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Routing Protocols in MANET: Comparative Analysis and Performance Evaluation

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ABSTRACT

Mobile Ad-hoc networks, also known as MANETs, are a type of network that can self-assemble wirelessly and dynamically. Each mobile node in a MANET also functions as a network router. These clusters have their own conscious selves, allowing them to traverse space in multiple dimensions; they are able to do so because they can traverse space. MANETs lack a fixed data topology because they establish networks only when mobile nodes require data exchange. Consequently, it is plausible to claim that MANETs lack a fixed data topology. Consequently, it is reasonable to assert that MANETs lack a predetermined data topology. Routing in MANETs is more difficult due to their inherent dynamic nature; however, routing protocols are designed to address all of these issues. Consequently, the routing process in MANETs can become less complicated. Routing protocols are commonly regarded as one of the most crucial components in establishing communication between mobile nodes. It is possible to evaluate the performance of a routing protocol using qualitative or quantitative metrics, so long as the performance of the routing protocol is directly related to the evaluated network quality. This article will discuss proactive routing protocols, reactive routing protocols, and geographical routing protocols. Using a variety of criteria, a comparison of these three distinct types of routing protocols will also be conducted. Each of these routing protocols has been further subdivided into additional categories to facilitate comprehension of the underlying concepts.

Keywords: *Proactive routing protocol; Reactive routing protocol; Routing protocols; Mobile Ad-hoc network (MANET), Dynamic network.*

1.0 Introduction

During the 1990s, the number of individuals interested in researching mobile ad hoc communication increased significantly. In order to provide dependable point-to-point connectivity, innovative networking strategies must be implemented due to the lack of architecture and rapid expansion of these networks. This is necessary due to the rapid growth of these networks. Due to the rapid expansion of these networks, this is an essential step. The wireless nodes that make up a MANET are the entities responsible for the network’s mobility and ad hoc organisation. Direct communication between wireless nodes is possible if they are within range of the radio transmission and close enough. In the event that this is not the case, a connection is established by employing intermediate nodes that are responsible for packet transmission and recognise MANET as a multi-hop connection.

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MANETs are distinguished from other types of wireless networks because each user can establish an instant connection with an access node or ground station, and the network can function without the presence of fixed infrastructure [2]. Due to their unique qualities and high degree of complexity, network protocols present a number of design challenges. These obstacles are depicted in Figure 3 and are discussed in greater detail below. In addition, these networks are susceptible to the prevalent problems that arise in wireless communications. Interference, time-varying channels, decreased reliability compared to traditional media, physical security restrictions, and other problems are examples of these obstacles. Also problematic are time-varying channels. Despite the numerous flaws in their designs, mobile ad hoc networks offer numerous benefits to their users. This networking solution is ideal for situations where a stable architecture is absent, unreliable, prohibitively expensive, unreliable, or all of the above. Despite numerous flaws in their designs, mobile ad hoc networks offer numerous benefits to their users.

Figure 1: Mobile Ad-hoc Network and Cellular Network

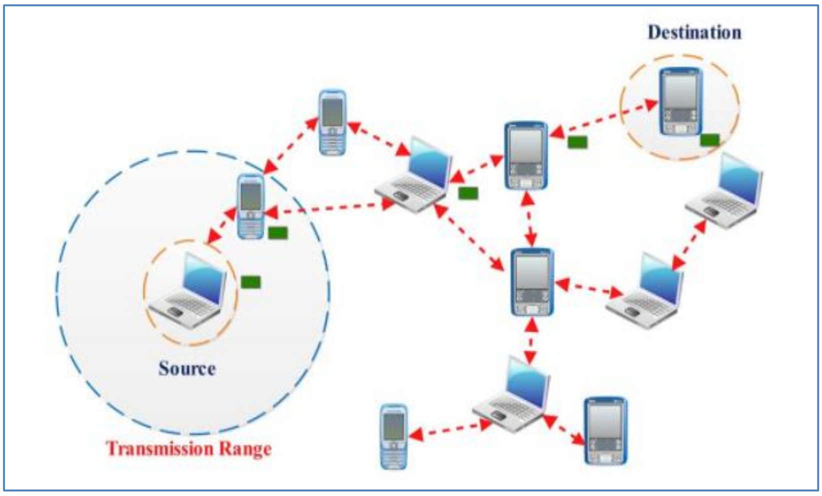

Figure 2: Issues Related with Mobile Ad-hoc Network

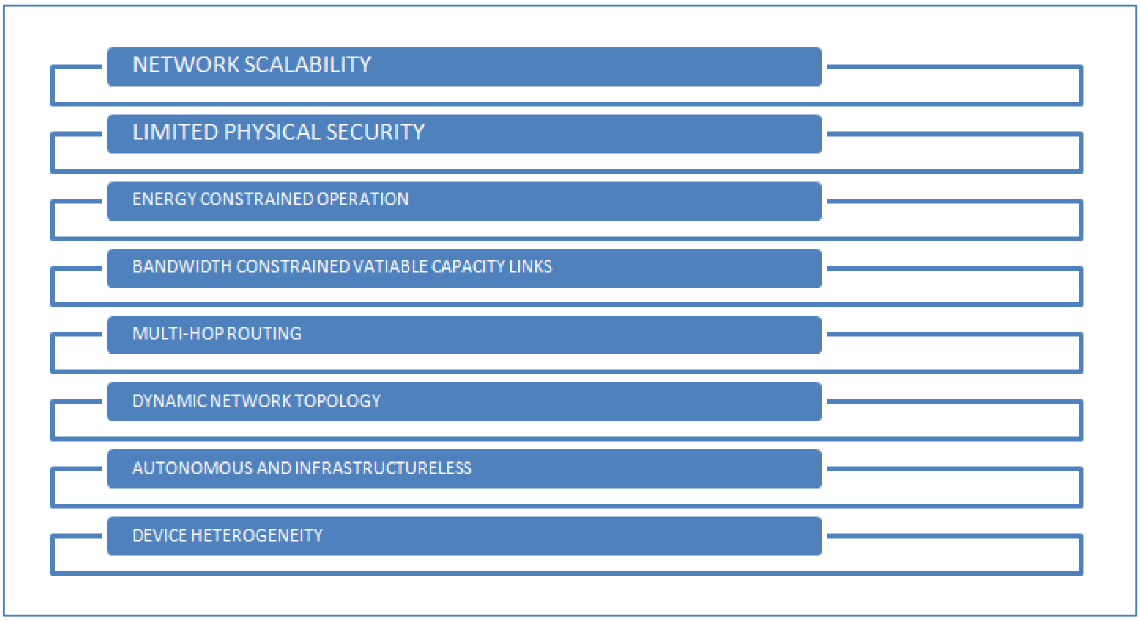

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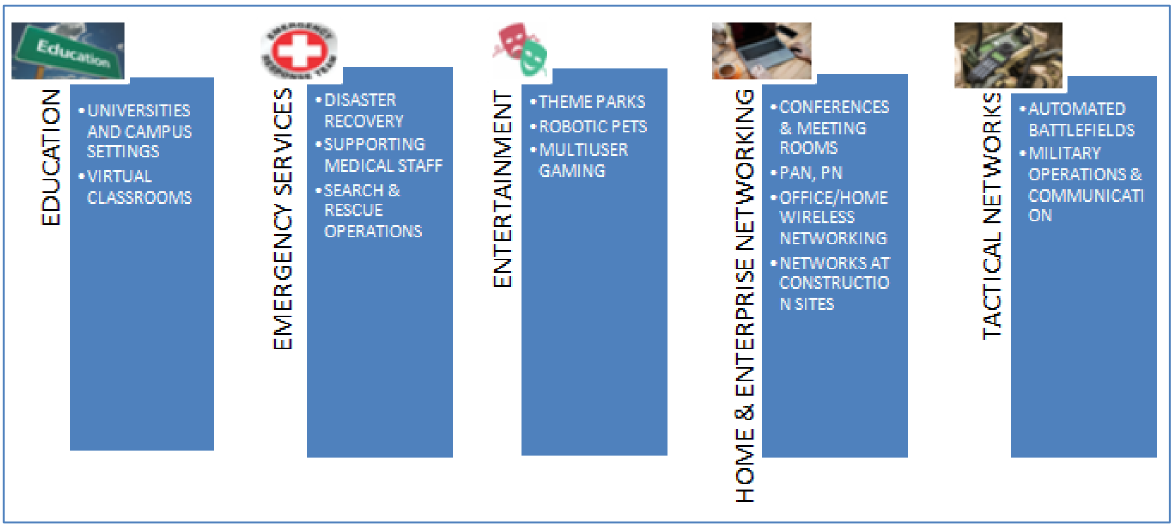
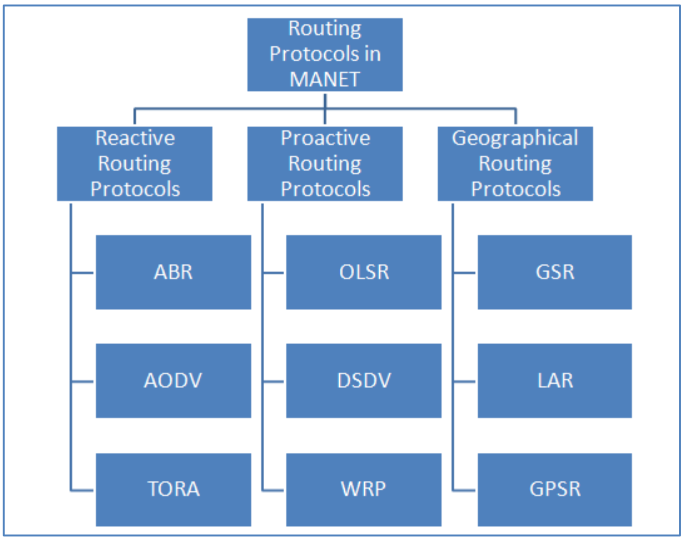
Figure 3: Prevailing Uses of MANET



MANET has witnessed the development of a wide variety of distinct routing protocols over the course of its existence. In terms of general protocol organisation, these protocols can be separated into three classes. The following three protocols must be adhered to:

- Geographical Routing Protocol (GRP)
- Proactive Routing Protocol (PRP)
- Reactive Routing Protocol (RRP)

Figure 4: Routing Protocol Categorization



2.0 Geographical Routing Protocol

Mobile Ad-hoc Networks, or MANETs, can use a type of routing protocol known as a "Geographical Routing Protocol." This routing protocol is suitable for use in MANETs. When making routing decisions, this type of routing protocol takes into account the geographical information held by network nodes. Geographic routing protocols, rather than more traditional addressing schemes such as IP addresses, use network location-based information to determine the next hop in the transmission of data packets. This information is used to determine which network will receive data packets. This method is more adaptable to changing conditions than IP addresses or other traditional addressing methods.

Every node in a MANET that uses a geographical routing protocol is aware of not only its own location, but also the locations of nodes nearby. This information allows for more efficient communication between nodes. The MANET can now operate more efficiently as a result of this knowledge. When a node wishes to send a packet to a destination node, it first determines the geographic coordinates of the destination and then chooses the next hop node based on its proximity to the destination. This is referred to as "hop counting." The number of hops involved is referred to as the "hop count." The victorious node is determined to be the one that is geographically located closest to the ultimate destination. Prior to reaching a conclusion, a decision is made with this information in mind. Because of the inherent mobility and dynamic behaviour of mobile ad hoc networks (MANETs), geographic routing protocols can be especially useful. This is because they apply these characteristics to their work. As a result, the protocols are capable of accomplishing a great deal while remaining highly effective. When nodes move or change positions, the decisions that determine the best route are altered to account for newly acquired location information. This ensures that the most efficient route is taken. As a result, you can be confident that the quickest and most convenient routes are always available to you.

Geographic routing protocols include Greedy Perimeter Stateless Routing (GPSR), Geographic Distance Routing (GEDIR), and Geographic Routing Protocol for Ad-hoc Networks (GRPAN). Greedy Perimeter Stateless Routing, Geographic Distance Routing, and Geographic Routing are the abbreviations for Greedy Perimeter Stateless Routing, Geographic Distance Routing, and Geographic Routing, respectively.

Geographic routing protocols have several advantages, including adaptability to constantly changing network conditions, scalability, and low overhead. They must also account for node mobility, ensure that their system is robust in highly dynamic scenarios, and account for any errors or inaccuracies in the location data. All of these elements are required for them to successfully complete the task. They, too, face a variety of challenges. Furthermore, they are put in situations where they must overcome obstacles.

3.0 Proactive Routing Protocol

In computer networks, a Proactive Routing Protocol is responsible for establishing and maintaining proactive routing information. This type of protocol is also known as a proactive routing protocol. This type of routing protocol is designated by its particular name, proactive routing protocol. The alternative name for these routing protocols is table-driven routing protocols. In proactive protocols, routing tables are constantly created and updated, regardless of whether there is an immediate need to transmit data packets. In contrast, reactive protocols only generate and update routing tables when an immediate need exists. Because proactive protocols are intended to prevent the occurrence of potential problems before they manifest, this is the case. This step is always performed, regardless of the urgency with which data packets must be transmitted. The routing tables contain information about the topology of the network. This data contains an abundance of alternative routes that users can take to reach their desired destinations. The provided tables contain a tabular listing of these particulars.

Doi: 10.51976/jfsa.612307

Using proactive routing protocols, which perform their functions through the periodic exchange of control messages among network nodes, it is possible to synchronise the routing information. Utilising proactive routing protocols makes this possible. These control messages are densely packed with network topology, link state, and routing table information. When nodes exchange this type of information, they are able to maintain the accuracy of their routing tables and obtain a complete view of the network.

The greatest benefit of using proactive routing protocols is their ability to make routing decisions quickly in the event that data needs to be transmitted. The primary benefit of utilising these protocols is that they are gratis. Due to the fact that routing tables are precomputed and continually updated, determining the next hop in a packet's transmission takes little time. This is feasible due to the fact that. Consequently, the procedure runs extremely smoothly. Consequently, network resources will be utilised more efficiently. Therefore, proactive protocols are ideal for low-latency networks and real-time applications, as they are well-suited to both of these environments. Consequently, they are ideal for use in real-time applications. Utilising proactive protocols in real-time applications is therefore strongly recommended.

Proactive routing protocols include the Destination-Sequenced Distance Vector (DSDV) and Optimised Link State Routing (OLSR) protocols. The abbreviations for these protocols are DSDV and OLSR, respectively. These protocols are known as DSDV and OLSR, respectively. DSDV and OLSR are utilised interchangeably. DSDV employs the hop-by-hop routing method as its primary transport mechanism. To comply with the requirements of this method, each node must maintain an up-to-date routing table that specifies the most time- and resource-efficient path to each destination. OLSR, on the other hand, uses multipoint relays to reduce the amount of control message overhead generated and enhance its scaling capacity. It achieves this by increasing its scalability.

In addition, proactive routing protocols must accommodate an extensive variety of conditions and requirements. Since routing tables are constantly updated, they consume network resources such as bandwidth and processing power even when no data is being transferred. This is because the routing table is frequently modified, which is the root cause of the issue. This is because routing tables are continually updated to incorporate new information. This can result in network inefficiency, which is particularly likely in large networks or networks with high node mobility. In addition, proactive protocols may encounter problems if they are required to deal with frequent topological changes or if they are utilised in highly dynamic environments. Both of these circumstances are likely to result in complications. In either of these two situations, problems will almost certainly arise as a natural result.

Table 1: The Comparative Strengths and Weaknesses of Geographical Routing Protocols, Proactive Routing Protocols, and Reactive Routing Protocols in Terms of Performance

Perimeters	Proactive	Geographical	Reactive
Mobility effect	Occurrence at fixed intervals	Constant variation	Localized broadcast query
Scalability	Generally, 100 nodes involved	Restricted scalability	Source routing protocols are involved
Traffic volume	Very high	Less traffic volume	Lower than proactive
Bandwidth	High	High	Low
Power	High	Low	Low
Services	Prefers shortest path	Supports node location service	Supports QoS

4.0 Reactive Routing Protocol

A reactive routing protocol is a type of computer network routing protocol that is also known as an on-demand routing protocol. This protocol is also known as a protocol for routing on demand. This protocol type is also referred to as an on-demand routing protocol. This type of routing protocol only establishes and maintains routes when data packet transmission is required. This demand is necessary for the protocol's route establishment and maintenance. These routing protocols are also known as "on-demand routing protocols." On-demand routing protocols are a subset of the category of routing protocols covered by this umbrella. This comprehensive concept encompasses all routing protocols. In contrast to proactive routing protocols, reactive routing protocols delay route discovery until a source node indicates that it wishes to send data to a destination node. Proactive routing protocols, on the other hand, initiate route discovery as soon as a source node decides to send data. In contrast, proactive routing protocols discover routes on their own and initiate the process. In contrast, proactive routing protocols routinely and automatically update their routing tables.

In a reactive routing protocol, if a source node needs to send data to a destination for which it does not have a pre-established route, it will broadcast a route request message, also known as an RREQ message. This occurs whenever the sending node needs to transmit the data. This enables the source node to communicate with other nodes regarding the transmission of data. Until it reaches the destination node or a node connected to a node representing a node with a route to the destination, this RREQ message will traverse the network. The message will continue to travel through the network until it reaches the destination node. If the message does not reach the node designated as its destination, it will be sent to every node in the network until it does. A route reply (RREP) message is sent back to the node that sent the RREQ message or to a node that already has a route after the RREQ message has been delivered to its final destination or to a node that already has a route. After the RREQ message has been delivered to a node with an existing route, this occurs. This action occurs after the RREQ message has been transmitted. This establishes the path that the transmitted data will take to reach its intended destination. When a route is created successfully, it is added to the routing table of the source node. This allows the route to be retrieved if necessary at a later time.

When there is only a moderate need for communication between certain network nodes, or when the network topology is dynamic or subject to frequent change, reactive routing protocols are advantageous for a network. When communication between nodes is of moderate importance, these protocols are useful for a network. By establishing routes only when necessary rather than at predetermined intervals, these protocols reduce the administrative burden associated with maintaining routing information for the entire network. This is achieved by establishing routes only when they are necessary. This is achieved by only generating routes when necessary.

Two examples of reactive routing protocols are the Ad-hoc On-demand Distance Vector (AODV) protocol and the Dynamic Source Routing (DSR) protocol. These two protocols are discussed in greater detail below. Cisco is responsible for the development of both of these protocols. Both protocols were designed by Cisco Systems, which is responsible for both of them. AODV uses sequence numbers to store routing information and prevent loops, whereas DSR uses source routing, which embeds the entire route within the data packet. AODV is the more effective of the two routing protocols. DSR cannot function in the absence of source routing. Sequence numbers ensure that the AODV system's various components function properly.

Before deciding to use reactive routing protocols, you should be aware of their drawbacks, which you should weigh carefully before moving forward. The process of establishing routes on-

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demand, which is required by the route discovery process, adds a delay to the data transmission process when compared to proactive protocols. The process of route discovery requires this. In contrast, proactive protocols generate routes before they are required. The delay in getting things done was due to the need to adhere to the procedure. In addition, there is a chance that the total control message overhead will increase as a result of the discovery of new routes and the consistent updating of existing routes. This is a common occurrence in networks with a high level of dynamism or an expansive operational scope.

5.0 Wireless Routing Protocol

The term "routing protocol" refers to a variety of protocols, one of which was designed for wireless networks and is known as a "Wireless Routing Protocol." Wireless networks communicate via wireless connections rather than the more prevalent wired links. These protocols establish and maintain data transmission routes between nodes in a wireless network. The routes enable the transfer of data from one node to another.

Protocols for wireless routing are essential components for managing the unique characteristics and challenges presented by wireless networks. These characteristics and difficulties include limited bandwidth, varying signal strengths, and frequent topological shifts brought on by the mobility of network nodes. These protocols aim to optimise routing decisions, maximise network performance, and ensure reliable data delivery in wireless environments.

The function of wireless routing protocols is to determine the most efficient path or route for data transmission. This is an essential component of the protocols. Several metrics, such as signal strength, interference levels, link quality, and available bandwidth, must be evaluated in order to identify the path that provides the best possible connection between a source and a destination node. This can only be achieved by identifying the path with the highest bandwidth. The routing protocol must be capable of adapting to changing wireless conditions and making dynamic route adjustments as the network topology evolves.

Numerous routing protocols designed specifically for wireless networks have been developed. This was done to address the unique challenges presented by wireless networks. The following are examples of standard operating procedures that are commonly used:

Table 2: Types of Routing Protocols

Destination-Sequenced Distance Vector (DSDV)	A proactive routing protocol for wireless networks that uses sequence numbers to ensure loop-free routes. DSDV checks and verifies the integrity of the routing table to achieve the most efficient data forwarding possible.
Ad-hoc On-demand Distance Vector (AODV)	A protocol for reactive routing that generates routes on demand and maintains their viability for as long as they are required. Due to the adaptability of AODV, it is ideally suited for use in ad hoc wireless networks characterised by frequent node movement and the establishment of temporary connections.
Wireless Mesh Routing Protocol (WMRP)	Considering that mesh networks are inherently dynamic, the Wireless Mesh Routing Protocol (WMRP) employs a hybrid strategy that combines proactive and reactive measures to deal with any given circumstance. The WMRP protocol was designed exclusively for wireless mesh networks. Multipath routing, for instance, is utilised to improve both load balancing and system reliability.
Dynamic Source Routing (DSR)	Another reactive protocol that employs source routing in which each data packet contains all destination route information. The source routing protocol employs this type of routing. As a result, routing table maintenance is no longer required, making DSR suitable for networks with limited resources.

6.0 Optimized Link State Routing Protocol (OLSR)

The constant progression of data packets from one node to the next, referred to as the hop-by-hop principle [4], is one of the most crucial aspects of MANET routing protocols.The OLSR is a system that can be used to guarantee that a route is always accessible. It is a pure link state method that is proactive, optimization-focused, and places primary emphasis on the link itself. These protocols cannot function without it because it is one of the most fundamental components. To effectively fulfil its role as a link-state routing method, OLSR must keep accurate information on network nodes and the paths connecting them. Only then will it be able to perform its function effectively. These data contain the paths along which the network's nodes are connected. The nodes have been granted permission to send frequent link-state response messages in order to implement this plan [5]. During an upgrade, it is possible to reduce the number of retransmitting nodes and, consequently, the quantity of control messages generated. This is possible due to the Multi Point Rely feature of the MPR. MPR's ability to facilitate frequent sharing of topographical data between nodes enables these nodes to avoid massive amounts of data traffic congestion that would otherwise occur. If they lacked this capability, the network would be incapable of functioning properly.

7.0 Geography Source Routing (GSR)

In GSR, determining the shortest path to a destination begins at the source node, where Dijkstra's algorithm and distance metrics are combined. The shortest route to a destination is determined in this manner. This action is taken in order to accomplish the goals established for this endeavour. Calculating the distance between the primary data source and intermediate transmission nodes accomplishes this. This enables it to calculate their distance apart. Calculating the distance between the primary data source and intermediate nodes yields this value. While the source node searches for the location and then sends the packet to each of the other nodes in the network, the available bandwidth is wasted. A Routing Strategy That Considers the Currently Available Space: Utilising the GSR packet forwarding mechanism, it is able to circumvent the issues caused by the GPSR recovery strategy. This allows it to successfully complete the task at hand. Each individual data packet transmitted from a source to a destination contains a list of the intermediate nodes the data passed through the route. This collection of references that has been compiled is also known as a GSR Set.

8.0 Associativity Based Routing (ABR)

ABR is responsible for defining a distinct routing metric for mobile ad-hoc networks. This is the responsibility of the ABR protocol. This measurement is referred to as the "degree of association stability." The hope is that the system will never encounter loops, deadlocks, or duplicate packets. The ABR algorithm determines which routes to take based on the existing connections between the various states of the nodes. It is essential that the selected nodes have a high resistance to deterioration. Each network node is responsible for transmitting beacons at predetermined intervals to demonstrate its continued operation. The associated tables are immediately updated when a neighbouring node recognises a beacon. Each time a node successfully receives a beacon, its total count will increase. In this case, the linked stability of a node's link to another node is also referred to as available space. ABR's primary objectives consist of route deletion, route discovery, and route

Doi: 10.51976/jfsa.612307

reconstruction (RRC). The overarching objective of all three is to determine routes for long-term dependability in ad hoc mobile networks.

9.0 Conclusion

This article contrasts and compares the different routing protocols used in mobile ad hoc networks. There are three distinct categories of protocols: geographical routing protocols, proactive or table-driven proactive routing protocols, and reactive or on-demand reactive routing protocols. Geographic routing protocols are the most typical type of protocol. Each protocol possesses a unique set of distinguishing characteristics. Geographic routing protocols are the most prevalent routing protocols currently in use, accounting for the vast majority of all routing protocols. To provide concrete examples for each of these categories, we investigated an extensive variety of protocols. This article provides a comparison and contrast of the various routing protocols used in mobile ad hoc networks. Proactive protocols, reactive protocols, and geographical routing protocols are the three types of protocols. Table-driven protocols are another name for proactive protocols. Both terms are applicable to proactive protocols. On-demand protocols are another term used to refer to reactive protocols. In each of these classes, we discussed numerous procedures and illustrated our discussions with numerous case studies. The proactive protocol requires a substantial amount of additional overhead, while the reactive protocol takes longer to complete. Each of these protocols has advantages and disadvantages. The geographical routing protocol is an excellent choice for the routing method in sensor networks because it enables data aggregation, which is used to reduce transmission to the base station by removing redundancy among packets originating from multiple sources. This is accomplished by eliminating redundancy from multiple-source packets. This is due to the fact that it is an excellent routing method for sensor networks.

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