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APPLICATION NUMBER	FILING or 371(c) DATE	GRP ART UNIT	FIL FEE REC'D	ATTY,DOCKET,NO	TOT CLAIMS	IND CLAIMS
61/947,922	03/04/2014		260	MP5524PR2		

CONFIRMATION NO. 6824

23624
MARVELL SEMICONDUCTOR, INC.
INTELLECTUAL PROPERTY DEPARTMENT
5488 Marvell Lane
Santa Clara, CA 95054

FILING RECEIPT



OC000000067453900

Date Mailed: 03/28/2014

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Inventor(s)

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If Required, Foreign Filing License Granted: 03/28/2014

The country code and number of your priority application, to be used for filing abroad under the Paris Convention, is **US 61/947,922**

Projected Publication Date: None, application is not eligible for pre-grant publication

Non-Publication Request: No

Early Publication Request: No

Title

OFDMA MAC Consideration

Statement under 37 CFR 1.55 or 1.78 for AIA (First Inventor to File) Transition Applications: No

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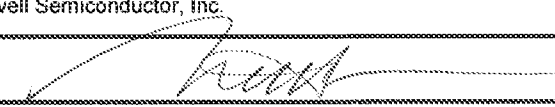
(to be used for all correspondence after initial filing)

TRANSMITTAL FORM (to be used for all correspondence after initial filing)	Application Number	Unassigned
	Filing Date	March 4, 2014
	First Named Inventor	Liwen Chu
	Art Unit	Unassigned
	Examiner Name	Unassigned
Total Number of Pages in This Submission	Attorney Docket Number	MP5524PR2

ENCLOSURES (check all that apply)

☐ Fee Transmittal Form ☐ Fee Attached ☐ Amendment / Reply ☐ After Final ☐ Affidavits/declaration(s) ☐ Extension of Time Request ☐ Express Abandonment Request ☐ Information Disclosure Statement ☐ Certified Copy of Priority Document(s) ☐ Response to Missing Parts/ Incomplete Application ☐ Response to Missing Parts under 37 CFR 1.52 or 1.53	☐ Drawing(s) ☐ Licensing-related Papers ☐ Petition ☐ Petition to Convert to a Provisional Application ☐ Power of Attorney, Revocation Change of Correspondence Address ☐ Terminal Disclaimer ☐ Request for Refund ☐ CD, Number of CD(s) _____ ☐ Landscape Table on CD	☐ After Allowance Communication to Technology Center (TC) ☐ Appeal Communication to Board of Appeals and Interferences ☐ Appeal Communication to TC (Appeal Notice, Brief, Reply Brief) ☐ Proprietary Information ☐ Status Letter ☒ Other Enclosure(s) (please identify below). Provisional Application (24 pgs) Application Data Sheet (3 pgs)
Remarks		

SIGNATURE OF APPLICANT, ATTORNEY, OR AGENT

Firm Name	Marvell Semiconductor, Inc.		
Signature			
Printed name	Horace Ng		
Date	March 4, 2014	Reg. No.	39,315

CERTIFICATE OF TRANSMISSION

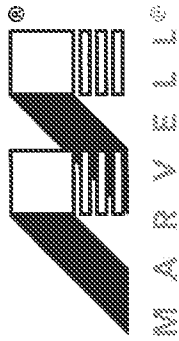
I hereby certify that this correspondence is being transmitted electronically to the USPTO on the date shown below.			
Typed or printed name	Lucie Valladares	Telephone No.	408-222-8728
Signature		Date	March 4, 2014

This collection of information is required by 37 CFR 1.5. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to 12 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

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Country:: United States
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OFDMA MAC Consideration

Liwen Chu, Hongyuan Zhang, Hui-Ling Lou, Yakun Sun

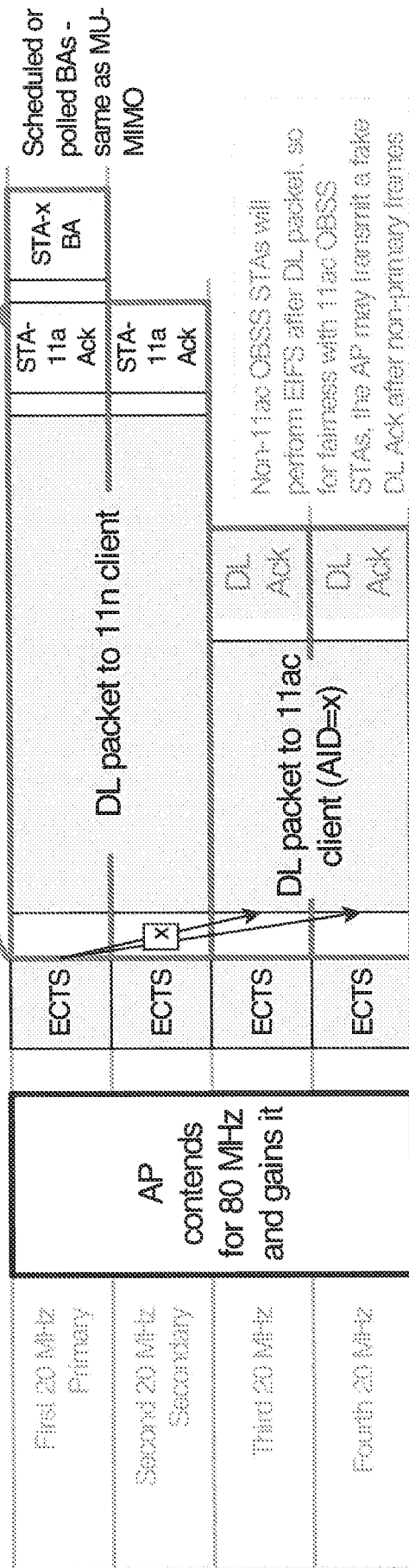
MAC Medium Access without OFDMA

- In a 40/80/160/80+80 BSS, all the transmissions include primary 20MHz channel.
- In a 80/160/80+80 BSS, all the 80Mhz transmissions include primary 40MHz channel.
- In a 160/80+80 BSS, all the 160/80+80MHz transmissions include primary 80MHz channel.
- A VHT STA does backoff in primary 20MHz channel. When it tries to transmit ≥ 40 MHz transmission, it needs to detect whether the secondary channel(s) is idle PIFS before its transmission.
- In 11ah's SST, a STA can transmit its frame without using primary 20MHz channel.

Mechanism Proposed for DL OFDMA in [1]

Each PLCP header indicates the subchannels of each frame in the DL-OFDMA transmission

The legacy frame must be the longest frame, and acks occur on the primary. The alternative of padding on the non-primary channel then FDMAing acks is inefficient for OBSSs



- 1) ECTS can set different NAVs per subchannel (red boxes)
- 2) Otherwise ECTS contents are the same: the duration to end-of-legacy-ack for ack scheduling, eoladuration (blue arrow), plus subchannel assignments by AID (black arrows)
- 3) ECTS is broadcasted using a basic legacy rate

Assume we have a multi-channel contention mechanism that minimizes collisions and maximizes fairness and throughput



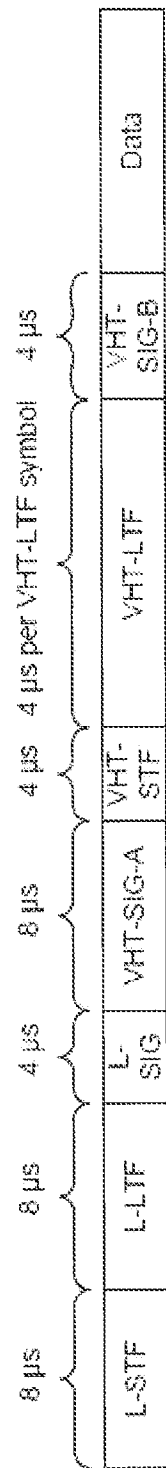
OFDMA Operation Summary

- A STA/AP indicates whether it supports OFDMA operation through HEW Capabilities element.
- Legacy (11n/ac) data PPDU's can be transmitted in a DL OFDMA TXOP to a legacy STA.
 - When padding is needed, A-MPDU is used.
 - Primary 20MHz is all/part of the transmission bandwidth for legacy PPDU transmission in a DL/UL OFDMA transmission.
- PPDU's with OFDMA indication can be transmitted in a DL/UL OFDMA transmission to OFDMA STAs.
 - It is allowed to add padding for OFDMA PPDU's to synchronize acknowledge of OFDMA transmission.
- OFDMA STAs can switch channel after receiving OFDMA SCHED frame or OFDMA Preamble.
- With SST and scheduled OFDMA service period, OFDMA STAs can switch channels at the beginning of the scheduled OFDMA service period.

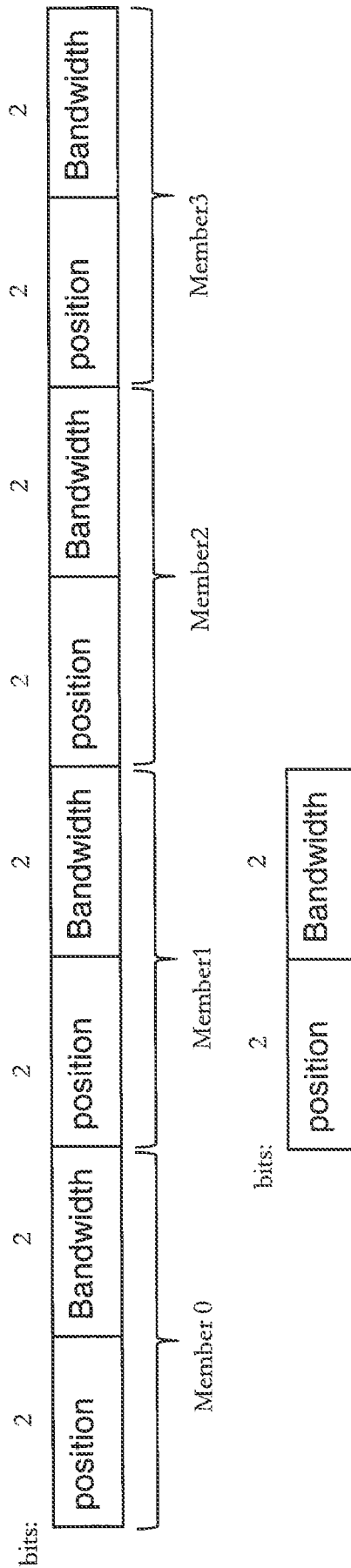


Group Management and OFDMA Preamble

- As in 11ac, in a OFDMA group, members can't be more than a fixed number, e.g. at most 4 members with fixed positions (OFDMA0, OFDMA1, OFDMA2, OFDMA3) as in 11ac's MU MIMO group.
- It is difficult to combine legacy PPDU with OFDMA PPDU when OFDMA preamble includes member channel allocation.
 - Legacy STA needs to use primary 20MHz channel. Then OFDMA STAs don't know where to detect OFDMA preamble.
 - When OFDMA group management frame includes member bandwidth allocation, member channel bandwidth indications are not required in PHY SIG.
- New control frame for OFDMA scheduling may not be required.



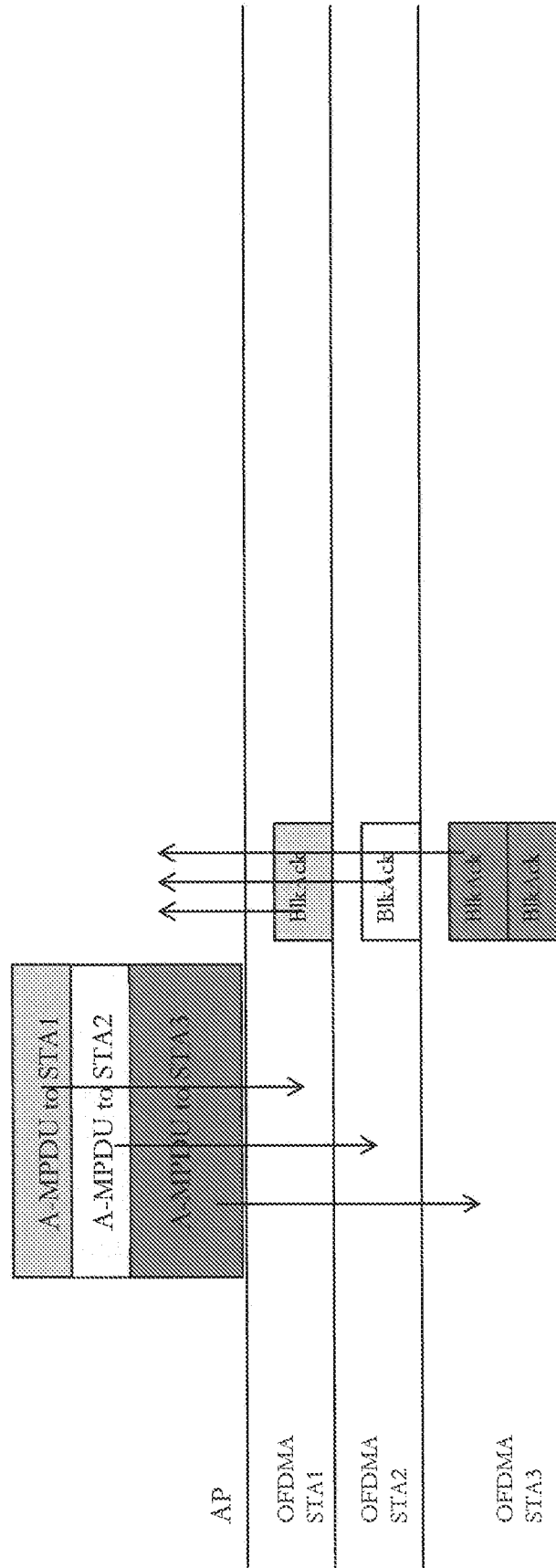
Group Management and OFDMA Preamble (Cont'd)



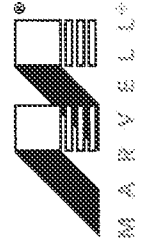
- Position:
- 00 means with lowest 20MHz channel.
 - 11 means with highest 20MHz channel.
 - X+1 means channel after x.
- Bandwidth:
- 00 ----20MHz bandwidth;
 - 01 ----40MHz bandwidth;
 - 10 ----80MHz bandwidth;
 - 11 ----160/80+80MHz bandwidth.



Group Management and OFDMA Preamble (Cont'd)

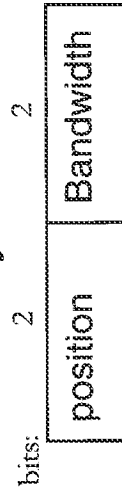


DL OFDMA



OFDMA SCHED

- Before DL/UL OFDMA, a duplicate OFDMA SCHED frame is transmitted in OFDMA TXOP channel.
- OFDMA SCHED frame includes the following information: UL PPDU length, {AID, channel position and bandwidth (4bits, see slide 5 for coding)} (1 to 4 AID channel position pairs) for DL and/or UL.
 - When OFDMA group management frame includes member bandwidth allocation, member channel bandwidth indications are not required in OFDMA CCHED.
 - Duration in OFDMA SCHED is used to protect the OFDMA TXOP.
- With OFDMA SCHED frame before UL/DL OFDMA PPDUs,
 - HEW preamble may add one bit to indicate OFDMA transmission for power control or synchronization or HEW preamble may not need to be changed. Other OFDMA indication in preamble header is also possible.
 - Legacy STAs can receives legacy PPDUs in primary 20MHz/40MHz/80MHz channel.
- OFDMA group management may not be required.



Position and Bandwidth

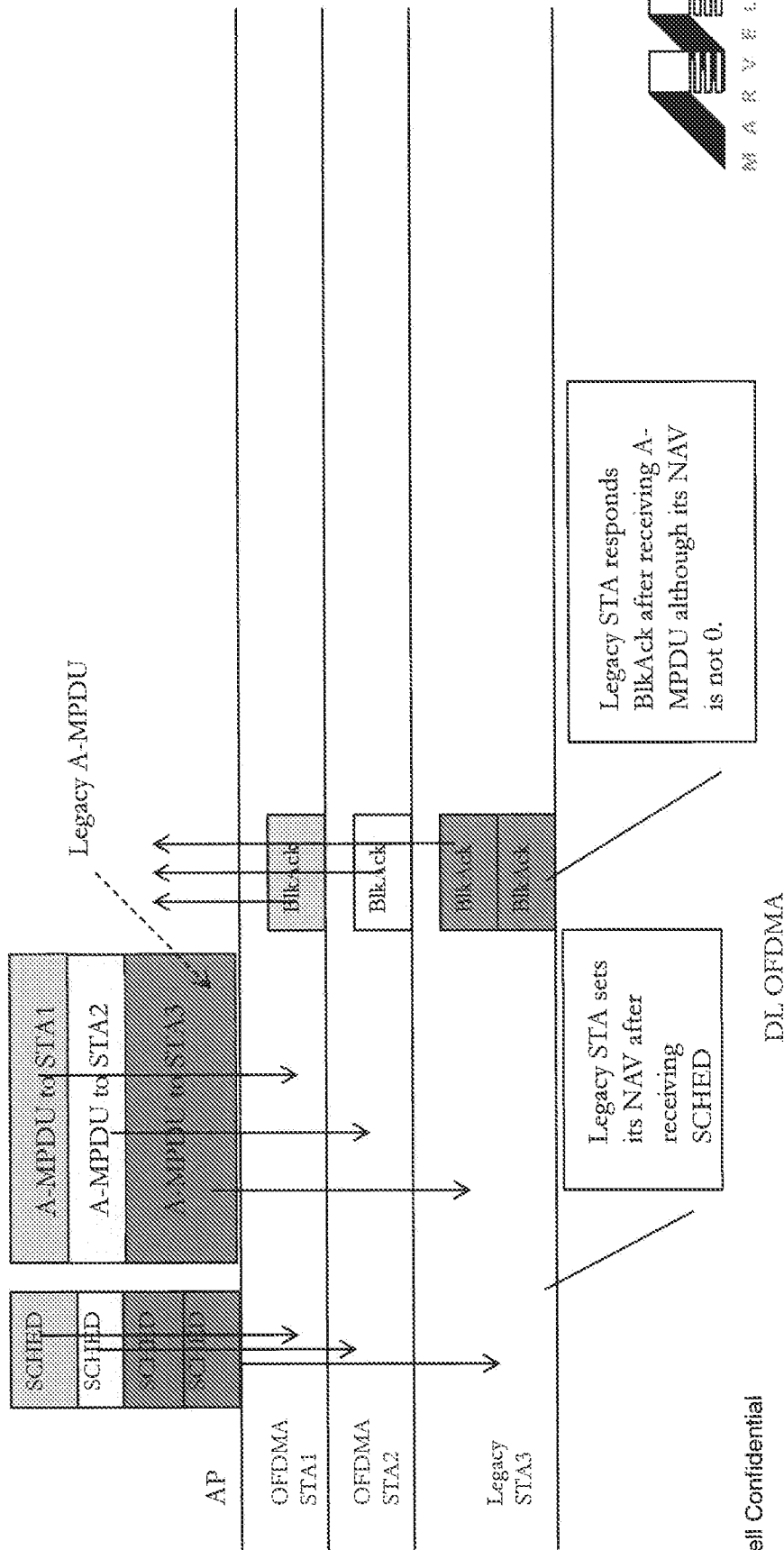


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OFDMA SCHED (Cond't)

- This is similar to [1] as shown in slide 3.
- Before SCHED transmission, primary channel backoff + secondary channel PIFS idle are used to select the OFDMA TXOP bandwidth.
- Legacy's behavior doesn't need any change in DL OFDMA.

OFDMA STAs switch to their destination channel per SCHED indication for the following DL OFDMA reception.



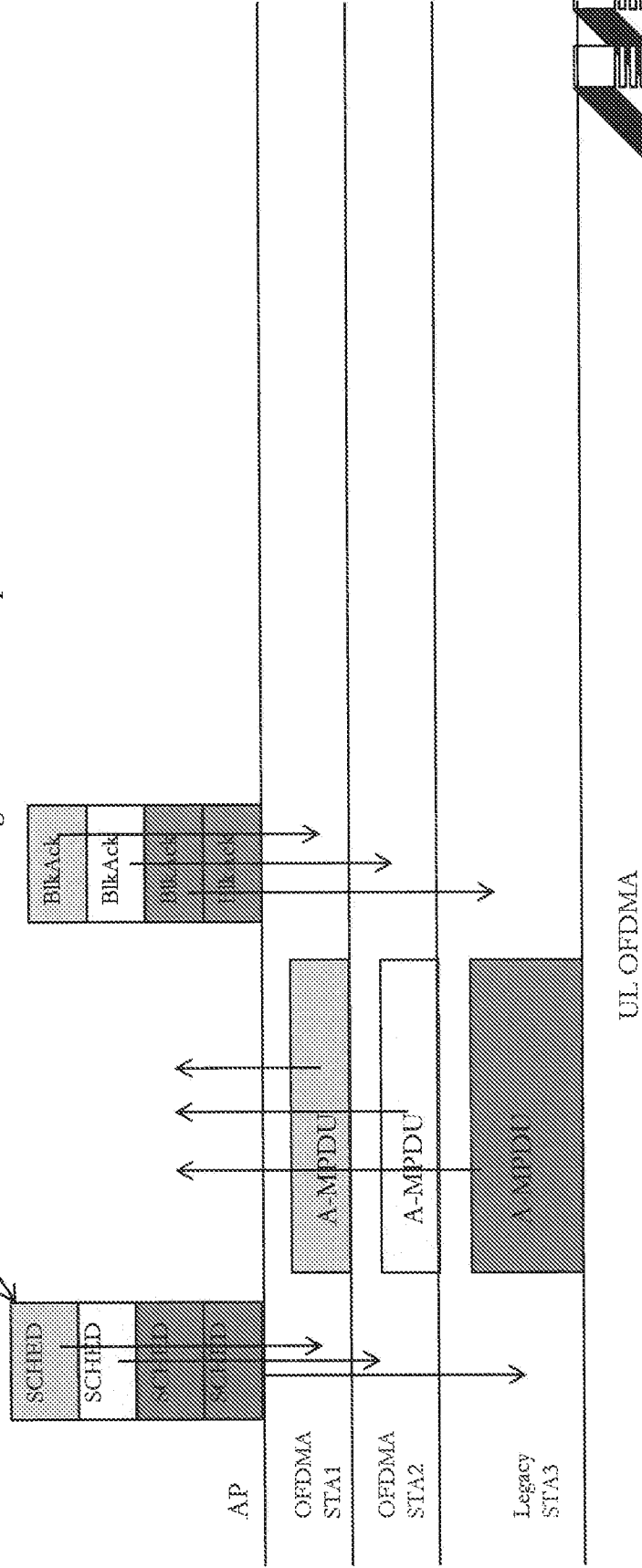
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OFDMA SCHED (Cond't)

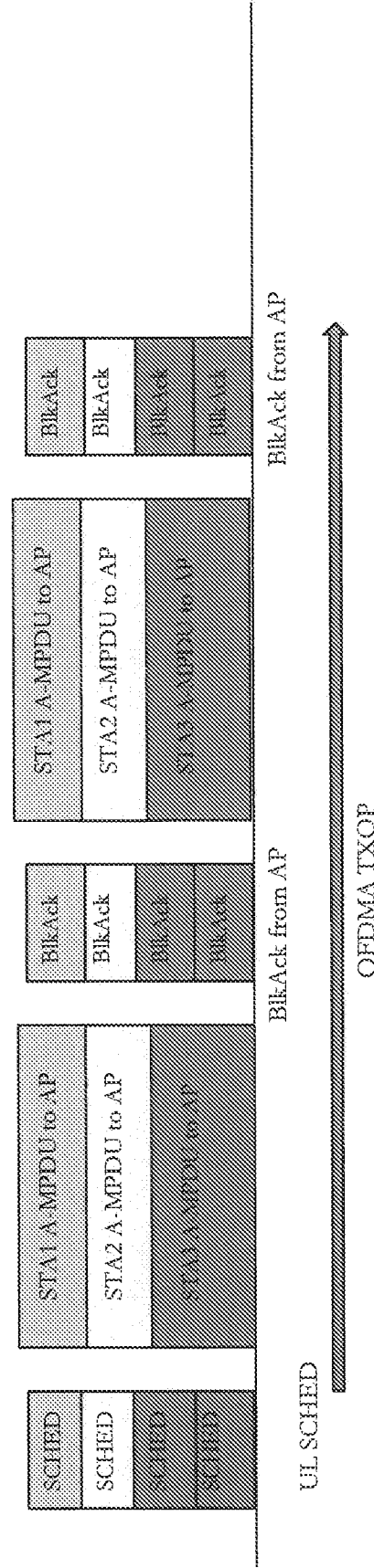
- OFDMA SCHED defines UL OFDMA PPDU length and channel allocation.
- Legacy devices is not allowed transmit UL PPDU with UL OFDMA (e.g. QoS Poll + UL PPDU).
- Otherwise, legacy STA or OFDMA STA will not get the correct channel allocation.

OFDMA STAs switch to their destination channel per SCHED indication for the following DL OFDMA reception.



UL SCHED Used for Multiple OFDMA Transmission

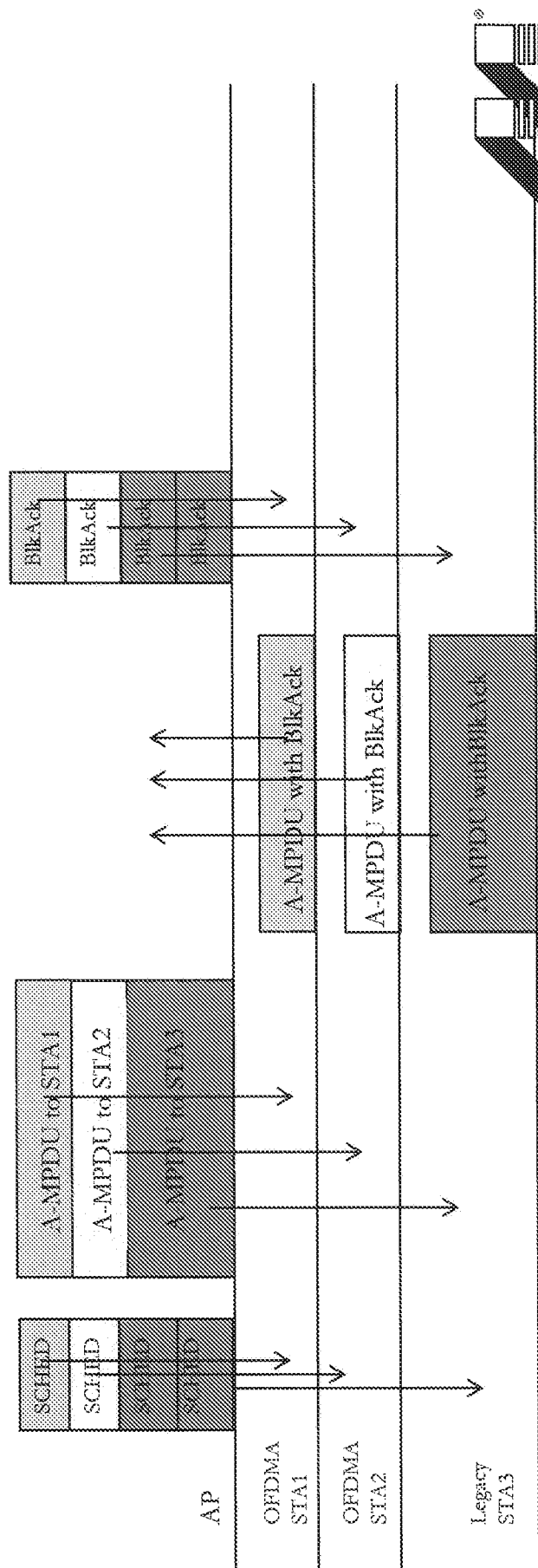
- When SCHED indicates repeat usage for the TXOP, the SCHED information can be used in the whole OFDMA TXOP.



Combination of DL+UL OFDMA

- SCHED includes DL channel bandwidth allocation, UL channel bandwidth allocation, and UL PPDU length with value > 0.
- UL BlkAck can be combined with UL A-MPDU.

OFDMA STAs switch to their destination channel per SCHED indication for the following DL OFDMA reception.



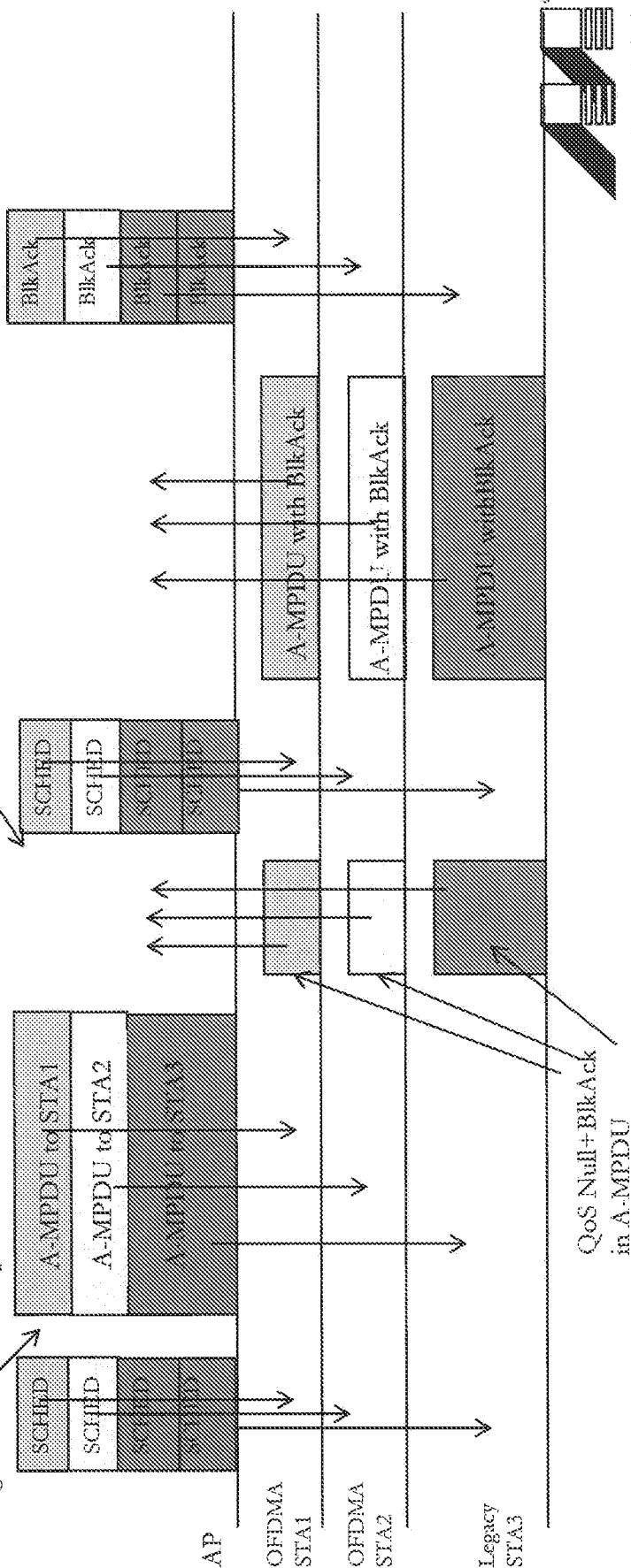
Marvell Confidential

Combination of DL+UL OFDMA (Cont'd)

- SCHED only includes DL channel bandwidth allocation when it wants to know STA's required TXOP/buffered data information.
- STAs responds with BlkAck and QoS Null to tell STA's buffered frame information.
- UL SCHED may have different channel allocation from DL SCHED.

OFDMA STAs switch to their destination channel per SCHED indication for the following DL OFDMA reception.

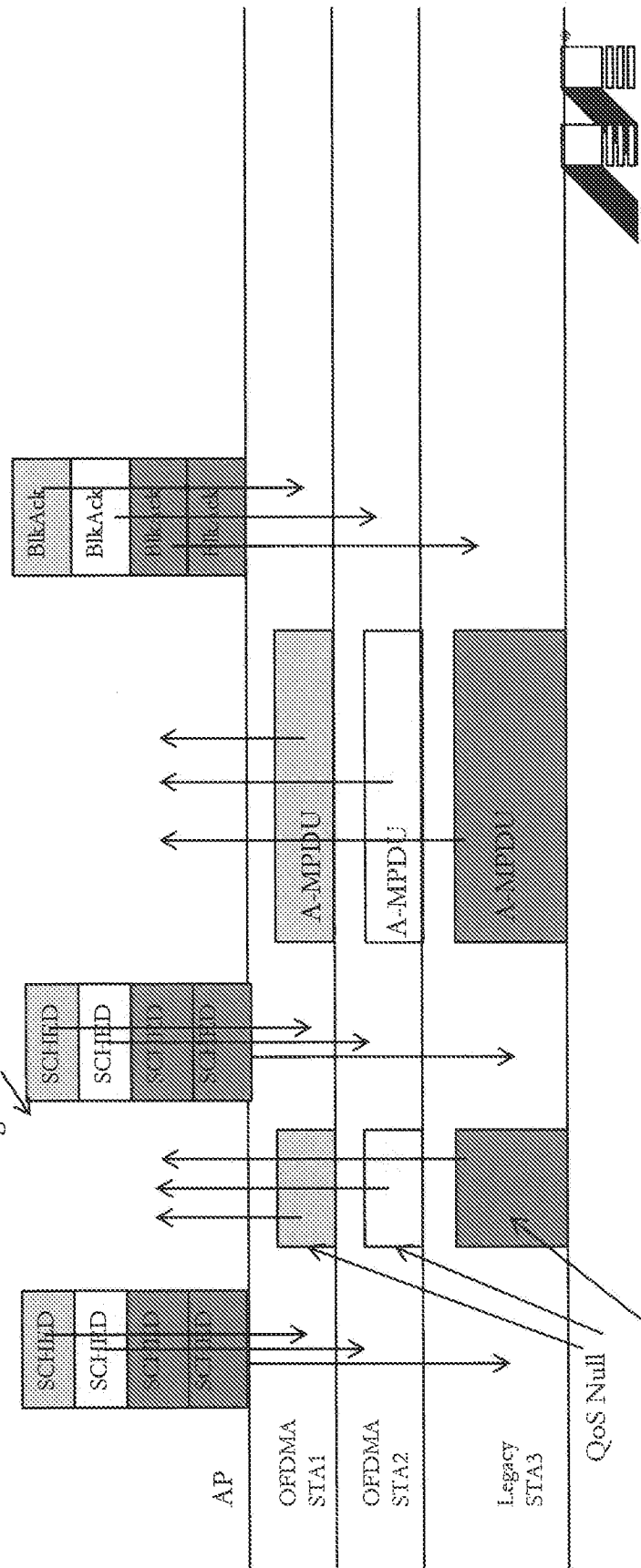
AP decides UL PPDU length per TXOP request/buffered frame indication in QoS Null. Other pull mechanism may also be used to get STAs' buffered frame information.



Uplink Buffer Polling

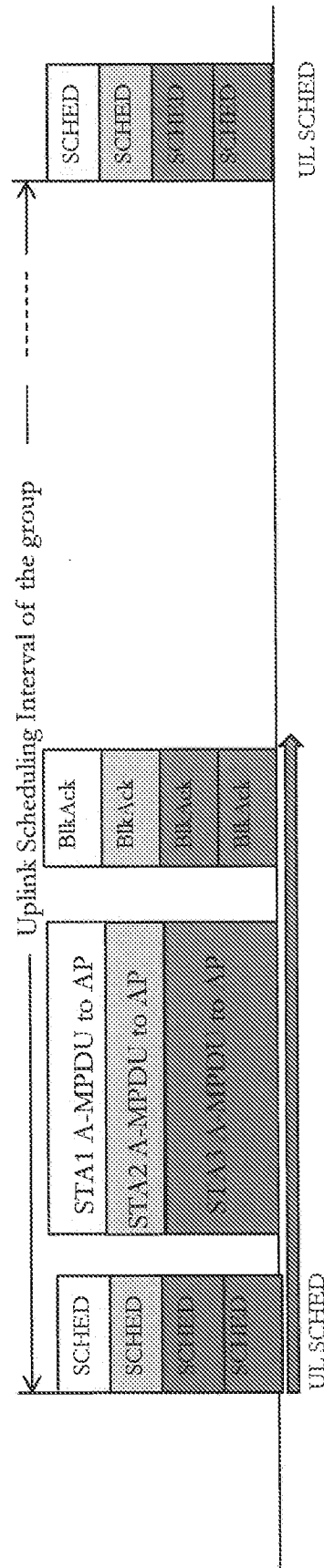
- When an AP doesn't know the buffered data information, it may poll STAs e.g.
 - through a UL SCHED with PPDU length shorter enough for QoS Null frame;
 - A poll bit in UL SCHED.
- The STAs use QoS Null or a new control frame to report buffered data length or requested TXOP.

AP decides UL PPDU length per TXOP request/buffered frame indication in QoS Null. Other pull mechanism may also be used to get STAs' buffered frame information.



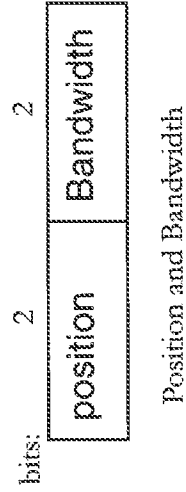
Uplink OFDMA Scheduling

- A OFDMA STA notifies the AP about its uplink traffic characteristics: proposed service interval, data rate of each AC, burst of the traffic etc. that wants UL OFDMA transmission. A new action frame and related IE may be required.
- The AP considers the STAs with similar uplink traffic characteristics as candidate to be in one UL group.
- The AP notifies the scheduling start time, duration, interval of each group to the group members. A new action frame and related IE may be required.
- The AP schedules SCHED per the negotiated scheduling information.
- AP and OFDMA can also negotiate DL OFDMA service period.

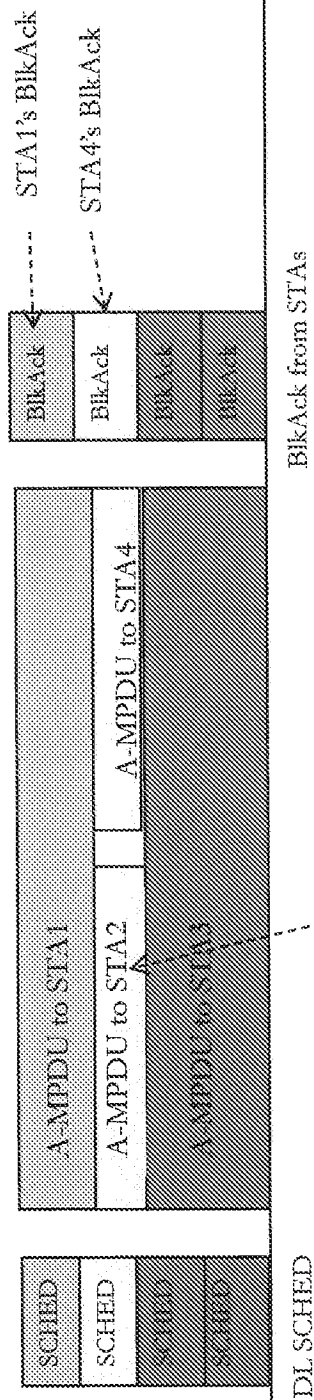


Multiple PPDUs of OFDMA in a Subchannel: SCHED

- OFDMA SCHED frame includes the following information: {AID, PPDU Length, channel position and bandwidth (4bits, see slide 5 for coding))} (Multiple AID channel position pairs) for DL and/or UL.

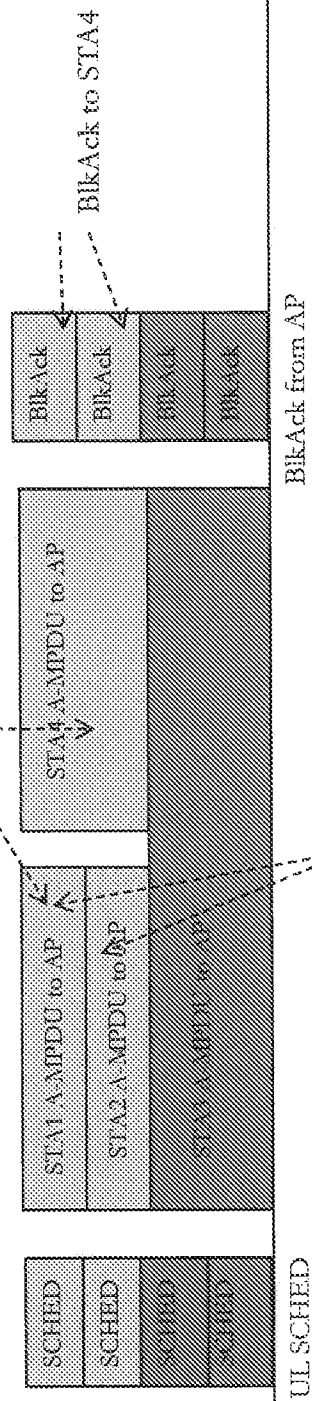


Multiple PPDUs in a Subchannel in a DL/UL OFDMA Schedule



ACK Policy is BlkAck which don't require immediate BlkAck.

A-MPDU's are from different STAs.

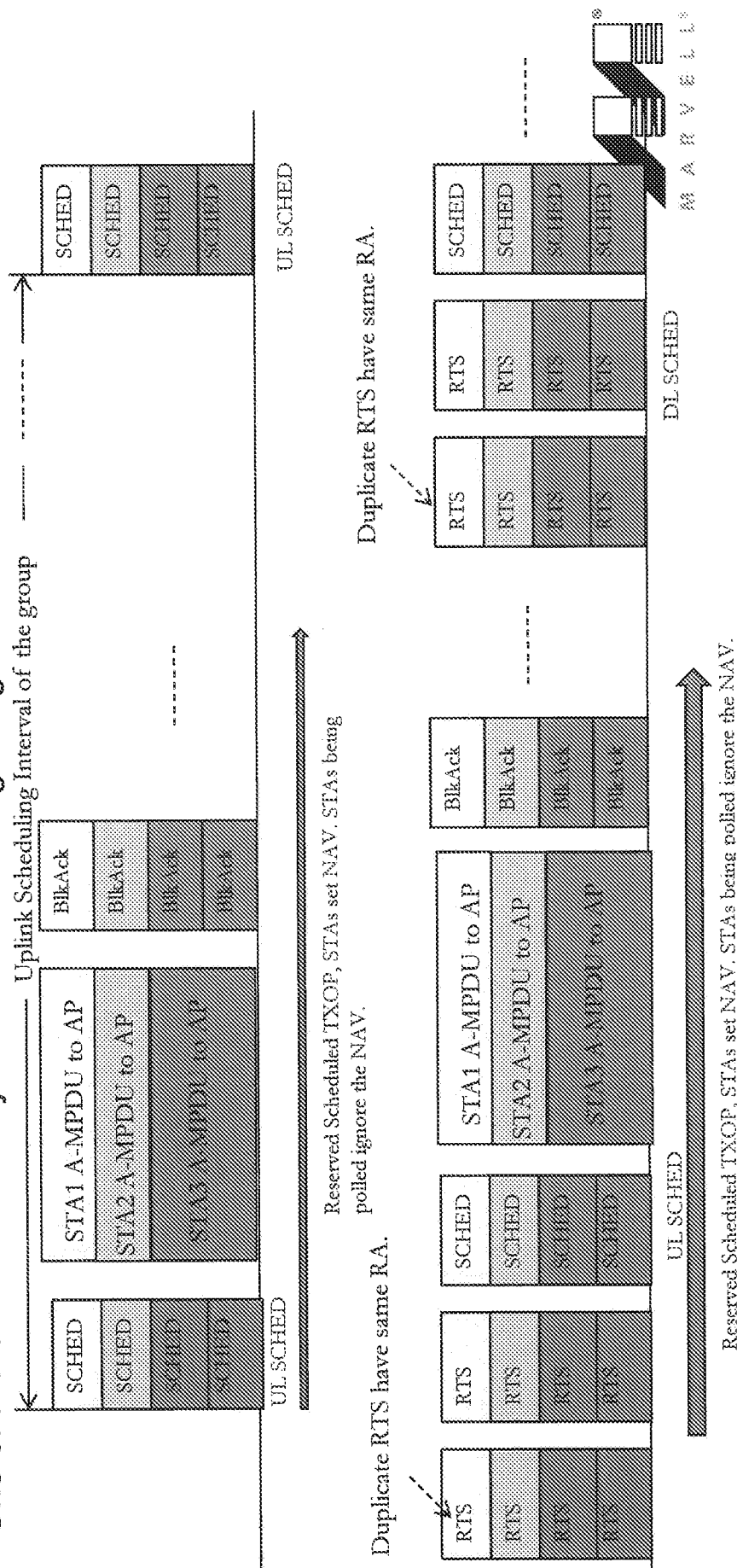


ACK Policy is BlkAck which don't require immediate BlkAck.



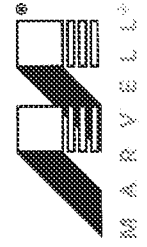
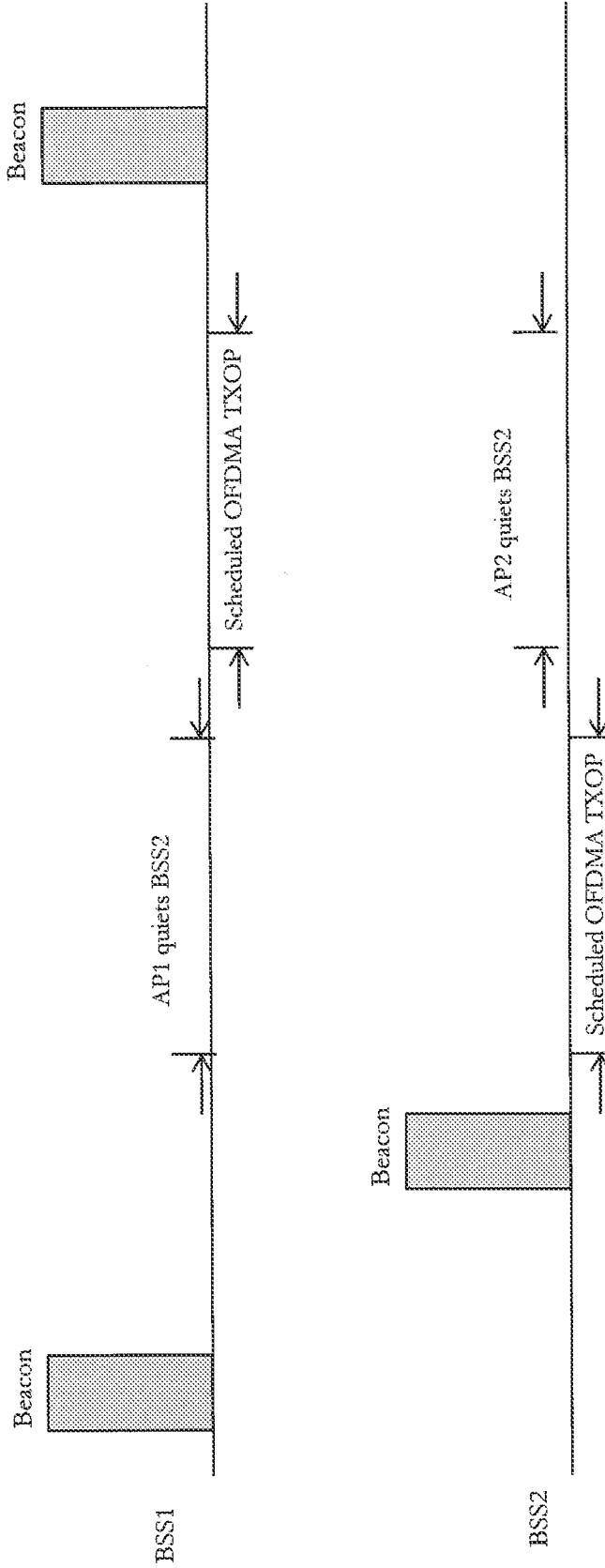
OFDMA TXOP Protection

- For the scheduled OFDMA TXOP, an AP can put the scheduled TXOP information (offset to the beacon, length of the TXOP, periodic indication etc.) in the Beacon. STAs in the BSS are not allowed to contend the medium in the scheduled TXOP Duration if they are not polled.
- 11ah's RAW may be used for protecting OFDMA service period.
- An AP may group multiple scheduled OFDMA TXOPs for the protection.
- One or more RTS/CTS may be used at the beginning of the OFDMA TXOP.



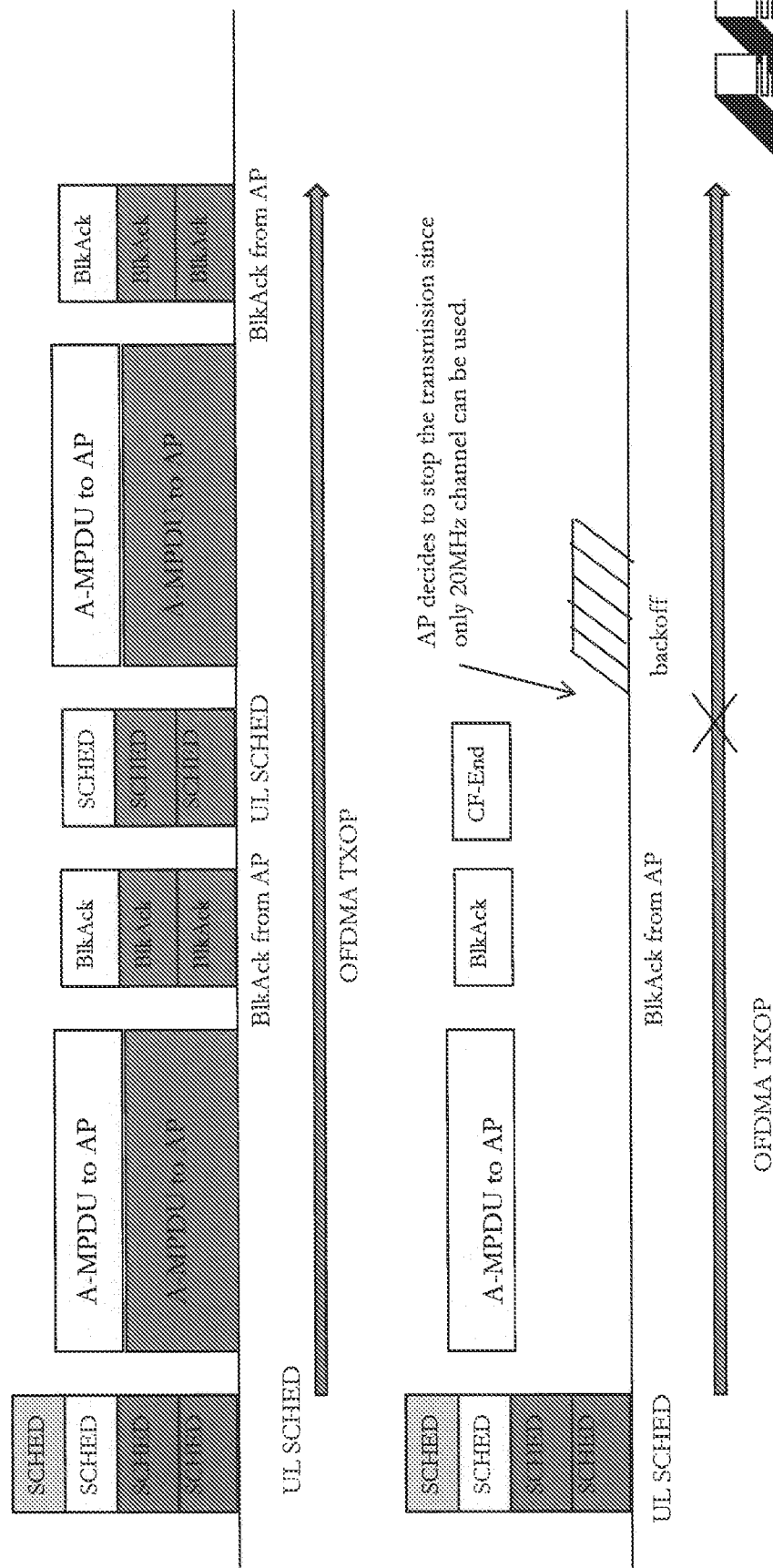
OFDMA TXOP Protection

- ◆ Neighbor BSSes can negotiate/notify scheduled OFDMA TXOP.
 - Neighbor BSSes allocate non-overlapping scheduled OFDMA TXOP.
 - A BSS can quiet its BSS when its neighbor BSS is in a scheduled OFDMA TXOP.

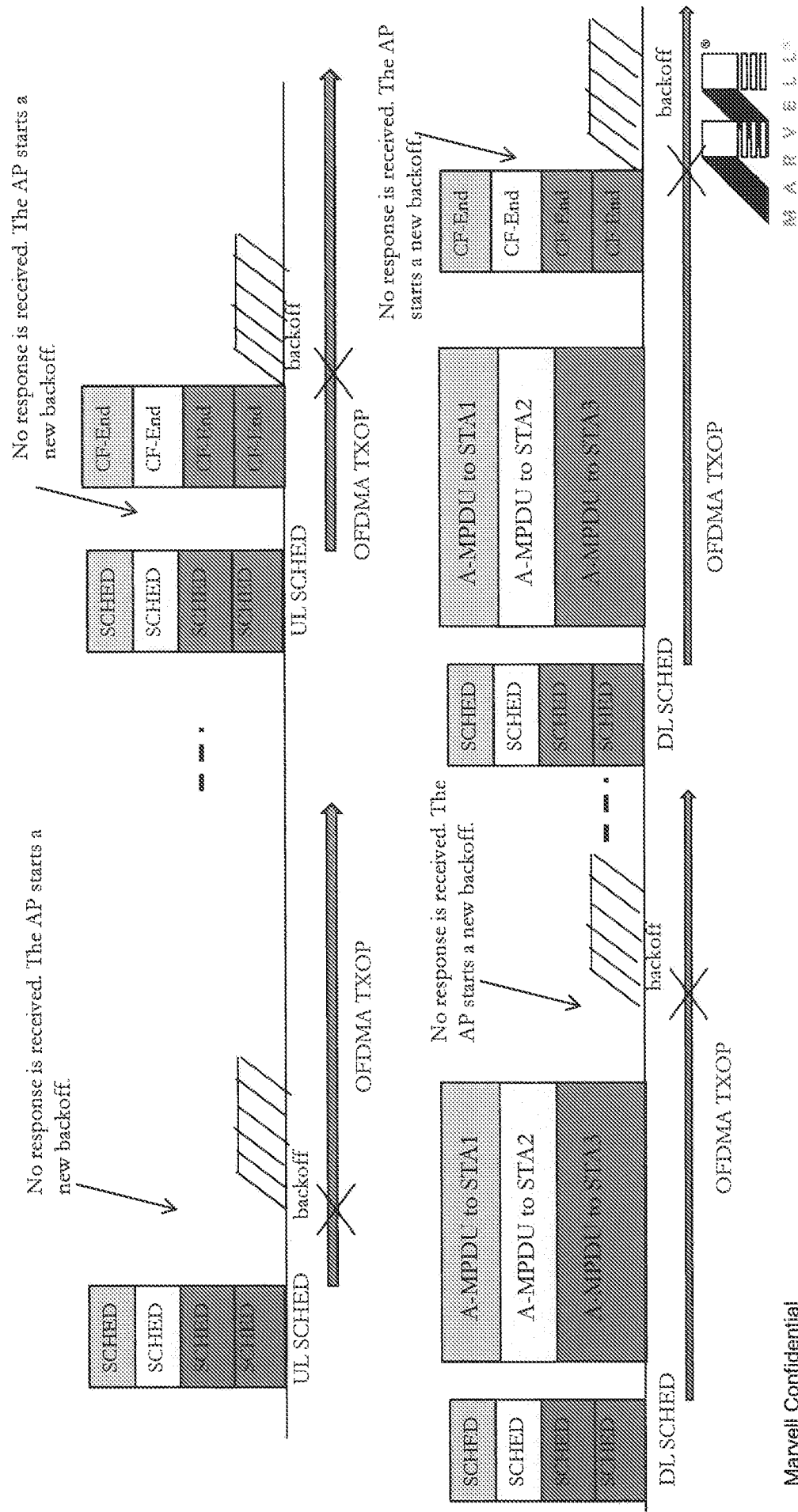


OFDMA TXOP Collision

- When no responding PPDU is received from a subchannel, the subchannel can't be used in the following frame exchange of OFDMA TXOP.

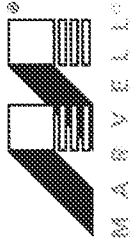
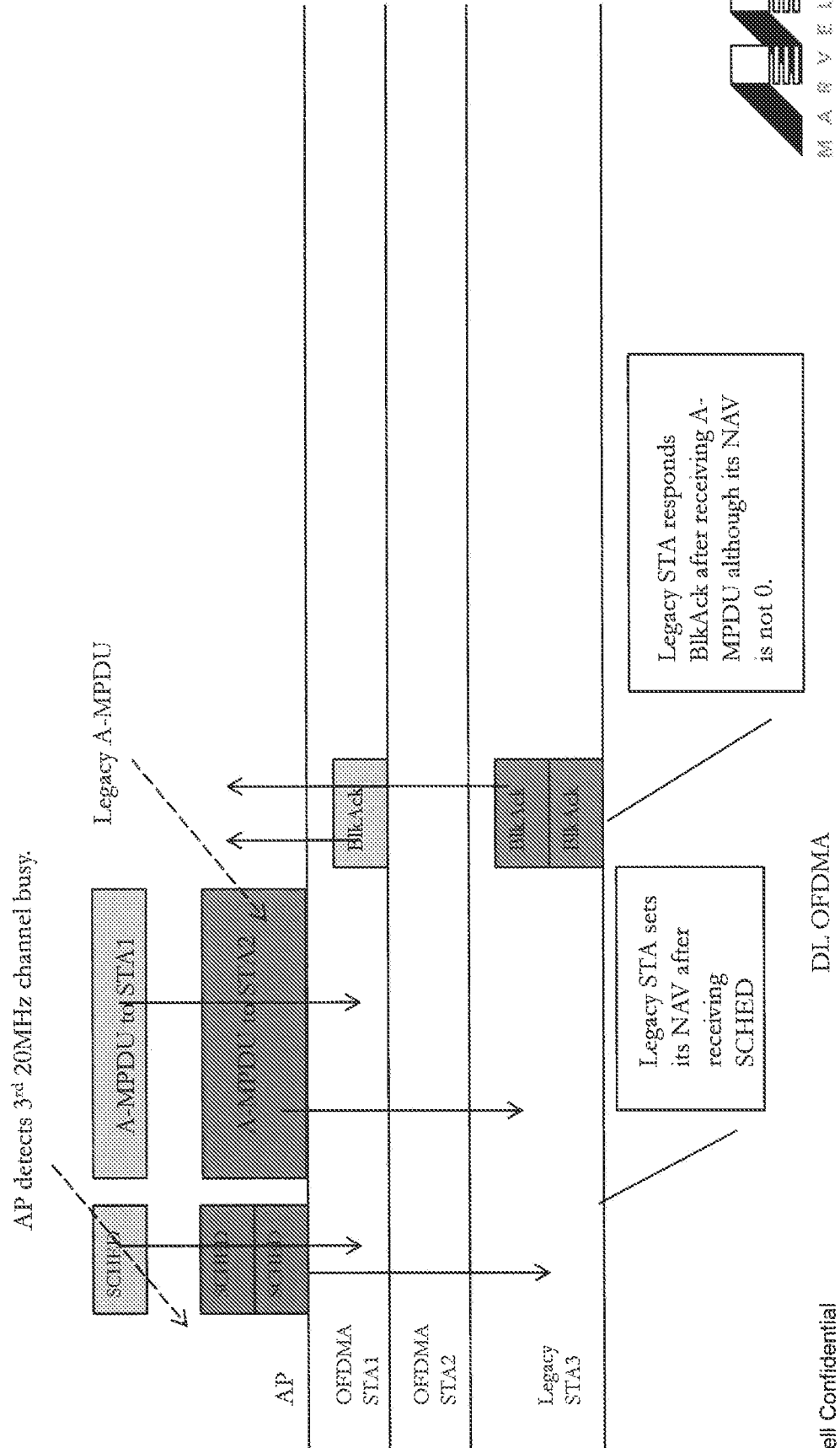


OFDMA TXOP Collision



OFDMA without Non Continuous bandwidth

- Non continuous transmission can improve throughput.



References

- [1] 11-10/371 DL-OFDMA for Mixed Clients
- [2] U.S. Application No. 12/730,651 filed on March 24, 2010, entitled "OFDMA with Block Tone Assignment for WLAN" by Hongyuan Zhang, Rohit U. Nabar and Hui-Ling Lou.
- [3] U.S. Patent No. 8,395,997, issued on March 12, 2013, entitled "MULTI-CHANNEL WIRELESS COMMUNICATIONS" by Hongyuan Zhang, Rohit U. Nabar and Hui-Ling Lou.

Electronic Patent Application Fee Transmittal

Application Number:

Filing Date:

Title of Invention:

OFDMA MAC Consideration

First Named Inventor/Applicant Name:

Liwen Chu

Filer:

Horace H. Ng/Lucie Valladares

Attorney Docket Number:

MP5524PR2

Filed as Large Entity

Provisional Filing Fees

Description

Fee Code

Quantity

Amount

**Sub-Total in
USD(\$)**

Basic Filing:

Provisional Application Filing

1005

1

260

260

Pages:

Claims:

Miscellaneous-Filing:

Petition:

Patent-Appeals-and-Interference:

Post-Allowance-and-Post-Issuance:

Extension-of-Time:

Description	Fee Code	Quantity	Amount	Sub-Total in USD(\$)
Miscellaneous:				
Total in USD (\$)				260

Electronic Acknowledgement Receipt

EFS ID:	18369535
Application Number:	61947922
International Application Number:	
Confirmation Number:	6824
Title of Invention:	OFDMA MAC Consideration
First Named Inventor/Applicant Name:	Liwen Chu
Customer Number:	23624
Filer:	Horace H. Ng/Lucie Valladares
Filer Authorized By:	Horace H. Ng
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Payment was successfully received in RAM	\$ 260
RAM confirmation Number	6491
Deposit Account	
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