

In this session, we will look at WWAN technologies besides 2G and 3G cellular solutions.

- Metro Wi-Fi
 - What is it?
 - How successful has it been?
 - What will become of it next?
- WiMAX – separating hype from reality
 - A quick history lesson
 - WiMAX differentiators and similarities with 3G
 - WiMAX versus WiBro
 - Issues/challenges that face Mobile WiMAX
 - The future of Mobile WiMAX
- What other WWAN technologies are coming?
- Questions and Answers

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☐ ● Metro Wi-Fi

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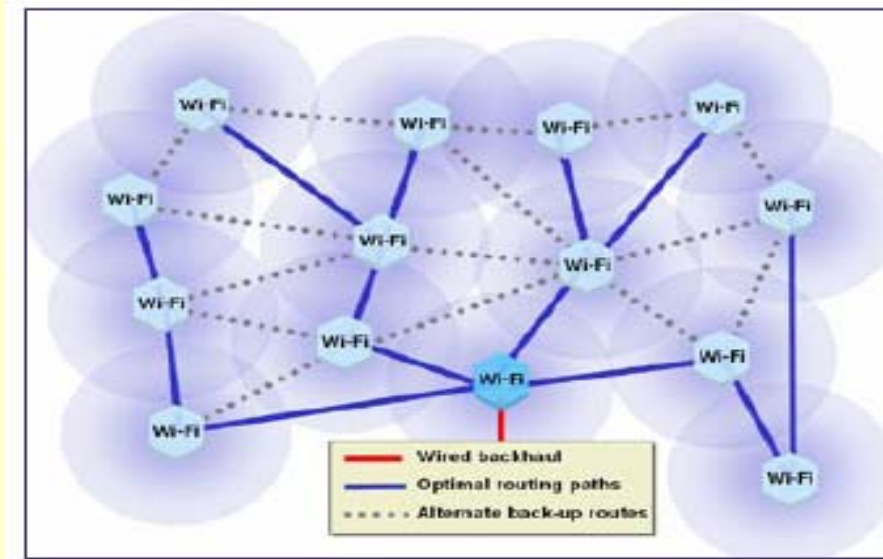
● What other WWAN technologies are coming?

● Questions and Answers

Metro Wi-Fi is all the rage in North America and in several major Asian markets (Taipei, Tokyo, etc).

- The service is generally free or heavily subsidized by the local municipality.
 - Some services used advertising-based models
- Seeks to take advantage of the ubiquitous nature of Wi-Fi devices and unlicensed spectrum.
- Objectives vary for why the technology is being deployed.
 - Provide low-cost broadband access to the masses
 - Promote tourism
 - Prove that the city is tech-savvy
 - Reduce government communications costs and improve productivity.
 - Fight crime
- Leading companies in the space include Google, MetroFi and Earthlink as service providers with Motorola, Nortel and Tropos Networks as suppliers.

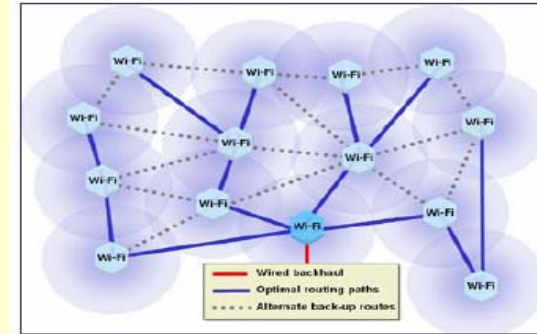
Metro Wi-Fi networks are typically based on a mesh network topology.



Source: Tropos Networks


- The 802.11 MAC (access layer) is “contention-based” versus a cellular MAC which is “contention-less.”
 - A contention-based MAC is not designed for “real-time applications”
 - “Listen then transmit” results in higher latency and lack of QoS
 - Each leg of the backhaul introduces additional latency (WiMAX is an option)
- 802.11e (approved in late 2005) provides enhancements to the MAC, including QoS, but it isn’t implemented in most solutions while it isn’t a panacea.

Metro Wi-Fi networks typically are based on a mesh network topology (cont'd).



- IEEE 802.11s is (will be) the standard that defines a Wi-Fi mesh network.
 - 15 proposals were submitted in July 2005
 - 2 proposals were selected in January 2006
 - Final 2 proposals were merged into one proposal in March 2006
 - Standard is not expected to be approved until 2008
- Anything and everything being deployed today is proprietary.
 - Multi-vendor interoperability isn't possible
 - Forward-compatibility with the new standard can't be guaranteed

Welcome to the world of almost free wireless



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EarthLink Wi-Fi **Google Wi-Fi**

Wireless Internet in San Francisco. Access for everyone.
Attend one of our community forums to learn more.

EarthLink® and Google® want to bring wireless broadband Internet access – Wi-Fi – to the people of San Francisco. This network is one of the first of its kind in the nation, offering **free broadband Internet access throughout San Francisco** - plus affordable options for higher speeds and home connections.

EarthLink and Google would love to tell you a bit more about our proposal and hear your ideas. We invite you to attend one of our upcoming neighborhood forums. We look forward to seeing you.

[See the meeting schedule](#)

- Network funded and maintained by Google and Earthlink.
 - Equipment from Motorola and Tropos
 - 802.11n upgradeable
 - 4.9GHz for backhaul
- Expected to cover 95% of the city (outdoors).
 - 68,000 Access Points (SRG estimate)
 - 90% indoor coverage (could require modem – sold separately)

Source: Google



Our Proposal At-A-Glance

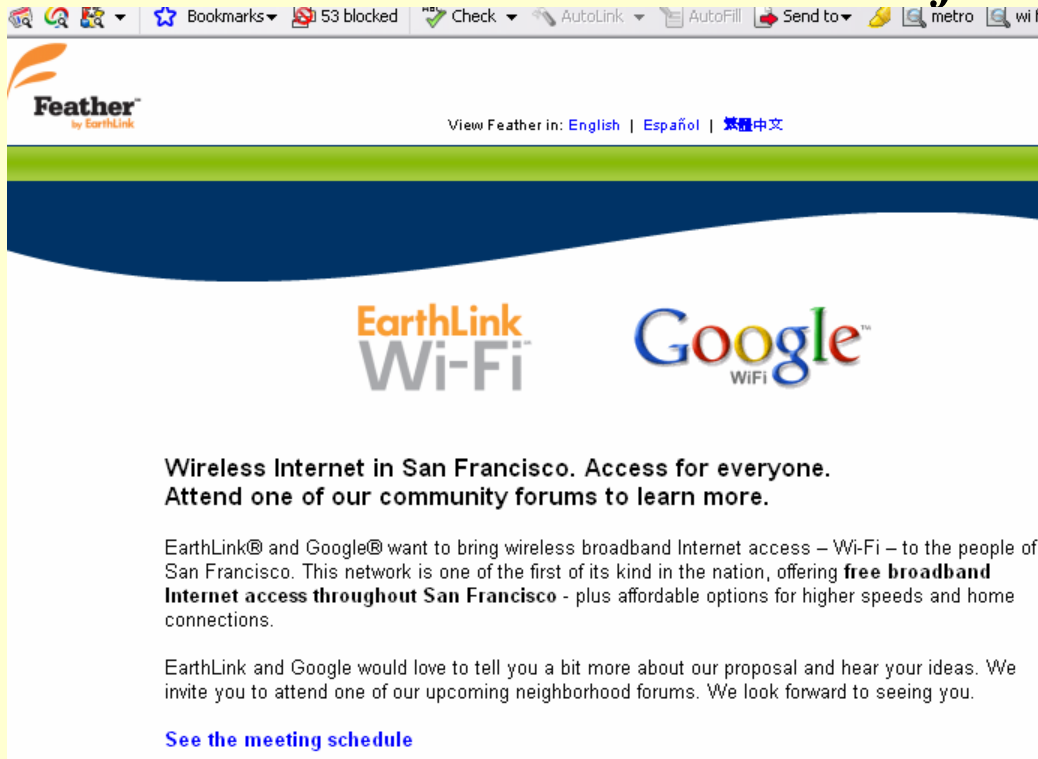
EarthLink and Google: Our San Francisco Wi-Fi Proposal at-a-glance

- Free broadband wireless Internet access throughout San Francisco
- Premium network access - higher speed at an affordable price
- Outdoor access with Wi-Fi enabled computers and devices
- Indoor access with "Wi-Fi modems" or other simple hardware
- Ongoing community trainings

For more information:

- [About EarthLink Wi-Fi](#)
- [About Google](#)

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- RFP requires 1Mbps symmetric (best effort).
 - With session level connectivity p to 30mph
- Fixed broadband up to 3Mbps.
- Traffic priority for city traffic (emergency situations)
- Free for up to 300kbps.

- Up to \$20 for 1Mbps
- Available to other ISPs for a wholesale price
- Computer purchase programs
- Training programs

Source: Google



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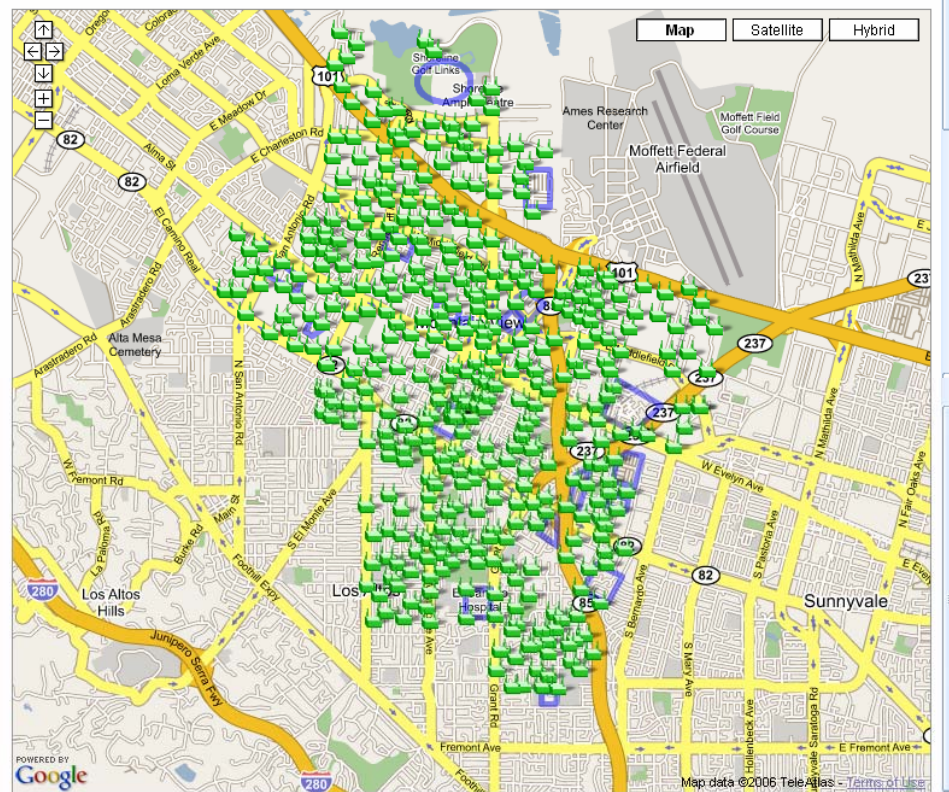
[About Google](#)

Welcome to the world of free wireless

Google WiFi Mountain View Coverage Map

This map shows the location of Google WiFi nodes in Mountain View, CA. The map also shows the areas of the city where we are not yet able to provide coverage. Often these locations do not have public light poles, on which we typically mount our network equipment. If you live in an area without coverage and you are interested in the possibility of hosting a Google WiFi node on your property, please email us at mvwifi-support@google.com.

Legend: Green icons indicate Google WiFi nodes. Purple shapes indicate areas of the city that are not currently covered by Google WiFi.



- Network is advertised as being an “outdoor network.”
 - 380 AP’s deployed to start (\$1M) - \$2.6K per site
 - Notable exception is the Mountain View library
 - Users advised that a PC isn’t good for transmitting to the AP (the uplink)



Google WiFi Mountain View

[Google WiFi Help](#)

[Google WiFi Help](#) > [Google WiFi Overview](#) > [Coverage](#)

What should I do if there is a tree/building/obstacle between me and the closest Google WiFi node?

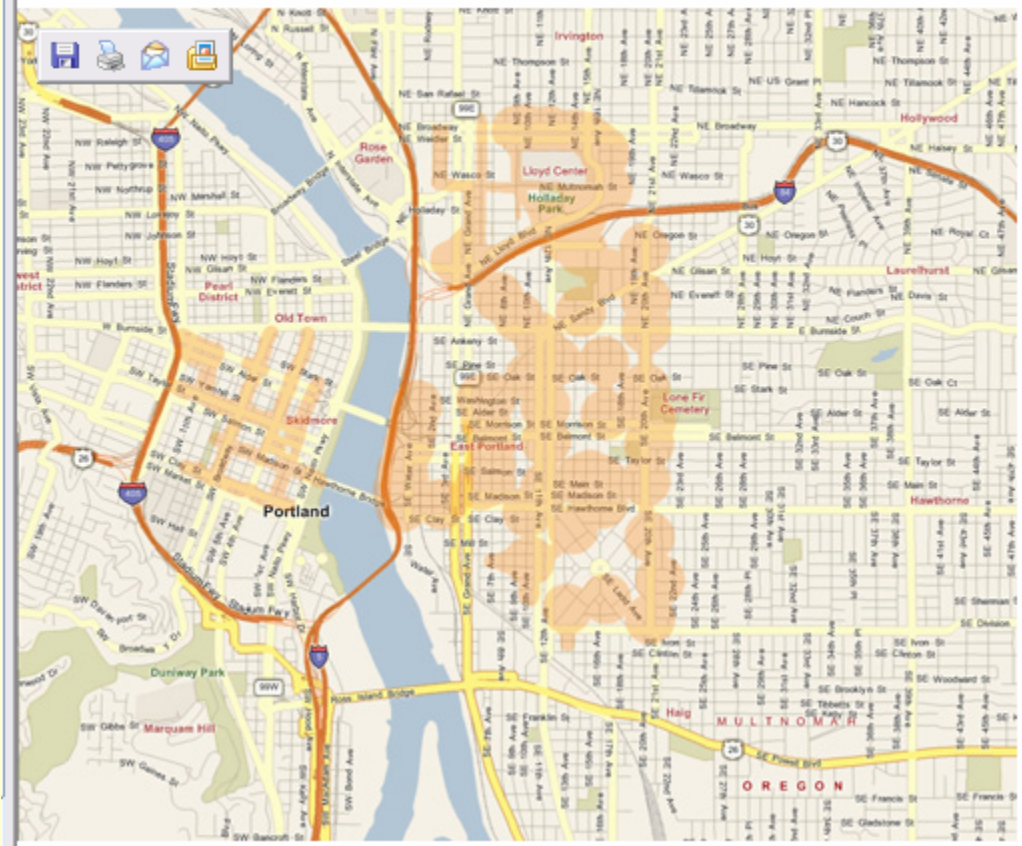
We apologize that your service is being obstructed. We hope that you are able to use Google WiFi in other outdoor areas of Mountain View.

Source: Google

Source: Google

Welcome to the world of free wireless

Results for: Portland, Oregon



“The City of Portland , which spans 134 square miles and has a population of approximately 540,000, will be blanketed by a state-of-the-art Wi-Fi mesh network. Residents and visitors of Portland will have wireless access to 1Mbps Wireless Internet at no cost.” *MetroFi Press Release 4/12/2006*

MetroFi is deploying coverage in several Northern California markets.



Source: ExpressNet



Source: Tranzeo

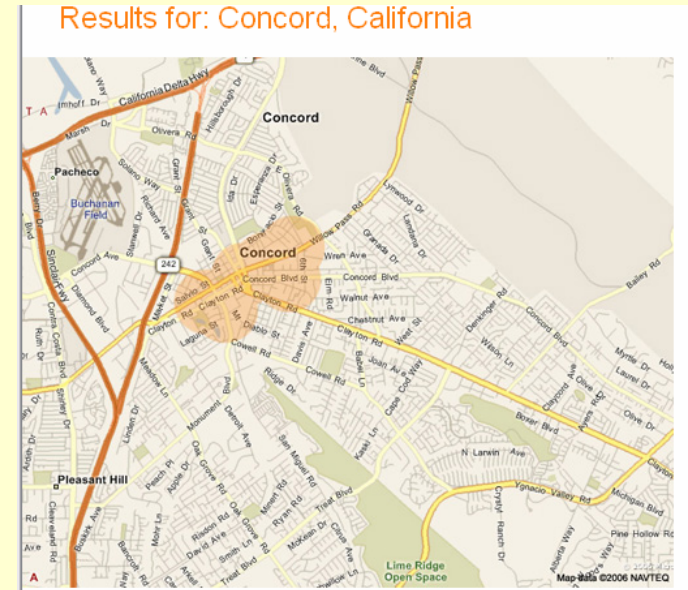
- Beyond 500 feet or indoors, subscribers are advised to purchase a wireless modem or externally mounted CPE.
- Wireless modem is \$99 (reasonable), but requires an AC power supply.
- Outdoor unit is \$137.
 - Plus installation
 - Plus Ethernet cable

MetroFi is deploying coverage in several Northern California markets (cont'd).

```
Command Prompt - ftp
226 Transfer complete.
ftp: 1099399 bytes received in 4.50Second 244.53Kbytes/sec.
ftp> get sa_0524.pdf
200 PORT command successful.
150 Opening ASCII mode data connection for sa_0524.pdf(1099399 bytes).
226 Transfer complete.
ftp: 1099399 bytes received in 9.58Second 114.71Kbytes/sec.
ftp> get sa_0524.pdf
200 PORT command successful.
150 Opening ASCII mode data connection for sa_0524.pdf(1099399 bytes).
226 Transfer complete.
ftp: 1099399 bytes received in 4.68Seconds 235.06Kbytes/sec.
ftp>
```

Average Downlink = 1.6Mbps

- Performance in an outdoors environment (downtown) is actually fairly impressive.
 - Downlink >1.5Mbps; Uplink >200kbps; Latency ~50-60ms
- Issue is indoor coverage, mobility and loading (all difficult to evaluate).
- Network is limited to downtown area (intent is to cover the entire population).
- Advertising model doesn't seem to be working well.



Source: MetroFi

So what does this all mean for the metro Wi-Fi market opportunity?

- There is no such thing as a free lunch.
 - Municipalities [and consumers] get what they pay for
- Wi-Fi is a great technology, but it just wasn't designed to scale in order to support a metropolitan deployment.
- Separate from performance concerns there are other hidden costs.
 - O&M of a network with thousands of base stations
 - vandalism
 - Technology obsolescence
- The business case needs to be understood as well as the long-term implications.
 - What happens after the PR fire dies down?
- At a minimum, interested parties may want to wait until standards-based solutions are available.
 - WiMAX complements very nicely for the backhaul and/or for the access network

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The relationship between IEEE and WiMAX.

- The IEEE standards body is responsible for developing the lower OSI layers – PHY and MAC – of a standard.
 - 3G standards bodies define all layers (soup to nuts)
- Higher layers (network, security, etc) and issues like interoperability and testing are outside the scope of the IEEE – enter trade organizations.
- In order to commercialize an IEEE standard a trade organization is used to promote the standard and ensure its commercial success.
 - IEEE 802.15.4 = Zigbee Alliance
 - IEEE 802.15.1 = Bluetooth
 - IEEE 802.11x = Wi-Fi Alliance
 - IEEE 802.15.3 = UWB
- On a similar vein, the WiMAX Forum is the trade organization responsible for promoting and commercializing 802.16-2004 (Rev D) and 802.16-2005 (802.16e).

IEEE 802.16 – a quick historical perspective.

- IEEE 802.16 is the standard around which WiMAX is based.
 - Initiative began in the late 1990's and covered 10GHz-60GHz
 - 802.16a then introduced for 2GHz-11GHz
 - 802.16c covered 10GHz-66GHz
- Unfortunately, the effort never reached commercialization.
 - Too many players with their own vested interest
 - The collapse of the BFWA industry
 - Technical limitations
 - NLOS
 - Self-installation
 - etc
 - Lack of a “WiMAX-like” trade organization

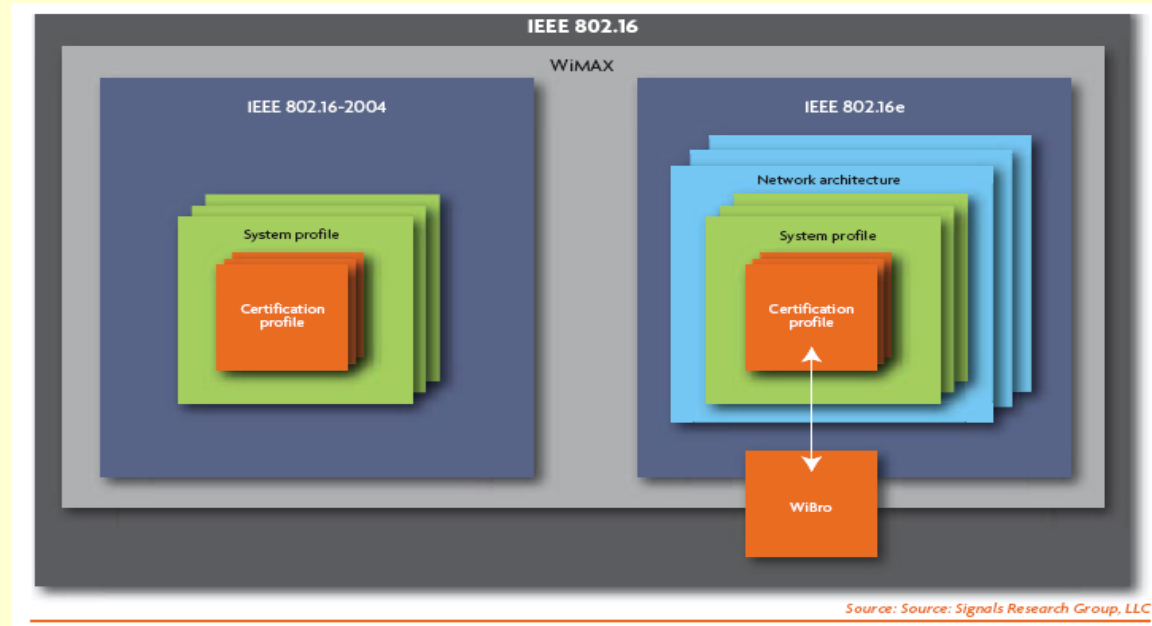
IEEE 802.16 – a quick historical perspective.

- In 2001 the WiMAX Forum was created to promote the efforts of IEEE 802.16.
 - At the time there were only a few members, including Intel and Fujitsu
 - No service providers, handset manufacturers or major OEMs were involved
- 802.16d PAR was approved in September 2003.
 - Revision to existing 802.16 PAR
 - Standard approved in June 2004
 - Published as IEEE 802.16-2004
- 802.16e PAR was approved in December 2002.
- 802.16e PAR was modified in September 2004.
 - Removed 2GHz lower limit
 - Backward compatibility with 802.16d no longer required
 - Enter the conflict with 802.20

802.16-2004 and 802.16e address different opportunities and are not compatible with each other.

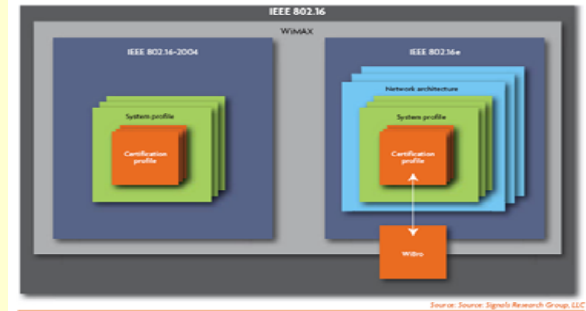
- 802.16-2004 is a “fixed solution” where throughput and data rates outweigh the need for some form of mobility.
 - 70Mbps at 70km
 - OFDM is used and fixed at 256 tones (sub-channelization is possible in the reverse link)
 - Results in higher output power requirements but with tradeoffs that preclude mobility
- 802.16e uses OFDMA with “scalable bandwidth.”
 - The number of tones, or sub-carriers, changes with the channel allocation
 - A 256 tone option is not included, hence the incompatibility

The relationship between the two IEEE standards and WiMAX can best explained via an illustration.



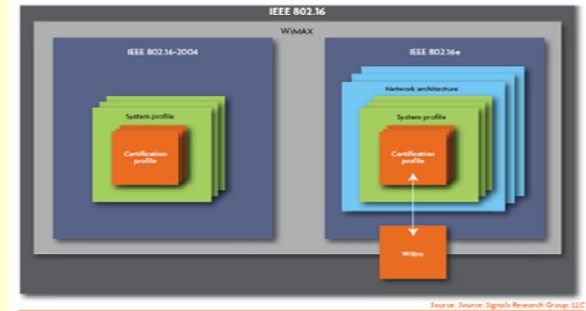
- In addition to being limited to the PHY and MAC, the IEEE standard contains a litany of options – some options are incompatible with each other.
 - Standard address a wide range of frequency bands, channel allocations and TDD/FDD
 - A “system profile” defines a set of optional features
 - A “certification profile” allows interoperability testing
 - A “network architecture” is only relevant for a mobile solution

WiBro will evolve to become a Mobile WiMAX profile, but it isn't there yet.



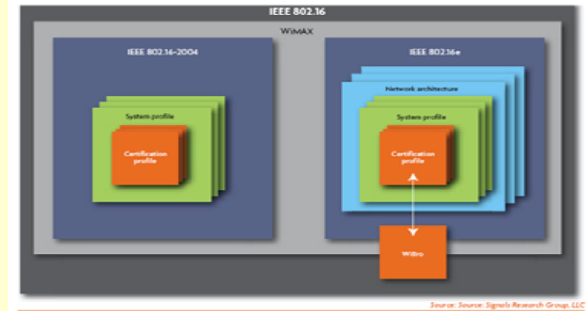
- In February 2002 the South Korean government assigned 100MHz of 2.3GHz for the deployment of a mobile broadband wireless technology.
 - Operators began trialing several proprietary solutions
- While IEEE 802.16 work was beginning, the South Korea MIC, ETRI and TTA were developing a “home-grown” standard for South Korea.
 - At its inception it was referred to as HPi (High-speed Portable Internet)
 - HPi was specific to the needs of the local market versus being designed for a global solution
- Politics and external pressure led to a convergence with IEEE 802.16e
 - HPi was re-branded WiBro (Wireless Broadband) in April 2004

WiBro will evolve to become a Mobile WiMAX profile, but it isn't there yet.



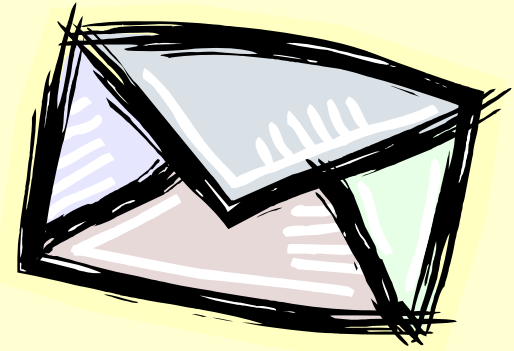
- Important to remember that IEEE 802.16e and WiMAX are not synonymous.
- Like Mobile WiMAX, WiBro is comprised of Phase 1 and Phase II.
 - Phase I retains the “proprietary” elements of HPI and reflects what is deployed today
 - Phase II, which was largely completed in late 2005 (before 802.16e was approved), more closely aligns with the PHY and MAC requirements of 802.16-2005.
 - South Korean documentation suggests alignment with WiMAX in 2008
- There are several key technical differences between WiBro and WiMAX.
 - Akin to FOMA versus UMTS
 - Number of assigned tones for data and signaling are not consistent
 - Handoff mechanism (WiBro uses FBSS; WiMAX uses HHO)

WiBro will evolve to become a Mobile WiMAX profile, but it isn't there yet.



- WiBro performance today is at best on par with HSDPA or EV-DO Rev 0
- Lack of compelling features, handsets, and coverage is limiting the technology's adoption.
 - Deployment limited to certain regions of the country – largely within Seoul
 - At launch there were only a few handsets and a data card
 - PDA devices are not popular in South Korea
- The next phase of the network rollout will likely kick off in 2007.
- Korea Telecom is the most supportive while SK Telecom is just playing it safe.
- KTF and SKT are focused on 3G (HSPA) for future growth.

The Mobile WiMAX reality check is not yet in the mail.



- Mobile WiMAX, as defined by the performance of WiBro, is not very compelling.
 - Average data rates are on par with EV-DO Release 0 from a fixed location
 - Sector throughput is no better than HSDPA
- Some leading Mobile WiMAX infrastructure suppliers do not yet support mobility.
- Despite all the hype surrounding MIMO, MIMO has never been proven in a WWAN.
 - Infrastructure and chipsets do not currently support the feature
 - MIMO is far more important than OFDMA

There are several similarities between Mobile WiMAX and the future evolution of 3G (both migration paths).



	Mobile WiMAX	3G LTE	Rev C
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

- The real question is one of legacy, timing, strategy and choice of frequency bands.
 - Why 2.5GHz is such a hotly contested spectrum band

There are also a few key differences between Mobile WiMAX and the future evolution of 3G (both migration paths).

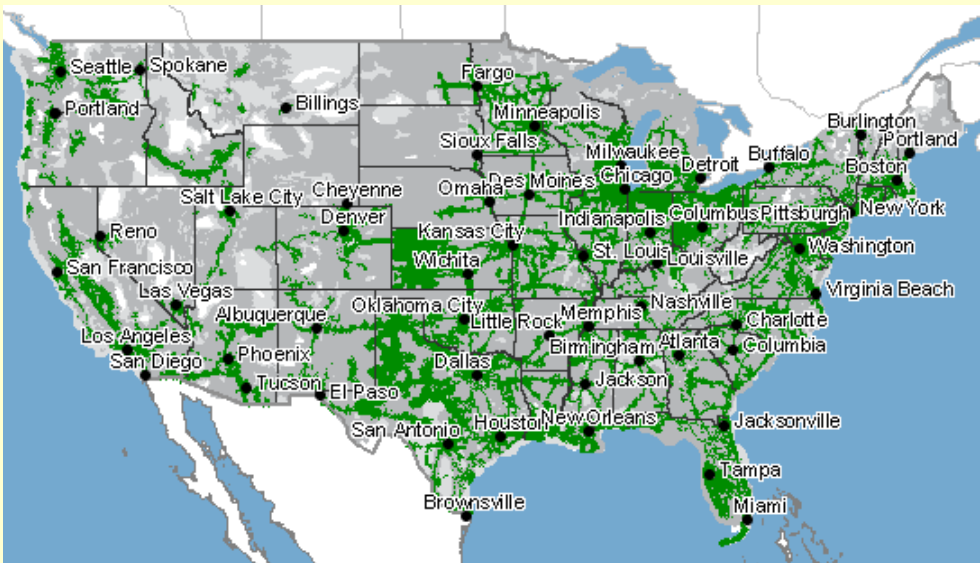
- The uplink between the three technologies follow different strategies.
 - WiMAX uses OFDMA
 - 3G LTE uses SC-FDMA
 - Rev C uses OFDMA and CDMA
- 3GPP dismissed OFDMA due to concerns about PAPR (Peak to Average Power Ratio).
 - Traded a potential performance hit for mobility
- Some concerns over how well Mobile WiMAX deals with interference.
 - Interference is one Achilles heel of OFDMA (another is PAPR)



Mobile WiMAX got a huge endorsement when Sprint Nextel announced its 2.5GHz strategy last August.

- Sprint Nextel announced a \$3B commitment to deploy a “nationwide” Mobile WiMAX network.
 - 100 million pops covered by the end of 2008
 - additional rollouts subject to the economics
- Announcement marks the first important operator commitment to the technology.
 - SK Telecom and Korea Telecom didn’t have a real choice of technologies
 - Clearwire’s investment from Intel and Motorola came with restrictions
 - Other operators are not significant or have not made firm commitments

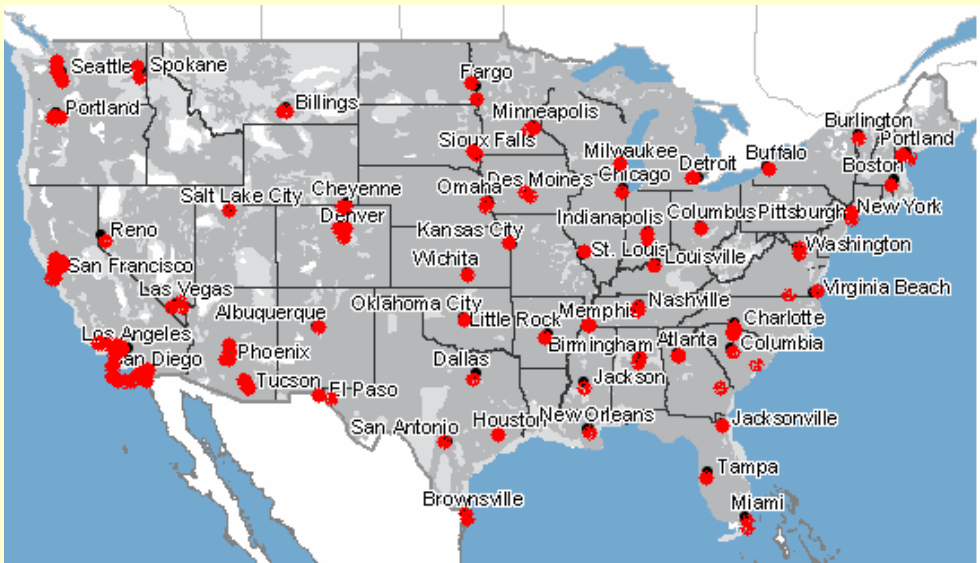
Mobile WiMAX may or may not be 1/10th the cost of 3G – the devil is in the details.



Source: Sprint Nextel website

- The US population is highly concentrated in non-rural areas (~230 million).
 - 57.2% of population live in a dense urban or urban area (6.7% of the landmass)
 - 19.1% of the population live in a suburban area (12.1% of the landmass)
 - Therefore, ~76% of the population live within 18% of the US landmass
- The Sprint Nextel 3G network reportedly covers 275 million pops
 - Data suggests that the 3G network covers at least 20-25% of the US landmass
 - This network will support Rev A by the end of October 2007

Mobile WiMAX may or may not be 1/10th the cost of 3G – the devil is in the details – (cont'd).



Source: SRG estimates

- The Sprint Nextel Mobile WiMAX network will cover 100 million pops.
- With 57.2% of the US population living on 6.7% of the landmass, this implies that the Mobile WiMAX network will cover less than 5% of US landmass.
 - Conservatively 1/4th to 1/5th the size of the 3G network
- In order to compare technologies, the same level of coverage and services must be assumed.
 - Comparing apples and bananas

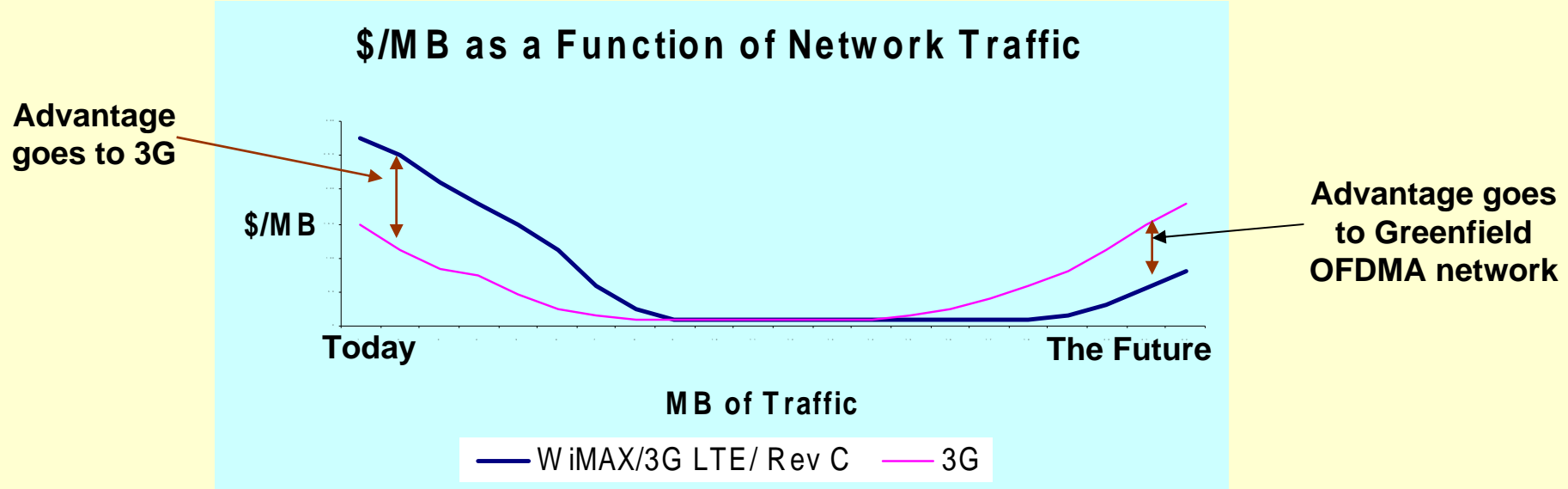
When deployed for coverage purposes, higher frequencies significantly increase the cell count.

Frequency	Cell Radius (km)	Cell Area (km ²)	Relative Cell Count
450MHz	48.9	7,521	1
850MHz	29.4	2,712	2.8
1900MHz	13.3	553	13.6
2500MHz	10	312	24.1

Source: ITU filing

- Relative to its 1900MHz network, the operator would need 1.7x more base stations.
 - All things being equal
- Technologies, like beamforming or higher power amplifiers can be used to make up some of the difference.
 - These solutions come with a cost
 - Spectrum in some markets comes with severe power limitations

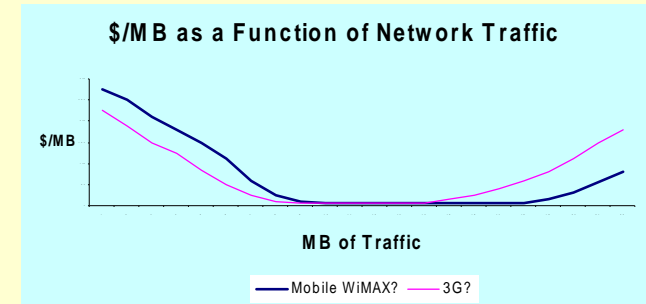
Mobile WiMAX may or may not be 1/10th the cost of 3G – the devil is in the details – (cont'd).



- The cost to deliver the first byte of data is infinitely expensive.
- Once the network is more heavily utilized the \$/MB becomes attractive.
- \$3B Greenfield networks with an abundance of capacity face a far greater challenge with respect to the economics.
- At some point the advantage will shift to favor a Greenfield OFDMA network.

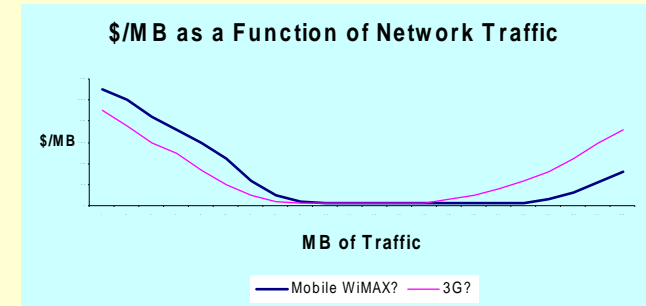
— But when?

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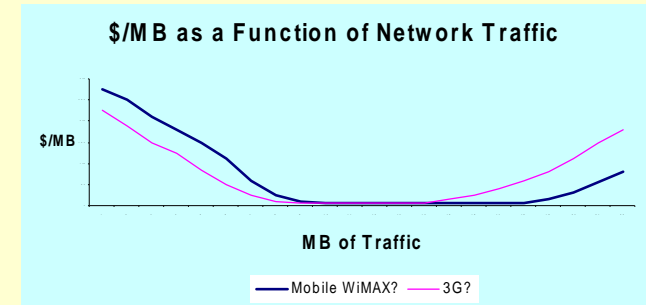
- Multi-mode WiMAX/3G handsets cannot be less expensive than single-mode 3G handsets.
 - Extra baseband silicon, RF and PA requirements
- Without compelling features like video encoders/decoders, high-quality displays, 3D graphics, etc, Mobile WiMAX handsets would not be compelling.
 - Suggests that Mobile WiMAX devices will have to be mid-tier or high-end devices
- Single-mode WiMAX (or any 2.5GHz technology) devices could conceivably be less expensive but with limited coverage they would not be appealing to most consumers.
 - Lower cost is best achieved through economies of scale

Mobile WiMAX may or may not be 1/10th the cost of 3G – the devil is in the details – (cont'd).



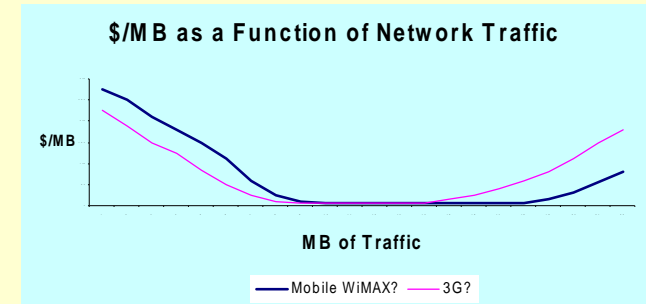
- Mobile WiMAX base stations can't be (aren't) less expensive than 3G base stations.
 - Again, economies of scale is a critical issue
 - Hundreds of thousands of 3G base stations versus a couple hundred WiBro base stations
- The digital portion of the base station is perhaps 25% of the total cost of the base station.
 - The cabinet doesn't care what technology is inside
 - The antenna cabling, multi-carrier amplifiers, etc don't care either
- PAPR constraints could actually drive up the cost of the analog portion (amplifiers must support higher power and be more linear to support the demands of OFDMA).

Yet there are valid reasons why Mobile WiMAX (LTE or Rev C) could be less expensive than today's 3G technologies.



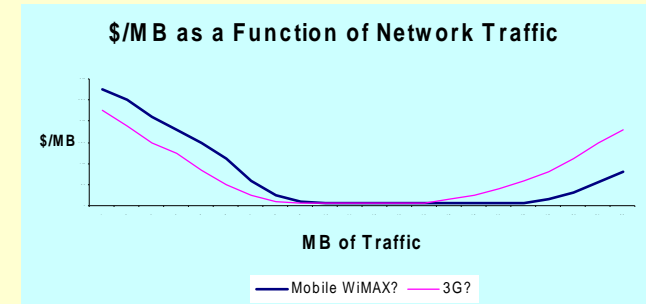
- “3G spectrum” is a limited resource – once its gone, its gone.
- Adding a few extra 3G carriers (HSPA or EV-DO) is arguably less expensive than deploying a network, but only to a certain limit.
 - Base stations only support so many channel cards
 - A 10MHz carrier can be less expensive than deploying multiple 1.25MHz/5MHz carriers
 - Savings comes from both digital and analog (RF, cabling and PA's)
- Technologies that facilitate more throughput per site should lead to lower costs even if the technology itself is more expensive.

But will there be enough demand to justify the new network?



- Taking vendor claims at face value Mobile WiMAX can support 14Mbps of sustained throughput in a 10MHz radio carrier.
 - This equates to 42Mbps per cell site ($\sim 2.3\text{km}^2$)
 - Arguably this impacts the backhaul, but we'll ignore this issue for the moment
- If a subscriber consumes 1GB per month it would equate to 2.7MB during a typical Busy Hour.
 - Equates to 15 users in a cell during BH
- At the moment Sprint Nextel has deployed at most 2 EV-DO carriers (2.5MHz of FDD spectrum) at any given point in its network.
 - Mobile WiMAX would at least double this amount while Rev A would remain (3x total)

But will there be enough demand to justify the new network (cont'd)?



- Wireless DSL services could consume a lot of bandwidth.
 - Wireless cannot compete when competitively-priced wireline services are available
 - DSL/cable modem extension is valid, but it isn't needed in urban areas
 - Mobile PC market isn't big relative to mobile devices yet mobile devices generally don't consume a lot of data
 - A Catch 22 situation
- Mobile TV is a viable application.
- Self-generated content for the youth market.
 - Again, devices would have to be affordable for the mass market

So what does the future hold for Mobile WiMAX?

- WiBro will (is) facing the same growing pains that NTT DoCoMo faced with its FOMA network in 2001-2003.
 - 494 subscribers during the first two months (versus 31,000 HSDPA subscribers)
 - Once the operators achieve nationwide coverage and offer several handsets with multi-mode capabilities the likelihood of attracting new subscribers increases
- Sprint Nextel's decision opened the flood gates for interested parties, but operators will be hesitant to jump in head first without trialing the waters.
 - Sprint Nextel's decision came without any verification beyond lab trials
 - Vendors' solutions don't support MIMO while one vendor's solution didn't even support mobility when it was selected.
 - With Rev A offering compelling performance at a user level, not to mention supporting any application that Mobile WiMAX supports, it will be difficult to convince consumers to adopt the new technology.
 - This holds true even if Mobile WiMAX is 1/10th the cost to the operator

So what does the future hold for Mobile WiMAX (cont'd)?

- There are numerous examples of where Mobile (Fixed) WiMAX can make logical sense versus 3G.
 - Wireless backhaul for cellular or Metro Wi-Fi networks
 - Wireless DSL and cable modem extension into rural regions
 - Markets where copper doesn't exist
- Service providers without a legacy 2G/3G network should consider the technology.
 - Solving the digital divide
 - ISP's that are looking for a wireless play
 - Service providers without traditional 3G spectrum
 - Metropolitan communities (a next-generation mesh Wi-Fi network)

So what does the future hold for Mobile WiMAX (cont'd)?

- Other mobile operators will not defect from their chosen 3G migration path.
 - While NGMN is technology independent, the operators (other than Sprint Nextel), have little interest in Mobile WiMAX
 - The critical 3G vendors are not diehard proponents of WiMAX
 - Different horses for different courses
- Reminiscent of Wi-Fi versus 3G debate.
 - WiMAX advantage over Wi-Fi is that the coverage will be more ubiquitous than Wi-Fi
 - WiMAX disadvantages include the need for an operator-driven business model and multi-mode handsets
 - Wi-Fi + cellular devices are still few and far between
 - Can WiMAX be easier/cheaper to integrate into a cellular handset?

In this session, we will look at WWAN technologies besides 2G and 3G cellular solutions.

- Metro Wi-Fi
 - What is it?
 - How successful has it been?
 - What will become of it next?
- WiMAX – separating hype from reality
 - A quick history lesson
 - WiMAX differentiators and similarities with 3G
 - WiMAX versus WiBro
 - Issues/challenges that face Mobile WiMAX
 - The future of Mobile WiMAX
- ◻ • What other WWAN technologies are coming?
- Questions and Answers

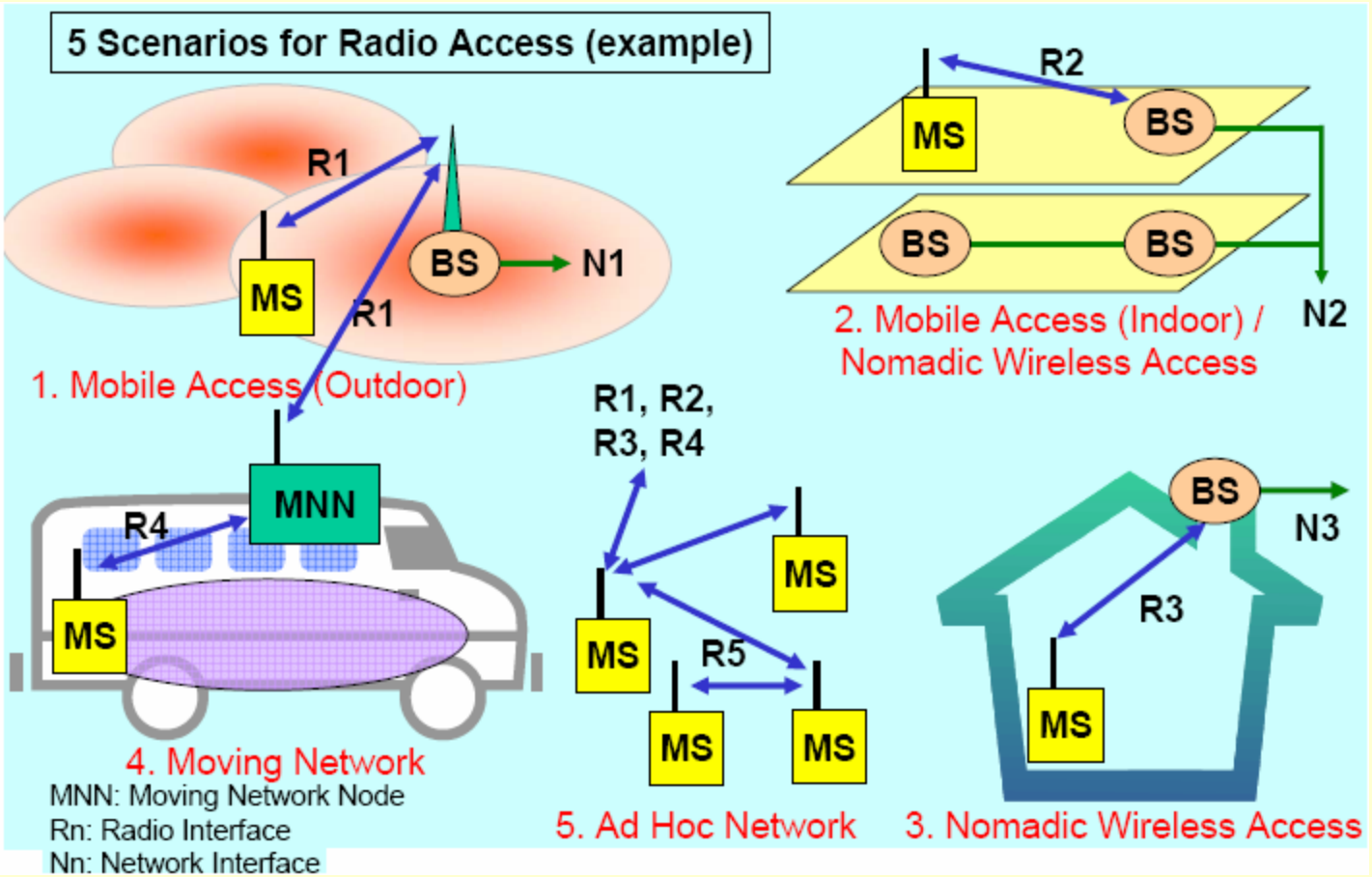
Some operators and vendors are already looking ahead to IMT-Advanced.

- IMT-Advanced requirements are being defined in ITU-R M.1645.
 - New spectrum will need to be identified (WRC 2007)
- Potential requirements and considerations include the following
 - >100MHz channel bandwidths (implies higher spectrum)
 - 100Mbps with high mobility
 - 1Gbps with low mobility
 - Interworking with legacy networks
 - Support for a laundry list of other wireless technologies (UWB, Wi-Fi, DVB-H, A-GPS, etc)
- The Mobile IT Forum, a contingent of Japanese companies and operators, appears to be the most active in looking at “4G.”

The work of the Mobile IT Forum may or may not lead to the universally accepted version of “4G.”

- The Mobile IT Forum has published several documents that describe its vision of “4G.”
- Could use the concept of an “Ad Hoc” network to fill in dead spots.
 - Mobile devices serve as relay points
- The system architecture includes a mini residential base station (BS) and a Moving Network Node (MNN).
 - Serves as relay points in the network
 - BS is deployed at home
 - MNN is deployed in moving vehicles, like buses or trains
 - Mobile devices communicate with the BS/MNN via a different technology
 - Solves PAPR concerns

The Mobile IT Forum's vision of a 4G system architecture.

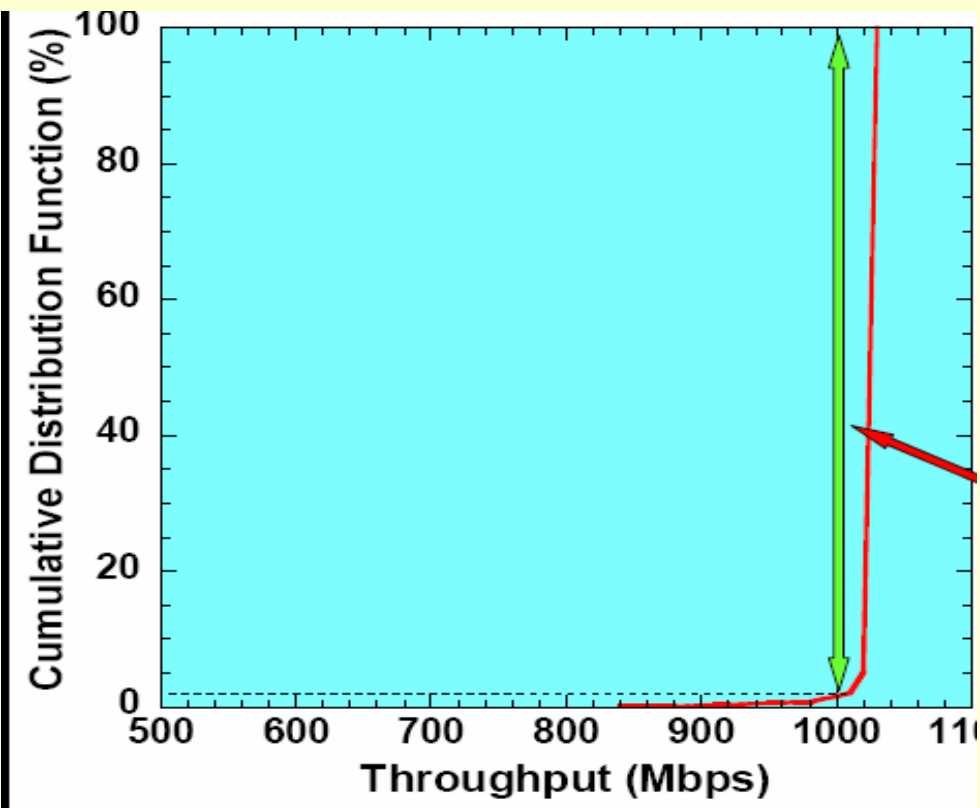


Source: Mobile IT Forum

Several new technologies are being considered for the Radio Access Network.

- VSF-OFCDM (Variable Spreading Factor – Orthogonal Frequency Code Division Multiplexing) is being considered and was used by NTT DoCoMo in its 4G technology demonstration.
- VSCRF-CDMA (Variable Spreading and Chip Repetition Factor CDMA) was used by NTT DoCoMo for uplink – wasn't mentioned in the Mobile IT Forum documentation.
- OFDMA (Orthogonal Frequency Division Multiple Access) is being considered, but there are concerns over PAPR.
- SCS-MC-CDMA (Sub-carrier selecting-multi carrier-CDMA) is being considered and is somewhat similar to MC-CDMA.
- IFDMA (Interleaving Frequency Division Multiple Access) is being considered and is somewhat similar to SC-FDMA (the 3G LTE uplink technology).

“4G-like” performance requirements can be achieved today as demonstrated by NTT DoCoMo.



- 1Gbps achieved over 95% of the course.
 - 4 by 4 MIMO
 - ~300m distance to BTS with NLOS conditions and 30km/h vehicular speeds

The “what” isn’t as important as the “why” and the “when.”

- “4G-like” performance requirements can be achieved today as demonstrated by NTT DoCoMo.
- The most important question is whether or not there is a sound business case for deploying a “4G” network.
 - Bandwidth over the air will always be limited to its wireline counterparts
 - Do operators really want another forklift upgrade to their networks?
 - If there is uncertainty regarding the need for OFDMA performance capabilities, 4G is stretching things even further
 - What applications and services will drive this level of usage?
- All of this leads to a question of when will 4G arrive?
 - Anything more than 12-18 months away will always be another year away from happening.