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A Survey on Load Balancing Gateway Selection Techniques in Wireless Mesh Networks

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ABSTRACT: Wireless Mesh Networks (WMNs) are developing to be the key technology of the next generation wireless network. As the WMNs are envisioned to provide high bandwidth broadband service to a large community of users, it is attracting the wireless internet service providers. Internet Gateway (IGW) which acts as a central point of internet attachment for the mesh routers, it is likely to be a potential bottleneck because of its limited wireless link capacity. Indeed, if traffic is routed in the mesh without considering traffic distribution, as well as link capacities, some gateways may rapidly get overloaded due to unevenly utilization of network resources. So, whenever the users intend to communicate with the outside networks via the internet gateways the load of the internet gateway must be balanced to a void overloading any gateways. In this paper we discuss about various load balancing techniques of gateway selection.

KEYWORDS: Wireless Mesh Networks, Load Balancing, Multihop, Gateway.

I. INTRODUCTION

Wireless mesh networks (WMN) have emerged as a key technology for next generation wireless networks, showing rapid progress and inspiring numerous applications. WMNs seem significantly attractive to network operators for providing new applications that cannot be easily supported by other wireless technologies. The major incentives for the deployment of wireless mesh networks come from their envisioned advantages: extended coverage, robustness, self configuration, easy maintenance, and low cost. The major characteristics of WMN is its self-organizing and self configurability properties[3], which enables the nodes in the mesh network to instinctively establish and maintain connectivity within themselves.

A WMN is formed by a set of wireless nodes, where each node can communicate and forward data of each other. Wireless Mesh Network consists of two types of nodes: mesh clients (MCs), mesh routers (MRs). Some of the mesh routers act as gateways to the internet using the wired links. These special WMRs are called Internet Gateway (IGWs). During communication the mesh networks divide the long distance into a series of smaller hops to boost the signal using intermediate nodes. Such structural design allows continues flow of data and reconfiguration when paths are blocked or broken. WMN is fully supported by wireless mesh router network, also called Backbone Wireless Mesh Network (BWMNs). IGWs acts as communication bridges between the internet and BWMN, and provides internet accessibility. These BWMNs provide internet connectivity to MCs.

The architecture of WMNs can be classified into three types based on the functions of the nodes.

- Infrastructure/Backbone WMNs
- Client WMNs
- Hybrid WMNs

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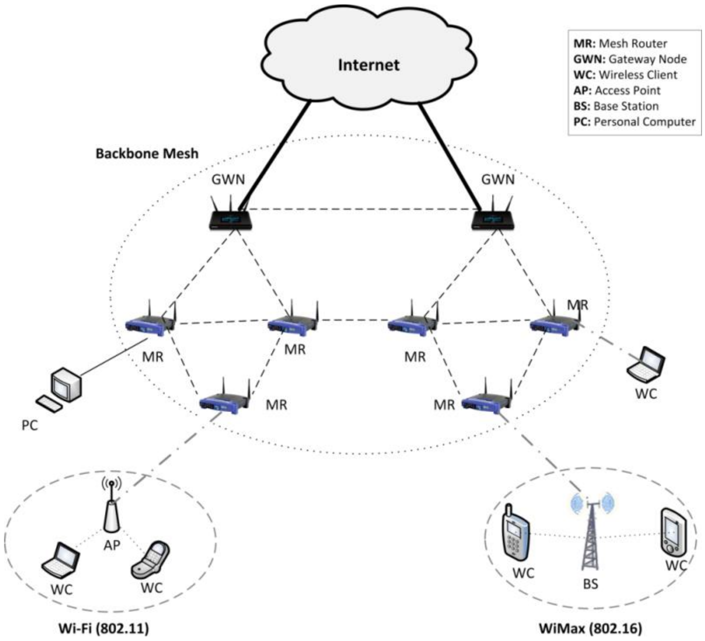

Fig.1. WMN Architectures

II. LOAD BALANCING AND ROUTING

Routing is an important factor for forwarding a data packet from source node to destination node. Wireless routing is totally different than routing in a wired network. Routing metrics are a crucial part of routing protocols affecting the performance of wireless mesh networks (WMN). When the routing protocols are implemented, the routing metrics are allocated to various paths. Their job is to compute the best routing path. The routing must enhance WMNs efficiency in terms of reliability, latency, throughput, error rate and cost.

WMN is a technology developed 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. The traffic/overload of a gateway may affect the performance of the network. If the routing algorithms doe no take into account the traffic load of the gateway into account while routing, then a gateway may be overloaded.

To mitigate this problem, multiple gateways are installed to distribute load among them, and hence, improve performance. However, increasing the number of GWs does not necessarily increase the network capacity of WMNs. Here the load balancing is very essential to avoid all the problems.

III. LOAD BALANCING TECHNIQUES

Congestion in a network causes different problems like packet drop, high end to end delay, throughput degradation etc. Different routing techniques have been suggested that considers load balancing are discussed below.

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A. *WCETT-LB[5]:*

Weighted Cumulative Expected Transmission Time with load balancing is a routing metric which is an enhancement of WCETT routing metric. WCETT-LB enforces load balancing at mesh routers and maintains global load aware routing. In this method average queue length at each node is considered for valuating congestion level. The average queue length is compared with a threshold value and if the queue length is greater than the threshold value, then the path is said to be overloaded. The actual time required for transmission can be calculated by dividing the queue length with the transmission rate at a node (bi). The routing metric for load balancing can be formulated as follows:

WCTT-LB(p)=WCETT(p) +L(p) - - - - - - - - - (1)

Where, L(p)= $QLi/binodeiEp$+min(ETT)Ni - - - - - - - - - - (2)

Load balancing component consist of two parts at each node in a particular path:

1) *Congestion Level:*
During the congestion aware routing phase a congestion threshold α is introduced to determine whether a particular node in the network is congested or not. A node *i* will calculate its own congestion level (QLi/bi) and if it is greater than the threshold value then the node will update this information by recomputing WCETT-LB, and this congested node will multicast this updated routing metric to all the nodes.

2) *Load Balancing Level:*
In the load balancing phase each node compares the current WCETT-LB with the best WCETT-LB after it receives updated WCETT-LB and if it is greater than the threshold value, then the mesh router will switch from the current path to the best there by avoiding congestion .This routing metric addresses both load balancing and interference and it effectively reduces ping-pong effect but introduces computational overhead.

B. *Hop-Count Based Congestion-Aware Routing[6]:*

A routing protocol is designed which permits each mesh router to quickly discover multiple paths based on hop count metric to the Internet Gateways. Here a bandwidth estimation technique has been proposed to apply at each mesh router to allow it to foresee congestion risk over its connected links and to select high available bandwidth link for forwarding packets.

For multipath routing protocol two phases are employed, they are

1) *Route Discovery Phase*
In the route discovery phase, whenever a mesh router needs a route to an internet gateway, it initiates a router discovery process by sending a route request (RREQ) to all its neighbours. The creator of the RREQ inserts its sequence number to avoid transmitting the same RREQ twice. A mesh router hearing the route request uses the information in the RREQ to set up a route back to the creator.

2) *Path Selection Phase*.
During the path selection phase a source should decide which one is the best path among the multiple path established in the route discover phase. The path selection can be prioritized in following order:

- If there exist manifold paths to a source's primary gateway then, take the path with lowest hop count and if there is still a tie, we can select a path randomly.
- There is no path to source's primary gateway but a several paths to secondary gateways then, take the path with lowest hop count and if there is still a tie select a path randomly.

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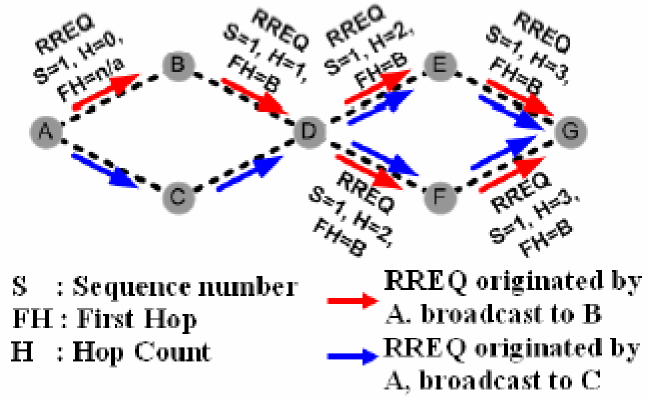

Fig 2: Broadcasting RREQs[6]

Congestion vigilance is based on bandwidth estimation technique. For that the available bandwidth on a explicit link should be identified .Here the consumed bandwidth information can be piggy packed on to the "Hello" message which is used to maintain local connectivity among nodes. Each host in the network determines its devoted bandwidth by monitoring the packets it sends on to the network. With the bandwidth estimation mechanism the mesh router can detect the congestion risk happening on its each link.

We assume that a link is in risk of congestion whenever the accessible bandwidth of that link is less than a threshold value of bandwidth. If one of the links cannot handle more traffic , the link will not accept more flows over that link. The main advantage of this protocol is its simplicity of routing algorithm but it requires accurate knowledge about the bandwidth.

C. *Load Balancing Through Multiple Gateways[7]:*

This technique balances the load among different internet gateways (IGWs) in a wireless mesh network. Depending upon the average queue length at the IGW, the gateway which services the active source can be switched.

The load balancing scheme includes two modules:

1) *Gateway Discovery Modules:*
This module determines a primary gateway for a mesh router and a load balancing module that rebalances the load among the gateways. During the gateways discovery phase all nodes discover their primary gateways. The gateways inform their presence by sending periodic beacons. On receipt of a beacon signal the node will register itself to the gateway.

2) Load Balancing Modules:
After the initial gateway discovery procedure, in the second phase, each IGW continuously monitors its queue length during a time window. When the average queue length exceeds a certain threshold value, the gateways sends a congestion notification message to the active sources.

D. *Distributed Load Balancing Protocol[8]:*

In this protocol the gateways coordinates to reroute flows from congested gateways to other underutilized gateways. Along with load balancing this scheme also considers interference which makes it suitable for implementation in practical scenarios, achieving good results and improving on shortest path routing. Here the mesh network is divided into domains. A domain *di* can be defined as set of sinks served by gateway, where sink is a router that receives internet traffic. For each domain a specific capacity is assigned and is compared against the load in the

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domain. The load is represented as the demands of the sinks. If the load exceeds the tolerable capacity then the domain is considered as overloaded. To avoid congestion in a domain we can reroute the traffic. This technique does not impose any routing overhead in the network.

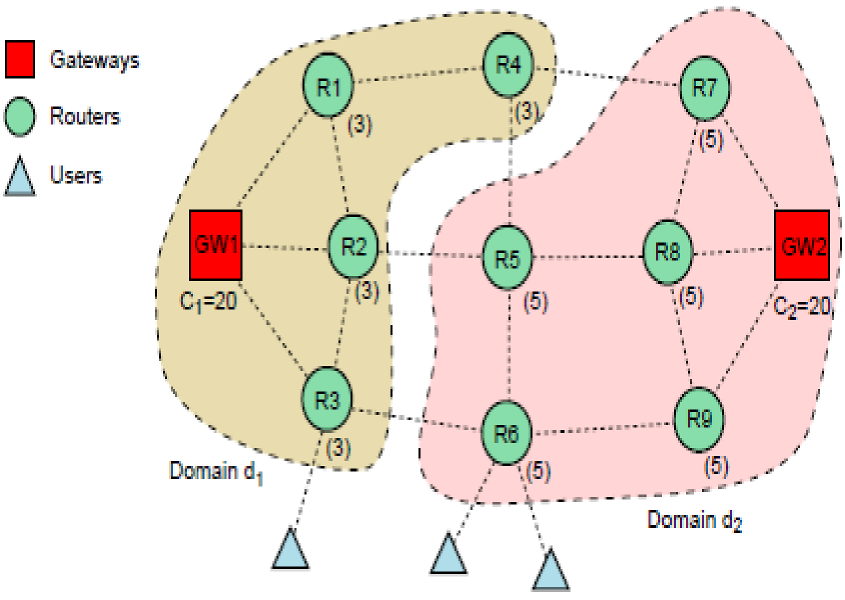

Fig 4: Mesh network divided into domains for load balancing [8]

E. *Gateway-Aware Routing:*

Here a gateway mesh aware routing solution that astutely selects gateways for each mesh router based on multihop route in the mesh as well as the potentiality of the gateway. A composite routing metric is designed that picks high throughput routes in the presence of multiple gateways. The metric designed is able to identify congested portion of each path, and choose an appropriate gateway. The gateway capacity metric can be defined as the time needed to transmit a packet of size S on the uplink and is expressed by

$$gwETT=ETXgw\ S/Bgw \text{ - - - - - - - - - - - - - } (3)$$

where ETXgw is the expected transmission count for the uplink and Bgw is the capacity of the gateway. For forwarding packets a GARM(Gareway Aware Routing Metric) is defined which is follows:

$$GARM = \beta.Mi + (1-\beta)\ .(mETT+gwETT) \text{ - - - } (4)$$

This Gateway-aware Routing Metric has two parts.The first part of the metric is responsible for bottleneck capacity and the second part accounts the delay of the path.To control the balance between these two factors β is used. The gateway with least GARM value can be selected as the default gateway for balancing the load. This paper overcomes the disadvantage of accurate bandwidth estimation suggested in [6] and also improves network throughput.

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IV. COMPARISON FOR LOAD BALANCING GATEWAY SELECTION TECHNIQUES

TECHNIQUE	METRIC USED	ADVANTAGES	ISSUES	THROUGHPUT
WCETT-LB	WCETT-LB	Low routing overhead Reduces ping- pong effect.	Computational overhead.	180pks
Hop Count based Congestion Aware routing.	Hop Count	No routing overhead.	Computational overhead. Accurate bandwidth information required.	5.5Mbps
Load Balancing through Multiple Gateways.	Queue Length	Low end to end delay	Routing Overhead.	350 Kbps
Distributed Load Balancing Protocol	Hop Count	No Routing overhead.	Computational Overhead.	1100 Kbps
Gateway-Aware Routing	GARM	No routing overhead, High throughput.	Computational Overhead.	7 Mbps

V. CONCLUSION

Load balancing is a significant issue that needs to be addressed in wireless mesh networks. The nodes in a wireless mesh network communicates in multihop manner, this causes congestion in the network due to high traffic towards the gateway. Load balancing is essential to utilize the entire available paths to the destination and prevent overloading the gateway nodes. In this paper we surveyed different load balancing techniques with different routing metrics that can be employed to tackle load overhead in the network to a great extent.

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