IEEE 802.11
Wireless Access Method and Physical Specification

Title: **FH Carrier Sense Proposal: Update to 94/70**

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Abstract

This submission discusses the requirements and considerations involved in selecting an FH PHY carrier sense method. Collisions caused by hidden terminals are one of the biggest problems in a wireless network and requires high sensitivity carrier sense to minimize. Arguments are presented for selecting a carrier sense method using a combination of power measurement and clock lock detect. The actual method may vary, but most of these should be acceptable if they meet a few minimum requirements.

Discussion

Hidden terminals occur when two or more terminals within a single infrastructure Basic Service Area (BSA) or single ad hoc network cannot hear each other, either temporary or longer term. The hidden terminal problem is one unique to wireless networks - wired networks are not allowed to be "out of range." Hidden terminals increase the probability of collisions and significantly reduce throughput due to the extra traffic generated from retransmissions. This is compounded by a secondary problem in wireless networks in that it is very difficult to distinguish two signals colliding from other types of noise or interference. To avoid unnecessary collisions, carrier sense in a wireless LAN radio should be as sensitive as possible to avoid the hidden terminal problem.

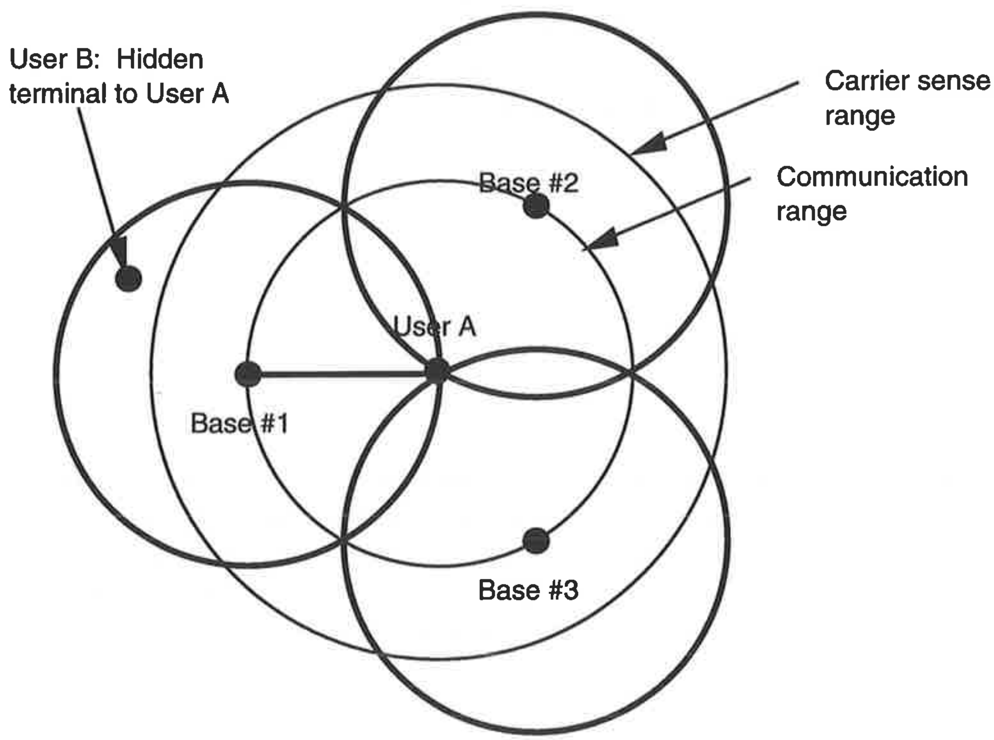

Figure 1. Wireless Network BSA and ESA

There have been concerns raised about excessive false deferrals due to overly sensitive carrier sense. While this may occur occasionally, it will be a very low probability of occurrence in FH systems. An adjacent BSA (or a different ad hoc network)would have a 1/79 chance of being at the same frequency as your own BSA or network. This ignores the probabilities of distance and power. Therefore, if you receive a very low power FH signal, the probability is _ 98.7% that the signal was from your own BSA. You could falsely defer to the adjacent BSA up to 1.3% of the time, a very small amount to pay to avoid hidden terminal collisions. This 1.3% would apply equally to large signals such as that from an overlapping ad hoc network, but it would be better to defer in this type of cross network collisions anyway.

In a typical cellular arrangement, the false deferral probability would increase by less than five times or 6.3%, still a small price to pay to avoid hidden terminal collisions. The five-fold increase is a worst case assuming that User A can sense all users in all five adjacent cells. If physical geometry is taken into account, this multiplier would average on the order of two.

The three possible carrier sense state machines proposed in submission 94/70 all use a combination of power threshold and clock lock detect. There are various combinations of these two measurements that provide quick detection, antenna selection, and reliable identification of network signals. Any of these or other methods should be valid as long as they meet certain minimum requirements. The first and most important of these is the sensitivity. The sensitivity determines the degree to which hidden terminals will be a problem.

Figure 2 shows the simplest carrier sense algorithm (slightly modified) described in 94/70. Any signal above the minimum power threshold should be processed through the clock lock detector. To minimize the hidden terminal problem, the minimum power threshold spec should be set as low as possible. This threshold effectively determines the carrier sense sensitivity. Note that a threshold lower than the maximum specified by 802.11 will result in better sensitivity and less hidden terminals. If a manufacturer wants to use -_ dB as threshold, i.e. no minimum threshold, this should be allowable as this provides the maximum sensitivity yet avoids the complexity of calibrating an RSSI A/D.

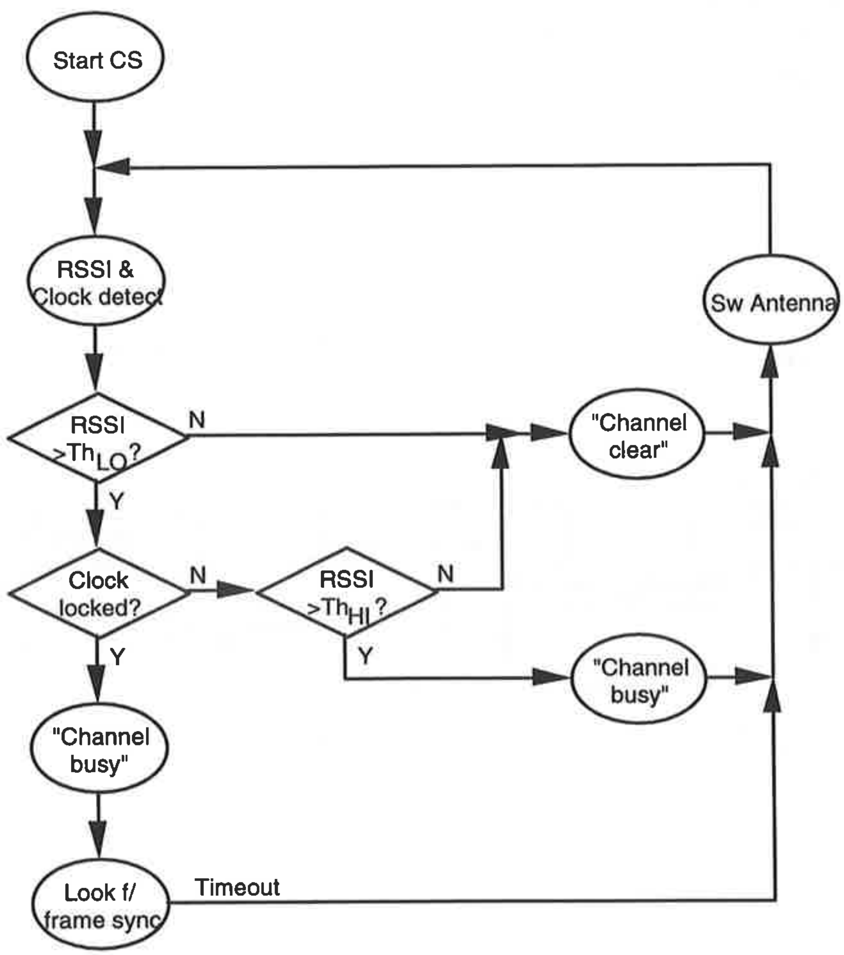

Figure 2. Simple Carrier Sense Algorithm - Pick first antenna you see signal

There should also be a maximum power threshold that if exceeded, regardless of the indication from the clock lock detector, would result in a busy determination. This is necessary to avoid colliding with microwave ovens or other large non-FH interferers. This is a change to 94/70.

The probability of false deferrals increases significantly if only energy detection is used. This is an important reason why clock lock detect is also necessary. It provides a fast and reliable means to filter out the non-network signals. 94/70 presented probability of detection and false alarm with measurement window sizes of 10, 20 and 40 µs. The bottom line was that the probabilities of detection and false alarm was acceptable using transition based clock lock detection.

Summary of Position

Carrier sense method:

Combination of power measurement and clock lock detect with very low minimum threshold and a high power interferer threshold

Specified parameters:

Sensitivity	-85 dBm
Probability of detection in preamble	0.95
Carrier sense and diversity selection time	80 µs

Minimum state machine:

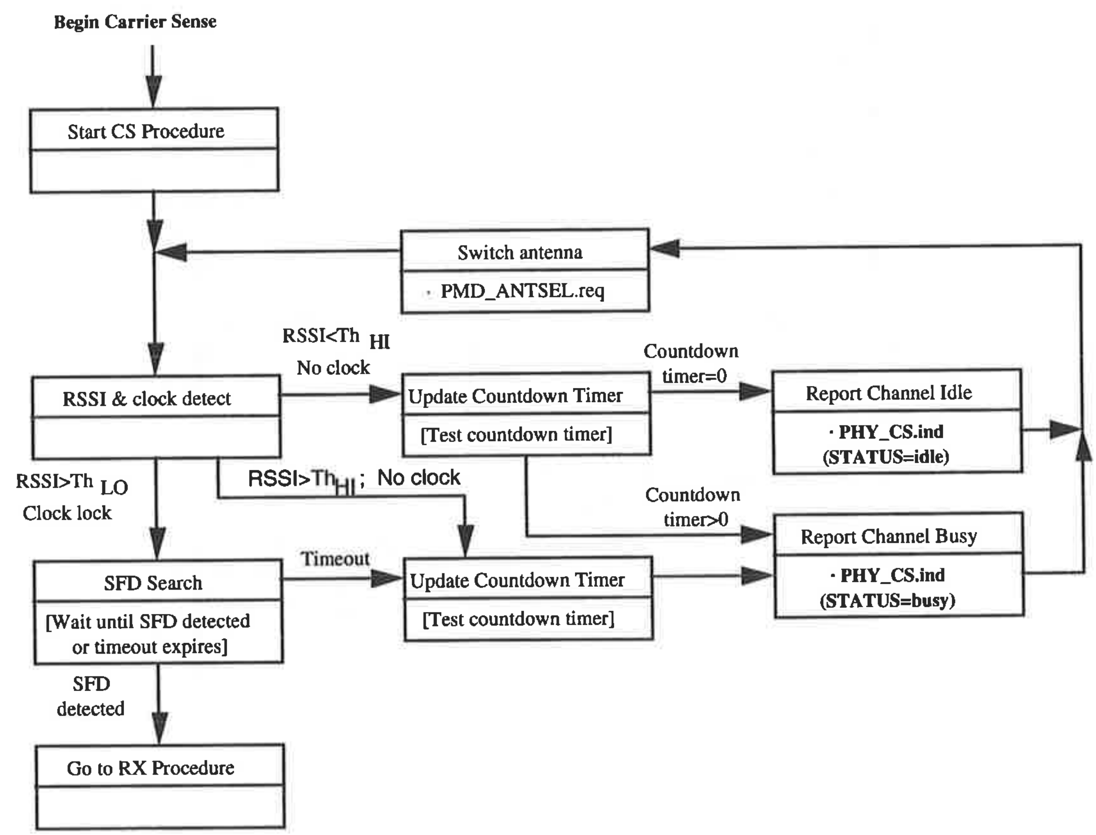

Figure 2. Simple Carrier Sense State Machine - Pick first antenna you see signal