

Comparative Analysis of Gateway Placement Approaches for Wireless Mesh Network

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Abstract:

Wireless mesh networks offer high bandwidth Internet access for mobile users anywhere and at any time. It is an emerging technology that uses wireless multi-hop networking to provide a cost-efficient way for community or enterprise users to have broadband Internet access and share network resource. In this paper, we have tried to give a comparative analysis of various Gateway Placement approaches which can be helpful in understanding which approach will be useful in which situation.

Keywords — Mesh networks, Gateway Placement, Clustering, Optimization, Throughput.

I. INTRODUCTION

A wireless mesh network (WMN)[1] is a communication network made up of radio nodes organized in a mesh topology, which often consists of mesh clients, mesh routers and gateways. The mesh clients are often laptops, cell phones and other wireless devices, which are connected to the Internet through the mesh routers. The mesh routers forward traffic to and from the gateways which is connected to the Internet. The coverage area of the radio nodes working as a single network is sometimes called a mesh cloud. Access to this mesh cloud is dependent on the radio nodes working in harmony with each other to create a radio network. A mesh network is reliable and offers redundancy. When one node can no longer operate, the rest of the nodes can still communicate with each other, directly or through one or more intermediate nodes. Wireless mesh networks can be implemented with various wireless technology including 802.11, 802.16, cellular technologies or combinations of more than one type. A wireless mesh network has some features which are similar to wireless ad-hoc network. It is often assumed that all nodes in a wireless mesh network are immobile but this is not necessary. The mesh routers may be highly mobile and are not limited to power, memory, calculating ability and operate as intelligent switching devices.

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A. Classification of WMNs

Wireless networks can be classified based on the connectivity types of the various network elements, which are either Point to Point (PTP), Point to Multi-Point (PTM) or Multi-Point to Multi-Point (MPM) networks. However, they are not scalable and their level of adaptability is low. PTM networks are moderately scalable, but they have low adaptability and reliability. In order to overcome these limitations, Multi-point to Multi-point (MTM) networks are offering features that provide high reliability, adaptability and scalability to accommodate a large number of users. As the number of nodes in the network [8] increases the transmission power needed for each node will be reduced. But, MTM wireless networks use multiple hops to increase coverage without the need for increasing the transmission power. MTM wireless networks are using today's standard like the IEEE 802.11 family. These types of networks are called mesh networks. In this paper we focus on

a special class of MTM network called Wireless Mesh Networks.

2. WMN ARCHITECTURE

In recent years, the optimizing WMN problem is interested in many researches. However it still remains open. In all of them, gateway placement is the most interested problem in optimizing WMN as most of the network traffic in such network either inside the network between the MCs via MRs or from/to the internet via the IGs and this may result in many problems such as these IGs may be potential bottleneck points because all traffics should be passed through these IGs. If the IGs placed, too far from the MRs this will increase the transmission time by increasing the number of hops that the packets will traverse from the source to the destination, which will result in delay. Thus, packet loss may happen, and if they placed close to MRs, the transmission time decreases, but the network cost will increase due to the high cost of the IG installation because of using physical links to be connected to the internet. Therefore, IG placement optimization is essential in planning and designing of the WMN, especially in the earlier stages of network design, which usually based on topology considerations to minimize overheads of using sophisticated protocols that will be used in the future to overcome the problem of IG placement in high levels of network planning and configuration. Therefore, the network performance depends largely on the optimal placement of MRs especially the IGs. In this paper, we highlight the various gateway placement approaches.

3. VARIOUS APPROACHES USED FOR GATEWAY PLACEMENT

3.1 Clustering Based Approach

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 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 [2-3] 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[6] 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 [6] 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 [5] 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

3.2 Throughput Based Approach

Throughput is one of the most important parameters that affect the quality of service of WMN.. A throughput based problem was studied by Ping Zhou, Xudong Wang, B. S. Manoj and Ramesh Rao in [7], however, their scheme was not updated step by step, and the locations of gateways were determined sequentially, so the location of previously-placed gateways affects the location of those placed later. In the paper published in [8]-[9], author studied the challenging problem of optimizing gateway placement for throughput in Wireless Mesh Networks and propose a novel algorithm based Particle Swarm Optimization (PSO)algorithm. They are generated randomly and independently, updated step by step with the best method, so quickly find the optimal scheme and achieve better result than previous studies.

Constructing computation model to calculate the throughput of WMNs is very necessary, but it is not simple to build. There are many computation models built in [10]-[14], but all of them,except [14], are not suitable for calculating through put of WMNs.

3.3 Load Based Approach

Bejerano et al. study the problem of load-balancing in mesh networks in [15]. The load-balancing algorithm is executed in a centralized point outside the mesh network, using a interference-free graph model. Several studies use

balanced trees rooted at the gateways and route traffic along the tree paths. Hsiao et al. [16] propose a distributed algorithm to find a fully top load-balanced tree, using a interference-free model. Raniwala et al. propose the Hyacinth architecture for multi-radio multichannel WMNs in [17].

Authors in [18] seek a delay-optimal routing forest, where a tree is rooted at each gateway. The cost function is not load-dependent, therefore their scheme won't achieve appreciable gains over shortest path routing in balanced topologies.

3.4 GPP Based Approach

Various techniques for GPP were used in different aspects using various methods such as Leaner Programming (LP), Integer Leaner Programming (ILP) based methods or metaheuristic methods such as Genetic Algorithm (GA).In[22], a fixed WMN Configuration model has been offered to find the maximum and the optimal throughput depending on fixed wireless nodes with specified locations where the data streams were generated logically as well as finding out how the network can be configured to attain the optimum throughput.The author prepared and investigated optimization framework to determine the optimal throughput and to lay the network configuration [19], enumerative method has been applied to bring different insights about the network structure considering the optimal routes, schedules, and physical layer factors. Thmodel assists in determining the achievable throughput in correspondent cenario [10]. In [23],an IG placement approach to minimize the number of IGs considering the bandwidth requirements in the MRs, where the Problem has been formulated as a network flow problem. A max-flow min-cut based algorithm has been developed for IG selection. An MR may be attached to multiple IGs through multiple paths [19]. In [24], a new approach has been proposed for solving the IGs' bottleneck problem in WMN, which aimed to optimize the network performance. Firstly, MRs were distributed and treated as normal nodes. Hence, a weighted objective function has been designed using the Algorithm normal distribution model to guarantee the connectivity of all nodes, including the IGs then the nodes with higher throughput and better

connectivity configured as IGs using TSP algorithm to choose among MRs [19]. In [20], a new scheme has been proposed using GA to plan and optimize to WMN backbone focusing on routing and channel assignment. The scheme achieves a good solution when dealing with large-scale WMN in relatively small computation time. The results show the effectiveness of GA operators [20]. In [21], a new scheme has been proposed for planning and optimizing WMN, GA used for planning the location of IGs and MRs as well as for routing and channel allocation optimization.

4. CONCLUSION

In the summary we would like to conclude that various researchers had given different algorithms for Gateway Placement considering different techniques and still many other researchers are working to improve upon the existing techniques. But none of the technique can fit in all cases. If some algorithm is suitable for one situation then it may not be suitable for the other. So, we cannot say that one particular algorithm may be suitable for all.

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