| | |
|---|---|
| Project | **IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>** |
| Title | **Initial PHY proposal for 802.16e** |
| Date Submitted | **2003-01-10** |
| Source(s) | Tal Kaitz<br>Naftali Chayat<br>Marianna Goldhammer<br>Miki Genossar<br>Vladimir Yanover<br>Alvarion Ltd.<br>21 A Habarzel St. Ramat - Hahayal<br>Tel - Aviv 69710<br>Voice: +972-36456273<br>Fax: +972-36456290<br>mailto:tal.kaitz@alvarion.com |
| Re: | The document is submitted in response to “Call for Contributions on Project802.16e: Mobility Enhancements to IEEE Standard 802.16/802.16a” (IEEE 802.16e -02/01) |
| Abstract | General concepts and initial OFDM PHY proposal for 802.16e. |
| Purpose | The document is submitted for consideration in IEEE 802.16 WG |
| Notice |  |
| Release |  |
| Patent Policy and Procedures |  |

# Initial PHY proposal for 802.16e

Tal kaitz, Naftali Chayat, Marianna Goldhammer, Miki Gennosar, Vladimir Yanover

*Alvarion*

## 1. Introduction

This contribution presents the general concepts of the proposed PHY layer for the 802.16e project. This contribution should serve as an initial proposal. Further study is required towards a detailed PHY proposal.

The requirements and operating conditions of the mobile system are outlined in [1] . The dominant factors in the design of the mobile system are:

A. High delay spreads and Doppler spreads. Delay spreads may span several microseconds RMS. Doppler spreads can be as high as several hundred Hz.

B. Highly Asymmetrical link. The transmit power of the mobile unit is often limited by factors such as size, heat dissipation, power consumption and cost. As a result there is a significant difference between the transmit power of the BS to that of the mobile unit. The difference can be higher than 15dB.

C. Highly asymmetrical applications. For many applications the bandwidth requirements for the UL are lower than those of the DL, by factors of 3-4.

D. High interference levels from adjacent cells, due to the use of omni-directional antennas.

We propose the use of an OFDM/OFDMA PHY. OFDM is an appropriate modulation scheme due to its inherent multi-path resistance. The application of OFDMA in the UL may provide the required gain, and may compensate for the asymmetry in the transmit power. The use of OFDM/OFDMA may facilitate advanced techniques such as transmit/receive spatial diversity and SDMA.

# 2. Principles of the Proposed PHY

## 2.1. PHY highlights

The mobile PHY is designed to provide robust and efficient operation in harsh mobile environments, while maintaining alignment and co-existence with the fixed 802.16a OFDM mode.

The proposed PHY layer is based on OFDM/OFDMA. The PHY is highly aligned with the 802.16a OFDM mode. This alignment eases dual (both fixed and mobile) implementations. The main parameters which are common to the 802.16a OFDM PHY are:

- OFDM /OFDMA operation.
- FFT size of 256 points.
- 200 active sub carriers.
- Sampling ratios of 8/7 or 7/6.

The major differences with respect to the 802.16a PHY are:

- UL OFDMA as a mandatory mode.
- 40-50 UL sub-channels.
- Changes in the structure of UL burst .
- Changes in preamble and pilot symbols to support mobility requirements.

An overview of the UL and DL section is the given below. Not all the PHY components are described in details. Additional PHY components are discussed in section 2.5.

## 2.2. Coexistence of Fixed and Mobile users

The system is designed such that both fix and mobile users can co-operate and share the media. The principles of media sharing are presented in [2] , and are repeated here. For brevity only TDD is considered.

- The time axis is divided into *superframes* of fixed length and within a superframe one or several frames of each type (fixed/mobile) appear.
- Superframe starts from a “fixed” preamble, DL frame prefix and a burst carrying DL-MAP and UL-MAP messages. The prefix and MAP messages have the same structure as specified in [3] and [4] .
- “Fixed” transmissions leave gaps for embedding of “mobile” transmissions into the superframe.
- “Mobile” frame contains its own DL-MAP and UL-MAP that specify DL and UL allocations
- Partitioning of superframe period between “fixed” and “mobile” is flexible i.e. may change from one superframe to another. As a consequence, “mobile” frames are of variable size
- For the sake of initial synchronization, either “fixed” DL Frame Prefix or “fixed” DL-MAP may point to the start of nearest “mobile” frame.

Figure 1describes an example of interleaving of “fixed” frames and “mobile” frames with one “mobile” frame contained by “fixed” frame. For each PHY type separated DL and UL subframes are allocated denoted as “F -DL”, “F-UL” (fixed) and “M-DL”, “M-UL” (mobile). “Fixed” versions of DL-MAP / UL-MAP messages are those described in [3] [4] .

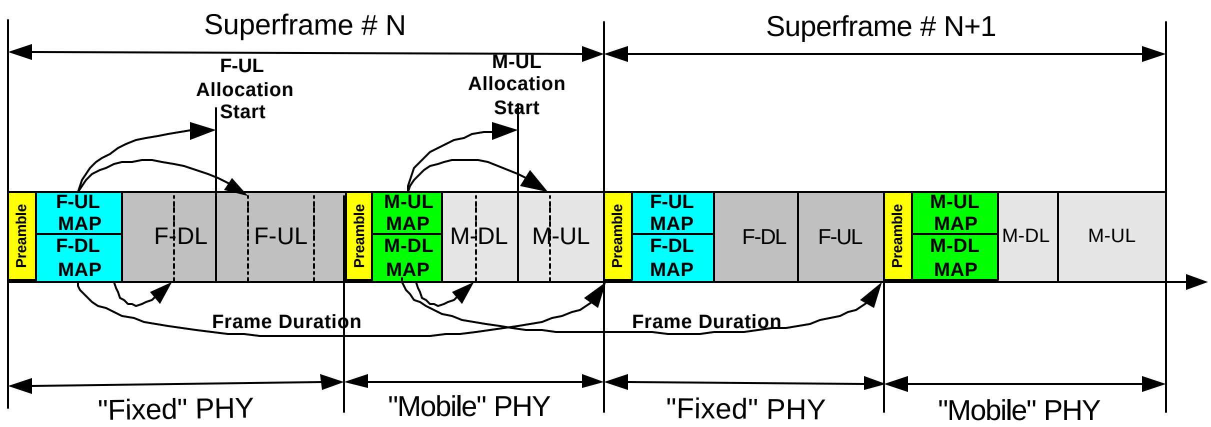


**Figure 1 Structure of a TDD super-frame**

## 2.3. Uplink transmissions.

We consider two schemes for the UL transmission. Both provide the desires UL gain. The schemes are mutually exclusive and only one should be accepted.

A. The clustered approach, in which the subcarriers are arranged in contiguous groups called clusters. The clustered approach minimizes inter-subchannel interference, and allows for robust channel estimation. A fast hopping mechanism insures sufficient frequency diversity is achieved.

B. The scattered approach, in which the subcarriers are scattered across the band. This approach maximizes the frequency diversity.

### 2.3.1. Clustered UL OFDMA

In the clustered approach, transmissions occur in rectangular blocks in the frequency-time space, called *clusters*. A cluster is a rectangular block composed of 5 contiguous sub-carriers in the frequency domain, over 6 OFDM symbol epochs in the time domain. This is illustrated in Figure 2.

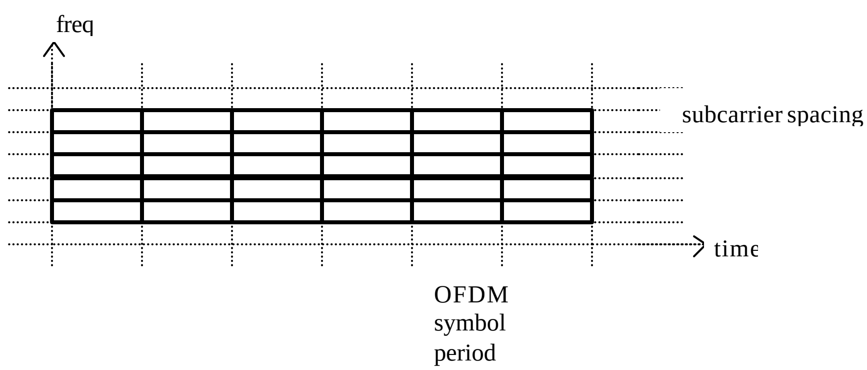

**Figure 2 A Cluster**

The clusters change their frequency locations according to a well-defined pattern. The change in location is referred to as *fast frequency hopping*. Frequency hopping allows for

a. A high degree of frequency and time diversity.
b. Averaging of interference from adjacent cells.

A sub-channel is composed of a single cluster at a time. Thus 40 sub-channels are defined. Figure 3 depicts two sub-channels. Sub-channels can be aggregated when high bandwidth is required.

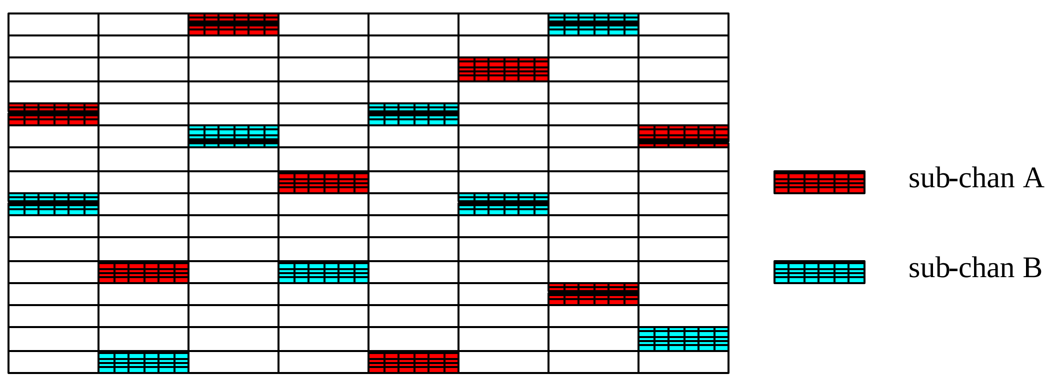


**Figure 3 An example of two subchannels**

A cluster contains all the pilots needed for channel estimation. A cluster is composed of 24 data carrying sub-carriers and 6 pilot sub-carriers. The structure of the cluster is shown in Figure 4. The pilots are boosted by about 1dB over the data subcarriers.

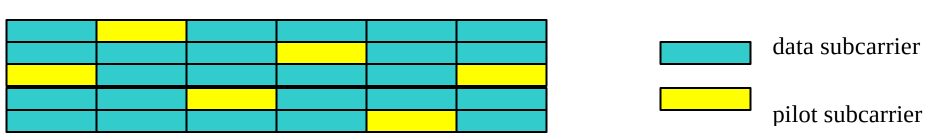


**Figure 4 Structure of a cluster**

The pilot subcarriers provide very robust channel estimation. Beginning and end pilots are used for frequency offset estimation.

### 2.3.2. Scattered UL OFDMA

In the scattered approach transmissions occur in non-contiguous groups of 4 subcarriers. This mode is similar to the Burst Structure 2 in DVB-RCT [5]. The subcarriers are scattered across the allocated band to maximize frequency diversity. There are 50 subchannels. Subchannels can be aggregated to achieve higher data rates.

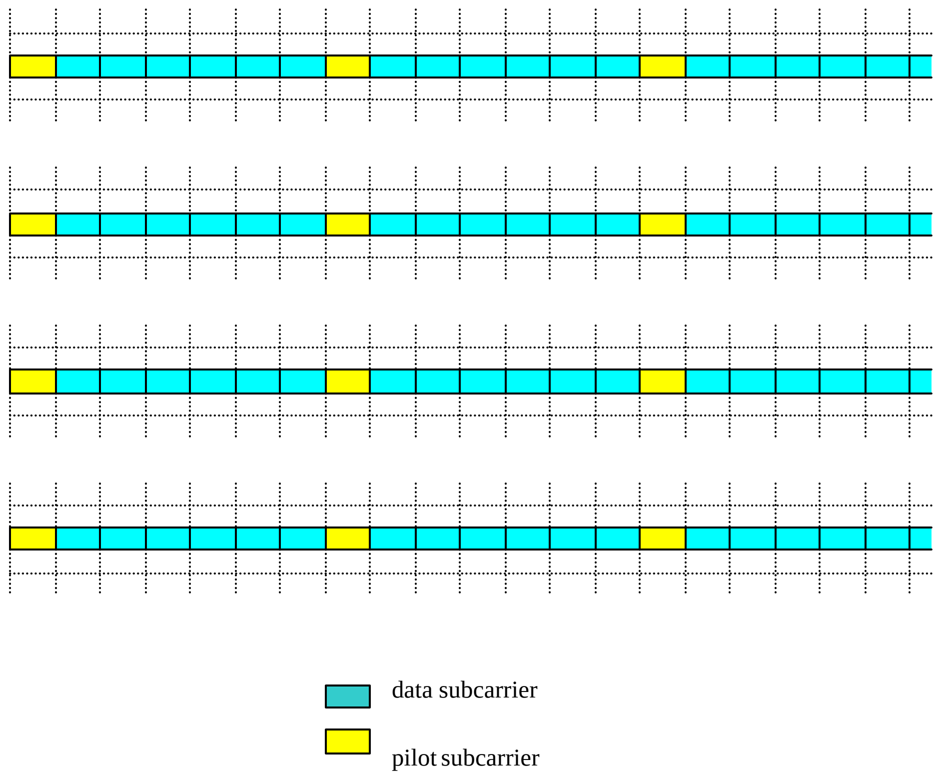


**Figure 5 Scattered allocations**

The minimal allocation is composed of 4 subcarriers over 8 OFDM symbol epochs. In the minimal allocation there are 32 subcarriers, which are composed of 8 pilot subcarriers and 24 data subcarriers. The pilot subcarriers are located at the beginning and end of the allocation. When longer allocations are required the pilot are inserted after every 6 data symbols.

The exact location of the sub-carriers is determined according to a cell parameters, and are designed so that the interference from adjacent cells is averaged over all subchannels.

## 2.4. Downlink transmissions

We propose the use of OFDM as a mandatory mode, and OFDMA as an optional mode. The exact format and parameters of the OFDMA mode require further study. However, we propose the following guidelines:

1. A small number of DL subchannels (<=8).

2. The implementation at subscriber side should be kept as simple as possible. The simplicity should manifest itself in the regularity of the design, processing and memory size requirements.

Specifically, the design should be such that the subscriber can process only one DL stream at a time, without significant buffering resources.

## 2.5. Additional PHY components

In this section additional PHY components are discussed.

### 2.5.1. Interleaving and forward error correction (FEC)

The interleaving and forward error correction mechanism should allow fine data granularity. Fine granularity is important due to the relatively narrow data stream in the UL.

Fine granularity may be accomplished by breaking the interleaving process into a two step process. The first step performs interleaving over small groups of bits, to provide a small group of subcarriers. The second step interleaves between several groups of subcarriers.

Fine granularity in the FEC mechanism be accomplished by using zero-tail convolutional code. This coding is proposed due to its very fine granularity. (effectively a single bit).

### 2.5.2. Low PAPR modes

Low PAPR modes may be optionally supported in the UL. In these modes the PAPR is reduced at the expense of data rate reduction. The exact details of the PAPR mode depend on the selected sub-channelization scheme.

# 3. References

[1] "Mobile system considerations", Marriana Goldhammer et al., Alvarion. Submitted to 802.16, January 2003.

[2] "Mobility support in 802.16 MAC", Vladimir Yanover, Alvarion. To be submitted to 802.16, January 2003.

[3] IEEE P802.16/D5-2001 IEEE Draft Standard for Local and Metropolitan Area Networks – Part 16: Air Interface for Fixed Broadband Wireless Access Systems, 2001-10-18

[4] IEEE P802.16a/D7-2002 Draft Amendment to IEEE Standard for Local and Metropolitan Area Networks Part 16: Air Interface for Fixed Broadband Wireless Access Systems –Medium Access Control Modifications and Additional Physical Layer Specifications for 2-11 GHz, 2002-11-17

[5] “Digital Video Broadcasting (DVB); Interaction channel for Digital Terrestrial Television (RCT); incorporating Multiple Access OFDM” ETSI EN 301 958