ATHEROS® COMMUNICATIONS

White Paper

Worldwide Regulatory Progress for Wireless LANs

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Introduction

While the spectrum available to Wireless LANs varies from one country to another, Wireless LANs have benefited from generally favorable treatment by spectrum regulators in the US and many other countries. New developments associated with the World Radio Conference in June 2003 are now opening the way for more Wireless LAN spectrum around the world.

Wireless networks can only operate in the spectrum (frequency bands) allowed by regulators and must follow rules governing the way that spectrum can be used. Both the makers and users of Wireless LAN technology thus rely on regulators to provide sufficient spectrum and to set usage rules that allow for technology innovations.

This white paper outlines the recent history of regulatory issues that affect today's Wireless LANs as well as the current state of spectrum availability and the changes coming out of the 2003 World Radio Conference. The Wireless LAN technologies affected by these regulatory issues include 5 GHz IEEE 802.11a, legacy 2.4 GHz IEEE 802.11b and the proposed IEEE 802.11g, which is expected to become widely available in the 2.4 GHz spectrum.

The Origins of Today's Rules

Until 1985, most of the radio spectrum in the US was leased to individuals for pre-defined services such as broadcasting or cellular communications. Interference was not an issue so long as users stayed within the spectrum they owned.

The FCC took a bold policy departure in 1985 when it opened unlicensed use of the 2.4 GHz band under FCC Part 15 rules. These rules allow new technologies to share the same bands with existing government and commercial services. Part 15 rules reduce the potential of interference to existing spectrum users but do not guarantee that such unlicensed devices will be free of interference from each other. The FCC reasoned that innovative and more efficient uses of radio spectrum would result from allowing shared use of portions of the spectrum for uncoordinated radio devices based on spread spectrum technology and operating on a non-interference basis. Other countries have instituted similar policies.

Following passage of the new rules, innovations have included 900 MHz and 2.4 GHz cordless phones, baby monitors and mobile data communication devices such as Wireless LAN equipment. New generations of mobile audio, point of sale, wireless headset and wireless PC peripherals continue to be deployed in the 2.4 GHz band.

In 1995, Apple Computer petitioned the FCC to create a new unlicensed 5 GHz band named National Information Infrastructure (NII). In contrast to the 900 MHz and 2.4 GHz unlicensed bands, the NII technical rules would restrict possible uses of the NII band to radios using wideband communications, thereby preventing the kind of free-for-all sharing of radio technologies in the 2.4 GHz band. Canada opened the same NII bands and adopted technical rules almost identical to those developed by the FCC.

The International Telecommunications Union (ITU) also declared a number of bands for industrial, scientific and medical (ISM) applications that are not restricted to any particular radio technology. The ITU develops global frequency assignments that are generally adopted by countries in all regions by international treaty (http://www.itu.int/ITU-R/). The ISM bands of importance to wireless LAN technology include 2.4—2.5 and 5.725—5.875 GHz. Most countries around the world opened these bands and allowed use of the 5.725—5.875 GHz band for commercial fixed-access communications.

The NII rules under FCC Part 15 cover the 5.725—5.825 GHz band and coexist with separate Part 15 rules for use of the 5.725—5.850 GHz ISM band. The FCC certifies suitably designed 802.11a Wireless LAN devices for operation across the entire overlapping NII and ISM band from 5.725 to 5.850 GHz in the US. This spectrum is in addition to NII operation from 5.150—5.350 GHz in the US reserved exclusively for NII devices such as 802.11a Wireless LANs.

Wireless LANs in 2.4 GHz

As a result of the early regulatory changes such as NII and ISM, many countries had spectrum policy in place, waiting for manufacturers to bring the technologies to market. Eventually Wireless LAN technologies arrived, thanks to the confluence of Internet growth, corporate data networking, mobile computing, and low-cost, highly integrated radio designs that conformed to IEEE project 802 standards.

The first widely deployed Wireless LAN solutions used the 2.4 GHz band since, in the beginning, this band was adequate for spread spectrum technology and there was no concern for overcrowding and limited network capacity. Both individuals and corporations have widely deployed wireless networking access points and client devices designed to the IEEE 802.11b physical layer specification using direct sequence radio modulation. Wireless LANs based on these products occupy up to three *non-overlapping channels*[1] in the 2.4 GHz band.

1. See **Appendix** for explanation of *non-overlapping channels.*

Over time, regulators have lifted most remaining restrictions in the 2.4 GHz band because military and other government users have relocated to other frequencies. Most recently, France lifted restrictions so that 802.11b/802.11g and all other unlicensed technologies may now operate using all three channels in most regions of France. However some regions of France still restrict usage to a single non-overlapping channel. Other remaining restrictions include Israel which is limited to a single channel and a handful of countries in Latin American, Asia and the Middle East that do not allow outdoor use of the 2.4 GHz band or impose burdensome licensing requirements or import restrictions.

Figure 1-1 summarizes the allowed usage of the 2.4 GHz band applicable to 802.11b and 802.11g devices. Regarding 802.11g which uses OFDM modulation in the 2.4 GHz band, some regulators are in the process of updating the scope of their 2.4 GHz spectrum usage rules so that this new type of Wireless LAN technology is included. But at this time most major markets do accept operation of devices which support 802.11g.

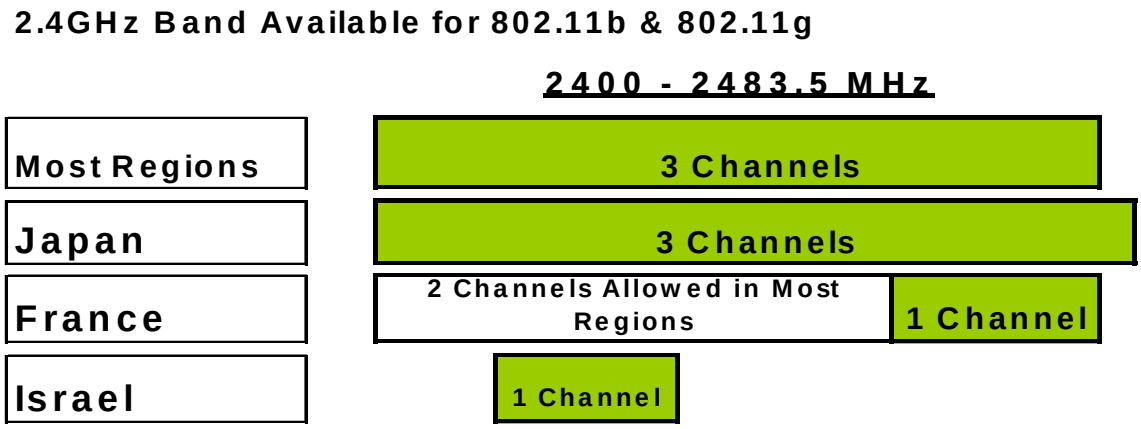

Figure 1-1. **Current Regulatory Picture for 2.4 GHz Wireless LANs**

5 GHz Wireless LANs

Regulators in various regions are becoming concerned that the 2.4 GHz unlicensed band will soon reach its usable limit, yet no regulators are proposing to fix this problem. Instead, the crowding at 2.4 GHz is helping to drive government support for next-generation, high-speed/high-capacity data communication in the 5 GHz band.

Use of the 5 GHz bands for high-capacity networking began in 2001 when Atheros Communications began shipping 5 GHz Wireless LAN chipsets compatible with the IEEE 802.11a standard. This technology relies upon Orthogonal Frequency Division Multiplexing (OFDM)—a more efficient modulation scheme than that used by 802.11b equipment.

Providing throughput up to five times greater than devices operating in the 2.4 GHz bands, 802.11a equipment became available under the existing NII rules in the US. The products

also rolled out under similar rules in Japan, allowing 5 GHz Wireless LAN devices to operate in the lower portion of the 5 GHz band.

5 GHz in Europe

In 1991, the European Telecommunications Standards Institute (ETSI) had begun work on a high-speed/high-capacity 5 GHz solution named HiperLAN. European spectrum regulators eventually set aside a total of 455 MHz of spectrum for HiperLAN use. As in the US, European regulators protected government uses of the 5 GHz bands (such as radar and satellite systems) by specifying power limits and indoor/outdoor designations that vary by sub-band. US and European rules differ on the specific sub-bands and limits, however. Figure 1-2 compares Europe's HiperLAN bands with the NII and 2.4 GHz unlicensed bands in the US.

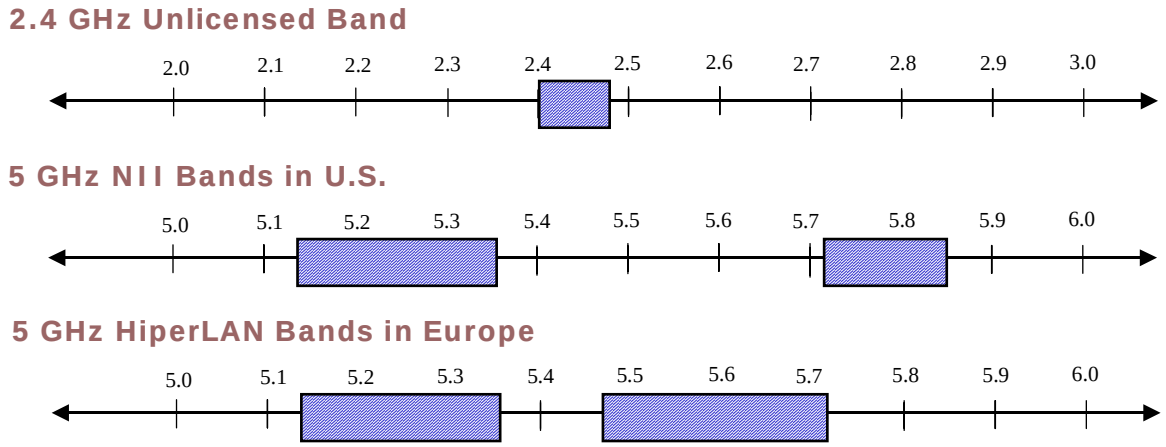

Figure 1-2. **A Comparison of HiperLAN Bands with NII and 2.4 GHz Unlicensed Bands**

As Europe developed functional standards for HiperLAN technology, the International Telecommunications Union (ITU) frequency tables incorporated spectrum and power limitations for part of the HiperLAN bands. Many countries around the world incorporated part or all of the HiperLAN bands into their national frequency usage tables. Nonetheless, HiperLAN products were not available, and HiperLAN technology was not well understood by most national administrations outside of Europe.

Some European regulators (more than 20 different national spectrum regulatory agencies) had a difficult time reconciling the launch of 802.11a products in mid-2001 using spectrum previously opened for HiperLAN technology. Partly due to the now-waning regime under which ETSI developed specific technology standards for exclusive use in license-free spectrum, some European administrations initially declared that only HiperLAN devices could use their 5 GHz bands—not 802.11a. However, regulators soon realized that 802.11a and HiperLAN radio characteristics were essentially equivalent when compared to the European spectrum allocation rules in place since 1999.

Some regulators objected that the 802.11 standard did not include two interference mitigation features that were part of the HiperLAN standard. More progressive

administrations promoted the idea that alternate mitigation techniques are acceptable and that 802.11a devices should be able to use parts of the 5 GHz band while technical and conformance test standards continue to be developed. Ultimately, manufacturers, consumers, the press and a growing number of supportive European regulatory agencies gave the hold-out regulators no other option than to adjust their thinking and sometimes-improvised policy.

The European Commission in Brussels was also helpful in changing European policy by fulfilling its mission to promote reform and competition in European telecom. The commission sent the message that national spectrum agencies cannot favor or restrict a particular radio technology so long as the devices use the spectrum effectively and avoid interference to primary users of the band. (By international convention, spectrum shared by government and commercial users can have primary and secondary uses that receive different regulatory treatment.) This message was in line with commission efforts to reform governments from the old practice of picking technology winners and losers. The legal vehicle, much unloved by many European regulators, is titled Radio & Telecommunications Terminal Equipment Directive (http://europa.eu.int/comm/enterprise/rtte/dir99-5.htm). The directive was most acutely felt when applied to the 5 GHz issue in Europe.

18 months after 802.11a devices first appeared in a handful of European countries, 17 out of 19 European Community countries accept 802.11a devices in up to 455 MHz of spectrum, which supports 19 non-overlapping channels. In contrast, 2.4 GHz 802.11b/g Wireless LANs make use of a maximum of three non-overlapping channels.

Resistance to opening 5 GHz spectrum in some countries surfaced during 2002 from 3G cellular licensees who argued that their large investments in spectrum license fees would be at risk. They feared competition in the high-speed wireless Internet access market from companies that use free spectrum. 3G licensees and other carriers now seem to be considering how to add high-speed, public Internet access/hot spots to their own business plans. Many public carriers who were poised to fight their governments' plans for free 5 GHz spectrum are now heeding the bold words of the head of the German regulatory agency. In July 2002, Matthias Kurth declared, “Wireless local area networks (WLANs) will not pose a threat to UMTS competitively, but the two systems will supplement each other effectively for the benefit of all market players.”
(http://www.regtp.de/en/aktuelles/pm/02605/)

Global Spectrum Summary for 5 GHz Wireless LANs

802.11a Wireless LAN devices are now widely available in North America, Europe and Asia. Complete harmonization of 5 GHz spectrum may not occur until after the ITU World Radio Conference in June 2003 (more on this later). The question of spectrum harmonization could be moot, however, because many 802.11a devices can be configured for operation in different bands using 802.11d or similar solutions. 802.11d is an extension to the IEEE 802.11 standard that enables Wireless LAN client devices to configure themselves automatically for the allowed power levels and spectrum in a particular country. This function and others implemented by Wireless LAN manufacturers will allow an 802.11a, 802.11b/g or multimode 802.11a/b/g mobile device to roam easily between countries while maintaining compliance with national spectrum usage restrictions. Countries that have not yet opened any 5 GHz spectrum can be easily serviced by multimode devices automatically

or manually configured to operate in 2.4 GHz bands while waiting for national regulators to open some portion of the 5 GHz band.

5 GHz in The Americas

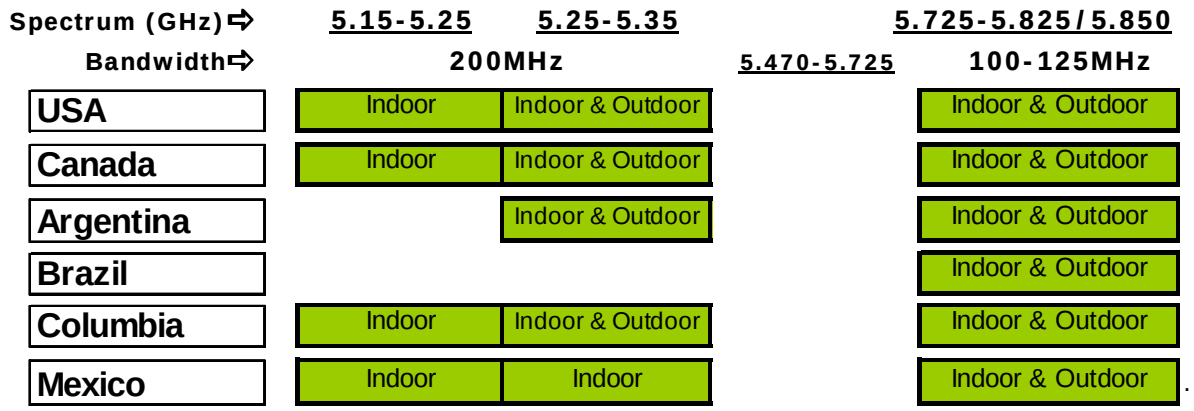

Figure 1-3. **Americas**

As shown in Figure 1-3, sub-bands in 5 GHz are designated for indoor or indoor-and-outdoor use. The 5.725—5.850 GHz band in the US and Canada serves as both ISM and NII bands under overlapping regulatory standards. However, 802.11a devices can comply with both sets of rules and coexist with higher-power, fixed-point-to-point/multipoint devices in the 5.725—5.850 GHz band. In Latin America and other regions, the 5.725—5.850 GHz band is commonly available as an ISM band. Now most countries allow use of 802.11a devices in this ISM band where lower parts of the 5 GHz band are not yet opened.

5 GHz in Asia Pacific

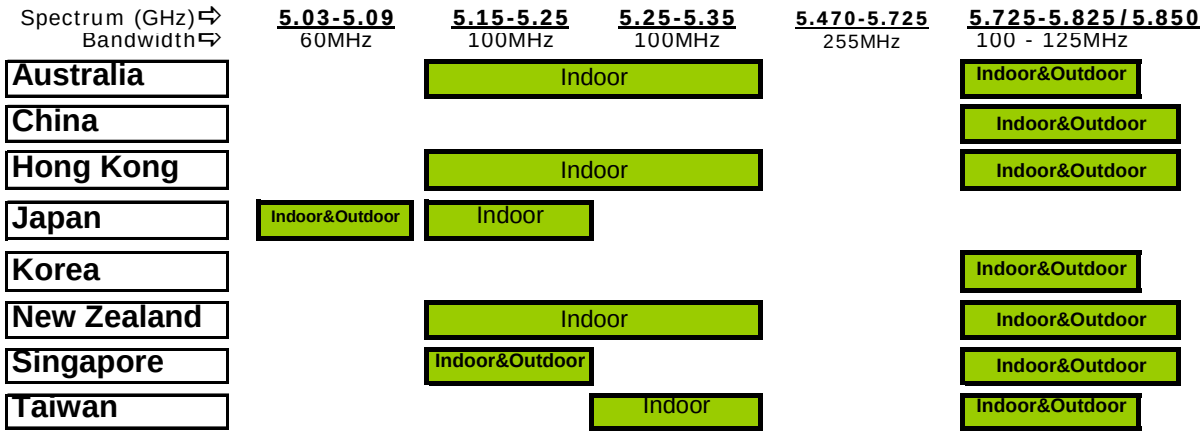

Figure 1-4. **Asia Pacific**

As shown in Figure 1-4, Japan deviated from other regions in opening bands below 5 GHz. Japan has opened 5.03 to 5.09 GHz to accommodate indoor-and-outdoor public wireless services and has reserved 4.9 to 5.0 GHz for possible future use by Wireless LAN applications. A global allocation in the World Radio Conference will likely result in Japan and other countries opening additional spectrum within the 5 GHz bands.

In July 2002, the Ministry of Information Industry (MII) in China announced that 125 MHz of spectrum at 5.725—5.850 GHz would open immediately for use by Wireless LAN devices (MII Notice [2002]277). The band was previously reserved for ISM and fixed wireless communications applications.

Recent legislation in Hong Kong has opened an additional 200 MHz of spectrum for Wireless LAN use in the 5.15—5.35 GHz band. This spectrum is in addition to 5.725—5.850 GHz, which was opened previously.

In January, 2003 Korea became the last major market in Asia to open 5 GHz spectrum for Wireless LAN operation. The Ministry of Information & Communications (MIC) Notice 2003-13 opened 5.725—5.825 GHz for use by 802.11a devices. Many domestic manufacturers and telecommunications operators are developing 802.11a and multimode solutions to serve high-speed commercial and public access segments as well as the large installed base of home-broadband users in Korea.

5 GHz in the European Community

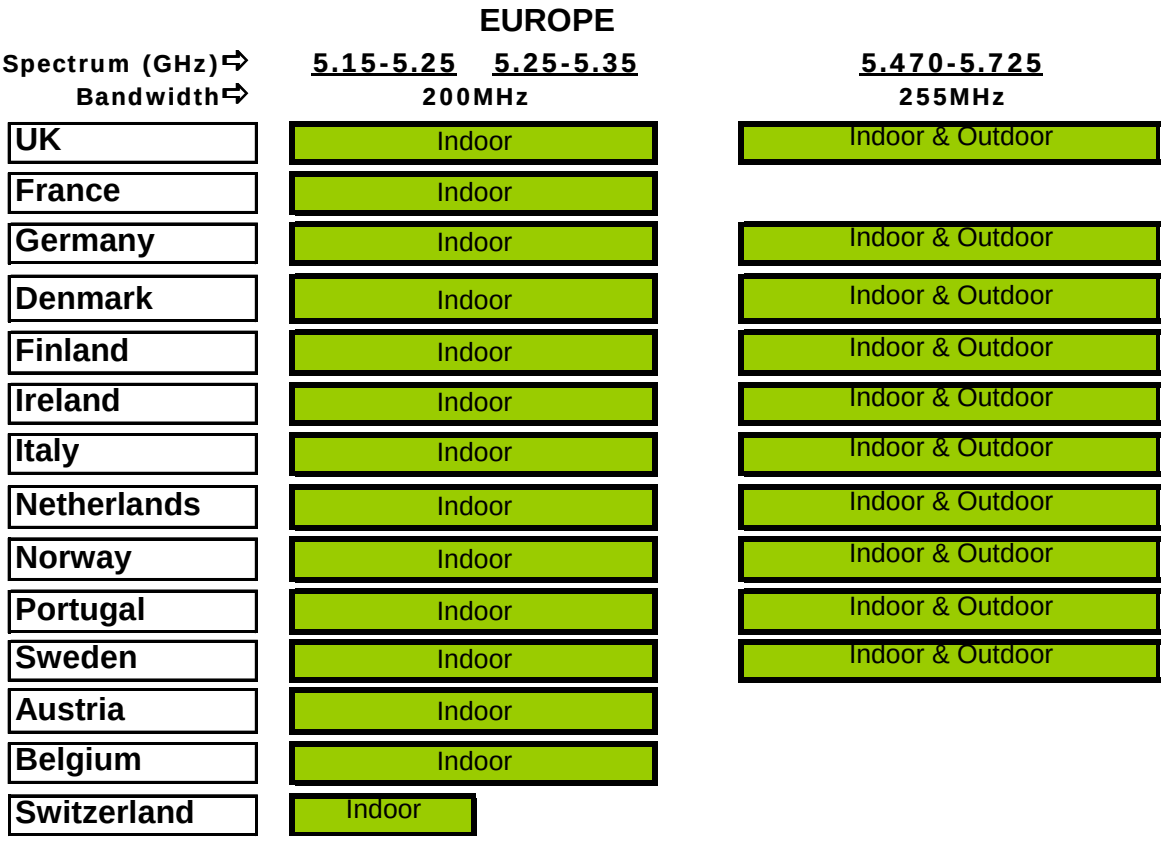

Figure 1-5. **European Community**

All major markets (as shown in Figure 1-5) in the European Community have opened a total of 455 MHz of spectrum reserved solely for high-capacity, mobile wireless technology such as 802.11a. Only Greece & Spain have not yet finalized legislation to open 5 GHz bands. The remaining countries in Europe which have only opened 100 or 200 MHz of spectrum, will likely update their national spectrum allocations in line with the rest of the region after the World Radio Conference in June of 2003.

In Central Europe, the major markets also have 5 GHz spectrum available for immediate use by 802.11a devices. As members of the Conference of Postal and Telecommunications Administrations (CEPT), Central European countries have opened spectrum under the same rules adopted in Western Europe. These countries include Hungary, Poland, Czech Republic, Turkey and Slovenia.

World Radio Conference 2003

For the past 2 years, the Wireless LAN industry, governments and other users of 5 GHz spectrum have negotiated technical conditions to achieve international support for an agenda item at the ITU World Radio Conference in June and July 2003 (WRC-03). Agenda Item 1.5 proposes a global allocation in the 5 GHz bands for use by Wireless LAN and equivalent high-capacity, mobile wireless access systems: 5.15—5.35 and 5.47—5.725 GHz, for a total of 455 MHz of new spectrum for Wireless LAN devices globally. Although all key Wireless LAN markets around the world have already opened at least some portion of the 5 GHz band, Agenda Item 1.5 would both increase the available 5 GHz spectrum in many countries (including the US) and cause remaining countries around the world to open at least 455 MHz of spectrum under a common set of rules.

After months of technical and political negotiations involving the US Department of Defense (DOD), the FCC and US industry, by January 2003 all parties in the US had reached agreement on technical rules that will prevent interference to sensitive radar systems when deployment densities of 5 GHz Wireless LAN devices reach high levels. Various government radar systems may operate in some portions of the 5 GHz bands in some locations. This agreement clears the way for a successful WRC-03 at which spectrum administrations from around the world are expected to reach agreement on the spectrum usage rules for the 5.15—5.35 and 5.47—5.725 GHz allocation.

As described earlier, many countries currently allow operation of 802.11a Wireless LAN devices in the 5.725—5.825/5.850 GHz band. This band is outside the scope of Agenda Item 1.5 and will remain open in addition to the new spectrum allocated in WRC-03. Therefore, the additional 455 MHz of spectrum from WRC-03 will yield as much as 580 MHz of total spectrum in these countries for Wireless LAN operation in the 5 GHz band. This spectrum provides capacity for up to 24 simultaneous, non-overlapping channels in one area, in contrast to the maximum of three non-overlapping channels in the 2.4 GHz band.

Unlike the unlicensed spectrum previously available for Wireless LANs, an ITU Allocation will give specific protections to Wireless LAN devices. This protection would effectively lock out competing technologies such as cordless phones or high-power fixed wireless transmitters. The proposed allocation requires that Wireless LAN devices not interfere with other primary users of the band, such as government and civilian radar and satellite operations. This requirement is already in force in the US, Europe and elsewhere under existing spectrum usage rules. Wireless LAN devices would be given Primary status, which comes with rights of protection from interference from any future users of the bands that may be considered in the ITU.

Dynamic Frequency Selection & Transmit Power Control

Part of the negotiations in preparation for the World Radio Conference revolve around two interference-mitigation techniques called Dynamic Frequency Selection (DFS) and Transmit Power Control (TPC). DFS uniformly spreads channels across a wide range and enables 5 GHz Wireless LAN devices to avoid channels on which radar systems may be operating. TPC reduces power across a wide Wireless LAN deployment area by having mobile devices transmit at reduced power levels when located close to access points.

The new rules slated for WRC-03 will require the use of DFS and TPC in the new 5 GHz spectrum. These mitigation techniques are already required in Europe. In all regions, only Wireless LAN access points need implement the DFS feature; the access points will then control associated client devices' channel use.

ITU rules are negotiated once every 3 or 4 years. Governments are bound by international treaty to reconcile national spectrum allocations to the outcome of each WRC. Once adopted within the ITU, a new allocation may stay in force for a decade or more. Industry and governments from all regions are thus working hard to ensure an ITU allocation with adequate protections, while avoiding unnecessarily restrictive parameters that could hinder future innovation. More details can be found at:
http://www.itu.int/ITU-R/conferences/wrc/wrc-03/index.asp.

Use of 802.11a Technology in Additional Frequency Bands

In addition to Wireless LAN applications, 802.11a technology has been chosen by the US Department of Transportation for its Intelligent Transportation Systems (ITS) program. 802.11a radio frequency (RF) and baseband technology will be used to develop transponders and access points for a wide range of vehicles and road locations. According to the Intermodal Surface Transportation Efficiency Act of 1991, the goal is “the development or application of electronics, communications, or information processing (including advanced traffic management systems, commercial vehicle operations, advanced traveler information systems, commercial and advanced vehicle control systems, advanced public transportation systems, satellite vehicle tracking systems, and advanced vehicle communications systems) used singly or in combination to improve the efficiency and safety of surface transportation systems.” The FCC has reserved 75 MHz of spectrum in the 5.85—5.925 GHz band for this service, which is also known as Dedicated Short Range Communications Service (DSRC).

Conclusions

- Spectrum is now open in 5 GHz in all major global markets.
- 802.11a and 802.11a/b/g multimode solutions may now operate in countries throughout the world using 2.4 and 5 GHz spectrum currently allocated.
- In June 2003, an agreement at the WRC-03 conference is expected to result in further harmonization in 5 GHz bands around the world. In many countries, total available channels for Wireless LAN deployment will be 8 times as great as that available in 2.4 GHz bands.

Appendix

Non-Overlapping Channels and Wireless LANs

802.11b / 802.11g Wireless LAN Networks

Any installation of 802.11b or 802.11g devices comprising an access point with all its associated nodes (PCs or other wireless-enabled devices) uses only a portion of the 83.5 MHz of spectrum available in the 2.4 GHz band. An access point and its associated devices occupy a single radio channel using approximately 25 MHz of the 83.5 MHz available. Therefore, in any one location, no more than three access points (25 MHz X 3) can operate without interfering with each other, as illustrated in Figure 1-6.

The 802.11b standard does allow nearby access points to use channels whose centers are separated by less than 25 MHz such that their channel usage partially overlaps. In the United States, an access point can be configured using one of 11 center frequencies. Europe allows use of up to 13 center frequencies and Japan up to 14 as shown at the top of Figure 1-6. However, in all cases, use of more than three of the allowed center frequencies in any location comes at the price of reduced performance due to interference between nearby access points. In 802.11b nomenclature, channels with full separation in frequency are referred to as **non-overlapping channels.** *There are a maximum of three non-overlapping channels available in the 2.4 GHz band in the United States, Europe, Japan and in the rest of the world*. This limitation applies equally to 802.11g operation since the channel usage is equivalent for these two modulation types operating in the 2.4 GHz band.

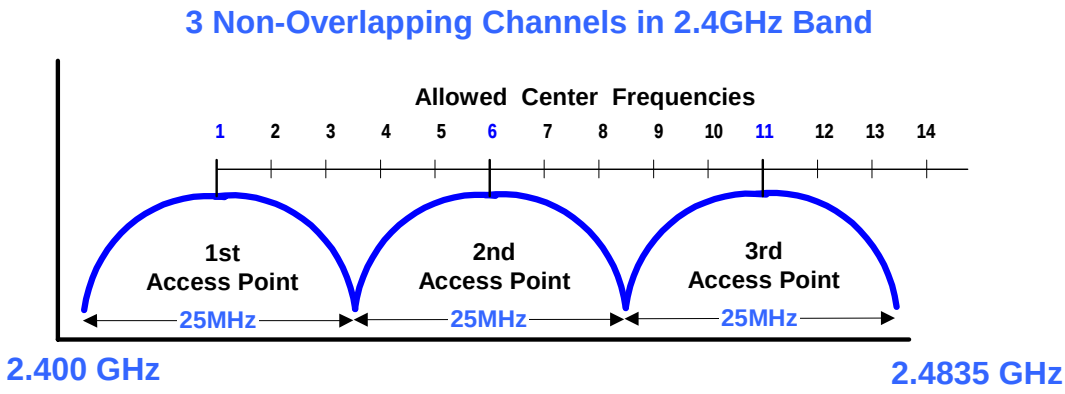

Figure 1-6. **Typically, channels 1, 6, and 11 are used as the three non-overlapping channels in the 2.4 GHz band**

802.11a Wireless LAN Networks

In contrast, the 802.11a standard accommodates up to *24 non-overlapping channels in the 5 GHz bands*. There is no need and no provision in the 802.11a standard for overlapping

channels in the 5 GHz bands. However, the term non-overlapping is sometimes used in reference to 5 GHz channels to reiterate that any 5 GHz channel is generally free of interference or degradation due to other Wireless LAN networks operating in its vicinity. An additional characteristic of most Wireless LAN networks operating in the 5 GHz bands is that the access points automatically seek out unused channels to begin operation.

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Document Number: 991-00004-004

Atheros Communications Incorporated
529 Almanor Avenue
Sunnyvale, CA 94086
t: 408/773-5200
f: 408/773-9940
www.atheros.com