Project: IEEE P802.15 Working Group for Wireless Personal Area Networks (WPANs)

Submission Title: [Performance of Standard Aggregation Method with Block ACK Policy]
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Abstract: [We analyze the performance of standard aggregation method with Block ACK Policy when the frame error is introduced. We compared existing ACK policies in terms of throughput and buffer size by varying payload size and suggested proper payload size and buffer size.]
Purpose: [To be considered in IEEE 802.15.3c standard]

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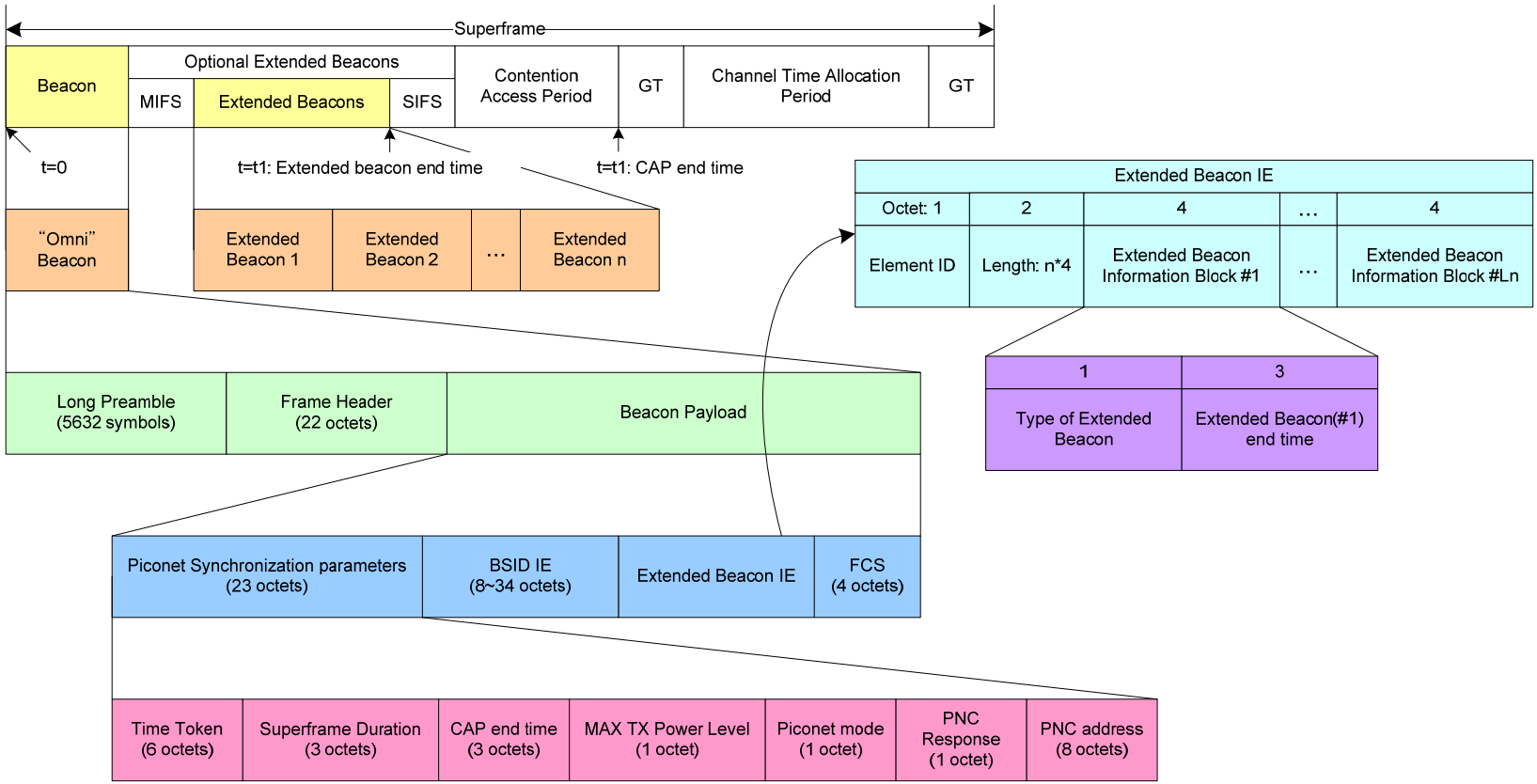
- Settings and parameters of simulation
- Throughput performance comparison of different ACK policies
- Buffer size of different ACK policies
- Conclusions

Introduction

- Purpose
  - Try to find advantages and shortcomings of standard aggregation method with Block ACK policy, and other ACK policies respectively.
  - Compare the performance of existing ACK policies in terms of throughput.
  - The buffer size (queue length) of the transmitter side is investigated.

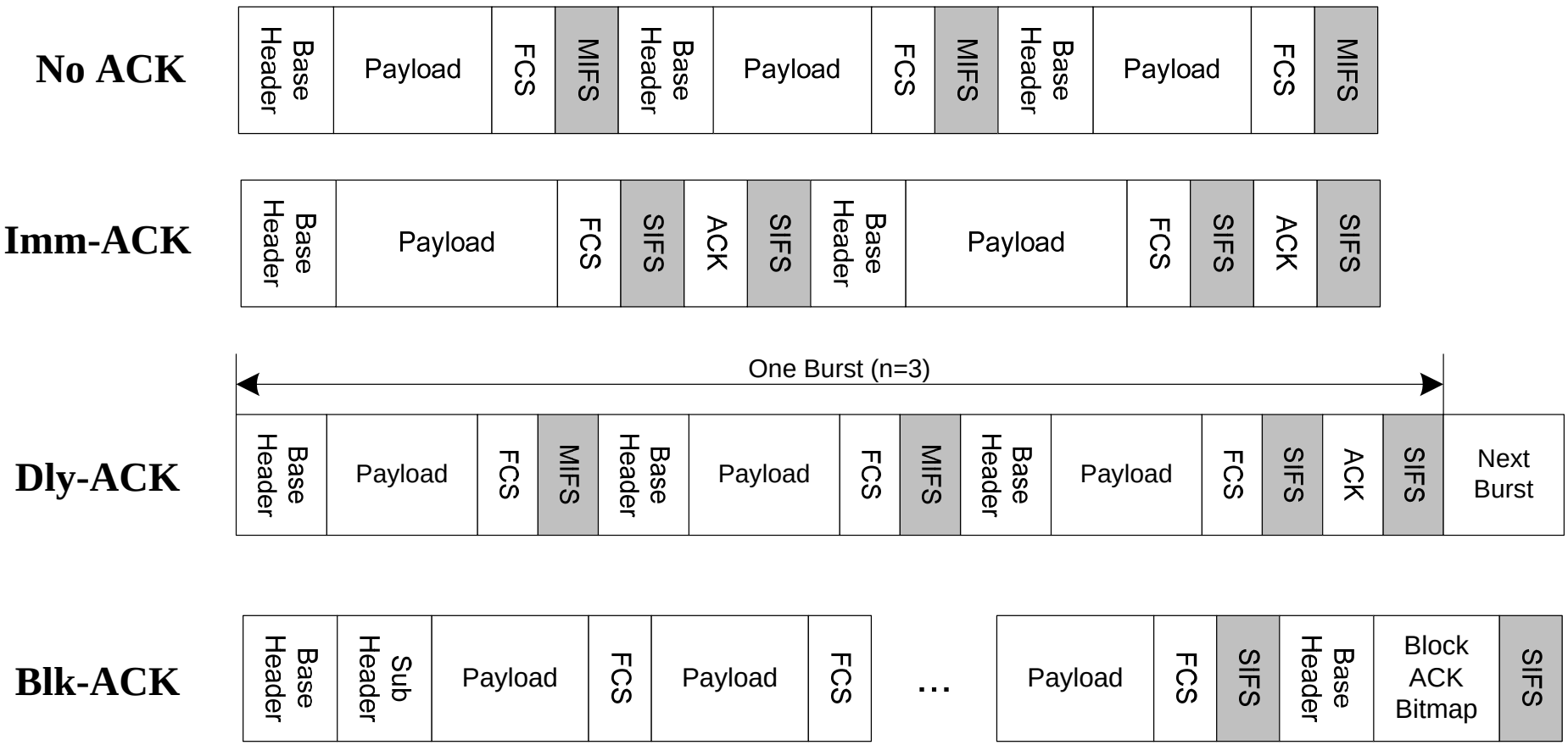
Superframe Structure



ACK Policy Type

- No ACK
- Immediate ACK (Imm-ACK)
- Delayed ACK (Dly-ACK)
  - *n*-Dly-ACK
  - Burst size *n* is the number of (MAC data) frames that are transmitted in a burst before requesting a Dly-ACK from the DEV receiving the frames.
- Block ACK (Blk-ACK)
  - *n*-Blk-ACK
  - *n* is the number of subframes in an aggregated frame.
  - Block-ACK policy is combined with aggregation method exclusively.

Transmission Sequence



Simulation Model (UM1)

PHY-SAP rate =2000 Mbps

Common mode (48.5 Mbps)

Parameters Assumed

- Simulation in the NS-2
  - Unidirectional communication
    - 2 nodes: one transmitter and one receiver
    - Assume no propagation delay due to short distance (<10 meter)
  - Generate uniform-distributed random MAC frame errors
  - Consider standard aggregation method with block ACK
  - Analyze the performance of MAC layer

Parameters	Value
Superframe Size	16 ms
Beacon Interval	15.344 us
CAP Duration	0 us
Guard Time	0.02 us
SIFS	2.5 us
MIFS	0.5 us
Preamble and Base Header	8.157 us
Sub-header size	4 Bytes
PHY-SAP Rate	2000 Mbps
ACK Policy	No ACK, Imm-ACK, Dly-ACK, Blk-ACK (with aggregation)
MSDU size	5.5 KB, 11 KB, 22 KB, etc
Payload size	= MSDU size

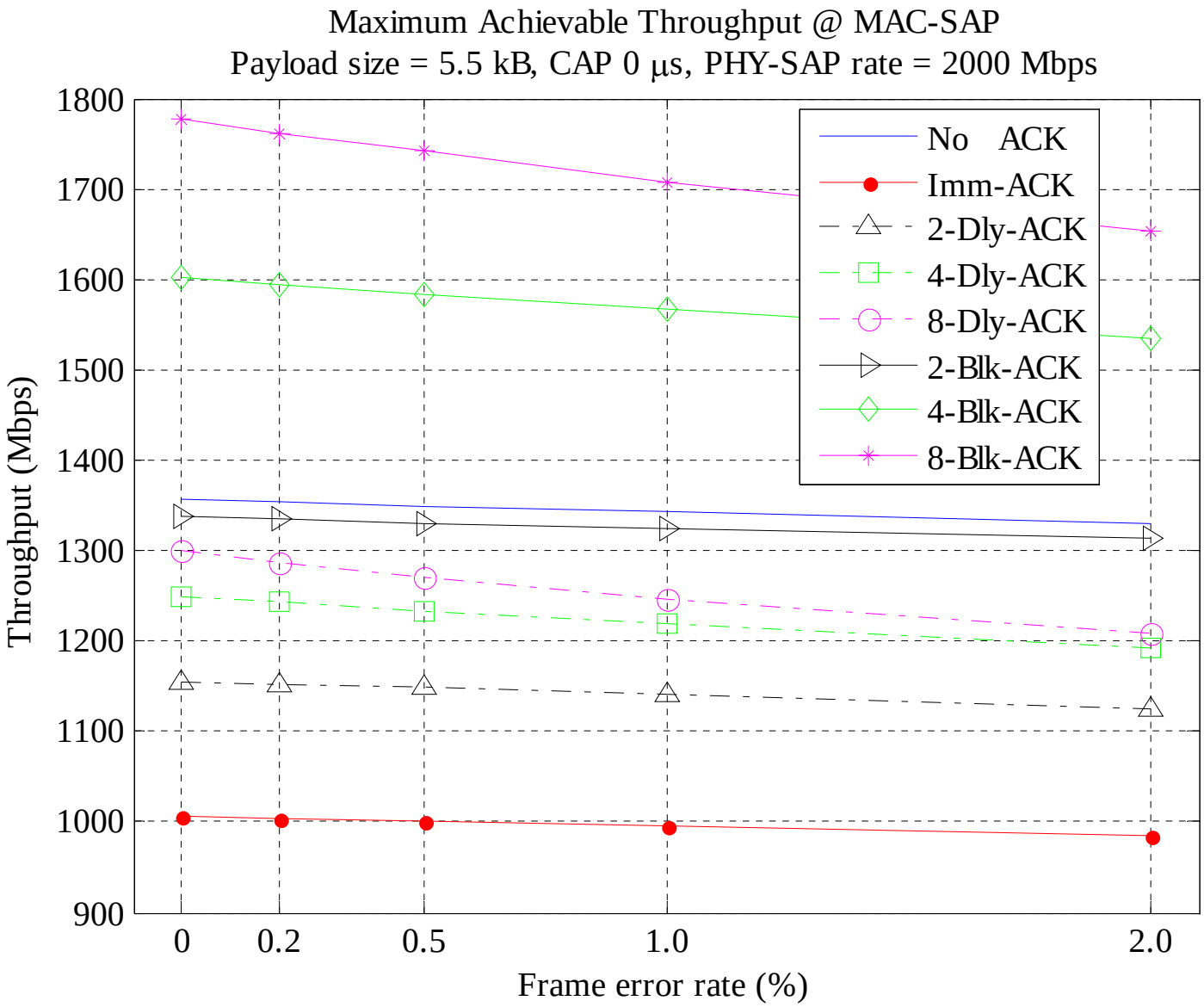
Performance Metrics

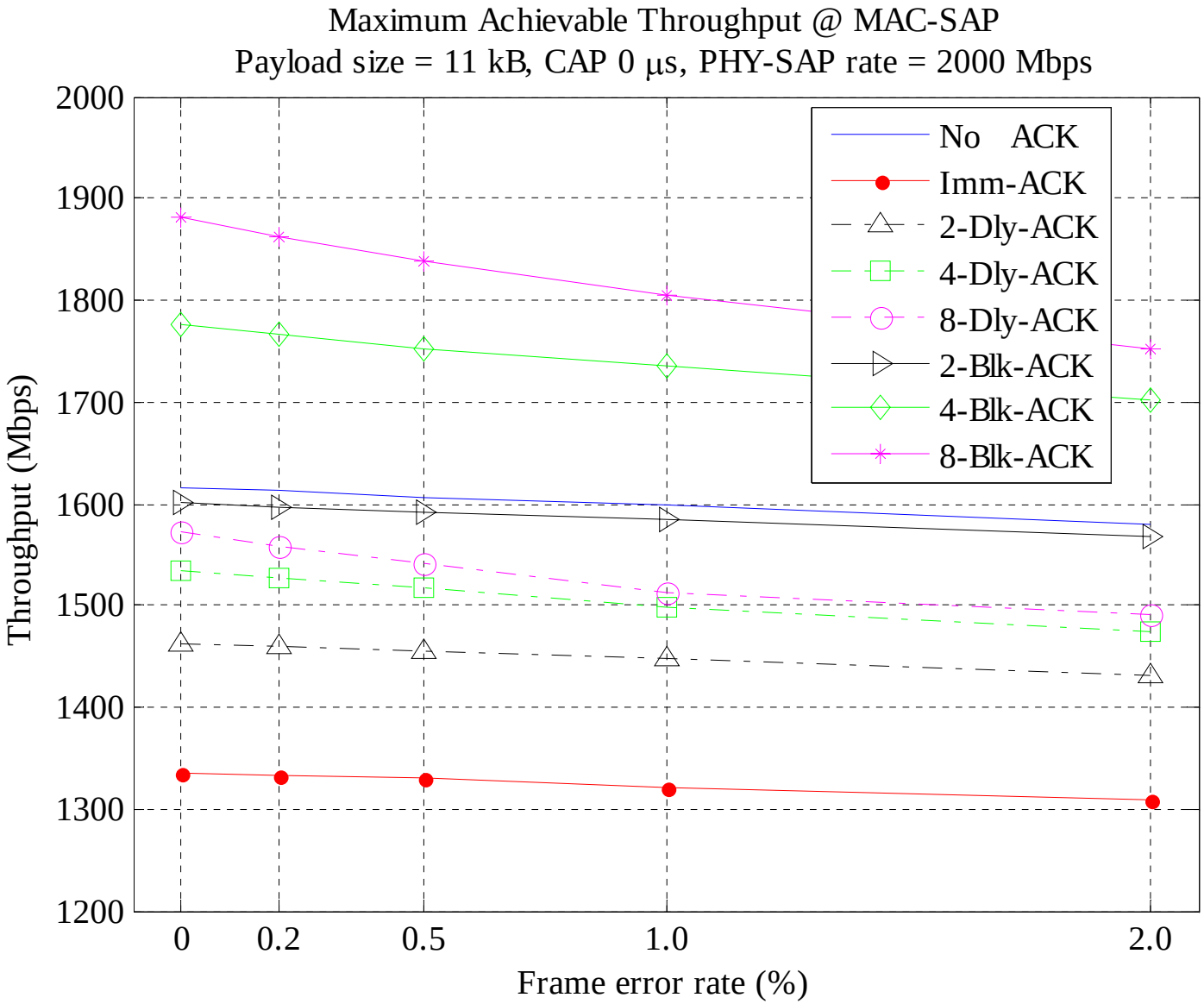
Throughput of MAC

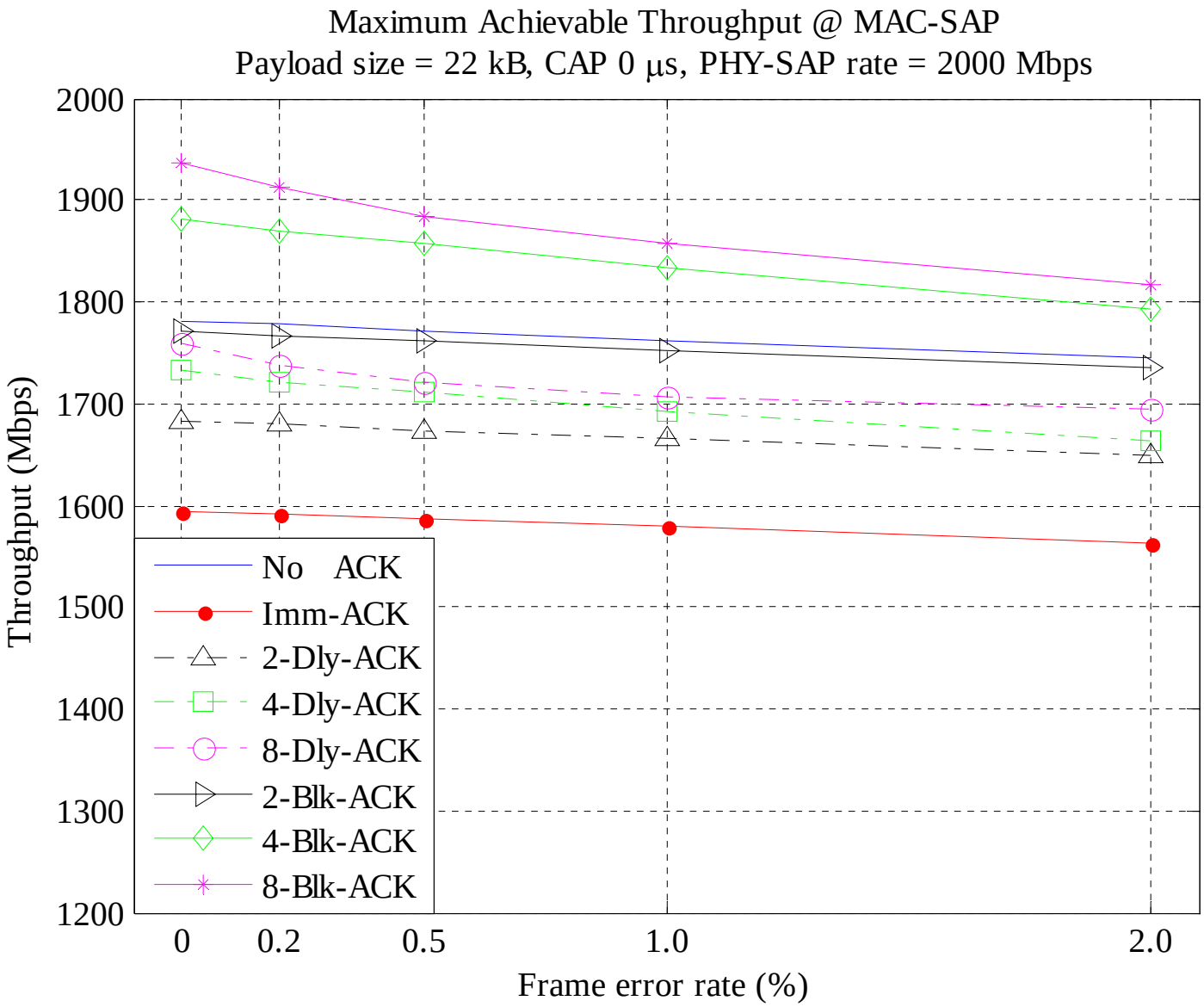
- measured in terms of bits per second, is the amount of data delivered successfully by the peer MAC-SAP.

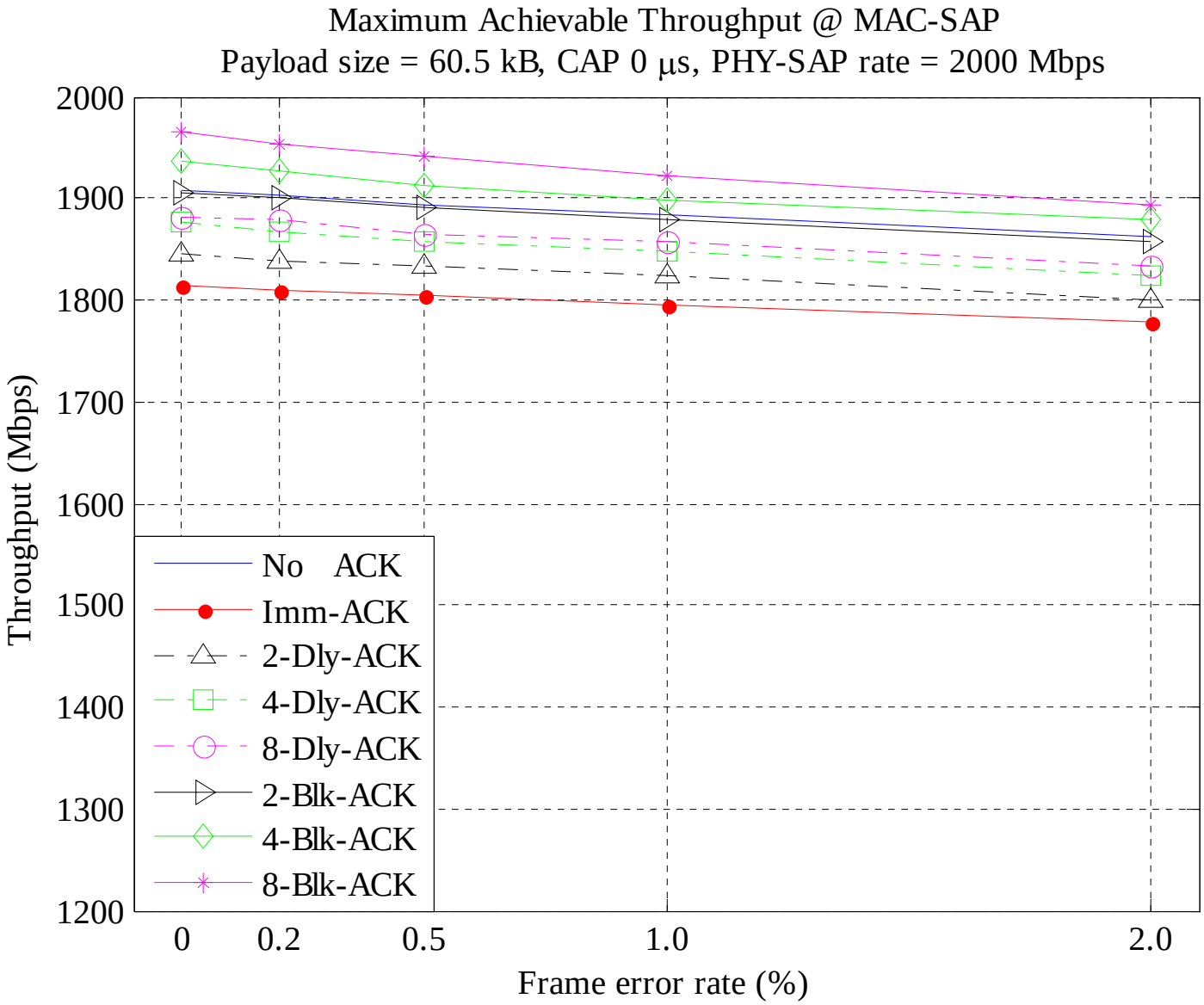
Buffer size of MAC

- the amount of memory occupied by frames buffered temporarily in the transmission queue for continuous video representation


Maximum Achievable Throughput @ MAC-SAP
Payload size = 5.5 kB, CAP 0 μs, PHY-SAP rate = 2000 Mbps
Throughput (Mbps)
1800
1700
1600
1500
1400
1300
1200
1100
1000
900
0
0.2
0.5
1.0
2.0
Frame error rate (%)
No ACK
Imm-ACK
2-Dly-ACK
4-Dly-ACK
8-Dly-ACK
2-Blk-ACK
4-Blk-ACK
8-Blk-ACK


Maximum Achievable Throughput @ MAC-SAP
Payload size = 11 kB, CAP 0 μs, PHY-SAP rate = 2000 Mbps
Throughput (Mbps)
2000
1900
1800
1700
1600
1500
1400
1300
1200
0
0.2
0.5
1.0
2.0
Frame error rate (%)
No ACK
Imm-ACK
2-Dly-ACK
4-Dly-ACK
8-Dly-ACK
2-Blk-ACK
4-Blk-ACK
8-Blk-ACK

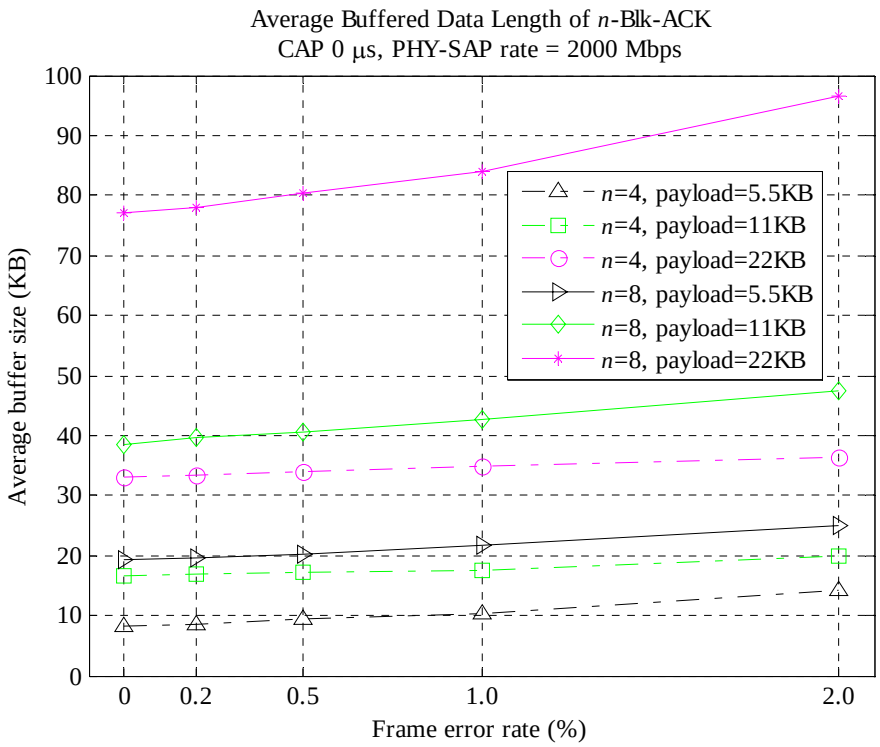

Maximum Achievable Throughput @ MAC-SAP
Payload size = 22 kB, CAP 0 μs, PHY-SAP rate = 2000 Mbps
Throughput (Mbps)
2000
1900
1800
1700
1600
1500
1400
1300
1200
0
0.2
0.5
1.0
2.0
Frame error rate (%)
No ACK
Imm-ACK
2-Dly-ACK
4-Dly-ACK
8-Dly-ACK
2-Blk-ACK
4-Blk-ACK
8-Blk-ACK

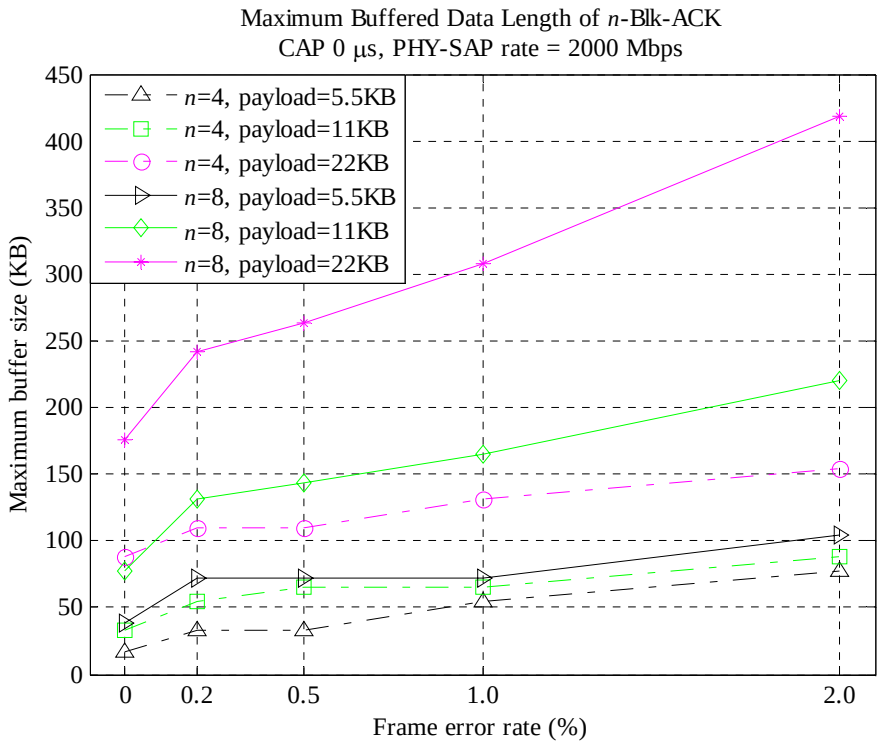

Maximum Achievable Throughput @ MAC-SAP
Payload size = 60.5 kB, CAP 0 μs, PHY-SAP rate = 2000 Mbps
Throughput (Mbps)
2000
1900
1800
1700
1600
1500
1400
1300
1200
0
0.2
0.5
1.0
2.0
Frame error rate (%)
No ACK
Imm-ACK
2-Dly-ACK
4-Dly-ACK
8-Dly-ACK
2-Blk-ACK
4-Blk-ACK
8-Blk-ACK

Traffic Model

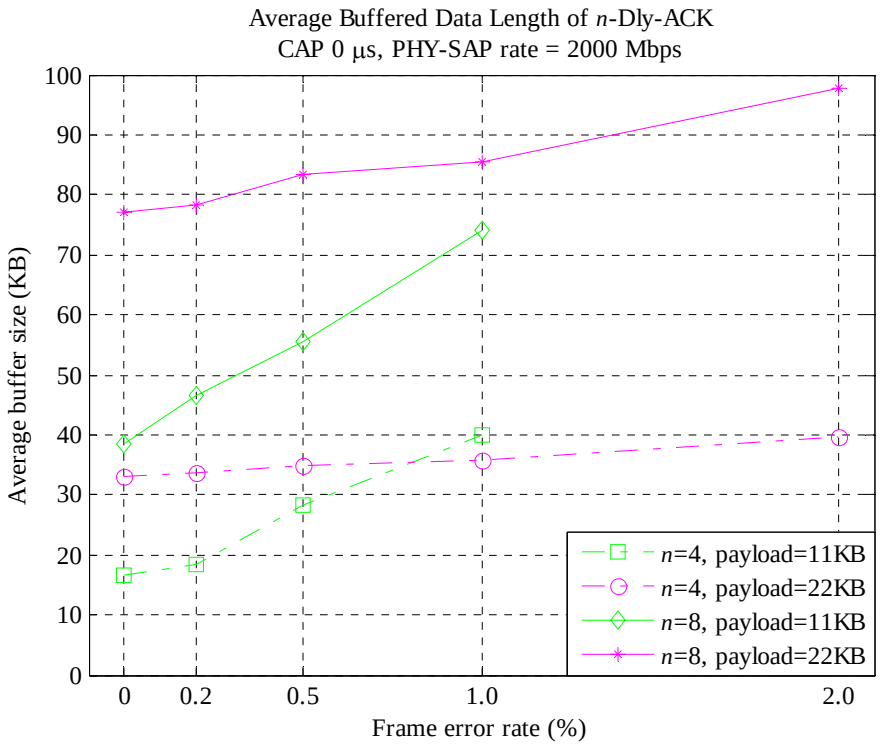
- Uncompressed Video Streaming: 1080p 30f 20b
  - Data Rate
    - 2200 x 1125 x 30 x 20 = 1.485 (Gbps)
  - CBR model
    - 44,000 bits (5.5 Kbytes) per 29.63 us
      - One MSDU is corresponding to one horizontal video line
      - 2200 x 20 = 44,000 bits
    - 88,000 bits (11 Kbytes) per 59.26 us
    - 176,000 bits (22 Kbytes) per 118.52 us
    - *etc*.
- The buffer size (queue length) of the transmitter side is investigated if the data rate of video traffic can be supported.

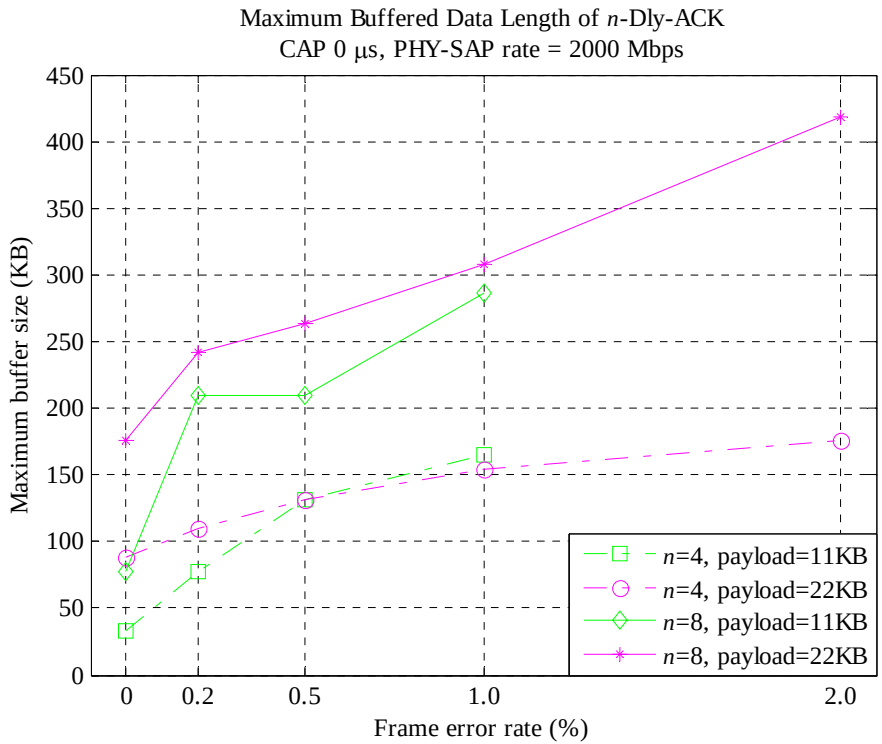
Buffer Size of Block ACK





Buffer Size of Delayed ACK





Conclusions

- *n*-Blk-ACK combined with aggregation outperforms other ACK policies, especially for small MSDUs. However, if *n* is too small (e. g. *n* = 2), it shows no advantage.
- When the preferred fragment size or actual payload size is larger, there is less advantage of Blk-ACK.
- For Dly-ACK and Blk-ACK, if the frame error rate increases, the fluctuation of throughput increases too, because of the missing ACK Requests, resulting in a rapid drop of throughput.
- More buffer size or queue length is needed to support very high throughput (larger MSDU/payload size or larger *n* in *n*-Dly-ACK/*n*-Blk-ACK) and deal with transmission errors.
- The transmission delay is almost negligible for small frames, because of the very high transmission speed. However, *n*-Blk-ACK introduces additional small buffer delay, because the transmitter has to wait till *n* MAC frames are accumulated.

Appendix

Parameters on Video Resolution

Formant	V Freq	HRES	VRES	DE_CNT	DE_LIN	Rate 24bit	Rate 20bit	Hsync (sec)	Vsync (sec)
1080i	30	2200	562/ 563	1920	1080	5760	4800	3.77104E-06	0.000652/ 0.000681
1080p	30	2200	1125	1920	1080	5760	4800	3.77104E-06	0.001333
1080p	60	2200	1125	1920	1080	5760	4800	1.88552E-06	0.000667