Before the
Federal Communications Commission
Washington D.C. 20554

In the Matter of	)	
	)	
Amendment of the Commission's Rules to Establish New Personal Communications Services	)	GEN Docket No. 90-314 ET Docket No. 92-100
	)	

To: The Commission

Comments on the Spectrum Etiquette

The Wireless Information Networks Forum ("WINForum") is an alliance of leading information technology companies that are working together to obtain, and effectively employ, radio spectrum for unlicensed, user-provided voice and data personal communications services ("User-PCS").[1] These include wireless local-area networks for computers, cordless telephone systems, and new types of portable information devices and software.

On May 17, 1993, WINForum filed its Spectrum Etiquette in the above-captioned docket. At the time of that filing, several issues were not resolved. We believed, however, that a timely submission of the available work was appropriate.

We are pleased to submit the latest version of the Etiquette and associated commentary ("Philosophical Basis for the WINForum Spectrum Etiquette"). The previously open, unresolved items have been closed using the consensus process established at the start of this effort.

The Etiquette is a means for widely differing applications and devices to gain fair access to the same spectrum. It is intended to foster technical advances and support applications including computer local area networks (LANs) and wireless private branch exchanges (PBXs), as well as other projected concepts. The Etiquette provides

[1] A list of participating companies is attached.

simple rules that enable the coexistence of a wide range of cost-effective, spectrum-efficient unlicensed digital radio systems and devices. The Etiquette is not intended to preclude any common air interface standards or access technologies.

Function of the Spectrum Etiquette

A device may not transmit if the spectrum it will occupy is already in use within its range; this function is called Listen-Before-Talk (LBT). Transmit power is limited to keep range short, so that spectrum can be reused in buildings with densely populated offices, meeting rooms and school facilities. Permitted power is also related to bandwidth so as to equalize mutual interaction among narrow- and wideband users. Under the Etiquette, use of minimum power is encouraged by a dynamic Listen-Before-Talk threshold.

Envisioned are services requiring continuous connection-oriented, isochronous operation (generally typified as voice services) and bursty, connectionless, asynchronous operation (generally typified as data services). Because the services are technically contrasting, separate sub-bands with differing Etiquette parameters are required.

For example, in isochronous applications it is permitted to complete a continuous conversation without dropping the connection. This is not the case in the Asynchronous sub-band where speed of access is critical. Another example is that the bandwidth in the Asynchronous sub-band may range from 50 kHz to 10 MHz, while the Isochronous sub-band is divided into 1.25 MHz segments that can also contain narrower-band signals. All systems and devices may use the entire spectrum as long as the Etiquette of that sub-band is used.

Development of the Spectrum Etiquette

WINForum first met formally in July 1992, with participation from large and small computer and communications companies. Its technical committee was established then. From July to December 1992, the committee met twice monthly, with typical attendance of twenty to forty professionals. By that time, the committee had spawned several working groups specializing in data, voice and spectrum use rules. Initially the working groups met by telephone and electronic conferencing. As these working groups established the philosophy of the Etiquette, full face-to-face committee meetings were scheduled monthly through June 1993. A favorable vote of two-thirds of the attendees is required to establish the consensus content of the Etiquette.

Initially it was anticipated that a single Etiquette might cover both voice and data applications. However, after substantial effort and numerous technical papers, it was seen with some disappointment that the key requirements for asynchronous services centered on discontinuous bursts of high-rate data with low overhead and transmission delay, while for isochronous services the key requirement was continuity, dictated by freedom from call dropping. At this stage in late 1992, it was determined to work toward separate sub-bands and Etiquette provisions for isochronous and asynchronous modes.

The proposed Etiquette in section 5.6 provides certain flexibility to interoperable unlicensed PCS devices. In no event, however, would interoperable devices be exempt from compliance with equipment authorization rules based on this Etiquette.

WINForum offers this completed Etiquette with the expectation that it will form the basis of equipment authorization rules for devices operating in the spectrum allocated to unlicensed PCS devices. Both modern cordless telephony and data networking have provided major breakthroughs in technologies that permit unlicensed operation of independent devices with high tolerance to interference. The WINForum Spectrum Etiquette sets out rules that will lead to the realization of the valuable unlicensed PCS services envisioned by the Commission.

WHEREAS, the Wireless Information Networks Forum urges the Commission to allocate spectrum for unlicensed PCS devices in accordance with the views expressed herein.

Respectfully submitted,
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Philosophical Basis for the WINForum Spectrum Etiquette

This document is intended to give insight into the reasoning behind the development of the WINForum Spectrum Etiquette. The organization of this document follows that of the proposed Etiquette. It avoids repeating specific Etiquette provisions, but offers background information as an aid to understanding.

Introduction and Motivation

WINForum's objective is to define a minimal set of rules that will provide a framework for coexistence of devices from multiple manufacturers delivering many different types of services; this set of rules is called the Spectrum Etiquette. It is the goal of this Etiquette to allow devices from different manufacturers to coexist in an interference-limited environment by constraining all devices to a known behavior. It is our expectation that compliance with this Etiquette shall be mandatory and shall be enforced by the FCC through equipment authorization. Systems comprised of devices that meet this Etiquette may experience some performance loss when operated in proximity to dissimilar but compliant systems.

It is the intent of the Etiquette to promote innovation and low cost while encouraging spectrum efficiency. It is intended to provide fair access and coexistence for short-range systems by defining power, bandwidth, transmission time and channel access mechanisms.

The Etiquette utilizes power detection techniques rather than exchange of information, and consequently does not address the interoperability of unrelated devices. The provisions of this Etiquette can be extended to additional spectrum allocations to unlicensed PCS devices.

Device Characteristics

Two classes of device characterize current and future applications.

1. The first exhibits long link holding times, periodic transmissions and flexible link access times (up to a second). WINForum describes this class of device as Isochronous; voice traffic is typically carried by this type of device.

2. The second class must begin transmission within milliseconds, uses relatively short bursts that contain large amounts of data, and releases the link quickly.

We describe this class of device as Asynchronous; LAN data is typically carried by this type of device.

These classes are technically contrasting and cannot share the same spectrum. WINForum proposes that the unlicensed PCS allocation be split into two equal portions: an Asynchronous sub-band and an Isochronous sub-band. The Etiquette provisions for channel access and use are different for the two sub-bands, reflecting the different services and data rates they provide.

Channelization

The Asynchronous sub-band supports services requiring high transmit rates, such as 10 Mbps. It is not channelized; this permits utilization of the maximum allocated spectrum. The Isochronous sub-band supports services that need to supply a large number of relatively low speed but long-duration services; it is channelized. This "channelization" is not the ordinary designation of channels with center frequencies, but should be viewed more as "sub-banding" of the Isochronous portion of the spectrum into discrete sections of spectrum to facilitate co-existence and sharing of the available spectrum among the low speed services. Devices requiring narrower bands of spectrum are permitted in the sub-bands.

The actual dimensions of the sub-banding were the subject of many meetings and extensive discussions, as well as the review of the work of other groups involved in radio communications. WINForum recognized the contrasting needs of different manufacturers and the overall need to provide for a sufficient number of service-unique sub-bands or "channels" to ensure a viable spectrum environment. In the end, the limitations imposed by the available spectrum to a large extent dictated the choice of the sub-banding.

Frequency Stability

WINForum believes that the frequency stability requirements in the NPRM were overly restrictive. We concluded that, given the types of services planned for this spectrum, it is sufficient to define the maximum energy spill outside the bands and sub-bands and a short term frequency stability requirement (defined in terms of the sub-band or channel access parameters).

RF Power limits

WINForum approached the issue of power limits with these objectives:

1. Limit interference by limiting the power used to that required for the specific service.

2. Minimize any asymmetry between the different services. Specifically, a wideband system's ability to detect the presence of a narrowband system is not commensurate with its potential to interfere.

Consequently, WINForum determined that the above objectives would be best served with a "less-than-linear" power-to-bandwidth relationship and recommends a square root of bandwidth power relationship. In order to ensure a reasonably flat spectral occupancy, we also recommend the adoption of a spectral power density distribution requirement.

WINForum believes that there should be an incentive to design devices for very low power levels. For that reason we suggest that devices that lower their power below that permitted receive a benefit for doing so. Specifically, for each dB power decrease, a dB increase in the Listen-Before-Talk threshold is permitted. Such devices can avail themselves of greater spectrum efficiency.

Channel Access Mechanism

WINForum recommends a strict "Listen-Before-Talk" requirement to access the unlicensed PCS frequencies. To be reliably effective, the monitoring mechanism should be required to operate via an antenna that covers at least the same area as the intended transmitter. The access mechanism is different for the two sub-bands.

Isochronous Channel Access

All transmitters operating in the Isochronous sub-band should be required to include an effective mechanism for monitoring the desired sub-band for at least the maximum frame time to verify that there is no detectable energy above the threshold before transmitting. This procedure would apply, for instance, at the initiating of a voice conversation, for an isolated data packet, or to the first data packet in a burst. Subsequent transmissions would occur without further monitoring. This mechanism confers "ownership" of that channel to transmitters cooperating in a given exchange.

The magnitude of the monitoring threshold has been carefully examined as it is of considerable concern. There are several factors to be considered, including carrier-to-interference levels, receiver noise figure, fade margin and interference from other transmitters. This Etiquette is intended to permit coexistence in an interference-limited environment. Consequently, the threshold defined in the Etiquette is one that is deemed to give reasonable levels of performance taking into account current and potential sources of interference.

In order to ensure that there is no unnecessary fragmentation of the Isochronous sub-band, the Etiquette invokes a "packing" rule which requires that systems requiring different amounts of spectrum for operation begin the search for available spectrum at different ends of the Isochronous sub-band.

Asynchronous Channel Access

Transceivers operating in the Asynchronous sub-band should be required to include an effective mechanism for monitoring the channel for a minimum period of time related to the data transmission rate. This is because high data rate devices will access and release access to the spectrum very quickly, while slower rate devices will take a longer time transmitting the data and must ensure that the spectrum is available for that longer period of time.

To prevent spectrum monopolization, the Etiquette provides for the insertion of random periods of time between transmission "bursts". Once a transmission "burst" has started, there is no need to further monitor the spectrum being used if the inter-transmission gap does not exceed the minimum monitoring period, i.e. there is "ownership" of the spectrum for a set maximum period . This mechanism is provided to ensure that a reasonably long period of time is available for data transmission.

The overhead of spectrum monitoring is kept to a minimum level while still providing for fair access to the spectrum for all asynchronous devices. In case of collisions, the Etiquette provides for a time-randomized back-off algorithm as an alternative to attempting to access an alternate section of the spectrum.

Interoperable Systems

WINForum recognizes that the channel access mechanisms outlined above can be improved if the spectrum is being used by a system of interoperating transmitters

that are allowed to use their native channel access mechanism. It is our intent to encourage this type of operation because spectrum utilization can be improved if the interoperable systems use their native and spectrally more efficient channel access mechanisms so long as fair access to the band is not denied to other systems.

In no event would interoperable systems be exempt from compliance with equipment authorization rules based on this Etiquette.

WINForum Spectrum Etiquette for Unlicensed PCS Devices

1.0 INTRODUCTION

1.1 Transmitters in this band shall be used only for digitally modulated transmission, and shall be limited by power, bandwidth, transmission time, and channel access mechanism so as to provide fair access and coexistence for short range systems.

1.2 Definitions

1.2.1 Isochronous Transmitters shall be defined as transmitters that emit at regular intervals, as typified by time-division voice systems.

1.2.2 Asynchronous Transmitters shall be defined as transmitters that emit at irregular intervals, as typified by Local Area Network (LAN) data systems.

1.2.3 The transmit power "P" is the maximum of the mean radiated power over any interval of continuous transmission.

1.2.4 All power measurements will be made over an interval of continuous transmission.

1.2.5 A marker transmission is a low-capacity, predominately one-way transmission used by a device to identify itself to other interoperable devices within its communication range. The content and purpose of marker transmissions shall be limited to minimal control and signaling information as needed by a device to establish or maintain communications with other interoperable devices.

2.0 TRANSMIT POWER LIMITS

2.1 Maximum Transmit Power

2.1.1 The transmit power "P" shall not exceed 1.0 E-4 * SQRT(B) watts, where "B" = occupied bandwidth in Hz.

2.1.2 Further, the transmit power shall not exceed 3 E-3 watts in any 3-kHz wide band at any time.

2.1.3 Power-Bandwidth Example Table

Power in mW	Bandwidth in MHz
32	0.1
52	0.3
100	1.0
173	3.0
316	10.0

2.1.4 The peak envelope power shall not exceed the transmit power by more than 10 dB.

2.2 Reduction with Antenna Gain

The permitted transmit power shall be reduced by the amount in dB that the maximum directional gain of the antenna exceeds 3 dBi.

2.3 Emission Limits

2.3.1 Inter-1.25 MHz Frequency Segment Emissions

The total power emanating from an intentional radiator operating in a 1.25 MHz frequency segment, detected in the immediately adjacent 1.25 MHz segment, shall be at least 30 dB below the power permitted that radiator.

The total power emanating from an intentional radiator operating in a 1.25 MHz frequency segment, detected in the 1.25 MHz segment separated from the occupied 1.25 MHz segment by 1.25 MHz, shall be at least 50 dB below the power permitted that radiator.

The total power emanating from an intentional radiator operating in a 1.25 MHz frequency segment, detected in the 1.25 MHz segment separated from the occupied 1.25 MHz segment by 2.5 MHz or more, shall be at least 60 dB below the power permitted that radiator.

2.3.2 Inter Sub-band Emissions

The total power emanating from an intentional radiator operating in either

sub-band, measured in the first 1.25 MHz frequency segment across the inter-band edge, shall be at least 30 dB below the transmit power permitted an intentional radiator operating with an 1.25 MHz occupied bandwidth.

The total power emanating from an intentional radiator operating in either sub-band, measured in the second 1.25 MHz frequency segment across the inter-band edge, shall be at least 50 dB below the transmit power permitted an intentional radiator operating with an 1.25 MHz occupied bandwidth.

The total power emanating from an intentional radiator operating in either sub-band, measured in the third and subsequent 1.25 MHz frequency segments across the inter-band edge, shall be at least 60 dB below the transmit power permitted an intentional radiator operating with an 1.25 MHz occupied bandwidth.

3.0 FREQUENCY LIMITS

3.1 Occupied Bandwidth

Occupied bandwidth is that bandwidth that contains 99% of the total transmit power, including allowance for frequency instability and spurious emissions.

3.2 Sub-Bands

The available band shall be divided into two equal sub-bands; one sub-band for Isochronous operation (the Isochronous sub-band) and one sub-band for Asynchronous operation (the Asynchronous sub-band).

3.3 Asynchronous Bandwidth Limits

In the Asynchronous sub-band, the occupied bandwidth of any allowable signal shall be between 500 kHz and 10 MHz.

All systems of less than 2.5 MHz bandwidth in the Asynchronous sub-band will first occupy spectrum beginning nearest the sub-band edges, while systems of more than 2.5 MHz bandwidth will first occupy the center half of the sub-band. Devices of occupied bandwidth of less than 1.0 MHz may not occupy the center half of the sub-band.

3.4 Isochronous Frequency Channel

The Isochronous sub-band shall be divided into frequency channels 1.25 MHz in width. Isochronous frequency channels are 1.25 MHz apart, beginning at the lower frequency band of the unlicensed PCS band. No occupied bandwidth greater than 1.25 MHz is permitted in this sub-band; narrower bandwidths are permitted within each 1.25 MHz channel.

3.5 Isochronous Frequency Search

In order to ensure that the available Isochronous frequency spectrum is efficiently utilized (i.e., packed), all systems in that sub-band shall implement the following process: Narrowband systems (< 625 kHz) shall start searching from the lower end of the Isochronous sub-band. Wideband systems (=>625 kHz) shall start searching from the upper end of the Isochronous sub-band.

3.6 Spectrum Sharing

Crossover between sub-bands will be governed by adherence to the rules of the sub-band entered.

3.7 Frequency Stability

The stability of the frequency determining elements in the transmitter shall be equal to or better than:

In the Asynchronous sub-band: +/- 10 ppm over 10 milliseconds or the interval between LBT monitorings, whichever is shorter.

In the Isochronous sub-band: +/- 10 ppm over 1 hour or the interval between LBT monitorings, whichever is shorter.

4.0 TIME LIMITS

4.1 Isochronous Frame Period

The frame period of an Isochronous transmitter shall be 10 milliseconds/N where N is a positive integer.

Devices operating in the Isochronous sub-band that implement time division for the purposes of maintaining a duplex connection on a given frequency carrier shall maintain their frame repetition rate with frequency stability of at least 50 ppm. Devices which further divide access in time in order to support multiple communication links on a given frequency channel shall maintain their frame repetition rate with frequency stability of at least 10 ppm. The jitter introduced at the two ends of such a communication link shall not exceed 25 microseconds for any two consecutive transmissions.

4.2 Asynchronous Transmission Bursts

4.2.1 An Asynchronous transmission burst is a series of transmissions from one or more transmitters acting cooperatively. Any intraburst gap shall not be greater than 25 microseconds. No burst duration shall be greater than 10 milliseconds.

4.2.2 Individual bursts shall be separated by at least a random-duration interval uniformly distributed between 50 microseconds and 375 microseconds.

4.3 Unacknowledged marker transmissions from a device shall be limited to 30 seconds. After that period the channel access procedure shall be required to initiate further marker transmissions.

5.0 CHANNEL ACCESS

5.1 Channel Access in the Isochronous Sub-band

5.1.1 Before initiating transmission, devices operating within the Isochronous sub-band shall monitor the portions(s) of the Isochronous frame(s) in which they intend to transmit over the period of at least 10 milliseconds to determine if the access criteria are met.

Devices which are in a state which prevents them from monitoring during their intended transmit interval may acquire additional spectrum by monitoring the intended receive interval(s) over 10 milliseconds so long as that spectrum is within the 1.25 MHz frequency segment already occupied by that device or co-located (within one meter) co-operating group of devices. The receive monitoring interval must total at least 50% of the 10 millisecond interval. If the power detected during the above state can be decoded as a connection signal from an interoperable device, transmission to establish a duplex connection to that device (A) may begin without further

monitoring. Device (A) shall monitor both its intended transmit and intended receive times before initiating the transmission.

5.1.2 Succeeding transmissions may be sent without further monitoring, as long as the occupied bandwidth is entirely within the Isochronous sub-band.

5.1.3 With the exception of marker transmissions, all access attempts initiated after following the procedure in section 5.1.1 must stop after one second if no acknowledgment has been received by the initiating device. Further access attempts must repeat the procedure outlined in section 5.1.1.

5.2 Channel Access in the Asynchronous Sub-band

5.2.1 Before each burst is transmitted, transmitters shall monitor the intended occupied bandwidth. The monitoring period shall be at least the longer of 50 microseconds or 20 times the inverse of the occupied bandwidth.

5.2.2 Once a burst has started, participating transmitters are not required to monitor the channel, providing the gap between transmissions does not exceed the intraburst gap 4.2.1.

5.3 Channel Access Criteria and Selection

5.3.1 If channel access procedures in sections 5.1 or 5.2 indicate that the particular frequency selected is in use, transmission may not proceed; there are two possible channel access alternatives.

5.3.1.1 Another frequency may be selected and monitored.

5.3.1.2 After the channel becomes idle, the transmitter shall wait a deference time chosen from a uniform random distribution between X and 15X, where X = 10 ms for Isochronous systems; x = 50 microseconds for Asynchronous systems. At the end of this period, the transmitter may again proceed according to the appropriate rule 5.1 or 5.2.

5.3.2 For Asynchronous systems, the range from which the deference time is chosen shall double for each occasion that an access attempt fails (after the inter-burst interval). This increase shall continue on each occurrence until an upper limit of 240X is reached. The range is reinitialized after each successful access attempt.

5.3.3 Each transmitter shall implement a channel access mechanism adequate to prevent catastrophic congestion.

5.4 Monitoring Requirements

5.4.1 The monitoring mechanism shall operate via the transmitting antenna, or one that includes the coverage area of the transmitting antenna.

5.4.2.1 Isochronous Monitoring Threshold

A device detecting energy below 30 dB above the thermal noise power in the occupied bandwidth in a channel (time/frequency combination) may access that "free" channel without further searching.

If no "free" channel is available, and at least 40 duplex system access channels are defined for the system, the time/frequency channel with the lowest power below a monitoring threshold of 50 dB above the thermal noise power in the occupied bandwidth may be used. A device utilizing the lowest detected power mechanism must have monitored all access channels defined for that device within the last 10 seconds and must verify within the 20 milliseconds immediately preceding channel access that the detected power of the channel selected is no higher than the previously detected value. The resolution for power measurements need not be more accurate than 6 dB. No device or group of cooperating devices within 1 meter of each other shall occupy more than three 1.25 MHz Isochronous frequency segments during any frame.

5.4.2.2 Asynchronous Monitoring Threshold

It shall have a threshold that is within 32 dB of the thermal noise power in the occupied bandwidth.

5.4.3 Maximum Reaction Time

The maximum reaction time of the monitoring system will be less than 50 x SQRT (1.25/B) microseconds for signals at the applicable threshold level (5.4.2) but shall not be required to be less than 50 microseconds. For a signal that is 6 dB or more above the applicable threshold level, the maximum reaction time shall be 35 x SQRT (1.25/B) microseconds but shall not be required to be less than 35 microseconds. "B" is defined as Occupied Bandwidth in MHz.

5.4.4 The threshold decision shall be made based on the maximum power detected during the monitoring interval.

5.4.5 Every transmitter shall discontinue transmission in case of either absence of information to transmit or failure.

5.5 Dynamic Power Control and Monitoring Sensitivity

Transmitters that radiate power that is lower than the maximum specified in section 2 may increase their detection threshold by one dB for each one dB that the transmitter power is below the maximum permitted.

5.6 Interoperability Rules

Interoperable transmitters are permitted to use more spectrally efficient access methods than those specified by this Etiquette, provided that other systems are not excluded from fair access under this Etiquette.

# # #

Wireless Information Networks Forum Participating Companies

Advanced Micro Devices
Apple Computer
AT&T
Bellcore
California Microwave
Diablo Research Corp.
Digital Equipment Corp.
Domestic Automation Co.
Ericsson Business Communications
Farallon Computing
GEC Plessey Semiconductor
Hewlett-Packard
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Local Area Communications
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