IEEE P802.11
Wireless Access Method and Physical Layer Specifications

Title: **Proposed Change to MAC Draft: AP based CTS**

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Abstract:

This submission proposes a modification to the MAC Proposal, which simplifies the ESS/BSS relaying decision, and the peer-to-Power Saving peer transmissions. It falls into the category of "could something be done better" issues.

Introduction

This submission proposes a minor change to the current MAC Proposal, which solves two problems: The ESS/BSS Relaying Decision Problem, and the peer-to-PS-peer (Power Saving peer) Traffic Problem.
The proposed change is to always let the AP send the CTS by himself, even when the traffic is peer-to-peer. This has a minor effect on the Stations' State Machines, while improving the whole Network Reliability (hence performance).
The proposal only applies to infrastructure-based networks, stations working on ad-hoc mode (as learned from the association process) work according to the original protocol.

The Problems

1. ESS/BSS Relaying Decision Problem

The current MAC Proposal does not describe who decides on ESS and/or BSS relaying of packets, and how the decision is being made. This occurs in the following scenario:

> The Data Source Node (DSN) A wants to transmit data to the Data Destination Node (DDN) B. Station B can not correctly receive RTS transmissions from A, because B is in the same BSS but out of reach of A, or because B is simply in another BSS through the DS.

2. Peer-to-PS Peer Traffic Problem

The MAC Proposal does not detail how to handle traffic of stations, to other Power Saving (PS) stations:

> DSN A wants to transmit data to a power saving station B (of the same BSS), that is within direct radio range from A. B is not in the Temporary Active Mode, hence it can not hear A.

Possible solutions

1. Unconditional AP relaying

One possible approach for resolving the described scenarios, is that stations will always send their traffic via the AP. The AP will perform it's forwarding role, either via the DS or directly within the same BSS. Data to PS stations, will be retransmitted during the DIT/DTIM intervals of the destination, that are always known to the AP.

This solution can be easily implemented, but will result on significant performance degradation for peer-to-peer traffic.

2. Station determined routing

Another solution is for stations to maintain topological knowledge of all "neighboring" stations within direct radio range. Thus, a station can conduct direct peer-to-peer transfers with it's neighbors, rather then going via the AP. Traffic to stations that are out of reach, or unknown, will be via the AP. Also, stations that can obtain only limited topological knowledge (e.g. power saving stations), will route all their traffic to the AP.

The authors believe that topology analysis and maintenance within stations is both impractical, since we are dealing with mobile elements, and not economical because it significantly complicates the station implementation.

Note also that this approach can not resolve the peer-to-PS peer problem, since only the AP has an updated knowledge of the stations power management status.

3. AP CTS after time-out

This approach allows peer-to-peer transactions when possible, and leaves all relaying decisions to the AP. Thus, all transmitted frames (including data) will be addressed to the ultimate destination. The AP will monitor any legal transmission, and respond as follows:

- **Un-answered RTS**

  If within the predefined CTS wait timer no CTS follows a legal RTS, and the destination is either associated with the BSS, or is a legal address over the DS, then the AP will produce the CTS.

- **Un-acknowledged data**

  If a legal data packed is not being acknowledged within the predefined Ack-waiting timer, and the destination is associated with the BSS, or is a legal address over the DS, then the AP will ACK the data. The AP will relay the data via the DS or within the same BSS. Data to PS stations, will be retransmitted during the appropriate DIT/DTIM intervals.

This approach provides a reasonable solution to the above problems. However, it requires longer values for the station CTS-wait and ACK-wait timers, and adds complexity to the AP implementation. Note also that the delayed CTS of the AP results with throughput degradation for outbound traffic to the DS, and for BSS traffic with out-of-reach stations.

4. Unconditional CTS from AP

This approach is merely an optimization of the AP time-out CTS solution: Based on the assumption that on the infrastructure-mode all stations hear the AP (otherwise they do not keep their association active), we can simply let the AP respond with CTSs to all legal RTSs.

A transition from station A to station B will be as follows:

- A sends RTS to B.
- The AP ***immediately*** responds with a CTS (B does not respond to the RTS!)
- A receives the CTS, and transmits the data.
- One of the following occurs:
  - If B received the data, it responds with an ACK.
  - If within the predefined ACK wait timer B does not send an ACK, the AP will ACK, and relay/buffer and relay (for PS destinations) the data as required.

This approach, that provides optimal throughput, efficiently solves the described problems. The station sends the RTS, receives a CTS and sends the data without even knowing who will be the immediate receiver. The AP (after responding with the CTS), has plenty of time to check the destination and determine how to handle the packet.

This approach requires only minor changes to the protocol:

- **On the AP**, respond to RTS in a promiscuous way,
- **On the station** running in infrastructure-mode (this is known from the association process), respond only to RTSs coming from the AP.
  Note that the terms for NAV updating remain unchanged.

5. The AP Proxy CTS

This approach is a reasonable combination of the two previously described solutions, that allows more flexibility in the implementation: It allows a station (e.g. PS or mobile server) to authorize the AP upon association, to unconditionally send CTSs in it's place. The default mode of operation for other stations will be timed-out CTS from the AP.

The apparent disadvantage of that solution is that it burdens the AP with a "real time" analysis of the receiver's CTS-authorization mode, upon every RTS request.

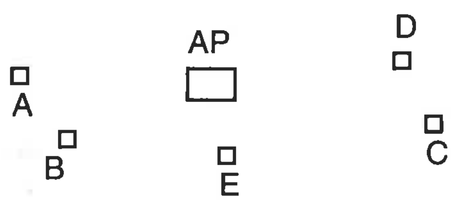
Another Advantage of the "Unconditional CTS"

The proposed change has an additional advantage on providing a Unique NAV Domain for the whole BSS. Since all stations hear the AP (at least most of the time), all the NAV vectors are synchronized with the AP's NAV, this feature solves the following two problems:

Unfairness Problem

The Unfairness Problem appears in the following scenario:

> On the same BSS there are two stations (A and B) on one side of the BSS, and two other stations (C and D) on the other side. Stations A and B cannot hear C and D (and viceversa), but stations in the center of the BSS (the AP and station E) do hear all the stations.



> When stations A and B are in a data transaction, the NAV Vectors of the AP and station E prevent them from start a new data transmission, but since C and D are unaware of A and B transmission, they may start a new transaction.
> This behavior that may be understood as a feature (duplicates traffic bandwidth), may eventually (in the case there is moderate traffic between stations A and B, and stations C and D) prevent other stations from accessing the medium. The authors believe that this situation will also reduce significantly the whole network performance by increasing the retransmission and collisions rate.

Silenced CTS

Another problem that is solved by the "Unconditional CTS" is the silenced CTS first described by Carlos Puig on document IEEE P802.11-94/20.
In this case, the different NAV domains cause a station to retransmit RTS to a station that is not able to respond with CTS because of the NAV vector.
It should be noted, anyhow, that this problem could be solved using another techniques.

Conclusion

The paper presents two unclear issues in the current MAC proposal: the ESS/BSS Relaying Decision Problem, and the peer-to-PS peer Traffic Problem. Of all the various solutions examined, the authors strongly recommend the highly efficient and simple approach by which the CTS is unconditionally sent by the AP, following every legal RTS request.

Acknowledgments

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References

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