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3G CDMA Technologies Enabling Advanced Broadband Wireless Access

QUALCOMM Incorporated is a leading developer and supplier of digital wireless communications products and services and is the innovator of CDMA, a technology that has become the world standard for the wireless communications industry.

Qualcomm Inc.

September 2005

Wide Area Broadband Wireless Access: Key Requirements

- Spectral Efficiency and Area of Coverage
- Compelling Network Economics
- Device Availability & Affordability
- Common Spectrum Availability Worldwide
 - Benefits from Global Economies of Scale
- Applications:
 - Email, Web-Browsing, Web Downloads
 - Public safety, National security, Utility Applications
 - E-commerce, Entertainment, Gaming
 - Agriculture, Education, Telemedicine
- Simultaneous Voice & Data Services
- Ancillary Business Services
 - Customer Care, Billing, etc.



3G Wireless Broadband Fully Mobile Internet Access

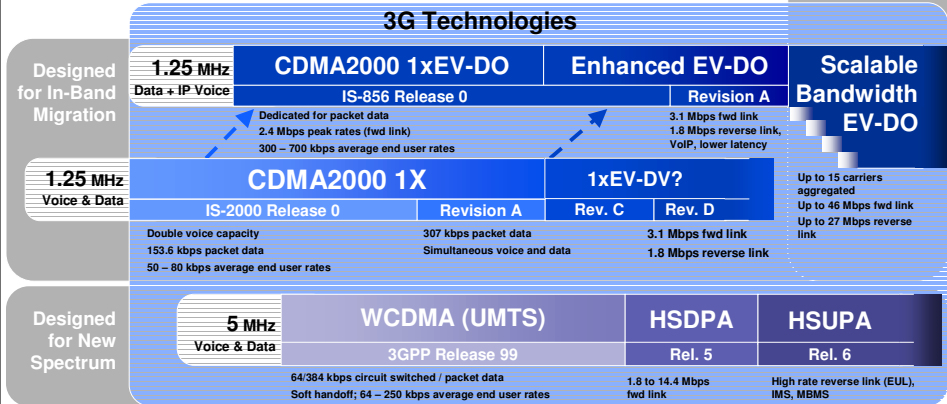
- 3G technologies make it possible for end users to connect with the world at anytime and anywhere.
 - Communities, both large and small, are gaining access to a wealth of resources and opportunities not previously available.
 - Applications pertaining to Connectivity, Public Safety, Healthcare, Education, Government and Conservation are particularly enticing!
- 3G technologies provide end users with extensive, fully mobile broadband access even while traveling at high rates of speed.
 - Since 2000, wireless carriers have begun to deploy mobile broadband technologies, such as CDMA 1X, EV-DO and WCDMA, over their existing networks in order to extend service offerings to their customers.

3G Wireless Broadband QUALCOMM's Key Wireless Technologies

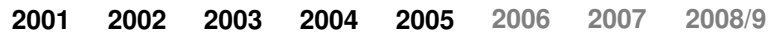
- **CDMA2000**
 - **CDMA2000 1X** (voice & high-speed data)
 - **CDMA2000 1xEV-DO** (very high-speed data)
- **Wideband CDMA (also known as WCDMA or UMTS)**
 - **WCDMA** (voice and high-speed data)
 - **HSDPA** (very high speed data)

3G Evolution Migration to VoIP and Scalable Bandwidth Up to 46 Mbps in 20 MHz

Designed for
In-Band Migration
or New Spectrum



Timeline depicts initial commercial availability for each technology



3G Today: 158 Commercial 3G Operators in 70 Countries



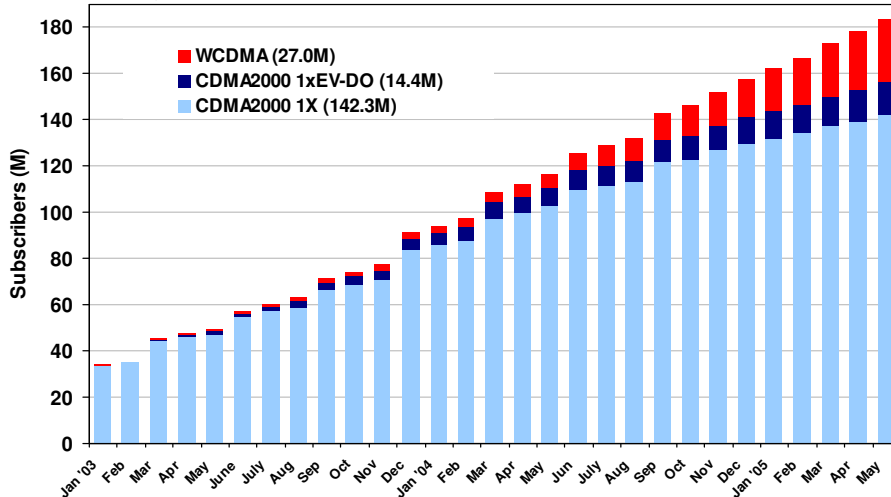
CDMA2000:
 - 1X: 90 operators
 - 1xEV-DO: 18 operators

WCDMA: 68 operators

Source: 3Gtoday.com (as of August 2005)

Over 187 Million 3G CDMA Reported* Subscribers

(Source: 3Gtoday.com, as of June 30, 2005)



*108 of the 147 operators have reported 3G CDMA subscriber totals at some point. 82 of those operators have updated their 3G CDMA subscriber totals for Apr 2005. 39 operators have yet to report 3G CDMA subscriber numbers.

Source: www.3gtoday.com

Benefits of 3G, Wi-Fi and WiMAX

3G Benefits

3G delivers the most ubiquitous access and best voice and data performance within the wide area

- Mobility requirement leads to strong coverage for both voice and data

Scale is tremendous, leading to lower costs and widest availability

- Over 180M 3G subscribers today, forecasted to grow to more than 900M* by 2009.
- Over 150M 3G devices shipped in 2004, forecasted to grow to over 500M units in 2009**
- 3G technologies will be embedded in laptops from leading manufacturers beginning in 2005
- Embedded in handsets, PDA's and data cards from 2002

Wi-Fi Benefits

Serves as low cost and flexible home and campus Ethernet extension

- Built into wide majority of laptops shipping today
- Consumer access points are commodity priced

802.11n will enable 100+ Mbps rates, ideally positioned for home entertainment distribution

- Market success is not predicated on service model

WiMAX

Makes 3G and Wi-Fi services more cost effective

- Backhaul for cellular base stations
- Backhaul for Wi-Fi hot-spots

Could supplement existing wired broadband services

- Fixed broadband access in areas where it is not cost feasible to deploy landline
- Market opportunity may be limited

* Source: Strategy Analytics (2004) and Yankee Group (2005)

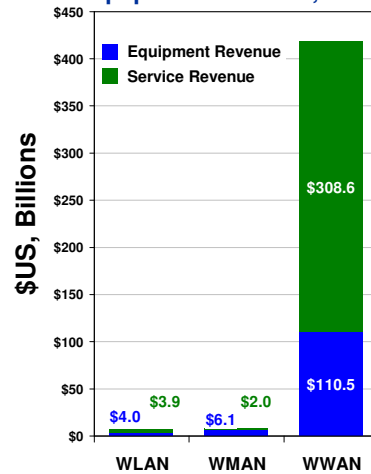
** Source: consensus forecasts

Wireless Market Landscape

2008 Market Size

- WLAN (Wi-Fi)**
 - **US\$4.03B** in customer equipment revenue (NICs, APs/bridges/gateways), (Source: IDC, 2004)
 - **\$3.94B** in Public WLAN service revenue by 2008 (Source: Strategy Analytics, 3/2005)
- WMAN (All Portable and Nomadic, incl. WiMAX)**
 - **\$6.08B** in equipment revenues (BTS, PiP and CPEs) by 2008 (In-STAT/MDR, 12/2004)
 - **\$1.96B** in service revenues by 2008, \$4.275B by 2009 (Source: ABI, Q1 2004)
- WWAN (3G Mobile)**
 - **\$110.5B** in 3G equipment revenue by 2008 (consensus forecast of ABI, Gartner, IDC, InStat/MDR, Shosteck Group, Signals Research and Yankee Group)
 - **\$308.6B** in 3G service revenue by 2008, \$402.7B by 2009 (Strategy Analytics, 12/2004)
 - **785M** 3G subscribers by 2008 (Strategy Analytics, 12/2004)

Worldwide Service and Equipment Revenue, 2008



Fragmented Spectrum Allocation by Region

BWA Spectrum Availability in Select Markets

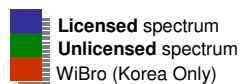
Region	2.3 GHz band (~2300-2400)	2.5 GHz MMDS band (~2500-2690)	3.5GHz band (~3400-3600)	5.8 GHz Upper UNII-band (~5725-5850)
North America	TD-SS	MMDS	Occupied by Radioloc., Amateur...	Available only in limited countries
Europe		IMT-2000 Extension band	Fixed BWA	(Generally available in these markets)
Korea	WiBro	MMDS/S-DMB (IMT-2000 Considered)	Fixed/Mobile, other users	
Japan		Occupied by MSS and BSS	Occupied by Broadcast Repeaters	
China	TD-SCDMA	MMDS (IMT-2000 Considered)	Fixed BWA	
India		Case-by-Case basis	3.3 GHz possible	Not assigned for Unlicensed

2.3 GHz band
~2300-2400

2.5 GHz
MMDS band
~2500-2690

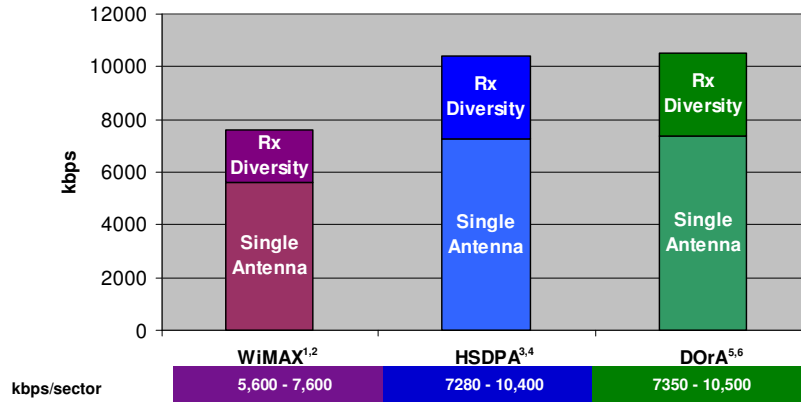
3.5GHz band
~3400-3600

5.8 GHz
Upper UNII-band
~5725-5850



Forward Link Throughput Comparison (Average Physical Layer Throughput per Sector in 10MHz)

Note: assumes 100% loading of data traffic

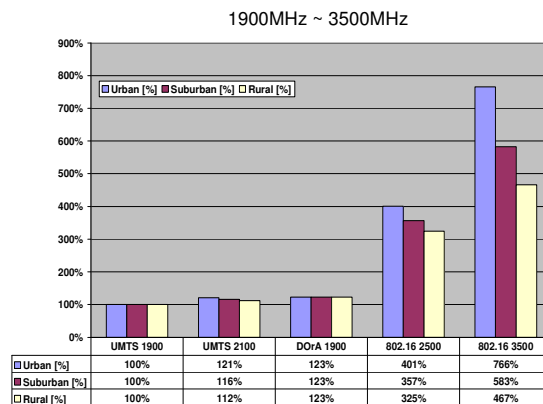


Simulation assumptions:

- 1 Full buffer; ITU channel models: pedA 3km/h 30%, pedB 10km/h 30%, vehA 30km/ 20%, pedA 120km/h 10%, Rician 10%
- 2 No Guard band assumed, frequency reuse of 1
- 3 Full buffer; ITU channel models: pedA 3km/h 30%, pedB 10km/h 30%, vehA 30km/ 20%, pedA 120km/h 10%, Rician 10%
- 4 Perfect Linear MMSE equalizer assumed, back off 0.75dB
- 5 Full buffer; ITU channel models: pedA 3km/h 30%, pedB 10km/h 30%, vehA 30km/ 20%, pedA 120km/h 10%, Rician 10%
- 6 Equalizer gain simulated; 1.25MHz carriers, 7 in 10MHz

Normalized Site Counts Comparison

- 3G technologies need less sites than WiMAX to cover the same area



Assumptions:

Link budget: DorA and 802.16 RL minimum data rate at 9.6kbps, UMTS minimum data rate at 12.2kbps
Propagation model: Cost-Hata model in 1900MHz, 2500MHz and 3500MHz

* Comparison for 802.16e, CDMA2000 and UMTS in the same frequency, not a typical implementation

Network Economics: WiMAX, DOrA & HSDPA

Spectral efficiency

S.E. Assumptions:

- S.E.: Spectral Efficiency: sector throughput in 5MHz divided by 5MHz, unit: bps/Hz/Sector
- Simulation assumptions:
 - Full Buffer
 - ITU Channel Models/probabilities: *pedA 3km/h 30%, pedB 10km/h 30%, vehA 30km/h 20%, pedA 120km/h 10%, Rician 10%*
- WiMAX sector throughput: 2rx, 3800kbps in 5MHz. No guard band assumed, frequency reuse of 1
- DOrA and HSDPA sector throughput: 2rx with equalizer

5MHz	WiMAX 2rx	DOrA/ HSDPA 2rx
Spectral Efficiency	0.76	1.05

Spectral efficiency drives network expense

NetX Assumptions:

- Network Expense includes all network operations expenses and depreciation on network capital
- 7.5% Busy Hour, Assumes 3 sector sites, Capacity Constrained Network
- Equipment Cost \$135k/3 Sector site
- Includes BHaul (\$4000/mbps/year) and Interconnect (\$3000/mbps/year) Expense

5MHz	WiMAX 2rx	DOrA/ HSDPA 2rx
NetX/Gbyte	\$12.00	\$10.40

Commercialization Timeline

3G

Wi-Fi

3G enjoys a major time-to-market advantage for portable and mobile access



Broadband Wireless Access: Business Factors

3G CDMA solutions present the lowest cost structure

– Network equipment

- 3G Technologies are all heading towards All-IP architectures
- Peak-to-Average Power requirements drive PA Costs: Consideration of 3G as an alternative
- Equipment Vendor NRE will be spread across a much larger volume of 3G units compared to alternatives driving significantly lower 3G prices

– Network Operations

- 3G enjoys very high spectral efficiency – drives lowest operations expense

– Devices

- 3G enjoys largest advanced-data device volumes
- Embedded devices require “harmonized” solutions: configuration-to-order drives increased device costs

Broadband Wireless Access: Business Factors

• Alternate Mobile solutions lack performance differentiation

- 3G Networks will operate in “broadband” configurations
- Wi-Fi is inexpensive, and easily available for PC platforms

• Deployment and Transitions

- The 802.16.2004 fixed solution and the 802.16e mobility solution network deployments are not compatible: Requires extensive vendor support

802.11n: The Wi-Fi Evolution

802.11n will satisfy the future demand for indoor broadband

- **802.11n is a high-throughput Wi-Fi technology based on MIMO OFDM**

- Multiple Input Multiple Output (MIMO) transmit and receive antennas support
 - Higher data rates & capacity
 - Increased range through beam steering
 - Higher QoS



- **Peak Data Rates:**

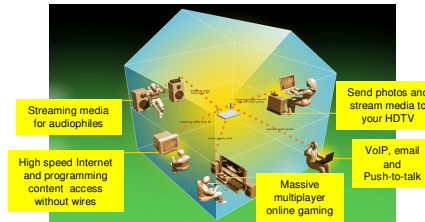
- ~300 Mbps in 20 MHz of bandwidth, with end-user data throughputs greater than 100 Mbps
- ~600 Mbps in 40 MHz of bandwidth

- **MAC Design Enhancements**

- Low latency (tens of milliseconds)
- Excellent QoS
- Efficient - reduced overhead for contention, headers, preambles etc.

- **Usage Models, Application Scenarios**

- Enterprise: Data, VoIP, video conferencing
- Hot Spot: Data, VoIP, video streaming
- Fiber-to-the-Pole: Last 100m wireless “drop”
- Residential multimedia distribution: HDTV, audio, VoIP



- **802.11n is backwards compatible with 802.11a,b,g**

3G is fulfilling Universal Service Obligations *Connecting Citizens to voice & Internet services*

Rainbow Chalta Firta PCO

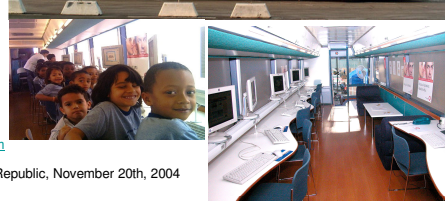
- **In India**, Reliance will meet universal service obligations by providing 3G service to 48,310 villages that don't have public phone facilities¹

- **In India**, Shyam Telecom has equipped a fleet of around 200 self-employed rickshaw drivers with a mobile calling office, including fax²

- **In Dominican Republic**, Tricom deployed over 1,700 public pay phones in underserved rural areas. These phones will eventually be used for high-speed Internet access³

- **In Brazil**, Anatel & Lucent provided universal broadband (800kbps @ 45km) access with 3G

- **In Ecuador**, Edumasters installed 3G kiosks at several public schools to provide free Internet access.



1. <http://www.thehindubusinessline.com/2004/09/20/stories/2004092002090100.htm>
 2. <http://www.hellorainbow.com/aboutus.asp>
 3. BNamericas.com, "GEC-Tel, Tricom Partner for wireless Network – Dominican Republic, November 20th, 2004
 4. <http://projetoiscd.isat.com.br>
 5. www.edumasters.net
 6. http://www.subtel.cl/servlet/page?_pageid=57&_dad=portal30&_schema=PORTAL30&p_language=e, Sept. 3, 2003

Conclusions

- **3G, Wi-Fi and their future enhancements continue to fulfill the demand for wireless broadband**
- **Fixed broadband wireless segment can potentially serve the backhaul needs but presents a limited business opportunity**
 - Will face stiff competition from well positioned Cable, DSL and Wi-Fi service providers
- **3G enjoys a vast market opportunity and a significant cost advantage**
 - 3G has established a robust value chain, a rich selection of services and successful business models
 - Commercialization of emerging alternative solutions lag broadband 3G services by several years
- **QUALCOMM's 3G CDMA Wireless Broadband Technologies, when combined with innovative applications, are addressing the needs of the global community and are helping to improve the quality of life for citizens around the world.**

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Thank You

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