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Effective Zone Based Routing Protocols for MANET

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ABSTRACT

The wireless mobile nodes communicate in a multi-hop fashion in mobile ad hoc networks (MANET). In multi-hop wireless ad-hoc networks, designing energy-efficient routing protocol is critical. Hence, here introduce a routing protocol to handle multi-hop situations known as Zone Based Effective Location Aided Routing (ZBELAR) Protocol to make significant reduction in the energy consumption of the mobile nodes by limiting the area of discovering a new route to a smaller zone. The work is continued with a novel approach Zone Based Optimal Selective Forwarding (ZBOSF). In ZBELAR protocol all mobile nodes are GPS enabled. Hence in ZBOSF protocol tried to minimize GPS nodes in the network by using location estimation algorithm for non GPS nodes. Also introduced additional location aided routing (LAR-2) protocol during the data transmission phase for achieving better performance in terms of throughput and PDR. Further work proposes accurate location estimation technique with a DV-hop propagation algorithm to achieve efficient localization of mobile nodes in ZBOSFWL (Zone-Based Optimal Selective Forwarding with Location). Further the paper proposes two routing protocols named MZBOSF (Modified associativity based Zone Based Optimal Selective Forwarding with location) and AZBOSF (Adaptive Request Zone Based Optimal Selective Forwarding with location) on zone based routing protocols. Different zones are used to avoid route request packet flooding storm during route establishment phage and then data transmission

Key words: Location Aided Routing (LAR), Request Zone, Expected Zone, Localization, Adaptive Request Zone, MANET, Zone based Routing protocols

1. INTRODUCTION

The Mobile Ad hoc Network (MANET) is a conventional ad hoc network. Nodes within the network are mobile, where each node is equipped with a transmitter and receiver, antenna and a local battery. Nodes within MANET are organized in different manners, they can be hierarchical or flat, they can move in any direction and with any speed and communicate to each other by means of routing protocols. In a network, because of nodes movement, network may experience rapid and unpredictable topology changes. Additionally, nodes in a mobile ad hoc network normally have limited transmission ranges, some nodes cannot communicate directly with each other. Hence, routing paths in mobile ad hoc networks potentially contain multiple hops, and every node in mobile ad hoc networks has the responsibility to act as a router. Because of the variable and unpredictable capacity of wireless links, packet losses may happen frequently. Additionally, mobile nodes have restricted power, computing, and bandwidth resources and require effective routing schemes. In order to communicate between a source and a destination, there are several routing protocols to discover paths through the network.

Routing protocols in a MANET can be categorized into three sets: proactive, reactive and hybrid. Any routing protocol in MANET is called ideal if it identify route with less utilization of network resources like time, energy and bandwidth. But route selection in MANET with blind flooding of RREQ packet leads to increase in routing overhead, traffic and conjunction over network. Typically proactive routing protocol includes DSDV (Destination Sequenced Distance Vector) [1] routing, reactive routing protocols includes AODV (Ad-hoc On-demand Distance Vector) [2] routing and DSR (Dynamic Source Routing) [3] and a well-known hybrid routing protocol is ZRP (Zone Routing Protocol) [4].

2. RELATED WORK

This section deals with the review of some of the past works that have made significant contribution to this research work.

Ghosh R.K [5] made general study on routing protocols in MANET. Almost all types of protocols are covered in his study. In [6] and [7] authors have performed analysis on reactive, proactive and hybrid routing protocols. Patidar, H. P. & Sharma, N. in [8] presented a Re-clustering approach using WCA (Weighted Clustering Algorithm) in AODV and DSDV routing protocols in MANET. Depending on energy available cluster head is selected and accordingly clusters are re-clustered in static, semi-dynamic and dynamic scenarios.
Natarajan, D. & Rajendran, A. P, Advance OLSR (Optimized Link State Routing) is proposed hybrid routing protocol based

on energy of nodes, links and mobility of the nodes [9]. Compared with DSR and OLSR, OLSR is proactive Routing Protocol and combined with modified Dijkshtra algorithm. It is a topology detection and path estimation methods. Malwe, S. R. & Biswas, G. P in [10] proposed dynamic clustering based hybrid routing protocol that uses distributed spanning tree method for clustering. Study in [11] presented a routing strategy which informs the mobile nodes in network about changes in the network topology without flooding. Authors used special packet called Carriage.

Overview of routing protocols in MANET is done in [12] and [13]. In [14] authors introduced a DOF-PA (Direction Oriented Forwarding with Power Aware) protocol which uses direction oriented forwarding through minimum number of Edge nodes. It selects one of its edge node as next hop for forwarding the data the remaining nodes are silent. C. Brill & T. Nash performance analysis of AODV and DSDV are compared with AntHocNet (ant colony optimization implementation) [15]. Authors proposed energy aware routing protocol but found implementation complications. In [16] authors performed a review on performance evaluation of reactive (AODV and DSR), proactive (DSDV) and hybrid (ZRP) routing protocols in MANET. They observed with constant speed and with less traffic scenario all protocols react in a similar way. With increase in number of nodes the proactive routing protocols shows high in PDR and throughput but shows poor delay factor and routing overhead. Whereas reactive routing protocols shows low routing overhead, low throughput, low PDR but delay factor increases. Finally authors concluded that no single routing protocol in MANET could be declared as best routing protocol. The performance is governed by several critical factors like network environment, network scenarios, speed of mobile node density of the node etc. Monakhov Y.M et al. [17] presented simulation results for DSR reactive protocol under the conditions of limited availability and heightened response times of network nodes in MANET. They concluded that the working of DSR in large network is inefficient and hence proposed a hybrid routing protocol that includes the proactive phase and uses availability criterion as a metric. Authors in [18] presented an on-demand routing protocol which uses greedy approach for route request propagation while establishing route, backtracking is used when the route request around the void. In [19] comparison of AODV, OLSR, FSR and LAR is done.

Jisha G. and Samuael P. [20] proposed a coverage based hybrid routing method. They first creates cover-set for each node by calculating the coverage area of corresponding node. Both reactive and proactive methods are used to find appropriate route according to position of destination node. Al-Shouiliy K.et al. [21] conducted a simulation study on the performance of reactive and position-based routing protocols in MANET

In [22] motivation was to review various power efficient routing protocols. Observations are proactive routing protocols are ideal for small networks with fixed nodes. Whereas reactive routing protocols possess greater scalability and performs good in dense networks but may cause higher end-to-end delay because it requires more time in route discovery. Power efficient location based approaches may be suitable for sustainable dynamic topological changes because such schemes uses node location to estimate the distances among nodes results in energy efficient, extends network life time. Only limitation they suggested was use of GPS.

Study in [23] Authors proposed a method which will increase lifetime of network also minimize delay by selecting shortest path which has more energy. Authors in [24] presented a hybrid type of routing protocol SZGP (Service Zone Gateway Prediction). This is a non-cooperative and hybrid type of routing with a hierarchical multilayered structure. This includes pre-computed multipath hop-by-hop distributed connectivity. The main goal is load balancing among the nodes and reliable and energy efficient communication. A weight parameter that is function of the nominal available power and the transmission range of the nodes in the network is introduced. The routing is based on the formation of ZS (Zone Service) in each network layer and choice of DG (Default Gateway) for each ZS considering the weight parameter which was pre-computed.

D. Choudhury et al. [25] proposes few energy efficient routing protocols in MANET. They stated that the wastage of energy can be optimized for effective routing by optimizing the transmission power. This technique reduces the overall transmission energy by not using low energy nodes and load distribution, also regulates the path by using energy rich nodes. Finally Sleep or Power down mode is used when nodes are not active. In [26] authors proposed a scheme Reliable and Energy Efficient Hybrid Multicast Routing Protocol (REHMRP) operates in the various phases like computation of node remaining energy and power level by applying designed energy model, then Determining the node Reliability Decisive Factor based on power level of a node, signal strength, and node mobility and finally choosing the best path from mesh of paths for data transmission based on Path Reliability Decisive Factor. Harshita Chaurasiya and Shivnath Ghosh evaluated the performance of energy efficient cluster based algorithms WSN [27]. A. Nageswar Rao et al [28] discussed about problems in relay node placement in WSN, also they proposed energy aware relay node deployment technique.

Nitin H. Vaidya et al. [29] proposed an approach to utilize location information to improve performance of routing protocol in MANET. They suggested two variations LAR1 and LAR2. In LAR1 expected zone means the region where source S expects the contain of destination D. Request zone is a RREQ flooding area which includes expected zone. In LAR2 S knows the location (Xd, Yd) of destination node D at time t0. After some time t1, where t1>t0 node S calculates the distance DISTs and includes this distance with RREQ message along with the coordinates (Xd, Yd). and shares with its neighbors. S. Thipchaksurat, P. and Kirdpipat [30] described that request zone may not be fixed but can be chosen adaptively depending on the distance between source node and destination node. MABR was implemented on AODV. In that protocol each node was maintaining Position Information Table. And this is updated using RREQ and RREP packets. In this method request zone and expected zones are adaptively chosen based on distance between source and destination

3. METHODOLOGY

3.1. ZBELAR (Zone Based Effective LAR)

In order to reduce the area of searching destination node ZBELAR protocol uses a wireless Base Station (BS) that covers all MNs in the network. BS efficiently route packets among MNs, it keeps a Position Table (PT) that stores locations of all MNs. PT is built by BS through Broadcasting Small BEACON Packets to all MNs in the Network. Based on the AoA, BS determines the network area in which each MN is located. Protocol first builds and updates Position Table in BS. If any node enter in the network area buildUpdate position table procedure is called to report position of the node to the BS. When S wants to send data to D, protocol will execute Data transmission procedure [34]. BS divides the network into six areas as follows. Figure 1 shows the working of this protocol. Source mobile node (MN) S lies in zone ID 1 and destination mobile node D is in zone ID 4. Hence MN S will forward data to BS and zone ID 4 will be flooding area

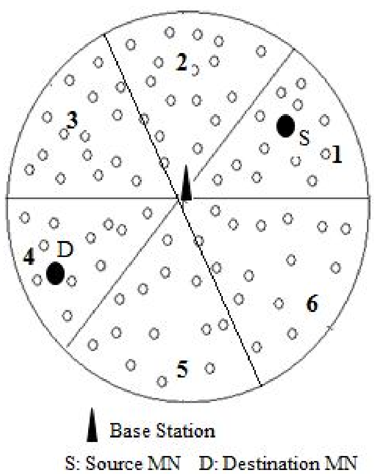


Figure 1: Working of ZBELAR

3.2. ZBOSF (Zone Based Optimal Selective Forwarding routing protocol)

The principle concept of this protocol is it incorporates location of mobile node in routing process. In the first phase, the location estimation algorithm finds the location of all the nodes which are available in the network. Mobile Host Node (MHN) prepares Position Table. Finally routing is accomplished using LAR2 protocol. Compared with ZBELAR, this protocol reduces number of GPS nodes in the networks [35]. Following figure 3 demonstrates source and destination node in different zone or in same zone respectively. Working is explained by following algorithms.

3.3 ZBOSFWL (ZBOSF with location)

Working of this Protocol [36] is same as ZBOSF protocol but with efficient Location Estimation. Location Estimation is done through DV-Hop Propagation Method. In [31] [32] method each node maintains a list of landmark nodes (GPS nodes). Few nodes with GPS called landmarks are available in the network. A distance vector is exchanged so that all nodes in network get distance in hop to the landmarks. Each node maintains a table {Xi, Yi, hi} and exchanges updates to its neighbours. Once a landmark gets distance to other landmarks, it estimates an average size for one hop, then deployed as a correction to the entire network. When receiving corrections an arbitrary node estimates distance to landmarks in meters using triangulation method. Lu Qingling et al. [31] is a kind of improved DV-hop algorithm extended work of [29] In this method there is one anchor node which knows its position. It broadcasts its position information to neighbors. Upon receiving the position information every neighbor estimates its position based on trilateration or multilateration methods. Finally unknown nodes coordinators are calculated. In this paper authors tried to minimize the errors of the original DV-Hop algorithm and an improved method proposed. Unknown node calculates per anchor hop size and only saves hop size of anchor closest to it. Using this hop size it calculates the distance to all anchors. Finally authors analyzed impact of number of anchor nodes. Result shows that when anchor nodes density increases location error reduces steadily.

3.4. MZBOSF (Modified associativity based ZBOSFWL)

This Method does not create six zones like ZBOSF and ZBOSFWL, but rather asks for adaptive request zone and expected zones and relies upon destination position. The Position Information Table (PIT) is covered for each node and it is updated by learning from the position information that is included in RREQ and RREP packets. When source node S_1 wants to communicate with destination D_1 at time stamp t_1 and node S_1 then it knows position of node D at time t_0 for which expected zone can be a circular region with $R=V(t_1-t_0)$ as shown in figure 2.

Position Information Table (PIT): Each intermediate includes PIT. Table is updated for the positions of mobile nodes by learning from RREQ and RREP packets. Node positions and time stamps are inserted in these packets. To calculate the request zone and expected zone in other intermediate nodes. To start communication with node D_1 source node S1 broadcast RREQ packet to node D_1 by including source node position, destination node position and both time stamps. All intermediate nodes (A, B, C, D, I, E, F, G and H) that received these route will update the destination node position of D_1 to PIT if time stamp is newer than in PIT. Then intermediate nodes calculate expected zone and request zones using this information. If these nodes are in request zone they will forward packet otherwise discarded to reduce routing overhead. The intermediate node (A, B, C, and D) will calculate the expected zone and request zone 1, because they don't know newer position of $_{D1new}$. But the nodes (I, E, F, G and H) adapt the direction and calculate the request zone 2 based on the position of node S_1 for considering its position. The working of this protocol is illustrated in figure 3.

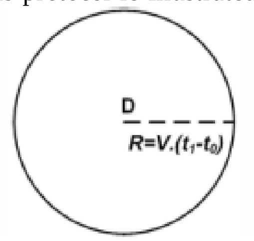


Figure 2: Expected Zone

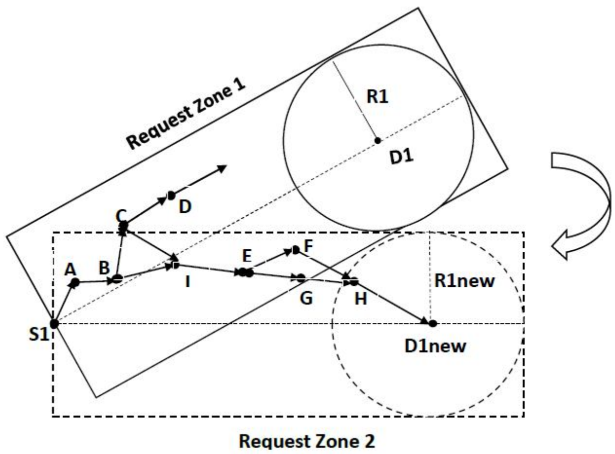


Figure 3: Modified Associativity-Based ZBOSF

As in figure 3 shown S_1 represents source node and D_1 indicates destination node.

Algorithm

Step1: If Source node (S_1) wants to communicate with Destination node (D_1), it broadcasts route request that includes source node position, destination node position and time stamp to reach at destination D_1.

Step2: All intermediate nodes update the Destination node position (D_1) in PIT accordingly.

Step3: All intermediate nodes will calculate expected zone and request zone by using position of source and destination nodes along with time stamps.

Step4: If these intermediate nodes are in request zone1 then forward packet otherwise discard it.

Step5: If destination node moves from its position (D_1-> D_1new) then intermediate nodes adapt the path and calculate the request zone 2 based totally on the position of source node S_1.

3.5 AZBOSF (Adaptive request zone for ZBOSFWL)

This protocol is implemented to consider the adaptive request zone and movement of nodes. Fig. 7 describes the overall working of the protocol. The distance between source node and destination node is based on diagonal line. For instance,

- If gap is larger than or equivalent to ¾ of diagonal line (S->D_4), then pick out the radius R_4 =250 m. This represents that nodes are far away from each other.
- If the gap is larger than or equal to ½ of the diagonal line (S->D_3), select the radius R_3 =187.5 meter.
- If the gap between source and destination node is larger than or equal to ¼ of the diagonal line (S->D_2), then pick the minimum of radius R_2 = 125 meter.
- If source and destination nodes are very close to each other such as node S and node D_1, the minimum of radius R_1 = 62.5 meter will be selected.

The maximum radius of 250 meters is taken into consideration due to the assumption of the diameter of expected zone which is equal to 500 meters which is approximately half of the simulation area of 1,000 X 1,000 m.

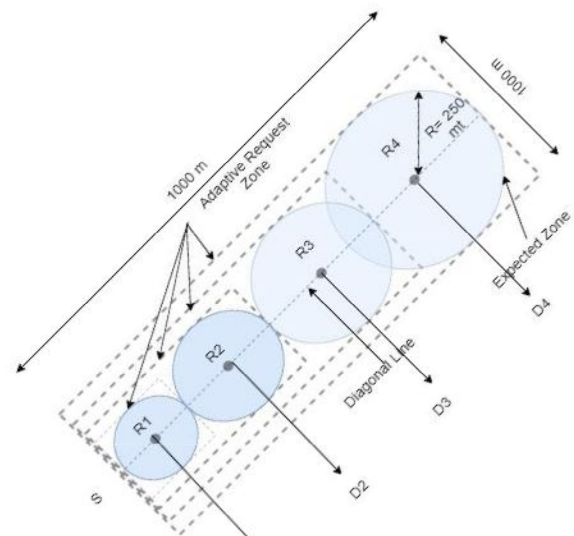


Figure 4: Working of AZBOSF protocol

Algorithm for Source Node:

- Check destination node position in PIT
- If found Broadcast route request pkt to request zone by including time stamp and node positions
- If not then send by flooding

Algorithm for Intermediate Nodes (During RReq packet)

- When Xi gets RReq pkt, update newer node position
- Calculate Src-Dest distance and diagonal line and adapt radius
- Compute expected zone and request zone and get node Xi position
- If node Xi in request zone; forward RReq pkt otherwise drop pkt

Algorithm for Destination Node

- After getting RReq check source node position, update source node position and Timestamp in RRep pkt
- If not select RRep pkt by using selection algorithm

- Finally send RRep pkt back to the src node via selected path

Algorithm for Intermediate Nodes (During RRep packet)

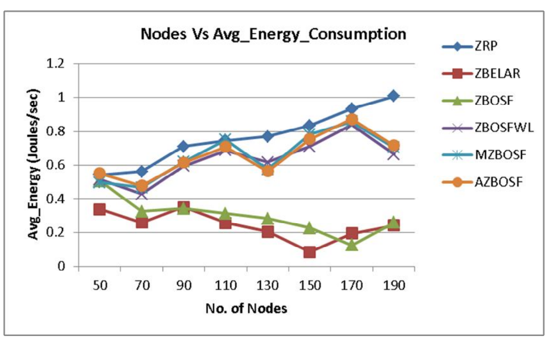
- Node Xi gets RRep packet
- Check node position in packet
- If position is newer then update it

4. SIMULATION RESULTS AND DISCUSSIONS

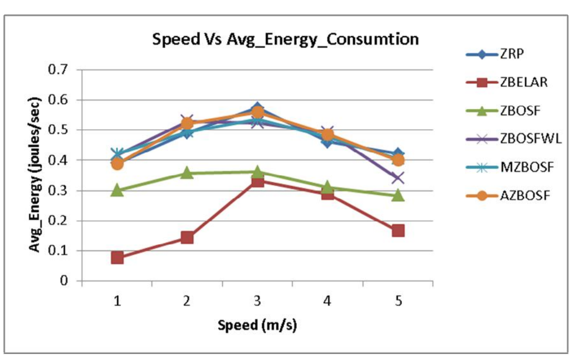
The network simulator NS-2 version 2.34 is used to evaluate the performances of the given zone based routing protocols. Table 1 shows the parameters used for simulation.

Table 1: Network Simulation Parameters

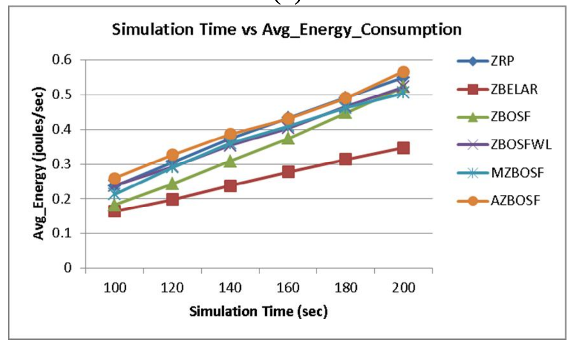
Parameter Type	Value
X & Y dimension	1000 m x 1000 m
Channel Type	WirelessPhy
Number of Nodes	50 to 200
MAC Type (mac)	IEEE 802.11
ifq Type	DropTail / Priqueue
ifq length	50
Antenna type	Antenna/DirAntenna
Propagation Model	TwoRayGround
Mobility Model	Random Way Point
Traffic type	CBR
Packet size	2000 bytes
Routing	ZRP, ZBELAR, ZBOSF, ZBOSFWL, MZBOSF, AZBOSF



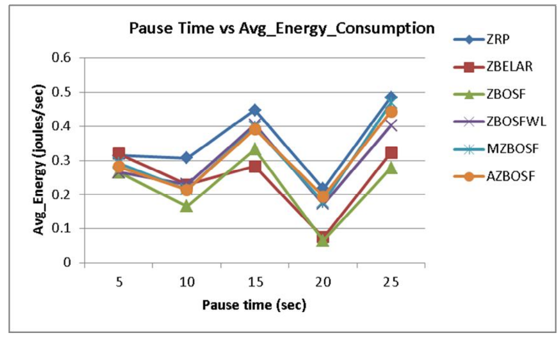
(a)



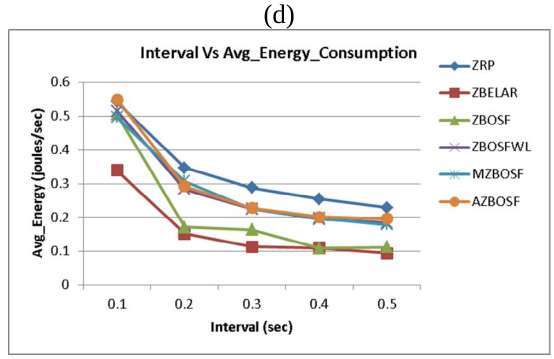
(b)



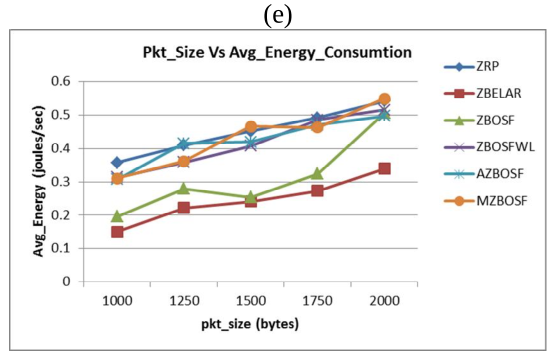
(c)



(d)



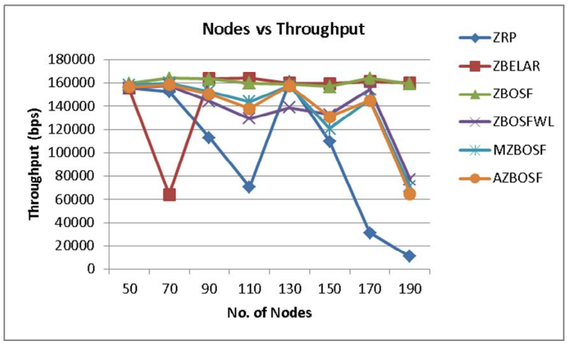
(e)



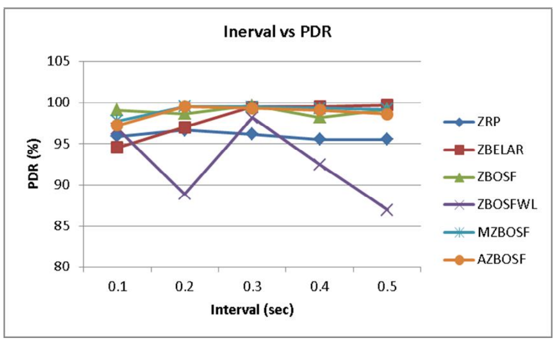
(f)

Figure 5: Comparative analysis of protocols for (a) No. of Nodes (b) Speed (c) Simulation time (d) Pause Time (e) Interval and (f) Packet Size Vs Avg_Energy_Consumption

Figure 5 shows the comparative analysis of implemented protocols for average energy consumption against different parameters. In figure 5 (a) average energy consumption is analyzed by varying number of nodes. Nodes are varied from 50 to 190. Results show that the average energy consumption of protocols ZBELAR and ZBOSF are very low. Protocols ZBOSFWL, MZBOSF and AZBOSF have higher energy consumption but less than ZRP. Average energy consumption of a network is analyzed by varying speed as shown on Figure 5 (b). It is observed that performance of ZBELAR is superior to all other protocols. ZBOSF protocol works better than other remaining protocols. In figure 5 (c) comparison is with simulation time. Result shows that the ZBELAR protocol outperforms others. Figure 5(d), 5(e) and 5 (f) are compared with pause time, interval and packet size respectively. Performance of ZBELAR and ZBOSF protocols is better than all other protocols in terms of average energy consumption. Remaining protocols are consuming more energy but less than ZRP protocol.



(a)



(b)

Figure 6: Comparative analysis of protocols (a) No. of Nodes Vs Throughput (b) Interval Vs PDR

Figure 6 (a) shows the comparison of number of nodes against throughput. By varying number of nodes from 50 to 190 the throughput of ZBELAR and ZBOSF protocols are highest. As number of nodes increases the throughput of ZRP protocol decreases continuously because it behaves like reactive routing protocol. The remaining protocols performance is almost similar. In figure 6 (b) result graphs of interval versus PDR is shown. The packet delivery ratio is almost constant and higher than ZRP of all routing protocols except ZBOSFWL.

The implemented protocols use different zones for route selection phase and then data transmission phase, the network area is restricted which results in generating less control overhead. Figure 7 shows the graph of number of nodes versus control overhead. As the number of nodes increases the control overhead of ZRP protocol is increases linearly. The performance of our protocols is excellent in terms of control overhead

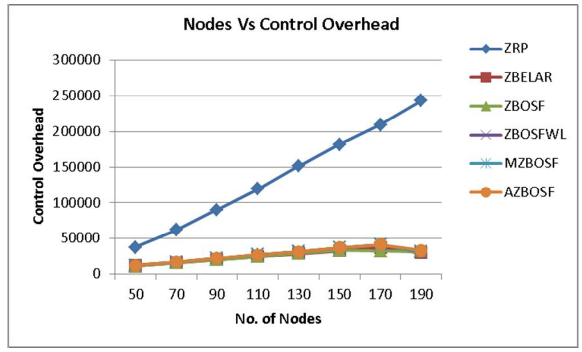


Figure 7: Comparative analysis of No. of Nodes Vs Control Overhead

5. CONCLUSION

This work has presented the various zone based routing protocols with different location estimation techniques. ZBELAR protocol divides whole network in six zones and selected zone is used for route selection phase followed by the data transmission phase. Result shows that this mechanism reduces energy consumption of mobile nodes when compared with LAR protocol. Limitation of this protocol is that every mobile node in the network has to be GPS enabled.

In ZBOSF protocol location estimation of every node is estimated based on the neighbor information shared by non GPS nodes and during data transmission phase it uses LAR-2 protocol. While DV-hop propagation method is used in ZBOSFWL protocol for location estimation it is more accurate than in ZBOSF protocol.

The need for dynamic request zone and response zone is explained in Modified associativity based and Adaptive Request Zone based methods. MZBOSF and AZBOSF protocol considered the unpredicted movements of mobile nodes. Simulation results show that ZBELAR and ZBOSF provide the better performance results over all other protocols in terms of average energy consumption, throughput and PDR. When compared the ZRP protocol for control overhead the performances of our protocols are outstanding. In future scope security can be added during communication.

REFERENCES

1. Mahdipour, E.; Rahmani, A.; Aminian, E.,"**Performance evaluation of destination-sequenced distance-vector (DSDV) routing protocol**", *International conference on future networks;* 2009, pp: 186–190.
2. Perkins, C. & Royer, E., **"Ad-hoc on-demand distance vector routing",** *Second IEEE workshop on mobile computing systems and applications*, *WMCSA*; 1999, pp: 90–100.
https://doi.org/10.1109/MCSA.1999.749281
3. Johnson, D. & Maltz, D.,**"Dynamic source routing in ad hoc wireless networks",** *Mobile computing, ser. The Kluwer International Series in Engineering and Computer Science*; 353; 1996, pp:153–181

https://doi.org/10.1007/978-0-585-29603-6_5

4. Haas, Z. J.; Pearlman, M. R.; Samar, P., **“The zone routing protocol (ZRP) for ad hoc networks”.** http://www.ietf.org/proceedings/02nov/I-D/draft-ietf-manetzone-zrp-04.txt, IETF MANET Working Group, INTERNET-DRAFT, July 2002.
5. Ghosh, R. K., **“Routing Protocols for Mobile Ad Hoc Network”,** *Wireless Networking and Mobile Data Management,* Springer Nature Singapore Pte Ltd., 2017, pp:179–215. https://doi.org/10.1007/978-981-10-3941-6_7
6. Kochher, R. & Mehta, R. **“Performance analysis of reactive AODV and DSR with Hybrid GRP Routing Protocols under IEEE 802.11g MANET”,** *International Conference on Wireless Communications, Signal Processing and Networking (WiSPNET),* IEEE, 2016, pp:1912-1916 https://doi.org/10.1109/WiSPNET.2016.7566475
7. Gouda, B. S.; Patro, D.; Shial, R. K., **“ Scenario-Based Performance Evaluation of Proactive, Reactive and Hybrid Routing Protocols in MANET Using Random Waypoint Model”,** *International Conference on Information Technology,* IEEE; 2014, pp:47-52 https://doi.org/10.1109/ICIT.2014.40
8. Patidar, H. P. & Sharma, N. **“Re-Clustering Approach Using WCA in AODV and DSDV Routing Protocols in MANET”**, *Proceedings of International Conference on ICT for Sustainable Development,* Springer Science+Business Media Singapore; 2016, pp:733–749. https://doi.org/10.1007/978-981-10-0135-2_70
9. Natarajan, D. & Rajendran, A. P.,**“AOLSR: hybrid ad hoc routing protocol based on a modified Dijkstra’s algorithm”,** *EURASIP Journal on Wireless Communications and Networking*, Springer Open Journal, 2014, pp: 1-10 https://doi.org/10.1186/1687-1499-2014-90
10. Malwe, S. R. & Biswas, G. P. **“Dynamic Clustering Based Hybrid Routing Protocol for Mobile Ad Hoc Networks”,** *Advances in Intelligent Systems and Computing,* Springer India; 2014, pp:3–9 https://doi.org/10.1007/978-81-322-1856-2_1
11. Saleh, A. I.; Arafat, H.; Hamed, A. M., **“An Adaptive hybrid routing strategy (AHRS) for mobile ad hoc networks”,** *Peer-to-Peer Networking and Applications, 11(3),* Springer Science+Business Media New York; 2017, pp:561–578. https://doi.org/10.1007/s12083-017-0558-4
12. Anuj K. Gupta; Harsh Sadawarti; Anil K. Verma.,**“ Review of Various Routing Protocols for MANETs”**, *International Journal of Information and Electronics Engineering,* Vol. 1, No. 3; 2011, pp:251-259
13. N. Gupta & R. Gupta **“Routing protocols in Mobile Ad-Hoc Networks: An overview”**, *INTERACT-2010,* Chennai, IEEE-2010; pp:173-177. https://doi.org/10.1109/INTERACT.2010.5706220
14. Suganthi, R. & Sankara Gomathi, S., **“Direction Oriented Forwarding with Power Adaption (DOF-PA) Protocol for MANETs”,** *International Conference on Communication and Signal Processing*. , IEEE-2014; pp:567-571 https://doi.org/10.1109/ICCSP.2014.6949905
15. C. Brill & T. Nash., **“A comparative analysis of MANET routing protocols through simulation”**, *12th International Conference for Internet Technology and Secured Transactions (ICITST),* Cambridge, IEEE-2017; pp:244-247.
16. Shruti Thapar & Anshuman Kalla, “**A Review on Performance Evaluation of Routing Protocols in MANET”**, *Proceedings of the International Conference on Recent Cognizance in Wireless Communication & Image Processing*, Springer India; 2016, pp:59–68. https://doi.org/10.1007/978-81-322-2638-3_7
17. Monakhov, Y. M.; Monakhov, M. Y.; Telny, A. V. **“Simulation of routing in an ad-hoc network in conditions of limited availability”**, *IEEE Dynamics of Systems, Mechanisms and Machines (Dynamics).* (Omsk, Russia),2017, pp:1-6
18. Mahmood, B. A.; Ibrahim, A.; Manivannan, D., **“Hybrid On-demand greedy routing protocol with backtracking for Mobile Ad-Hoc Networks”,** *9th IFIP Wireless and Mobile Networking Conference {(WMNC).* IEEE-2016; pp:110-116 https://doi.org/10.1109/WMNC.2016.7543977
19. P. Goyal., **“Simulation study of comparative performance of AODV, OLSR, FSR & LAR, routing protocols in MANET in large scale scenarios”**, *2012 World Congress on Information and Communication Technologies*, Trivandrum, IEEE-2012; pp:283-286 https://doi.org/10.1109/WICT.2012.6409089
20. Jisha, G. & Samuel, P., **“Coverage based route maintenance in MANET routing protocol”**, *12th International Conference on Intelligent Systems Design and Applications (ISDA)* , IEEE-2012; pp:398-402
21. Al-Shouiliy, K.; Alsaqour, R.; Uddin, M., **“Simulation Study on the Performance of Reactive and Position-Based Routing Protocols in MANET”**, *Innovations and Advances in Computing, Informatics, Systems Sciences, Networking and Engineering,* Springer International Publishing Switzerland; 2014, pp:25-29.
22. Jabbar, W. A.; Ismail, M.; Nordin, R.; Arif, S., **“Power-efficient routing schemes for MANETs: a survey and open issues”**, *Wireless Networks,* 23(6), Springer Science+Business Media New York; 2016, pp:1917–1952. https://doi.org/10.1007/s11276-016-1263-6
23. Mafirabadza, C. & Khatri, P., **“Efficient Power Aware AODV Routing Protocol for MANET”**, *Wireless Personal Communications, 97(4),* Springer Science+Business Media, LLC; 2017, pp:5707–5717.
24. M. Chaudhari, P. Koleva; V. Poulkov.,**“Performance analysis of service zone gateway prediction algorithm for MANETs”,** *40th International Conference on Telecommunications and Signal Processing (TSP),* Barcelona, IEEE-2017; pp:69-73.

25. D. Choudhury; D. Kar; K. R. Biswas; H. N. Saha. **"Energy efficient routing in mobile ad-hoc networks",** *2015 International Conference and Workshop on Computing and Communication (IEMCON)*, Vancouver, BC, IEEE-2015; pp:1-7. https://doi.org/10.1109/IEMCON.2015.7344477
26. G. A. Walikar & R. C. Biradar.,**"Reliable and energy efficient hybrid multicast routing in Mobile Ad Hoc Networks"**, *International Conference on Signal Processing, Communication, Power and Embedded System (SCOPES),* Paralakhemundi, IEEE-2016; pp:1077-1083
27. Harshita Chaurasiya and Dr. Shivnath Ghosh, "**Performance Evaluation of Energy-Efficient Cluster based Algorithms in Wireless Sensor Network",** *International Journal of Advanced Trends in Computer Science and Engineering,* Volume 7, No.5, ISSN 2278-3091, September –October 2018, pp:77-81 https://doi.org/10.30534/ijatcse/2018/03752018
28. A. Nageswar Rao, B. Rajendra Naik and L. Nirmala Devi, "**Location Aware Relay Node Placement for Energy Constrained Wireless Sensor Networks",** *International Journal of Advanced Trends in Computer Science and Engineering,* Volume 8, No.3, ISSN 2278-3091, May - June 2019, pp:519-526 https://doi.org/10.30534/ijatcse/2019/28832019
29. Young-Bae Ko & Nitin H. Vaidya.,**"Location-Aided Routing (LAR) in mobile ad hoc networks"**, *Wireless Networks* -6,2000, pp:307–321
30. S. Thipchaksurat & P. Kirdpipat "**Position-based Routing Protocol by Reducing Routing Overhead with Adaptive Request Zone for Mobile Ad Hoc Networks",** Communication Systems Wireless! Mobile Communications & Technologies, *The 8th Electrical Engineering! Electronics, Computer, Telecomm. and Information Technology (ECTI)* Association of Thailand - Conference 2011, pp:389-392 https://doi.org/10.1109/ECTICON.2011.5947856
31. Dragos Niculescu & B. R. Badrinath. **"Ad hoc positioning system (aps)"**, *IEEE GLOBECOM'01* (San Antonio), 2001, pp:2926-2931
32. DRAGO¸S NICULESCU & BADRI NATH, **"DV Based Positioning in Ad Hoc Networks",** *Telecommunication Systems* 22:1–4, Kluwer Academic Publishers. Manufactured in The Netherlands, 2003,pp:267–280
33. Lu Qingling; Bai Mengliang; Zhang Wei; Lian Enjie, **"A kind of Improved DV-hop Algorithm",** *2nd international conference on intelligent control and information processing*, IEEE-2011; pp:867-869
34. G.T. Chavan & Vemuru Srikanth, **"Zone Based Effective Location Aided Routing Protocol for MANET",** *AIM/CCPE 2012, CCIS* 296, © Springer-Verlag Berlin Heidelberg; 2013, pp:404–407 https://doi.org/10.1007/978-3-642-35864-7_61
35. G. T. Chavan & Vemuru Srikanth, **" Zone Based Optimal Selective Forwarding (ZBOSF) Routing Protocol For MANET",** *PONTE International Scientific Research Journal*, .Vol- 73, Issue 12,2017, pp: 339-346 https://doi.org/10.21506/j.ponte.2017.12.23
36. G. T. Chavan & Vemuru Srikanth, **"Zone Based Routing Protocol With Improved Location Estimation For MANET",** *ARPN Journal of Engineering and Applied Sciences*, VOL. 13, NO. 11, 2018, pp:3650-3656