Mobile WiMax
Overview and Architecture

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WiMAX

Worldwide Interoperability For Microwave Access
Agenda

- WiMAX Introduction
- WiMAX Forum Update
- Radio Interface
- Core Architecture
- Cisco WiMax Products
- Q & A
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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.
WiMax Standards

- IEEE 802.16 – specifies radio aspects of WiMax
  - 802.16-2004 (known as 802.16d) – Fixed WiMax
  - 802.16e-2005 – Mobile WiMax
  - 802.16m – next generation of WiMax

- WiMax Forum – specifies subsets of 802.16 functionality for certification and the network architecture
  - WiMax System Profile Release 1
  - WiMax Forum Network Architecture Release 1
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
The Real Opportunity
*Country Transformation and ‘Digital Inclusion’*

Broadband Wireless Solutions Enable ‘Digital Inclusion’

Emerging Markets

GDP Growth +5%

Source: EIU, Telegeography, Point Topic, Cisco Analysis
## Cisco IP Next Generation Networks

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

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<td>WiFi</td>
<td>Wireless Mesh</td>
<td>CDMA</td>
<td>UMTS / HSPA</td>
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</table>

- **Persistent Roaming Across Wireless Access Networks**
- **Subscriber-Differentiated IP Service Delivery**

**Cisco IP Next Generation Networks**

- **Corporate VPNs**
- **Internet**
- **Roaming Exchanges**
- **Application Partners**
- **IP Media Partners**
- **Signaling Networks**

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# 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
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 Introduction
- **WiMAX Forum Update**
- Radio Interface
- Core Architecture
- Cisco WiMax Products
- Q & A
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
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 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 to allow interoperability and certification of Mobile Stations, Subscriber Stations and Base Stations conforming to the IEEE 802.16 standards.
WiMAX Intellectual Property Rights

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

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

1550 patents are distributed among 330 companies

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

Source: Schwegman, Lundberg, Woessner & Kluth
Oct 2006
# Mobile Certification in 2008

## 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 Wimax Roadmap

Mobile WiMAX Rel 1.0 (802.16e)

30mbs @ 30MPH

Mobile WiMAX Rel 1.5 (802.16e)

100mbs @ 70MPH

Mobile WiMAX Rel 2.0 (802.16m)

100mbs @ 300MPH

2007 2008 2009 2010
Mobile WiMAX Technology Evolution Vision

A fully backward compatible evolution on standards and products

Projections subject to change
Agenda

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- Core Architecture
- Cisco WiMax Products
- Q & A
Multiple Access Technologies

- FDMA
- TDMA
- CDMA
- OFDM
- OFDMA
### 802.16 vs. 802.16-2004 and 802.16e-2005 Features

<table>
<thead>
<tr>
<th></th>
<th>802.16</th>
<th>802.16-2004</th>
<th>802.16e-2005</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Date completed</strong></td>
<td>December 2001</td>
<td>June 2004</td>
<td>December 2005</td>
</tr>
<tr>
<td><strong>Spectrum</strong></td>
<td>10-66 GHz</td>
<td>&lt; 11 GHz</td>
<td>&lt; 6 GHz</td>
</tr>
<tr>
<td><strong>Channel Conditions</strong></td>
<td>LOS only</td>
<td>NLOS</td>
<td>NLOS</td>
</tr>
<tr>
<td><strong>Bit Rate</strong></td>
<td>32-134 Mbps in 28 MHz channel bandwidth</td>
<td>Up to 75 Mbps in 20 MHz channel bandwidth</td>
<td>Up to 15 Mbps in 5 MHz channel bandwidth</td>
</tr>
<tr>
<td><strong>Air Interface</strong></td>
<td>TDMA with TDD and FDD</td>
<td>OFDM &amp; OFDMA with TDD &amp; FDD</td>
<td>Scalable OFDAMA with TDD &amp; FDD</td>
</tr>
<tr>
<td><strong>Mobility</strong></td>
<td>Fixed</td>
<td>Fixed, portable</td>
<td>Nomadic portability, Full mobility</td>
</tr>
<tr>
<td><strong>Channel Bandwidths</strong></td>
<td>20, 25, 28 MHz</td>
<td>Scalable 1.5 to 20 MHz</td>
<td>Scalable 1.5 to 20 MHz</td>
</tr>
<tr>
<td><strong>Typical Cell Radius</strong></td>
<td>2-5 km</td>
<td>7-10 km</td>
<td>2-5 km</td>
</tr>
</tbody>
</table>

*Source: WiMAX Forum as of December, 2007*
Scalable-OFDMA

- Why go *scalable*?
  
  Various bandwidth sizes are required to meet numerous worldwide needs

- What does it mean to be scalable?
  
  # of sub-carriers available is dependent on the bandwidth size

- 802.16e-2005 standard specifies bandwidths ranging from 1.25 MHz to 20 MHz

- WiMAX Forum supports:
  
  3.5 MHz with 512 FFT
  5 MHz with 512 FFT
  7, 8.75, or 10 MHz with 1024 FFT
The **Sampling Rate** is a basic concept in WiMAX. For the bandwidths that are multiple of 1.25 MHz (that is, 1.25, 5, 10, and 20 MHz) it is defined as $28/25$ of the bandwidth, but for other bandwidth a different fraction is used. In the case of 5 MHz, the Sampling Rate is $28/25 \times 5 \text{ MHz} = 5.6 \text{ MHz}$.

The **Symbol Period PS** is a basic time unit defined as $4 \times$ the inverse of the Sampling Rate: $4/5.6 \text{ MHz} = 0.7143 \mu\text{s}$. Base on the PS, the following time intervals are defined:

- **OFDM Symbol** (or just “Symbol”, for short) = $144 \times \text{PS} = 102.86 \mu\text{s}$
- **Useful Time Tu** of a symbol = $8/9$ of the Symbol duration = $(8/9) \times 102.86 \mu\text{s} = 91.43 \mu\text{s}$
- **Transmit-to-Receive Gap (TTG)** = $148 \times \text{PS} = 0.105 \text{ ms}$
- **Receive-to-Transmit GAP (RTG)** = $84 \times \text{PS} = 0.060 \text{ ms}$
- **Frame** = $47 \times \text{Symbol} + 1 \times \text{TTG} + 1 \times \text{RTG} = 5.0 \text{ ms}$

The 47 symbols in a frame are subdivided into **DL Sub-frame** (with 35 to 26 symbols) and **UL Sub-frame** (with the reminding 12 to 21 symbols). The number of symbols in each sub-frame is configurable. Navini uses the combination of 32 symbols in the DL and 15 in the UL.

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**Diagram:**

- **DL SUBFRAME**
  - 32 symbols
  - (3.292 ms)
- **TTG**
  - (0.105 ms)
- **UL SUBFRAME**
  - 15 symbols
  - (1.543 ms)
- **RTG**
  - (0.060 ms)

**One Frame (5.000 ms)**
WiMAX – Frequency Dimension

- **Tone** (a.k.a. “sub-carrier”): a sinusoidal voltage, which is modulated with coded information and then converted to RF. This RF is radiated by the transmitting antenna and carries the information to the receiving antenna at the speed of light.
  - There are 512 tones in 5 MHz of bandwidth.

- **Tone Separation**: $1 / \text{Useful Symbol Time} = 1 / Tu = 1 / 91.43 = 10.94 \text{ kHz}$

- **Types of tones**:
  - **Active Tones**
    - **Data tones** – for data transmission
    - **Pilot tones** – continuous signal for channel tracking and synchronization
  - **Null tones** – not used for transmission
  - **Guard bands**
  - **DC carriers**

- **Sub-Channel**: a group of **active** tones

- **Permutation**: a scheme for grouping active tones into sub-channels
  - Some of the tones in a sub-channel are pilot tones, others are data tones.
  - Which tones are used for data and which for pilot may change from one symbol to the next and depends on the permutation scheme.
  - The tones making up a sub-channel may or may not be adjacent.
Mobile WiMAX TDD Frame Structure
PUSC, FUSC, and AMC

**Allocation Schemes**

**AMC**
- DL & UL
- Used with data bursts
- Supports adaptive coding & modulation
- Provides better protection against fading and interference for poor quality sub-carriers & better throughput for good quality sub-carriers
- In 5 MHz system, has 24 sub-channels in both the DL and UL

**PUSC**
- Default DL & UL method
- Reduces interference
- Provides robustness
- Used to send critical info such as preambles, allocation messages, & BS parameters
- In 5 MHz system, has 15 sub-channels in the DL and 17 sub-channels in the UL

**FUSC**
- Optional for DL only
- Maximizes throughput
- All usable sub-carriers used across all cells
- Power control is critical
- Supports real-time and non real-time traffic
- In 5 MHz system, has 8 sub-channels in the DL

**Permutation Types**

- **Distributed**
- **Contiguous**
Randomization – about 50% of the original bits change (1→0 and 0→1), the rest do not. The result is a stream with about the same number of 1’s as of 0’s.

Forward Error Correction – redundancy is added to make possible a certain degree of error detection and correction at the receiving end.

- Reed Solomon – not supported at this time
- Convolutional Coding – characterized by the “constraint length” and the “rate”

Interleaving – the coded bits are rearranged in a predefined way so that the bits that were produced together are not transmitted together.

- Helps fight noise bursts

The randomized, coded and interleaved bits are mapped into the desired modulation scheme and the data tones are modulated and then radiated.
QPSK and 16QAM

QPSK

4 possible states
(each state = 2 bits)

00, 01, 10, 11

16QAM

16 possible states
(each state = 4 bits)

0000, 0001, 0010, 0011, 0100, 0101, 0110, 0111,
1000, 1001, 1010, 1011, 1100, 1101, 1110, 1111

Each state is defined either by the distance from the center (amplitude) and the angle (phase) OR by the horizontal (I) and vertical distance (Q) from the center.
Adaptive Modulation

- **QPSK** (QPSK)
- **QAM4** (QPSK)
- **QAM8** (QPSK)
- **QAM16**
- **QAM64**

More attenuation of the signal

Less attenuation of the signal
Beamforming Basics

Makes Zero-install, plug-n-play, mobile, personal BB a reality
- Downlink performance improved by 18dB ($20\log(N)$) – more capacity & building penetration
- Uplink performance improved by 9dB ($10\log(N)$) – larger cell sizes
- Additional capacity and better frequency reuse due to reduced interference
- Uplink gain permits reduced radiated power by subscriber devices – size, cost & battery life

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

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

Non Beam-Forming

Smart Beam-Forming + MIMO
Cisco Beamforming

Not all Beamforming approaches are equal…

Switched Lobe Smart Antenna (Vendor X)
Cheap, but inflexible. Uses multiple small, immobile “sub sectors”. Base Station selects which sub sector to use based on strongest signal received. Suffers from limited gain.

Dynamically Phased Array/Beam Steering (Vendor Y)
Uses multiple small, immobile “sub sectors”. Base Station selects which sub sector to use based angle of arrival, and steers beam. Suffers from multipath interference.

Adaptive Antenna Array - Cisco
Best performance. System measures angle, phase and strength of arrival from uplink sounding. Uses results to send downlink using all available multipaths to add constructively at the source.
The DSP engine applies complex algorithms on the I & Q portions of the signals such that they would add more “constructively” with the resultant U/L output signal being 9 dBs larger than a non-BF system.

Similarly on the D/L in combination of the DSP engine & 8 PAs, the 8-signals coming from 8 different antennas add constructively within a couple of meters from the CPE resulting in a signal that is 18 dB larger than the CPE would have seen had the BTS had only 1 antenna.
Multiple Input/Multiple Output (MIMO)

- MIMO systems employ multiple antennas at both Base Station and SS device

- Two types of Simple MIMO

- In Wave 2, WiMAX certified SS devices must be able to support both types of MIMO

"Twice" + "as fast" = “Twice as fast”

“da s nt“ + “d ta se ” = “data sent”
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- WiMAX Introduction
- WiMAX Forum Update
- Radio Interface
- Core Architecture
- Cisco WiMax Products
- Q & A
WiMAX End to End Network Reference Model

- **R1**: 802.16e (MSS-ASN)
- **R2**: MSS – CSN
- **R3**: ASN GW – HA
- **R4**: Inter-ASN
- **R5**: CSN-CSN
- **R6**: BS - ASNGW
- **R8**: Inter BS

### 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

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ASN Profile A - removed from Standards

Separate ASNG, BS and Split RRM

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

CPE

ASP

MPLS CORE

NSP SERVICES

Residential

Business

ISP

Internet

Corporate

Voice

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

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ASN Profile C - approved and current development

Separate ASNG, BS and RRM in BS
# Profile Comparison

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<th>ASN Profile</th>
<th>Description</th>
<th>Pro</th>
<th>Con</th>
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<tr>
<td>Profile A (Deprecated)</td>
<td>Centralized platform&lt;br&gt;Separate BS and ASNGW&lt;br&gt;Split RRM: RRA at BS and RRC at ASNGW&lt;br&gt;PHY and partly MAC in BTS&lt;br&gt;Handover-Control (RRM) in ASNGW. Routing and AAA/Paging in ASNGW</td>
<td>Able to provide simplified pico-cell&lt;br&gt;Able to provide soft handover&lt;br&gt;Fewer backhauls for RRM messages</td>
<td>Difficult Interoperability between BS and ASNGW from different vendors&lt;br&gt;Heavy workload at ASNGW&lt;br&gt;Fewer vendors</td>
</tr>
<tr>
<td>Profile B (No further Development)</td>
<td>Distributed platform&lt;br&gt;Combined BS and ASNGW&lt;br&gt;BS anchored by standard router&lt;br&gt;Inter-BS control over Ethernet</td>
<td>Simple architecture&lt;br&gt;Suitable for small-scale deployment</td>
<td>Difficult to customize IP and wireless functions for operators&lt;br&gt;Expensive for large scale deployment</td>
</tr>
<tr>
<td>Profile C (Standards Track)</td>
<td>Distributed platform&lt;br&gt;Separate BS and ASNGW&lt;br&gt;All RRM functions in BS&lt;br&gt;Handover-Control (RRM) in BS&lt;br&gt;Routing and AAA/Paging in ASNGW</td>
<td>Able to provide simplified pico-cell&lt;br&gt;Open – multi -vendors can supply BS and ASNGW</td>
<td>Extra backhauls for RRM messages</td>
</tr>
</tbody>
</table>
“Mobile” Context & Industry Timing

- **Fixed wireless** – assumes an externally mounted antenna or a modem in the home and AC power
- **Nomadic** -- Very much the WiFi experience of carrying your laptop around and logging-in again every time you move
- **Portable** – Pedestrian speed mobility (<5 mph)
- **Simple mobility** – Lower speeds (<60 mph) and slower handoffs (>1 sec)
- **Full mobility** – High speed
Migration – Fixed

- Fixed addresses,
- No mobility
- Access could be all layer 2
Migration – Fixed/Nomadic

- Add DHCP and AAA, for ability of end user to move and reconnect
- Access could be all layer 2 or IP
Migration – Mobility (2008)

- Adds MIP
- Basic R6
- Radio Independence
  - Functionality at BS only
  - no RRM for fast mobility
Migration – Full Mobility (2009)

- Adds WiMAX Forum standard interfaces
  - R4 for Inter FA handoff
  - R6 for micro mobility
  - Rx for RRM interface
- Radio Independent Functionality
- Policy support
- Dynamic service flow creation
- Multicast
- VoIP
WiMAX Convergence Sub-layers
*Optimized for Service Delivery*

- **IP-CS (Simple IP)**
  - Stationary/Nomadic/Portable usage model
  - R6 Bearer path terminates at the ASNGW for policy enforcement
  - Dynamic SF to meet application SLA
  - Intra-ASN Mobility

- **IP-CS (PMIP)**
  - Mobile usage model
  - Bearer path terminates at the HA for policy enforcement
  - Inter-ASN Mobility

- **Ethernet-CS**
  - Stationary/Nomadic/Portable usage model
  - Centralized control plane via ASNGW
  - Bearer path terminates at BS (decoupled from R6)
  - Interworking with Carrier Ethernet for Ethernet Services
WiMAX IP-CS
(Simple IP)

- R6 User-Plane based on GRE between BS and ASN GW
- R6 Control Plane handles Authentication, SF Assignment, etc
- SF Session per user uniquely identified through GRE-Key
- GRE to VRF at ASN GW for service separation
- Targets Residential and Nomadic model plus managed Voice
WiMAX IP-CS (PMIP)

- R6 Control Plane handles Authentication, SF Assignment, etc
- SF Session per user uniquely identified through GRE-Key
- PMIP Client and FA embedded in ASN GW
- HA is the Local Mobility Anchor (LMA)
**WiMAX Ethernet-CS**

*Control Plane de-coupling (Future..)*

- Decouples the Bearer Path from R6 (local breakout at BS)
- R6 Control Plane handles Authentication, SF Assignment, etc
- Service Interworking with Carrier Ethernet
- Enables Integration with DSL TR-101 (V-Interface)
- Avoids turning the ASN GW into L2 bridge
- Targets business and wholesale model
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 QoS & Scheduling Schemes
Specifications & Applications...

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

- **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**
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>MPLS/IP</td>
<td>Ethernet</td>
<td>DSL, ETTX</td>
</tr>
<tr>
<td>PHB</td>
<td>DSCP</td>
<td>MPLS EXP</td>
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<td>Business Real-time</td>
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<td>Business Critical In Contract</td>
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<td>Business Critical Out of Contract</td>
<td>AF</td>
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<tr>
<td>Residential HSI</td>
<td>BE</td>
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</table>
Cisco WiMAX Solution
ASN-gw QoS Models

- **Pre-Provisioned Service Flow:**
  
  Profile Downloaded from AAA at registration may indicate number of pre-provisioned service flows, and/or default behaviour (e.g: default service flow)

  A service flow request initiated by the MS or BS is evaluated against the provisioned information, and the service flow is created if permissible

- **Dynamic Service Flow:**

  Triggered by the network with Application Function Interaction
  – External Application Function

  MS initiated based on classification policy
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

- WiMAX Introduction
- WiMAX Forum Update
- Radio Interface
- Core Architecture
- **Cisco WiMax Products**
- Q & A
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

A smaller “standalone”, 1RU high appliance based ASNgw based on C7301 is available for Field/Demo trials.
What is Cisco Acquiring?

*Advanced WiMAX Broadband Wireless BTS & CPE*

Navini provides Cisco with a full-range, industry-leading portfolio of IEEE 802.16e-2005 compliant products and technologies.

<table>
<thead>
<tr>
<th>RipWave® MX BTS MX</th>
</tr>
</thead>
<tbody>
<tr>
<td>▪ Software upgradeable for WiMAX 802.16e-2005 Wave 2 certification</td>
</tr>
<tr>
<td>▪ Unmatched radio link budgets</td>
</tr>
<tr>
<td>▪ First to support WiMAX Advanced Antenna Systems (AAS) for Beam-Forming</td>
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<table>
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<tr>
<th>RipWave® MX Antenna Systems</th>
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<tbody>
<tr>
<td>▪ Multi-antenna configuration for beam-forming and MIMO</td>
</tr>
<tr>
<td>▪ Omni-directional and sector configurations</td>
</tr>
<tr>
<td>▪ Market-leading gain, reliability and availability</td>
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<table>
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<tr>
<th>RipWave® MX Customer Premise Equipment</th>
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<tbody>
<tr>
<td>▪ Zero-install, plug-and-play portable/mobile operation</td>
</tr>
<tr>
<td>▪ Sleek, appealing retail-friendly design</td>
</tr>
<tr>
<td>▪ Over-the-air activation</td>
</tr>
</tbody>
</table>
Carrier Ethernet Aggregation System
The SEF Building Blocks

- Policy Server
- NASS/AAA
- VoIP/IMS
- IPTV/VOD server
- Other
- Access Aggregation (ASNGw)
- Service Control (SCE, CSG)
- Border Control (SBC, FW)
- Core Internet
- Internet
- Core

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Agenda

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