Chapter 7
WiMAX for Traffic Control in Urban Environments

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ABSTRACT
This chapter addresses the wireless communication aspect of traffic control in an urban vehicular environment. The IEEE 802.16e-2005 standard is used for Infrastructure to Vehicle communication. An architecture is developed with the target of minimizing overall data loss. Access Service Network Gateway (ASN-GW) is used to manage vehicle communication while roaming. OPNET simulations show that using ASN-GW gives good performance in mobility management. Simulations also show that introducing an interference source drastically degrades system performance. Using Dual Trigger HO (DTH) in a congested scenario improves system performance and reduces the impact of interference on the system.

INTRODUCTION
Traffic congestion has a number of negative effects on world economy as well as people’s lives (Mohandas, 2009). Significant activities are underway worldwide to accelerate the development of Intelligent Transportation Systems for safe, efficient, and convenient driving. For example, the department of transportation in the USA funds projects like IntelliDrive (Weil, 2009). In Europe, the European Union funds projects like CityMobil (Wahl, 2008), COOPERS (Toulminet, 2008), and GeoNet (Mariyasagayam, 2008). On the other side of the world, the Ministry of Land, Infrastructure, Transport, and Tourism in Japan funds the SmartWay project for driving safety support systems based on vehicle-highway cooperation (Oyama, 2008).

ITS is about integrating wireless communications, computing, and advanced sensor technologies into vehicular and transportation systems. One of the main challenges in providing a complete ITS is the design of protocols for Vehicle-to-Vehicle (V2V) and/or Infrastructure-to-Vehicle (I2V) networking that adapt to changes of roadway conditions in order to provide fast, reliable com-
 communications technologies while achieving security and privacy standards (Chen, 2009).

Research was conducted in the context of V2V communication in highway environments and produced good results (Schwartz, 2010). On the other hand, in city centers, V2V was not an optimal choice as the area is smaller and the flow of vehicles is more complex. Introducing central node (Correspondent Node, CN) was a very attractive solution to control the traffic flow and measure the load on every segment of the roads; vehicles sent status to the CN (V2I) and the CN sent information to the vehicles (I2V) (Daoud, 2006).

There are a lot of protocols that can provide wireless communication for the vehicles like WiFi, GPRS, 3G, WiMAX, and others (Rebeiro, 2005). GPRS and 3G appear to be an attractive solution as the networks are already in place and can easily be integrated with the CN. However, from a practical point of view, commercial networks have limited bandwidth which is costly for the operators; furthermore, they are already congested and hence, cannot guarantee the QoS for the ITS traffic. The other option is to build a dedicated network for the vehicles communication. WiFi is a big step in the world of wireless internetworking and communication. WiFi offers better data rates than the GPRS and 3G of the personal mobile communication systems. It is operating in the unlicensed Industrial Scientific and Medical (ISM) band. The ISM band is a free band under power regulations by the federation of each country.

The Hand-off HO (or Handover) mechanism is an issue for wireless networks. WiFi (IEEE 802.11 protocols) does not define a built-in handover mechanism in its layer (layer 2) of the stack. Providing mobility in WiFi requires a higher layer (layer 3 or the IP layer) to control the mobility. Each wireless node is identified by a unique Internet Protocol (IP) address. It is then difficult to maintain connectivity when the Mobile Node (MN) changes its point of attachment to the network, because it changes its IP address.

The large growth in network use generally demands a new address protocol to accommodate this large number. After Internet Protocol version 4 (IPv4), Internet Protocol version 6 (IPv6) is introduced and is currently being deployed. A big share of the network cards manufacturers are now making these cards IPv6 compatible (wired as well as wireless).

With the presence of both IPv4 and IPv6, hand-off task forces worked first on MIPv4 (Mobile IPv4) and then migrated to MIPv6 (Mobile IPv6) to support mobility in IPv4 and IPv6, respectively (RFC3775, 2004; RFC4260, 2005). Many efforts are put in this context to provide a solution for wireless communication using WiFi in light urban areas and make use of the free band the WiFi is utilizing. The solution includes a lot of techniques to overcome the impact of the long handover delays generated from the layer 3 handover of the MIP protocols (Daoud, 2007). The same techniques could not provide an acceptable solution in urban or more congested environment due to the limitation of the coverage area of WiFi in urban areas and the long handover delay in the layer 3 handover protocols.

The rapid development and deployment of Worldwide Interoperability for Microwave Access (WiMAX) and the introduction of the mobility concept made it possible to use this system in traffic control. The IEEE 802.16e commercially known as mobile WiMAX is an attractive wireless solution to cover large areas and provide wireless access with carrier grade performance, as well as real-time experience for users by efficiently handling handovers during user movement.

In El-Dakrouy (2010), an infrastructure was proposed to manage downtown vehicle traffic. The infrastructure was based on the mobile WiMAX IEEE 802.16e standard to maintain the communication between the Infrastructure (Correspondent Node) and the vehicle (MN). A Correspondent Node was star-connected to all serving Base Stations (BSs). Mobile IP version 6 (MIPv6) was used as a handover protocol. Dual Trigger Handover
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