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# Tiny MAP: An efficient MAP in IEEE 802.16/WiMAX broadband wireless access systems

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**Abstract**

The IEEE 802.16 standard for broadband wireless access systems is best known as WiMAX, and operates on the licensed band of 2–6 GHz. Its OFDMA mode has enabled the mobile Internet to emerge as the latest mobile seamless service. In order to enhance the IEEE 802.16 broadband wireless access systems, this paper focuses on inefficient aspects of the existing MAP message, which may be a major overhead in a frame. We propose a further compressed MAP called Tiny MAP where redundant elements are removed through small modifications of the standard. We show that the throughput of the OFDMA PHY frame is improved by comparing the existing MAC data rate with the improved MAC data rate. The simulation evaluates the performance of the proposed Tiny MAP message in terms of improvement ratio, considering the impact of several influential factors such as channel bandwidth, the number of users, burst count, FFT size and frame utilization.


*Keywords:* IEEE 802.16; WiMAX; MAP; OFDMA; MAC header

## 1. Introduction

The IEEE 802.16 broadband wireless access air interface standard [1] is a wireless protocol intended to supply broadband data and voice services. It is the basis of WiMAX (Worldwide Interoperability for Microwave Access) technology, which is a broadband wireless network. The IEEE 802.16e standard [2] for mobile applications has enabled the mobile Internet to emerge as the latest mobile service. As an example of the service, the first IEEE 802.16e-compatible mobile internet service, WiBro, was launched in South Korea in 2006. WiMAX and WiBro services are based on the Orthogonal Frequency Division Multiple Access (OFDMA) PHY mode of the IEEE 802.16 standard. OFDMA allows multiple users to receive data simultaneously on different subcarriers during the same symbol period by dividing channels into sub-channels and uniformly allocating subcarriers to them [6]. Fig. 1 shows a typical Time Division Duplex (TDD)/OFDMA frame structure. The TDD frame should have a downlink (DL) sub-frame and an uplink (UL) sub-frame. Every small interval on the horizontal axis and vertical axis represents a symbol and a sub-channel, respectively. Receive/transmit Transition Gap (RTG) and Transmit/receive Transition Gap (TTG) represent an interval between consequent frames, and an interval between the DL sub-frame and UL sub-frame, respectively, as indicated in Fig. 1.

In the DL sub-frame, the first symbol is occupied by a preamble. The Frame Control Header (FCH) follows the preamble and describes the sub-channels and the length of the DL-MAP. The DL-MAP and UL-MAP contain information on allocation scheduled for downlink and uplink, respectively. They include the modulation and coding type, and the size and position of each allocation. The UL sub-frame consists of UL bursts, ranging sub-channels, a channel quality indicator (CQI), and ACK/NACK.

The broadcast messages such as DL-MAP and UL-MAP should be sent at the highest reliability needed to

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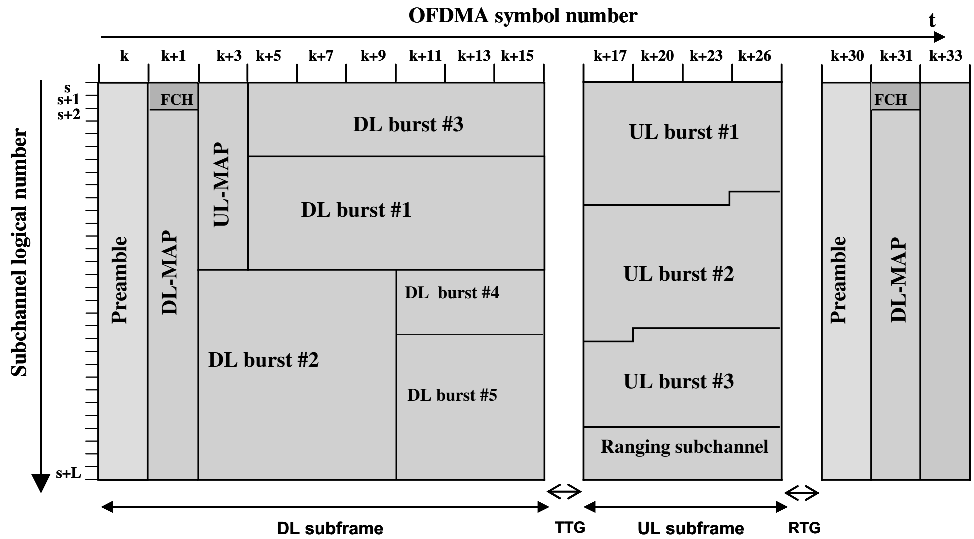


Fig. 1. Typical TDD/OFDMA frame structure.

meet the cell edge coverage. The DL-MAP is the most frequently delivered message among them, as it should be included in every frame. If a broken DL-MAP is delivered, then terminals cannot find the location of the bursts allocated to them. Thus, DL-MAP has to be reliable by using a quite robust modulation and encoding type, e.g. QPSK 1/12. As a result, the control overhead is significantly increased. Moreover, in a VoIP system where a base station serves a lot of users, the MAP overhead increases linearly as the number of scheduled users increases. The MAP overhead might even occupy up to 50% of the frame in a specific environment where short data bursts for a lot of users are in a frame.

To alleviate the MAP overhead, the IEEE 802.16 standard has optional MAPs such as the compressed MAP and sub-MAPs: the compressed MAP integrates DL-MAP with UL-MAP, and reduces the size of several fields; sub-MAPs allow multiple sub-MAP messages to be sent at different data rates to users with different SINRs. Although these optional MAPs decrease the MAP overhead, there may be further compressions to save MAP space and achieve more data throughput. A study [4] evaluated MAC performance of IEEE 802.16 and mentioned about the problem of MAP overhead. However, it did not introduce solutions relieving the overhead. Another study [5] proposed a burst scheduling algorithm which can alleviate the MAP overhead a little for specific traffic patterns. As other approaches increasing throughput under the fixed channel bandwidth, multiple advanced antennas have been studied to achieve more throughput and wider coverage, including multiple input and multiple output (MIMO) [7] and beamforming (BF) [8]. However, these smart multiple antenna systems incur higher cost and require additional physical antennas and complicated algorithms.

We propose a new MAP structure called Tiny MAP to extract the redundancy from the MAP under a fixed channel bandwidth. This requires no additional physical modules or antennas; rather, all it requires are small modifications of a part of the standard. To our knowledge, no such study reducing the MAP overhead of the current IEEE 802.16 standard and evaluating the performance has been produced. We will evaluate the data throughput improved by utilizing subcarriers which have been allocated for the redundant elements of MAP.

This paper is organized as follows. Section 2 describes the existing MAP of the IEEE 802.16 standard and proposes a new MAP structure called Tiny MAP. We also present numerical analysis for the MAC data rate and improvement ratio. Section 3 evaluates the performance of Tiny MAP in terms of downlink throughput and improvement ratio. Section 4 concludes this paper.

## 2. Tiny MAP structure

In the MAC layer, one or more Service Data Units (SDUs) are encapsulated into Protocol Data Units (PDUs), which are appropriately modulated and mapped onto a PHY frame. DL-MAP and Compressed MAP are the broadcasting messages, and either of these MAPs is the first MAC management message located in the frame. It includes information elements (IEs) describing the frame structure and the allocation of data bursts. Our approach can be applied to both normal DL-MAP and Compressed MAP in a similar manner, and thus, for the sake of convenience, this paper will use normal DL-MAP as an example to describe new approaches.

In order to reveal the redundant factors of DL-MAP, we will first examine elements of the MAC PDU because DL-MAP is also a MAC PDU. The MAC PDU format of IEEE 802.16 [1] is illustrated in Fig. 2. Generic MAC Header (GMH) of the MAC PDU describes information on payload data and the CID as illustrated in Fig. 3. DL-MAP consists of a GMH, a payload and CRC. The