A Survey on Channel Scheduling in WLAN

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Abstract—A heavy deployment of IEEE 802.11 Wireless LANs and limited number of orthogonal channels make lots of Access Points (APs) overlap their interference regions, which greatly increases interferences between APs and stations. In order to cope with the performance degradation caused by the interferences, proper scheduling of AP must be done, so that the interference is reduced. In this survey paper, we study the channel scheduling algorithms in WLAN and identify the problems in them so that it can be used by others to design effective solutions for the problems.

I. INTRODUCTION

IEEE 802.11 Wireless LAN (WLAN) is one of the most popular wireless communication technologies developed so far. Its tremendous success has led to the dense deployment of WLANs almost everywhere. However, the high density also incurs interferences more frequently among wireless Access Points (APs) and devices (or stations) [1]. Hence, more APs may do more harm than good, and hamper the optimal performance of WLANs [2].

Interference in WLAN can be classified into three types.

For this, we adopt a well-known data structure called Conflict Graph. A vertex in a conflict graph represents an AP or a station, and a directed edge between two vertices means a wireless link. If there is a wireless link (same as an edge in a conflict graph), it means that a signal from an AP (or station) can successfully be transmitted to the other AP (or station). Figure 1 illustrates three types of interferences. Stations A and B in the figure are associated with AP1 and AP2, respectively. In addition, the wireless links outgoing from the APs are only shown in Figure 1 since we only consider the interferences caused by downlink transmissions. A wireless link from node i to node j is denoted as Lid. For instance, L1A represents the wireless link from AP1 to Station a and other wireless links are denoted in the same manner. Although the concepts of hidden-node and exposed-node problems are well known, the way to identify them from a conflict graph varies across studies. Thus, we slightly modify them and use the following equations when the edge set, E, of a conflict graph is given:.

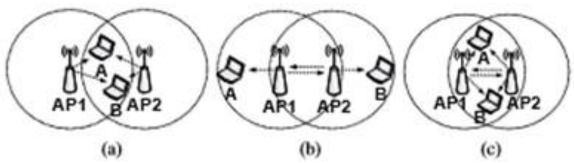

Fig. 1: Types of interferences: (a) Hidden-Node (HN), (b) Exposed-Node (EN) and (c) Non-Hidden/Non-Exposed Node (NHNEN). *Stations A* and *B* are associated with *AP1* and *AP2*, respectively.

- Hidden-Node (HN) interference:

$$\{L_{12}, L_{21}\} \not\subset E \textbf{ and } \{L_{1A}, L_{2B}\} \subset E \textbf{ and } (L_{1B} \in E \textbf{ or } L_{2A} \in E), \quad (1)$$

- Exposed-Node (EN) interference:

$$(L_{12} \in E \textbf{ or } L_{21} \in E) \textbf{ and } \{L_{1A}, L_{2B}\} \subset E \textbf{ and } (L_{1B} \notin E \textbf{ and } L_{2A} \notin E), \quad (2)$$

- Non-Hidden/Non-Exposed Node (NHNEN) interference:

$$(L_{12} \in E \textbf{ or } L_{21} \in E) \textbf{ and } \{L_{1A}, L_{2B}\} \subset E \textbf{ and } (L_{1B} \in E \textbf{ or } L_{2A} \in E). \quad (3)$$

The HN and NHNEN interferences result in collision at APs when simultaneous transmissions take place from APs to stations. This therefore causes retransmissions and even frames drops. While OCF may mitigate the impact of these interferences, not all collisions can be avoided. Moreover, frame collisions may make the APs decrease their PHY transmission rate, which results in performance degradation. On the other band, if stations experience EN interference, their associated APs can benefit from simultaneous transmissions and achieve improved throughput. However, if an AP senses the signal of other APs, it defers its transmission and fails to exploit the EN interference.

To reduce interference, proper channel scheduling is needed In this survey paper, we survey the solutions for channel scheduling in WLAN and identify the problems in these approaches.

II. SURVEY

A Perro in his work[I] Present eda unique measurement study of WiFi experience in home environments through the lens of WiSe APs across 30 homes (§2.3). Through our measurements we observed that while most of the WiFi clients experience moderate to good performance, poor performance plagues these environments about 2.1% of the time. The major cause of poor network performance (airtime, signal strengths) was dependent on the environment. Some APs experienced short periods of high impact

interference (81% degradation] from external sources (e.g., microwaves). Also, majority of APs at homes tend to have static channel configurations over time, indicating that these APs do not adapt to interference or contention experienced by APs due to external sources.

M A Ergin in his work[2] proposed the analysis of system performance using a realistic TCP dominated traffic mix in multi-cell WLANs. Results show that a single-cell network remains remarkably robust even with 125+ clients: the collision rate remains low. This extends Choi et.al.'s empirical results [3] for 16 clients to a much larger network, with realistic client association patterns, and bursty traffic mixes. We also show that, in a multi-cell network, however, the collision rate increases significantly. And also Providing novel insights into the behavior of TCP in multi• cell WLANs. Due to TCP flow control the number of backlogged stations equals twice the number of access points, meaning that network efficiency is determined by the nwnber of interfering access points, not the nwnber of clients.

R Gummadi in his work [4] identify several factors that lead to these vulnerabilities, ranging from MAC layer driver implementation strategies to PHY layer radio frequency implementation strategies. Our results further show that these factors are not overcome by simply changing 802.11 operational parameters (such as CCA threshold, rate and packet size) with the exception of frequency shifts. This leads us to explore rapid channel hopping as a strategy to withstand RF interference. We prototype a channel hopping design using PRISM NICs, and find that it can sustain throughput at levels of RF interference well above that needed to disrupt unmodified links, and at a reasonable cost in terms of switching overheads.

Y. Lee in his work [5] proposed \VLAN service design process in following steps: Estimation of the demand area map, Selection of candidate locations for APs, Signal measurement al the demand point in the service area, Decide APs without channel interference, Re-configuration of APs and channels with feedback infonnation.

V Shrivastava in his work [6] captures a significant research and engineering effort in exploring the role of centralization in enterprise WLANs and makes the following contributions:

• Demonstrates the importance of addressing downJink hidden and exposed tenninal problems: We start by demonstrating that we are solving a practical problem that occurs in enterprise \VLAN settings. We show that downlink hidden and exposed terminals are prevalent in multiple enterprise \VLANs through analysis and measurement of production WLANs, as well as measurements on our testbeds. We quantify the performance loss observed due to hidden and exposed terminals in such settings.

• Demonstrates the role of selective data-path centralization in enterprise WLANs and how it can be implemented independently by a single enterprise WLAN vendor: We show that a selective amount of data-path centralization is useful in enterprise WLANs in directly mitigating perfonnance loss due to downlink hidden and exposed terminal scenarios. Further, such a mechanism can indirectly help improve the performance of the entire WLAN environment. All proposed mechanisms require no changes in clients and hence can be implemented solely by an enterprise \VLAN vendor.

• Implements and deploys CENTAUR over two different testbeds and platforms: We implement CEl\'rfAUR over two different testbeds, each with a different wireless platform, NIC, and wired backplane. (i) Testbed l: located across five floors of a building consisting of 30 266-MHz Soekris 4826 nodes equipped with Atheros-based 802.11 NICs deployed and interconnected with a 100 Mbps Ethernet backplane, and (ii) Testbed 2 deployed across a single floor consisting of 20 1.2-GHz VIA nodes equipped with Intel 2915 802.11 ABG NICs deployed in a single floor of a building and interconnected with a Gigabit Ethernet backplane.

Evaluates CENTAUR usmg controlled experiments and playback of real traffic traces: We evaluate the performance of CENTAUR through a combination of controlled experiments as well as by playing back real traffic traces on these testbeds. We use different metrics for all our measurements including throughput (UDP and TCP), fairness, completion time of web transactions (http downloads), and MOS for VoIP-like traffic. Example results from our experiments on playback of real traffic traces, under observed periods of high loads, and averaged over all traffic across an enterprise WLAN, include: up to 1.48 x improvements in data throughputs, 1.38 x reductions in web transaction completion times, and 1.21 x improvements in MOS for VoIP-like traffic. for individual hidden and exposed terminal links are obviously much higher.

J Manweiler in his work [7] motivating MIM-aware revisions to link-scheduling protocols. He identifies the opportunity m MIM-aware reordering, characterizes the optimal improvement in throughput, and designs a link-layer protocol for enterprise wireless LANs to achieve it. Testbed and simulation results confirm the performance gains of the proposed system.

M. Lacage in his work [8] focus on the task of ma.ximizing the application-level throughput in infrastructure networks through practical rate· adaptation algorithms. Because no published paper discusses the issues surrounding real implementations of 802.11 rate adaptation algorithms, we believe our main contribution to be the identification of two classes of 802.11 devices: low latency and high latency systems. Low latency systems allow the implementation of per-packet adaptation algorithms while high latency systems require periodic analysis of the transmission characteristics and updates to the transmission parameters.

H. Falaki in his work [9] study the interaction of smartphone traffic with the radio power management policy. They find that the current sleep timers, that is, the idle period after which the radio will go to sleep, are overly long. By reducing them based on current traffic patterns, radio power consumption can be reduced by at least 35% with minimal impact on performance.

Smartphone traffic represents an increasingly large share of Internet traffic. Cellular traffic is projected to grow lO times faster than fixed Internet traffic [!OJ and most of this traffic is generated by smartphones [I l]. By next year, smartphone sales are projected to smpass desktop PCs [12]. However, little is known today about the nature of smartphone traffic. Two recent studies have shed valuable light on some aspects of this traffic.

Trestianet al. study the kinds of Web sites accessed at different times of the day [13). Maier et al. study HTTP traffic generated by mobile handheld devices (which include music players and personal gaming consoles in addition to smartphones) in homes [14]. Both studies are based on data gathered at a link in the middle of the network. As a result, while they can analyze traffic from a large number of devices, they do not capture a detailed, comprehensive view of individual devices. For instance, the second study misses traffic exchanged by devices through the cellular interfaces or outside of their homes.

Arpit Gupta in his work [15] demonstrates that solving the problem of traffic asymmetry results in maximum performance improvements for large audience envirorunents. They find correlation between the presence of asymmetry in network traffic and instantaneous transmission queue al the WiFi AP and develop a mechanism where traffic asymmetry is inferred in real time, prioritizing the AP accordingly for channel resource access over competing STAs. For large audience environments, the prioritization of AP's traffic enables efficient realization of AP-only fairness solutions. The key contribution of our work is the empirical study of the performance implications of these solutions in order to optimize the performance of busy WiFi hotspots. To add realism to our results, we implemented our solutions in an off-the-shelf commercial IEEE 802.11g AP, constructed a real network testbed of 45 WiFi nodes and tested the performance of various o timization settings in network traffic loads emulating the traffic patterns captured from real traces.

N. Ahmed in his work (16] present SMARTA, an architecture that takes the above-mentioned challenges into account. Our infrastructure based solution, targeted towards enterprise wireless LANs, does not require client-side modifications, allowing backwards compatibility. Utility functions provide a unified framework for capturing multiple and even conflicting performance objectives. Moreover, SMARTA makes no assumptions about RF propagation and uses dynamic optimization to address varying channel conditions. At a high level, SMARTA uses active probes to build a con- flict graph to accurately model the RF environment without making path loss assumptions. Utility functions are defined on the conflict graph to characterize network performance. Finally, a variety of operating parameters are used to optimize the computed utility.

J. Elson in his work [17] presents their idea for post-facto synchronization, an extremely low-power method of synchronizing clocks in a local area when accurate timestamps are needed for specific events. We also present an experiment that suggests this multi-modal scheme is capable of precision on the order of 1 msec–an order of magnitude better than either of the two modes of which it is composed. These results are encouraging, although still preliminary and performed under idealized laboratory conditions.

B. A Mah in his work [18) developed an empirical model of network traffic produced by HTTP. Instead of relying on server or client logs. our approach is based on packet traces of HTTP conversations. Through traffic analysis, author have determined statistics and distributions for higher• level quantities such as the size of HTTP files, the number of files per "web page", and user browsing behavior. These quantities form a model can then be used by simulations to mimic World Wide Web network applications.

Y. Bejerano in his work [19) present the Managed WiFi system, called MiFi, for supporting fairness and QoS in the existing IEEE 802.11 MAC layer. To the best of our knowledge this is the first comprehensive system that overcomes both the hidden node and the overlapping cell problems in multiple-AP \VLAN networks.

C Coutras in bis work (20] propsed the 802.11 MAC layer protocol provides asynchronous, time• bounded, and contention free access control on a variety of physical layers. In this paper we examine the ability of the point coordination function to support time bounded services. We present our proposal to support real-time services within the framework of the point coordination function and discuss the specifics of the connection establishment procedure.

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III. CONCLUSION AND ENHANCEMENTS

The paper summarizes the current works in the channel scheduling in WLAN to reduce the interference. We explored the problems in the current solutions and identified the open areas for concrete solutions for these open problems to enable effective channel utilization by reducing the interference.

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