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An Efficient Approach of Fair Routing in Mobile Ad Hoc Network

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Abstract: *MANET, or mobile ad hoc network, is concerned with the network's boneless structure, which is widely used in hazardous environments. MANET is concerned with self-configuring nodes with router-like capabilities. This property of nodes may result in an unjust decision when it comes to reaching the destination. Because the topology of a MANET differs from case to case, it is difficult to select the optimal method for establishing good communication while minimising data loss and expense. We presented a fair routing technique that takes into account load overhead concerns.*
We examine all characteristics of routing in an ad hoc medium using the discrete event simulator NS2. In terms of load overhead reduction, the suggested approach provides a superior outcome for achieving fair routing.

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I. Introduction

1.1 Introduction of Mobile Ad hoc Network

A mobile ad hoc network (MANET) is a network composed of self-learning and portable nodes that may link any computer device within a 100-meter radius. Ad-hoc networks are multi-bound wireless systems in which all portable nodes are connected and work together to achieve their goals. Such systems do not need centralised management and have no size constraints. Every node may act as both a host and a router at the same time.

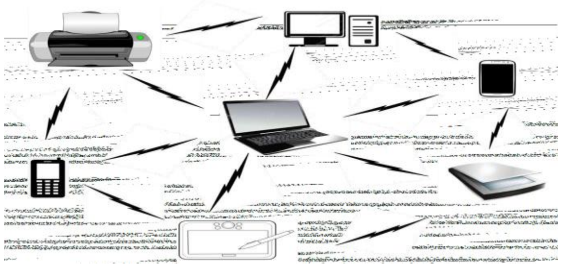

Figure 1: Mobile ad hoc network

The first generation was born in 1972. They were known as PRNETs (Packet Radio Networks) at the time [1]. Together with ALOHA (Areal Locations of Hazardous Atmospheres) and CSMA, approaches for medium access management and a kind of distance-vector routing are employed

(Carrier Sense Medium Access). PRNET was tested in a military environment to provide diverse networking capabilities.

The second wave of ad-hoc network technologies the Global Mobile Information System and Near-Term Digital Radio arrived in the 1980s, providing advancements in applications, radio performance, scalability, and security. As a consequence, they introduced SURAN (Survival Radio Network) [2]. The third generation of ad-hoc networks, including applications such as Bluetooth and Ad hoc sensors, debuted in the early 1990s.

Its demand and use in various areas make it a powerful standard protocol, such as Associative based routing [3,4] (Figure 1.2) shows the generation-by-generation incrementation of wireless ad hoc technology, and it's credited to IEFT (Internet Engineering Task Force) [5] in (1990-1999) for creating its well-structured form of standard protocol, which still works very well today.

Because of their characteristics that make it a user-friendly emergency network that was built with minimal cost and time without any cable, the MANET has contributed to the expansion of networking users and ground-level work. Its adaptability improves the area of MANET in a variety of situations.

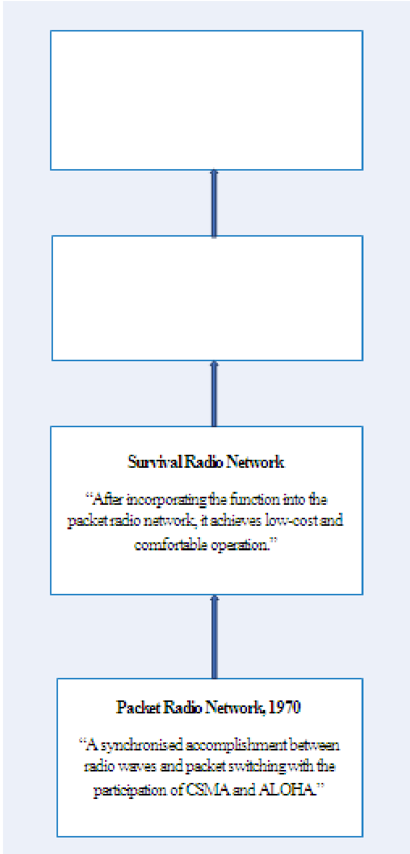

Figure 2: Generation of MANET

1.2 Applications of Mobile Ad hoc Network

- Despite its scattered structure and a combination of insufficient resources [7], MANET operates in a diverse environment with countless benefits that continue to expand MANET's range. In the low-cost budget, If we want to construct a network for interacting with two parties or conveying a message to the proper category, we can easily join with the assistance of an ad hoc network and most likely the radio waves will make the entire scenario. There are various general- In the aftermath of the epidemic, all government and commercial sector organisations in India switched to an online digital platform and achieved digitization. The most basic example of all operations is presented in (Figure 1.). Keep track of patient activities in the medical sector [11], such as coronatine patient activity, online classes, or provincial conferences.

purpose usage of ad hoc networks that change human life.

- Work under a private and home area network.
- Smart office and home appliances, Stereo Music Service, and Smart Presentation Task are examples of PAN and LAN devices that execute tasks and connect under MANET.

Figure 3: MANET in smart appliances

- FANET and VANET, two sub-groups of MANET, help with situation control and video streaming without requiring physical activity. As a result of their navigation policy, in (Figure 4), it aids in reaching assistance at its rescue site.

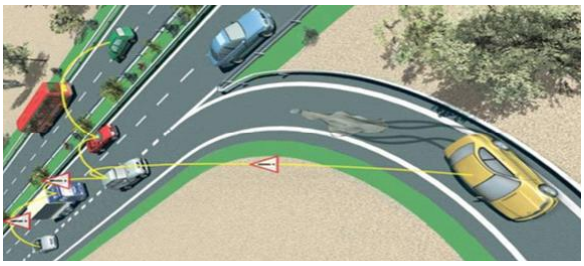

Figure 4: MANET in transportations

- "An Android-based mess network for communication and rescue operations." [10], illustrates army activities and various defence actions in which concealment is more important to the success of our army's plan.

- MANET aids in weather forecasting and danger conditions (Figure. 5), and natural tragedy (e.g., earthquake, flood, etc.) by notifying the government about the weather and other natural catastrophes.

Figure 5: MANET in natural tragedy

1.4 Characteristics of Mobile Ad hoc Network

1. The dynamic method is used to determine the path for communication in an ad hoc setting when there is no existing road map.
2. It operates on an independent paradigm, which simplifies the establishment of ad hoc networks and admits that its installation is not expensive.
3. Every node in a MANET has fixed resources to deal with a dangerous scenario such as a malicious attack or a black hole event.

1.5 Challenges of MANET

The TCP/IP suites approach is used to analyse the challenges of mobile ad hoc networks based on their distinct levels of operation.

- **Physical layer Issues of MANET:** link diversity, rate adaptations, etc.
- **Mac layer Issues of MANET:** The Hidden Terminal Problem, host blocking, synchronisation in a distributed infrastructure-less paradigm, and unfairness in channel access and resource allocation The IEEE 802.11 [12] standard makes little progress in terms of QoS (throughput, bandwidth, data rate, and latency).
- **Network layer Issues of MANET:**

Routing strategies are important to the network layer's concept. Apart from that, network security [13] for malicious attacks such as the black hole, grey hole spoofing, and so on, has several issues, including a manet error in flow management and the need to reconfigure the broken path, which creates a delay.

- **Transport layer Issues of MANET:**

This layer's core protocol is only dedicated to packet transmission. These topics include the connection-oriented TCP protocol as well as the connectionless UDP protocol. The excessive amount of traffic and the condition of user datagram packets in this tier distorts the route's basic feature of unreliability.

II. Literature Survey

2.1 Fundamental Study of Ad hoc Routing

2.1.1 Introduction of Ad Hoc Routing:

Communication formation in an ad hoc network is essential, and the underlying difficulty is that as the number of internet users increases, network quality degrades. The network's growth is directly influenced by its users. As a result, we have uneven communication between the sender and the recipient, which is the worst-case situation for an ad hoc environment. It lacks centralised access, which raises the possibility of a third party disguising the message throughout the routing process.

For fair routing, we deal with the breakage factor of routing protocol and the reason behind it. for that reason, it is important to have all knowledge of routing procedure in an ad hoc environment. for that purpose, we analysed all background works and as well as all related work which goes for concluding fairness feature in ad hoc routing. The purpose of Fair routing not only worked for routing procedure but also affected all layers of network and resource allocation.
We addressed routing characteristics and classification [14] in ad hoc networks, as well as some key recommended protocols that contribute considerably to the fairness of the MANET routing protocol, in this chapter.
Based on ad hoc network routing, we divide routing systems into three groups, which are depicted in Figure 2.1 below:

- The proactive routing protocol (Table driven routing protocol) [15]
- The reactive routing protocol (On-demand routing protocol) [16]
- Hybrid Routing protocol

2.1.2 Proactive Routing Protocol

The proactive routing protocol [17] is a routing protocol that maintains track of routing information at each node in a systematic manner. This method is known as a table-driven method since it relies on updating the routing table. This routing protocol consumes a lot of space to keep track of all the other nodes in the routing process. Such as DSDV, OLSR, CGSR, and so on.

DSDV was the first standard protocol developed by IEFT (Internet Engineering Force Task). The footprint of the Bellman ford algorithm method is used to find the optimum way for routing. In this protocol, all participating nodes have complete knowledge about the traverse to any place. To keep all information about the routing current, its nodes utilise periodic updation, which refreshes its information regularly. Periodic updates are also carried out in two ways: one is a "full dump," and the other is an "incremental update." Each participant affects the DSDV regularly.
The following are some advantages and disadvantages of DSDV:
• It uses a single path transmission protocol for routing and provides a loop-free path.
• The method of automatically eliminating path construction saves time.
• The sole explanation for its low utilisation is a waste of bandwidth and access overhead.

2.1.3 Reactive Routing Protocol

The reactive routing protocol [18] is intended to overcome the difficulties of the proactive routing protocol because the proactive routing protocol carries all information of participating routers, which causes unwanted memory storage, and the result of proactive routing performance is a reduction in overhead. A reactive routing protocol is the on-demand routing protocol that starts the routing procedure when it seems to need the routing. Like DSR, AODV, etc.

AODV is a major on-demand routing protocol [19] for MANETs. Its entire method is determined by the user's requirement. It was created to compensate for the lack of DSDV. When compared to proactive routing, reactive routing minimises broadcasting during the path selection process.

The main message kinds that are affected by the change are RREQ, RREP, and RERR. Every message type works on its functionality, for example, RREQ packets continue processing until they reach the destination, and if an error occurs between the source and the destination, the RERR packet activates and performs its procedure, If there are no barriers between the sender and the recipient, the RREP packet is activated and takes the shortest path.

In this entire operation, intermediary nodes also participate for future reference. It keeps the cache [20] for forthcoming nodes and also verifies the freshness of incoming nodes using the sequence number. The technique of detecting duplication based on the sequence number functions similarly to a firewall. As a result, this ongoing procedure completes the AODV job.

2.1.4 Hybrid Routing Protocol

The hybrid routing system [21] was created to eliminate the flaws of previous routing protocols, and as a consequence, it combines the advantages of proactive and reactive routing methods. The Zone Routing Protocol (ZRP) attempts to address the difficulties by combining the best aspects of both approaches. ZRP is a reactive/proactive routing method. TORA, ZRP, CEDAR, and others are a few instances.

The Zone Routing Protocol (ZRP) [22] operates in a massive network in which we create the road plan and divide the network into sub-networks based on the zonal distribution. This routing is further subdivided into inter-zone routing and intra-zone routing [23]. ZRP refers to the locally proactive routing component as the Intra-zone Routing Protocol (IARP). The name of the globally reactive routing component is Inter-zone Routing Protocol (IERP). IARP holds routing information for nodes inside the routing zone of the node. Based on an IARP-monitored local connection, IERP delivers improved route discovery and route management capabilities.

2.2 Related Fairness Approaches

We analyse a large body of relevant research that effectively focuses on the fairness of routing. In general, when we talk about fair routing, we mean the equal distribution of everything, including aspects such as the fair selection of routes, nodes, and resources. As part of my objective to alter the AODV (ad hoc on-demand routing protocol), we sought to tackle the overhead problem in routing so that we could achieve a fair routing solution in terms of load balancing and energy consumptions.

Huaizhou SHI et al. [24] provided a comprehensive analysis of fairness in mobile ad hoc networks. The authors addressed the many types of fairness, as well as their applications and techniques. All critical components of routing, including the source of unfairness, are discussed in chronological order.

Younghwan Yoo and Sanghyun Ahn [25] presented a simple load balancing solution based on the credit-based protocol-independent fairness algorithm (PIFA), in which all forwarding nodes volunteer to ensure that they are not selfish. This method decides on the state to node and saves the unnecessary use of resources during the transition phase.

The Neighbour Coverage-Based Probabilistic Rebroadcast Protocol (NCPR) was developed by Prajkta S. Nagrare and Vaishali N. Sahare al. [26], in which the author used the information of related neighbours and their range of connectivity to affect the probability of choosing the fair path and control the rebroadcasting. As a result, we discovered a low-overhead routing method.

Masaru Yoshimachi et al. [27] suggested a fairness-based model that is produced throughout the route discovery process to pick the best option and accomplish fair routing. To achieve fair routing, the author classified transmission in terms of self-benefit and other benefits, which he then used in the form of a fairness ratio in every path selection process. This approach addressed the load concentration but raised the RREQ overhead.

Marchang Jims et al. [28] proposed Priority-based Fairness provisioning QoS-Aware MAC protocol (PFQAMP), in which the load is distributed in an ad hoc network based on priority. In this approach, the author sets the priority as load high to low and determines the ranking, which works better in different types of routing scenarios but does not improve MANET QoS.

Tai Hieng Tie et al. [29] proposed the Maximum Energy Level Ad Hoc Distance Vector protocol MEL-AODV, which used the maximum energy-based path for route selection, thereby increasing the lifetime of participating nodes.

R. Guha et al. [30] suggested "Fair coalitions for wireless power-aware routing." Proposed algorithms sharing their resources for fair coalition routing that is based on a fair profit vector of individual and group sharing through mutually advantageous means.

Y. Gadallah et al. [31] have researched "an assessment of an energy-efficient fair technology for Ad-hoc mobile networks" in which the authors have attempted to integrate a fair and efficient energy consumption of the all-participating node into the routing process.

Tian Lan et al. [32] developed an axiomatic theory based on the equity of the network resources. The researcher has set the axioms in this referencing module. These axioms were obeyed by all types of fairness measurement methods such as the Jian index, Gini indices, etc. and the fairness theory was correct output.

The trust-based fairness router that operates according to certain evolutionary criteria, the credibility, and dependability of the agent, was suggested by Ivan Daniel Burke et al. [33]. These parameters can greatly determine the fair conduct of the agent.

Zhifei Li and others [34] submitted a fairness method for adaptive transmission control (ATC), which mainly aims to improve a fairness factor without declining performance metrics. It needs support with the scope and effective node which helped include this idea to deal with the backdoor and unfairness.

All this above all study has led us to address unfair routing because many words in routing impact their ability to deal with ad hoc networks and therefore it is important to understand their unfairness factor and to focus more on that particular phrase.

III. Model of Proposed Work

3.1 Ad hoc On-Demand Routing Protocol

The ad hoc on-demand routing protocol is a step forward in proactive routing. The essential feature of this routing protocol is that it activates performance only when it is required, resulting in a less burdensome mode of communication.
Aodv routing protocol conducts various operations that complete ad hoc communication.

- Generating route requests by source node or intermediate node.
- Generating route reply by destination node or intermediate node.
- Route maintenance or error
- Maintenance of the freshness of path by the sequence number.

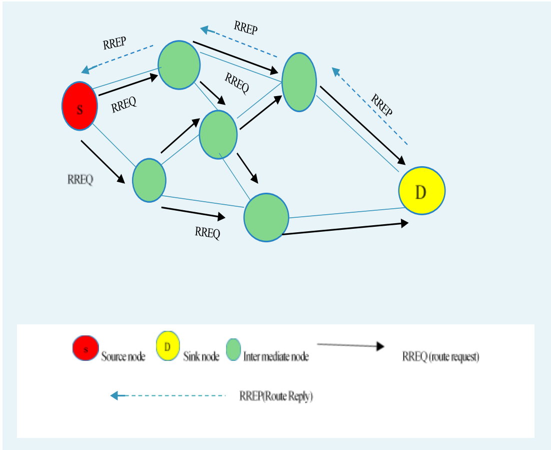

Figure 6: AODV process model

- When a source node wants to deliver a message to a destination node but doesn't have a route to that node in its cache, it sends out a route request (RREQ) packet to start the path discovery process.
- When a node (either a source or an intermediate node) receives an RREQ packet, it examines its routing table to see whether it has already received the identical packet and if so, the packet is rejected by the node.

- The node then examines its cache to determine if a route to the destination node exists. If it is unable to fulfil the route requirement set by the source, After establishing a reverse path to the source, it rebroadcasts the packet.

- To create a reverse path, a node records the address of the neighbour from whom the original copy of RREQ was obtained as the next hop to the source. An RREQ eventually arrives at a node (perhaps the destination) with the most recent path to the destination.

- In unicast mode, the node subsequently transmits a route reply (RREP) packet back to the source. As the RREP returns to the source, each node along the path sets up a forward pointer to the node from whom the RREP was received as the next hop to the destination and updates its timeout information for the route entries to the source and destination.

3.2 Proposed Model for Achieving Fair Routing

The new characteristics in the packet header are referred to as FI (fairness indicator), and they are used in the reactive routing protocol's route finding process. This signal of fairness applies to all RREQ and RREP message types. In the proposed work, we focus on communication establishment such that in fair routing, we also aim to reduce load, enhance lifespan, and preserve message quality so that no unnecessary nodes participate in that routing.

Overhead and unwanted attacks are caused by rebroadcasting and energy limitations. So, to deal with these issues, we used the simple load balancing criteria of using the minimal distance between neighbors while also checking the link weight; these two elements work together to pick the most convenient way. This method is also useful for maintaining resource storage and providing a genuine hacker-less and hassle-free routing path.

Algorithm:

Step 1: The source node sends an RREQ packet to its neighbours to determine the route, with the help of the minimum value of neighbour's distance and link weight of select the path.
Step 2: The neighbour node will check the RREQ packet for the future process to reach the destination.
Step 3: To locate neighbour nodes and determine optimal hop-by-hop communication, use the discovery node distance.
Step 4: To avoid repeating RREQ packets at neighbour nodes, FAODV generates the routing packet by categorising relay and forward values.
Step 5: We alter the RREQ packet structure by grouping the source address, the destination address, and the fairness interaction information (FI) (Last address) details.
Step 6: The last address field maintains the last transaction of the forwarded node.
Step 7: When a node gets an RREQ with a TTL of 0 or a duplicate RREQ, i.e. one with the same broadcast ID as a previously processed RREQ, it looks for the FI field.
Step 8: If a node's address matches the FI in RREQ, the node's Relay value will be permitted to forward the packet; otherwise, the message will be discarded.
Step 9: Else, the node will not participate in the route discovery process.

IV. Performance Evaluation and Result Analysis

To save resources and decrease overhead, we strive to incorporate flawless load balancing in mobile ad hoc networks, so that we may achieve the fair routing method. In this phenomenon, we attempt to bind the RREQ broadcasting approach between the fair node selection process and an enhanced fairness value parameter that determines unbiased routing.

4.1 Network Criteria and Configuration

When we compare both AODV and (proposed protocol), we obtain the result based on performance metrics and various pause lengths and time; we establish a simulation scenario of 50 nodes in the 1000 1000 sq. meter. We used a connectionless UDP protocol to transport data from a sender to a receiver.
There are various models for comparing two protocols, but the two most common ways are:

- On the foundation of the traffic model.
- On the foundation of the mobility model.

On the various model of comparisons scheme, we explored our model in a variety of scenarios in which performance is computed based on maximum connection and pause-time [37]. We validate the model in all feasible ways, including changing the area, pause amount of time, maximum connection, and the number of nodes.
All other aspects, such as latency, packet delivery ratio, and control overhead, yield the best results, but in terms of energy, we receive the least residual energy-based proposed protocol, which helps to extend the lifetime of the proposed AODV routing protocol.

4.2 Performance Metrics and Results

Throughput:

Throughput is defined as the highest quantity of data successfully sent from one location to another during a certain time span. The primary unit of throughput used in the measurement is Gbps or Mbps.

$$\boldsymbol{Throughput} = \frac{\boldsymbol{count\ of\ successful\ data\ received}(\boldsymbol{bits\ or\ bytes})}{\boldsymbol{Transmission\ Time}(\boldsymbol{sec.})}$$

Protocols	AODV, FAODV
Propagation Model	TwoRayGround
Interface Queue Type	Drop Tail/PriQueue
Antenna Type	Omni Antenna
Interface Queue Length	50
Interval of simulation	200sec
Maximum speed	20 m/s
Pause time	0 sec
Mobility model	Random waypoint
Traffic Type	CBR
Connection rate	2 pkt/sec
No of nodes	50
Packet size	512 Bytes
Energy	1 joule
Simulation area	1000 by 1000 meter

Velocity	20 meters/second

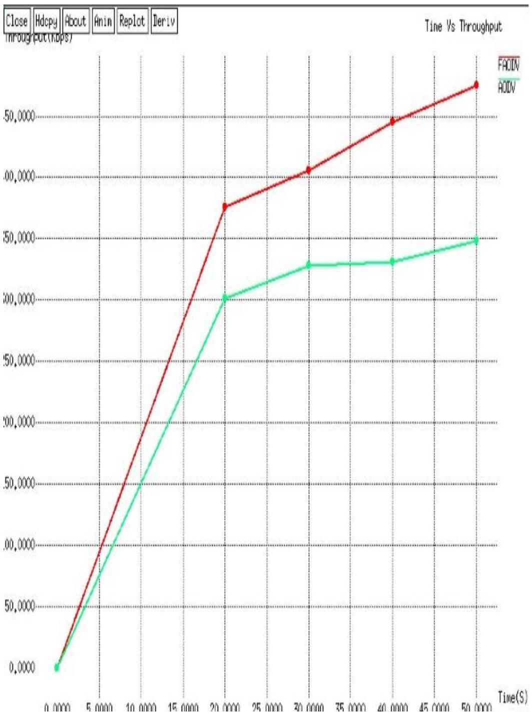

Figure 7: Throughput vs time

Delay:
End-to-end delay refers to the amount of time it takes to get from source to destination. We got a better outcome through performance analysis.

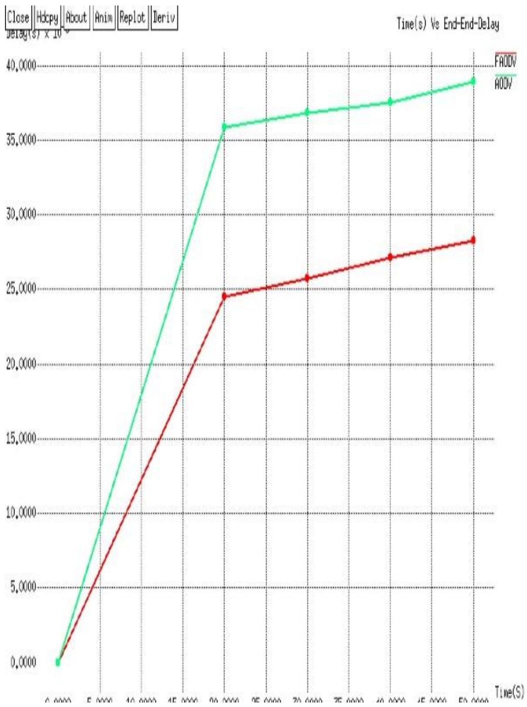

Figure 8: Delay vs time

Packet Delivery Ratio:
This is the ratio of successfully received packets to the total number of sent packets.

Figure 9: PDR vs time

Overhead:
As the simulation time increases and all participating nodes do their tasks, we discover that the overhead increases. So, we compared the original AODV with the suggested protocol and discovered that the proposed protocol has a lower overhead than the original protocol.

Figure 10: Overhead vs time

Energy Consumption:
Energy consumption is the total amount of energy used by the participating medium within a given work cycle duration. When we compared our proposed protocol FAODV to the original AODV routing protocol, we discovered that the proposed protocol used less energy than AODV, demonstrating that by using the proposed method, we can maintain the remaining energy, which will help to increase the lifetime of participating nodes.

Figure 11: Energy vs time

V. Conclusion

The purpose of this study is to modify the AODV routing protocol's route discovery, which has been done freely, and each parameter has been tested using Network Simulator 2. Researchers are aiming to make the reactive routing protocol more efficient based on network resources and more powerful to reduce overhead because it has been widely researched and performs more successfully in an ad hoc context.

Protocol for AODV routing Having very few resources to deal with in an ad hoc setting, we strive to overcome the resource-constrained problem and routing overhead to create ideal communication. With the load balancing technique of the fairness index, which interacts with all intermediate nodes based on heavy load and vital energy level, that node that removes high load and potentially low energy may be simply discarded.

The suggested technique achieves the desired outcome in terms of load balancing, congestion-free routing, and improved energy efficiency. This method reduces overhead and increases the amount of energy left in the node, extending the lifetime of AODV routing.

5.2 Future Scope

My recommendation for future research is that they use the new concept to develop a resource-saving technique for the security components of ad hoc networks that can be quickly changed. Because dealing with cryptography costs more time and resources, designing a fair security-based routing system is preferable.

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