Chapter 12
TPC and Non−TPC Based Topology Control Approaches for QoS Improvement in MR−WMN

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ABSTRACT
A grand challenge in Multi-Radio Wireless Mesh Networks (MR-WMN) is to limit the interference such that its net capacity increases without compromising scalability and stability. In this chapter, the authors first provide an insight into the implications of transmit power control (TPC) on the MR-WMN topology and QoS. In this regard, a review of some of the key work is carried out they then explore the approach of non-TPC based topology control schemes for limiting the interference in a static nodes based MR-WMN system that uses a distributed, light-weight, cooperative multiagents. A path reduction (PR) algorithm is the principle behind our topology control scheme and its viability is explained through NetLogo tool based simulation results. The effectiveness of the PR algorithm is shown in terms of improved interference cost reduction and decrease in path length. The focus of this chapter is mainly on non-TPC approach rather than the TPC approach.

INTRODUCTION
A wireless mesh network (WMN) is a networking paradigm, which enables inexpensive peer wireless network nodes to relay frames from one node to another by leveraging the broadcast nature of wireless medium. Essentially, WMN facilitates to cost-effectively and quickly extend a wired network by creating multiple topologically diversified wireless connections between peer nodes. This feature
coupled with the dynamic reconfiguration of links, increases robustness. Mesh networks are very reliable and self-healing (Hossain & Leung, 2007), i.e., the network can still operate even when a node breaks down or a specific link is not usable any more. A mesh network whose nodes are all connected to each other is known as a fully connected WMN.

The drawback of a single radio mesh network is that the throughput of the link between each hop progressively decreases due to the co-channel interference (BelAir networks, 2006). As such, the core network considered in this chapter and shown in Figure 1 is a multi-radio wireless mesh network (MR-WMN) in which multi-radio nodes, which are also known as wireless routers, are used to result in a decrease of the interference between the channels of two adjacent routers (Mobileman, 2005). In Figure 1 the multi-radio routers with an exclusive wireless connectivity are termed as client nodes. The root node in the mesh networking terminology is known as the mesh portal node. MR-WMN is used to facilitate broadband wireless connectivity to the heterogeneous access networks such as 2G/3G, PSTN, Cdma etc. In the MR-WMN node, we are considering multiple 802.11 based interfaces corresponding to the 802.11 radios in a node. The 802.11 radios are: 802.11a, 802.11b, 802.11g. Each of the radio interfaces can communicate with an interface of the same radio type by using a channel within the frequency range of the radio type. The mesh nodes i.e. mesh routers which also have an access point functionality are termed as mesh access point (MAP). The MAPs in Figure 1 essentially multi-hop the traffic to and from the access networks and the wired Internet.

A self-organization (defined later in section on multi-agent systems) process that methodically allocates the channels to the MR-WMN nodes in the system facilitates to make the throughput of the links, as much as possible, less susceptible to the channel interference.

Transmit power control (TPC) has a bearing on the transmission range of the node’s radio. As such, it influences the physical distance of the link between the radios of two nodes. This leads to a topology control (TC) of the wireless mesh networks. The topology of a MR-WMN has a bearing on the overall system capacity and other Quality of Service (QoS) metrics viz. end-to-end packet transfer latency, jitter and throughput. TC is an extensively studied topic in the area of wireless telecommunication networks, particularly in the mobile ad hoc and sensor networks wherein energy is considered as a critical resource. Reference (Mobileman, 2005) informally defines TC as:

*The art of coordinating nodes decision regarding their transmitting ranges, in order to generate a network with the desired properties (e.g. connectivity) while reducing node energy consumption and/or increasing network capacity.*

There are two key reasons that motivate to have a proper TC in a MR-WMN. These are enumerated below:

- The power used to transmit messages has a bearing on the amount of interference caused between two simultaneous transmissions on the same channel within a common interference range. Limiting the amount of interference between channels in the MR-WMN system is a major factor that contributes towards the gain in overall network capacity. Ref (Santi, 2005) has shown that a decrease in interference hence a gain in network capacity is possible by communicating over short multi-hops between the sender and receiver nodes. The purpose of topology control in this regard is to prune the MR-WMN so as to have only “capacity-efficient” links.
- Generally, in an ad hoc and sensor networks energy is a critical resource. Santi (2005) has shown that transmitting