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Router Level Load Balancing Mechanisms in Wireless Mesh Networks - A Survey

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Abstract—Wireless Mesh Network is emerging to be the dominant technology for next generation wireless networking as it is advantageous over other wireless technologies. Load balancing mechanism at router level is essential for wireless mesh network in configuring and maintaining the topology of the network. The performance of network paths is governed by routing metrics. This paper aims at presenting the review of various techniques used for router level load balancing in wireless mesh network.

Keywords-Load Balancing, Routing Metric, network throughput, congestion, bandwidth estimation

I. INTRODUCTION

Wireless Mesh Network has emerged as a promising technology for next generation wireless networks, which offers low cost, easily deployable solution to broadband last-mile Internet access [1]. The architecture of mesh network is comprised of mesh clients, routers and gateways [2]. Mesh routers have least mobility and act as the backbone of wireless mesh network [3]. Each node in the network operates as a host as well as a router and takes up the responsibility of forwarding packets on behalf of other nodes that may not be within direct wireless transmission scope of their destinations. Clients can be of users' handheld PCs or laptops which are either mobile or stationary. One or multiple mesh routers can be connected to the Internet in case of Mesh Topology and can serve as Gateways and provide Internet connectivity for the entire mesh network. WMN contains wireless access and wireless backbone network, in contrast to other wireless networks. Wireless Mesh Network provides reliable service and is dynamically self-organizing, self-configuring, self-healing and easily maintainable. If a single node goes down, other nodes are available in the network.

The components of wireless mesh network: It is consisting of three different network elements namely, Wireless Mesh Network client, Wireless Mesh Network router, and Network Gateway.
Wireless Mesh Network Clients: They are the end-user devices covering a wide range of varieties such as laptops, handheld PCs, smart phones, etc. They can access the network for using variety of applications. These devices are considered to be mobile having limited power and routing capability. They may or may not be always connected to the network.
Wireless Mesh Network routers: They are in the network to route the network traffic. They are neither responsible for originating nor terminating the traffic. The limitation of mesh routers is, they have least mobility.
Wireless Mesh Network gateways: These are routers which have direct access to the wired infrastructure/Internet. The gateways in Wireless Mesh Network have multiple interfaces to connect to both wired and wireless networks.

In Section II describes the need for load balancing techniques in wireless mesh network. Section III covers related work pertaining to load balancing at router level in wireless mesh network. Section IV concludes the paper.

II. ROUTING IN WIRELESS MESH NETWORK

In Wireless Mesh Network, the process of routing is performed by finding a path from a source node to destination node. This process requires each node to share route information with others. The factors to be considered by an efficient routing algorithm are minimizing delay, maximizing probability of path delivery, fault tolerance and load balancing.

The primary intension of Wireless Mesh Network is to provide high bandwidth broadband service to a large community of users. As a result a great portion of users intends to communicate with the outside networks via the internet gateways, so due to high traffic there will be potential bottleneck in the gateway. Incrementing the number of gateway nodes does not improve the throughput of Wireless mesh network unless load balancing scheme is employed. If the traffic load is not taken into consideration, some gateway may be overburdened while others may not have any load. The problem of rerouting of the traffic from congested to underutilized gateways is very essential to exploit the underutilized paths in the network. Load balancing plays significant role in wireless mesh network to attain greater capacity utilization and higher network throughput.

III. RELATED WORK

There are various Load balancing techniques in wireless mesh network that can be achieved through three levels such as Path-based load balancing, Mesh-router-based load balancing and Gateway-based load balancing. We have considered router level load balancing techniques for discussion.

Router Level Load Balancing Techniques:

Hop Count based Routing algorithm [4]: In this approach, discovering multiple paths by each mesh router is easily performed based on hop count metric to the Internet Gateways. A bandwidth estimation technique is applied at each mesh router to predict the congestion risk over its connected links so that high available bandwidth link can be selected for forwarding packets. There are two phases employed in case of multipath routing protocol:

- **Route discovery phase:** In this phase, a mesh router which is need of route to internet gateway initiates the process of discovering by sending a Route Request (RREQ) to all its neighbors and inserts its sequence number to avoid the duplicate transmission of same RREQ. A mesh router after receiving the route request considers the information present in the RREQ and sets up a route back to the creator.
- P**ath selection phase:** In this phase, decision of selecting best path among the multiple paths established in the first phase is done by the source. The path selection takes place in the following manner: If there are many paths to a source's primary gateway then take the path with least hop count and if there is a tie, select a path randomly. If there is no path available to source's primary gateway but there exists several paths to secondary gateways then take the path with least hop count and if there is a tie select a path randomly.

Congestion alertness is based on bandwidth estimation mechanism. In this approach, the mesh router detects the congestion risk arising on its each link. If one of the links cannot handle more traffic, the link will not allow any more flows over that link. This algorithm is simple but it requires correct knowledge about the bandwidth.

Weighted Cumulative Expected Transmission Time with Load Balancing (WCETT-LB) is a routing metric for load balancing in wireless mesh network which is proposed by Liang and Mieso [5]. WCETTT-LB is an enhancement of the basic Weighted Cumulative Expected Transmission Time (WCETT) by integrating load balancing into the routing metric. WCETT-LB enforces load balancing at Mesh routers. WCETT-LB provides a technique for congestion aware routing and traffic splitting to achieve global load balancing in the network. Load balancing element consist of two parts namely congestion level and traffic concentration level at each node in a particular path. Congestion level at each node is valuated based on Average queue length. This average queue length

is then compared with a threshold value. If the queue length is higher than the threshold value, then the path is said to be overloaded.

- **Congestion aware routing:** In this phase a congestion threshold is introduced to find out whether a particular node in the network is congested or not .Congestion level at each node is calculated and if it is greater than the threshold value then the node will update this information by recomposing WCETT-LB. This congested node will multicast this updated routing metric to all the other nodes.
- **Load Balancing Phase:** In this the current WCETT-LB is compared with the best WCETT-LB by each node after it receives updated WCETT-LB. If it is higher than the threshold value, then the mesh router will shift from the current path to the best and thereby avoids congestion. The advantage of this is routing metric is that, it addresses both load balancing and interference. The main demerit of this metric is it introduces computational overhead.

Adaptive partitioning Approach for sink routers: Load balancing routing algorithm for Wireless Mesh Network is proposed by Choi and Han [6] focusing on sink routers. Since most traffic that is happening in WMNs is relayed to the gateways through wireless links in a multi-hop fashion, the sink routers are effortlessly overloaded. During such a situation, if a user starts off a communication session and the corresponding route toward the sink router fails to provide the required services, the session gets rejected. Thus, it is essential to attain load balancing routing which reduces the number of such rejections. The adaptive partitioning approach split up the entire network into partitions and carry out load balancing for between partitions and within partitions. This algorithm is comprised of three phases. The load balancing algorithm, PLB consists of 3 phases.

- Load-Adaptive Clustering phase: This phase takes the responsibility of partitioning the entire network into domains.
- Inner Domain Load Balancing phase: In this phase, load balancing within each domain is performed.
- Outer Domain Load Balancing phase: Load balancing across domains is performed in this phase.

Load Adaptive Clustering is executed first. Inner Domain Load Balancing runs during Load Adaptive Clustering phase and Outer Domain Load Balancing phase. Dynamic balancing of network load among domains and also load balance in a single domain is balanced significantly in this approach. As it considers the load and hop-count of nodes simultaneously, it plays a significant role in reducing the overheads for load balancing and can attain near optimal routing.

Load-Aware Routing Metric: The approach proposed by Anh-Ngoc, Dong-Won, You-Ze, Chai-Keong [7] addresses the interference and load imbalance problems in multi-radio infrastructure Mesh Networks where each mesh node is equipped with multiple radio interfaces and a subset of nodes work as internet gateways. This algorithm captures the differences in transmission rates, packet loss ratio, intra/inter-flow interference and traffic load in Multi-radio Mesh Networks. The research is based on some assumptions in channel assignment, load aware routing metric (LARM), and the operation of load balancing routing protocol for Multi-radio Mesh Network (LBM). Thus it is essential to design a generalized scheme which is free of such assumptions. According to the paper, Load Aware Routing Metric provides superior performance compared to Weighted Cumulative Expected Transmission Time approach and hop count routing metrics.

IV. CONCLUSION

Router level Load balancing protocols are essential for wireless mesh network to control the formation, configuration and maintenance of the topology of the network. Routing metrics are significant component of any routing protocol since they govern the performance of network paths. In this paper, we focused our discussion on the different load balancing techniques at router level for wireless mesh network. The algorithms which provide a promising advancement over the

conventional algorithms for traditional wireless networks are presented in this paper that can be employed to tackle load overhead in the network to a great extent.

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