Enhancing Multi-STA BlockAck (M-BA) Frames with Rich Low-Latency (LL) Traffic Feedback

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Introduction

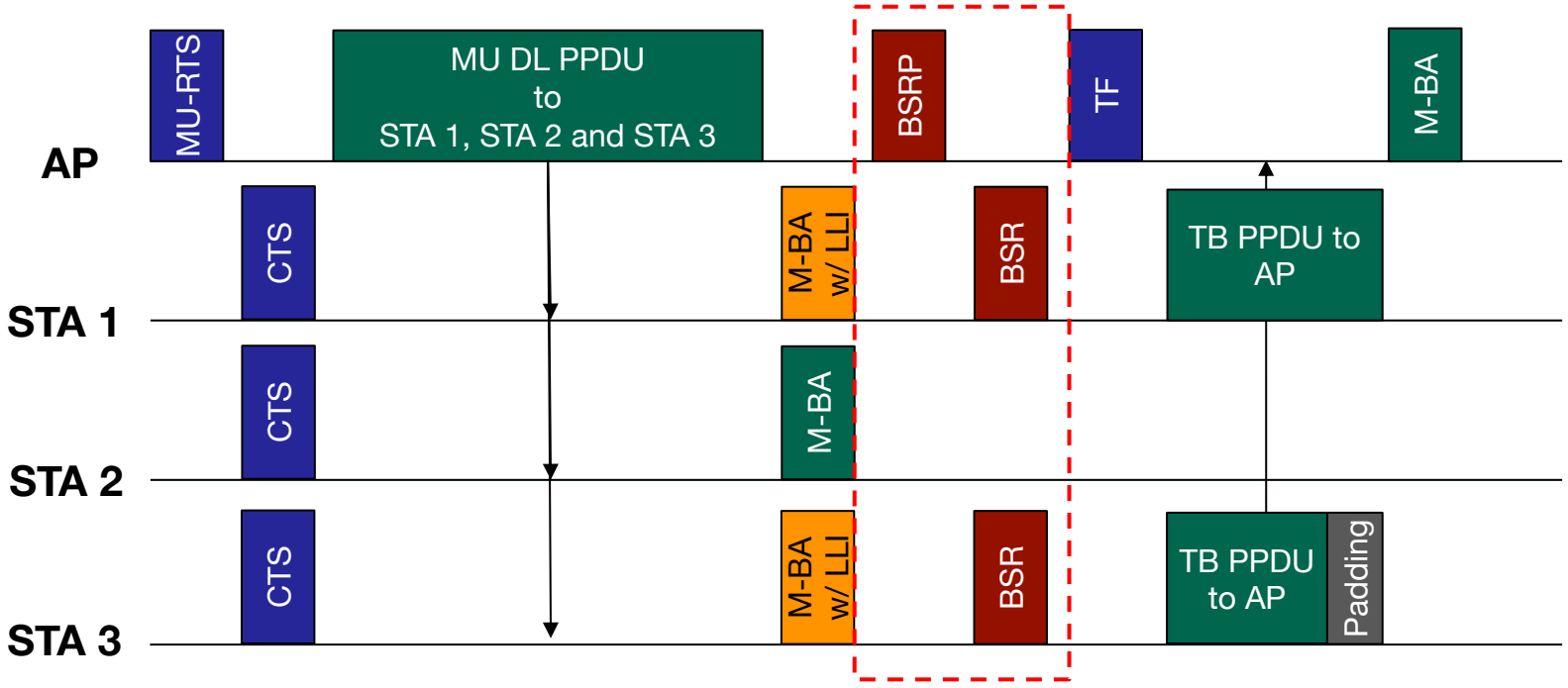
- **Low-Latency Indication (LLI) allows a TXOP responder to indicate to the TXOP holder that it has buffered low-latency (LL) traffic, ensuring such traffic gets prioritized handling**
- LLI informs the TXOP holder (e.g., AP) to adjust its scheduling and allocate time/resources appropriately
  - LLI is critical for time-sensitive services like AR/VR, gaming, and industrial automation
- LLI is sent via a **Multi-STA BlockAck** frame, using a dedicated LLI subfield [802.11-24/0543r1], [802.11-24/0857r1], [802.11-24/1226r0], [802.11-24/1558r2]

- Upon receiving an LLI signal, the AP is expected to consider it when scheduling transmissions within current or future TXOPs
  - Though exact AP behavior is implementation-specific
- The inclusion of feedback information in M-BA frames has been proposed in [802.11-25/0062r0] and [802.11-25/0312r0]
- **In this contribution, we propose the inclusion of information such as BSR, EBSR, traffic urgency and traffic destination type, allowing the TXOP responder to make more informed decisions about its next actions**

Motivation

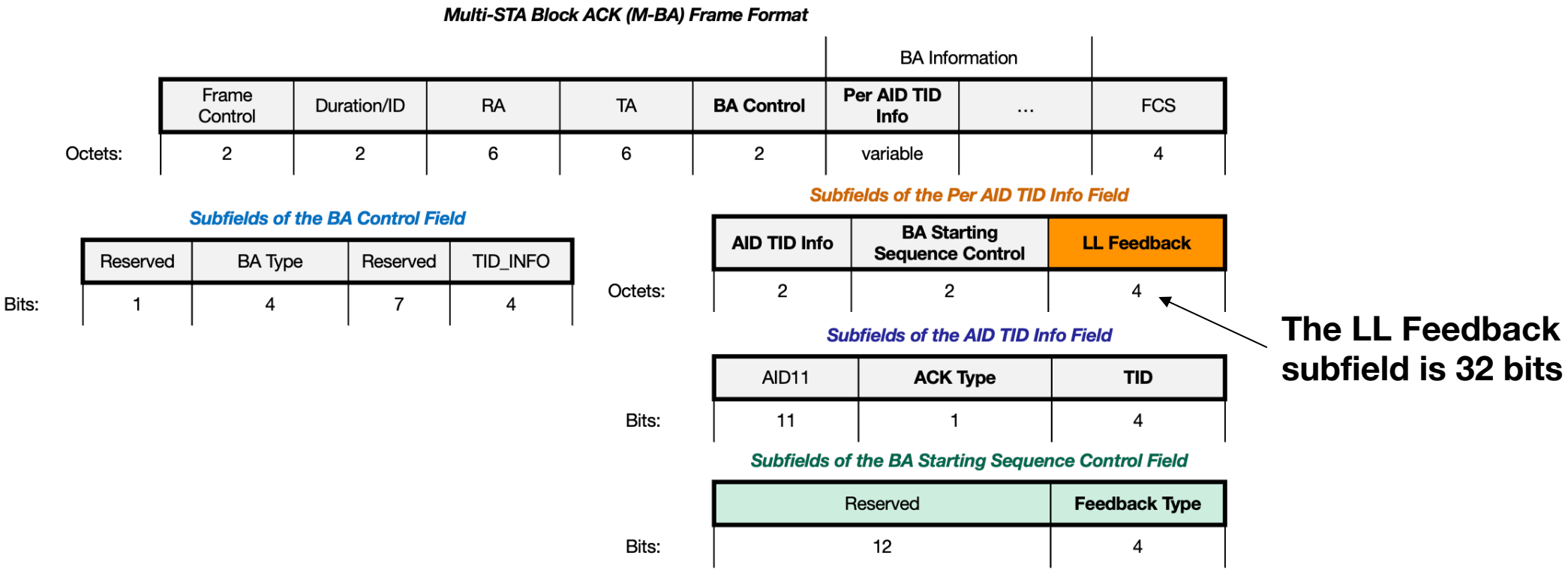
- If the M-BA frame includes only an indication of LL traffic, the TXOP holder does not receive sufficient information to make an informed decision about its next actions

- **Example:** The AP sends DL MU PPDUs to three STAs; in response, two STAs include LLI in their M-BA frames



- Since the AP does not know the amount of such LL traffic, **it needs to utilize the BSRP/BSR process and poll the non-AP STAs**
- **The high overhead of polling STAs has been demonstrated in various works (e.g., [11-24/1870r2])**

Multi-STA BlockAck (M-BA) Frame



- When the M-BA frame is repurposed for feedback, the frame includes Per-AID TID Info field with
  - Ack Type subfield = 0
  - TID subfield = 13
  - Feedback Type = 1

Enhancing Multi-STA BlockAck (M-BA) Frames

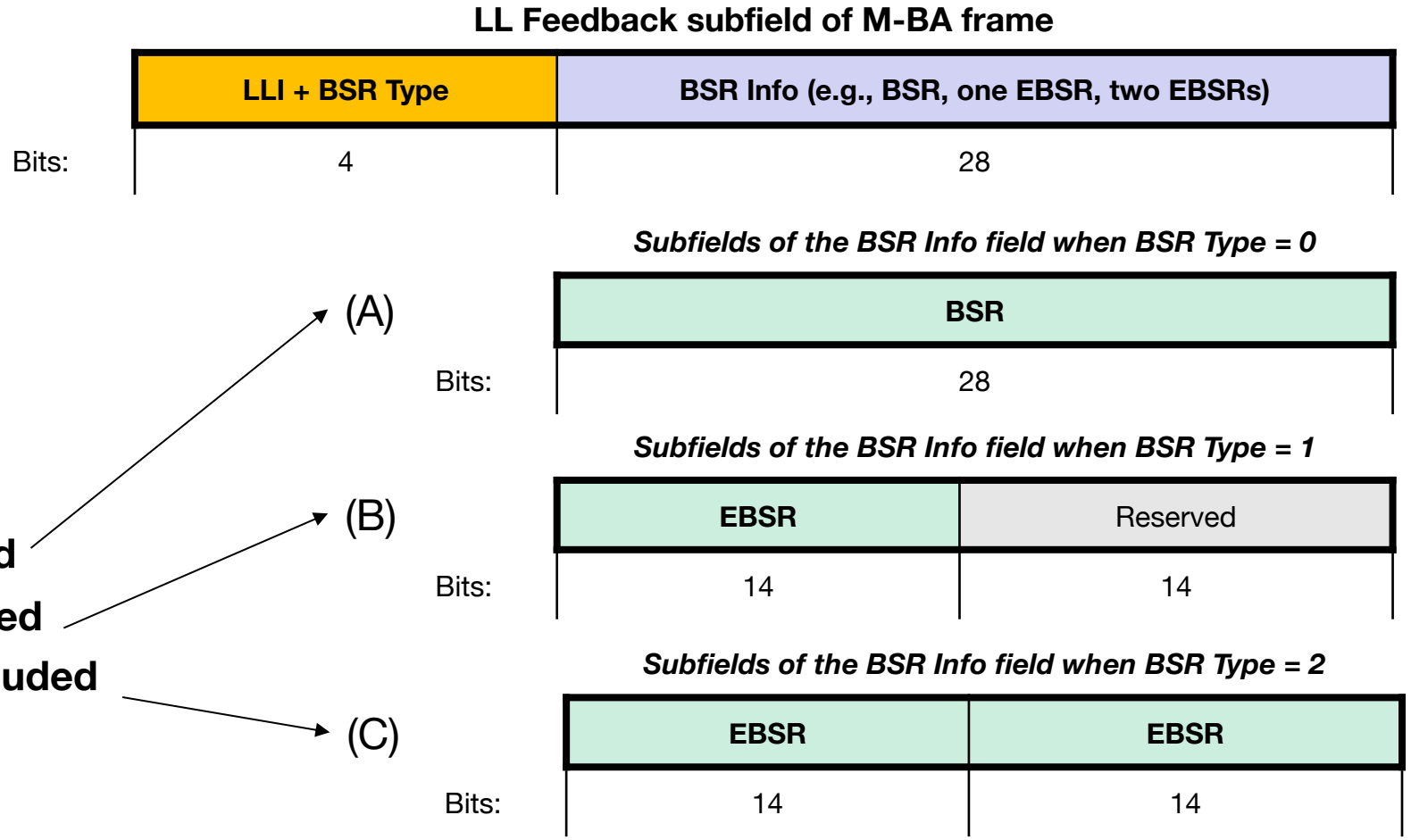
- We propose to enhance M-BA frames with additional information, such as:
  - **BSR or Enhanced BSR subfields**
  - **Urgency level of the LL traffic**
  - **Destination type of LL traffic (e.g., TXOP holder or third-party STA)**

- A TXOP responder may **optionally** include **one or more of these fields**
- The TXOP holder may **optionally** use **one or more of the included fields** to make informed decisions and more effectively address the LL traffic exchange needs of LL TXOP responders

Including BSR or EBSR in M-BA Frame

- The **LL Feedback** subfield has two main parts:
  - The first part indicates LLI and **specifies the BSR Type** (i.e., BSR or EBSR)
  - The second part **includes BSR or EBSR subfields**

- For example, the **BSR Type** bits indicate if:
  - **A. One BSR subfield is included**
  - **B. One EBSR subfield is included**
  - **C. Two EBSR subfields are included**



❑ Including BSR or EBSR in M-BA Frame

Example: A non-AP STA:

- Sets LLI = 1 and BSR Type = 2: This means two EBSR subfields are included
- Reports the TID and amount of its LL traffic

LL Feedback subfield of M-BA frame

	LLI = 1 and **BSR Type = 2**	**BSR Info (e.g., BSR, one EBSR, two EBSRs)**
Bits:	4	28

Subfields of the BSR Info field when BSR Type = 2

	TID = 7, Size = *x* Bytes	**TID = 6, Size = *y* Bytes**
	EBSR	**EBSR**
Bits:	14	14

Leveraging the Two Reserved Bits of EBSR to Convey Traffic Urgency

- The current format of EBSR defines two reserved bits

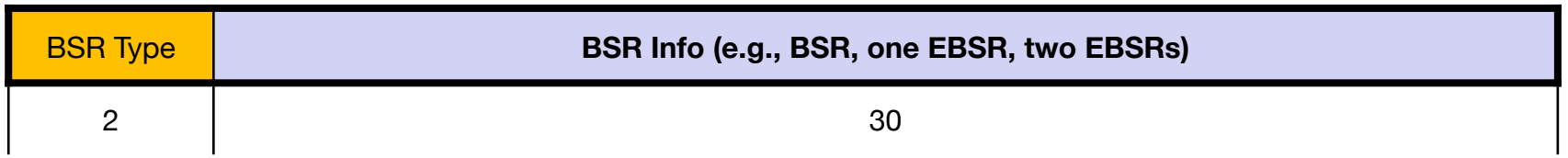
Enhanced BSR (14 bits)

2 bits	4 bits	8 bits
Reserved	TID	Queue Size Indicator

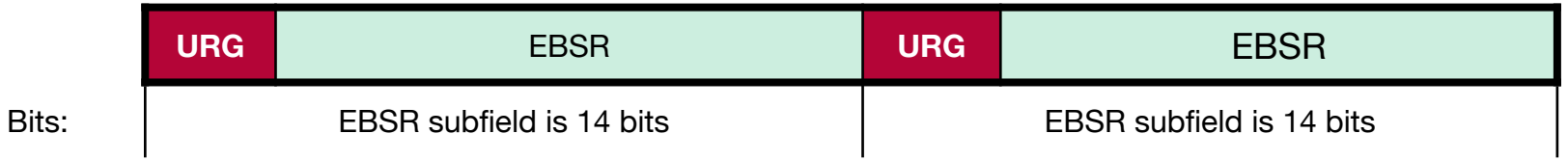
- These two reserved bits may be employed for **indicating the urgency of the LL traffic**

- Example: The two reserved bits of EBSR are used to indicate the urgency of the reported traffic

LL Feedback subfield of M-BA frame



Subfields of the BSR Info field when BSR Type = 2



❑ Leveraging the Two Reserved Bits of EBSR to Convery Traffic Urgency

- Urgency may be defined based on the **remaining time before the deadline of packets** associated with LL traffic

Example: Direct mapping

Undefined (not supported)	0 <= delay < a millisecond	a <= delay < b millisecond	b <= delay < c millisecond
00	01	10	11

Example: Inverse mapping

Undefined (not supported)	0 <= (1/delay) < a millisecond	a <= (1/delay) < b millisecond	b <= (1/delay) < c millisecond
00	01	10	11

- **If a vendor or device does not support urgency calculation, it can simply use the value '00' to indicate an *undefined* urgency level**

Specifying the Destination Type of LL Traffic

- There are three potential **destination types** for LL traffic:
  - For the TXOP Holder
  - For a 3rd party STA (i.e., a STA other than the TXOP Holder, e.g., for P2P traffic)
  - For the TXOP holder and 3rd party STA (e.g., when a STA is preforming relaying)

- Conveying the traffic destination type is important because it helps the TXOP holder make appropriate decisions
- For example, if a non-AP STA has peer-to-peer (P2P) traffic and sets the LLI indication in its M-BA frame sent to the AP, **the AP has no way of knowing whether it should terminate the TXOP, schedule uplink traffic, or take some other action**

- Specifying the destination type information can be conveyed by adding one or two bits to the M-BA frame sent from TXOP responder to holder

❑ Specifying the Destination Type of LL Traffic

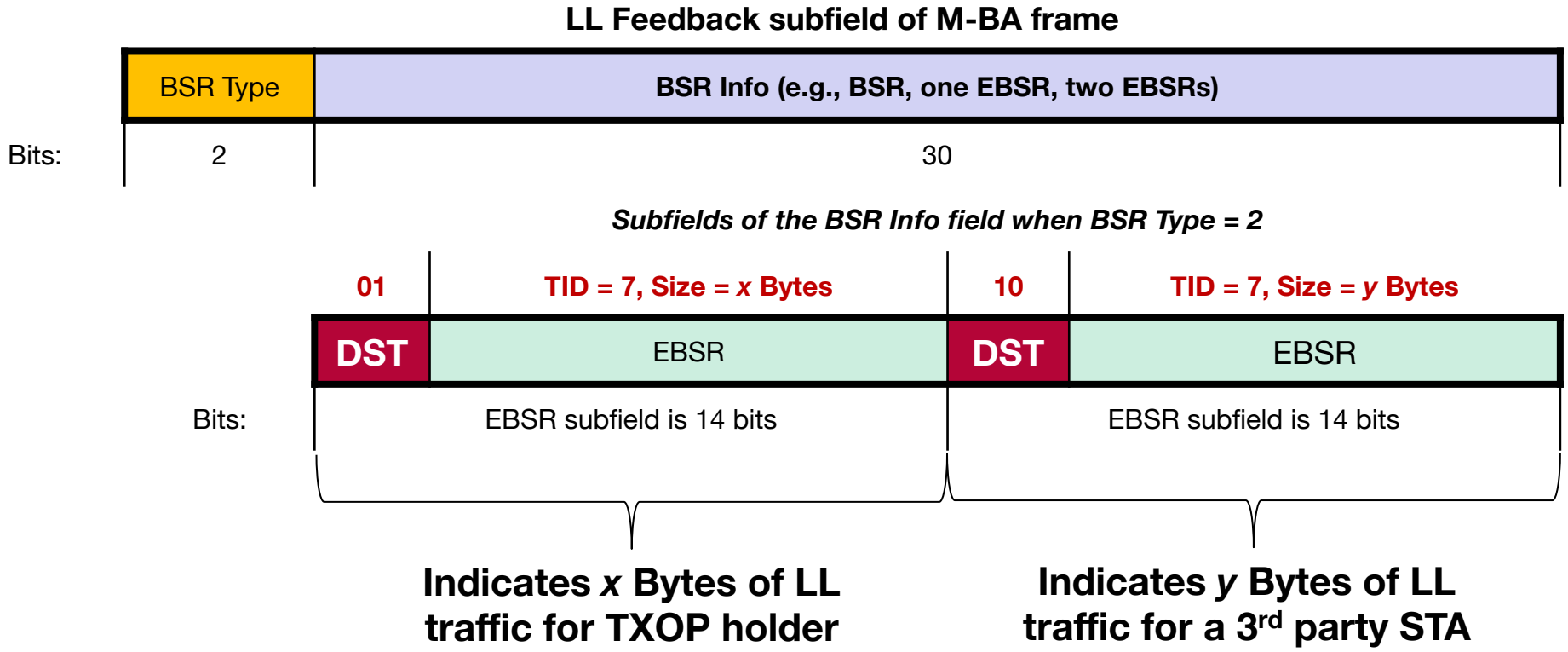
Examples

LLI (2 bits)		Meaning
LL Traffic Existence	Destination Type	
0	0	• No LL traffic
1	0	• LL traffic for TXOP holder only
1	1	• LL traffic for 3rd party STAs and potentially the TXOP holder as well

LLI (3 bits)		Meaning
LL Traffic Existence	Destination Type	
0	00	• No LL traffic
1	01	• LL traffic for TXOP holder only
1	10	• LL traffic for 3rd party STAs only
1	11	• LL traffic for 3rd party STAs and potentially the TXOP holder as well

Leveraging the Two Reserved Bits of EBSR to Specify Destination Type

- The two reserved bits of EBSR may be employed for **indicating the Destination Type of the specified traffic (e.g., for TXOP Holder, 3rd party STA)**



Conclusion

- A TXOP responder can use one or more LLI bits in the M-BA frame to inform the TXOP holder about its LL traffic
- Based on this information, the TXOP holder can make decisions such as scheduling UL traffic, sharing the TXOP, or terminating it
- **However, to make an informed decision, the TXOP holder requires additional information**

- In this contribution, we propose enhancing the M-BA frame with the following information:
  - **BSR or EBSR subfields**
  - **The urgency of the LL traffic**
  - **The destination type of the LL traffic (e.g., TXOP holder or a third-party STA)**
- A TXOP responder may optionally include some or all of this information in its response to the TXOP holder
- The TXOP holder, in turn, may selectively use this additional information to guide its decision-making process

Straw Polls

- **Do you agree to optionally include BSR or EBSR subfields within M-BA frame sent from a TXOP responder to a TXOP responder?**
  - One or two bits can be used to specify if one BSR is included, or one or more EBSRs are included

YES/NO/ABSTAIN

- **Do you agree to optionally use the two reserved bits of Enhanced BSR in response frame sent from a TXOP responder to a TXOP holder for conveying the urgency of LL traffic?**

YES/NO/ABSTAIN

- **Do you agree to optionally use one or two bits in response frame sent from a TXOP responder to a TXOP holder to convey the destination type (i.e., TXOP holder, 3rd party STA) of LL traffic?**

YES/NO/ABSTAIN

Appendix:

Inclusion of an LLI subfield for each BSR or EBSR Subfield

❑ Inclusion of an LLI subfield for each BSR or EBSR Subfield

- **We can separate the LLI subfield from the BSR Type subfield**
- The LLI subfield can be placed **before each BSR or EBSR subfield**

LL Feedback subfield of M-BA frame

	BSR Type	BSR Info (e.g., BSR, one EBSR, two EBSRs)
Bits:	2	30

Subfields of the BSR Info field when BSR Type = 0

(A) When BSR Type is 0, LLI is placed before the BSR subfield

	LLI	Reserved	BSR
Bits:	1	1	28

Subfields of the BSR Info field when BSR Type = 1

(B) When BSR Type is 1, LLI is placed before the EBSR subfield

	LLI	EBSR	Reserved
Bits:	1	14	14

Subfields of the BSR Info field when BSR Type = 2

(C) When BSR Type is 2, LLI is placed before each EBSR subfield

	LLI	EBSR	LLI	EBSR
Bits:	1	14	1	14

❑ Inclusion of an LLI subfield for each BSR or EBSR Subfield

- Example: **A STA reports the TIDs and amount of of its LL traffic**

LL Feedback subfield of M-BA frame

	BSR Type	BSR Info (e.g., BSR, one EBSR, two EBSRs)
Bits:	2	30

Subfields of the BSR Info field when BSR Type = 2

The AP, as the TXOP holder, may schedule both TID 6 and TID 7, or prioritize TID 7 and schedule only that traffic

	1	TID = 7, Size = x Bytes	1	TID = 6, Size = y Bytes
	LLI	EBSR	LLI	EBSR
Bits:	**1**	**14**	**1**	**14**

- Example: **A STA reports the TIDs and amount of of both LL and non-LL traffic**

Subfields of the BSR Info field when BSR Type = 2

The AP may schedule UL transmission of LL traffic immediately, and schedule UL transmission of non-LL traffic after the current TXOP

	1	TID = 7, Size = x Bytes	0	TID = 6, Size = y Bytes
	LLI	EBSR	LLI	EBSR
Bits:	**1**	**14**	**1**	**14**