

The wireless landscape...

...at a crossroads

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The logo for Signals Research Group. It features the word "SIGNALS" in a large, bold, black sans-serif font. Above the letter "I" in "SIGNALS" are three curved lines of increasing size, resembling a signal wave. Below "SIGNALS" is the phrase "Research Group" in a smaller, orange sans-serif font.

A quick introduction to Signals Research Group, LLC.

- Signals Research Group, LLC offers thought-leading field research and proprietary consulting services on the wireless telecommunications industry.
- Our flagship research product, a bi-weekly newsletter entitled “Signals Ahead,” includes more than 70 corporate subscribers on five continents across the entire wireless ecosystem, as well as trade organizations, government regulatory bodies, and organizations within the financial community.



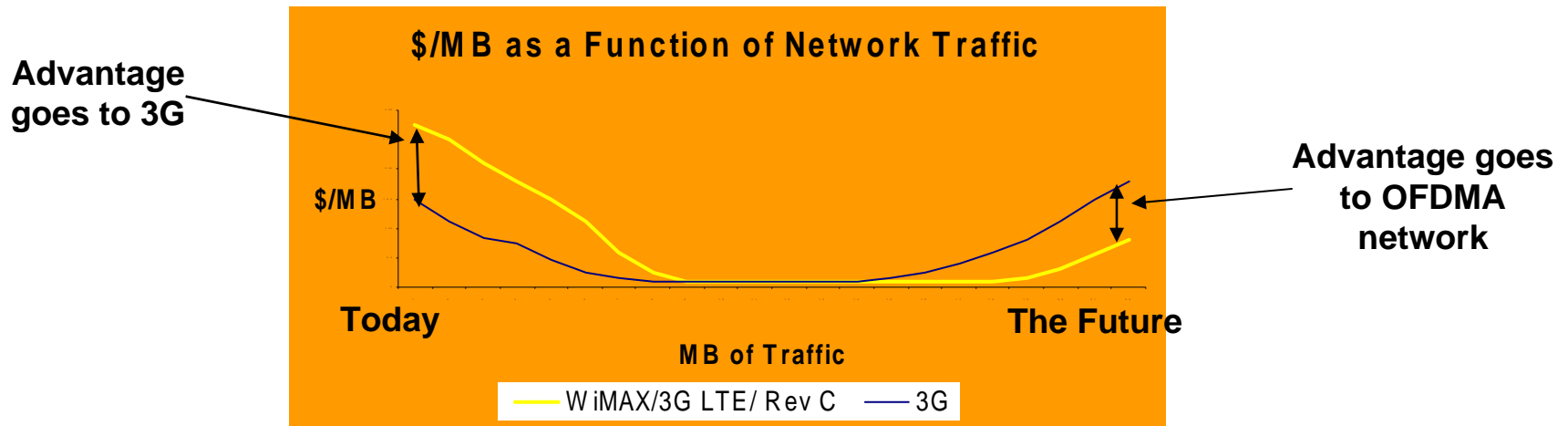
Technology fragmentation and operator strategies are becoming more pronounced on a regional basis.

- Most of the developed markets have moved to various flavors of 3G with 3G enhancements (Release 5, Rev A) already being implemented.
 - 2G spending and commitment are less noticeable
 - Some indications that the industry is less focused on 2G in favor of next-generation technologies
- In other markets like India, China, Latin America and Africa the economics of low-cost 2G solutions make it difficult to justify 3G.
 - 1X and GSM handsets exist below \$30
 - Voice capacity rivals 3G thanks to new codecs and aggressive freq reuse schemes
 - Popular mobile data services are already being delivered on 2G
- Developing [and developed] markets are giving serious consideration to jumping directly to OFDMA.
 - Opportunities to provide fixed voice and data services in addition to traditional mobile wireless services

As such, the technology and business decisions are becoming more difficult to make while the ramifications are becoming more dramatic.

- Existing 3G networks are largely able to handle the current demand for traffic.
 - HSDPA (Cat 6) and Rev A are more than adequate for most high-end data users
- Upgrades to existing 3G networks are relatively inexpensive, delivering tremendous amounts of “bang for the buck.”
 - The economics of a blade upgrade favor that of a network overlay
 - Rev B and HSPA Evolved offer further increases in spectral efficiency and voice capacity (VoIP)
 - Backwards compatibility across networks and devices is a huge advantage
 - Further performance/capacity gains can be gained through 6 sector cells and receive diversity in handsets.
- OFDMA technologies offer tremendous performance gains but come at a high cost.
 - New [higher] spectrum is frequently required
 - New device and infrastructure ecosystem needs to be created

Only with high network utilization will the economics become more favorable.

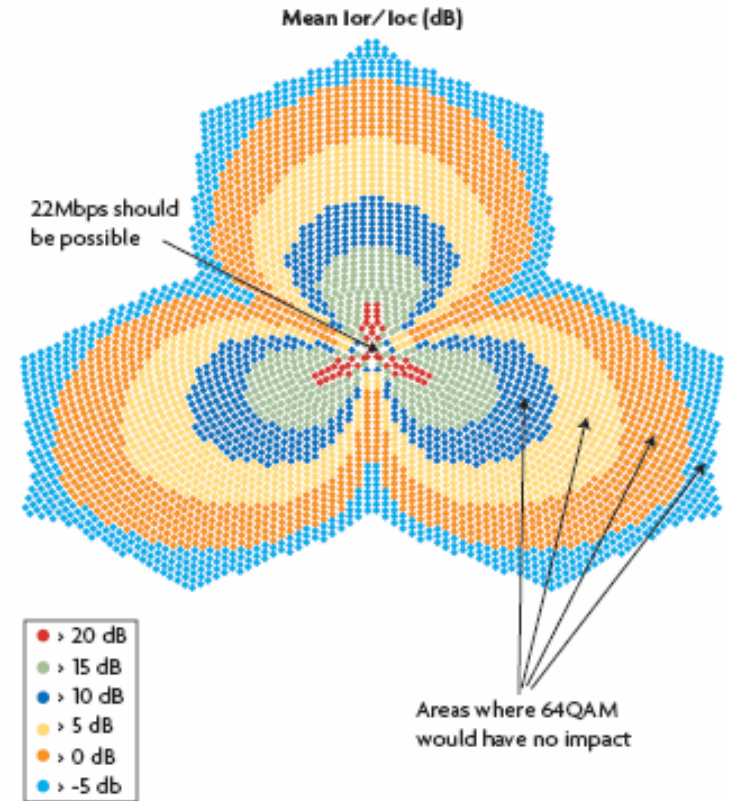


- The cost to deliver the first byte of data is infinite.
- Once the network is more heavily utilized the \$/MB becomes more attractive.
 - Cell densification, wideband channels, and the higher spectral efficiencies meaningfully increase the amount of available capacity.
- 3G networks today are largely under utilized with far more capacity available.
- OFDMA, however, creates new business models that CDMA-based solutions cannot address.

New technologies and new opportunities mean new challenges.

- HSPA Evolved promises very high data rates, yet these data rates could remain limited to certain regions of the network.
- Rev B implies multiple RF chains in the devices.
- OFDMA technologies exhibit high PAPR (Peak-To-Average-Ratio) characteristics, yet require high linearization to achieve target data rates.
 - High linearity and high PA efficiency are counter-productive
 - Could impact link budget, electrical bill and handset device battery life (e.g., user satisfaction)
- With very efficient PA's RRU (remote radio units) can dramatically alter the economics
 - Active components on the tower?

In search of 22Mbps



Source: Signals Research Group, LLC

The business case for OFDMA is predicated on an indoor usage model, yet OFDMA doesn't solve the "brick wall dilemma."

Probability of Coverage by bearer channel

	Dense Urban	Urban	Suburban	Rural
Outdoor PoC	98%	98%	98%	98%
Indoor PoCs				
12.2kbps (inbuilding PoC)	67%	70%	72%	68%
64kbps (inbuilding PoC)	50%	50%	46%	38%
144kbps (inbuilding PoC)	41%	39%	34%	26%
384kbps (inbuilding PoC)	31%	28%	22%	16%

Source: Signals Research Group, LLC

- Most traffic occurs indoors.
- Heavy data usage (e.g., data cards) generally occurs indoors.
- Probability of providing a favorable user experience is severely impacted.
- A successful triple- or quad-play strategy is predicated on good in-home wireless coverage.
- Some form of in-building solution (e.g., femtocells, etc) is critical.
- Also applies to CDMA-based technologies.

Key Assumptions

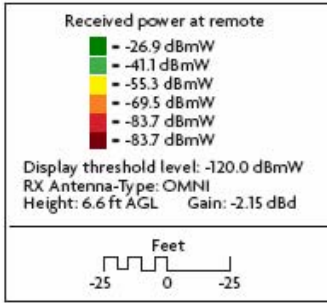
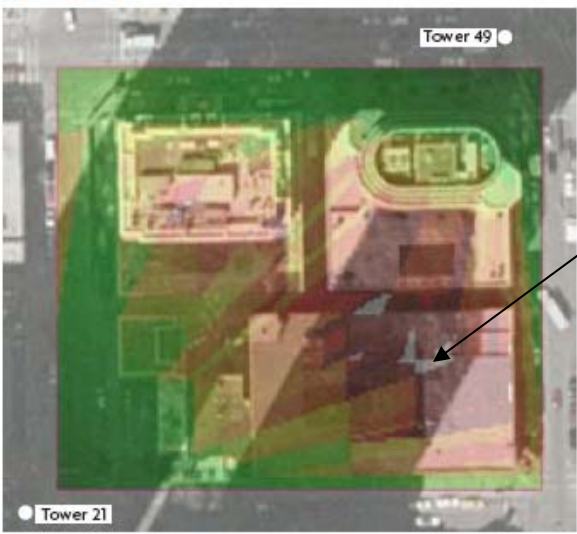
	Unit	DU	U	S	R
Link Budget Margin Parameters					
Propagation Index	N	3.53	3.53	3.53	3.53
Log Normal Standard Deviation	dB	12.00	10.00	8.00	6.00
Indoor Path Loss Standard Deviation	dB	8.00	6.00	4.00	4.00
Combined Standard Deviation	dB	14.42	11.66	8.94	7.21
Indoor Path Loss Mean	dB	20.00	16.00	13.00	11.00
Baseline Design Specifications					
Design Bearer Rate	kbps	12.20	12.20	12.20	12.20
Cell Area Outdoor Probability of Coverage	%	98%	98%	98%	98%
Required Margin for Area Coverage	dB	19.83	16.02	12.27	8.63

Source: Signals Research Group, LLC



Operators that overlay two technologies/frequencies suffer even more.

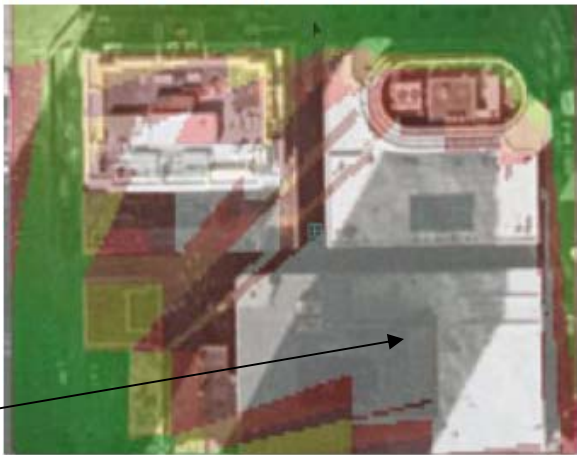
UMTS in-building coverage at the ground floor (1900MHz)



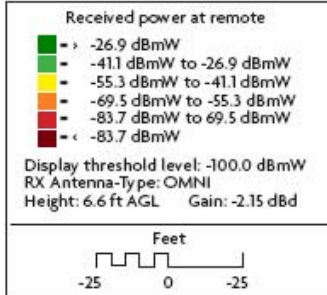
Source: EDX Wireless

A modest amount of dead space, but weak signals throughout the building

Mobile WiMAX in-building coverage at the ground floor – close-up view (2500MHz)



Lot's more dead space

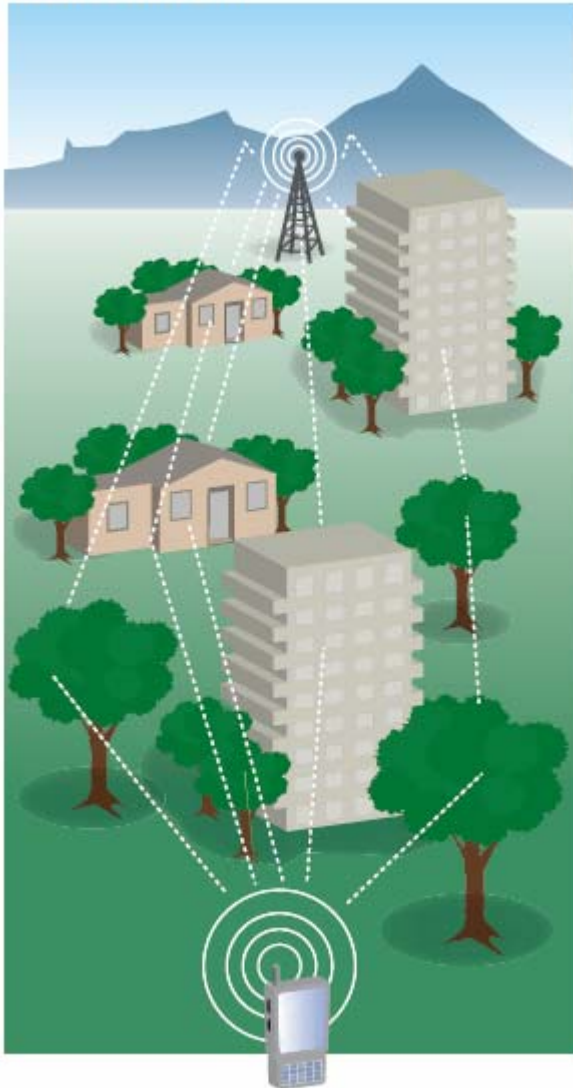


Source: EDX Wireless

- Results shows two Node B's covering a city block in downtown Chicago.
 - Device characteristics dependent on the respective technology.

MIMO and other “smart antenna” schemes are a critical part of all next-generation wireless technologies.

Multi-path in action



Source: Signals Research Group, LLC

- MIMO takes advantage of multi-path to stretch Shannon’s Limit to the limit.
- Transmit and receive diversity are “MIMO-Lite.”
- Various flavors of MIMO exist,
 - Spatial Multiplexing (SM) can theoretically double the throughput to an individual user.
 - Spatial Division Multiple Access (SDMA) reuses the same tones to send data to two physically separate users
 - Space Time Coding (STC) can make a weak signal more robust in challenging RF environments.
- AAS uses multiple antennas to intelligently steer RF energy to its destination.
 - Reduces interference

With a few exceptions all OFDMA technologies are largely created equal.



	Mobile WiMAX	3G LTE	UMB
OFDMA	X	X	X
All-IP Architecture	X	X	X
MIMO and AAS, etc	X	X	X
Scalable Bandwidth	X	X	X
Multiple Duplex Schemes (FDD, TDD, etc)	X	X	X
Large Ecosystem of Suppliers	X	X	
Uncertain IPR future	X	X	X

- Operators will likely follow their respective 3G migration path
 - Greenfield operators will generally enter the market with Mobile WiMAX

Thank you for listening!