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Business View of the Convergence/Integration of Wi-Fi, WiMAX and 3G Cellular

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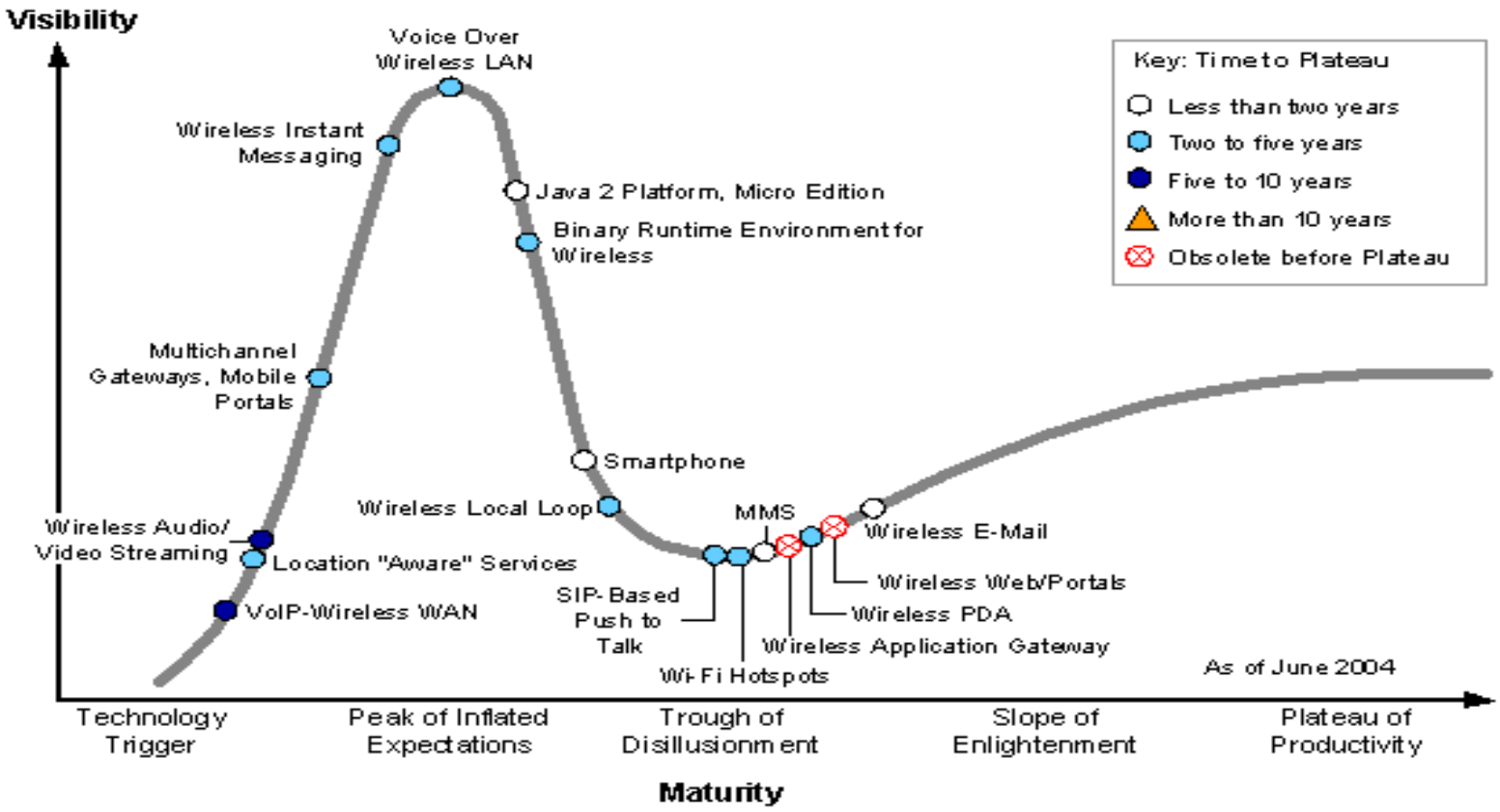
Outline

- **Landscape (Market, Standards, Roadmap)**
  - Mobile
  - WiFi
  - WiMAX
- **Economical Comparisons 2005-2008**
- **Adoption Activities**
- **Conclusion**

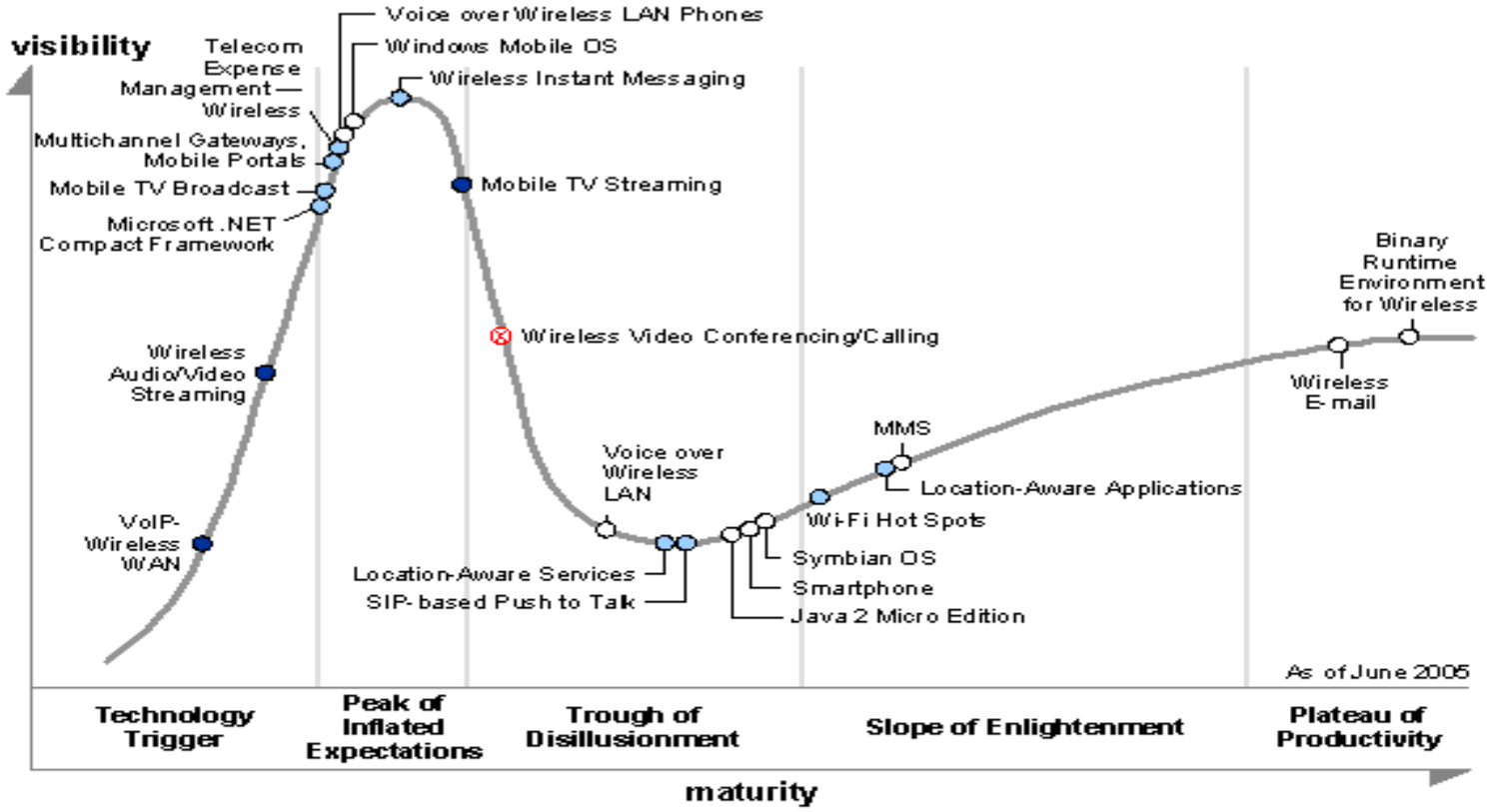
Hype Cycle for Mobile and Wireless Hardware, Software, 2004



Acronym Key	
MMS	Multimedia Messaging Service
SIP	Session Initiation Protocol
VoIP	voice over IP

Source: Gartner June 2005
Hype Cycle for Mobile and Wireless Hardware, Software, 2004
P. Redman, K. Dulaney, M. King, C. Mianesl, S. Pittet, E. Liew, N. Ingelbrecht, M. Basso

Hype Cycle for Mobile and Wireless Hardware, Software and Services, 2005



Plateau will be reached in:

○ less than 2 years ◉ 2 to 5 years ● 5 to 10 years ▲ more than 10 years ⊗ obsolete before plateau

Acronym key:

IM	Instant Messaging
OS	operating system
SIP	Session Initiation Protocol
VoIP	voice over IP

Source: Gartner June 2005
Hype Cycle for Mobile and Wireless Hardware, Software and Services, 2005
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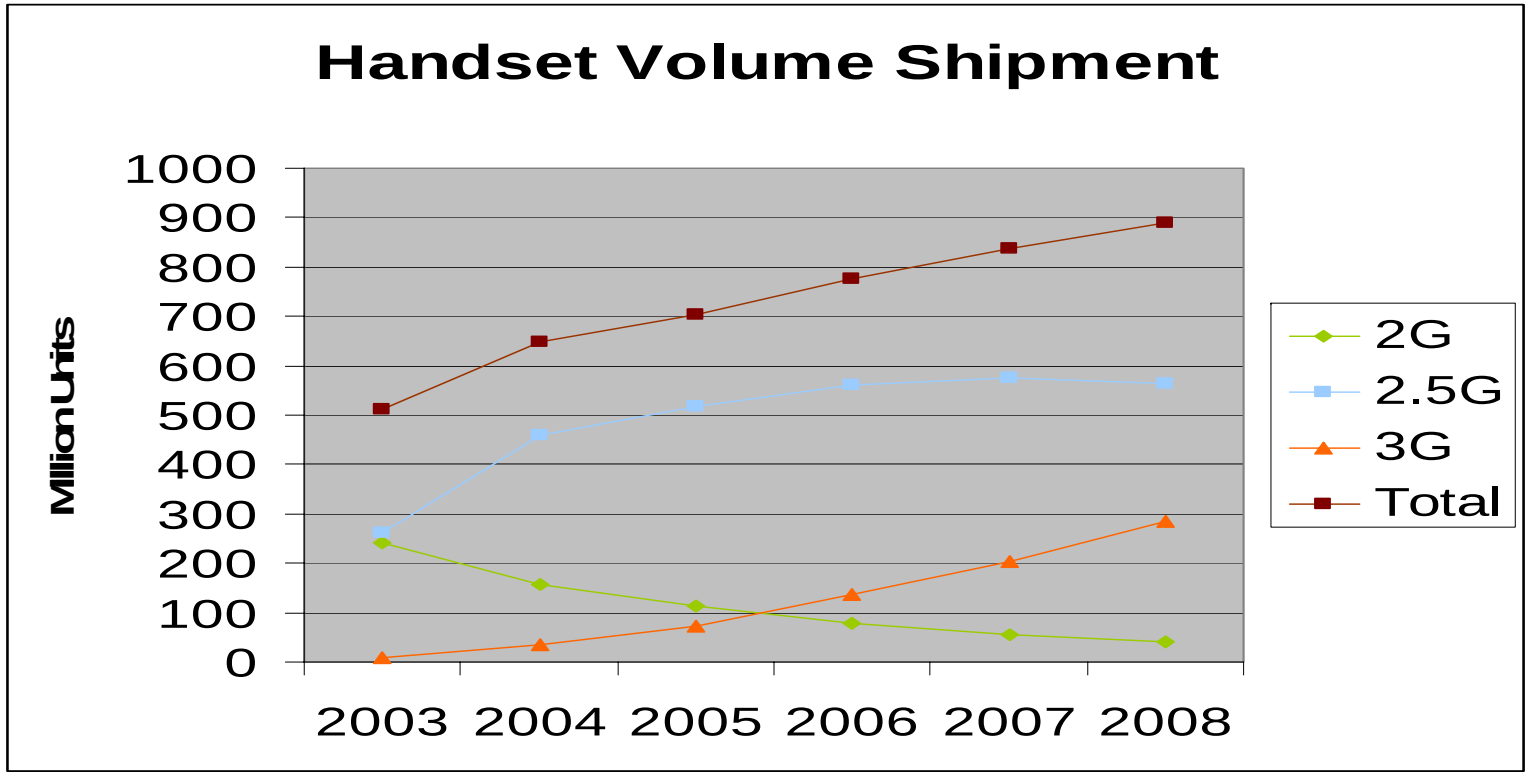
Mobile Market Growth

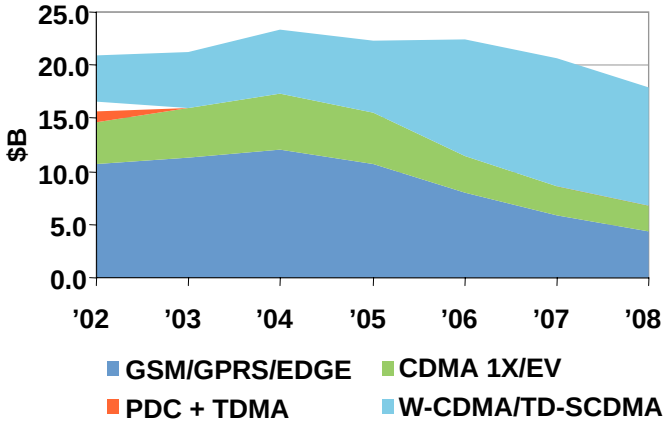


Source: IDC , 2004

- **Volume projection by 2008 is 890M; CAGR ’05-’08 is 8%**
- **2.5G volume surpassed 2G in 2003 and estimate 3G surpass 2G in 2005**
- **Estimate 3G surpass 2.5G in 2010**

Mobile Evolution

Total Mobile Hardware & Software Revenue by Technology



$20.6B by 2007
$17.9B by 2008
-13% AGR

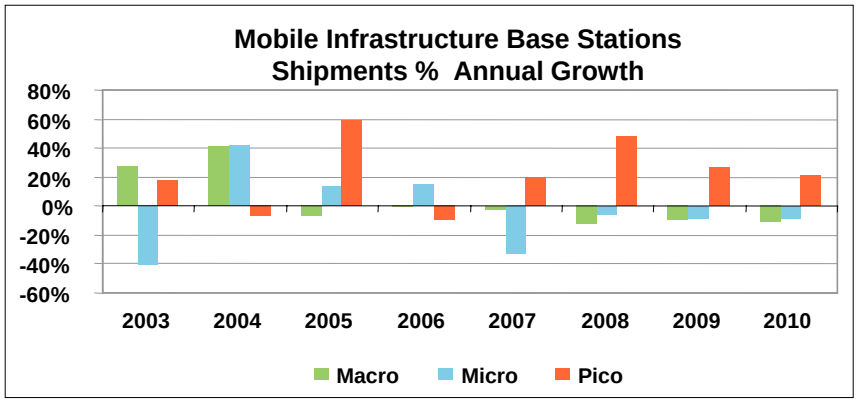
Generation	1G, 2G, 2.5G	3G	3GPP	Next Gen 3G
Technology	TACS, GSM, TDMA, GPRS, EDGE	TD-CDMA, W-CDMA, TD-SCDMA, FDD, TDD	Digital Enhanced 3G, HSDPA	
Implementation	AMPS, iDEN, CDMAOne, CDPD	CDMA2000 1xRTT, CDMA2000 1x EV-DO/DV		
Frequency	**900, 1800, 1900 MHz**	**1900 MHz, others**	**1900 MHz, others**	
Data Network Speed	**9.6 - 144 Kbps**	**200-500 Kbps**	**300kbps-1Mbps**	**> 1Mbps**
Applications		Digital Voice, SMS, MMS, e-mail, photo transfer, Internet access with handsets and notebook computers	Enriched previous services, hight data rate devices.	Digital data with QoS, video streaming, high performance games.
Base Stations Open System Design Spec. Standards		OBSAI specifies electrical, software, mechanical interface between baseband and transceiver cards. Supports WCDMA, CDMA2000, GSM/EDGE	CPRI specifies the software interface. Supports 3GPP UTRA FDD Release 5	Release 6,7

Major transition as higher data rate 3G systems, including WCDMA (node Bs)

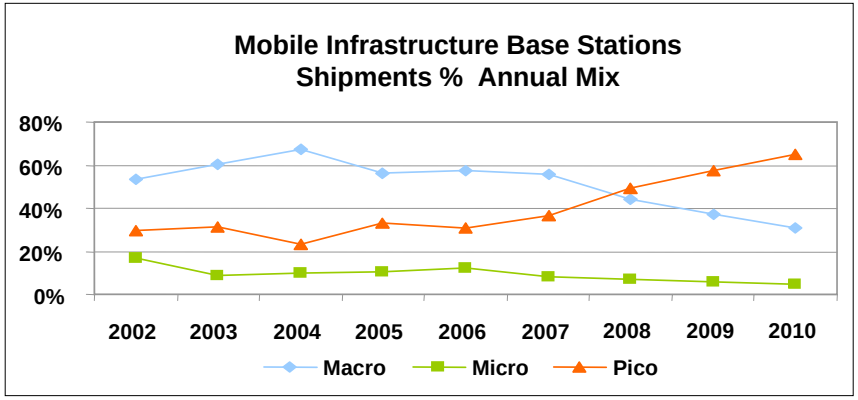
Mobile Base Stations — Shipment & Market Position

Base Stations Volume

510K by 2007 **564K by 2008** **11% AGR**



- **Highest growth for Macro/Micro cells reached in 2004. Both decline in ’05-’08 at -5.1%, -10.5% CAGR.**
- **Pico is growing 48% by 2008. ’05-’08 CAGR is 17.1%**



- **Pico cells is growing from 33% of total shipments in 2005 to 49% in 2008.**
- **Pico cells shipment will surpass combined Macro/Micro cells by 2009.**

High growth in Pico cell infrastructure

802.11 WiFi Technology

802.11b, a, g and dual band 802.11a+b/g and pre-standard "pre-n" MIMO-like

Technology	Frequency	Typical Reach	Max Data Rate	Common Usage
802.11a	5GHz	300 feet	54Mbps	Enterprise WLANS, particularly in high density areas
802.11b	2.4GHz	300 feet	11 Mbps	Public wireless hotspots, residential WLANS, enterprise WLANS
802.11g	2.4GHz	300 feet	54 Mbps	Public wireless hotspots, residential WLANS, enterprise WLANS
802.11n	5 GHz (at least)	?	100+ Mbps	Pre-n residential WLANs today; will eventually dominate in enterprise WLANs
802.11e	QoS			
802.11i	Security			
MIMO	Increase Bandwidth and Range			

802.11 WiFi Market

Client-Side

- Notebook PCs
- Desktop PCs
- Handheld Devices
- Consumer Devices
- PoS Point of Sales Devices

Access-Point

- Home AP
- Enterprise AP
- Routers
- Switches
- Residential gateways

Revenue $M	2003	2004	2005	2006	2007	2008	2009	CAGR '05-'08
Client Access	1,864	2,441	2,809	3,154	3,419	3,419	3,764	7%
Access Point/Bridge	992	1,508	1,666	1,837	1,944	2,031	2,202	7%
Total	2,856	3,949	4,475	4,991	5,363	5,450	5,966	7%
Y-Y Growth		38%	13%	12%	7%	2%	9%	

Source: iSuppli February 2005

Market Trends

- Top players will continue to cross into each other's path
- Key differentiation in 2005, 2006 is time-to-market and innovation in applications
- Key Applications: VoWLAN, multimedia, and streaming video applications
- Key enables: Software and standards development for handoff, billing and roaming

802.11 WiFi Adoption

Voice
Data
Video Control

The addition of WLAN to support VoIP provides a compelling story for Enterprise.

Converged Devices
Remote Control
Gaming

Streaming audio and video will be the primary application for consumer electronics designs.

Adoption of WiFi in mobile phone and consumer electronics continue to show strong upside potential

WiMAX Evolution

Fixed Wireless Access

- **Competes with DSL, cable, etc.**
- **Migrates from rooftop antenna to zero install**
- **Migrates from 802.16-2004 to 802.16e**

Nomadic/Portable Access

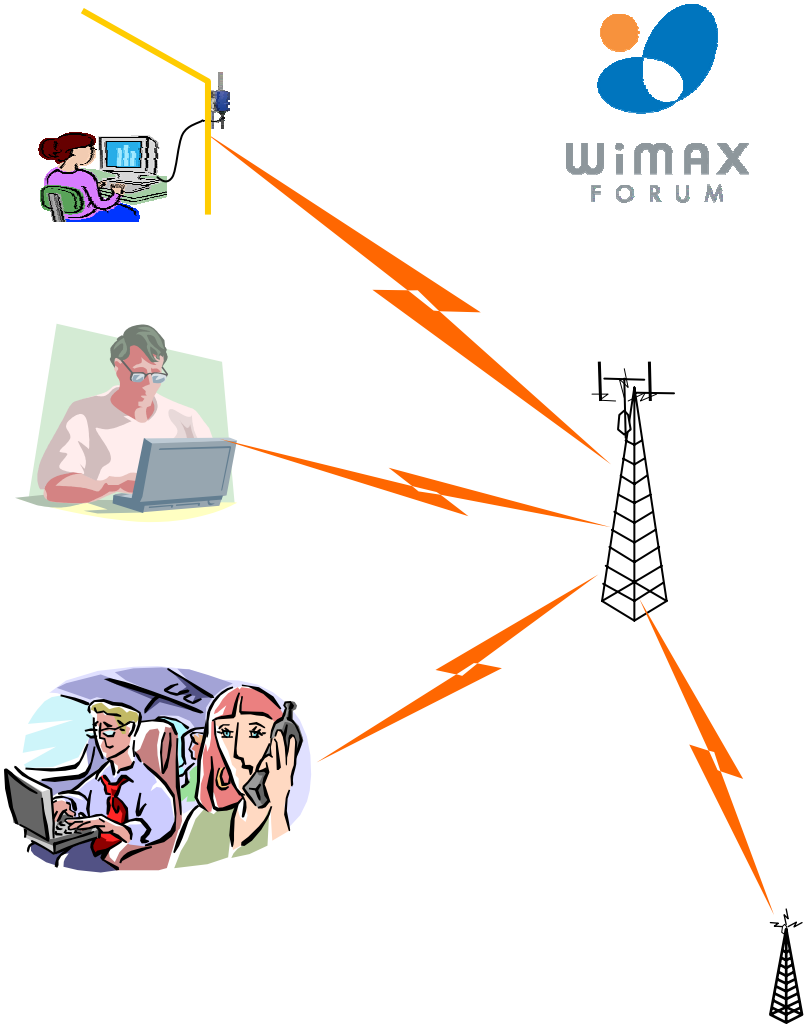
- **Modems are PC plug cards transitioning to integrated**
- **Ability to connect at multiple base stations**
- **Supports pedestrian mobility and limited handover**

Mobile Access

- **Handover function enabling data mobility for mobile users, train feeding and coach feeding**
- **Mobility enables future market growth**

Backhaul

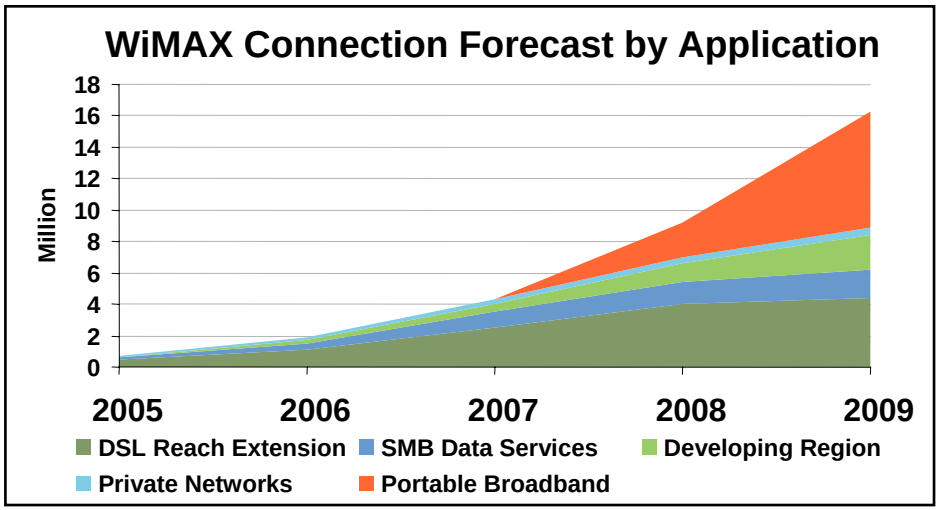
- **PTP links for cellular infrastructure**



WiMAX 802.16 Standards & Attributes

Comparison of Broadband Wireless Standards			
	WiMAX Fixed	WiMAX Fixed/Nomadic	WiMAX Mobile (TBD)
Standard	**802.16 (original)**	**802.16 – 2004 (incl. Rev a & d)**	**802.16e**
Spectrum – Frequencies	10-66GHz	2-11 GHz Target: ***2.50-2.69 GHz*** ***3.4-3.6 GHz*** ***5.725-5.85 GHz***	2-6 GHz Target: ***2.50-2.69 GHz*** ***3.4-3.6 GHz*** ***5.725-5.85 GHz***
Channel Bandwidth	**20, 25 & 28 MHz**	**1.5 – 20 MHz**	**1.5 – 20 MHz with Uplink subchannels**
Multiple Access & Modulation Options	**QPSK, 16QAM, 64QAM**	**OFDM 256 subcarriers, QPSK, 16 QAM, 64QAM**	**SOFDMA 256 subcarriers, QPSK, 16QAM, 64QAM**
Line of Sight (LOS)/ Non Line of Sight (NLOS)	**LOS**	**NLOS**	**NLOS**
Channel Plan	**TDD/FDD**	**TDD/FDD**	**TDD/FDD**
Theoretical Peak Bit rate; Circuit/IP Packet	**32-134 Mbps (28 MHz channel)**	**75 Mbps (20 MHz channel) w. 64 QAM @ 7km**	**15 Mbps (5 MHz channel)**
Typical User Peak Rate – Downlink	**17-50 Mbps (20 MHz channel) w. ½ QPSK to 16 QAM @ 10km**	**50 Mbps (20 MHz channel) w. 16 QAM @ 7-10km**	**TBD**
Typical User Peak Rate – Uplink			**TBD**
Typical Cell Radius – Range: Target in Bold	Over 10km	**Under 7km,** 7-10 km**, 10-50 km**	2-5 km
Spectral Efficiency – bps/Hz	**2 bps/Hz**	**2 bps/Hz (FFT @ 5bps/Hz)**	**2 bps/Hz (FFT @ 5bps/Hz)**
Latency Est.	**<20 ms est.**	**<20 ms. est**	**TBD**

WiMAX Market



Application	2005	2006	2007	2008	2009
DSL Reach Extension	**330**	**300**	**270**	**270**	**270**
SMB* Data Services	**420**	**400**	**409**	**423**	**440**
Developing Region	**330**	**300**	**270**	**270**	**270**
Private Networks	**470**	**440**	**400**	**400**	**400**
Portable Broadband			**180**	**150**	**140**

(*) SMB – Small and Medium Business

Source: Gartner, 2005
Gartner Data source – Market Opportunities for WiMAX Take Shape,Dec. 2004
By J. Forsman, I. Keene, B. Tratz-Ryan, R. Simpson

- WiMAX includes all WiMAX compatible products (like WiMAX pre-standard).
- Estimate WiMAX certified products for 2005 is 20% reaching 80% by 2009.

	Volume M	Revenue $B
2007	4.3	1.3
2008	9.2	2.5
2009	16	3.8

- The cost of SMB connection will increase from 2007 as more bandwidth and voice support becomes necessary.
- The cost of Nomadic Broadband connection will be lower due to the PC card form factor, higher penetration and introduction of internal CPE from 2009.

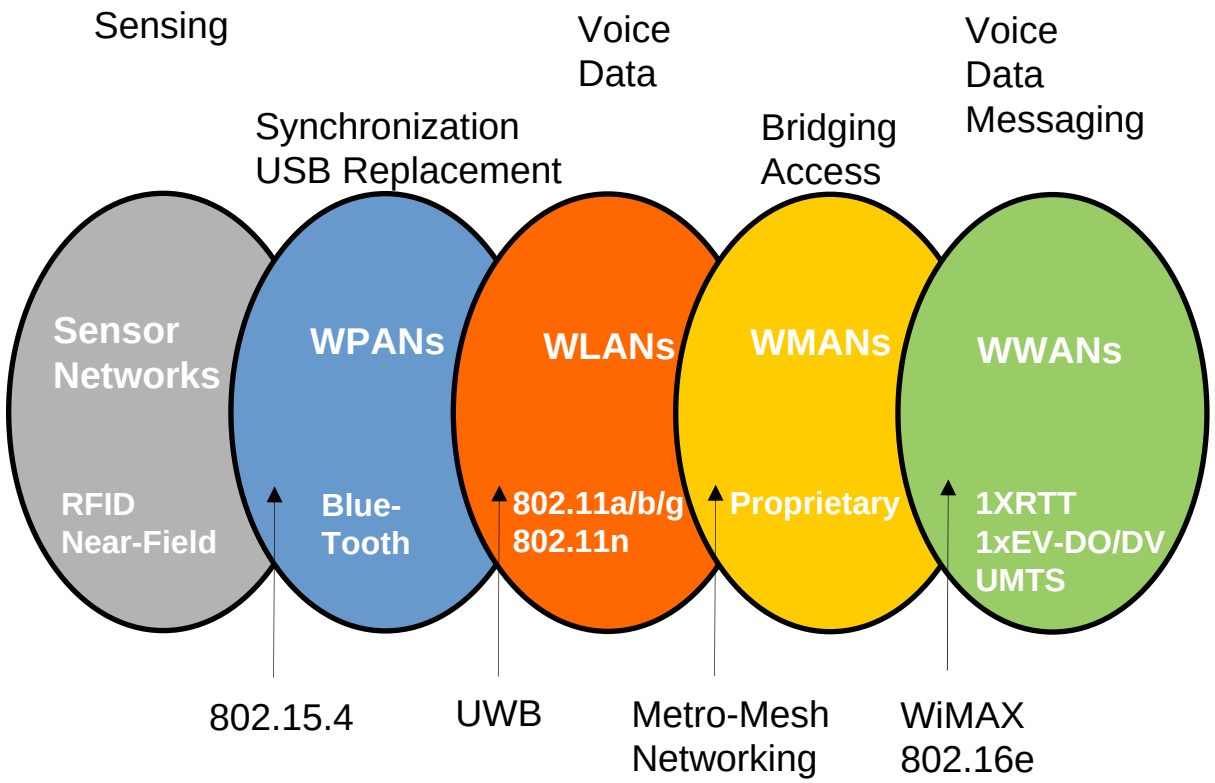
Source: Freescale 2005

WiMAX Initial deployment is for DSL/CMTS extension followed by Nomadic for consumer broadband.

WiMAX Technology compared to 3G

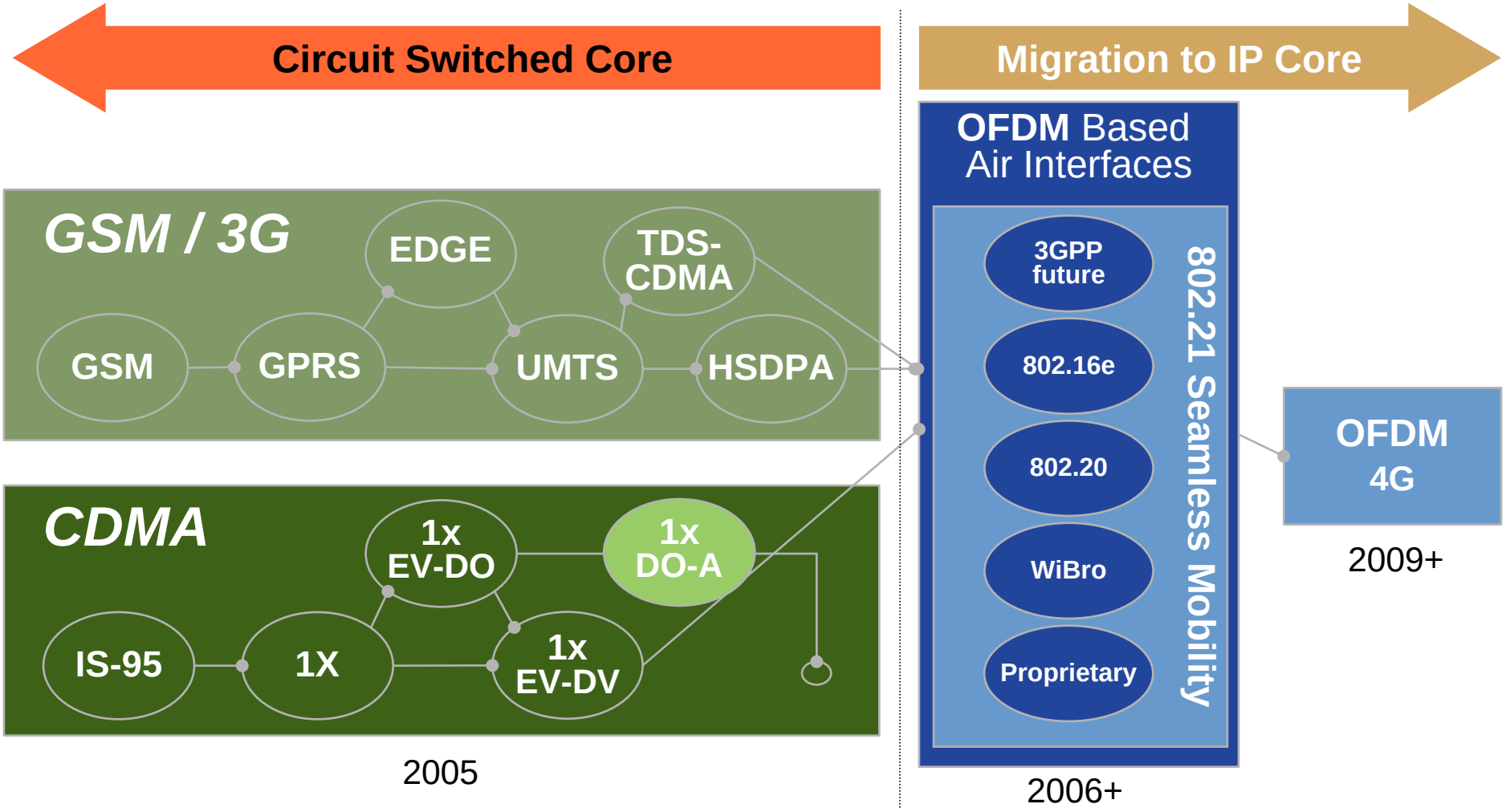
Item		WiBro	802.16e with MIMO	CDMA 2000		W-CDMA	
				1xEV-DO	1xEV-DO (rev.A)	R4	R5 (HSDPA)
Frequency		2.3-2.4 GHz	2.5, 3.5, 5 GHz	800M/1.8GHz	800M/1.8GHz	DL: 2.13~2.17 GHz, UL: 1.94~1.98 GHz	
Bandwidth		10MHz	5-20MHz	1.25MHzX2	1.25MHzX2	5MHzX2	5MHzX2
MAX Data Rate	Down	30Mbps	120Mbps	2.4Mbps	3.2Mbps	2Mbps	13.9Mbps
	Up	6.2Mbps/User	20Mbps	153Kbps/User	1.2Mbps/User	2Mbps/User	2Mbps/User
Multiple Access		OFDMA	OFDMA	CDMA	CDMA	CDMA	CDMA
Duplex		TDD	TDD/HFDD	FDD	FDD	FDD	FDD
Network Deployment		2006	2006	Existing	2005	2005	2006

Wireless/Mobile Technologies by Range

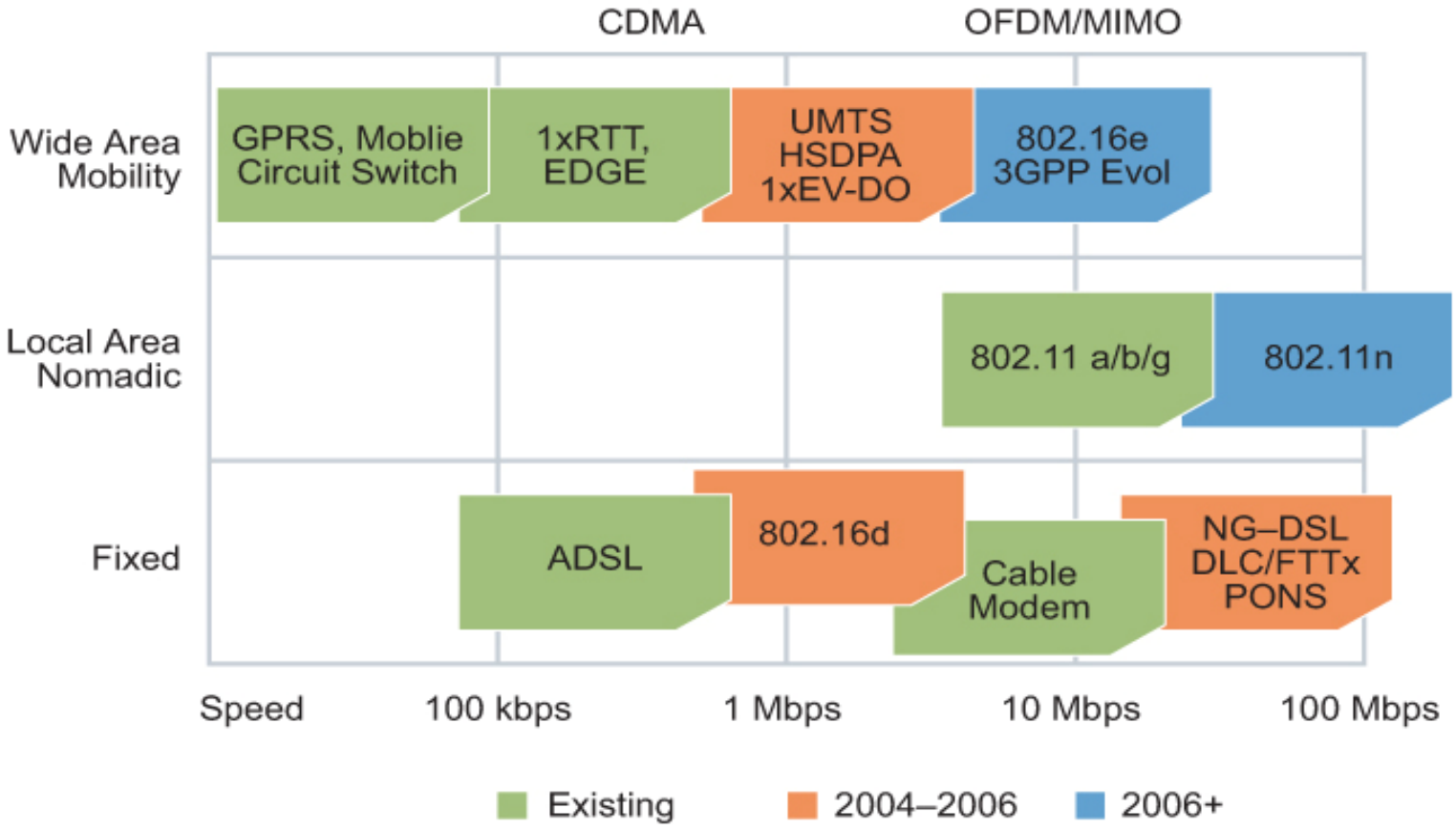


Increasing Distance

Next Generation Air Interface
Providing Greater Spectral Efficiency and Lower Cost Per Bit



Cellular/Wireless Roadmap



Cellular 3GPP/802.16e potential convergence in the next 5 years.

Competitive Broadband Access Technologies – Economical Comparisons

	3G		WiFi		WiMAX	
	2005	2008	2005	2008	2005	2008
DSL Extension						
Time required to deploy in a new market	++	++	++	++	+	++
Low-cost CPE/total cost	+	+	++	++	+	++
Reach	+	++	--	-	++	++
Connectivity for SMBs						
Bandwidth, QoS and Security	-	+	-	+	++	++
Availability	-	+	+	++	--	+
Private Networks						
Time required to deploy in new areas	++	++	++	++	+	++
Reach	+	+	--	-	++	++
Bandwidth, QoS and Security	-	-	-	+	++	++
Nomadic or Portable Broadband						
Mobility	++	++	+	+	-	+
Reach	+	++	--	-	++	++
Bandwidth, QoS and Security	-	-	-	+	++	++
Backhaul						
Time required to deploy in a new area	++	++	++	++	+	++
Reach	+	+	--	-	++	++
Bandwidth, QoS and Security	-	-	-	+	++	++
Availability	-	+	+	++	-	+

++	Very Good
+	Good
-	Poor
--	Very Poor

By late 2008 fixed market volume, low cost, low power components will drive broadband wireless infrastructure costs down to make portable WiMAX devices possible. Seamless mobility (handover, security, QoS) remains a challenge.

Adoption Activities in Broadband Wireless Access

- **Intel**
  - Leadership with WiFi and WiMAX
- **Cisco**
  - Initiatives in WiFi with LinkSys and follow closely WiMAX
- **Siemens**
  - Resale Agreement with Alvarion for WiMAX – delivering additional data capacity
- **Alcatel**
  - Strategic alliance with Intel to bring end-to-end solution to the market
- **Motorola**
  - WiMAX member. Delivery of license-free 5.8GHz solution with Canopy
- **Ericsson**
  - Joined WiMAX forum Dec. 2004
- **Marconi**
  - Following WiMAX development for solution deployment in rural area

Strategic Alliance for TTM leading to potential Merger/Acquisition.

Next Wave is Mobility.

Adoption Directions in Broadband Wireless Access Cont'd

3G Operators

- Are introducing high-speed data and limited multimedia services for incremental revenue
- Route traffic on wireless infrastructure when cost of transmission is cheaper
- Release 6, 7 enable Mobile operators for inter-working & management between cellular infrastructure and WiMAX
- User will expect WiMAX "front end" interoperability with WiFi at Hotspots and "back end" 4G interoperability with WiMAX as they travel.

Wireless Broadband Strategic Government Goal

- Stronger thrust in Asia Pacific region specially South Korea, China and India for widespread low-cost broadband access by 2010.
- Implementation of WiMAX-like "WiBro" standard for both Korea and China. WiMAX is targeted to interoperate with 4G mobile systems in India

Enterprise

- For mobile phone, the addition of WLAN to support VoIP provides a compelling story.

Consumer Electronics

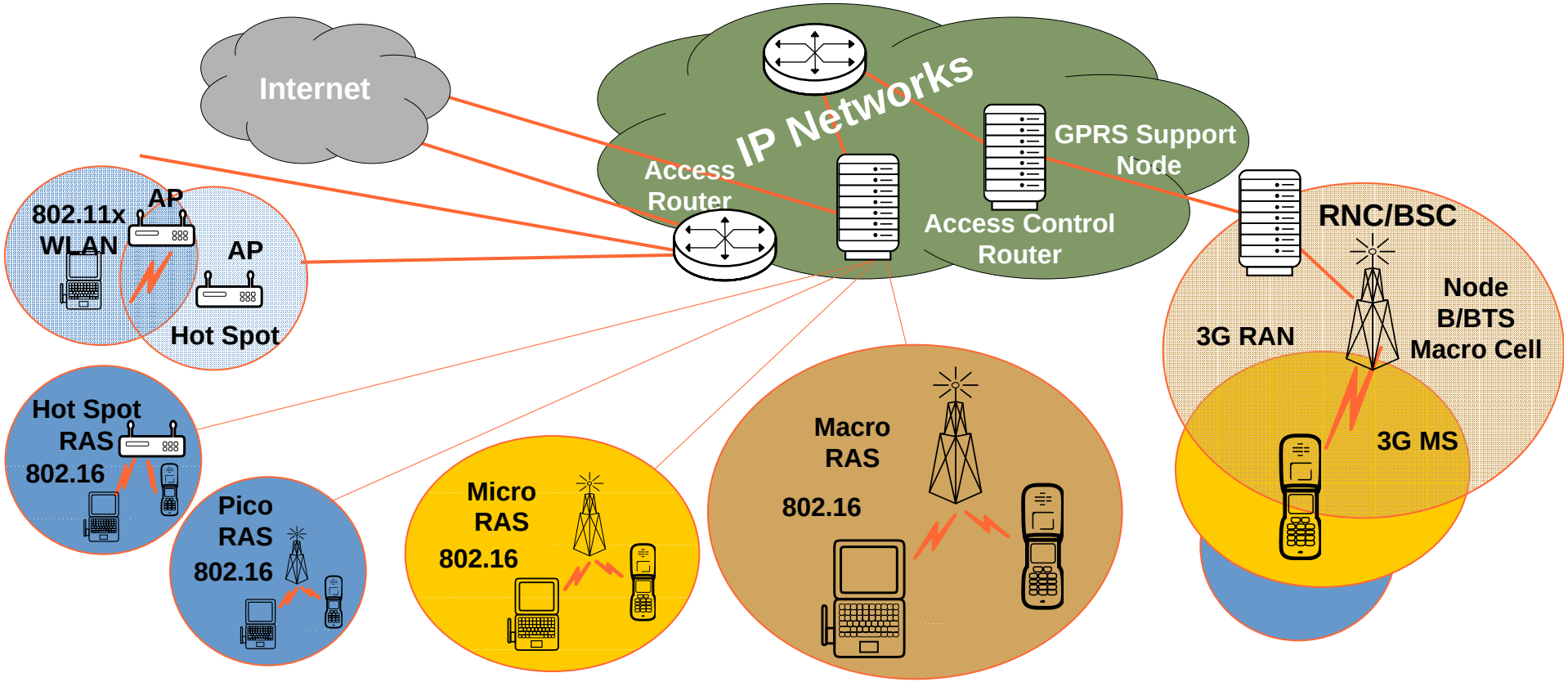
- Streaming audio and video will be the primary application for consumer electronics designs.

Broadband Wireless Access = co-existence, interoperability, moving towards convergence of WiFi, WiMAX, 3GPP into 4G?

Conclusion

Multimode, Interoperability, Convergence leading to offering end-end solution & infrastructure to support seamless mobile broadband advanced multimedia interactive services.

By 2009, the market will accelerate for multimedia broadband applications and user devices



Thank You

Questions

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