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Routing In Multi-Channel Allocation Using ZRP for Wireless Mesh Network

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Abstract — Wireless Mesh Network is a growing technology which is being targeted highly by researchers and has become part of our daily life. Routing has been one of the major issues in the Ad hoc networks other than interference. Various routing protocols used in wireless networks are broadly classified into proactive, reactive and hybrid protocols. The Zone Routing Protocol (ZRP) is a hybrid protocol that puts together the advantages of the proactive and reactive protocols by maintaining an up-to-date topological map of a zone centered on each node. In this paper, the proposed approach targets on improving ZRP using greedy heuristic algorithm in order to reduce end to end delay, packet loss and enhance the throughput of the network. The simulation has been performed using MATLAB R2016a and then the results are compared with existing Dynamic Source Routing (DSR). Tabu Search has been used to improve the overall performance of the network. Simulation has been carried out for 300 seconds over 10 nodes in a mesh topology and the results were then calculated and compared using different metrics.

Keywords — Wireless Mesh Networks, ZRP, IARP, IERP, BRP, Greedy heuristic Algorithm.

I. INTRODUCTION

Wireless Mesh Networks (WMNs) is an emerging technology that has brought the dream of a seamlessly connected world into reality. The existing affordable wireless mesh network technology has connected the entire city, effectively and wirelessly. The users are connected via traditional networks through small wired access points or wireless hotspots. The network connections are unrolled among tens and hundreds of mesh nodes that communicate with each other to share the network connection over a wider area. Mesh nodes are the small radio transmitters that work in the similar manner as a wireless router. 802.11a, b and g are the regular Wi-Fi standards used by nodes to interact wirelessly among different users, and essentially with one another. Basic attributes like fast and cost-effective deployment, self-manageable, infrastructure-less, etc, make Ad hoc networks quite popular [1,2].

Information travels from point A to point B across the network by hopping wirelessly from one mesh node to the following mesh node and various software are used to program the nodes in order to guide them that how to interact within the wider network . Dynamic routing is the process in which the nodes automatically choose the fastest and the secure path [3].

Different types of WSN applications can enforce various quality-of-service (QoS) requirements, e.g. gathering air parameter measurements and air quality monitoring application. Nevertheless, every WSN applications take advantage from improved network throughput, minimal end to end delays, and prolonged system lifespan [4].

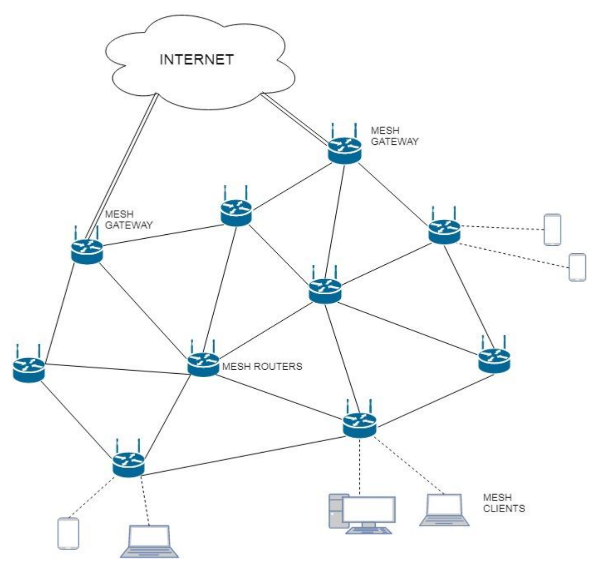

Figure 1: MRMC WMN

A wireless mesh network can be categorized into three different network architecture on the basis of their topology and node functionality stated as following [4].

1. Infrastructure/backbone WMNs
2. Client WMNs
3. Hybrid WMNs

To meet the prerequisite of different applications, many companies are using wireless mesh network technology for providing connectivity and the wider coverage area with the high speed broadband home network. The complexity of its structure is one of the major drawbacks. It enters the picture by the union of wireless technology and wireless node (router and host). There are numerous unsolved issues/problems that still prevail in the design WMN which affect its outcome. The solution to these challenges and issues can help us maximize the efficiency and improve the performance of this technology [4]. Rest of the paper is organized as follows, Section I contains the introduction of Wireless Mesh Networks, Section II contain the related work of Routing Protocols, Section III contain the network parameters, Section IV contain the architecture of Zone Routing Protocol, section V explain the proposed algorithm with flow chart, Section VI describes the performance evaluation of the existing and proposed method, Section VII concludes research work with future directions.

II. RELATED WORK

Recently the research community has paid a lot of attention to various issues related to ad hoc networks [5]. One a class where no fixed station is required for communication is known as the mobile ad hoc network, which is also a type of wireless network. A number of protocols have been suggested for routing in such an environment. Proactive and reactive routing protocols are two types of protocols where Proactive/table-driven protocols aims to maintain routes to all the nodes in the wireless network by the method known as broadcasting, which does the routing updates all the times within the network for example, TBRPF, DSDV, WRP, OLSR, FSR, and STAR whereas reactive protocols seek a route only when the source has a packet which has to be sent across the network to reach its intended destination for example TORA, AODV, and DSR [6].

The routing information is maintained from one node to another by proactive protocols using routing tables. Each and every time the route to the destination is demanded, it is instantly made available without any further delay at that very moment. If these available routes aren't used properly it can lead to massive wastage of network resources [6].

In a dynamic network, reactive protocols are often linked with minimum control traffic where nodes have to halt until route query replies are received. Also, frequent flooding of the network can lead to network congestion which can be resolved using these protocols [6].

A kind of routing protocol in which the routing depends on the technique of zones is known as ZRP [7, 8, 9, 10]. It is more of routing framework than a routing protocol as it consists of three protocols namely IntrA-Zone Routing Protocol (IARP), IntEr-zone Routing Protocol (IERP) and the Border cast Resolution Protocol

(BRP). In comparison to proactive protocols and reactive protocols, the performance of ZRP is superior.

III. NETWORK PARAMETERS

In this study the performance of routing protocol is evaluated on various metrics, namely, end-to-end delay, packet loss and throughput.

3.1. End-to-End Delay

The time taken by a packet from source 'A' to destination 'B' is known as end-to-end delay. The time taken by a packet from the source node to the destination node is determined by calculating the elapse time. Queuing, buffering and processing are different kinds of delays that occur at intermediate routers. This metric has huge significance in real time and time critical applications for swift and well-timed delivery of messages.

3.2. Packet Loss

Packet loss is the condition where the data packet transmitted from the source does not reach its intended destination. It's either caused by network congestion or the errors which are encountered during data transmission across the wireless network.

3.3. Throughput

The average rate of successful data packets received at the destination is known as throughput [11]. In video streaming, multimedia based applications, teleconferencing etc, it's an important parameter to maintain the quality of service. Signal interference and network congestion from neighboring networks severely affects the throughput.

IV. ZRP (Zone Routing Protocol)

The Zone Routing Protocol (ZRP) was created to take advantages of both on-demand and table-driven routing protocols [12, 13]. The zones of neighboring nodes overlap each other but the routing zone is defined separately for each node. The radius of the routing zone can be denoted by ρ and is expressed in hops. The particular zone inculcates the different number of nodes and farthest distance of the node is at most ρ hops.

Furthermore, the nodes of that particular zone are divided into interior nodes and peripheral nodes. The nodes, whose least distance is smaller than ρ, are called interior nodes and the nodes, whose least distance from the central node is absolutely identical to the zone radius ρ, are called peripheral nodes. By adjusting the transmission power of the nodes, their amount in a particular routing zone can be controlled. Swelling up the power in the routing zone increases the amount of nodes within its straight reach and vice versa. To provide reachability and redundancy, the amount of neighboring nodes should be adequate. In the contrary, greater coverage leads to increased members of the zone due to which updating the traffic becomes an issue [14].

Both IARP and IERP are not fixed routing protocols. The IntrA-zone Routing Protocol (IARP) has the proactive routing component whereas the IntEr-zone Routing Protocol (IERP) is marked as global reactive routing component. IARP includes proactive link-state routing protocols which preserves the routing statistics for nodes that are inside the routing radius of the node. On the other hand, IERP defines reactive routing protocols that recommend better route discovery and route maintenance services based on local connectivity supervised by IARP [14].

ZRP uses an idea called border-casting. Information about the topology is given by IARP, which is further utilized to direct query request to the border of the routing zone and the service of packet delivery is made available by Border-cast Resolution Protocol, abbreviated as (BRP). For construction of border cast trees for the query packets, it utilizes a map of a bigger routing area. The deployment of query control mechanisms can redirect route requests away from the areas that have already has covered in the network [15].

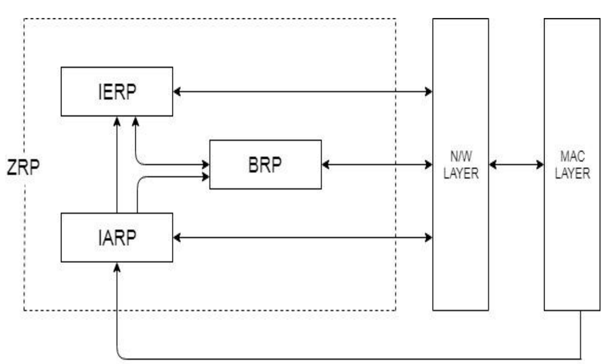

Figure 2: ZRP Architecture

V. PROPOSED ALGORITHM

Suppose, the proposed algorithm has already created a network using mesh topology with zone radius ρ and the Hop Count (HC) is taken as 1 where S = Source and D = Destination.

1. For generating the routing table in the routing zone we will use timer based link state protocol as an implementation of IARP.
2. In order to send the packets from source 'S' to destination 'D'. We first need to locate 'D' using Tabu Search i.e. a greedy heuristic algorithm for integer linear programming.
   a) The source 'S' sends IARP packets to its 'K' neighbors in the zone radius of ρ-1. If route request gets the corresponding route reply then the search is stopped else execute step (b).

   b) On N-K border nodes we will use tabu search to detect the destination node which is nearest to the current border node. IERP packets are again bordercasted. A new zone is created on the border

   c) nodes with same zone radius having M nodes. LSR protocol is used to maintain routing information.

   d) Repeat a & b until destination is found.

3. Destination dispatches a route reply packet to the source.
4. End

5.1. Flowchart:

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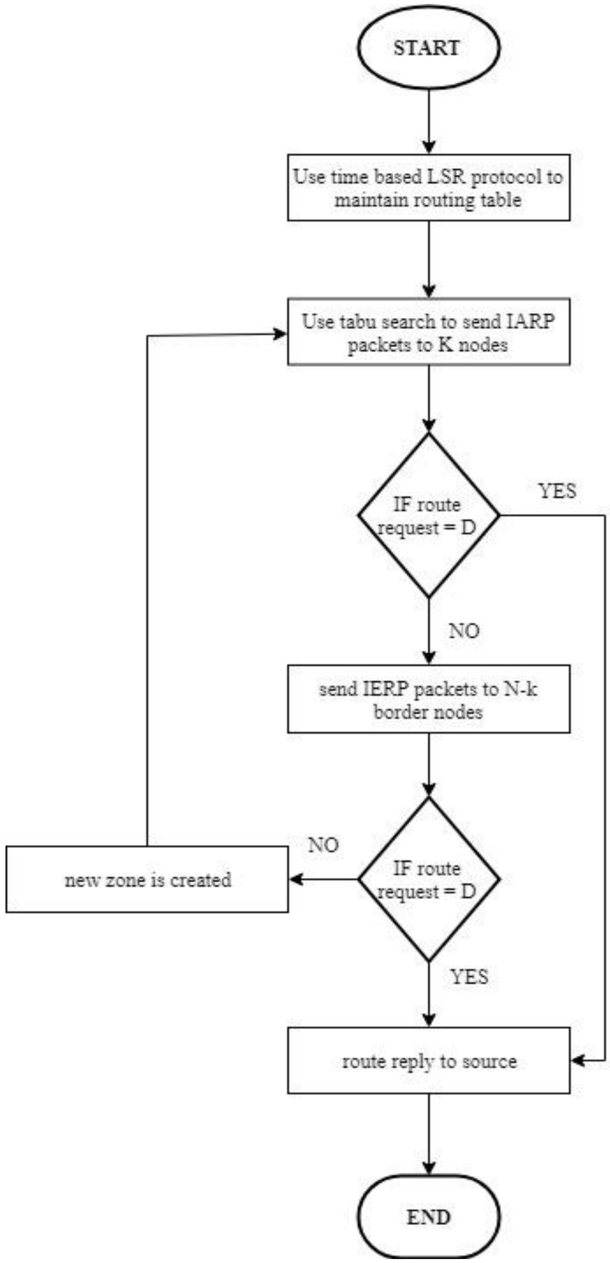

Figure 3: flowchart of the proposed algorithm

VI. PERFORMANCE EVALUATION

For implementing ZRP (Zone Routing Protocol) and ZRP-G i.e. the proposed algorithm, we simulate the results in MATLAB R2016a. The simulation is conducted in 1000m × 1000m.The constant bit rate traffic type is used in routing protocol. The total of 10 nodes is used to determine the end to end delay packet loss percentage and throughput of the network which is simulated for 300 seconds.

Following is the table describing different parameters and values used in the simulation environment:-

Table 1: Different Parameters and their values in WMN

PARAMETER	VALUE
Simulation Area	1000m×1000m
Simulation Time	300 seconds
Transmission Range	250m
IEEE Standard	802.11ac
Traffic type	CBR
No. of nodes	10
Packet size	1500 bytes
Protocol examined	Zone Routing Protocol

6.1. End to End Delay

It takes time for a packet to reach from the source to the destination and different types of delays can be experienced before the packet finally reaches its destination. In the following line graph, it can be observed that the delays are almost 37.9% more in the ZRP which uses dynamic source routing whereas the delays in the proposed algorithm i.e. ZRP-G is less due to less overhead and queuing delays as it uses the greedy heuristic algorithm. Figure 4 shows that the delay increases gradually from 0 milliseconds to 3000 milliseconds (max.) for both algorithms due to the increase in CBR flow the energy consumption at every node increases.

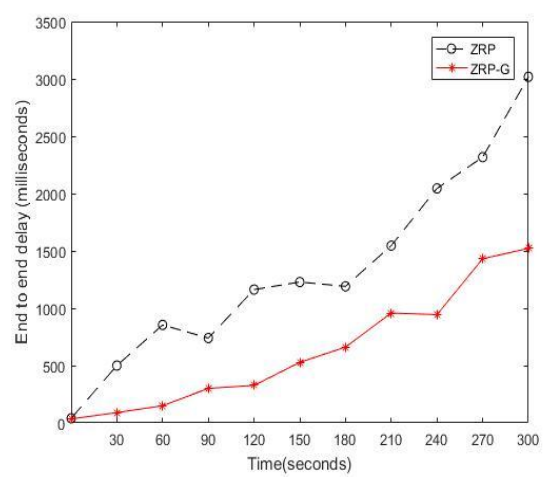

Figure 4: End to end delay in the network

6.2. Packet Loss

Packets that are intended to reach its destination are sometimes lost or get destroyed during transmission. The performance of the network is examined on this parameter and it is observed that the route recovery and maintenance mechanism of the proposed algorithm yields better results. The loss percentage varies from 0% to 30% and it increases with the increase in no. of nodes as shown in figure 5. The value becomes bit stable for ZRP and ZRP-G from 25% to 30% and 17% to 20% respectively. The proposed algorithm i.e. ZRP-G performs 30.3% better than ZRP, as its routes are more stable.

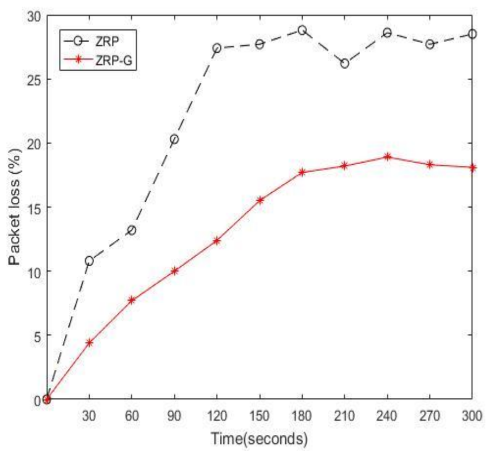

Figure 5: packet loss (%) of the network

6.3. Throughput

By varying CBR levels, the throughput of the network can be analyzed. It can be observed that both lines are almost parallel to each and due to less routing overhead ZRP-G performs 15.2% better than ZRP. Throughput for ZRP gradually decreases from 85 mbps to 81 mbps whereas for ZRP-G, it remains constant and on the upside from 93 mbps to 96 mbps. The channel allocation is optimized using the greedy heuristic algorithm as the integer linear programming method and the maximum throughput of the network is recorded at 210 second as 96.5 mbps.

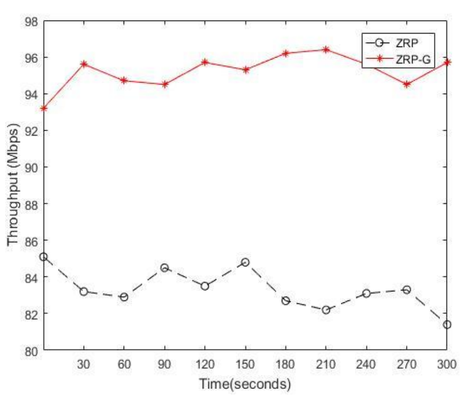

Figure 6: The total throughput of network

VII. COCLUSION AND FUTURE SCOPE

This paper proposes ZRP-G, which meets the system performance constraints by using a greedy heuristic algorithm, i.e. (tabu search) as a solution for channel allocation optimization. ZRP yields poor results as it does not have a suitable mechanism to invalidate the expired routes. It can also be observed that the quality of service for ZRP-G is better than that of ZRP as well as the solution time is reduced effectively. There is always scope of improvement in the concluded results. Rather than using TS as intEr-zone routing protocol any other optimization method can be used to calculate the results. Performance of the mesh networks can be analyzed for other parameters such as network load, network capacity, jitter, routing overhead etc. Moreover, number of nodes in the network can be increased and simulation time can be increased as well which can change the entire scenario of the simulated results.

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