WDS-Based Layer 2 Routing for Wireless Mesh Networks

[Extended Abstract]

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1. INTRODUCTION AND MOTIVATION

An increasing number of people today depend on the ability to connect to wireless network access points in a variety of situations. While one-hop access points were a suitable solution in the beginning, they suffered from problems such as low coverage area and over-load. One promising solution is the use of wireless mesh networks (WMNs). This allows wireless access points to be placed in a very flexible fashion, so that they can extend wireless coverage into places that do not have easily accessible wired infrastructure.

There are existing projects that examine some methods for deploying mesh access networks. For example, the MIT Roofnet project [1] has created a system that can easily add new access points at random, and incorporate them into a large scale mesh. However, we are more interested in a planned mesh network. In such a network, concepts like quality of service will be important, so a robust admission control scheme is necessary.

This poster will present a foundational centralized route-management system for WMNs. Our scheme is based on the *Wireless Distribution System* (WDS). Our work has been an extension of the existing implementation of WDS in the MADWiFi driver for Atheros wireless LAN chipsets.

We are interested in provisioning quality of service guarantees for planned WMNs being used as access networks, as well as providing fault tolerance. Very few admission control schemes have been proposed so far for WMNs, and most apply to the case of unplanned WMNs, using routing protocols developed for ad hoc networks. Planned WMNs are witnessing an increasing number of deployments across enterprises, universities and cities. These networks will require an efficient admission control scheme in place for providing better service to end users. By implementing a centralized routing scheme for WMNs, we can provision QoS guarantees such as admission control in the network. The lack of an existing routing protocol for planned WMNs prompted us to look at a new approach for routing in WMNs.

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2. WDS ROUTING

IEEE 802.11 frames generally use only three of the four available address fields, with the address1 field holding the address of the intended receiver and address2 field indicating the address of the station transmitting the frame. WDS is a mechanism to enable the 4-address format for 802.11 frames. This 4-address format enables the implementation of relay type devices, such as wireless repeaters or an infrastructure mode device with bridging capabilities [2]. In the 4-address WDS mode, the final source and destination addresses can be different from the receiver or transmitter address.

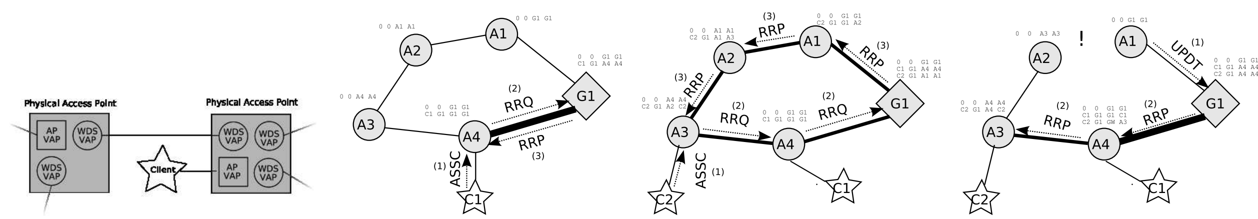
We propose a centralized WDS based, layer 2 routing scheme for wireless mesh networks. We can specify the next hop towards the final destination, using Layer-2 MAC addresses at each node. In this way, we can control the route taken by each flow. To achieve this, we propose to construct flow-based MAC tables at each wireless router. For an incoming packet, the router will match the packet to an appropriate flow entry in the table and then forward the packet to the next hop as specified in the table.

The MAC tables will be populated by a centralized controller. Each mesh AP in the network sends periodic information back to the central controller, indicating neighbors, traffic flow through that AP, and channel conditions. An edge AP, on receiving a connection request would send a Route Request to the central controller. The controller, having a global view of the network, will find a route from the source to the gateway node and send back a Route Reply on the chosen route. As the Route Reply traverses each node towards the source, it will set the appropriate entry in the MAC table of those nodes. The requesting AP will then forward the packet to the next hop in its MAC table and so on.

Figures 1(b)-1(d) show how the centralized controller can use information received from mesh APs to manage admission control and fault tolerance. Figure 1(b) shows the steps for a basic client connection. In this case, there is only one hop in the mesh to update, and so the path for the RREQ and RREP messages is the same. Figure 1(c) shows a more complex case. Here, the centralized route controller decides

Mode	To DS	From DS	No. of Address Fields	Address 1	Address 2	Address 3	Address 4
Ad hoc	0	0	3	RA=DA	TA=SA	BSSID	N/A
LAN access	0	1	3	RA=DA	TA=BSSID	SA	N/A
LAN access	1	0	3	RA=BSSID	TA=SA	DA	N/A
4 address	1	1	4	RA	TA	DA	SA

Table 1: To/From DS and address fields



(a) AP Details (b) The first client connects (c) Another client comes in (d) A path fails

Figure 1: Layer 2 Routing Scheme

to assign the path A1 A2 A3 C2 for the second client, since there is less traffic along that path. In the third example, shown in figure 1(d), the link between A2 and A1 is damaged. A1 notifies the gateway that A2 is no longer its neighbor, and the gateway recomputes the necessary paths and sends out any route replies that are necessary: in this case, the route for C2. Although this adds more bandwidth pressure to the A4-G1 link, it is better than having no route at all.

3. IMPLEMENTATION

For our implementation, we are using the Soekris net4826 [3] embedded devices. This device runs on a 266 Mhz 586 processor with 128MB SDRAM main memory and 64MB compact flash for the Operating System and other storage. They are optimized for wireless communications with dual Mini-PCI Type III sockets. We use the MADWiFi drivers for Atheros wireless cards [4]. These drivers include some basic support for 4-address MAC headers, which we extend to implement the system described in this poster.

In our system, each physical access point contains a number of virtual access points, or VAPs, as shown in Figure 1(a). Each VAP either maintains a peering connection to another physical AP, or maintains a number of client station connections. A VAP that is configured to connect to a neighboring AP is called a WDS VAP, while a VAP that is configured to connect to a number of clients is called an AP VAP. We create the necessary VAPs manually to reflect the mesh topology that we create, but in future works, VAPs could be created automatically.

The mesh network is initialized with a starting static topology along which control packets can be routed to a gateway. This initialization process is done manually for now, as the network is deployed, but it could be done automatically, as well. When a client connects to an AP, the new MAC address is sent to the gateway so that a new data path can be determined for that client.

With the current MADWiFi WDS implementation, a 4-address packet that is received from a nearby node is sent, where Ethernet bridging pushes it immediately back to all of the other VAP interfaces. Each WDS VAP interface has a forwarding list that is a table modified by RREP packets that pass by. If the source address in the MAC header is in the WDS VAP's forwarding list, that WDS VAP will forward the packet to its single WDS peer. Otherwise, it will simply do nothing.

The forwarding control table in each WDS VAP contains 4 fields: the source MAC address, the destination MAC address, the outbound next hop, and the inbound next hop. These are shown next to nodes in Figure 1. When the WDS VAP receives a packet, it searches through the forwarding table to find an entry containing both the source and the destination MAC address. If it does not find such an entry, the packet is dropped. If it finds an entry, and the source address and destination address correspond, the outbound next hop is used. If the source and destination are swapped, the inbound next-hop is used.

4. CONCLUSION

In this poster, we present routing scheme for centralized QoS management in a wireless mesh network. We present an implementation based on the MADWiFi WDS implementation. Eventual extension to our centralized controller will allow for more complex route computation based on a combination of metrics including signal quality and perceived bandwidth.

5. REFERENCES

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