Frame Format adjustment Proposal

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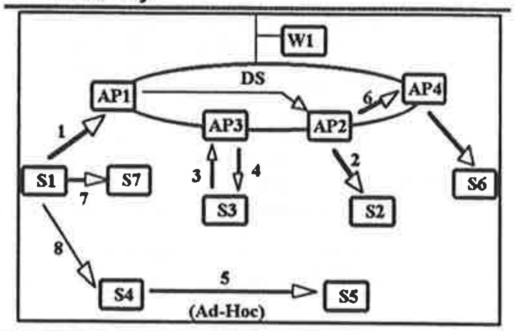
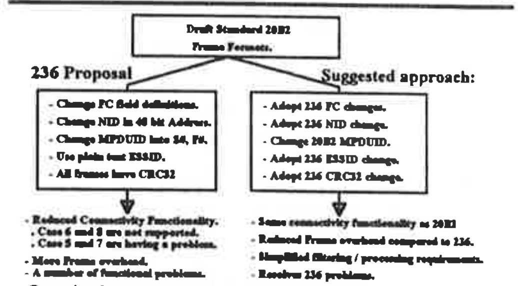
Problems identified in 236.

- The connectivity functionality is decreased compared to the B2 draft.
  - Does not allow AP-to-AP transfers.
  - Infra 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 responses.
- Frame overhead is significantly increased.

Connectivity model:



Basic adjustment Proposal:



- Conclusion: Change the 20B2 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:

	12 bits	4 bits
MID Field:	Dialog Token	Fragment#

- DT# 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 "DT# match" will cause a problem with data communication is negligable.
  - Only relevant during Data collisions.
  - and only when colliding Data PDU's have approx. equal length.
  - Further reduction when Data/Ack uses a different DT# than for the RTS/CTS.
- Suggest that RTS/CTS have different DT# than Data/Ack.
- Includes 4-bit Fragment number.

Field Definitions:

- FC: Function and Control Field (2 Bytes)
  - Identifies PDU Type and contain necessary control bits.
  - Same as the B3 or doc 94/248 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).
  - Contains a 4-bit Fragment number (F#)
- 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.
    - This is the Final Destination Address when the ToAp=0.
    - This is the field used by all MAC's for address filtering.
- DA: Destination Address (6 Bytes)(when ToAP=1).
  - This is the final Destination Address when the PDU is sent via the AP, or to the AP.
- BID: BSSID (6 Bytes) (when ToAP=0).
  - Uniqually 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 Mngt 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
Mngt:	FC, MID, Dur, RA, BID/DA, SA	= 24
Poll:	FC, MID, Dur, RA, SID	= 14

Savings compared to Doc 94/236 and 20B3:

RTS + CTS + Data + Ack = 48 Bytes (was 60 -20 %)

Data + Ack = 30 Bytes (was 34 -11.8 %)

- All Header are sizes, mod 2 Bytes.
- Data and Management Header size are, mod 4 Byte.

Resulting changes compared to 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 then a Hash.
  - Elminates need for 6 Byte address fields in RTS,CTS and Ack.
- Sequence# and Fragment# fields eliminated / moved.
  - MID allows Duplicate detection, and contains the F#.
- Address Filtering and Duration fields always on fixed field position in Header.
- Reduced / Simplified address comparison requirements and processing
  - BSSID filtering only needed on BC/MC frames.
- Header lengths have been considerably decreased.

Different address field filters:

- Improved Frame ordering of 94/254 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:	RTS:	FC $\boxed{\text{DA}}$ SA DUR
	CTS:	FC $\boxed{\text{DA}}$
Sta to DS: (or to AP)	Data:	FC $\boxed{\text{BSSID}}$ DA SA S# F# DUR
	Ack:	FC $\boxed{\text{DA}}$
AP to AP:	Data:	FC $\boxed{\text{RA}}$ DA TA S# F# DUR SA
	Ack:	FC $\boxed{\text{DA}}$

$\boxed{}$ = Address Filtering ◯ = Field copy

AP's filter always on first address field.

- The Sta to AP works because BSSID=Maddr(AP)

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Station Filtering (248):

Slide 13

All RTS:	RTS:	FC	DA	SA	DUR				
	CTS:	FC	DA						
DS to Sta:	Data:	FC	BSSID	DA	SA	S#	F#	DUR	
	Ack:	FC	DA						
AP to Sta:	Data:	FC	BSSID	DA	SA	S#	F#	DUR	
	Ack:	FC	DA		*AP address				
Sta to Sta:	Data:	FC	BSSID	DA	SA	S#	F#	DUR	
	Ack:	FC	DA						

= Address Filtering =Field copy

Stations filter depending on type.
The field used for Ack address depends on From bit.

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94/254 Filtering:

Slide 14

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			
Sta to AP:	Data:	FC	MID	DUR	RA	DA	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	DA	SA
	Ack:	FC	MID	DUR			

= Address Filtering =Field copy = Matching

Very consistent filtering independent of AP/Sta or type.

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Conclusion:

Slide 15

- The 20B2 version MPDUID functions are restored and repaired and combined with fragment numbering in the MID consept.
  - 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.

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Where are we?

Slide 16

- Connectivity problems in 236 are recognised 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 248a.
  - Difference in implementation complexity.
    - » especially filtering differences.
  - Difference in Frame overhead.

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How does this compare with 248:

Slide 17

- Both proposals offer the same functionality.
- The main difference is:
  - Garanteed 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 <u>every frame</u> for uniformity.

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Miscorrelation probability is very low:

Slide 18

- 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 an 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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Benefit Summary

Slide 19

254	248
Supports WDS	Supports WDS
Uniform header lengths	WDS headers have 6 octets inserted and removed enroute
Simpler filtering than 20b3	Same filtering as 20b3
Lower overhead than 20b3 with RTS: 48 octets vs. 60; no RTS: 30 octets vs. 34	Same overhead as 20b3 except +6 octets for WDS
Risk of miscorrelation 1 frame in 3e5 (under rather pessimistic assumptions)	No risk of miscorrelation

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Miscorrelation: A NON–Problem

Slide 20

- 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.

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Miscorrelation: A Rare Occurrence

Slide 21

- The sequence of events for a miscorrelation is:

Event	(pessimistic) Probability
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:	3.05e-6

- NOTE 1: Pessimistic, assuming a CWmin=32 slots 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 p(equal frame length) increases.

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Miscorrelation: The Bottom Line

Slide 22

- 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= 5e-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.

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Extreme case analyses:

Slide 23

- The sequence of events for a miscorrelation is:

Event	(Very pessimistic) Probability
High Simultaneous TX start [NOTE 1]	0.25
Same frame type	1.00
Approx. equal frame length	1.00
Same fragment number [NOTE 3]	1.00
Min 1 frame received correctly	0.50
Same Dialog Token value[Note 4]	.97e-3
OVERALL PROBABILITY:	1.22e-4

- NOTE 1: This is an extreme load case using exponential backoff.
- NOTE 3: Assumes BSS that does not require fragmentation.
- NOTE 4: Assume that 4 responses are generated (hardly possible).

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Miscorrelation in extreme overload:

Slide 24

- 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-4max. 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.

Conclusion:

Slide 25

- The miscorrelation 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 then the miscorrelation 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:

Slide 26

- Move:

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

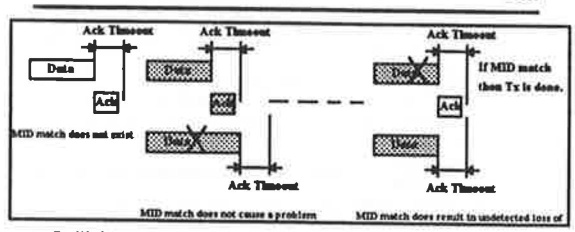
MID Match failure modes backgrounds:

Slide 27

- 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:

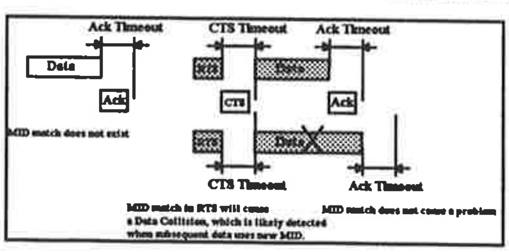
Slide 28



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

MID match effects in RTS/CTS:

Slide 29



Understanding the failure mode.

Slide 30

- 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:

Slide 31

- The DT# in the MID uses is 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 then .5

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The failure mode is then:

Slide 32

- 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 succesfull.
  - 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 occuring depend on the network load, and is approaximately:
  - "Collision Probability / 4K / 2 (equal length)/ 2 (only one is succesfull)".
    - » Assuming a collision probability of 5% is approx. <3*10-6
    - » This means that the higher layers need to recover from this.

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Is this acceptable:

Slide 33

- 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 then 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.