IEEE 802.11

Wireless Access Method and Physical Layer Specification

Title: Discussion of RF Sensitivity as it Pertains to CCA Threshold Author: Jim McDonald Motorola, Inc. 50 E. Commerce Drive Suite M-1 Schaumburg, Ill 60173 Tel: 708 576 3169 Fax: 708 538 5152 Abstract: The author has proposed that the 802.11 standard should not address RF power other than to provide for a minimum RF power of 1 to 10 mWs. The author further proposes that locking the CCA threshold to transmit power in an inverse manner provides a reasonable means of fair access for both high and low power units. This submission addresses the issue of RF sensitivity with specific reference to CCA threshold. Based on actual performance data, it is concluded that a CCA threshold of -95 dBm is reasonable for a

Introduction

The efforts of the Frequency Hop Group to address the area of RF power specification has resulted in a paradox in that there appears to be no compromise on the horizon that would be acceptable to all. This submission first lists some of the divergent thoughts, proposals and objections to RF power related issues, and then proposes a compromise. First, the background of the various positions is presented, some conclusions are then drawn, and finally the proposal with specific motions is made.

transceiver with a 1 Watt transmitter.

Background

In order to provide the flavor of the debate, the following list of positions is provided in an attempt to fairly depict the range of opinions of the members of the Frequency Hop Group.

Some want maximum RF power to achieve maximum range (1 Watt).

Some want an RF power level consistent with PCMCIA package constraints (100 to 250 mW range).

Some want EIRP limited to 100 mW maximum for ETSI standards.

Some want antenna gain included in the power specification, of course, some don't.

Some or most want one power level: simple is good. There is, however, little agreement on what that power level should be!

Some feel that multiple power levels won't be compatible in a system environment. Other suggest that it may not be ideal, but yet workable. Cellular has multiple power levels for mobile and portable applications. If the 802.11 standard is as successful as Cellular, then perhaps this standard would also be considered successful.

Some want power control. The idea is to use high power only if it's necessary to achieve the range, otherwise lower power would be appropriate. The Mac, however, has not agreed to provide this control.

Some want no RF power specification. Let the local regulators control this specification.

In September, the Frequency Hop Group elected to have RF power bracketed into 4 classes. There is second guessing occurring now as to what the classes mean. The classes refer to maximum_nominal RF power. It's not clear that all have the same understanding of maximum_nominal RF power. Should the classes address minimum, maximum, nominal or maximum_nominal RF power?

In September, the Frequency Hop Group fixed the CCA threshold at -65 dBm + RF power in dBm. This means that the CCA threshold of the receiver portion of a transceiver depends inversely on the transmit power of the transmitter part. Thus, 1 Watt transmitters must be more polite than 10 mWatt transmitters.

Some raise the question of tolerance on the RF power ratings. This indicates that they feel that the ranges defined by the RF power classes are too narrow. If the RF power tolerance is +-6 dB, as suggested by some, then the utility of the RF power classes defined in September may be in question.

Some feel that the -65 dBm + RF power (in dBm) CCA threshold is too heavy a burden for the suppliers of 1 Watt transmitters. There is one Reflector comment that disagrees that this is a burden. Data is presented below that indicates that a -95 dBm CCA threshold is readily achievable for the 1 Watt transceivers without major difficulty.

Since the primary function of the standard is to provide for interoperability, some believe that only a minimum, not a maximum, RF power specification is required. That minimum could be 1 to 10 mWatts.

CCA Sensitivity Discussion

CCA is a detection process wherein the receiver within a transceiver is expected to sense the presence of a conformant 802.11 Frequency Hop signal if its magnitude is greater than a threshold called the CCA threshold. The detection probability was defined earlier as 90% if the signal is a 1,0 pattern and 70% if the signal is random data. There is no requirement pertaining to false alarm rate.

Before addressing the issue of CCA sensitivity, it is appropriate to review the BER threshold performance that one might expect from a 802.11 Frequency Hop receiver. Figure #1 illustrates typical performance Motorola is achieving with a

submission



Figure #1

production radio tested to the 802.11 format as it now stands. The worst case performance experienced is about 2 dB less sensitive. Note that the dashed line indicates the expected performance at signal levels below -94 dBm. The test setup used for this data is obviously not accurate for BER above 1%.

Note that the BER at -95 dBm is less than 1%. Even worst case BER, by projection, is 10% if a worst case margin of 3 dB above the data presented is allowed. Recalling that the SNR to achieve a BER of 10⁻⁵ is 19 dB, the SNR to achieve 10% BER is about 10 dB less or about 9 dB.

The question then is, is it reasonable to set the CCA threshold at a level corresponding to 9 dB SNR? Considering that the decision process may take several symbol periods, the answer is, yes, it is quite practical.

It becomes even more practical when one considers the following:

The 1 Watt transmitter option is viable in the eyes of some, because it would be used to provide the maximum possible range within the rules of the FCC. If one is interested in maximizing range, however, economics would dictate that one would address receiver sensitivity before undertaking the cost issues associated with an RF output power of 1 Watt. Thus, one would not produce a receiver with a sensitivity of -80 dBm as allowed by the 802.11 standard to date. The Motorola design presented represents what can be achieved with available commercial technology.

The Motorola receiver has a T/R switch and a diversity switch in series with the receiver. Before assuming the cost of a 1 Watt capability, it seems reasonable that one would devise means to eliminate the losses associated with the series switches and thus achieve an additional 2 to 3 dB in sensitivity.

In consideration of these factors, the -95 dBm CCA threshold is indeed reasonable for the 1 Watt devices.

Conclusions:

Because of the various regulatory rules and the various market objectives, the standard must provide the hardware suppliers of 802.11 equipment wide latitude in setting RF power and EIRP.

There is a legitimate concern that in an arena of low and high power radios, the high power radios would put the low power users at a disadvantage. It should be noted that higher power inherently implies greater range at least in some applications. The standards group can't change this. The standards group however, can provide a more level playing field by requiring that high power transmitters have a more polite CCA requirement than low power transmitters. The CCA requirement passed by the Frequency hop group in September did just that.

The CCA threshold requirement passed by the Frequency Hop Group in its September meeting is reasonable for both high and low power transceivers.

submission

Proposal:

What is propose therefore, is that the standard provide no RF power requirements except perhaps a minimum of say 1 or 10 mW. Let the local regulatory agencies impose the upper limit on RF power or EIRP.

In order to provide reasonable compatibility between high and low power devices, it is proposed here that the standard simply utilize the CCA agreement already in place.

Thus, there is no need for classes or control in the standard.

Motions

Motion:

It is moved that the standard establish the minimum EIRP for Frequency Hop 802.11 transmitters with integral antennas at 10 mW and establish the minimum RF power for transmitters with antenna connectors at 10 mW.

Motion:

It is moved that reference to maximum RF power limits be stricken from the standard. The regulatory bodies will control this parameter.

Motion:

It is moved that reference to RF power classes be stricken from the standard.

Motion:

It is moved that reference to a requirement for RF power control be stricken from the standard.

Motion:

It is moved that at an input level 10 dB greater than the CCA threshold, the probability of detection for a 802.11 compliant signal modulated with either a 1,0 pattern or random data be greater than 99%.

. 14