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Improving Performance of Wireless Mesh Network using Channel Allocation Schemes

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Abstract — **One of the major advantages of wireless communication over wired is the flexibility when creating links between nodes. But this comes at a price as influences from outside the mesh network can distort communication between the nodes and even the nodes themselves interfere with each other. By carefully selecting channels where each link transmits data on, the interference can be minimized causing the throughput and end-to-end delay to be improved. We compares the channel allocation schemes to find the best channel selection for each link. While single radio mesh nodes operating on a single channel suffer from capacity constraints, equipping mesh routers with multiple radios using multiple non overlapping channels can significantly alleviate the capacity problem and increase the aggregate bandwidth available to the network. The goal of channel assignment algorithms in multi radio mesh networks is to minimize interference while improving the aggregate network capacity and maintaining the connectivity of the network.**

Index Terms — **Channel allocation, Wireless mesh network.**

I. INTRODUCTION

Wireless mesh networks (WMNs) [1] consist of a number of stationary wireless routers interconnected by wireless links. These wireless routers serve as access points (APs) for wireless mobile devices. Some of them also act as gateways to the Internet via high-speed wired links. Wireless mobile devices first transfer data to the associated wireless router, and these data are then transferred to the Internet (or other networks) via the intermediate wireless routers in a multi-hop manner (see Fig. 1). In our work, we focus on improving the aggregate capacity of the IEEE 802.11a/b/g-based WMNs via the use of multiple channels in each router. In this scenario, stationary wireless routers are assumed to have multiple network interface cards (NICs). Each network interface is assigned to a distinct frequency channel. A router can establish a link with a neighboring router when each router has one of its interfaces using the same channel. The number of available channels depends on the frequency band. For example, the IEEE 802.11b/802.11g standards [2] and IEEE 802.11a standard [3] provide 3 and 12 non-overlapping frequency channels within the 2.4 GHz frequency band, respectively. Since the number of channels is limited, some links in the WMNs may be allocated to the same channel. In this case, interference will occur if these links are close to each other. Interference between neighboring links can potentially cause network congestion.

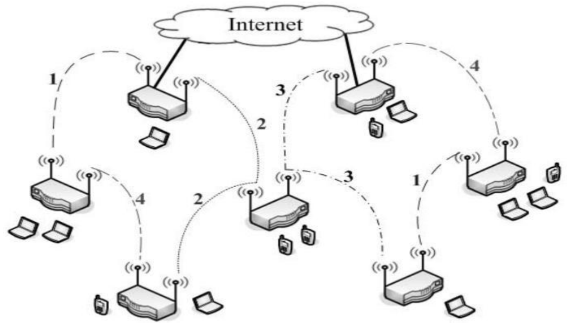

Fig.1. A multi-channel wireless mesh network with 4 channels.

The next generation of wireless communication systems is envisaged to provide high-speed, high-bandwidth ubiquitous connectivity to end users through a converged network of different technologies, such as third- and fourth-generation (3G/4G) mobile cellular systems, IEEE 802.11 (Wi-Fi) based wireless local area networks (WLANs), and emerging broadband wireless technologies such as IEEE 802.16 (WiMAX). One of the key components of such converged networks is the wireless mesh network (WMN), which is a fully wireless network that employs multi hop ad hoc networking techniques to forward traffic to/from the Internet. Unlike the mobile ad hoc network (MANET), a mesh network uses dedicated nodes (called mesh routers) to build a wireless backbone to provide multi hop connectivity between nomadic users and the Internet gateways [4]. WMNs can provide significant advantages in deploying cost efficient, highly flexible, and reconfigurable backhaul connectivity over large areas. The wireless backbone, consisting of wireless mesh routers equipped with one or more radio interfaces, highly affects the capacity of the mesh network. This has a significant impact on the over-all performance of the system, thus generating extensive research in order to tackle the specific challenges of the WMN. Current state-of-the-art mesh networks, which use off-the-shelf 802.11-based network cards, are typically configured to operate on a single channel using a single radio. This configuration adversely affects the capacity of the mesh due to interference from adjacent nodes in the

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network.

To improve capacity and reduce interference between nodes of wireless mesh network in this paper we systematically studied different channel allocation schemes for WMNs, and examine their relative strengths and weaknesses.

II. CHANNEL ALLOCATION SCHEMES

Wireless Technologies such as the 802.11a, provides several non-overlapping channels, which means that nodes can be transmitting or receiving at the same time on different channels without interfering with each other. However, to ensure such interference free communication, all the nodes within each other's interference range must be on different channels. This problem of making sure that all the interfering nodes are allocated different channels is known as the Channel Allocation (CA). Channel allocation in a multi radio WMN environment consists of allocating channels to the radio interfaces in order to achieve efficient channel utilization and minimize interference. However, if it can be ensured that in a node, if each of the multiple radio interfaces operate on different channels then this will improve the networks performance. The benefits of using Multi-Radio Multi-Channel (MR-MC) nodes are studied in [5, 6] which consider channel allocation. In this section we present a classification of various CA schemes for mesh networks. Specifically, the proposed CA schemes can be divided into three main categories — static, dynamic, and hybrid — depending on the frequency with which the CA scheme is modified. In a static scheme the CA is almost constant, while in a dynamic scheme it is continuously updated to improve performance. A hybrid scheme applies a static scheme for some interfaces and a dynamic one for others. Fig.2. shows classification of these channel allocation scheme.

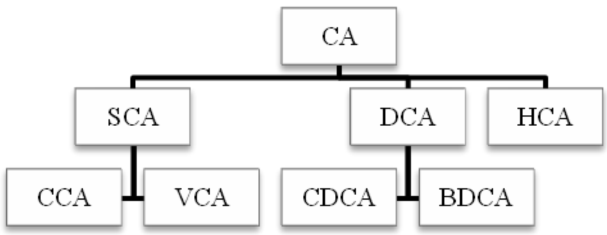

Fig.2. classification channel allocation scheme

A. *Static Channel Allocation*

Static Channel Allocation (SCA) schemes allocate channels to interfaces either permanently or for some time intervals with respect to the interface switching time. Such schemes can be further subdivided into common channel Allocation and varying channel Allocation.

1) *Common Channel Allocation Scheme*

Common Channel Allocation (CCA) is the simplest scheme. In this case the radio interfaces of each node are all allocated the same set of channels. The main benefit is that the connectivity of the network is the same as that of a single-channel approach, while the use of multiple channels increases network throughput. However, the gain may be limited in scenarios where the number of non-overlapping channels is much greater than the number of network interface cards (NICs) used per node.

2) *Varying Channel Allocation Scheme*

In the Varying Channel Allocation (VCA) scheme, interfaces of different nodes may be allocated different sets of channels. However, the allocation of channels may lead to network partitions and topology changes that may increase the length of routes between the mesh nodes. Therefore, in this scheme, allocation needs to be carried out carefully.

One obvious disadvantage of using this static channel allocation scheme can best be explained using an example. Imagine two neighboring nodes with their allocated channels. If at any time, one of the nodes happens to have all its channels occupied, and another request for service is made at this same node, this new request will be denied even though there may be free channels in the neighboring node at this very instant. The overall result is one of poor channel utilization.

B. *Dynamic Channel Allocation*

In Dynamic Channel Allocation (DCA) strategy any interface can be allocated to any channel and interfaces are allowed to switch from one channel to another. A network using such a strategy needs some kind of synchronization mechanisms to enable communication between nodes in the network. An example of such mechanism is that nodes can periodically visit a common channel [7] and tune the interfaces accordingly to establish a communication link.

1) *Centralized Dynamic Channel Allocation Scheme*

In a Centralized Dynamic Channel Allocation (CDCA) scheme a good allocation policy requires as a central authority to take care of all requests, dispatching its decisions to nodes but maintaining a central knowledge base. In this case, the status of the system is globally known and every decision can take advantage of the whole configuration, of statistics about future requirements and so it is more likely to maintain a good configuration of the system. On the other hand, having a central authority is more error prone: what if it breaks down?

The main hurdle in the dynamic strategy is to decide which channel to switch the interface and also when to switching needs to occur so that interference free communication is ensured.

2) *Borrowed Dynamic Channel Allocation Scheme*

In a Borrowed Dynamic Channel Allocation (BDCA) scheme, an acceptor node that has used all its nominal channels can borrow free channels from its neighboring nodes (donors) to accommodate new service request. A channel can be borrowed by a node if the borrowed channel does not interfere with existing services. When a channel is borrowed, several other nodes are prohibited from using it. This is called channel locking.

C. *Hybrid Channel Allocation*

Hybrid channel allocation strategies combine both static and dynamic allocation properties by applying a static allocation for some interfaces and a dynamic allocation for other inter-faces [8, 10, 11]. Hybrid strategies can be further classified based on whether the static interfaces use a common channel [11] or varying channel [8, 10] approach. The static interfaces can be allocate a dedicated control channel [9] or a data and control channel [11], while the other interfaces can be switched dynamically among channels. Hybrid allocation strategies are attractive because, as with static allocation, they allow for simple coordination algorithms, while still retaining the flexibility of dynamic channel allocation.

III. DESCRIPTION OF SIMULATED SYSTEM

Basic assumptions

1. For the investigation of the optimum division between static and dynamic channels, a system with a very large mesh layout should be used, but the statistics should be collected from the central nodes only. The reason for considering a large mesh layout was to overcome the edge effects. Using a small system for this kind of study is bad because the nodes around the edges do not have enough neighboring nodes to cause services to be blocked, whereas the centrally located nodes have a lot of neighboring nodes and therefore every time the central nodes wish to borrow, chances are the neighboring nodes will be using the desired channels. This gives rise to the central nodes having higher blocking probabilities than those at edges.

2. The services in each node are assumed to have a Poisson distribution with known arrival rate, λ services/hour.

3. The service time per service, in any node, is assumed to be exponentially distributed, with a mean of 180 seconds.

4. The first available channel in the search that satisfies the spacing constraint is borrowed for use.

5. The access points could transmit on any borrowed frequency at all times, as allocated to them by the system controller.

Now consider a system having uniform spatial offered traffic and using a CA scheme. The steps involved in the simulation are as follows:

a) Assumed that the long term average offered traffic in Erlangs was known. Then using the tables for the Erlang B traffic formula [12] now determine the number of channels required in each cell to give the desired grade of service assuming that a FCA scheme was in use.

In performance evaluation of a system, Erlang B formula for estimating the blocking probability (P_b) for a node which has 'n' channels and the amount of traffic is 'A' Erlang:

$$P_b = \frac{\frac{A^n}{n!}}{\sum_{i=0}^{n} \frac{A^i}{i!}}$$

b) Then consider a wireless communications system with uniformly offered traffic that requires N channels per node, on the average. the ratio of Static to Dynamic channels that carry the most traffic at the desired grade of service. Let this, ratio be represented S **:** D, where S is the average number of static channels per node, D is the average number of dynamic channels per node and Total Channel (TC) is –

$$\mathbf{TC = S + D}$$

c) Now using the results obtained in Step b above, channels are assigned to the cells of the mobile communications system.

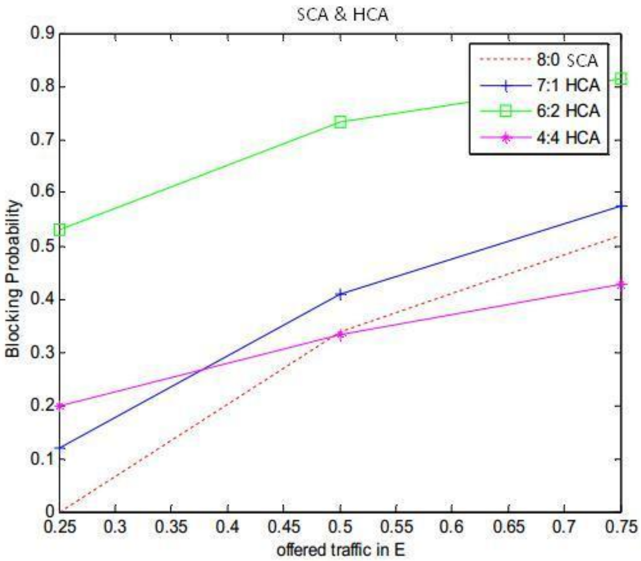

Fig.3. Simulation results showing the comparison between SCA and HCA

IV. CONCLUSION

The obtained results indicate that the Static to Dynamic Channel Allocation scheme ratio per node is equal performs better than other ratios. The simulation study of the protocol indicates that the blocking probability low for less traffic in SCA case, while for high traffic static and dynamic channels should equal so that blocking probability remain less. Beyond this, for different combination of ratios HCA has low blocking for less traffic and high for high traffic.

To further improve the performance, there is no division of static and dynamic channels groups. Dynamic channel pool includes all the channels in the system.

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