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User-Based Channel Assignment Algorithm in a Load-Balanced IEEE 802.11 WLAN

Mohamad Haidar, Ecole de Technolgie Superieure, Canada

Hussain Al-Rizzo, University of Arkansas at Little Rock, USA

Yupo Chan, University of Arkansas at Little Rock, USA

Robert Akl, University of North Texas, USA

ABSTRACT

A new load balancing algorithm is presented based on power management of Access Points (APs) to reduce congestion at hot spots in Wireless Local Area Networks (WLANs) and to assign channels to APs The algorithm first finds the Most Congested Access Point (MCAP), then decreases its transmitted power in discrete steps, and the process continues until the users' assignment which leads to a high balance index is reached. A new mathematical programming formulation is then applied to assign channels to the APs such that the Signal-to-Interference Ratio (SIR) at the users' level is maximized. Results show that the algorithm is capable of reducing the overall congestion at hot spots in a WLAN and increases the SIR significantly for cases involving relatively large WLANs. In the process, network throughput is increased. [Article copies are available for purchase from InfoSci-on-Demand.com]

Keywords: *Access Point; Channel Assignment; Congestion; Load Balancing; Signal-to-Interference Ratio; Wireless Local Area Network*

INTRODUCTION

More industries, organizations, and offices are installing WLANs to support the growing demand of wireless users. The motivation is to reduce the cost of running cables and, more importantly, meet the demand of users who wish to stay connected to the network, communicate with others, and access the World Wide Web while roaming.

Numerous research has been conducted on load balancing (Akl & Park, 2005; Fang & Low, 2004; Haidar, et al., May 2007; Papanikos & Logothetis, 2001; Velayos, et al., 2004) and channel assignment (Akl & Arepally, 2007; Eisenblätter, et al., 2007; Haidar, et al., Sept 2007; Kulkrani & Shenoy, 2004; Lee, et al., 2002; Mishra, et al., 2005) separately. The authors are aware of only one research that involved combining load balancing and channel assignment (Mishra, et al., 2006). The advantage of combining load balancing and channel assignment in one algorithm is to increase network throughput by utilizing available resources efficiently.

In the load balancing related literature, the authors of (Akl & Park, 2005; Fang & Low, 2004) proposed minimizing AP congestion in WLANs using an Integer Linear Programming (ILP) formulation. In (Akl & Park, 2005; Fang & Low, 2004), the load at the MCAP was minimized once without applying power management. A free space propagation model is used in (Akl & Park, 2005; Fang & Low, 2004) to associate demand points with candidate APs. The authors in (Papanikos & Logothetis, 2001) proposed a load balancing technique that allows a wireless station to join an AP depending on the number of existing users and the mean Received Signal Strength Indicator (RSSI). In (Velayos, et al., 2004), the authors proposed a load-balancing scheme for overlapping wireless cells. Load Balancing Agents (LBA) running at each AP broadcast periodically the local loads via the Ethernet backbone and determine whether the AP is overloaded, under-loaded, or balanced. Users in overloaded APs are forced to dissociate from their corresponding AP and associate with an under-loaded AP. In (Haidar, et al., May 2007), we proposed an algorithm that decrements the transmitted power at the MCAP in discrete steps until any of the three following conditions is met: (1) at least one user can no longer associate with any potential AP, (2) the desired user's data rate can no longer be accommodated, or (3) the balance index value exceeds a predefined threshold. At that stage, the network's load is distributed efficiently over the network compared to traditional association based on the highest RSSI. This is accomplished with a lower transmitted power levels at the MCAPs leading to less co-channel and adjacent channel interferences.

At the planning stage, channel assignment is often considered in the context of the problem of AP placement (Eisenblätter, et al., 2007; Kulkrani & Shenoy, 2004; Lee, et al., 2002). In (Lee, et al., 2002), an algorithm was proposed for channel assignment in hot-spot service areas using an ILP formulation. The objective was to avoid assigning non-overlapping channels among neighboring APs, leaving other available channels unutilized. The authors in (Eisenblätter, et al., 2007) noted that previous AP placement and channel assignment were always designed sequentially. An integrated model that addresses both issues concurrently was proposed. It was shown that through an ILP formulation, AP placement and channel assignment could be combined, resulting in better performance. In (Kulkrani & Shenoy, 2004), the authors presented a greedy heuristic algorithm that provides maximum coverage while minimizing interference in the overlapping APs. A channel-assignment based on a Non-Linear Integer Program (NLIP) that minimizes channel interference among neighboring APs was provided in (Akl & Arepally, 2007). The authors in (Mishra, et al., 2005) proposed a weighted variant of the coloring-graph algorithm to improve the usage of wireless spectrum in WLANs. In (Haidar, et al., Sept 2007), we proposed a channel assignment algorithm, based on minimizing interference between APs. The algorithm was invoked after the load has been balanced based on the power management scheme presented in (Haidar, et al., May 2007). Results indicate that a different channel assignment is required to meet users' demands. Note that the channel assignment at the planning stage may result in severe interferences due to users' distribution—even after power has been adjusted on APs. Finally, the authors in (Mishra, et al., 2006) also proposed a client-based channel assignment and load balancing approach that lead to better usage of the wireless spectrum. They showed that a joint solution has significant advantages, such as capturing the effect of interference at the clients and a better channel re-use. Since the authors did not employ any specific indoor propagation model, their model was based on minimizing channel conflicts between APs within one-hop distance from each other, as-

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