Chapter 29

Capacity Estimation of OFDMA-Based Wireless Cellular Networks

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ABSTRACT

The usage of wireless cellular network architecture increases the capacity of a wireless system, by combining cells into clusters in which channels are uniquely assigned per cell and reusing such clusters throughout the network. Unfortunately, a cellular network system may become interference limited regarding its capacity instead of noise/range limited due to intensive resources reuse like time, frequency and space. Using as input the physical layer parameters and deployment scenario, an analytical approach is proposed for capacity estimation of networks based on Orthogonal Frequency Division Multiple Access (OFDMA) technology whose subchannels are composed of distributed subcarriers. This innovative approach is based on a new analytical method for SINR calculation based on a proposed subcarrier collision probability model. The usage of such method is exemplified for a single-hop sectorized Mobile WiMAX cellular network and the results are validated against published works.

INTRODUCTION

The Orthogonal Frequency Division Multiple Access (OFDMA) physical layer technology has been included in some wireless network standards like Digital Video Broadcasting - Return Channel Terrestrial (DVB-RCT) (ETSI EN 301 958, 2002), Worldwide Interoperability for Microwave Access (Mobile WiMAX) (IEEE 802.16e, 2005) and Evolved Universal Terrestrial Radio Access (E-UTRA) (ETSI LTE, 2008). OFDMA is also the candidate access method for the IEEE 802.22 (Wireless Regional Area Network) standard.

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OFDMA provides some useful features like efficient usage of spectrum, robustness against narrow-band interference from co-channel cells (Einhaus, 2005), controlled inter-symbol interference, reduced intra-cell interference, non-line-of-sight (NLOS) operation capability and flexible allocation of radio resources.

This chapter uses an analytical approach to determine the capacity of interference and noise limited OFDMA-based cellular networks. Given the subscribers geographical distribution, cellular architecture (cell size, sectoring and reuse strategy), base station (BS) and terminal characteristics (antenna system, MIMO support, scheduling and power allocation schemes), physical layer specifications (subchannel size, smallest allocable resource unit size, subcarrier permutation mode), scenario (urban, suburban, rural, LOS, NLOS), channel and path loss models, the quality of service (QoS) requirements like BER and delay must be matched providing an affordable quality of experience (QoE) for subscribers.

This work extends the previous work of (Hoymann & Göbbels, 2008) related to the dimensioning and capacity estimation of OFDM-based cellular systems by using an analytical interference method for SINR calculation based on a subcarrier collision probability model (Reis & Gondim, 2009). This method considers the effects of the OFDMA concentration and processing gains into the SINR calculation. It also considers the effect of subscriber station mobility by calculating an uplink correction factor using the same procedure as (Hoymann & Göbbels, 2008) but with slightly different results. Numerical results have already been obtained for DVB-T/RCT (Reis & Gondim, 2006). An example of the application of our model has been presented at the end of the Chapter for a single-hop sectorized Mobile WiMAX network.

BACKGROUND

This section provides basic concepts regarding wireless cellular systems.

Interference

In a cellular system, a large geographical area is divided into many smaller contiguous areas called cells which are served by its own radio base station. Each base station provides transmission resources to handle communication services to many mobile user terminals. Cells separation can occur in the time, frequency and space dimensions, allowing the reuse of transmission resources without producing interference.

Interference is defined as the effect of unwanted signal energy due to a combination of one or more emissions upon reception of the desired signal, manifested by any performance degradation which could be avoided by the absence of such combination. Interference is usually generated by the intensive reuse of transmission resources in the aforementioned dimensions within a cellular system.

Interference Classification

Interference can come from signals transmitted by the same system (intra-system interference) and/or signals transmitted by other systems (inter-system interference). Within a cellular system, interference among cells that use the same channel or adjacent channels is called co-channel interference or adjacent channel interference, respectively. Such interference can emanate from transmissions in the same cell (intracell interference) or in neighboring cells (intercell interference). Figure 1 summarizes this classification.

Usually intercell interference is dominated by co-channel interference and intracell interference between uplink and downlink transmissions can be neglected under the assumption of a proper separation either in the time (time division duplexing) or frequency (frequency division duplexing) dimensions.

Co-Channel Interference

In wireless cellular systems, co-channel interference is one of the main limiting factors for system capacity. System capacity can be expressed as the number of users the system can serve with quality of service (QoS) and quality of experience

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