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A Study to Assess the Effectiveness of Cuckoo-Based Routing in Dynamic Network Conditions

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ABSTRACT

An adaptable and dynamic method to routing is provided by the cuckoo-based algorithm, which takes its cues from the cuckoo bird's behavior and uses swarm intelligence principles to explore paths using Lévy flying. An innovative routing algorithm is introduced in this study, which utilizes OPNET Modeler 10.5 to assess a suggested approach and compares it to the popular AODV algorithm and the FRP, which is based on fuzzy logic. Measurements such as received packets, latency, number of hops, and route discovery time are used to assess the proposed approach in both error-free and failure modes. When compared to AODV, the cuckoo-based method reduces network latency and achieves better packet delivery rates, according to the simulation findings. The results demonstrate that the cuckoo algorithm constantly provides superior performance in terms of packet delivery and latency, even in failure circumstances, compared to the FRRP protocol, which works well under stable settings. The findings show that the suggested strategy works, which is great news for dynamic ad hoc networks since it improves stability and efficiency, decreases network delay and route discovery time, and so on.

Keywords: Route Discovery, Packet Delivery, Network Delay, Energy Efficiency, Algorithm

INTRODUCTION

The development of ad hoc networks has created several opportunities in the fast changing wireless communication sector, particularly in settings where traditional infrastructure-based communication is impractical. Decentralized and self-configuring, ad hoc networks let devices—also called nodes—talk to one another without needing a set network infrastructure, including routers or base stations. Highly dynamic and versatile, these networks are appropriate for a wide spectrum of uses including military communications, disaster recovery, vehicle networks, and sensor networks. But mobile mobility and decentralized control create special routing problems like low bandwidth, high latency, regular topology changes, and erratic node behavior.

Routing in ad hoc networks is essential to guarantee effective delivery of data packets between nodes despite these obstacles. Especially when nodes are always changing and network topologies change regularly, conventional routing algorithms often find it difficult to preserve efficient routes in such dynamic settings. New and creative routing methods have been created to overcome these constraints; one of them is the cuckoo-based routing algorithm. The cuckoo-based method takes its cue from the behavior of cuckoo birds, famed for their parasitic breeding technique, whereby they deposit their eggs in the nests of other birds, usually displacing the host bird's eggs. This interesting phenomenon has been turned into a mathematical and computational framework providing original answers to routing issues in ad hoc networks.

To maximize the routing process in ad hoc networks, the cuckoo-based routing algorithm uses the concepts of swarm intelligence, an area of artificial intelligence. Inspired by the group behavior of decentralized systems like bird flocking, fish schooling, and insect colonies, swarm intelligence is Without central authority, these systems show extraordinary problem-solving ability and their ideas have been effectively used to several optimization challenges, including routing in mobile ad hoc networks (MANETs). The cuckoo-based routing method seeks to identify the optimum feasible routes for data transmission by use of natural processes seen in cuckoo nest-laying behavior, hence reducing congestion, latency, and packet loss.

Cuckoo-based routing's fundamental concept is to use Lévy flight, a random walk technique, to investigate possible network paths. This approach guarantees that the algorithm may investigate new and perhaps superior routes while avoiding local optima, a frequent problem in traditional routing algorithms. By causing big, unanticipated leaps in the search space, Lévy flight—a random walk with step lengths following a heavy-tailed probability distribution—allows the algorithm to conduct a more thorough search for optimum solutions. In ad hoc networks where node mobility and network topology changes need adaptive and flexible routing techniques, this is especially beneficial.

The cuckoo-based routing algorithm also makes use of the idea of route discovery and route maintenance, which are vital in guaranteeing consistent communication in a dynamic network environment. The method starts a search for possible pathways between source and destination nodes during the route discovery phase. The method keeps this route by frequently updating the routing tables and monitoring for topological changes that can influence the current path after the best path is found. This proactive route maintenance guarantees that data packets are delivered with least latency and packet loss and helps to reduce the effect of network disturbances.

Apart from its versatility and flexibility, the cuckoo-based routing algorithm provides scalability, which qualifies it for big ad hoc networks. Traditional routing techniques could suffer performance decline as the network grows because of the greater overhead and complexity of sustaining routing tables. The cuckoo-based method, on the other hand, is meant to scale effectively as it depends on local node interactions rather than preserving a worldwide network state. This lowers the total memory and processing needs, hence enabling the technique to manage networks with many nodes without sacrificing speed.

REVIEW OF LITERATURE

Yu, Xiuwu et al., (2021) An adaptive cuckoo optimized WSNs routing algorithm (ACRFD) based on forward transmission dynamic programming is suggested to assure the real-time performance of data transmission while successfully balancing the energy consumption of wireless sensor networks. To begin forming an energy-saving routing toward the Sink node, the forward transmission region of the node must first be determined. Additionally, a dynamic programming model for energy-balanced WSNs with minimal latency has been developed, taking into account the multi-hop nature of data transmission in WSNs. In order to find the best solution for the model, the cuckoo search algorithm is finally used, which includes an adaptive search stage. The simulation findings demonstrate that the ACRFD algorithm outperforms the other three routing algorithms in terms of real-time data transmission performance, energy consumption balance, and network longevity.

Moila, Lerato &Velempini, Mthulisi. (2021) A cognitive radio ad hoc network (CRAHN) is a decentralized mobile network that may connect with one another. The nodes have the ability to understand their surroundings and choose their own routes. Additionally, additional spectrum is needed for data transmission due to the creation of massive data sets via distributed computing, spectrum mobility, and the Internet of Things. Regrettably, legal users are wasting this precious resource, while unlicensed users are clogging up the available spectrum. A potential answer to the problem of spectrum underutilization is the CRAHNs technology. Using the optimized cuckoo search algorithm, this work aims to solve the routing issue of CRAHNs by making routing more effective and reducing energy usage. The routing methods' performance is negatively impacted in CRAHNs due to the frequent connection breaks caused by the mobility of both nodes and spectrum. A routing solution is necessary for this particular routing issue. With the help of a cognitive radio cognitive network (CRCN) patch, the suggested method was applied to NS2 running on the Linux operating system. Results from experiments showed that compared to CS-DSDV and ACO-AODV, the suggested OCS-AODV scheme worked better. There was a packet loss rate of 2.56% or less, and the delivery ratio was at least 3.87%. The plan allowed the mobile nodes to make the necessary adjustments to reduce power use. In order to save battery power, they enter an idle mode while they are not in use.

Walunjkar, Gajanan & Anne, Koteswara. (2020) Due to its ad hoc nature and usefulness during crisis management when infrastructure support is not available, mobile ad hoc networks have been popular in research. Nodes may need to make many network hops in order to share data across the network since wireless network interfaces have a restricted transmission range. Every mobile node in this network acts as a router, directing data packets to other nodes that aren't always in the same physical location.

Distance vector and link state protocols, which were designed for use in wired networks, are insufficient in this context due to their significant overheads and the assumption that the topology is mainly stable. A number of routing algorithms tailored to ad hoc networks have emerged as a result. Various performance metrics, including packet delivery ratio, latency, throughput, control overhead, energy, and more, are analyzed in this article, along with the MANET routing protocols that enable them.

Zhang, Wenbo et al., (2019) Current study is centered around the failure prediction challenge for modern industrial equipment. Consequently, a dynamic cuckoo search method is initially suggested in this study. Both the step size and the discovery probability are enhanced by the technique. In order to achieve a balance between search speed and accuracy, it updates the step size formula with the trend of the fitness function value. While the local search step size decreases towards the end of the algorithm, the initial global search step is bigger. Finding the best answer on a global scale improves the uncertainty of the random walk and increases the likelihood of producing healthy offspring. In later stages of evolution, it is easier to create new people since the likelihood of discovery decreases as the search continues.

On top of it, we build a BP neural network prediction model using an optimized dynamic cuckoo search method. In addition, the experimental findings demonstrate that the suggested prediction model converges more quickly and with more accuracy.

Anbuchelian, S. & C M, Sowmya. (2017) Wireless sensor networks (WSNs) are poised to revolutionize healthcare and are among the most highly sought-after technologies in the field of computer science. Since WSNs suffer greatly from poor connection as a result of nodes' erratic movements, routing is the primary area of study in WSNs. One possible solution to this problem is Delay Tolerant Networks (DTN), which typically use carrier-transfer based routing. The suggested research introduces DTN routing based on Cuckoo Search (CS). The foundation of CS is reproduction behavior, which may aid in resolving a number of optimization problems. To put it simply, it outperforms competing meta-heuristic algorithms. The experimental findings demonstrate that the suggested method can improve performance.

Proposed Method

Implementing and verifying the effectiveness of the suggested technique using OPNET Modeler 10.5 is the focus of this article. It then compares the method to the well-known AODV algorithm and the fuzzy logic-based reliable routing protocol (FRRP). Thirty nodes spread out over an area of 1,127 square meters make up the network topology seen in Figure 1. Also, it's taken for granted that every node may spin in a range of 0 to 359 degrees.

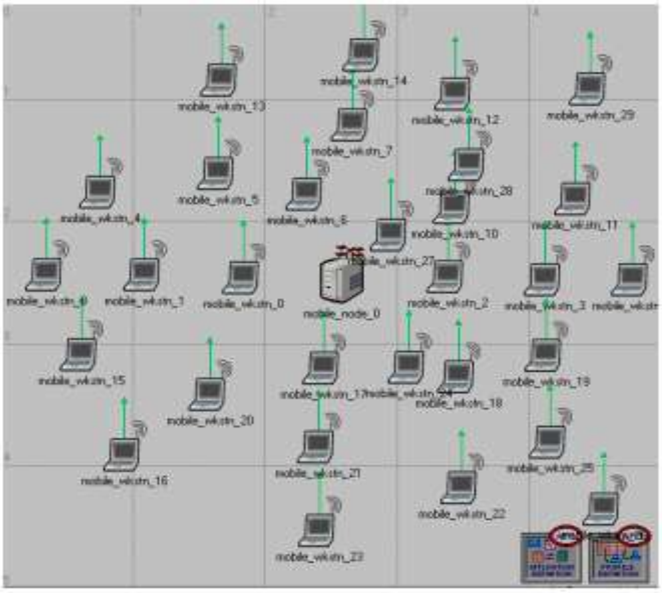

Figure 1: Optimal Network Architecture For Error-Free Simulation

The rotation duration ranges from 0 to 200 seconds, while the displacement of each node varies from 1 to 10 meters. Figure 2 illustrates the node editor for the network model. The transmission range of each node is 250 meters, with bandwidth varying randomly between 1 and 10 gigabytes.

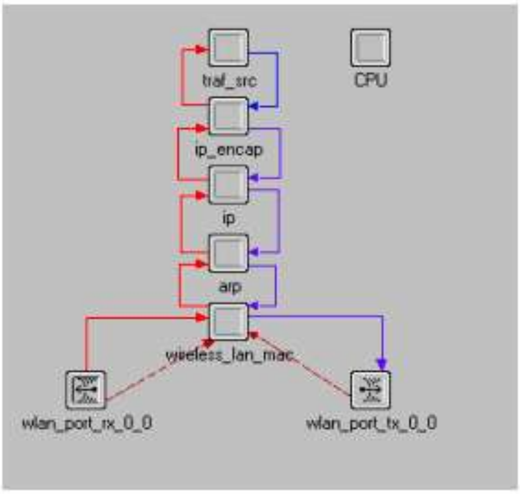

Figure 2: Node editor for simulated model

We utilize the metrics of received packets, delay, number of hops, and route discovery time to assess the performance of our approach. We want to evaluate the performance of the suggested method in both error-free and failure conditions.

RESULTS AND DISCUSSION

The count of successfully received packets demonstrates the superior performance of our suggested method relative to the AODV and FRRP algorithms. The cuckoo algorithm, which identifies more stable paths to the destination, can transmit a higher volume of packets compared to the AODV algorithm. Additionally, the FRRP protocol can identify appropriate links for data transmission more effectively than the proposed algorithm. Figures 3 and 4 depict the performance assessment of the proposed method under error-free and failure conditions.

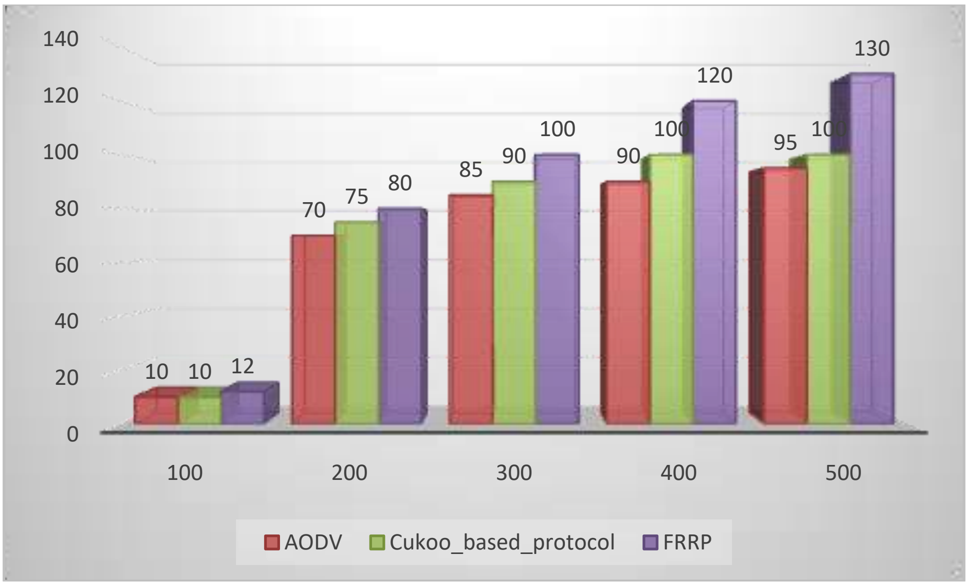

Figure3: Analysis of Received Packets for Cuckoo, FRRP, and AODV in error-free state

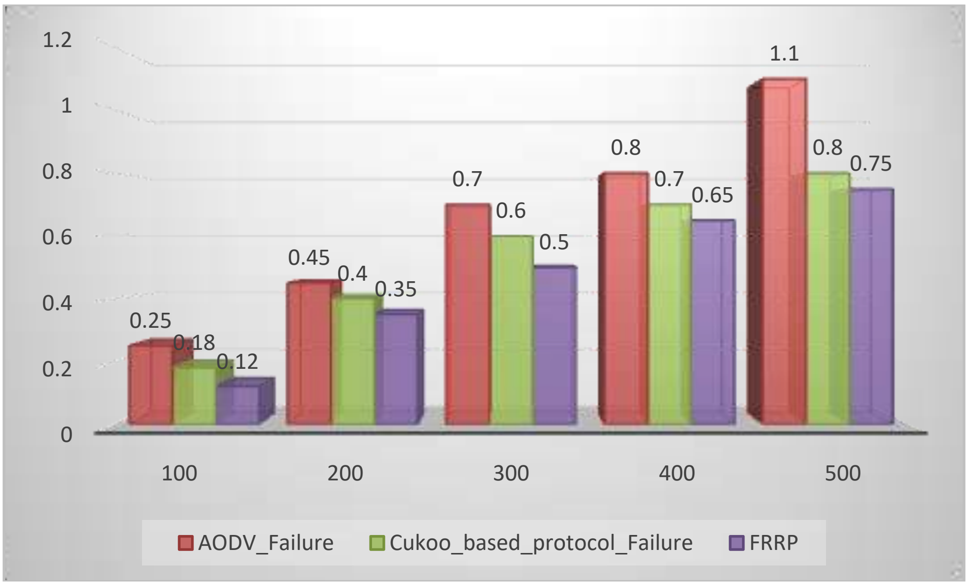

Figure4: Analysis of Received Packets for Cuckoo, FRRP, and AODV in Failure State

Figures 5 and 6 show that the Cuckoo algorithm chooses better pathways for data transmission, which leads to a reduction in network latency throughout the course of the simulation, compared to the AODV method. It is unnecessary to rediscover routes since the ones that are known to transport packets with a high probability have already been found. The result is a considerable reduction in network latency. Delays occur as a result of calculations of available bandwidth and energy levels; nevertheless, our technique significantly reduces delays, demonstrating that computation and comparison take very little time and have no effect on the network's performance. Since the appropriate connections have not been formed in the first seconds, there is a significant delay in the network. Even after learning, the FRRP protocol may take stability factors into account and choose the right connections based on the data they provide. Even in the worst-case scenario, the FRRP protocol chooses the right connections to send data across.

Notably, cuckoos choose pathways with a lower hop count. Cuckoo, in contrast to AODV, employs a shorter hop count in its route creation and optimization processes, with the goal of reducing energy consumption during data transmission.

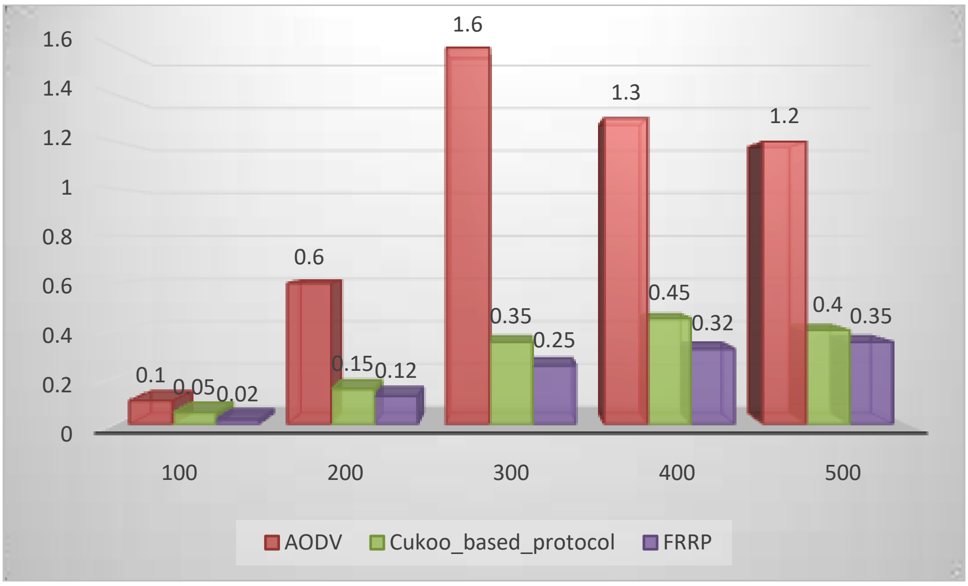

Figure 5: Network Delay for Cuckoo, FRRP and AODV in an Error-Free State

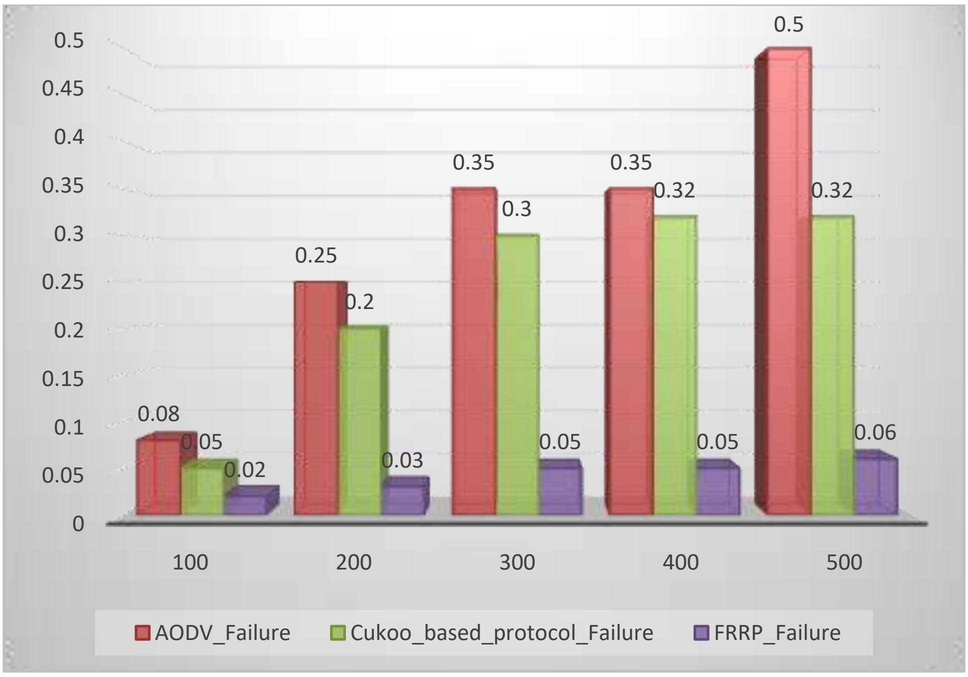

Figure 6: Network Delay for Cuckoo, FRRP and AODV in failure state

The results of comparing the cuckoo, FRRP protocol, and AODV algorithms with respect to hop count are shown in Figures 7 and 8. Network discovery time for Cuckoo, FRRP protocol, and AODV are calculated in Figures 9 and 10, respectively; the Cuckoo method significantly reduces this parameter compared to the AODV algorithm.

The reason for this decrease is because the nodes' neighbor routing tables include information about appropriate linkages. Because the network has not yet been properly trained using the Cuckoo method and appropriate linkages have not been discovered, the initial network discovery time is high.

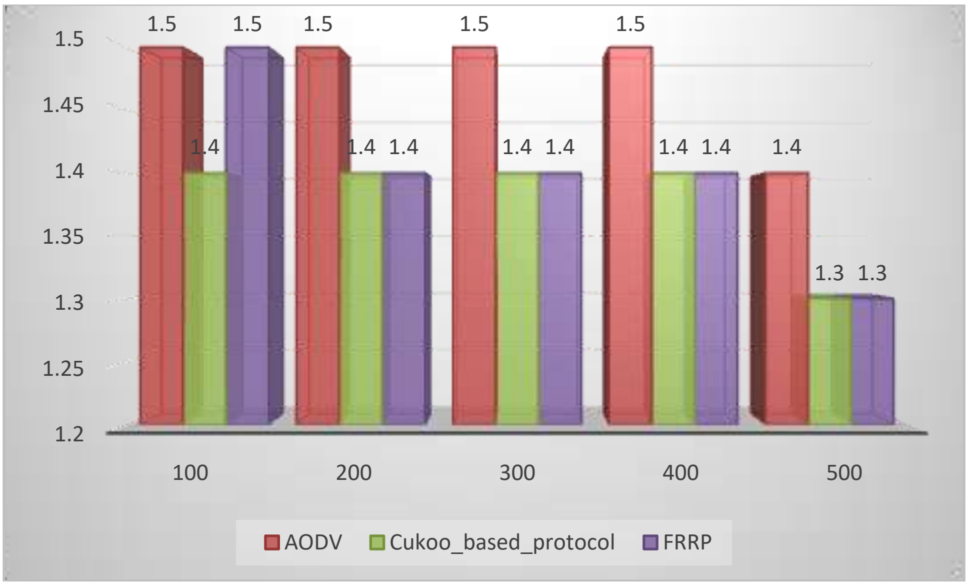

Figure7: Hop Count Analysis for Cuckoo, FRRP, and AODV Algorithms in Error-Free State

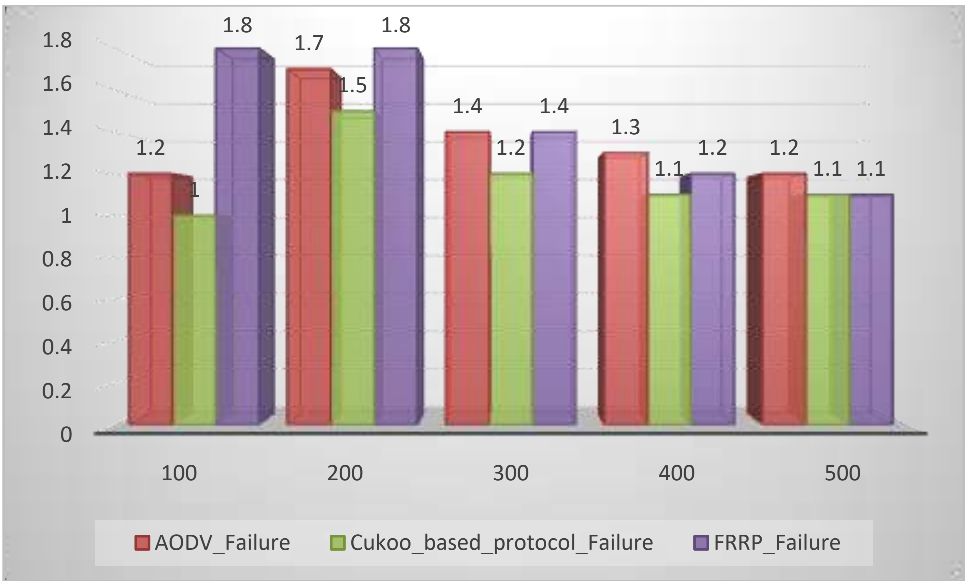

Figure 8: Hop Count Analysis for Cuckoo, FRRP, and AODV Algorithms in failure state

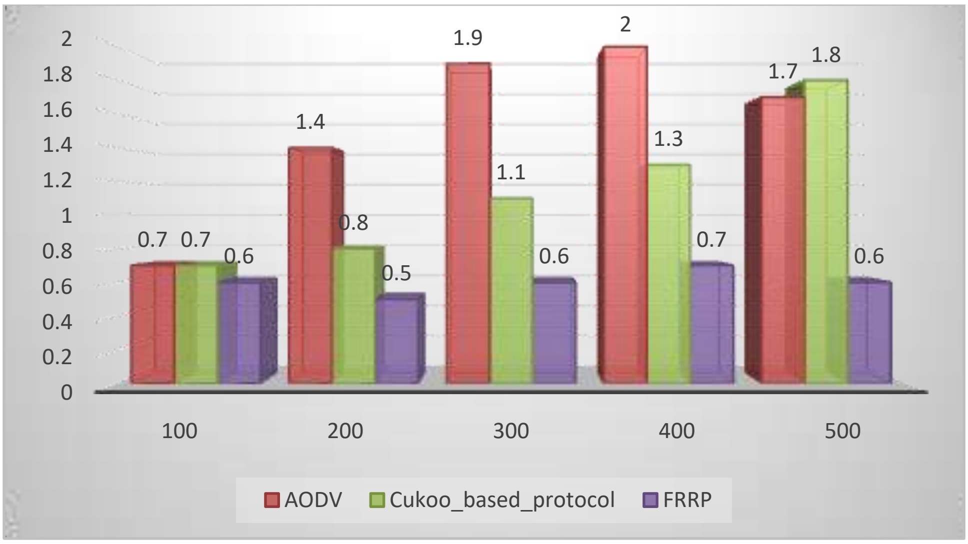

Figure 9: Network discovery time for Cuckoo, FRRP protocol, and AODV in error-free state

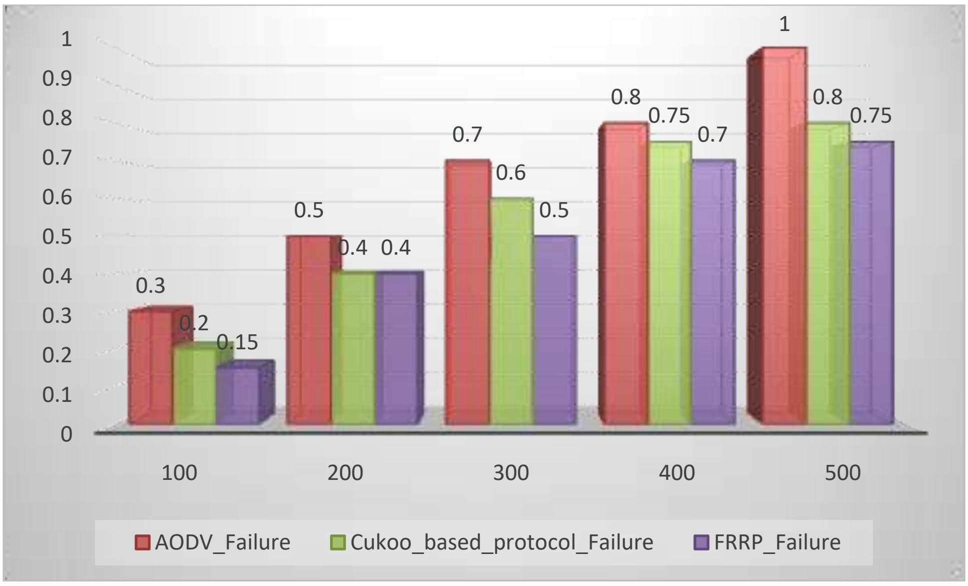

Figure 10: Network discovery time for Cuckoo, FRRP protocol, and AODV in failure state

The figure also shows that the suggested technique has a longer route discovery time than the FRRP protocol, which reduces as the simulation period grows. The FRRP protocol is responsible for this as it can identify good data transmission lines.

CONCLUSION

Network performance is noticeably enhanced by the suggested cuckoo-based routing algorithm when contrasted with conventional AODV and the FRRP protocol, which is based on fuzzy logic. Important parameters like packet delivery, network latency, hop count, and route discovery time are clearly excelled by the cuckoo method in the simulated results. The cuckoo algorithm minimizes power consumption and maximizes data transmission, especially in failure and error-free situations, by choosing more reliable and efficient pathways with fewer hops. One example of the algorithm's dependability and resilience is its capacity to respond dynamically to changes in the network, lowering latency without sacrificing throughput. When it comes to overall network efficiency, the cuckoo algorithm routinely surpasses, even if the FRRP protocol works well in stable conditions. These results point to the cuckoo-based routing algorithm as a possible future option for wireless communication system improvements, as it has the ability to significantly boost the performance of dynamic ad hoc networks.

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