



Wireless Technology Quick Reference Guide

This document is a quick source of information on current wireless technologies. Within, the wireless technologies are divided into three main categories: Cellular, WiFi, and WiMax, and the speeds, ranges, advantages and disadvantages of each technology are listed.

It is important to note that the theoretical speeds and ranges mentioned here are just that; many environmental factors such as radio-frequency (RF) interference and physical barriers will affect the actual performance of these technologies.

For further in-depth descriptions of the technologies and specifications, please see the list of references at the end of this guide.

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Cellular “3G”, IMT-2000

The IMT-2000 project is the International Telecommunications Union's project to “harmonize third-generation mobile network radio interfaces in to a single standard.”¹ Two interfaces in the IMT-2000 family have emerged as the more popular interfaces: W-CDMA, and CDMA2000. Both W-CDMA and CDMA2000 use existing cellular infrastructure originally designed for voice communication. Users who wish to connect to the Internet over cellular 3G will typically pay an extra fee on top of their monthly cell phone bill for an extra ‘data plan’, or by paying on a pay-per-use basis (which is relatively expensive). Computers can connect to the Internet using either a special 3G modem card or by attaching and configuring a capable cell phone to act as a 3G data modem. The most common use for mobile data is business-related;² however there is a growing trend of consumer devices that will demand data services in the near future.³

W-CDMA

Speed: Theoretical speeds of 384 kbps in mobile implementations; 2mbps for fixed implementations. The new HSDPA specification has theoretical transfer rates of up to 14mbps.

Range: Several kilometers, depending on terrain.

Advantages: Easy upgrade path for GSM operators in Australia, Europe, Asia and North America.

Disadvantages: Relatively expensive infrastructure upgrade costs. The cellular phone infrastructure was originally built for symmetrical voice-only applications rather than data.

CDMA2000

Speed: 700kbps to 3mbps with the EV-DO standard.

Range: Several kilometers, depending on terrain.

Advantages: Natural upgrade path for North American and other CDMA operators.

Disadvantages: Technology originally built for symmetrical voice-only applications rather than data. Costs are higher than some other wireless technologies.

WiFi (802.11b, 802.11g, 802.11a, and 802.11n)

WiFi is considered a short-range wireless technology. It is relatively easy to set up and comes in several flavours, the most common being 802.11b and 802.11g. 802.11a is usually reserved for instances where

¹ ITU “The Portable Internet” (2004):11

² “EV-DO Cellular Data Services Catch On” Network World (2007): 20.

³ “Cellular Data Ramps Up.” [InfoWorld](#) (2005).



802.11b and 802.11g are less feasible (e.g. due to RF interference). A new standard, 802.11n, is becoming more popular.

WiFi is most often used in residences to share an Internet connection, and in businesses to provide wireless access to the network. Businesses such as hotels and coffee shops often have WiFi 'hotspots' to provide wireless access for customers to connect their devices (usually for a fee).

Many communities have deployed WiFi networks made up of many WiFi nodes that use existing backhaul infrastructure to give coverage to large areas. Examples include the Toronto One Zone and the Fredericton Fred E Zone.

WiFi operates on 'license-exempt' bands of the radio spectrum. The advantage to using license-exempt spectrum is the ease of setup. However many other devices also use these bands of spectrum, including several common household appliances such as portable phones and microwave ovens. License-exempt bands are becoming increasingly crowded, and this increase in traffic leads to RF interference which diminishes the strength of WiFi signals.

Advantages: WiFi has considerable market acceptance, with the equipment now being very inexpensive and widely used.

Disadvantages: The license-exempt spectrum is becoming crowded in many areas. WiFi has limited range, and the technology does not allow for reliable use of mobile VOIP voice service.

Speed and Range:

802.11b has a max speed of 11 mbps (typical speed is about half of this, depending on the environment), and typical ranges of approximately 30 metres indoors.

802.11g has a max speed of 54 mbps (typical speed is about half of this, depending on the environment), and typical ranges of approximately 30 metres indoors.

802.11a has a max speed of 54 mbps (typical speed is about half of this, depending on the environment), and typical ranges of approximately 30 metres indoors. Unlike 802.11b and 802.11g which use the 2.4 GHz band, 802.11a uses license-exempt bands in the 5 GHz portion of the spectrum.

802.11n has a theoretical max speed of 600mbps. Typical speed is about 144 mbps, depending on the environment. Typical ranges are approximately 50 metres indoors and 160 metres outdoors.

Note: These speeds are limited by the speed of their backhaul connection. For example, users connecting to an 11 mbps WiFi router that has a 3 mbps DSL connection to the Internet will only connect at the 3 mbps 'bottleneck' speed.



WiMax (Fixed 802.16d and Mobile 806.16e)

WiMax technology promises to be both much lower in cost than existing cellular data services while offering higher speeds and much greater ranges compared to WiFi. There is a considerable amount of industry investment in the technology, from corporations such as Intel, Motorola, Sprint, and Nortel. Many user devices will soon have WiMax⁴ modems built in that will allow people to easily connect without any additional hardware. Meanwhile, devices that do not have the necessary hardware built in can connect with an interface card or similar external hardware.

Equipment prices are rapidly decreasing as more manufacturers invest in the technology. Also, the potentially much lower cost of providing WiMax services compared to cellular services^{5,6} could represent a break-down in the barriers to entry for new service providers, thereby increasing competition in the telecommunications industry.

WiMax can be used as the 'last mile' connection through which users connect to the Internet, and in some cases used as the backhaul network infrastructure in its fixed (802.16d) form.

It is important to note that WiMax is a standard of interoperability, and devices must be certified by the WiMax Forum to carry the WiMax name. In contrast, there are many other wireless products and solutions that have similar speeds and characteristics, yet are proprietary and not interoperable with WiMax devices from other manufacturers.

WiMax and Spectrum

Unlike WiFi, WiMax usually operates in licensed bands of spectrum. Licensed bands are like exclusive lanes on a highway—there is no other radio traffic to share the space with. Conversely, WiFi operates in license-exempt spectrum that must be shared with other devices (such as portable phones and microwave ovens).

Recently, there has been more discussion about WiMax implementations operating in license-exempt bands of spectrum, as WiFi does, particularly in the 5.8 GHz range. There would be advantages and disadvantages to these implementations. On one hand, not having to purchase spectrum licenses would reduce costs for operators. On the other hand, the use of non-exclusive spectrum means other operators could also deploy in that range, which would introduce interference and reduce service quality for all operators in that range. Also, license-exempt spectrum tends to be at higher frequencies, which are less capable of propagating through walls and over greater distances.⁷

⁴ "Cutting the Cord" Government Executive (2007).

⁵ "WiMax Gathers Momentum" Financial Times UK (2007).

⁶ "New WiMax Products Raise Stakes in 4G Battle" (2006).

⁷ "The Implications of WiMax for Competition and Regulation." Organization for Economic Cooperation and Development (2005)



As in cellular phones, there is no universal WiMax spectrum that is consistent throughout the world. The most common is in the 3.5 GHz range.

Fixed WiMax

In fixed WiMax (802.16d), the connection points are stationary. Fixed WiMax is appropriate for backhaul connections and for ‘last mile’ connections to residences and businesses. In the case of last mile connections, fixed WiMax can compete with existing DSL and cable solutions, or be a solution in areas such as rural areas and developing nations where DSL and cable broadband are currently unavailable.

Advantages: WiMax is an inexpensive backhaul or last-mile solution where traditional broadband infrastructure does not exist such as in rural areas and developing countries. Use of licensed spectrum allows for much more reliable signal strength (and therefore more realistic business service level agreements) than WiFi.

Disadvantages: Line-of-sight or near-line-of-sight is needed. Users devices cannot easily transfer from node to node. Licensed spectrum is limited and can be expensive to obtain.

Speed and Range:

Fixed WiMax speed and range figures vary greatly depending on the frequencies used and the amount of physical interference. The theoretical max speed is about 70 mbps, though this is only in ideal line-of-sight conditions and at short range. Generally the lower the frequency, the greater the distance the signal will reach. The WiMax Forum (which certifies WiMax equipment) states that typical speeds are around 15mbps to 40mbps with ranges of 4 to 10 kilometres.⁸

Mobile WiMax

In mobile WiMax (802.16e), devices can go from area to area using ‘hand-offs’ from node to node, similar to the way cell phones do. Mobile WiMax is more flexible than Fixed WiMax, and allows for high-speed WiMax connections directly to user devices such as laptop computers and PDAs. QoS (Quality of Service) technology allows for mobile VOIP voice service and phones, which could represent significant cost savings over traditional phone plans. In Canada, the Inukshuk project (a joint venture between Bell and Rogers) uses a form of pre-certified WiMax.⁹

Advantages: Mobile WiMax has the ability to support a high number of users per node (and therefore a lower cost per user). Users can carry devices from node to node at speeds of up to 120km/hour, and OFDMA technology allows for non-line-of-sight transmission. Use of licensed spectrum allows for much more reliable signal strength (and therefore more realistic service level agreements) than WiFi.

⁸ WiMax Forum. 2007 <www.wimaxforum.org/technology>

⁹ Inukshuk Internet 2007 <www.inukshuk.ca>



Disadvantages: Licensed spectrum can be difficult to obtain, and is currently for the most part held by incumbent service providers. Other spectrum in the lower ranges (700 MHz) will however soon become available as analog TV channel spectrum is reclaimed.

Speed and Range:

Mobile WiMax (802.16e) has typical speeds of about 10Mbps over several kilometers in urban areas, which is slightly less than fixed WiMax. This again depends on the frequencies used and the amount of physical interference (e.g. trees, buildings, etc.). Also, speed will depend on the number of users sharing a given node.

Convergence

In recent years, an evolution has been underway where voice and data services are converging. Rather than voice and data being treated as completely separate content, traditional telephone traffic can be converted and transmitted as Internet data, similar to the way that email and web browsing data is transmitted. It is from this trend in the telecommunications industry that terms such as VoIP (Voice over Internet Protocol) are becoming more common. While several challenges still exist for data/voice convergence¹⁰, the potential advantages are significant, such as much more efficient transmission of traffic of all types. Newer wireless technologies such as WiMax and 802.11n were designed with the convergence trend in mind, and offer improved handling of converged voice/data traffic.

If the convergence trend continues and the remaining issues are resolved, devices such as Mobile VoIP phones may be feasible as an alternative to traditional cellular phones. This could in turn lead to much less expensive mobile phone rates for subscribers. Interim solutions include technologies such as Generic Access Networks¹¹, where telephone calls can transition between wireless data and cellular networks seamlessly, connecting users to whichever network type is available at the time.

Further Reading

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Analysis of WiFi and cellular technologies, how they may compete with and/or complement one another, and how this may shape the industry.

¹⁰ "Implementing VoIP." IEEE Communications (2004).

¹¹ "Generic Access Network Dual-Mode Services." Cisco Mobile Exchange (2007).

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