WiMAX Library

Accelerating Wireless Design Productivity

Overview

CoWare® Signal Processing Designer WiMAX (Worldwide Interoperability for Microwave Access) library is an environment for the development of products based on IEEE 802.16-2004, IEEE 802.16e-2005 and IEEE 802.16-2004/Cor 1-2005 (Standards for Local and Metropolitan Area Networks: The Air Interface for Fixed and Mobile Broadband Wireless Access Systems).

It helps you design, implement, and verify systems based on the WirelessMAN-OFDMA physical layer specification of IEEE 802.16 standards for licensed and license-exempt frequencies below 11 GHz. It can significantly reduce your development time and can increase your chance of first-time design success.

The WiMAX library contains both the basic blocks and the system models describing the IEEE802.16 WirelessMAN-OFDMA technology.

This library can be used to develop systems and ICs for building both fixed and mobile broadband wireless access systems that cover a range of data rates between very high data rate wireless local area networks and very high mobility cellular systems.

Using this library within the CoWare Signal Processing Designer environment accelerates the designer's process of embedded systems' algorithm optimization and algorithm implementation. The baseband design elements of a WiMAX reference model can be integrated into a complete system model, a model which includes all aspects of the environment. Rapid simulation followed by signal analysis enables optimization of the system model. Performance optimization may result in a more valuable product that has higher bandwidth, lower error rates, greater communication range, better interference mitigation and/or has additional features valued by the end-user.

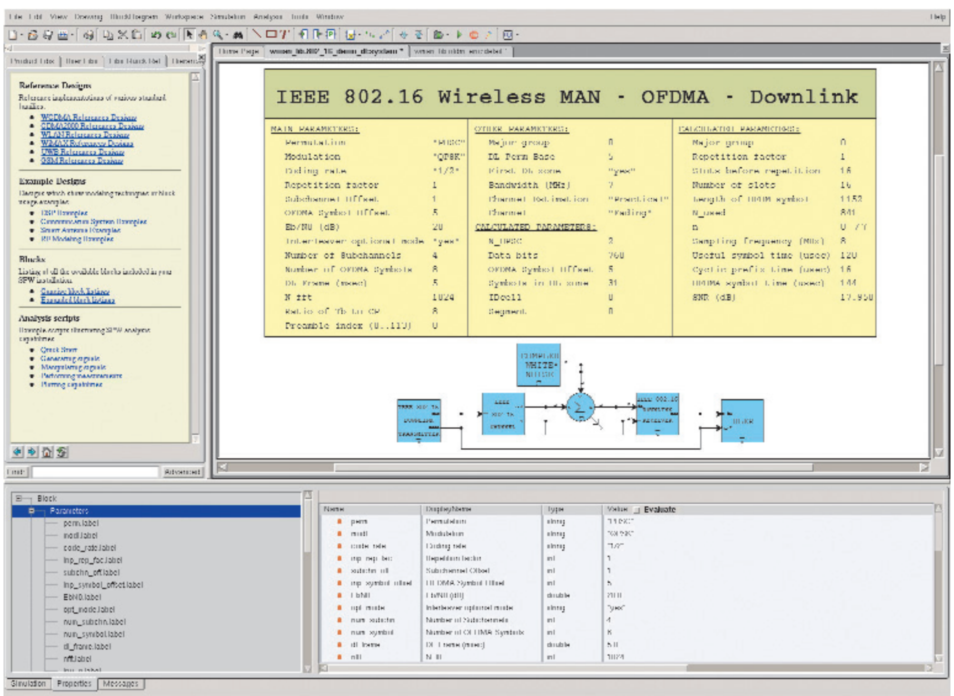

Figure 1: WiMAX end-to-end physical layer model.

HIGHLIGHTS

- **Accommodates the design of wireless networks and terminals, including network infrastructure, for various consumer or enterprise wireless media**
- **Includes IEEE 802.16 system testbenches for downlink and uplink.**
- **Enables fixed-point algorithmic design capture and datapath performance analysis.**
- **Allows direct co-simulation of C (or C++) and HDL blocks using a single simulation process.**
- **Designed for both systems and implementation (Hardware/Software) engineers.**

Benefits

- Rich set of blocks allows to quick assembly of designs for various WiMAX downlink and uplink modes
- Reference systems for IEEE 802.16 standard help to quickly verify the design
- Golden models accommodating different environmental conditions can be used as a starting point for design implementation

Introduction

CoWare Signal Processing Designer's IEEE 802.16 models are based on the WirelessMAN-OFDMA specification of the IEEE 802.16 standards. Two system models are implemented in this library, one for downlink and another for uplink.

The transmitter generates data bits that are randomized, using a PRBS generator with polynomial $1 + x^{14} + x^{15}$. The randomized bits are encoded using a convolutional encoder with coding rate R=1/2. Coding rates R=2/3 and R=3/4 are achieved by puncturing the encoder output. Encoded bits are interleaved using a block interleaver and mapped to modulated symbols, using one of the following modulation schemes: QPSK, 16-QAM and

64-QAM. Repetition Coding may also be done (for QPSK modulation only) at repetition rates of 2, 4 or 6.

In the downlink (DL) system model, modulated symbols are mapped to OFDMA data subcarriers to form a DL burst (multiple DL bursts can be combined if needed). Preamble and DL-MAP are then added to form the DL sub frame[1]. In the uplink (UL) system model, modulated symbols are first combined with pilot symbols and then mapped to OFDMA subcarriers to form a UL burst. In both models, two parameters, *Subchannel Offset* and *OFDMA Symbol Offset*, determine the location of the DL/UL bursts within the DL/UL sub frames, respectively. In the downlink model, another two parameters, *Number of Subchannels* and *Number of OFDMA Symbols*, determine the size of the DL burst. In the uplink model, two parameters, *Symbols in UL zone* and *Number of UL Slots*, determine the length of UL suffrage and the size of the UL burst, respectively.

IFFT transform is performed on each OFDMA symbol to create an OFDMA waveform with duration T_b. A cyclic prefix of length T_g is then added to each OFDMA waveform. FFT sizes of 2048, 1024, 512 and 128 and Tg/Tb ratios of 1/4, 1/8, 1/16 and 1/32 are implemented. In the downlink system model, Full Usage of SubChannels (FUSC) and Partial Usage of SubChannels (PUSC) are implemented, while in the uplink system model, PUSC mode is implemented.

Both system models in the CoWare WiMAX library include models for multipath fading channels and Additive White Gaussian Noise. The Eb/No ratio is set considering the varying signal levels based on the very sophisticated coding and modulation schemes, instead of estimating the signal power. This makes the noise level precise and the simulation very fast. Two fading channel models are included in this library: one models a fixed wireless channel, based on a model developed by IEEE 802.16 working group[2]; the other is a pedestrian/vehicular channel, based on the model developed by ITU IMT-2000[3].

The receivers in the downlink and uplink models are ideal receivers, where they assume complete knowledge of the timing of the received signal. Channel estimation and compensation, however, are performed using the received pilot subcarriers. An FFT transform is first performed on the received waveform and the pilot subcarriers are removed from the resulting OFDMA symbols. Information on data received data subcarriers is then de-mapped to data symbols. Using channel estimates derived from received pilot symbols, the received data symbols are then demodulated. The received data bits are recovered after de-interleaving, de-puncturing, decoding (using a Viterbi decoder with either hard or soft decision decoding) and de-randomizing the demodulated symbols.

The transmitted and decoded bits are then compared and the resulting block and bit error rates are recoded.

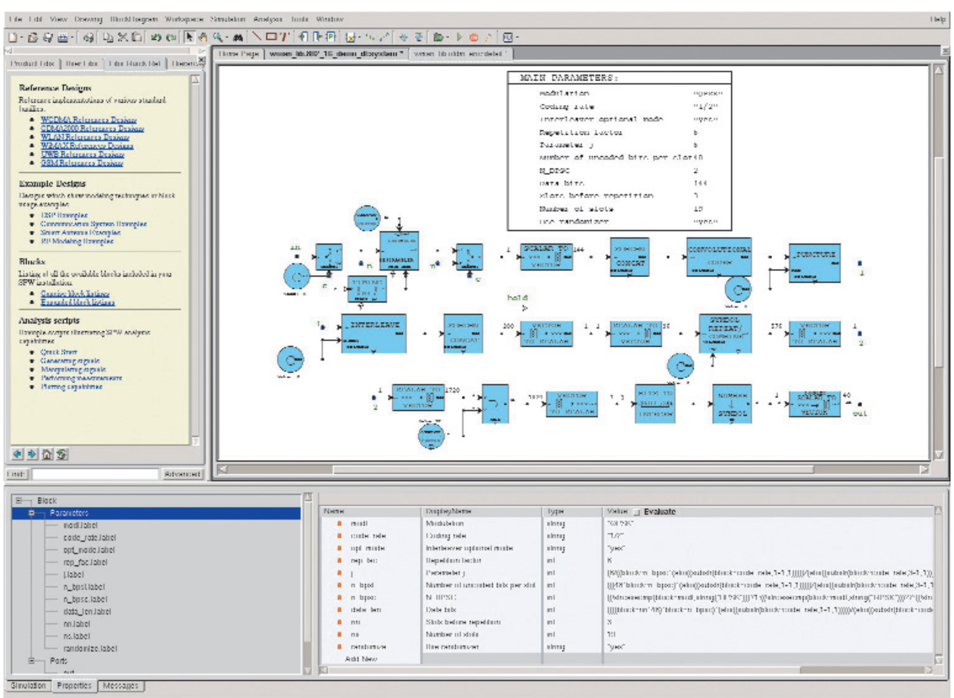

Figure 2: Detail expansion of the OFDM encoder from the WiMAX transmitter.

Key Library Blocks

- IEEE 802.16 Transmitter (Downlink & Uplink)
  - IEEE 802.16 Preamble
  - IEEE 802.16 FCH
  - Zone Transmitter Downlink
    - Burst Transmitter Downlink
      - OFDM Encode
        - IEEE 802.16 Scrambler/Descrambler
        - Slot Concatenate
        - IEEE 802.16 Convolutional Encoder
        - IEEE 802.16 Puncture/De-puncture
        - Interleave/De-interleave
        - Symbol Repeat/Combine
      - Subcarrier Reorder
      - Subcarrier Map (Downlink & Uplink)
      - Frame Insert Downlink
    - Pilot Insert (Downlink & Uplink)
    - Subcarrier Randomizer
      - PRBS Modulator
  - OFDM Modulator
- Impairments
  - IEEE 802.16 Channel
    - Channel Delays
    - IEEE 802.16 Channel Weights
  - Additive White Gaussian Noise
- IEEE 802.16 Receiver (Downlink & Uplink)
  - OFDM Demodulator
  - Zone Receiver Downlink
    - Subcarrier Randomizer
      - PRBS Modulator
    - Pilot Remove (Downlink & Uplink)

- Burst Receiver Downlink
  - Frame Remove Downlink
  - Subcarrier De-Map (Downlink & Uplink)
  - Subcarrier Reorder
  - OFDM Decode
    - Symbol Repeat/Combine
    - Demodulator
    - Interleave/De-interleave
    - IEEE 802.16 Puncture/De-puncture
    - IEEE 802.16 Viterbi Decoder
    - Slot Concatenate
    - IEEE 802.16 Scrambler/Descrambler
- Channel Estimation Downlink
  - Pilot Reorder
  - Interpolate
  - Generate Estimates Downlink
- Channel Estimation Uplink

Key Parameters

- Permutation, Modulation, Coding rate, Repetition factor, Subchannel offset, OFDMA symbol offset
- Eb/No (dB), Calculated SNR (dB), channel type
- Interleaver optional mode, cell ID, UL perm base,
- Number of UL slots, symbols in UL zone, segment, major group, Tb to CP ratio, FFT length, length of OFDM symbol, number of used symbols
- Bandwidth (MHz), sampling frequency (MHz), useful symbol time (µsec), cyclic prefix time (µsec)

Customer Focus

CoWare provides a complete range of training, support, design methodology consulting, and integration services. Technical support requests are handled directly by experienced design engineers who are fully familiar with the application of CoWare tools and methodologies to real-world designs. Training courses are available at CoWare offices or at the customer site and can be tailored to meet the specific needs of the design team.

Sales Offices

CoWare has sales offices in the U.S., Europe, Asia Pacific and Japan. For a complete listing with contact information visit www.CoWare.com. For technical or sales information call 1-888-CoWare8 or email info@CoWare.com.

1 Only FCH containing DL_Frame Prefix is currently implemented from DL-MAP

2 IEEE 802.16.3c-01/29r4; Channel Models for Fixed Wireless Applications

3 Recommendation ITU-R M.1225; Guidelines For Evaluation Of Radio Transmission Technologies For IMT-2000

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