October 2006

WiMAX Deployments - Licensed or Unlicensed Spectrum: What are the options?

Visitors to this month's WiMAX World will go from vendor booth to vendor booth checking out the vendors. "So, what spectrum should we build your WiMAX radios for?" they politely ask. Answering this question often involves questions of its own…

…the Radio Act of 1927 … set the parameters of frequency and geography as the chief means to determine who would be allowed to transmit.

Everything electromagnetic operates on a given frequency we call spectrum. Transmitting on the same frequency as a WiMAX radio will interfere with it, potentially to a point where service is rendered useless. To avoid this, two regulatory approaches are used:

The first is limiting the number of transmitters on a given frequency in a given geographic area. In the US, this was codified by the Radio Act of 1927 which essentially set the parameters of frequency and geography as the chief means to determine who would be allowed to transmit. Implementing spectrum policy focuses on three factors: allocation, assignment and enforcement.

Allocation sets aside spectrum for specific uses such as cell phones at 1.9 GHz, broadcast TV at 500 MHz, etc. Assignment is most widely represented by spectrum auctions such as the recent AWS auction held by the FCC. Enforcement occurs when someone breaks the rules and the federal police show up to arrest the offending radios and take them away to radio jail.

Unlicensed transmitters are limited by regulation in the amount of power they use, and use a variety of technologies to "peacefully coexist" with other transmitters in the same spectrum.

The second way to avoid interference is a combination of technology and regulation: unlicensed spectrum. While the term unlicensed implies there is little regulation, this is not entirely true. Unlicensed transmitters are limited by regulation in the amount of power they use, and use a variety of technologies to "peacefully coexist" with other transmitters in the same spectrum (see below).

Aside from regulatory issues, the physics of propagation also mean that the quantity and frequency of spectrum matter. From a quantity perspective, more spectrum can carry more data at higher speeds, all other factors being equal. This allows a tradeoff between capital expenditures and spectrum - using more spectrum to substitute for fewer towers or vice versa. The frequency of spectrum affects the ability of transmissions to penetrate foliage, walls and around corners – lower frequencies are best, and thus tend to require less expense for deploying equipment.

The various spectrum bands of interest to potential broadband wireless operators are summarized in the following table:

Table 1: Popular spectrum for WiMAX uses worldwide

Frequency	Amount	Uses
900 mHz	30 mHz	U.S. unlicensed. Superior propagation characteristics due to low frequency.
1.7 and 2.1 GHz	90 mHz	Advanced Wireless Services in US; can be used for WiMax - service rules for this spectrum also permit voice services, making it particularly valuable. Just auctioned for $13.7 billion.
2.3 GHz	60 mHz	Wireless Communications Services in US; expect incumbent service providers who already hold this spectrum to use it for WiMAX services
2.4 – 2.483 GHz	83 mHz	ISM and FCC Part 15, largely unlicensed, used for WiFi; to be avoided by WiMAX operators on concerns of interference from WiFi
2.5 GHz	195 mHz	BRS/EBS in US; - Projected as being a popular licensed WiMAX spectrum choice in US and for those who could not get 3.5 GHz in other nations, probably the second most popular spectrum vendors will build product for. Largely held by Spring and ClearWire i
3.5 GHz	N/A	Unlicensed in many nations outside the US. Many nations have allocated it as the WiMAX spectrum. Almost all vendors offer WiMAX product for this frequency. Not useable commercially in the U.S. (military use).
3.65 GHz	50 mHz	FCC issued an announcement in 2004 promoting opening spectrum here for quasi-unlicensed use. Has yet to be finalized. Many products made for 3.5 GHz may work well in 3.65 GHz U.S. application
4.9 GHz	50 mHz	aka "Public Safety", in the US, intended for use by First Responders (police, fire, ambulance and other emergency services)
5.4 and 5.8 GHz	125 mHz	U.S. unlicensed; many vendors will offer this as their US unlicensed spectrum offering.

Source: WiMAX in 50 Pages

…more spectrum can carry more data at higher speeds, all other factors being equal…you can substitute more spectrum for fewer towers or vice versa.

Licensed Spectrum

In the U.S. licensed spectrum can be obtained via auctions (infrequent) or sublease. Subleasing occurs when an operator negotiates a sublease from the primary license holder. In the US, license holders can be identified via the FCC's online database known as the Universal Licensing System (ULS). Contact information for both the license holder and their attorney is listed as well as frequencies and geographic areas covered. The FCC considers subleasing to be an efficient means of distributing spectrum after the auction.
Cantor Fitzgerald also operates the Cantor tower and spectrum exchange – sort of an eBay for spectrum buyers.

Pricing for licensed spectrum is quoted in the follow units: cents/MHz/POP. That is, X cents per one MHz multiplied by population in the geographic area in question. Recent spectrum transactions in frequencies used for WiMAX range from $0.15-$0.55 per MHz-POP. Negotiations to acquire spectrum can take many months or more.

Finally, some high frequency spectrum can be obtained from the FCC via a simple application process.

WiMAX operators expecting to use unlicensed spectrum can learn a lot from the experiences of WiFi operators.

Unlicensed spectrum

Many are the successful WiFi (unlicensed 2.4 GHz) service providers. They have learned to deal with interference from other unlicensed operators via agreements with the other operators, changing channels within the unlicensed bands, changing antenna polarity and other tricks of the trade to mitigate interference on open standards equipment using unlicensed frequencies. WiMAX operators expecting to use unlicensed spectrum can learn a lot from the experiences of WiFi operators.

Service providers using WiMAX on unlicensed frequencies will have more tools than WiFi operators to use in overcoming interference from other operators. Some of those tools are summarized in the table below.

Table 2: Technologies in the WiMAX specs that mitigate interference

Technology	Description
Orthogonal Frequency Division Multiplexing (OFDM)/Multiple Access (OFDMA)	Breaks the signal into multiple subcarriers; up to 2048 smaller signals. If some signals are negated due to interference, other signals get through such that interference may not be discernible to end user
Dynamic Frequency Selection	If interference is occurring on one frequency the transmission dynamically shifts to a different frequency to avoid the interference.
Dynamic Bandwidth Allocation	If interference is detected, more bandwidth is allocated to the transmission to strengthen the link budget and overcome the interference
Adaptive Antenna Systems (beam forming/steering)	Rather than broadcast over a wide geographic range, a narrow beam is formed between base station and subscriber unit, thus avoiding interference via a strong beam
Multiple In/Multiple Out (MIMO) Antennas	Uses multiple antennas at both base station and subscriber unit such that as interference is detected at one frequency, bulk of transmission can shift to another frequency; also boosts throughput via multiple antennas overcoming limitations of a single an
Software Defined Radios (SDR)	Also known as “smart antenna”; computer associated with the antenna dynamically reads the electromagnetic atmosphere and transmit on best available frequency

These technologies should not be thought of as panaceas or "get out of radio jail free cards" for the unlicensed operator; they may make the difference between acceptable and unacceptable services.

Some very characteristics and general rules of thumb for choosing the respective types of spectrum are summarized below:

Table 3: Comparing applications for licensed vs. unlicensed spectrum use

Licensed spectrum	Unlicensed spectrum
Best for urban markets where potential for interference is	Rural markets: low propensity for collision with other service providers
Best for business subscribers or where QoS (uninterruptible	Best for backhaul using directional antennas as opposed to interference prone point to multipoint configurations
Wherever a high level of security and reliability are	Some residential markets
Requires extensive pre-planning	Rapid time to market
No regulatory limit on power; enables a strong link budget to overcome interference	Limited to 1 watt of power; can limit range, throughput and interference mitigation
Substantial (i.e. millions of dollars) in up front start up costs.	Free spectrum, much lower start up costs.
Less capital expense as network grows	More capital expense as network grows

Providers may use one, the other or even a balanced mix of licensed and unlicensed spectrum to serve their markets.

Conclusion

As evidenced in the text and tables of this article, there are advantages to both licensed and unlicensed operations. Providers may use one, the other or even a balanced mix of licensed and unlicensed spectrum to serve their markets. The service provider must determine via a rigorous site survey as to what potential sources of interference exist in their markets. The service provider will also have to evaluate the trade offs of protected vs. unprotected spectrum when offering service to their customers be they business (very demanding) or residential (equally demanding, they just don't have an IT director).

By Frank Ohrtman

WiMax.com

WiMax.com is a clearinghouse for WiMAX industry information and a provider of WiMAX training and consulting services. People with questions regarding this article can contact Michael Wollenben at mwollenben@wimax.com.