Uplink multi-user MAC protocol for 11ax

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Abstract

- The support for Uplink multi-user (UL MU) for 802.11ax is currently unclear.
- However, numerous studies have shown the benefit UL MU schemes in high-density environments.
- This presentation aims to start the discussion to formally support UL MU in 802.11ax.
- We also present a simple UL MU MAC Protocol to support our objective.

Background

- In a highly dense Wireless LAN environment, many collisions occur reducing the total network throughput and possibly lead to congestive collapse.

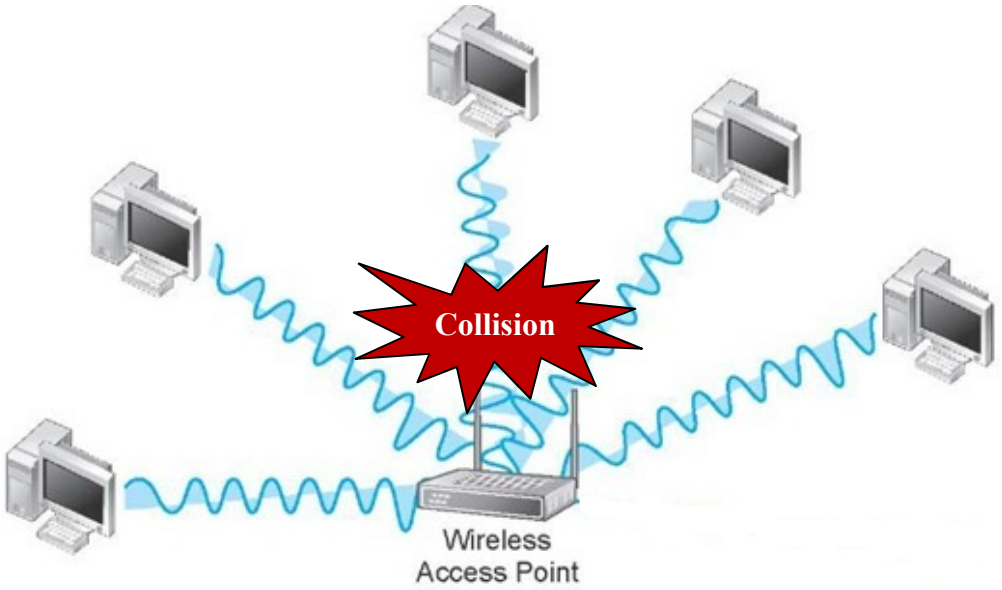
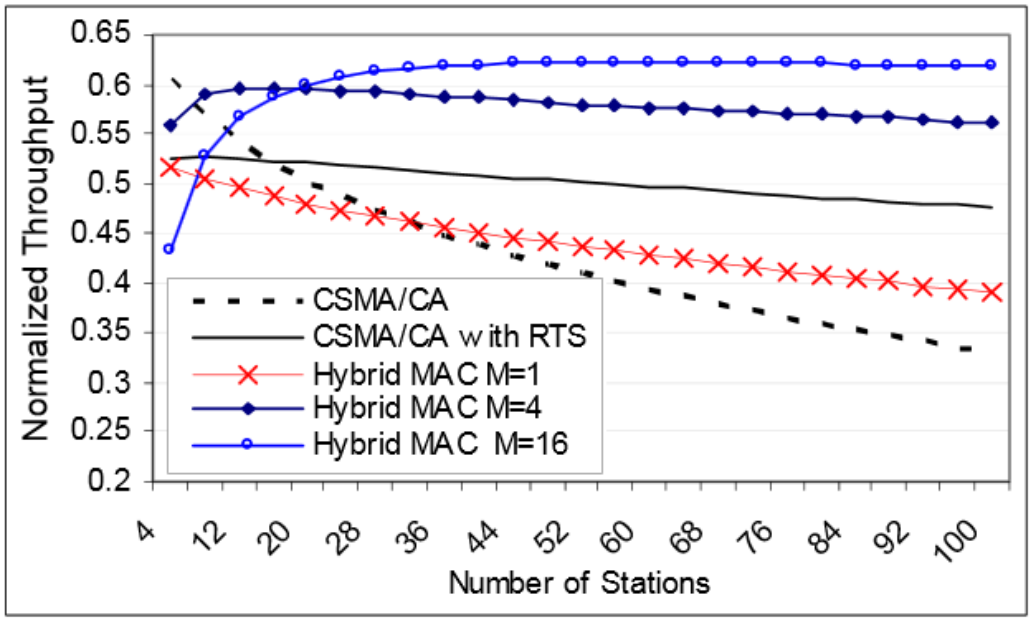


Figure 1: Multi-user transmit their data to AP at the same time[1]

Background

- Uplink Multi-user transmission reduces collision and hence the total throughput by allowing multiple transmission in a single TXOP. Multi-user transmission can be done in the frequency or spatial domain.



- This figure is the result of combination of the OFDMA access and a CSMA scheme to improve efficiency.
- By adjusting the number of sub-channels, as the number of stations grows → maintain a higher throughput than CSMA/CA based schemes.

M: Number of subchannels
Hybrid: OFDMA/CSMA

Figure 2: Benefit of UL MU (OFDMA) in frequency domain [2]

Uplink Multi-user Transmission

Definition

- Users transmit their data to an AP at the same time. [3]

Type of uplink multi-user transmission

Type	Application
Frequency Domain Multiplexing (FDM)	• OFDMA in a channel or in multiple channels such as LTE or WiMAX
Spatial Domain Multiplexing (SDM)	• UL MU MIMO such as LTE
Code Domain Multiplexing (CDM)	• UL feedback in cellular network such as 3G cellular • E.g. IDMA, CDMA
Hybrid Multiplexing	• E.g. Multicarrier-CDMA, OFDM-IDMA

UL MU MAC Protocol

- **The benefit of UL MU can be easily demonstrated by the figure below**

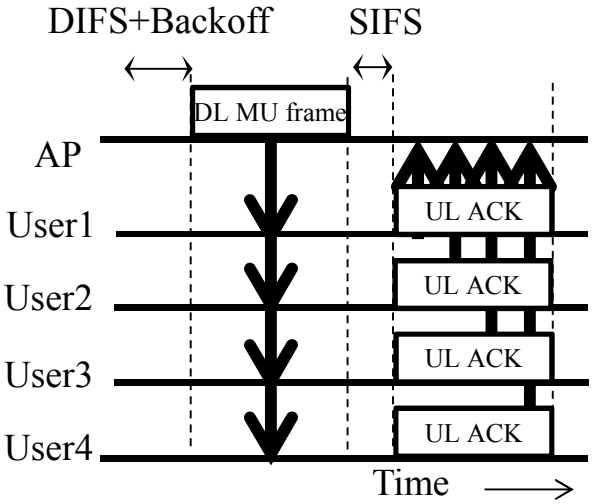


Figure 3a: UL MU

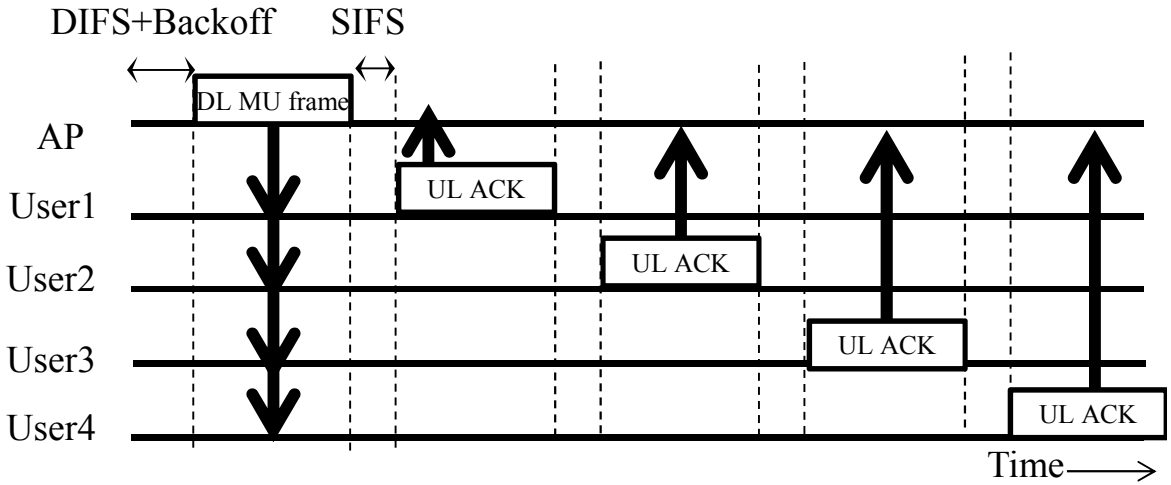


Figure 3b: Conventional

- **However, the benefit of this scenario is limited because it is highly dependent on the transmitted DL frame.**

UL MU MAC Protocol for general case

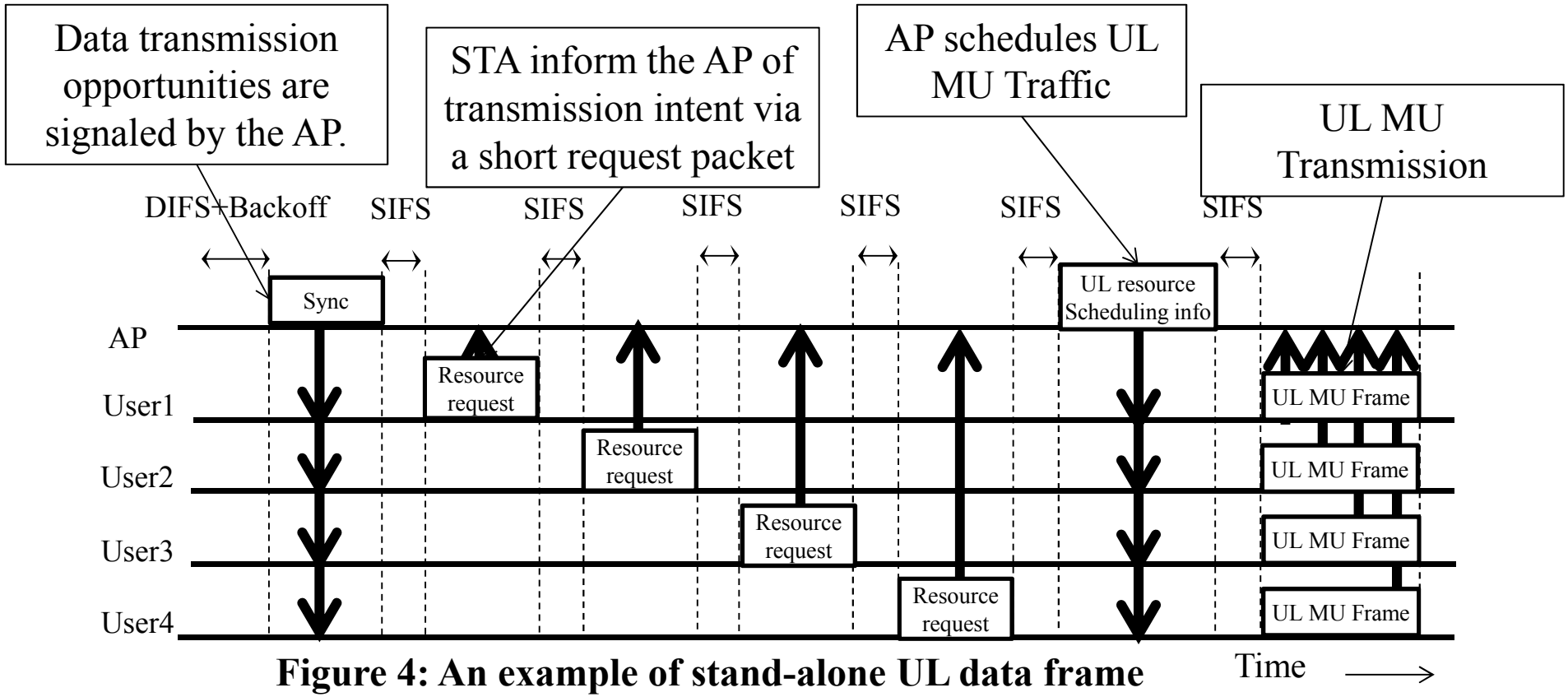


Figure 4: An example of stand-alone UL data frame

- Many UL MU MAC protocol in literature follows this protocol [2][3]
- In this protocol, the sequence is initiated by the AP similar to a point coordinator in PCF.
- We refer to this as **centralized UL MU**

Our ideas

- A UL MU MAC Protocol should be
  - Applicable to many scenarios to maximize its effect.
  - Initiated by a participating STA and not the AP.
    - Users that obtain TXOP should be able to send right away regardless of UL MU is used or not.
    - If UL MU is used, users with TXOP don't have to wait for UL transmission timing. It means each users can initiate UL MU data frame transmission without any control from AP.
    - We call this kind of protocol as **Distributed UL MU**.
  - ➢ In contrast, in the case of **Centralized UL MU** protocol, frame transmission timing is always come from the AP.
  - Minimal overhead
  - Applicable in DCF/EDCA.

Environment scenario

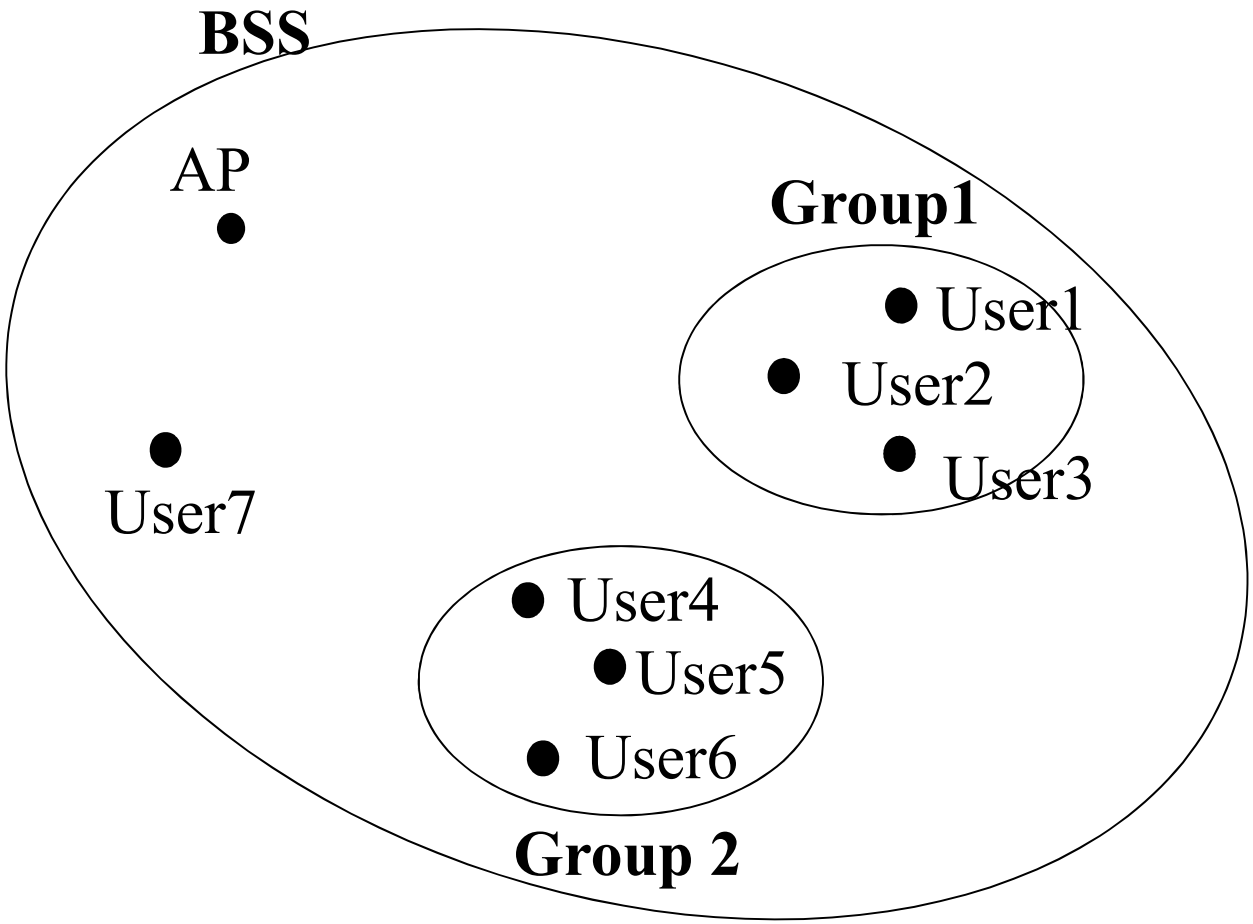


Figure 5: Environment scenario

Grouping concept here is the same as 11ac DL MU-MIMO grouping.

User1, User2, User3	11ax Users supporting UL MU belonging to Group 1
User4, User5, User6	11ax Users supporting UL MU belonging to Group 2
User7	Legacy device

Distributed UL MU frame transmission (Example)

Scenario 1 : UL MU permitted

- Transmission sequence -

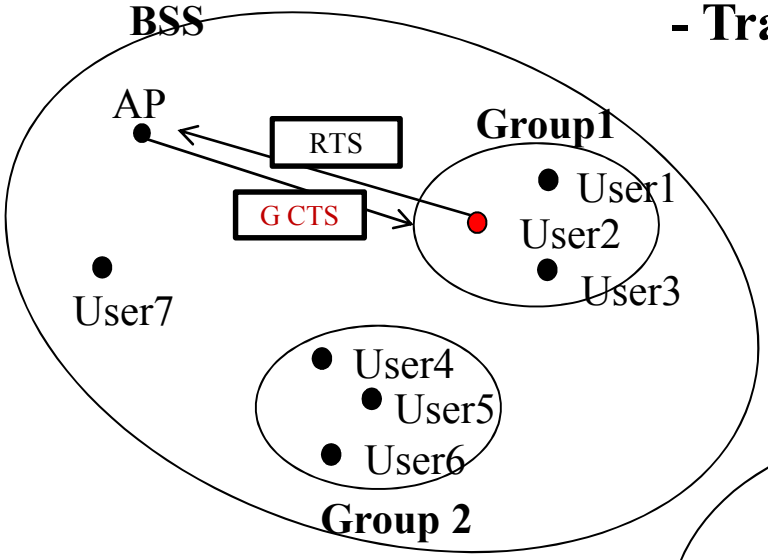


Figure 6a: RTS and Group-CTS exchange

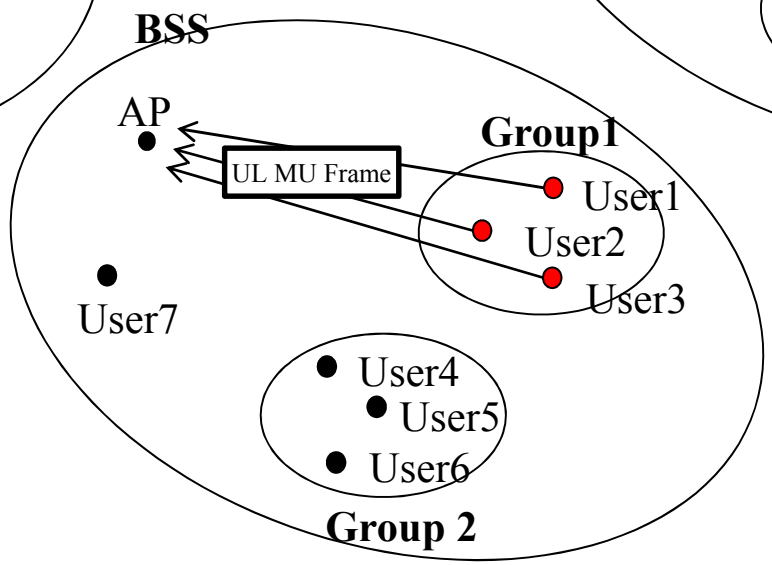


Figure 6b: UL MU Frame transmission

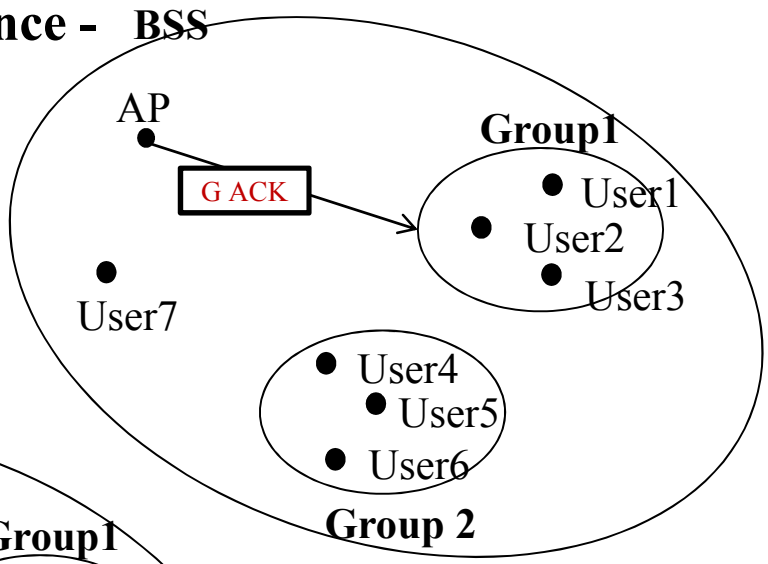


Figure 6c: Group-ACK transmission

Distributed UL MU frame transmission (Example)

Scenario 1 : UL MU permitted
- Timing Diagram -

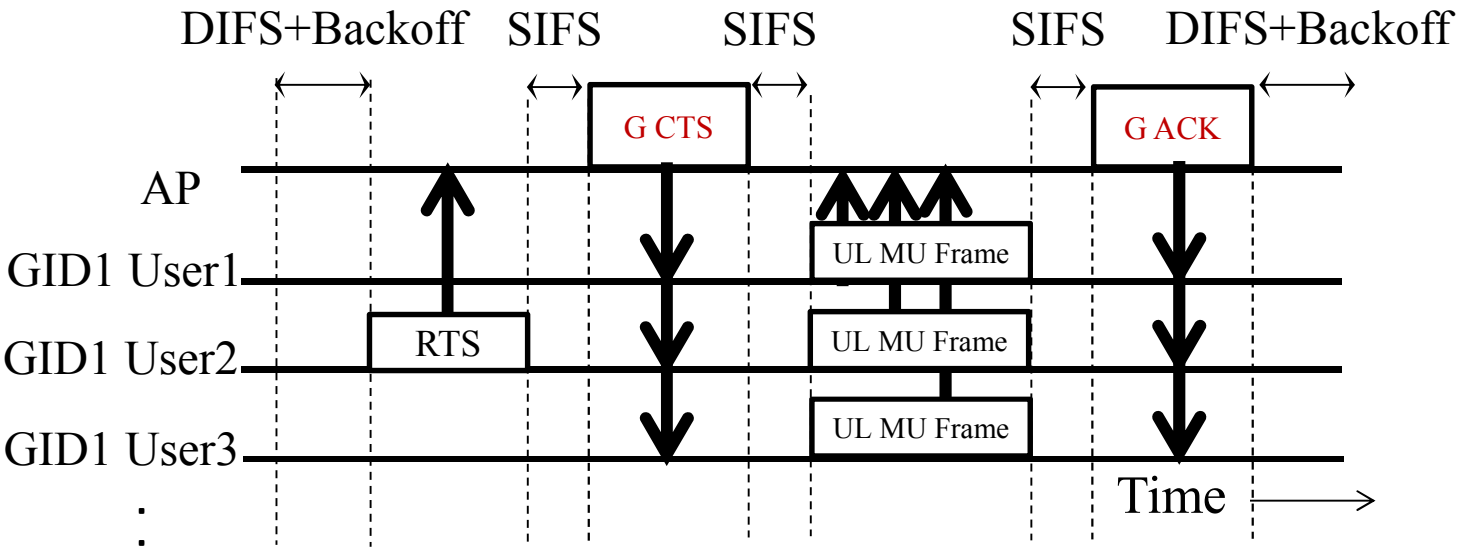


Figure 7: An example of Distributed UL MU frame transmission

GID1 **Group 1**

G CTS **CTS frame with Group ID for UL**

G ACK **ACK frame with Group ID for UL MU Frame**

Distributed UL MU frame transmission (Example)

Scenario 2 : UL MU not permitted

- Transmission sequence -

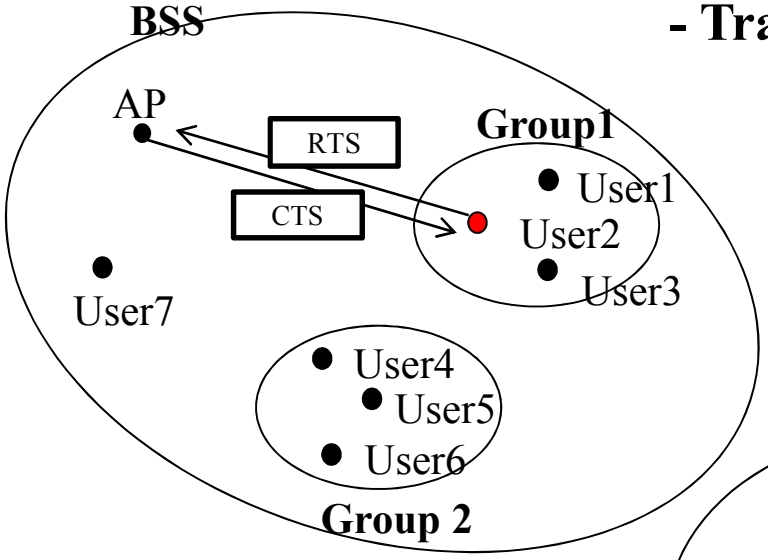


Figure 8a: RTS and CTS exchange

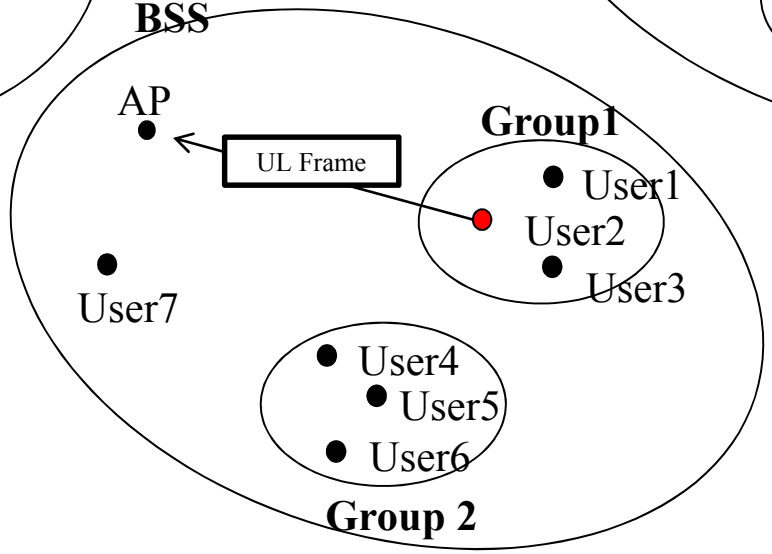


Figure 8b: UL Frame transmission

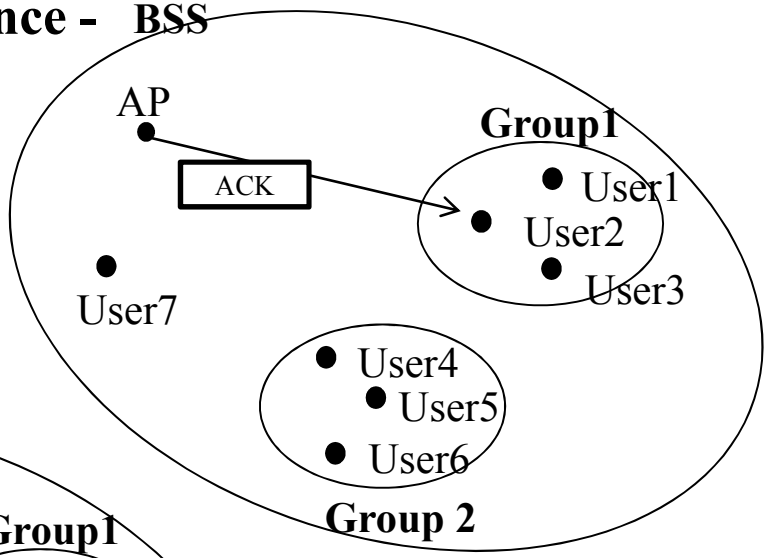


Figure 8c: ACK transmission

Distributed UL MU frame transmission (Example)

Backward compatibility

- When any legacy device use RTS, the 11ax AP will always send normal CTS for backward compatibility. Hence, a normal RTS/CTS frame exchange will occur.

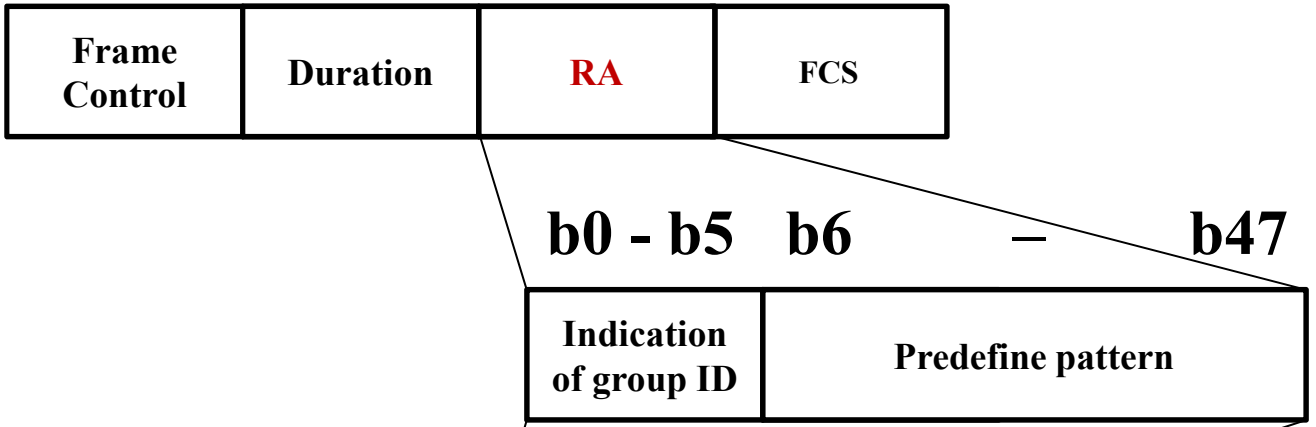
- When any legacy device hear a distributed UL MU sequence, it will be as if a normal RTS/CTS frame exchange has occurred.

Summary

	Centralized	Distributed
Advantages	- "Guarantees" latency. - Might have better theoretical performance benefit than distributed.	- Low overhead - Symmetric with current 802.11ac DL MU scheme.
Disadvantages	- High overhead - Neighbor BSSes operating in the same mode will hinder performance.	- Effect is dependent on whether users within the same group have the same traffic characteristics.

New frame type definition

- The function same as 11ac CTS or ACK, but is for a Group.
- G CTS frame (Same control frame Subtype as CTS)



- G ACK frame

New control frame Subtype

Conclusion and Future Work

- We show a UL MU MAC Protocol which has low overhead and easily applicable in frequency domain or spatial domain UL MU.
- We plan to show MAC simulation results of the proposed scheme in a future contribution.

References

[1] "WLAN components (Data Communications and Networking), what-when-how In Depth Tutorials and Information", http://what-when-how.com/data-communications-and-networking/wlan-components-data-communications-and-networking/

[2] Yaser Pourmohammadi Fallah, Salman Khan, Panos Nasiopoulos, Hussein Alnuweiri, "Hybrid OFDMA/CSMA Based Medium Access Control for Next-Generation Wireless LANs", IEEE Communications Society ICC 2008

[3] Jinyoung Chun, Wookbong Lee, "Uplink multi-user transmission", 11-13/1388r0, LG Electronics