Agenda

- WiMAX Value Proposition
- WiMAX Forum Update
- WiMAX Access - ASNG Architecture
- Cisco Broadband Architecture
- Broadband Wireless Solution Partners
- Service Enablement using Cisco IP-NGN
- Q & A
Cisco’s Mobility Vision
‘Any Play Services’

“Any Play” Services

Across Devices

Across Segments

Across Technologies
WHY WiMAX?

Following the same adoption curve …

The Path to Volume Economics

- Standard, Certification and multi vendor interoperability drive exponential revenue growth and reduction in system cost
- Strong Ecosystem: more than 400 members of WiMAX Forum (>125 Service Providers)
- Large Estimated Market Size
  - $7B Fixed/Stationary by 2010
  - $20 – 30B Portable/Mobile by 2015
IMT-2000 Approval of WiMAX

- The ITU-R approved the WiMAX Forum's version of IEEE Standard 802.16 as an IMT-2000 technology.

- This significantly escalates opportunities to deliver mobile internet in the 2.5-2.69 GHz band, for both rural and urban markets.

- This is the first time that a new air interface has been added to the IMT-2000 set of standards since the original technologies were selected nearly a decade ago.

- WiMAX technology currently has the potential to reach 2.7 billion people.
Reaching Critical Mass

2.7B people covered by WiMAX spectrum licenses today, estimated 4B as a result of ITU IMT-2000 inclusion
Broadband Wireless Market Adoption

Reason for WiMAX as preferred technology is simple...

- Higher throughput per subscriber, lower latency, built for IP
- Business Case for 802.16 better than traditional 3G systems
- Models the successful “plug & play” scheme of Wi-Fi
- First licensed-RF technology to enable “personal wireless broadband”
- Taiwan picked WiMAX due to extraordinary expense of 3G
Why M-Taiwan – WiMAX Selection

Bottleneck of Mobile Data Services in Taiwan

<table>
<thead>
<tr>
<th></th>
<th>3G (now)</th>
<th>WiMAX (by M-Taiwan)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data Rate</td>
<td>384Kbps</td>
<td>2Mbps</td>
</tr>
<tr>
<td>Revenue Model</td>
<td>•90% revenues come from voice service</td>
<td>•Most revenues come from data services</td>
</tr>
</tbody>
</table>
| Device Loyalty       | US$100-150 loyalty per unit shipment | All IP networking
                        |                                     | ➔ Lower technology complexity
                        |                                     | ➔ Less device loyalty               |

Challenge from Neighboring Countries

– South Korea and Singapore released WiBro/WiMAX spectrum in 2005 respectively
– Although the WiMAX spectrum in Taiwan wasn’t released until July

2007, Taiwan ecosystem is affirmed of overtaking the other countries in spite of late launch.
Why WiMAX?

- Responding to end-users’ demand
  - Over 50% people in Taiwan are looking forward to broadband wireless applications, such as mobile IPTV, ITS, and etc.

- Taiwan plays an important role of ICT manufacturing
  - Eg. The worldwide market share of WLAN is over 90%

- International vendors are investing WiMAX
  - Moto, Nokia, Alcatel-Lucent and many other vendors commit for 802.16e development

Downloading time for a DVD film (around 4.7GBytes)

- GPRS 2.5G: 1 Week
- EDGE 2.75G: 3.5 Days
- WCDMA 3G: 1 Day
- HSDPA 3.5G: 6 Hours
- WiMAX: 1 Hour
The Real Opportunity

Country Transformation and ‘Digital Inclusion’

Broadband Penetration—2006

Wireless Penetration—2006

Source: EIU, Telegeography, Point Topic, Cisco Analysis
Country Transformation

*IP Communication Technologies Drive Growth*

Network as the Platform
The Broadband Wireless Market

Why is WiMAX Important?

- WiMAX Leverages IP technologies throughout; a natural fit for Cisco
- WiMAX Enhances Cisco’s existing market-leading WiFi and WiFi mesh solutions

WiMAX (802.16e-2005) enables a wide range of fixed and mobile ‘any play’ services to deliver the Connected Life experience

- Service Providers: Improved cost effectiveness with significant reductions in capital and operational expenditures
  Faster time-to-market; no wires
  Complements and extends existing cellular / broadband offerings
- Governments: An efficient means to enable ‘Digital Inclusion’
Why is Mobile WiMAX attractive to operators?

- Intellectual Property Rights (IPR) problems with 3G (Qualcomm)
- Large ecosystem is developing including handset vendors
- Lots of mobile CAPEX up for grabs
- Spectrum is becoming available
- Will go all-IP e2e years ahead of 3G
- Leading the movement to “open” systems
- Is being incorporated into WiFi muni-mesh opportunities (Cisco Digital Cities Initiative)
- WiMAX Forum driving the technology forward (approaching 400 members)
- Will adopt OFDMA and MIMO well ahead of the 3G camps
- Emerging Market is seeing lots of activity
## Cisco IP Next Generation Networks

**IP Forms the Foundation for True Mobility for WiMAX**

### Subscriber
- UMTS / HSPA
- CDMA
- WIMAX
- WiFi
- Wireless Mesh

### Radio Networks
- GGSN
- PDSN
- ASN-GW
- Wireless LAN Controller

### Mobile Service Exchange
- Packet Gateways
- IP Anchor Point
- IP Service Control
- Mobile IP Home Agent
- Service Control
- Session Border Controller
- IP Transfer Point
- Content Services Gateway

### Multiservice IP/MPLS Core

### Internal Services and Operations
- News Portals
- Location Services
- Broadcast
- VoD
- VoIP
- Music
- Billing
- AAA
- DNS
- Policies
- Logging
- Subscriber Profiles

### External Services
- Corporate VPNs
- Internet
- Roaming Exchanges
- Application Partners
- IP Media Partners
- Signaling Networks

### Persistent Roaming Across Wireless Access Networks

### Subscriber-Differentiated IP Service Delivery
Cisco Broadband Wireless Strategy Overview

**WiMAX is one of the Access Choices & Options Available**

<table>
<thead>
<tr>
<th>Clients</th>
<th>Base Station</th>
<th>Transmission</th>
<th>Aggregation</th>
<th>Multi-service Core</th>
<th>Services OSS/BSS</th>
</tr>
</thead>
<tbody>
<tr>
<td>SME Indoor &amp; Outdoor</td>
<td></td>
<td>Backhaul and pre-aggregation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nomadic User</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Residential Indoor &amp; Outdoor</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mobile</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nomadic User</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Portable</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**WiMAX**
- Subscriber
- Cellular

**Cellular**
- Subscriber

**WiMAX**
- RAN Edge
- RAN Core
- L3 IP/MPLS Core
- Application & Services

**Connectivity Services Network (CSN)**
- PSTN
- PSTN Interworking
- Internet
- On net services
- Internet

**SEF**
- On net services
- Interworking
- SEF Policy Framework

**Operator provided services**
- AAA
- DHCP
- DNS
- NMS
- VoD
- VoIP
- Broadcast

**Service Offerings**
- AAA
- DHCP
- DNS
- NMS
- VoD
- VoIP
- Broadcast

**Backhaul and pre-aggregation**
- Mesh
- Microwave
- Metro Ethernet
- EoSDH
- (Ethernet) SDH/SONET
- TDM/ATM/IP
- EoSDDH

**Multi-service Core**
- ISP
- PE
- PE
- PE
- IP/MPLS
- L3 IP/MPLS Core
- ASGW
- MIP HA
- ASN GW
- ASN GW
- ASN GW
- RAN
- RAN
- RAN
- SEF
- SEF

**Services OSS/BSS**
- SEF Policy Framework
- Application & Services

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WiMAX Value Summary

- WiMAX value proposition is for operators to make money out of delivering services on the **new Internet model**
- WiMAX is free from the legacy wire line-cellular because it’s roots are derived **from the Internet**
- WiMAX will match speeds of LTE (current proposal of 20 MHz now part of 1.5 Release.)
- WiMAX will have a cellular-based flavor of multicasting available via HSPA called Multimedia Broadcast Multicast Service or MBMS
- WiMAX embraces **QoS** controls and tools which allow operators to embrace multi-tier service pricing and level marketing.
- WiMAX is excellent where countries – locations have no existing infrastructure
Agenda

- WiMAX Value Proposition
- **WiMAX Forum Update**
- WiMAX Access - ASNG Architecture
- Cisco Broadband Architecture
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- Q & A
WiMAX Forum Approach

**Intellectual Property Rights**

- Basically a IT vs. Mobile industry approach to IPR.
- Significant problems with existing 3G approach to royalty payments in the mobile world.
- Avoiding the pitfalls of CDMA/UMTS licensing as we move to OFDMA and MIMO and other advanced Antenna technologies.
- Spread IPR over large # of companies instead of having 1 company holding the lion-share.
WiMAX IPR

- Dispersed distribution of ownership of US patents*
- No single company has a dominant IPR position.

1550 patents are distributed among 330 companies

Of the 23 Companies that hold more than 10 Patents...
74% are WiMAX Forum members, representing 82% of the patents held in concentrations of 11 or more patents per company

*Based on independent survey of relevant and potentially relevant patents/applications for United States

Source: Schwegman, Lundberg, Woessner & Kluth
Oct 2006
The WiMAX Forum – 519 Members

27%
137 Content Eco-systems

31%
161 Service Providers

17%
87 Components Silicon Mfrs

25%
127 System Vendors

• Deliver a trusted certification process
• Develop a framework for a high performance end to end IP mobile network architecture supporting all usage models
• Promote WiMAX as the leading business model to deliver global wireless broadband services
• WiMAX Forum contributes to foster a thriving ecosystem
Nine WiMAX Forum Working Groups

- Service Provider Working Group (SPWG)
- Global Roaming Working Group (GRWG)
- Network Working Group (NWG)
- Technical Working Group (TWG)
- Evolutionary Technical Work Group (ETWG)
- Certification Working Group (CWG)
- Regulatory Working Group (RWG)
- Applications Working Group (AWG)
- Marketing Working Group (MWG)

- Network & Air Interface Requirements
- Assure & Accelerate Global Roaming
- End-to-End Network Specifications
- Air Interface System Profiles & Test Scripts
- Evolve WiMAX Technologies
- Certification Testing & Plugfests
- Worldwide Spectrum Policy
- Real World Showcase & Simulation Modeling
- Marketing Communications & Membership
WiMAX forum’s nine working groups

- **Applications Working Group**: Define applications over WiMAX™ that are necessary to meet core competitive offerings and that are uniquely enhanced by WiMAX technology.
- **Certification Working Group**: Handles the operational aspects of the WiMAX Forum Certified program.
- **Evolutionary Technical Working Group**: Maintains existing OFDM profiles, develops additional fixed OFDM profiles, and develops technical specifications for the evolution of the WiMAX Forum’s OFDM based networks from fixed to nomadic to portable, to mobile.
- **Global Roaming Working Group**: Assures the availability of global roaming service for WiMAX networks in a timely manner as demanded by the marketplace.
- **Marketing Working Group**: Influences WiMAX technology adoption worldwide. Promotes WiMAX products, brands and standards, which form the basis for global interoperability of wireless broadband Internet anytime anywhere.
- **Network Working Group**: Creates higher level networking specifications for fixed, nomadic, portable and mobile WiMAX systems, beyond what is defined in the scope of 802.16.
- **Regulatory Working Group**: Influences worldwide regulatory agencies to promote WiMAX-friendly, globally harmonized spectrum allocations. *Chair: Tim Hewitt, BT*
- **Service Provider Working Group**: Gives service providers a platform for influencing BWA product and spectrum requirements to ensure that their individual market needs are fulfilled.
- **Technical Working Group**: The main goal of the TWG is to develop technical product specifications and certification test suites for the air interface based on the OFDMA PHY, complementary to the IEEE 802.16 standards, primarily for the purpose of interoperability and certification of Mobile Stations, Subscriber Stations and Base Stations conforming to the IEEE 802.16 standards.
Mobile Certification in FY08

Release 1.0 Wave 1
Mandatory testing:
Key functionality, including QoS, AES, PKMv2, handoff, H-ARQ, power control, sleep and idle mode and header compression

Release 1.0 Wave 2
Mandatory testing: Additional test on handover, QoS, power saving and IPV6

Base Station
Optional Modules:
MIMO
Beamforming
Ethernet I/O
MBS

Mobile Station
Mandatory Testing:
MIMO
Beamforming
MBS
Optional:
Ethernet I/O

Backward Compatible    More Features Tested
Mobile Profiles for Taipei Plugfest

Vendors have registered in a mix of 6 Certification Profiles

- 34 Equipment Vendors and 8 test equipment vendors registered with 220+ participating Engineers which makes this Plugfest the largest one.

- **A 24% increase in participating companies and a 37% increase in attending engineers since the May 2007 Plugfest which demonstrates how WiMAX Technology is growing!**

<table>
<thead>
<tr>
<th>Plugfest Profiles</th>
<th>DESCRIPTION</th>
<th>SS</th>
<th>BS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1A</td>
<td>2.3-2.4 GHz, 8.75 MHz, TDD</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>3A</td>
<td>2.496-2.69 GHz, 5 MHz, TDD</td>
<td>20</td>
<td>10</td>
</tr>
<tr>
<td>3A</td>
<td>2.496-2.69 GHz, 10 MHz, TDD</td>
<td>24</td>
<td>19</td>
</tr>
<tr>
<td>5A</td>
<td>3.4-3.8 GHz, 5 MHz, TDD</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>5AL</td>
<td>3.4-3.6 GHz, 5 MHz, TDD</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>5BL</td>
<td>3.4-3.8 GHz, 7 MHz, TDD</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Totals</td>
<td>6 Profiles</td>
<td>61</td>
<td>41</td>
</tr>
</tbody>
</table>
## October 2007 Taipei Participants

<table>
<thead>
<tr>
<th>Equipment Vendors</th>
<th>Test Equipment Vendors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Accton Technology</td>
<td>Institute for Information Industry</td>
</tr>
<tr>
<td>Airspan Networks</td>
<td>Japan Radio</td>
</tr>
<tr>
<td>Alcatel-Lucent</td>
<td>M/A - COM</td>
</tr>
<tr>
<td>Alpha Networks</td>
<td>Marvel Semiconductor</td>
</tr>
<tr>
<td>Alvarion</td>
<td>Motorola</td>
</tr>
<tr>
<td>Amicus Wireless</td>
<td>Navini Networks</td>
</tr>
<tr>
<td>ApaceWave Technologies</td>
<td>NEC</td>
</tr>
<tr>
<td>ASUSTek Computer</td>
<td>Nokia</td>
</tr>
<tr>
<td>Beceem Communications</td>
<td>Nortel Networks</td>
</tr>
<tr>
<td>Fujitsu</td>
<td>picoChip Designs Ltd.</td>
</tr>
<tr>
<td>GCT Semiconductor</td>
<td>Posdata</td>
</tr>
<tr>
<td>Gemtek</td>
<td>Quanta Computer</td>
</tr>
<tr>
<td>Huawei</td>
<td>Redline Communications.</td>
</tr>
<tr>
<td>Intel Corporation</td>
<td>Runcom Technologies Ltd.</td>
</tr>
</tbody>
</table>
Four Plugfest Scheduled for FY08

- **Feb 10th – 17th** - .16e Plugfest – (MIMO, Beam Forming IO & SISO implementations) – New Delhi, India

- **May 4th – 11th** - .16e Plugfest – (MIMO, Beam Forming IO) - Vienna, Austria

- **Oct 12th – Oct 19th** - .16e Plugfest – (MIMO, Beam Forming IO) – Singapore

- **Nov 3rd – Nov 9th** - NWIOT Plugfest – Site TBD
## WiMAX Roaming Services

<table>
<thead>
<tr>
<th>Year</th>
<th>Services</th>
<th>Network</th>
<th>Devices</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>Internet Access Enterprise VPN</td>
<td>WiMAX</td>
<td>Connection Cards USB Dongle PDAs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>WiMAX to Wi-Fi</td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td>Services w/QoS:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- VoIP</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Video Conferencing</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Streaming Video and Music</td>
<td>WiMAX</td>
<td>Embedded Devices Phones</td>
</tr>
<tr>
<td></td>
<td>- Games</td>
<td>WiMAX to 3G</td>
<td></td>
</tr>
</tbody>
</table>

Home services available to WiMax users wherever they travel.
Mobile WiMAX Roadmap

- **Mobile WiMAX Rel 1.0** (802.16e)
  - 30mbs @ 30MPH
  - 2007

- **Mobile WiMAX Rel 1.5** (802.16e)
  - 100mbs @ 70MPH
  - 2008

- **Mobile WiMAX Rel 2.0** (802.16m)
  - 100mbs @ 300MPH
  - 2009

- **Mobile WiMAX Rel 2.0** (802.16m)
  - 100mbs @ 300MPH
  - 2010
Mobile WiMAX Technology Evolution Vision

Mobile WiMAX Forum Technology

Network Specification
- Release 1.0: WIMAX Network (2007)
- Release 1.5: WIMAX Network (Q3 2008)
- Release 2.0: WIMAX Network (2009 - 2010)

Certification
- Wave 1 Certification (Q1 2008)
- Wave 2 Certification + Baseline Network Services (Q3 2008)
- Wave 2 Certification + Enhanced Optional Network Services (Q2 - Q3 2009)
- Certification + Enhanced Optional Network Services (2011)

System Specification
- Mobile WiMAX System Profile (2007)
- Mobile WiMAX System Profile (Q2 2008)
- Mobile WiMAX System Profile (2010 - 2011)

IEEE Standards
- 802.16e (Dec 2005) + Cor2 (Q2 2007)
- 802.16Rev2 (Q2 2008)
- 802.16m (Q4’ 2009) (Targeting IMT-Adv.)

A fully backward compatible evolution on standards and products
Projections subject to change
# IEEE Standard Evolution to 16m

<table>
<thead>
<tr>
<th>Feature</th>
<th>IEEE 802.16m* (From Approved System Requirements)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RF Bands</td>
<td>Below 6 GHz, licensed</td>
</tr>
<tr>
<td>Duplexing Modes</td>
<td>TDD and FDD/HFDD</td>
</tr>
<tr>
<td>Channel Bandwidths</td>
<td>5, 10, 20, others optional BWs</td>
</tr>
<tr>
<td>Peak Data Rates (per sector)</td>
<td>DL: &gt; 130 Mbps</td>
</tr>
<tr>
<td></td>
<td>UL: &gt; 56 Mbps</td>
</tr>
<tr>
<td></td>
<td>(20 MHz, baseline antenna configuration)</td>
</tr>
<tr>
<td>Mobility</td>
<td>Up to 350 km/h (optimum performance &lt; 15 km/h)</td>
</tr>
<tr>
<td>Latency</td>
<td>Link-Layer Access: &lt; 10 ms</td>
</tr>
<tr>
<td></td>
<td>Handoff: &lt; 50 ms</td>
</tr>
<tr>
<td>MIMO Configuration</td>
<td>DL: 2x2, 2x4, 4x2, 4x4 MIMO</td>
</tr>
<tr>
<td></td>
<td>UL: 1x2, 1x4, 2x2, 2x4, 4x4 MIMO</td>
</tr>
<tr>
<td>Peak Spectral efficiency</td>
<td>Peak: DL &gt; 6.5 bps/Hz</td>
</tr>
<tr>
<td>(per sector)</td>
<td>UL &gt; 2.8 bps/Hz</td>
</tr>
<tr>
<td>Average User Throughput</td>
<td>&gt; 2x Release 1.0</td>
</tr>
<tr>
<td>Cell Edge User Throughput</td>
<td></td>
</tr>
<tr>
<td>Number of VoIP Active Users</td>
<td>&gt; 60 users/sector/FDD MHz</td>
</tr>
<tr>
<td></td>
<td>&gt; 30 users/sector/TDD MHz</td>
</tr>
</tbody>
</table>

*Minimum Requirements to be Exceeded by 16m

16m Standards Completion expected by end of 2009
Mobile WiMAX Profile Release 1.0

Underlying Standards
Air Interface: IEEE802.16e-2005
Network: NWG Release 1.0/1.5

Specifications
Channel BW: 8.75(Korea), 5, 10MHz
Focus on TDD in

Modulation:
DL: 64QAM, 16QAM, QPSK
UL: 16QAM, QPSK
Peak Data Rates Per Sector/Per Carrier:

Specifications Completed
Products 2007-8
Mobile WiMAX Profile Release 1.x

**Underlying Standards**
Air Interface: IEEE802.16 REV2
Network: NWG Release 1.5

**Enhancements**
Extension to new Spectrum Bands
Enabling both TDD and (H)FDD with Maximum Commonality
Some Performance Improvement (Focus on Software Upgrades)
Enabling Network Release 1.5 Advanced Features

**Applications**
Higher VoIP Capacity
Enhanced LBS
Enhanced Multicast and Broadcast Services

Specifications 2008
Products 2009
Mobile WiMAX Profile Release 2.0

Underlying Standards
Air Interface: IEEE802.16m
Network: NWG Release 2.0

Enhancements
Wider Band Channels (TDD & FDD in 5, 10, 20MHz)
Multiple Carrier Support
Higher Spectrum Efficiency/Capacity
Higher Peak And Average User Data Rates
Integrated Relay
Improved Mobility And Lower Latency
Improved MIMO (focus on higher order and multiuser MIMO)
Enhanced Inter-tech Handoffs/Coexistence With 3G and WiFi
Improved Power Saving

Applications
Multi-hop relay deployments

Specifications 2010
Products 2011
Documentation Outline

- **Network Rel 1.5 Requirements Status** – approved changes
  - Simple IP, USI, MCBCS, Ethernet/VLAN, ND&S, SmartCard, IMS
- **Uploaded Release 1.5 today to forum data base**
- **Air Interface Rel 1.x Requirements Status**
  - Near-term evolution of mobile WiMAX profile based on 802.16-REV2
  - Requirements address alignment of Rel 1.x with network Rel 1.5
  - Rel 1.x document is in ballot review, with ongoing ballot comment resolution
  - Target completion: Dec 2007 (Santa Clara)
- **Network Rel 2.0 Requirements Status**
  - Release 2.0 Network Requirements (Target: Q308)
  - Multimedia Session Continuity Work Item
  - Network Management Requirements
  - Aligned with Air interface Release 2.0
WiMAX Network Standards Roadmap

Expected Timeline for Specifications

**Release 1:**
- Mobile and stationary WiMAX base spec: ASN, CSN mobility, Sleep/Idle modes,
- IPv4 & IPv6 connectivity
- Pre-provisioned/static QoS,
- Optional RRM
- Network discovery/selection
- IP/Eth CS support
- Flexible credentials, pre- and postpaid accounting
- Roaming (RADIUS only)
- 3GPP I-WLAN compatible IWK
- Mobile Internet applications
- 3 ASN profiles
- Start of NWIOT (NCT/IIOT) specs

**Release 1.5:**
- IMS and PCC/Dynamic QoS
- Telephony VoIP with emergency services
- Lawful interception
- MCBCS
- Diameter based AAA
- OTA APDO and device management
- 3GPP SAE IWK, 3GPP2 IWK optimizations
- Ethernet services, VLAN, DSL IWK
- Multi-host support
- Location based services
- RoHC
- Normative R8
- Non-IMS/Universal Services Interface
- NWIOT Release 1.5 (NCT/IIOT) and enabling IOT for retail devices

**Release 2:**
- Multimedia Session Continuity
- Seamless WiFi-WiMAX handover
- 3GPP/2 IWK (optimized HO)
- Network Management
- Enhancements in
  - Roaming
  - MCBCS
  - Emergency Services
  - IMS Support
  - Support for Relay (TBD)
- Second-gen. NWIOT framework

Last updated Oct 25, 2007
Four Additional Certification Labs

- 4 additional labs across the globe in addition to Malaga, Spain
- Test vendors including Agilent, Anite, AT4, Azimuth, Innowireless, Tektronics, Rohde and Schwarz and Sanjole have developed test equipment to support our certification needs.
- The 4th Public, Mobile WiMAX PlugFest held October 13 - 20 in Taipei, was the largest successful Plugfest to date
  - 34 equipment vendors,
  - 8 test equipment vendors and
  - 220+ engineers!
- First official testing of Beamforming I/O
- Introduction of General Handoff and Hybrid ARQ Scenario
- Vendors had over 60 MIMO setups
- Vendors tested Collaborative MIMO and UL MIMO successfully – a first for our Mobile Plugfest.
- 200+ setups with different BS-MS achieved basic interoperability
- 125 setups achieved extended interoperability
- Several set ups achieved connectivity using Beamforming.
WiMAX Certification Process

- All tests must be performed at a certified WiMAX lab (CETECOM)
- Two steps to obtain WiMAX certified status
  - Pass standard conformance tests (multiple waves/releases)
  - Complete interoperability testing with two (3) other vendors

Return to self test

Conformance Testing → Pass? → Interoperability Testing

PCT: Protocol Conformance Tester
RCT: Radio Conformance Tester
WiMAX Interoperability

- A minimum of three (3) vendors required
- Must test at least three (3) separate products
2007-2008 NWG/NWIOT TG F2Fs

Oct 22 – 26, 2007, Taipei WiMAX Forum Member Conference

Dec 3 – 6, 2007, Santa Clara – SPWG F2F Air Interface

Dec 10 – 14, 2007, Tel Aviv Alvarion NWG F2F
  - NWIOT TG F2F December 10, 2007
  - NWG Interim F2F December 11 – 14, 2007

Jan 28 – Feb 1, 2008, Kona WiMAX Forum Member Conference
  - NWIOT TG F2F January 28, 2008
  - NWG F2F January 29 – February 1, 2008
Agenda

- WiMAX Value Proposition
- WiMAX Forum Update
- WiMAX Access - ASNG Architecture
- Cisco Broadband Architecture
- Broadband Wireless Solution Partners
- Q & A
WiMAX End to End Network Reference Model

**ACCESS SERVICE NETWORK (ASN)**
Access gateway (ASN GW) – provides the micro-mobility anchor point and supports bearer services. Also supports the Foreign Agent.
Base station (BS) – provides the radio dependent functions and has limited IP functionality.

**CORE SERVICES NETWORK (CSN)**
Home agent (HA) – provides the macro-mobility anchor point and supports bearer services, if roaming/mobility is desired.
Other Network Elements such as AAA, DHCP servers and more are also in the CSN.

- MSS – Mobile Subscriber Station
- NAP – Network Access Provider
- NSP – Network Service Provider
ASN Profiles

- Three ASN Profiles have been specified in WiMAX as a tool to manage diversity in ASN node usage and implementation.
  - Release 1 of NWG Specifications on WiMAX supports 3 ASN

Profiles:

Profile A:
- Centralized ASN Model with BS and ASN GW in separate platforms through R6 interface
- Split RRM: RRA in BS and RRC in ASN-GW
- Open interfaces for Profile A: R1, R6, R4, and R3

Profile B:
- Distributed ASN solution with the BS and ASN GW functionalities implemented in a single platform
- Open interfaces Profile B: R4 and R3

Profile C: Similar to Profile A, except for RRM being non-split and located in BS. A big departure from the way things used to be done in the mobile radio world.
ASN Profile A - removed from Standards

Separate ASNG, BS and Split RRM

CPE

Residential

Business

ASP

R2

R6

BS

R1

ASNG/FA

R4

MPLS CORE

PE

P

P

R3

NSP SERVICES

ISP Internet

Voice

Corporate

Home Agent

AAA

ASP/ASN

Profile A

- HO
- Data Path 1 & 2
- Authentication Relay
- Paging Agent
- Key Receiver
- Context
- RRA
- SF Management

BS

ASN-GW

- HO
- Data Path 1 & 2
- Authenticator
- Key Distributor
- Context
- RRC
- SF Authorization

- DHCP Proxy/Relay
- MIP FA
- Location Register
- PMIP Client
- AAA Client
- Paging Controller
ASN Profile B – no future development

Separate BS, ASN-Gateway, RRM in BS

- BS+ASNG_FA
- BS+ASNG
- BS+ASNG_FA
- BS+ASNG

CPE

ASP

R2

MPLS CORE

R3

NSP SERVICES

Voice

ISP Internet

Corporate

Home Agent

AAA

- HO
- Data Path 1 & 2
- Authenticator
- Key Rec. & Dist.
- Context
- RRA + RRC
- SF Auth & Mgt
- DHCP Proxy/Relay
- MIP FA
- Location Register
- PMIP Client/Assist
- AAA Client

ASN Profile B

R1

R4

R3
ASN Profile C - approved and current development

Separate ASNG, BS and RRM in BS

CPE

- Residential
- Business

ASP

R2

- ASNG/FA
- Authentication Delay
- HO
- Data Path 1 & 2
- Authentication Relay
- Paging Agent
- Key Receiver
- Context
- RRA + RRC
- SF Management

MPLS CORE

PE

P

- HO
- Data Path 1 & 2
- Authenticator
- Key Distributor
- Context
- SF Authorization

- DHCP Proxy/Relay
- MIP FA
- Location Register
- PMIP Client
- AAA Client
- Paging Controller

NSP SERVICES

ISP

- Voice

Internet

- Corporate

Home Agent

AAA

ASN Profile C

BS

ASN-GW

- HO
- Data Path 1 & 2
- Paging Relay

- Paging Agent
- Key Receiver
- Context
- RRA + RRC
- SF Management
# Profile Comparison

<table>
<thead>
<tr>
<th>ASN Profile</th>
<th>Description</th>
<th>Pro</th>
<th>Con</th>
</tr>
</thead>
</table>
| Profile A            | Centralized platform  
Separate BS and ASNGW  
Split RRM: RRA at BS  
and RRC at ASN-GW  
PHY and partly MAC in BTS  
Handover-Control (RRM) in ASN-GW. Routing and AAA/Paging in ASN-GW | Able to provide simplified pico-cell  
Able to provide soft handover  
Fewer backhauls for RRM messages | Difficult Interoperability between BS and ASNGW from different vendors  
Heavy workload at ASN-GW  
Fewer vendors |
| Profile B            | Distributed platform  
Combined BS and ASNGW  
BS anchored by standard router  
Inter-BS control over Ethernet | Simple architecture  
Suitable for small-scale deployment | Difficult to customize IP and wireless functions for operators  
Expensive for large scale deployment |
| Profile C            | Distributed platform  
Separate BS and ASNGW  
All RRM functions in BS  
Handover-Control (RRM) in BS  
Routing and AAA/Paging in ASN-GW | Able to provide simplified pico-cell  
Open – multi -vendors can supply BS and ASNGW | Extra backhauls for RRM messages |

**Profile A ( Deprecated)**

**Profile B (No further Development)**

**Profile C (Standards Track)**
WiMAX 802.16 Service Flow

Model Definitions

- Packets are associated with a service flow, which is the central concept of the MAC protocol

- **Service flow** = an unidirectional flow of packets with a particular QoS

- Service flow has parameters like bandwidth, latency, jitter and other QoS-related variables

- When data comes to MAC layer, the convergence sublayer gives it an connection ID (CID)

- The service flow is mapped to this ID {CID, SFID}

- The Service Flow ID is fixed across Base-Stations. Each Base-Station maps a SFID to a new CID.

  - Created on-demand or pre-provisioned
    
    On-demand SF creation subject to authorization against permitted QoS parameters
WiMAX Solution QOS
Architecture using IP-NGN

Consumer and Business Traffic Utilize Per-Subscriber or Per Service QoS Model in Access, Aggregation and Core

<table>
<thead>
<tr>
<th>Traffic Class</th>
<th>Core /Edge/ Aggregation</th>
<th>Access</th>
<th>UNI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Core/MPLS/IP</td>
<td>Ethernet DSL, ETTX</td>
<td>DSL, ATM WiMAX</td>
</tr>
<tr>
<td></td>
<td>PHB MPLS/EXP</td>
<td>802.1P</td>
<td>802.16</td>
</tr>
<tr>
<td>Control Protocols Network Management</td>
<td>AF 48</td>
<td>6 (6)</td>
<td>VBR-nrt nrtPS</td>
</tr>
<tr>
<td>Residential Voice</td>
<td>EF 46</td>
<td>5 5/7</td>
<td>VBR-rt rtPS</td>
</tr>
<tr>
<td>Business Real-time</td>
<td>EF 56</td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Residential TV and VoD</td>
<td>AF 32</td>
<td>4 4/3</td>
<td>VBR-nrt NA</td>
</tr>
<tr>
<td>Residential D-Server Video</td>
<td>AF 24</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Business Critical In Contract</td>
<td>AF 16</td>
<td>2 2/1</td>
<td>VBR-nrt nrtPS</td>
</tr>
<tr>
<td>Business Critical Out of Contract</td>
<td>BE 8</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Residential HSI Business Best Effort</td>
<td>BE 0</td>
<td>0</td>
<td>UBR Best Effort</td>
</tr>
</tbody>
</table>

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### WiMAX QoS & Scheduling Schemes

**Specifications & Applications...**

#### Service Flows:
Mechanism defined in Mobile WiMAX to provide QoS
Uni-directional flow of packets associated with certain defined QoS parameters for traffic

#### Connections:
Unidirectional logical link between BS and CPE
Each connection is associated with a service flow delivering the necessary QoS over the air interface

#### Packet Classifiers:
Each service flow also has packet classifiers associated with it to determine criteria used by the MAC layer to associate packets into service flows

#### Mobile WiMAX scheduling based on QoS service Flows associated with each packet

<table>
<thead>
<tr>
<th>QoS Category</th>
<th>Applications</th>
<th>QoS Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>UGS Unsolicited Grant Service</td>
<td>VoIP</td>
<td>• Maximum Sustained Rate • Maximum</td>
</tr>
<tr>
<td>rtVR Real-Time Variable Rate Service</td>
<td>Streaming Audio or Video</td>
<td>• Minimum Reserved Rate • Maximum Sustained Rate • Maximum</td>
</tr>
<tr>
<td>ErtVR Extended Real-Time Variable Rate Service</td>
<td>Voice with Activity Detection (VoIP)</td>
<td>• Minimum Reserved Rate • Maximum Sustained Rate • Maximum</td>
</tr>
<tr>
<td>nrtVR Non-Real-Time Variable Rate Service</td>
<td>FTP File Transfer Protocol</td>
<td>• Minimum Reserved Rate • Maximum Sustained Rate • Maximum</td>
</tr>
<tr>
<td>BE Best-Effort</td>
<td>Data, Web Browsing, etc.</td>
<td>• Maximum Sustained Rate</td>
</tr>
</tbody>
</table>
WiMAX Solution Security and Authentication

Framework Overview...

- **PKMv2 Framework**
  Mobile WiMax uses the Privacy and Key Management Protocol Version 2 (PKMv2) to manage all security, authentication and encryption schemes over the air interface.
  PKMv2 manages AK security using PKM messaging between BS and CPE.

- **Device and User authentication:**
  User authentication in Mobile WiMAX is done using EAP authentication schemes.
  Navini Mobile WiMAX solution supports EAP-TLS, EAP-TTLS and EAP-AKA etc.
  Device authentication done using X.509 certificates in WiMAX CPE.

- **Traffic Encryption:**
  Traffic encryption using 128 bit AES encryption scheme.
  AES encryption keys derives from EAP authentication and transported over PKMv2 framework.

- **Security context and associations:**
  All security and encryption contexts and associations maintained over mobility events and other network events.
Agenda

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## Cisco Broadband Wireless Solution

### Fixed and Mobile WiMAX using Dot16d and/or Dot16e

<table>
<thead>
<tr>
<th>Fixed WiMAX</th>
<th>Fixed and Mobile WiMAX</th>
</tr>
</thead>
<tbody>
<tr>
<td>802.16-2004 base stations (BS)</td>
<td>802.16e-2005 base station</td>
</tr>
<tr>
<td>Layer 2 Interworking between BS and transport network</td>
<td>Layer 3 interworking between BS and transport network</td>
</tr>
<tr>
<td>Transport based on 802.1q/ad or EoMPLS</td>
<td>Transport based R6 (GRE encapsulation)</td>
</tr>
<tr>
<td>Access Gateway (L2/L3 switch) provides IP address allocation, security</td>
<td>ASN Gateway, authentication, QoS policy, DHCP, security, mobility (tight coupling with BS)</td>
</tr>
<tr>
<td>policies (loose coupling with BS)</td>
<td>Fall 2007/Spring 2008 availability from WiMAX vendors, based on WiMAX forum certification timelines and</td>
</tr>
<tr>
<td>Inteelligent Services and user identification function can be added via</td>
<td>volume quantities for BS and CPE</td>
</tr>
<tr>
<td>ISG</td>
<td></td>
</tr>
<tr>
<td>Immediate availability from WiMAX vendors (CPE and BS)</td>
<td></td>
</tr>
</tbody>
</table>
Solution Architectural Building blocks

Policy / Service Layer

Portal  Subscriber and Service Data base  Authentication And Billing  Broadband Policy Manager  EMS and Provisioning

CPE  ACCESS  AGGR. & EDGE  CORE  SERVICES

Residential  Residential  Business  ISP  Corporate  Voice

Policy Manager  EMS and Provisioning

Broadband Access Core Services

AGGR. & EDGE

BRAS/ISG

P

PE

P

P

ISP BRAS

Corporate

Voice
Aggregation and Edge Network

**Distribution Node**
- 7600
- Multi Access aggregation
- H-QoS
- EoMPLS Aggregation
- H-VPLS Switching
- MPLS PE
- DHCP Relay
- ASN Gateway module (Mobile WiMAX gateway)

**BRAS/ISG**
- 7200/7300/10K
- PPPoE/IPoE model
- Dynamic Subscriber Policy (RADIUS CoA)

**MPLS PE**
- 7600/12K
- MPLS PE
- EoMPLS/VPLS
Cisco Broadband Wireless Solution

*Multi Access Aggregation (including WiMAX)*

- Solution utilizes any IP enabled access strategies (WiMAX, WiFi, ETTx, Cable, DSL others...).
- Solution provides seamless and consistent services across all access types.
- Solution allows for Seamless Migration & Roaming using Cisco Mobile IP architecture.
Cisco ASN Gateway service module

- ASN-GW software will run on a service module in the 7600 Series Router
- Allows the system to rapidly scale by adding more service modules to meet traffic loads
- 7600 offers a variety of chassis configurations for different deployment scenarios
- A very robust and proven approach that has been used to support a variety of different applications in the mobile space
- A smaller “standalone”, 1RU high appliance based ASN-gw based on C7301 is available for Field/Demo trials
Cisco ASNgw Overview

Architecture

- Carrier Class Features
  - ASNgw Clustering using ASNgw-SLB
  - Geographic Load Balancing & Scaling
  - Stateful 1:1 Redundancy
  - Deep Packet Inspection & Accounting
  - Carrier-grade billing support using CSG2 (pre & postpaid)

Software

- Release 1 Features
  - Authentication/Security
  - QoS
  - Mobility (micro)
  - IP address allocation
  - Initial Network Entry of a user
  - Service Flow creation for a user (with only pre-provisioned service flows)
  - De-registration of a MS
  - Support for unpredicted Hard Handoff
  - Support for IP Convergence sublayer (CS) only

Scaling

- Carrier Class Performance
  - 8 Gbps per card using IMIX packet
  - 100K Subscribers, 30% active, 70% idle
  - Unlimited # of sessions per Subscribers
<table>
<thead>
<tr>
<th>RELEASE 1.0</th>
<th>RELEASE 2.0</th>
<th>RELEASE 3.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>EFT: 9 July 07</td>
<td>NC</td>
<td>NC</td>
</tr>
<tr>
<td>FCS: 14 Sep 07</td>
<td>PLAN</td>
<td>RADAR</td>
</tr>
<tr>
<td>EFT: Q3CY08</td>
<td>EFT: Q1CY08</td>
<td>EFT: Q3CY08</td>
</tr>
<tr>
<td>FCS: Q2CY08</td>
<td>FCS: Q2CY08</td>
<td>FCS: Q4CY08</td>
</tr>
</tbody>
</table>

### Profile C → R6 (IP-cs), keepalive
- C/U plane split
- Mobility
  - Micro → Intra – ASNGW H.O
  - Macro → MIPv4 in Cooa
- Authentication / Security (per domain)
  - Unauthenticated / Emergency
  - EAP
  - Security Key Exchange
  - Context Caching
  - Per domain
- Accounting (per domain)
  - Post Paid
  - Per Service Flow
  - Advanced Billing, Pre-Paid, through CSG2
- Address allocation
  - DHCP Relay
  - Option 82 (Remote, Circuit, VPN, Subscriber ID)
  - Multi-Host
  - Overlapping address support

### Static Pre-provisioning (per domain)
- QoS (ToS/DSCP, BE/NRT, RT/ER/UG, CBWFQ) rules
- Classifier rules
- Service flows (up to 4 -- bi-directional--)

### High Availability (7600)
- 1:1 card Intra and Inter chassis
- Stateful redundancy
- Load Balancing

### NAP Sharing
- Connectivity/Domain
- VRF → MLS/VPN
- Tunneling Mechanism
- CSN Connectivity (GRE, MPLS,…) 

### NMS
- MIBS (systems & R6)

Hwr: 76xx /SAM1/SUP720-3BXL 12.2(33),SRBxx
Hwr: 7301 (no SR or SLB support)

### Profile C → R6 (Eth-cs), Stage 3 Mobility
- Macro → CMIPv4/PMIPv4 (as per wimax)
- in-line with HAR4.0

### Enhancement VoIP Ph1
- Call Admission Control / Integration to Softswitch for Voice and Policy
- PHS (Packet Header Suppression)

### Enhancement QoS
- Dynamic QoS
- Rate limiting (Bidirectional bandwidth policing)

### Dynamic Provisioning (Through AAA)

### Push Services
- Idle/Paging/Location

### Service Control / Awareness
- Hot Lining (CoA / PoD)
- PPP regen / L2tp
- per service flow VRF
- Client Network (NAP/NSP) Discovery
- Lawful Intercept
- Line Id (option 82)

### NMS
- MWTM support/ SNMP/ MIBs Enhancements (TBD)

Hwr: SUP32 (7604) / RSP720

### Profile C → R6 (IPv6-CS/16ng ?) Mobility
- Micro → R4
- Macro → CMipv6/ NEtlmn?

### Enhancement VoIP Ph2
- R4
- Low Latency Support / Bi-casting
- Gx+ Diameter

### Address allocation
- AAA based IP address allocation
- Local pool

### Single IP

### Service Control / Awareness
- Broadcast / Multicast Services
- Auto Domain, ISG/SCE
- IPv6: IPv6-to-IPv4
- Prepaid Billing

### NMS
- Provisioning through Network Management
- MWTM Enhancements (TBD)

Hwr: MCP

---

**FCS** = First Customer Ship  
**EFT** = Early Field Trials  
**EC** = Execute Committed  
**CC** = Concept Committed  
**NC** = Not Committed
HA Product - Roadmap

**HA R4.0 (EC)**
- CC: Jan '07
- EC: Feb '07
- EFT: Oct '07
- FCS: Dec '07
- Platform: SAMI, (CC for 7301)

- Hot-lining: Support HSRP-HA, Support for new standard
- CPS rate increase to 900/processor
- CAC (Call Admission Control), Metrics affecting CAC, CLI for max bindings and DFP
- SIP roaming support (LNS)
- QoS: Support MQC feature set including traffic shaping
- **WiMAX**: HA-AAA attribute support for WiMAX
  - Mobile IPv4 Host Configuration Extensions RFC4332
  - Priority metric for local pool
  - MAR Support, assignment of subnet to MAR
  - Framed Pool
  - MIP/LAC

**HA R5.0 (NC)**
- CC: Q4 '07
- EC: Q4 '07
- EFT: Q2 '08
- FCS: Q3 '08
- Platform: SAMI, 7301

- MIPv6
- Additional VRF support
- MIB Enhancements
- Legal Intercept, CALEA
- Subscriber tracking
- Single Interface
- **WiMAX enhancements, support for Cisco ASN-GW R2**
  - GRE Keying
  - Simultaneous LNS and HA on a processor
  - Dynamic Home Agent Assignment

**HA Future (NC)**
- CC: Q3 '08
- EC: Q3 '08
- EFT: Q1 '09
- FCS: Q1 '09
- Platform: SAMI, MCP

- Diameter Policy Interface
- Flow based QoS for Rev A/B
- MBMS
- L3 Geographical Redundancy
- L2TP Redundancy
- MAR Support, Dual Path Application Routing
- MIP Dual Anchor for fast Handoff

---

FCS = First Customer Ship  EFT = Early Field Trials  EC = Execute Committed  CC = Concept Committed  NC = Not Committed
## WiMAX Services

### Residential Services
- Internet Access
- Parental Control
- Residential Voice
- Walled Garden

### Business Services
- Managed Services
- L2 VPN
- L3 VPN (MPLS)
- Internet access and presence
- Backhaul of Hotspots

### Wholesale Services
- Internet Access
- Voice Services

### Consumer Services
- Internet Access
- Voice Services
Agenda

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4Motion: Mobile WiMAX (802.16e) solution

- Fully complies with mobile WiMAX (IEEE 802.16e-2005)
- Employs an open, standard all-IP architecture enabling a Best-of-Breed multi-vendor solution
- Delivery of mobile and fixed video, voice, and data services
- Supports the full range of business, residential, and Personal Broadband services
- FCS expected Q1 2008
PacketMAX architecture: 802.16e-2005 compliant base station offerings:

- **PacketMAX 5000** with WSC-e blade (wireless system controller) can accommodate both fixed and mobile subscribers
- **PacketMAX 4000** supports mobile WiMAX in a single sector “stackable” form factor
- **PacketMAX 3000** is optimized for fixed operation and can coexist in a mobile network
- **PacketMAX 2000** all-outdoor pico base station for mobile WiMAX

PacketMax CPE:

- **PacketMAX 100** series CPE are designed to suit the needs of a small office or home user.
- **PacketMAX 300** series CPE delivers the scalability and performance required by business grade users in an outdoor gateway form factor.
- **PacketMAX 500** series CPE provides a wireless alternative to DSL for indoor consumers.
Redline new RedMax 4C platform aimed at .16e-2005 Mobile Services.

RedMax 4C includes MIMO and will be a Wave-2 Certified product.

Redline demonstrated high per-sector occupancy rates, to enable better ROI for operators.

Redline is in discussion with Intel re: next-generation wave-2 CPE devices.

ASNgw IOT completion expected in August.

FCS expected Jan/2008
Navini Smart WiMAX

- Integrates Beamforming, and MIMO all in one system
- Combines RF adaptations, using both MIMO and Beamforming simultaneously for any subscriber unit
- Selects the most effective MIMO adaptation on per subscriber basis
- Mobile, portable, stationary
- Switches between MIMO type and Beamforming as required on timeslot basis
- FCS Expected for R6.2 in Q1/2008
## Why Navini?

### Best-in-Class Innovation, Experience, Technology

<table>
<thead>
<tr>
<th>Leading WiMAX Portfolio</th>
<th>Strong Value Proposition</th>
</tr>
</thead>
<tbody>
<tr>
<td>- From base stations to modems</td>
<td>- Yields OpEx and CapEx savings requiring up to 50% fewer sites</td>
</tr>
<tr>
<td>- Commercially deployed smart beam-forming technology</td>
<td>- Delivers higher peak data-rates and throughput – indoor and out</td>
</tr>
<tr>
<td>- Mobile WiMAX 802.16e-2005 compliant</td>
<td>- 75 customers in 50 countries on 6 continents</td>
</tr>
</tbody>
</table>

### Unmatched Innovation

- Advanced WiMAX RF capabilities
- Pioneering Smart Beam-Forming with MIMO; 13 patents, 49 more pending

### Cisco Fit

- Shared IP-centric vision on mass market wireless broadband
- Geographically co-located (Richardson and Bangalore)
- Experienced people innovative culture
Navini Technical Leadership
The Only Commercially Deployed Smart Beam-Forming

Non Beam-Forming

- Inefficient Spectral Use
- Less Coverage
- Energy Dispersed in All Directions

Smart Beam-Forming + MIMO

- Efficient Spectral Use
- Long Range
- Energy Directed to the Intended User

Pioneering the Combination of Smart Beam-Forming with MIMO:
- Requires up to 50% fewer sites than competition
- Yields up to 50% savings in both OpEx and CapEx
- Enables the use of low powered consumer broadband devices (up to 4 times power reduction)
- Two to three times the network capacity
- Higher signal strength to both stationary and mobile users
- Enhanced indoor coverage / performance
- Improved roaming capabilities; fewer dropped signals
Navini’s Leading WiMAX Performance

**AAS: BeamForming + MIMO**

Simulation based on:
- 21 Sector network
- 200 Users per sector
- 5 MHz OFDMA carrier
- N=3 Reuse

- 2:1 DL/UL Ratio
- 20kbps Min. at cell edge
- 2.5 GHz TDD
- 3GPP Mobility (SCM)

87% More than MIMO Alone

<table>
<thead>
<tr>
<th>Mb/s</th>
<th>SISO</th>
<th>MIMO Only</th>
<th>Beamforming</th>
<th>BF+MIMO</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2</td>
<td>4</td>
<td>8</td>
<td>10</td>
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<tr>
<td>10</td>
<td>7</td>
<td>14</td>
<td>26</td>
<td>28</td>
</tr>
</tbody>
</table>
Mobile-WiMAX compliant based on IEEE 802.16e Mobile standard

All outdoor installation - easy to install on walls, poles, power lines and cabinets

Support of worldwide WiMAX deployments in the 1.X, 2.X and 3.X GHz bands

Low cost of ownership - An ideal solution for entry-level deployment with a pay-as-you-grow build-out for rapid penetration into new market segments with minimal CAPEX

Optimize link performance in NLOS conditions through STC/MRC and MIMO (2x2) radio technologies

FCS expected Dec/2007 with Cisco ASN-gw R1.0
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Q & A