Multi Rate Support in the MAC

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Why Multiple Rates?

- Extensibility
  - Migration Path to future higher rates.
  - We want to re-use the current spectrum for the future rates.

- Speed/Range Tradeoff
  - Providing the best speed on all the area will be difficult or expensive to the customer. The user will prefer that some areas would be served with a different Quality of Service, rather than having "black spots".

- Speed/Power Consumption Tradeoff
  - IR case: higher rates transmission consume more power, hence the AP may transmit in high rates, while the stations may choose lower rates.
Multi-Rate support in the MAC

Possible Configurations

- Fixed Rate for ESS
  - Not recommended because it restricts ESS to use a single PHY. This limits migration to a complete new network and infrastructure.
  - Would still have an ESS overlap problem.
- Fixed Rate for BSS
  - Would require overlapping BSS's on the different speeds.
  - The NAV will not work when BSS's of different rates overlap.
  - Therefore this is not recommended.
- Multi Rate BSS
  - Need a way to resolve the NAV update issue.
  - This is the recommended approach.

MAC Concerns to be analyzed:

- Control Packets (Probes, Beacons, etc) must be heard by all stations
- Multicast/Broadcast must be heard by all stations
- How does a station know which rate to use for transmission?
- How do stations update their NAV for transactions in other speeds?
- What is the effect of fragmentation.
- How are hidden-stations affected?
- How does CCA work for different speeds?
- How are Contention Free Services Affected?
- What hooks are needed?
Basic assumptions / definitions:

- **BSS_BASIC_RATE_SET:**
  - A set of rates that all the stations on the given BSS are capable of receiving.
  - According to the PHYs definitions the default BSS BASIC RATE SETs for the different PHYs will be:
    - For DS: {1,2}
    - For FH: {1}
    - For IR: {1,2}

- **STATION_BASIC_RATE:**
  - A value belonging to the BSS BASIC RATE SET, that is used by the station for its transmissions.

Basic assumptions / definitions (cont):

- **EXTENDED_RATE_SET:**
  - The set of rates beyond the BASIC_RATE_SET that a station supports, this could in the future be \{1,2 and future x Mbit/s\} for any of the existing plus future PHYs.

- **PLCP_RATE:**
  - The rate used for transmitting the PHY preamble, and PLCP header,
  - This is transparent to the MAC, but must be the same for all stations in the BSS.
  - This assumption is already implemented on all the current PHY proposals.
**Assumptions:**

- The Preamble and the PLCP Headers are transmitted always at the PLCP_RATE.
- SIFS, PIFS, DIFS are the same for the whole ESS.
- All the Control, Multicast and Broadcast Messages are sent at one of the STATION_BASIC_RATE set.
- All RTS/CTS are sent at one of the STATION_BASIC_RATE set.
- The RTS/CTS "duration" field is specified in time (usec). This is already in the 802.11 Draft.

**How is the rate selected?**

Multiple approaches possible:

- Transmitter to determine rate (Does not require interaction with the receiver).
  - Tx-only decision based on gathered information.
  - Decide on station characteristics (Power Save mode).
  - Or decide on link condition.
- Negotiate rate using the RTS/CTS exchange.
  - This requires Tx-Rx interaction.

Recommend to allow both mechanisms.
Example:

- Unicast Data Frames are sent on any rate as selected by the transmitter. The algorithm for selecting this rate is implementation specific.
  - Some trivial algorithms could be:
    » Try high, retransmit on lower (go back to high after T time).
    » Keep fixed tables for each peer.
      - Active query using management Supported_Rate Request/Responses
    » Keep dynamic tables for each peer using a signal quality (or any other parameter) dependent algorithm.
    » And, obviously, transmit always in BASIC_RATE.

What is needed:

- To allow rate switching, the transmitter should know:
  - The supported rate of the local PHY.
  - The supported rate of the destination PHY.
  - Link quality, Power Saving, or other relevant condition if dynamic switching is used (implementation specific).
Hooks required:

- Define a "Supported_Rate" Element to be included in:
  - The "Association Request"
  - The "Association Response"
  - The "Beacon" (useful for the Ad Hoc networks)
  - Request / Response Management frame to query the capabilities of a destination.

Hooks required:

- To support rate negotiation, the following elements are defined.
  - "Requested_Rate" in RTS Frame
    » Indicates the rate that the sender wants to transmit the data.
  - "Granted_Rate" in CTS Frame
    » Set to "Requested_Rate" if supported and conditions allow, or BASIC_RATE if not.
How is the NAV updated:

- RTS/CTS messages are send in BASIC_RATE.
  - No NAV update problem.

- Situation for fragmented frames:
  - Ack (with CTS function) is transmitted at the BASIC_RATE.
  - Not all Stations can understand the duration field in the data frame, but Physical CS will assure deferral.

Hidden station effects:

- The CTS function (Distribute duration around the receiver) is working fine.
- The RTS function (Distribute duration around transmitter) has a potential problem.
  - NAV is not or incorrectly updated.
  - Stations will hear this transmission and do properly defer until DIFS after ICCA drop.
- The danger is that the Ack gets jammed by those stations that are out of Rx range.
- This problem is basic to the MAC and unrelated to the rate switching (need DIFS > 2*SIFS + Ack).
  - Has been detected also in the DTBS proposal.
  - Is also present when RTS/CTS is not used.
  - Same effect occurs when RTS or Data frame has CRC errors.
Effect on CCA for different speeds:

- Assumptions about the CCA function:
  - Current PHY’s use “Length” to aid in “End Delimiter detection”.
  - “Length” is encoded at the common PLCP rate.
  - Use “Length” to control CCA indication, independent of the modulation used in the Payload area.

- Suggest to code the “Length” in “Time”(usec) rather than bits/octets.
  - This makes it bitrate independent.
  - Rate Coding for future speeds can freely be defined in future standards.

How is Contention Free affected:

- Contention Free services are not affected:
  - CF-Ack to be transmitted at the BASIC_RATE.
  - The Poll Messages are sent in BASIC_RATE, and NAV operation of hidden stations (or stations not supporting the transmitted rate) is guaranteed by the stations setting their NAVs to the Maximum CF-Burst length.
Summary:

- To support Multiple Rate BSSs in a flexible way, we need to specify:
  - "Supported_Rate" element.
    - In Association, Beacon and Mngt Request/Response PDU's.
  - "Requested_Rate" element / Field (in RTS)
  - "Granted_Rate" element / Field (in CTS)
- And a simple set of rules defined above.

Motion:

Move:
To adopt the recommendations in 94/164 as the basic hooks for the support of Multi rate support in the MAC.