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A Critical Review of Optimization MANET Routing Protocols

Riyadh Rahef Nuiaa[1,*], Ali Hakem Alsaeedi[2], Salam Saad Alkafagi[3] and Ali Saeed D. Alfoudi[2]

[1]College of Education for Pure Sciences, Wasit University, Iraq
[2]College of Computer Science and Information Technology, University of Al-Qadisiyah, Iraq
[3]Babylon Education Directorate, Ministry of Education, Babil, Iraq

*Corresponding Author: Riyadh Rahef Nuiaa

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ABSTRACT: The main challenges in routing protocols are node mobility, resource constraints, error-prone channel states, and problems with hidden and unprotected terminals. This article provides an overview of the main protocols, their problems, and ways to improve them. The cell phone allows communication between two moving units via mobile stations (MS), mobile units, and landing units. The term "mobile ad hoc network" (MANET) refers to a group of devices connecting and communicating. The military, law enforcement, and emergency services have quickly become interested in MANETS because they provide a high quality of service. Path loss (PL), one of the biggest problems in wireless communications, can be caused by multiple reflections from an obstacle or by the source of the signal being far from the destination on the network. Multipath propagation, path loss, and interference reduce the network's quality of service (QoS). The best route is added to a router's routing table using a dynamic routing protocol, and an alternate path is chosen when the primary route is unavailable.

Keywords: Routing protocols, Optimization Network, Metaheuristics Optimization, Path loss, quality of service

1. INTRODUCTION

The use of wireless media and radio transmission for data and voice communication inside a particular mobile network is known as mobile networks [1]. Devices made with purpose, portable, and relatively lightweight are typically referred to as "mobile.". The cell phone connects two moving units through Mobile Stations (MSs), Mobile Units, and land units [2]. The mobile service provider has to supply three major services: locate and track the caller, assign the talking channel, and transfer the channel across base stations as the mobile moves. [3–5]

To enable localization, the cellular service area is divided into cells. The size of the cells depends on the population of the coverage areas. The cell center is computerized and responsible for the calls: (connecting, recording, billing) and the typical cell range (1.6 - 19.3) km [6]. Therefore, in an area with a high population density, smaller cells are required to meet traffic demands, and the transmit power of the cells must be low to avoid overlapping [7]. Figure 1 illustrates the cellular network.

A WSN is a group of interconnected devices, also called nodes, capable of sensing their environment and transmitting data about the monitored area (e.g., a place or a volume) to other nodes via wireless links [8]. The data is transmitted, perhaps across several hops, to a sink (also known as a controller or monitor), which can be used locally or connected to other networks (like the Internet) via a gateway. The nodes can move or stand still. It may or may not be aware of the location [9]. In either case, they may be homogeneous [10]. There are almost innumerable real-world applications for WSNs, including environmental monitoring, health care, location determination and tracking, logistics, localization,

*Corresponding author: riyadh@uowasit.edu.iq

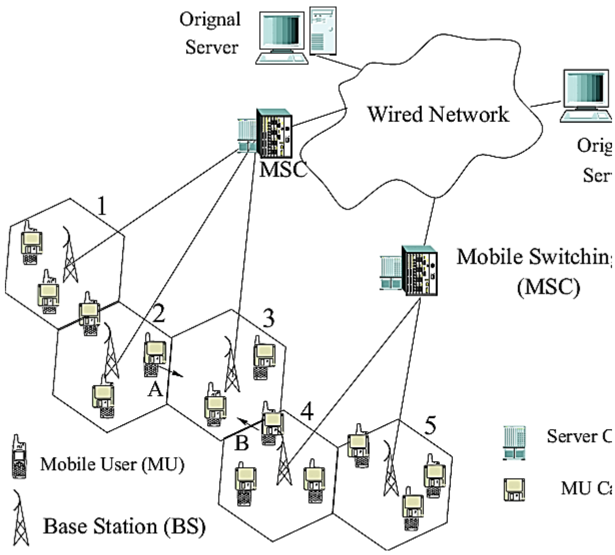

FIGURE 1. **Mobile network**

and more [11–13]. In this section, we offer a categorization of the possible applications. Multiple sinks in the network are a typical case. The likelihood of isolated node clusters failing to give data because of suboptimal signal propagation conditions is decreased by increasing the density of sinks per node. In theory, a WSN with multiple sinks can scale (i.e., the same performance can be obtained even if the number of nodes is increased); however, this is not true for a network with a single sink [14]. However, for the network engineer, a multi-sink WSN is not simply an extension of the single-sink scenario. In many instances, the nodes send the data they have collected to one of the sinks they have chosen from a variety of sinks, which ultimately sends the data to the gateway for the final user [15], [16]. Figure 3 shows the two primary seniors of the WSN on both single and multi-sink sinks.

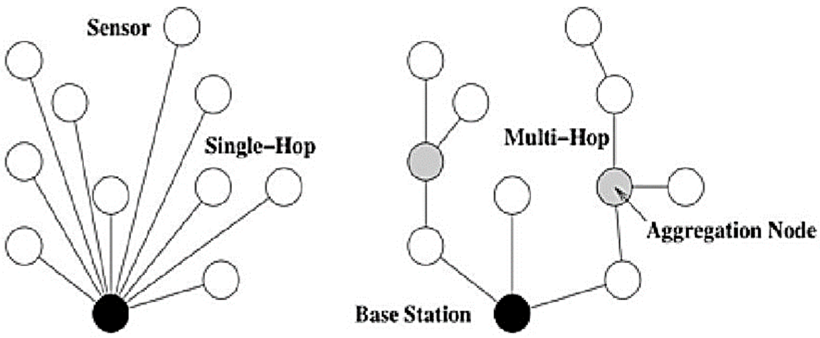

FIGURE 2. **Single and multi-sink of WSN.**

One way to classify apps is based on the type of data that has to be collected on the network. Event detection (ED) and spatial process estimation(SPE) can be used to categorize almost every application [17–19]. In the first scenario, sensors detect an occurrence, such as a forest fire, earthquake, etc. A specific physical event that may be described as a two-dimensional random (usually non-stationary) process, such as ground temperature changes in a small volcanic area, or atmospheric pressure in a broad area, is what WSN in SPE seeks to estimate [20]. In this case, the main problem is to estimate the spatial process's overall behavior based on the sensors' samples, which are usually placed at random positions.

2. MOBILE AD-HOC NETWORK

A mobile device group that connects and interacts without using a preexisting framework is known as a mobile ad hoc network (MANET) [11]. The uniform or focused organization is less common in MANET [21]. Instead of using permanent infrastructure, it creates connections using self-organizing, self-managing networks [1]. Each node performs the functions of a host and a router since the wireless transmission range of each node is constrained. The MANET architecture is shown in Figure 3.

MANETS may be dispatched to any site rapidly and at any time and can adapt to individual situations. These outstanding benefits sparked an immediate interest in MANETS among the military, police, and emergency services, particularly in chaotic or hostile environments [22], [23]. Before it, business applications started to appear, relying on continually developing standards like IEEE 802.11. This kind of network, which may function alone or with one or more points of attachment to cellular networks or the Internet [18], opens the door for a wide range of innovative and intriguing applications. Only a few examples of application scenarios include emergency and rescue operations, conference or university settings, vehicle networks, personal networking, etc. Static and dynamic routing technologies are both used in MANET [9]. Technically speaking, the fixed network topology is used with the static routing protocol. The physical connection between nodes in a LAN network serves as a great illustration of a static routing system with defined destination nodes [24]. If the node and link topology exhibit mobility features, the network may be ad hoc and employ a dynamic routing system. A router can learn about routing specifics on its own and add the ideal route to its routing table by using dynamic routing. When using a dynamic routing protocol, a router adds the optimal route to its routing table and chooses an alternative path in case the primary route goes completely inaccessible.

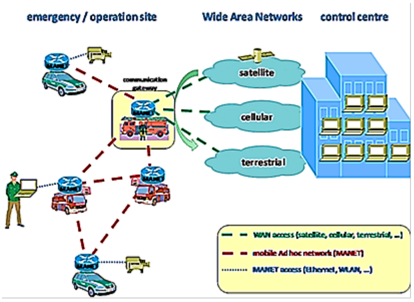

FIGURE 3. General architecture of MANET

Radio frequencies are wireless media that typically transmit data between ad hoc network nodes [25], so the network often suffers from interference. Weather and the frequencies of other nearby devices or networks also cause interference. Furthermore, individual devices can obstruct the transmission of a single piece of data to the following network nodes [22]. The singles reflected from obstacles cause multipath propagation. Due to scattering of singles from hard things, it receives the same signal from multipath in delayed time. One of the major problems in wireless communication is path loss (PL) [25], [26]. It arises either because the source of the signal is far from the destination in the network or because of multiple reflections from an obstacle. The mathematical calculation of path loss depends on the ratio of the power of the transmitted signal to the received signal. Equation 1x calculates the path loss [27].

$$PL(d) = PL(d_0) + 10nlog_{10}\left(\frac{d}{d_0}\right) \quad (1)$$

where d is the distance, d_0 is the reference point at 1 km, and n is the path loss exponent. Interference is another core problem in the management of wireless communication during the propagation of traffic in space [27]. The interference, path loss, and multipath propagation reduce the network's quality of service (QoS). The routing protocols for wireless networks should be able to link and maintain paths to other nearby nodes and, in most situations, manage path change brought on by the dynamic behavior of nodes. Although the majority of routing protocols are available, they do not take quality of service into account. The network user's expectation of communication is satisfied by the quality of service, which offers an effective transmission service. Over the past few years, vehicular ad hoc networks (VANETs) technology has been a significant topic of research [28]. VANET is an ad-hoc network built by constructing a network of cars for a particular demand or situation. Now that VANETs have been proven to be effective networks used by vehicles on highways or in metro regions. Along with its advantages, VANET also has several drawbacks, such as the problems of providing high-quality service, high connectivity, bandwidth, vehicle security, and individual privacy. The communication between moving cars in a certain environment is handled by vehicular ad hoc networks [29]. Vehicle-to-vehicle (V2V) communication is the direct communication between two vehicles. Vehicle-to-infrastructure (V2I) communication is the direct communication between a vehicle and infrastructure, such as a Road Side Unit (RSU) (V2I). Figure 4 shows a typical VANET scenario.

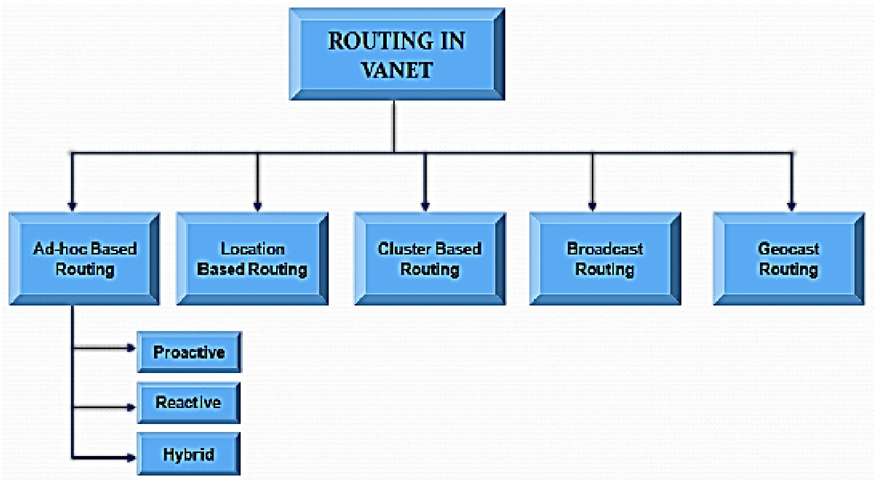

FIGURE 4. **Routing Types in VANET**

The creation of a dynamic routing protocol that permits the transmission of information from one node (vehicle) to another is one of the major issues in the development of vehicular ad hoc networks. Because the topology of a VANET is very dynamic and continually changing, routing in a VANET differs from standard MANET routing. Some previous protocols developed for MANET environments have been tested in VANET [28]. However, there is still work to be done in order to speed up information transfer between nodes. By addressing these issues in MANET protocols, real-time applications for the VANET environment can be developed. It's important to carefully evaluate additional effects, such as reducing control overhead [1]. Given the previously mentioned dynamic properties of VANET, the routing protocol should be resilient to vehicular network architecture's unpredictable and dynamic properties. Finding and maintaining the optimum communication paths in the intended environments may be the most challenging challenge in VANET routing [6]. The performance of most routing protocols in VANET varies as the network topology changes since these protocols are closely related to the topology utilized in the network architecture. Five broad criteria can be used to categorize routing in VANET:

- Ad-hoc or topology-driven protocols
- Location-based routing protocols
- Cluster-based
- Broadcast protocols
- Geocast protocols

3. QUALITY OF SERVICE (QOS

The QoS-aware routing protocol must consist of the following requirements, which must be met:

3.1 RESOURCE ESTIMATION

Ad hoc networks allow for resource sharing between the host node and its nearby nodes. Due to the dynamic nature of MANET's architecture, it is necessary to estimate resource availability in order to improve QoS [30].

3.2 ROUTE DISCOVERY

Reactive and proactive procedures are available for route finding in MANET [31]. In the proactive mechanism, routes are discovered and established with minimal delay, while in the reactive mechanism, the route establishment time is high but still reduces the routing overhead [32]. To obtain better QoS, route discovery must be done with lower overhead and delay. Figure 5 illustrates the discovered route in MANT.

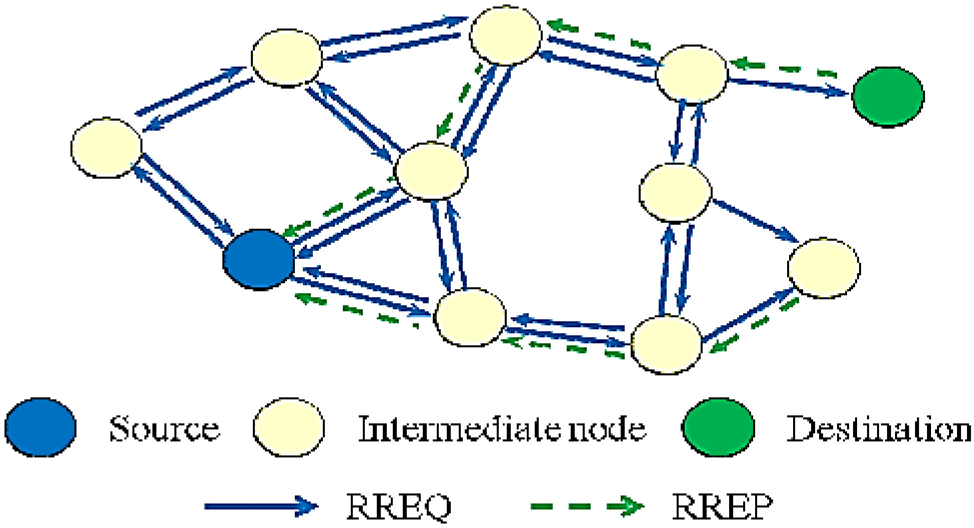

FIGURE 5. discovering routes

3.3 RESOURCE RESERVATION QOS

Resource distribution to the nodes in dynamic topology presents a significant issue in the situation of resource scarcity. In addition to insufficiency, giving resources to nodes that participate in transmission improves quality of service [33].

3.4 ROUTE MAINTENANCE

Due to the mobility of nodes, identified data transmission routes can sometimes get disconnected [34]. To deal with this issue, the route's nodes must be predicted, and some redundant routes must be identified for the same data transmission. This helps in better QoS. Figure 6 shows the route maintenance in MANET.

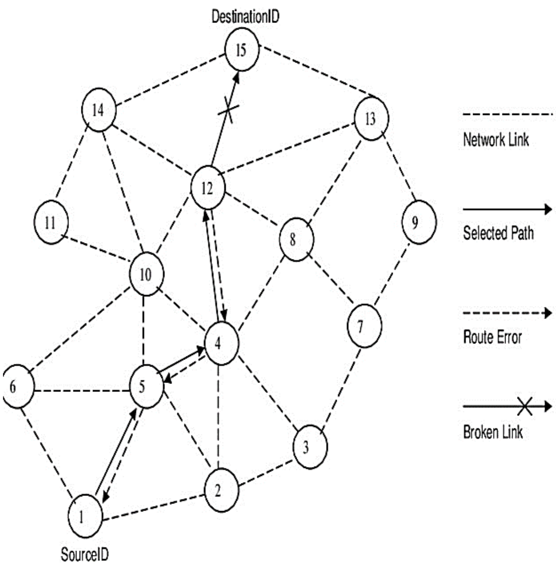

FIGURE 6. Route maintenance

3.5 ROUTE SELECTION

Routes from source to destination must be selected from among the several existing routes based on bandwidth availability, the distance of the route, and the amount of hop counts for the route. [35]. Figure 7 shows the type of media that could be transmitted over MANT's networks and QoS.

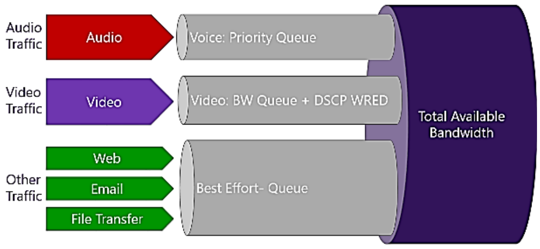

FIGURE 7. **Type of Media in QoS**

4. MANET ROUTING PROTOCOLS

A set of systematic guidelines known as a network protocol governs how data is exchanged among various devices connected to the same network [11]. Routing, data transfer, communication, and resource sharing require network protocols. As seen in Figure 8, a mobile ad hoc network (MANET) is an autonomous group of mobile users (nodes) interacting across wireless networks with restricted bandwidth. Due to the nodes' mobility, the network topology might rapidly and unexpectedly alter over time. Because the network is decentralized, nodes must organize and exchange sms. Routing messages might be problematic in a decentralized setting where the topology fluctuates [36]. In a static network, the shortest path between two points based on a specified cost function is typically the best route, but this idea is challenging to apply in MANETs.

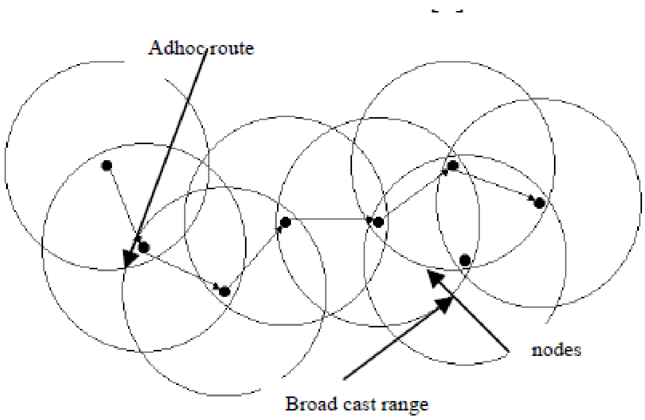

FIGURE 8. **Example of mobility in an Ad-hoc Network.**

Reactive and proactive routing protocols are used to manage routing in the MANET network. The two reactive routing protocols that are most frequently used are Dynamic Source Routing (DSR) and the Ad Hoc On-Demand Distance Vector (ADOV) [22] [1]. The proactive routing protocol family includes the Ad Hoc On-Demand Distance Vector (ADOV). The different routing techniques based on topology are shown in Figure 9.

Reactive routing group techniques are needed for dynamic network topologies, despite proactive routing group protocols being better suited to decrease bandwidth utilization and give faster convergence times [37]. The AODV and DSR topology-based routing protocols used more CPU, memory, bandwidth, and battery power than the DSDV routing protocol.

4.1 AD HOC ON-DEMAND DISTANCE VECTOR (ADOV)

TADSV is a reactive routing protocol developed for MANET and other mobile networks [6]. It is suited for MANET networks due to a number of advantageous features, such as dynamic, self-starting multi-hop routing between mobile

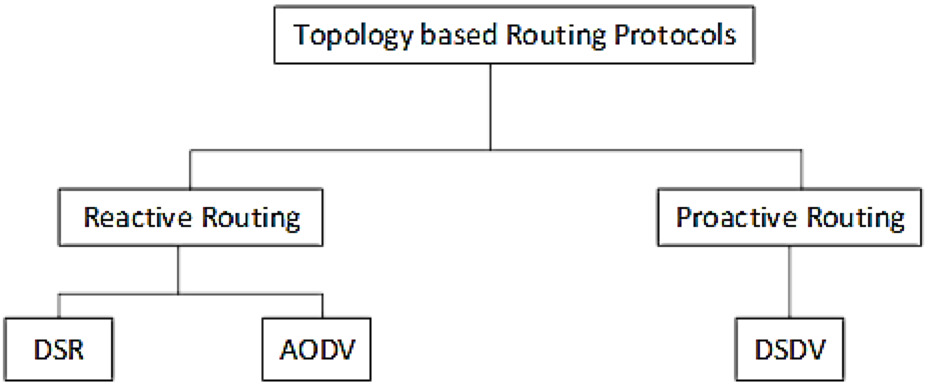

FIGURE 9. **Topology-based routing protocols.**

nodes aiming to set up and maintain an ad hoc network [38]. AODV enables the evolution of routes to specific locations without requiring nodes to maintain these routes while not communicating [39]. Using objective sequence numbers, AODV circumvents the problem of "counting to infinity." As a result, AODV is loop-free. The AODV routing protocol's routing messages contain only information about the source and destination, not the entire route path through the network [40]. The transmission of an RREQ (Route Request) packet in the MANET network can be seen in Figure 10.

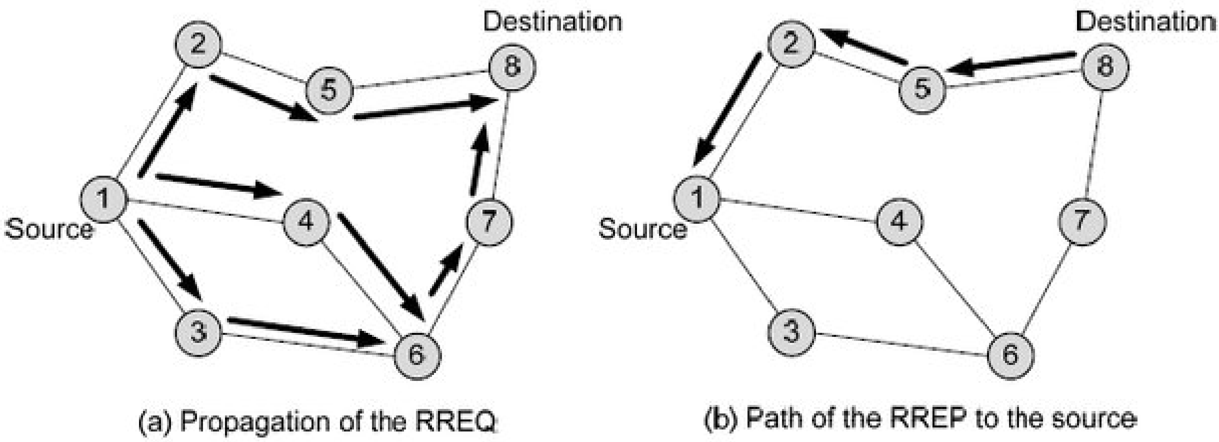

FIGURE 10. **AODV broadcast RREQ.**

The AODV routing protocol was created for mobile ad hoc networks that contain tens to thousands of mobile nodes. AODV can manage a range of data traffic levels as well as low, moderate, and rather high mobility rates. As a result of the usage of preconfigured keys or the knowledge that there are no harmful attacker nodes, in networks where every node can trust one another AODV is intended for use [25]. AODV was developed to decrease the spread of control traffic and eliminate overhead on data traffic, hence boosting scalability and performance [30]. Formats for Messages Routing Request Message Format (RREQ) When a link breaks and some of the node's neighbors can no longer access one or more destinations, the RERR message is sent.

4.2 DYNAMIC SOURCE ROUTING (DSR)

The route packets take within the MANET, from source to destination, is governed by a routing method known as TDSR. With the help of this method, nodes can locate a source route over several network hops to any desired destination node [41]. The two main aspects of the DSR routing protocol are route discovery and route maintenance. When sending packets over the DSR protocol, mobile hosts must first determine if they already have a route to the desired destination by checking their route cache [39]. A packet is sent to the host when the network contains the source-to-destination route. Imagine that the host node lacks a route. Let's say the route is still active and hasn't been discontinued. In this instance, it initiates the route discovery procedure by sending a route request packet, including the destination addresses and the mobile source host in addition to a special identifying number [41]. Each node in the network receives a packet using the DSR routing protocol to determine whether a route to the destination exists [36]. If not, it forwards the packet after adding its address to the route entry and using its routing links. When a request reaches the destination and an unclaimed route to the destination is present in the intermediate node's cache, the route of a packet is established in both cases [35]. The delivered package using DSR routing across the MANET network is shown in Figure 11.

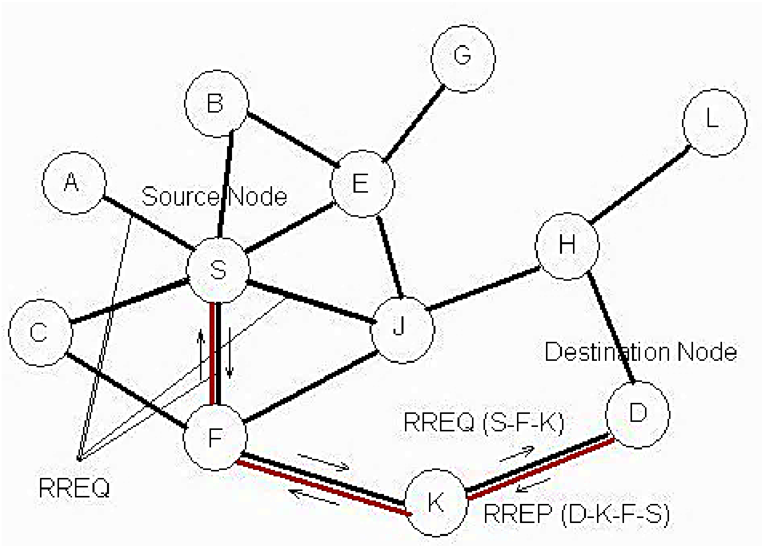

FIGURE 11. **DSR broadcast RREQ.**

5. OPTIMIZATION ALGORITHMS FOR ENHANCING ROUTING PROTOCOLS

The term meta-heuristic comes from ancient Greek. The word meta-heuristic is composed of two words: Meta means "higher level method," and heuristics means "discovering new strategies" [42–44]. Meta-heuristics is technically concerned with finding the best existing solution among huge and complex solutions. It obtains an approximate solution, i.e., it "guides" the search process by using the chance to find the best possible solutions [16], [14], [45]. The metaheuristic algorithms have strong properties representing flexibility, speed, and success in solving various real-world problems, making them interesting for researchers. The metaheuristic algorithms are classified into two categories according to the type of population (proposed solutions) [46]: single-solution metaheuristics and population-based metaheuristics. Single solution metaheuristics is a heuristic technique that uses iterative improvement of a single solution to find an optimal solution. S-metaheuristics can be described as a "walk" through neighborhoods to get from the current solution to another key in the search space [47]. Some examples of this approach are Hill-Clamping, Variable Neighborhood Searches (VNS), Tabu Search (TS), and Scatter Search (SS) [43]. The implementation of metaheuristic algorithms for optimizing the routing protocols in the following scenario [48–53]:

- Set the initialization parameters.
- Select optimal parameters for MANET routing protocols
- Set the route that achieves the best performance of the MANET routing protocols.
- Visualize the best-performing mobile network.
- The challenges of using metaheuristic algorithms for optimizing the routing protocols:
- In metaphoric optimization, there is stagnation in the leak.
- Improving major routing protocol parameters such as the number of connections, mobility rate, and several nodes.
- Enhancing one aspect of the MANET routing protocol and ignoring the protocol's primary parameter.

- The protocol's use of the deflate parameter F is not adaptable to each simulation scenario.
- Select optimal protocol characteristics by testing a few values to test each paragraph.
- The parameters of the routing protocol are not optimized.
- To evaluate the routing protocol's performance, use the static weight of the network.

Table 1 llustrates some of the technologies that aim to enhance the performance of MANET routing protocols

Table 1. **Comparison between some of the technologies of Optimize MANET routing protocols.**

Ref.	**Paper name**	**Published year**	**Enhanced Protocols**	**Description**
[51]	Enhanced-Ant-AODV for optimal route selection in a mobile ad-hoc network	2021	DSR, AODV	Using the ACO to optimize only the number of nodes and speed of nods. The proposed model did not solve time consumption and stagnation in AOC.
[22]	Performance Evaluation of Different Mobile Ad-hoc Network Routing Protocols in Difficult Situations	2021	DSR, AODV	The routing protocol's parameters are not optimized. Examine the performance of the routing protocol using static values from the network.
[52]	Improvisation of optimization technique and AODV routing protocol in VANET	2020	AODV	The AOC optimized initial condition to the selected node for transmitting data from source to distention. The proposed model potentially suffers from the end terminal node.
[23]	Performance analysis and enhancement of position-based routing protocols in MANETS	2019	DSR, AODV	This study's analysis concentrated on some metrics, such as power consumption, throughput, delay, and packet transmission rate. By testing a small number of values for each parameter, choose the best protocol characteristics.
[53]	A Stable Routing Protocol based on DSR Protocol for Mobile Ad Hoc Networks	2018	DSR	This paper aims to provide a reliable and highly effective routing protocol for these networks. Improving one component of the MANET routing protocol while ignoring its main parameter

6. CONCLUSION

Routing protocols govern the identification of the data path from source to destination. A collection of mobile devices connected informally forms a mobile network. It can be either a wireless ad hoc network (VANET) or a mobile ad hoc network (MANET). Self-organized, self-managed networks that MANET uses allow connections without needing a set infrastructure. Every node serves as a host and a router. The MANET routing protocol uses either proactive or reactive routing protocols. For dynamic network topologies, the routing protocol used is. Dynamic Source Routing (DSR) and Ad Hoc On-Demand Distance Vector are two instances (ADOV). Proactive routing protocols can achieve longer convergence times with lower bandwidth consumption. Destination-sequenced distance vector routing (DSDV) serves as an illustration. The optimization multi-objective searches an optimal path from various delay, packet loss, and PDR scenarios. Finding the most effective routing for numerous protocols, including DSR, AODV, and DSDV, is the primary objective function of metaheuristics.

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CONFLICTS OF INTEREST

The author declares no conflict of interest.

REFERENCES

[1] A. S. Mustafa, M. M. Al-Heeti, M. M. Hamdi, and A. M. Shantaf, "Performance Analyzing the Effect of Network Size on Routing Protocols in MANETs," *Int. Congr. Human-Computer Interact. Optim. Robot. Appl. Proc*, pp. 2020–2022, 2020.
[2] A. Singh, K. Chatterjee, and S. C. Satapathy, "An edge based hybrid intrusion detection framework for mobile edge computing," *Complex Intell. Syst*, 2021.
[3] J. Khan, A. Abbas, and K. Khan, "Cellular Handover approaches in 2.5G to 5G Technology," *Int. J. Comput. Appl*, vol. 21, no. 2, pp. 28–37, 2011.
[4] H. M. E. Mohamed, "Non Orthogonal Multiple Access Technique for 5G Network," 2022.
[5] R. R. Nuiaa, S. Manickam, and A. H. Alsaeedi, "Distributed reflection denial of service attack: A critical review," *Int. J. Electr. Comput. Eng*, vol. 11, no. 6, pp. 5327–5341, 2021.
[6] F. T. Al-Dhief, N. Sabri, M. S. Salim, S. Fouad, and S. A. Aljunid, "MANET Routing Protocols Evaluation: AODV, DSR and DSDV Perspective," *MATEC Web Conf*, vol. 150, pp. 1–6, 2018.
[7] D. Leite, I. Škrjanc, and F. Gomide, "An overview on evolving systems and learning from stream data," *Evol. Syst*, vol. 11, no. 2, pp. 181–198, 2020.
[8] M. S. Alsahli, M. M. Almasri, M. Al-Akhras, A. I. Al-Issa, and M. Alawairdhi, "Evaluation of Machine Learning Algorithms for Intrusion Detection System in WSN," *Int. J. Adv. Comput. Sci. Appl*, vol. 12, no. 5, pp. 617–626, 2021.
[9] A. K. Habboush, "Ant Colony Optimization (ACO) Based MANET Routing Protocols: A Comprehensive Review," *Comput. Inf. Sci*, vol. 12, no. 1, pp. 82–82, 2019.
[10] T. A. N. Abdali, R. Hassan, R. C. Muniyandi, A. H. M. Aman, Q. N. Nguyen, and A. S. Al-Khaleefa, "Optimized particle swarm optimization algorithm for the realization of an enhanced energy-aware location-aided routing protocol in manet," *Inf*, vol. 11, no. 11, pp. 1–17, 2020.
[11] A. Mishra, S. Singh, and A. K. Tripathi, "Comparison of MANET routing protocols," *Int. J. Comput. Sci. Mob. Comput*, vol. 8, pp. 67–74, 2019.
[12] H. M. Anwer, "A Framework for Efficient Network Anomaly Intrusion Detection with Features Selection," 2018. 157-162.
[13] M. Whitney, "Teaching Accessible Design: Integrating Accessibility Principles and Practices into an Introductory Web Design Course," *Proc. EDSIG Conf*, vol. 18, pp. 1–10, 2019.
[14] R. R. Nuiaa, A. H. Alsaeedi, S. Manickam, and D. E. J. Al-Shammary, "Evolving Dynamic Fuzzy Clustering (EDFC) to Enhance DRDoS_DNS Attacks Detection Mechnism," *Int. J. Intell. Eng. Syst*, vol. 15, no. 1, pp. 509–519, 2022.
[15] A. K. Sangaiah, S. Rezaei, A. Javadpour, F. Miri, W. Zhang, and D. Wang, "Automatic Fault Detection and Diagnosis in Cellular Networks and Beyond 5G: Intelligent Network Management," *Algorithms*, vol. 15, no. 11, pp. 432–432, 2022.
[16] R. R. Nuiaa, S. Manickam, A. H. Alsaeedi, and E. S. Alomari, "A new proactive feature selection model based on the enhanced optimization algorithms to detect DRDoS attacks," *Int. J. Electr. Comput. Eng*, vol. 12, no. 2, pp. 1869–1880, 2022.
[17] J. M. G. Hidalgo, G. C. Bringas, E. P. Sánz, and F. C. García, "Content based SMS spam filtering," *Proc*, pp. 107–114, 2006.
[18] S. M. Hadi, "Trigonometric words ranking model for spam message classification," *IET Networks*, pp. 2022–2022.
[19] S. S. Ali, A. H. Alsaeedi, D. Al-Shammary, H. H. Alsaeedi, and H. W. Abid, "Efficient intelligent system for diagnosis pneumonia (SARSCOVID19) in X-ray images empowered with initial clustering," *Indones. J. Electr. Eng. Comput. Sci*, vol. 22, no. 1, pp. 241–251, 2021.
[20] H. Luo, P. Zerfos, J. Kong, S. Lu, and L. Zhang, "Self-securing ad hoc wireless networks," *Proc. - IEEE Symp*, pp. 567–574, 2002.
[21] M. S. Daas and S. Chikhi, "Response surface methodology for performance analysis and modeling of MANET routing protocols," *Int. J. Comput. Networks Commun*, vol. 10, no. 1, pp. 45–61, 2018.
[22] S. M. Alkahtani and F. Alturki, "Performance Evaluation of Different Mobile Ad-hoc Network Routing Protocols in Difficult Situations," *Int. J. Adv. Comput. Sci. Appl*, vol. 12, no. 1, pp. 158–167, 2021.
[23] M. Alnabhan, S. Alsaraireh, B. K. Pattanayak, A. K. Habboush, and M. Hammad, "Performance analysis and enhancement of position-based routing protocols in MANETS," *Int. J. Knowledge-Based Intell. Eng. Syst*, vol. 23, no. 2, pp. 109–120, 2019.
[24] D. J. Fehér and B. Sándor, "Log File Authentication and Storage on Blockchain Network," *SISY 2018 - IEEE 16th Int. Symp. Intell. Syst. Informatics, Proc*, pp. 243–247, 2018.
[25] M. Z. Zakaria, S. Mutalib, S. A. Rahman, S. J. Elias, and A. Z. Shahuddin, "Solving RFID mobile reader path problem with optimization algorithms," *Indones. J. Electr. Eng. Comput. Sci*, vol. 13, no. 3, pp. 1110–1116, 2019.
[26] P. Tang, "Channel measurement and path loss modeling from 220 GHz to 330 GHz for 6G wireless communications," *China Commun*, vol. 18, no. 5, pp. 19–32, 2021.
[27] W. Tang, "Wireless Communications with Reconfigurable Intelligent Surface: Path Loss Modeling and Experimental Measurement," *IEEE Trans. Wirel. Commun*, vol. 20, no. 1, pp. 421–439, 2021.
[28] A. R. Gad, A. A. Nashat, and T. M. Barkat, "Intrusion Detection System Using Machine Learning for Vehicular Ad Hoc Networks Based on ToN-IoT Dataset," *IEEE Access*, vol. 9, pp. 142206–142217, 2021.
[29] M. J. N. Mahi, "A Review on VANET Research: Perspective of Recent Emerging Technologies," *IEEE Access*, vol. 10, pp. 65760–65783, 2022.
[30] M. Alnabhan, M. Alshuqran, M. Hammad, and M. A. Nawayseh, "Performance evaluation of unicast routing protocols in MANETs-current state and future prospects," *Int. J. Interact. Mob. Technol*, vol. 11, no. 1, pp. 84–97, 2017.
[31] R. Hemalatha, R. Umamaheswari, and S. Jothi, "Optimal route maintenance based on adaptive equilibrium optimization and GTA based route discovery model in MANET," Peer-to-Peer Netw," *Appl*, vol. 14, no. 6, pp. 3416–3430, 2021.
[32] U. Allimuthu and K. Mahalakshmi, "Intelligent route discovery towards rushing attacks in ad hoc wireless networks," *J. Ambient Intell. Humaniz. Comput*, vol. 13, no. 2, pp. 921–960, 2022.
[33] S. Venkatasubramanian, A. Suhasini, and C. Vennila, "QoS Provisioning in MANET Using Fuzzy-Based Multifactor Multipath Routing Metric," *Sustainable Communication Networks and Application*, pp. 555–566, 2022.
[34] A. M. Soomro, "Comparative Review of Routing Protocols in MANET for Future Research in Disaster Management," *J. Commun*, vol. 17, no. 9, pp. 2022–2022.
[35] R. Ramalingam, "Routing Protocol for MANET Based on QoS-Aware Service Composition with Dynamic Secured Broker Selection," vol. 11, pp. 2637–2637, 2022.
[36] S. Manickam, R. Nuiaa, A. H. Alsaeedi, Z. A. A. Alyasseri, M. A. Mohammed, and M. M. Jaber, "An enhanced mechanism for detection

of Domain Name System-based distributed reflection denial of service attacks depending on modified metaheuristic algorithms and adaptive thresholding techniques," *IET Networks*, vol. 11, no. 5, pp. 169–181, 2022.
[37] A. S. Alfoudi, "Hyper clustering model for dynamic network intrusion detection," *IET Commun*, 2022.
[38] H. S. Mansour, "Cross-Layer and Energy-Aware AODV Routing Protocol for Flying Ad-hoc Networks," sustainability," vol. 14, pp. 8980–8980, 2022.
[39] P. Sarao, "Comparison of AODV, DSR, and DSDV routing protocols in a wireless network," *J. Commun*, vol. 13, no. 4, pp. 175–181, 2018.
[40] Z. Yang, L. Li, F. Gu, X. Ling, and M. Hajiee, "TADR-EAODV: A trust-aware dynamic routing algorithm based on extended AODV protocol for secure communications in wireless sensor networks," *Internet of Things*, vol. 20, pp. 100627–100627, 2022.
[41] M. G. K. Alabdullah, B. M. Atiyah, K. S. Khalaf, and S. H. Yadgar, "Analysis and simulation of three MANET routing protocols: A research on AODV, DSR & DSDV characteristics and their performance evaluation," *Period. Eng. Nat. Sci*, vol. 7, no. 3, pp. 1228–1238, 2019.
[42] A. H. Jabor and A. H. Ali, "Dual Heuristic Feature Selection Based on Genetic Algorithm and Binary Particle Swarm Optimization," *J. Univ. BABYLON Pure Appl. Sci*, vol. 27, no. 1, pp. 171–183, 2019.
[43] A. H. Al-Saeedi, "Binary Mean-Variance Mapping Optimization Algorithm (BMVMO)," *J. Appl. Phys. Sci*, vol. 2, no. 2, pp. 42–47, 2016.
[44] A. S. Alfoudi, A. H. Alsaeedi, M. H. Abed, A. M. Otebolaku, and Y. S. Razooqi, "Palm Vein Identification Based on Hybrid Feature Selection Model," *Int. J. Intell. Eng. Syst*, vol. 14, no. 5, pp. 469–478, 2021.
[45] M. Mafarja, A. Qasem, A. Asghar, and I. Aljarah, "Efficient Hybrid Nature-Inspired Binary Optimizers for Feature Selection," 2019.
[46] D. Al-Shammary, A. L. Albukhnefis, A. H. Alsaeedi, and M. Al-Asfoor, "Extended particle swarm optimization for feature selection of high-dimensional biomedical data," *Concurr. Comput. Pract. Exp*, vol. 34, no. 10, pp. 2022–2022.
[47] S. Al-Janabi and A. Alkaim, "A novel optimization algorithm (Lion-AYAD) to find optimal DNA protein synthesis," *Egypt. Informatics J*, vol. 23, no. 2, pp. 271–290, 2022.
[48] N. Subramani, P. Mohan, Y. Alotaibi, S. Alghamdi, and O. I. Khalaf, "An efficient metaheuristic-based clustering with routing protocol for underwater wireless sensor networks," *Sensors*, vol. 22, no. 2, pp. 415–415, 2022.
[49] Y. Yang, Y. Wu, H. Yuan, M. Khishe, and M. Mohammadi, "Nodes clustering and multi-hop routing protocol optimization using hybrid chimp optimization and hunger games search algorithms for sustainable energy efficient underwater wireless sensor networks," *Sustain. Comput. Informatics Syst*, vol. 35, pp. 100731–100731, 2022.
[50] A. A. Bahattab, "Designing ROACM routing protocol along with bandwidth allocation using seagull optimization for ad hoc wireless network," *Telecommun. Syst*, vol. 81, no. 3, pp. 357–372, 2022.
[51] D. Sarkar, S. Choudhury, and A. Majumder, "Enhanced-Ant-AODV for optimal route selection in mobile ad-hoc network," *J. King Saud Univ. - Comput. Inf. Sci*, vol. 33, no. 10, pp. 1186–1201, 2021.
[52] M. Sindhwani, R. Singh, A. Sachdeva, and C. Singh, "Improvisation of optimization technique and AODV routing protocol in VANET," *Mater. Today Proc*, vol. 49, pp. 3457–3461, 2020.
[53] G. Najafi and S. J. Gudakahriz, "A Stable Routing Protocol based on DSR Protocol for Mobile Ad Hoc Networks," *Int. J. Wirel. Microw. Technol*, vol. 8, no. 3, pp. 14–22, 2018.