

Consideration on UL MU transmission

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Motivation

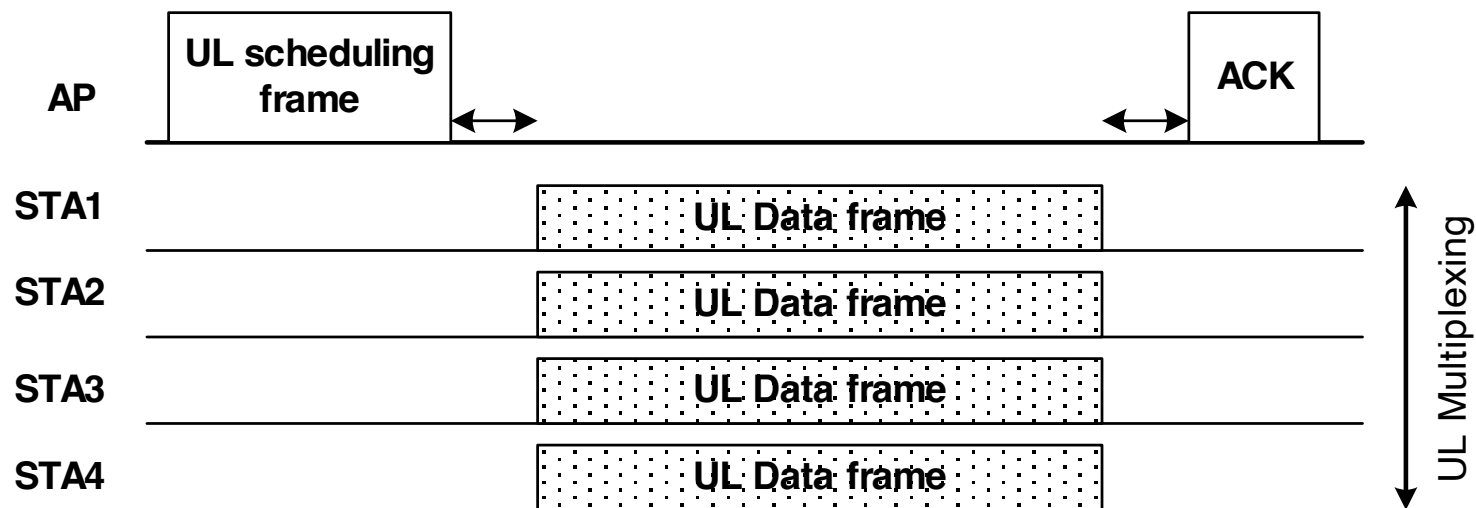
- In [1], we checked PHY and MAC feasibility to support UL MU transmission.
- In this contribution, we further discuss the procedure of UL MU transmission and the related issues in 11ax.

Procedure of UL MU transmission

- **AP's scheduling**

- For STAs to transmit UL data frame simultaneously, AP has to set TXOP and let each STA know its own resource such as frequency band in FDM and stream index in SDM.

- **Therefore, we suggest the procedure of UL MU transmission as below.**



UL MU transmission

- **UL Scheduling frame**

- AP sets TXOP for UL MU transmission and indicates the transmission method to STAs such as frequency/spatial resource to use.

Issue 1. How to send UL MU scheduling frame

Issue 2. How to choose UL MU STAs

- **UL data frames**

- STAs transmit their UL data frames respectively as AP indicates.

Issue 3. How to make UL data frames synchronously received by AP.

- **ACK frame**

- AP transmits ACK frame(s) to STAs separately or together.

Issue 1. How to send UL MU scheduling frame

- **Option1. With PIFS access**

- It is used to send CF-Poll frame for assignment of polled TXOP
- It provides the highest priority to access channel and doesn't have to manage CW

- **Option2. Using a specific AC (e.g., AC_VO) parameters**

- It is used to send a management frame using AC_VO
- It provides fixed priority to access channel and has to manage CW

- **Option3. Using AC parameters of STAs assigned UL MU TXOP**

- It is used to send RTS or CTS frame using the access category of the corresponding QoS Data
- It provides variable priority to access channel and has to manage CW

Issue 2. How to choose UL MU STAs

- **In order to select UL MU STAs and to set UL MU TXOP,**
 - STA's buffer status helps the AP assigning UL MU resource efficiently.
- **To report the STA's buffer status**
 - Current standard can be leveraged, i.e.,
 - Piggybacked in UL data (e.g., Queue size in QoS Control field)
 - Standalone UL frame (e.g., QoS Null frame including Queue size)
 - Additionally
 - Piggybacked in DL dependent UL control frames (e.g., Modified CTS, BA, ACK, etc.)

Issue 3. How to make UL data frames synchronously received by AP (1/2)

● Timing synchronization

	Indoor (scenario 3)	Outdoor (scenario 4)
Radius ^[3]	20 meters	150 meters
95% channel delay ^[1]	58 <i>nsec</i>	700/1200 <i>nsec</i> in UMi/UMa
Max. round trip delay	67 <i>nsec</i>	500 <i>nsec</i>
Time difference	125 <i>nsec</i>	1200 <i>nsec</i> ~ 1700 <i>nsec</i>

- Need 2 or 4 times longer CP for UL MU transmission in outdoor environment

● Frequency synchronization

- By [2], over $\pm 4\text{kHz}$ difference between 2 STAs causes performance degradation in UL MU MIMO.

● Power synchronization [1]

- More critical in SDM/CDM than in FDM where UL data is separated in frequency domain before quantization.

Issue 3. How to make UL data frames synchronously received by AP (2/2)

● Potential solution(s) for synchronization in UL MU

- Longer CP size
 - Need 2 or 4 times longer CP for UL MU in outdoor environment
 - Need further system-level verification
- Adjustment procedure for synchronization
 - AP indicates each STA to adjust time/frequency/power difference.
 - AP calculates the difference among MU STAs by frame exchange with STAs.
- UL MU only for STAs who are sufficiently synchronized
 - Implementation-specific, but usage is limited

Conclusion

- **We discussed the procedure of UL MU transmission and related issues to support UL MU transmission in 11ax.**
 - AP initiates UL MU transmission by transmitting UL scheduling frame.
 - AP needs information to schedule STAs in advance.
 - 11ax system needs to align the differences of time, frequency and power among STAs.
- **Next issues are**
 - TXOP protection based on RTS-CTS, L-SIG protection, etc.
 - Processing time of UL data frame
 - Need to check if the time is enough for STA to prepare data packet within SIFS after receiving UL MU scheduling frame which includes MU scheduling information (e.g., STAs' ID, assigned MU channel, TXOP, etc.).
 - Channel access and retransmission rule
 - And verification of system-level gain of UL MU transmission

Reference

- [1] 11-13-1388, “Uplink multi-user transmission”
- [2] 11-09-1036, “Uplink MU-MIMO Sensitivity to Power Differences and Synchronization Errors”
- [3] 11-14-0621-03, “Simulation scenarios”