Dynamic Channel Access Mechanism for TXOP Preemption

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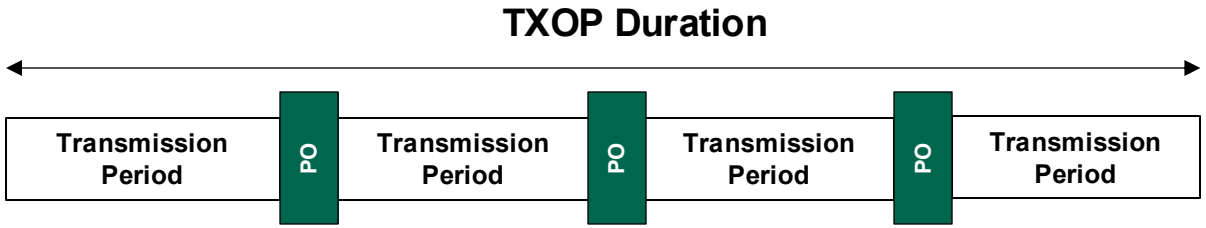
Introduction

- UHR aims to provide more predictable delays and reduce tail latency
- One of the objectives of 802.11bn is: "**Enabling at least one mode of operation capable of improving the tail of the latency distribution and jitter compared to EHT MAC/PHY operation, with mobility between BSSs**" [1]
- When a STA is in possession of a TXOP, other STAs with event-triggered (aperiodic) low-latency (LL) traffic must wait at least until the end of the ongoing TXOP
- **TXOP preemption has been proposed as a solution to this problem**

- **Existing works address various aspects of TXOP preemption**
  - Announcement of preemption and channel access issues [2]
  - Different UL and DL preemption cases [3,4,7]
  - Methods for informing STAs about aperiodic LL traffic [6,9]

Problem Statement

- **Preemption Opportunity (PO):** A specific time interval (within a TXOP) during which some STAs are allowed to preempt the TXOP



- Two common approaches to perform TXOP preemption (during POs)
  - **Polling:** The AP polls STAs and then schedules UL traffic (or sends DL traffic if it has higher priority data to send) [3, 4, 10]
    - **Shortcoming: Overhead**
  - **Contention:** Non-AP STAs are informed about the preemption opportunity to compete and send LL traffic [2, 3, 8, 10, 11]
    - **Shortcoming: Collisions intensify vs the number of STAs**

- **In this work, we consider the contention case and propose a structure for managing random channel access contention during preemption opportunities (POs)**

Which STAs can compete for channel access during a PO?

- For each PO, the set of **Preemption-Eligible STAs (PES)** includes the STAs that are allowed to contend and potentially preempt the TXOP

- Only the STAs **with traffic that meets the pre-defined preemption criteria** are allowed to preempt the TXOP
- **Preemption criteria may be related to, for instance, traffic priority and/or characteristics**

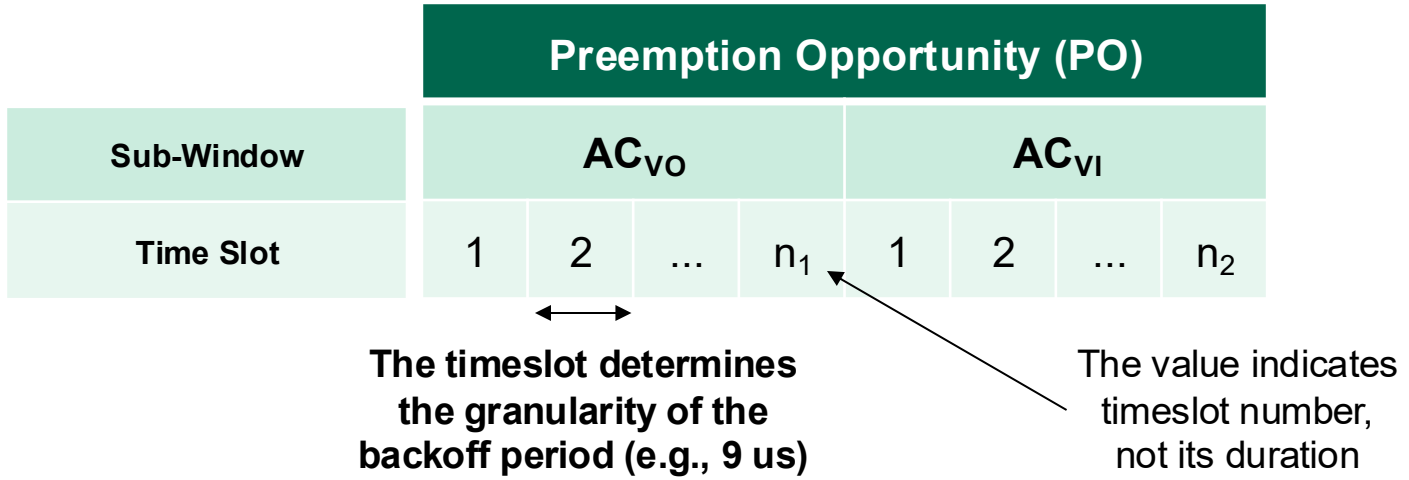
- One method to determine PES is through the **Access Category (AC)** of STAs' traffic
  - **The lowest AC that can be used by PES is denoted as AC_{TXOP}**
    - This value is announced by the TXOP holder, AP, or another entity
  - **The maximum AC that STAs can use is denoted as AC_{MAX}**
    - This value typically is the highest AC defined by the standard

- **Signaling of PO parameters is TBD**
  - Some potential methods are SCS, QoS Characteristics, etc.

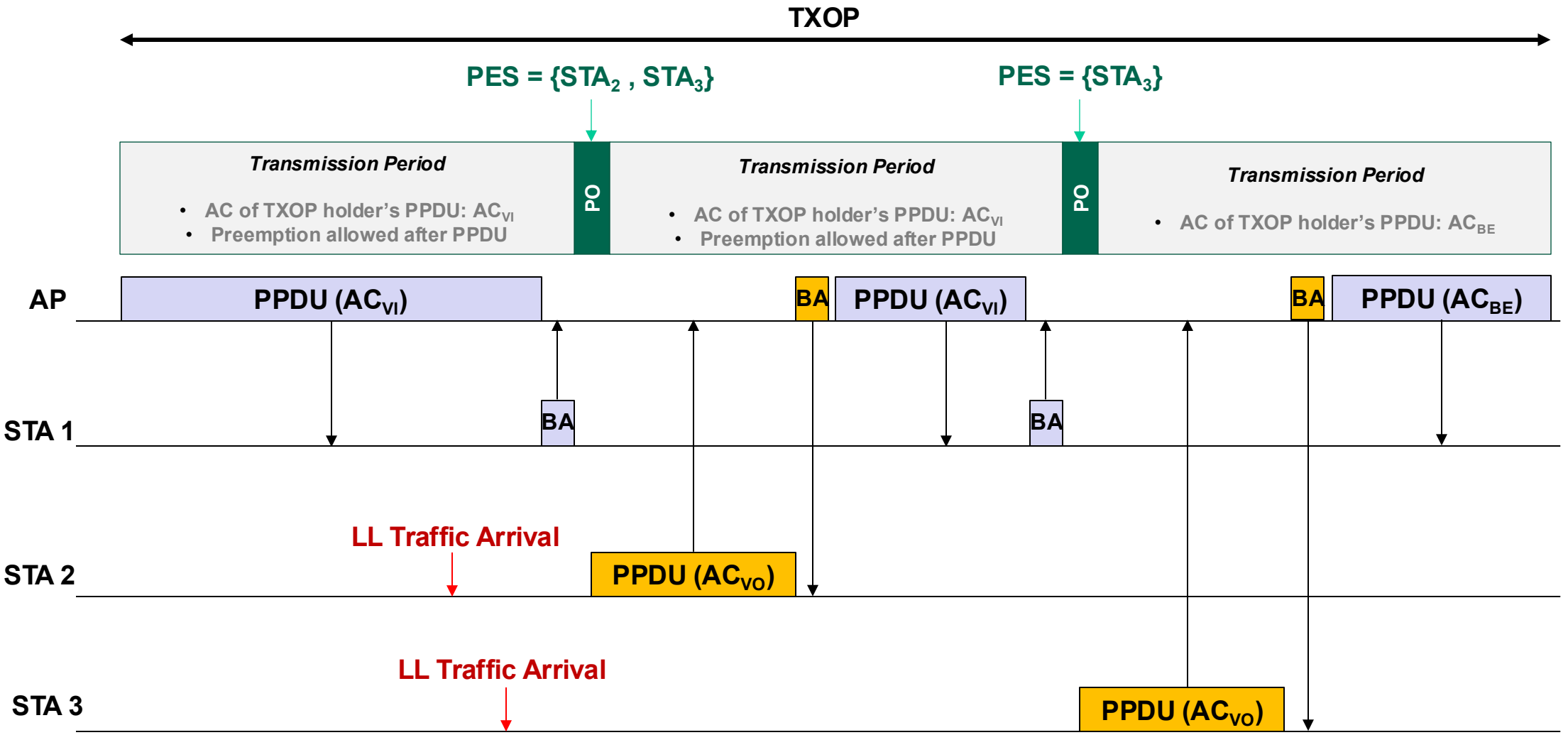
Performing Channel Access in each PO

- The PO is split into **sub-windows**
- **Each sub-window corresponds to a priority level (e.g., Access Category)**
- The number of sub-windows depends on AC_{TXOP} and AC_{MAX}
  - Each PO includes **AC_{MAX} - AC_{TXOP} +1** sub-windows

- **Example: Assume $AC_{TXOP} = AC_{VI}$**
- **The number of sub-windows is: $AC_{VO} - AC_{VI} + 1 = 2$**



- **For two Preemption Eligible STAs X and Y, if X has traffic belonging to a higher AC, then X takes precedence over Y to compete for channel access**
- **STA pick a random time slot in the sub-window corresponding to its AC to start contending**


TXOP
PES = {STA2 , STA3}
PES = {STA3}
Transmission Period
• AC of TXOP holder's PPDU: ACVI
• Preemption allowed after PPDU
PO
Transmission Period
• AC of TXOP holder's PPDU: ACVI
• Preemption allowed after PPDU
PO
Transmission Period
• AC of TXOP holder's PPDU: ACBE
AP
PPDU (ACVI)
BA
PPDU (ACVI)
BA
PPDU (ACBE)
STA 1
BA
BA
LL Traffic Arrival
STA 2
PPDU (ACVO)
LL Traffic Arrival
STA 3
PPDU (ACVO)

Summary

- TXOP preemption can be utilized to send LL traffic and reduce tail latency
- We proposed a priority-based method to organize channel access and reduce the probability of collisions by STAs that need to preempt the TXOP
- The Preemption Opportunity (PO) is organized into sub-windows that are mapped to the traffic priority of the STAs that are allowed to preempt the TXOP
- The structure of the PO can be dynamically adjusted based on various parameters such as the traffic demands of STAs, collisions, etc.

- Signaling PO parameters is TBD

Straw Poll

- **Do you agree that preemption should be allowed to be performed by not just the TXOP holder/responder, but any STA with LL traffic?**
  Y/N/Abstain
- **Do you agree that the type of the traffic that can preempt the ongoing TXOP should be explicitly (e.g., via PPDUs) or implicitly (certain ACs) defined?**
  Y/N/Abstain
- **Do you agree that performing preemption requires signaling of preemption parameters such as enable/disable preemption, duration, preemptable TIDs, etc.?**
  - Y/N/Abstain

References

1. 11-23/0480r3, UHR Proposed PAR
2. 11-23/1242r0, “Considerations on Inter-PPDU based Preemption Scheme,” July 2023
3. 11-24/0168r0, “TXOP preemption in 11bn,” January 2024
4. 11-24/0390r0, “A Uniform Procedure for Preemption,” February 2024
5. 11-24/629r0, “UL Low Latency Traffic Indication,” April 2024
6. 11-24/0811r0, “Overlapped indication for aperiodic low latency traffic,” May 2024
7. 11-23/1886r3, “Preemption techniques to meet low-latency (LL) targets,” January 2024
8. 11-24/1074r0, “Preemption TXOP,” July 2024
9. 11-24/1183r1, “Low latency, low collision, low power medium access—continued,” July 2024
10. 11-23/2076r0, “Multiple Channel Access in Preemption Sequence,”, November 2023
11. 11-24/416r1, “Target STA Prioritization in EDCA-based Preemption Mechanisms during a DL TXOP,” April 2024