Chapter 10
Cross-Layer Framework for Power Conservation in Wireless Ad Hoc Networks: A Case Study

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ABSTRACT

Most of the wireless ad hoc networks have battery-powered nodes, so the life of the network depends on the power of the nodes. Power conservation is one of the main issues of wireless ad hoc networks. Power conservation can be achieved in two different ways: power control algorithms and power management algorithms. Transmission power control is one example of a cross-layer design problem. The purpose of this chapter is to discuss transmission power control problems and one possible solution by using cross layer framework through a case study. This chapter describes two cross-layer power control protocols developed at two different layers and also presents the effect of applying the combination of these protocols through a simulation study using Glomosim.

INTRODUCTION

A critical design issue for future wireless ad hoc networks is to develop suitable communication architectures, protocols, and services that efficiently reduce power consumption of wireless devices and thus increasing their operational lifetime in the network. In wireless ad hoc networks, power conservation can be achieved in two different ways: power control algorithms and power management algorithms. Power management in

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ad hoc networks means that a station can decide when to switch its radio transceiver off to save energy. However, turning its transceiver off means that other stations cannot send their packets to the station, if any. Therefore, it should be done with caution to avoid possible delays. The power management issue is challenging especially in a multihop ad hoc network because hosts may sometimes lose synchronization. On the other hand, power control refers to the technique of tuning hosts transmission powers to the proper range to conserve energy. In addition, power control can also reduce interference and improve spatial reuse of wireless channels. The scope of the chapter is on power control algorithms in wireless ad hoc networks.

A wireless node in an ad hoc network has limited battery power; therefore, it is important to reduce its energy consumption. A wireless node has four modes: transmit, receive, idle, and sleep. It consumes most power in the transmit mode. In the idle mode, it needs to sense the medium and consumes a little less than in the receive mode. The sleep mode consumes very little and can be ignored compared to the other modes (Nilson, 2001). To save energy, one direction is to force a node to enter the sleep mode when it is not necessary to be awake (Jamieson, Balakrishnan, & Morris, 2001; Jung & Vaidya, 2002). The other direction is to apply a Transmission Power Control (TPC) protocol (Gomez, Campbell, Naghshineh, & Bisdikian, 2001; Agarwal, Krishnamurthy, Katz, & Dao, 2001; Pursley, Russell, & Wysocarski, 2000; Jung & Vaidya, 2002). This chapter is focused on the second direction. TPC looks for the minimum required transmit power between the transmitter and the receiver.

TPC is a simple and fundamental technique which is used for communications and impacts the operational lifetime of devices in different ways. Reducing the transmission power to significantly improve operational life time for some devices may not be significant if the transmission power accounts only for a small percentage of the overall power consumed, (e.g., a Wireless Local Area Network [WLAN] radio attached to a notebook computer). In contrast, for small computing devices with built-in or attached radios (e.g., sensors) reducing the transmission power may significantly extend the operational lifetime of a device, thus, improving the overall user experience.

The power control problem in wireless ad hoc networks is that of choosing the transmit power for each packet in a distributed fashion at each node (Kawadia & Kumar, 2005). Selecting power level fundamentally affects the network at various layers as follows:

- Power control affects the **physical layer** because the transmit power level determines the quality of the signal received at the receiver.
- Transmit power level determines the range of a transmission. Since the contention for the medium depends on the number of other nodes within range, the power levels determine the performance of medium access control and thus power control affects the **mac layer**.
- The basic functionality of the network layer is to discover and maintain routes between sources and destinations. The transmit power determines the set of possible neighbors a node can reach and hence the potential set of next hops and the overall network connectivity. Power control affects the **network layer** since the transmission range affects routing.
- The transmit power level determines the magnitude of the interference it creates for the other receivers. Power control affects the **transport layer** because interference causes congestion.
- Also the transmit power control problem affects several key performance measures including throughput, delay and energy consumption.

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