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Association management for data dissemination over wireless mesh networks

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Abstract

To enable multimedia broadcasting services in mesh networks, it is critical to optimize the broadcast traffic load. Traditionally, users associate with access points (APs) with the strongest signal strength. We explore the concept of dual-association, where the AP for unicast traffic and the AP for broadcast traffic are independently chosen by exploiting overlapping coverages that are typical in mesh networks. The goal of our proposed solution is to optimize the overall network load by exploiting the flexibility provided by independent selection of unicast and broadcast APs. We propose a novel cost metric based on ETT (Expected Transmission Time) and the number of nodes in range of the APs, that are advertised in the beacons from the APs. Users periodically scan and associate with the AP which has the lowest cost metric. The proposed approach reduces the number of APs that handle the broadcast traffic resulting in a heavy reduction in control and data packet overhead. This leads to higher packet delivery rate and enhanced video quality measured in terms of PSNR. Our approach allows the freed up resources at APs to increase the unicast throughput. We compare the performance of our approach with traditional signal strength based association using extensive simulations and real experiments on an indoor testbed of 180 IEEE 802.11b based devices.

Keywords: Association control; Broadcast; Wireless LAN; Dual-association; AP switching

1. Introduction

Mesh Networking is emerging as a promising technology that brings Wireless LANs to the masses at a reduced deployment cost. Mesh networks are either flat or hierarchical in terms of the architecture [1,2]. Our study is focused on hierarchical architectures, where the client–client communication is

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always via the APs (access points) and the APs are connected through a multi-hop wireless backbone. Public deployments of mesh networks are already operational in several cities including Philadelphia, Las Vegas, and Urbana-Champaign. Various types of WLANs, such as city-wide WLANs[1], in-building WLANs, and temporary WLANs, can all benefit from the Mesh network technology.

While unicast services are essential for providing Internet access to individual users, emerging broadcast services are needed to deliver local news, visitor's information, TV channels, or other multimedia content. In order to support efficient multimedia services with minimal impact to unicast services, it is critical to optimize the multicast load on the network.

In this paper we study the problem of optimizing the broadcast traffic load in the mesh using the concept of dual-association, where users maintain distinct associations for unicast and broadcast traffic. We use the AP with the best signal strength for unicast traffic, but other metrics such as unicast traffic load [3] can also be used to select the unicast AP. For reducing the broadcast traffic load, users select the AP for broadcast services independent of the AP selected for unicast traffic. The selected broadcast APs can be connected to the AP with the backbone access (Main AP or MAP) using any ad-hoc multicast routing protocol. As the multicast structure construction is not the focus of the paper, we choose to connect the selected APs to the MAP using a tree, only for purposes of simplicity. The tree construction and maintenance mechanisms are based on MAODV [4], but any other multicast routing protocol can be used as well. The concept of dual-association was first introduced in our prior work [5] where a simple multicast metric was also proposed. In contrast, this paper proposes a cost metric that captures the global cost on the network (in addition to the cost on the last hop between the user and the AP), and an efficient local synchronization algorithm to make it practicable to implement association based on the cost-metric. Moreover, in this paper we present data from real experiments and extensive simulations.

Our contributions in this paper are as follows. (1) We formalize the problem of efficient association for data dissemination over Mesh networks. (2) We prove that the problem is NP-hard by showing a reduction from the Steiner tree problem. (3) We propose the dual-association concept and a local synchronization method for ease of deployment. (4) We introduce a novel metric that optimizes the broadcast traffic load in the mesh and present a heuristic based distributed protocol, called COST, based on our metric. (5) Using simulations in *ns2* we evaluate the performance of our approach and compare it with the traditional approach that uses signal strength based association. The key metrics studied are the size of the tree, and the quality of received MPEG video measured using PSNR (Peak Signal-to-Noise Ratio). (6) We have implemented the distributed approach and compared its performance with the traditional signal strength based approach, on an indoor testbed of 180 nodes with 802.11b radio.

The rest of the paper is organized as follows. Section 2 summarizes related work. Section 3 defines the problem, the notations, and the terminology used in the paper. Dual-AP management framework is described in Section 4. The distributed solution is presented in Section 5. Section 6 presents a detailed evaluation of our approach and comparison with signal strength based approach using simulations. The results from the testbed experiments are presented in Section 7. Finally, Section 8 concludes the paper.

2. Related work

In this section, we outline related work in the areas of mesh networking, controlled association in 802.11 networks, and sub-structure computation in ad-hoc and mesh networks.

Mesh networking: Providing connectivity to large communities using wireless back-haul networks, also known as mesh networks, has lately received an increased attention [6,7]. Several companies including Mesh networks, Firetide, Strix, and Bel-Air Networks have various commercial products and large-scale public deployments based on the concept of mesh networks.

Controlled association: The concept of dual-association is first introduced in [5], where a metric based broadcast AP association algorithm is proposed. The algorithm requires global synchronization between APs and users, and the cost metric only concerns with the last hop between the user and the APs. In contrast, this paper proposes a cost metric that captures the global cost in addition to the cost on the last hop between the user and the

[1] The city of Chaska, Minnesota provides WLAN coverage in a 15 sq miles area since Oct 2004 (www.chaska.net).