IEEE P802.11
Wireless Access Method and Physical Layer Specifications

Title: Multirate provisions in the MAC.

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Abstract:
This submission contains a discussion of the functions that are needed in the MAC to support MultiRate PHYs, the possible solutions, and a proposal for the minimum set of hooks in order to support this option.

Background:
This contribution is based on the doc 94/164 contribution presented in September. The modifications presented herein avoid the aparent conflict with the U.S. patent cited in doc 94/234. The main change is that the "Rate negotiation" mechanism is deleted, while "Supported_Rate announcements are modified.
The 94/164 contribution includes an analyses of the reasons for, and the requirements for multi rate support, and concludes that a mixed bitrate environment should be supported.
In addition, 94/164 provides an analyses of the effects of multiple rate support on the MAC, and in particular investigates the associated NAV update issue's.
At the September meeting doc 94/234 identified a potentially significant intellectual property conflict between the solutions proposed in doc 94/164 and U.S. Patent 5,077,732.
This proposal contains a modified rate control mechanism that avoids use of the mechanisms claimed in that patent.

General:

The multirate provisions of the solutions proposed in doc 94/164 can be subdivided in the following levels:

1- Definition of the Basic_Rate_Set and the rules that assure coexistance and interoperability in a mixed bitrate environment.
2- Provisions to gather / distribute "Rate Capability" information.
3- Rate negotiation per frame procedure.

Level 1 provisions are considered the minimum that is needed to support mixed bitrates within an ESS. The level 2 provisions are very desirable because they provide a uniform interface to gather the necessary information to manage the use of Extended_Rates.

The level 1 provisions are definitional and unrelated to the coverage of the cited patent. The level 2 provisions require some modification compared to doc 94/164. The level 3 provision appears to be sufficiently close to the patented subject matter that the mechanism has been deleted in this proposal.

Level 1 provisions

The level 1 provisions will assure that stations with different rate capabilities can coexist, when they use a common Basic_Rate_Set to interoperate between them. This Basic_Rate_Set should also be used to distribute the information that is of interrest for all stations.

The following are the definitions to support level 1.
Definitions
ESS_BASIC_RATE_SET:
A set of rates that all the stations on the given ESS are required to be capable to **receive**. According to the PHYs definitions the default ESS BASIC_RATE_SETs for the different PHYs will be:
For DS: {1 Mbps, 2 Mbps}
For FH: {1 Mbps}
For IR: {1 Mbps, 2 Mbps}
Note that this value is preset for all stations in the ESS.

STATION_BASIC_RATE:
A value belonging to the ESS_BASIC_RATE_SET, that is used by the station for specific transmissions (This value could change dynamically, for example the Station Basic Rate selected by the IR Phy depends on the allowable power consumption level of the station).

EXTENDED_RATE_SET:

> The set of rates beyond the ESS_BASIC_RATE_SET that a station supports. This can be a speed that is defined in future PHY standards.

PLCP_RATE:

> This is transparent to the MAC, but must be the same for all stations in the ESS. This is the basic assumption that is already followed in the current multi-rate PHY proposals. The use of a common PLCP_Rate allows stations to automatically detect the speed and duration of an incomming frame, and decode/receive it at the intended rate if it is supported by that PHY.

The following is a set of rules that must be followed to assure coexistance and interoperability:

A. The Preamble and the PLCP Headers are transmitted always at the PLCP_RATE. The PLCP Headers contain both the rate used to transmit the MPDU and the PhSDU length information. For all versions of a given PHY independent of what extended rates they may or may not support the PHY specific CCA mechanism must be able to determine the PhPDU duration solely from information in the STA MIB and information in the portion of the PhPDU sent at the PLCP_RATE.

B. The different **IFS**s are independent of the station bitrate, and are common per Phy.

C. All the **Control, Multicast and Broadcast Messages** are sent on the **STATION_BASIC_RATE** (which as specified above belongs to the ESS_BASIC_RATE_SET).

D. All Control type frames, (RTS, CTS, Ack etc.) are transmitted on the STATION_BASIC_RATE. This allows reception of the duration information by all stations.

E. The duration fields in the frames of 20B3 are already specified in time (usec) rather then bittimes. Therefore, remote stations do not need to interpret the bitrate, but just use the value in the "Duration" field to update their NAV. The destination station that is returning the CTS (or Ack), does only need to substract the CTS duration from the "Duration" field.

F. All unicast data frames are sent on any available Tx-rate. The algorithm for selecting this rate is implementation specific. It is something that is determined by the transmitter only, which can use any rate that the PHY of that station is capable of using.
   In general two approaches can be followed:
   - Transmitter gathers information on rate supported by the remote, and uses the supported rate for subsequent (unicast) transfers to that destination.

- Transmitter decides the transmission rate based on the own station characteristics (e.g. Power Consumption Mode).

Again the algorithm for selecting this rate does not need to be standardized. Some trivial algorithms could be:

1. Try high, retransmit on lower (go back to high after T time).
2. Keep dynamic tables for each active destination using a signal quality (or any other parameter) dependent algorithm.
3. Transmit always in BASIC_RATE.

The basic idea is that a MAC transmitter is controlling the rate at which it is desired to transmit, depending on its capabilities, while the selected rate should be supported by the intended receiver, over a link that has sufficient quality to achieve sufficient performance.

Level 2 provisions

The level 2 provisions are intended to provide a consistant management mechanism to gather and distribute "Rate Capability" information. This information can then be used by the transmitter to select the rate to use for unicast communication to remote stations, whether they support the Extended_Rate_Set or not.

To allow dynamic rate switching the transmitter would preferably need to know the following information:

- The supported rate of the local PHY.
- The supported rate of the destination station.
- Link quality conditions of the link to the destination.

Although there are ways to gather part of this information without any remote station involvement, it is considered desirable for the standard to have the hooks specified to allow a management entity to gather that information.

In an infrastructure network "Supported Rate" information can easily be exchanged in the association process between the station and the "Distribution Services" above the MAC.

In ad-Hoc networks such information could be gathered by specifying a probe function that can similarly be invoked by a management application **above the MAC** to gather this sort of information.

This can be accomplished in the standard by specifying a **"Supported_Rate"** MIB variable that specifies the receive rates. To allow exchange of this information a Supported_Rate field needs to be included in:

- The "Association Request"
- The "Association Response"
- A specific "Supported_Rate" element in a Probe Request / Response frame.

The **"Supported_Rate"** field should also be used in a management Probe Request/Response PDU as a method to allow stations to gather the required information

to build their Supported_Rate database. It can be invoked by a Management application outside the MAC, that can so modify the station MIB.

An alternative method for the specific "Supported_Rate" Probe Request / Response frame is to exchange the MIB information using an SNMP application.

Distinctions between this Proposal and the Claims of the '732 Patent.

The facilities proposed herein are specifically defined in a manner that avoids use of techniques described in U.S. Patent 5,077,732 ("the '732 patent"), and discussed in document 94/234. However, the authors of this submission are NOT attorneys and this document is NEITHER a legal opinion on the scope of the '732 patent claims NOR an expression of official position by the employers of any of the authors.

The Level 1 provisions are definitions and rules that specify neither means for dynamic selection of bitrate nor methods of dynamic exchange of bitrate capability information among peer nodes of a LAN. Accordingly, the Level 1 provisions appear to be disjoint from the material covered by the '732 patent unless they are used in ways not suggested in this submission and not recommended for inclusion in the draft standard.

The Level 2 provisions for infrastructure networks accomplish an exchange of capability information, but do so in a distinctive manner from the exchange among "equal peers" as specified in the '732 patent. Specifically, the proposed capability exchange is part of the association process, which takes place between a station and the "Distribution Services" function of the distribution system. The station functionality of the AP is involved in conveying the association request/response management frames, but is not the end-point of the capability exchange. The distribution services MAY be located at the AP, but are NOT a "node" of the network, having neither station functionality nor the ability to be either a source or sink of MDSUs generated by higher-layer (non-management) entities. This is not the approach practiced in the network that was the basis of the '732 patent filing, nor an instance where the communicating entities are "equal peers."

The Level 2 provisions for ad-hoc networks require the use of higher-layer functionality, because in an ad-hoc network the stations are "equal peers" and distribution services are not available. (If distribution services are available the network is an infrastructure network, possibly with a null DSM.) The inclusion of capability information in the MAC MIB, and the provision of query access to this MIB by higher-layer entities is directly equivalent to facilities used in wide-area networks since the 1960s and used with LANs since (at least) the late 1970s, which significantly pre-date the '732 patent.

NAV update issues:

As indicated in doc 94/164, there are no NAV update issue's specifically associated with mixed bitrate operations.

One potential problem was identified for a hidden station using fragmentation. The "Duration" information in the Data frame that specifies the length for the next fragment dialog may not be interpreted by all stations that do not support the extended rate. The normal CCA defer provisions as specified in the standard will prevent collisions with the data fragment, but the Ack may not be seen by all stations around the transmitter, and can be stepped on, depending on the DIFS specification.

However this problem is not unique to mixed bitrate, and does also have a similar or worse effect in an active priority mechanism, and in all operations without RTS/CTS.

The solution for this problem will be a type dependent DIFS specification, and will be subject of a separate proposal.

Requirements for CCA to work at different speeds?

The current DS and FH PHY's do specify a PLCP header that contain "Current_Rate" and "PhSDU_Length" information. This allows them to use different speeds in the Dataphase, while all headers can be received by all receivers independent on their rate capabilities.

Stations that are only capable of receiving the BASIC_RATE_SET need to be able to successfully interprete the "PhSDU Length" information of current and future EXTENDED_RATE frames, to allow proper CCA indication to the MAC. It is therefore important that the "Current_Rate" and "PhSDU_Length" information in the PLCP header are specified in a uniform way that support EXTENDED_RATE interpretation.

Preferably a mechanism should be specified in the PHY that allows calculation of "Time".

The importance of this is the following functionality that should be enforced in the standard:

-   One of the functions of the "Length" field should be that it determines when the CCA is indicating a free medium. So when a station receives a PLCP header of a frame with a future x Mbps, then the length field will determine when the CCA is raised, to indicate that the medium is free again.
-   Future higher speed standard extensions should be such that the CCA of lower speed implementations can still signal a busy indication although they may not able to interpret the modulation used in the dataphase of that frame.
-   The other function is to use it as the end delimiter in the intended receiver, to subsequently signal to the MAC where the frame ends, so where the CRC is located.

One possible example of such a mechanism could be to specify the PhSDU_Length in terms of the number of PLCP header symbols.

With the above PHY functionality, coexistance can be assured in a mixed rate environment, such that the CCA will work independent of the bitrate.
The different Phy standards should be reviewed for this functionality.

Summary:

To support multiple rate within an ESS in a flexible way, a number of definitions and a basic set of rules are specified. In addition a means to gather **"Supported_Rate"** information has been defined.
A **"Supported_Rate"** field should be included in every Associate Request and Associate Response. It can also be used to gather the supported rate information using the Probe Request/Response management frames, which can be invoked by a management application above the MAC.
The above defined rules provide a mechanism to operate the multiple rate PHY's that are currently defined, and provides a migration path to future higher rate technologies, while introducing little overhead in the current MAC and PHY specifications.

Conclusion:
This paper defines the mechanisms that should be incorporated in the MAC standard for multiple bitrate support. The draft standard text proposal is provided in a subsequent document.
The proposed solution avoids use of mechanisms that are described in the cited patent.

References
[1] IEEE DOC P802.11-94/119: Gear Shifting Proposal, P. Brenner,M. Rothenberg - LANNAIR
[2] IEEE DOC P802.11-94/157: Proposed Changes to Draft Standard in order to support MultiRate PHYs, P. Brenner - LANNAIR
[3] IEEE Doc P802.11-94/164 Required MAC functions to support Mulrirate Phy's, Diepstraten, Dobyns, Brenner and Valadas.
[4] IEEE Doc P802.11-94/234 Intellectual Property Issue for Multi-Rate Phy's. Michael Fischer Digital Ocean.
[5] US Patent 5,077,732, LAN with dynamically selectable multiple operational capabilities.