Chapter 19
Using Wireless Mesh Network for Traffic Control

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ABSTRACT

Wireless mesh networks (WMN) have attracted considerable interest in recent years as a convenient, flexible and low-cost alternative to wired communication infrastructures in many contexts. However, the great majority of research on metropolitan-scale WMN has been centered around maximization of available bandwidth, suitable for non-real-time applications such as Internet access for the general public. On the other hand, the suitability of WMN for missioncritical infrastructure applications remains by and large unknown, as protocols typically employed in WMN are, for the most part, not designed for real-time communications. In this chapter, we describe a real-world testbed, which sets a goal of designing a wireless mesh network architecture to solve the communication needs of the traffic control system in Sydney, Australia. This system, known as SCATS (Sydney Coordinated Adaptive Traffic System) and used in over 100 cities around the world, connects a hierarchy of several thousand devices -- from individual traffic light controllers to regional computers and the central Traffic Management Centre (TMC) - and places stringent requirements on the reliability and latency of the data exchanges. We discuss some issues in the deployment of this testbed consisting of 7 mesh nodes placed at intersections with traffic lights, and show some results from the testbed measurements.

INTRODUCTION

Adaptive traffic control systems are employed in cities worldwide to improve the efficiency of traffic flows, reduce average travel times and benefit the environment via a reduction in fuel consumption. One of the main and most common functions of such systems lies in adaptive control of traffic lights. This ranges from simple lengthening or shortening of green and red light durations in an intersection according to the actual presence of cars in the respective lanes, to coordination of green light

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phases among neighboring intersections on main thoroughfares. This adaptivity is made possible with the use of sensors (typically in the form of magnetic loop detectors embedded under the road pavement) that feed data to roadside traffic light controllers, and a communications infrastructure that connects among the intersections and a traffic management centre, as well as, in some cases (typically in large cities), a hierarchy of regional computers (RC) that perform the control decisions for respective portions of the system.

Traditionally, the communications layer of traffic control systems has been based on wired connections, either private or leased from public telecommunications operators. While for many years such leased lines (operating at 300bps) have served their purpose well, they have several shortcomings, such as a significant operating cost, inflexibility, and difficulty of installation in new sites. In certain cases, alternative solutions, operating over public infrastructure, have been deployed for specific sites where private or leased lines were not a viable option; these ranged from ADSL, regular dialup, or cellular (GPRS). However, using public network for traffic control could suffer from inconsistent delay jitters and reliability issues. For example, previous experimental studies (Chakravorty et al., 2002) have shown GPRS links could have very high RTTs (>1000ms), fluctuating bandwidths and occasional link outages.

In recent years, there has been considerable interest in wireless mesh networks and their deployment in metropolitan areas, from both a commercial and a research perspective (Lundgren et al., 2006). Trials in several major cities in the US (e.g. Philadelphia, New Orleans, and others (Tropos networks, 2009; Locust world, 2009) and worldwide (e.g. Taiwan (Mobile Taiwan) have shown mesh networks to be a viable technology that can compete well with alternative "last-mile" connectivity solutions to the public. Correspondingly, most of the research on metropolitan-area wireless mesh networks (MAWMN) has focused on maximising the throughput that can be extracted from them, in the anticipation that their major use will be public, for purposes such as accessing the Internet or conducting voice calls (Ganguly et al., 2006). On the other hand, little attention has been directed to the aspects of reliability and latency, which are most important if MAWMN are to be considered for replacement of mission-critical infrastructure, such as traffic control system communications.

In this chapter, we describe a wireless mesh network testbed that has been built. The testbed physically covers seven traffic lights in the suburban area of Sydney. These intersections are chosen because they represent a typical suburban area with lots of traffic, foliages, pedestrians and high-rise residential buildings. In addition, the inter-node distance (ranging from 200 to-500m) is representative of 90% of the distance between traffic controllers in the Sydney CBD (Central Business District) area. The testbed nodes have been custom-built.

The contribution of this paper is three-fold. First, to the best of our knowledge, our work is one of the first efforts to study the feasibility of using wireless mesh networking for traffic control. Second, we describe the details of our testbed implementation and some experiences we gained during the deployment of the testbed in an urban environment. Finally, we present some initial measurement studies of link characteristics of different wireless and wired technologies used in our testbed (including the use of 900MHz, 2.4GHz and 3.5GHz radios and Ethernet-over-powerline). Although our results are still very preliminary, they are useful to serve as a reality check toward the goal of applying wireless mesh networking to traffic control applications.

The rest of this paper is structured as follows. In section 2, we describe the details of SCATS, the traffic control system used in Sydney and many other cities worldwide, and its communication requirements. We describe related work in Section 3. Section 4 presents a simple analysis of the topology of traffic lights in the Sydney met-

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