IEEE 802.22 PHY Overview

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Name	Company	Address	Phone	Email
Authors: Zander (Zhongding) Lei	Institute for Infocomm Research (I^{2}R)	1 Fusionopolis Way #21-01 Connexis, 138632, Singapore	65-6408-2436	leizd@i2r.a-star.edu.sg
Sung Hyun Hwang	Electronics and Telecommunications Research Institute (ETRI)	138 Gajeongno, Yuseong-Gu, Daejeon, 305-700, KOREA	82-42-860-1133	shwang@etri.re.kr

Abstract

- **TV Channel Characteristics**

- **IEEE 802.22 PHY Features**

- **Comparisons to IEEE 802.16/WiMax**

- **Conclusions**

TV Channels

- **Multipath Channel Characteristics**
  - Frequency selective with large excessive delay
    - Excessive delay (measurements in US, Germany, France*)
      - Longest delay: >60 μsec
      - 85% test location with delay spread ~**35 μsec**
    - Low frequency (54~862 MHz)
    - Long range (up to 100 km)
  - Slow fading
    - Small Doppler spread (up to a few Hz)
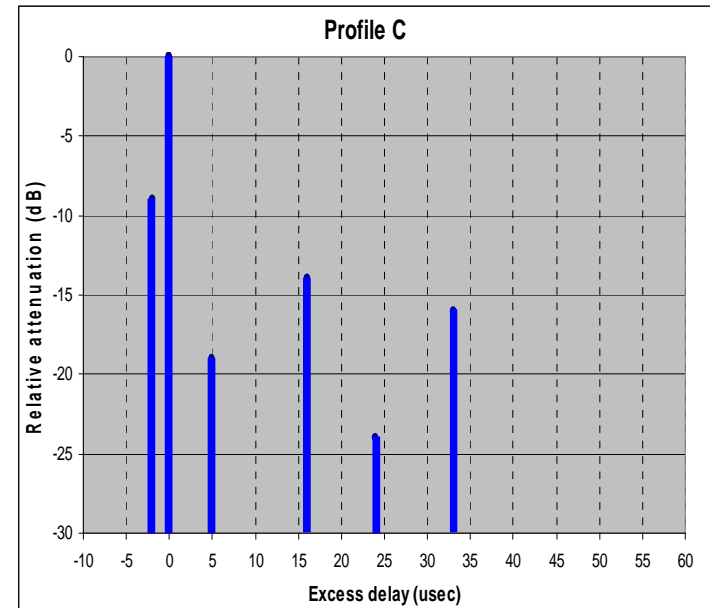
* WRAN Channel Modeling, IEEE802.22-05/0055r7, Aug 05

Profile C

PHY Features (1)

- **Robust OFDMA Design**
  - Longer symbol time
    - $1/\Delta f \sim 300$ μsec*; CP ~ 75 μsec
    - WiMAX: CP ~ 11.4 μsec
  - Slow fading
    - $\Delta f \sim 3.3$ kHz (Robustness to ICI better than WiMax in 3.5 GHz)
    - WiMAX: $\Delta f \sim 11$ kHz (Overkilled in VHF/UHF band)

- **High throughput**
  - Peak data rate per channel: 22.69 Mb/s (rate 5/6, 64-QAM)
  - WiMAX: 15.84 Mb/s (rate 5/6, 64-QAM)

* US 6 MHz TV channel

PHY Features (2)

- **Simple and Light Specs**
  - Single PHY mode: OFDMA
  - Single FFT mode: 2048
  - Single antenna spec
    - Heavy multiple antennas specs (MIMO or beamforming) are not support due to physical sizes of antenna structures at lower frequencies
  - Linear burst allocation
    - DS: little time diversity gain could be achieved across symbols due to channel changes slowly
    - US: allocated across symbols to minimize the number of subchannels used by a CPE, hence reducing (EIRP) to mitigate potential interference to incumbent systems
    - WiMAX: 2 dimension burst mapping

PHY Features (3)

- **Worldwide Operation**
  - TDD
  - Support worldwide TV channels (6, 7, or 8 MHz) in the VHF/UHF broadcast bands from 54 MHz to 862 MHz
  - Same frame/symbol structure, preamble/pilot pattern, FFT size, number of data/pilot subcarriers, modulation and coding, interleaving etc.
  - Sampling frequency, carrier spacing, symbol duration, signal bandwidth, and data rates are scaled by channel bandwidth

PHY Features (4)

- **Adaptive Modulation and Coding**
  - Four CP factors: 1/4, 1/8, 1/16, and 1/32
  - 3 modulations (QPSK, 16QAM, 64QAM) and 4 coding rates (1/2, 2/3, 3/4, 5/6)
  - Mandatory CC + optional turbo (CTC or SBTC) and LDPC codes
  - Turbo-block bit interleaver and subcarrier interleaver
    - Maximize the distance between adjacent samples to achieve better frequency diversity

PHY Features (5)

- **Preamble, Pilot Pattern and Channelization**
    - 3 types preambles: superframe, frame, and CBP
    - Tile pilot pattern
        - For each symbol, every 7 useful subcarriers has a pilot
        - For each subcarrier, every 7 symbols has a pilot
        - Robust channel estimation combining 7 OFDMA symbols.
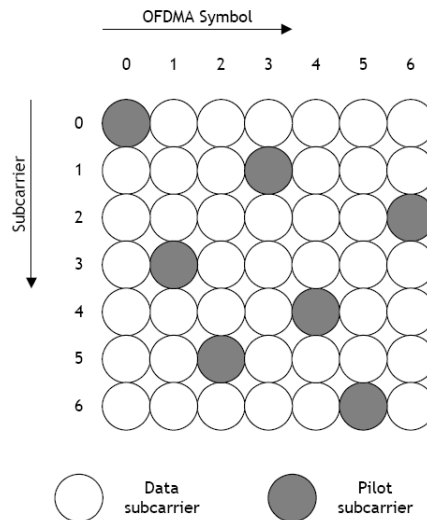
Comparison to IEEE 802.16

	IEEE 802.22	IEEE 802.16e
Air Interface	OFDMA	OFDMA, OFDM, Single Carriers
FFT Mode	Single mode (2048)	Multiple modes (2048, 1024, 512, 128)
OFDMA Channel Profile (MHz)	6, 7, or 8 (one per regulatory domain)	28, 20, 17.5, 14, 10, 8.75, 7, 3.5, 1.25
Burst Allocation	Linear	Two dimensional
Subcarrier Permutation	Distributed with enhanced interleaver	Adjacent or distributed
Multiple Antenna Techniques	Not supported	Support Multiplexing, space time coding, and beamforming
Robustness to delay spread	Strong (CP= 74.7 μsec)	Weak (CP= 22.8 μsec)
Subcarrier Spacing (kHz)	3.3	10.9

Comparison to Mobile WiMAX

	IEEE 802.22	WiMax
PHY Profile	OFDMA, 6 MHz	OFDMA, 5 MHz
FFT Mode	2048	512
Sampling Frequency (MHz)	6.9	5.6
Subcarrier Spacing (KHz)	3.3	10.9
Useful Symbol Time (1/Δf) (μsec)	298.7	91.4
Max CP Time (μsec)	74.7	11.4
Peak Data Rate (Mbps)	22.7	15.8
Burst Allocation	Linear	Two dimensional
Subcarrier Permutation	Distributed with enhanced interleaver	Adjacent or distributed
Multiple Antenna Techniques	Not supported	Support Multiplexing, space time coding, beamforming

Conclusions

- **IEEE 802.22 standard is optimized for VHF/UHF TV channels to provide broadband services with up to 100km coverage**
  - Robust to large delay spread
  - Robust to Doppler spread
  - Simple and light specs