IEEE 802.11
Wireless Access Method and Physical Specification

Maximizing Primary Rate Traffic in a Multirate BSS

January 8, 1996

Chris Zegelin
Greg Ennis
Sarosh Vesuna

Symbol Technologies, Inc.
2145 Hamilton Ave
San Jose, CA. 95125
Telephone: (408)369-2600
FAX: (408)446-4630
email: chrisz@psd.symbol.com
gennis@netcom.com
saroshv@psd.symbol.com

Abstract:

This paper proposes a modest modification to the D2.1 specification with the intent of maximizing the transmission of traffic at higher rates within a multirate infrastructure BSS. This is accomplished by allowing management frames and RTS/CTS frames to be transmitted at the higher rate. Lower "fallback" rates can still be used within the BSS as required for enhanced robustness. With D2.1 it is necessary to transmit managment and RTS/CTS frames at the basic rate. The improvement to D2.1 stems from the inclusion of a new AP MIB variable (aPrimary_Rate) which indicates the maximum rate at which frames will be transmitted within this BSS, together with a requirement that only stations capable of operating at that rate be associated with the BSS.

The actual text changes to D2.1 are minimal and are defined here.

1. Overview

The current D2.1 multirate service has the following characteristics:

1. the PLCP header is transmitted at a rate guaranteed to be receivable by all stations (the "basic" rate
2. the MAC frame subsequent to the PLCP header may be transmitted at a higher rate than the basic rate, as indicated by control information within the PLCP header
3. the algorithms by which stations decide upon a transmission rate are viewed as outside the scope of the standard
4. within a BSS, some stations may not be capable of receiving or transmitting at rates besides the basic rate

Number 4 has some mildly unfortunate side effects. First, it requires that all management frames (beacons, association requests, etc.) be transmitted at the basic rate, since there may be some stations within the BSS which can only receive at that rate. Second, it requires that RTS/CTS transmission all occur at the basic rate. In practice this limits the actual higher rate transmissions to the MAC bits within data frames, since preambles, PLCP headers, management and RTS/CTS frames all must go out at the basic rate. D2.1's multirate capability does provide a performance benefit, but it could be improved if more bits could be transmitted at the higher rate.

This paper proposes a modest modification to D2.1 which reduces the negative impact of Number 4, namely by replacing Number 4 with the following "Number 4A":

> 4A: each BSS has a "primary rate" which is the maximum rate at which frames may be transmitted, and stations only associate into a BSS whose primary rate they support.

Since all stations within the BSS are known to support the primary rate, management and RTS/CTS frames can be transmitted at the primary rate. However, each station within the BSS - including the AP - may independently fallback to a lower rate as required for enhanced robustness in the face of signal quality degradation.

The following sections address these issues:

- how would the D2.1 multirate provisions as modified in this proposal actually work in a real environment containing "old" basic-rate-only units and "new" higher-rate-capable units?
- what needs to be specified, if anything, regarding the use of fallback rates?
- how are management frames handled?
- how are RTS/CTS frames handled?
- what changes are necessary to the D2.1 specification?

2. Realistic Evolution of a Site from Single Rate to Multirate

We propose that the following is a realistic picture of the manner in which most sites will evolve from lower rates to higher rates. This is important in understanding why the "restriction" inherent in 4A above is in fact not a significant restriction.

Suppose a site is initially configured with 1 Mb APs. These access points will be positioned in a way that considers the site's application requirements (where is coverage needed?), cost constraints (how many APs can I afford?) **and the physics of the 1 Mb medium**. Now suppose we want to introduce 2 Mb stations. If we simply upgrade the APs to 2 Mb operation, the site will be far from optimal, since the coverage area of a 2Mb AP will likely be 25% of a 1 Mb AP for equivalent error performance. It could require up to three times as many APs at the higher rate for full coverage. Perhaps the customer was farsighted and installed a denser AP environment than was necessary for 1 Mb operation at the outset. In this case some of the APs could be upgraded to 2 Mb operation without adversely affecting the coverage of the other 1 Mb APs. However, in most cases more AP purchases will be necessary to really reap the benefits of 2 Mb operation.

In any event, what will result is an environment with full coverage at the lower rate, together with partial or full coverage at the higher rate. The customer would likely configure things so that high rate coverage is provided in those areas which are likely to have the highest utilization.

The upshot is that in such an environment there is no need for a 1 Mb-only station to associate with any AP which is operating at 2 Mb, since there will be an AP operating at the 1 Mb rate within decent range. Consequently, the requirement that a station only be allowed to associate with an AP if the station supports that AP's primary rate **will not in practice** constrain the roaming ability of the station.

3. The Use of Fallback Rates

It is necessary to allow stations (including APs) to be able to transmit at rates below their primary rate if necessary. This is to achieve a more robust operation in the face of worsening signal quality. However, it is necessary to transmit the PLCP header at the basic rate (as is currently specified in D2) since a multirate-capable station cannot know in advance the rate of an incoming transmission.

Such fallbacks may be triggered by a variety of monitored error conditions or by actions taken by a communicating peer - the specific algorithms here, as in D2.1, are beyond the scope of the standard and are not required for interoperability. For example, a station may fall back to a lower rate if it is requiring too many retransmissions. An AP may decide to start transmitting beacons at a lower rate if it receives traffic from one of its stations at a lower rate.

Note that a station which has fallen back to a lower rate may be likely to find that there is a better lower rate AP in its neighborhood, and consequently may be ready to roam. The support of stations operating at a fallback rate within a higher rate BSS is simply a robustness requirement fully consistent with this proposal.

4. Management Frames

Management frames (for association, beacons, etc.) may be transmitted within a BSS at the primary rate or any rate below that. Note that all stations within the BSS must be capable of receiving at these rates, so there is no requirement to transmit management frames at lower rates unless the AP or a specific station decides to do so for robustness reasons. As was described above, the AP may use whatever algorithm it wants in determining the speed with which management frames are transmitted.

Probes may be thought to be a special case, as they may be generated by stations which are not currently associated. However, probes sent at the basic rate will be received by all APs. Note that this allows the following probing strategy to be taken by stations which are multirate capable: to find all access points within range, including those with different primary rates, simply send all probes at the basic rate. The best AP can then be selected based upon whatever criteria the station desires. Of course this is not the only strategy, and such algorithms need not be part of the standard.

5. RTS/CTS

RTS and CTS can be generated at any rate allowed within the BSS (i.e. primary rate on down). The following cases are properly handled:

- All stations will be capable of receiving and properly interpreting RTS and CTS frames generated by a station within its BSS.
- All higher rate stations will be capable of receiving and properly interpreting RTS and CTS generated by any lower rate station, independent of which BSS they belong to.
- All stations will be able to receive and properly interpret RTS and CTS frames transmitted at the basic rate by a station which is currently associated with an AP which uses a higher primary rate. Note that this last case covers those stations which are relatively far from their higher-rate AP and consequently covers those which are most likely to be interfering with other BSS's.

These three cases will likely cover the majority of exchanges. The only case not covered involves the reception by a low-rate-only station of RTS/CTS exchanges transmitted at a high rate. So be it - RTS/CTS is only used to marginally increase our probability of collision avoidance anyway. If a station finds that it experiences poor performance with higher-rate RTS/CTS exchanges, it can always shift down to a lower rate.

6. Text Changes to D2.1

The text changes to D2.1 are minimal.

Section 4.3.1.9: add a new status code:

Code 20: Association denied because station does not support the primary rate.

Section 8.3.1: At the end of the section add the following sentence:

A station may not associate with an access point unless it can transmit and receive frames at the access point's primary rate.

Section 8.3.3: At the end of the section add the following sentence:

A station may not reassociate with an access point unless it can transmit and receive frames at the access point's primary rate.

Section 8.4: Add a new MIB variable:

aPrimary Rate

Primary_Rate ATTRIBUTE
WITH APPROPRIATE SYNTAX
integer;
BEHAVIOUR
"The primary rate shall indicate the highest data rate, in bits per second, at which any frame may be transmitted by this access point".
REGISTERED AS
{iso(1)member-body(2)us(840)ieee802dot11(10036)SMT(0)attribute(7)primary_rate(XXX)}