Chapter 13
Supporting Multiple Quality-of-Service Classes in IEEE 802.16e Handoff

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ABSTRACT

IEEE 802.16 WiMAX (Worldwide Interoperability for Microwave Access) is a major standard technology for Wireless Metropolitan Area Networks (Wireless MAN). Quality-of-service (QoS) scheduling class and mobility management are two main issues for supporting seamless high-speed data and media-stream communications. Previous works on WiMAX handoff however have mainly addressed a particular scenario or a single QoS class. This chapter first presents an overview of the QoS scheduling classes supported by the IEEE 802.16 standard, followed by a survey of major related works proposed to enhance 802.16e handoffs. Next, it will present a new context-sensitive handoff scheme that supports the five 802.16 QoS scheduling classes, and is energy-aware – it may switch to energy-saving mode during handoff. It will then illustrate performance evaluation, which will show that, compared to three existing methods, the proposed scheme successfully supports the five QoS classes in both layers 2 and 3 handoff, decreases end-to-end handoff delay, delay jitter, and service disruption time; it also increases throughput and energy efficiency. Finally, key implementation and cost issues are discussed. We believe that this chapter is a significant contribution for providing high-quality, seamless data and media streaming over 802.16 as well as LTE (Long-Term Evolution) cellular networks, and would be a valuable part of QoS architectures in the wireless networking domain.

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INTRODUCTION

The recent rapid progress in wireless networking has paved the way for ubiquitous and pervasive computing. Its fast advancement has motivated the evolution of next-generation wireless technologies to reach longer distance, higher data rate, and better QoS. This has culminated the widespread of academic and industry efforts in both broadband wireless networks and metropolitan area networks.

The IEEE standard 802.16, also called WiMAX, specifies the "Air-Interface for Fixed Broadband Wireless Access Systems" (IEEE 802.16 Working Group, 2004). The amendment 802.16e has been defined to support mobility and other extensions (IEEE 802.16 Working Group, 2005). Based on the 802.16e handoff (HO) mechanism, many new HO enhancements have been proposed (Chang, 2005; Chen & Hsieh, 2007; Cho et al., 2006; Choi et al., 2005; Das et al., 2006; Hu et al., 2007; Jang et al., 2007; Kim et al., 2005; Lee et al., 2006; Leung et al., 2005; Rouil & Golmie, 2006; Rouil & Golmie, 2007; Yang et al., 2007; Zhong et al., 2007). Most of them, however, try to address only a specific scenario or a particular QoS issue.

The IEEE 802.16d and 802.16e have specified five QoS scheduling classes (IEEE 802.16 Working Group, 2004;, IEEE 802.16 Working Group, 2005): (1) *Unsolicited Grant Services* (*UGS*) – for real-time uplink of fixed-size data packets generated periodically, such as voice over IP (VoIP). (2) *Real-Time Polling Services* (*rtPS*) – for real-time uplink of variable-sized data packets on a periodic basis, such as video streaming. (3) *Extended Real Time Polling Services* (*ErtPS*) – added in 802.16e and an enhancement of rtPS, in which the base station (BS) provides unicast grants in an unsolicited manner with dynamics allocations. (4) *Non-Real-Time Polling Services* (nrtPS) – for delay-tolerant, loss-sensitive data streams with variable-sized packets for which a minimum data rate is required, such as file transfer. (5) *Best Effort Services* (BE) – supporting data for which no minimum service level is required.

We observed that the QoS requirement of a mobile station (MS) may vary over time; a HO scheme that supports only one QoS class is neither complete nor practical. Further, many MSs are battery-powered, yet few of the existing schemes have addressed energy consumption issue.

This chapter proposes a QoS-aware HO scheme with the following major features:

1. *It is context-sensitive, supporting five QoS modes that correspond to 802.16 QoS scheduling classes* (Arunachalam, 1999; 11IEEE 802.16 Working Group, 2004; IEEE 802.16 Working Group, 2005).
2. *It is energy-sensitive and is designed to conserve energy during low-activity modes.*
3. *Depending on the particular handoff scenario, it may operate in either layer 3 or layer 2, and in either predictive or reactive modes (Jang et al., 2007).*

The chapter is organized as follows. Following this section, the next section presents background and related studies, including the five QoS scheduling classes, the basic IEEE 802.16 handoff scheme, and related works on the 802.16 handoff. Then, proposed context-sensitive, QoS-aware handoff scheme is described. This is followed by performance evaluation of the new scheme. Issues on implementation and costs are then discussed. Finally, a conclusion remark is presented, with suggested future directions.

BACKGROUND AND RELATED STUDIES

This section first illustrates the quality of services support in IEEE 802.16. Next, the basic handoff scheme of 802.16e is described. A brief survey of existing proposed HO mechanisms is then presented.