Improved Routing Protocols: A First Step Towards Quality of Service in Mobile Ad-hoc Networks

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Abstract: **The recent developments in wireless technology have piqued academics' curiosity. Mobile Adhoc Networks (MANET) is a fast-growing networking architecture used in emergency, disaster, and tactical operations applications. It covers a wide range of applications with some degradation due to its flexible and expandable nature. Because routing is the primary function of wireless networks, routing protocol design is critical in Adhoc networks. Various methods have been used to improve the performance of current routing protocols in different categories. Technical advances in routing protocols have recently been achieved, combined with optimization approaches to improve the overall performance of MANETs routing protocols. This research initially looked at several sorts of routing protocols before going through their variations for energy economy and latency reduction. The previous protocols, which were created utilizing optimization methods, will then illustrate the current requirement. Finally, the review analysis delves into many aspects such as commonly used protocols, optimization techniques, QoS parameters, performance metrics, and future paths.**

Keywords**: MANETs, Energy, Delay, Optimized Protocols, QoS**.

I. INTRODUCTION

Mobile Ad-Hoc Networks (MANET) are non- centralized wireless networks with mobile phone nodes. The node is self-configuring and managed. It also has routing capabilities, which allow it to send messages or information. When on a mission, it is utilized by the troops to avoid mines and communicate with the other camps. These networks may be found worldwide, and the nodes are all linked together. The network establishes communication whether the nodes are in close range or not[1]. The nodes link to create huge series and use a routing mechanism to send packets from one node to the next. A path is always required to transport these packets from source to destination, and various routing strategies assist in making these transmissions feasible [2]. The ad- hoc network has a specific broadcast range, and stations within that range are referred to as one-hop neighbors. When stations desire to communicate with more than one hop distance station, they use intermediate stations (or relaying stations), referred to as multi-hop ad hoc networks[3]. Nodes in the network use a random way to send data and information to other nodes known as multi- hop ad-hoc forwarding. Routing techniques assist the node in routing data throughout the network; thus, these nodes are more than simply hosts; they are also routers[4].

The functioning of nodes in an ad hoc network is limited by battery power [5]. A sufficient number of intermediary nodes are required to route a packet from a source to a destination. As a result, a node's battery power is a valuable resource that must be managed wisely to avoid a node or network's premature termination. As a result, energy awareness is a critical problem in such networks, as it extends both the node's and the network's lifespan. In ad-hoc networks, the problem of a node failure, which leads to network splitting, is a major issue[6]. A single node failure in sensor networks, on the other hand, is typically insignificant if it does not result in a loss of sensing and communication coverage, as mentioned above. The loss of connectivity to any node is crucial in ad-hoc networks geared for personal conversations. Mechanisms that guarantee limited latency and delay jitter are required for real-time applications[7]. The queuing delay at the source and intermediate nodes, the processing time at the intermediate nodes, the transmission delay, and the propagation duration over multiple hops from the source node to the destination node, for example, are the most significant delays that affect the end-to-end delay in packet delivery from one node to another node. In ad-hoc networks, quality of service refers to the network's available resources and their mobility speed. It is because node mobility in ad-hoc networks can result in connection failures and broken pathways. As a result, establishing a new channel to continue communicating is necessary[8].

Communication (transmission and receiving) is one of the most energy-intensive processes [9]. Other steps must be done to meet the objective of obtaining more performance out of the already available battery resources, given the sluggish rate of battery performance development and the lack of breakthroughs in this sector[10]. This research aims to analyze energy and delay awareness in communications between Adhoc network nodes. The problem of energy and delay restrictions and the optimal procedures have been addressed in this work. The following section of this article goes through the various delay and energy-aware methods currently in use. Existing optimized protocols are also studied, and the difficulties and challenges of the Adhoc network are explored based on the existing research.

II. DELAY AND ENERGY-AWARE ROUTING

Routing protocols in MANETs are divided into three types based on how mobile nodes obtain and store routing information. The proactive routing methods fall under the first group. In these routing protocols, mobile nodes construct routes to all accessible nodes a priori and use a periodic update mechanism to keep routing information consistent and up-to-date. Destination-sequenced distance- vector routing (DSDV) and optimal link-state routing protocol are examples of proactive routing protocols (OLSR). Reactive (on-demand) routing protocols are the second type of routing protocol. When a node in these protocols wishes to interact with another node, it uses an on-demand route discovery method to establish connections. Dynamic source routing (DSR) and AODV are two reactive routing systems. The third category includes hybrid routing protocols, which integrate bestpractices proactive and reactive routing methods. Hybrid, The example of this is the zone routing protocol (ZRP)[11]. The following table 1 describes some basic protocols and variants specially generated to achieve energy efficiency and minimize the delay

Table 1. Delay and Energy-Aware Routing Protocols

Protocol	RC	Protocol Variants Available	RS	RR	Routing Metrics	Delay	Energy
AODV[12]	R	Yes	FRR	RT	Hop-Count	MD-AODV [13]	LBAODV [12]
DSR[13]	R	Yes	FRR	RC	Hop-Count	MET-MFOD SR[10]	MET-MFOD SR[10]
TORA[14]	R	Yes	FRR	RT	Hop-Count	PDTORA [14]	PDTORA [14]
DSDV[15]	P	Yes	FRR	RT	Hop-Count	EDSDV [16]	EA-DSDV [17]
OLSR [16]	P	Yes	FRR	RT	Hop-Count	-	EE-OLSR [19]
ZRP[17]	H	Yes	FRR	IIRT	Throughput, end-end delay, packet loss percentage	MRC [21]	EA-ZRP [22]
LAR[18]	LA	Yes	DF	-	Hop-Count	QDAR [24]	GPSR-S [25]

*RC-Routing Category, R-Reactive, P-Proactive, H-Hybrid, LA-Location Aware, RS- Routing Structure, FRR-Flat Routing Repository, DF-Directional Flooding, RR- Route Repository, RT-Route Table, RC-Route Cache, IIRT-Intrazone and Interzone RT

The details of energy and delay aware protocols are given below to understand the nature and behavior of these protocols

Load *Balancing Adhoc on Demand Vector Routing Protocol (LBAODV):* EffatParvar et al. [19] introduced the LBAODV protocol, which is an on-demand routing protocol with three phases: (a) Path Discovery Process, (b) Data Transmission, and (c) Route Maintenance. The route records are maintained in this protocol to address RREQ Packet duplication, which helps decrease overhead and energy usage.

MAC *Delay AODV (MDAODV)*: Fan [20] suggested the AODV changes by replacing the hop count measure with the MAC delay metric. The suggested metric is calculated as C=αf+η, where □ and □ specify the data rate and modulation, and f specifies the frame size. The protocol adds the route cost field to the RREQ and RREP packets. Scheme performs well on multi-rate ad hoc networks.

Minimum *execution time scheduling and Moth flame optimization DSR (MET-MFODSR*): Almazok and Bilgehan [13] presented a unique and efficient routing method based on a hybrid approach combining MET scheduling and the moth flame optimization (MFO) technique. The (MET-MFODSR) method is a hybridized version of DSR that seeks to enhance the routing mechanism by generating an optimum route with minimal energy consumption, increasing network lifespan, and reducing route failure concerns. The proposed MET- MFODSR protocol was developed on the MATLAB platform and tested in various simulated settings. The simulation results show that the proposed routing method is applicable and feasible. It outperforms the current Bee DSR (BEEDSR) and Bee-inspired protocol (BeeIP) algorithms in terms of performance.

Power *and Delay aware Temporally Ordered Routing Algorithm (PDTORA)*: Based on the Temporally Ordered Routing Algorithm (TORA) Protocol, Jagadev et al. [21] proposed a protocol called Power and Delay aware Temporally Ordered Routing Algorithm (PDTORA). In this protocol, power and delay requirements verification is carried out with a query packet at each node along the path between source and destination. Simulations show that the proposed new protocol outperforms TORA in terms of network lifespan, end-to-end latency, and packet delivery ratio.

Efficient *DSDV (EDSDV):* The basic destination sequenced distance vector routing protocol (DSDV) for ad-hoc networks with improvement was proposed by Naseem and Kumar [22]. In terms of routing protocol latency, it was an improvement. In addition, the suggested method decreases network congestion. It necessitates a small modification to the idea of weighted settling time for packets arriving on nodes with the same sequence number. Simulation has demonstrated that for packets with the same sequence number, the delay without weighted settling time is shorter than that for the same packets.

Energy-*Aware DSDV (EA-DSDV):* Kumar et al. [23] presented an energy-efficient routing protocol that reduces node power consumption by routing data via the least-power-consuming pathways. To develop an energy- efficient routing system, they employed an effective caching approach for storing information. They demonstrated that it performs better in energy savings than the FSR procedure.

Energy *Efficient OLSR (EE-OLSR):* Rango et al. [24] presented a change to the OLSR protocol's MPR selection
mechanism based on the Willingness notion to extend network lifetime without sacrificing performance. A comparison of an Energy-Efficient OLSR (EE-OLSR) and a traditional OLSR protocol is made, with various well-known energy-conscious measures including MTPR, CMMBCR, and MDR being tested. They discovered that EE-OLSR beats traditional OLSR, and MDR is the most effective measure for conserving battery power in a crowded mobile network with high traffic loads. Furthermore, they demonstrate that excluding energy expenditure due to overheating can increase the lifetime of nodes without impacting OLSR functionality.

Delay Aware Hybrid Routing (MRC): Devulapalli et al. [25] presented a hybrid cluster-based D2D cooperative routing system by integrating geographic and clustering routing. The primary goal of this method is to create communication between comparable mobility devices to decrease the mobility impact since the link between devices traveling at the same speed is dependable. The equal mobility devices were joined together to form a cluster, with one of the devices chosen as the cluster head. The Cluster Head (CH) was chosen to increase network performance based on geographic routing and threshold- based cooperative communication. They compared the suggested method against existing routing approaches in the literature to see how effective it is. According to the results, the suggested routing method improves End-to-End transmission latency by 39%, energy usage by 35%, and Bit Error Rate performance.

Energy-Aware Zone Routing Protocol (EA-ZRP): Emil et al. [26] suggested a hybrid method that combines zone and cluster-based routing to address the shortcomings of reactive and proactive techniques. The ZRP is a continuous zone routing protocol that splits the network into zones. In addition to some supporting computational protocols, the suggested protocol employs a one-hop clustering method that divides the network into zones governed by dependable leaders who are mainly static and have sufficient battery resources. The ZRP's on-demand parallel broadcasting has been shown to speed up the routing process in a MANET by reducing duplicate rebroadcasts. ZRP extends the network's life and improves throughput and end-to-end latency communication efficiency. In conclusion, the modeling results demonstrate that the ZRP achieves its design objectives and significantly increases energy efficiency.

Q-learning-based delay-aware routing (QDAR): To increase the lifespan of underwater sensor networks, Jin et al. [27] presented a Q-learning-based delay-aware routing (QDAR) method. A data collecting step in QDAR was created to adapt to the changing environment. QDAR can identify a global optimum next hop rather than a greedy one by using the Q-learning approach. An action-utility function is defined in this, in which residual energy and propagation delay are taken into account while making routing decisions. As a result of consistently dispersing residual energy and providing decreased end-to-end latency, the QDAR algorithm can increase the network lifetime. When compared to a traditional lifespan-extended routing protocol, simulation results demonstrate that our approach can achieve roughly the same network lifetime while reducing end-to-end delay by 20–25%.

Location-Based Routing Protocol for Energy Efficiency (GPRS-S): Cho and Baek [28] proposed the GPSR-S protocol, a location-based routing system for energy efficiency in wireless sensor networks. GPSR-S is a wireless ad hoc network routing system based on GPSR, one of the most well-known location-based routing technologies. They increase GPSR's energy efficiency by considering node energy levels and position data. They also changed the algorithm's address-centric character to one that is data-centric. ACCORDING TO SIMULATION FINDINGS, the GPSR-S performs well in terms of energy economy and packet count. The GPSR-S network transmits around 10% fewer packets than the GPSR network, but it has a 10% longer lifespan.

III. OPTIMIZED ROUTING PROTOCOLS

Routing protocols use optimization techniques to provide an optimum route that meets the stated objectives. Optimization is currently widely used to improve the performance of routing protocols based on certain features. This section describes several current optimized protocols in mobile Adhoc networks and suggested improvements.
Jamali et al. [29] presented the Binary Particle Swarm Optimization algorithm-based TORA protocol to include the energy awareness feature. In its route selection procedure, the suggested protocol took route length into account and the energy intensity of the routes. It turned the routing problem into an optimization problem and used BPSO to find a route that maximized a weighted function of the route length and energy level. Extensive simulations in the ns-2 simulator environment indicate that the proposed routing protocol, dubbed BPSO-TORA, significantly increases network lifespan and beats TORA in the network, system, and total delivered data.

Banerjee et al. [30] presented a new on-demand power-balanced routing algorithm for mobile, multi-hop ad-hoc networks. The protocol is based on swarm intelligence, especially the ant colony-based metaheuristic. These approaches try to map the solution capability of swarms to mathematical and engineering problems. The proposed routing protocol is highly adaptive, efficient, and scalable. The main goal in the protocol design is to reduce the overhead for routing. The simulation results show that the proposed routing protocol differs significantly from existing protocols.

Prasath and Sreemathy [31] presented an enhanced DSR routing protocol that uses the firefly algorithm to transport packets from the source to the destination node in a well-organized manner. The best path was discovered based on link quality, node mobility, and end-to-end delay. The performance of the proposed algorithm is then compared with traditional algorithms.

Wei et al. [32] developed an Evolutionary-algorithm- based routing protocol for Flying Adhoc Networks route search based on an enhanced genetic algorithm, which considers connection stability, link bandwidth, node energy, and other variables. GAR enhances the genetic algorithm's selection, crossover, and variation operators, allowing it to build an optimal path from the communication starting node to the destination node rapidly and at a lower cost. The experiments demonstrate that GAR can significantly enhance throughput, minimize latency, and improve network stability, making it more suited for FANETs.

Choudhary and Sharma [33] presented a novel MANET routing system that is power-aware. The suggested approach employs a Genetic Algorithm to discover a path in MANETs that consumes the least power while routing data. The method was implemented in JAVA programming on a sample network, and power consumption in data routing was decreased.

The AODV-BBO routing technique suggested by Jayaramu and Banga [34] considered three separate goal functions in the routing strategy: residual energy, distance, and the number of hops. Furthermore, rerouting was done in the event of a network node or connection failure. The packet drop over the MPLS-based MANET was overcome using this rerouting. The percentage of living nodes, dead nodes, energy consumption, end-to-end latency, and bandwidth of the AODV-BBO technique were evaluated. The performance of the AODV-BBO approach was compared to P2R2 and PS-ROGR, two current methodologies. The energy consumption of the AODV- BBO approach with 400 nodes was 536.52 J, which islower than the PS-ROGR method.

Garaaghaji and Alfi [35] used a fuzzy logic (FL) method, specifically the fuzzy hierarchical algorithm, to create an optimal allocation strategy in wireless networks. FL was chosen because of its ease of calculation and ability to enhance performance by decreasing the amount of data transferred. The results proved the suggested algorithm's viability.

Xiao et al. [36] presented a clone adaptive whale optimization algorithm (CAWOA) and a novel clone operator for decreasing the routing energy consumption of IWSNs with QoS restrictions. CAWOA also pioneered a discrete binary-based routing coding technique, which offers significant support for optimum routing systems. In addition, a unique IWSN routing model with QoS restrictions has been developed, which considers bandwidth, latency, delay jitter, and packet loss rate in detail. The proposed approach is then compared to existing heuristic-based routing techniques, such as the whale optimization algorithm (WOA), simulated annealing (SA), particle swarm optimization (PSO), and genetic algorithm, in a series of simulations (GA). In terms of routing energy consumption, convergence speed, and optimization ability, simulation findings show that the CAWOA-based routing algorithm beats existing approaches. When compared to GA, SA, PSO, and WOA, the energy consumption of CAWOA-based routing is reduced by 12%, 17%, 19%, and 7%, respectively, when the number of nodes is 120, the maximum delay is 120 ms, the maximum delay jitter is 25 ms, the maximum bandwidth is 9 Mbps, and the packetloss rate is 0.02.

Kumar et al. [37] presented a DYMO-Based ACO for MANETs Using Node Density and Distance. The ACO highlights were incorporated into the DYMO methodology. The DYMO control packages were replaced with ANT parcels, and the new protocol suggested was dubbed M- DYMO. The separation factor and density factor were also studied to simplify the impact of floods. The ANT packets were sent out to meet the distance requirement and density criteria in both states. Different parameters are used to compare the new protocol's execution to AODV, TORA, and DYMO. The results show that the suggested protocol outperforms three existing protocols when the network size is large.

Abdali et al. [38] proposed the Optimized PSO (OPSO) using a uniform mutation operation instead of a non-uniform mutation process. All-important performance parameters, including packet delivery ratio, energy consumption, overhead, and end-to-end latency, are improved by integrating the OPSO into the LAR protocol.

Persis and Robert [39] introduced the firefly method for addressing the multi-objective shortest route problem in small-scale networks for various network topologies. In Matlab, simulation tests were carried out by changing the number of nodes, edges, and connection topologies for each target at random. To compare the Pareto-optimal set generated by the firefly method to the non-dominated set of pathways acquired from the classical exhaustive search algorithm described in this work, non-dominated paths were obtained using the classical exhaustive search technique presented in this work-study.

The Cuckoo optimization method (COA), Tabatabaei, and Nahook [40] presented a novel MANET routing strategy. COA is based on the lifestyle of the cuckoo family of birds. There are two sorts of cuckoo populations in various civilizations: mature cuckoos and eggs. The creation of this optimization method is based on the lifestyle, egg-laying characteristics, and breeding of these birds. An initial population kicks off COA. This algorithm seeks out more reliable routing links. The suggested work's strong performance in throughput, latency, hop count, and simulation results demonstrate discovery time.

Babu and Ussenaiah [41] presented the multicast routing protocol, named cuckoo search and M-tree-based multicast ad hoc on-demand distance vector (CS-MAODV) protocol for MANET. The proposed routing protocol includes a two-step process: M-tree construction and optimal multicast route selection. Here, the divisional- based cluster (DIVC) technique was used for building the M-tree using three constraints: destination flag, path- inclusion factor, and multifactor. Then, the cuckoo search algorithm selected the optimal route by considering the multiple objectives, such as energy, link lifetime, distance, and delay. The performance of the proposed multicast routing protocol was analyzed, and the comparative analysis was performed with the existing routing protocols, such as MAODV, QoS-based multicast routing protocol using reliable neighbor nodes selection (QMRPRNS), efficient fuzzy based multiconstraint protocol (EFMMRP), and energy-efficient lifetime aware multicast route selection (EELAM). From the simulation results, it was clear that the proposed CS-MAODV protocol attains the maximum energy of 90.3513%, LLT of 158.7708 s, the throughput of 86.2226%, and PDR of 87.1606, respectively. Also, the proposed protocol has a minimum control overhead of 2.1415% and PDD of 0.0563 s.

Table 2 below lists some of the currently available efficient routing protocols. The researcher's procedure is also described in the table, which has been improved using the optimization algorithm. Along with the performance criteria, the major emphasis of the optimization strategy is also indicated.

Table 2. Optimized Routing Protocols

Author	**Base Protocol**	**Optimization Algorithm**	**Main Focus**	**Performance**
Jamali et al.[29]	TORA	PSO	Route Length and Energy	Packet delivery and network lifetime improved
Banerjee et al.[30]	-	ACO	Power Balancing	PDR and delay improved
Prasath and Sreemathy[31]	DSR	Firefly	Link Quality and Delay	Throughput improved
Wei et al. [32]	AODV	Enhanced GA	Connection stability, link bandwidth, and node energy	Reduces Overhead, Delay and improve throughput
Choudhary and Sharma [33]	Table Driven	GA	Remaining Battery Power	33% lesser number of activenodes
Jayaramu and Banga [34]	AODV	BBO	residual energy, distance, and number of hops	Reduces delay and number ofdead nodes
Garaaghaji and Alfi [35]	AODV	Fuzzy	Energy, Bandwidth, and Network Traffic	convergence rate improved
Xiao et al. [36]	-	CAWOA	Energy and QoS	Reduced Energy Consumption and packet loss
Kumar et al. [37]	DYMO	ACO	Separation and Density factor	Improved PDR and Delay
Abdali et al. [38]	LAR	OPSO	Energy	Energy consumption reduced
Persis and Robert [39]	-	Firefly	delay, hop-distance, load, cost, and reliability	Improved delay andreliability
Tabatabaei and Nahook [40]	AODV	COA	Energy and Bandwidth	Improved performance based on various parameters
Babu and Ussenaiah [41]	MAODV	COA	energy, link lifetime, distance, and delay	Improved Throughput andPDR

IV. REVIEW ANALYSIS

This research looks at numerous protocols to reduce latency and energy usage and other optimization protocols to expound on other QoS aspects. To predict the future demand for MANETs, this study examines many aspects such as the frequently used protocol, the usage of various optimization algorithms, various criteria considered to achieve QoS, and ultimately the commonly used performance measures.

Frequently used Protocols: According to the findings of this study, the AODV protocol is the protocol that researchers favor the most, as seen in Figure 1, and several optimizations have been applied to improve this protocol. Almost all optimizations, including GA, ACO, BBO, Fuzzy, and others, were coupled with the AODV protocol for various purposes.

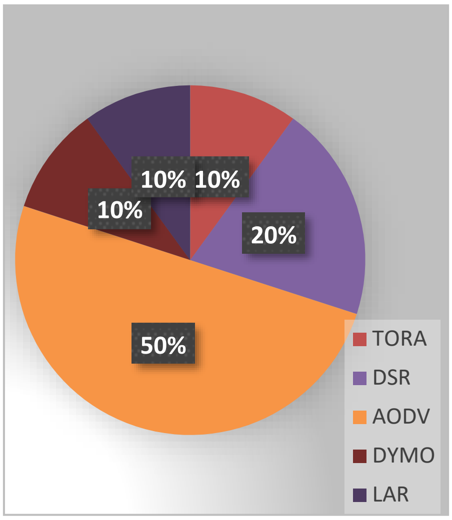

Figure 1: Protocol enhanced by different optimization

The researchers chose several other protocols, such as TORA, DYMO, and LAR, as shown in Figure 1, and stated that the performance of these protocols was improved utilizing optimization methods. As a result, it paves the way for us to investigate these procedures shortly.

Optimization Algorithms: There are various optimization algorithms accessible currently, each with its methodology and goals. Some are tweaked and included in the mobile ad hoc network. These methods are depicted in the diagram below.

Figure 2: Optimization Algorithms

Figure 2 above shows that researchers prefer PSO, ACO, GA, and firefly optimization over Cuckoo, BBO, Fuzzy, and Whale optimization.

QoS Parameters: The study also discloses the elements when creating the optimized protocols. As seen in figure 3, this study yielded different results for various variables.

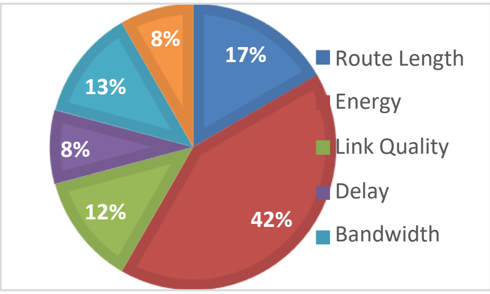

Figure 3: QoS Parameters

The figure above demonstrates that most of the optimized procedures were created with energy conservation in mind. On the other hand, Delay parameters receive the least attention during optimization. Delay is another critical characteristic that significantly influences performance and should not be overlooked. ***Performance Parameters:*** Different performance metrics are used to evaluate the performance of protocols intended for MANETs. The following figure depicts some of the parameters identified by this investigation.

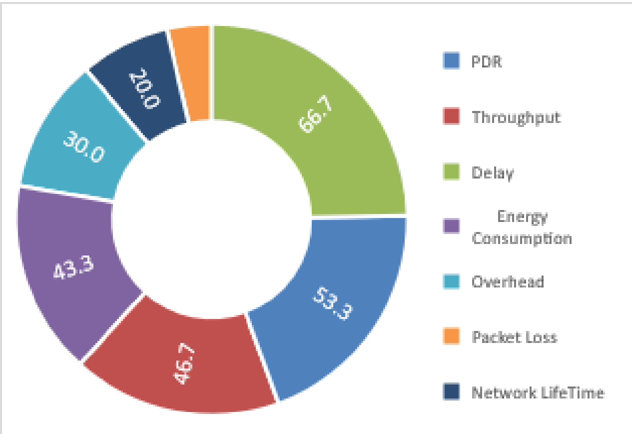

Figure 4: Performance Metrics

The chart shows (figure 4) that not all performance measures are given equal weighting. Delay, PDR, Throughput, and Energy Consumption are some of theanalyzed characteristics more thoroughly. On the otherhand, while evaluating the performance of the various protocols covered in this paper, the researchers pay relatively little attention to overhead, network lifespan,and packet loss.

V. CONCLUSION

The different routing protocols used in MANETs are discussed in this article. The protocols are primarily divided into reactive, proactive, and hybrid groups. All three protocols have benefits and drawbacks, but their use is dependent on the network setup and requirements. The major focus of this work is on two parameters: Delay and energy, and discusses various newly developed procedures for each of the stated categories. The procedures are generally accessible with either energy or a delay focus. Furthermore, optimized protocols are reviewed in this article, and it was discovered that most of the researchers worked on the AODV protocol rather than any other protocol. Other aspects such as optimization methods, performance measurements, and QoS settings are also examined in this study, and alternative future paths are discovered. The study's major finding is that optimized protocols greatly influence performance improvement; thus, various protocols require a chance to enhance their performance. Furthermore, the most common component, delay, requires attention and maybe an objective function for optimization methods to achieve QoS. Finally, all performance metrics should be incorporated while analyzing the performance to assess the QoS.

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