*International Journal on Recent and Innovation Trends in Computing and Communication*
*ISSN: 2321-8169 Volume: 11 Issue: 8*
*DOI: https://doi.org/10.17762/ijritcc.v11i8.8030*
***Article Received**: 20 May 2023 **Revised**: 28 July 2023 **Accepted**: 16 August 2023*

# Dissection of Mobility Model Routing Protocols in MANET on QoS Criterion

**Dr. N Sivapriya[1], Dr. R Mohandas[2], Padakanti Kiran Kumar[3], Karthik Kumar Vaigandla[4]**
[1]Assistant Professor, Department of Computer Application, Cauvery College for Women, Trichy, TamilNadu, India
[2] Associate Professor, Department of ECE, Balaji Institute of Technology & Science, Warangal, Telangana, India
[3,4]Assistant Professor, Department of ECE, Balaji Institute of Technology & Science, Warangal, Telangana, India
[1]nmsivapriya@gmail.com, [2]mohandasbe@gmail.com, [3]kiranpadakanti0430@gmail.com, [4]vkvaigandla@gmail.com

**Abstract**—Essential difficulties in Mobile Ad Hoc Networks (MANET) are routing selection and Quality of Service(QoS) support. Several different approaches have been described in the literature, and a number of performance simulations have been produced, in an attempt to tackle this challenging problem. In this study, we take a close look at the relative merits of several popular routing protocols. In this research, we looked into how changing QoS parameters in tandem with routing protocol choices affected network throughput. Typical measures for measuring network efficiency include average throughput, packet delivery ratio (PDR), average delay, and power usage. NS-3 is used to run the simulations.

**Keywords**-Ad hoc networks (ANET), Delay, Energy Consumption, Mobility Model(MM), MANET, Network simulation, Packet Delivery Ratio(PDR), Performance evaluation, QoS, Routing Protocols, Throughput.

## I. INTRODUCTION

Information and communication technologies are essential in many areas, including energy conservation. The evolution of state-of-the-art wireless communication systems is profoundly affected by this criterion [1-2]. This requires improvements over already existing infrastructure. A wireless network architecture termed a Mobile Ad-hoc Network (MANET) developed in the 1970s with the goal of facilitating instantaneous information sharing. Thanks to MANETs' advanced characteristics like self-organization and self-configuration, it's possible to create low-cost network connections that don't rely on any existing infrastructure. Many new practical uses for MANETs have evolved in recent years [3], including healthcare, rescue, disaster recovery, entertainment, the military, and smart traffic.

The use of MANET is widespread. There is no central authority in a MANET network, which consists of a dispersed group of mobile stations that broadcast radio signals to one another. The MANET network structure is fluid. Battery life and processing power are just two of the scarce commodities at each station. The nodes in a mobile ad hoc network (MANET) engage in a form of multi-hop communication. Therefore, a station can act as both an endpoint and a router, and a packet can be sent from one node to another via intermediate mobile stations[4]. The network's routing mechanism is used to improve power efficiency as much as possible. Proactive routing, geographical routing, and reactive routing are the three main categories of ad hoc network (ANET) routing protocols [5]. In this study, we analyze how different mobility models (MMs) influence an ad hoc network (ANET). The study's conclusion is a set of suggestions for future researchers and evidence for the importance of using the right MM for protocol analysis in ANETs. To model a routing system, an MM is utilized to describe the location and velocity changes of a mobile node (MN) over time. It's a must-check for academics attempting to analyze and simulate routing protocol efficiency. We looked into how using different MM scans might impact the efficiency of a routing system. Therefore, picking the right MM is crucial for MANET protocol analysis [6].

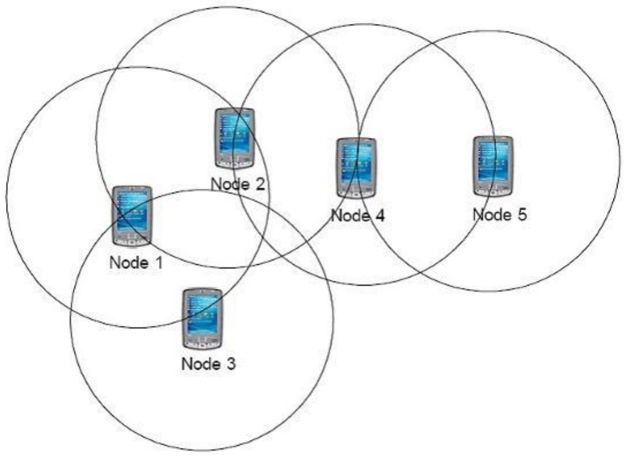


Figure 1. Mobile stations serve as routers in MANET.

The effects of Quality of Service (QoS) considerations on various protocols were examined. Performance was evaluated with regards to variables such as Packet Delivery Ratio (PDR), throughput, delay, packet loss, energy usage, and routing overhead. When throughput, PDR, packet loss, and delay are all minimal, a network is said to be performing optimally. Several MANET routing protocols are compared in this work, with emphasis on the parameter count [7].

## II. LITERATURE SURVEY

There have been numerous related studies on ANET models completed in a variety of network-related domains. The data used to validate the conclusions is mostly synthetic data, which is exceedingly vague, ambiguous, and approximate; the researchers overcome these problems. The authors of [8] ran simulations of the OLSR, AODV, and DSDV protocols over varying network conditions and time periods, drawing conclusions about their relative merits. The experiment conducted by the author was conducted with a varying number of nodes. In [9], the authors analyzed and compared results for a range of allowed metric values. The simulation was run by changing mobility in a variety of predefined situations with a constant number of nodes. The effects of routing protocols on mobility and traffic were described in [10]. Delay and load performance in MANET were analyzed in [11]. In [12], the impact of mobility on the effectiveness of on-demand routing strategies was examined. [13] tried strategies utilizing different packet sizes. Multiple MANET routing techniques and approaches were discussed in [14]. Several types of broadcast systems were studied, and a mapping between probability-based broadcasting and omnidirectional broadcasting was proposed in [15]. Through the use of the ns2 simulator, the research in [16] compared the efficacy of the DSR, AODV, and DSDV routing protocols. In terms of packet delivery ratio (PDR), packet loss rate (PLR), and round-trip delay (RTD), the results favored DSDV over AODV and DSR. In [17], the authors used the NS-2 simulator to evaluate the performance of DSR, AODV, and DSDV in terms of mobility and throughput. PDR, ETA, and Avg. Routing Load are three metrics that have been studied in relation to DSR, AODV, and DSDV as impacted by mobility patterns [18]. The effect of adjusting performance parameters has not been studied in previous AODV-based research. Topology changes in a MANET are handled by the route discovery and route maintenance mechanism [19]. In [20-21], researchers looked at the effect that route maintenance and HELLO message parameters had on the default parameters' functionality.

## III. MOBILITY MODELS

The most important aspect of an MM is its level of realism in terms of the movement of actual users. The simulation and evaluation of network performance characteristics improve with more realistic models. The reality's movement patterns can't be represented by a single, comprehensive MM. There are many different kinds of artificial MMs, but broadly speaking, there are two categories distinguished by their mobility properties. The classification of various MMs is shown in Figure 2.

### *A. Entity Mobility Models (EMMs)*

MNs in EMMs move independently inside the simulation area.

*a) Random Waypoint Mobility Model (RWPMM) :*The RWPMM developed by Johnson and Lee [23, 24] includes rest periods in between directional and/or velocity changes. All random-based MMs allow the MNs to freely roam the whole simulated space. A node's destination, velocity, and heading are all completely under its control, unrelated to those of its neighbors. The Routing Workload Performance Measurement Model (RWPMM) is the most widely used and studied model for simulating routing protocols. The original proposal came from Johnson and Maltz [25]. Each MN waits for the pause period at the beginning of the simulation before picking a location at random.

*b) Random Direction Mobility Model (RDMM) :*To fix a flaw in the RWPMM, researchers came up with the RDMM [26]. Here, instead of picking a random final destination, the MNs model picks a random direction. It is common for an MN to go toward the center of the simulation area, sometimes all the way to the edge or to an intermediate nesting location. Its primary purpose was to dampen the RWPMM's density waves. All MNs are uniformly dispersed across the network region with a random angular velocity between 0 and 2. When MN approaches the boundary of the simulation region, it stops for a certain amount of time and a new direction of motion and speed are given to the node. This continues till the simulation has run its course.

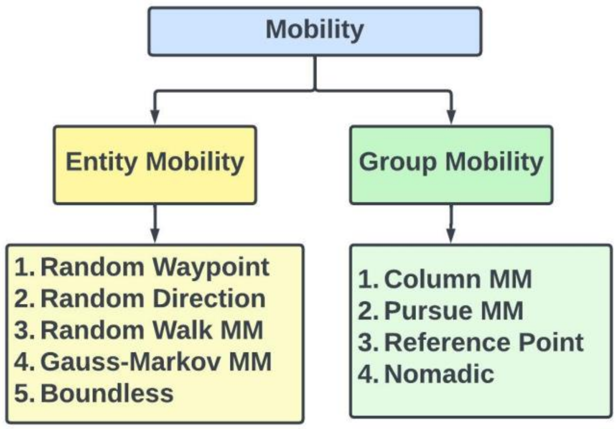


Figure 2. Mobility Model Classification

*c) Random Walk Mobility Model (RWMM) :* Einstein initially mathematically introduced the RWMM in 1926 [27]. One of the most popular MMs, it excels at depicting individual motions in context with cells. This procedure for shifting from one choice to another does not remember the state of the node in question.

*d) Random Gauss-Markov Mobility Model (RGMM)* : The Gauss-Markov MM was initially created by Liang and Haas [28] to mimic PCS networks, but it has since found widespread application in simulating ANET. The speed of a given MN is connected across time slots, and the system runs on this principle.

*e) Boundless Simulation Area Mobility Model (BSAMM*) : According to Haas [29], it relies on the correlation between the past and present velocity and direction of an MN. The time and position are both updated when the speed vector is changed. In the Haas model, a moving neutron (MN) will continue travelling until it reaches the opposite side of the simulation region, where it will then resurface.

*f) Freeway Mobility Model (FWMM) :*It can be used for both sharing and tracking traffic data on the highway [30]. Many highways are depicted on the road map, and they all have at least two lanes in each direction [31]. The expected freeway traffic pattern shows a strong reliance on both space and time.

### *B. Group Mobility Models (GMM)*

In practice, however, complex movement patterns are often observed in military settings. A small percentage of the nodes stay still, whereas the majority either move together or independently. As an added bonus, membership in the collective is temporary. In a dynamically changing environment, mobile groups may split up or merge. These numerous modes of mobility exist side by side in a military setting. A good realistic mobility model will account for all of these aspects of motion to provide accurate performance evaluation results.

*a) Column Mobility Model (CMM)* : Scanners and search engines make extensive use of it. The MNs march in a straight line, all facing the same way. Every MN is in order, starting with the first. According to Sanchez [27], CMM allows for individual MNs to be entered in a single file line and then to shift around their initial positions. The MNs all go around their home stars.

*b) Nomadic Community Mobility Model (NCMM)* : In this model, a swarm of MNs moves around the simulated environment. Each node has its own independent region within any given community or network. In contrast to CMM's individual grids for each column, NCMM's grids are all same. In addition, there is minimal activity in NCMM but constant activity in CMM.

*c) Pursue Mobility Model (PMM)* : In this scenario, many nodes race to catch up to the one MN in the lead. The node being pursued, known as the target node in the RWPMM, is free to move about. According to [27], this model attempts to portray MNs aiming at a certain target. The MN shift is factored into the random vector calculation using RWMM.

## IV. MANET ROUTING PROTOCOLS

The dynamic nature of an ANET makes routing difficult. Developing a suitable communication system and protocol for this type of network is a very challenging undertaking. Since establishing a route, maintaining it, and transmitting data between nodes or devices is the most important portion of communication, protocols play a vital role in this process. The topic of protocol design has seen extensive research and experimentation. Many different methods have been developed by researchers, each tailored to a specific type of complex network. The efficiency of a protocol can be measured in part by how well it handles mobility and traffic.

### *A. Flat Routing Protocol*

Flat routing has no network structure or subnet for transmitting or receiving data packets. It searches for the optimal route hop by hop to the destination by any path without making any attempt to manage the network or its traffic. All router settings in flat routing protocol are on a flat geometric plane.

*a) Proactive Routing Protoco*l

In the Proactive approach, routing data is stored locally at each network node. Maintaining the node's path assists in forwarding the packet to the appropriate node, making the search quicker. The drawback of this type of protocol is that it consumes a lot of network resources owing to the constant updating of routing table information.

*Destination Sequenced Distance Vector (DSDV)* :

The destination, the next hop, and the total number of hops to get there are all stored in the routing node of each node. The frequency of route updates is determined by the frequency of route broadcasts. The nodes receive two sets of routing data: a full dump and an incremental dump that only includes the differences between the two. Each route has a unique sequence number, and changes to the routes are tracked by that number [32]. The routing table is changed, disregarding the previous sequence number and replacing it with the most recent sequence number. If an existing sequence number matches, the next hop and number of hops are examined for updating (best metrics). The updated information becomes distributed into the packet.

*Fisheye State Routing (FSR):*

By maintaining a topology map locally, FSR is a form of link state table-driven routing. The link status method has been modified to decrease the cost caused by control packets. Only neighbouring nodes share link state information in FSR. Information about close nodes within a predetermined scope is disseminated more often than information about distant nodes.

*International Journal on Recent and Innovation Trends in Computing and Communication*
*ISSN: 2321-8169 Volume: 11 Issue: 8*
*DOI: https://doi.org/10.17762/ijritcc.v11i8.8030*
***Article Received**: 20 May 2023 **Revised**: 28 July 2023 **Accepted**: 16 August 2023*

This decreases overhead by reducing both the size of control packets and the frequency of broadcasts.

*Optimized Link State Routing Protocol (OLSR) :*

To route a packet, each node utilizes the most recent information available to it. The greedy approach is used to pick Multipoint Relay nodes. The OLSR protocol routes hop by hop. Through multipoint relay nodes, the source node connects with its two-hop neighbours.

*Wireless Routing Protocol (WRP) :*

It is a variant of the DSDV protocol. Four tables are kept in this system: distance, routing, link cost, and message retransmission.

*b) Reactive Routing Protocol*

The primary idea behind this method is that each node in the network only keeps active route destinations. Because data transmitting and receiving are not continuous, this technique overcomes excessive resource utilization. Communication overhead is also decreased and is mostly utilized.

*Ad-Hoc On Demand Vector Routing (AODV) :*

Each node creates and caches routes only when requested by the beginning node. Nodes retain a tree-like structure holding information on local connectivity, and if the cache is unable to supply the required data, the source flags an RREQ route request broadcast packet. The receiving node examines its cache for the availability of the destination node's information and sends a (RREP) route reply. Loops are not present in AODV. It can manage route modifications and construct new routes if there is an issue.

*Dynamic Source Routing (DSR) :*

In DSR, the source is aware of all possible pathways to the destination. The packet header contains these routes. A route discovery procedure is employed by flooding for a new node whose route is unknown. The route discovery algorithm operates by overwhelming the network with requests. If a node is the destination or has a path to the destination, it responds. There is no need for a particular technique to detect routing loops [33].

*An Optimized Ad-hoc On-demand Multipath Distance Vector (AOMDV) :*

In each course revelation, an optimized ad hoc on-demand multipath distance vector spreads out the unambiguous ad hoc on-demand distance vector to locate different connections in fragmented ways between the source and the target. It makes heavy use of the direction input that is readily available in the ad hoc on demand distance vector convention.

*c) Geographical Routing Protocols*

Geological steering makes use of data from a specific location to design and develop the looking route towards the goal. There is also a greater possibility for large multi-jump distant organisations' geography to alter as frequently as feasible. The growth of single-jump geography data as the optimal neighbour to pick exactly on sending is required for topographical steering. The restricted nature of its approach avoids the necessity for affecting requirement overloading [34-35], directing table maintenance, and central control.

*Geography Source Routing (GSR) :*

Dijkstra's distance-based algorithm is used to determine the shortest path from the source hub to the destination hub in GSR. It keeps track of how far away the material is from the moderated hubs that will distribute it [36]. The parcel is probed by the source hub, and then sent in bulk to the hubs, which is an inefficient use of network bandwidth. Geographical Awareness in Routing makes use of the GSR bundle-sending mechanism to overcome the GPSR recovery methodology difficulty. It determines the most constrained path by employing Dijkstra's computation. Every data packet that originates from a source will have a GSR appended to its header; this is a list of intermediate hubs. Each sending hub maps the status of its neighbours into diagram hubs and selects the next hub with the most constrained path to the target.

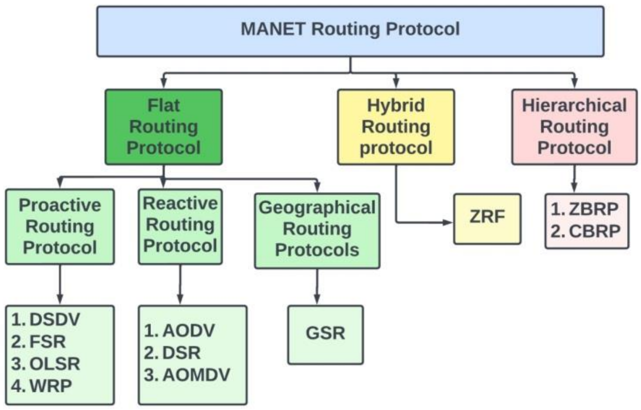


Figure 3. MANET Routing Protocols

*B. Hybrid Routing protocol*

The core concept is to mix proactive and reactive methods on the network. The network is partitioned into smaller subnetworks called clusters. Both the proactive and reactive protocols are used, however the former is used within clusters and the latter between them.

*a) Zone Routing Protocol (ZRP)*

Each zone has its own set of "inside" nodes (nodes that are aware of one another in the zone). Proactive measures are taken to complete the intra-zone routing. Neighbor discovery is the responsibility of the neighbor discovery protocol. A reactive method is used to locate the route to the outside zone. When looking for new routes, source nodes first do a series of checks within their own zone, then those of their neighbors, and finally those of nodes outside of their own. This method of route discovery has been successful.

*International Journal on Recent and Innovation Trends in Computing and Communication*
*ISSN: 2321-8169 Volume: 11 Issue: 8*
*DOI: https://doi.org/10.17762/ijritcc.v11i8.8030*
***Article Received**: 20 May 2023 **Revised**: 28 July 2023 **Accepted**: 16 August 2023*

*C. Hierarchical Routing protocol*

Direct control is the concept of dividing self-organizing network hosts into distinct coverage zones or incompatible groupings. When the network size of a MANET grows considerably, a hierarchical network is used. Organizations are structured as a cluster tree using the direct control protocol [37, 38], with separate tasks and hub components located at each level.

*a) Zone–Based Hierarchical Routing Protocol (ZBRP)*

The covering extensions are traversed by correspondences, with each hub having a local scope and various mechanisms for directing correspondences within and beyond the extension. As a result of this adaptability, general steering execution is improved. Furthermore, by maintaining steering data for all hubs in the organization, portable hubs in a comparable zone realize how to arrive at one another at a lower cost [39]. Explicit hubs are entrance hubs and full between-zone correspondences in various zone-based directing protocols. Along similar lines, the organization will have allotments or different zones.

*b) Cluster-Based Hierarchical Routing Protocol (CBRP)*

The CBRP protocol forms groups of moving hosts. The leader of a cluster has access to all of the members' IP addresses, and a cluster is only two hops across. Through a route request published to its neighbors, the source host identifies the cluster leader. The gateway nodes then forward the request to their neighboring cluster heads, and so on, until the request reaches the cluster head of the destination host and is unicast there [40]. The only information remembered by the route request is which cluster heads it has already traversed. The actual route is calculated during the route response phase. Each node along the way back tries to figure out the optimum hop-by-hop path to the next cluster head in the chain.

Table 1. Comparison of protocols

| Parameter | DSR | CBRP | DSDV | AODV | OLSR | TORA |
|---|---|---|---|---|---|---|
| PDR | H | VH | H | H | M | L |
| Throughput | H | H | H | L | VH | H |
| Delay | H | VH | VL | H | M | VH |
| Routing Overhead | L | VH | H | M | H | VH |
| L- Low; VL - Very Low; M-Moderate; H-High; VH-Very High | | | | | | |

## V. PERFORMANCE METRICS

*A. Packet Delivery Ratio (PDR)*

It is the fraction of packets delivered by a node (Ps) that reach its intended recipient (Pd). How many packets were received relative to how many were sent over the course of the simulation.

$$PDR = \frac{Total\ packets\ received\ by\ receiver}{Total\ packets\ sent\ by\ sender} X100$$

$$PDR = \frac{P_d}{P_s} X100$$

*B. Average residual energy (ARE) of node*

It is found by dividing the system's current energy, Et, by the number of nodes, N.

$$ARE = \frac{Total\ Energy}{No.\ of\ nodes}$$

$$ARE = \frac{E_t}{N}$$

*C. Network lifetime*

How long it takes for one of the first network nodes to run out of energy, or more precisely, for its energy level to drop below the threshold and the network to shut down.

*D. Normalized Routing Load*

It is the proportion of data packets received by all destination nodes to the total number of routing control packets supplied by all source nodes.

*E. Average Throughput (ATP)*

It is the proportion of transmitted data that successfully reaches its destination during a given time period. The number of bits sent per second is used to determine this value.

$$TP = \frac{Total\ number\ of\ delivered\ packets}{Total\ simulation\ time}$$

*F. Routing Overhead (RO)*

Routing overhead represents the total amount of packets routed in a simulation.

$$Normalized\ Routing\, Overhead = \frac{Total\ no.\ of\ routing\ packets}{Total\ no.\ of\ deliver\ packets}$$

*G. Delay*

The delay is the time it takes for a packet to get from its origin to its destination through a network of nodes.

$$Delay = \frac{time\ packet\ received\ - time\ packet\ sent}{total\ package\ received}$$

## VI. RESULTS

This section shows findings from a NS-3 simulation of a MANET using routing protocols. Table 2 displays the values used in the simulations.

*International Journal on Recent and Innovation Trends in Computing and Communication*
***ISSN: 2321-8169 Volume: 11 Issue: 8***
***DOI: https://doi.org/10.17762/ijritcc.v11i8.8030***
***Article Received**: 20 May 2023 **Revised**: 28 July 2023 **Accepted**: 16 August 2023*

Table 2. Simulation Parameters

| Parameters | Value |
|---|---|
| No. of nodes | 60 |
| Environment size | 800 × 800 |
| Simulation time | 150 seconds |
| Agent type | TCP |
| Application type | FTP |
| Packet size | 1024 bytes |
| Packet transfer rate | 4 packets/second |
| Mobility model | Random-way point |
| No. of TCP sources | 16 |
| Maximum speed | 90 m/s |
| Pause time | 0, 30, 60, 90, 120, 150 |
| Protocols | AODV, DSR, DSDV, GSR, AOMDV |
| Simulator | NS-3 |

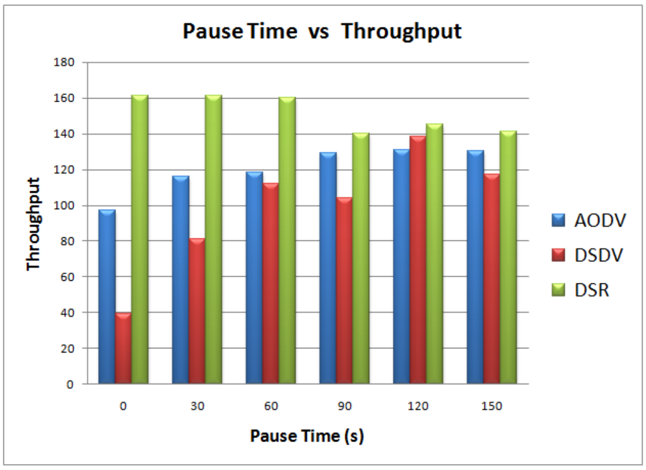


Figure 4. Pause Time vs Throughput

There will always be 60 nodes, regardless of the scenario, but the pause time of mobile nodes will range from 0 to 150 seconds. Figure 4 illustrates a comparison of pause time with throughput. In terms of throughput, the protocol DSR significantly outperforms compared to AODV and DSDV. At pause time of 0, the performance of DSDV is very low. As the pause time increases the performance of DSDV increases. The relation between pause time and PDR is represented in figure 5 with various protocols. Figure 5 demonstrates that the DSR is superior to the DSDV and the AODV. Figure 6 contrasts the average delay and pause time of different methods. Figure 7 displays the comparison between pause time and average energy. In comparison to AODV and DSDV, we demonstrated that the DSR protocol outperforms in terms of throughput, PDR, energy and delay.


Figure 5. Pause Time vs PDR

Figures 8 through 11 display a comparison of times for throughput, packet delivery ratio, energy, and delay. The number of nodes and the pause duration were held constant, while the node speed was varied from 10 to 90 m/s by a margin of 20 m/s. As the speed increases the throughput is increases of the DSR protocol. When comparing the speed with throughput, PDR, energy and delay, the DSR gives better values as compared to AODV and DSDV.

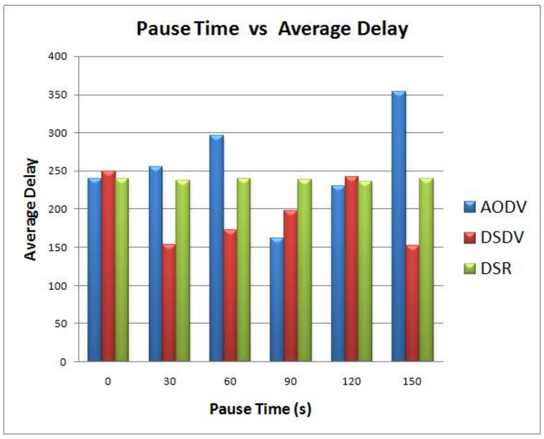


Figure 6. Pause Time vs Delay

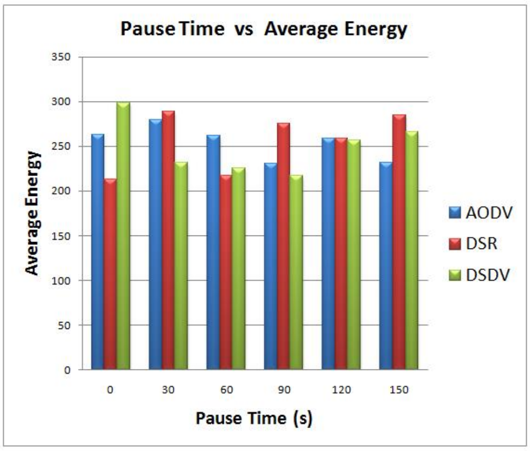


Figure 7. Pause Time vs Energy

*International Journal on Recent and Innovation Trends in Computing and Communication*
***ISSN: 2321-8169 Volume: 11 Issue: 8***
***DOI: https://doi.org/10.17762/ijritcc.v11i8.8030***
***Article Received**: 20 May 2023 **Revised**: 28 July 2023 **Accepted**: 16 August 2023*

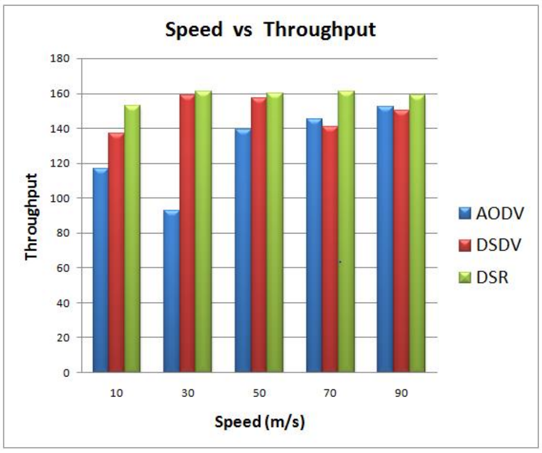


Figure 8. Speed vs Throughput

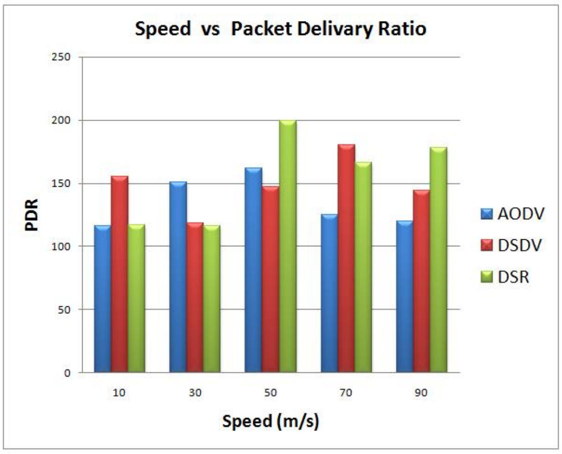


Figure 9. Speed vs PDR

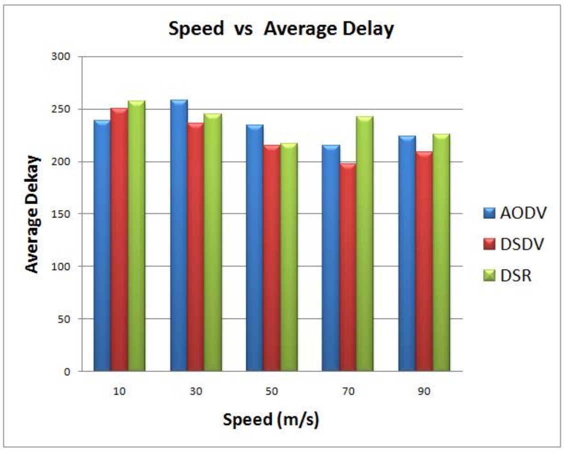


Figure 10. Speed vs Average Delay

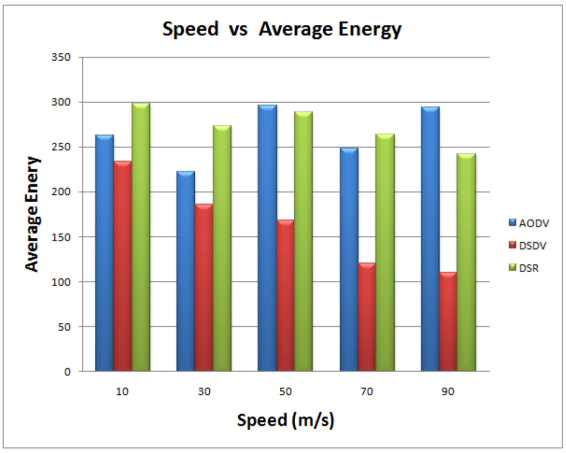


Figure 11. Speed vs Average Energy

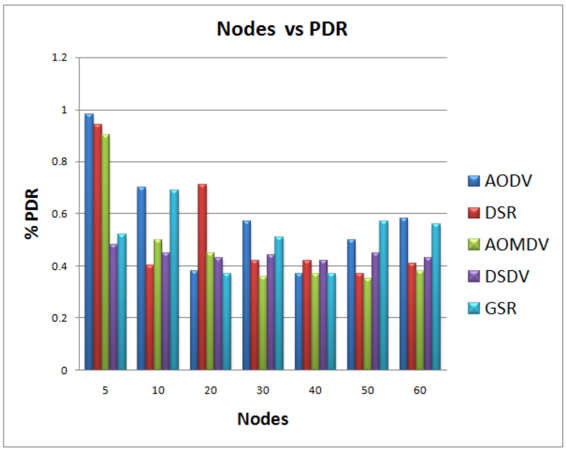


Figure 12. Nodes vs PDR

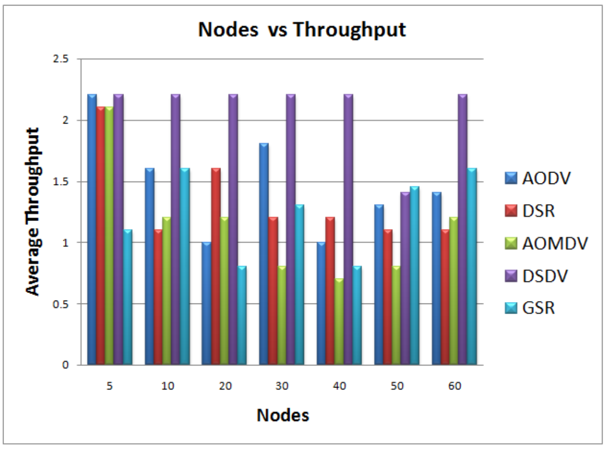


Figure 13. Nodes vs Throughput

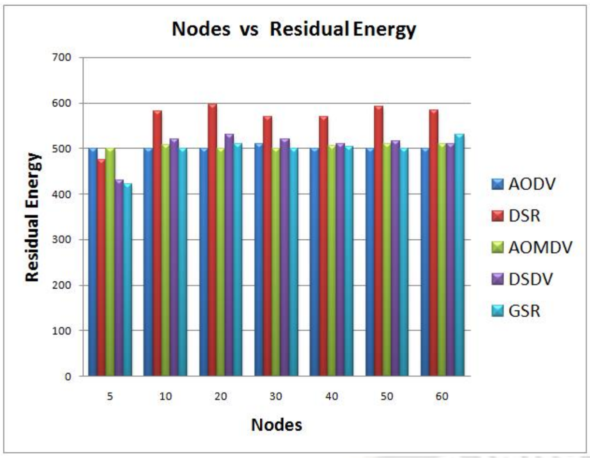


Figure 14. Nodes vs Energy

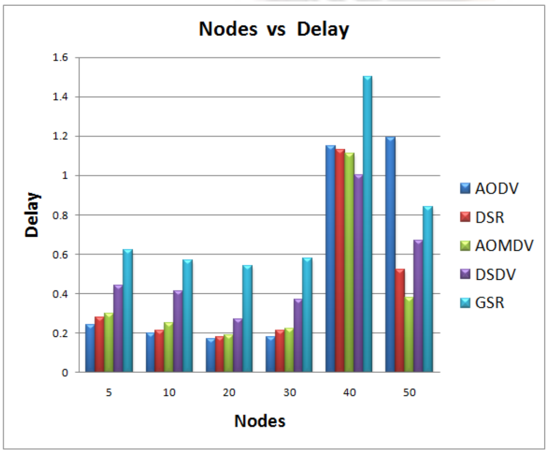


Figure 15. Nodes vs Delay

The comparison of nodes with respect to throughput, PDR, energy and delay are shown in figure 12, figure 13, figure 14 and figure 15, respectively. In this condition, the nodes are considered from 0 to 60 with a fixed pause time and speed. Compared different MANET protocols with various QoS parameters.

## VII. CONCLUSION

The QoS metrics throughput, packet delivery ratio, energy, and average delay were used in an experimental investigation of the mobility and energy models of the MANET routing protocols AODV, GSR, DSDV, AOMDV, and DSR. The DSR protocol outperforms compared to all other protocols. Dynamic DSR give better outcomes for low loads and low portability. The DSR convention reduces energy consumption. In this study, we analyze the performance of different MANET routing protocols using a variety of different measures. Our future research and development efforts will center on enhancing MANETs with more efficient routing protocols.

## REFERENCES

[1] Vaigandla, K. K. ., & Benita, J. (2023). A Novel PAPR Reduction in Filter Bank Multi-Carrier (FBMC) with Offset Quadrature Amplitude Modulation (OQAM) Based VLC Systems. International Journal on Recent and Innovation Trends in Computing and Communication, 11(5), 288–299. https://doi.org/10.17762/ijritcc.v11i5.6616

[2] Karthik Kumar Vaigandla and J.Benita (2022), Novel Algorithm for Nonlinear Distortion Reduction Based on Clipping and Compressive Sensing in OFDM/OQAM System. IJEER 10(3), 620-626. https://doi.org/10.37391/IJEER.100334.

[3] Vu Khanh Quy, Nguyen Tien Ban, and Nguyen Dinh Han, "An Advanced Energy Efficient and High Performance Routing Protocol for MANET in 5G," Journal of Communications Vol. 13, No. 12, December 2018, pp. 743-749, doi:10.12720/jcm.13.12.743-749

[4] Mohamed Elboukhari, Mostafa Azizi and Abdelmalek Azizi, "PERFORMANCE COMPARISON OF ROUTING PROTOCOLS IN MOBILE AD HOC NETWORKS, "International Journal of UbiComp (IJU), Vol.6, No.2, April 2015, DOI:10.5121/iju.2015.6201

[5] Salma S. Mohamed, Abdel-Fatah I. Abdel-Fatah, Mohamed A. Mohamed, " Performance evaluation of MANET routing protocols based on QoS and energy parameters, " International Journal of Electrical and Computer Engineering, Vol. 10, No. 4, August2020, pp. 3635-3642, DOI: 10.11591/ijece.v10i4.

[6] Anuj K. Gupta, Harsh Sadawarti, Anil K. Verma,"Performance Analysis of MANET Routing Protocols in Different Mobility Models", International Journal of Information Technology and Computer Science(IJITCS), vol.5, no.6, pp.73-82, 2013. DOI: 10.5815/ijitcs.2013.06.10

[7] Priyambodo, T.K.; Wijayanto, D.; Gitakarma, M.S. Performance Optimization of MANET Networks through Routing Protocol Analysis. Computers 2021, 10, 2. https://doi.org/10.3390/computers10010002.

[8] Radha Krishna Karne and Dr. T. K. Sreeja (2022), A Novel Approach for Dynamic Stable Clustering in VANET Using Deep Learning (LSTM) Model. IJEER 10(4), 1092-1098. DOI: 10.37391/IJEER.100454.

[9] Mehmood Z, Iqbal M, Wang X. Comprehensive experimental performance analysis of DSR, AODV and DSDV routing protocol for different metrics values with predefined constraints. International Journal of Information Technology and Computer Science. 2014; 6(7):24–31.

[10] Kaur D, Kumar N. Comparative analysis of AODV, OLSR, TORA, DSR and DSDV. International Journal Computer Network and Information Security. 2013; 5(3):39–46.

[11] Mittal P, Singh P, Rani S. Performance analysis of AODV, OLSR, GRP and DSR routing protocols with database load in MANET. International Journal of Research in Engineering and Technology. 2013; 2(9):412–20.

[12] Sharma LD, Roberts N. Effects of velocity on performance of DYMO, AODV and DSR routing protocols in mobile Ad-hoc networks. Procedia Technology. 2012; 4:727–31.

[13] Ashtiani H, Moradi H, Pour P, Nikpour M. A Survey of MANET Routing Protocols in Large-Scale and Ordinary

Networks. Global Journal of Computer Science and Technology. 2010; 10(13):39–46.
[14] Jayakumar G, Gopinath G. Ad Hoc Mobile Wireless Networks Routing Protocols – A Review. Journal of Computer Sciences. 2007; 3(8):574–82.
[15] ShenZhuochuan CC, Jaikaeo HC. Directional broadcast for mobile ad hoc networks with percolation theory. IEEE Transactions on Mobile Computing. 2006; 5(4):317–32.
[16] C.E. Perkins, E.M. Royer, and S.R. Das, "Ad Hoc On Demand Distance Vector (AODV) Routing," IETF Draft, 2000.
[17] F. Mohammed, C. Badr, and E. Abdellah "Comparative Study of Routing Protocols in MANET,"International Conference on Next Generation Networks and Services, pp. 149-153. 2014.
[18] K. Natarajan,and G. Mahadevan. "Mobility based Performance Analysis of MANET Routing Protocols," International Journal of Computer Applications, vol.163, no.10, pp. 37-43, 2017.
[19] Gupta, S.K.; Saket, R.K. Observation of AODV routing protocol's performance at variation in ART value for various node's mobility. In Proceedings of the First International Conference on Information and Communication Technology for Intelligent Systems: Volume 1, Ahmedabad, India, 28–29 November 2015;
[20] Gupta, S.K.; Alsamhi, S.H.; Saket, R.K. Comparative performance analysis of AODV for CBR & VBR traffic under influence of ART & DPC. In Proceedings of the 2016 11th International Conference on Industrial and Information Systems (ICIIS), Roorkee, India, 3–4 December 2016; pp. 112–117.
[21] Gupta, S.K.; Sharma, R.; Saket, R.K. Effect of variation in active route timeout and delete period constant on the performance of AODV protocol. IJMC 2014, 12, 177. [CrossRef]
[22] Azzuhri, S.R.; Mhd Noor, M.B.; Jamaludin, J.; Ahmedy, I.; Md Noor, R. Towards a better approach for link breaks detection and route repairs strategy in AODV protocol. Wirel. Commun. Mob. Comput. 2018, 2018, 1–9. [CrossRef]
[23] Gupta, S.K.; Alsamhi, S.H.; Saket, R.K. Optimal relation between ART and mobility & transmission range at default QualNet& calculated transmission powers. In Proceedings of the 6th International Conference on Advances in Engineering Sciences and Applied Mathematics (ICAESAM-2016), Kuala Lumpur, Malaysia, 21–22 December 2016.
[24] J. Broch, D. Maltz, D. Johnson, Y. Hu, and J. Jetcheva. ―Multi-Hop Wireless Ad Hoc Network Routing Protocols.‖ ACM/IEEE International Conference on Mobile Computing and Networking (MOBICOM'98), pages 85-97, 1998
[25] S. Lee, M. Gerla, and C. Chiang. ―On-Demand Multicast Routing Protocol.‖ IEEE Wireless Communications and Networking Conference (WCNC'99), 1999.
[26] D. Johnson and D. Maltz. Dynamic source routing in ad hoc wireless networks. In T. Imelinsky and H. Korth editors, Mobile Computing, pages 153–181. Kluwer Academic Publishers, 1996.
[27] E. Royer, P. Melliar-Smith, and L. Moser. ―An Analysis of the Optimum Node Density for Ad hoc Mobile Networks.‖ 2000.
[28] M. Sanchez and P. Manzoni. A java based ad hoc networks simulator.
[29] Z. Haas and B. Liang. ―Predictive Distance-Based Mobility Management for PCS Networks.‖ IEEE Conference on Computer Communication (INFOCOM' 99), March 1999.
[30] Z. Haas. A new routing protocol for reconfigurable wireless networks. In Proceedings of the IEEE International Conference on Universal Personal Communications (ICUPC), pages 562–565, Oct. 1997.
[31] Tracy Camp, Jeff Boleng and Vanessa Davies, ― A survey of Mobility Models for Ad hoc Network Research‖, Wireless Communications and Mobile computing: A special issue on Ad hoc network Research, vol 2, No5, pp. 483-502, 2002
[32] Tracy Camp, Jeff Boleng and V Davies, ―A survey of Mobility Models for Ad Hoc Network Research‖, http://toilers.mines.edu last accessed on February 15, 2007.
[33] Karne, RadhaKrishna, et al. "Simulation of ACO for Shortest Path Finding Using NS2." (2021): 12866-12873.
[34] Das, S.R., Perkins, C.E.,and Royer, E.E, "Performance Comparison of Two on Demand Routing Protocols for Ad Hoc Networks," Proc. lNFOCOM, 2000, pp. 3-12.
[35] P. Kumar, A. Chaturvedi, M. Kulkarni, "Geographical location based hierarchical routing strategy for wireless sensor networks", Proceedings of the International Conference on Devices, Circuits and Systems, 2012, pp. 9-14.
[36] P. Karkazis, H. C. Leligou, T. Orphanoudakis, T. Zahariadis, "Geographical routing in wireless sensor networks", Proceedings of the International Conference on Ad-Hoc Networks and Wireless, September 2014, pp. 19-24
[37] L. Liu, Z. Wang, W. K. Jehng, "A geographic source routing protocol for traffic sensing in an urban environment", Proceedings of the IEEE International Conference on Automation Science and Engineering, 2008, pp. 347-352.
[38] Sabah M. Ahmed Nabil Sabor, Shigenobu Sasaki, Mohammed Abo-Zahhad, "A Comprehensive Survey on Hierarchical-Based Routing Protocols for Mobile Wireless Sensor Networks: Review, Taxonomy, and Future Directions", Wireless Communications and Mobile Computing, 2017, pp. 1-23.
[39] S. Barakovi, S. Kasapovi, J. Barakovi, "Comparison of MANET Routing Protocols in Different Traffic and Mobility Models", Telfor Journal, Vol. 2, No. 1, 2010, pp. 8-12.
[40] Karne, R. K. ., & Sreeja, T. K. . (2023). PMLC- Predictions of Mobility and Transmission in a Lane-Based Cluster VANET Validated on Machine Learning. International Journal on Recent and Innovation Trends in Computing and Communication, 11(5s), 477–483. https://doi.org/10.17762/ijritcc.v11i5s.7109
[41] Sivapriya, N., Ravi, T.N.A framework for fuzzy-based fault tolerant routing mechanism with capacity delay tradeoff in MANET.International Journal of Advanced Science and Technology, 2019, 28(17), pp. 420–429