Evolution of Wi-Fi and its Integration with Cellular Networks

March 17, 2005

Rias Muhamed
Lead Member of Technical Staff
Wireless Networks
SBC Laboratories Inc.

Outline

1. Wi-Fi Momentum and Evolution
2. Motivation for Wi-Fi Cellular Integration
3. Differences between Wi-Fi and cellular
4. Levels of Integration
5. Wi-Fi Cellular Data Roaming and Session Continuity
6. Wi-Fi Cellular Voice Mobility
7. Next Generation Convergence Architecture
8. Summary and Conclusions

Wi-Fi Momentum

- Strong Industry Acceptance – Wi-Fi Alliance
  - Over 1000 products from over 100 companies certified
  - Wi-Fi equipment market was $2.8B in 2004, up 15%, (Source: Infonetics)
- Wi-Fi being built-into several notebook computers, Pocket PC, PDA, etc.
- Intel launches the Centrino Platform for Mobile Computing
- 55 percent of the 32 million laptops shipped in 2003 had embedded Wi-Fi (Source: In-Stat/MDR)
- Wireless LAN Hotspot deployment gaining momentum
  - Over 20,000 hotspots deployed in the US
- Wi-Fi voice starting to pick-up
  - Several Wi-Fi phones in market
  - Products with Wireless Multi-Media (WMM) QoS standard certifications in market now

Comparison of Current 802.11 Standards

- Wi-Fi (802.11b/g/a) has been remarkably successful as a wireless data connectivity solution

	802.11b	*802.11g*	*802.11a*
Frequency Band	2.4 GHz ISM	2.4 GHz ISM	5.2 GHz U-NII
Maximum Data Rate	11 Mbps	54 Mbps	54 Mbps
Number of Channels	11	3	8
Non-overlapping Channels	3	3	8
Physical Layer	DS-SS, CCK	CCK, OFDM	OFDM
MAC Layer	CSMA/CA	CSMA/CA	CSMA/CA
Coverage Range	100 feet; typical indoor	100 feet; typical indoor	70 feet; typical indoor
Interference Issues	Crowded band; microwave ovens	Crowded band; microwave ovens	Clearer band; lesser issues
Status	Most popular	Rapid popularity after Jun 2003 release	Largely adopted for niche applications

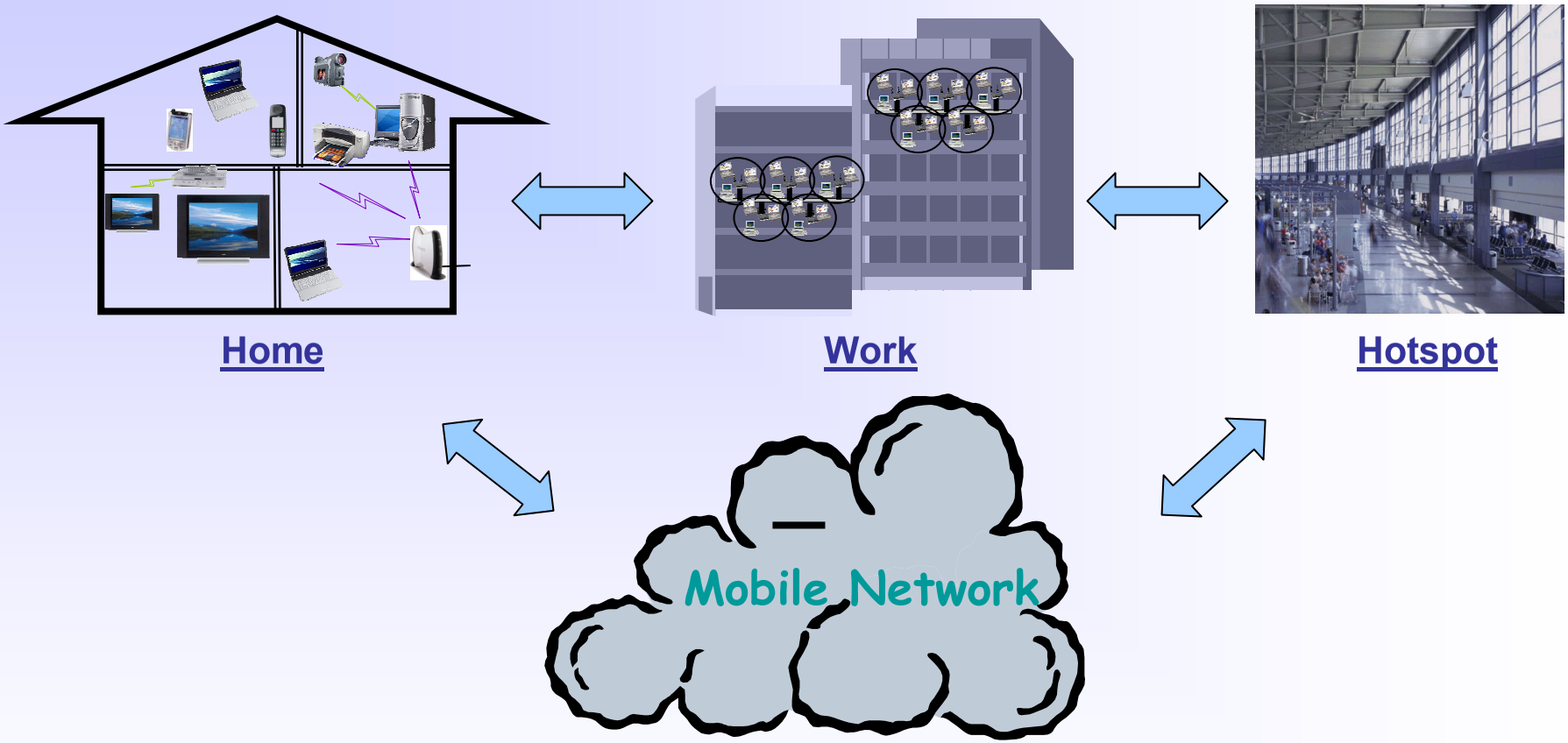
802.11g emerging as the most popular standard; many Access Points and cards now support all three modes

Enhancements to 802.11

- IEEE 802.11 Standard evolving to enhance support for:
  - Quality of Service (802.11e)
  - Robust Security (802.11i)
  - Radio Resource Management (802.11k)
  - Fast Roaming (802.11r)
  - Mesh Networks (802.11s)
  - Higher Throughput (802.11n)
  - Integration with Cellular Networks (3GPP)

Task Group Name	Task	Status
I	Improve security of 802.11 networks	Ratified on June 24, 2004
E	Enhance MAC layer to support QoS, multimedia	Draft 7.0 now. Expected completion 2Q05
K	Improve Radio Resource Management	Moving to sponsor ballot; expected to complete in 4Q 2005
R	Fast Roaming for better support of VoIP and other applications	Currently in draft; Expected to complete in 1Q 2006
S	Mesh Networking for interconnecting Access Points	Currently in draft; Expected to complete 4Q2006
N	Over 100 Mbps throughput support	Currently in early stages. Expected to complete in 1Q 2007

Wi-Fi Applications



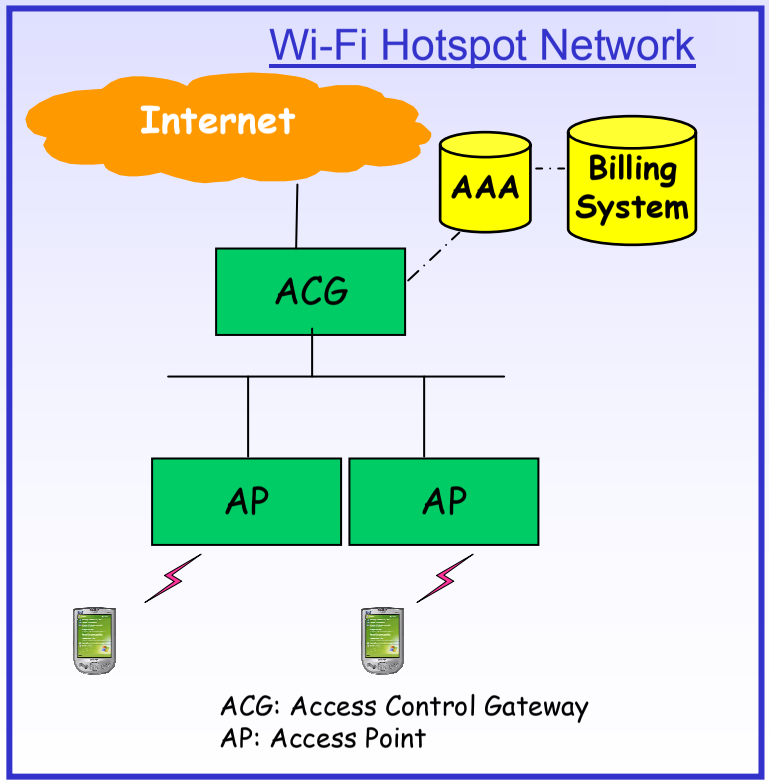
Wi-Fi has emerged as a common standard for the enterprise, home and public space domains. Integrating Wi-Fi and cellular can provide significant benefits to users and service providers

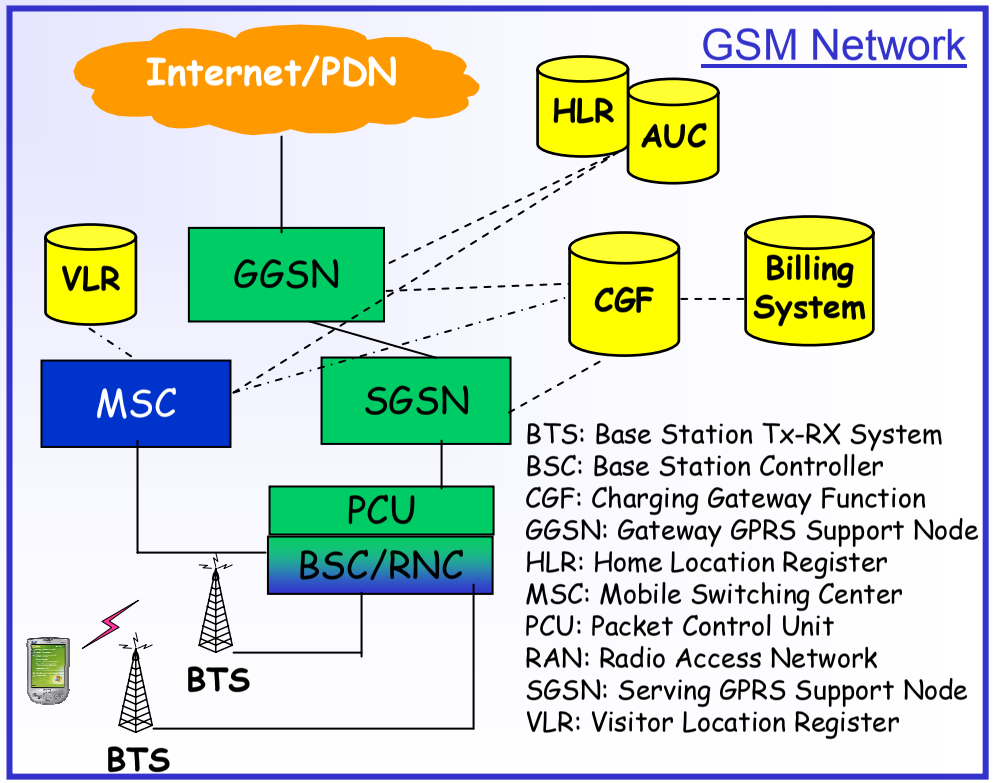
Motivation for Wi-Fi - Cellular Convergence

- End User Motivation
  - Access to their voice and data network wherever they are
  - Minimizes number of terminal devices to carry
  - Would like to deal with fewer service providers
- Mobile Service Provider Motivation
  - Over 30% of mobile use is now within the home and office – Yankee Group
  - Exploiting on-premise Wi-Fi can enhance wireless coverage and throughput performance inside buildings
  - Relieve capacity strains on wide area network.
  - Exploiting cheaper Wi-Fi networks can reduce cost
- Broadband Service Provider Motivation
  - 52% of broadband households are interested in VoIP telephone service – Park Associates
  - Make home VoIP phones mobile by converging with cellular networks
  - Extend enterprise PBX/Centrex offerings to cellular networks
  - Enhance wireless data service at hotspots by combining with cellular service

Wi-Fi – Cellular Service Comparison

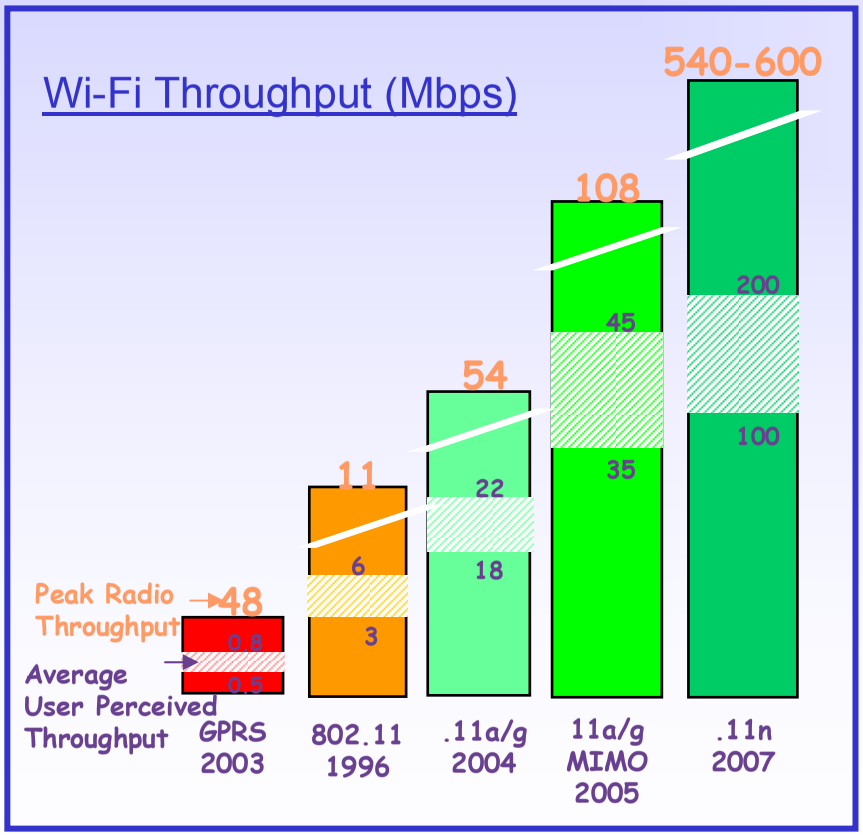
1. Wi-Fi systems are designed for fixed/nomadic, local area data and later voice communications. Cellular systems are designed for full-mobility, wide area, voice and later data communications

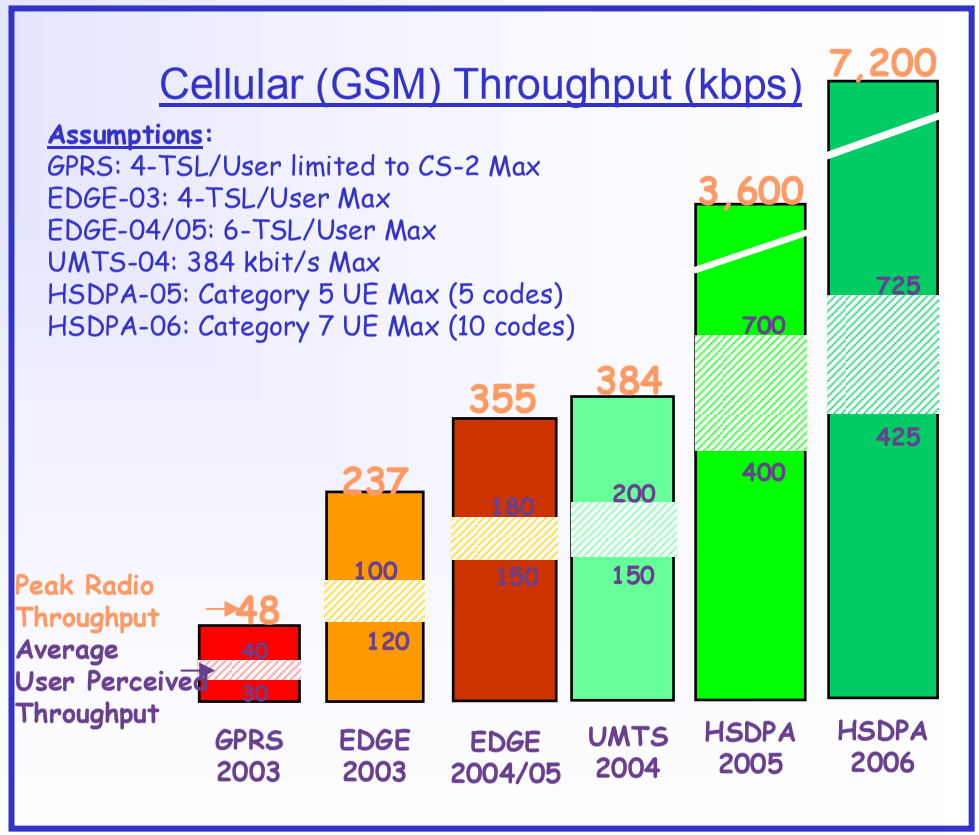




Wi-Fi – Cellular Service Comparison (Contd.)

2. Wi-Fi Networks offer multi-Mbps data throughput, Cellular Networks offer 10s-100s of Kbps





Wi-Fi – Cellular Service Comparison (Contd.)

3. QoS support built into cellular networks with circuit switched voice and priority based data service; QoS support still evolving for Wi-Fi
4. Cellular systems operate in licensed band where service quality and reliability can be assured; Wi-Fi systems operate in unlicensed bands with no such assurances.
5. Cellular systems provide robust security and authentication; Many deployed Wi-Fi systems still have security concerns
6. Roaming mechanisms and arrangements are well defined and established among cellular carriers. Wi-Fi roaming is evolving in an ad-hoc fashion.

Significant differences between the two networks and services makes the integration work challenging

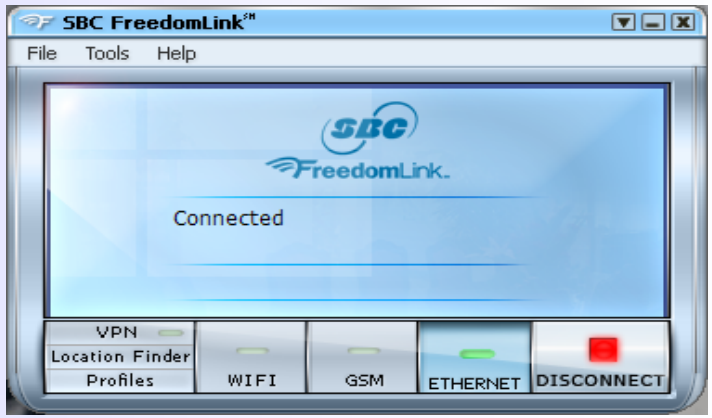
Levels of Integration

1. Common Billing and Customer Care
2. Seamless roaming between Wi-Fi and cellular data services using a Common Connection Manager
3. Common Authentication scheme and subscriber data bases
4. Common Multi-system terminals
5. Seamless handover of data sessions between Wi-Fi and cellular
6. Access to 3GPP Packet Services over Wi-Fi
7. Seamless handover of voice calls between Wi-Fi and cellular
8. Full services and application integration with personal, terminal, session and service mobility across the two networks

Roaming Using Common Connection Manager

FreedomLink Splash Page

Roaming Client

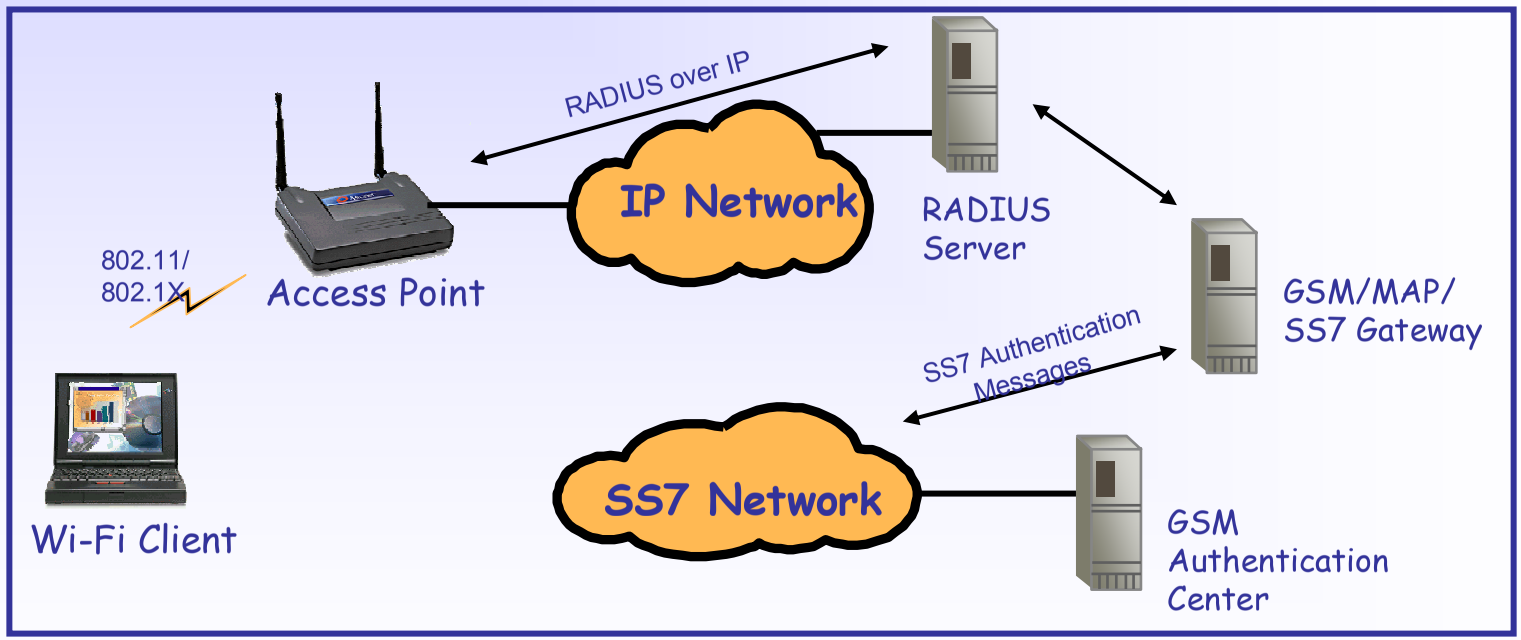


- Manages both Wi-Fi and GPRS/EDGE network connections
- Does Automatic and Manual Network Selection
- Hides roaming complexity from user
- Does User and Carrier Profile Management
- Supports Wi-Fi Location finding
- Customer support
- Enhances customer experience

A common connection manager can enable roaming across Wi-Fi and cellular networks today

Common Authentication Using EAP-SIM

- IETF has a draft standard that uses GSM SIM card based identity for authentication within the 802.1X framework used by Wi-Fi
  - Extensible Authentication Protocol Method for GSM Subscriber Identity Modules
    - (EAP-SIM) draft-haverinen-pppext-eap-sim-16.txt
  - Overcomes concerns over simple password authentication
  - EAP-SIM adopted as part of 3GPP WLAN Interworking Specification



- Some carriers have deployed SMS based one-time password authentication for Wi-Fi hotspots as well

Common Multi-System Terminals

- Multi-system terminals in a variety of form-factors are emerging in the market-place

Type	Vendor	Model
Combo PC Card	Nokia	D211
	Sony Ericsson	GC79
	Option	GlobeTrotter
	Novatel	Merlin G100
PDA	HP	iPAQ 6315
	Qtek	9090/Cu928
	Symbol	PPT 8000
Smart Phones	Motorola	MPx/MPx100
	LG	SC8000
	Nokia	Communicator 9500
	Audiovox	PPC5050/PPC4100
	Samsung	PPC i600/i700
Multi-system Handset	Motorola	CN620

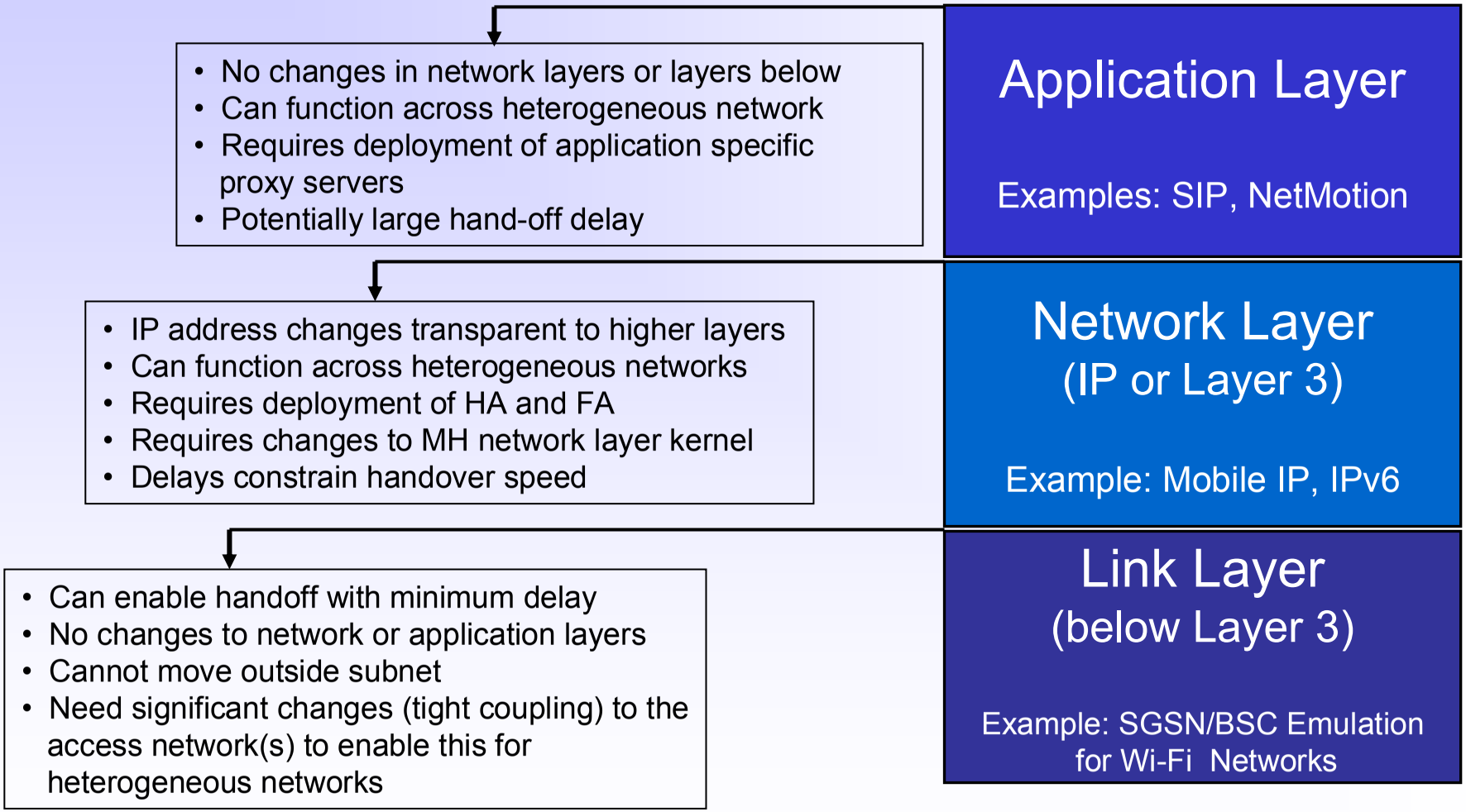
- In addition to having multiple radios, for tighter integration, terminals should:
  - Support intelligent network selection
  - Support intelligent power management
  - Support seamless handover mechanisms

Seamless Data Session Continuity

Definition:

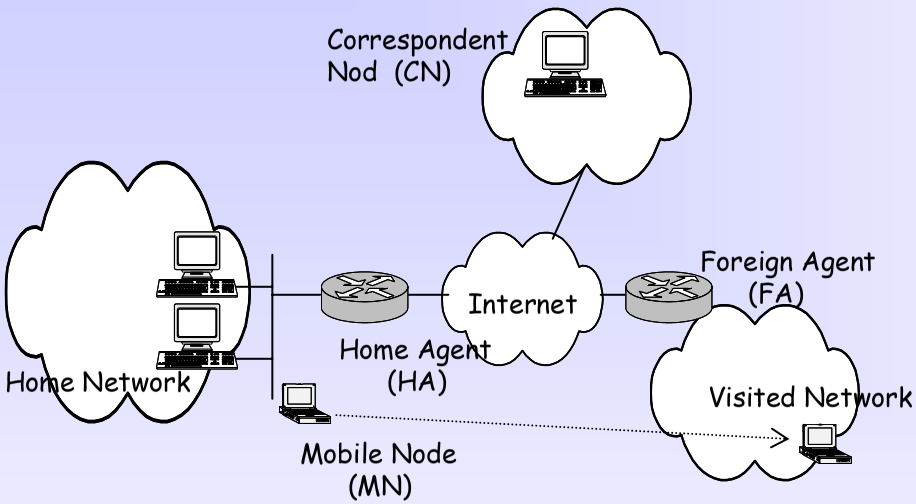
- Data Session Continuity: Ability to continue a data session (e.g. file download, streaming video) unbroken while moving between two networks. E.g. Wi-Fi and cellular networks
- Seamless: Implies transfer of connectivity from one network to the other is perceived by the user as being without significant delay (fast) and without packet loss (smooth).
  - Characteristics varies with application
  - Does the session have to maintain same QoS?
- Since Wi-Fi and cellular networks are typically in different IP subnets, providing Data Session Continuity across Wi-Fi and cellular networks can be thought of as fundamentally an **IP Mobility** problem with additional quirks.

Mobility Management at Which Layer?

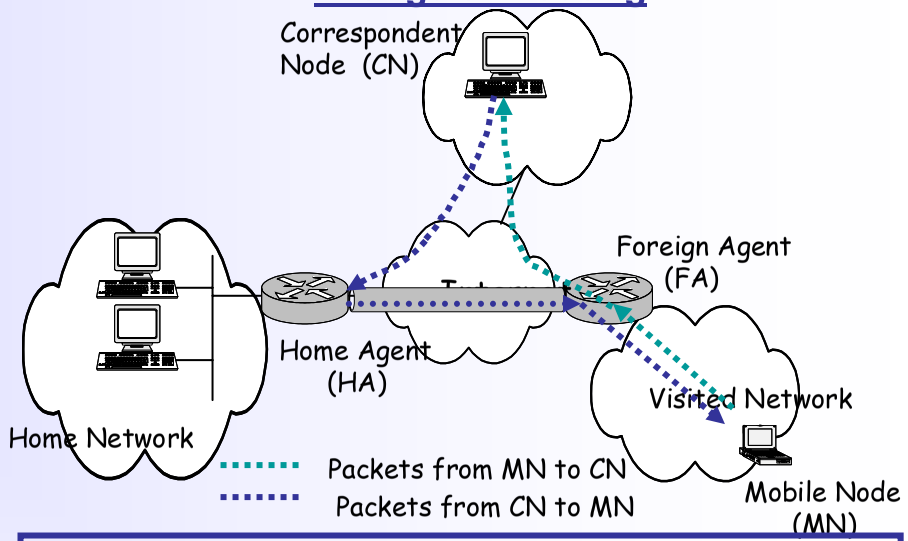


Mobile IP

Mobile IP Components



Triangular Routing



Basics:

- Defined in RFC 3344 for IPv4
- Each mobile node has two addresses: 1. A permanent identifier IP address issued by the home network, 2. A locator IP address (care-of-address) issued by the visited network.
- Components: Home Agent (HA), Foreign Agent (FA), Mobile Node (MN), and Correspondent Node (CN)
- MN informs HA when at a visited network through registrations and binding updates
- Packets to mobile are tunneled to CoA from HA to FA using IP in IP encapsulation (RFC2003)

Benefits:

- Supports terminal mobility
- Transparent to application
- Transparent to network

Issues:

- Triangular Routing – partly solved with RO
- Ingress filtering – solvable with reverse tunneling
- NAT Traversal
- Every MN needs a permanent home address.
- Need to deploy Foreign Agents
- QoS implementation problematic
- Signaling overhead may be large
- Handover may be slow

Mobile VPN

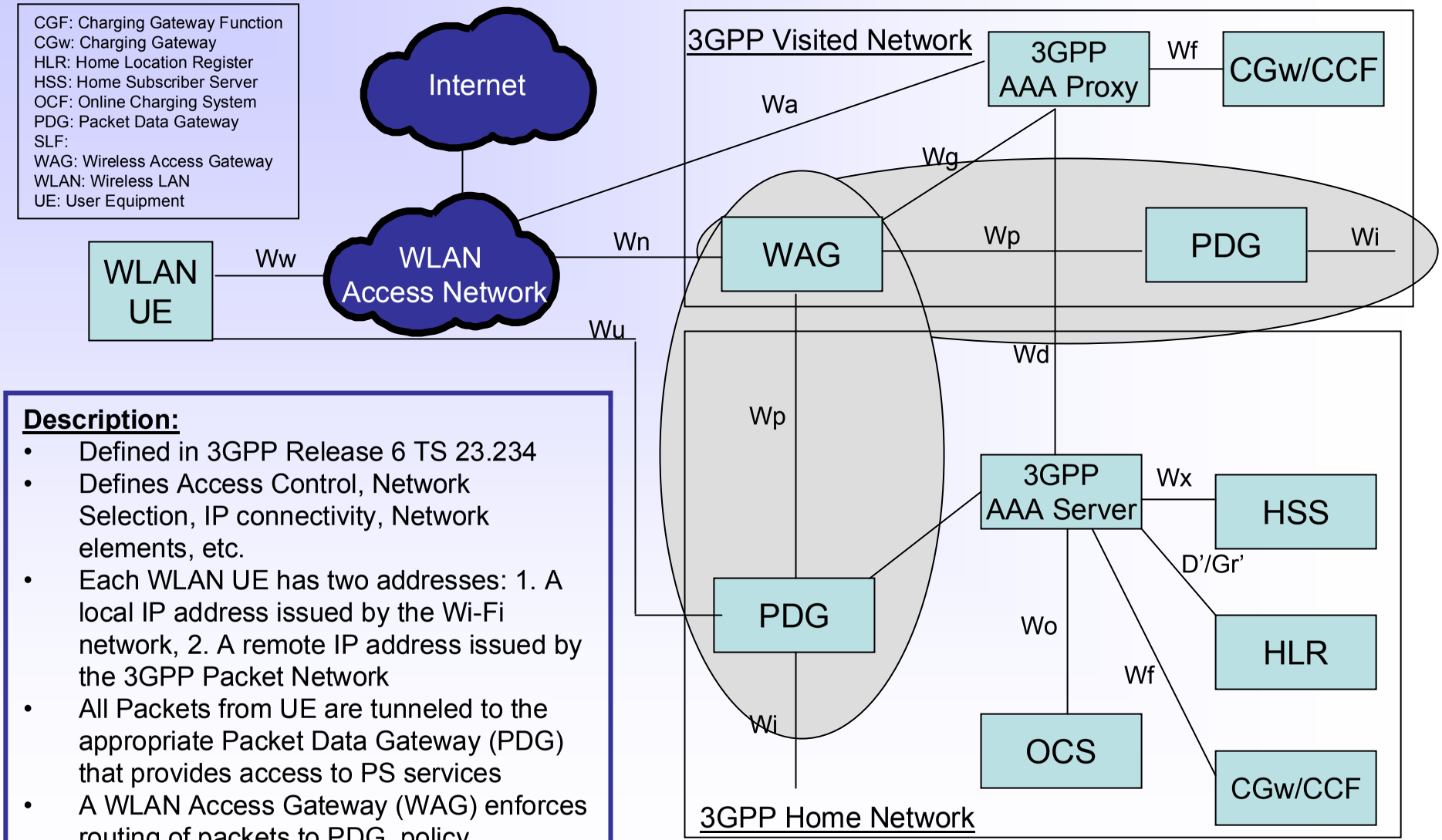
- One important application of Seamless Data Session Mobility is the ability to keep a VPN connection up when moving between networks
- Mobile IP with standard VPN client/infrastructure may not cut it.
- A good mobile VPN solution must address:
  - Intermittent connectivity and mobility
  - Variable and unpredictable bandwidth and latency
  - Need to keep overhead low
  - Mobile device form factors and Operating Systems
  - Scalability for large carrier deployments
- What is available today are proprietary Mobile VPN solutions mostly targeted at the enterprise
  - E.g. IBM Websphere Everyplace Connection Manager (WECM)
- **Challenge**: Can we enable seamless mobility without changes to deployed enterprise VPN solutions?

Wi-Fi Access to 3GPP Packet Services

- Getting access to 3GPP Packet Service (PS) Domain applications and services over a public Wi-Fi Access network
- Examples of Applications include:
  - Sending and receiving SMS and MMS from a Wi-Fi hotspot
  - Support for Push-to-talk service over a Wi-Fi access network
  - Extend network based VPN services offered over cellular network to Wi-Fi hotspots.
  - Access to Parley, Location Services, etc.

3GPP Model for WLAN Access to PS

CGF: Charging Gateway Function
CGw: Charging Gateway
HLR: Home Location Register
HSS: Home Subscriber Server
OCF: Online Charging System
PDG: Packet Data Gateway
SLF:
WAG: Wireless Access Gateway
WLAN: Wireless LAN
UE: User Equipment



Description:

- Defined in 3GPP Release 6 TS 23.234
- Defines Access Control, Network Selection, IP connectivity, Network elements, etc.
- Each WLAN UE has two addresses: 1. A local IP address issued by the Wi-Fi network, 2. A remote IP address issued by the 3GPP Packet Network
- All Packets from UE are tunneled to the appropriate Packet Data Gateway (PDG) that provides access to PS services
- A WLAN Access Gateway (WAG) enforces routing of packets to PDG, policy enforcement, collects accounting information, etc.

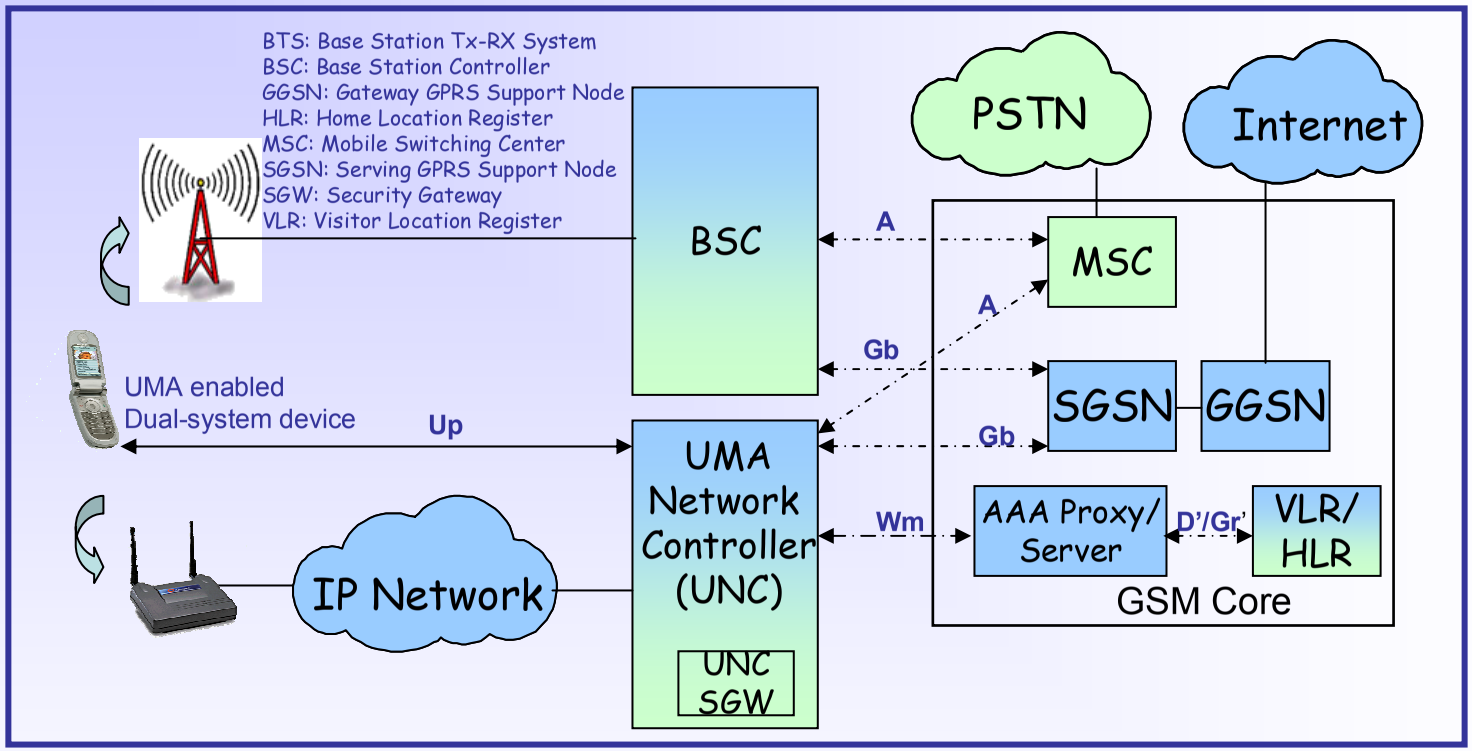
Seamless Voice Mobility

- Ability to switch between cellular and Wi-Fi networks during a voice call without any user perceived interruption.
- Big driver for wireless-wireline convergence
  - Operators interested in providing voice service transparency across the two networks.
- Several End-User Scenarios Possible. For e.g.
  - Single Wireless Number: Take Mobile Phone home as cordless Home phone
  - Single Wireline Number: Take cordless Home Phone out as Mobile Phone
  - Wireless and Wireline Number: Presence Aware Routing of calls
  - Wireless or Wireline Number: Take Mobile phone or cordless Home phone to a hotspot
- Several solutions emerging from:
  - Consortiums such as UMA and SCCAN
  - Single vendors such as Bridgeport and Varaha
  - Standards bodies such as 3GPP

Unlicensed Mobile Access (UMA)

- Broad consortium of GSM mobile operators and vendors
  - BT, Cingular, Rogers Wireless, O2, T-Mobile
  - Alcatel, Ericsson, Kineto, Motorola, Nokia, Nortel, Siemens, Sony-Ericsson
- An extension of GSM/GPRS mobile service to the unlicensed customer premise environment
  - Enhance customer premise coverage, network capacity, and potentially lower cost
- Allows roaming and handover across GSM and Wi-Fi networks
- Achieved by tunneling GSM/GPRS protocols through a broadband IP network and an unlicensed radio link (e.g. Wi-Fi, Bluetooth) in the customer premise
- UMA is now included in 3GPP Release 6 specification within GERAN as GAN (Generic Access Network) or Technical Specification 43.318

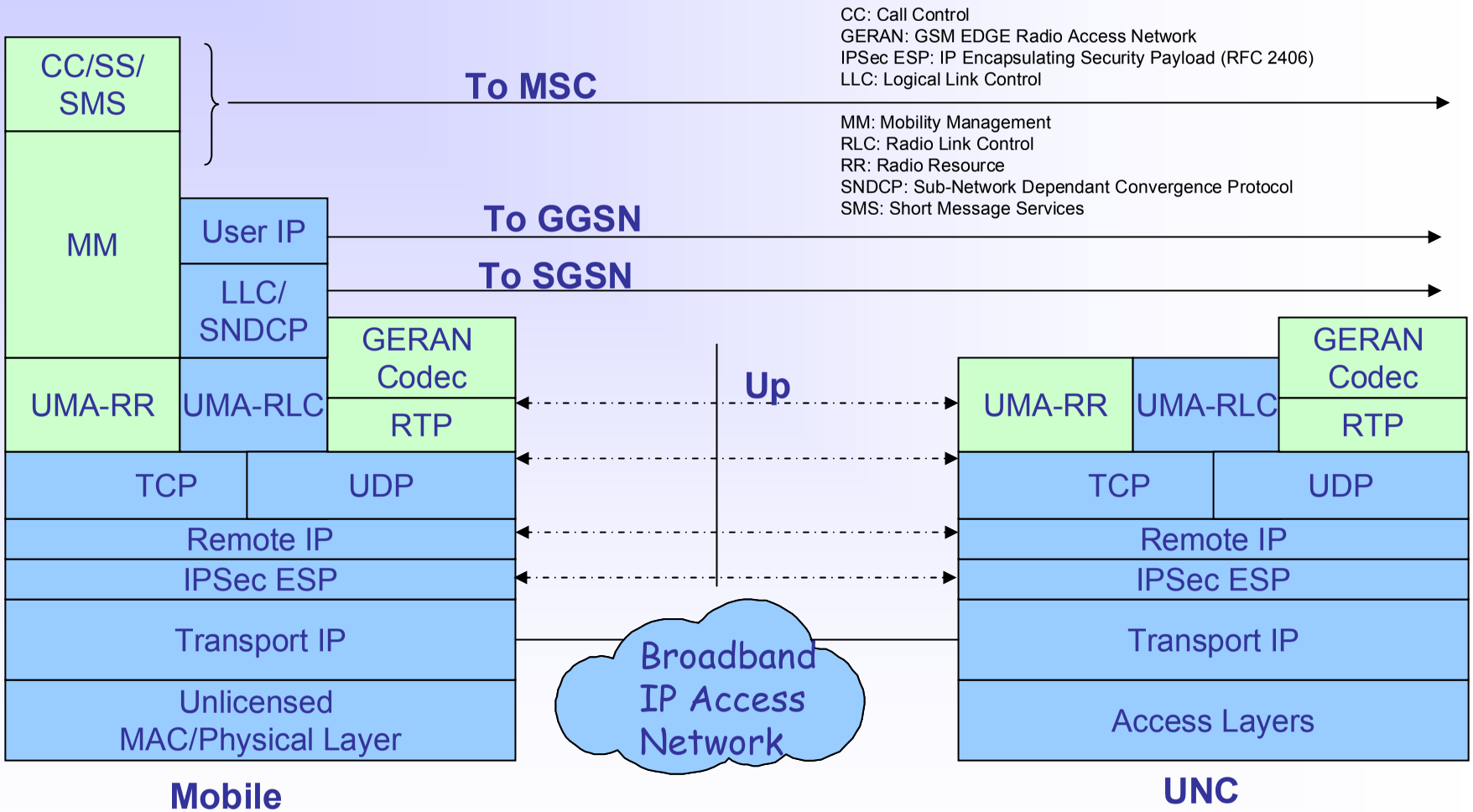
UMA Network Architecture



- UMA defines a new network element called UNC and a new interface Up
- UNC appears to the core network as a GERAN Base station subsystem and includes a Security Gateway (SGW) that terminates tunnels from Mobile.
- Up interface between UMA mobile and UNC; tunnels GSM protocols over an IP network

UMA deployment requires UNC and a mobile with Up interface; no changes to broadband network

UMA Protocol Stack



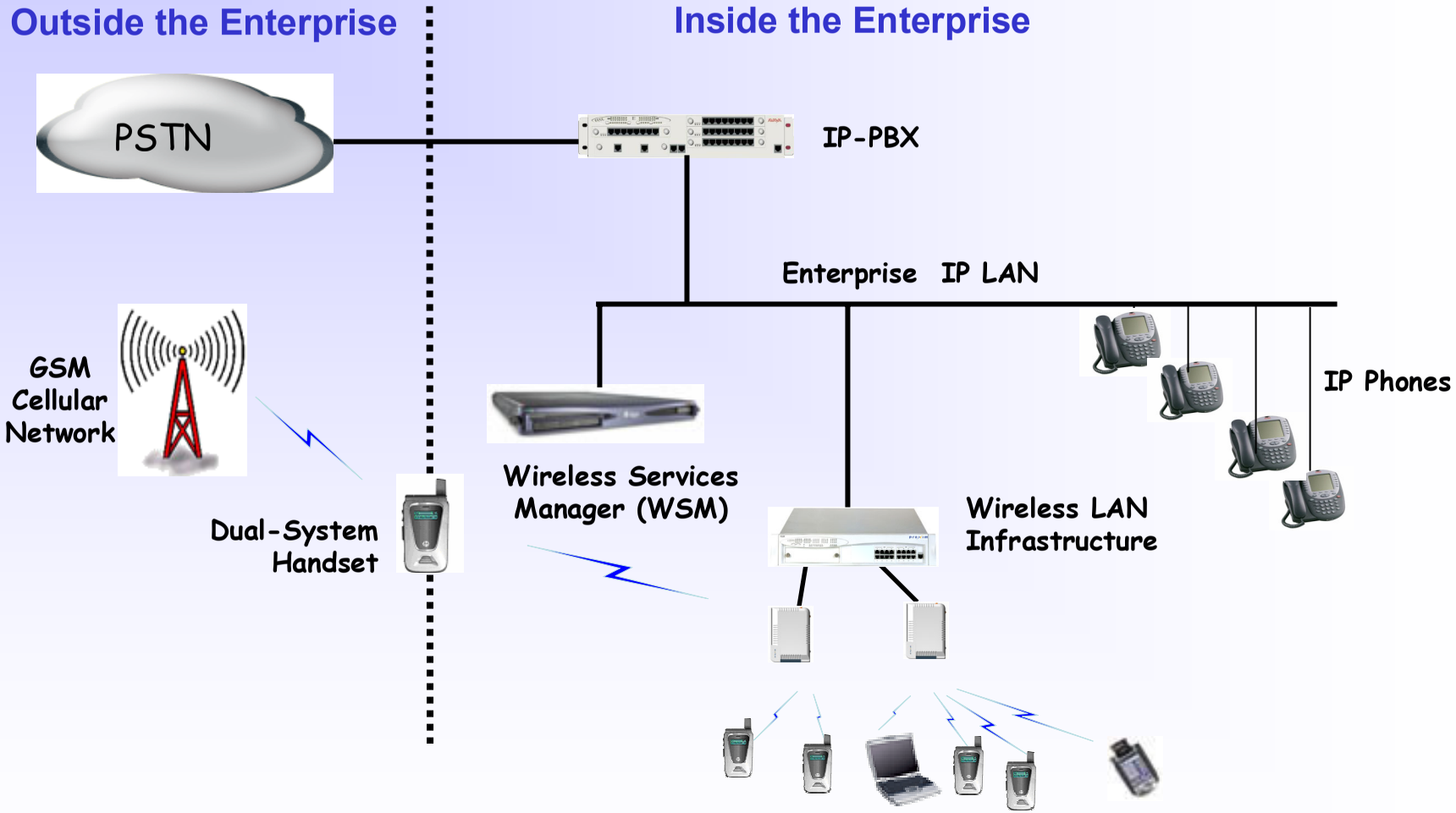
SCCAN Forum

- Seamless Converged Communications Across Networks
- Consortium to build wireless-wireline converged products
- Solution targeted at enterprise customer
  - extends enterprise PBX functionality into the wide area cellular network (e.g. abbreviated dialing, conference call, directory)
  - extends some cellular functionality into the enterprise (e.g. in-building coverage)
  - Seamless roaming and handover across Wi-Fi and cellular for all calls involving the enterprise PBX
  - Currently being trialed by a few large enterprise

Founded by: MOTOROLA, Proxim Wireless Networks, AVAYA

Supported by: 2Wire, Chantry Networks, ColubrisNetworks, Meru Networks

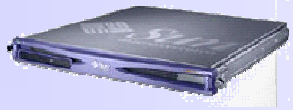
SCCAN Architecture



SCCAN – Solution Components

Motorola CN620 Dual System Handset

- Combined enterprise desk phone and cell phone
- Dual mode 802.11a and GSM/GPRS 850/1900 MHz
- MS Windows CE.NET 4.2
- HTML 4.0, WAP 2.0
- GSM AMR, EFR; G.711, G.729
- 150-190 min. talk-time; 50-80 hrs standby



Wireless Services Manager (WSM)

- Made by Motorola
- Provisioning Server
- SIP Proxy/Registrar
- Macro-Mobility Manager
- Voice Mail Notification
- Push-to-talk Application Server

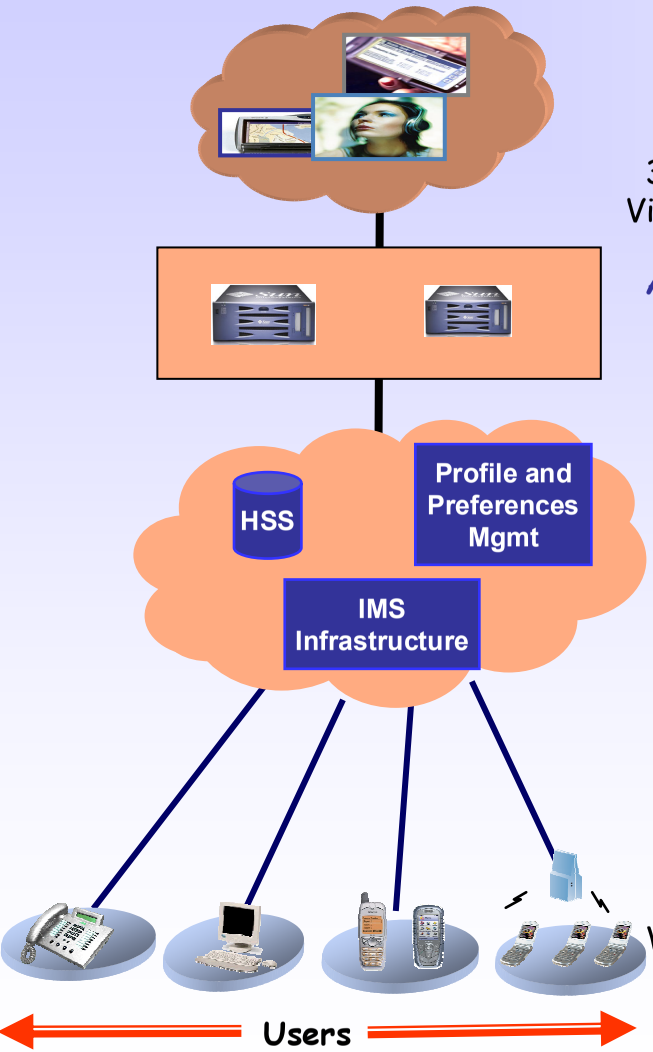
Avaya IP-PBX

- Communications Manager
- Media Servers
- Media Gateways
- SIP Call Processing
- 802.1p/q, DiffServ
- 600+ enterprise telephony features

Proxim WLAN

- Wireless- Enabled Switch with advanced
  - Security
  - QoS
  - mobility features
- Dual-band 802.11a/g Access Point
- WME, WPA support

IMS Based Architecture



Applications and Services
Telephony, SCP, 3rd party services, Video streaming, etc.

Access Independent Gateways
OSA-Parlay

Call Control (IMS)
CSCF, BGCF, HSS, MGCF

Access Networks
WiFi, GSM/GPRS/EDGE, DSL

- IP-Multimedia Subsystems (IMS) was developed by 3GPP to support next generation IP Services
- Based on model that divides networks into a set of three functional planes – the Access Layer , Session Layer, Service Layer
- Session Management based on SIP
- Can support personal, session, service and terminal mobility
- Provisions for QoS
- Access Independent Gateways (OSA-Parley) allow for applications and service to be made available on any access network.
- Prime Candidate for Wireless-Wireline Integration Services

Summary and Conclusions

- Remarkable success of Wi-Fi and cellular has led to the desire to integrate them so that:
  - Performance of existing services can be improved
  - New converged services can be offered
- Where we are?
  - Bundled offerings of Wi-Fi and cellular data services available
  - Roaming integration of Wi-Fi and cellular data available
  - Dual mode handsets emerging
  - Both wireline and wireless carriers are defining new converged services.
- What's coming?
  - Seamless voice and data session continuity
  - Wireless and Wireline carriers may move to IMS to enable converged wireless-wireline services

Thank You