IEEE P802.11

Wireless Access Method and Physical Layer Specification

MAC Provisions to Support Conformance Testing

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Abstract

This submission is a preliminary attempt to define a small set of management functions that could be added to the 802.11 MAC to provide adequate access to low–level functions and permit generation of the necessary erroneous cases to serve as the mechanism for conformance testing of 802.11 MAC/PHY pairs. If possible, these mechanisms should also be usable to test MAC implementations, independently from most aspects of their attached PHY.

For: Conformance Test Sub–Group

Overview

Most of the initial work by the conformance test ad–hoc group has been directed toward the provisions needed for PHY conformance testing. PHY test definition, suitable to verify both standard compliance and regulatory compliance, is an important objective for the conformance test group. However, there have been a few statements which suggest that some members of the PHY groups believe that when the PHYs can be shown to conform to their specifications, the resulting MAC/PHY pairs will inherently be workable and interoperable. This is definitely **not** the case. The 802.11 MAC is extremely complex, and has numerous "boundary conditions" at which the station's behavior is not (yet) adequately specified. The probability that two, independent implementations of the 802.11 MAC will be **fully** interoperable, even if they both use the same PHY, is small unless a thorough conformance test suite can be developed. The current focus is on the provisions needed to make such a conformance test suite possible. The actual definition of MAC conformance tests is impractical until these test provisions are defined.

The general scope of MAC conformance testing involves tests that verify two classes of behavior:

1) Ensuring that the functions specified by every "will," "shall," and "is" in the MAC definition do occur in the defined manner when the stated initial conditions are present.

2) Ensuring that the functions specified by every "will not," "shall not," and "is not" in the MAC definition do not occur under the stated inapplicability conditions.

In general, the need for special conformance test provisions are most important to facilitate testing of the negative conditions (item 2). This is because a properly–functioning MAC is incapable of generating the erroneous sequences and mal–formed frames needed to validate the protocol boundary conditions.

The easiest way to test the MAC would be to observe MAC operational behavior between the exposed LLC and MAC management interfaces at the "top" of the MAC and an exposed MAC/PHY interface at the "bottom" of the MAC. Unfortunately, the optional exposed MAC/PHY interface was eliminated from the draft standard in late 1994. In the absence of that exposable interface, this submission proposes a combination of test functions, accessible via the station management interface, and an embedded diagnostic frame generation and echo function within MAC management. The proposed facilities are believed to be adequate to construct a comprehensive conformance test of MAC station functionality, and the portions of access point functionality relating to STA/AP communication via the WM. It is likely that additional test facilities will be needed to perform conformance testing of AP/DS interaction, AP/AP communication via the DSM (including wireless DSM), and BSS–transitions by stations of an ESS.

Many portions of the MAC can be tested by generating appropriate requests at the MAC Data SAP (LLC interface) and monitoring the resultant activity on the WM. However, this type of test generally yields nothing more than a qualitative validation of affirmative behavior. Neither negative behavior, nor quantitative validation of specific timing relationships can be readily determined when both MAC and PHY are operating in tandem. The major variable that needs to be controlled is time — For example, a repeatable test of MAC behavior when a medium busy event starts 1 symbol period before the end of an IFS versus starting after the IFS timer has expired is straightforward to construct when all of the stimulus inputs are generated by the test suite, according to a single timebase, and very difficult to construct if the timing uncertainties of a separate transmission generator, test source PHY, and local PHY at the station under test are concatenated. It is important to **know** that the limiting case on each side of the time boundary has been tested, since the alternative is to run a large number of attempts with "random" timing and to hope that all of the relevant combinations have occurred. Repeatable results under such "random" testing means that either the protocol function works properly, or that the problematic case has not yet occurred, or that the test generator does not happen to generate the problematic case. In general, it is more productive to spend time developing deterministic tests than to spend time evaluating the likelihood that a probabilistic test has indeed exercised all of the necessary cases.

Accessing and Monitoring the Lower MAC

A substitute for the physical test access that would be available at an exposed MAC/PHY interface is logical access to the service primitives that cross the unexposed MAC/PHY interface. This logical access would take place via the MLME_SAP. A set of service primitives that provide the necessary functionality are listed below:

- MLME_OUTPUT_MONITOR.request (oState)
  Controls monitoring of outputs from the MAC to the PHY. oState may have values "ON," "OFF," or "INTERCEPT" to control the output monitoring activity. If oState=OFF, no output monitoring occurs. If oState=ON, the MAC outputs are passed to the PHY and copied to the monitoring function. If oState=INTERCEPT, the MAC outputs are passed only to the monitoring function, allowing execution of test sequences which involve output sequences which should not be transmitted onto the WM. Monitored outputs are reported using the MLME_OUTPUT_MONITOR.indicate function.

- MLME_OUTPUT_MONITOR.indicate (Output)
  Provides the monitored output information to the MLME_SAP when the MLME_OUTPUT_MONITOR oState=ON or oState=INTERCEPT. The value of Output is the PHY service primitive output from the MAC, along with any parameters. Possible values of Output include PHY_DATA.request, PHY_TXSTART.request, PHY_TXEND.request, and PHY_CCARST.request. Each instance of MLME_OUTPUT_MONITOR.indicate shall occur a fixed (implementation specific) time delay after the request being reported was output by the MAC. This time delay shall be specified (per implementation) in units of the MAC timebase (currently 1 microsecond).

- MLME_INPUT_MONITOR.request (iState)
  Controls monitoring of inputs from the PHY to the MAC. iState may have values "ON," "OFF," or "SUBSTITUTE" to control the input monitoring activity. If iState=OFF, no input monitoring occurs. If iState=ON, the MAC inputs are copied to the monitoring function in parallel with being provided to the MAC. These monitored inputs are reported using the MLME_INPUT_MONITOR.indicate function. If iState=SUBSTITUTE, the PHY outputs are blocked, and MAC inputs are provided by the test program using the MLME_INPUT_GENERATE.request function.

- MLME_INPUT_MONITOR.indicate (Input)
  Provides the monitored input information to the MLME_SAP when the MLME_INPUT_MONITOR iState=ON. The value of Input is the PHY service primitive input to the MAC, along with any parameters. Possible values of Input include PHY_DATA.indicate, PHY_DATA.confirm, PHY_CCA.indicate, PHY_RXSTART.indicate, and PHY_RXEND.indicate. Each MLME_INPUT_MONITOR.indicate shall occur a fixed (implementation specific) time delay after the indication or confirmation being reported was input to the MAC. This time delay shall be specified (per implementation) in units of the MAC timebase (currently 1 microsecond).

- MLME_INPUT_GENERATE.request (Input)
  Used by the test program to provide substitute PHY indications and confirmations to the MAC when MLME_INPUT_MONITOR iState=SUBSTITUTE. The value of Input is the substitute PHY service primitive to be supplied as input to the MAC, along with any parameters. Possible values of Input include PHY_DATA.indicate, PHY_DATA.confirm, PHY_CCA.indicate, PHY_RXSTART.indicate, and PHY_RXEND.indicate. Each primitive shall be supplied to the MAC a fixed (implementation specific) time delay after the occurrence of MLME_INPUT_GENERATE.request. This time delay shall be specified (per implementation) in units of the MAC timebase (currently 1 microsecond).

These service primitives permit extensive, quantitative testing of an isolated MAC entity. They are superior to loopback testing with the "loop" at the bottom of the MAC because they exercise the actual MAC operation sequences (the MAC receiver and transmitter are never active simultaneously during normal operation due to the characteristics of the wireless PHYs), and because they permit both passive monitoring and active input substitution. The only major type of test which is possible with an exposed MAC/PHY interface, but is not possible with this test interface, is direct MAC–to–MAC communication via a "null" (wired) link.

Generating Erroneous Frames and Transactions

A major advantage of the test interface defined above is that the MAC negative behaviors and handling of boundary conditions can be tested directly, without requiring a special station entity that can generate overlength frames, truncated frames, and other mal–formed frames. This input substitution approach also avoids potential problems with transmitting the mal–formed frames on the WM, which might cause regulatory violations in certain cases.

If desired, a similar set of test primitives could be defined at the PLME_SAP, providing direct inputs to the top of the PHY, bypassing the MAC, and allowing direct monitoring of outputs from the PHY while receiving test or calibration signals. This facility would allow many types of test transmissions to be generated directly from a PHY entity, reducing, although not eliminating, the need for special–purpose test transmitters for PHY testing.

Diagnostic Frames for Operational Testing

The use of predefined test frames that any station could send in response to appropriate SMT or WM inputs has been suggested for some aspects of PHY testing. This technique could also be useful for MAC testing, and the MAC is a logical place to generate and check these frames. The suggested approach is to define two control sub–types as diagnostic frames. One of these diagnostic frame types (perhaps called Diagnostic Request) would be generated upon request from the management interface. The request would include the destination address to be used in the frame, and the remainder of the frame header and payload would be predefined (either fixed values or the current values of various parameters within the MAC or PHY). If the Diagnostic Request frame was received as a directed frame at a station, that station would respond by sending the second diagnostic frame type (perhaps called Diagnostic Response) as a directed frame to the source of the Diagnostic Request. This response frame would include the same predefined information (calibration patterns, etc.) as the Diagnostic Request, plus appropriate information on the reception of the request frame. The response should be sent with a fixed time offset from the request, although not necessarily an SIFS if the generation of the parameter information cannot be accomplished quickly enough.