Volume 5, Issue 5, May 2015 ISSN: 2277 128X
International Journal of Advanced Research in Computer Science and Software Engineering
Research Paper
Available online at: www.ijarcsse.com

Bandwidth Guaranteed Hop-by-Hop Routing in Wireless Mesh Networks

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Abstract— 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— BCRP, hop-by-hop, isotonic, Intraflow, MBP, WMN.

I. INTRODUCTION

A wireless mesh network (WMN) consists of a large number of wireless nodes. The nodes form a wireless overlay to cover the service area while a few nodes are wired to the Internet. As part of the Internet, WMN has to support diversified multimedia applications for its users. It is essential to provide efficient Quality-of-Service (QoS) support in this kind of networks. Seeking 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. This paper focuses on 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. In the literatures, maximum available bandwidth path is also called widest path.

Finding the widest path between the source and the destination in wireless networks is very challenging due to the wireless transmission interference. Generally speaking, there are two types of interference: interflow interference and intraflow interference. Interflow interference refers to the situation that the resource available for a flow is affected by the presence of other flows. In other words, the interflow interference affects the amount of residual channel resources on each link that can be allocated for a new flow. The work gives how to estimate the available bandwidth (residual channel resources) of each link. It means that if the link has to carry another 1-hop flow without violating the bandwidth guarantees of existing flows, the rate of this flow can be at most the available bandwidth of the link. On the other hand, intraflow interference refers to the scenario where when a data packet is being transmitted on a link along a path, some link along the path has to remain idle to avoid conflict. Intraflow interference complicates the process of developing hop-by-hop routing protocol for finding widest paths. Considering intraflow interference, the works present a formula to compute the available bandwidth of a path with the knowledge of the available bandwidth on individual links of the path. Unfortunately, finding widest path in a hop-by-hop manner is still not solved.

The unique structure of the path bandwidth computation formula introduces two challenges described below:

1. Some nodes may not find the widest path if only the available bandwidth is used as the routing metric.
2. Even though 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.

II. EXISTING SYSTEM

Wireless Mesh Network has become an important edge network to provide Internet access to remote areas and wireless connections in a metropolitan scale. 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.
Seeking 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.

DRAWBACKS OF EXISTING SYSTEM

- Identifying the maximum available bandwidth path from a source to destination.

III. PROPOSED SYSTEM

We propose 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. We formally prove that the proposed path weight is left-isotonic. We describe how to construct the routing table and distance table, and we develop a hop-by-hop packet forwarding scheme. We formally prove that our routing protocol satisfies the optimality and consistency requirements. Finally, we implement our routing protocol based on the DSDV protocol in the NS2 simulator. The extensive simulation experiments demonstrate that our routing protocol outperforms the existing routing protocols for finding the maximum available bandwidth paths.

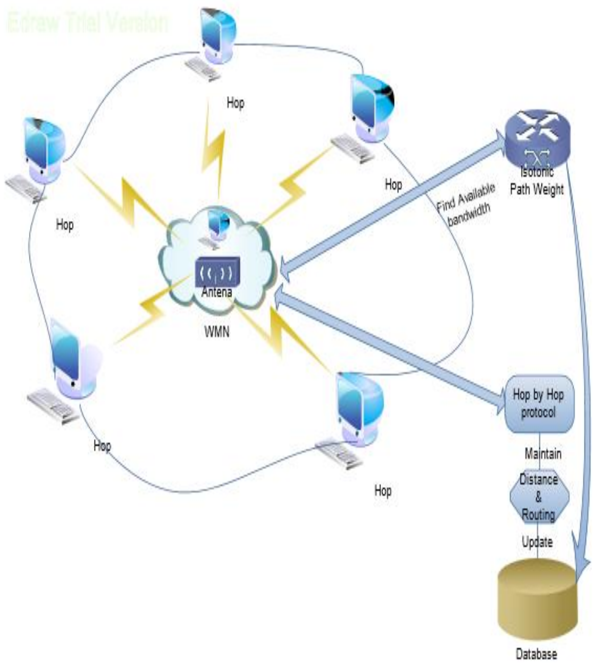

Fig 1: Architecture of proposed system.

ADVANTAGES OF PROPOSED SYSTEM

- Our routing protocol satisfies the optimality and consistency requirements.
- Finds the maximum available bandwidth paths.

IV. IMPLEMENTATION OF PROPOSED SYSTEM

The framework of our proposed system has the accompanying modules alongside the following prerequisites.

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. If a node only advertises the widest path from its own perspective, its neighbors may not be able to find the widest path. In order to assure that the widest path from each node to a destination can be identified, a trivial way is to advertise all the possible paths to a destination. This is definitely too expensive. On the other hand, as long as we advertise every path which is a subpath of a widest path (e.g., <v; a; b; c; d> is a subpath of the widest path of <s; v; a; b; c; d>), we allow every node to identify its own widest path. Thus, to reduce the overhead, we should not advertise those paths that would not be a subpath of any widest path.

Isotonic Path Weight

We introduce our new isotonic path weight, while the next section describes how we use the path weight to construct routing tables. The isotonicity property of a path weight is the necessary and sufficient condition for developing a routing protocol satisfying the optimality and consistency requirements. Given two paths p1 and p2 from a node s to d, assume that p1 is better than p2 by comparing their weights. If the path weight used is left-isotonic, given any path p0 from a node v to s, p0   p1 must be better than p0   p2. Available bandwidth of a path alone is not left isotonic.

Table Construction and Optimality

The isotonicity 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 subpath of a widest path. In our routing protocol, if a node finds a new nondominated path, it will advertise this path information to its neighbors. We call the packet carrying the path information the route packet. Based on the information contained in a route packet, each node knows the information about the first four hops of a path identified.

Each node keeps two tables: distance table and routing table. Node s puts all the nondominated paths advertised by its neighbors in its distance table. It keeps all the nondominated paths found by s itself in its routing table.

Packet Forwarding and Consistency

In a traditional hop-by-hop routing protocol, a packet carries the destination of the packet, and when a node receives a packet, it looks up the next hop by the destination only. In our mechanism, apart from the destination, a packet also carries a Routing Field which specifies the next four hops the packet should traverse. When a node receives this packet, it identifies the path based on the information in the Routing Field. It updates the Routing Field and sends it to the next hop. In our packet forwarding mechanism, each intermediate node determines the fourth next hop but not the next hop as in the traditional mechanism. Our packet forwarding mechanism still requires each intermediate node to make route decision based on its routing table. Besides, only the information of the first few hops of a path is kept in the routing table in each node and the routing field in a packet. Therefore, our mechanism possesses the same characteristics of a hop-by-hop packet routing mechanism, and is a distributed packet forwarding scheme.

Route Update

After the network accepts a new flow or releases an existing connection, the local available bandwidth of each node will change, and thus the widest path from a source to a destination may be different. When the change of the local available bandwidth of a node is larger than a threshold (say 10 percent), the node will advertise the new information to its neighbors. After receiving the new bandwidth information, the available bandwidth of a path to a destination may be changed. Although the node is static, the network state information changes very often. Therefore, our routing protocol applies the route update mechanism in DSDV . Based on DSDV, each routing entry is tagged with a sequence number which is originated by the destination, so that nodes can quickly distinguish stale routes from the new ones. Each node periodically transmits updates and transmits updates immediately when significant new route information is available. Given two route entries from a source to a destination, the source always selects the one the larger sequence number, which is newer, to be kept in the routing table. Only if two entries have the same sequence number, our path comparison is used to determine which path should be kept. Due to the delay of the route update propagation, it is possible that route information kept in some nodes is inconsistent. For instance, the widest path kept in the routing table may not be the widest anymore. Routing loops may occur as well. The situations are referred as inconsistency due to transient route updates, which is different from the definition used in. In and this paper, we consider whether packets can be routed on the computed widest path when the routing tables are stable. How to avoid loops when routing tables change is an important but difficult problem, and is outside the scope of this paper. We refer readers to [29] for the techniques to reduce route update inconsistencies in the distance-vector protocol which can be applied in our mechanism as well.

V. CONCLUSION

In this paper, we studied the maximum available bandwidth path problem, which is a fundamental issue to support quality-of-service in wireless mesh networks. The main contribution of our work is a new left-isotonic path weight which captures the available path bandwidth information. The left-isotonicity property of our proposed path weight facilitates us to develop a proactive hop-by-hop routing protocol, and we formally proved that our protocol satisfies the optimality and consistency requirements. Based on the available path bandwidth information, a source can immediately determine some infeasible connection requests with the high bandwidth requirement. We tested the performance of our protocol under different scenarios.

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