Frame Format adjustment Proposal

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PROBLEMS IDENTIFIED IN 236.

- The connectivity functionality is decreased compared to the B2 draft.
- Does not allow AP-to-AP transfers.
- Intra Station to/from Ad-Hoc station not possible.
- There is a problem with Sta-to-Sta Acknowledgement.
- More complex Filtering requirements in 236
- Different address field filters for station and AP.
- Different fields involved as source for returning the CTS or Ack response.
- Frame overhead is significantly increased.

CONNECTIVITY MODEL:

Basic adjustment Proposal:

- Change FC field definitions.
- Change MID in 48 bit Address.
- Change MPDUID into SM, SI.
- Use plain text ESSID.
- All frames have CRC32.

Suggested approach:

- Adopt 236 FC changes.
- Adopt 236 NID changes.
- Change MID.
- Adopt 236 ESSID change.
- Adopt 236 CRC32 change.

Revised Connectivity functionality.
- Case 4 and 5 are supported.
- Case 4 and 7 are having a problem.
- More Frames overhead.

A number of functional problems.

Conclusion: Change the 2082 MPDUID mechanism.

WHAT WAS THE FUNCTION OF THE MPDUID:

- Matches RTS, CTS, Data, Ack together for a given MSDU.
  - Mechanism: Use Hash to create a unique value per source.
  - Used to detect and eliminate duplicates.
  - Mechanism: Include a Sequence number in the Hash.

To resolve the problem:

- The functions are OK, but the proposed mechanisms were a problem, so:
  - Change the mechanism to serve both purposes.
  - Use a sequence number per MSDU with a minimum sequence length and unique sequence.

MID DEFINITION:

- DTH is a sequence number (generated per MSDU).
  - Need low probability of two stations using the same sequence.
  - Long Sequence length desirable for duplicate detection and it determines the uniqueness probability.
  - Sequence can be generated using a counter with a unique (odd) increment value per station.
- Probability that a "DTH match" will cause a problem with data communication is negligible.
  - Only relevant during Data collisions.
  - and only when colliding Data PDU's have approx. equal length.
  - Further reduction when Data/Ack uses a different DTH than for the RTS/CTS.
- Suggest that RTS/CTS have different DTH than Data/Ack.
- Includes 4-bit Fragment number.
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Field Definitions:

- **FC**: Function and Control Field (2 Bytes)
  - Identifies PDU Type and contains necessary control bits.
  - Same as the 802.3 or 802.4/248 proposal.

- **MID**: MSDU-Identification Field (2 Bytes).
  - Contains a 12-bit "Dialog Token" (DT).
  - This is a sequence number used to identify PDU's that belong together, like RTS/CTS and Data/Ack.
  - It is also used for duplicate detection (if Retry bit in FC).

- **Dur**: Duration Field (2 Bytes).
  - This field contains the time in usec from the end of the current frame until the end of the Ack for the next Data/Ack exchange.

Field Definitions (cont'd):

- **RA**: Recipient Address (6 Bytes).
  - Identifies the IEEE address of the direct Wireless recipient.
  - This is the AP address when the PDU is destined to the AP, or needs to go via the AP to a final destination.
  - The MAC address of the station that is to receive the PDU.

- **DA**: Destination Address (6 Bytes).
  - The final destination address when the PDU is sent via the AP, or to the AP.

- **BID**: BSSID (6 Bytes).
  - Uniquely identifies the BSS.
  - By using the 48-bit IEEE address of the AP, or the Ad-Hoc station that initiated the creation of the BSS.

- **SA**: Source Address (6 Bytes).
  - This is the original source address of the MSDU or Mgmt frame.

Resulting Frame Header Formats:

- **RTS**: FC, MID, Dur, RA = 12
- **CTS**: FC, MID, Dur = 6
- **Data**: FC, MID, Dur, RA, BID/DA, SA = 24
- **Ack**: FC, MID, Dur = 6
- **Mgmt**: FC, MID, Dur, RA, BID/DA, SA = 24
- **Poll**: FC, MID, Dur, RA, SID = 14

Savings compared to Doc 94/236 and 20B3:

- MID functionality restored.
  - Does restore the AP-to-AP functionality and other as was available in 20B2, but was inadvertently lost in 20B3.
  - MID contains a 12 bit random number rather than a Hash.
  - Eliminates need for 6 Byte address fields in RTS,CTS and Ack.

- Sequence and Fragment fields eliminated and moved.
  - This is the final Destination Address when the PDU is sent via the AP, or to the AP.
  - MID allows Duplicate detection, and contains the FII.

- Address Filtering and Duration fields always on fixed field position in Header.

- Reduced / Simplified address comparison requirements and processing
  - BSSID filtering only needed on BClMC frames.

- Header lengths have been considerably decreased.

Different address field filters:

- **Improved Frame ordering**: Simplifies address field filtering.
  - Variability of Address fields is resolved in the transmitter.
  - Receive rules are static and requires no real-time processing.

- The 248 proposal requires additional receiver complexity:
  - Real time filter complexity in the receiver.
  - Different rules for AP and a Station.
  - RTS and Data have different filtering rules.
  - The field used as return address in the Ack is different:
    - For an AP it is the SA or TA field.
    - For an Infrastructure Station it is the BSSID.
    - For an Ad-Hoc station it is the SA field.

AP Filtering (248):

- All RTS: RT$: FC $A DUR
  - CTS: FC $A
- Sta to AP: Data: FC $A S# F# DUR
  - Ack: FC $A
- AP to AP: Data: FC $A DUR $F# $S# SA
  - Ack: FC $A

AP's filter always on first address field.
- The Sta to AP works because BSSID=Maddr(AP)
# Frame Format Adjustment Proposal

**Nov 94**  

**IEEE P802.11-94/254b**

### Frame Format Adjustment Proposal

#### Station Filtering (248):

- **All RTS:**
  - RTS: FC DA RA S# F# DUR
  - CTS: FC DA

- **DS to Sta:**
  - Data: FC BSSID DA RA S# F# DUR
  - Ack: FC DA

- **AP to Sta:**
  - Data: FC BSSID DA RA S# F# DUR
  - Ack: FC DA

- **Sta to Sta:**
  - Data: FC BSSID DA RA S# F# DUR
  - Ack: FC DA

#### Address Filtering:

- Address filtering is field copy.

- Stations filter depending on type.

- The field used for Ack address depends on From bit.

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#### 94/254 Filtering:

- **All RTS:**
  - RTS: FC MID DUR RA
  - CTS: FC MID DUR

- **Sta to Sta:**
  - Data: FC MID DUR RA BID SA
  - Ack: FC MID DUR

- **AP to Sta:**
  - Data: FC MID DUR RA BID SA
  - Ack: FC MID DUR

- **AP to AP:**
  - Data: FC MID DUR RA SA
  - Ack: FC MID DUR

#### Address Filtering:

- Address filtering is field copy.

- Very consistent filtering independent of AP/Sta or type.

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### Conclusion:

- The 20B2 version MPDU functions are restored and repaired and combined with fragment numbering in the MID concept.
  - All connectivity functionality is restored.
  - Duplicate filtering function improved compared to 236.
  - No need for separate Fragment number field.
- All other 236 changes are adopted.
- Frame format field sequence is adapted for consistent filtering implementations.
  - No unique formats needed to support all connectivity cases.

### Where are we?

- Connectivity problems in 236 are recognized and considered valid.
  - WDS support
  - All Station to Station cases.
- There are two proposals that try to correct the 236/20B3 flaws.
  - Mechanisms proposed are different.
    - Differences in WDS support mechanism.
      - A separate Frame format with 6 more Bytes is suggested in 248.
      - Differences in implementation complexity.
      - Especially filtering differences.
      - Differences in frame overhead.

### How does this compare with 248:

- Both proposals offer the same functionality.
- The main difference is:
  - Guaranteed uniqueness versus acceptable failure mode.
  - High overhead versus Low overhead.
  - Differences in real time filtering complexity.
- The 248 proposal can be improved to reduce the field order to ease filtering.
  - This does not solve the separate WDS frame format, unless an extra address field is added to every frame for uniformity.

### Miscorrelation probability is very low:

- It compares to the Lost frame probability of an Ethernet network.
  - 802.3 with 10e-9 BER will have 5e-6 packet failure rate when using 600 Byte frames.
  - Higher layers are designed to cope with that.
- Doc 270 does not take all factors into account.
  - The collision probability is not considered.
  - Miscorrelation only is an issue when there is a medium access collision with an approximate equal length frame.
  - Doc 270 assumes a high danger of repeated matching errors.
  - We did take bimodal frame length distribution into account.

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Frame Format adjustment proposal

Benefit Summary

<table>
<thead>
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<th>Requirement</th>
<th>AUTIDO Frame Format adjustment proposal</th>
<th>IEEE P802.11-94/254b</th>
</tr>
</thead>
<tbody>
<tr>
<td>254</td>
<td>Supports WDS</td>
<td>Supports WDS</td>
</tr>
<tr>
<td></td>
<td>Uniform header lengths</td>
<td>WDS headers have</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6 octets inserted and</td>
</tr>
<tr>
<td></td>
<td></td>
<td>removed enroute</td>
</tr>
<tr>
<td>248</td>
<td>Supports WDS</td>
<td>Same filtering as 20b3</td>
</tr>
<tr>
<td></td>
<td>Lower overhead than 20b3</td>
<td>Same overhead as 20b3</td>
</tr>
<tr>
<td></td>
<td>with RTS: 48 octets vs. 60</td>
<td>except +6 octets for WDS</td>
</tr>
<tr>
<td></td>
<td>no RTS: 30 octets vs. 34</td>
<td>No risk of miscorrelation</td>
</tr>
<tr>
<td>Risk of miscorrelation</td>
<td>1 frame in 3e5 (under rather pessimistic assumptions)</td>
<td></td>
</tr>
</tbody>
</table>

Miscorrelation: A NON-Problem

- MAC-layer acknowledgement is for use within the MAC, not for use by higher layers:
  - 802.3 has no MAC-layer acknowledgement.
  - The 802.5 "frame copied" bit is not used by higher layers.
  - Experience with ARCNET has indicates strongly to not rely upon indication of MAC acknowledgement to mean that the recipient NOS (vs. recipient NIC) received the frame.
- LAN protocol stacks use acknowledgement at the Network and/or Transport layers:
  - A miscorrelation is indistinguishable, by LLC and higher layers, from an 802.3 frame that has no collision detected, but does not reach the intended recipient.
  - All common LAN protocol stacks work over 802.3, where higher-layer acknowledgement is the only confirmation of delivery.

Miscorrelation: A Rare Occurrence

- The sequence of events for a miscorrelation is:
  - Simultaneous TX start [NOTE 1] 0.05
  - Same frame type 1.00
  - Approx. equal frame length [NOTE 2] 0.50
  - Same fragment number [NOTE 3] 1.00
  - Exactly 1 frame received correctly 0.50
  - Same Dialog Token value 2.44e-4
  - OVERALL PROBABILITY: 3.03e-6

- NOTE 1: Pessimistic, assuming a CWithin=32 slot then p=0.031.
- NOTE 2: This requires >70% of frames to be equal length.
- NOTE 3: Assumes BSS that does not require fragmentation.
- This probability decreases as (equal frame length) increases.

Miscorrelation: The Bottom Line

- The frequency of miscorrelation is no worse, and typically much better, than frame loss on a wired LAN:
  - A wired LAN with 1e-9 BER will fail to deliver 600-octet frames due to bit errors with p=9e-6; and 1100-octet frames due to bit errors with p=9e-6.
  - This 254 proposal will fail to deliver frames due to miscorrelation with p=3e-6.
  - If a protocol stack works over 802.3, it will work just as well over 802.11 using this 254 proposal, and better (due to shorter headers and simpler filtering) than 802.11 using 248.

Miscorrelation in extreme overload:

- Assume extreme peak load.
  - Many stations contending with same frame length.
  - Collision probability is momentarily higher.
  - Yes this will cause higher lost frames @ LLC boundary but it is still only 1.22e-4 max. per station.
  - However this does not cost bandwidth.
  - The number of frames retransmitted DOES NOT INCREASE.
  - It takes only longer to discover "Lost Frame", before retransmission can start by the higher layer (Time-out).
  - This creates a “Soft overload” because the load will smear out over a longer period.
  - Lost frames will also start to occur due to a “Retry-limit overrun”.
  - This does not have effect on stability.

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Conclusion:

• The mis-correlation failure mode does not affect stability even in the extreme case.
• The number of frames retransmitted does not increase.
• In those cases it is possible that the "Max-retry limit" failure will be higher than the mis-correlation error.
• It does compare very well with a wired "lost frame" failures.
• We should adopt the most efficient implementation.
  - and reduce complexity at the same time.

Motion:

• Move:
  To adopt the Frame Formats and associated mechanisms as defined in 94/254.

MID Match failure modes backgrounds:

• These slides show more extensively the failure mode analyses.
• This assumes:
  - Unique sequences due to station dependent seeds.
  - RTS and Data will have different MID's.

MID match effects:

• Collisions on approx. Equal Length frames can have a MID matching problem.

Understanding the failure mode:

• MID collisions are only relevant during an actual collision on the medium.
• The MID value of the CTS and Ack frames are only relevant for those stations that are waiting for a CTS or Ack during a small window following an RTS or Data fragment respectively.
• So only when two (or more) sources generate a CTS or Ack in response to an RTS in the same window are relevant.
  - This is only when an RTS collides with an other RTS,
  - or when a Data frame collides with an other Data frame with approximately the same length.
  - Only this results in an Ack within the Ack Time-out window.
  - If so then both transmitters conclude that the transmission was a success, while likely only one succeeded.
• Note that the Data is going to the correct destination.
• Collisions of RTS and Data are not relevant for the MID match failure mode.
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What is the probability:

- The DT# in the MID uses a PRN generator with sequence length of 4K.
- So the MID match probability is:
  - "Collision Probability / 4K".
- This does not take into account the frame length distribution, which will be application dependent.
- Lets assume a File transfer environment:
  - Many small length frames with a number of lengths <64 Bytes.
  - These are higher layer dependent.
  - Most frames >64 Bytes will be of the maximum size.
  - There will be occasional frames with lengths in between.
  - Assume that in a busy network the Long/Short frame ratio is 70%.
  - So the probability that two equal length frames collide is less than .5

Is this acceptable:

- Please note that this is NOT the same as the "undetected error rate", because that concerns with the probability that a received frame is not flagged to be in error, while it is.
- The resulting error rate of less than approx. 3 out of 10^6 frames is lost at the MAC level is considered very acceptable, in a "Best effort" service scenario.

Conclusion:
- The MID non-uniqueness is no issue, and does not reduce the functionality.
- No special provisions are needed to resolve its effects.

The failure mode is then:

- If RTS collision: Two stations will generate the subsequent Data frame which will collide.
  - Detection of this collision is very likely when the subsequent Data/Ack does use a different MID then the RTS/CTS.
- If Data Collision: Two transmitters that generated the data frames, will both assume that the transmission was successful.
  - Although that is possible, it is more likely that only one actually came through. So assume probability is 50%.
  - A lost frame goes undetected in this case.
  - In case that none get through there is no matching issue.
- The probability of this occurring depend on the network load, and is approximately:
  - "Collision Probability / 4K / 2 (equal length) / 2 (only one is successful)"
  - Assuming a collision probability of 5% is approx. <3*10^-6
  - This means that the higher layers need to recover from this.