Interference Aware Channel Allocation in a Multichannel, Multi-interface Wireless Network

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I. Introduction

Multi-channel, multi-interface (MCMI) wireless networks provide the flexibility to utilize the available spectrum efficiently to achieve improved system performance in terms of throughput and capacity gains. Kyasanur and Vaidya [1] have showed that the capacity of a multi-channel network with n randomly distributed nodes scales linearly with the number of channels when the ratio of the number of channels to the number of interfaces is of the order of $O(\log n)$. For practical networks, this would mean that we can achieve higher throughputs by utilizing as many channels as possible depending on the wireless technology used. For instance, IEEE 802.11a specifies twelve non-overlapping channels in the 5GHz band for communication. The devices that currently use 802.11a, however, use only one of these channels at any point of time. Better performance can be obtained if the devices can use more than one channels simultaneously.

The capacity benefit of a multi-channel, multi-interface wireless network is often restricted by interference between the adjacent channels. The interference effects are mainly due to poor signal processing and interference characteristics of the wireless cards and other hardware. This imposes a restriction on the number of channels that could be used, which in turn brings down the total capacity benefit of the network. Improper channel management can have significant impact on the throughput and spatial re-use of the network (number of simultaneous transmissions that can take place in the network). We formulate an efficient channel allocation algorithm that incorporates awareness to the adjacent and co-channel interference effects that arise in MCMI networks. The proposed channel assignment makes use of all the available channels in the network, whenever possible. We demonstrate the performance benefit obtained through our channel management scheme by comparing it with a naive scheme that uses only orthogonal channels.

II. Background on Multi-channel Testbed

In this section, we present the relevant background on our testbed and the multi-channel protocol used.

A. Testbed Overview

We have deployed a multi-channel, multi-interface, and multi-hop wireless testbed of 20+ nodes distributed across various offices in our lab. Each of the testbed node is a Soekris 4521 net board with a 133MHz microprocessor, a compact flash (CF) card slot, two PCMCIA slots, and one mini-PCI slot. We run linux kernel 2.4.26-based operating system on each of these boards. For our experiments, we equip the test nodes with one mini-PCI and one PCMCIA wireless card. These wireless cards are based on Atheros chipsets and are driven by madwifi drivers. We operate these cards in IEEE 802.11a mode at a fixed data rate of 6 Mbps. The cards are capable of operating in all the twelve channels of 802.11a[1]. The mini-PCI cards make use of a pair of external antennas, and the PCMCIA card has its own internal antenna for communication. The two wireless cards have different functionalities, as explained later in this section. Figure 1 shows a Soekris net board used in our testbed.

Fig. 1. A Soekris net board used in our testbed

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[1]IEEE 802.11a numbers the channels as 36, 40, 44, 48, 52, 56, 60, 64, 149, 153, 157, and 161.

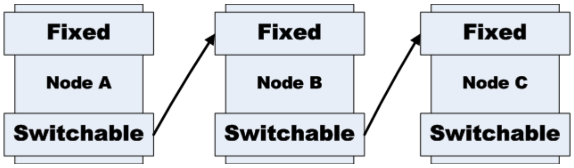

Fig. 2. Example multi-channel protocol operation

B. Protocol operation

In this section, we present a brief overview of the general operation of our multi-channel protocol implemented on the testbed. Among the two wireless interfaces in a node, one is capable of switching across multiple channels whenever required, while the other remains fixed on a channel as long as the channel is perceived to be good. We call the interface that is capable of switching across channels as the *switchable* interface and the interface that operates on a fixed channel as the *fixed* interface. The fixed interface is used for data reception. However, a data transmission can be from any of the two interfaces, fixed or switchable; this depends on the channel of the fixed interface on the neighboring node to which a multi-hop flow is directed. In general, if a neighboring node is operating on the same fixed channel as the current node, then the transmission can be through the fixed interface, else the switchable interface is used for transmission after switching its channel to the fixed channel of the neighboring node. Thus, a node can potentially transmit and receive simultaneously, if the channels on which they transmit and receive are different. Because the channel on which a switchable interface operates depends on the fixed channel of a neighboring node, it is clear that we need to allocate channels only to the fixed interface of a node. Figure 2 shows an example of our protocol operation for a data transmission from node A to node C, with node B as an intermediate node.

More details on our testbed's system architecture and protocols can be found in [2] and [3].

C. Net-X visualization tool

We have developed a graphical visualization tool to assist in network visualization and management. Figure 3 shows a snapshot of the nodes deployed in our lab as seen using the visualization tool.

Fig. 3. A map of indoor network in our lab showing the testbed nodes location

III. Channel Assignment Algorithm

We intend to demonstrate our interference-aware, distributed, channel allocation algorithm. Our algorithm makes use of the channel information of two-hop neighbors, made available at the nodes by the exchange of broadcast 'hello' messages. The main steps in our algorithm (we have not provided the exact details of the algorithm) are as follows,

At every node n,

1) Form the set F of channels that are not adjacent to any of the channels chosen by the two-hop neighbors.
2) If F is non-empty, choose a channel from F.
3) If F is empty, choose a channel that is allocated to the least number of two-hop neighbors.
4) The fixed interface of node n is allocated the chosen channel.

We observe from our algorithm that it always assigns the channel that causes the minimum interference to the neighbors. Furthermore, the algorithm makes use of all the channels in the network. We will be comparing the performance of our algorithm with another algorithm that uses only orthogonal channels, proposed in [4].

References

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