Improving Overall WMN Performance in Peak Times Using Load-sharing Aware Gateways*

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Abstract

In recent years, Wireless Mesh Network (WMN) is a compelling topic to many network researchers due to its low cost in deployment, ease and simplicity in installation and scalability and robustness in operation. In WMN, Gateway nodes (Access Point-AP) are in charge of steering the traffic from the external network (e.g. Internet…) to client devices or mesh clients. The limited bandwidth of wireless links between Gateways and intermediate mesh routers makes the Gateways becomes the bottleneck of the mesh network in both uplink stream and downlink stream. In this paper, we propose a mechanism to permit Gateways collaboratively work to manipulate the traffic to fit our network. They will move the traffic from congested links to the unused capacity on other links.

1. Introduction

WMN has emerged as a promising technology with many important attributes: reliability, adaptability, simplicity but scalability and cost saving. A mesh architecture comprises of mesh routers and mesh clients. The mesh routers, considered stationary or low mobility, are ad hoc-like connected to form network backbone. Some of them operate as Gateways to the Internet where they act as proxies for admission control and flow reservation [1]. Through the backbone formed by mesh routers, mesh clients can access the Internet through intermediate mesh routers before getting corresponding Gateways.

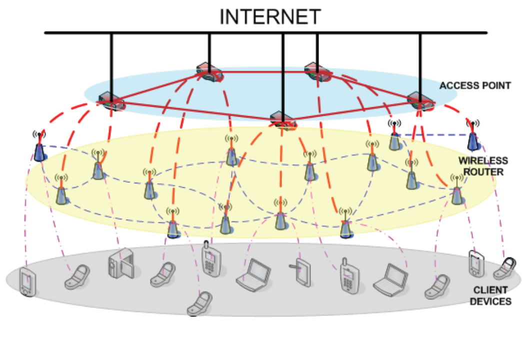

Figure 1: A typical wireless mesh network.

Generally, although network suffers a rapid traffic growth, network outages which can cause major demands for bandwidth, we often have links in our networks that are underutilized. That situation likely happens in WMN where some Gateways overwhelm direct links on the routes from them to the destination while the other routes to the destination from other Gateways still have available bandwidth. It results in degradation in overall network performance. Our work is to design a mechanism to prevent Gateways from being the bottlenecks of the network by letting them co-operate to share the load.

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The rest of this paper is organized as follows: Section 2 lists related work and the inspiration leading to our idea. Section 3 depicts the network model and our proposed mechanism. Section 4 presents our performance analysis on the proposed scheme using ns2. Section 5 concludes main points of this paper and future works.

2. Related Works

Gateways are now considered the weak points in wireless mesh network due to their limited bandwidth direct links connecting them to intermediate mesh routers on the way to destination. Many research on Wireless Mesh Network focused on designing new methods for each Gateway individually. It is suggested that intermediate mesh routers will run multi-path routing protocol described in [2] to setup routing table from them to Gateways. After that one mesh router should choose the best route in multiple routes leading to Gateways for their applications to increase the quality of service. As for Gateways, they can balance the load among the paths [3] to avoid congestion. In [3], they proposed a mechanism in which Gateway can notify to source node to migrate the traffic to another Gateway when congestion happens. However, the authors just consider the situation in which the source node is sending the traffic to external network while download stream are always many times larger than upload stream in multimedia applications.

Our proposal is inspired by the existing studies about Resource Reservation Protocol and how to apply that protocol in traffic engineering in WMN. To do that, each Gateway must be capable of supporting a mechanism that can establish a route among Gateways that can reach the same destination. Traffic will be shared among them through a wired network when congestion happens in peak times.

3. Network model and proposed mechanism

3.1 Network model

In our discussion, mesh routers run multi-path routing [2] to set up multiple routes to Gateways. So, a destination can be reached from more than one Gateway. In the topology shown in figure 2, from gateway GM1, we have two routes to get to MR3: (R1) GM1→ MR1→ MR2 → MR3 and (R2) GM1→MR4→MR5→ MR3. From GW2, we have only one route to reach MR3: (R3) GM2→MR6→MR7→MR3.

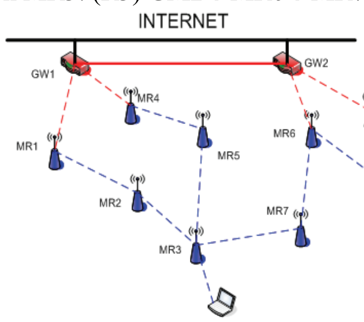

Figure 2: Mesh network scenario

We suppose that the traffic from the external network is now occupying all the bandwidth on both links GW1→MR1 and GW1→MR4. In this case, a bandwidth request for a new connection to destination MR3 from external network will be rejected by GW1 to ensure the quality for existing connections. Meanwhile, the bandwidth on link GM2→MR3 is still enough for the new requests but GW2 doesn't know about the congestion happening to GW1. So, we propose a mechanism which permits GW1 to ask GW2 if GW2 can help GW1 to share the load of new connections to MR3. Obviously, GW2 can do that because it can reach MR3 through (R3) GM2→MR6→MR7→MR3.

3.2 Proposed mechanism

If a Gateway receives a request for bandwidth from another Gateway to establish a new connection to a certain destination, it first checks for the capacity of its direct links on the routes to the expected destination. If it can find out a route satisfying the requirement of connection, it sends a message to accept the request to requesting Gateway. If it realizes that it can not reach the destination or a new request connection will impact the quality of existing ones, it will send a message to decline the suggestion.

In the scheme shown in figure 3, we see that external network wants to set up three new connections to the destination through GW1. Connection 1 accepted by GW1 means that GW1 can assure its requirement. When connection 2 comes later, GW1 finds that the available bandwidth on its direct link to the destination node can not handle the requirement of new connection. So it sends ROUTE_REQUEST message to ask GW2 for help because GW2 is in reach of GW1. GW2 also has a route to the destination and that route now can support the request, so it accepts the request from GW1 by sending ROUTE_ACCEPT message. Connection 2 is then accepted by GW1 and the traffic of connection 2 is routed from GW1 to the right destination through GW2. After that, the connection 3 comes to GW1, GW1 repeats its checking and send ROUTE_REQUEST to GW2 to ask for a route to the specific destination. GW2 now can not accept the connection due to following possible reasons: GW2 doesn't know the destination node or GW2 can not accept more traffic on the route to required destination to avoid congestion. So it refuses the request by the message ROUTE_REFUSE. GW1 continues sending ROUTE_REQUEST to GW3. GW3 now can accept the route, so it sends ROUTE_ACCEPT to GW1 to accept the connection. GW1 then assigns the new connection traffic to GW3. Finally, the connections end at GW1. Other Gateways are not responsible for managing the new connections but helping GW1 to setup paths.

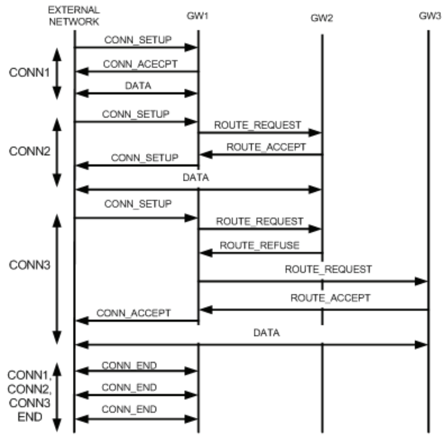

Figure 3: Connections setup scheme for new mechanism

4. Performance analysis

This session presents the simulation results for our proposed mechanism using NS-2 simulator. The goal of this simulation is to evaluate the quantity and quality of connections established by GW1 in two cases: with and without the proposed mechanism. In the scenario shown in figure 4, there are 4 mesh routers connected with each other by a 100 Mbps Ethernet network and acting like Internet gateways. Each Gateway connects with one wireless mesh router using 802.11b standard which supports 11Mbps maximum data rate. The mesh routers connect with each other to form the backbone. They also use 802.11b for data transmission.

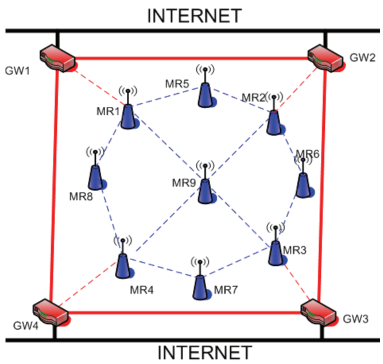

Figure 4: Wireless mesh network simulation scenario

Table 1 shows the setup time, destination and bit rate (constant bit rate) of incoming connections at GW1 (suppose that the simulation starts at t=0s and stops at t=25s). All the connections have the same data transmission speed.

Connections	Setup time	Dest.	Rate
1, 2, 3, 4	t=1s; 1.5s;2s;2.5s	MR1	1Mbps
5, 6, 7, 8	t=3s; 3.5s;4s;4.5s	MR5	1Mbps
9, 10, 11, 12	t=5s; 5.5s;6s;6.5s	MR8	1Mbps
13, 14, 15, 16	t=7s; 7.5s;8s;8.5s	MR9	1Mbps

Table 1: Connections parameters

Before simulation, we can predict that if all 16 connections pass through GW1 on GW1-MR1 link to get to their destination, that link will be overloaded. So, the later connections will be dropped by GW1 to avoid congestion. Figure 5 shows the results of dropping connections. While connections from 1 to 10 can get enough bandwidth, those from 11 to 16 can not be set up due to congestion at link GW1-MR1 and get dropped. In the figure, we see that dropping connections can not get any bandwidth from GW1's admission control.

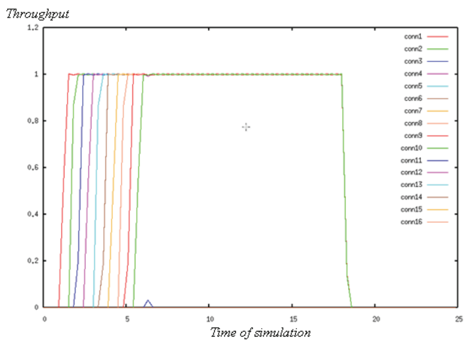

Figure 5: Throughput V.S. time of connections (without new mechanism)

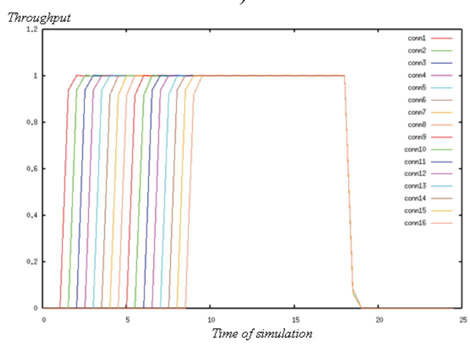

Figure 6: Throughput V.S. time of connections (with new mechanism)

Now we enable new mechanism that permits GW1 to ask GW2, GW3 and GW4 to help it route the traffic of connections to the destination if possible. When connection 11th comes, the admission control at GW1 realizes that the available bandwidth is not enough for the new one. So it asks for support from GW2, GW3 and GW4. In figure 6, more 6 connections are successfully set up. The total number of connections is 16 and all of them have enough bandwidth.

Figure 7 shows the relations between the number of connections owned by GW1 and the number of Gateways in assumption that all four Gateways can reach the same expected destination. The blue line (1) is the upper bound of the number of connections when all gateways can share 100% their own bandwidth with GW1. So the total number of connections established by GW1 is up to 40 with 4 free Gateways. The green line (2) is the lower bound of connections when new mechanism is not applied. The number of connections is independent on the number of Gateways. It is equal to the maximum number of connections which GW1 can manage. Two other lines, (3) and (4) lie between upper bound and lower bound. The cyan line (3) illustrates the situation in which 2 connections are shared by GW2, 2 by GW3 and 4 by GW4. Similarly, red line (4) shows that 3 connections are supported by GW2, 2 by GW3 and 1 by GW4.

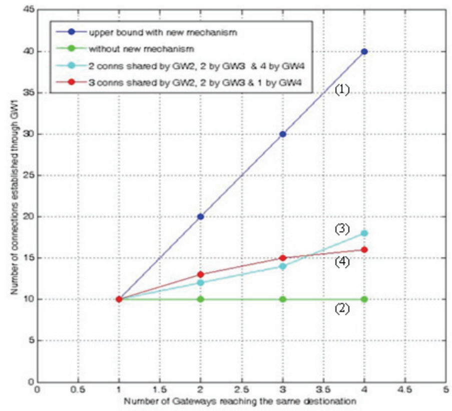

Figure 7: New mechanism supports more connections for a specific Gateway.

5. Conclusions

In this paper, we propose a traffic engineering method to use effectively all available resources in network instead of installing a new hardware to get better network performance. This mechanism is likely to apply to some partial upgraded wireless mesh networks where bandwidth is underutilized at some places but seriously deficient at other places. The simulation partly demonstrates that our proposal is able to improve overall network performance by assuring an adequate bandwidth for connections through sharing the load among Gateways.

As a part of future work, we plan to apply this mechanism in association with diffserv-aware gateways to guarantee QoS for each kind of services.

References

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