

High-Priority Timeout for P-EDCA Operation

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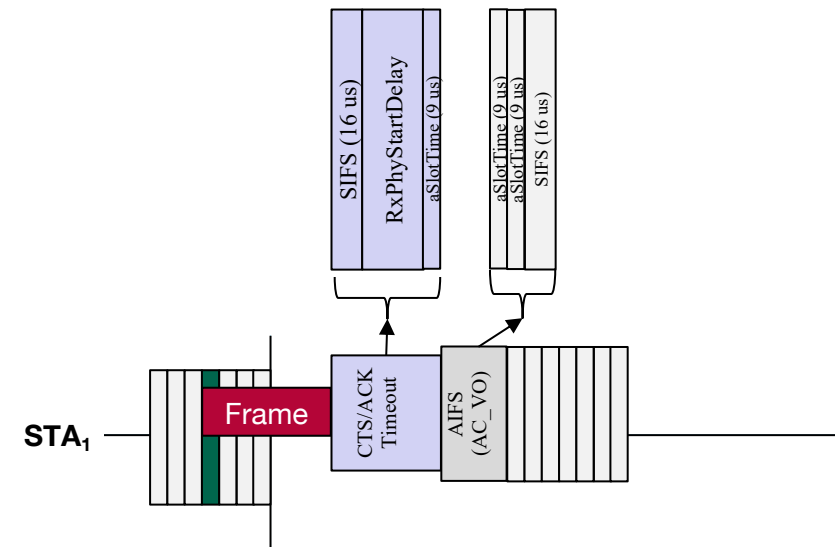
Introduction

- EDCA is the primary access method for STAs to reserve a TXOP, especially to send aperiodic, event-driven traffic
- EDCA struggles when multiple STAs with Low-Latency (LL) traffic (AC_VO) compete, or when LL STAs contend with AC_BE STAs
- Lowering the tail-time latency of STAs competing for channel access through EDCA has been addressed in several contributions [11-24/1918][11-24/1144][11-24/0864]
- The High-Priority (HiP) EDCA mechanism [11-24/1918][11-24/1144] allows STAs with LL traffic to send Defer Signal (DS) frame after a certain number of retries, and then use RTS/CTS to reserve a TXOP
 - **Shortcoming:** Using the CTS/ACK Timeout duration after sending response-soliciting frames leads to wasted channel time before successful channel reservation
- **In this contribution, we propose a method to reduce the overhead of the P-EDCA procedure by minimizing the time required to detect transmission failure after sending a response-soliciting frame**
- **A STA is allowed to use a High-Priority Timeout (HPTO) duration instead of CTS/ACK Timeout to retry channel access during P-EDCA**

ACK Timeout in 802.11

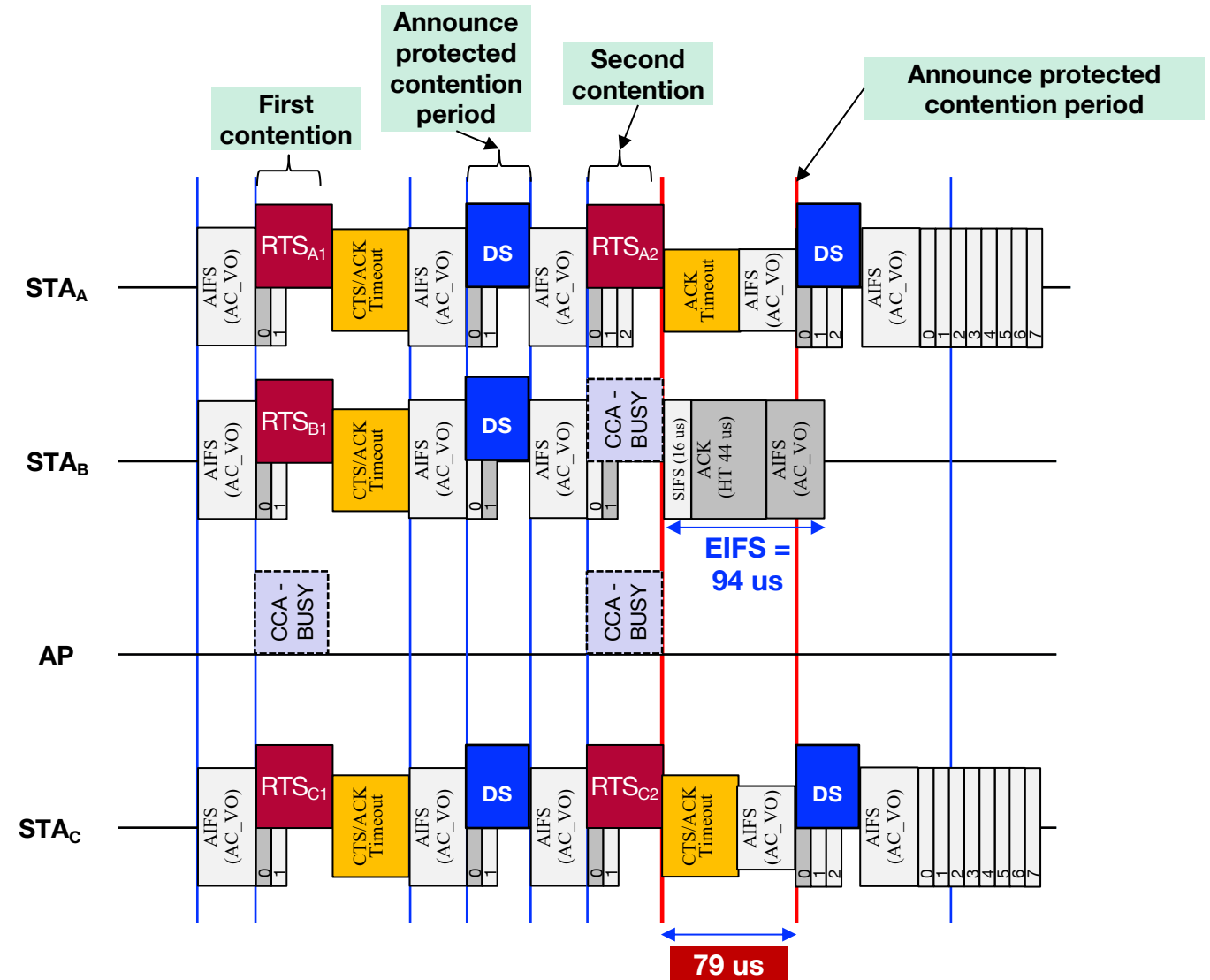
- When a STA sends a **response-soliciting frame (e.g., RTS)**, it needs to wait for **CTS/ACK Timeout + AIFS[AC]** before competing for channel access again
 - The ACK Timeout duration depends on the PHY layer

	RxPhyStartDelay (us)
OFDM	20
HT	28 (HT-mixed), 24 (HT-greenfield)
VHT	$36 + 4 \times N_{\text{VHT-LTF}} + 4$
EHT	$32 + 4 \times N_{\text{EHT-SIG}}$ for EHT MU PPDU 32 μ s for EHT TB PPDU



□ Sample Scenario

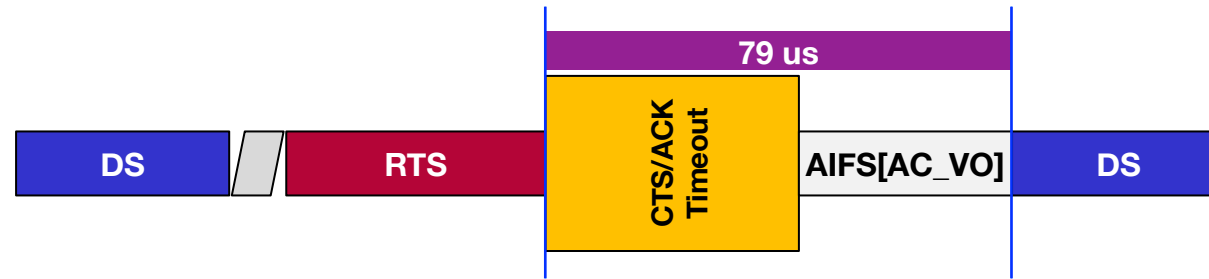
- **First contention round:** STA_A, STA_B, and STA_C compete; all three STAs use ACK Timeout after sending their frames
- STA_A, STA_B, and STA_C send DS frames to announce **protected contention period**
- **Second contention round (protected):** STA_A and STA_B send RTS frames, and they both fail
- They are allowed to send another DS frames
- **Both STAs wait for CTS/ACK Timeout before sending the next DS frame**



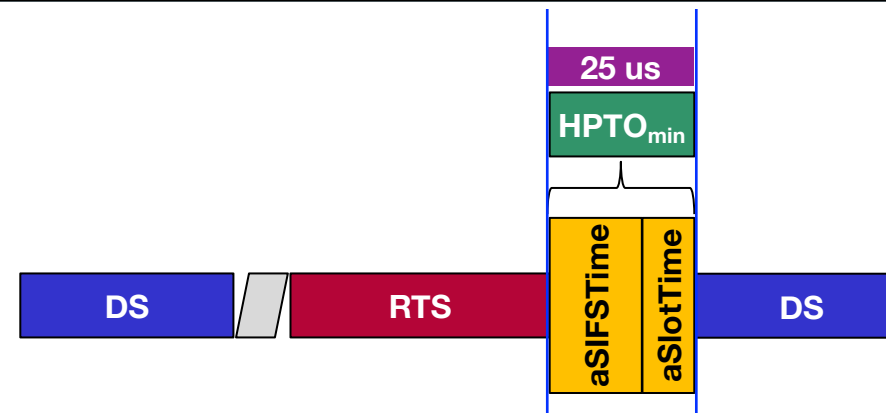
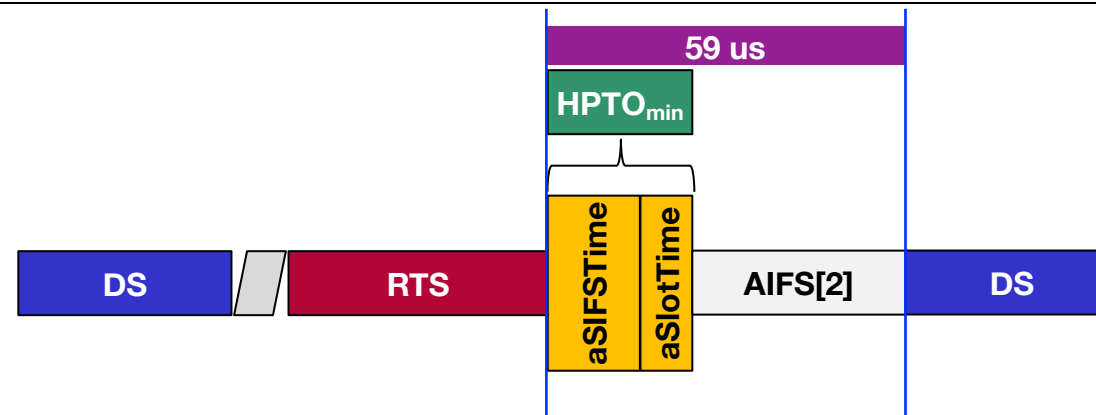
A Shorter Retry Timeout: High-Priority Timeout (HPTO)

- In this contribution, we allow STAs involved in P-EDCA to **use a High-Priority Timeout (HPTO) duration instead of CTS/ACK Timeout** to reduce the channel time used by P-EDCA
- **$HPTO_{min} = aSIFTtime + aSlotTime$**
 - $HPTO_{min}$ provides
 - Enough time for the **receiver** of the response-soliciting frame to receive, process, and start sending a reply to the sender, and
 - Enough time for the **sender** of the response-soliciting frame to perform carrier sensing (CCA) and switch to TX mode if the channel is sensed as idle
- **When a STA sends a response-soliciting frame (e.g., RTS), it can detect transmission failure if the channel is sensed as idle during the aSlotTime**
- Note: A longer HPTO, such as $aSIFTtime + 2 \times aSlotTime$ may be used if sensing the channel for a longer duration is necessary

High-Priority Timeout (HPTO)

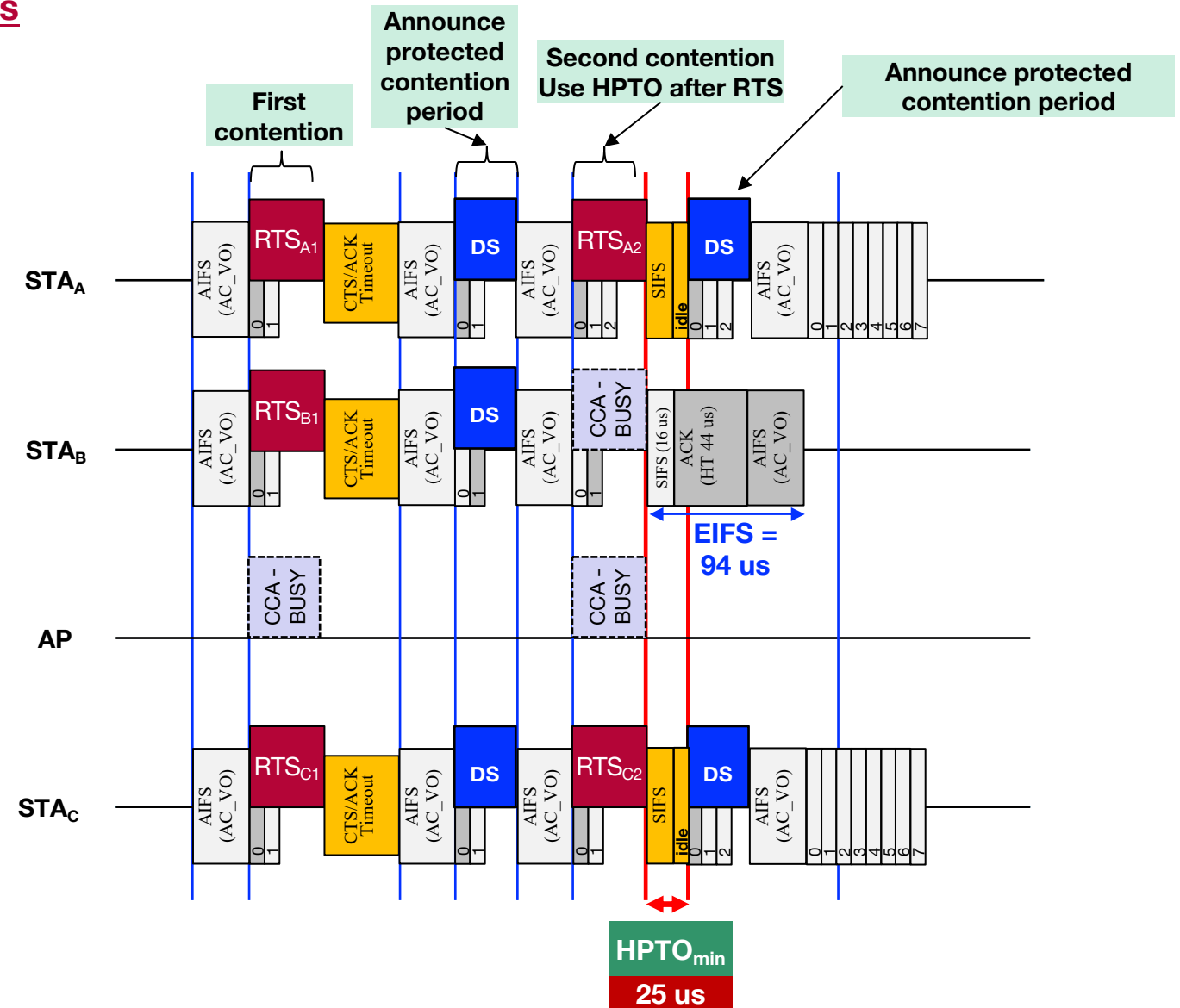


- After sending an RTS, a STA may use the $HPTO_{min}$ duration to determine transmission failure
- If the channel is sensed as idle during the aTimeSlot duration, the transmission is considered as failed



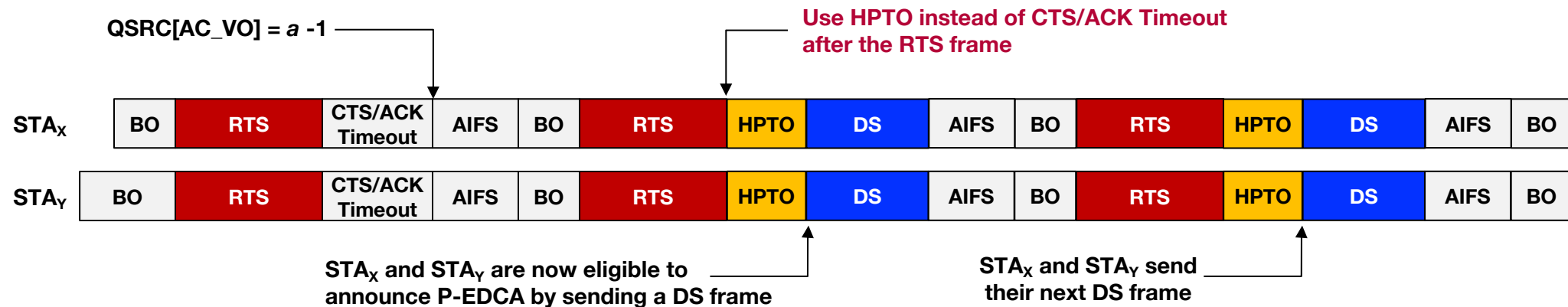
❑ Using HPTO before DS retransmissions

- $HPTO = HPTO_{min} + aSlotTime$
- **First contention round:** STA_A, STA_B, and STA_C compete; all three STAs use CTS/ACK Timeout after sending their frames
- STA_A, STA_B, and STA_C send DS frames to announce **protected contention period**
- **Second contention round (protected):** STA_A and STA_B send RTS frames, and they both fail
- They are allowed to send another DS frames
- **Instead of using CTS/ACK Timeout after their RTS frames, both STAs wait for HPTO before sending the next DS frame**



❑ Using HPTO before sending the first DS frame

- HPTO may also be used before sending the first DS frame
- Assume a STA may start P-EDCA contention by sending DS frame when $QSRC[AC_VO] = a$
- When $QSRC[AC_VO] = a - 1$, and after sending an RTS frame, the STA uses HPTO to determine if the transmission of the RTS frame has failed
 - If the channel is sensed idle during the aSlotTime of HPTO, the STA sends a DS frame immediately



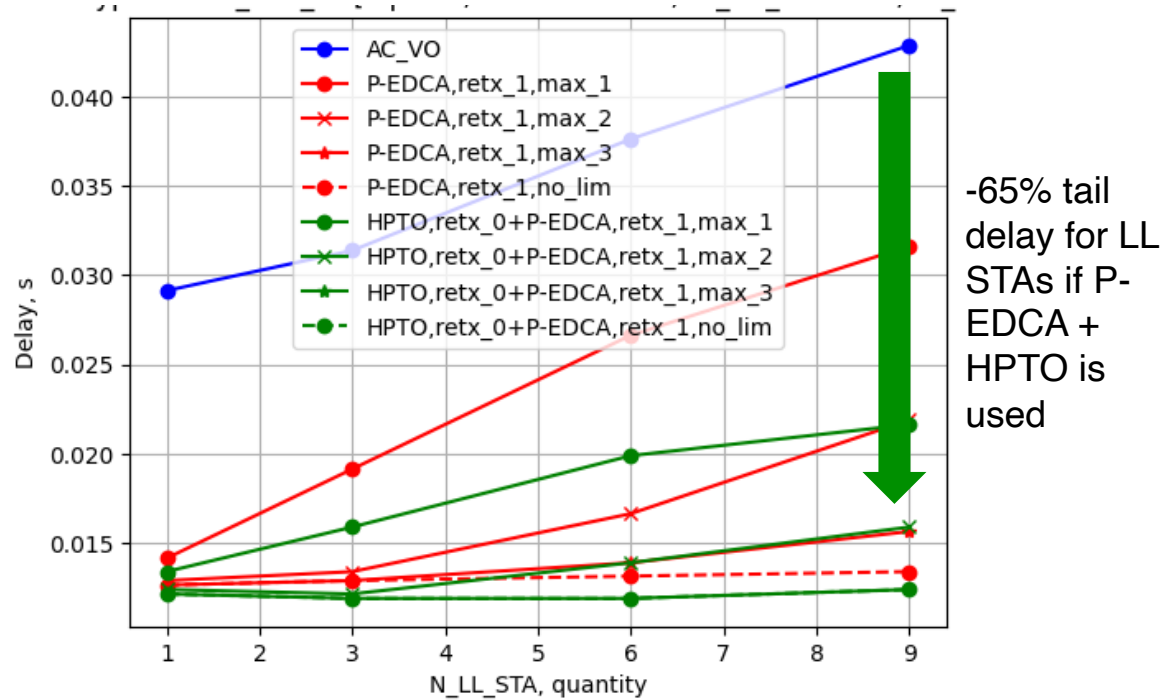
Performance benefits of HPTO. Scenario

Scenario:

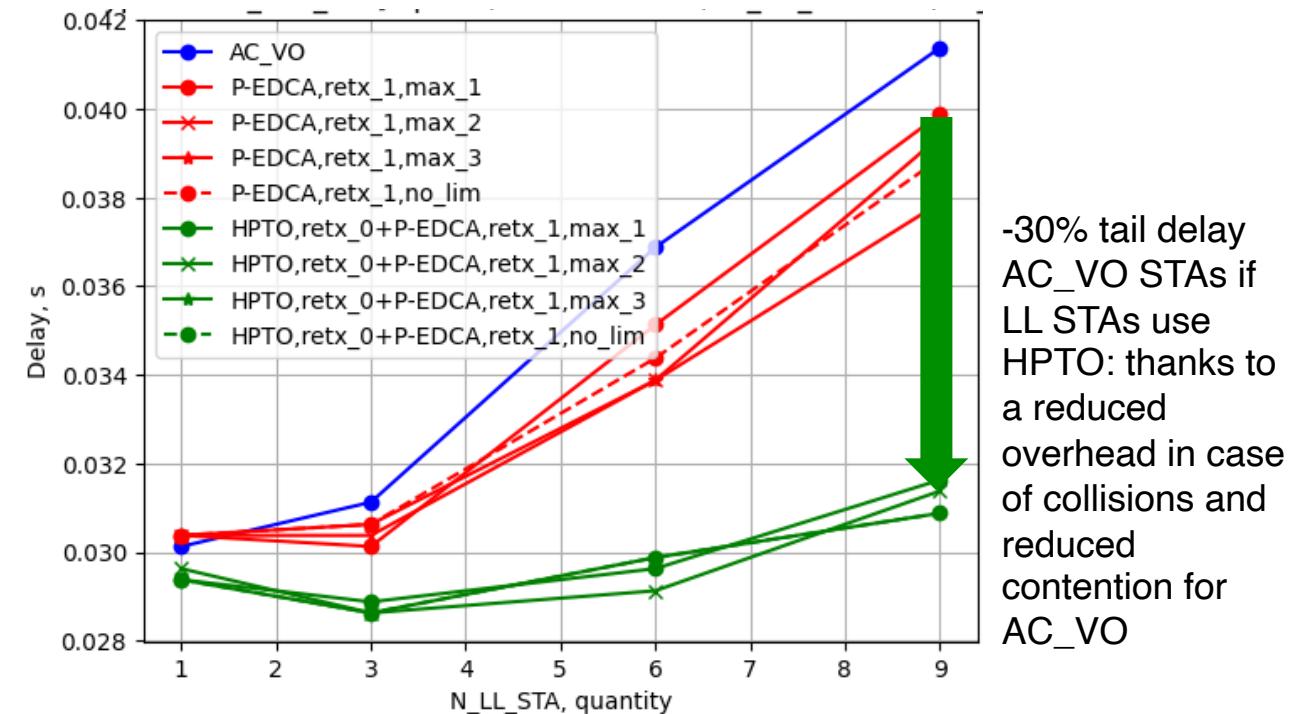
- **1 BSS**
- **20 BE STAs**
 - full-buffer UL+DL traffic
 - TxOP limit = 5ms
 - RTS/CTS always
- **5 legacy VO STAs**
 - UL
 - packet size 160 B
 - Uniform [10, 20] ms inter-arrival time
 - RTS/CTS always
- **N LL STAs**
 - UL
 - packet size 160 B
 - Uniform [10, 22] ms inter-arrival time
 - RTS/CTS always
 - Channel access methods:
 - Legacy AC_VO
 - P-EDCA with QSRC threshold = 1
 - P-EDCA+HPTO with QSRC threshold = 1
 - DS max consecutive attempts PSRC = {1, 2, 3, inf}.

Performance benefits of HPTO. Results

LL STAs, 99th percentile



AC_VO STAs, 99th percentile



Summary

- Normally, when a STA sends a response-soliciting frame (e.g., RTS, data), it waits for an CTS/ACK Timeout duration to determine if the transmission has failed
- **In this contribution, we proposed that STAs involved in P-EDCA may bypass CTS/ACK Timeout and instead use a High-Priority Timeout (HPTO) duration**
 - After sending a response-soliciting frame, a STA waits for $HPTO_{min} = aSIFSTime + aSlotTime$ to determine transmission failure
- The combination of P-EDCA with HPTO allows improving latencies for both LL STAs, which use P-EDCA and HPTO, and the legacy AC_VO STAs, which benefit from a low-overhead collision resolution by the LL STAs.

Straw Poll

- Do you agree that a STA using P-EDCA determines the failure of a response-soliciting frame (e.g., RTS) transmission using the High-Priority Timeout (HPTO), defined as SIFS + aSlotTime, instead of the CTS/ACK timeout?
- *YES/NO/ABSTAIN*

- Do you agree that when a STA using P-EDCA determines the failure of a response-soliciting frame (e.g., RTS) transmission using the High-Priority Timeout (HPTO), it sends the next DS frame transmission at:
 - Option A: The end of HPTO
 - Option B: The end of HPTO plus AIFS?
- Note: P-EDCA consecutive attempt count is $CAC[AC_VO]$, and the above rule applies as long as $CAC[AC_VO] < MAX$
- *YES/NO/ABSTAIN*

Straw Poll

- Do you agree that when the QSRC[AC_VO] counter of a STA allows it to initiate P-EDCA (i.e., transmit a DS frame) after one more failure, the STA may use the High-Priority Timeout (HPTO), defined as SIFS + aSlotTime, to detect the failure of the RTS frame?

YES/NO/ABSTAIN

- Do you agree that when the QSRC[AC_VO] counter of a STA permits it to announce P-EDCA (i.e., transmit a DS frame) upon one more transmission failure, the STA may use the High-Priority Timeout (HPTO), defined as SIFS + aSlotTime, to detect the failure of an RTS frame and subsequently transmit the DS frame at:
 - Option A: The end of HPTO
 - Option B: The end of HPTO + AIFS?

YES/NO/ABSTAIN