Routing in Multi-Hop Wireless Mesh Networks with Bandwidth Assurance using QoS Routing Algorithm

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Abstract- A Wireless Mesh Network is defined as an infrastructure network working with in as ad hoc mode. In a multi-hop wireless mesh network, it is always preferable to choose a path with higher throughput between a pair of source /destination nodes to fully exploit the network capacity. Since Wireless Mesh Networks have emerged as a practical solution for the wireless extension of the broadband internet, finding high throughput path is important. This paper surveys the different routing approaches for wireless mesh network that using bandwidth as routing metric. It discusses the problem statement, approach and the result obtaining on these methods. Wireless Mesh Network (WMN) has become an important edge network to provide Internet access to remote areas and wireless connections in a metropolitan scale. In this paper, we study the problem of identifying the maximum available bandwidth path, a fundamental issue in supporting quality-of-service in WMNs. Due to interference among links, bandwidth, a well-known bottleneck metric in wired networks, is neither concave nor additive in wireless networks. We propose a new path weight which captures the available path bandwidth information. We formally prove that our hop-by-hop routing protocol based on the new path weight satisfies the consistency and loop-freeness requirements. The consistency property guarantees that each node makes a proper packet forwarding decision, so that a data packet does traverse over the intended path. Our extensive simulation experiments also show that our proposed path weight outperforms existing path metrics in identifying high-throughput paths.

Keywords – WMN, Routing, Multi-Hop, QoS

I. INTRODUCTION

A wireless mesh networks (WMN) are combination of a large number of wireless nodes. The nodes form a wireless overlay to cover the service area while a few nodes sitting on the edge are wired to the Internet. As part of the Internet, WMN has to support diversified multimedia applications for its users.

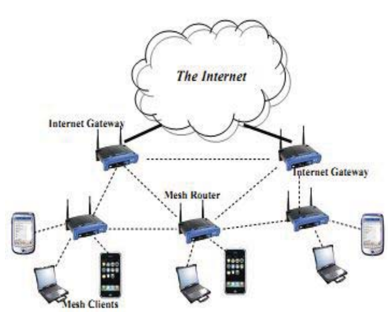


Figure 1. Quality-of-Service (QoS) routing.

Quality-of-Service (QoS) routing, which focus on finding a path satisfying the application requirements, is one of the building blocks for supporting QoS. In this paper, we study how to find a path satisfying the bandwidth requirement of an incoming connection request. We adopt the proactive approach, which computes the maximum bandwidth supported by the paths from a source to a destination prior to the requests arrives. By pre-computing the supported QoS, we can determine whether a request is feasible upon its arrival. If this request is feasible, a resource reservation will be initiated; otherwise, this request is blocked. QoS routing in wireless networks is very challenging due to the wireless transmission interference.

II. LITERATURE SURVEY

In Wireless mesh networks the language that is used is JAVA which is platform independent language and contains packages providing classes of different types it provides package containing network components distributed architecture, graphical tools and multi thread system, bean components etc., to design distributed system.

III. TECHNOLOGY

Wireless mesh networks (WMNs) is a latest technology that envisages supplementing wired infrastructure with a wireless backbone for providing Internet connectivity to mobile nodes (MNs) or users in residential areas or offices so called the Web-in-the-sky. WMNs are characterized by self-organizing self-configuring capability, ease, and (quick) rapidity of network deployment. Since its inception in the early years of this millennium, it has been in the limelight of all researchers.

IV. IMPLEMENTATION

A. Network Model-

We use a hybrid mesh architecture [1] consisting of three types of nodes, Mesh Clients representing end users, Mesh Routers that communicate with clients and other mesh routers, and Internet Gateways that communicate with mesh routers and the external Internet. An example is shown in Figure 1. Mesh routers and clients run the same routing protocol. Mesh routers have two interfaces operating on orthogonal channels, one for communicating with mesh clients and other for communicating with other mesh routers. Mesh clients have only one interface. Three types of routes are possible: those that connect two mesh clients served by the same mesh router, those that connect mesh clients served by different mesh routers, and those that connect a mesh client to an Internet host. Also, note that our network uses Layer 3 routing throughout in order to leverage the advantages of MANETs, including ease of deployment and extended connectivity.

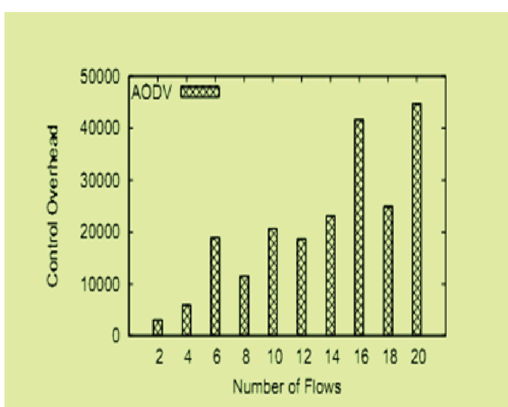


Figure 2. Control overhead in a 50 node network. Overhead is calculated as the total number of RREQs forwarded by all the nodes in the network.

B. Testbed-

Our test bed is located on one floor of a fairly typical office building, with the nodes placed in offices, conference rooms. and labs. Unlike wireless-friendly cubicle environments, our building has rooms with floor-to-ceiling walls and solid wood doors. The nodes are located in fixed locations and did not move during testing. The node density was deliberately kept high enough to enable a wide variety of multi-hop path choices. See Figure 3. The nodes are all Hewlett-Packard model d530 SFF PCs. Each of these machines has a 2.66GHz Intel Pentium 4 processor with 512MB of memory. They all run Microsoft Windows XP. The TCP stack included with XP supports the SACK option by default, and we left it enabled. All of our experiments were conducted over IPv4 using statically assigned addresses. Each node has two 802.11 radios, connected to the PC via Prism PCD-TP-202CS PCI-to-Card bus adapter cards. The configuration of the PCI bus on these machines limits the separation distance between the radio antennas on the two cards to just under 3 cm. Each node has one Proxim ORiNOCO Combo Card Gold, and also either a Net Gear WAG 511 or a Net Gear WAB 501 card. These are multiband radios. Unfortunately, the Windows drivers do not allow two cards of the same model to co-exist in a machine. Except for configuring ad-hoc mode and fixing the frequency band and channel number, we used the default configuration for the radios. In particular, the cards all perform auto rate selection and have RTS/CTS disabled. In 119our future work, we plan to explore the impact of enabling RTS/CTS. There are no other 802.11a or 802.11g users in our building, although there are some 802.11b access points. We have verified that the 802.11b access points had no significant impact on our results.

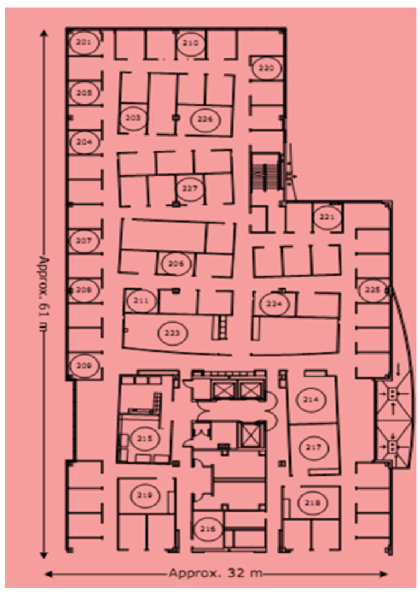


Figure 3. Test bed

C. Band and Channel Assignment-

One of the assumptions we made in designing our routing metric is that the channels used by the multiple radios are non-interfering. We performed a series of tests to verify that this was indeed the case for the bands and channels we use in our test bed environment. These tests were performed using three dual-radio nodes from our test bed, namely 201, 204, and 205. See Figure 3. Nodes 201 and 204 were always the senders, and 205 was always the receiver. Our methodology was to first measure the TCP throughput between each of the senders and the receiver alone, and then simultaneously with both senders operating. If the transfers are truly non-interfering, we would expect the throughputs to be essentially the same whether run independently or simultaneously. Using Net Gear cards on 802.11a channel 36 between 201 and 205, we measured an average throughput of 15351Kbps. Likewise, using Proxim cards on 802.11a channel 64 between 204 and 205, and we saw 13483Kbps. When run simultaneously, however, these throughputs dropped to 4155Kbps and 9143Kbps, respectively. This is a reduction in throughput of 73% between 201 and 205 and 32% between 204 and 205.

This difference is greater than we might ascribe to additional load on the receiver from sinking two streams simultaneously. Indeed, our subsequent tests using 802.11g with 802.11a bear this out. In that case, we measured an average throughput of 15329Kbps between 201 and 205 (using Net Gear cards on 802.11a channel 36) and 9743Kbps between 204 and 205 (using Proxim cards on 802.11g channel 10) when run independently. Simultaneously, the respective results were 14898Kbps and 9685Kbps. The reduction in throughput for this situation is only 3% between 201 and 205 and 1% between 204 and 205. We have also verified that two 802.11g radios or two 802.11b radios in our test bed interfere, regardless of channel. Our suspicion is that the physical proximity of the two antennas on each node is contributing to this interference problem. For this reason, we elected not to use two channels in the same band when running experiments to evaluate our metric. Instead, we set our Net Gear cards to use 802.11a and our Proxim cards to use 802.11g.

D. Accuracy of Bandwidth Estimation-

We conducted the following experiment to measure the accuracy of the packet-pair technique. Two of our test bed nodes were placed near one another in the same room. We estimated the bandwidth of the wireless link between them using packet-pair probes. The time between successive pairs was 2 seconds, and each bandwidth estimate was obtained by taking the minimum of 50 such pairs. We set the channel bandwidth on the radios to each of the possible transmission speeds in turn. We took 5 successive estimates for each setting. The results of this experiment for Net Gear cards on 802.11a and for Proxim cards on 802.11g are shown in Figure 4. Each point represents the average of these 5estimates, and the error bar shows the maximum and the minimum estimates. The two plots show that the packet-pair estimate is accurate for low channel data rates, while at high data rates it underestimates the channel bandwidth. This could be due to the fact that the fixed overheads involved in a packet transmission (such as the time required to send the 802.11ACK) become more important at higher data rates. Our technique does not account for these overheads. Despite these inaccuracies, note that in both the plots, we are able to unambiguously distinguish between various channel bandwidths, except for the highest 11g data rates. Thus, the overall conclusion from this experiment is that the packet-pair technique produces sufficiently accurate estimates of channel bandwidth.

V. EXISTING SYSTEM

The path with the maximum available bandwidth is one of the fundamental issues for supporting QoS in the wireless mesh networks. The available path bandwidth is defined as the maximum additional rate a flow can push before saturating its path. Therefore, if the traffic rate of a new flow on a path is no greater than the available bandwidth of this path, accepting the new traffic will not violate the bandwidth Guaranteed of the existing flows. The extensive simulation experiments demonstrate that our routing protocol outperforms the existing routing protocols for finding the maximum available bandwidth paths. ETT metric adjusted based on the number of the interference links and the existing traffic load on the interference links. IRU is the ETT metric weighted with the number of the interference links, while CATT extends IRU by considering the effect of packet size and raw data rate on the links because of the use of multiple channels.

VI. DISADVANTAGE OF EXISTING SYSTEM

The traffic rate of a new flow on a path is no greater than the available bandwidth of this path, accepting the new traffic will not violate the bandwidth guaranteed. A source identifies a widest path to a destination; intermediate nodes on the widest path may not make a consistent packet forwarding decisions by using the traditional destination-based hop-by-hop packet forwarding mechanism. To avoid loops when routing tables change is an important but difficult problem, and is outside the scope. The problem of identifying the maximum available bandwidth Path from a source to a destination, which is also, called the Maximum Bandwidth Problem (MBP). MBP is a sub problem of the Bandwidth-Constrained Routing Problem (BCRP), the problem of identifying a path with at least a given amount of available bandwidth polynomial-time, because the problem is NP-complete in nature. Even though we can find the available bandwidth of a given path, it is not easy to identify a schedule that achieves that bandwidth since the scheduling.

VII. PROPOSED SYSTEM

A new path weight that captures the concept of available bandwidth. We give the mechanism to compare two paths based on the new path weight. The widest path, many researchers develop new path weights, and the path with the minimum/maximum weight is assumed to be the maximum available bandwidth path. The expected transmission count (ETX) metric. The bandwidth requirement of a certain request. The protocol in checks the local available bandwidth of each node to determine whether it can satisfy the bandwidth requirement. Some works consider the TDMA-based MAC model and discuss how to assign the available time slots on each link for a new flow in order to satisfy the bandwidth requirement. This tonicity property of the proposed path weight allows us to develop a routing protocol that can identify the maximum bandwidth path from each node to each destination. In particular, it tells us whether a path is worthwhile to be advertised, meaning whether a path is a potential sub path of a widest path.

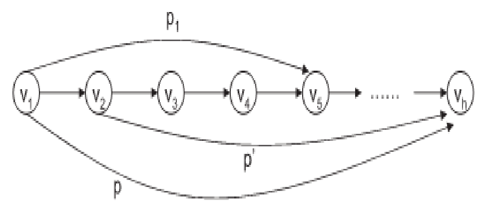


Figure 4. Path bandwidth computation in a hop-by-hop manner.

E. QoS Routing Protocol-

In this section, we first present our path selection mechanism. It is based on the distance-vector mechanism. We give the necessary and sufficient condition to determine whether a path is not worthwhile to be advertised. We then describe our new isotonic path weight. We show that the routing protocol based on this new path weight satisfies the optimality requirement. Afterward, we present our hop-by-hop packet forwarding mechanism which satisfies the consistency requirement. We apply to estimate the available bandwidth of a path. To simplify our discussion, in the rest of our paper, we use “available bandwidth” instead of “estimated available bandwidth” when the context is clear. On the other hand, “widest path” refers to the path that has the maximum estimated available bandwidth.

F. Path Selection-

We would like to develop a distance-vector based mechanism. In the traditional distance-vector mechanism, a node only has to advertise the information of its own best path to its neighbors. Each neighbor can then identify its own best path. We mentioned that if a node only advertises the widest path from its own perspective, its neighbors may not be able to find the widest path. To illustrate, consider the network in Fig where the number of each link is the available bandwidth on the link.

G. Topology-Aware Route Discovery-

We optimize QUORUM for hierarchical wireless mesh networks by limiting the flooding of control messages using explicit knowledge of the network topology. Recall that for streaming-media applications such as Video-on-Demand, much of the data traffic can be localized to a mesh group if the request can be met locally by data caches. In these cases, broadcasting control packets beyond the mesh group creates unnecessary network congestion and disruption to other flows. We illustrate two examples of this technique in Figure. Figure shows a scenario where both the source and destination are under the same mesh router (MR).

Algorithm

1: Let V = {v|v 2MCG}

2: while notAllVerticesVisited {V} do

3: Let h = smallestHopCount (V)

4: Q = {v|v 2 V and notVisited (v) and hopcount (v) == h}

5: sort (Q)

6: while size (Q) > 0 do

7: vcurrent = removeHead (Q)

8: if visited (vcurrent) then

9: continue

10: end if

11: visit (vcurrent)

12: Vn = {u|u 2 MCG and edgeInMCG (u, vcurrent) == TRUE}

13: permanently assign highest ranked channel c from vcurrent's channel ranking that does not conflict with ui, {ui 2 Vn and 0 i<size (Vn)}

14: if c does not exist then

15: permanently assign random channel to current

16: end if

17: L = {v|v 2MCG and v contains either radio from vcurrent}

18: removeVerticesInListFromMCG (L)

19: tentatively assign c to radios in L that are not part of vcurrent

20: Let rf be router with interface in vcurrent that is farthest away from gateway

21: Let Tail = list of all active v (v 2 MCG) such that v contains an interface from rf

22: sort (T)

23: addToQueue (Q, Tail)

24: end while

25: permanently assign channels to radios that are unassigned a permanent channel.

26: end while

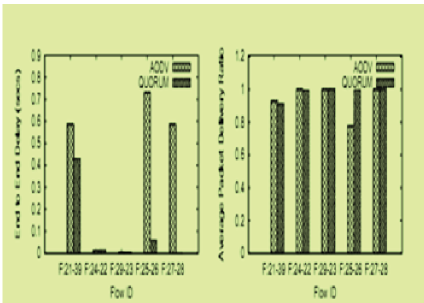
VIII. RESULTS

In this section, we describe the results of our experiments. First, we present measurements that show that the packet pair technique works well for estimating the bandwidth of wireless links. Then, we present experiments that study the performance of the WCETT metric in various conditions. We begin by comparing the performance of WCETT to ETX as well as basic shortest-path routing using only one radio per node. These results provide a baseline. Next, we activate the second radio on each node and compare the performance of WCETT, ETX and shortest-path routing. Then, we explore the performance of WCETT for different values of β.

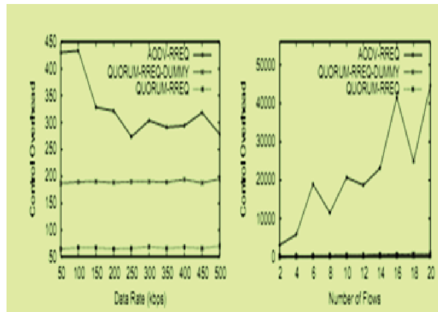
Finally, we consider the impact of multiple simultaneous TCP transfers. We conclude with a discussion of the results and some of the limitations of our test bed.

H. End to End Delay Estimation-

This section evaluates one of the major contributions of this paper, End to End delay estimation during route setup.



(a) End to End Delay of the different flows (b) Packet Delivery Ratio of the different flows



(a) Control Overhead vs Data Rate (b) Control Overhead vs Number of Flows

IX. CONCLUSION

In this paper, we have developed QUORUM, a novel QoS-aware routing protocol for wireless mesh networks. Specifically, QUO- RUM takes three QoS metrics into account: bandwidth, end to end delay and route robustness. To optimize QUORUM for wire- less mesh networks, we propose several mechanisms for topology-aware route discovery that drastically reduce the control overhead and network congestion from route discovery. In addition, we introduce the novel DUMMY-RREP data latency estimator, and show it to be effective in providing accurate estimates of end-to-end de- lay experienced by data packets. Finally, our proposed link robustness metric allows QUORUM to punish and discourage free-riding behavior by selfish nodes.

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