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Abstract	For the cellular operation of 802.16, some new requirements should be defined like cell/sector identification, frequency reuse factor etc. In this contribution, we propose a new 802.16 OFDMA preamble satisfying the requirements.
Purpose	To propose a new preamble structure suitable for 802.16 cellular operation.
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Downlink Preamble for Cellular Operation of 802.16 OFDMA

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1. Introduction

For the cellular operation of 802.16, some new requirements should be defined like fast physical level cell/sector identification, frequency reuse factor etc. In this contribution, we propose a new 802.16 OFDMA preamble satisfying the requirements. In section 2, we present some requirements that are essential for the cellular operation. In section 3 and 4, we propose a new preamble structure and verify the performance of the system. The conclusions are reached in section 5.

2. Requirements for the preamble

For the cellular operation of 802.16, the downlink preamble should work in various frequency reuse conditions. The reuse factor should include ‘1’.

The downlink preamble should also satisfy the following requirements:

- Supporting easy deployment of system
- Supporting higher system throughput
- Fast and accurate initial synchronization
- Fast and accurate synchronization for handoff
- Channel estimation performance
- Enough number of cell IDs
- Reliable cell (or sector) search performance.

3. Proposed downlink preamble structure for OFDMA mode

The DL preamble, which is transmitted at the beginning of the frame, has a repeating pattern so that a 1024 sample long pattern is repeated once. A time-domain illustration of the DL preamble structure is shown in Figure 1.

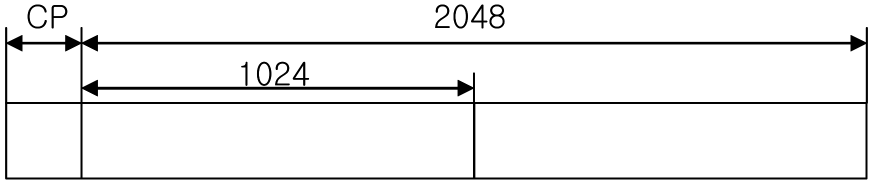


Figure 1-Time domain illustration of the DL preamble.

The preamble has one of 128 distinct patterns and the neighboring cells or sectors shall have different patterns so that the terminals should (or may) distinguish a cell or sector from others. The preamble is generated from the subcarriers, which are BPSK modulated as follows:

$$c_k = \begin{cases} \sqrt{2}(1-2q_{c,s}[(k-1)/2]), & k = 1,3,5,\cdots,849 \\ \sqrt{2}(1-2q_{c,s}[k/2-1]), & k = 852,854,856,\cdots,1700 \\ 0, & \text{otherwise,} \end{cases} \tag{1}$$

where c is the cell number from the set {0, 1, 2, …, 127} and s is a Walsh number.

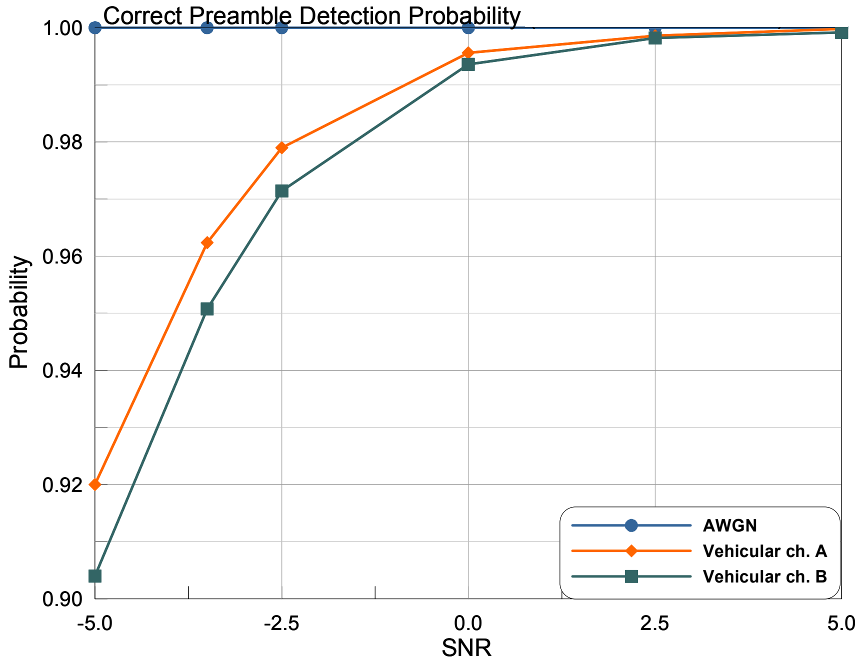
If c_k is IFFT processed, it results in a pattern repeating itself once in time domain. In Eq. (1), $\sqrt{2}$ is multiplied so that the DL preamble has the same average power level as that of the data OFDMA symbols and $q_{c,s}[m]$ is defined as follows.

$$q_{c,s}[m] = w^s_{m \bmod 8} \oplus p_{(16c+m) \bmod 2047}, \quad m = 0,1,2,\cdots,847 \tag{2}$$

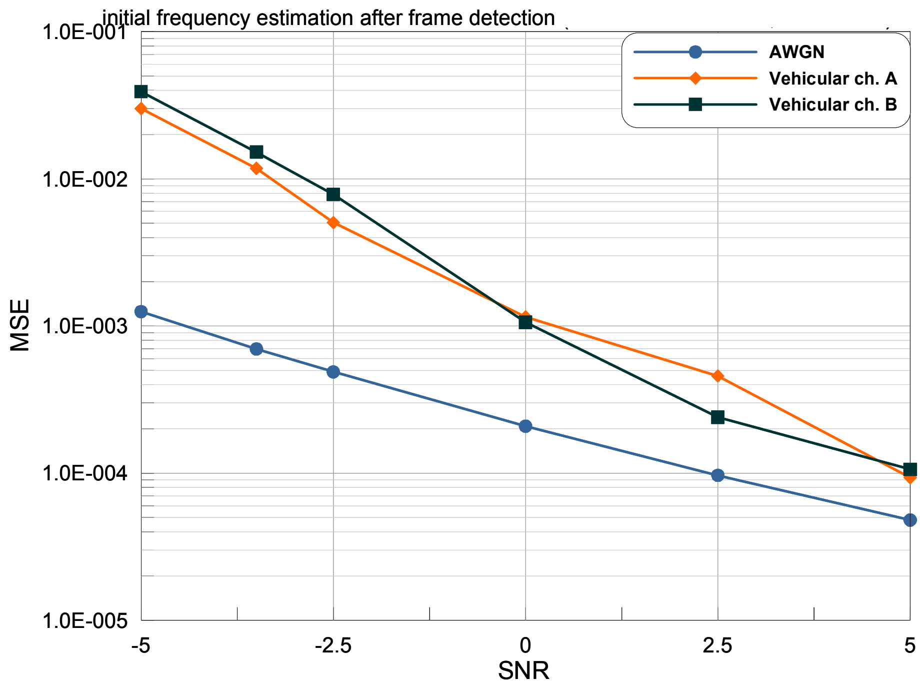
where $\oplus$ denotes the exclusive-OR operator, $w^s_n \in \{0,1\}$ is the n-th value of the s-th codeword in the 8-ary Walsh code set, and pn is the n th value of the PN sequence generated from the PRBS. The generator polynomial of the PRBS is $X^{11} + X^9 + 1$. The initialization vector of the PRBS for the preamble modulation is [01010101010].

4. Simulation results

In this section, some simulation results of an initial synchronization and a channel estimation scheme are presented. The initial synchronization algorithm determines the start of the frame by observing the autocorrelation of the time domain replica to detect the preamble. Figure 2 shows the initial synchronization performances obtained with the proposed downlink preamble. AWGN, ITU Ped B and ITU Veh A channel models are used for the simulations. Figure 2 (a) shows the correct preamble detection probability. As can be seen from this figure, the preamble can be detected with high reliability at the low SNRs around -3 dB. This makes the system deployment possible under the frequency reuse ‘1’ condition since the received SINR can be well below 0 dB for the MSSs at cell (or sector) boundary.



(a) Probability of correct preamble detection



(b) Performance of the initial frequency offset estimation

Figure 2-Performance of the initial synchronization

Figure 2 (b) shows the performance of the initial frequency offset estimation after the frame detection. The average phase difference between the time domain replica is assumed to be used for the frequency offset estimation. The simulation result shows that the estimation is satisfactory at very low SNRs around –3 dB. From the results, we would like to presume that the proposed preamble lends itself to the cellular system with frequency reuse factor ‘1’.

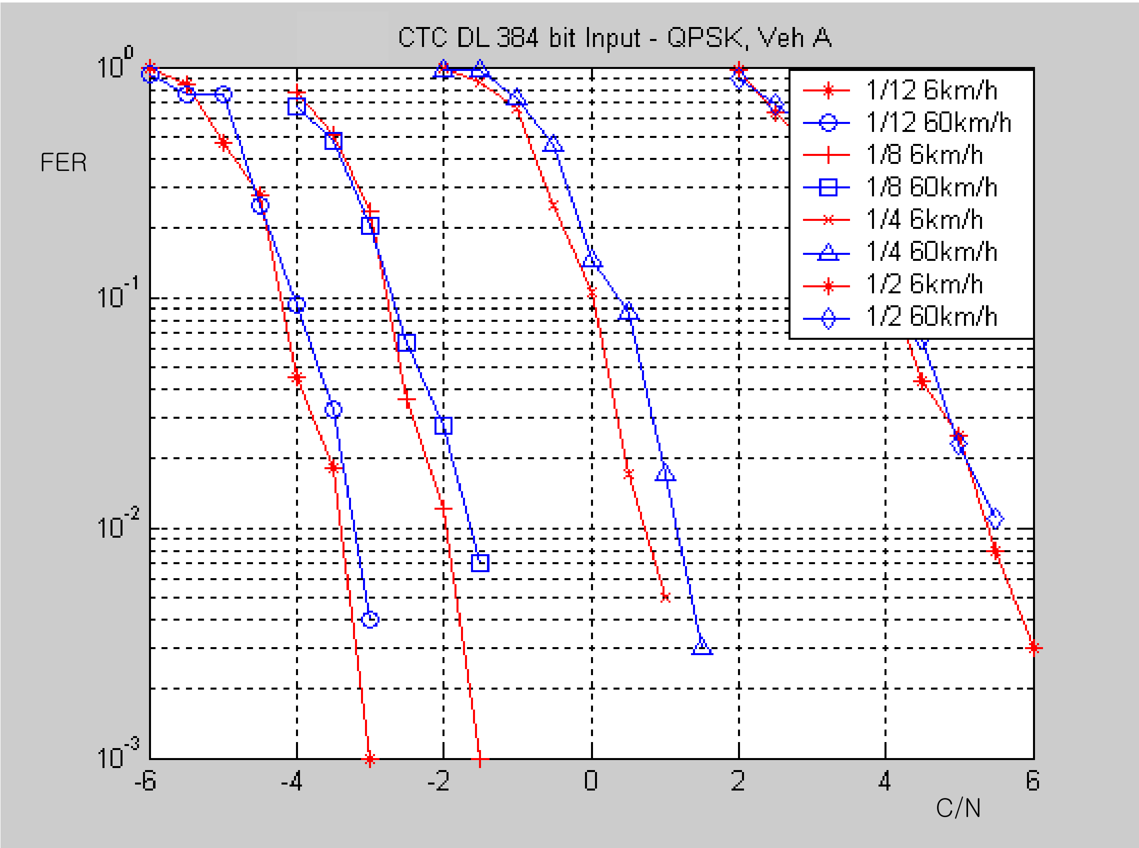


Figure 3-The performance of the channel estimation with the proposed preamble

Figure 3 shows the channel estimation performance using the proposed preamble. It is assumed that the preamble is inserted every 4 OFDM symbol times as midambles. The ITU Veh A channel model is used for the simulation. In frequency domain, the partial despreading of PN Walsh is used for the noise reduction. The time domain interpolation is used for the symbols between midambles. For the verification of the cell edge performance in frequency reuse ‘1’ condition, low rate (1/2 ~ 1/12) convolution turbo code (CTC) and QPSK is used for the simulation. Under the frequency reuse ‘1’ condition, the SINRs well below 0 dB occur frequently at the cell/sector boundary. The simulation results show that the low rate coding with the proposed preamble and midamble structure ensures the cell/sector edge coverage. When the neighboring cells or sectors use different Walsh codes, but share an identical PN code, the orthogonality of Walsh codes reduces the inter cell/sector interference so that proper channel estimation can be made.

Finally, the preamble is exploited for cell/sector search or identification. Basically, the basic scheme of the cell/sector identification is the same as that of the CDMA based ranging scheme. Since the PN codes of the preamble are much longer than those of ranging, the cell/sector identification using the preamble can be highly reliable. Furthermore, the orthogonality of Walsh codes enhances the cell/sector identification when neighboring cells or sectors use different Walsh codes, but share an identical PN code.

5. Conclusions

In this contribution, we propose new preamble structure that is optimized for the cellular operation even with frequency reuse '1'. We present some simulation results to show that the proposed preamble meets the requirements that are essential for the operation of cellular operation of the frequency reuse '1'.

Appendix: Text changes

[Replace section 8.5.6.1.1 with the following:]

8.5.6.1.1 Preamble

The first OFDM symbol of the downlink is the preamble. The preamble has one of 128 distinct patterns and the neighboring cells/sectors shall have different patterns so that the terminals can distinguish a cell/sector from the others. The preamble is generated from the subcarriers, which are BPSK modulated. The allocated subcarriers are defined as follows:

$$preamble = 1,3,5,\cdots,849,852,854,856,\cdots,1700$$

The following PN Walsh sequence is mapped onto the subcarriers allocated to the preamble. The sequence is as follows.

$$q_{c,s}[m] = w^{s}_{m \bmod 8} \oplus p_{(16c+m) \bmod 2047}, \quad m = 0,1,2,\cdots,847.$$

where c is the cell number from the set {0, 1, 2, …, 127} and s is the Walsh number. $\oplus$ denotes the exclusive-OR operation, $w^{s}_{n} \in \{0,1\}$ is the n-th value of the s-th codeword in the 8-ary Walsh code set, and p_n is the n-th value of the PN sequence generated from the PRBS. The generator polynomial of the PRBS is $\mathrm{X}^{11} + \mathrm{X}^{9} + 1$. The initialization vector of the PRBS for the preamble modulation is [01010101010].

[Replace section 8.5.8.4.1 with the following:]

8.5.8.4.1 Preamble pilot modulation

Antenna0 and antenna1 respectively use $q_{c,0}[m]$ and $q_{c,1}[m]$ as their sequence for the preamble pilot modulation patterns, which is defined in 8.5.6.1.1.

[Replace section 8.5.9.4.3.1 with the following:]

8.5.9.4.3.1 Preamble pilot modulation

The preamble is generated from the subcarriers, which are BPSK modulated as follows:

$$c_k = \begin{cases} \sqrt{2}(1 - 2q_{c,s}[(k-1)/2]), & k = 1,3,5,\cdots,849 \\ \sqrt{2}(1 - 2q_{c,s}[k/2 - 1]), & k = 852,854,856,\cdots,1700. \\ 0, & \text{otherwise,} \end{cases} \tag{81}$$