Evolution of WiMAX
Beyond Fixed Access Networks

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Dr. Kevin Kahn
Intel Senior Fellow & Director
Communications Technology Lab
Intel Corporation
Agenda

• What is WiMax?
• Deployment Vision, Roadmap, Spectrum
• End to end architecture
• Relationship to 3G evolution and “4G”
What is WiMax

- WiMax is IEEE WWAN technology (802.16)
- 802.16-2004: Fixed access BB access
- 802.16e: Mobile BB access
  - Initially nomadic usage
  - Ultimately mobile usage
- 3G adjunct or competitor?
  - Optimized for data not voice
  - Some technical advantages for data vs 3G
- Licensed and unlicensed roles
- WiMax Forum is the industry group
WiMAX PHY Advantages

• Bandwidth scalability
  • Subcarrier allocation: wider BW allocation range than variable rate CDMA
  • Supports higher peak data rate for bursty users (flexible allocation per user)
  • Supports wider variation of spectrum bandwidths (HSDPA limited to 5 MHz)
• Symmetric downlink/uplink
  • HSDPA only for downlink; uplink counterpart HSUPA yet to be developed
  • DL/UL ratio is fixed in WCDMA/HSDPA; dynamically configurable in WiMAX
• Spectrum efficiency
  • Subcarrier allocation takes advantage of multi-user frequency selectivity
  • Per-subcarrier adaptive coding/modulation achieves better efficiency
• MIMO friendly
  • Supports adaptive antenna enhancements in frequency selective channel (beam forming, space time coding, spatial multiplexing and SDMA)
  • MIMO for WCDMA requires complex pre-processing for similar gains
• Reduced uplink near-far problem
  • Orthogonal subcarrier uplink allocation relaxes need for tight power control (HSDPA must have fast power-control to avoid the near-far problem)
Portability and Mobility

- Portable Service ‘Extended WiFi’ Usage Model
  - Predominately notebook PC clients and PDA devices
  - Nomadic usage – Stationary access
    - reconnect, authenticate at each location
  - Portable usage – Nomadic service plus limited L3 mobility
    - pedestrian movement, latency tolerant handoff
  - Mobility: Best effort QoS / handoff moving from BS to BS

- Mobility Service ‘Enhanced 3G data’ usage model
  - PC, PDA plus voice/data handhelds, vehicular telematics
  - Full mobile usage: portable model plus
    - Real time handoff during BS/BS transitions
    - Continuity of sessions and real-time applications
    - Support for vehicular data access while moving
Worldwide Standards Are Key

- One 802.16 Standard for portable and mobile
- Harmonize WiFi, WiMAX networks, clients for complementary use
- Work toward common spectrum for licensed and unlicensed radios
- E2E architecture that comprehends IP and 3G based operators

North America
Licensed 2.5 GHz
Unlicensed 5 GHz
Licensed 700MHz

W. & E, Europe
3.5 & 5 GHz

APAC
2.3, 3.5 & 5 GHz

Central and South America
2.5, 3.5 & 5 GHz

Middle East & Africa
3.5 & 5 GHz

IEEE 802.16
Air Interface

IEEE 802.16e
Air Interface

IEEE 802.11
Air Interface

WiMAX Compatibility
& Interoperability

Harmonization of
802.16 portable/mobile
and 802.11 WiFi

WiFi Compatibility
& Interoperability

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**Applicable Spectrum**

- **Licensed**
  - 2.5GHz, 3.5Ghz depending upon national rules
  - possible sub 1GHz, possible IMT-2000
- **Unlicensed**
  - 5.8GHz worldwide
  - Rural deployment
  - Emerging market deployment
  - Large campus private deployment
  - Grass roots usage (similar to .11 free nets)
## WiMAX Spectrum Outlook

<table>
<thead>
<tr>
<th>Frequency Range</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>Key Operators</th>
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<tbody>
<tr>
<td>5.8 GHz FDD</td>
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<td>WISPs</td>
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<td>Fixed Unlicensed</td>
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<td>3.5 GHz FDD/TDD</td>
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<td>ILECs, CLECs, CNC, Reliance</td>
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<td>Fixed WLL Spectrum</td>
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<tr>
<td>2.5 GHz FDD/TDD</td>
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<td>McCaw, Sprint, BT, Korea</td>
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<td>IMT-2000 Extension</td>
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<td>US</td>
<td>Asia</td>
<td>Europe</td>
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<td>1.7-1.9, 2.1 GHz FDD</td>
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<td>2.5/3G</td>
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<td>2.5/3G Spectrum</td>
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<td>1.5 GHz</td>
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<td>2G/Cellular</td>
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<td>Broadcast</td>
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**Suitability for Mobility?**

- **Korea**
- **US**
- **Asia**
- **Europe**

**Explore Future**

### Frequency Details
- **700 MHz**
  - 6 MHz Channels
- **1.7-1.9 GHz**
  - 1.25 MHz Channels
- **2.3/2.5 GHz**
  - 5-10 MHz Channels
- **3.3/3.5 GHz**
  - 3.5-7 MHz Channels
- **5.5-8 GHz**
  - 20 MHz Channels
End-end Architecture

- 802.16 Focus is Phy/MAC
- MINA group started to define architecture
- Work moved into WiMax Forum
- 3GPP for harmonization discussions ahead
Why MINA Specification?

MINA addresses upper layer architecture & interface specifications out of scope for 802.16, NETMAN, & core network efforts.
Relationship to 3G+ Trends

- Interest in OFDM add-on to 3G
  - E.g., DoCoMo Super 3G proposals
- Interest in IP Infrastructure (all IP net)
  - Data services inherently packet oriented
- Better Packet handling
- More flexible radio phy
  - Variety of bands and evolving modulations
Key WiMAX Success Factors

• **Client Capabilities**
  - Applications and devices that utilize network services
  - Power management for extended battery life

• **Radio Performance**
  - Improvement in spectral efficiency for data services vs. 3G
  - Comparable or better indoor penetration vs. 3G
  - Complementary range and coverage to WiFi

• **Flexible Networks**
  - Fully interoperable IP based network elements
  - RAN architectures that support multi-operator interests
    - Greenfield operators
    - DSL/Cable wireline operators
    - 2G/3G mobile operators
  - RAN architecture independence from operator IP core networks

• **Overall System**
  - Wide area wireless network that meets market cost models
    - CapEx: Infrastructure and client costs, spectrum licenses
    - OpEx: Spectrum efficiency, client management and support
Evolution of Mobile Networks

- **Coverage/mobility**
  - Indoor stationary
  - Pedestrian stationary
  - Vehicular pedestrian

- **Bandwidth (Mbps)**
  - ISM-WLAN
  - WiMAX (802.16e)
  - HSDPA (3G)
  - WiMAX (802.16e) MINA

- **Evolution**
  - Super 3G
  - TOWARD 4G
  - WiMAX/802.16e
  - IMT2000 Evolution

- **Technologies**
  - 3GPP/PP2
  - WiMax Forum 802.16e
  - WWRF
  - DVB/OMA/3GPP

- **Networks**
  - Seamless interworking
  - DVB Broadcast Downlink

- **Institution**
  - Intel Research & Development
  - Communications Technology Lab

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