Chapter 2
FiWi Networks

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ABSTRACT
Optical access network is a promising solution to meet the ever-increasing demand for broadband services. Fiber-based technologies such as Fiber To The Home (FTTH), Fiber To The Building (FTTB), and Fiber To The Curb (FTTC) are well suited to support high bandwidth services and mitigate bandwidth bottlenecks. However, implementing optical fiber to all end points imposes considerable CAPEX. Moreover, fiber cannot directly reach mobile users and devices. Although untethered features of wireless networks are attractive, their limited supported bandwidth cannot answer today’s enormous demands. Combining complementary features of these two technologies for broadband access is imminent and meritorious. Thus, integrated Fiber-Wireless (FiWi) access networks are considered as a scalable and economical means for broadband access. In FiWi, end points receive services through a wireless subnetwork, which acts as the front end and is connected to the optical subnetwork, which serves as the back end via gateway nodes.

INTRODUCTION
Owing to enormous increase in the bandwidth demand for telecommunication services, wireless and copper technologies can not completely meet this challenge. Copper access networks can provide around 50 Mb/s for each user in a short loop length. Increasing the copper length attenuates the provisioned bandwidth rapidly, and could easily limit the bandwidth to 10 Mb/s or less. Hence, noise and signal interference in copper is the major culprit in provisioning high bandwidth for such an access network. On the other hand, wireless technologies such as WiFi and WiMAX can provide users with almost ubiquitous connectivity. WiFi networks can provide local access up to a few hundred feet at a rate of up to 50 Mb/s while a WiMAX antenna can support up to 30 miles at a rate of 70 Mb/s. Essentially, wireless technology does not scale up well in terms of provisioned bandwidth. So far, the best solution for access is fiber (Effenberger, 2007). Although optical fiber cannot
FiWi Networks reach everywhere, it can provide a large amount of accessible bandwidth. On the other hand, wireless access networks can reach almost anywhere, but with a limited amount of bandwidth. Combining the advantages of these two access networks is a no-brainer to provision tethered Internet access. Thus, Fiber-wireless (FiWi) access networks have been proposed to provision the high capacity of fiber networks along with the mobility of wireless networks into one single infrastructure. FiWi networks hold great promise to change the way we live and work by replacing commuting with teleworking, and thus protect our environment by reducing the carbon footprint of commuting. In this chapter, the distinct and unique characteristics of FiWi broadband networks will be presented.

The rest of the chapter is organized as follows. We will next provide an overview of optical and wireless enabling technologies and introduces related traffic based classes and traffic scheduling. We will then present several architectures that can be used to support the integration of optical and wireless networks. Quality of Service (QoS) provisioning techniques for FiWi networks including integrated path selections, bandwidth allocation, mapping techniques and handover, which supports user mobility, will be discussed next. We will also evaluate energy efficiency of each network as ICT carbon footprints are becoming a serious concern. Methods for greening FiWi networks will also be discussed in this chapter. Then, we elaborate on future research challenges of FiWi networks. Finally, concluding remarks are provided.

BACKGROUND

Merging high capacity of optical fiber networks with the mobility of wireless networks creates a promising technology to support existing and emerging bandwidth hungry services. In this section, enabling technologies of wireless and optical access networks are briefly reviewed.

Wireless Mesh Networks

Wireless Mesh NETWORKS (WMNs) forward traffic to and from wired entry points by using multi hop communications (Bruno, Conti, & Gregori, 2005). These networks can easily, effectively and wirelessly connect entire cities using inexpensive existing technologies. Contrary to WLANS and Mobiles and Adhoc Networks (MANETs), WMNs provide greater flexibility, effective connectivity, and increased flexibility because they can facilitate efficient routing through the mesh that can react dynamically to changes in the topology.

WMNs are categorized into three groups (Akyildiz, Wang, & Wang 2005): infrastructure, client, and hybrid (Figure 1). In an infrastructure WMN, mesh routers form an infrastructure for clients. In a client WMN, client nodes constitute the actual network to perform routing and configuration functionalities. In hybrid WMN, mesh clients can perform mesh functions with other mesh clients as well as accessing the network.

It is worth emphasizing that WMNs can exploit adhoc routing protocols such as AODV (adhoc on-demand distance vector) and DSR (dynamic source routing) because WMNs and MANETs share some commonalities.

Several technologies and routing protocols have been employed to optimize the performance of WMNs. For instance, in the physical layer, in addition to smart antenna, MIMO (Multiple-Input Multiple-Output) and UWB (Ultra Wideband) systems are used to increase the capacity of networks. Besides, wireless gigabit transmission is enabled by synergizing MIMO and OFDM (orthogonal frequency division multiplexing) technologies. On the other hand, bandwidth efficiency of CSMA/CA has been improved by adopting MAC protocols based upon TDMA and CDMA. Moreover, IEEE 802.11 (WiFi) technologies are widely used in commercial products due to their low cost, technological maturity, and high product penetration. However, these protocols are not optimized
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