



# Cisco Broadband Wireless



## WiMAX Overview

**February 23<sup>rd</sup>, 2009**

**WiMAX**

**=**

**Worldwide interoperability Microwave Access**

# IEEE & WiMAX Forum

IEEE 802.16e

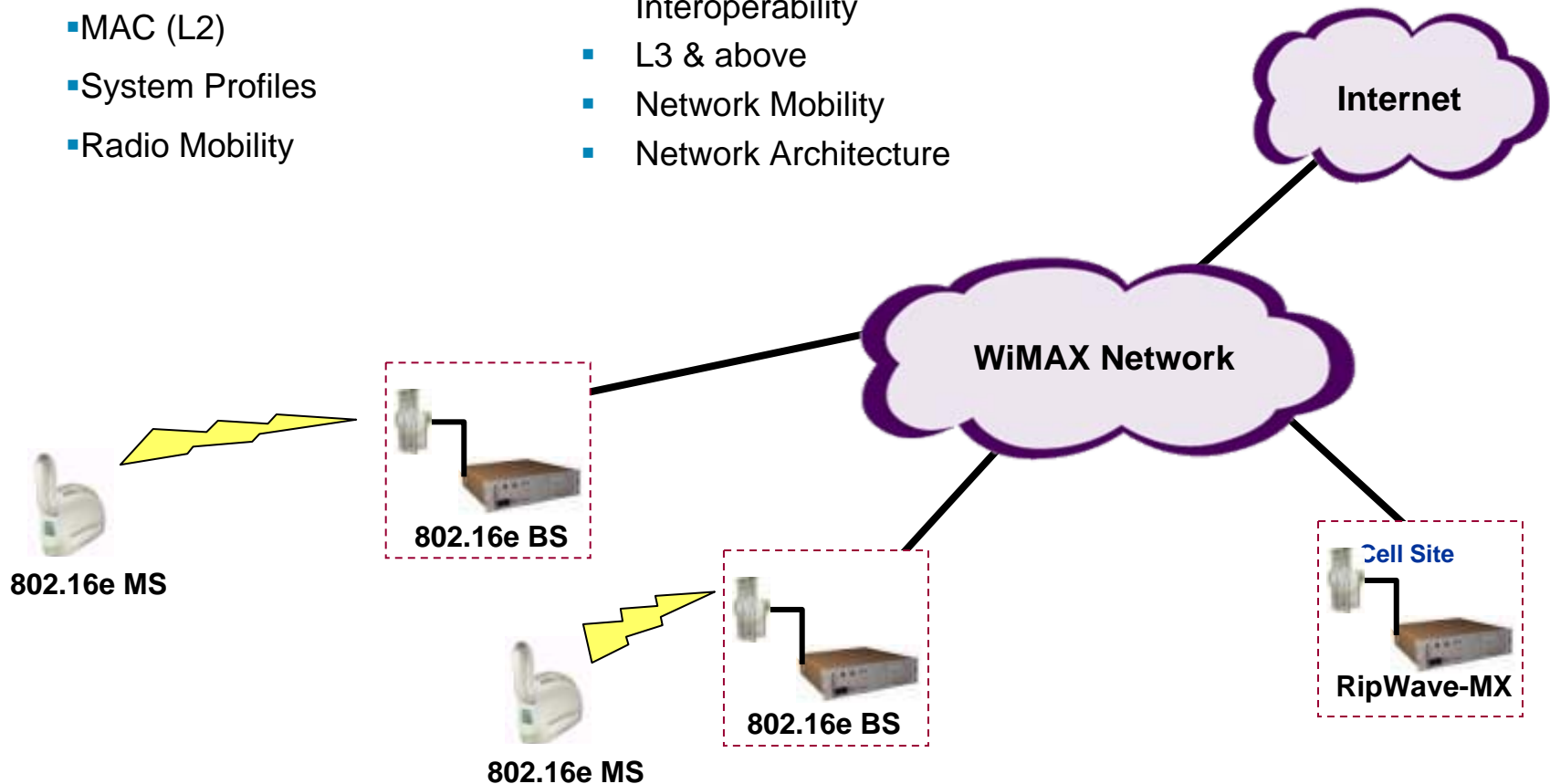
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WiMAX Forum

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E2E Interop

- Air Interface
  - PHY (L1)
  - MAC (L2)
  - System Profiles
  - Radio Mobility
- Network Architecture
  - Certification & Interoperability
  - L3 & above
  - Network Mobility
  - Network Architecture



# 802.16 vs. 802.16-2004 and 802.16e-2005 Features

	802.16a	802.16d-2004	802.16e-2005
<b>Date completed</b>	December 2001	<b>June 2004</b>	<b>December 2005</b>
<b>Spectrum</b>	10-66 GHz	<b>&lt; 11 GHz</b>	<b>&lt; 6 GHz</b>
<b>Channel Conditions</b>	LOS only	<b>Near LOS</b>	<b>None LOS</b>
<b>Bit Rate</b>	32-134 Mbps in 28 MHz channel bandwidth	<b>Up to 75 Mbps in 20 MHz channel bandwidth</b>	<b>Up to 15 Mbps in 5 MHz channel bandwidth</b>
<b>Air Interface</b>	TDMA with TDD and FDD	<b>OFDM &amp; OFDMA with TDD &amp; FDD</b>	<b>Scalable OFDMA with TDD &amp; FDD</b>
<b>Mobility</b>	Fixed	<b>Fixed, portable</b>	<b>Nomadic portability, Full mobility</b>
<b>Channel Bandwidths</b>	20, 25, 28 MHz	<b>Scalable 1.5 to 20 MHz</b>	<b>Scalable 1.5 to 20 MHz</b>
<b>Typical Cell Radius</b>	2-5 km	<b>7-10 km</b>	<b>2-5 km</b>

**Source:** WiMAX Forum as of December, 2007

# Where does WiMAX fit?

**WAN**

**MAN**

**LAN**

**PAN**

**3G**

WCDMA  
GPRS  
EDGE  
HSDPA

**WiMAX**  
**802.16e**

**Wi-Fi**  
802.11

**UWB  
&  
Bluetooth**

N-WAN	B-WAN	LAN	PAN	
Cellular, 3G	802.16e	802.11a,b,g HiperLAN2	Bluetooth	Standards
10-384 Kbps	2-10 Mbps	2-54 Mbps	< 1 Mbps	Speed
Long	Medium-Long	Medium	Short	Range
PDA Mobile Phones	BB WAN in Metro area	Enterprise Networks	Peer-2-Peer Device-2-Device	Applications

# Mobile WiMAX System Profiles



- Created by WiMAX Forum as guideline for Mobile WiMAX SS and BS conformance testing
- Comprised of subset of features from 802.16e standard
- 4 system profiles
  - PHY Profile
  - MAC Profile
  - Radio Profile
  - Power Class Profile
- Profiles contain
  - Mandatory features
  - Optional features
    - MIMO and Beamforming
  - Performance requirements
- Guarantees Mobile WiMAX SSs and BSs configuration is built on a common baseline of functionality

# Mobile WiMAX Roadmap



Mobile WiMAX Rel 1.0  
(802.16e)

Mobile WiMAX Rel 1.5  
(802.16e)

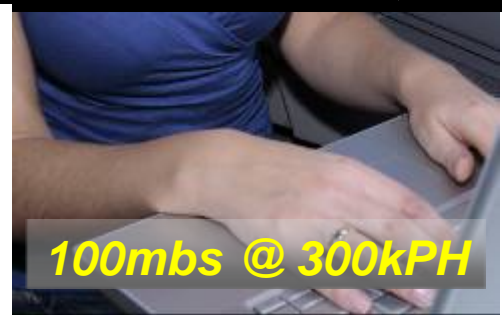
Mobile WiMAX Rel 2.0  
(802.16m)



**30mbps @ 30MPH**



**100mbps @ 70MPH**



**100mbps @ 300kPH**

2007

2009

2010

# Mobile WiMAX

## WiMAX Forum Services Evolution

	Incremental		
Use models	Fixed / Nomadic / Portable	Mobile	Mobile Multimedia
Consumer Services	Internet Voice (fixed line) Wholesale	Voice roaming/HO Location management	Multi Media* (MCBS)
SMB Services	Internet L3 VPN Managed Services	Managed Voice L2 VPN Mobile VPN	Telemetry Unified Mobile Communicator Services*
Key Applications	Web browsing Portals E-commerce	Voice/data mobility E911 Social Networks Collaboration	Visual Networking* Video surveillance Visual Voicemail* Single number reach



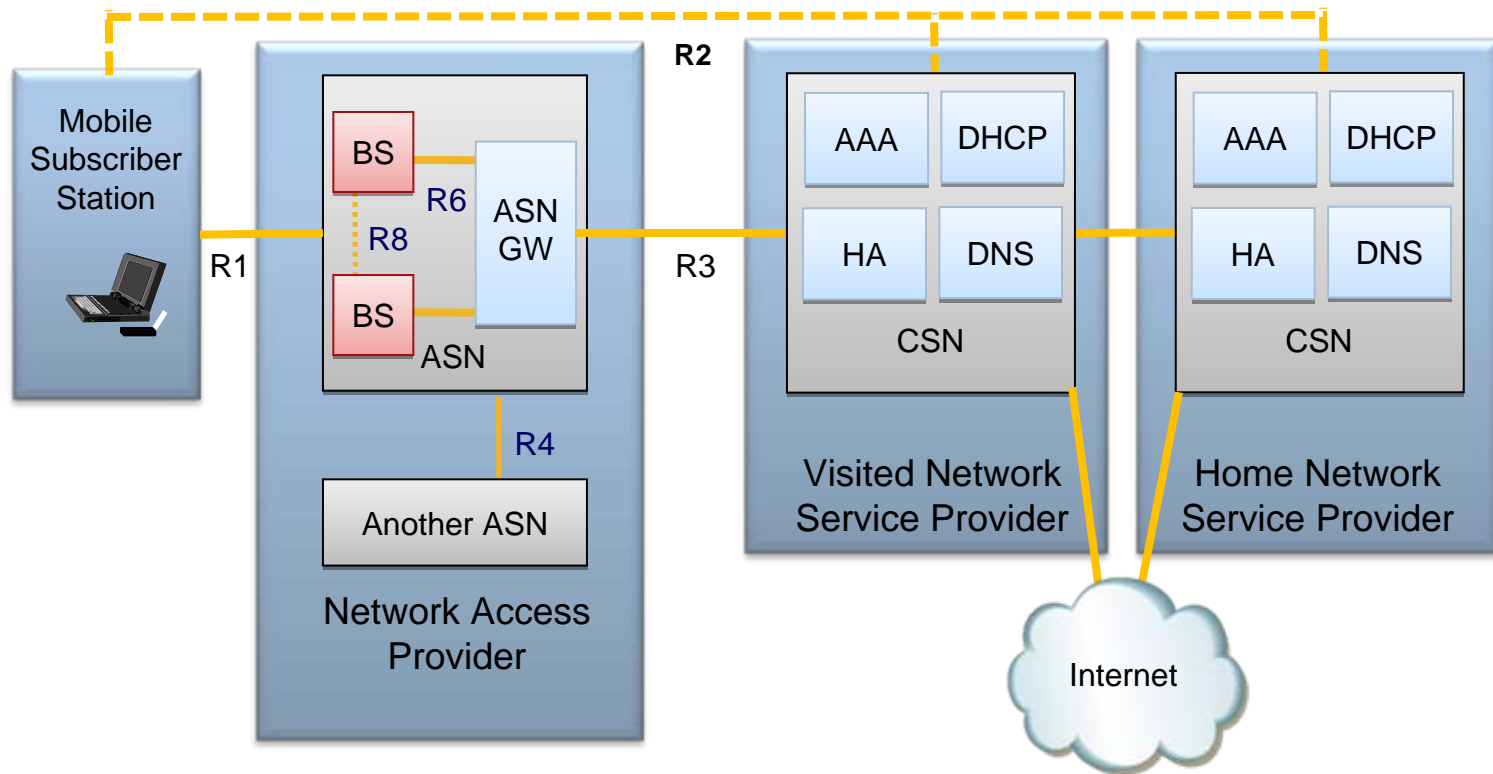
# WiMAX QoS schemes

	<b>Unsolicited Grant Service (UGS)</b>	<b>Real-Time Variable Rate (RT-VR) Service aka rtPS</b>	<b>Extended Real-Time Variable Rate (ERT-VR) Service aka nrtPS</b>	<b>Non-Real-Time Variable Rate (NRT-VR) Service aka nrtPS</b>	<b>Best Effort (BE)</b>
<b>Description</b>	For Constant Bit Rate (CBR) & delay-dependent applications	For Variable Rate with delay dependent applications	For Variable Rate with delay dependent applications	Variable Rate non-real time	Best Effort
<b>Bandwidth Allocation</b>	Fixed bandwidth allocation at fixed intervals	Periodic bandwidth request opportunities to get uplink transmission. <u>No contention-based bandwidth requests</u>	Variable bandwidth allocations at fixed intervals. Application may request additional bandwidth	Timely bandwidth request opportunities. <u>Additional contention-based bandwidth requests</u>	Bandwidth request opportunities when possible. Additional contention-based requests
<b>Example</b>	VoIP without silence suppression	Streaming	VoIP with silence suppression	FTP, web	Background e-mail retrieval

\*Standard Sections: 6.3.20 and 11.13

# Mobile WiMAX

## Network Reference Model



### ACCESS SERVICES NETWORK (ASN)

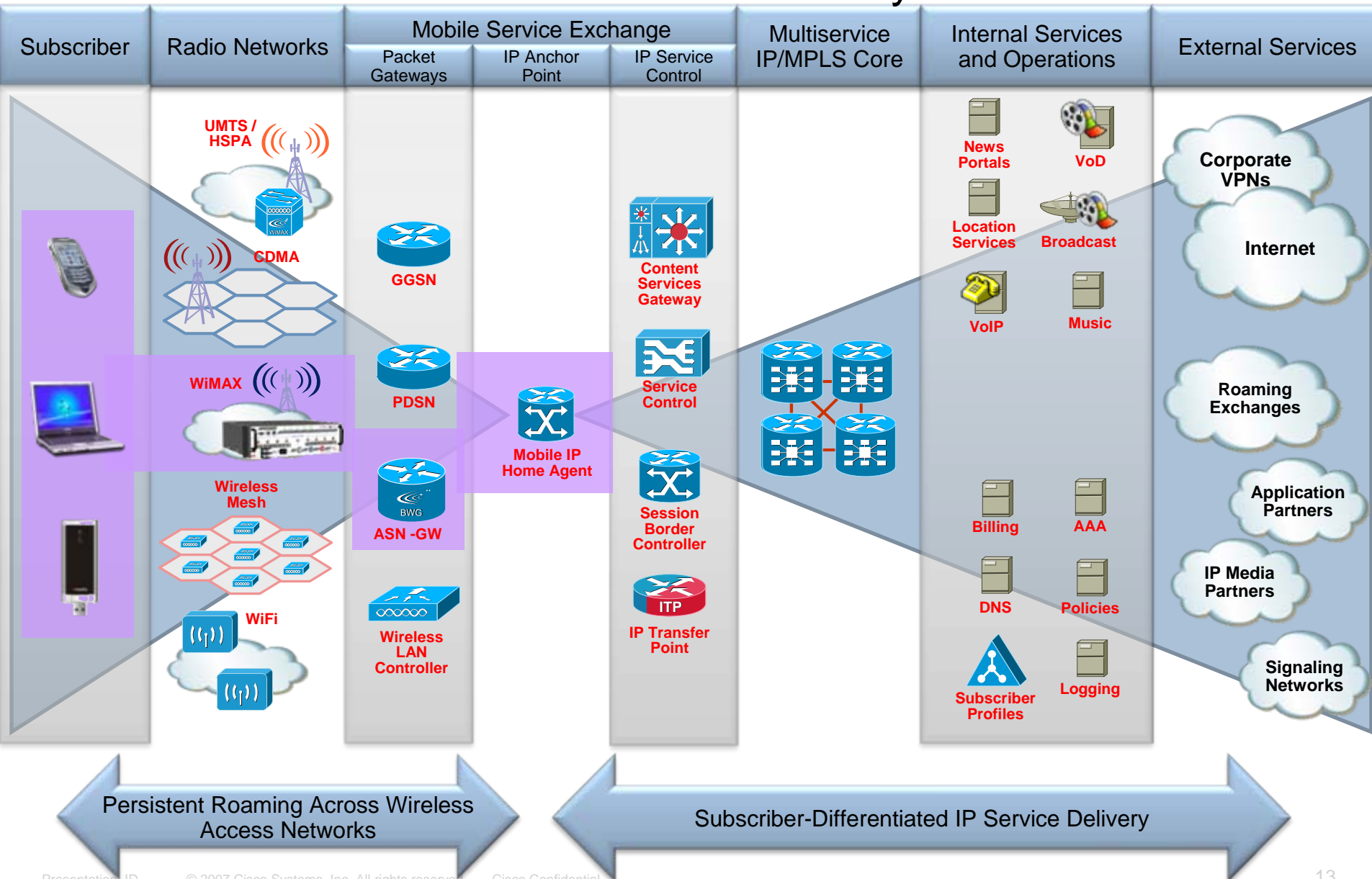
- Access gateway (ASN GW) anchors the subscribers IP/Ethernet session and supports mobility management (Paging, AAA, Foreign Agent), policy enforcement (QoS, Service Flow Authorization, Charging), and addressing (e.g. SLAAC, DHCP)
- Base station (BS) provides radio link and connectivity /handoff within and between ASNs, controls allocation of ASN resources (Channels, Sub-Carriers, Time-Slots), admission control, and per user service flow management (SFA)/BW allocation

### CONNECTIVITY SERVICES NETWORK (CSN)

- Provides Authentication, Accounting, Addressing, Name Management, links to OSS/BSS systems, and Mobile-IP Services (HA)
- MIP-HA provides Inter-ASN Addressing and Handoff, Inter-CSN Roaming

# Cisco IP Next Generation Network

## IP Forms the Foundation for True Mobility for WiMAX



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# Cisco Surfer 3000 Modem Family



WiMAX certifiable devices  
(Wave 2 compliant)

- Frequency Band
  - a. 2300-2390 MHz
  - b. 2496-2690 MHz
  - c. 3400-3600 MHz
- 4 different Devices
  - a. Desktop w/RJ11
  - b. Desktop
  - c. USB Modem
  - d. Outdoor Modem
- 5 and 10MHz channel sizes
- Full suite of devices for personal, residential and enterprise solutions

# Cisco Broadband Wireless Access

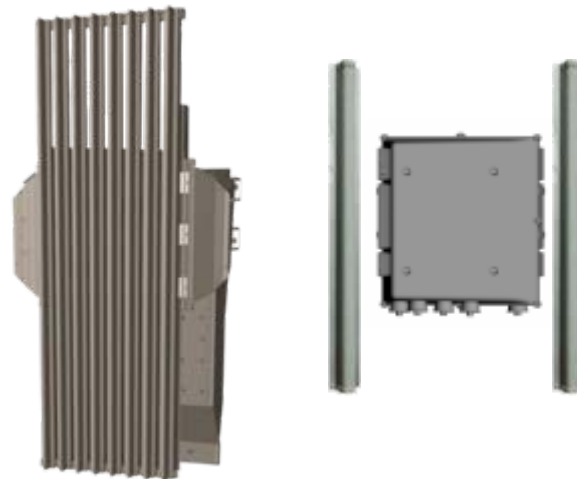
## Mobile WiMAX Networking

### The **Cisco BWX** Broadband Wireless Access Solution



#### **BWX 8305 / 2305 Mobile WiMAX Basestations**

- WiMAX 802.16e-2005 certifiable
- Industry-leading RF Link-Budget
- First Mobile WiMAX with Adaptive Beamforming; Advanced Antenna Systems (AAS)
- Combines Beamforming+MIMO for capacity & class-leading performance



#### **BWX 8305 / 2305 Mobile WiMAX Antennas**

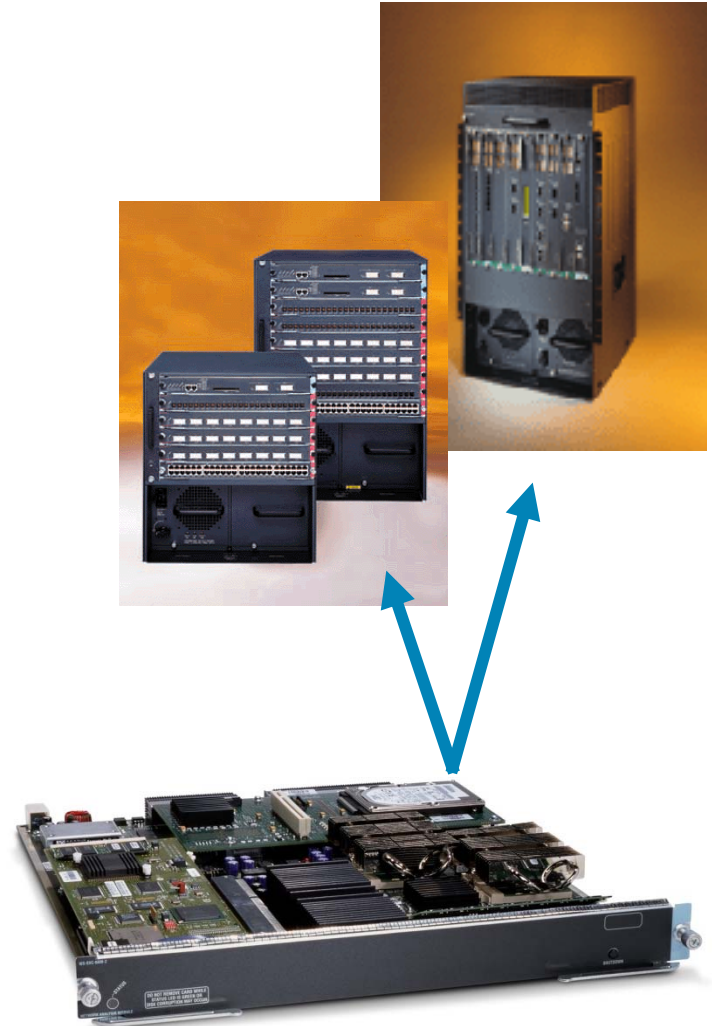
- BWX 8305 8-element array provides 120° sector coverage with Beamforming & MIMO
- BWX 2305 2-element antenna provides in-fill coverage with MIMO & diversity



# Cisco Broadband Wireless Gateway

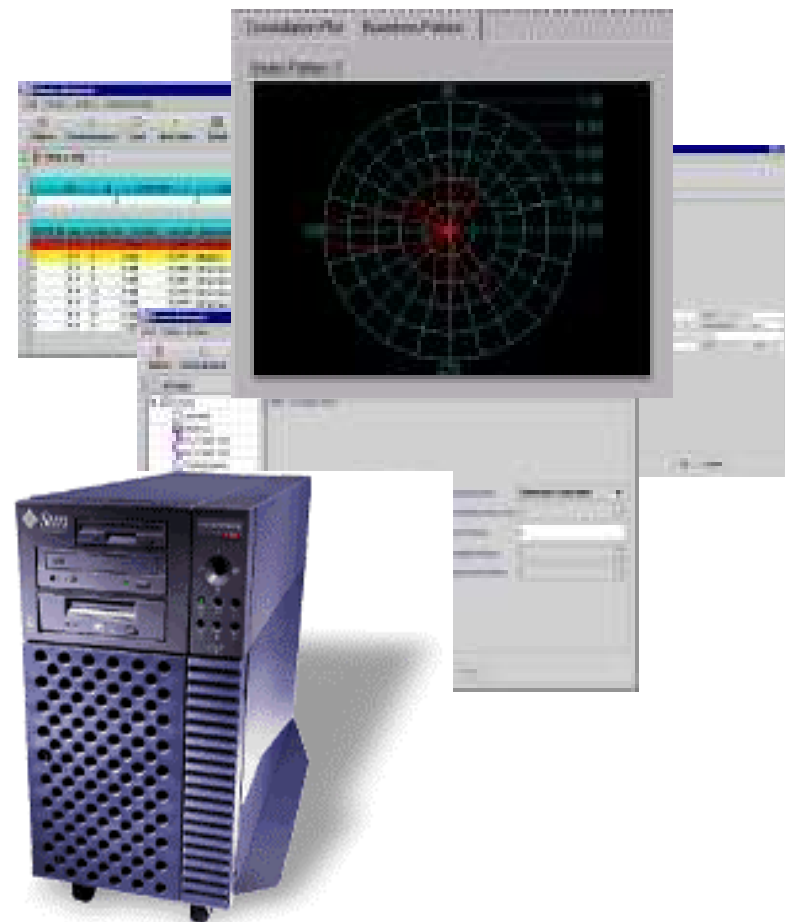
## Platform Support

- BWG 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



# Element Management System (EMS)

- 750,000 CPE's & 750 BTS/EMS
- Server based, GUI, Remote Client Support
- Supports standard FCAP's functionality:
  - Fault
  - Configuration
  - Alarms
  - Performance
- Supports CPE Level Diagnostics
- Beam forming, Constellation etc
- Software Upgrades (BTS/ CPE)  
Over the air software downloads





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# Cisco's Adaptive Beamforming

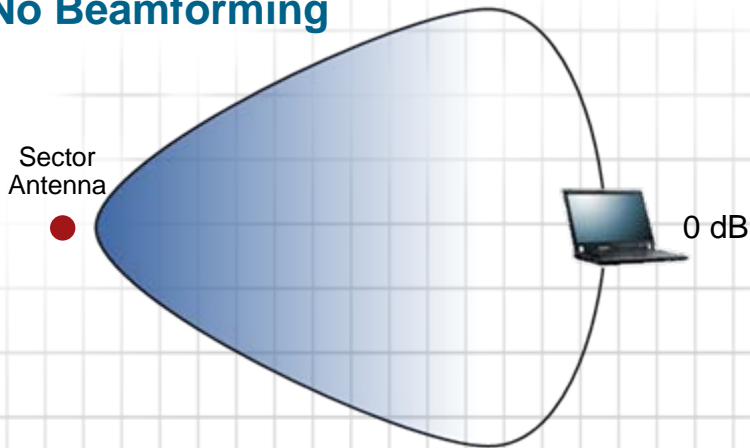
- Adaptive Beamforming creates a unique spatial RF signature for each user for each frame.
- Benefits in performance and key for deployments in limited frequency.
- Uses multi path to its advantage in phasing antennas (distinct from Beam Switching or Beam Steering).
- Benefits Traffic Channel Uplink and Downlink, uses power summing and concentration ratios to extend range of MAP channel.

# Cisco BWX Adaptive Beamforming

## Mobile WiMAX Beamforming Innovation

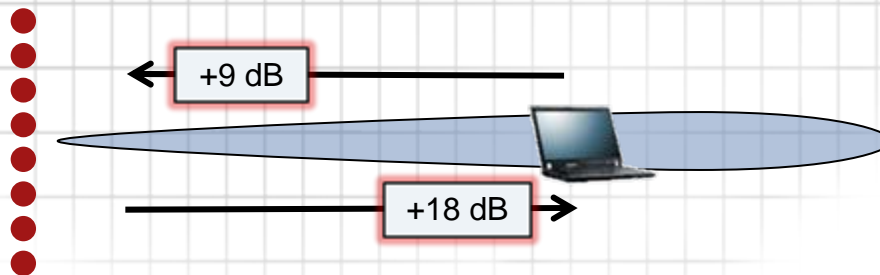
Beamforming uses antenna array and signal processing techniques to maximize signal strength for subscriber devices

### No Beamforming



- Energy is **dispersed** across an entire 90° or 120° sector
- Gain decreases quickly with distance, **degrading** performance
- Limited coverage. Cells must be **tightly spaced** for good performance
- Inter-cell interference adversely affects frequency reuse

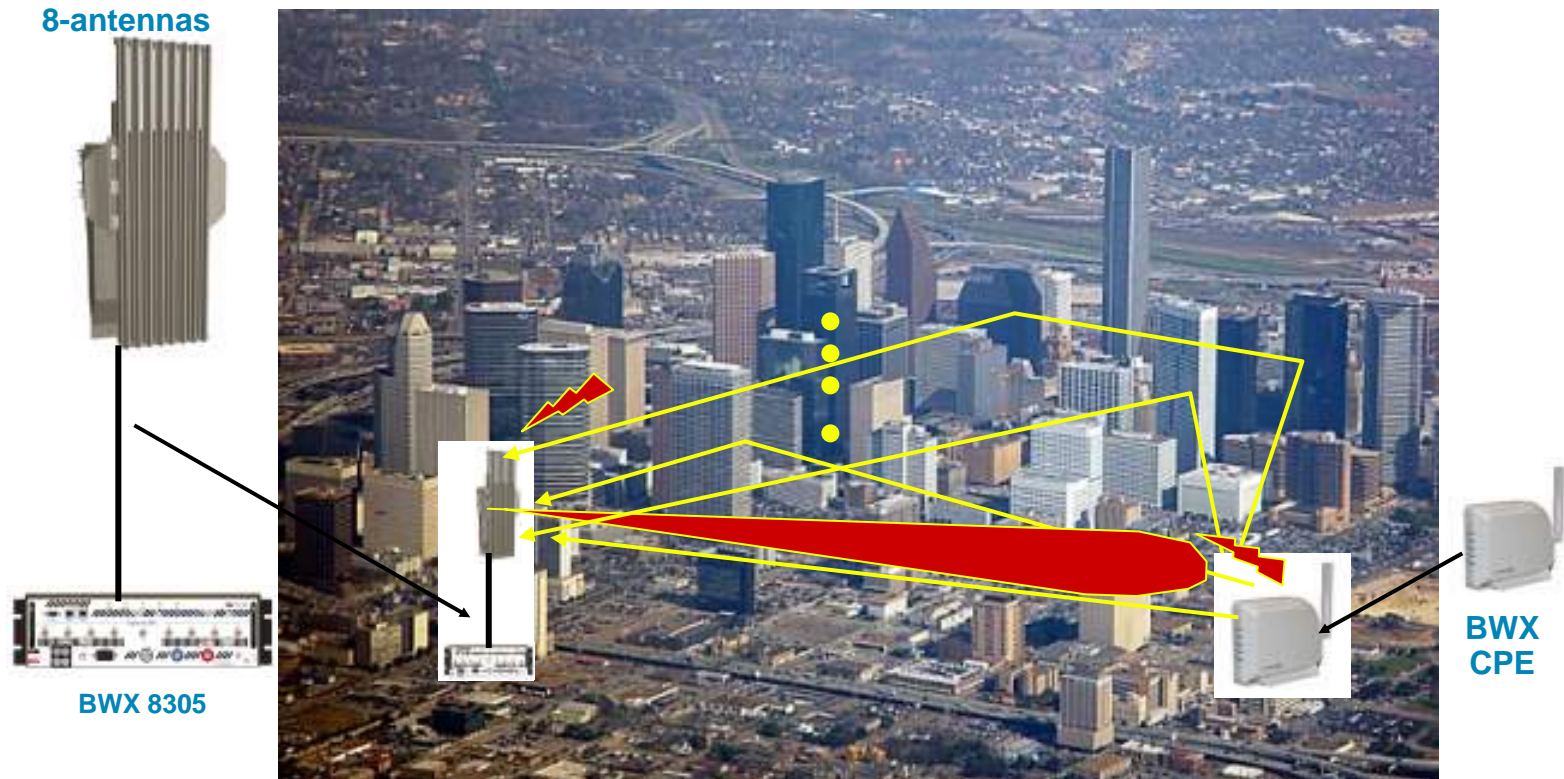
### Cisco's Beamforming Implementation



Cisco 8-Element 120°  
Beamforming Array

- Array is recalibrated every 5ms, energy is **focused** at individual subscribers
- Gain remains high over long distances for static CPE , **improving** performance
- Expanded Coverage. Cells can be **widely spaced** while providing good performance
- Inter-cell interference is minimized, allowing maximum frequency reuse

# How Beamforming Works



- **Uplink:**

- Signal from CPE bounces off buildings & arrives at the 8-antenna system.
- Each antenna "sees" the signal a bit differently. Derives spatial signature for each CPE

- **Downlink:**

- All 8 signals are manipulated by phase/amplitude to have the equivalent effect of an antenna system with a very narrow beam maximizing signal intensity at that particular CPE.

# Cisco BWX Adaptive Beamforming

## Mobile WiMAX MIMO Explained

MIMO antenna systems enable techniques that improve received power levels, path reliability, and path performance

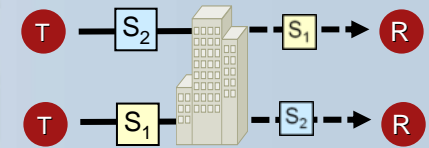
### Single-Input Single-Output

- Single antennas at both basestation and subscriber device
- Used in WiMAX Wave 1 deployments



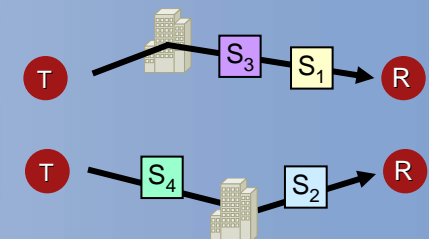
### MIMO Matrix-A (Space Time Coding)

- Symbols are sent redundantly in both space and time
- Streams are reconstructed using intact symbols at the receiver
- **Increases link reliability and fading margins (+3 dB)**



### MIMO Matrix-B (Spatial Multiplexing)

- Symbols are divided and multiplexed in space
- Multipath must exist to prevent signals from becoming coherent and therefore indistinguishable at the receiver
- **Increases throughput for stationary subscriber devices**





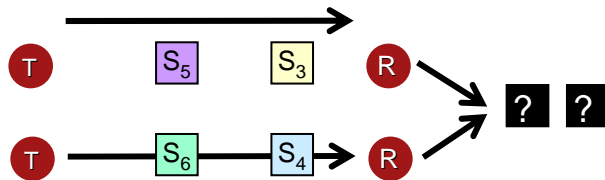
# Cisco BWX Adaptive Beamforming

## Mobile WiMAX Beamforming / MIMO Integration

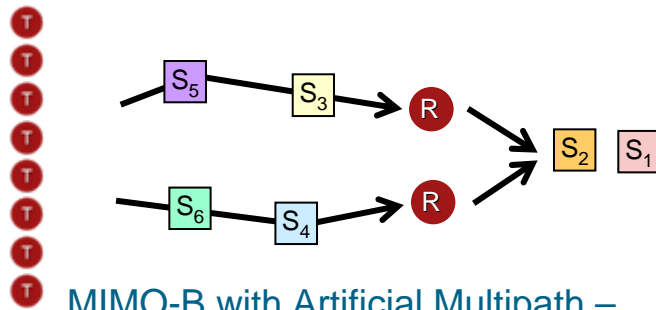


Integrating Beamforming with MIMO further enhances the range, reliability, and throughput of Mobile WiMAX services

Beamforming can create artificial multipath characteristics where none exists naturally

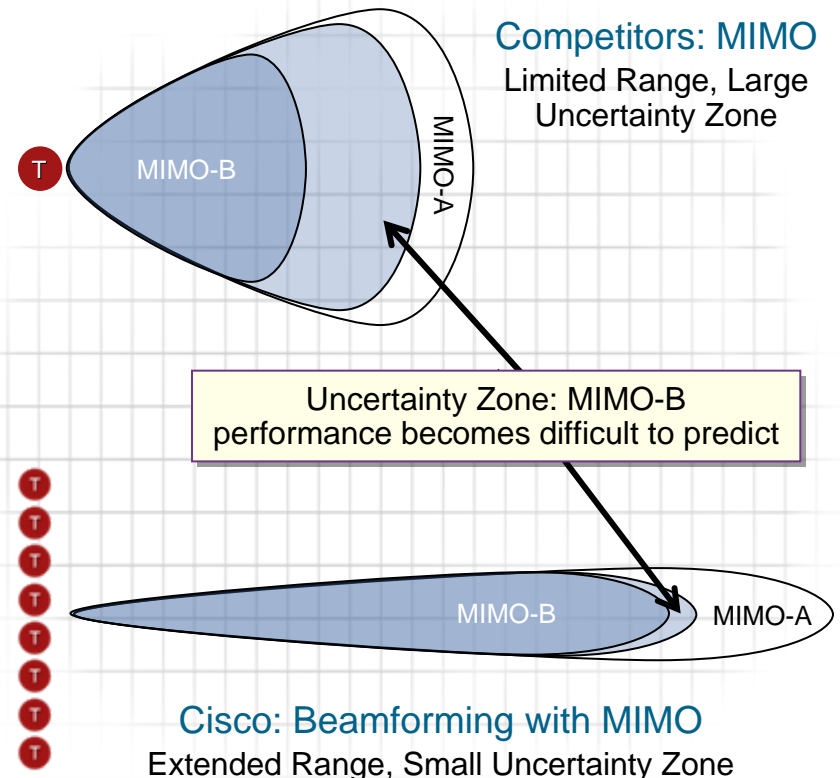


MIMO-B without Multipath – Symbols Lost



MIMO-B with Artificial Multipath – Symbols Received

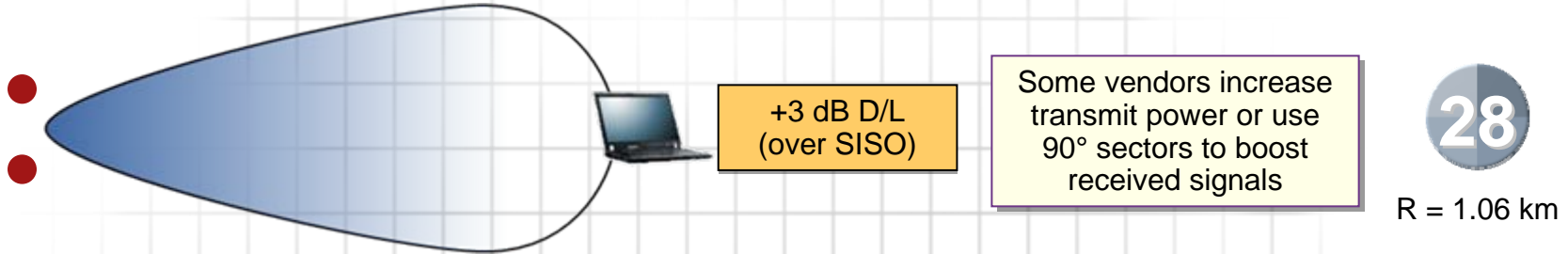
Beamforming extends the range and predictability of both MIMO-A & MIMO-B



# Cisco Broadband Wireless Access

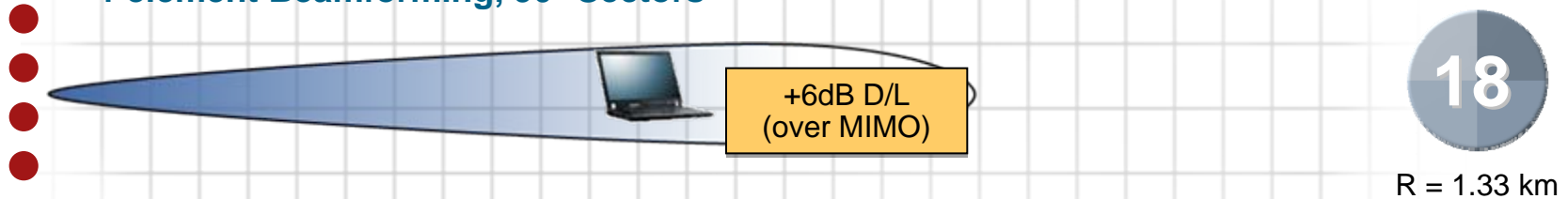
## Mobile WiMAX Competitive Comparison

### 2-element MIMO (no Beamforming), 90° Sectors

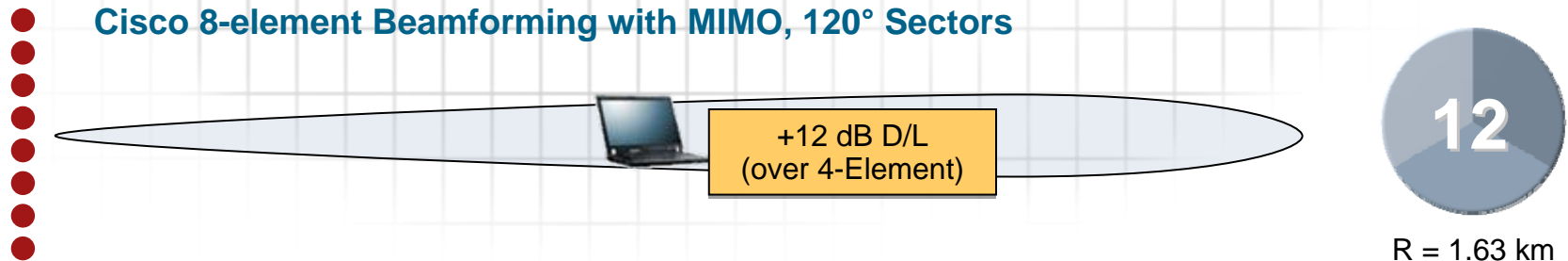


Cells to cover a 5k radius (80km²)

### 4-element Beamforming, 90° Sectors



### Cisco 8-element Beamforming with MIMO, 120° Sectors



## A collage of 12 images illustrating various aspects of the construction and infrastructure industry. The images are arranged in a grid-like fashion, with some overlapping. Overlaid on the entire collage is a network of yellow circles of varying sizes, some of which are connected by thin yellow lines, suggesting a global or interconnected theme. The images include: 1. A worker in a blue shirt working on a large metal structure, possibly a ship's hull. 2. A worker in a white shirt standing next to a large metal structure. 3. A worker in a blue shirt working on a large metal structure. 4. A worker in a blue shirt working on a large metal structure. 5. A large industrial facility with several large storage tanks. 6. A worker in a blue shirt working on a large metal structure. 7. A worker in a blue shirt working on a large metal structure. 8. A worker in a blue shirt working on a large metal structure. 9. A large industrial facility with several large storage tanks. 10. A worker in a blue shirt working on a large metal structure. 11. A worker in a blue shirt working on a large metal structure. 12. A large industrial facility with several large storage tanks.



# Why WiMAX in the Education Sector?

- All IP Based Wireless solution
- Ideal coverage for Metro Network, Campus facilities
- Improved throughput over GSM, WiFi and some DSL
- Service rich platform – Voice, Streaming media, VPN
- Choice of access devices
- Complete Network control and Management
- Mobility

# Rich Service Models

Market	Services	CS Type	Model
Residential	Internet Access	IP-CS	Fixed
	VoIP Telephony	IP-CS	Fixed
Personal Broadband	Internet Access	IP-CS (PMIP)	Nomadic / mobile
	L3 VPN	IP-CS (PMIP)	Nomadic / mobile
	VoIP Telephony	IP-CS (PMIP)	Full Mobile
Business	L3 VPN	Ethernet-CS	Fixed
	E-Line (L2VPN P2P)	Ethernet-CS	Fixed
	E-LAN (L2VPN P2MP)	Ethernet-CS	Fixed
	Managed Voice	IP-CS	Fixed
Wholesale	L3 (P2P, MP)	Ethernet-CS	Fixed
	L2 (P2P, MP)	Ethernet-CS	Fixed

Cisco supports Ethernet-CS and IP-CS bearers allowing for a wide variety of service types to be delivered across the entire network to the end user.

Many business services deployed over IP networks require an Ethernet convergent sub layer.

***Flexible Bearers Optimized for Service Delivery***

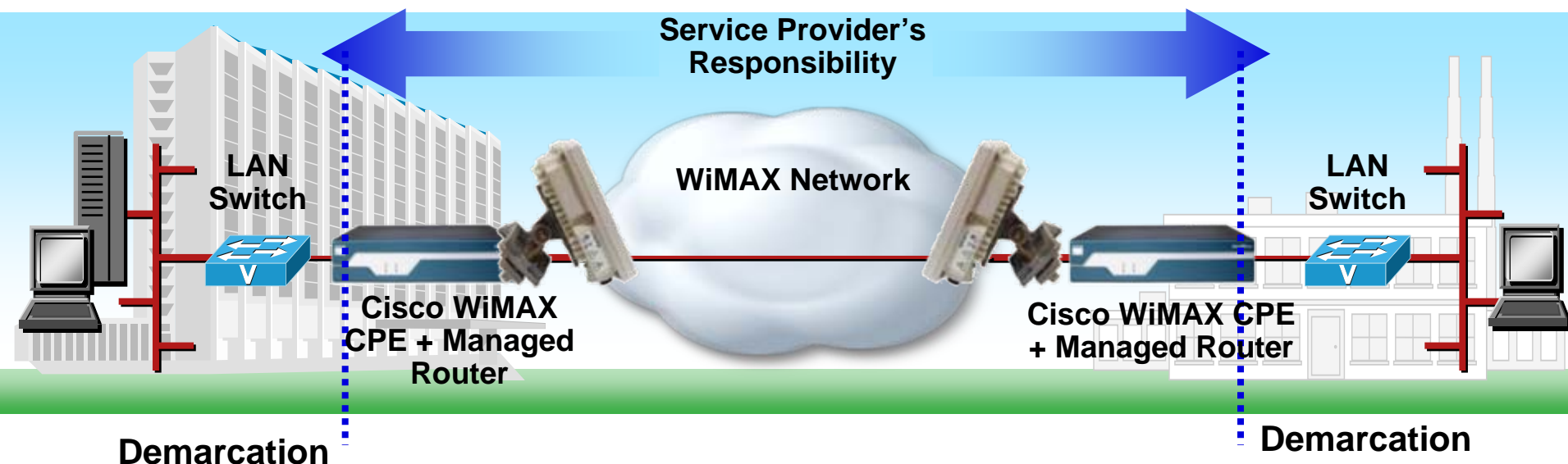
# Students Services

- Access to VPN services- Faculty Data . User Groups
- VoIP Services
- Remote Worker
- Mobility on Campus

# WiMAX Other Campus Applications

- Video Security
- Inter site connectivity
- Remote Workers

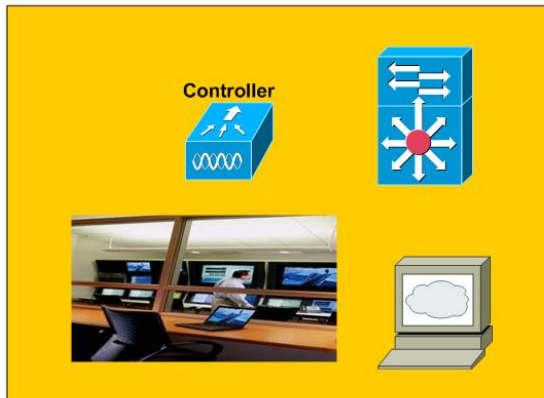
# Site-to-Site VPN Service



- **Outdoor WiMAX CPE for Maximum Performance**
- **Managed router service allows remote configuration**
- **SP enables Site-to-Site MPLS or IPSec VPN features in Cisco Router**
- **Extend support for VPN Acceleration from SP to customer premise through AES wide-key support in both**
- **Provide Managed Site-to-Site VPN Service without truck-roll**
- **Obtain new service revenue from already deployed and managed CPE**

# Example Public Sector Solution

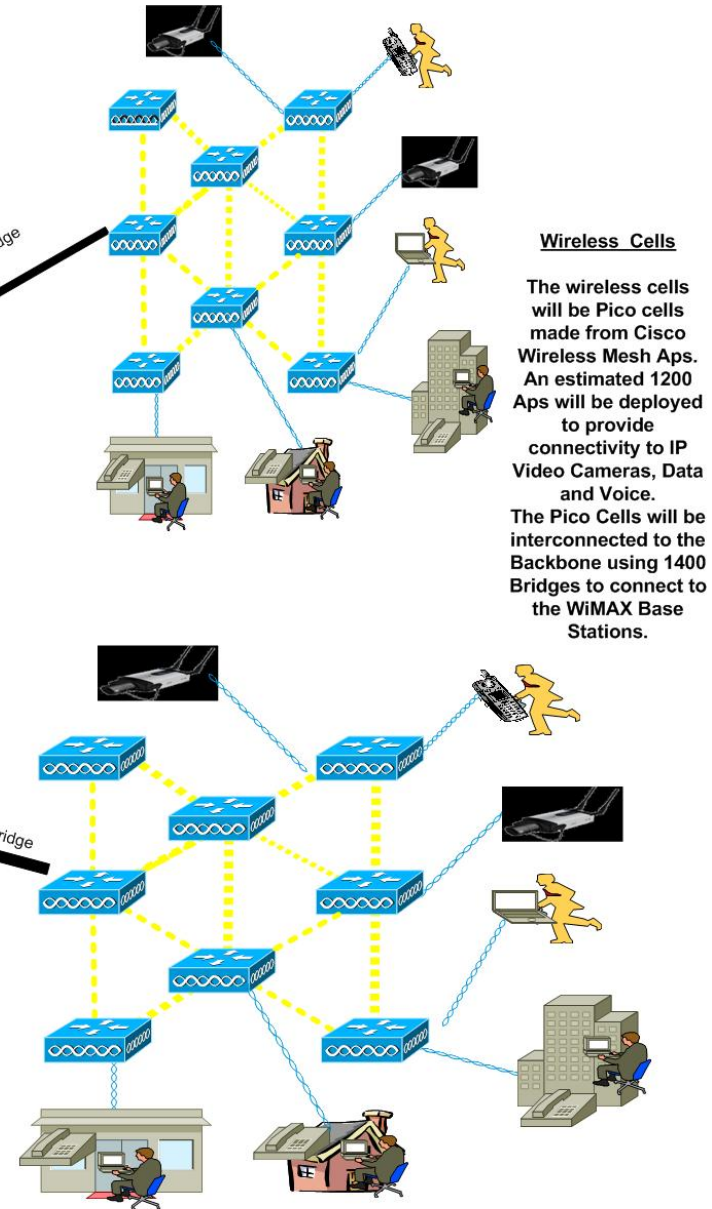
There will be 2 Command and Control Centers to allow for an active-active redundancy. The CCC will be co-located with the Data Centers in which there will be convergence of the Voice, Video and data streams.



Backbone connectivity will be achieved by using Dragon Wave Radios to give a backhaul bandwidth of up to 680Mbps based on the Airpair radio Configuration.

1400 Series Bridge

WiMAX base stations numbering about 300 will be deployed to provide coverage for 900 cameras with 3 IP Cameras co-located with 1 WiMAX Base Station.



## Wireless Cells

The wireless cells will be Pico cells made from Cisco Wireless Mesh Aps. An estimated 1200 Aps will be deployed to provide connectivity to IP Video Cameras, Data and Voice. The Pico Cells will be interconnected to the Backbone using 1400 Bridges to connect to the WiMAX Base Stations.

