Wi-Fi Technology Fundamentals

Module-3

WLAN MAC Layer

Session-3d

Data Transfer and Aggregation

Last Session Recap......

Module-3

WLAN MAC Layer

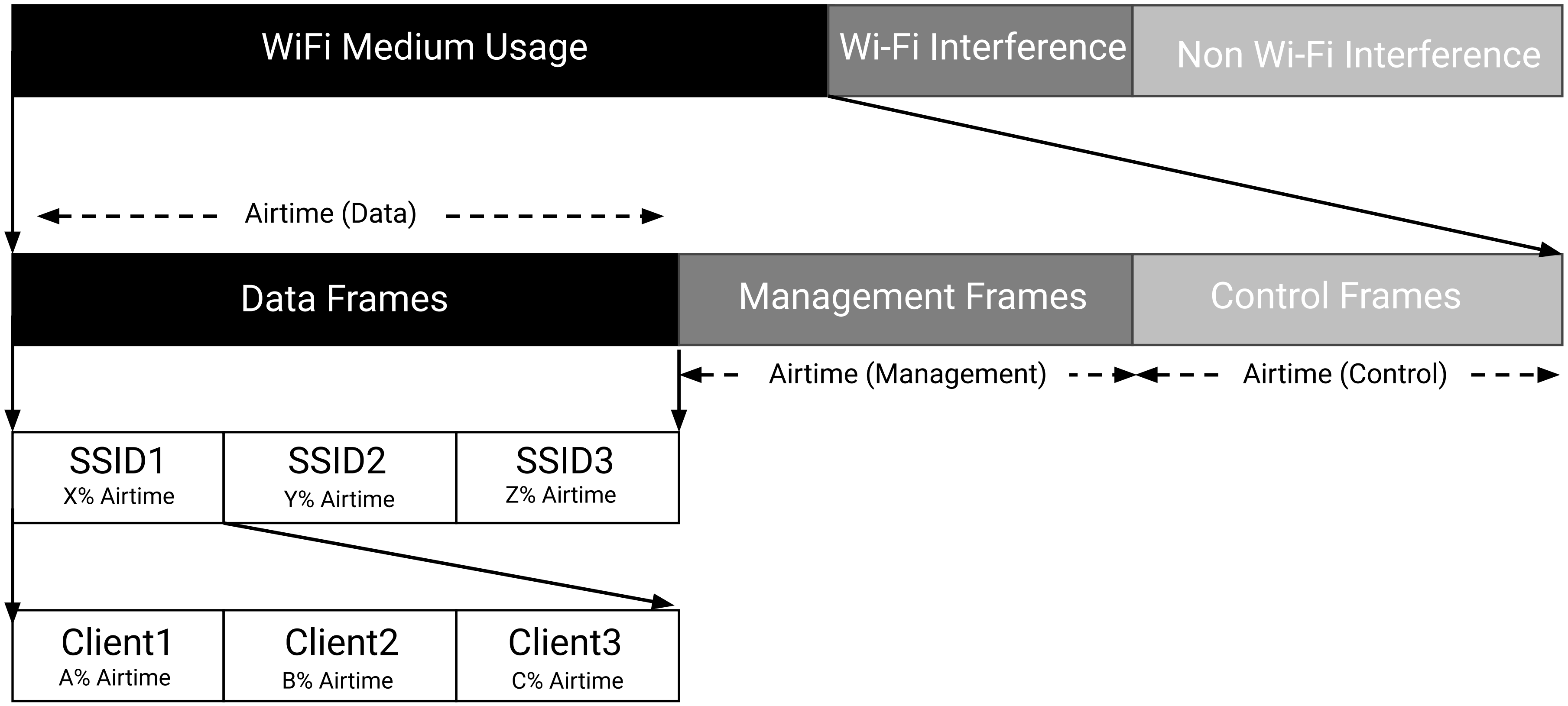
Session-3c

Carrier Sense and Medium Access

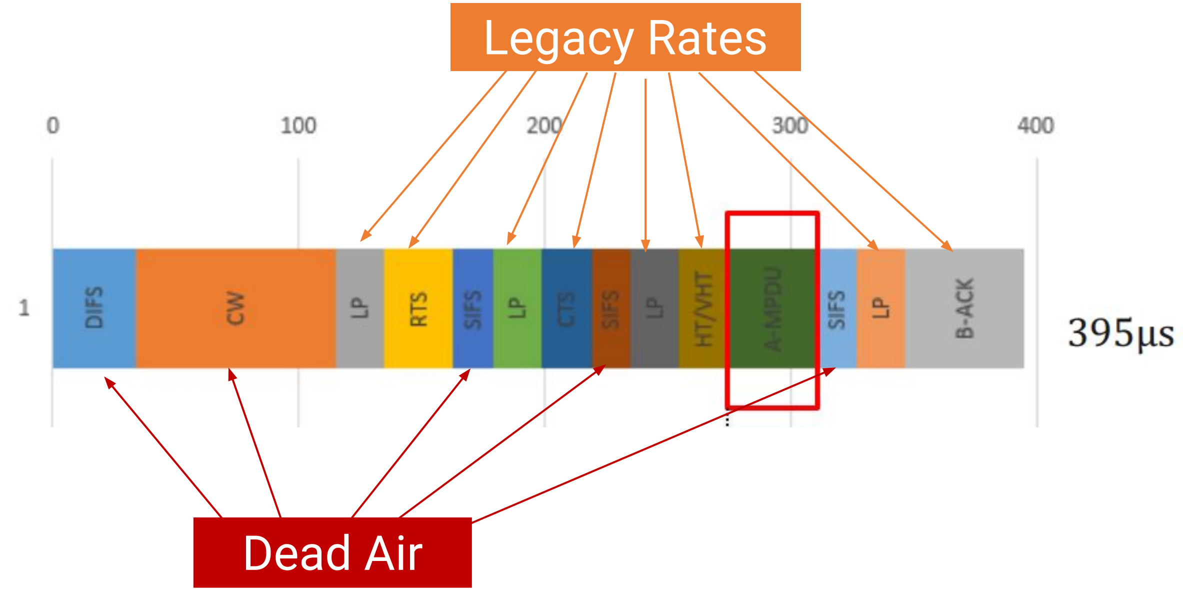
- ✔ CSMA/CD vs CSMA/CA
- ✔ PCF and DCF
- ✔ Network Allocation Vector
- ✔ Random Backoff
- ✔ Interframe Space
- ✔ Contention Window
- ✔ EDCA Parameter Set
- ✔ 802.11e QoS
- ✔ Basic Demo

Wi-Fi Airtime

- Airtime taken by actual Wi-Fi Tx/Rx within a cell and then Wi-Fi interference from neighboring APs and also non Wi-Fi interference.
- Of the actual Tx/Rx in the cell, a small percentage is used for Data Frames, rest goes to Management and Control Frames.
- Of the Data frame, airtime is then split between various WiFi clients.



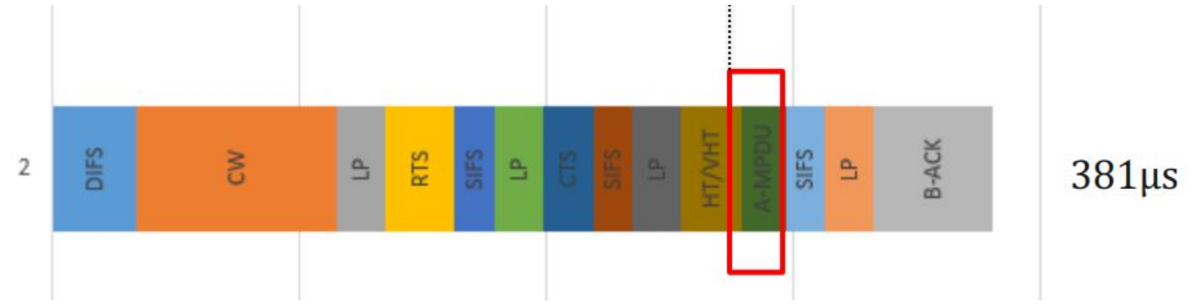
Wi-Fi Protocol and Medium Access Overhead



300 byte MPDU
MCS7 SGI
1SS --> 72.2 Mbps
DIFS CW=9

33.4 µs out of 395 µs

91.6% overhead

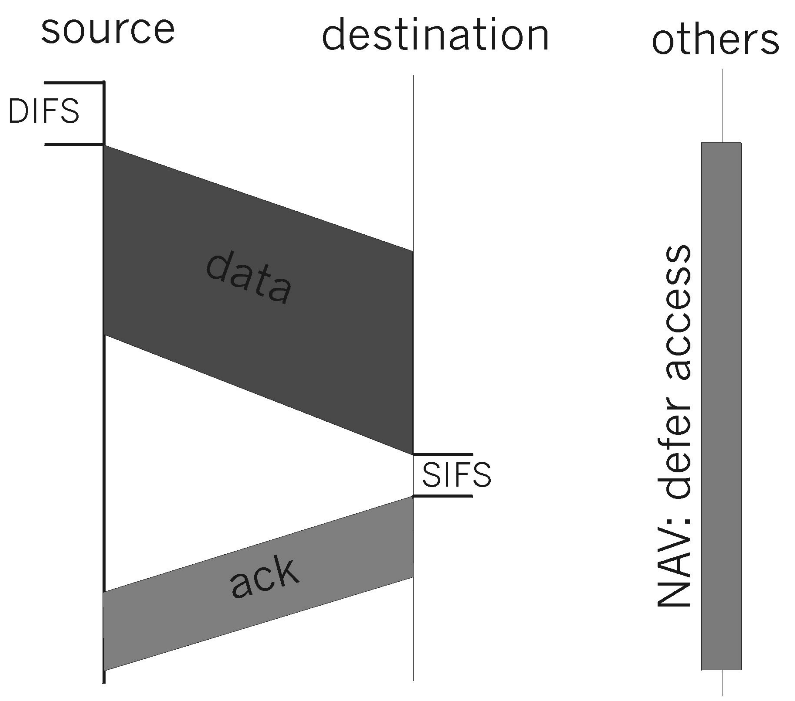


300 byte MPDU
MCS7 SGI
2SS --> 144.4 Mbps
DIFS CW=9

16.6 µs out of 381 µs

95.7% overhead

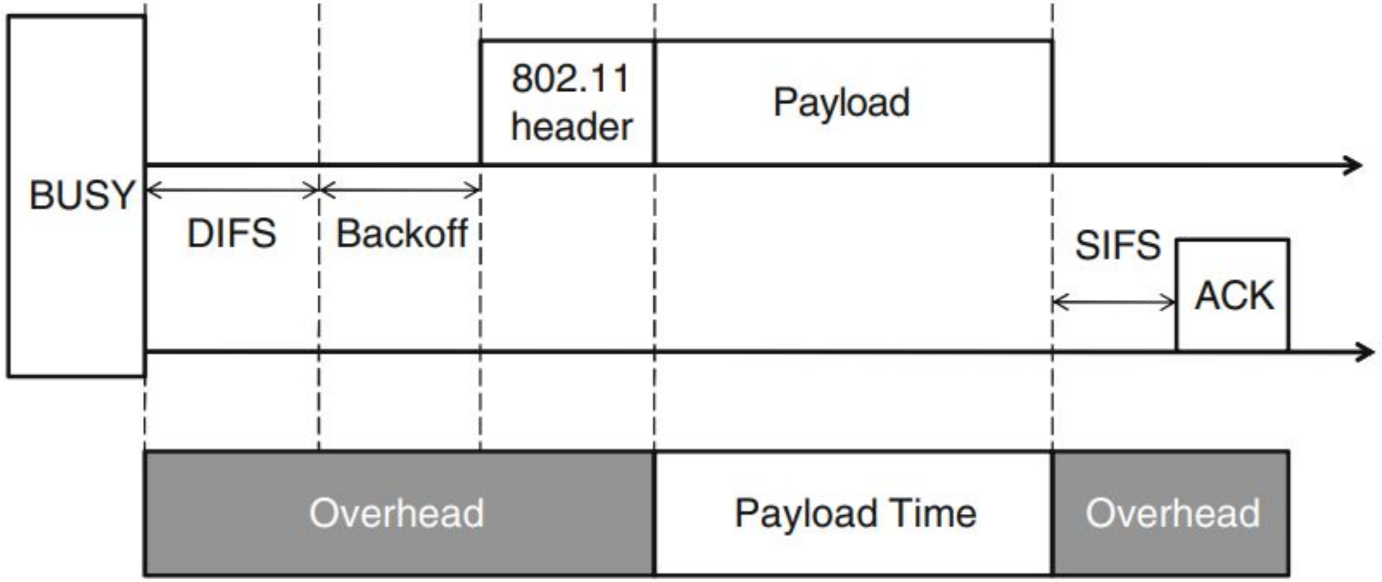
Data Frame Transmission Overhead



Overhead comes from:

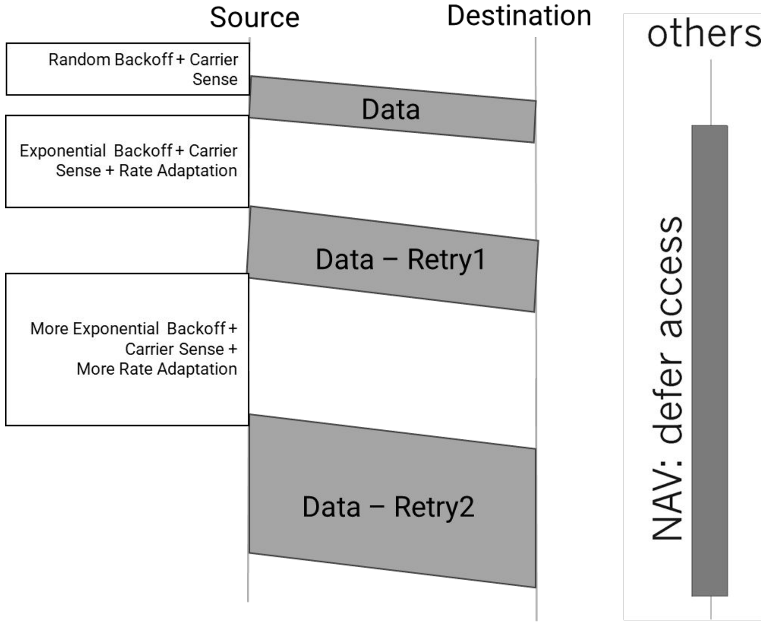
- Interframe Spaces
- Random Backoff
- PHY and MAC Headers
- Smaller Frame Sizes
- ACKs
- Retries

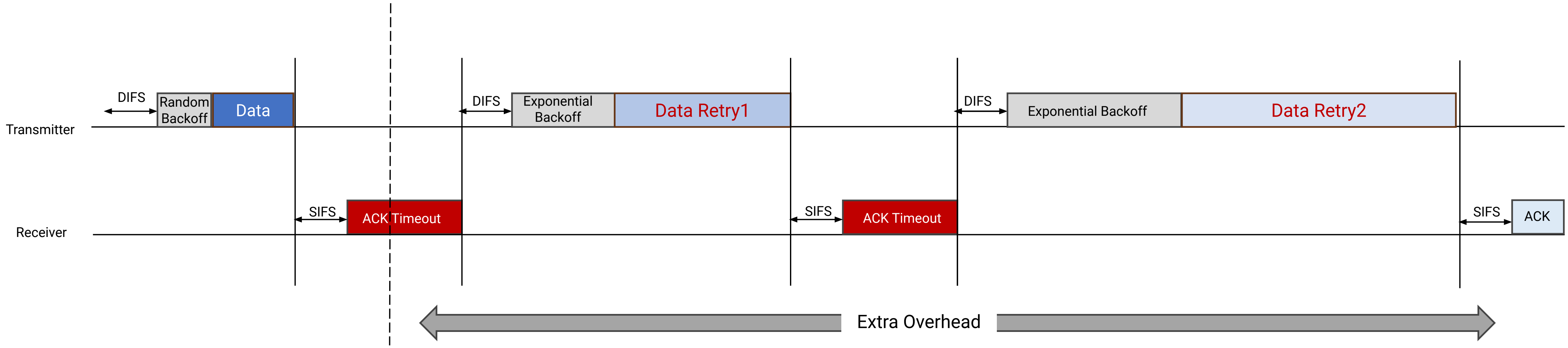
IEEE 802.11a/g	Frame Size (Bytes)			
	100		1500	
	Throughput	% Loss efficiency	Throughput	% Loss efficiency
6 Mbps	2.164	63.93	5.372	10.46
9 Mbps	2.687	70.14	7.784	13.51
12 Mbps	3.011	74.91	10.019	16.51
18 Mbps	3.483	80.65	14.123	21.54
24 Mbps	3.744	84.40	17.603	26.65
36 Mbps	4.047	88.76	23.543	34.60
48 Mbps	4.217	91.21	28.189	41.27
54 Mbps	4.217	92.19	30.480	43.56



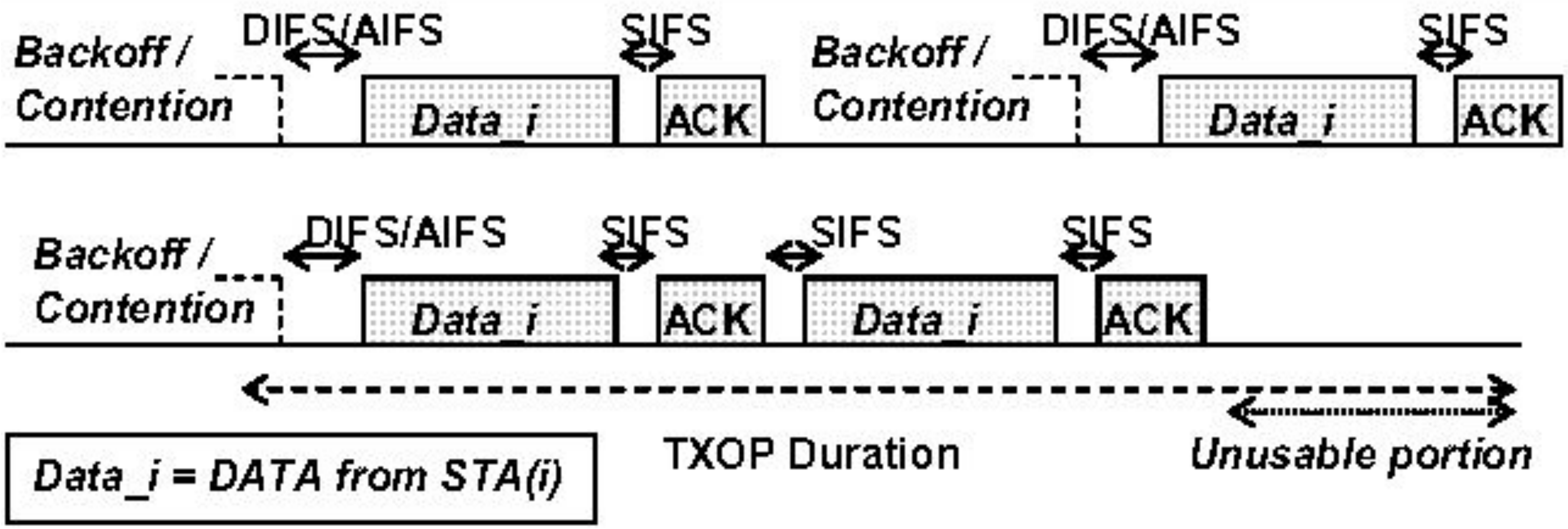
Data Re-Transmission

- Retries can exponentially increase the amount of overhead
- Every retry will increase backoff and will reduce PHY rates that will be increase the airtime consumed for transmission of the same frame.





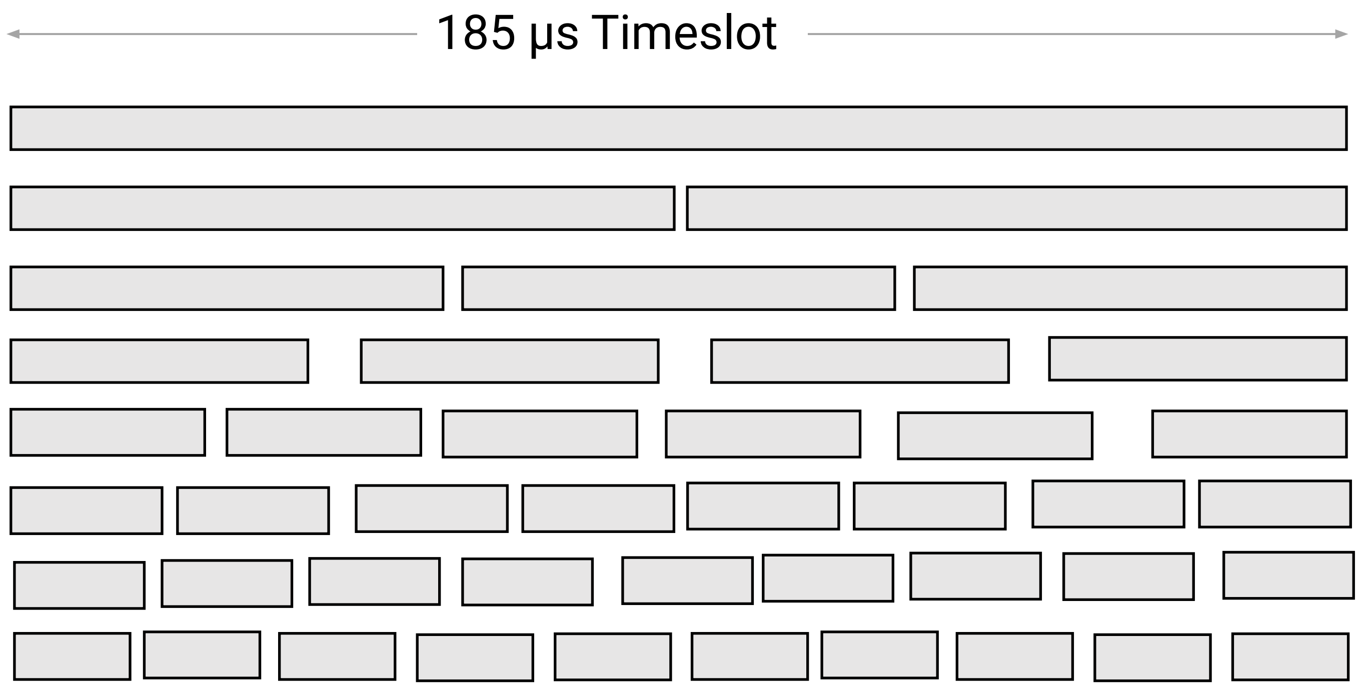
Reducing overhead using TXOP



TXOP will allow device to transmit multiple frames without doing backoff/contention for each frame.
This allows for a substantial decrease in overhead.

The Airtime used by Frames

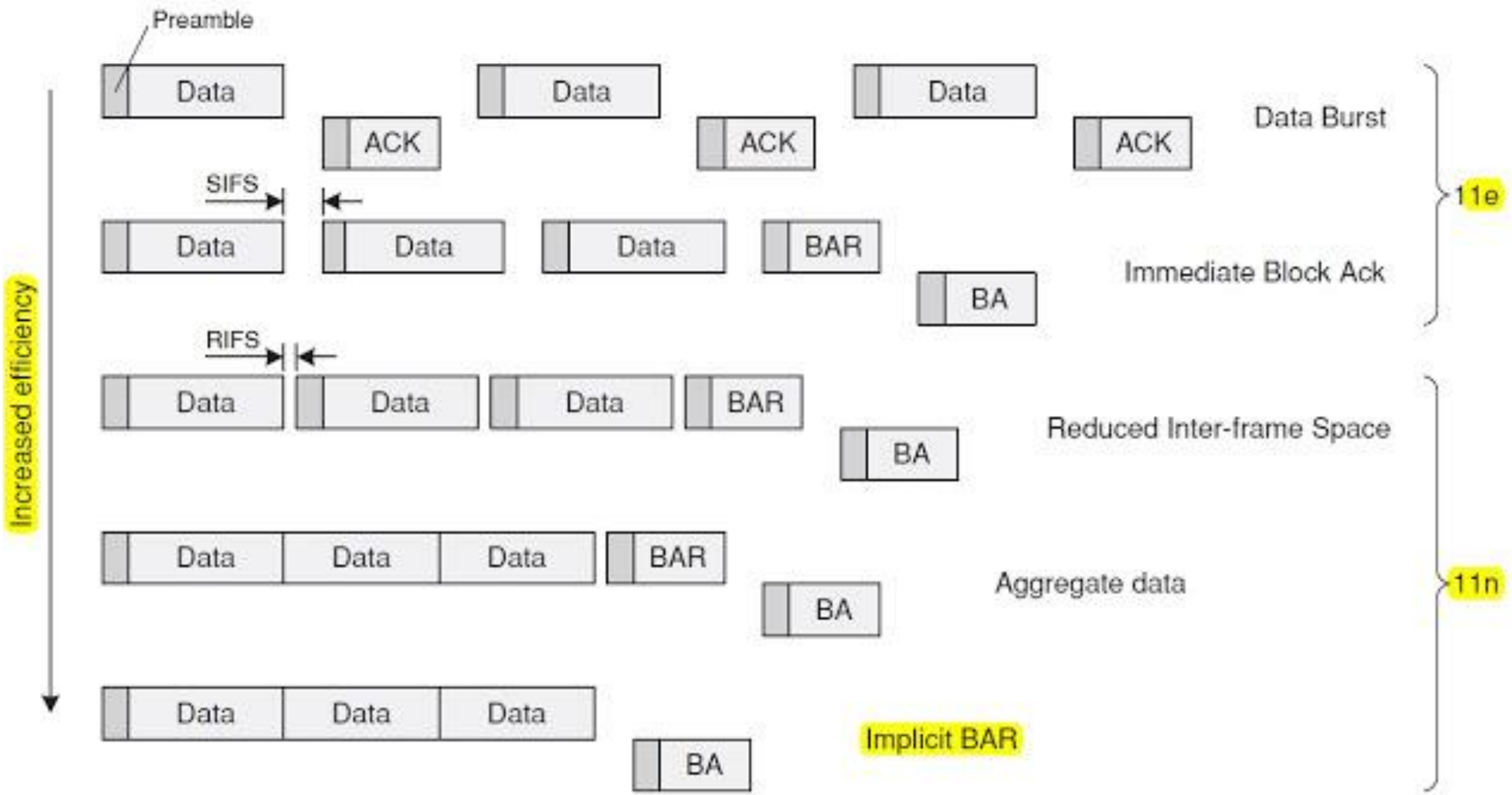
Modulation	Coding	Nss1 SGI 160Mhz	Airtime for 1500 Byte Frame	Number of Frames in same airtime
BPSK	1/2	65.0	184.62	1
QPSK	1/2	130.0	92.31	2
QPSK	3/4	195.0	61.54	3
16-QAM	1/2	260.0	46.15	4
16-QAM	3/4	390.0	30.77	6
64-QAM	2/3	520.0	23.08	8
64-QAM	3/4	585.0	20.51	9
64-QAM	5/6	650.0	18.46	10



The higher the data rates the more frames that can be transmitted in the same amount of time.

Methods used to increase thought put and reduce overhead

- Data bursts using TXOP
- Aggregation with Block ACK
- Reduced Interframe Space
- Aggregation without IFS
- Aggregation with Implicit BA



Concept of Aggregation

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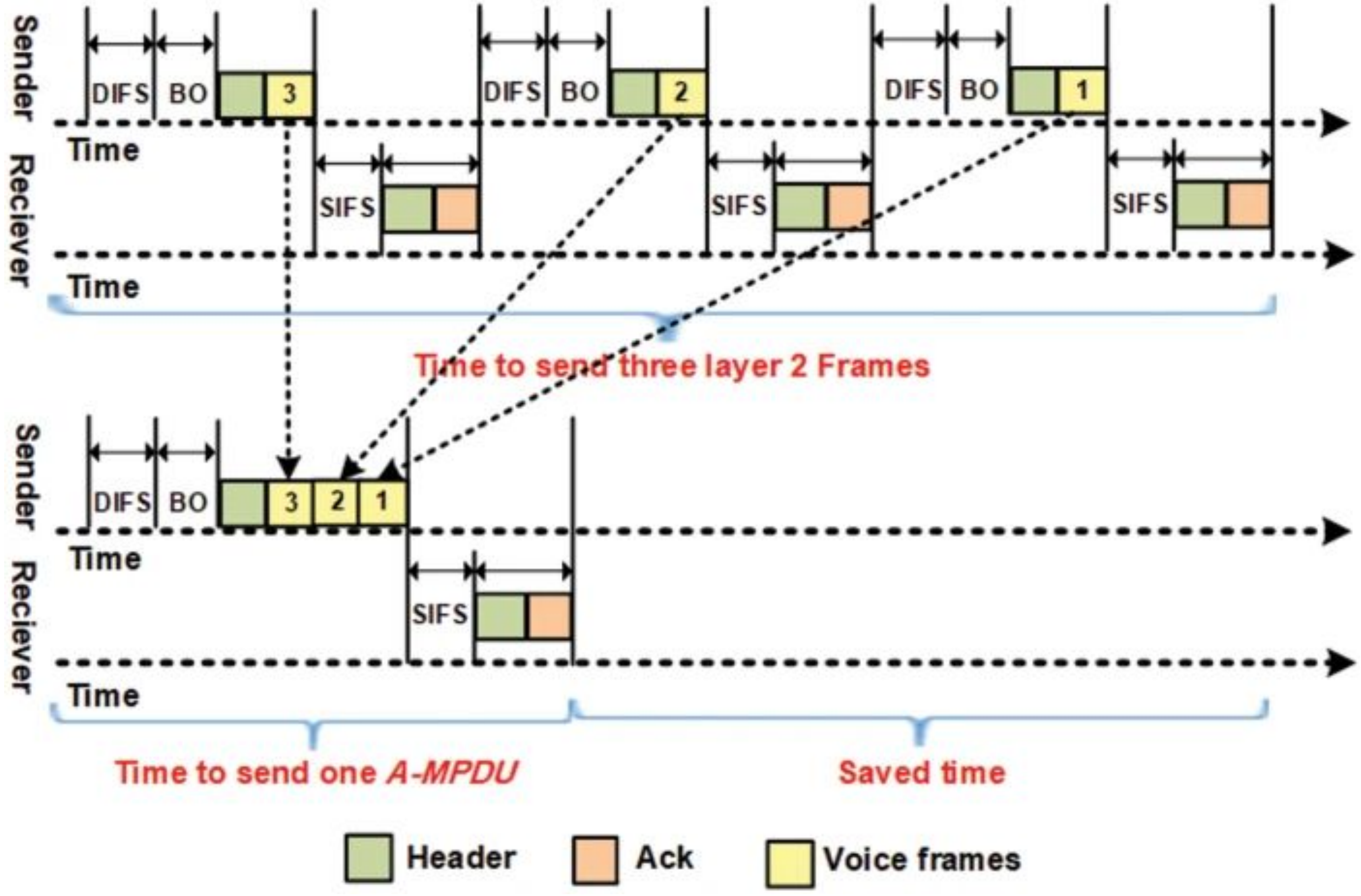
Frame Aggregation

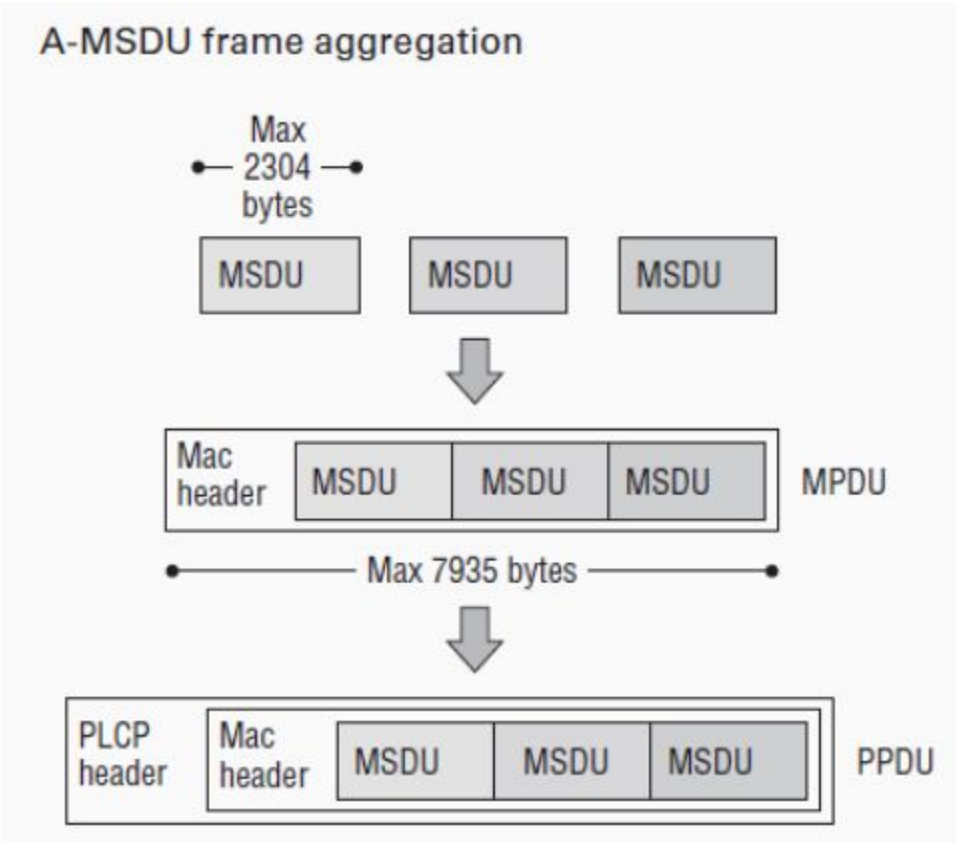
Frame aggregation increases throughput by sending multiple data frames in a single transmission. It reduces 802.11 protocol overhead, as multiple packets can be sent with a single PHY and MAC header, instead of each packet having its own headers. The number of ACKs and interframe spaces (and contention periods, if not in a TXOP) is also reduced.

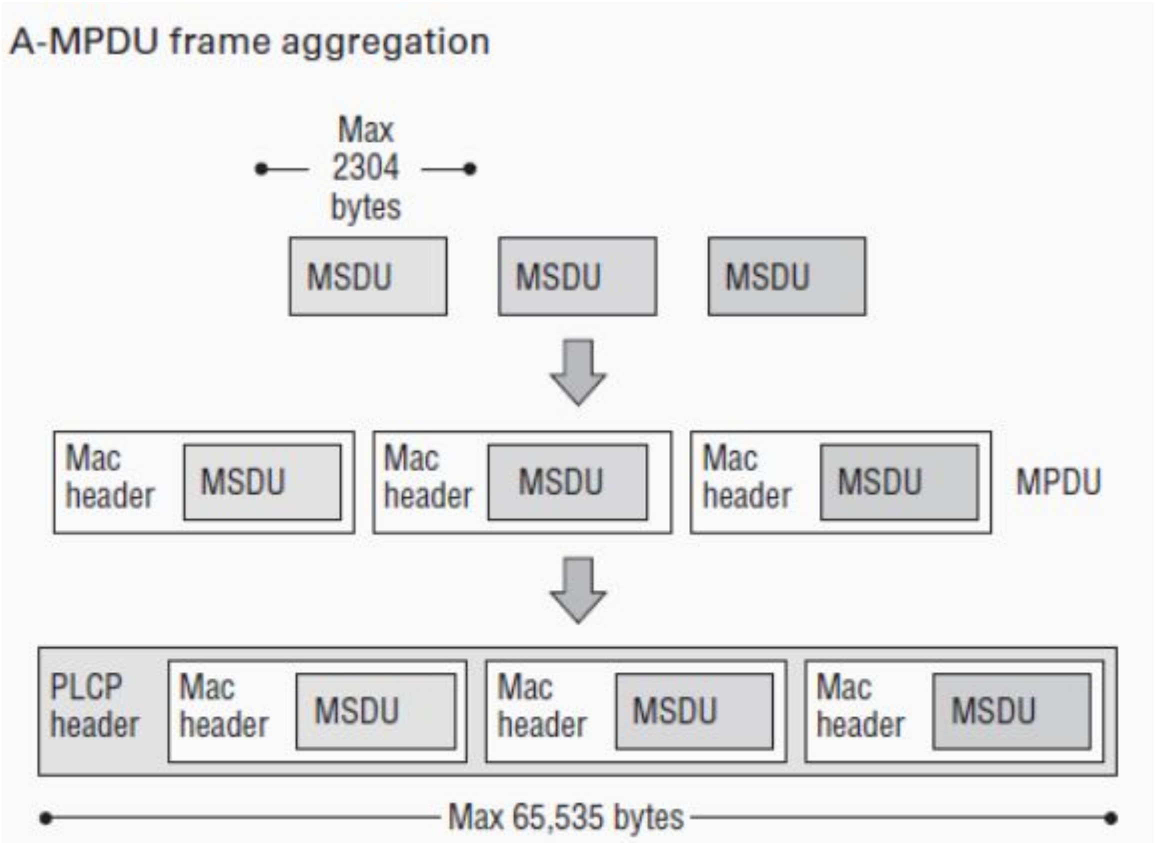


Types of Frame Aggregation

MAC Service Data Unit (MSDU) aggregation: the packets received by the MAC from the upper layer are MSDUs. Each packet gets an MSDU subframe header. Two or more subframes are bundled together and put in an 802.11 MAC frame (header + trailer). The resulting frame is an aggregate-MSDU (a-MSDU). The a-MSDUs are transmitted with a single PHY header by the radio.

MAC Protocol Data Unit (MPDU) aggregation: MPDUs are frames passed from the MAC to the PHY layer. Each MPDU has a MAC header and trailer. Multiple MPDU-s are bundled together to create an aggregate MPDU (a-MPDU), which is transmitted with a PHY header by the radio.

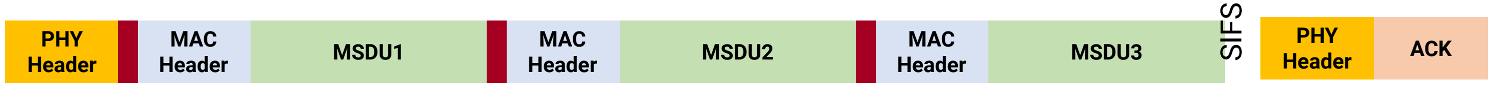




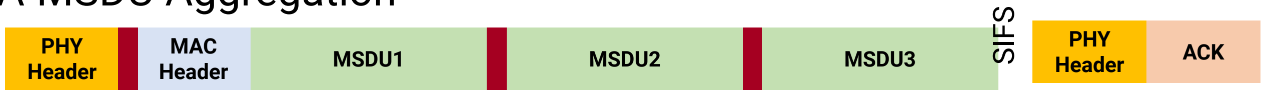
Types of Frame Aggregation

NO Aggregation

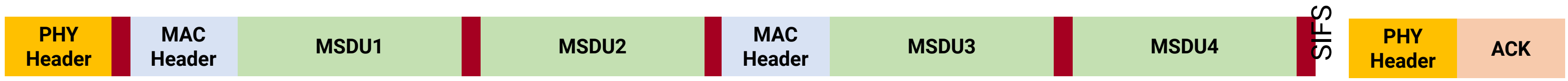
A-MPDU Aggregation



A-MSDU Aggregation

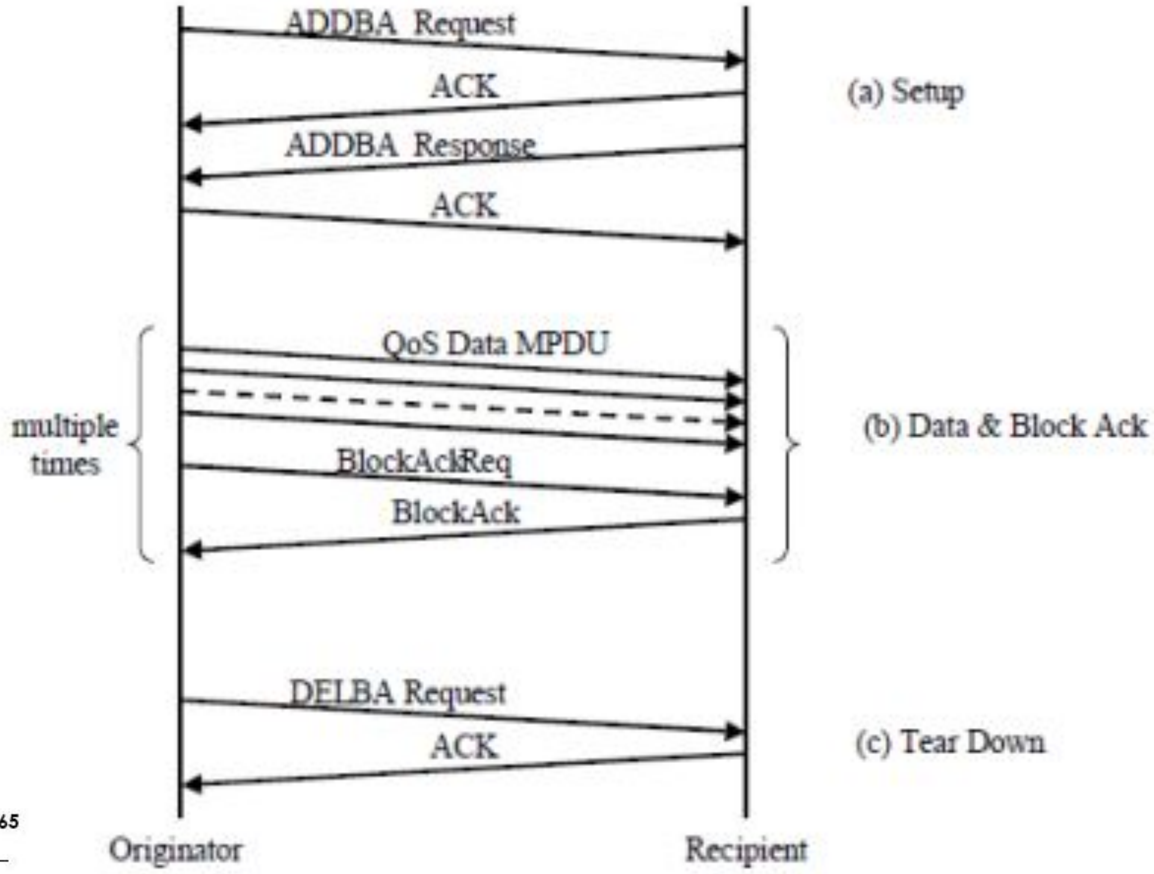


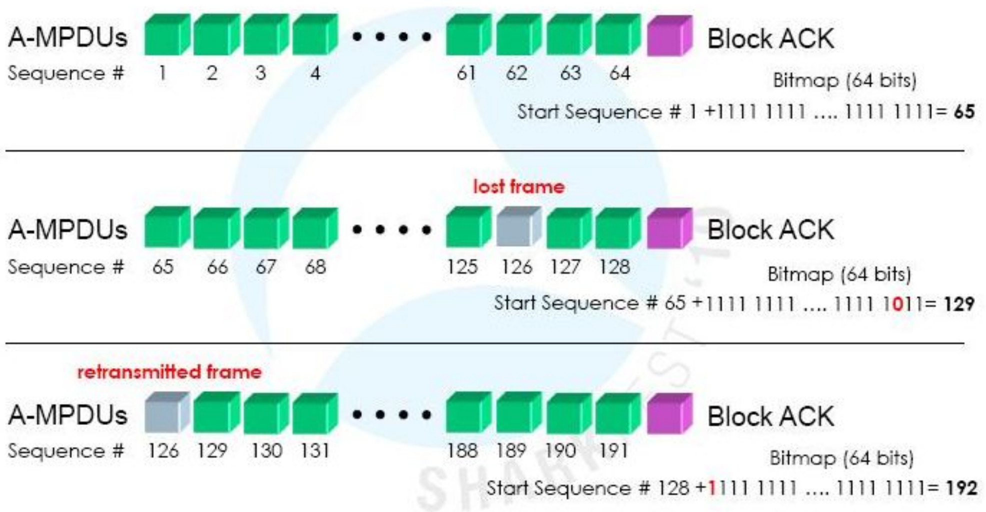
A-MSDUs inside A-MPDU Aggregation



Block Acknowledgements

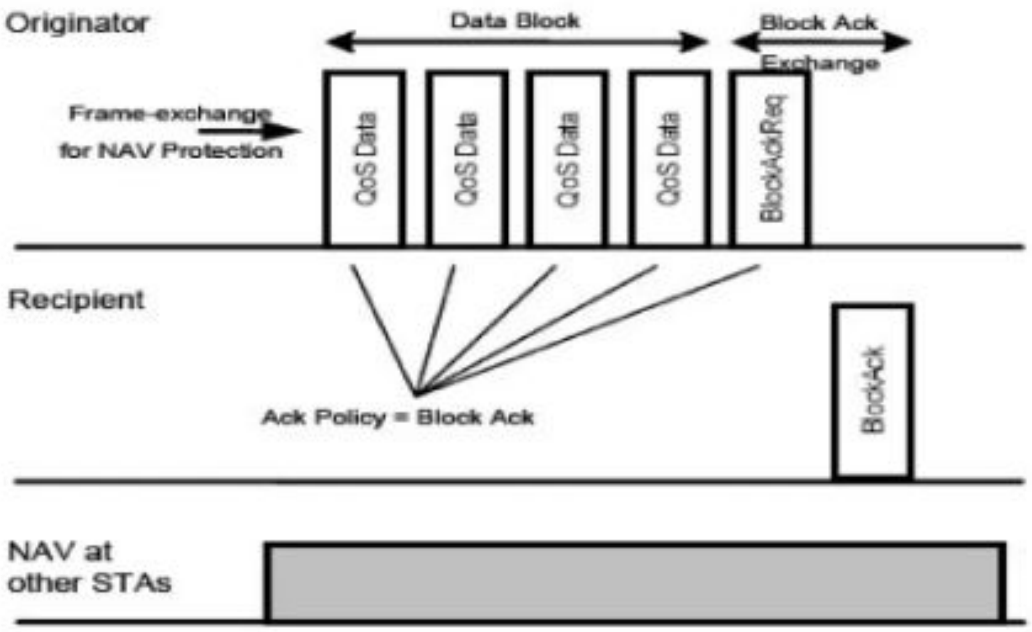
- Block ACK is a concept where several data frames can be Acknowledged in a single block instead of the receiver having to acknowledge each transmitted frame separately.
- Block ACK is used during Aggregation.
- First Transmitter needs to check if the receiver supports block ACK feature.
- To find out TX can send Add Block ACK (ADDBA) request and to that the RX can respond with a ADDBA response.
- After data transmission is completed the TX can send a Block Ack Request Frame to received the Block ACK.
- The block ACK frame will have bitmap that indicates which frames were not received and this allows the Tx to retransmit those frames.
- At the end of the session the Tx can close by sending a Delete Block Ack (DELBA) message



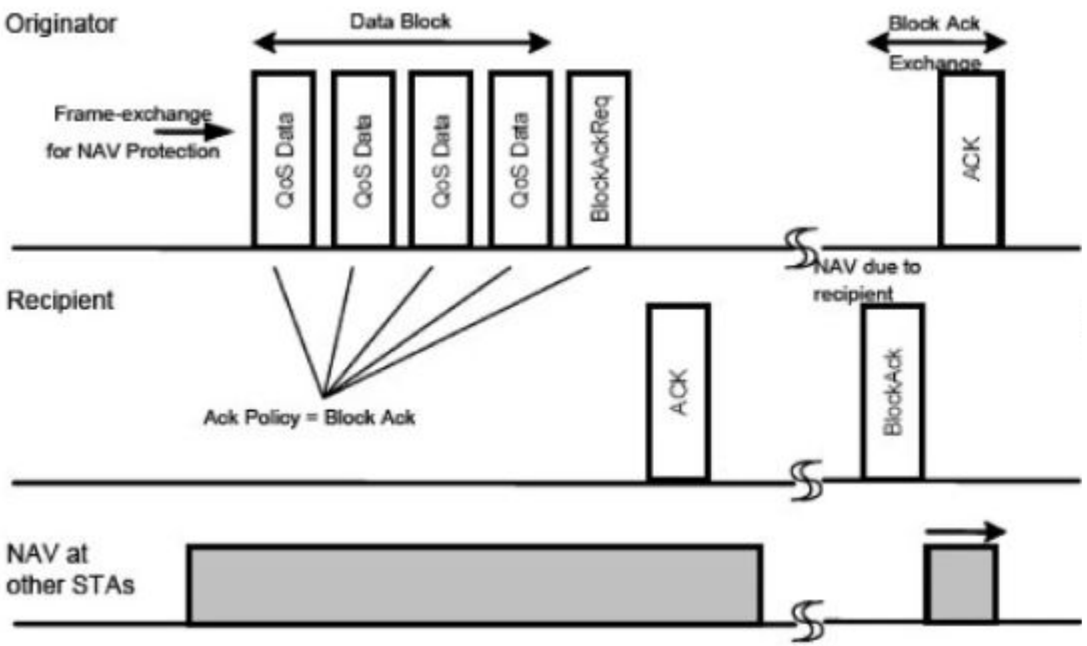


Immediate vs Delayed Block ACK

- There are two types of Block Ack mechanisms: immediate and delayed.
- Immediate Block Ack is suitable for high-bandwidth, low latency traffic
- Delayed Block Ack is suitable for applications that can tolerate moderate latency



Immediate Block ACK



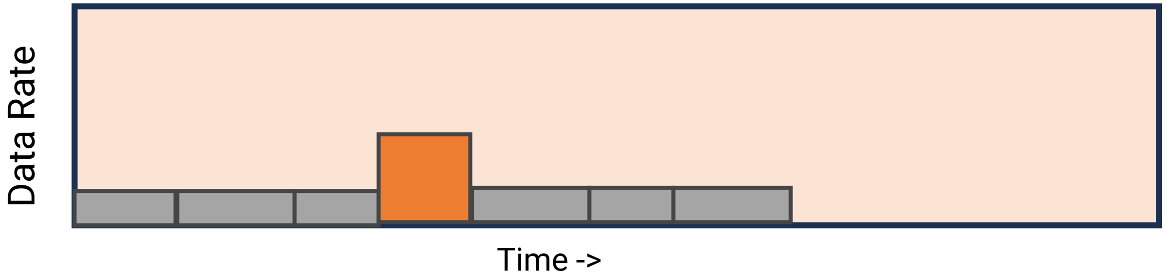
Delayed Block ACK

Effects of Aggregation on Throughput

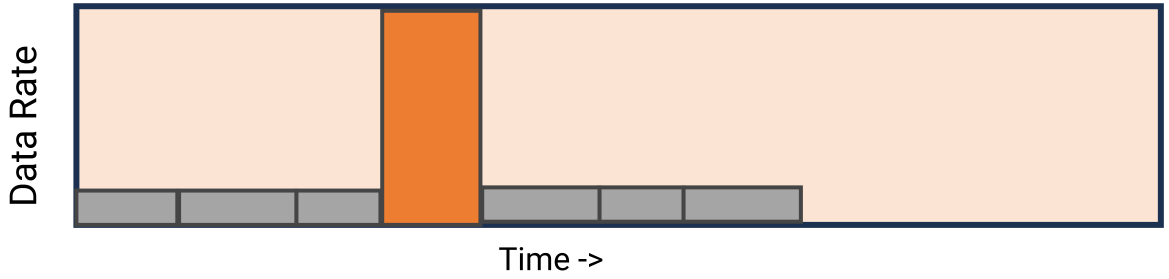
- At lower data rates the difference is small but at high data rates, there is a huge difference in throughput with and without aggregation.
- At smaller packet sizes also there is not much difference but at large packet sizes the difference is very big.

HT Mixed Mode 1500 Bytes		WITHOUT Aggregation		WITH Aggregation	
PHY Type	PHY Rate	Throughput	% Medium Wastage	Throughput	% Medium Wastage
11n 20MHz 1SS	72.2Mbps	32.45 Mbps	55%	67.76 Mbps	6%
11n 20MHz 2SS	144.4Mbps	42 Mbps	71%	132.99 Mbps	8%
11n 20MHz 3SS	216.7Mbps	45.16 Mbps	79%	193.71 Mbps	11%
11n 20MHz 4SS	288.9Mbps	48.05 Mbps	83%	251.28 Mbps	13%
11n 40MHz 1SS	150Mbps	43.21 Mbps	71%	137.94 Mbps	8%
11n 40MHz 4SS	600Mbps	52.24 Mbps	91%	469.4 Mbps	21%

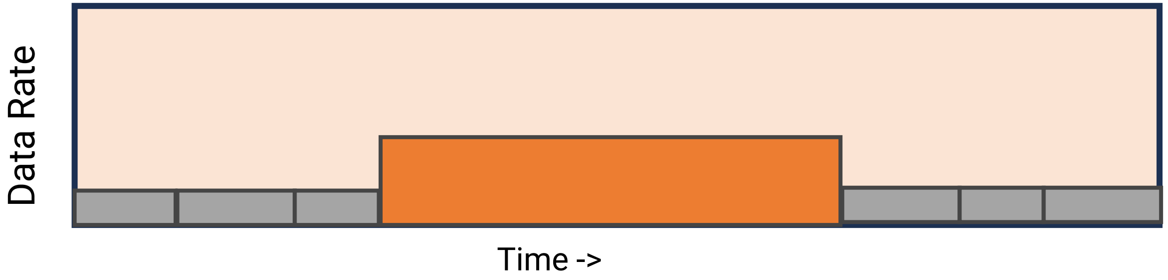
Lower PHY Rates –WITHOUT Aggregation



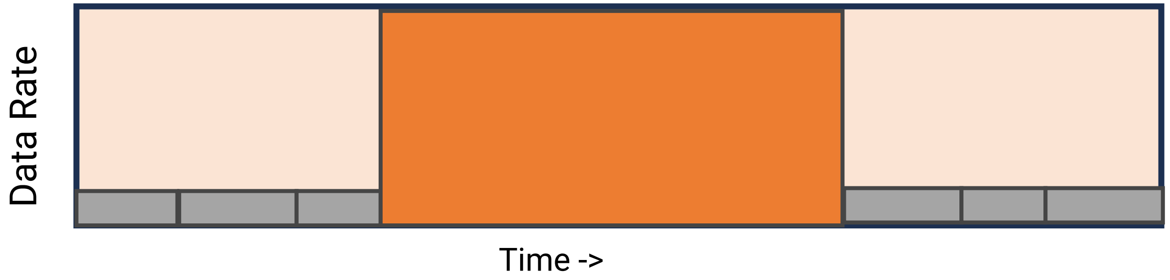
Higher PHY Rates –WITHOUT Aggregation



Lower PHY Rates –WITH Aggregation



Higher PHY Rates –WITH Aggregation

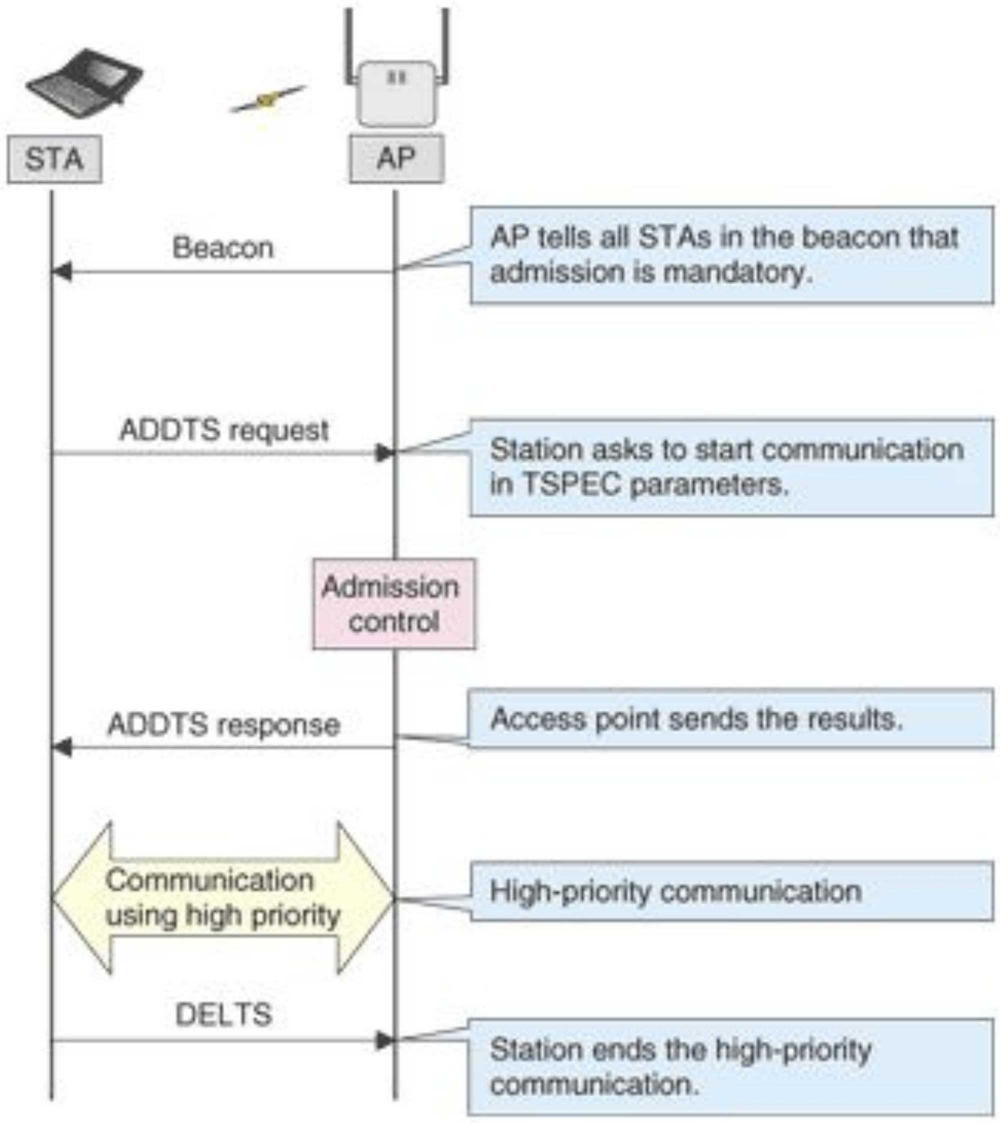


Data Overhead Medium Wastage

802.11e Admission Control

- The TSPEC (traffic specifications) negotiation procedure is defined in the IEEE802.11e standard
- Station asks the AP for its QoS requirements, such as mean data rate, packet length, and physical rate via an add traffic stream (ADDTS) request.
- The AP decides whether the request is acceptable or not and transmits its decision to the station.
- The station can start high-priority communication only when it is permitted to do so by the AP.
- The station also sends a delete traffic stream (DELTS) message when it has finished communicating.

TSPEC negotiation can prevent the wireless link from becoming congested and can keep the communication quality good. Stations then know that congestion has occurred in the wireless link before they start communicating and can wait to connect. This enables stations to use real-time applications such as VoIP and video comfortably.



Source: https://www.ntt-review.jp/archive/ntttechnical.php?contents=ntr200711sf7.html

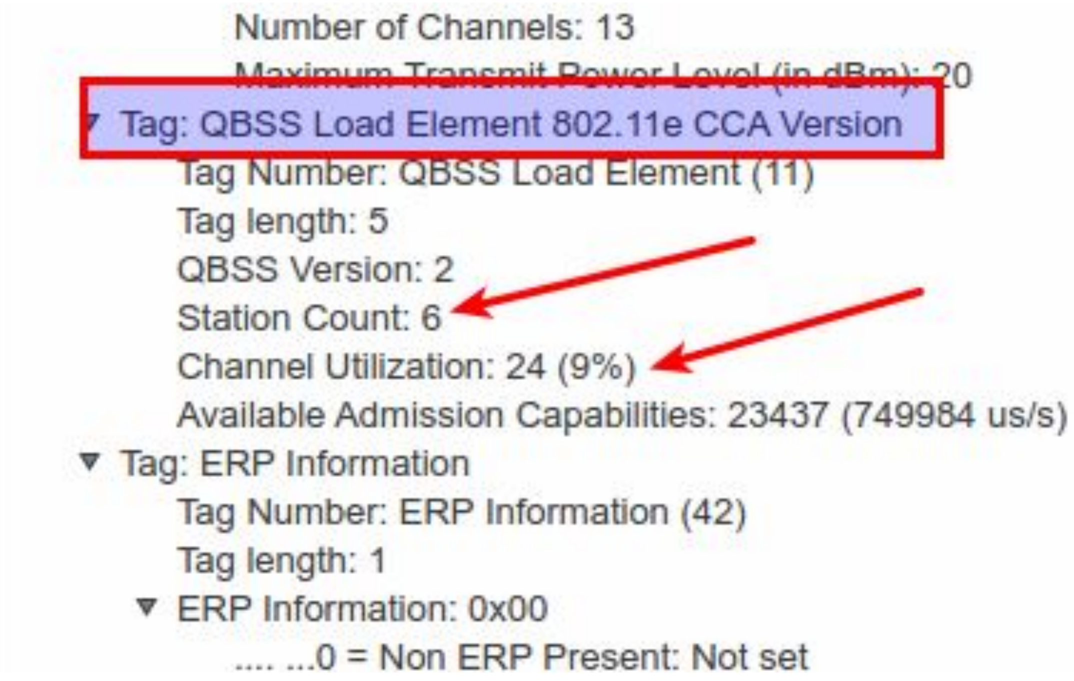
QBSS Element

The QBSS (QOS enhanced basic service set) information element is an 802.11e construct that enables an access point to communicate its channel usage to wireless clients. It is intended to solve the problem of candidate access point selection, or intelligent roaming. It is located in the beacon frames of access points.

Station Count : Indicates the total number STAs currently associated with the QBSS (2 octets, unsigned integer value)

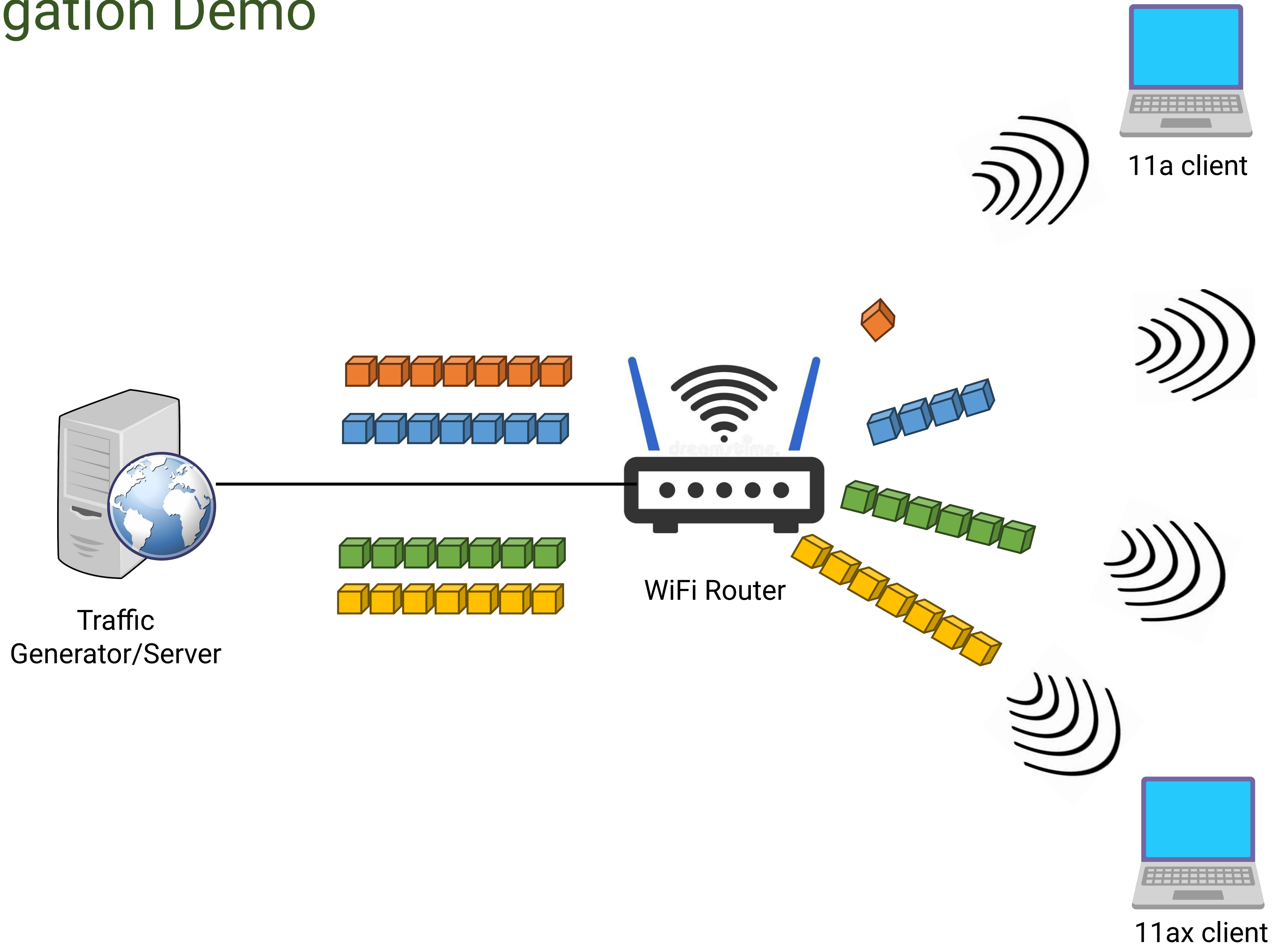
Channel Utilization: A percentage of time (normalized to 255) that the QAP sensed the medium was busy, Medium busy measured as physical or virtual carrier sense (CS) mechanism

Available Admission Capacity: Signals the remaining amount of medium time available via explicit admission control, Values from 0-31250 (2 octets long), Units of 32 µs/s



Source: https://support.accessagility.com/hc/802.11e-qbss-and-wmm

Aggregation Demo



References

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Q&A

QUIZ!

TIME

Quiz 3c Results

Winner

Madhu R

INDIA

Number of participants - 100