

Balancing the Tail Time Latency of STAs during High-Priority EDCA Periods

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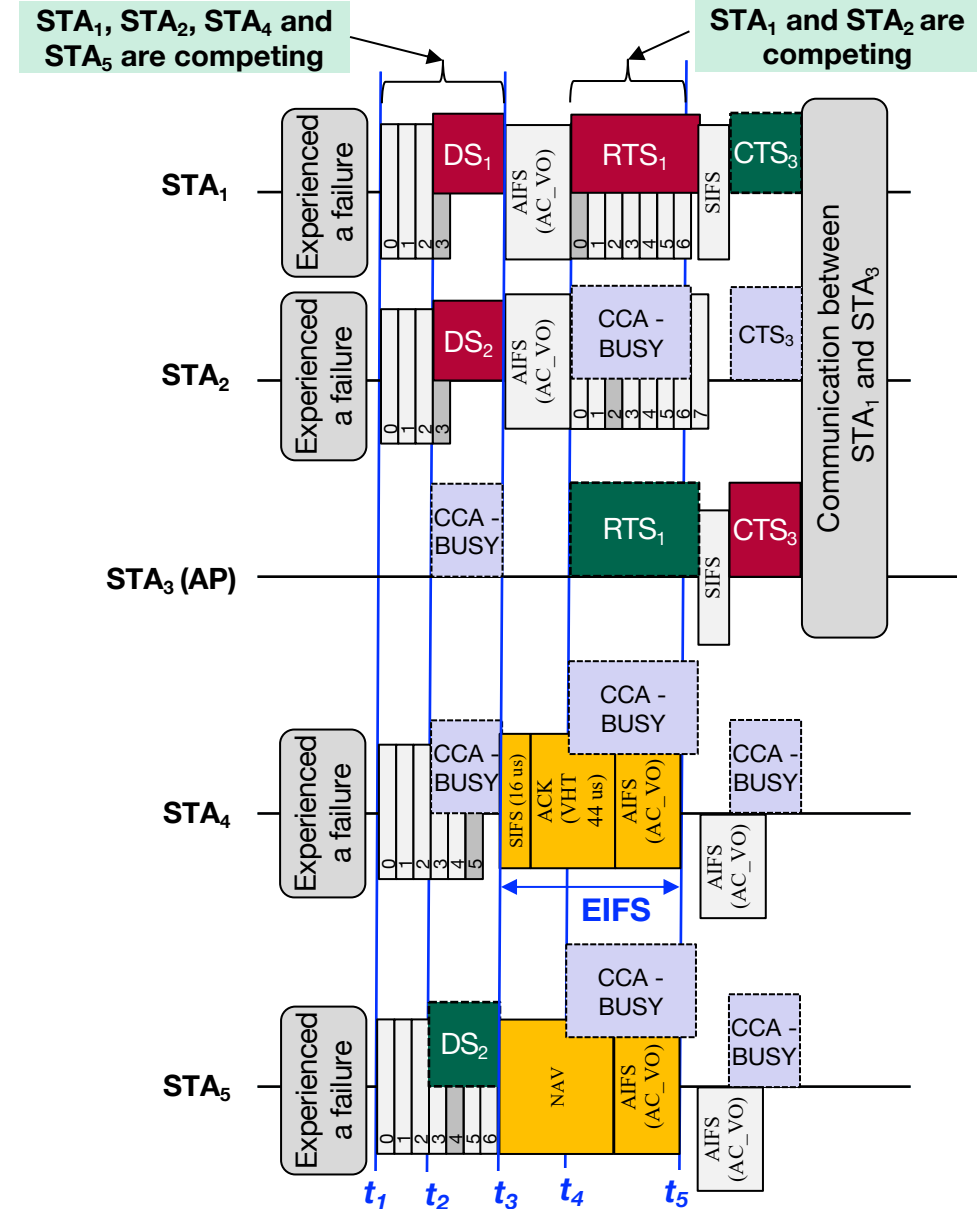
Introduction

- 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]
- 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
 - These STAs can compete for channel access AIFS[AC] after the end of the DS frame
 - STAs that receive at least the preamble of a DS frame will refrain from contention for EIFS
 - STAs that receive the DS frame will refrain from contention for NAV
- In this contribution, **we focus on the unfairness problem caused by the difference in the received signal quality (strength) from non-AP STAs at the AP and propose solutions to balance the tail time latency of these STAs**
- **We propose methods where STAs switch to sending a DS frame based on factors such as the signal quality received at the AP**

Overview of the HiP EDCA

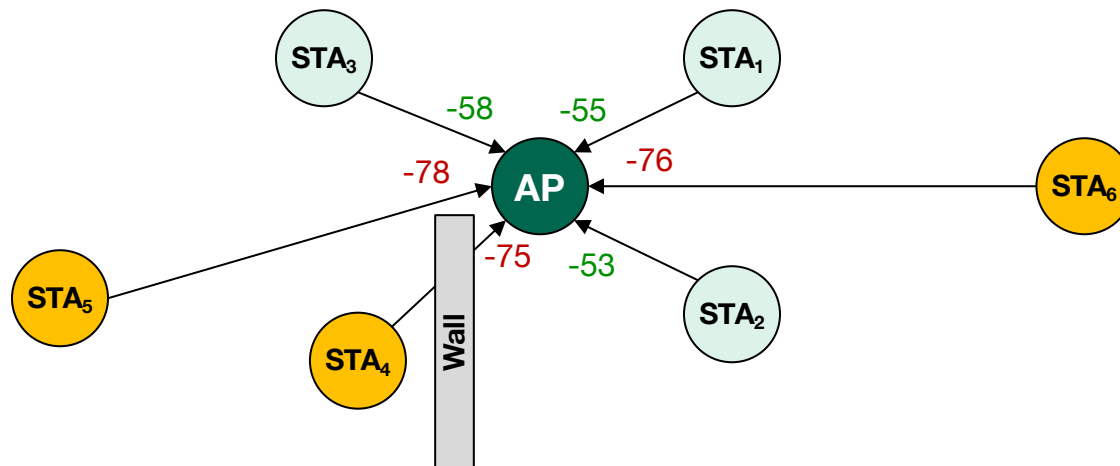
[11-24/1918][11-24/1144]

- STA₁, STA₂, STA₄ and STA₅ have LL (AC_VO) traffic to send to the AP (STA₃)
- All these STAs have experienced a certain number of failures (e.g., one or more)
- **All STAs are eligible to send DS frame**
- STA₁ and STA₂ select earlier timeslot (#3) and send DS frames
- We assume STA₄ receives the preamble of DS₂ frame sent by STA₂: **Sets EIFS**
 - 94 microsecond assuming non-HT PHY parameters
- We assume STA₅ receives the entire DS₂ frame sent by STA₂: **Sets NAV**
- **In the contention round starting at t_4 , only STA₁ and STA₂ compete**
 - **STA₁ wins the channel**



The Unfairness Problem and Tail Time Latency

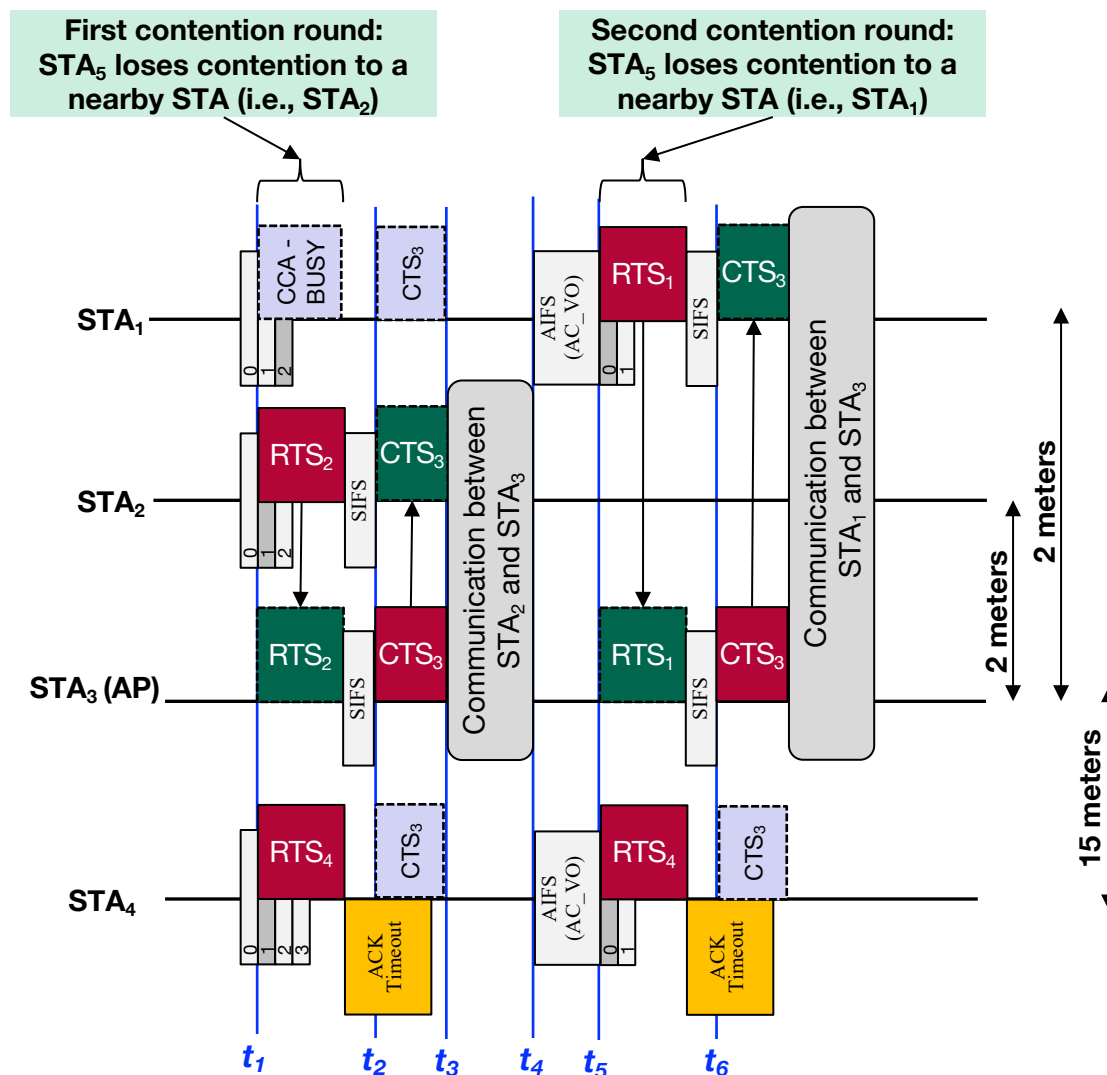
- When a STA_x competes with STAs whose received signal quality at the AP is higher, STA_x keeps losing the channel contention to those STAs
 - This occurs due to the capture effect, which results in receiving a frame from the STA with higher signal quality, even in the presence of interference from other STAs
 - For example, the greater the number of STAs that are closer to the AP than STA_x , the higher the probability that STA_x will lose the contention



- The numerical values represent the RSSI received by the AP from each STA
- **STA₄, STA₅, and STA₆ are at a disadvantage when competing with STA₁, STA₂, and STA₃**

□ The Unfairness Problem

- STA₁, STA₂ and STA₄ need to send AC_VO traffic to STA₃ (the AP)
- **STA₁ and STA₂ are located 2 meters from STA₃ (AP), while STA₄ is 15 meters away from the AP**
- **First contention round:** STA₂ and STA₄ both select timeslot #1 and transmit RTS frames simultaneously at time t_1
 - Since STA₂ is closer to the AP, the AP successfully receives the RTS frame sent by STA₂ (i.e., RTS₂)
- **Second contention round B:** STA₁ and STA₄ select timeslot #0 and transmit RTS frames simultaneously
 - The AP successfully receives the RTS frame sent by STA₁ because it is closer than STA₄
- Note: The first and second contention rounds may not be consecutive

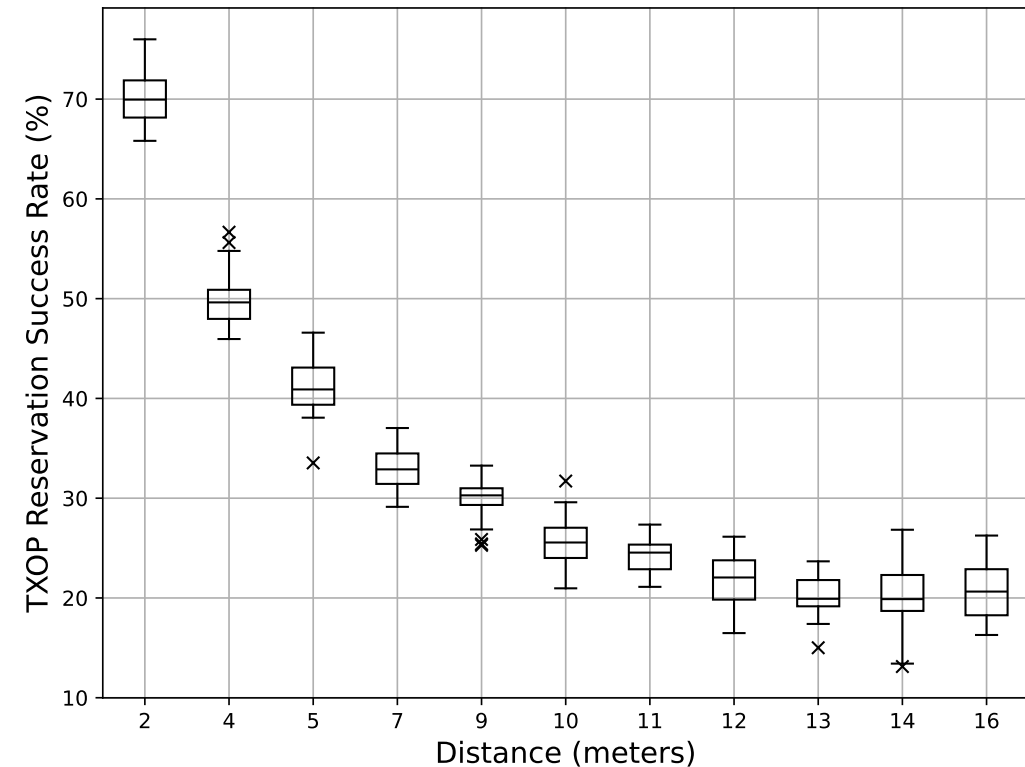


Observing the Unfairness Problem through Simulation

- Simulation parameters: 1 BSS, 30 x 30 m², 40 STAs uniformly distributed, STAs sending AC_VO traffic at the same rate

TXOP reservation success rate versus distance

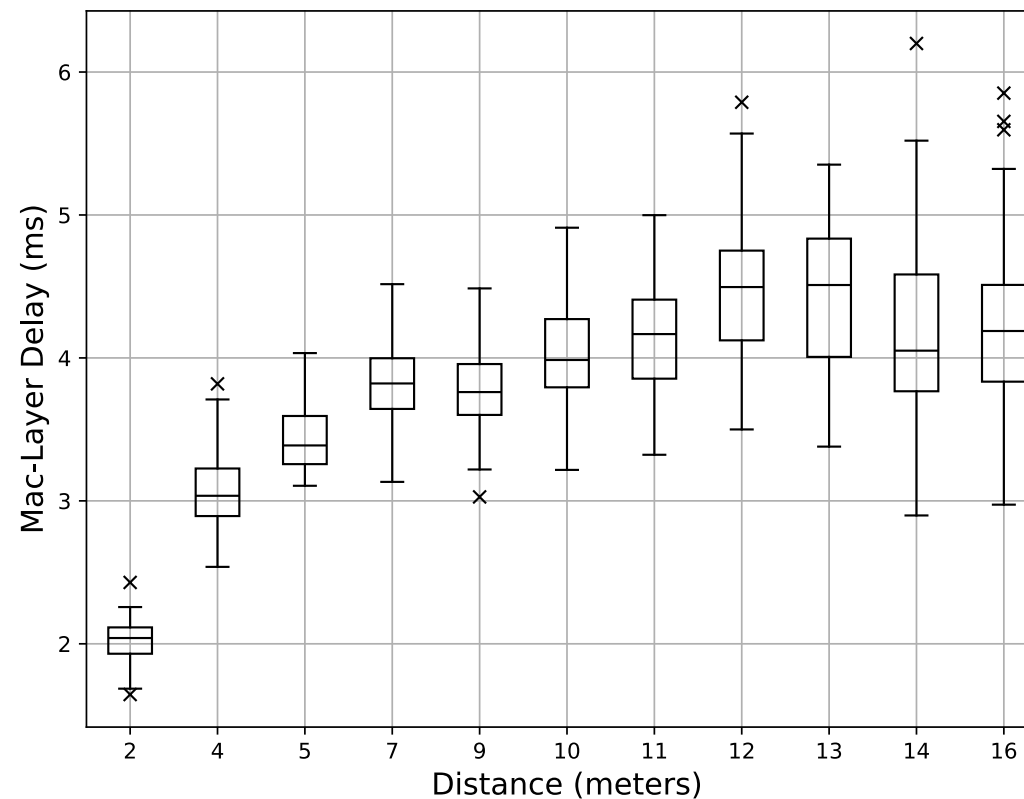
- A TXOP reservation is successfully reserved when the RTS sent by the STA is received and acknowledged by the AP
- If no response (CTS) is received, the STA needs to compete for channel access again
- Observation: The TXOP reservation success rate decreases as the signal quality received at the AP deteriorates**



❑ Observing the Unfairness Problem through Simulation

Latency

- Measured as the time between the arrival of a frame in the MAC layer of a non-AP STA until successful delivery to the AP
- **Observation: Latency increases as the signal quality received at the AP deteriorates**

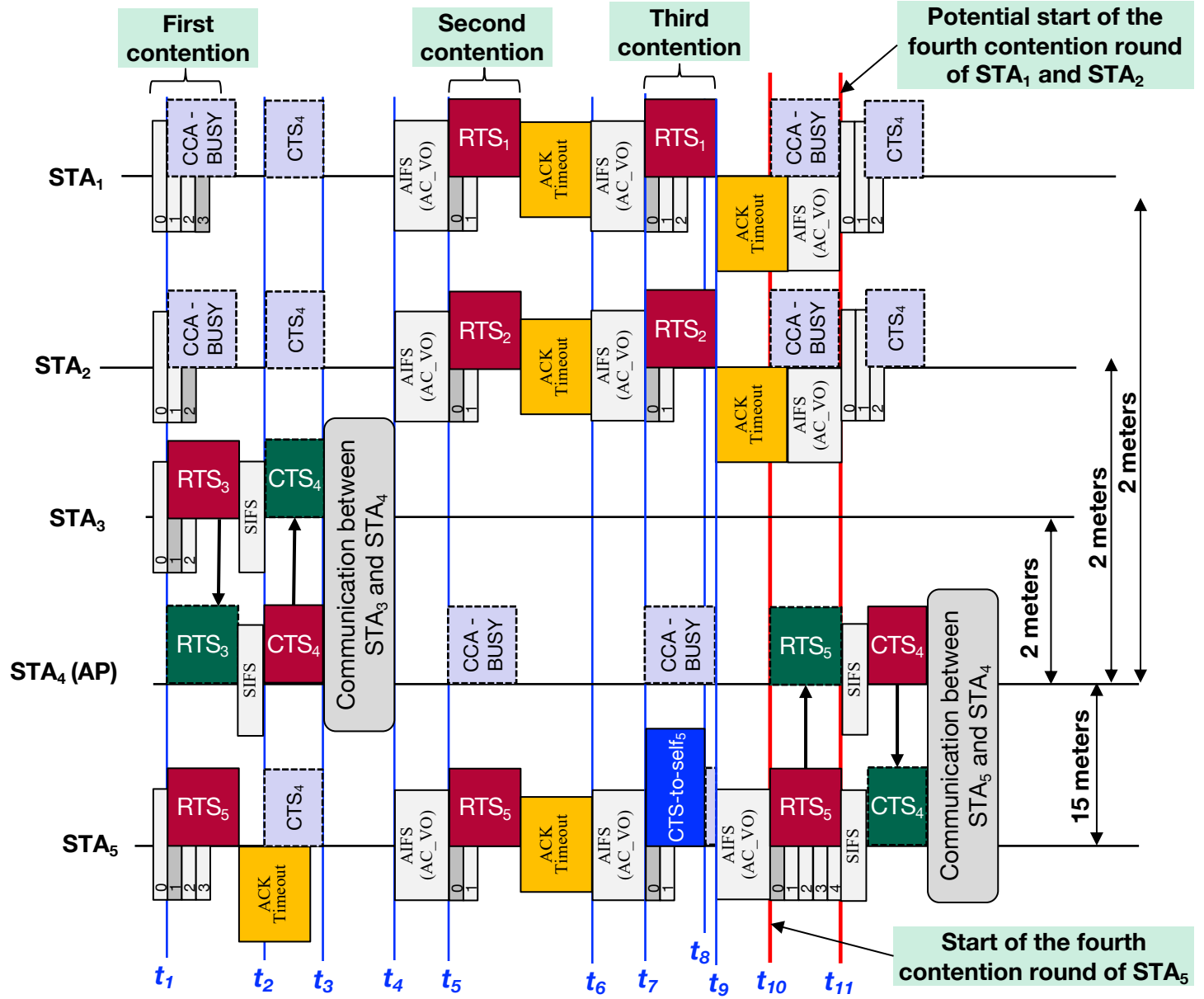


Switching between Response-Soliciting and Non-Response-Soliciting Frames

- In this contribution, we strive to provide the STAs with a signal-quality-aware channel access probability and balance the tail time latency of all STAs
- We propose that, during EDCA periods, **STAs switch from sending response-soliciting frames (e.g., RTS, data frames) to non-response-soliciting frames (e.g., CTS-to-self) based on different metrics**
 - e.g., **Received RSSI from/by AP**
- **Justification: A STA sending a non-response-soliciting frame can compete for channel access before the STAs sending response-soliciting frames**
 - A STA sending a non-response-soliciting frame may compete for channel access after **AIFS[AC]** after the end of the frame
 - In contrast, a STA sending a response-soliciting frame must wait for **ACK Timeout + AIFS[AC]** before competing for channel access

Proposed Solution

- STA₅, which is located 15 meters from the AP, is competing with STA₁, STA₂ and STA₃, which are located 2 meters from the AP
- **First contention:** STA₁ loses the first contention round to STA₃
- **Second contention:** No STA succeeds
- **Third contention:** STA₁ switches to sending DS frame (CTS-to-self), while STA₁ and STA₂ use RTS
- **The fourth contention round of STA₅ is earlier than that of STA₁ and STA₂**
 - STA₅ wins the channel and reserves a TXOP successfully



Switching Criteria

- The criteria for switching between sending response-soliciting and non-response-soliciting frames can be determined in various ways
- **Sample method**
 - The AP announces the range of RSSI values that are eligible for sending non-response-soliciting frames
 - In addition, the AP may announce probabilities or priorities for each RSSI range

Eligible RSSI	#retries	Switching probability	Eligible RSSI	#retries	Switching probability
-60 to -69	2	0.4	-70 to -79	2	0.6

The AP allows STAs with RSSI between -60 to -69 dBm to switch to sending non-response-soliciting frames for 40% of contentions rounds after experiencing 2 retries

The AP allows STAs with RSSI between -70 to -79 dBm to switch to sending non-response-soliciting frames for 60% of contentions rounds after experiencing 2 retries

❑ Switching Criteria

• Sample method

- The AP announces the RSSI distribution of STAs
- Based on this information, non-AP STAs decide about the criteria, such as the number of failed transmissions (i.e., channel access retries), before switching to non-response-soliciting frames

RSSI	#STAs	RSSI	#STAs	RSSI	#STAs
-50 to -59	4	-60 to -69	3	-70 to -79	2

Summary

- **When STAs whose received signal quality at the AP is different, the STAs with higher signal quality have a higher chance of capturing the channel and succeeding during EDCA periods**
 - This results in longer tail time latency of STAs whose signal quality at the AP is lower
- **To balance the tail time of STAs, in this contribution, we proposed to use different criteria for switching between response-soliciting and non-response-soliciting frames**
- For example, STAs that are further from the AP or located behind obstacles may switch to sending a Defer Signal (DS) frame after two failures, whereas STAs closer to the AP may switch to sending a Defer Signal (DS) frame after three failures

Straw Poll

- Do you agree that the signal quality (e.g., RSSI) between the AP and non-AP STAs should be considered when determining the switching criteria between response-soliciting (e.g., RTS) and non-response-soliciting (e.g., Defer Signal/CTS-to-Self) frames during high-priority EDCA periods?

YES/NO/ABSTAIN