Project	**IEEE 802.16 Broadband Wireless Access Working Group** <http://ieee802.org/16>
Title	**802.16m DL Control Structure: Preamble Design**
Date Submitted	**2008-03-10**
Source(s)	Gene Marsh, William Burchill and Ramon Khalona NextWave Wireless Voice: +1-858-480-3148 E-mail: (gmarsh, wburchill, rkhalona)@nextwave.com
Re:	Call for Contributions on Project 802.16m System Description Document (SDD) (IEEE 802.16m-08/005) - DL Control Structures
Abstract	This contribution addresses preamble design in 802.16m to improve system acquisition performance
Purpose	Discuss as part of SDD call for contributions and consider for adoption
Notice	
Release	
Patent Policy	

802.16m DL Control Structure: Preamble Design

Gene Marsh, William Burchill and Ramon Khalona
NextWave Wireless

1 Introduction

A key requirement in the 802.16m SRD [1] is to support the ability to synchronize frame timing across an entire system in a given geographic area, including synchronization among all BSs and MSs operating on the same or on different carrier frequencies and among neighboring 802.16m systems. This is a critical requirement for the coexistence of TDD systems.

Frame timing is addressed by the use of an effective preamble in a frame. The preamble sequence must be sufficiently distinct to enable fast detection for quick system acquisition. In this contribution, we address preamble design in view of previous proposals made in 802.16 and also proposed in other competing systems, such as LTE.

In [2], Constant Amplitude Zero Auto-Correlation (CAZAC) sequences were previously proposed for use in 802.16. These sequences have the following attractive properties

a) They enable fast cell search due to their unique correlation structure

b) Sequence matching can be easily done in the frequency domain using efficient algorithms

c) Low PAPR due to their constant amplitude feature

More recently, a class of CAZAC sequences, known as Zadoff-Chu sequences [3] (also see Appendix and references in [2] for the mathematical properties of these sequences) have been considered by LTE for preamble design showing attractive results. In this contribution we propose a preamble design based on these sequences and indicate some of the advantages for 802.16m

2 Downlink Preambles

The 802.16m preamble is partitioned into two parts, the primary preamble and the secondary preamble.
The primary preamble is used by the MS to identify frame timing. It occupies subcarriers[1] -48 to 48 in symbol 2 of slot time 0 within a frame (all parameters are in accordance with our proposal for DL Physical Resource Unit [4]) . Of these 96 subcarriers, only subcarriers -41 to 41 are occupied, the other subcarriers within these subchannels having no energy placed upon them (the DC subcarrier is also vacant). The occupied subcarriers are modulated with a frequency domain Zadoff-Chu sequence based on $p_u(x)=\exp(-j\pi u x(x+1)/83)$ for $x=0,1,\ldots,83$. The mapping of $p_u(x)$ onto subcarriers is given by:

$$\text{Subcarrier}(m) = \begin{cases} p_1(m+41) & -41 \le m < 0 \quad or \quad 0 < m \le 41 \\ 0 & \text{otherwise} \end{cases}$$

[1] For algorithmic convenience, negative and positive subcarrier indexing is used, with subcarrier index 0 corresponding to DC. Conversion to indexing using positive subcarrier numbers is straightforward.

Note that all sectors are transmitting the same primary preamble. Assuming the sectors are aligned in time, this would provide macro-diversity for this first preamble, enabling easy acquisition of 5ms time and location of the center of the transmit band.

The secondary preamble is used to allow the mobile to identify particular sectors. Each sector is assigned an identity from 0 to 624[2], and transmit a frequency domain Zadoff-Chu sequence based on that ID. In particular, the secondary preamble occupies subcarriers -48 to 48 in symbol 3 of slot time 0 within a frame. Of these 96 subcarriers, only subcarriers -41 to 41 are occupied, the other subcarriers having no energy placed upon them. Of course, the DC subcarrier is also vacant. Let $N_{\mathrm{cell}}^{\mathrm{ID}}$ represent the cell identity. The subcarrier modulation is provided by:

$$Subcarrier(m) = \begin{cases} p_{16+\lfloor N_{CELL}^{ID}/25 \rfloor}([m+41+3(N_{CELL}^{ID} \bmod 25)] \bmod 83) & if \quad -41 \le m < 0 \ \ or \ \ 0 < m \le 41 \\ 0 & otherwise \end{cases}$$

Since a time delay corresponds to a frequency shift in the Zadoff-Chu sequence, the parameters in this formula have been selected so that sectors can be uniquely identified in the case of expected time of arrival differences between BSs.

The cross-correlation between any two different Zadoff-Chu sequences, even after puncturing for a DC carrier, is still approximately -9 dB below the correlation peak, even against shifts in frequency.

3 Summary of the Contribution

We have presented a preamble design for 802.16m, which offers the following attractive features

a) It enables fast cell search and system acquisition due to the unique correlation structure of Zadoff-Chu sequences (a special class of CAZAC sequences)

b) Since all sectors transmit the same primary preamble, macro-diversity can be used to enable fast preamble acquisition

c) Primary and secondary preamble searches can be run in parallel to speed up system timing

d) No multipliers are needed to perform correlation because Zadoff-Chu sequences are complex roots of unity and cordic techniques can be used instead (see [2])

e) This scheme reduces preamble overhead relative to 802.16e

f) This scheme enables system acquisition without knowledge of the channel bandwidth

---

[2] This large number of cell IDs makes for a simple assignment of IDs

4 References

[1] IEEE 802.16m-07/002r4. See Section 8.2.

[2] J. Hou et al (ZTE), “Preamble Sequence For Fast Cell Search, Low Computational Complexity, and Low PAPR” (IEEE C802.16e-04/265r1), 28 August 2004.

[3] Ericsson, “Comparison of Zero Cross-Correlation Sequences and Zadoff-Chu Sequences for E-UTRA RACH,” TSG-RAN WG1 LTE AdHoc R1-061869, Cannes, France, June 27–30, 2006.

[4] G. Marsh et al. (NextWave), “Proposal for Downlink Physical Resource Allocation Unit,” C80216m-08_189