Chapter 20

A Framework for External Interference–Aware Distributed Channel Assignment

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ABSTRACT

DES-Chan is a framework for experimentally driven research on distributed channel assignment algorithms in wireless mesh networks. DES-Chan eases the development process by providing a set of common services required by distributed channel assignment algorithms. A new challenge for channel assignment algorithms are sources of external interferences. With the increasing number of wireless devices in the unlicensed radio spectrum, co-located devices that share the same radio channel may have a severe impact on the network performance. DES-Chan provides a sensing component to detect such external devices and predict their future activity. As a proof of concept, the authors present a reference implementation of a distributed greedy channel assignment algorithm. The authors evaluate its performance in the DES-Testbed, a multi-transceiver wireless mesh network with 128 nodes at the Freie Universität Berlin.

INTRODUCTION

Channel assignment for multi-transceiver wireless mesh networks (WMNs) attempts to increase the network performance by decreasing the interference of simultaneous transmissions. Multi-transceiver mesh routers allow the communication over several wireless network interfaces at the same time. However, this can result in high interference of the wireless interfaces leading to a low network performance. With channel assignment, the reduction of interference is achieved by exploiting the availability of fully or partially non-overlapping channels. Channel assignment can be applied to all wireless networks based on technologies that
provide non-overlapping or orthogonal channels. Currently, wide-spread technologies are IEEE 802.11a/b/g, IEEE 802.11n, and IEEE 802.16 (WiMAX). With the low cost for IEEE 802.11 hardware, the number of deployments based on this technology is increasing and channel assignment algorithms are gaining in importance.

With the success of IEEE 802.11 technology, there is a dense distribution in urban areas of private and commercial network deployments of WLANs. These co-located networks compete for the wireless medium and can interfere with each other, thus decreasing the achievable network performance in terms of throughput and latency. Additionally, non-IEEE 802.11 devices, such as cordless phones, microwave ovens, and Bluetooth devices, operate on the unlicensed 2.4 GHz and 5 GHz frequency bands and can further decrease the network performance. It is therefore an important issue for efficient channel assignment, to also address the external interference. This task is not trivial, since the external networks and devices are not under the control of the network operator.

Although channel assignment is still a young research area, many different approaches have already been developed (Si et al., 2009). These approaches can be distinguished into centralized and distributed algorithms. Centralized algorithms rely on a central entity, usually called channel assignment server (CAS), which calculates the network-wide channel assignment and sends the result to the network nodes. In distributed approaches, each node calculates its channel assignment based on local information. Distributed approaches can react faster to topology changes due to node failures or mobility and usually introduce less protocol overhead, since communication with the CAS is not necessary. As a result, distributed approaches are more suitable once the network is operational and running. Another classification considers the frequency of channel switches on a network node. In fast channel switching approaches, channel switches may occur frequently, in the extreme for every subsequent packet a different channel is chosen. The limiting factor for such algorithms is the relative long channel switching time with commodity IEEE 802.11 hardware, which is in the order of milliseconds. Slow channel switching approaches switch the interfaces to a particular channel for a longer period, usually in the order of minutes or hours. Hybrid approaches combine both methods.

The focus of this paper is on the experimentally-driven research of distributed, slow channel switching algorithms on wireless testbeds. This process yields several challenges and pitfalls because the researcher has to deal with operating system specifics, drivers for the wireless interfaces, and the capabilities and limitations of the particular hardware. If more than one particular algorithm should be studied, the same problems and services have to be addressed multiple times because algorithms of this domain often require a set of common services. Among them are interface management, message exchange for node-to-node communication over the wireless medium, and data structures for network and conflict graphs. Additionally, a research framework for channel assignment algorithms can speed up the development process significantly by using the already available services.

The contribution of this article is DES-Chan, a framework for external interference-aware distributed channel assignment in multi-transceiver WMNs. We analyze several algorithms for distributed channel assignment and derive the required services for their implementation. We describe the architecture of DES-Chan that provides these services as well as the implementation of the greedy distributed algorithm (DGA) as a proof of concept. We present results obtained from the algorithm implementation in the DES-Testbed, a 128 multi-radio node wireless mesh testbed.

The remainder of this article is structured as follows. In the next section we present channel assignment algorithms and derive their required ser-
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