Indonesian Journal of Electrical Engineering and Computer Science
Vol. 34, No. 2, May 2024, pp. 1226~1234
ISSN: 2502-4752, DOI: 10.11591/ijeecs.v34.i2.pp1226-1234

A hybrid framework for routing and channel assignment in WMN's

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Article Info

Article history:

Received Dec 22, 2023
Revised Feb 7, 2024
Accepted Feb 9, 2024

Keywords:

Ant colony optimization
Breath first search
Congestion
Greedy algorithm
Load balancing
Wireless mesh network

ABSTRACT

Wireless mesh network (WMNs) can replace the physical existence of wired network; nevertheless, to solve the problem of traffic and congestion, they must carefully arrange radio resource assignment. In this paper, we focus on the major issues while transferring the data over the network and optimization of resources. WMN mainly suffers from congestion problem when numbers of channel transfer data at a same time which indirectly leads to overlapping channels and sometime data cannot be mitigated to destination. To overcome this problem and provide optimal solution we proposed hybrid channel assignment technique which offers four phase solution technique, in this technique firstly by mitigating the traffic than assigning the optimal path based on greedy and BFS. The purpose of this congestion control hybrid ant based greedy-BFS-load balancing (CCHAGBL) technique is to diminish the number of used slots, which is directly related to the overall resource assignment. We also provide optimal solution using Ant colony optimization technique with hybrid algorithm to achieve the network efficiency and resource utilization with randomly generated traffic. With the help of hybrid ant based greedy-BFS-load balancing (GBL) channel assignment algorithm throughput and packet delivery ratio is upgraded and delay is reduced to minimum.

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1. INTRODUCTION

Wireless mesh network (WMN) is a group of interconnected systems that exchange or communicate information over a common transmission medium. A network is also defined as two or more networks that are connected to share resources such as data, printers, modems, or services such as a database or an email system and communicate via a common communications link. Individual systems must be linked via a path known as the transmission medium, which is used to transfer resources or services between computers [1], [2].

Wireless networks are multi-hop networks that use multiple nodes to communicate using radio signals is shown in Figure 1. Because it is wireless, it eliminates the majority of the restrictions of traditional wired networks [3]. The network's mobile nodes collaborate to improve communication. Each mobile node serves as both a host and a router for routing the data [4], [5]. The networks are more prone to utilizing resources and achieving throughput due to dynamic topology, restricted channel capacity, power limits, open shared medium, and wireless transmission impairments. As a result, developing an appropriate routing protocol for an ad hoc network remains a difficult issue. There are options for static channel assignment, dynamic channel assignment, or a combination of the two. capable traffic. Static channel assignment permanently tunes the interfaces at all nodes to a specific channel to eliminate cross-router interference.

Dynamic channel assignment, on the other hand, provides a system for assigning channels dynamically. The interface is moved to a different channel as the network load varies. Dynamic channel assignment is more difficult to implement since it requires an underlying channel switching algorithm, a mechanism for synchronizing channel switches, and a way for dealing with channel switch delay [6], [7]. This lag is caused by the limitations of current 802.11 devices [8]. A hybrid channel assignment can also be used, which mixes static and dynamic channel assignment shown in Figure 1. Some interfaces in these systems are assigned a fixed channel (often referred to as a control channel), while others can switch channels dynamically.

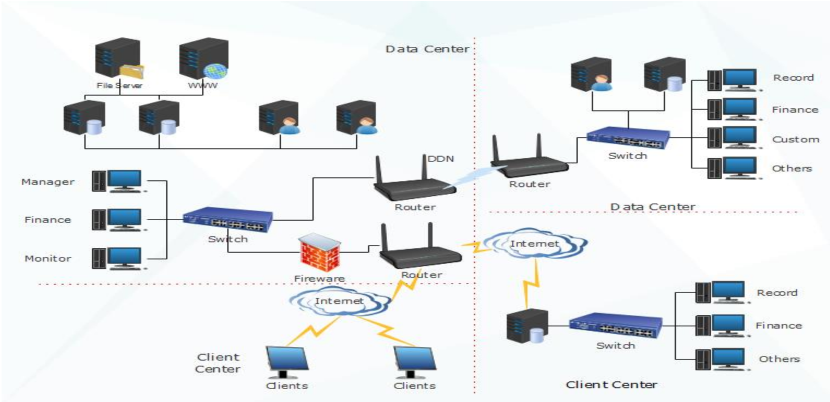

Figure 1. Communication network

While designing a WMN, several challenges are to be taken care off. For an efficient system design, we have considered the major acting factors- routing and congestion. Routing is the process of determining the best path from the source node to the destination node. Routing protocols are at the heart of multi-hop wireless networks because they manage network construction, configuration, and maintenance [9]. Routing protocols in wireless networks are classed as proactive, reactive, or hybrid (hierarchical). It generates a table to establish the full network architecture and updates the routing information regularly [10]. It depicts how proactive procedures work on multiple routers based on the static behavior of the network. Each link's cost is constant, as are the pathways. Proactive protocols are preferred for small networks due to their smaller routing and lookup tables. A given node is never aware of the network topology. Route requests are used to generate the routing table [11]. It causes greater latency since the route must be determined; nevertheless, it reduces the load of traffic control because the communication overhead is low. In general, this is best suited for networks with low node density and static traffic patterns [12]. Congestion control is a mechanism for controlling or preventing network traffic or congestion [13]. When there is network congestion, some packets are lost or damaged, and the packets do not reach their destination. There are different sorts of congestion-aware strategies that are used to prevent system congestion and packet loss. Interference becomes one of the challenges when doing channel assignments in WMNs. The issue with channel assignments is that when two or more wireless nodes assign the same channel, interference can arise, affecting data transmissions. Furthermore, this creates delay and reduces throughput [14] WMNs are gaining popularity due to the ability to maximize total network capacity by utilizing non-overlapping channels. Centralized channel assignment (CA) [15] is used in WMN to determine the current state of each node and then communicates that information to the center unit. This information provides the current state of interference, which is then accessed and allocated to a specific channel node. The centralized unit makes use of thisinformation [16]–[18].

This paper focuses on Traffic problems in WMNs because data is transmitted on the same channel at the same time, causing congestion. Due to congestion, data is received by an undesired recipient, causing packets to be dropped continually in the network and lowering overall network performance. We will utilize the multi-radio, multi-channel with hybrid routing algorithm to solve the congestion problem, which simultaneously provides many channels to each router for data transport over the network.

WMN [19] method based on access point (AP) power management to optimize load distribution and channel assignment. We develop a method that adjusts the broadcast strength of over congested access point's auto-rating is prevented since the transmitted power of the data packets is not changed. After that, the algorithm decides on a user assignment that effectively divides the workload. Ultimately, we provide a channel assignment method on every access point to minimize overall interference. The results reveal that the projected algorithm may greatly reduce congestion at multi-channel adaptive pacing (MCAP), provide improved load distribution, and improve channel assignment. This work discusses the issue of performance deterioration caused by congestion in mesh network. Further investigation of existing solutions to this problem, a cross-layer congestion control technique MCAP is developed [20], capable of increasing channel usage while improving flow fairness. On other hand, when a router experiences heavy contention, the packets it sends are coordinated and sent in groups, which improves maximum channel consumption and relieves traffic. Numerous simulations demonstrate that MCAP greatly increases network throughput. Current implemented methods, such as data center quantized congestion notification (DCQCN), are still far from perfect in a large number of likely scenarios, particularly about tail latency. To make up for this, several operators operate their networks at low average usage, which significantly increases costs. In this study, we suggest that end-to-end congestion control has reached its practical limits. WMN adoption has been rapid due to its low cost and self-organizing capabilities. Using multi-radio multi-channel MRMC, network capacity can be increased overall. IEEE 8021.11a specifies 12 non-overlapping channels. AODV-MRCR uses path optimization [21], [22] as a clever method to identify the least-interfering path and get rid of intra-flow interference to guarantee a high throughput path [23]. Furthermore, the system creates a multilink routing framework to smooth flow of data over network. The final designed approach helps to route the traffic through gateway and hybrid mechanism to divide the traffic over channels. WMNs are a promising way to offer low-cost, flexible, and speedy internet access and it gives high performance by utilizing many radios and channels. However, interference across channels is regarded as the most significant impediment to WMN performance. As a result, the quality of vital edges near gateways should be adequately evaluated during channel assignment. Otherwise, bottleneck problems may emerge, affecting network performance owing to congestion and uneven channel distribution. Unfortunately, existing channel allocations prioritize links close to gateways while ignoring other vital links [24]. In many likely scenarios, existing algorithms like DCQCN [25] are still far from perfect, particularly in terms of tail latency. To make up for this, several operators operate their networks at low average usage, which significantly increases costs. In this study, we suggest that end-to-end congestion control has reached its practical limits. The MRMC-WMN has been identified as a critical technology for improving network performance. The MRMC-WMN [26] network is a multi-hop network that allows for simultaneous data transfer over several radio interfaces [27].

The rest of this paper is structured as follows. Section 2 presents an in-depth examination of proposed hybrid ant-based greedy-BFS-load balancing GBL mesh networking solutions. And section 3 provides the simulation results. Finally, section 4 has final observations.

2. PROPOSED METHOD

In this, we proposed a congestion control hybrid ant based greedy-BFS-load balancing (CCHAGBL) channel assignment algorithm which overcomes the disadvantages of fixed and dynamic route assignment so that routes can be allocated based on dynamic traffic behavior. Hybrid netwok divide the flow of data in two parts on the basis of traffic flow and further greedy helps to allocate the channels on the bais of minimul weight of channels and load balancing maintain a queue for data transmission and then results will be evaluated and optamized used Ant colony optamization technique. This proposed algorithm create a optamized channle allocation framework to upgrade the network performance using channel assignment and congestion avoidance algorithim that is explained in subsections step by step.

2.1. Routing in multi radio multi-channel WMN

In this work, we employ multipath routing to control congestion. The majority of routing protocols only route data packets along a single path. In the presence of network congestion, this single path routing technique results in severe performance deterioration. As a result, routing data packets across various paths during network congestion minimizes the likelihood of packet loss due to primary link failure. Figure 2 consist of sub figures that shows simulations of how alternate paths between the nodes are chosen with the distance between the nodes, bandwidth, and other factors in mind. Data packets are initially delivered in the principal path. The network initiates alternate path discovery if any of the nodes on the primary path detects congestions shown below in Figure 2(a). When the intermediate node detects congestion, it sends a risk message to the source. The data packets are subsequently forwarded by the source down the other pathways [28].

Estimating available bandwidth assists in detecting congestion in each link which is shown in Figure 2(b). A link is said to be in danger of congestion if its available bandwidth falls below a certain threshold known as the critical threshold. Upon sensing congestion, an intermediate node sends a congestion notification risk (CNR) message to the source. The originating node then redirects the traffic to different pathways. Data packets are routed over the major path n1 n2 n3 n4 between n1 and n4. The total bandwidth required for this chosen primary path is anticipated to be 10, however, the bandwidth available is only 5. Congestion arises due to a lack of bandwidth. Figure 2(c) depicts the incidence of congestion in the link during data packet routing, when node n2 detects congestion on its outgoing link, it sends a congestion notification risk message to the source. Consider a scenario in which data packets are divided into smaller chunks based on an estimate of the expected transmission count and traffic is splitting shown in Figure 2(d). This estimation takes into account the path and its network connections.

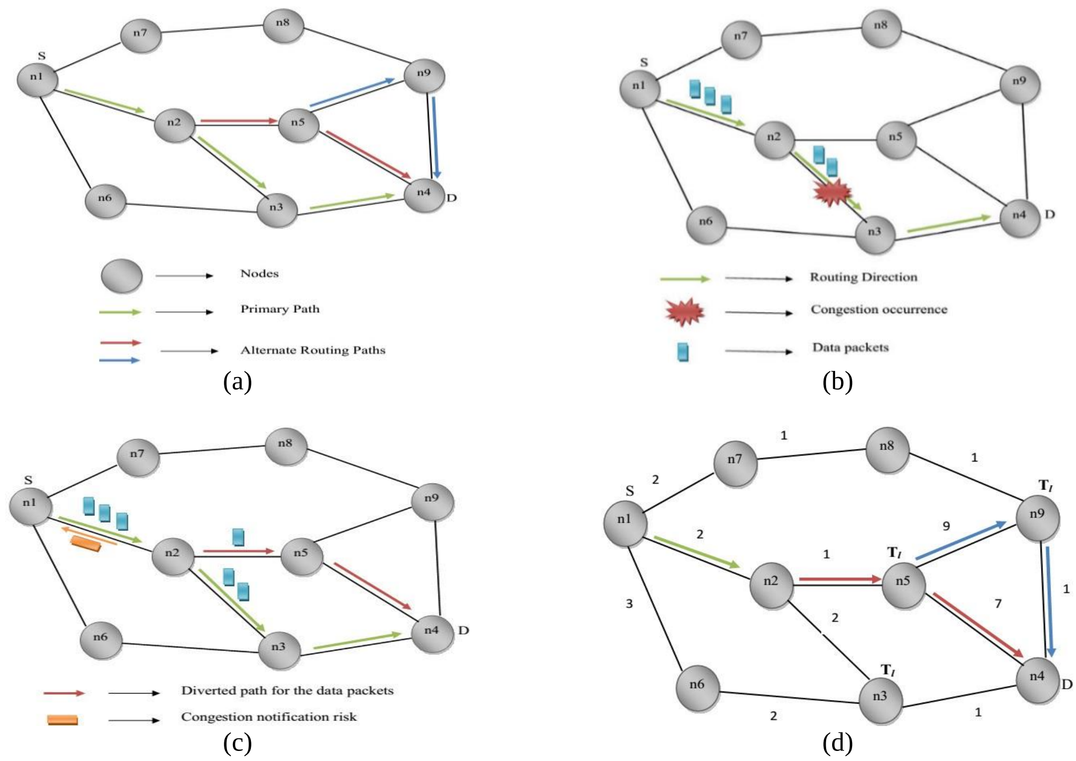

Figure 2. Steps for routing; (a) path discovery, (b) illustration of congestion, (c) congestion avoidance by routing through multiple paths, and (d) traffic splitting

2.2. Load balancing

Load-balanced routing protocols' main goal is to reroute data traffic away from crowded routes and nodes, as well as those with high data throughput rates in comparison to other nodes and routes. Data packets will take paths that may cause additional delay if there is no load-balancing mechanism in place, which may increase latency. By taking the right actions, it is possible to move traffic loads onto more efficient routes, which will improve throughput and decrease latency [29]–[31].

2.3. Channel assignment using greedy algorithm

In this phase, after balancing the load between the nodes optimal channels between the nodes are assigned through the greedy algorithm which finds the weight of each node by routing metrics, and sum of the weights of all sub-nodes from source to destination is known as final weight of the route. In a WMN, the route which is having less weight know as optimal path to greedy algorithm but the optimal path generated by greedy algorithm is not always optimal so to perform better, we will use breath first search (BFS) algorithm to choose optimal path. Several studies have been conducted to investigate the usage of greedy channel allocation algorithms in various communication systems. Zander [32] proposed a maximal independent set (MIS) technique for cognitive radios that balances utilization and fairness. Akbar and Safaei [33] focused on dynamic channel allocation in orthogonal frequency division multiple access downlink systems to show how multiuser diversity increases performance. Alghamdi [34] extended this concept to meshed wideband HF radio networks, introducing a "Constrained Greedy" channel allocation scheme that significantly boosted throughput and message latency. Greedy-based [35], [36] dynamic channel assignment strategy in cellular mobile networks that surpassed existing strategies in terms of call blocking likelihood. These studies demonstrate that greedy algorithms can optimize channel allocation in a range of communication systems. Figure 3 represents the process of proposed methodology development and is used in this paper to improve the overall performance of the network.

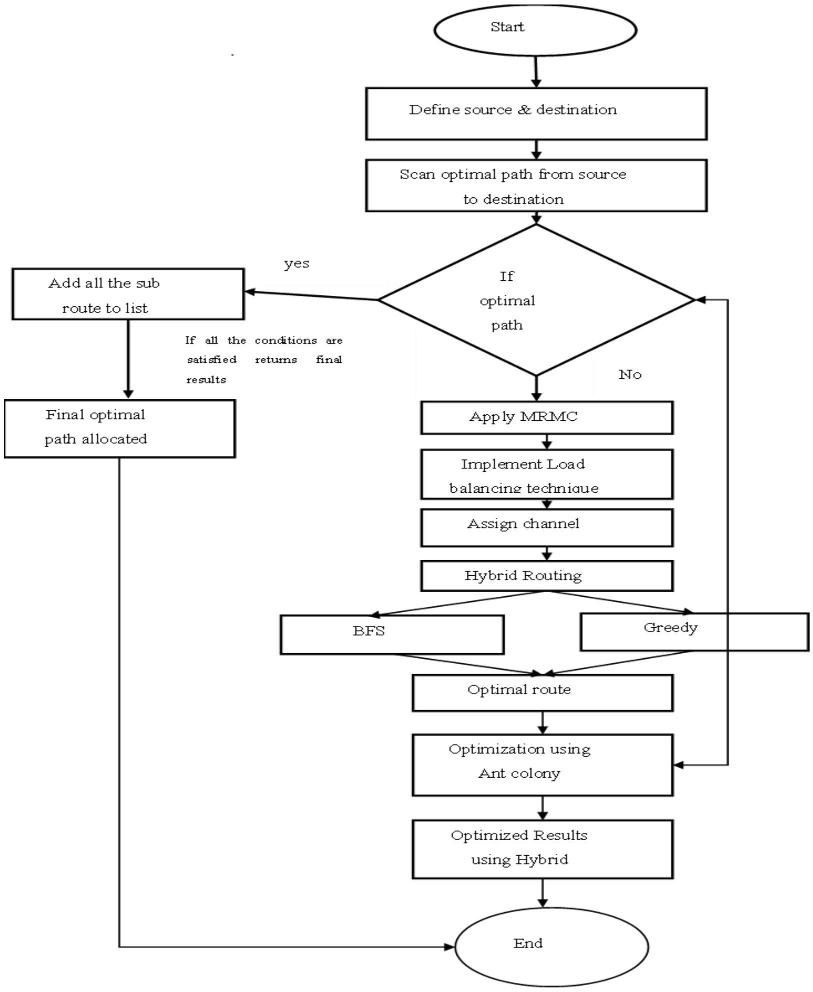

Figure 3. Flowchart for hybrid routing

2.4. Breath first search algorithm

Breadth first search is graph traversal algorithm and interference-aware channel assignment which implement on queue -based approach by initializing source vertex and visit all the adjacent nodes and put the unvisited node to the queue and it ensures that all the nodes should be traversed level wise and algorithm terminates when the queue become empty. Finally shortest path should be evaluated on the basis of visited nodes. Remember, BFS accesses these nodes one by one. If we use greedy with BFS it will perform well because routes are assigned level wise so that we can compare the weight of each sub route before finalizing optimal path in mesh network [37].

2.5. Optimization using in WMN

Ant colony optimization provide a dynamic path selection, which has many advantages for WMNs. Finding the best routes for packet routing is one important result. Ant colony optamization (ACO) can help with the selection of pathways by taking into account elements like path length, link quality, congestion, and other pertinent metrics. This will help to minimize delays and increase throughput. As a result, the network performs better, and resources are used more effectively [38]–[41].

3. RESULTS AND DISCUSSIONS

This chapter presents the simulation results obtained after the implementation of the algorithm discussed in the proposed methodology. In this section different performance metrics were evaluated to check the performance of proposed network with existing network. The existing and proposed techniques for congestion control are simulated using MATLAB by taking multiple scenarios into consideration shown in Table 1.

Table 1. Simulation parameters

Simulator	MATLAB
Number of mobile-nodes	44
Routing protocol	MRMC-AODV
Simulation time	50 sec
Network size	1000 *1000
Network	Wireless Mesh Network

3.1. Performance metrics

In this section, evaluation metrics like network throughput, end-to-end delay, packet loss ratio, and packet delivery ratio, are analyzed. In subsections, the performance of the network has been identified using different performance metrics and analysis to be done by considering the traffic flow concerning time. Different color has been used to represent the previous and proposed result.

3.1.1. Network throughput

It describes an entire number of data packets that are effectively spreading during data transmission in multicast WMN. The throughput analysis for the existing and suggested algorithms is shown in Figure 4 below. The whole simulation period is 50.0 seconds, during which data is delivered and received between nodes. The orange line represents the proposed algorithm's throughput while the blue line represents the prior algorithm's throughput. The comparison graph indicates a gradual increase in the number of requests sent to other nodes from the default source to the destination. The graph shows that as time passes, the rate of packets sent increases, which is the natural behavior of the network.

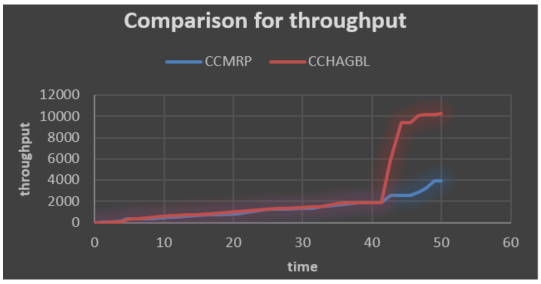

Figure 4. Comparison of throughput

3.1.2. End-to-end delay

This multicast WMN is directly compared to the distance between source mesh node and the destination mesh node. The Delay analysis for the simple and proposed algorithms is shown in Figure 5. The whole simulation period is 50.0 seconds, during which data is exchanged and received among the nodes. The orange line represents the suggested algorithm's delay, while the blue line represents the prior algorithm's delay. This graph compares delay in terms of the number of packets received at the destination. The delay time to complete the simulation has decreased while the number of packets received has increased significantly after using the technique. The orange line is significantly lower than the red line owing to the applied method, indicating that there will be less interference than in the earlier simulation of the wireless mesh protocol.

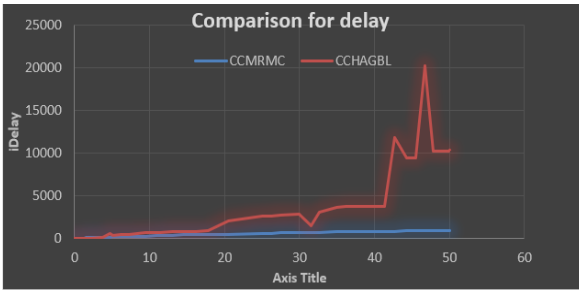

Figure 5. Comparison of delay

3.1.3. Packet delivery ratio

Packet delivery ratio in the multicast WMN is delineated as the relation among the mesh node destinations arrived packets and source mesh node produced packets. Figure 6 displays the performance evaluation of the proposed and previous scenarios using the packet delivery ratio (PDR). The orange line in the graph above clearly depicts the proposed scenario, in which the rate of packet delivery is noticeably higher than the preceding one in the blue line. The total simulation period is 50.0 seconds, during which time the sender and receiver can send and receive data packets. The rate of packet delivery ratio is continually increasing up to 50.0 sec in simulation time 40.0 sec, as a result, we find that the suggested packet delivery ration is superior than the old one.

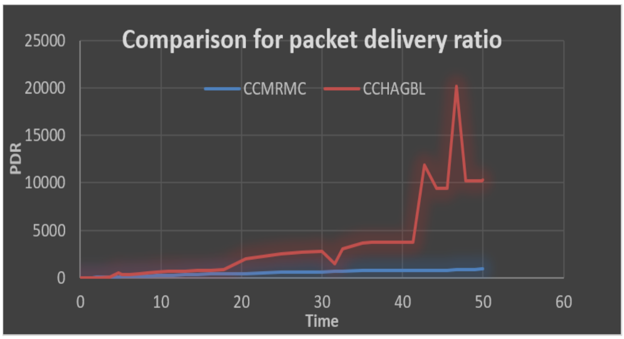

Figure 6. Comparison of PDR

3.2. Performance metrics

The performance of different routing metrics can be evaluated based on different simulation parameters time and no of packets to be transmitted within the range that is explained in Table 2. In this table, three performance metrics throughput, delay, and PDR concerning previous and proposed simulations were explained. Through analysis of metric values, we can validate that the proposed model is working optimally in the given input conditions.

Table 2. Comparison of previous and proposed simulation results

Time (Sec)	Throughput		Delay		PDR	
	CCMRMC	CCHAGLB	CCMRMC	CCHAGLB	CCMRMC	CCHAGLB
10	512	661	389	237	279	661
20	786	997	565	434	455	1,994
30	1,311	1,395	739	581	636	2,790
40	1,905	1,888	895	693	790	3,776
50	3,897	10,290	10,205	889	926	10,290

4. CONCLUSION

In conclusion, the successful implementation of a hybrid Ant-GBL channel assignment algorithm for data packet routing in a WMN is demonstrated by this research. GBL algorithm helps to allocate the optimal path based on weight of each sub route. Further ACO effectively determines the best routing path between two fixed nodes by taking into account elements like interference and congestion by considering the dynamic behavior of traffic. The ACO method successfully generates a routing table that is dynamically updated and modified to accommodate network changes. The system intelligently chooses the next hop for data packets by utilizing pheromone trails and local information sharing while taking into account the quality of networks, delay, and node congestion. Hybrid optimization algorithm improve the performance and to minimizes traffic congestion on particular networks or nodes by spreading traffic across numerous paths. This improves network performance and lowers the likelihood of bottlenecks, assuring dependable and seamless communication. Further we have evaluated the different performance metric such as throughput, delay, packet delivery ratio of the network and compare the network performance with ACO and without ACO. After implementing a congestion free network this area of research is open for implanting a real word application i.e., traffic system.

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