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A Ranging Process in IEEE 802.16 Relay System

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ABSTRACT

With the introduction of relay networks in IEEE 802.16 systems, modifications of the conventional system configuration are necessary. Although the standardization work of IEEE 802.16 relay systems is ongoing by the IEEE 802.16 relay task group, a few problems to be solved and optimized still exist. Among them, this article addresses a problem of ranging processes in the existing draft standard, and provides the solution. First, a thorough study of IEEE 802.16 relay systems and ranging processes is provided. Second, a problem of the existing ranging algorithm is stated, which considers the ranging transmit power control algorithm and the effect of the interference between MS-BS ranging (i.e. ranging between mobile station and base station), and MS-RS ranging (i.e. ranging between mobile station and relay station). Third, a solution of the described problem is provided, and modifications of the existing draft standard are proposed. Fourth, the performance of both existing and proposed ranging algorithms are analyzed and evaluated. A benefit of this article will be the provision of a guideline for the design of IEEE 802.16 relay systems.

Keywords: *IEEE 802.16; Transmit Power Control; Ranging Process; Relay*

INTRODUCTION

The standardization work for IEEE 802.16e broadband wireless access systems has been finished and its commercialization has been ongoing (IEEE LAN/MAN Standards Committee, 2004, 2006). IEEE 802.16e is based on orthogonal frequency division multiple access (OFDMA) which has advantages due to its spectral efficiency, the capability to cope with inter symbol interference, and robustness in multipath propagation environments (Nee & Prasad, 1999; Cimini, 1985; Keller & Hanzo, 2000). These advantages can be further improved by adopting a relay system (Pabst et al., 2004). Discussion on the enhancement of 802.16e using relay system is ongoing (IEEE 802.16's Relay Task Group).

By using relays in IEEE 802.16 system, system throughput improvement and coverage extension can be feasible with low deployment cost (Tao, Teo, & Zhang, 2007). Several contributions in the literature regarding IEEE 802.16 relay system exist (Tao, Teo, & Zhang, 2007; Bian, Nix, Sun, & Strauch, 2007; Liu, Wang, Liu, Shen, & Jin, 2007; Jo & Cho, 2007; IEEE

LAN/MAN Standards Committee, 2008). Tao et al. (2007), proposed a new frame structure, and Bian et al. characterized the system throughput of IEEE 802.16 relay system. Liu et al. (2007) developed a new spectrum-efficient channel allocation algorithm, and Jo and Cho (2007) proposed an uplink data traffic scheduling algorithm. In particular, IEEE LAN/MAN standards committee provided the sixth draft standard of the multihop relay specification (IEEE LAN/MAN Standards Committee, 2008).

We adopt fundamental system configuration of the draft standard since it is the most promising candidate. Although the modification work of IEEE 802.16 relay system is still ongoing, basic system models and parameters are determined (IEEE LAN/MAN Standards Committee, 2008). Thus, it is meaningful to refer to (IEEE LAN/MAN Standards Committee, 2008). However, there still exists a technical problem to be solved regarding the ranging process. This article describes the problem, provides a solution, and validates the efficiency of the provided solution.

The ranging process relies upon contention-based wireless random access, and it provides a number of functions such as initial network entry, uplink synchronization, power adjustment, and system coordination (Fu, Li, & Minn, 2007; Lee & Morikawa, 2007). The conventional ranging process of IEEE 802.16 has to be modified and optimized under the relay deployed environment. The draft standard provided new frame structures and a modified ranging detection procedure for the IEEE 802.16 system deployed with relays. However, a ranging transmit power control (TPC) algorithm for the relay-augmented system is not provided. TPC is crucial for minimizing interference among concurrent ranging signals. Thus, we propose a new ranging TPC algorithm the relay systems and evaluate the efficiency of this algorithm.

This article provides the following contributions. First, a thorough study of IEEE 802.16 relay systems and their ranging process is provided. Second, a problem of the existing ranging algorithm is stated, which considers the effect of the interference between MS-BS ranging and MS-RS ranging. In the existing ranging TPC algorithm adopted by the draft standard, the MS-BS ranging process interferes with MS-RS ranging. Third, a solution of the described problem is provided, and modifications of the draft standard are proposed. Fourth, the performance of both existing and proposed ranging algorithms are analyzed and evaluated.

The remainder of this article is organized as follows: The *Background* section provides relevant details of IEEE 802.16, IEEE 802.16 relay systems, and the ranging process. The *Problem Statement and Solution of the Existing Ranging Algorithm In IEEE 802.16 Relay System* section addresses the problem of the ranging process in the existing draft standard, provides the solution, and proposes standard modifications. The *Performance Evaluation* section provides the performance analysis of the ranging process in IEEE 802.16 relay system. The *Conclustion* section summarizes and concludes this article.

BACKGROUND

Frame Structure of IEEE 802.16e OFDMA System

Figure 1 depicts the frame structure of IEEE 802.16e OFDMA system with the time division duplex mode. Horizontal and vertical axes refer to the time domain (OFDMA symbol) and the frequency domain (subchannel), respectively. Downlink (DL) and uplink (UL) utilize the whole frequency band, and they are divided by a transmit/receive transition time gap (TTG/RTG). The base station (BS) manages DL and UL channel resources, and broadcasts the scheduling information through a downlink (DL-MAP) and uplink (UL-MAP) maps. Data traffic is transmitted through a DL/UL burst channel. One or multiple DL/UL burst(s) can be allocated to a single mobile station (MS) depending on the traffic rate. However, a DL/UL burst should be only allocated to a single