IPWireless
Generations Ahead

Evaluating the Prospects and Key Questions for 3GPP LTE

Jon Hambidge
VP Global Marketing, IPWireless
Mobile Broadband Americas
October 2006

Agenda

An Introduction to LTE

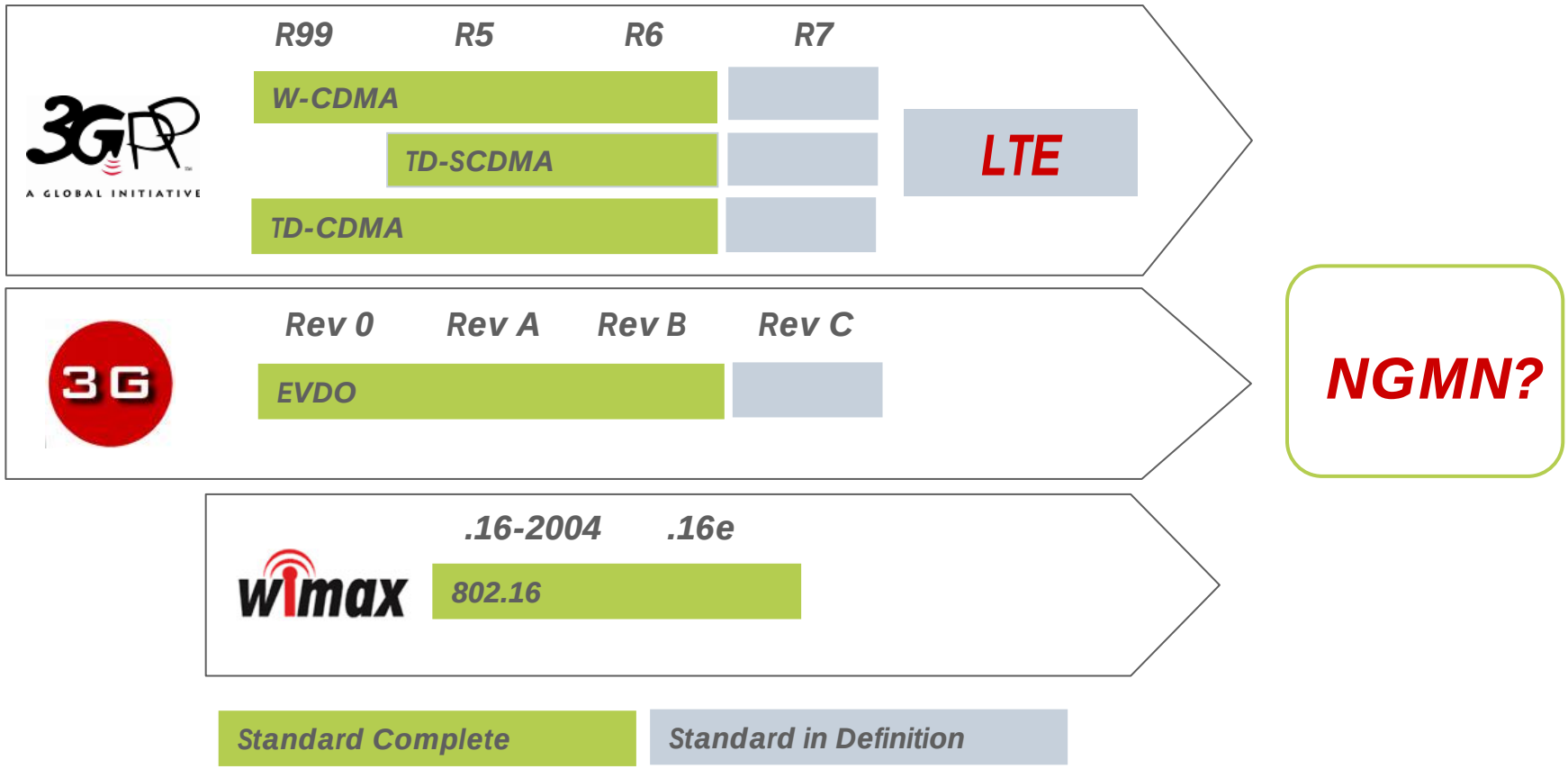
Expected LTE Performance

What Services will LTE Support?

Key Questions for Beyond 3G

IPWireless
Generations Ahead

Hype Around Multiple Standards Paths Has Caused Significant Confusion in the Market



The Big Question – Are Any of These 4G?

IPWireless Generations Ahead

Long Term Evolution (LTE) is Intended as an Evolution to Existing 3GPP Standards

LTE

- Evolution from GSM and current 3GPP technology
  - The leading standards path in terms of subscribers
- 3GPP unification of TDD &FDD single air interface that works in both paired & unpaired spectrum
- Targeted as the standard technology for 2.5 GHz "3G Extension Band"
- Requirements set by operators would make this the highest performance wireless platform
- Timing
  - Study Items were completed this year
  - Work Items targeted for completion in late 2007
  - Multiple vendors have stated they will have commercial LTE product by 2009

IPWireless
Generations Ahead

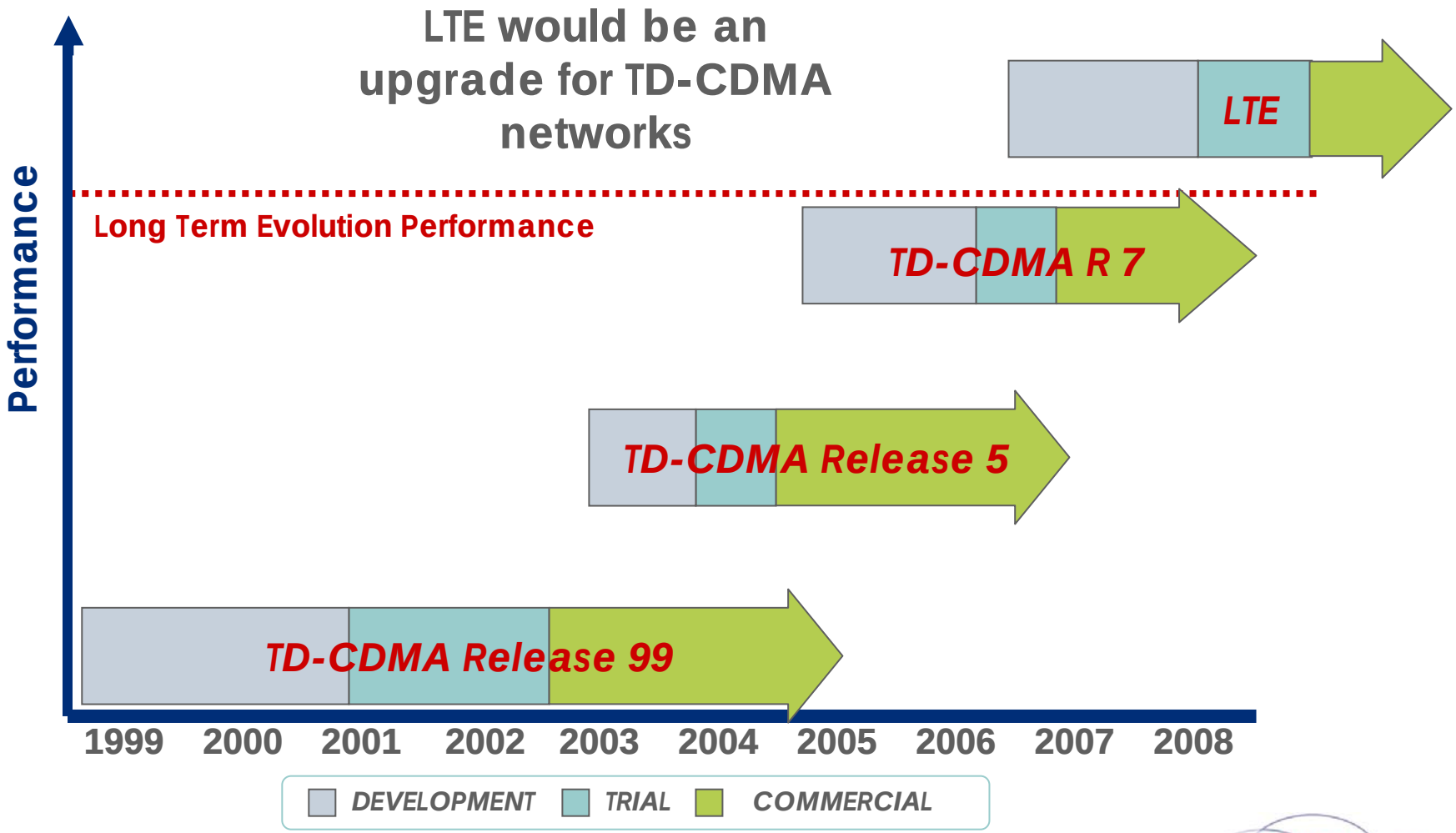
LTE Standards Development

- The LTE work in 3GPP is effectively being carried out in 2 separate parts
- The RAN working groups are defining the Air Interface and radio access parts
  - Work is progressing steadily
- The SA working groups are defining the other aspects (referred to as System Architecture Evolution or SAE)
  - Progress is much slower than the RAN part

LTE compared to UMTS Architecture

- Air interface is OFDMA (DL) / SC-FDMA (UL) in TDD and FDD modes
  - Not TD-CDMA or W-CDMA as in 3G
  - No macro diversity (soft handover)
- LTE is exclusively packet-switched and IP-based
  - Circuit Switched(CS) Core network does not exist
  - Voice and other services previously delivered over the CS Core network in UMTS are provided via a packet switched IP core and IMS
- A key target of System Architecture Evolution is the interworking of multiple access networks under the same packet-switched core network. So the SAE has two major goals:
  - Become the Core Network for LTE
  - Integrate legacy 3GPP and non-3GPP access network in the same architecture.

IPWireless Roadmap Currently Would Have LTE Producs Available For Trial in 2008



IPWireless
Generations Ahead

Agenda

An Introduction to LTE

Expected LTE Performance

What Services will LTE Support

Key Questions for Beyond 3G

IPWireless Generations Ahead

The LTE Requirements Set by 3GPP Operators Would Make It The Highest Performance Standard

Parameter	LTE Target	Net Requirement	Requirement in 5+5 MHz
Downlink Peak User Throughput	5b/s/Hz	5b/s/Hz	25 Mbps
Uplink Peak User Throughput	2.5b/s/Hz	2.5b/s/Hz	12.5 Mbps
Spectral efficiency - Downlink	3 - 4 X HSDPA	1.2 – 1.6 b/s/Hz	6 – 8 Mbps
Spectral efficiency - Uplink	2 - 3 X HSUPA	0.48 – 0.72 b/s/Hz	2.4 – 3.6 Mbps
Cell Edge Rate - Downlink	3 - 4 X HSDPA	1 – 2 Mbps	1 – 2 Mbps
Cell Edge Rate - Uplink	2 - 3 X HSUPA	128-192 kbps	128-192 kbps
Latency one way (active state, single user, unloaded)	< 5ms		
Support for scaleable bandwidths	1.25, 2.5, 5, 10, 15, 20 MHz		
Duplex Modes	Paired & Unpaired		
MBMS	"further enhanced"		
Core Network	IP Based		
High Speed Mobility	Up to 350 km/hr		

Note: as per 3GPP LTE requirements definition, rates are instantaneous

IPWireless Generations Ahead

How Will This Performance Compare to Predicted Performance of Other Technologies in 2007?

	WiMAX 802.16e	1xEVDO (Rev.A)	HSDPA (R5)	*TD-CDMA (ER7)*
Channel bandwidth	10 MHz	1.25MHz+1.25MHz	5MHz+5MHz	10MHz
Link Budget (See Note)	150 dB	153 dB	151 dB	155 dB
Peak DL Sector Throughput	20.1 Mbps	3.1 Mbps	3.6 Mbps	31.8 Mbps
Peak UL Sector Throughput	5.0 Mbps	1.8 Mbps	2.3 Mbps	7.9 Mbps
Average Sector DL Throughput	2.3 Mbps	1.2 Mbps	2 Mbps	9.5 Mbps
Average UL Sector Throughput	2.2 Mbps	500 kbps	700 kbps	2.2 Mbps
Cell Edge DL Sector Throughput	1.1 Mbps	No data	640 kbps	2.2 Mbps
Cell Edge UL Sector Throughput	390 kbps	No data	600 kbps	512 kbps
Cell Edge DL User Throughput	32 kbps (See Note)	307.2 kbps	384 kbps	2.2 Mbps
Cell Edge UL User Throughput	9.6 kbps (See Note)	9.6 kbps	64 kbps	512 kbps
Support N=1 frequency reuse?	No (See Note)	Yes	Yes	Yes
Latency RTT	No data	~ 80 ms	170 ms	50 ms
Frequency band	No global band. 2.3 GHz (Korea) 2.5 GHz (USA) 3.5 GHz (Europe)	450 MHz 800 MHz 1900 MHz	1850-1990 MHz 1920-2170MHz	1900-1920MHz 2010-2025MHz 2500-2700MHz
Standards compliance	Yes - IEEE	Yes - 3GPP2	Yes - 3GPP	3GPP UTRA TDD (Evolve to 3GPP LTE)
Commercial ready in 2007	2007+?	Yes	Yes	Yes

Notes

Throughput

- Peak throughput: Marketing figures. Not to be used for business modelling and network dimensioning.
- Average sector throughput: Important for business modelling and network dimensioning. Average sector throughput affects the number of users/sector.
- Cell edge throughput: These are minimum throughput figures that the end user will experience.

Link Budget

- Link budget varies with the assumed cell edge data rate. In order to make fair comparisons between technologies, quoted link budget assumes at least 384 kbps DL and 64 kbps UL at the cell edg

WiMAX

- WiMAX figures are extracted from WiMAX forum and independent analysis. There is currently no 802.16e compliant commercial products to validate the claims.
- Cell edge user throughput of 32 kbps DL and 9.6 kbps UL for 2% outage (Source: Motorola's WiMAX presentation to Japanese Telecom Council)
- WiMAX claims to support N=1 reuse. However, in the cell overlap areas and cell edge, only a fraction of the bandwidth is used. This has significant impact on deployment and sector throughput.

EVDO Rev.0 and Rev.A

- Source of average sector throughput figures: Qualcomm - Lehman Brothers Global Wireless Conference May 24, 2004.
- Cell edge throughput from Airvana's analysis - 76.8 kbps for 2% outage, 153.6 kbps for 10% outage.

IPWireless Generations Ahead

The Standards Battle is About More Than Which Technology Performs Better

- **IPR Situation** – trying to break the current WCDMA Quagmire
- **Vendor Strategy –** Leading 3G vendors backing LTE – Vendors that are not 3G leaders using WiMAX as an end around
- **Geopolitical Power –** Europe vs. US vs. APAC
- **Spectrum** – UMTS lock on key spectrum in Europe and parts of Asia
- **New Versus Incumbent Mobile Operators**
- **Operator Control of Value Chain** – Will the mobile operators use their market power to force vendors in specific directions?

IPWireless Generations Ahead

Agenda

An Introduction to LTE

Expected LTE Performance

What Services will LTE Support

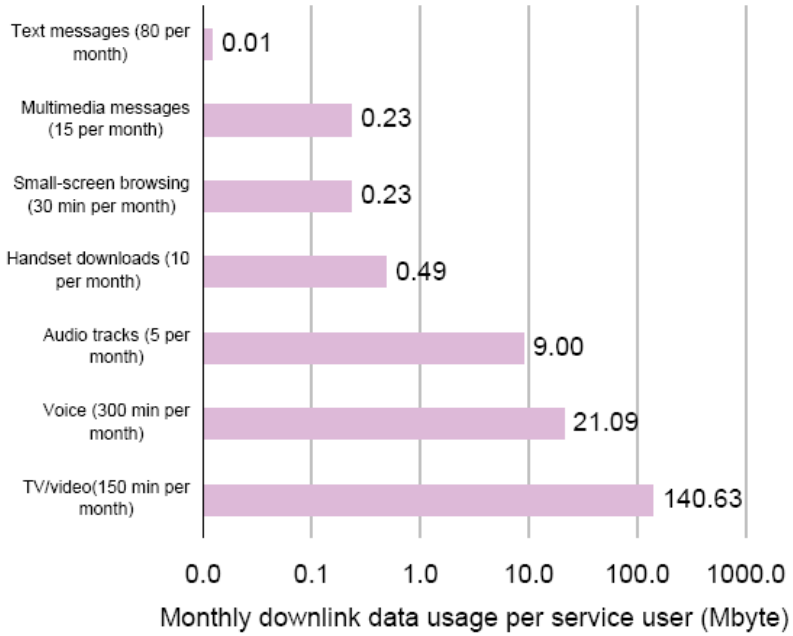
Key Questions for Beyond 3G

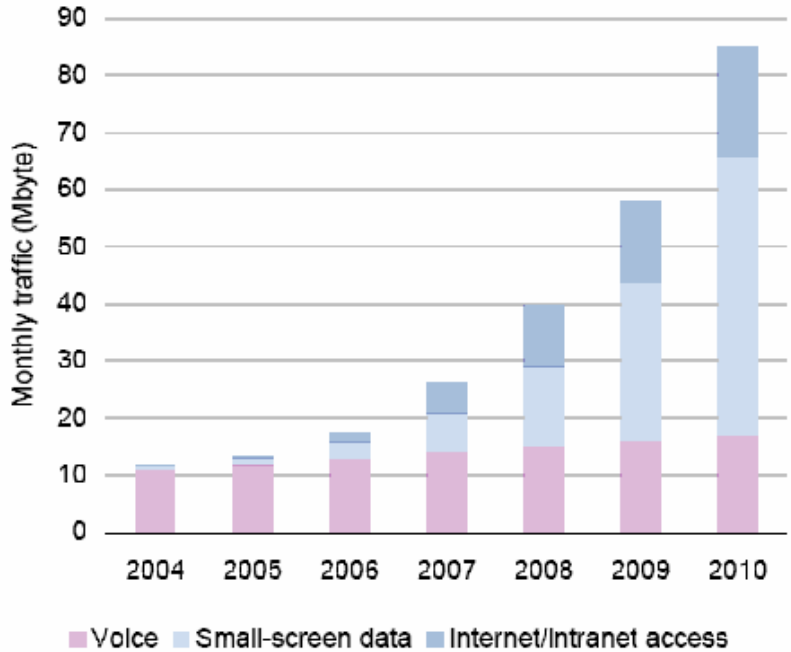
IPWireless Generations Ahead

What Services Can Current Mainstream 3G Networks Support?

- Microbrowsing (e.g., Wireless Application Protocol [WAP]): 8 to 32 kilobits per second (kbps)
- Multimedia messaging: 8 to 64 kbps
- Video telephony: 64 to 384 kbps
- General purpose Web browsing: 32 kbps to more than 1 Mbps
- Enterprise applications, including e-mail, database access, and VPNs: - 32 kbps to more than 1 Mbps
- Video and audio streaming: 32 to 384 kbps

Current 3G Networks Will Support Handset Services for the Foreseeable Future

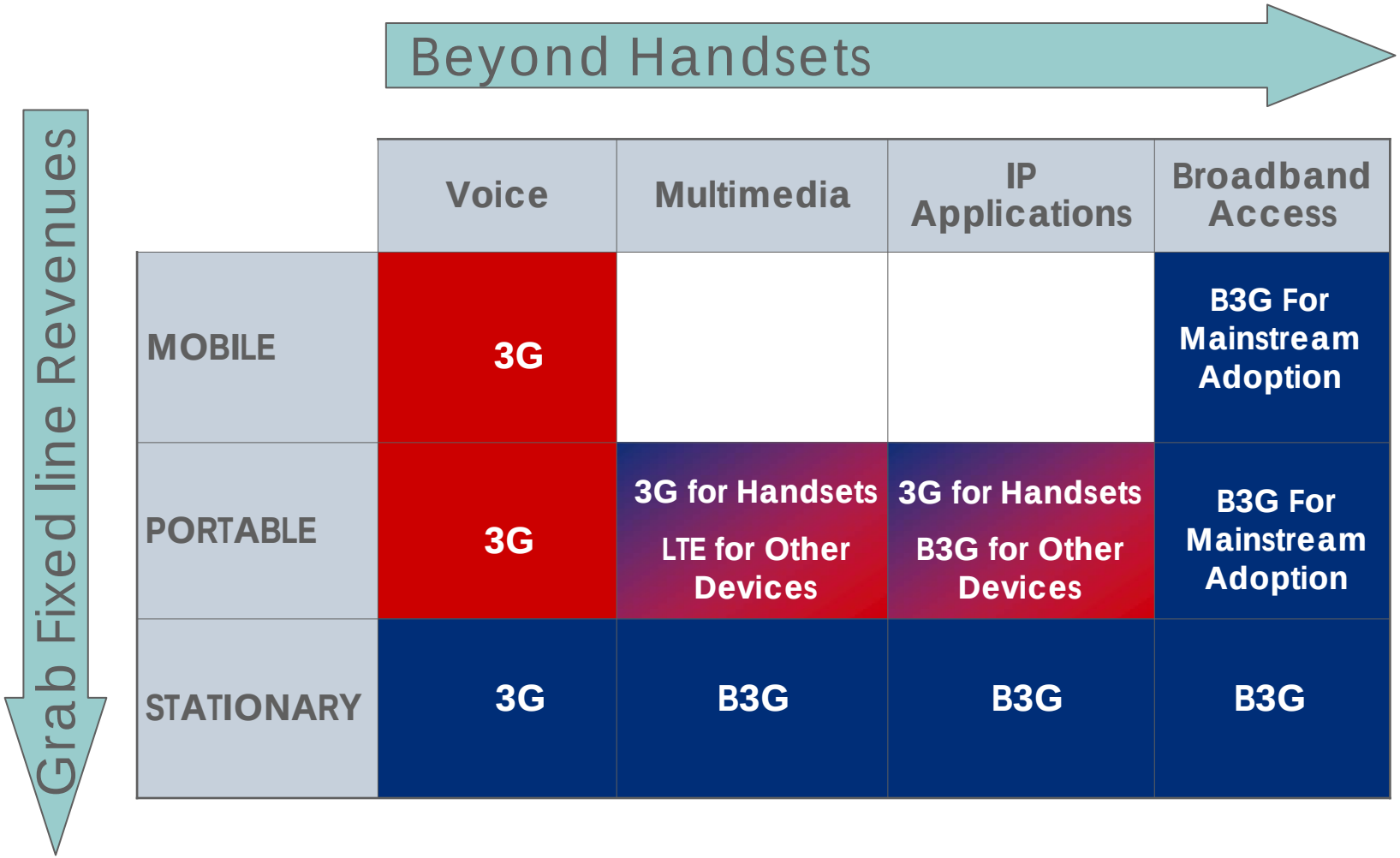




Source – UMTS Forum HSPA White Paper

IPWireless Generations Ahead

Beyond 3G Performance is Required To Go Beyond Handsets and Beyond Nomadic

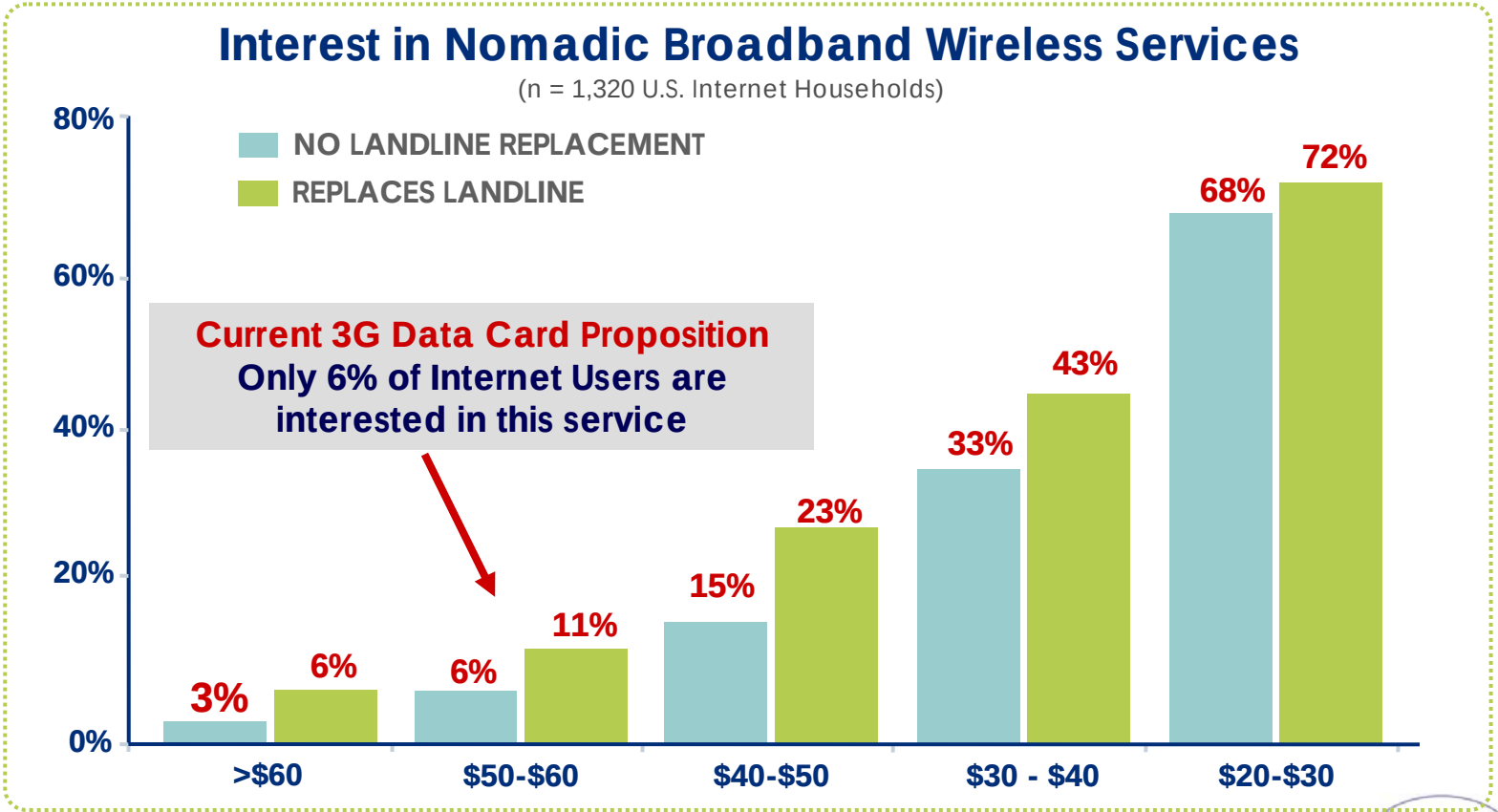


	Voice	Multimedia	IP Applications	Broadband Access
MOBILE	3G			B3G For Mainstream Adoption
PORTABLE	3G	3G for Handsets LTE for Other Devices	3G for Handsets B3G for Other Devices	B3G For Mainstream Adoption
STATIONARY	3G	B3G	B3G	B3G

IPWireless
Generations Ahead

Current 3G and Mobile Data Cards Do Not Address This Mass Market Opportunity

Current 3G and mobile data cards are too expensive and don't have the performance to replace a consumer's landline Internet connection.



Source: © 2003 Parks Associates *Untethering Broadband*

IPWireless Generations Ahead

Household Spending By Service

Average Consumer Spending for All Households

Service	Average Monthly Spending	Change from Previous Quarter
Wired	$ 43.57	1%
Wireless	$ 60.53	6%
Cable/Satellite TV	$ 48.54	2%
Internet	$ 22.36	2%
TOTAL	$ 175.00	3%

Average Consumer Spending
Only For HHs That Used The Service

Service	Average Monthly Spending	Change from Previous Quarter
Local	37.11	-1%
Long Distance	13.38	5%
Wireless	80.88	3%
Video	59.38	1%
Internet	31.58	-3%

Souce: TNS Telecoms Q1 2006

With the mobile voice market reaching full penetration in most markets – mobile operators will have to grab share of other spending from the fixed line carriers.

IPWireless Generations Ahead

The User Traffic Requirement To Target The Mainstream Broadband Access Market

Actual Traffic Stats from Commercial TD-CDMA Network

Service Plan (data cap)	Actual Usage	Average Monthly Usage	Busy Hour Usage	Average Rate During Busy Hour		Rate in Business Plan
1 GB	~1 GB	959 MB	2.1MB	4.6kbps		8.9 kbps
Unlimited	< 10 GB	2.20 GB	4.1 MB	9.2 kbps	15.5 kbps	12.5 kbps
	10-15 GB	13.34 GB	21.7 MB	48.1 kbps		
	> 15 GB	24.12 GB	33.93 MB	75.3 kbps		
2-10 GB	1-10 GB	1.39 GB	2.1 MB	4.6 kbps	4.6 kbps	23.3 kbps
Average All Users	-	3.23 GB	5.5 MB	-	12.1 kbps	12.3 kbps

- Popular Internet Sites and applications like YouTube, MySpace, and iTunes are increasing bandwidth requirements for this market
- User generated content and community sites also create more uplink bandwidth demands

IPWireless Generations Ahead

Agenda

An Introduction to LTE

Expected LTE Performance

What Services will LTE Support

Key Questions for Beyond 3G

IPWireless Generations Ahead

Key Questions for Beyond 3G

1. **The Timing Question**
   Will WiMAX be commercial in early 2008? Will LTE be commercial in 2009?
2. **The Spectrum Question**
   Will WiMAX be able to get access to a global band or is technology neutral best hope? In technology neutral bands will operators choose WiMAX or LTE?
3. **The Operator Question**
   Will new operators use Wimax to attack the existing mobile operators? Can they compete with these operators with existing cell sites, spectrum, customer bases, and a potentially better technology (LTE)?
4. **The Capital Question**
   Is there enough capital to fund new Greenfield networks globally until the business model is proven? Will vendor financing continue?
5. **The NGMN Question**
   Will operators force a merger of Beyond 3G standards through NGMN?

IPWireless
Generations Ahead