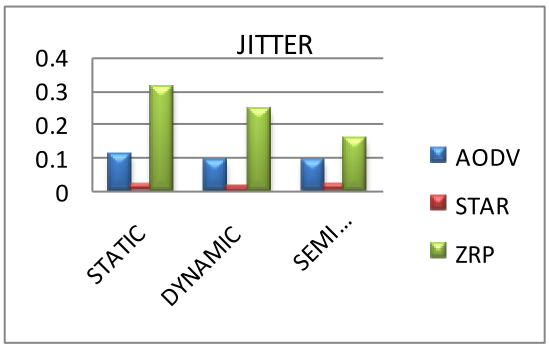


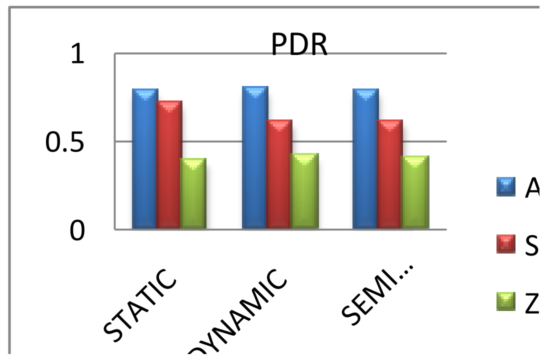


The graphs obtained for a node density of 100 are as follows:









Throughput**:** It was observed that for small node density ZRP performs exceptionally well in case of throughput. But as and when the node density increases the throughput of ZRP degrades drastically. For large node density AODV performs best. STAR performs well for medium node density.

End to End Delay: It was observed that STAR has minimum end to end delay (almost negligible) while ZRP has the maximum delay. As the node density increases the delay in case of ZRP decreases but it still remains the maximum as compared to other protocols.

Jitter: It was observed that ZRP has the maximum jitter while STAR has the minimum. AODV has moderate values of jitter in case of the varying range of the node densities. As seen in case of delay in ZRP, here too with increase in node density the value of jitter decreases.

Packet Delivery Ratio: It was seen that for small node densities ZRP has the maximum PDR followed by AODV and STAR. But as the node density increases the performance of ZRP starts degrading. AODV has the maximum PDR in case of medium and high node density followed by STAR.

The performance variation with varying simulation environment is summarised in the table below. It shows the maximum value of the performance metrics in each case.

Table 2. Summary of Performance of Routing Protocols in Different Environment

METRICS	PROTOCOLS	25	50	75	100
THROUGHPUT	AODV	DYNAMIC	DYNAMIC	DYNAMIC	DYNAMIC
	STAR	STATIC	STATIC	STATIC	STATIC
	ZRP	SEMI-DYNAMIC	STATIC AND SEMI DYNAMIC	STATIC	DYNAMIC

END TO END DELAY	AODV	STATIC	STATIC	STATIC	STATIC
	STAR	STATIC	STATIC	STATIC	STATIC
	ZRP	STATIC	STATIC	STATIC	DYNAMIC
JITTER	AODV	STATIC	STATIC	STATIC	STATIC
	STAR	DYNAMIC	DYNAMIC	DYNAMIC AND SEMI DYNAMIC	DYNAMIC AND SEMI-DYNAMIC
	ZRP	STATIC	STATIC	STATIC	STATIC
PDR	AODV	DYNAMIC	DYNAMIC	DYNAMIC AND SEMI DYNAMIC	DYNAMIC
	STAR	STATIC	DYNAMIC	STATIC	STATIC
	ZRP	SEMI DYNAMIC	SEMI DYNAMIC	SEMI DYNAMIC	SEMI DYNAMIC

It has been observed from the Table that ZRP gives maximum throughput in static and semi dynamic condition whereas AODV performs well in dynamic environment and STAR performs well in static environment in terms of throughput. AODV, STAR and ZRP have maximum delay in static condition. STAR has maximum jitter in dynamic and semi dynamic condition whereas AODV and ZRP have maximum jitter in case of static. It was also seen that AODV has maximum PDR in dynamic condition, STAR has maximum PDR in static and ZRP has maximum PDR in case of semi dynamic condition.

6. Conclusion

It has been observed that AODV gives the maximum throughput and PDR in dynamic condition and its throughput and PDR increases with the increase in node density. STAR has the lowest end to end delay and jitter and it performs best in static condition and medium node density. ZRP shows maximum value of throughput and PDR in case of small node density and static and semi dynamic conditions. Hence it can be concluded that for small node density if only throughput and PDR is considered then ZRP performs the best but delay and jitter has to be compromised as they have very high values. For large node densities AODV performs the best in dynamic conditions. And for medium node densities STAR performs the best as it has very low end to end delay and jitter with considerable throughput and PDR.

Acknowledgments

We take this opportunity to express our gratitude to all the people who helped and supported us to complete this thesis. We express our sincere thanks to **Dr. Kalpana Sharma**, Head of Computer Science & Engineering Department and professor in Computer Science & Engineering, for providing us invaluable support and able guidance throughout the thesis. She has been a source of inspiration for us that helped us and motivated us throughout.

References

[1] A. Chaudhary, V. N. Tiwari and A. Kumar, "Analysis of Routing Protocols Based on Energy Consumption in Mobile Ad Hoc Networks Using Qualnet Simulator", International Journal of Applied Research and Studies (IJARS), ISSN, vol. 3, Issue 1, **(2014)** January, pp. 2278-9480.

[2] I. D. Aron, S. K. S. Gupta, “On the scalability of on-demand routing protocols for mobile ad hoc networks: an analytical study”, J. Interconnect. Networks, vol. 2, no. **(2001)**, 1, pp. 5-29.
[3] C. Perkins, E. Royer and S. Das, "Ad hoc on demand distance vector (AODV) routing”, IETF RFC, no. 3561, **(2003)** July.
[4] D. Vir, S. K. Agarwal and S. A. Imam, “A Simulation Study on Node Energy Constraints of Routing Protocols of Mobile Ad hoc Networks use of QualNet Simulator”, International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, vol. 1, Issue 5, **(2012)** November.
[5] D. Vir, S.K. Agarwal and S.A. Imam, “Power Control and Performance of Reactive Routing Protocols using Qualnet Simulator”, International Journal of Application or Innovation in Engineering and Management (IJAIEM), vol. 2, Issue 4, **(2013)** April.
[6] J. H Chang and L. Tassiulas, “Energy Conserving Routing in Wireless Ad-hoc Networks”, Proc. IEEE INFOCOM, Tel Aviv, Israel, **(2000)** March, pp. 22-31.
[7] M. K. Garg, E. Kumar, “The Performance Evaluation of AODV & DSR (On-Demand- Driven) Routing Protocols using QualNet 5.0 Simulator”, International Journal of Computer Science and Network (IJCSN), vol. 2, Issue 2, **(2013)** April.
[8] N. Tantubay, D. R. Gautam and M. K. Dhariwal, “A Review of Power Conservation in Wireless Mobile Adhoc Network (MANET)”, IJCSI, vol. 8, Issue 4, no 1, **(2011)** July.
[9] N. Arora and S. Kumar, “Simulation analysis of proactive, reactive and hybrid routing protocols in mobile ad hoc network using Qualnet simulator 5.0.2 ”, International Journal of Computer Engineering Research, vol. 3, no. 4, **(2012)** November, pp. 63-68.
[10] N. S. Yadav and R. P. Yadav, “Performance Comparison and Analysis of Table- Driven and On-Demand Routing Protocols for Mobile Ad-hoc Networks”, International Journal of Information Technology, vol. 4, no. 2, **(2007),** pp 101-109.
[11] P. Nand and S. C. Sharma, “Performance study of Broadcast based Mobile Ad hoc Routing Protocols AODV, DSR and DYMO", International Journal of Security and Its Applications , vol. 5, no. 1, **(2011)**.
[12] P. N. Renjith and E. Baburaj, “Analysis on Ad hoc Routing Protocols in Wireless Sensor Networks”, International Journal of Ad hoc, Sensor & Ubiquitous Computing (IJASUC), vol. 3, no. 6, **(2012)** December.
[13] S. Mishra, A. X. Das and A. K.Jaisawal, “Effect of Mobility and Different Data Traffic in Wireless Ad-hoc Network through QualNet”, International Journal of Engineering and Advanced Technology (IJEAT), ISSN: 2249-8958, vol. 2, Issue-5, **(2013)**.
[14] S. Tang and W. Li, “Qos supporting and optimal energy allocation for a cluster based wireless sensor network”. Elsevier Computer Communications, vol. 29, no. 13-14, **(2006),** pp. 2569-2577.
[15] Z. J. Haas, Senior member IEEE and Marc R. Pearlman, member, IEEE “The performance of query control schemes for the zone routing protocol” ieee/acm transactions on networking, vol. 9, no. 4, **(2001)** August.
[16] C. K. Toh, “Ad Hoc Mobile Wireless Networks: Protocols and Systems”, Prentice Hall PTR, **(2002),** pp. 55-77.
[17] C. S. R. Murthy and B. S. Manoj, “Ad Hoc Wireless Networks, Architectures and Protocols”, Second Edition, Low price Edition, Pearson Education, **(2007)**.
[18] Z. J. Haas and M. R. Pearlman, "ZRP: A Hybrid Framework for Routing in Ad Hoc Networks", Boston, MA, USA, Addison-Wesley Longman Publishing Co., Inc. **(2001)**, pp. 221-253.
[19] B. David and P. Johnson, “Routing in Ad Hoc Networks of Mobile Hosts, Proceedings”, IEEE Workshop on Mobile Computing Systems and Applications (WMCSA’94), **(1994)** December.
[20] D. Nitanaware and A. Verma, “Energy Evaluation of Two on Demand Routing protocol Under Stochastic Traffic”, 978-1-4244-2746-8/08, **(2008)**.
[21] J. J. Garcia- Luna- Aceves and M. Spohn, “Source-Tree Routing in Wireless Networks”, Proceedings of IEEE ICNP, **(1999)** October, pp. 273-282.

Authors

Dr. Kalpana Sharma, is an Associate Professor of the Department of Computer Science & Engineering at Sikkim Manipal. Institute of Technology, Mazitar, Sikkim, India since August, 1998. She did her BE from National Institute of Technology, Silchar, India and M.Tech from IIT Kharagpur, India. She completed her PhD on 2011 and her topic of research was security in wireless sensor networks. Her areas of research interest are Wireless Sensor Networks, Steganography, Network & Information Security, Real Time Systems and Software Engineering. She has published a number of technical papers in various national and international journals in addition to presentation/ publication in several international/ national conferences. She can be reached at kalpanaiitkgp@yahoo.com.

Neha Mittal, is a final year B. Tech student of Computer Science and Engineering Department at Sikkim Manipal Institute and Technology. Her areas of interest are Wireless Sensor Networks and Ad hoc Networks. She can be reached at nehamittal135@gmail.com.

Priyanka Rathi, is a final year B. Tech student of Computer Science and Engineering Department at Sikkim Manipal Institute and Technology. Her areas of interest are Wireless Sensor Networks and Ad hoc Networks. She can be reached at priyanka.rathi7792@gmail.com.

