IEEE P802.11
Wireless Access Methods and Physical Layer Specifications

GENERIC AUTOMATED COMPLIANCE TESTING CONFIGURATION FOR THE 802.11 WIRELESS LAN SPECIFICATIONS

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ABSTRACT

In order to assist the P802.11 Committee in its efforts to develop a complete set of tests to unambiguously definitize the subject Wireless LAN ("WLAN") interoperability standards ("Standards"), an initial, rough framework of conformance testing is offered. This framework is embodied in a Test Suite specifically designed to automatically perform all tests via radiative, as opposed to conductive RF connections. The intent of this submission is not to assert that the test suite and procedures suggested herein are the best (i.e. most elegant, competent, etc.) or the most comprehensive--only to act as a springboard to facilitate discussions.

BACKGROUND

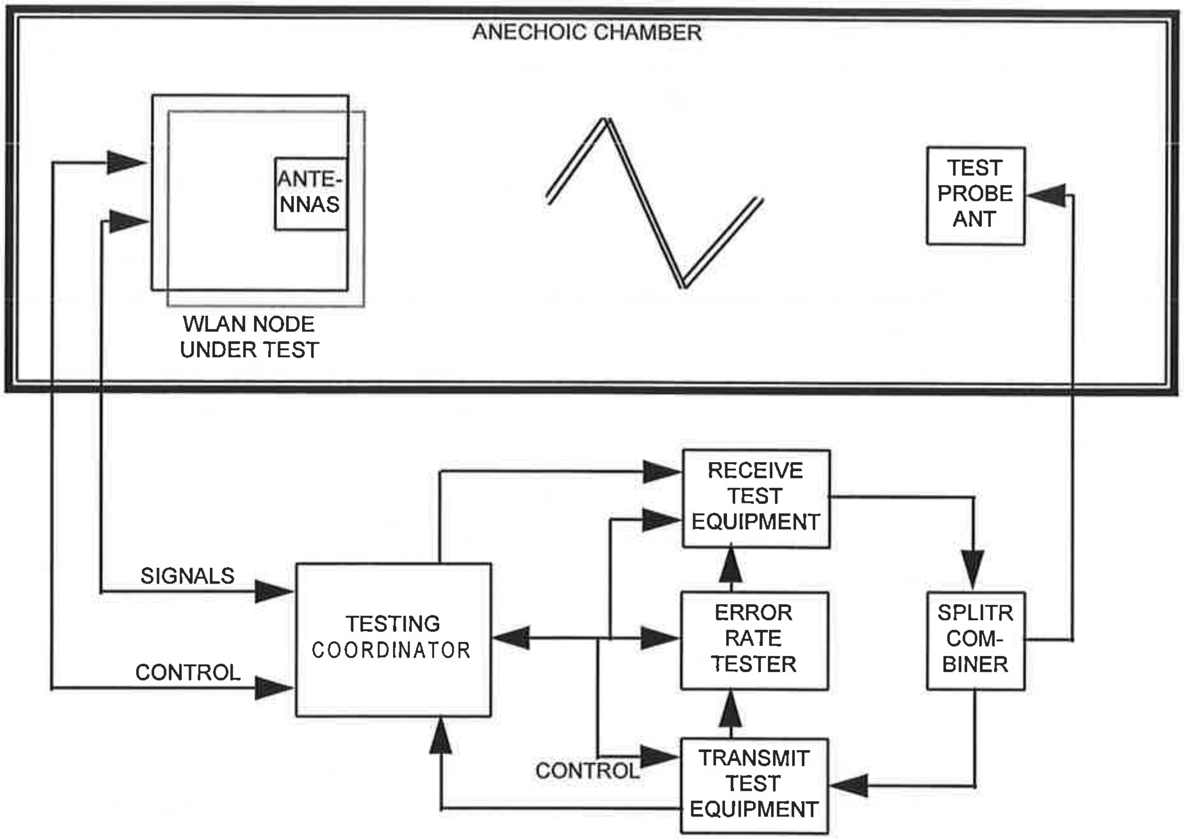
The IEEE P802.11 PAR requires an "Addendum" or "Annexure" to the Standard specifications, which contains sufficient equipment bench test procedures to eliminate all ambiguities and thereby ensure that the intent of the writers is communicated. It is the consensus of opinion that without tests, some of the specifications could be either misconstrued or even manipulated. Indeed, maximum mental clarity on the efficacy of the specifications within the standard (other than building the systems and discovering all the flaws by real world experience) is obtained by figuring out how one would test them. Even the preliminary discussions on test methods which took place during a small part of the January session in San Jose resulted in second thoughts about some of the specifications. The participants quickly realized, for instance, that inasmuch as the antenna system is an integral part of any Wireless LAN Adapter, it could not in general be removed for compliance testing.

The antenna cannot be separated from the remainder of the node under test; because the Standard is permitted to address only the <u>interoperability</u> between compliant nodes--not how the manufacturer obtains same. The ability of any wireless node to interoperate (i.e. have implied range and directionality) can be fully evaluated only by wireless methods, and the manufacturer has the sole option to apportion this ability over a fairly wide range by adjusting his circuitry/components and antenna system in a complementary fashion. Moreover, removing an "integral" antenna from miniaturized equipment and testing the equipment using a cable more often than not presents great difficulties, because efficient design and manufacture seldom result in standard feed line impedances. These considerations led immediately to an apparent consensus to revise the Draft Standard to specify field strength measurements as opposed to those made with RF cables.

Once the decision has been made that radiative rather than conducted measurements are appropriate, avoiding contamination of the region of space around the Unit under Test assumes great importance. The unit (assumed here to be a PCMCIA card) needs to be tested in its actual operating environment, which makes it very difficult to add test wires for special access to circuit nodes. These considerations led to our discussions of changing Bit-Error Rate specifications to Block-Error Rate. Related to this issue is the importance of being able to perform tests which do not require separation of the MAC/PHY interface within the particular equipment being tested. Once again, the Standard is intended to govern only interoperability of WLAN equipment manufactured in accordance with different designs, not the designs themselves. For instance, we must anticipate the possible use of a common microprocessor which performs certain MAC and PHY functions. Such implementation completely obliterates physical demarcation between MAC and PHY; the demarcation becomes strictly logical.

MASTER TEST SETUP

The salient feature of this Test Setup is that it makes no attempt to address the design of the WLAN Node Under Test ("WLNUT"). The truth of this statement can be inferred from the following figure and the definitions of its blocks.

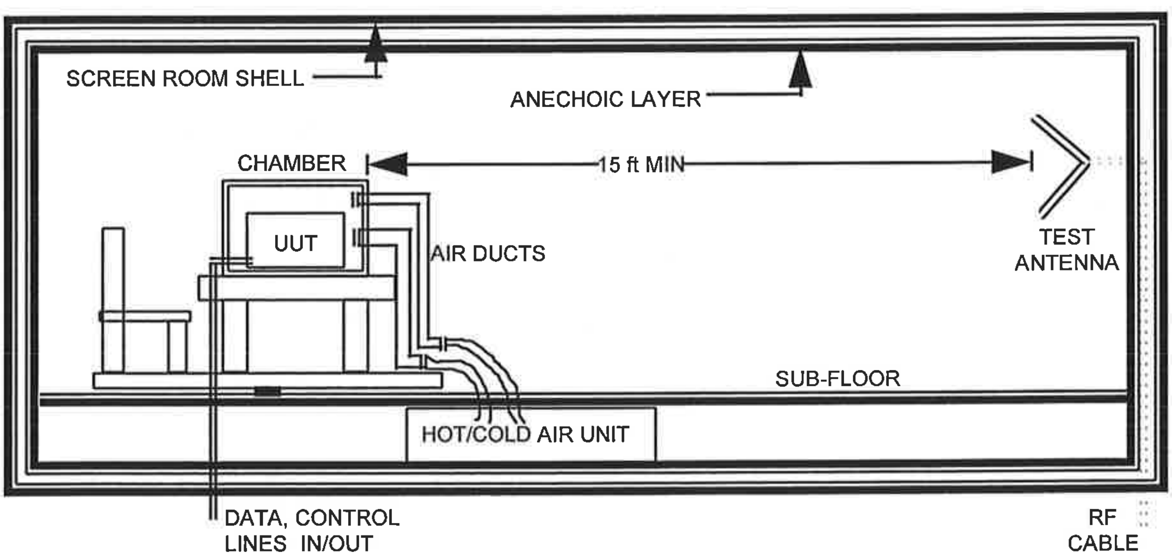


802.11 TEST SUITE--TOP LEVEL DIAGRAM

1. The *Wireless LAN Node Under Test* is the equipment to be tested for compliance, together with its projected immediate environment. For instance, if a PCMCIA Wireless LAN Adapter is being tested, it is installed in a notebook computer which is sitting on a table of normal height (whose composition and dimensions are selected by the proprietor), with a person sitting in the normal position relative to the computer in some chair (specified by the proprietor) normally used in that situation. The orientation of this entire "assembly" relative to the Test Antenna (specified hereunder) is also specified by the proprietor (but all relevant tests will be performed with the assembly in three equally spaced--120 degrees +/-5 degrees specified by the proprietor--azimuthal directions, and the results for the three orientations will be averaged).
2. The *Anechoic Chamber* is any region and configuration which guarantees that almost none (1% or less) of the radiation passing between the WLNUT and the Test antenna is via an indirect path. If the Test Probe Antenna is sufficiently directive, the dissipative property requirements of the walls is reduced.

3. The *Test Probe Antenna* is calibrated for gain in the frequency band being tested. (For transmission, the Effective Radiated Power is known if the input power in the feedline is known; for reception, the field strength of the signal coming from the WLNUT is known if the power in the feedline is known.) It is understood that the primary antenna operates in the 2.4 GHz to 2.5 GHz band.
4. The *Transmit Test Equipment* consists of an array of spectrum analyzers, demodulators, decoders, modulation analyzers, frequency counters, oscilloscopes, and miscellaneous receiving equipment as necessary to represent all relevant parameters of signals coming in from the WLNUT as digital information suitable for the Test Computer *(Testing Coordinator)* and visual information suitable for an observer.
5. The *Receive Test Equipment* consists of an array of signal generators, modulators, and miscellaneous transmitting equipment (such as modulation filters) whose purpose is to represent the digital bit streams from the Testing Coordinator by the RF waveforms specified in the Standard. Some of the signal generators will be used to generate various forms of simultaneous interfering signals. In accordance with instructions from the *Testing Coordinator*, this equipment will vary the modulation and RF parameters (carrier frequency, power level, frequency deviation, baseband group delay, etc.) as necessary to insure that the WLNUT operates properly over the full tolerance ranges specified in the Standard.
6. The *Error Rate Tester* operates in the normal manner. It should be part of a protocol analyzer. It could be combined with the *Testing Coordinator*.
7. The *Testing Coordinator* orchestrates the entire MAC and PHY test sequence and records its results. It not only specifies the PHY parameters for the Transmit and Receive Test Equipment on a per-test basis but varies digital parameters such as bit rate, in order to further check operating tolerances of the WLNUT.

The next figure shows a rough pictorial of the Test Suite, showing how the testing can be performed over a wide temperature range without disturbing the radio wave propagation.



TEST CAGE, PICTORIAL

The temperature/humidity test chamber and the air ducts can be constructed of materials which minimize contamination of the RF fields. Not shown on the Pictorial is that the ducts approach the chamber from the two sides not in line with the radiation "path" to/from the antenna. Also not shown is that whenever the turntable is rotated, the flexible air ducts are moved to mate with rigid ones. (The signal/control cable is also moved.)

SPECULATION ON SPECIFIC PROBLEMS

The conversion of testing from conducted to radiated energy has at least some straightforward aspects. The probable underlying assumption made when originally setting the (1 Mb/sec FH) conducted specifications for a receiver sensitivity of -80 dBm was that a unity gain antenna would provide acceptable communications range (say 200 feet inside a building) for some nominal transmitter power (100 mWatt). Converting the available field power at the antenna of -80 dBm to what the signal generator needs to produce is certainly not difficult:

- -80 dBm (available to receive antenna) + 53.4 dB (15 ft of path loss) - 10 dB (gain of Test Antenna) + 6 dB (loss of cable) = -30.6 dB (delivered by signal generator).

For the high signal level case, (-20 dBm), about 1 Watt is needed; so the Receive Test Equipment needs to switch in an amplifier system for these tests. Testing the transmitter is equally convenient; the Test Receiver needs to handle the range from -20 dBm down to -40 dBm, corresponding to the WLNUT transmitting 1 Watt down to 1 mWatt.

We may not become aware of any special problems of testing in this manner (i.e. without access between the user's computer parallel port and antenna) until each test is fully specified; however, a quick review of all the major PHY tests reveals no obvious difficulties. Some of the tests, such as frequency change settling time, require a little more thought and planning, but they can indeed be done, even if the results need to be inferred indirectly. Checking out all aspects of Clear Channel Assessment--depending upon how that is eventually defined--could prove to be most interesting. (Checking transmitter turnaround time could be tricky for the test system, but those problems can be greatly mitigated by using separate, directional, side-by-side test antennas in the chamber.) It would probably take a week for a team of two engineers (1 each MAC and PHY) to review all the tests and look for problems.

It is possible that certain manipulations of the PHY (such as certain frequency change patterns and bit patterns) will be needed which the MAC never does during normal operation. It is also possible that the MAC will need to display parameters (such as RSSI readings) that it never does during normal operation. If so, the MAC should include special firmware for test procedures. Some manufacturers may include "power-up" automated test procedures anyway.

The author believes that a joint MAC/PHY discussion is needed on the topic of this submission in the very near future.

Notes