Cisco WiMAX E2E Solution

Architecture Overview

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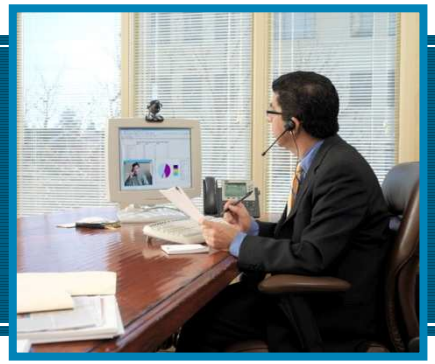
Agenda

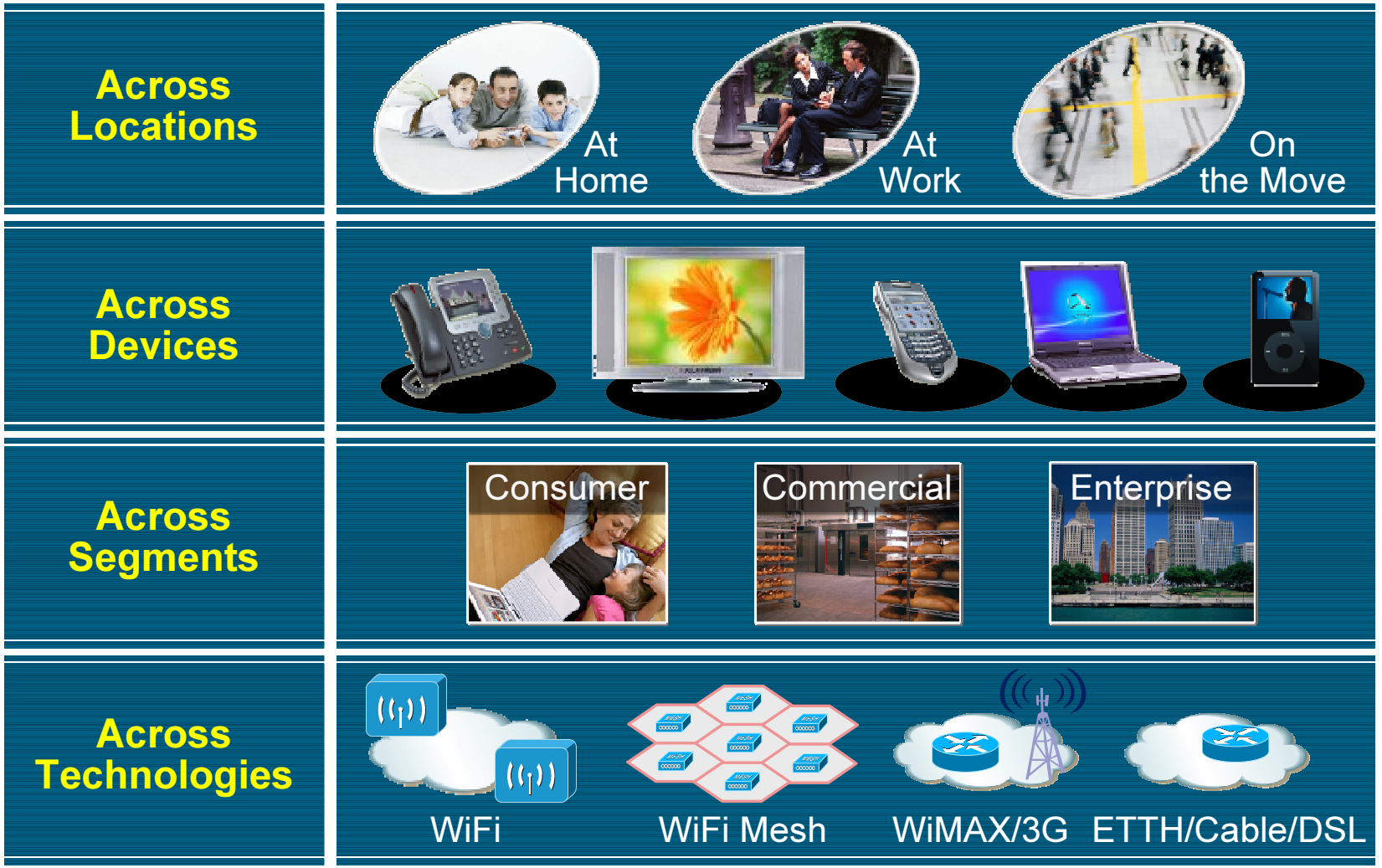
- WiMAX Introduction
- Cisco WiMAX Broadband Architecture
- Cisco WiMAX Service Models
- Cisco References
- Summary

Businesses and Consumers Want Mobility

- Connected Anywhere, Any Time With Any Device
- The Mobility Experience Needs to be Simple, Convenient and Reliable
- Demand a High-Quality Multimedia Experience
- Seamless Roaming Across Networks




Cisco Mobility:
Enabling 'The Connected Life'



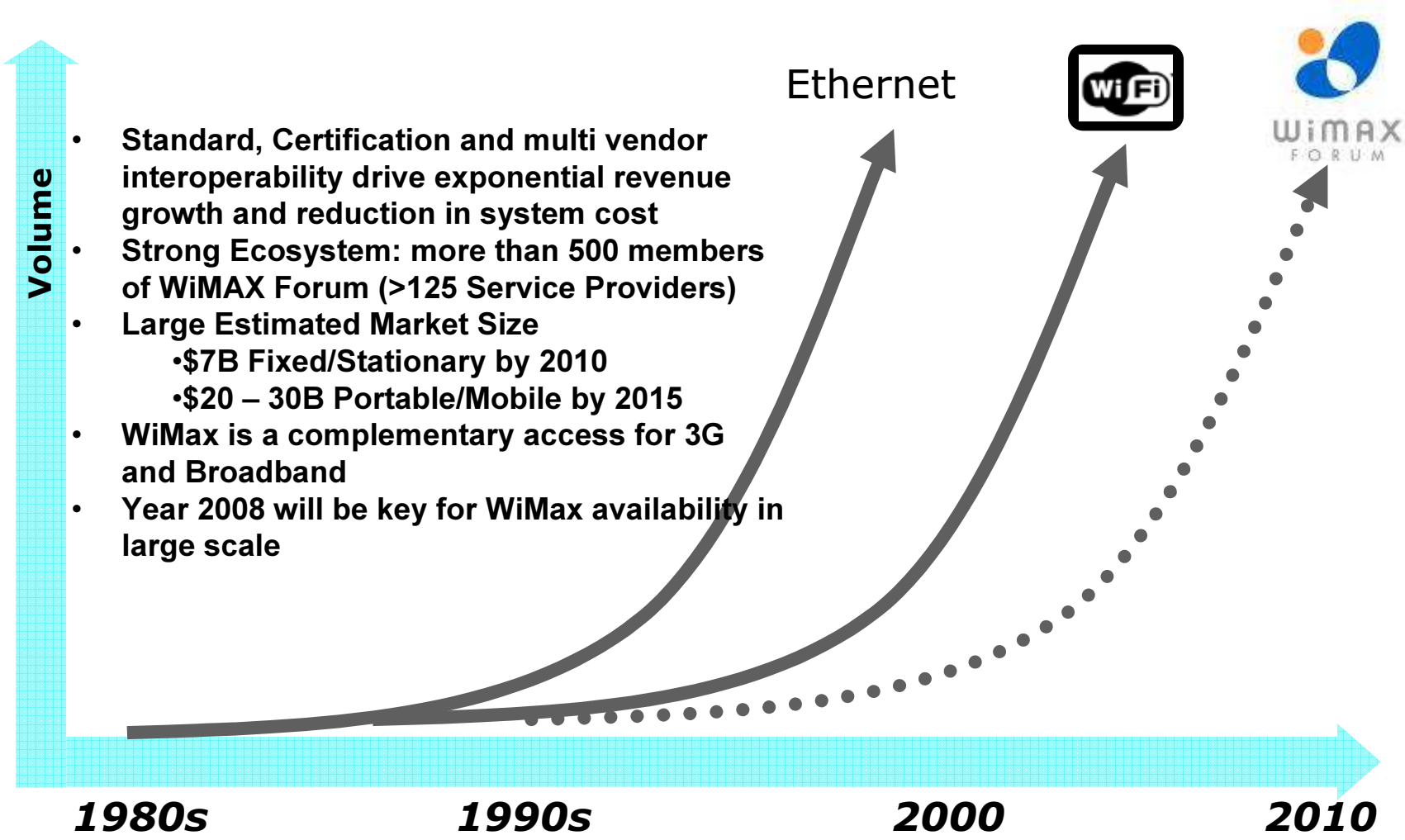
Cisco Mobility:
Why IP Mobility?

- IP Is the single common element in all transport architectures: GSM, WiMAX, WiFi-Mesh
- IP Mobility enables services to be ‘anchored’ even while subscribers move between transports
- IP-Centered service exchange framework (SEF) enables per-subscriber customization of services
- IP ‘Openness’ ensures a thriving ecosystem that delivers cost benefits throughout the service-delivery chain: transport, operations, applications…

WHY WiMAX?

Following the same adoption curve …

The Path to Volume Economics

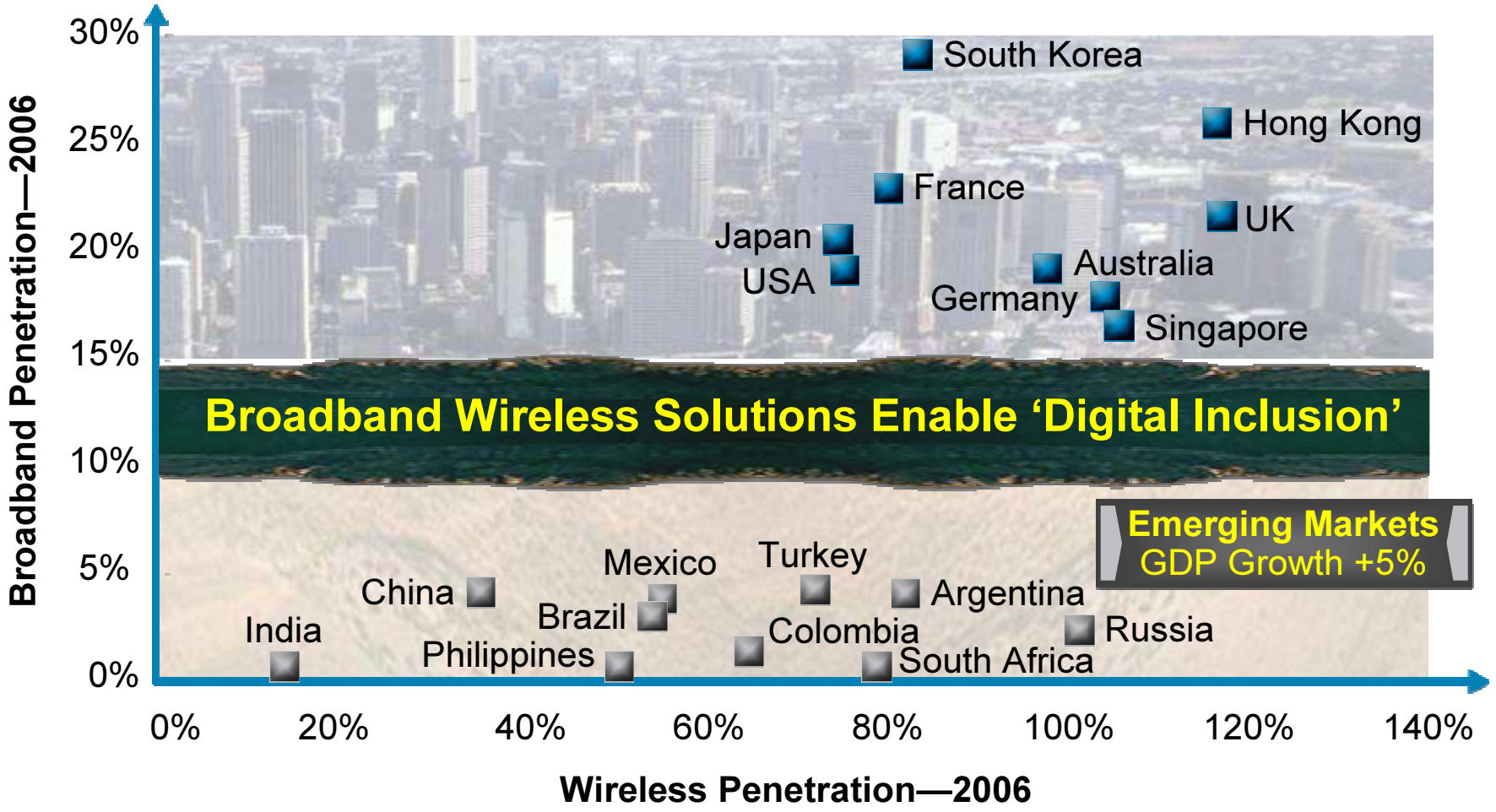


- **Standard, Certification and multi vendor interoperability drive exponential revenue growth and reduction in system cost**
- **Strong Ecosystem: more than 500 members of WiMAX Forum (>125 Service Providers)**
- **Large Estimated Market Size**
  - **$7B Fixed/Stationary by 2010**
  - **$20 – 30B Portable/Mobile by 2015**
- **WiMax is a complementary access for 3G and Broadband**
- **Year 2008 will be key for WiMax availability in large scale**

*Other names and brands may be claimed as the property of others.

The Real Opportunity

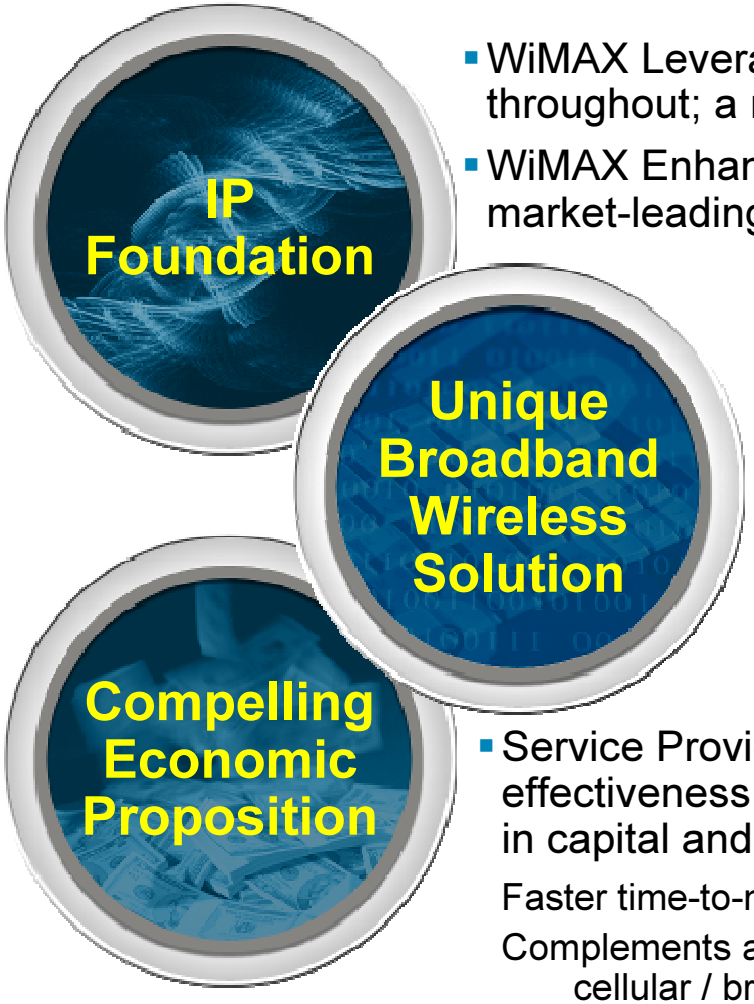
Country Transformation and 'Digital Inclusion'



Source: EIU, Telegeography, Point Topic, Cisco Analysis

The Broadband Wireless Market

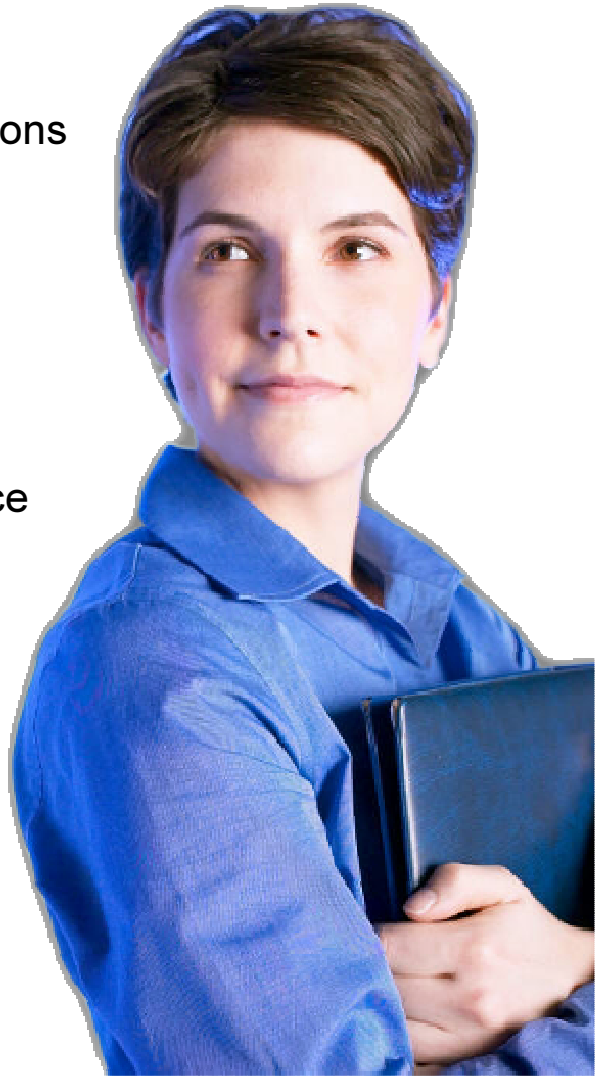
Why is WiMAX Important for Cisco ?



- 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'



Cisco Acquired Navini on Dec. 21, 2007
Best-in-Class Innovation, Experience, Technology

Leading WiMAX Portfolio

- From base stations to modems
- Commercially deployed smart beam-forming technology
- Mobile WiMAX 802.16e-2005 compliant

Strong Value Proposition

- Yields OpEx & CapEx savings requiring up to 50% fewer sites
- Delivers higher peak data-rates and throughput – out & indoor
- 75 networks in 50 countries on 6 continents

Unmatched Innovation

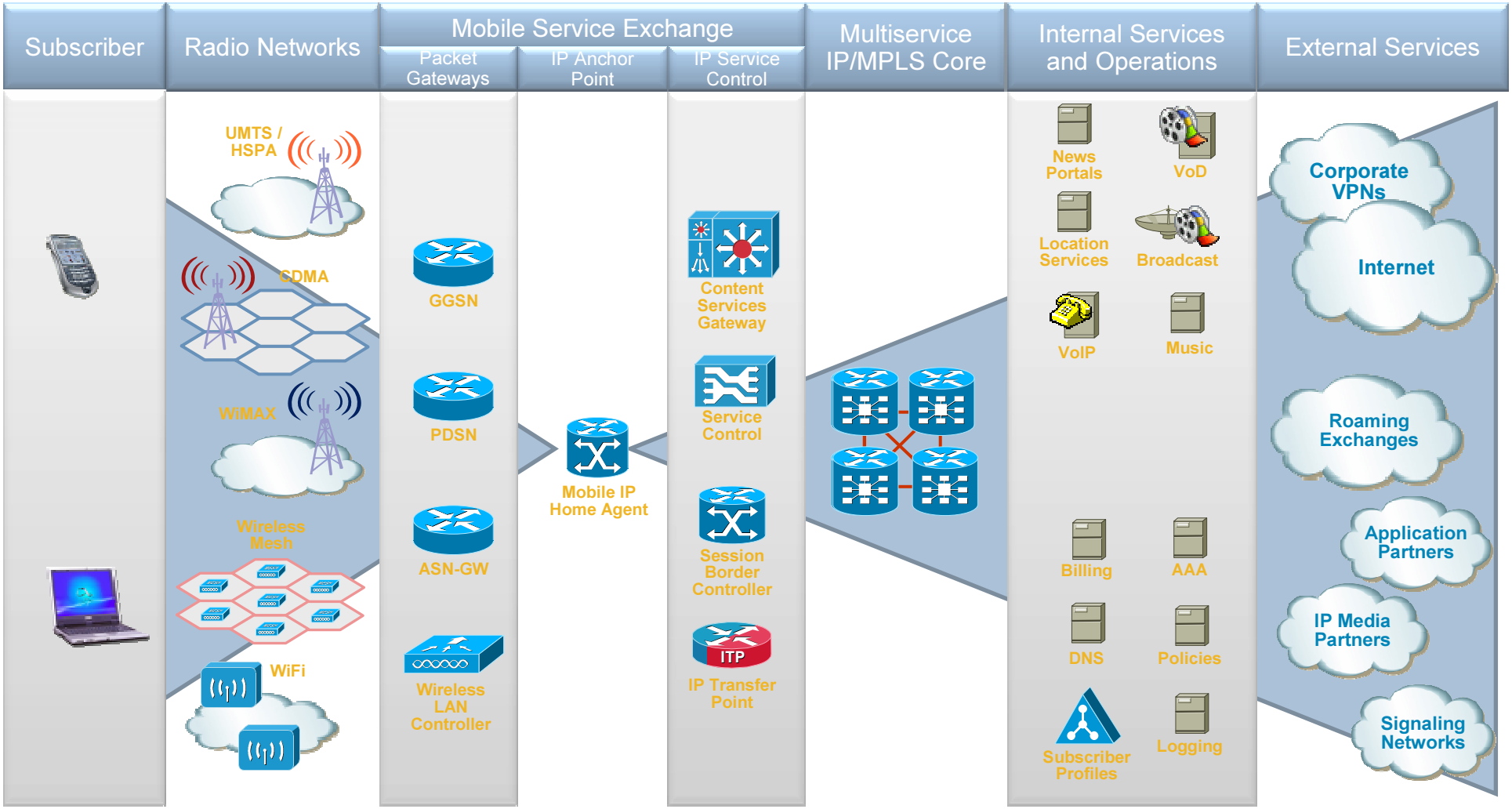
- Advanced WiMAX RF capabilities
- Pioneering Smart Beam-Forming with MIMO; 75 patents (granted/pending)

Cisco Fit

- Shared IP-centric vision on mass market wireless broadband
- Geographically co-located (Richardson & Bangalore)
- Experienced people innovative culture

Cisco IP Next Generation Networks

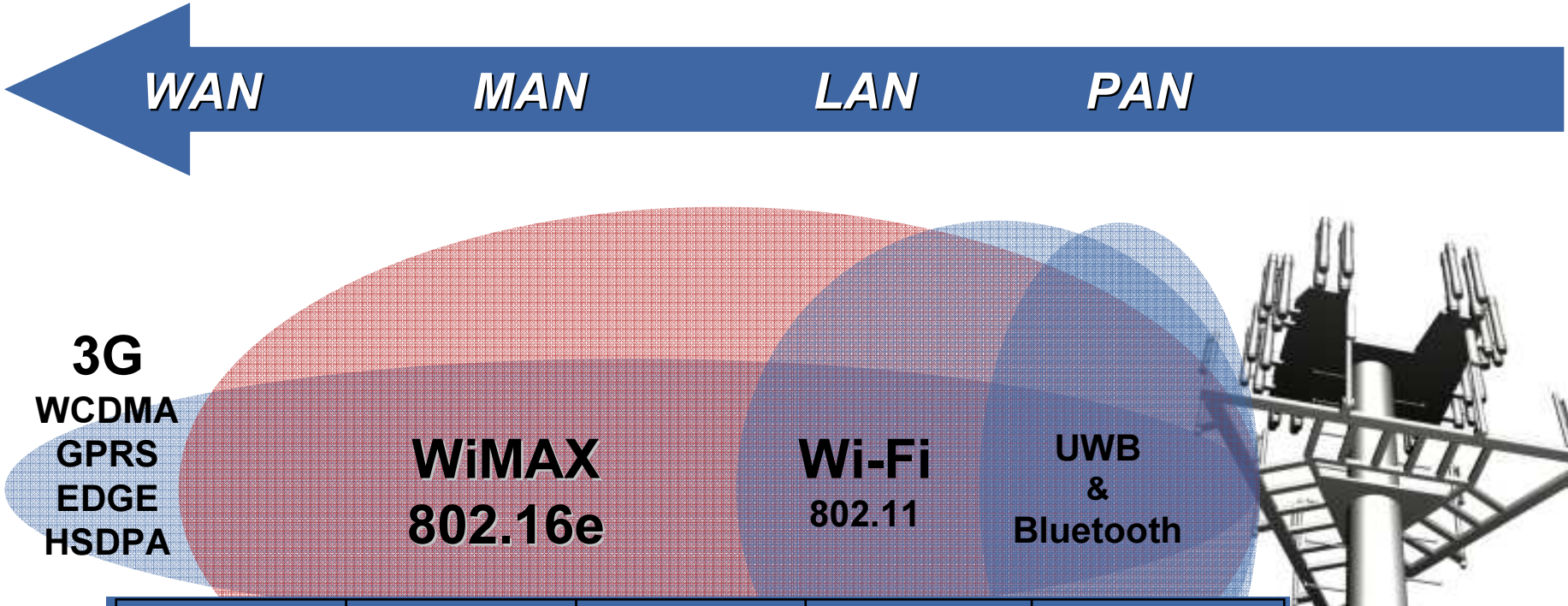
IP Forms the Foundation for True Mobility for WiMAX



WiMAX Technology Overview

Where does WiMAX fit?

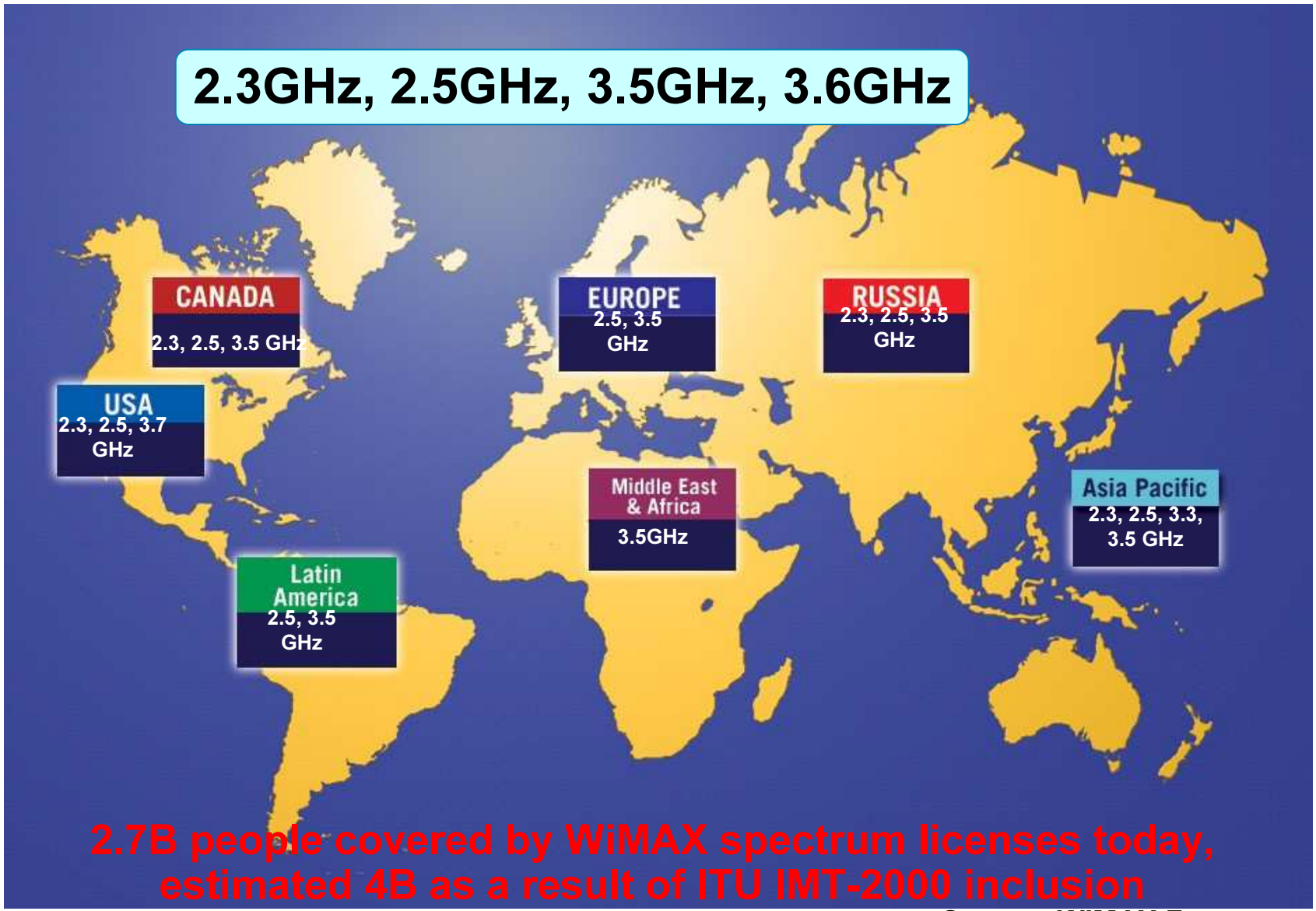
(WiMAX: Worldwide Interoperability for Microwave Access)



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

Spectrum by Region for 16e

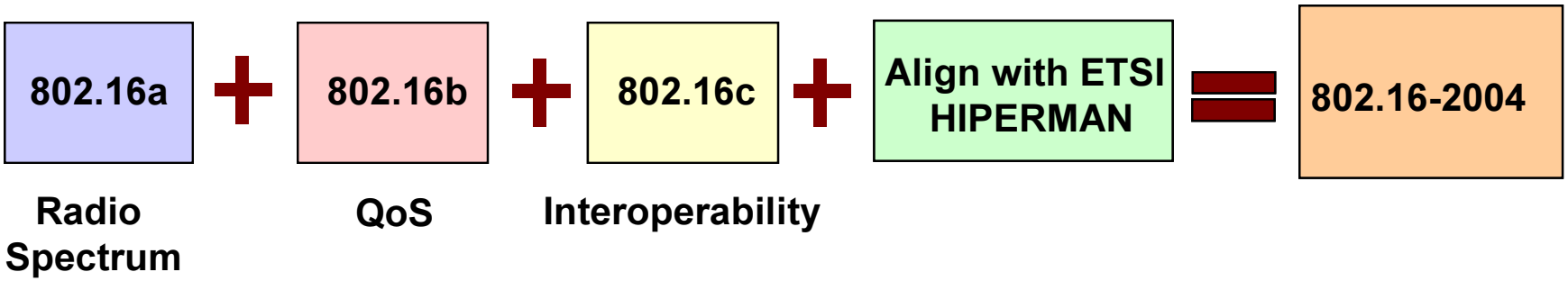
2005 - 2007 Spectrum Focus



Source: WiMAX Forum

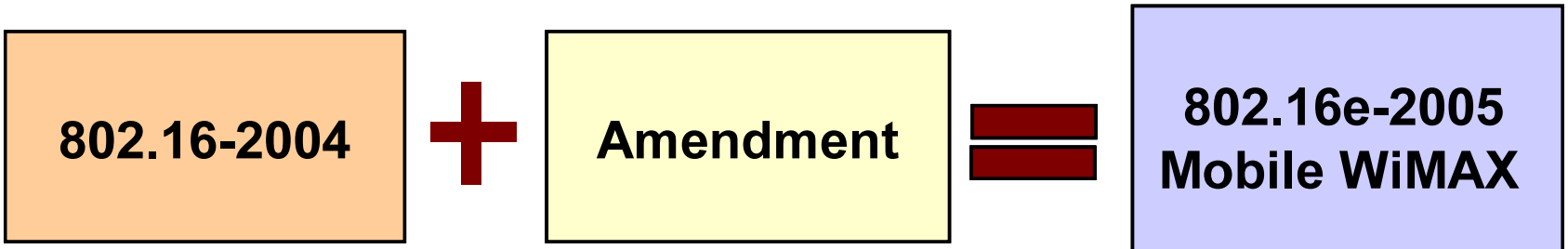
IEEE 802.16 Standards Evolution

December 2001: First 802.16 Standard Approved



June 2004: 802.16d-2004 Approved

IEEE 802.16 Standards Evolution, continued

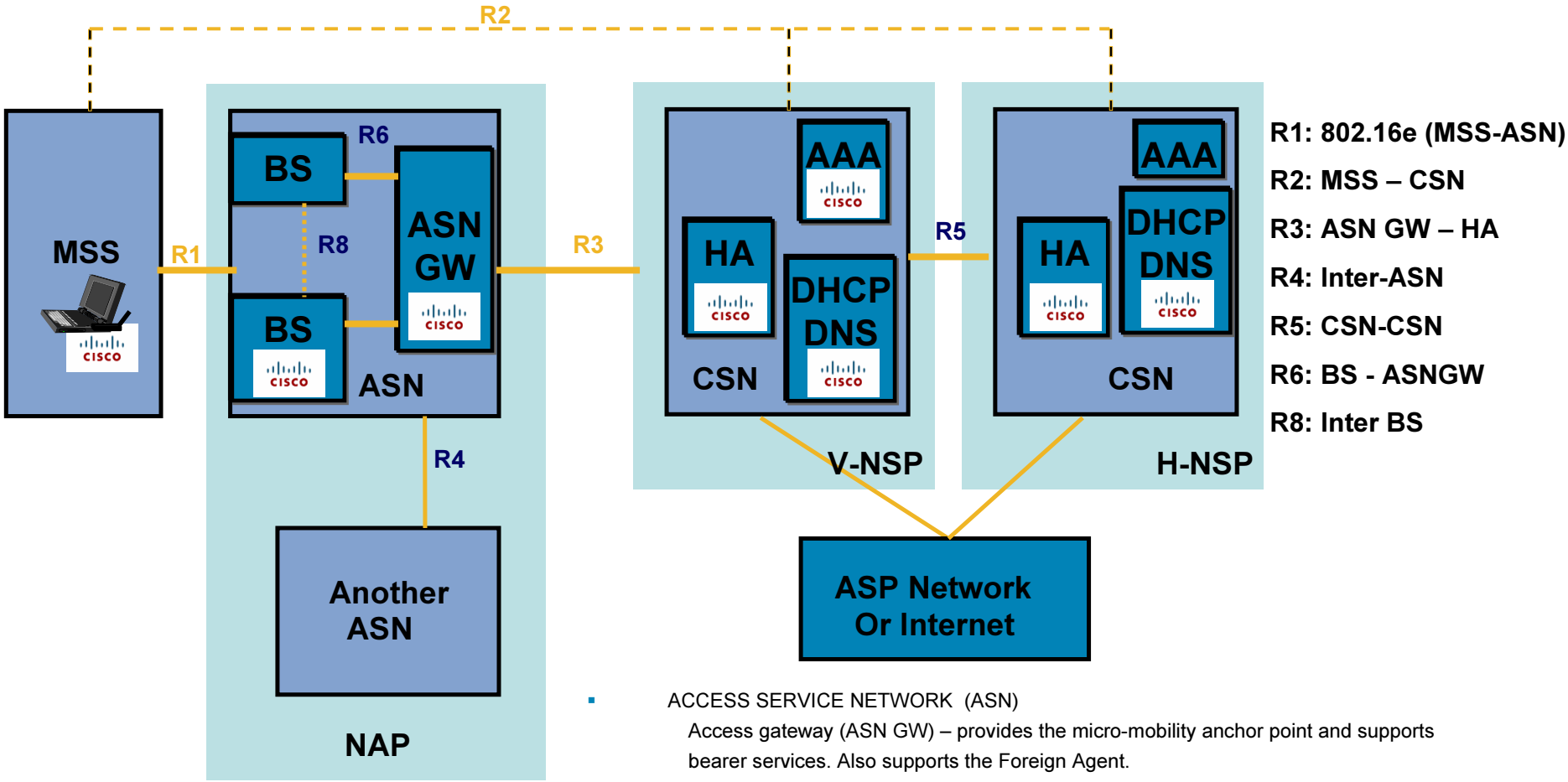


Adds mobility and Scalable OFDMA

WiMAX Forum Certification

- WiMAX Forum acts as a certification body
- 2 components of certification:
  - Conformance testing
  - Interoperability testing
- To certify, equipment must adhere and comply with a defined WiMAX Forum profile
- Certification is intended to guarantee
  - Equipment complies with the 802.16e-2005 standard
  - Equipment can interoperate with equipment from other manufacturers
- Only WiMAX Forum Certified equipment has been proven interoperable with other vendors' WiMAX Forum Certified equipment

WiMAX End to End Network Reference Model



MSS – Mobile Subscriber Station

NAP – Network Access Provider

NSP – Network Service Provider

- 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.

WiMAX QoS & Scheduling Schemes

Specifications & Applications…

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

- **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 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

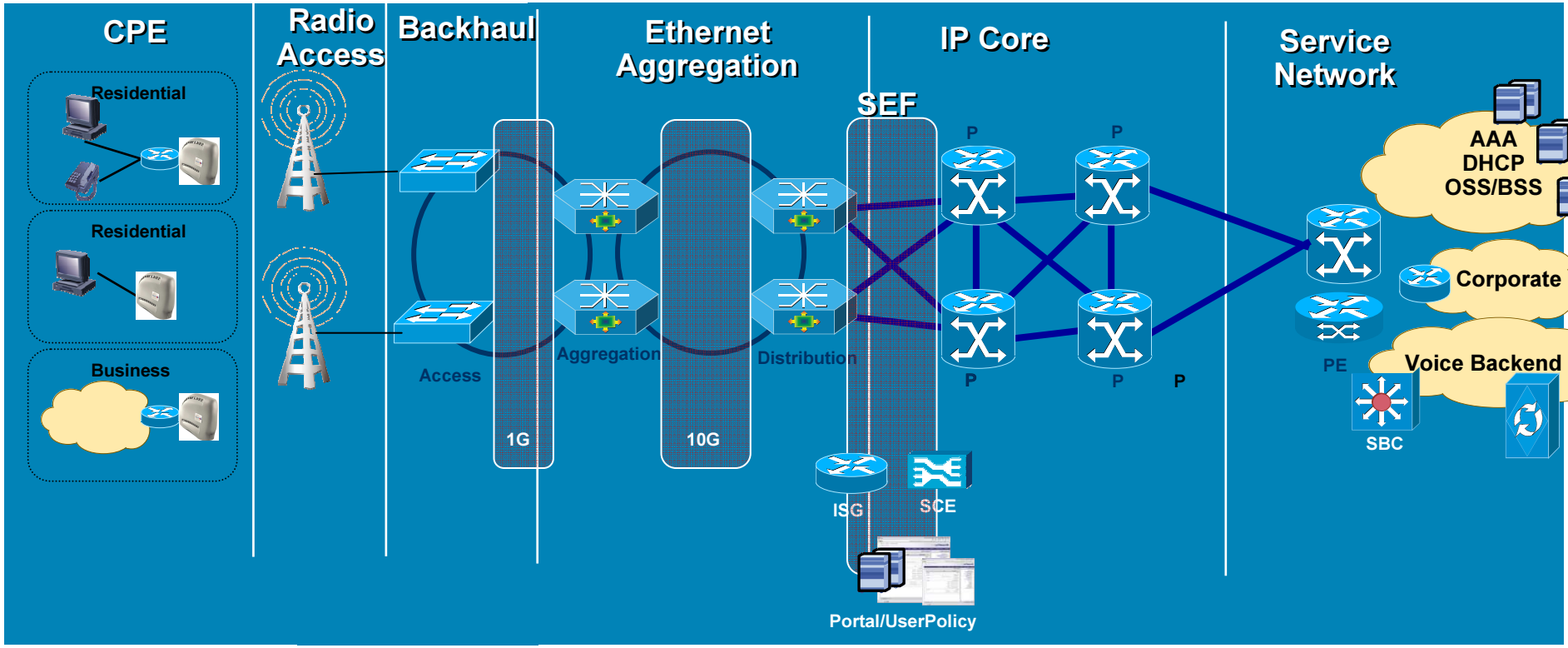
  AES encryption keys derives from EAP authentication and transported over PKMv2 framework

- **Security context and associations:**

  All security and encryption contexts and associations maintained over mobility events and other network events

Cisco Wimax Broadband Architecture

E2E Solution Components (Phase 1 Q2CY08)



ISR Routers
- 8xx/18/28/38xx

LinkSys Voice
- PAP2v2
- WRP400

CPE
- LMX

BTS (2.3/2.5/3.5)
- MX8
- MX2

BackHaul
- ME3400
- ME3750

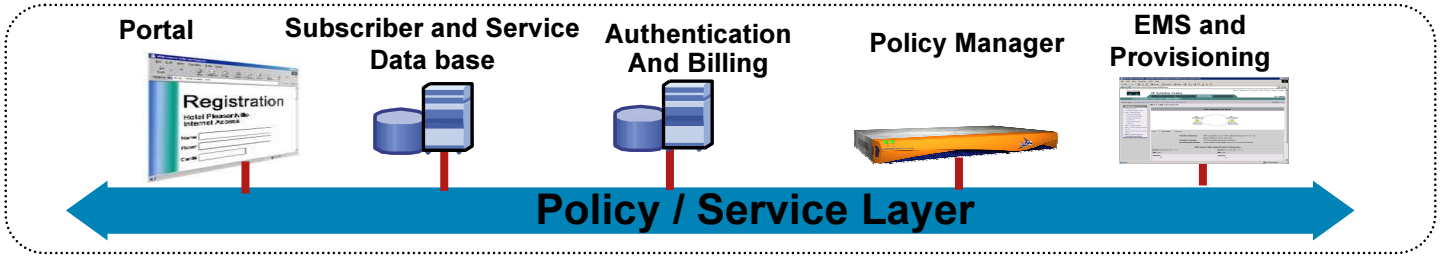
ASN GW
- 7300
- 7600(SAMI)

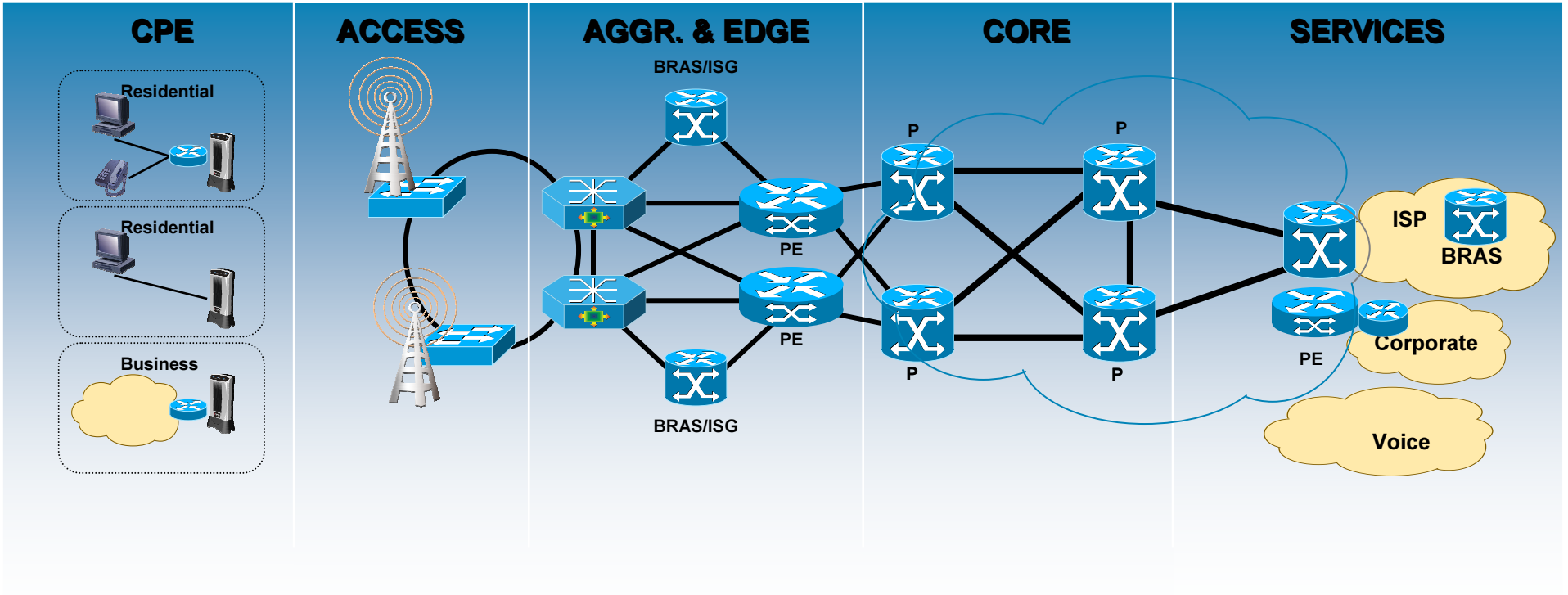
Aggregation /MSE
- 7600(ES20)

IP Core
- ISG
- SCE (Packet Inspection)
- CME (Broadhop)
- BTS10200 (Softwitch)
- CNR (DHCP)
- CAR (AAA)

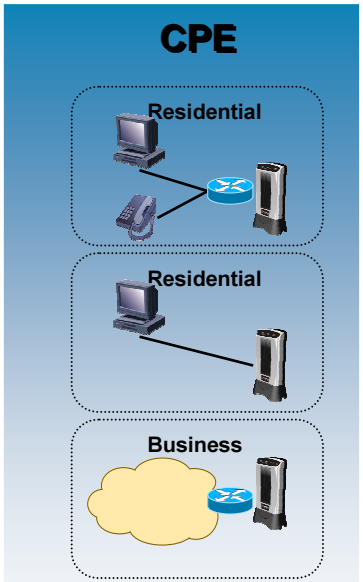
Network Mgmt
- BTS / ASN EMS
- Cisco Works

Solution Architectural Building blocks





Customer Premises Equipment



Cisco/partner CPE

- WiMAX Forum Certified (16d-2004, 16e-2005)
- Indoor and outdoor models
- Transparant bridging (Ethernet CS)
  - 802.1q/AD support
- L3 support using R1 (IP CS)
- QoS pre-configured or dynamic
- L2/L3 Classification
- X.509/3DES
- EAP Authentication (16e-2005) & signaling

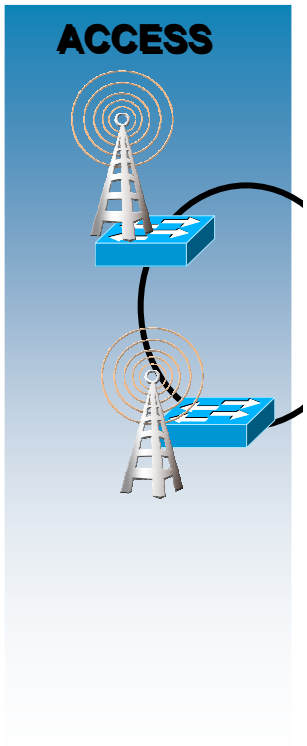
Residential Gateways

- Cisco/Linksys or third party
- Ethernet WAN
- POTS (voice)
- Firewall/NAT
- PPPoE/DHCP

Business Gateways

- Cisco ISR platforms
- Managed security and voice

Access Network



WiMAX partner Base-Station

- WiMAX Forum Certified (16d-2004 or 16e-2005)
- Micro base station (sector controller) or Chassis
- Point to Multipoint Access
- Transparant bridging or L3 (Ethernet CS or IP CS)
- 3.5, 5, 7, 10, 20 Mhz Channel sizes
- QoS – based on L2/L3 classification
- Fast Ethernet, Gigabit Ethernet uplinks
- X.509/3DES (authentication/key exchange)
- EAP proxy authenticator
- R6 Tunnel Initiator (keyed-GRE) to ASN-gw
- DHCP Option 82 (release 1.2)

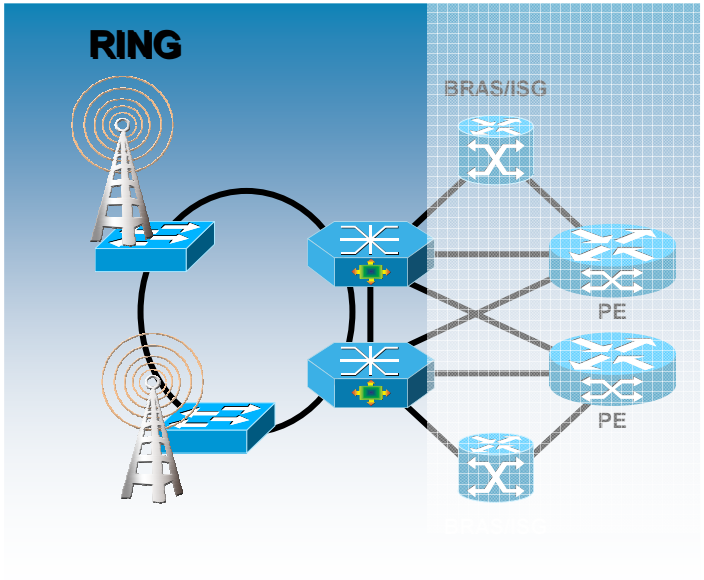
Cisco ME3400

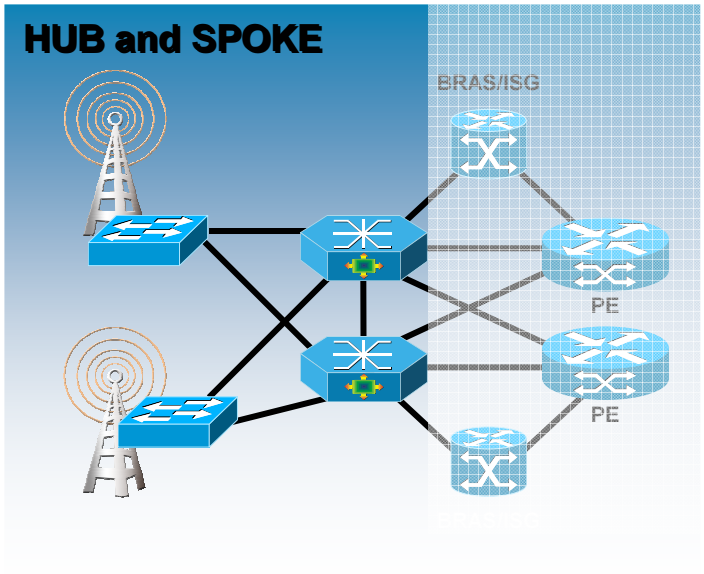
- Sector controller/Mirco BS aggregation
- UNI isolated and communities
- Ethernet/IP Model

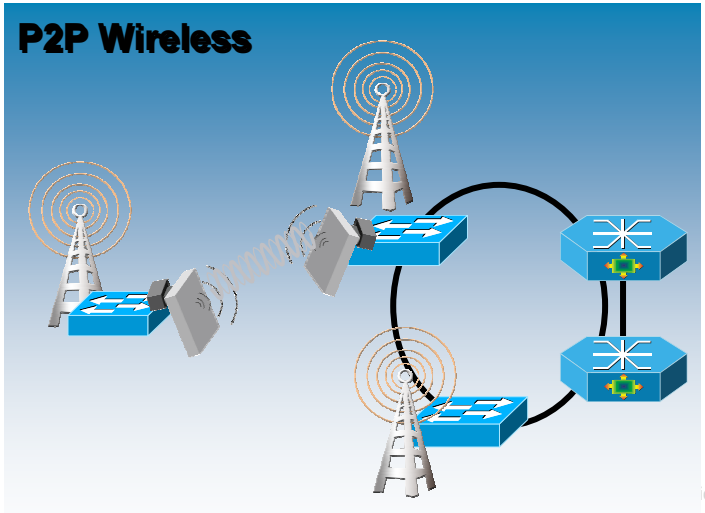
Cisco 3750ME

- Sector controller/ Micro BS aggregation
- Ethernet/IP and MPLS/IP Model
- H-QoS / H-VPLS

Access Network Topologies



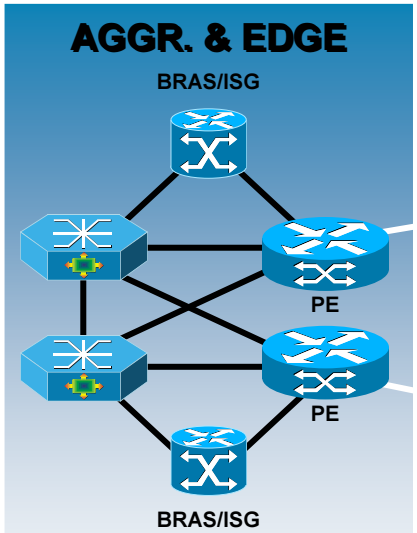




Access Network Topologies

1. Switched Gigabit Ethernet rings
2. Switched GE Hub and Spoke
3. Wireless P2P links (remote areas) using:
   - Private (Licensed) uWave
   - Public (unlicensed) RF (Wi-Fi)
   - P2P Wireless WiMAX

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)

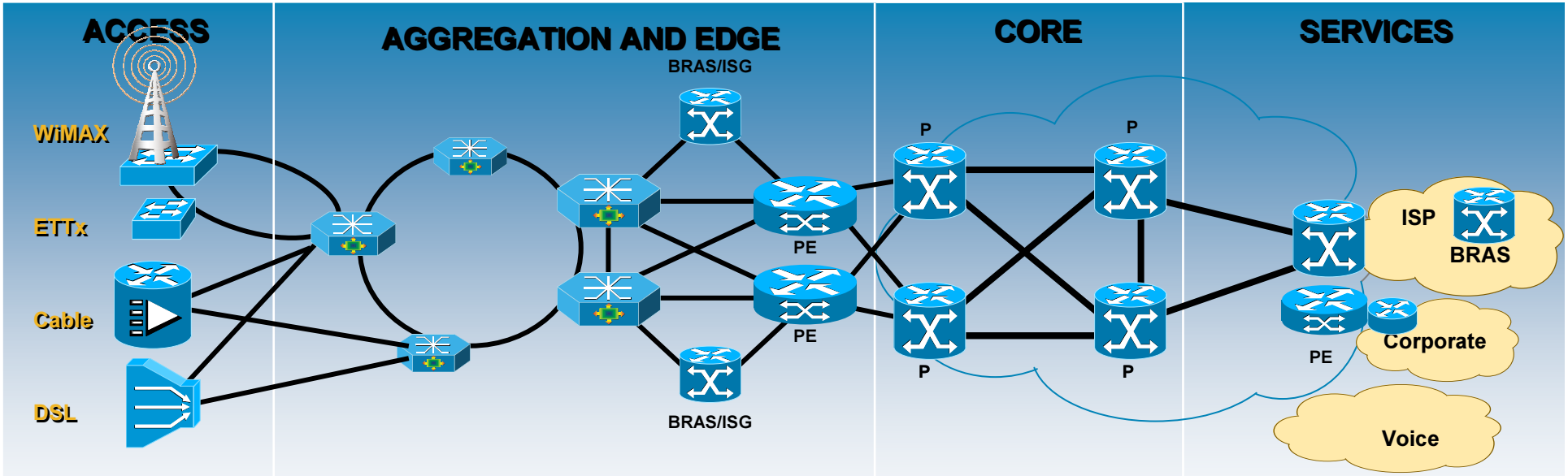
MPLS PE

- 7600/12K
- MPLS PE
- EoMPLS/VPLS

Products

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

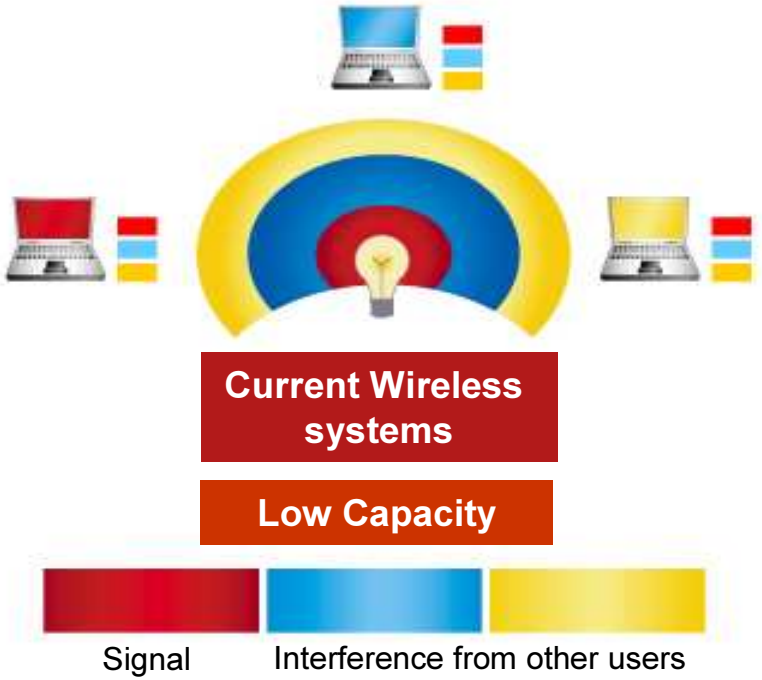
Cisco WiMAX Radio Components

Smart WiMAX

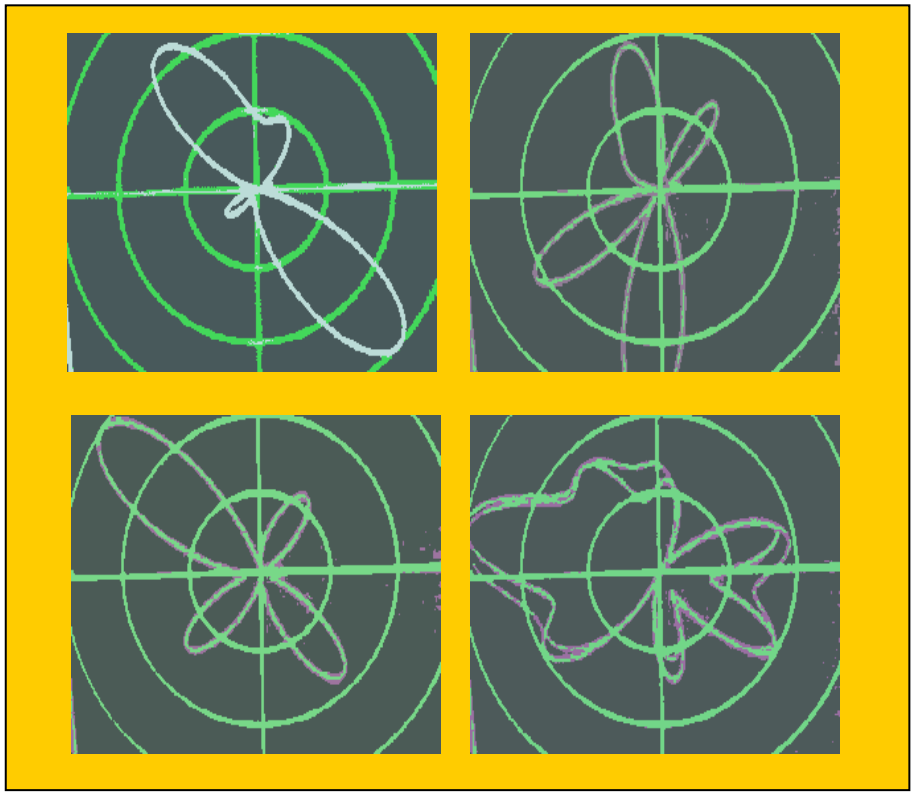
- Combines beamforming and MIMO to optimise the performance of the WiMAX network

- MIMO provides significant gains in capacity & robustness
- Beamforming provides significant gains in coverage and building penetration
- Both in combination is better than any one
- The link budget increases the performance

Smart Antenna principles



Energy dispersed in all directions.



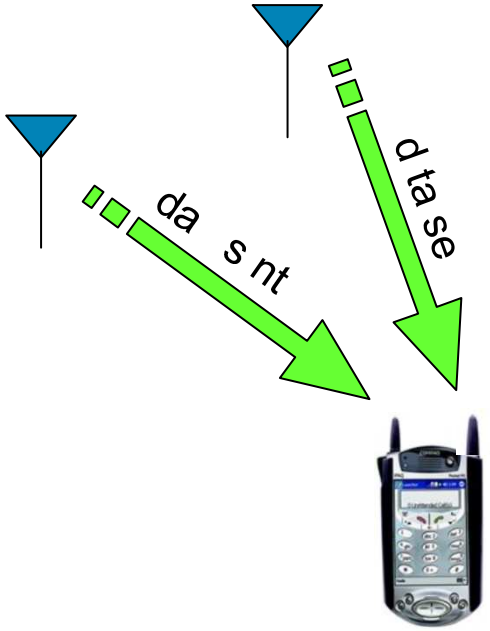
Energy directed to the intended user.

- Link budget (168 dB) provides superior coverage & performance
- Enables non line of sight, indoor coverage
- Reduces interference, allowing more capacity/ better frequency reuse
- Minimises the number of cell sites needed

MIMO Matrix A

- *<u>Matrix A</u> (Space Time Coding) is for robust highly <u>mobile</u> connectivity*

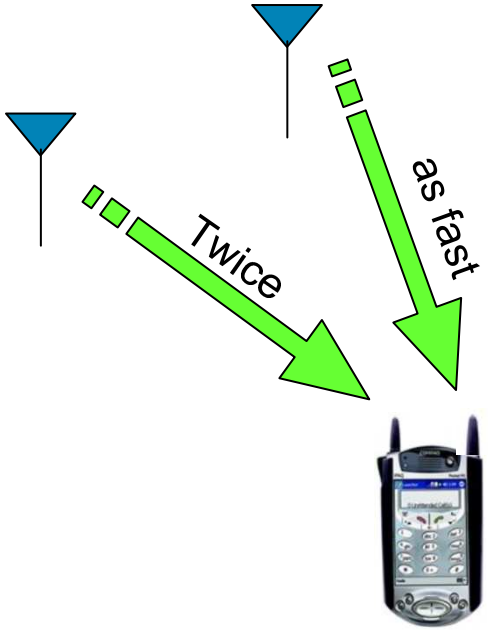
  - Transmits multiple, redundant, time-shifted copies of same data stream
  - Increases mobile link reliability & predictability
  - Creates link budget gain (+3db to +10db) & reduces fade margin



“da s nt“ + “d ta se ” **= “<u>data sent</u>”**

MIMO Matrix B

- *Matrix B (Spatial Multiplexing) is for high capacity stationary operation*



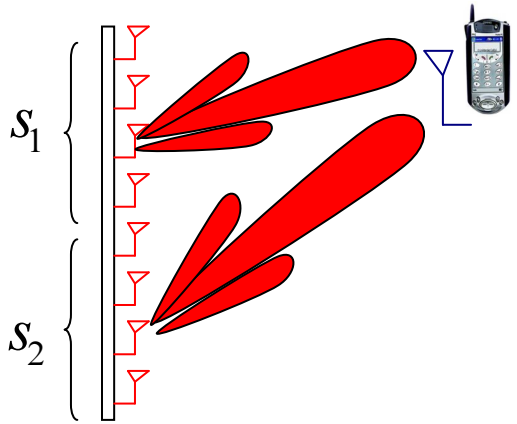
"Twice" + "as fast" = **"Twice as fast"**

- Transmits multiple data streams simultaneously using all available multi-paths
- Doubles throughput (in theory) by multiplexing multiple data streams over a short range for some users
  - Relies on naturally occurring multipath to decorrelate signals
  - 20-30% system capacity gain predicted
    - (Not 100% as some claim)

MIMO mandatory for Mobile WiMAX subscriber units under wave 2

BF & MIMO matrix A for Robustness

STC + Beamforming (for Mobile Users)



- **Adds channel feedback for beamforming power control**
- **Provides Diversity gain**
- **Up to *12 dB incremental BF gain* on top of STC gain (+3 to +10dB)**
- **9dB gain on the Uplink**

Dynamically combining Smart Beamforming & MiMO A delivers much more reliable connectivity for mobile users

BWX Products

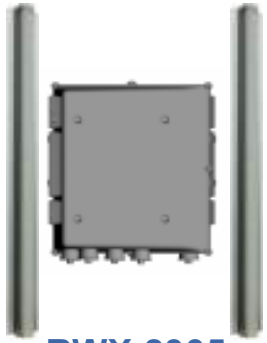
BWX 8305 Basestation

BWX 2305 Basestation

BWX 8326 Basestation Combiner

BWX 8303 Basestation Timing System

BWX 8305 Basestation Antenna



BWX 2305 Basestation Antenna

BWX 360 Outdoor Modem

BWX 350 USB Modem

BWX 320 desktop VoIP Modem

BWX 210 Desktop Modem

BWX 110 Desktop Modem

BWX 120 PCMCIA Modem

WiMAX Certification Profiles

Band Class	Spectrum Range GHz	Duplex	Channel BW (MHz) BS= “or”, CPE=“and”
1.A	2.300 - 2.400 GHz	TDD	8.75
1.B	2.300 - 2.400 GHz	TDD	5 & 10
2.A	2.305-2.320 GHz 2.345-2.360 GHz	TDD	3.5
* 2.B	2.305-2.320 GHz 2.345-2.360 GHz	TDD	5
2.C	2.305-2.320 GHz 2.345-2.360 GHz	TDD	10
3.A	2.496-2.690 GHz	TDD	5 & 10
4.A	3.3-3.4 GHz	TDD	5
4.B	3.3-3.4 GHz	TDD	7
4.C	3.3-3.4 GHz	TDD	10
5.AL 5.AH	3.4-3.6 GHz 3.6-3.8 GHz	TDD	5 5
5.BL 5.BH	3.4-3.6 GHz 3.6-3.8 GHz	TDD	7 7
5.CL 5.CH	3.4-3.6 GHz 3.6-3.8 GHz	TDD	10 10

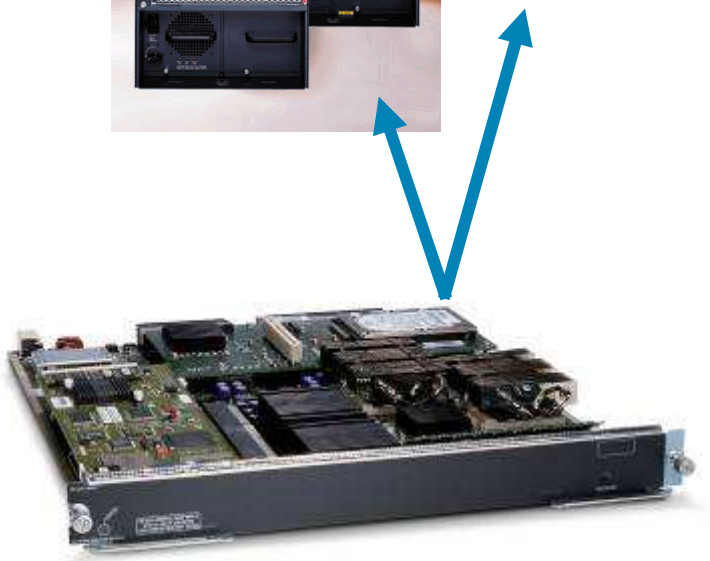
Cisco available products will be certified according to the above band classes

* Operation in USA WCS C & D bands is subject to incremental development & associate commercial agreement.

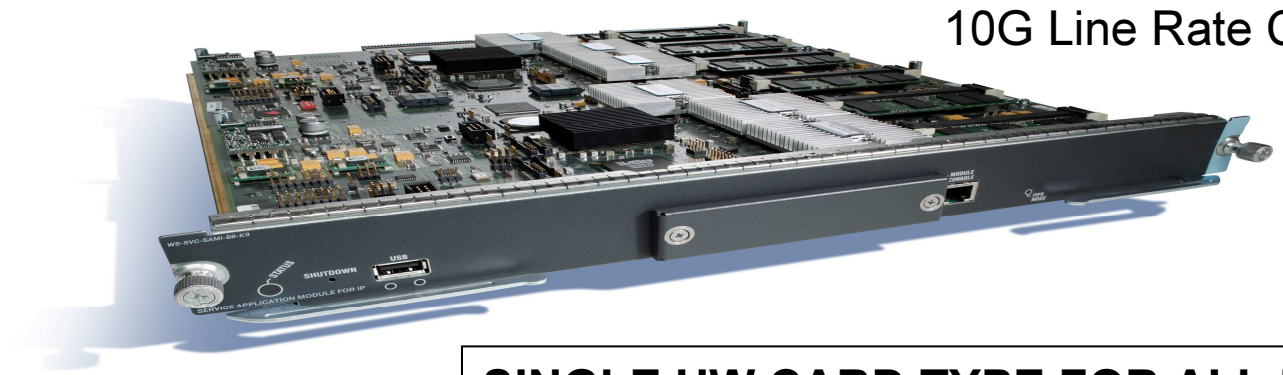
Cisco ASN-gw

Cisco BWG Gateway service module

- 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 BWG based on C7301 is available for Field/Demo trials

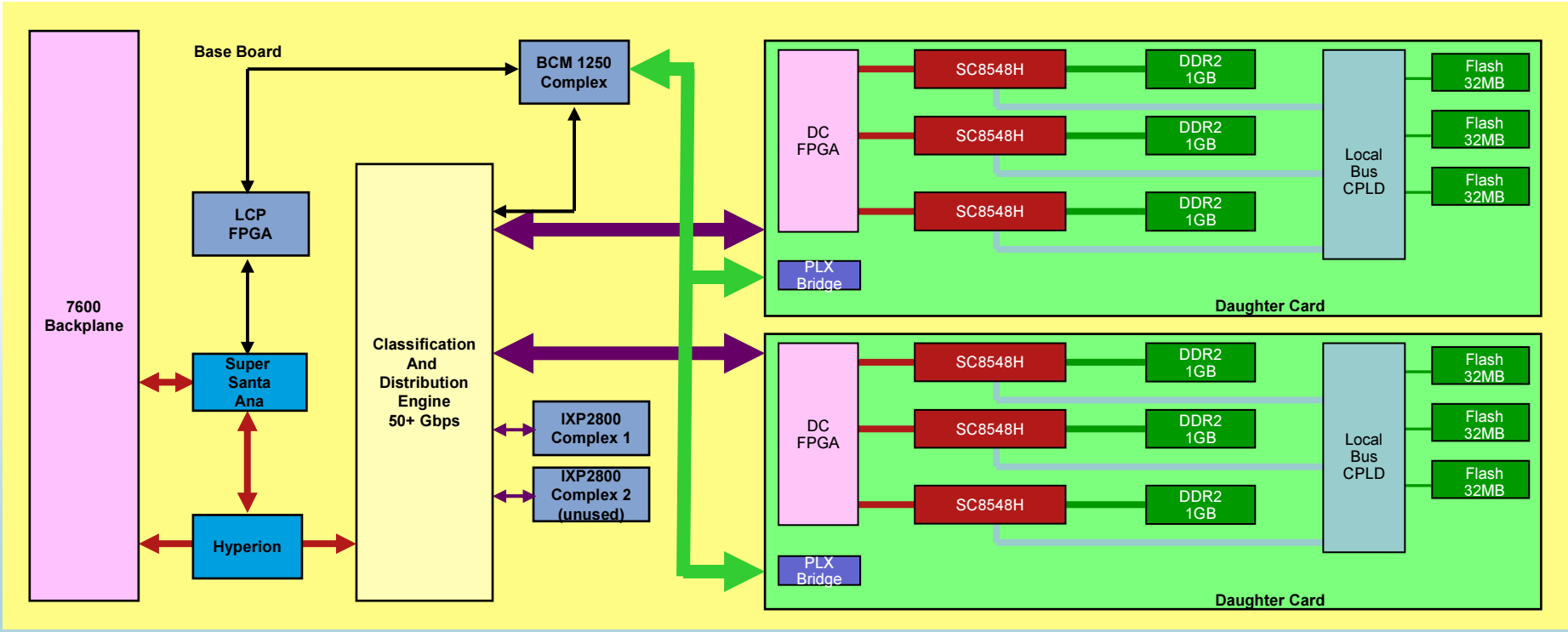


mSEF Hw: SAMI (starting Aug 07) → in 76xx chassis



S ervice
A pplication
M odule for
Ip

SINGLE HW CARD TYPE FOR ALL MOBILE APPLICATIONS



Cisco BWG Gateway Overview

Architecture

→**Carrier Class Features**

- BWG Clustering using ASNgw-SLB
- Geographic Load Balancing & Scaling
- Stateful 1:1 Redundancy

- Deep Packet Inspection & Accounting
- Carrier-grade billing support using CSG2 (pre & postpaid)

Scaling

→**Carrier Class Performance**

- 8 Gbps per card using IMIX packet
- 100K Subscribers, 30% active, 70% idle
- Unlimited # of sessions per Subscribers

Integration

→**Cico BWX RF Solution features**

Profile C: **R6 IP-cs, Keep-alives, C/U plane split**

Software

→**Release 1.1 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-CS and E-CS

Cisco WiMAX Service Models

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

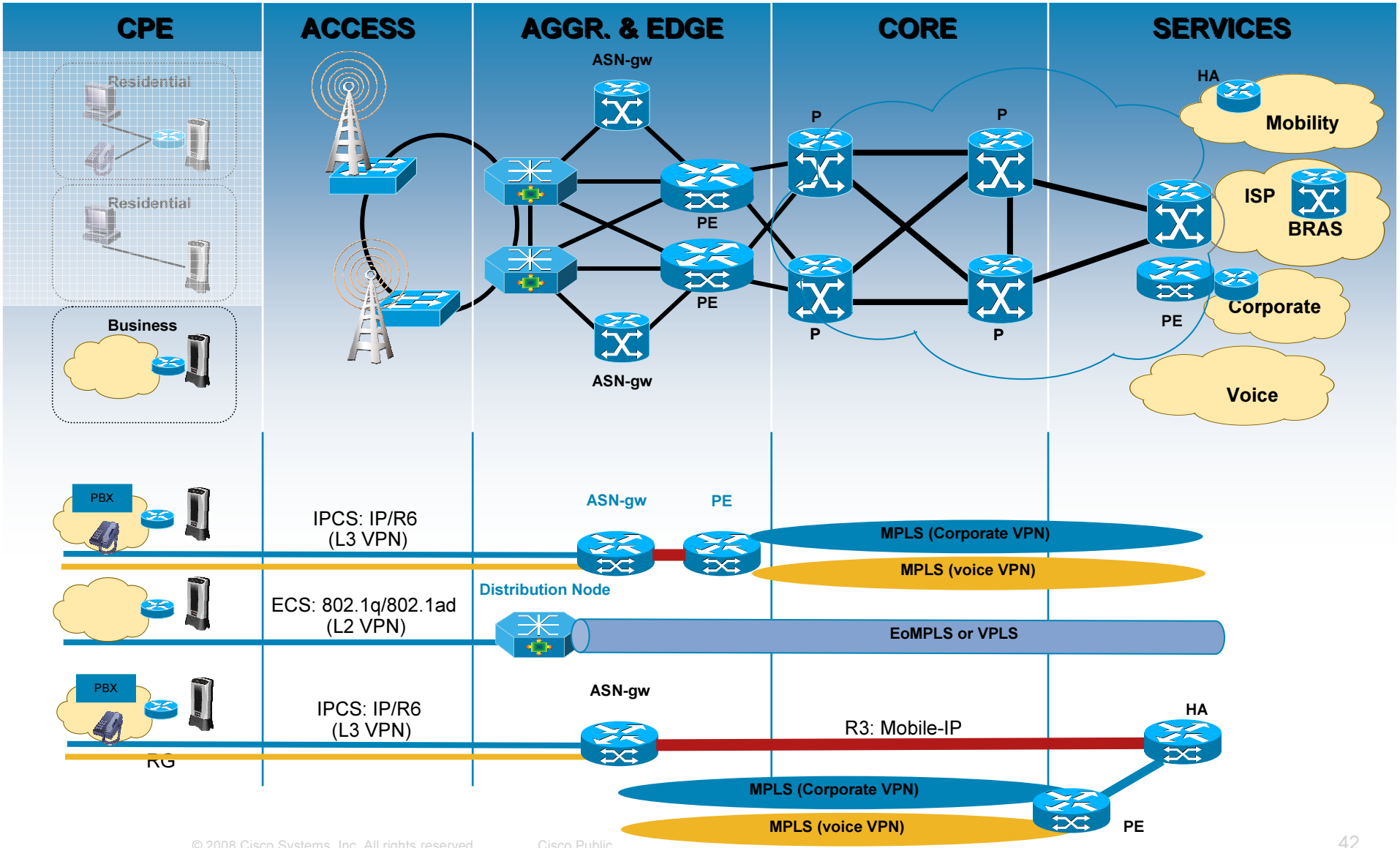
- Internet Access
- Voice Services

Consumer Services

- Internet Access
- Voice Services

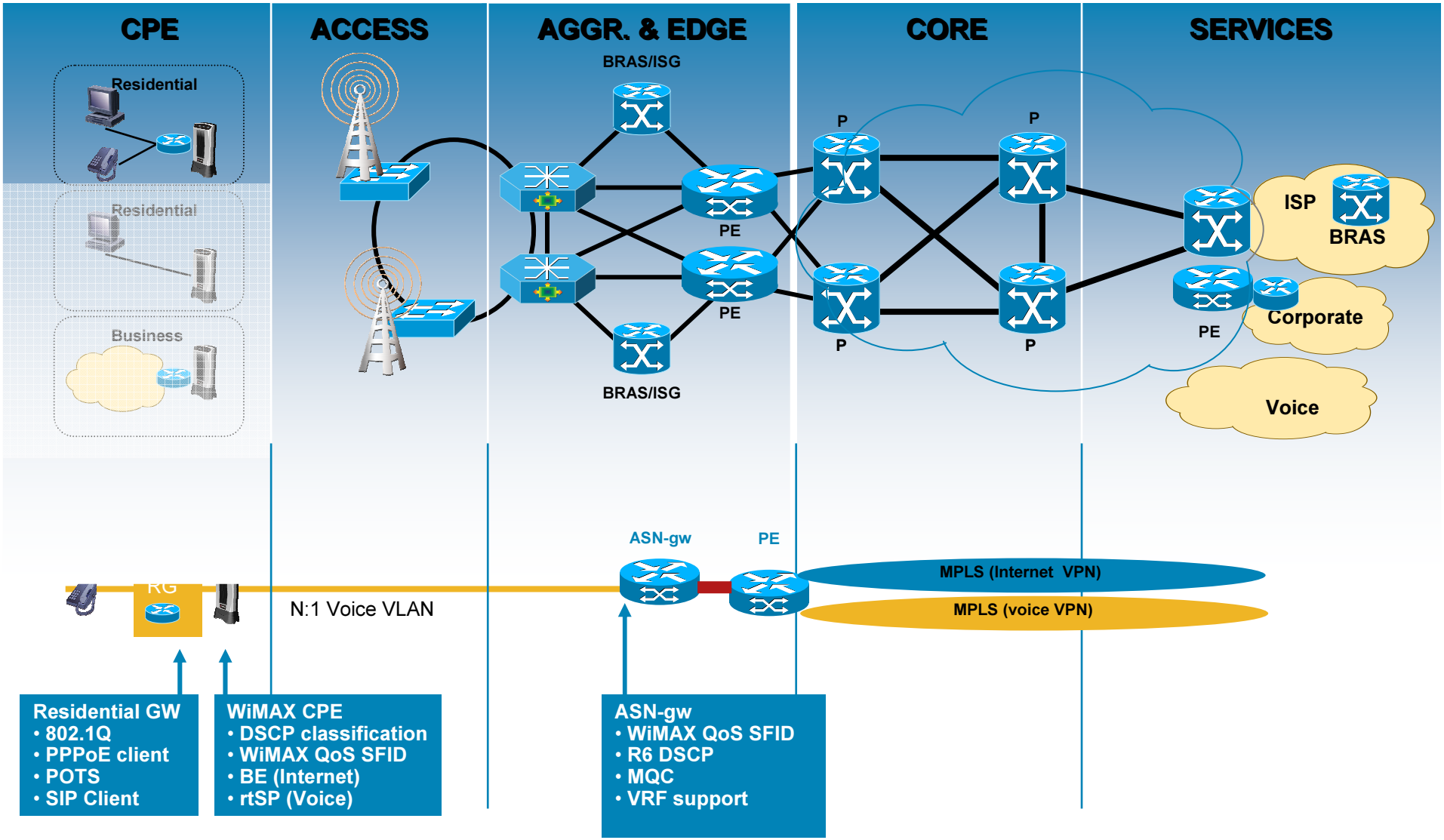
Business Voice & Data Service Model

802.16e-2005 based



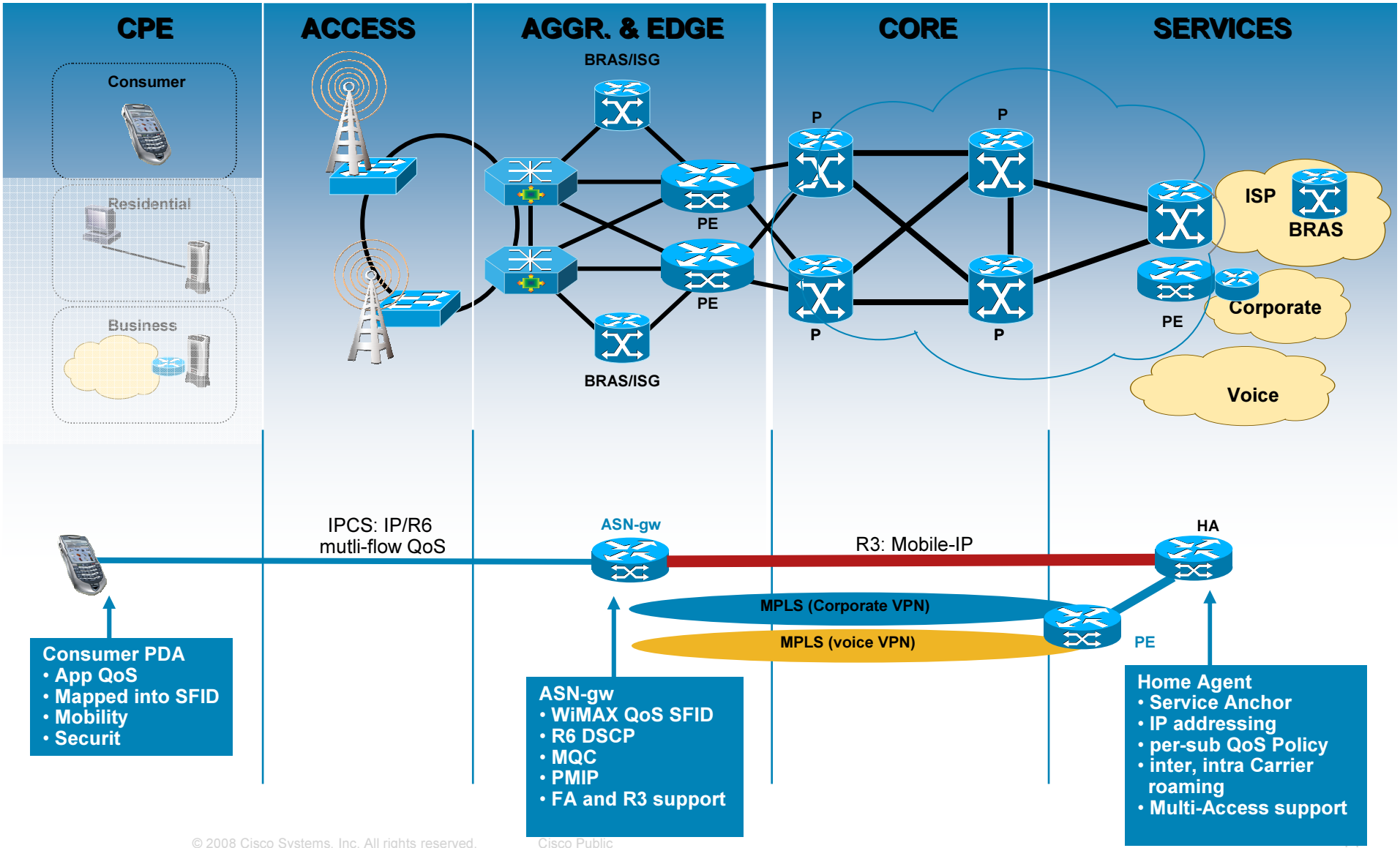
Residential Voice and Data Service Model

802.16e-2005 based



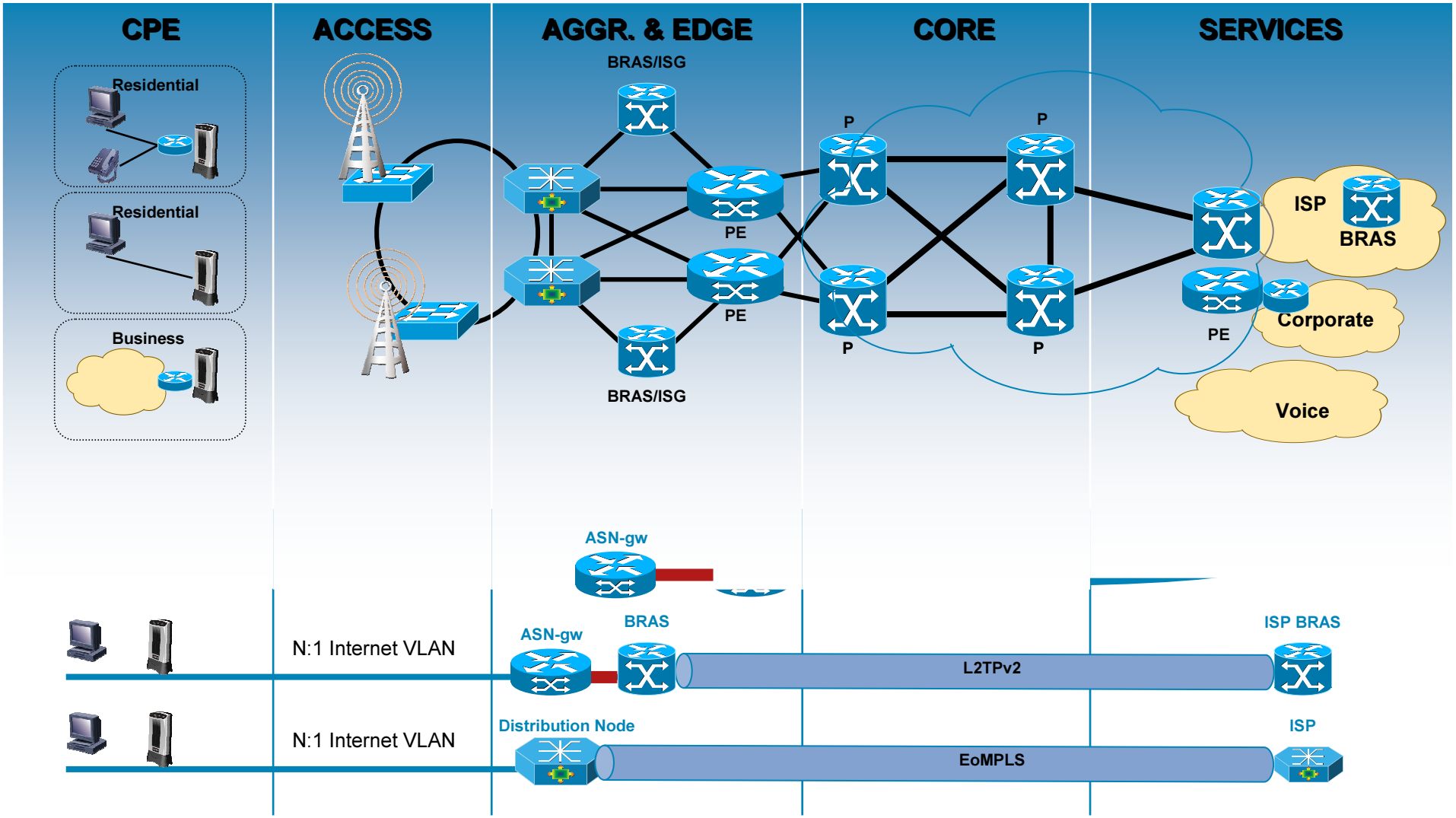
Consumer Voice and Data Service Model

802.16e-2005 based



Wholesale Voice & Data Service Model

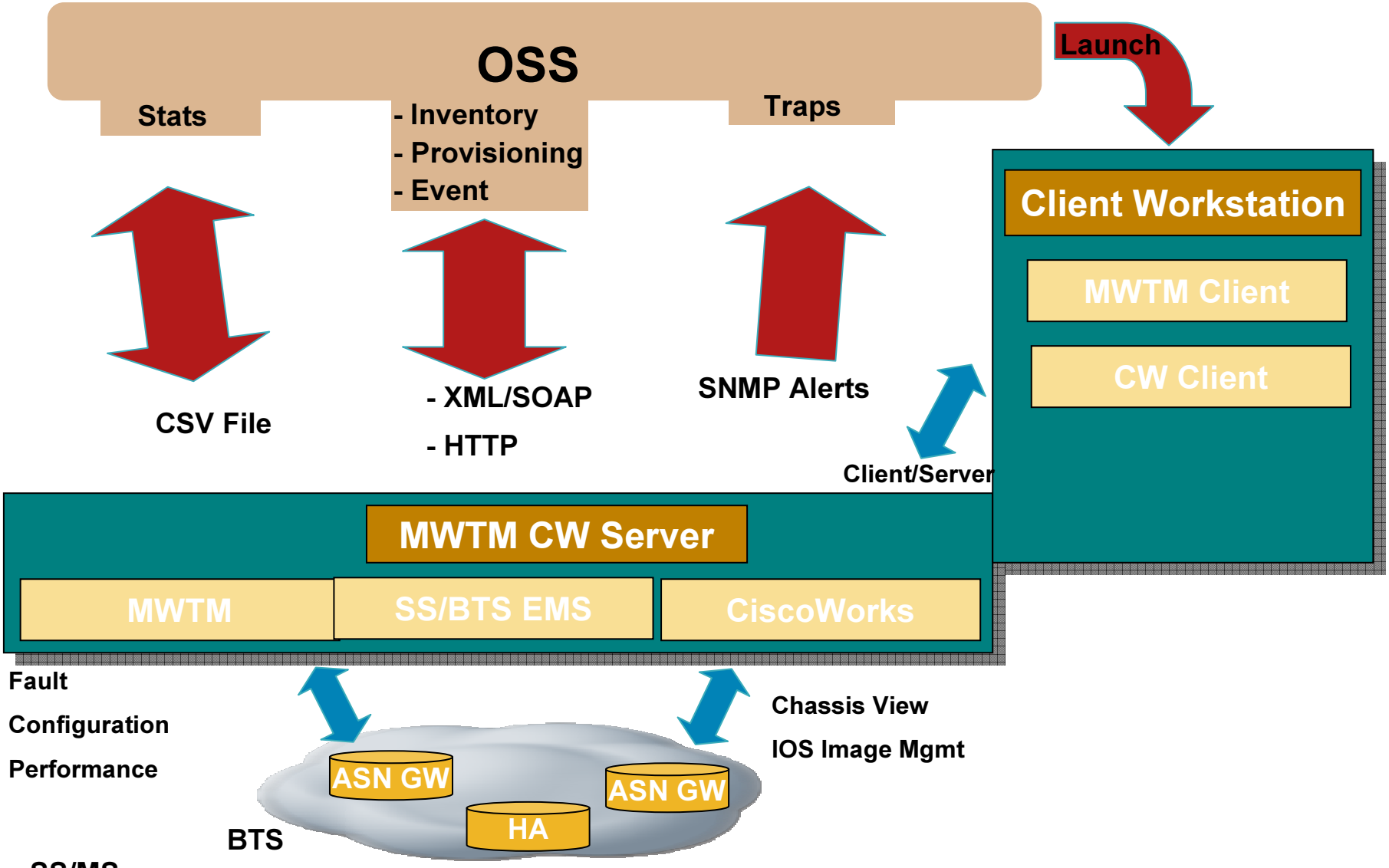
802.16e-2005 based



Element & Network Management Solution

Cisco EMS Solution Architecture

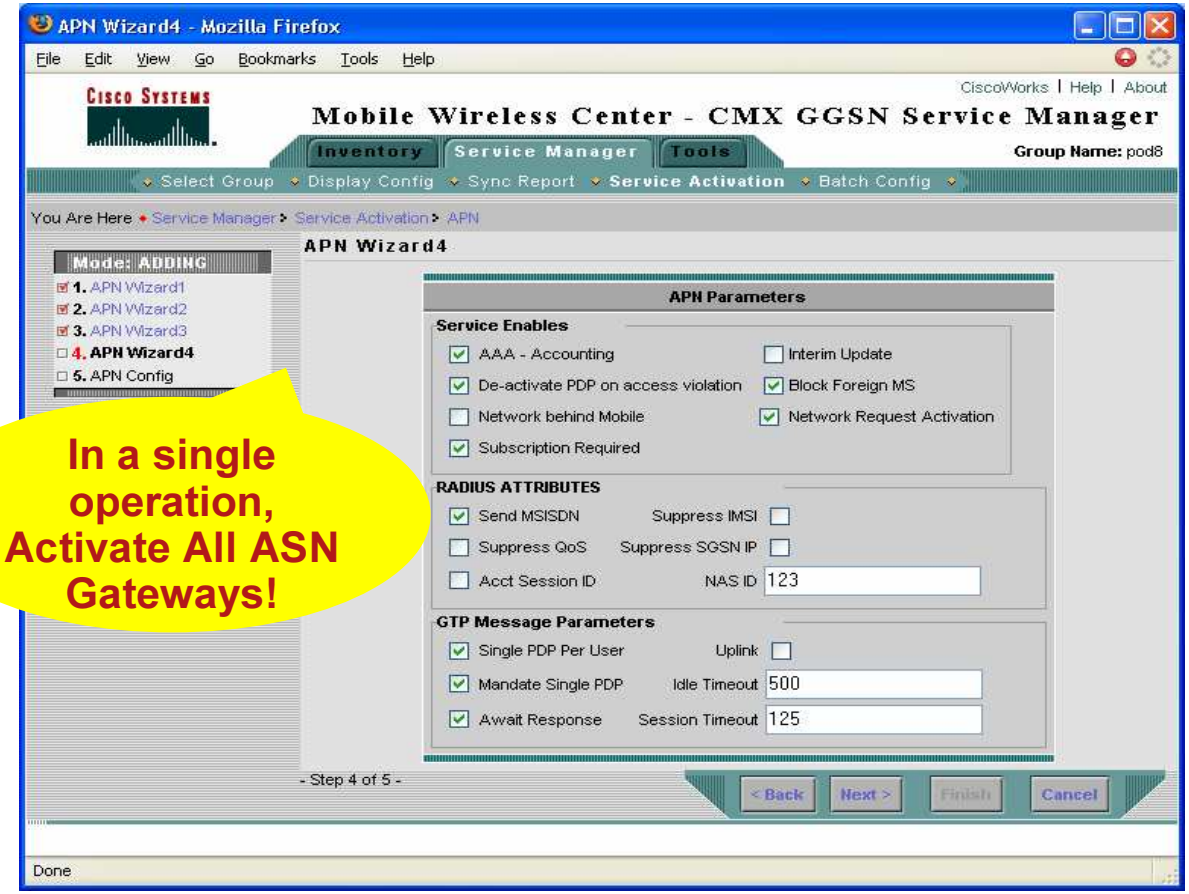
ASN-gw & Home Agent



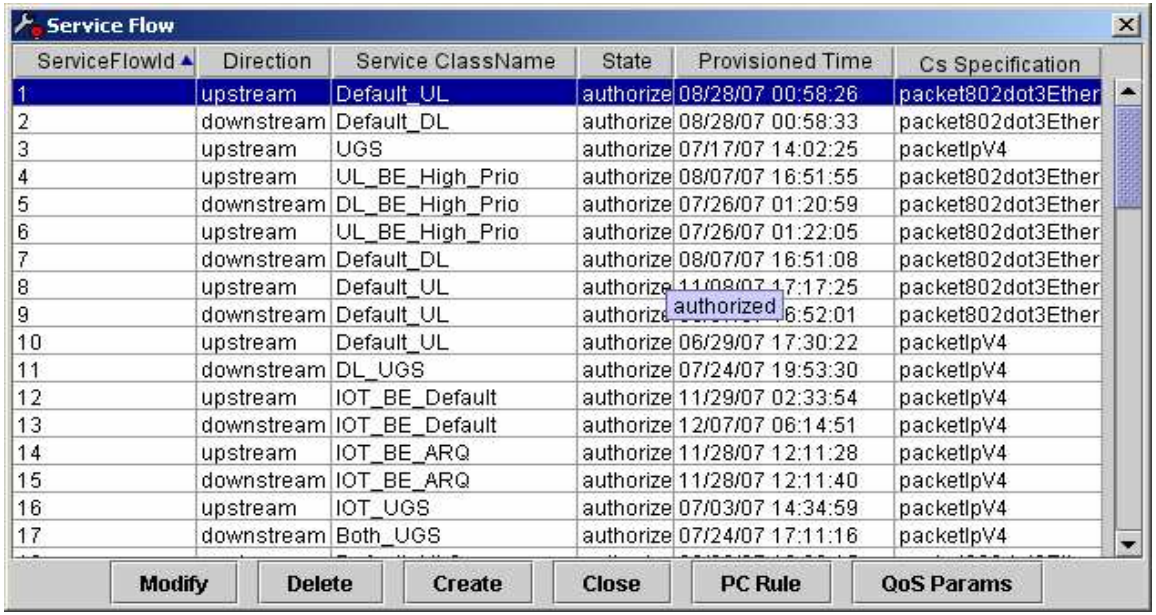
WiMAX EMS

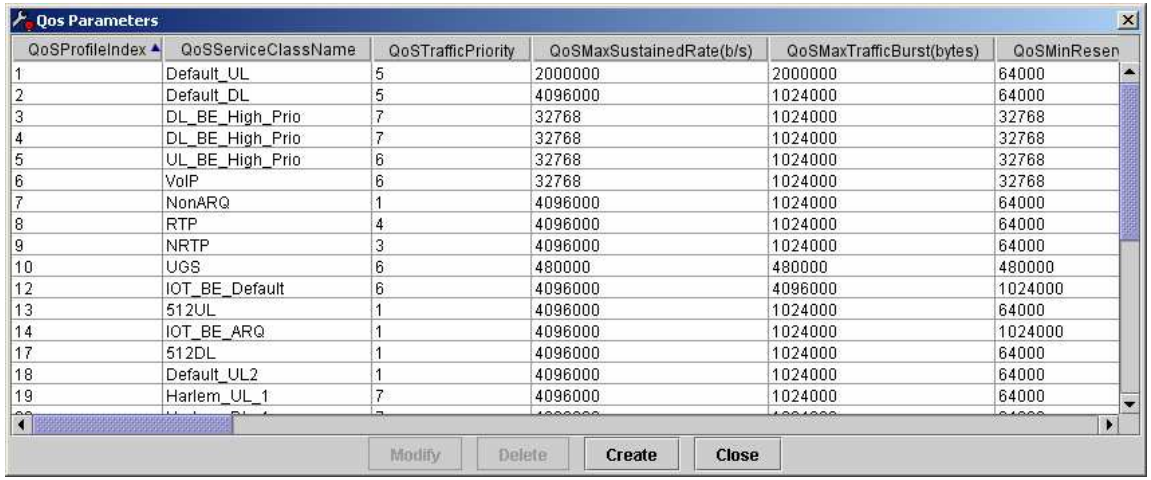
ASN-gw and HA Configuration Management (MWTM)

- **Deployment Wizards**
- **Base Stations**
- **User Groups**
- **Service Flows**
- **Classifier Profile**
- **QoS Profile**
- **MoIP Security Associations**
- **Virtual Networks**



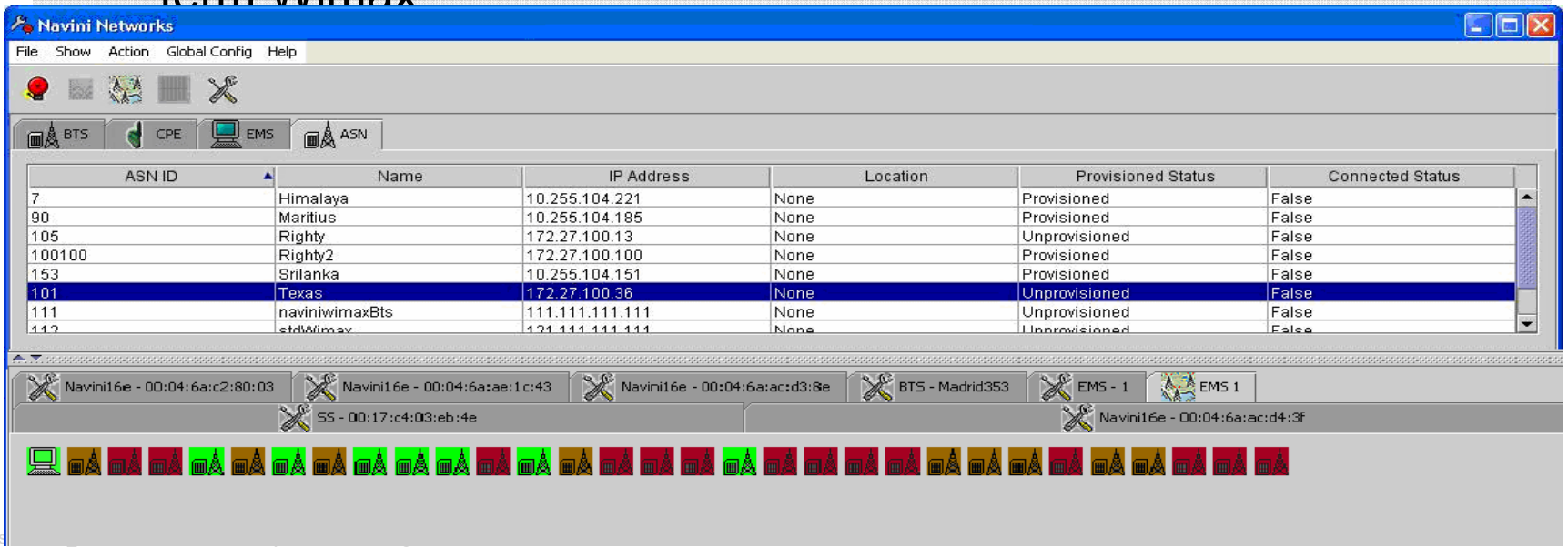
BWG/BTS/CPE Service Flow and QoS Configuration



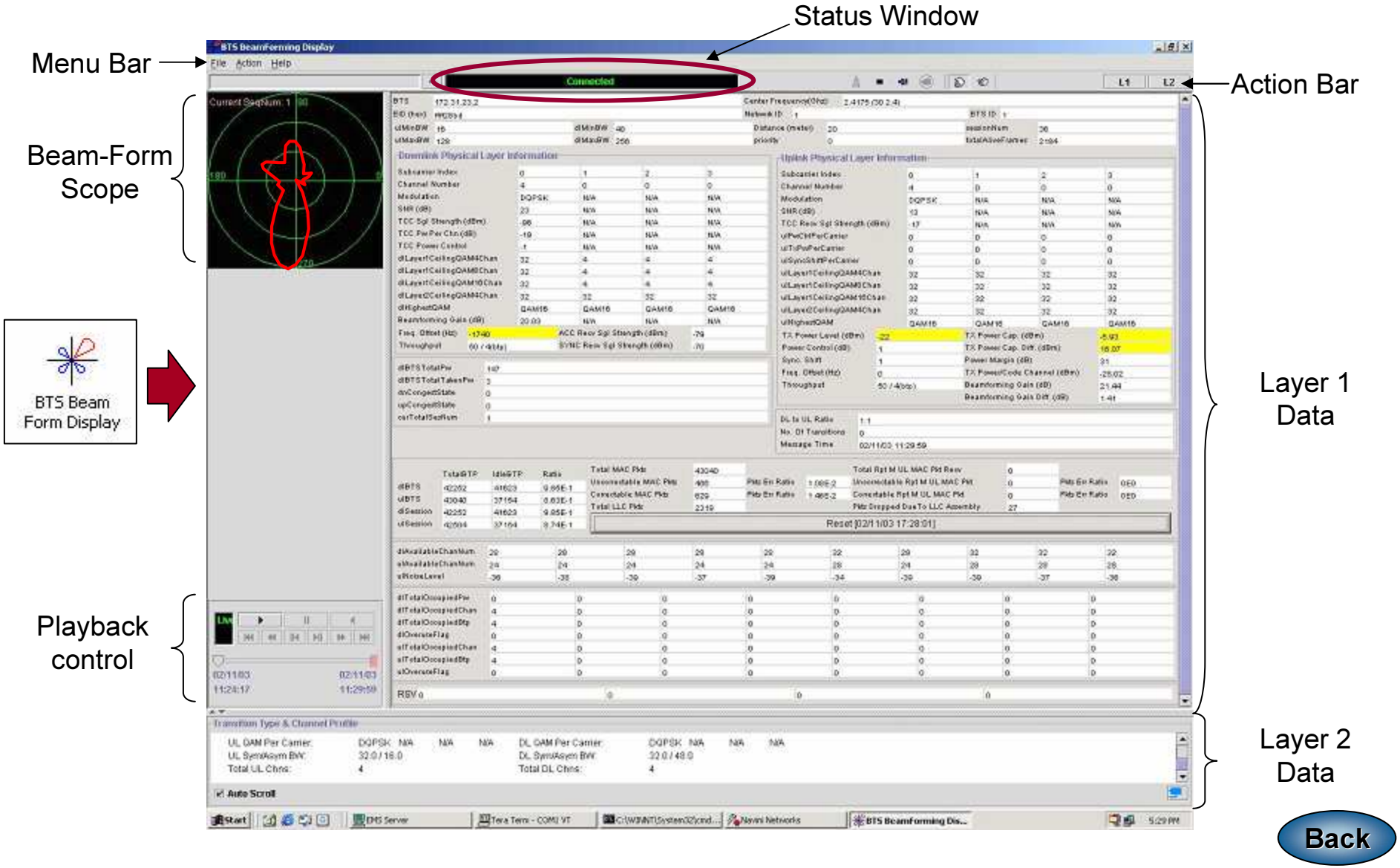


Modem Management

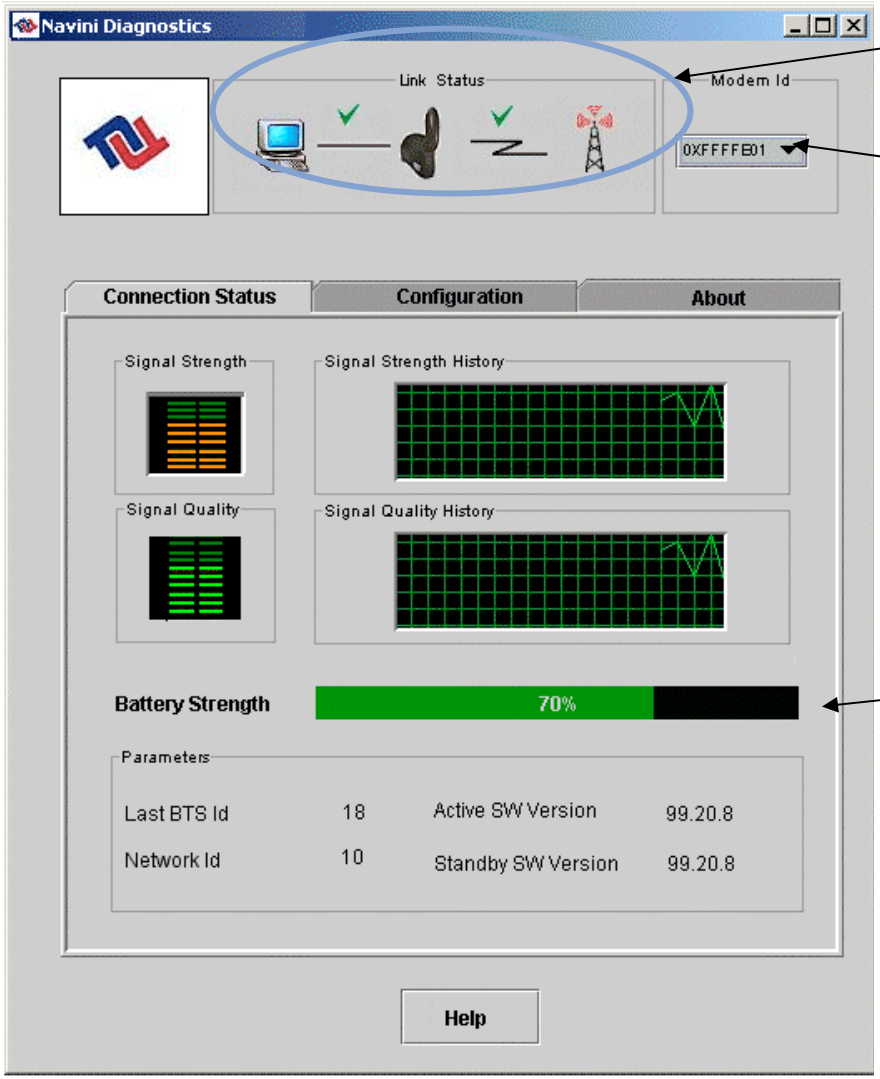
- AAA Modem Registration
  - For Wimax Certified modems and LMX, PMX, Surfer
- OTA Modem Upgrades, broadcast, auto-unicast
  - Already exists for Navini LMX, PMX, Surfer modems
  - Working with ODMs for 3rd party for short-term
  - Adopt Wimax Forum OMA-DM and TR-69 protocols for long-term Wimax



BTS Beamform Display



End user display



Connectivity Status:
cable to modem and BTS Sync.

Modem ID

Received Sync. Signal Strength, and SNR Readings

Battery Charge Status Bar Indicator

Key system parameters:

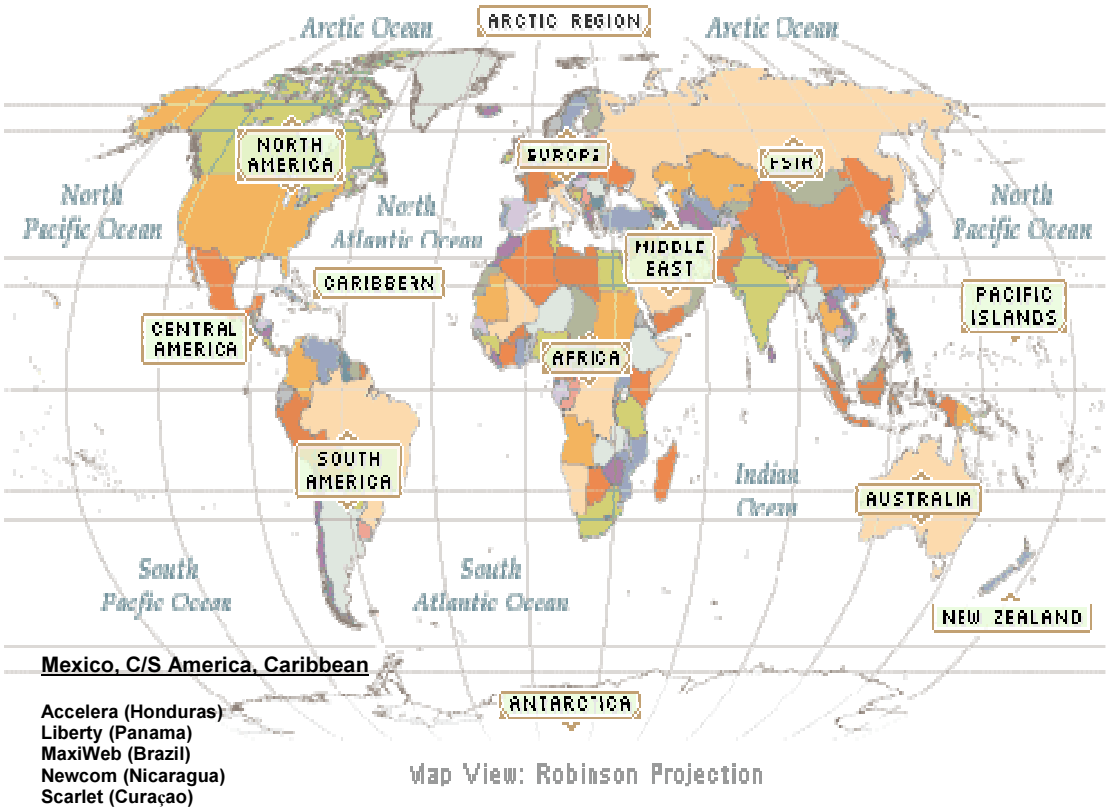
- **BTS Registration ID**
- **Network ID**
- **Software Version**

References

References

North America (US, Canada)

4D Networks (Oklahoma)
AmericaConnect (North Carolina)
BellSouth (Florida)
Black Hills Fibercom(South Dakota)
Camvera (Georgia)
Connect Data (Virginia)
Cooptel –trial (Quebec)
Down2Earth (Illinois)
EyeCom (Wisconsin)
James Cable (TX,Louisiana, Alabama)
MegaNet (Massachusetts)
NEC (Ohio)
NTELOS (Virginia)
NetDigital (Alabama)
Omnicity – (Indiana)
Rioplex (Texas)
Tessco (Maryland)
Unlimited Data (Missouri)
US Wireless On-line (Kentucky)
Winbeam (Pennsylvania)



Mexico, C/S America, Caribbean

Accelera (Honduras)
Liberty (Panama)
MaxiWeb (Brazil)
Newcom (Nicaragua)
Scarlet (Curaçao)
Telecable (Peru)
Ultravision (Mexico)

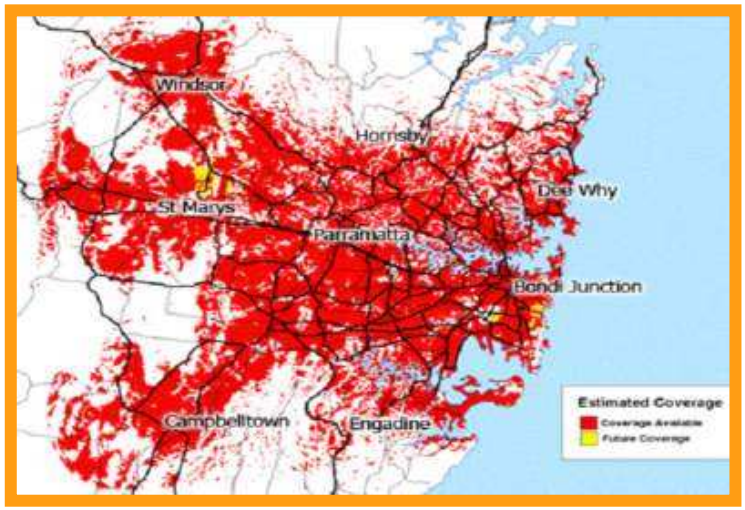
EMEA

Nomad Mauritius
Baltic Broadband Estonia
British Telecom UK
IBAX Italy
Irish Broadband Ireland
Panintra Mozambique
UKBroadband England
BT England
Hyperia Nigeria
Cobranet Nigeria
Direct on PC Nigeria
Zamnet Zambia
Gulfsat Madagascar
Internet Ghana
Benson online Tanzania

Asia-Pacific

China Mobile (China)
ElectroTek (Sri Lanka)
Focus Infocom (Maldives)
i-Pac (Fiji)
Samora Digital (Indonesia)
Sirius Broadband (Bangladesh)
Unwired (Australia)

Unwired Australia 3.5 GHz



- One of Australia's largest carriers, < 1 year
- In six months connected 20,000 users
- Achieved by self install network retail model
- 90% population coverage Sydney, 2,000 Km^2
  - 70 sites, 220 sectors

- **Getting 23% of all new broadband adds**
  - Over 70,000 subscribers
  - 70-80% customers can get DSL

- **Primary reason for picking Unwired**
  - No need for a phone line
  - Easy self-install, plug and play installation
  - Portablity / mobilty

Irish Broadband 3.5 GHz

- Irish Broadband was awarded 7 licenses in the 3.5GHZ spectrum
- Launched Ripwave service for the residential, SOHO and SME market in March 2004
- Have 150 Base stations and 26,000+ CPE
- Cover 100 percent of Dublin, now expanding into new cities
- Provide easy access to multi-megabit wireless broadband services for residential and small business customers.
- Using the RipWave branding aggressively in their marketing campaign.
- The key differentiator to the competition in Ireland is the mobile capability and fast service provision (no truck roll, no cabling)

Zamnet 2.5 GHz

- Largest ISP in Zambia, owned by the University
- Day one coverage to Lusaka and the copper mining belt
- VSAT Internet connectivity
- Focused on business then residential markets
- Recent deployment, 5 BTS's and 1,500 modems
- Expansion to other towns & capacity upgrade
- Successful TV campaign and excellent customer traction

Commercial 802.16e – Max Telecom

- 3.5GHz, 802.16e operator in Bulgaria
- Network coverage of 7.5M Pops, network launch in October 2007
- 100 BTS deployed, own network build and RF planning teams
- Services
  - Residential Access/ VOIP with nationwide numbering plan
  - Business/ Wholesale
  - Self Activation / Retail Model
- Navini RAN / Cisco Core network

Summary

- **Provide broadband services to mass markets**
  - Rapidly and very cost effectively
  - Retain your customers through differentiation
- **Cisco has the leading WiMAX technology and End-End all IP solution**
  - SMART WIMAX provides significant performance and business benefits over all other technologies
  - Cisco End-End all IP solution provides flexibility and assurance in your service offerings and therefore business strategy – competitive advantage
- **Technology & business case has been validated in many diverse markets**