

Block Ack generation and selection rules

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Name	Affiliation	Address	Phone	Email
Alfred Asterjadhi	Qualcomm	5775 Morehouse Dr. San Diego, CA, USA		aasterja@qti.qualcomm.com
Albert Van Zelst		Straatweg 66-S Breukelen, 3621 BR Netherlands		allert@qti.qualcomm.com
Alice Chen		5775 Morehouse Dr. San Diego, CA, USA		alice1@qti.qualcomm.com
Arjun Bharadwaj		5775 Morehouse Dr. San Diego, CA, USA		arj unb@qti.qualcomm.com
Bin Tian		5775 Morehouse Dr. San Diego, CA, USA		btian@qti.qualcomm.com
Carlos Aldana		1700 Technology Drive San Jose, CA 95110, USA		caldana@qca.qualcomm.com
George Cherian		5775 Morehouse Dr. San Diego, CA, USA		gcherian@qti.qualcomm.com
Gwendolyn Barriac		5775 Morehouse Dr. San Diego, CA, USA		gbarriac@qti.qualcomm.com
Hemanth Sampath		5775 Morehouse Dr. San Diego, CA, USA		hsampath@qti.qualcomm.com
Lin Yang		5775 Morehouse Dr. San Diego, CA, USA		linyang@qti.qualcomm.com
Menzo Wentink		Straatweg 66-S Breukelen, 3621 BR Netherlands		mwentink@qti.qualcomm.com
Naveen Kakani		2100 Lakeside Boulevard Suite 475, Richardson TX 75082, USA		nkakani@qti.qualcomm.com
Raja Banerjea		1060 Rincon Circle San Jose CA 95131, USA		rajab@qit.qualcomm.com
Richard Van Nee		Straatweg 66-S Breukelen, 3621 BR Netherlands		rvannee@qti.qualcomm.com

Submission

Slide 1

Authors (continued)

Name	Affiliation	Address	Phone	Email
Rolf De Vegt	Qualcomm	1700 Technology Drive San Jose, CA 95110, USA		rolfv@qca.qualcomm.com
Sameer Vermani		5775 Morehouse Dr. San Diego, CA, USA		svverman@qti.qualcomm.com
Simone Merlin		5775 Morehouse Dr. San Diego, CA, USA		smerlin@qti.qualcomm.com
Tao Tian		5775 Morehouse Dr. San Diego, CA, USA		ttian@qti.qualcomm.com
Tevfik Yucek		1700 Technology Drive San Jose, CA 95110, USA		tyucek@qca.qualcomm.com
VK Jones		1700 Technology Drive San Jose, CA 95110, USA		vkjones@qca.qualcomm.com
Youhan Kim		1700 Technology Drive San Jose, CA 95110, USA		youhank@qca.qualcomm.com
Robert Stacey	Intel	2111 NE 25th Ave, Hillsboro OR 97124, USA	+1-503-724-893	robert.stacey@intel.com
Shahrnaz Azizi				shahrnaz.azizi@intel.com
Po-Kai Huang				po-kai.huang@intel.com
Qinghua Li				qinghua.li@intel.com
Xiaogang Chen				xiaogang.c.chen@intel.com
Chitto Ghosh				chittabrata.ghosh@intel.com
Laurent Cariou				laurent.cariou@intel.com
Yaron Alpert				yaron.alpert@intel.com
Assaf Gurevitz				assaf.gurevitz@intel.com
Ilan Sutskover				ilan.sutskover@intel.com

Authors (continued)

Name	Affiliation	Address	Phone	Email
Hongyuan Zhang	Marvell	5488 Marvell Lane, Santa Clara, CA, 95054	408-222-2500	hongyuan@marvell.com
Yakun Sun				yakunsun@marvell.com
Lei Wang				Leileiw@marvell.com
Liwen Chu				liwenchu@marvell.com
Jinjing Jiang				jinjing@marvell.com
Yan Zhang				yzhang@marvell.com
Rui Cao				ruicao@marvell.com
Sudhir Srinivasa				sudhirs@marvell.com
Bo Yu				boyu@marvell.com
Saga Tamhane				sagar@marvell.com
Mao Yu				my@marvel.com
Xiayu Zheng				xzheng@marvell.com
Christian Berger				crberger@marvell.com
Niranjan Grandhe				ngrandhe@marvell.com
Hui-Ling Lou				hlou@marvell.com

Authors (continued)

Name	Affiliation	Address	Phone	Email
James Yee	Mediatek	No. 1 Dusing 1 st Road, Hsinchu, Taiwan	+886-3-567-0766	james.yee@mediatek.com
Alan Jauh				alan.jauh@mediatek.com
Chingwa Hu				chinghwa.yu@mediatek.com
Frank Hsu				frank.hsu@mediatek.com
Thomas Pare	Mediatek USA	2860 Junction Ave, San Jose, CA 95134, USA	+1-408-526-1899	thomas.pare@mediatek.com
ChaoChun Wang				chaochun.wang@mediatek.com
James Wang				james.wang@mediatek.com
Jianhan Liu				Jianhan.Liu@mediatek.com
Tianyu Wu				tianyu.wu@mediatek.com
Zhou Lan				Zhou.lan@mediaTek.com
Russell Huang	Apple			russell.huang@mediatek.com
Joonsuk Kim				joonsuk@apple.com
Aon Mujtaba				mujtaba@apple.com
Guoqing Li				guoqing_li@apple.com
Eric Wong				ericwong@apple.com
Chris Hartman				chartman@apple.com

Authors (continued)

Name	Affiliation	Address	Phone	Email
Peter Loc	Huawei			peterloc@iwirelesstech.com
Le Liu		F1-17, Huawei Base, Bantian, Shenzhen	+86-18601656691	liule@huawei.com
Jun Luo		5B-N8, No.2222 Xinjinqiao Road, Pudong, Shanghai		jun.l@huawei.com
Yi Luo		F1-17, Huawei Base, Bantian, Shenzhen	+86-18665891036	Roy.luoyi@huawei.com
Yingpei Lin		5B-N8, No.2222 Xinjinqiao Road, Pudong, Shanghai		linyngpei@huawei.com
Jiyong Pang		5B-N8, No.2222 Xinjinqiao Road, Pudong, Shanghai		pangjiyong@huawei.com
Zhigang Rong		10180 Telesis Court, Suite 365, San Diego, CA 92121 NA		zhigang.rong@huawei.com
Rob Sun		303 Terry Fox, Suite 400 Kanata, Ottawa, Canada		Rob.Sun@huawei.com
David X. Yang		F1-17, Huawei Base, Bantian, Shenzhen		david.yangxun@huawei.com
Yunsong Yang		10180 Telesis Court, Suite 365, San Diego, CA 92121 NA		yangyunsong@huawei.com
Junghoon Suh		303 Terry Fox, Suite 400 Kanata, Ottawa, Canada		Junghoon.Suh@huawei.com
Jiayin Zhang		5B-N8, No.2222 Xinjinqiao Road, Pudong, Shanghai	+86-18601656691	zhangjiayin@huawei.com
Edward Au		303 Terry Fox, Suite 400 Kanata, Ottawa, Canada		edward.ks.au@huawei.com
Teyan Chen		F1-17, Huawei Base, Bantian, Shenzhen		chenteyan@huawei.com
Yunbo Li		F1-17, Huawei Base, Bantian, Shenzhen		liyunbo@huawei.com

Authors (continued)

Name	Affiliation	Address	Phone	Email
Jinmin Kim	LG Electronics	19, Yangjae-daero 11gil, Seocho-gu, Seoul 137- 130, Korea		Jinmin1230.kim@lge.com
Kiseon Ryu				kiseon.ryu@lge.com
Jinyoung Chun				jiny.chun@lge.com
Jinsoo Choi				js.choi@lge.com
Jeongki Kim				jeongki.kim@lge.com
Dongguk Lim				dongguk.lim@lge.com
Suhwook Kim				suhwook.kim@lge.com
Eunsung Park				esung.park@lge.com
JayH Park				Hyunh.park@lge.com
HanGyu Cho				hg.cho@lge.com
Thomas Derham	Orange			thomas.derham@orange.com
Bo Sun	ZTE	#9 Wuxingduan, Xifeng Rd., Xi'an, China		sun.bo1@zte.com.cn
Kaiying Lv				lv.kaiying@zte.com.cn
Yonggang Fang				yfang@ztetx.com
Ke Yao				yao.ke5@zte.com.cn
Weimin Xing				xing.weimin@zte.com.cn
Brian Hart	Cisco Systems	170 W Tasman Dr, San Jose, CA 95134		brianh@cisco.com
Pooya Monajemi				pmonajem@cisco.com

Authors (continued)

Name	Affiliation	Address	Phone	Email
Fei Tong	Samsung	Innovation Park, Cambridge CB4 0DS (U.K.)	+44 1223 434633	f.tong@samsung.com
Hyunjeong Kang		Maetan 3-dong; Yongtong-Gu Suwon; South Korea	+82-31-279-9028	hyunjeong.kang@samsung.com
Kaushik Josiam		1301, E. Lookout Dr, Richardson TX 75070	(972) 761 7437	k.josiam@samsung.com
Mark Rison		Innovation Park, Cambridge CB4 0DS (U.K.)	+44 1223 434600	m.rison@samsung.com
Rakesh Taori		1301, E. Lookout Dr, Richardson TX 75070	(972) 761 7470	rakesh.taori@samsung.com
Sanghyun Chang		Maetan 3-dong; Yongtong-Gu Suwon; South Korea	+82-10-8864-1751	s29.chang@samsung.com
Yasushi Takatori	NTT	1-1 Hikari-no-oka, Yokosuka, Kanagawa 239-0847 Japan		takatori.yasushi@lab.ntt.co.jp
Yasuhiko Inoue				inoue.yasuhiko@lab.ntt.co.jp
Shoko Shinohara				Shinohara.shoko@lab.ntt.co.jp
Yusuke Asai				asai.yusuke@lab.ntt.co.jp
Koichi Ishihara				ishihara.koichi@lab.ntt.co.jp
Junichi Iwatani				Iwatani.junichi@lab.ntt.co.jp
Akira Yamada	NTT DOCOMO	3-6, Hikarinooka, Yokosuka-shi, Kanagawa, 239-8536, Japan		yamadaakira@nttdocomo.com
Fujio Watanabe				watanabe@docomoinnovations.com
Haralabos Papadopoulos				hpapadopoulos@docomoinnovations.com
Sigurd Schelstraete	Quantenna			Sigurd@quantenna.com
Huizhao Wang				hwang@quantenna.com

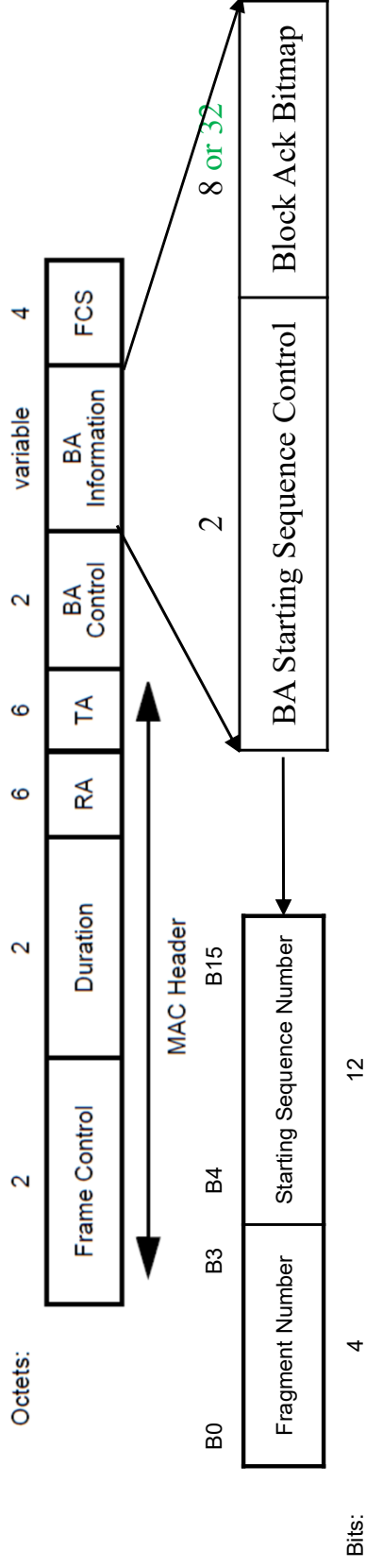
Authors (continued)

Name	Affiliation	Address	Phone	Email
Ron Porat	Broadcom			rporat@broadcom.com
Sriram Venkateswaran				mfischer@broadcom.com
Matthew Fischer				
Leo Montreuil				
Andrew Blanksby				
Vinko Erceg				
Masahito Mori	Sony Corp.			YusukeC.Tanaka@jp.sony.com
Yusuke Tanaka				Yuichi.Morioka@jp.sony.com
Yuichi Morioka				Kazuyuki.Sakoda@am.sony.com
Kazuyuki Sakoda				William.Carney@am.sony.com
William Carney				
Minho Cheong	Newracom	9008 Research Dr. Irvine, CA 92618		minho.cheong@newracom.com
Reza Hedayat				reza.hedayat@newracom.com
Young Hoon Kwon				younghoon.kwon@newracom.com
Yongho Seok				yongho.seok@newracom.com
Daewon Lee				daewon.lee@newracom.com
Yujin Noh				yujin.noh@newracom.com

Introduction

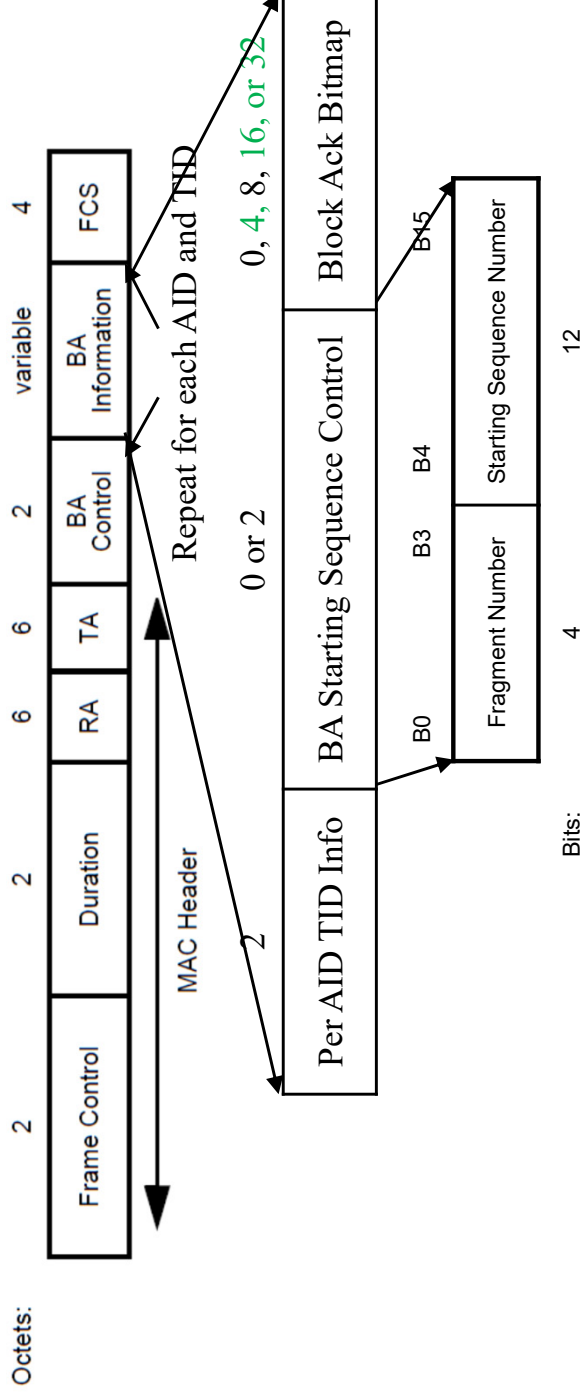
- **11ax uses two frame formats for BlockAck frames**
 - Compressed BlockAck (C-BA) and Multi-STA BlockAck (M-BA)
- **Each of which has signaling details for Bitmap lengths yet to be specified**
 - Both use the Fragment Number fields, though with undefined mapping[1, 2]
- **Same consideration for BlockAck frame/length selection rules [3]**
 - Both need signaling on which frame/length needs to be used
- **We propose to finalize the following design details:**
 - Mapping of Fragment Number subfield of BA frames and their BA Bitmap lengths
 - Negotiation and selection of BlockAck frames during a block ack session
 - Including BAR solicitation of these BA frames
- **While being compliant to baseline and passed motions on these topics**

Compressed BlockAck frame



- According to REVmc D5.0 and 11ax D0.1:
 - Fragment Number is 0 in C-BlockAck frame
 - Fragment Number equal to 1 indicates re-mapping of BA Bitmap for fragmentation level 3 [3]
- [1] proposed a variant of C-BA frame with 256-bits BA Bitmap field
 - Reserved bit(s) in Fragment Number field of the frame indicates length of the BA Bitmap
- We propose this mapping of the Fragment Number subfield
 - B0 of Fragment Number is 1 to indicate that re-mapping of BA Bitmap for Fragmentation level 3 is ON [3]
 - B2 and B1 of Fragment Number indicate the length of the BA Bitmap field for C-BA frame
 - Only two values are defined in this case: 8 or 32 Bytes, as defined in [1]
 - B3 is reserved
- Same signaling applies to M-BA frames as well, with more options for Bitmap length [2]
 - See next slide for more details

Multi-STA BlockAck frame



- [2] proposed a variant of M-BA frame with variable length BA Bitmap field

- Length of the BA Bitmap field is indicated in Fragment Number field of the M-BA

- We propose this mapping of the Fragment Number subfield

- B0 of Fragment Number is 1 to indicate that re-mapping of BA Bitmap for Frag. L3 is ON [3]
- B2 and B1 of Fragment Number indicate the length of the BA Bitmap field for M-BA frame
 - Possible values are 4, 8, 32 and TBD, as defined in [2]
 - We also propose to define the TBD as 16
- B3 is reserved

Mapping for FN subfield of BA frames

4, 8, 16, or 32

Fragment Number	Starting Sequence Number	Block Ack Bitmap
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4

12

variable

Fragment Number subfield			BA Bitmap Length field [Octets]-Fragmentation L3 [ON/OFF]		Maximum number of MSDUs/A-MSDUs that can be acknowledged
B3	B2	B1	B0	Multi-STA Block Ack	
0	0		0	Compressed Block Ack Bitmap [8 Octets] – Frag [OFF]	64
0	1		0	Reserved	128
0	2		0	Bitmap [32 Octets] – Frag [OFF]	256
0	3		0	Reserved	32
0	0		1	Bitmap [8 Octets] – Frag [ON]	16
0	1		1	Reserved	32
0	2		1	Bitmap [32 Octets] – Frag [ON]	64
0	3		1	Reserved	8
1	Any		Any	Reserved	

Block Ack negotiation/selection

- **Reminder - Baseline rules:**
 - Originator/recipient negotiate BA op. parameters during HT-Immediate BA setup
 - During which, along other parameters for a TID, Buffer Size is also negotiated
 - Note: each MPDU consumes one of these Buffers
- **Passed motions:**
 - Both C-BA and M-BA frames can be used, both with variable Bitmap lengths [1, 2]
 - M-BA will be used as a response frame for UL MU PPDU, multi-TID A-MPDUs:
 - A value of 15 in TID subfield of Per STA TID Info field of M-BA frame indicates successful acknowledgement of a MGMT frame that requires an immediate response and is carried in the soliciting A-MPDU [5]
 - The spec shall allow UL MU transmission of Multi-STA Block ACK frame in response to multi-TID A-MPDU of DL MU transmission. The value of AID field in M-BA is TBD [6]
 - MPDUs from multiple TIDs that ask for Ack/BA acknowledgement and one MGMT frame that asks for Ack may be aggregated in one A-MPDU of MU transmission [6]
 - RX indicates max. # of TIDs the originator can aggregate in multi-TID A-MPDU[4]
 - Etc.

Proposed rules: BA Bitmap/TID selection

- **BA Bitmap length is negotiated during BA setup (for each TID)**
 - Block Ack Bitmap length of the BA frame is tied to the negotiated buffer size, e.g.,
 - If buffer size is within [1, 64] then Bitmap length of 64 will be used during the BA session
 - If buffer size is within [65, 256] then Bitmap length of 256 will be used during the session
- **Max. number of TIDs that can be aggregated in an A-MPDU is indicated in the HE Capabilities IE sent by the recipient**
 - Zero value indicates no support for multi-TID A-MPDU
 - >0 indicates support for multi-TID A-MPDU and # of TIDs allowed in A-MPDU
 - Note 1: Currently D0.1 has 1 bit for multi-TID support in HE Capabilities IE
 - This indication is valid for both AP and non-AP STAs
 - Note 2: The AP can still dynamically govern the max # of TIDs of QoS Data frames that each STA is allowed to aggregate in their A-MPDUs within an UL MU PPDU*
 - By signaling that number to each STA in the Trigger frame

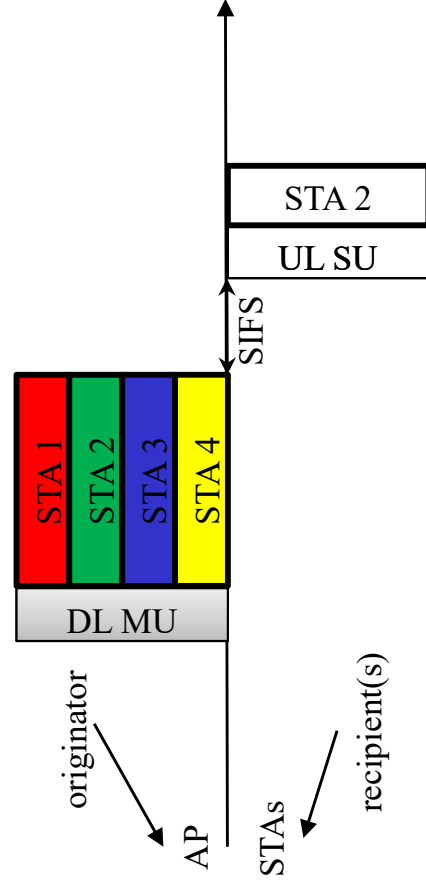
***UL MU PPDU refers to trigger-based PPDU in this slide deck**

BlockAck frame selection

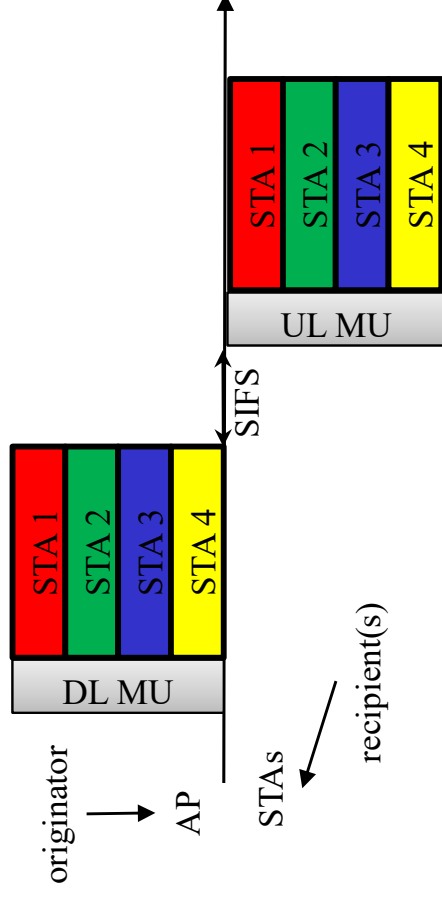
- **Support/selection of BA frames**
 - C-BlockAck shall be supported if HT-immediate BA is supported
 - Same as baseline
 - M-BA shall be supported if either UL MU or multi-TID A-MPDU is supported
 - Used as default response by AP to UL MU PPDUs and by STA to multi-TID A-MPDUs*
 - Which could contain an Action Ack frame as well.
 - We need capability bit from the originator to indicate RX support of ALL ACK signaling
 - This is because originator needs to keep track of the state of all TXed MPDUs in an A-MPDU for all TIDs, Action Ack frame, and compare this state with each of Rxed multi-TID blockack records
- **Control response frame generation for SU PPDUs follow baseline:**
 - Consistently use Ack/C-BA frames
 - C-BA Bitmap length is negotiated during setup, and used consistently during BA session
 - This ensures consistency in BW/MCS/NAV setting rules
- **Control response frame generation for MU PPDUs is described next**
 - See slides 16-20

Reference exchange sequences

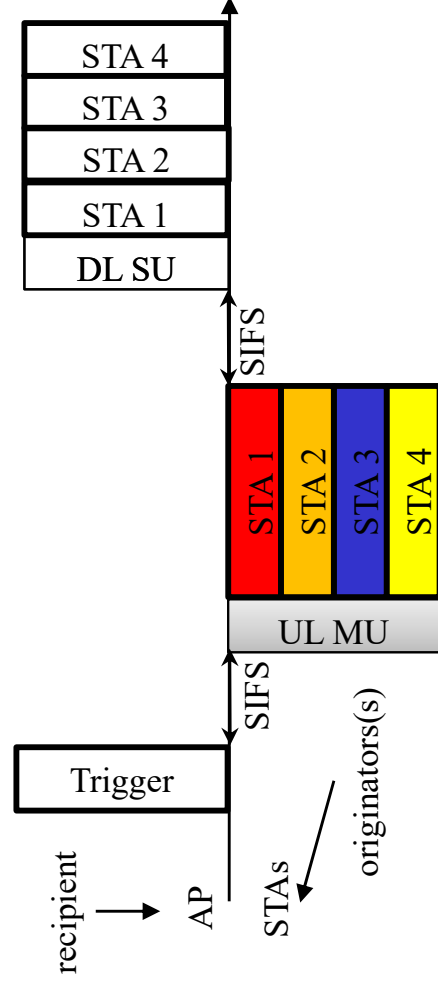
1) DL MU PPDU | SIFS | UL SU response



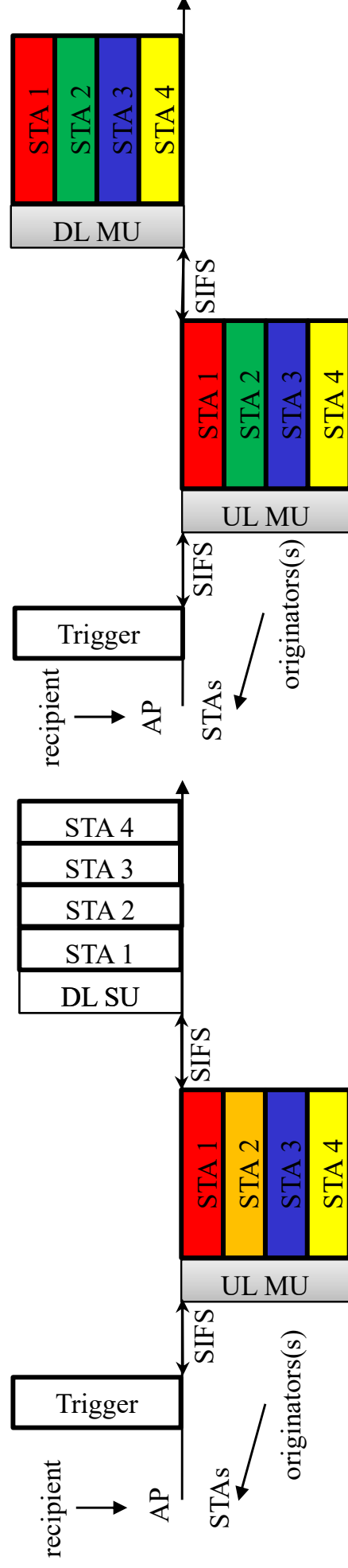
2) DL MU PPDU | SIFS | UL MU response



3) UL MU PPDU | SIFS | DL SU response



4) UL MU PPDU | SIFS | DL MU response



1) DL MU PPDU | SIFS | UL SU response

# of originators generating the DL MU PPDU	Content of the A-MPDU(s) carried in the DL MU PPDU	Ack Policy setting	Control response frame generated by the recipient	UL PPDU response format
ONE (AP)	(A-) MPDU	No Ack or BlockAck	No Response	N/A
ONE	VHT Single MPDU	Normal Ack*	Ack frame	SU
ONE	A-MPDU	Implicit BAR*	C-BA frame	SU
ONE	Multi-TID A-MPDU**	Implicit BAR*	M-BA frame	SU
*Normal Ack and Implicit BAR are represented by the same value of the Ack Policy.				

- **Further considerations for the soliciting DL MU PPDU:**
 - Only one of the recipients can have the Ack Policy setting to Normal Ack* within the DL MU PPDU
 - The A-MPDU under these conditions** cannot contain an Action Ack frame
 - Action Ack frames do not have an Ack Policy field to differentiate between SU and MU
 - As such we can enable one way (preferred UL MU since most common case for DL MU responses)
 - DL MU PPDU contains neither Trigger frames nor UL MU Response scheduling

2) DL MU PPDU | SIFS | UL MU response

# of originators generating the DL MU PPDU	Content of an (A-) MPDU carried in the DL MU PPDU	Ack Policy setting [# recipients]	Control response frame generated by each recipient	UL PPDU response format
ONE (AP)	(A-) MPDU	No Ack or BlockAck [ALL]	No Response	N/A
ONE	VHT Single MPDU	MU Ack** [≥ 0]	Ack frame	UL MU PPDU*
ONE	A-MPDU	MU Ack [> 0]	C-BA frame	UL MU PPDU*
ONE	Multi-TID A-MPDU***	MU Ack [> 0]	M-BA frame	UL MU PPDU*

*STAs cannot solicit response from AP to an UL MU PPDU if Trigger info in DL MU PPDU was not Basic or was UL MU Response Sched.
 *STAs can solicit a response from the AP to the UL MU PPDU if the Trigger carried in the DL MU PPDU was a Basic Trigger.
 **MU Ack is signaled by a value of PSMP Ack value of the Ack Policy.

- **Further considerations for the soliciting DL MU PPDU:**
 - An A-MPDU under these conditions*** may contain an Action Ack frame
 - Action Ack frames do not have an Ack Policy field to differentiate between SU and MU (preferred)
 - I.e., by default the response to DL Multi-TID A-MPDU frames containing this MPDU is in MU mode
 - The # of TIDs carried in multi-TID A-MPDU cannot exceed the # of TIDs specified by RX [4]
- **Recipient can only respond to the DL MU PPDU if its allocated RU contained:**
 - Either one/more Trigger frames or one/more HE variant HT Control fields with UL MU Response Scheduling but not both

3) UL MU PPDU | SIFS | DL SU response

# of originators generating the UL MU PPDU	Content of the A-MPDU(s) carried in the UL MU PPDU	Ack Policy setting [# originators]	Control response frame generated by the recipient (AP)	DL PPDU response format
ONE/MORE (non-AP STAs)	(A-)MPDU	No Ack [ALL]	No Response	N/A*
ONE/MORE	VHT Single MPDU	Normal Ack [≥ 0]	Ack [if 1 orig.] or M-BA [if > 1 orig.]	SU**
ONE/MORE	A-MPDU	Implicit BAR [> 0]	C-BA [if 1 orig.] or M-BA [if > 1 orig.]	SU**
ONE/MORE	Multi-TID A-MPDU***	Implicit BAR [> 0]	M-BA frame [if > 0 orig.]	SU**

*STAs cannot solicit response to UL MU PPDU if Trigger soliciting this UL MU PPDU was not Basic or was UL MU Response Sched. field.
 **STAs can solicit a response to the UL MU PPDU if the Trigger that solicited this UL MU PPDU was a Basic Trigger.

- **Further considerations for the soliciting UL MU PPDU:**
 - An A-MPDU under these conditions*** may contain an Action Ack frame
 - By default the response to Multi-TID A-MPDU frames containing this MPDU is an M-BA
 - The # of TIDs carried in multi-TID A-MPDU cannot exceed the number of TIDs specified by the recipient [4]

4) UL MU PPDU | SIFS | DL MU response

# of originators generating the UL MU PPDU	Content of the A-MPDU(s) carried in the UL MU PPDU	Ack Policy setting [# originators]	Control response frame generated by the recipient (AP)	DL PPDU response format
ONE/MORE (non-AP STAs)	(A-)MPDU	No Ack [ALL]	No Response	N/A*
ONE/MORE	VHT Single MPDU	Normal Ack [> 0]	Ack [if 1 orig.] M-BA [if > 1 orig.]	MU**
ONE/MORE	A-MPDU	Implicit BAR [>0]	C-BA [if 1 orig.] M-BA [if > 1 orig.]	MU**
ONE/MORE	Multi-TID A-MPDU***	Implicit BAR [>0]	M-BA frame [if > 0 orig.]	MU**

*STAs cannot solicit response to UL MU PPDU if Trigger soliciting this UL MU PPDU was not Basic or was UL MU Response Sched. field.
 **STAs can solicit a response to UL MU PPDU if the Trigger that solicited this UL MU PPDU was a Basic Trigger.

- **Further considerations for the soliciting UL MU PPDU:**
 - An A-MPDU under these conditions*** may contain an Action Ack frame
 - By default the response to Multi-TID A-MPDU frames containing this MPDU is an M-BA
 - The # of TIDs carried in multi-TID A-MPDU cannot exceed the number of TIDs specified by the recipient [4]

BAR-solicited BA frames

- **Originator may solicit BA frames with a BAR frame which shall be either:**
 - The only MPDU carried in the PPDU (same as baseline)
 - The last MPDU of the A-MPDU (same as baseline)
 - Included as part of the BAR variant of the Trigger frame
 - If this Trigger is aggregated in an A-MPDU then no other BAR frames shall be present in the A-MPDU
- **BAR frame (or content of the MU BAR variant of Trigger) can be either:**
 - Compressed BAR if maximum number of TIDs supported by recipient is 1
 - Multi-TID BAR if maximum number of TIDs supported by recipient is 1 or more

Summary

- **We discuss the remaining design details for BA operation:**
 - Provide BA selection rules for variable bitmaps and multi-TID support
 - And propose FN signaling for the variable lengths of BA frames
 - Provide the respective per-PPDU acknowledgment rules
 - Clarify presence of BAR frames
- **While ensuring that the new operations/additions do not affect:**
 - NAV duration setting, MCS selection rules, BA rules, scoreboard maintenance, its advancement, etc.

Straw Poll 1

Do you support to add to the 11ax SFD the following mapping for the FN subfield of BA frames?

Fragment Number subfield				BA Bitmap Length field [Octets]-Fragmentation L3 [ON/OFF]	Maximum number of MSDUs/A-MSDUs that can be acknowledged
B3	B2	B1	B0	Compressed Block Ack	Multi-STA Block Ack
0	0	0	0	Bitmap [8 Octets] – Frag [OFF]	Bitmap [8 Octets] – Frag [OFF]
0	1	0	0	Reserved	Bitmap [16 Octets] – Frag [OFF]
0	2	0	0	Bitmap [32 Octets] – Frag [OFF]	Bitmap [32 Octets] – Frag [OFF]
0	3	0	0	Reserved	Bitmap [4 Octets] – Frag [OFF]
0	0	1	1	Bitmap [8 Octets] – Frag [ON]	Bitmap [8 Octets] – Frag [ON]
0	1	1	1	Reserved	Bitmap [16 Octets] – Frag [ON]
0	2	1	1	Bitmap [32 Octets] – Frag [ON]	Bitmap [32 Octets] – Frag [ON]
0	3	1	1	Reserved	Bitmap [4 Octets] – Frag [ON]
1	Any	Any	Any	Reserved	

Straw Poll 2

Do you support to add to the 11ax SFD:

- **The BA Bitmap length of BA frames generated during a BA session is negotiated during the BA setup**
 - If the negotiated buffer size is within $[1, X]$ then a BA Bitmap length of X bits will be used during the BA session for the negotiated TID
 - If the negotiated buffer size is within $[X+1, Y]$ then a BA Bitmap length of Y bits will be used during the BA session for the negotiated TID
 - Note: X and Y correspond to the agreed BA Bitmap lengths of the respective BA frame (e.g., 32, 64, etc.)
 - Per-PPDU BA selection rules within a BA session for the BA Bitmap length of the BA frames is TBD for $\langle RA, TA, TID \rangle$

Straw Poll 3

Do you support to add to the 11ax SFD:

- The maximum number of TIDs of QoS Data frames that an originator can aggregate in a multi-TID A-MPDU is indicated in the HE Capabilities element sent by the recipient
 - A nonzero value also indicates that the recipient supports reception of multi-TID A-MPDUs
 - Note: A multi-TID A-MPDU allows the aggregation of an Action Ack frame as well
- A STA that transmits a trigger-based PPDU as an immediate response to the Basic variant Trigger frame follows the indication of max number of TIDs contained in the Trigger Dependent Per User Info field of the Trigger frame addressed to the STA (i.e., AID of the Per User Info field is that of the STA) and can transmit an A-MPDU that contains a number of aggregated TIDs in the A-MPDU that is up to that value.

Straw Poll 4

Do you support to add to the 11ax SFD:

- Multi STA BA frames shall be supported if either UL MU or multi-TID A-MPDU operation is supported
- Originator indicates support for reception of ALL ACK signaling (Ack Type subfield set to 0 when responding to the soliciting A-MPDU) in Multi STA Block Ack frame that is sent as a response to the A-MPDU via a capability bit

Straw Poll 5

Do you support to add to the 11ax SFD:

- **HE STAs follow the solicitation/response rules listed in slides 17-20.**

Straw Poll 6

Do you support to add to the 11ax SFD:

- A STA shall not send a Multi TID BAR to a STA that has not indicated support for multi-TID A-MPDU.
 - Also applicable to each BAR information carried in the MU BAR variant Trigger frame

References

- [1] *S. Merlin (Qualcomm Inc.) et.al., 11-16-0378-02-00ax-extended-ba-bitmap*
- [2] *D. Qiao (Huawei) et. al., 11-16-0404-00-00ax-blockack-bitmap*
- [3] *IEEE members, et. al Draft P802.11ax_D0.1*
- [4] *C. Ghosh (Intel) et. al., 11-16/0362r1 Multi-TID Aggregation Limit*
- [5] *L. Chu (Marvell) et. al., 11-16/0359r0 Management Ack*
- [6] *L. Chu (Marvell) et. al., 11-16/0069r0 Multi-TID A-MPDU in MU transmission*