WiMAX Update (Technology and Standards)

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WiMAX Overview and Update

- **WiMAX Overview**
  - **WiMAX Technology**
  - **OFDM Access Method**
  - **802.16d and 802.16e standards**

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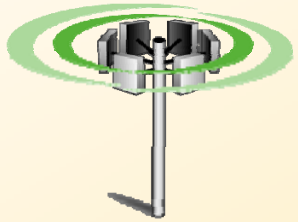
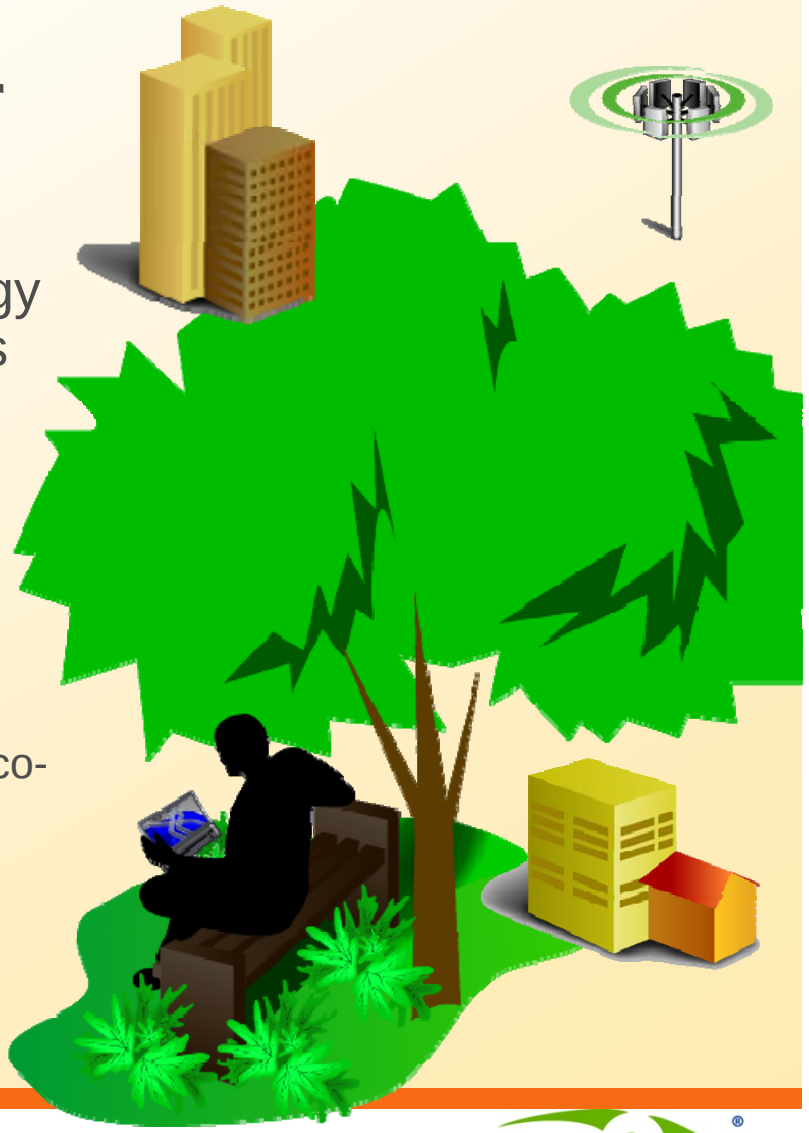
WiMAX Overview

What is WiMAX?

Worldwide Interoperability for Microwave Access

- WiMAX is a standards-based technology enabling the delivery of mobile wireless broadband connectivity
- WiMAX is:
  - 4G
  - Broadband
  - IP native
  - Standard-based: IEEE 802.16
  - Industry to create interoperable complete eco-system





WiMAX Mission Statement

The purpose of WiMAX is to promote deployment of broadband wireless access networks by using a global standard and certifying interoperability of products and technologies

- **Writing test specs**
- **Qualifying test labs**
- **Certifying products**

- **Focus on interoperability**

WiMAX is the next revolutionary technology after WiFi!

WiMAX and its relation to Standards

- **WiMAX is a commercial association which promotes the Broadband Wireless Access standards**
  - **Fixed Wireless Access – based on** IEEE 802.16 **and on** ETSI HIPERMAN
  - **Mobile Wireless Access – based on** IEEE 802.16e
  - **Relation similar to WiFi and 802.11**
- **In a continuous growth - about 530 members**
- **In an advanced stage for Fixed Wireless Access**
  - **Over two years of work**
- **Advancing on Mobile Wireless Access**
  - **Initial certification to be achieved in 2008**

Relations of Standards (802.16d and 802.16e)

IEEE802.16 and HIPERMAN

- 802.16-2004 – FWA standard
  - One MAC, three PHYs
    - OFDM, OFDMA and Single Carrier
- 802.16e – Fixed + Mobile Broadband Wireless Standard
  - Improvements to PHY to support mobility
    - provides Handoff and power-save mechanisms
- HIPERMAN – the parallel ETSI effort
  - Identical to 802.16-2004 with OFDM PHY only
- SPECIFY AIR PROTOCOL ONLY!

WiMAX

- WiMAX focuses on
  - OFDM PHY for FWA
  - OFDMA PHY for mobility
- WiMAX Selects which options in the IEEE air protocol are mandatory
  - System profiles
- WiMAX defines a Networking specification for an End-toEnd Solution

WiMAX Forum Working Groups

Shankar, at&t

Tom Tofigh, at&t
Howard Liu, Disney

Prakash, Intel

TWG: Wonil Roh– Samsung
Vladimir Yanover- **Alvarion**

Ed Agis, Intel

Tim Hewitt, British Telecom

Mo Shakuri, **Alvarion**

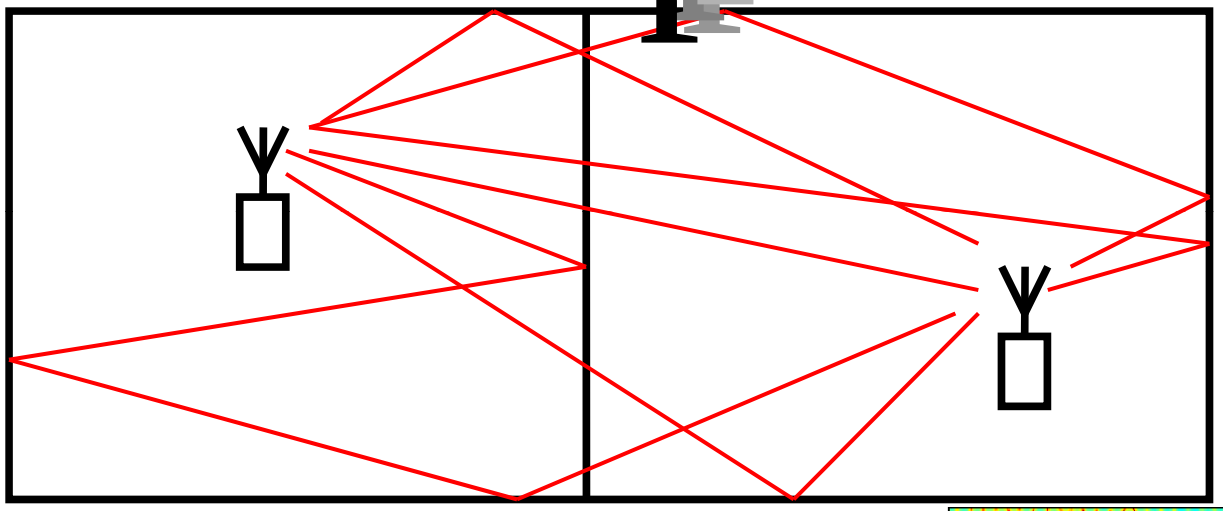
Hyung Kim, Mary Clark

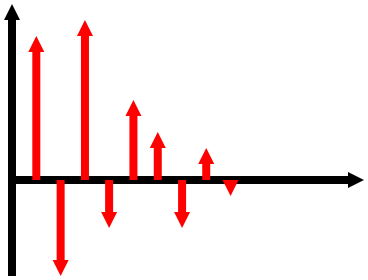
SPWG, NWG, TWG, CWG

- SPWG – Service Providers Working Group
  - Develop requirements (from operators' point of view) for both air-protocol and networking protocols
- NWG - Networking Working Group
  - Develops specs for layers higher than PHY and MAC to define and end to end system
- TWG – Technical Working Group
  - Defining the preferred profiles
    - 802.16 is full of options – somebody has to choose
  - Writing PICS and TSS/TP (testing) documents
- CWG Conformance Working Group
  - Driving the Certification process
    - Test labs, test scripts

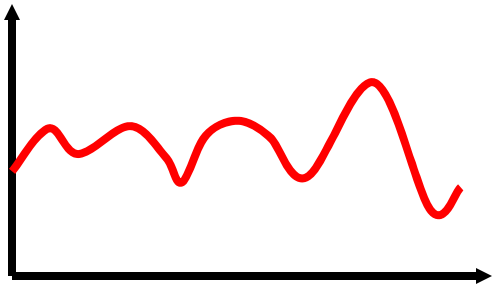
OFDM Access Method

Multipath

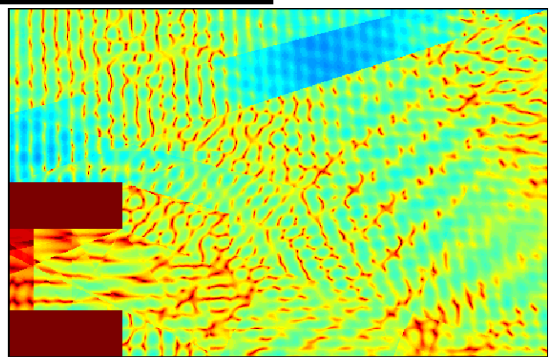




time



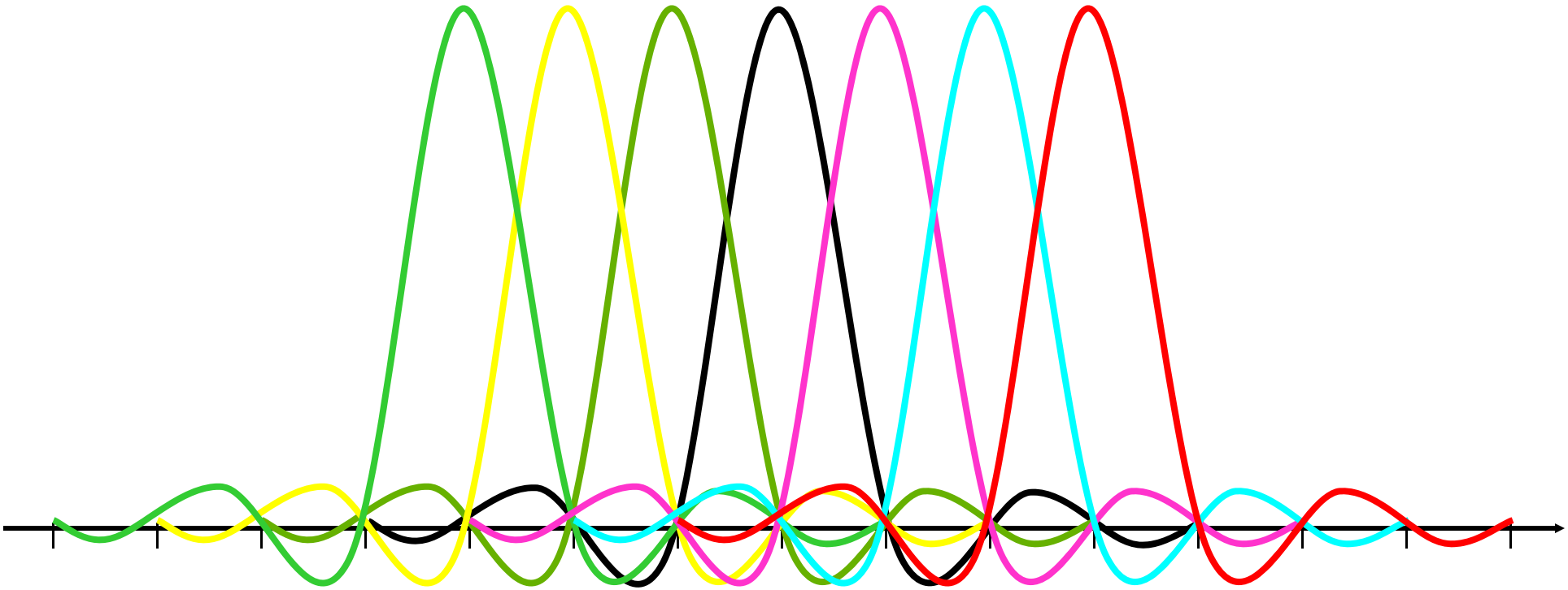
frequency



space

Frequency domain view

- **ORTOGONALITY**
  - **The peak of each signal coincides with nulls of other signals**



IEEE 802.16e

- **Attributes**
  - OFDMA based
  - Scheduled air protocol
  - Designed for mobile environment
- **Advantages**
  - Scalable to wide bandwidths
  - Friendly to MIMO and AAS
  - Incorporates advanced features

802.16e PHY Technology Features

- Scalable OFDMA – adapts FFT size to bandwidth
- Adaptive modulation
  - Communicate to each terminal at proper rate
- Advanced forward error correction schemes (Turbo Codes)
- H-ARQ
  - Retransmission of erroneous data units with combining of pieces at PHY level
- Fast Power management
- MIMO
  - Use of multiple simultaneous signals (two or more radio waveforms) in a single frequency channel to exploit multipath propagation and thereby multiply spectral efficiency.
- Space-Time Code based Transmit Diversity
- Advanced Antenna techniques
  - Fixed and adaptive beamforming
- Soft Combining for MDHO (“Soft Handover”) support

802.16e MAC Technology Features

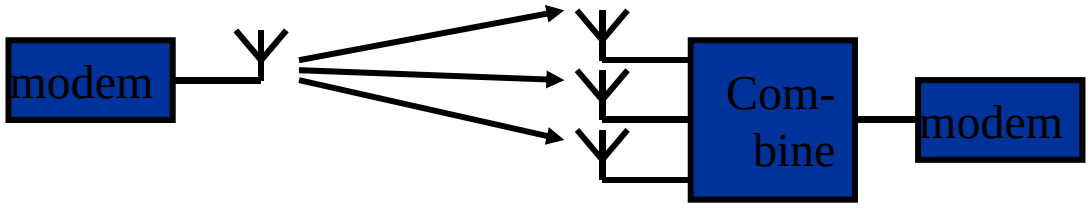
- Centrally coordinated (scheduled)
- Frame based, TDD
- Fragmentation, packing
  - Provide for low MAC overhead
- Connection oriented
  - Provides for classification capabilities with inherent QoS support
- MAC layer ARQ
  - Provides for stable communication in noisy Radio channel
- Handover
  - Regular (“Hard” handover)
  - FBSS (Fast BS Switching)
  - MDHO (“Soft Handover”)
- Sleep Mode
  - Power Saving procedures aligned with traffic type / statistics
- Idle Mode
  - Saves terminal power as well as network resources
- Multicast and Broadcast Services (MBS)
  - Terminal can receive the MBS traffic even in Idle Mode

802.16e - Main technical differentiators

- OFDMA is considered the main PHY mode
- The OFDMA was upgraded to “Scalable OFDMA”
  - The FFT size depends on channel bandwidth
    - In 802.16 ODMA had only 2048 FFT size
- Enhancements to handle time varying channels
- Strengthening of the ECC to handle low-C/I scenarios
  - Repetition mode, Hybrid ARQ
- MIMO capabilities added
- MAC enhanced to support handoff
- Sleep mechanisms
  - Power conservation

Smart Antennas for Diversity and Link Budget

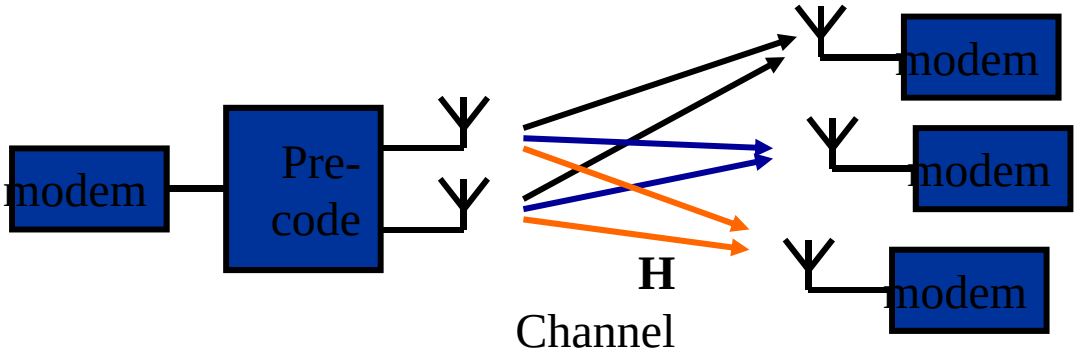
Receive Diversity



H
Channel
matrix

H*
Combining
matrix

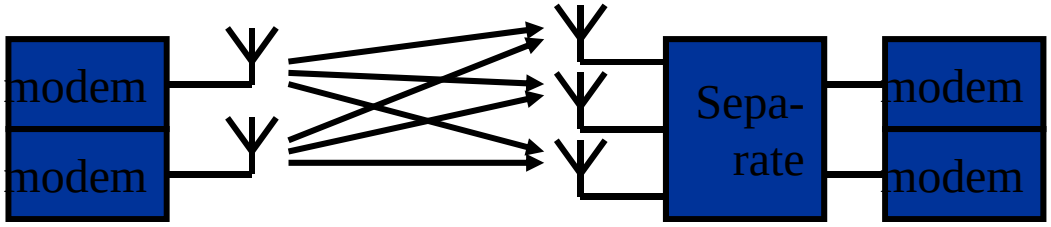
Transmit Diversity



H
Channel
matrices

Smart Antennas for Capacity

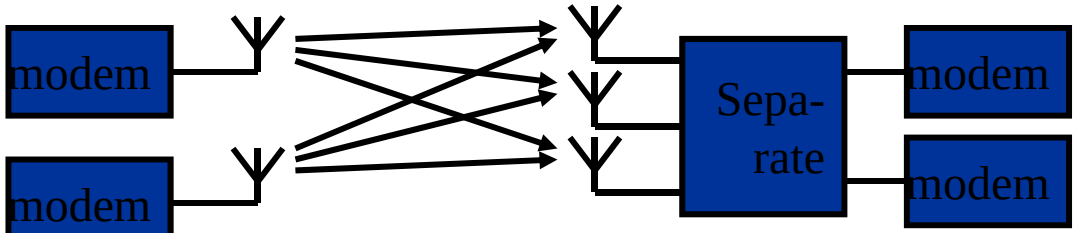
Multi-Input Multi-Output (MIMO)



H
Channel
matrix

"H^{-1}"
Separation
matrix

Spatial Division Multiple Access (SDMA)



H
Channel
matrix

"H^{-1}"
Separation
matrix

WiMAX and IEEE 802.16

- **WiMAX is a subset of IEEE 802.16**
  - **No new features can be added**

- **IEEE 802.16a – A Fixed Wireless Access standard**
  - **PtMP, connection oriented MAC layer**
  - **Three Physical layers: OFDM, OFDMA and Single Carrier**
  - **Approved in April 2003**
- **IEEE 802.16d – now called IEEE 802.16-2004**
  - **Approved in July 2004**
  - **Focused on fixed applications**
  - **Consolidates all amendments and base standard for WiMAX**
- **IEEE 802.16e – called IEEE 802.16-2005 - A Mobile Wireless Access standard**
  - **Incorporate features and protocols needed for portability/mobility**
  - **Modes added to enhance portability/mobility performance**
  - **Approval in Nov05**

WiMAX System Profiles: Fixed and Mobile

	Fixed WiMAX (IEEE 802.16-2004)	Mobile WiMAX (IEEE 802.16e-2005)
Multiplexing	OFDM	OFDMA
Duplexing mode	TDD, FDD	TDD
Modulation	BPSK, QPSK, 16-QAM, 64-QAM	QPSK, 16-QAM, 64-QAM (optional uplink)
Channel bandwidth	3.5, 7, 10 MHz	5, 7, 10 MHz
Frequency bands	2 GHz – 11 GHz	2.3-2.4 GHz 2.5-2.7 GHz 3.3-3.4 GHz 3.4-3.6 GHz

WiMAX Technology Benefits

- **Optimized for fixed and mobile broadband**
  - **Optimal performance – quality of service**
  - **Optimal cost – less investment, better coverage**
- **Widest range of frequency channels for broadband connectivity**
  - **Next generation radios**
  - **Improved business case with high capacity and coverage**
- **Non Line of Sight (NLOS) Capabilities**
  - **OFDM, OFDMA**
  - **Scalable transmission coding for optimized signal & reception**
  - **Advanced antenna systems (AAS)**
    - **MIMO, beam forming**
- **Advanced over-the-air QoS for real-time voice and multimedia services**

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