Project	**IEEE 802.16 Broadband Wireless Access Working Group** <http://ieee802.org/16>
Title	**Multiple-User Unsolicited Grant Service (UGS) Slot**
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Re:	IEEE 802.16m-07/040 - Call for Contributions on Project 802.16m System Description Document
Abstract	This document proposes a method to schedule multiple VoIP users onto a UGS slot in order to improve spectral efficiency.
Purpose	To propose a section treating VoIP capacity improvement in the 802.16m SDD document containing the scheduling concept in this proposal.
Notice	
Release	
Patent Policy	

Multiple-User Unsolicited Grant Service (UGS) Slot

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Introduction

This contribution addresses the VoIP capacity requirement as specified in [1] and proposes multiple-user unsolicited grant service (UGS) slots. UGS would normally be very inefficient for voice applications with Voice Activity Factors (VAF) of the order of 45-55% but this proposal utilizes the VAF to eliminate idle UGS slots by means of multiplexing more than one VoIP user to the same slot. This can be accomplished as long as the interference level does not result in error rates beyond the outage criterion. In addition, a finer adjustment of loading across the bandwidth used for voice users is allowed. This proposal also satisfies the legacy support requirement as specified in [1].

We propose that a section on VoIP capacity improvement be added in the System Description Document (SDD). Additionally, we recommend that the multiple-user UGS slot proposal be included in that section of the SDD.

Proposed SDD Text

[Section] VoIP Capacity Improvement

[Subsection] Multiple-User UGS Slot

A multiplexing scheme that allows more than one user to be allocated to one UGS slot shall be introduced to 802.16m. The multiplexing scheme enables UGS users to transmit on the uplink with partially overlapping frequency and time resources. Interference resulting from tile collisions is randomized to have Gaussian-like statistics. The interference randomization is achieved by superimposing tiles with code channels.

Detailed Description of Multiple-User UGS Slot

Introduction

The WirelessMAN OFDMA reference system [2][3] provides 5 scheduling mechanisms: unsolicited grant service (UGS), real-time polling service (rtPS), extended real-time polling service (ertPS), non-real-time polling service (nrtPS) and Best Effort [1]. UGS gives MS access to the uplink periodically without explicit request from the MS. The service, rtPS, provides periodic opportunities for the MS to request service based on its latency requirements and grants uplink access accordingly. The service, ertPS, may turn off the periodic polling after certain inactive periods and triggers the periodic polling upon receiving a BW-request indicator. Then the mobile sends requests in response to the resumed periodic polling and the base station grants uplink transmission accordingly. The service, nrtPS, polls a mobile's uplink bandwidth needs based on its minimum reserved traffic rate, while best effort service schedules the mobile whenever the uplink system resource is available.

UGS consumes radio resources in the same way as fixed, pre-assigned slots in TDMA. This approach has the following drawbacks: not making use of the stochastic behavior of voice, and taking no advantage of the error-resilience of voice frames in conjunction with channel coding. In some cases, vocoders generate null-rate frames during silence periods that can be omitted from transmission, therefore creating idle UGS slots over the air. In some other cases, vocoders generate full-, half-, quarter- and eighth-rate frames, where lower vocoder rates have lower power requirements and higher error rate tolerance, often making the constant bandwidth and power allocated in UGS slots excessive. Some other types of traffic possess similar characteristics, e.g. motion pictures with occasional still-image scenes.

One way to improve efficiency is to use ertPS [1]. However, there are drawbacks associated with ertPS. First, some vocoders, even during silence periods, still transmit null frames to maintain the state machine at the receiver decoders. The null frames may be sent on the order of every hundred milliseconds. These null frames create ambiguity and keep the ertPS mostly staying in costly request-grant operations. Second, not all vocoders support silence suppression. Some VoIP applications generate continuous traffic. In those cases, ertPS reduces to UGS, where the regular uplink allocation IE's are constantly sent with low efficiency. In sum, the existing solutions are not efficient for stochastic, low-rate, error-tolerant but delay intolerant traffic such as voice.

Basic Concept

Due to the intermittent characteristics of voice, in addition to its low-data-rate and delay-sensitive nature, it can be more spectrally efficient to multiplex voice users onto fixed allocated resources instead of frequently sending request-and-grant signaling. The proposed concept accomplishes this without the previously described drawbacks of TDMA.

We propose that multiple users can be allocated with partially overlapping frequency and time resources of UGS slots. The concept is illustrated in Figure 1.

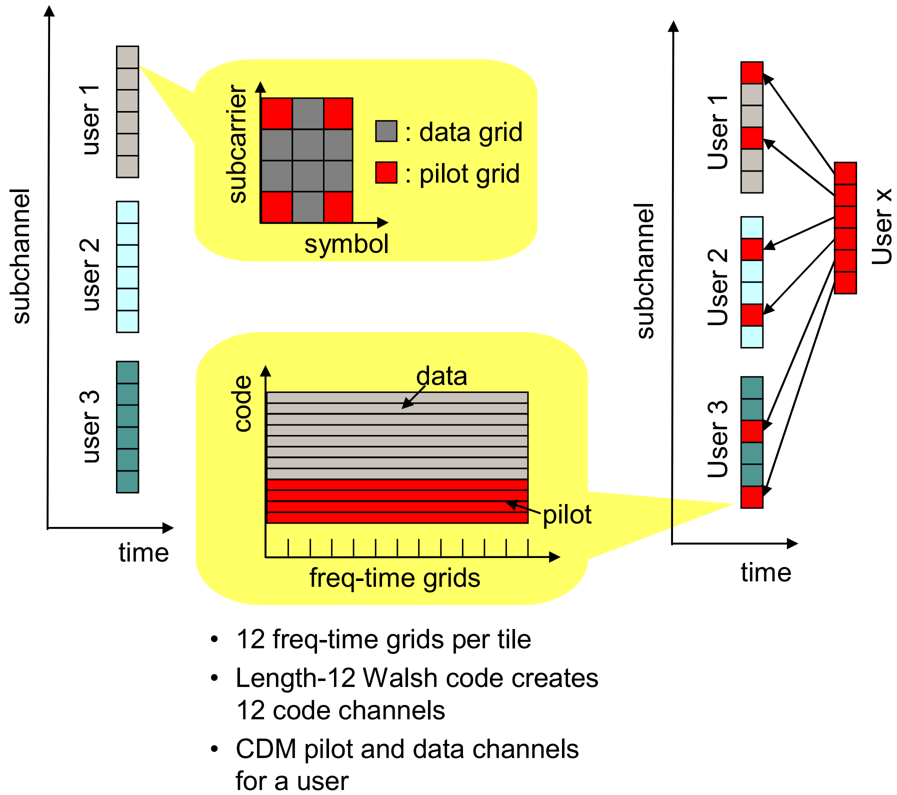

Figure 1: Illustration of multiple-user UGS slot with UL PUSC permutation

In Figure 1, users 1 through 3 (which could be legacy users or 802.16m users) are allocated by the UGS scheduling mechanism. After the number of UGS users reaches a certain threshold, there will be an increasing number of UGS slots that are under-utilized because of the voice activity factor. As an example, we assume that adding a fourth user, denoted by user x in Figure 1, in such a way that it collides equally with the first 3 users does not increase the error rate beyond a specific voice outage criterion, e.g. 2% block error rate. Then user x can use 2 tiles from each of the first three users' subchannels to form a subchannel for UL transmission. We propose that user x will be a 802.16m user.

The interference from user x can be made Gaussian-like by orthogonal coding, as also illustrated in Figure 1. The tile signal spaces in the two call-out boxes occupy the same frequency and time resources. The 12 frequency-time "grids" provided by a tile can be used to create a set of length-12 Walsh orthogonal codes. Each of the 8 data symbols of user x can modulate one Walsh code channel and then be added with pilot code channels to form a code-division multiplexed signal. For the first 3 users, each symbol in the tile will see interference from user x as a result of sum of Walsh codes, which has a Gaussian-like statistical distribution. Likewise, the interference from the first 3 users to each code channel of user x is averaged by the orthogonal code despreading, which is also randomized and effectively Gaussian.

For voice traffic, utilization of the voice activity factor, optionally combined with power and rate control, results in capacity gain similar to that known to be experienced by CDMA systems.

Conclusions

This contribution addresses the VoIP capacity requirement as specified in [1] and proposes multiplexing more than one user in a UGS slot. We recommend that this multiple-user UGS slot proposal be adopted in the VoIP capacity section of the System Description Document.

References

[1] IEEE 802.16 Broadband Wireless Access Working Group, "IEEE 802.16m System Requirements", IEEE 802.16m-07/002r4, Oct 19, 2007.

[2] IEEE Std 802.16e-2005 and IEEE Std 802.16 Cor2/D3, "IEEE Standard for local and metropolitan area networks, Part 16: Air Interface for Fixed and Mobile Broadband Wireless Access Systems, Amendment 2: Physical and Medium Access Control Layers for Combined Fixed and Mobile Operation in License Bands,"

[3] WiMAX Forum™ Mobile System Profile, Release 1.0 Approved Specification (Revision 1.4.0: 2007-05-02)