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Gateway Placement Approaches: A Survey

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Abstract-Gateway placement is an important part of WMN design that determines how to place the gateways in WMN. Placing too many Gateways will, on one side improve the throughput and reduces congestion but on the other side increase interference and cost. So various approaches have been given by various researchers for Gateway placement taking care of various parameters important in Backbone network. In this paper, we present a detailed survey on various issues related to Gateway placement, approaches given by various authors along with the recommendation as to which approach is better and suitable in which condition.

Index-Terms **-Gateway, Placement, Wireless Mesh Network, Issues, Recommendation.**

I. INTRODUCTION

WMNs are undergoing rapid progress and inspiring numerous applications and have emerged as a key technology for next-generation wireless networking. Yet many research issues still exist in this field. The WMN is a hierarchical network consisting of mesh routers (MRs), gateways (GWs) and mesh clients (MCs).MRs with minimal mobility, acts as a wireless backbone, which not only provide wireless connections for MCs in their respective service areas as access points, but also relay traffic for other MRs. In the wireless backbone, gateways are special MRs configured with wired links, which act as the bridges between the WMN and the Internet. MCs are mobile clients, e.g., desktops, laptops, PDAs and phones. Each MC associates with one of the nearest MRs, and accesses the Internet by wireless multi-hop forwarding. Akyildiz et al. [5] presented a survey of WMNs, and discussed some open research issues. One of the important and challenging issue is gateway placement that is to find the optimal number and optimum location of gateways. Gateway placement determines how many gateways are needed and where they should be placed. Adding more gateways can improve network throughput, and choosing proper gateway locations can also optimize network topology and traffic distribution. But, due to expensive construction of wired links in gateways, deploying more gateways will increase the cost. In this paper we present a detailed survey on various issue related to gateway placement and approaches given by various researchers for gateway placement.

II. ISSUES RELATED TO GATEWAY PLACEMENT

A. Congestion: In WMN most of the traffic is forwarded towards the gateway, so some gateways might be overloaded while some seldom used. So one of major issue is each gateways should be placed in such a way that load is properly balanced and no node is over congested.

B.Bandwidth: Bandwidth is a rate of data transfer, measured in bits per second. While placing the gateways, one must keep in mind that the placement satisfies the bandwidth requirement of all the clients.

C.Interference: Interference in a wireless mesh network is a key issue impacting performance. The gateway node should be placed in such a way that the throughput is maximum and interference among gateways is minimum.

D.Distance: Interference among gateways will degrade network throughput if gateways are placed densely and if the distance between the gateway is too much then the signal strength is degraded. So distance between gateways should me optimum.

E.Delay: There is no direct communication between the source node and the destination node in the network, thus the data sent to the destination from the source has to be stored and transmitted by many intermediate nodes. The transmission delay time is the storage time and transmission time of the data. If the transmission path goes through too many intermediate nodes, then the frequent storage and transmission on intermediate nodes would add the transmission delay time, and the efficiency of communication will decrease. While placing for the placement of gateways one must keep in mind that the delay in transmission should be minimum.

F.Location: Location of the gateway has a great impact on network performance. If gateways as located densely then it may lead to interference and increase of setup cost and if located sparsely then it may lead to poor signal strength. So choosing a proper location of gateways is another issue.

G. Cost: If we add more number of gateways, it will improve network throughput but due to expensive construction of wired links it will increase the cost. So it is necessary to minimise the number of gateways and still do not compromise on throughput or delay.

H. Coverage: It means number of nodes served by each gateway. Each Mesh Routers must be covered by more than one gateway so that one of the gateway fails the MRs may be covered by the backup gateway.

III. STUDY OF APPROACHES FOR GATEWAY PLACEMENT

Several researchers have given several approaches for gateway placement problem. Some of them have considered some issue while others considered some other issue. In this paper we give the brief of these approaches.

A. Clustering Based Approaches

In wireless mesh networks (WMNs), load balancing placement of gateways is important to the network performance. The process of grouping a set of nodes into classes of similar nodes is called clustering. Clustering

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Based Gateway Placement Algorithm (*CBGPA*) [1] guarantees end-to-end bounded delay communications with a good handling of network scalability. While in one of the approach the researcher divided the network into a set of disjoint clusters, subject to multiple constraints, and then within each cluster a single mesh router is chosen as the gateway to serve the nodes within the cluster. Research [2-4] has used different clustering-based approaches to find near-optimal solutions to the gateway placement problem under quality-of-service (QoS) requirements (such as delay and throughput performance). In paper [2] the author addressed the problem of gateways placement, consisting of placing a minimum number of gateways such that quality-of-service (QoS) requirements are satisfied and presented a near optimal heuristics algorithm for gateway placement, and later compared its performance with some previously known sub-optimal solutions. B. Aoun et al. [3] addressed the problem of gateways placement by placing a minimum number of gateways such that quality-of-service (QoS) requirements are satisfied using polynomial time near-optimal algorithm which recursively computes minimum weighted Dominating Sets (DS), while consistently using both analysis and simulation, and showed that it outperforms other alternative schemes by comparing the number of gateways placed in different scenarios. F. Zeng et al. [4] addressed the problem of load balanced gateway placement, and proposed a greedy algorithm GA-LBC to partition a WMN into load-balance and disjointed clusters, each cluster satisfies QoS requirements. Based on GA-LBC algorithm and the principles of genetic algorithm, author proposed a hybrid algorithm HA-LBPG to get the near-optimal solution. Using this approach the number of gateways generated by HA-LBPG is nearly equal to the result from other gateway placement algorithms, and as far as the load balancing on the gateways is concerned, HA-LBPG performs much better than the other existing techniques. Bejerano[16] addressed the gateway placement problem as a variant of the capacitated facility location problem (CFLP), and proposed a clustering algorithm. Each gateway served a cluster of its nearby MRs, and a spanning tree rooted at the gateway (cluster head) was used for message delivery. Bejerano's approach [16] involves two steps algorithm. The first step was to find a minimal number of disjoint clusters containing all the nodes subject to an upper bound on clusters' radius. The second step was to generate a spanning tree in each cluster and subdivide the clusters which violated the relay load or cluster size constraints. Paper [8] has investigated the performance of several clustering algorithms for gateway placement in WMNs Using the network topology of an already-deployed network.

RECOMMENDATION - If the distance between the gateways and the routers can be bounded, load-based algorithms perform the best. However, in situations where the distance between the routers and the gateways is not constrained, interference-based approaches lead to better load distribution.

B. Antenna Based Approaches

All the approaches discussed above has studied the gateway placement problem in wireless mesh networks that have broadcasting feature using omni-directional antennas therefore interference can not be avoided. Z.Hu et al.[18] has investigated gateway placement problem in backbone wireless mesh networks using directional antenna. A heuristic gateway placement algorithm is proposed in order to minimize the total number of gateways and the average and maximum hop count between any mesh router and its closest gateway. Here, the gateway placement problem addressed is quite different because of directional antennas and all wireless links in directional BWMNs are point-to-point directional links. Interference is greatly mitigated because of the use of directional antennas. Here proposed algorithm operates as follows: In step 1 node with the highest capacity, is choosen as a gateway. At step 2 a minimum distance (h) is set to make sure that the gateways are kept apart from each other. Step 3 assures that the least number of gateways is set to meet the total traffic demand. Another researcher [19] proposed multiple antenna array based gateway considering fault tolerant issue and load balancing as well. In this approach each MR is covered by atleast two gateways so that if one of them fails other can be used.

RECOMMENDATION – Multiple Antenna based fault tolerant approach is better than others as it takes care of fault-tolerance, throughput as well as cost of setup.

C. Heuristic Approaches

Several factors greatly influence the quality of service (QoS) in multihop wireless mesh networks (WMNs). These include the transmission range, number of gateways, number of nodes served by each gateway, gateway location, relay load and access fairness. While finding an optimal solution to simultaneously satisfy the above constraints is known to be NP-hard, near optimal solutions can be found within the feasibility region in polynomial time using heuristic algorithms. A heuristic gateway placement algorithm has been proposed by P.Jun et al. [14] in order to improve throughput and connectivity of the gateways. B.He et al. [17] also proposed a heuristic gateway placement approach. The optimization objectives included not only minimizing the number of gateways, but also minimizing the average length (hop count) of MR-GW paths.

D. Throughput Optimization Approaches

Different gateway placement schemes [10-12] have also been proposed for network throughput optimization. In paper [10] an innovative gateway placement approach was proposed for (WMNs) in which the proposed gateway placement scheme provides a framework of maximizing the throughput of WMNs through proper placement of these gateways. A new performance metric called multi-hop traffic-flow weight (MTW) has been considered for measuring the location of a gateway. The MTW computation takes into account many factors that impact the throughput of WMNs, i.e., the number of mesh routers, the number of mesh clients, the number of

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gateways, traffic demand from mesh clients, locations of gateways, and possible interference among gateways. F.Li et al. [11] addressed the problem of gateway placement for throughput optimization in multi-hop wireless mesh networks. Here author proposed a novel grid-based gateway deployment method using a cross-layer throughput optimization that can be extended to work with multi-channel and multi-radio mesh networks. Q. Xin et al. [12] have studied the problem of gateway selection for throughput optimization in multi-radio multi-channel wireless mesh networks which explicitly modelled the delay overhead that was incurred during channel switching, and considered this delay issue and also considered switching overhead into the scenario of gateway placement in multi-radio multi-channel wireless networks. He also proposed a new gateway deployment method using a cross layer throughput optimization, and proved that the performance of this scheme in term of the achieved throughput is only a constant factor far to the one of optimum.

RECOMMENDATION – Q.Xin et al. mechanism can effectively exploit the available resources and achieved much better performance on network throughput than random, fixed deployment and grid-based methods.

E. Miscellaneous Approaches

W.Wu et al. [9] have considered load balancing issue in the gateway placement. To address this problem a two-stage load balanced gateway placement algorithm was proposed in which three objectives were optimized, i.e. the number of gateways, the average MR (mesh router)-GW (gateway) hop count and the variance of gateway load. The first stage was weight-based greedy gateway selection, and the second stage was load balanced MR attachment. Paper [13] addressed the reliability of multipath routing using multiple gateways in a wireless mesh network and proposed a greedy gateway placement algorithm that minimised the number of gateways needed when a maximum distance between each node and a predefine number of gateways is guaranteed. Simulations results showed that intelligent gateways placement can be employed to complement multipath routing to further improve the reliability of packet delivery. S.Tajima et al.[15] have studied the problem in order to minimize the total traffic in WMNs and presented a study of the gateway access-point selection problem for the wireless infrastructure mesh network WIMNET. They defined a cost function to minimize the total traffic in WIMNET in order to reduce congestions and present a simple algorithm. Results show that our intelligent gateways placement can be employed to complement multipath routing to further improve the reliability of packet delivery.

IV. CONCLUSION AND FUTURE WORK

Several researches had been done to place gateways in WMNs. These approaches aim to minimize the number of gateways with various network parameters, such as traffic demand, network throughput, node capacity, link bandwidth, delay, congestion etc. In order to satisfy good network performance requirement, it is necessary to minimize the number of gateways by not compromising the throughput and cost. We have analysed many approaches by various researchers who have worked on various parameter on gateway placement. We have also given our recommendation to the readers as to which approach is better than others. In future we will also build an approach for Gateway placement in Wireless Mesh Network.

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