

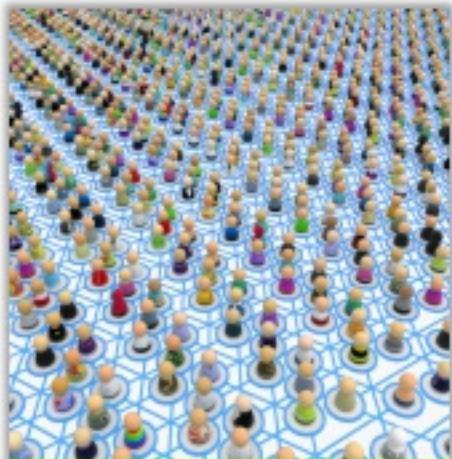
Coexistence Study of Different Medium Access Mechanisms Using a Software Defined Radio Testbed

Bachelor Thesis Talk

Alexander Pastor - December 18th, 2017



Contents

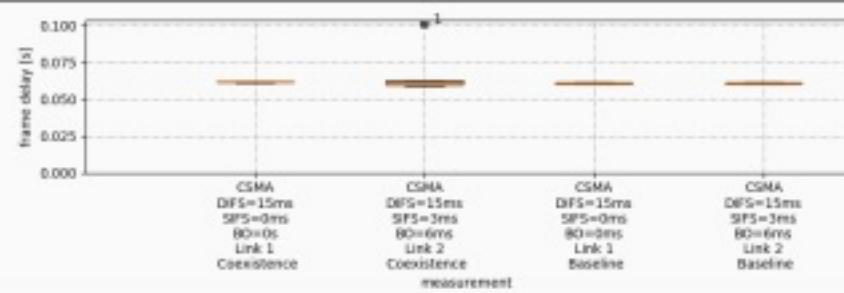
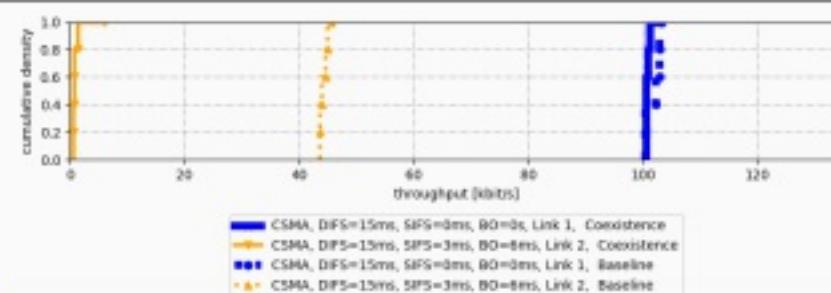


Motivation



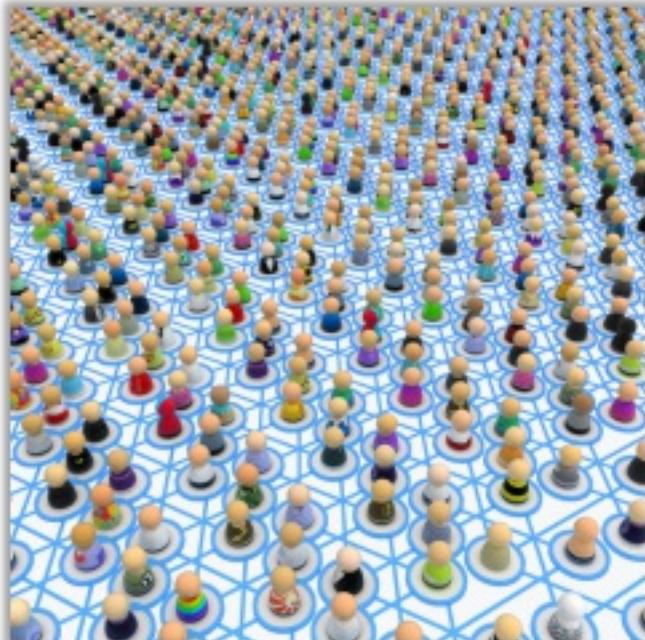
Scenario Type	Link 1	Link 2
Same MAC	ALOHA CSMA/CA (3 variants) 1-persistent CSMA	
Different MAC	ALOHA unsaturated ALOHA CSMA/CA 1-persistent CSMA 1-persistent CSMA	CSMA/CA CSMA/CA CSMA/CA unsaturated ALOHA CSMA/CA

Methodology



Results and Conclusions

Motivation



- Demand for high transfer rates
- Network Densification
- Intertechnological Coexistence

⇒ **Need to design good MAC protocols**

Motivation

Why is it hard to design good MAC protocols?

Design Drivers

Maximize

- **Throughput**
- Coverage
- Security
- Flexibility

Minimize

- Latency
- Jitter
- Power Consumption
- Complexity

Challenges Wireless MAC

- **Interference**

- Hidden Node Problem
- Exposed Node Problem
- Security
- Power Supply

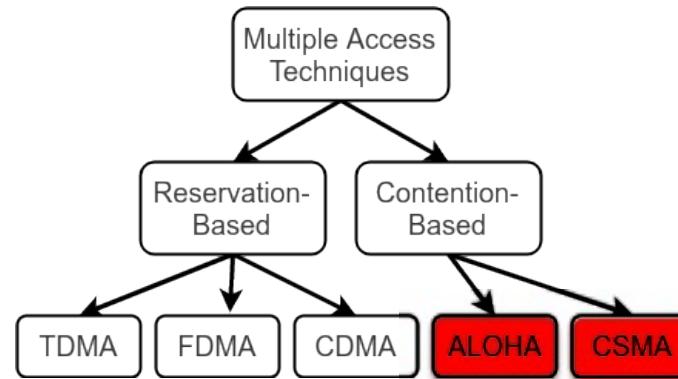
Operating Conditions

- **Intertechnological Coexistence**
- Traffic Patterns
- Directional Traffic

⇒ **Protocol design has to be confined/focussed on certain aspects depending on the application**

Motivation

Protocol Classification



Some MAC Mechanisms

Coordinator

- Time Domain
- Frequency Domain
- Code Domain

Carrier Sensing

- Thresholding
- Preamble Sampling
- Outlier Detection

Handshaking

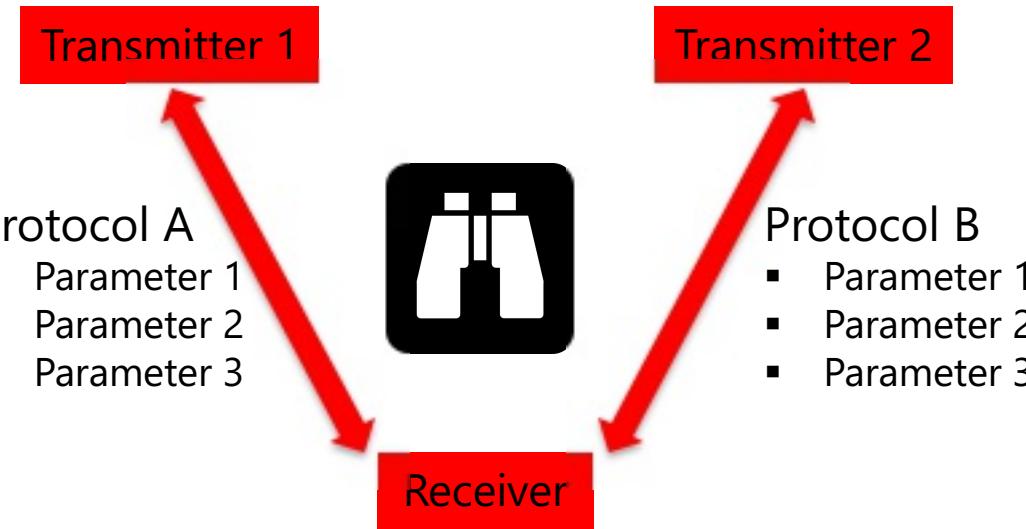
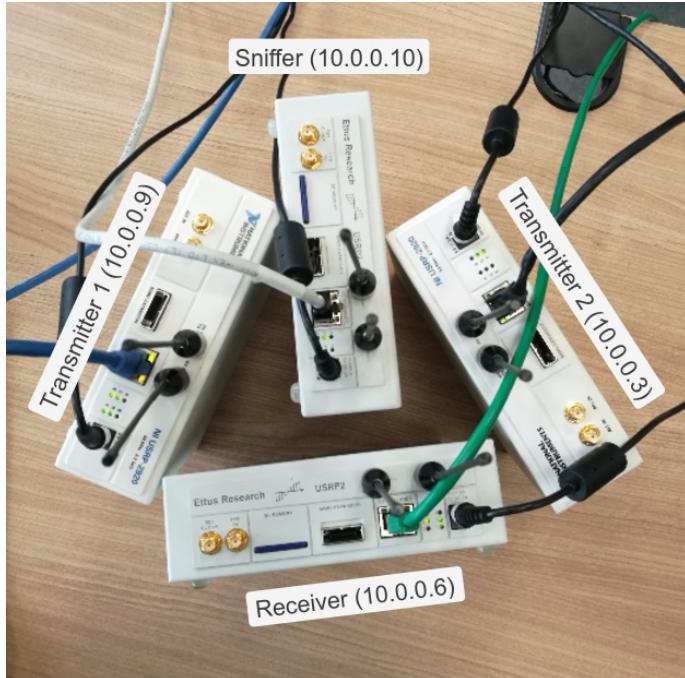
- Timeouts
- Acknowledgments
- RTS/CTS Exchange
- Sliding Windows

using size 1 =
Stop-and-Wait
ARQ

Random Backoff

- Minimum CW
- CW Growth

Methodology



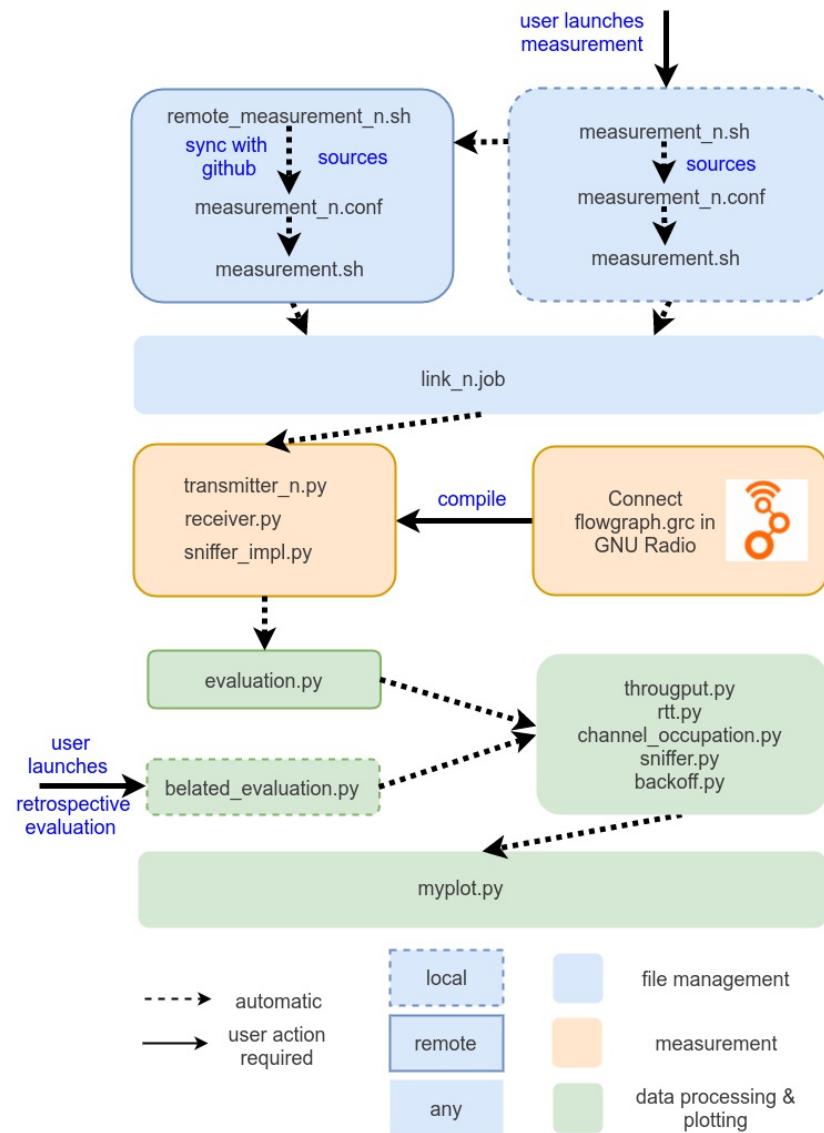
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Different MAC	ALOHA unsaturated ALOHA CSMA/CA 1-persistent CSMA 1-persistent CSMA	CSMA/CA CSMA/CA CSMA/CA unsaturated ALOHA CSMA/CA

- SDR, GNU Radio
- USRPs: NI 2920, Ettus Research USRP2

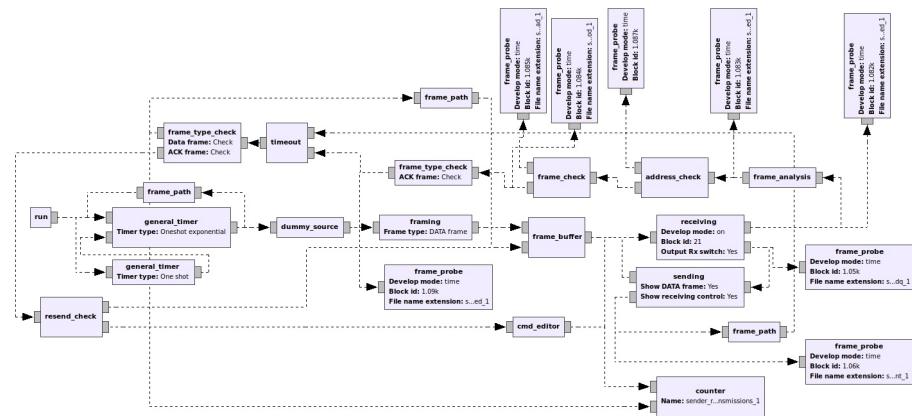
Scenarios

- same MAC scenarios
- different MAC scenarios
- baseline vs. coexistence

Methodology

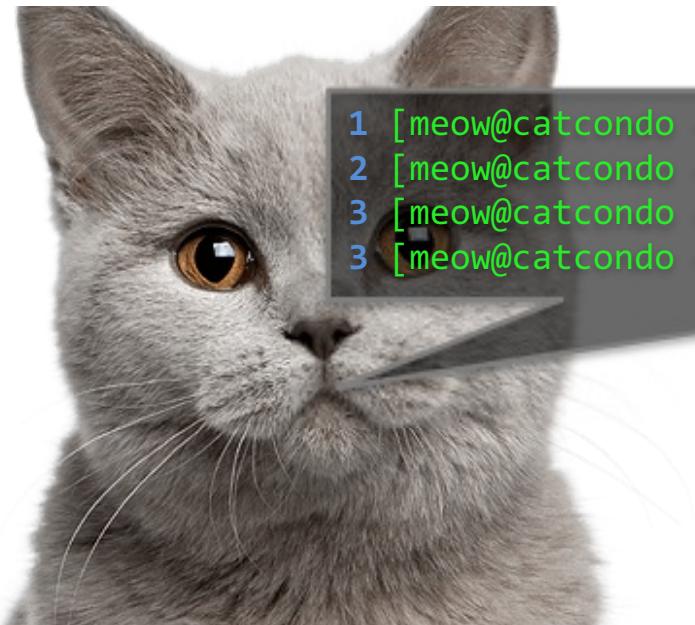


- automated measurement procedure
- modular design principle
- file management
- GNU Radio flowgraphs
- data processing & plotting



Cat the logs

log is the path to the log file

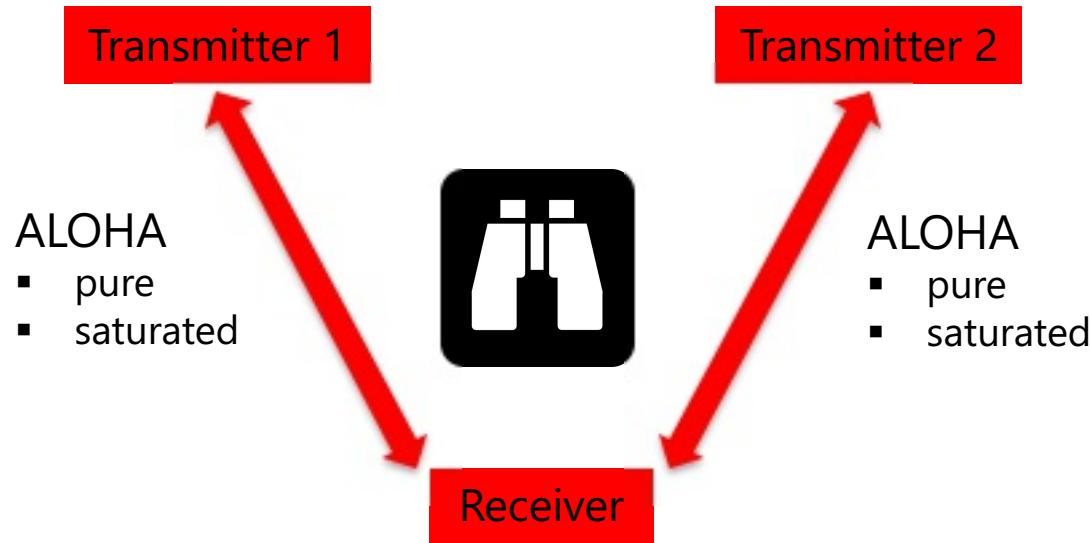


```
1 [meow@catcondo ~]$ cat log
2 [meow@catcondo ~]$ tail -n +17 log
3 [meow@catcondo ~]$ tail -n 150 log
3 [meow@catcondo ~]$ cat log $(python belated_evaluation.py &> log)
```

- 1 file management
- 2 measurement
- 3 data processing & plotting

Results

Pure ALOHA x2



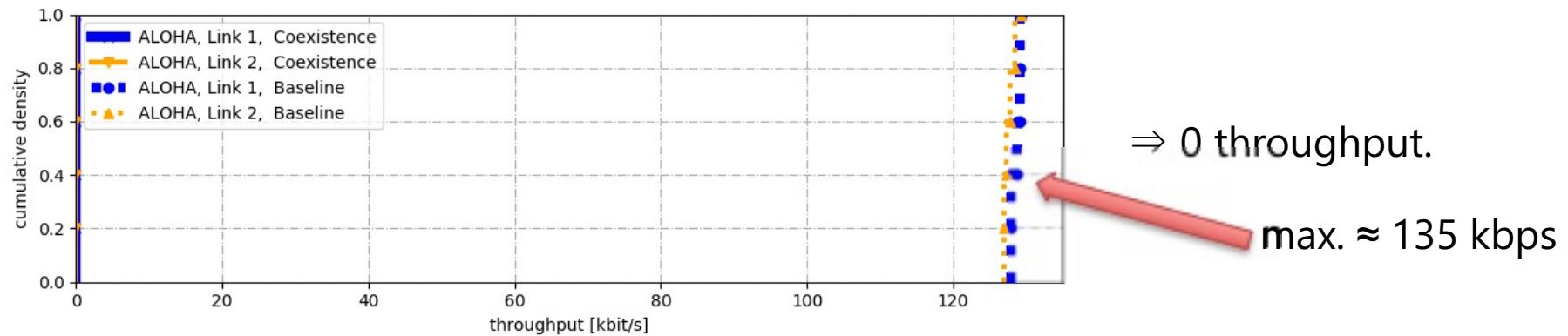
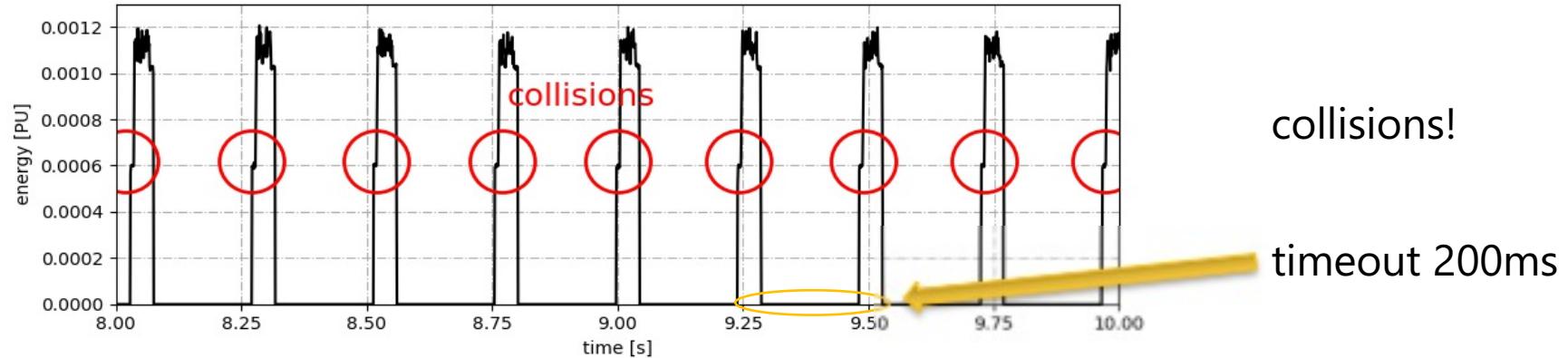
Expectations:

- Only Collisions
- No throughput
- 100% packet loss

Scenario Type	Link 1	Link 2
Same MAC	ALOHA CSMA/CA (3 variants) 1-persistent CSMA	
Different MAC	ALOHA unsaturated ALOHA CSMA/CA 1-persistent CSMA 1-persistent CSMA	CSMA/CA CSMA/CA CSMA/CA unsaturated ALOHA CSMA/CA

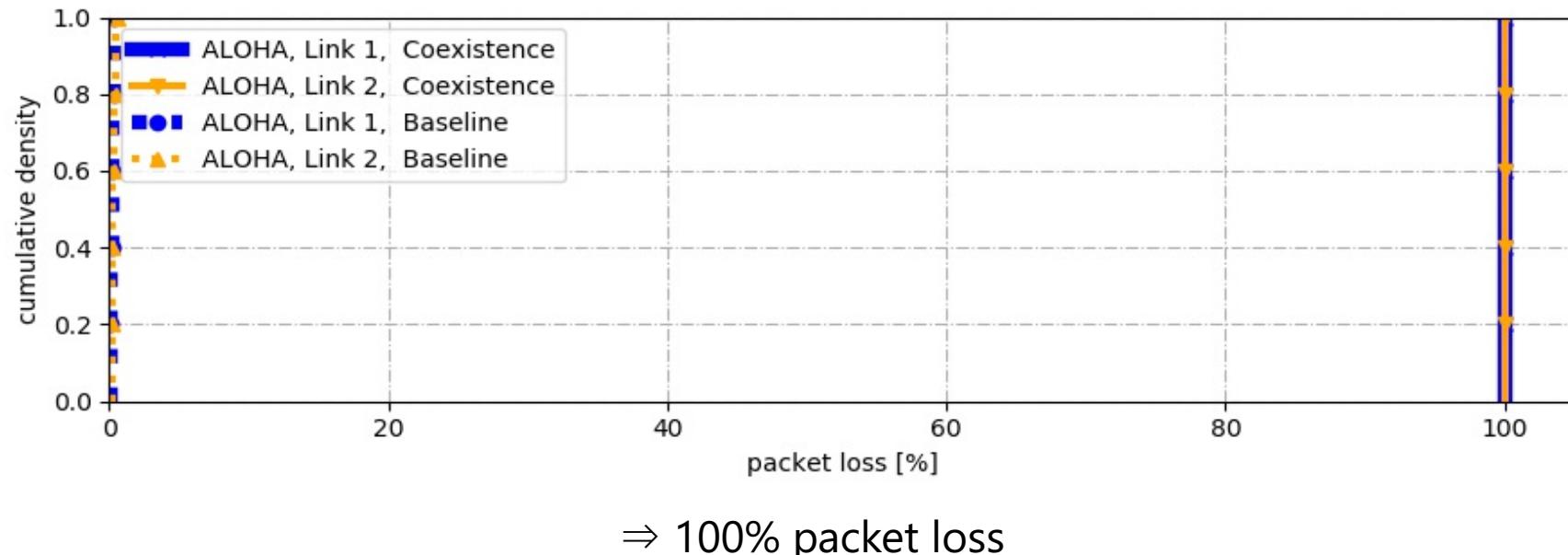
Results

Same MAC protocol on the two links - Pure ALOHA



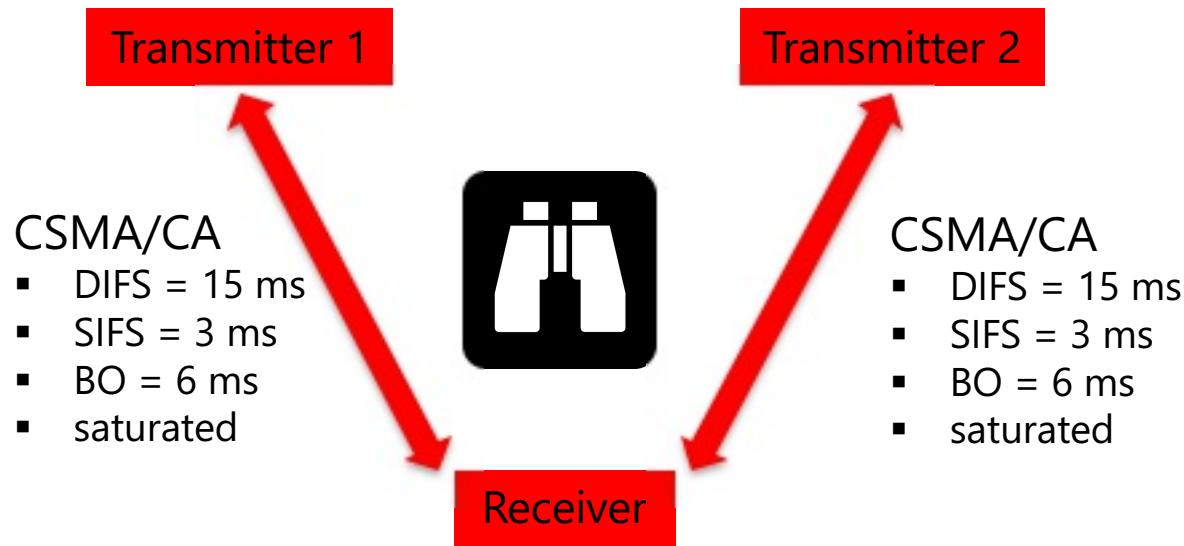
Results

Same MAC protocol on the two links - Pure ALOHA



Results

CSMA/CA (high parameter values) x2



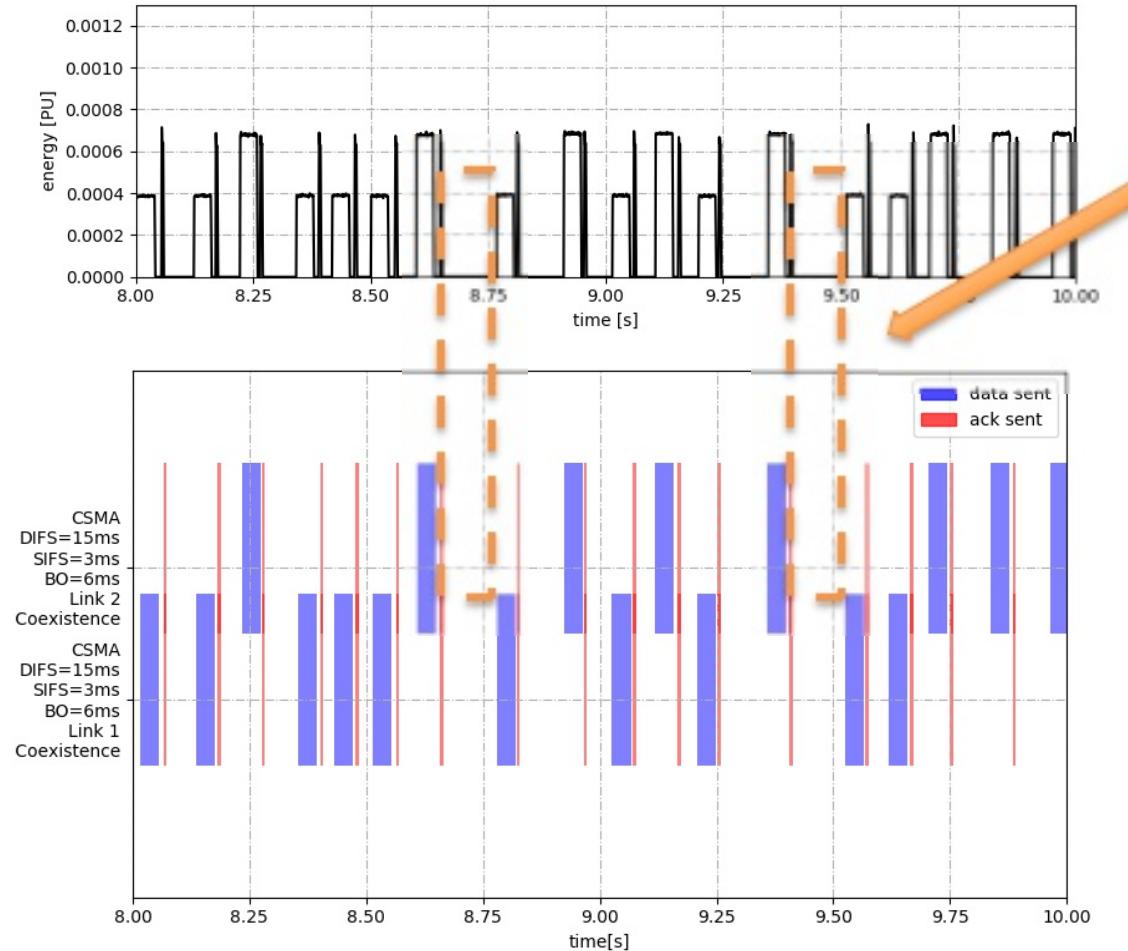
Expectations:

- Few Collisions
- Mediocre,
evenly distributed throughput
- Low packet loss

Scenario Type	Link 1	Link 2
Same MAC	ALOHA	
	CSMA/CA (3 variants)	
	1-persistent CSMA	
Different MAC	ALOHA	CSMA/CA
	unsaturated ALOHA	CSMA/CA
	CSMA/CA	CSMA/CA
	1-persistent CSMA	unsaturated ALOHA
	1-persistent CSMA	CSMA/CA

Results

Same MAC protocol on the two links - CSMA/CA high parameter values



Sniffer energy plot

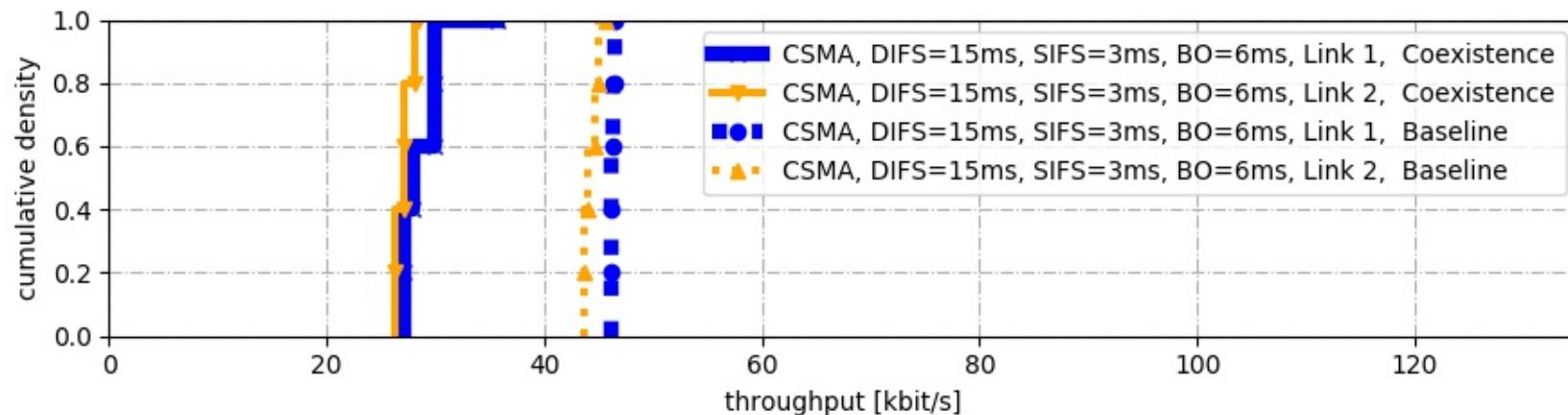
- distinct power levels
- long idle periods due to backoff
- negative impact on throughput

Logical channel occupation

- data frames transmitter POV
- ack frames receiver POV

Results

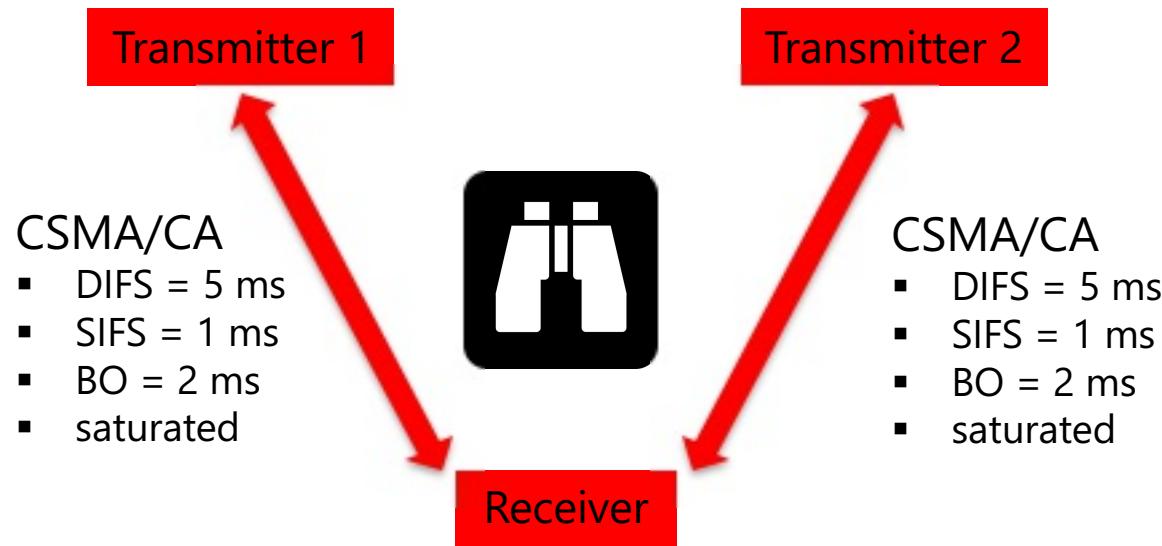
Same MAC protocol on the two links - CSMA/CA high parameter values



Baseline throughput only about a third of ALOHA
Coexistence throughput roughly halves compared to baseline

Results

CSMA/CA (low parameter values) x2



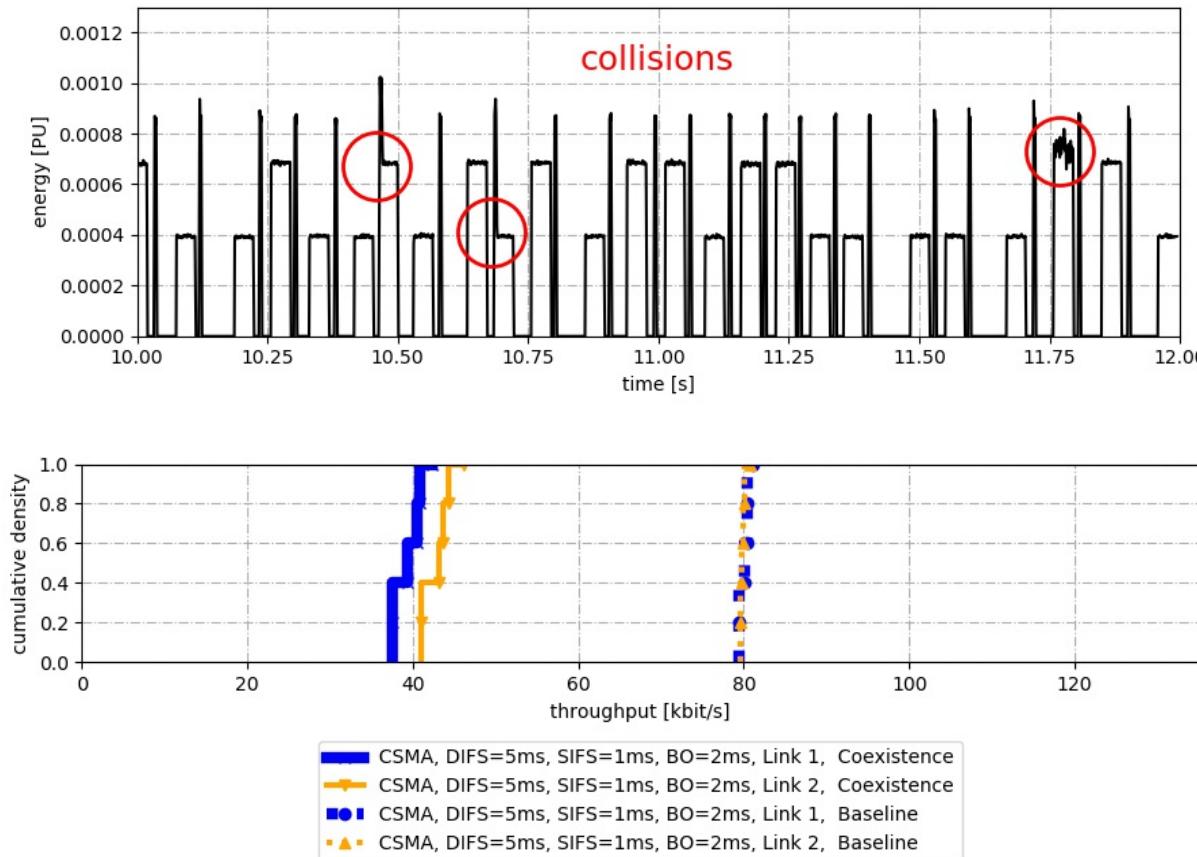
Expectations:

- Some collisions
- High channel utilization
- High, evenly distributed throughput
- Low packet loss

Scenario Type	Link 1	Link 2
Same MAC	ALOHA	
	CSMA/CA (3 variants)	1-persistent CSMA
Different MAC	ALOHA	CSMA/CA
	unsaturated ALOHA	CSMA/CA
	CSMA/CA	CSMA/CA
	1-persistent CSMA	unsaturated ALOHA
	1-persistent CSMA	CSMA/CA

Results

Same MAC protocol on the two links - CSMA/CA low parameter values



Types of collisions

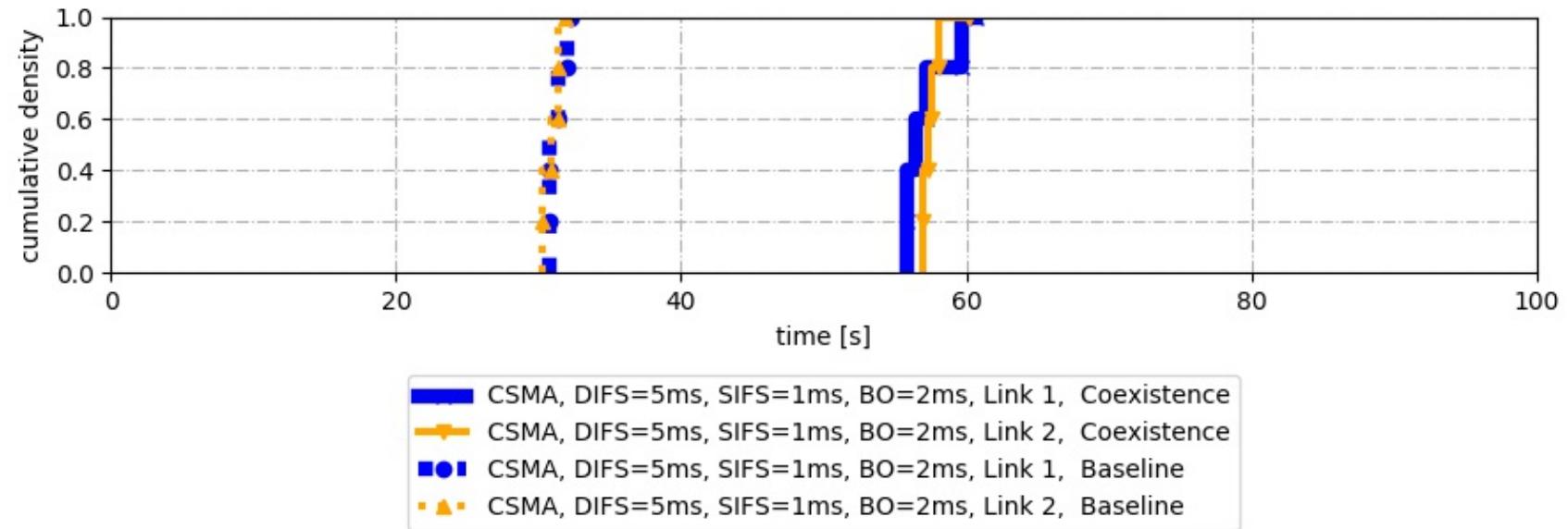
- "granularity type"
- "1-persistent type"

Throughput expectations met!

- 80 kbps baseline
- \approx halves in coexistence

Results

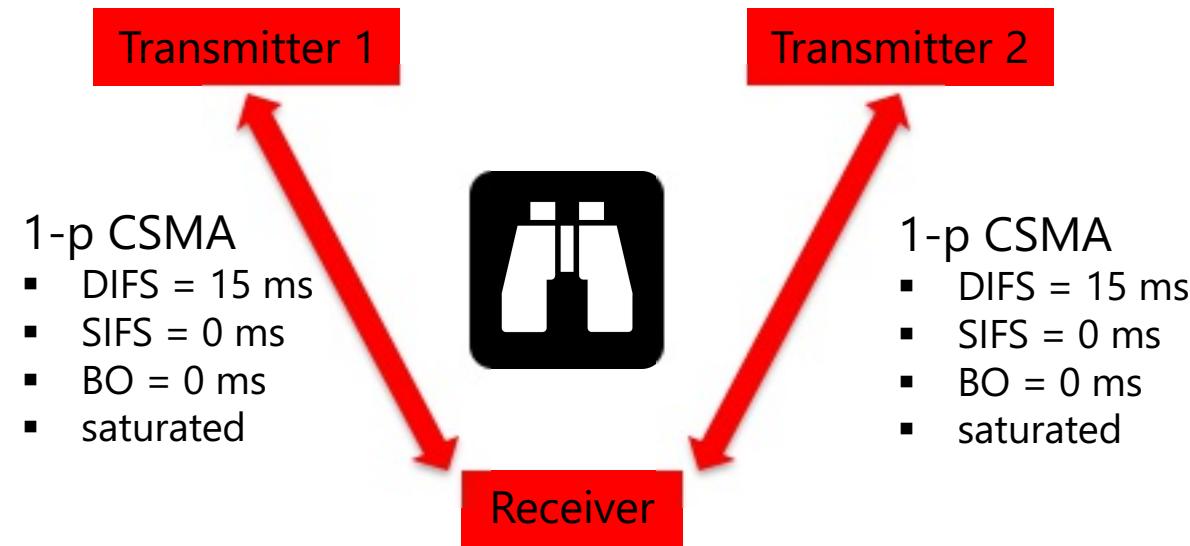
Same MAC protocol on the two links - CSMA/CA low parameter values



Backoff 55-60 s per 100 s
close to ideal backoff duration

Results

1-persistent CSMA x2



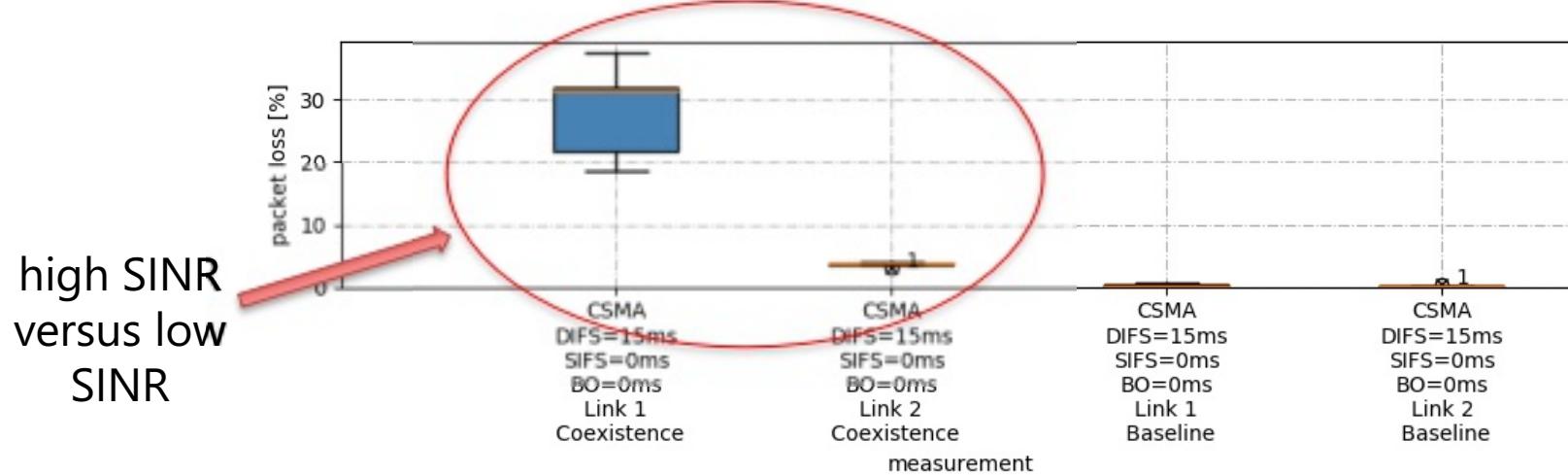
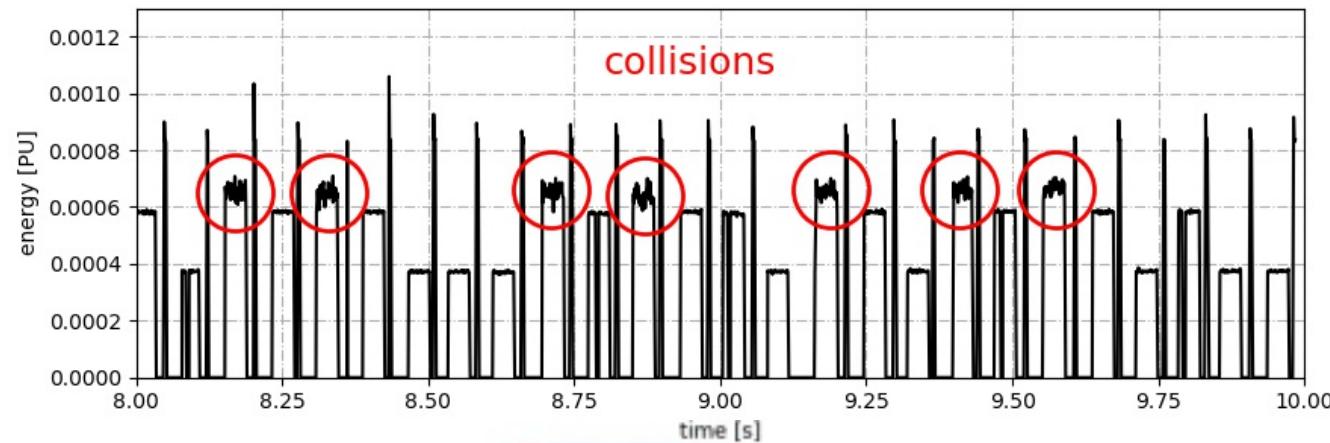
Expectations:

- Lots of collisions
- Very high channel utilization
- Capture effect

Scenario Type	Link 1	Link 2
Same MAC	ALOHA	
	CSMA/CA (3 variants)	1-persistent CSMA
Different MAC	ALOHA	CSMA/CA
	unsaturated ALOHA	CSMA/CA
	CSMA/CA	CSMA/CA
	1-persistent CSMA	unsaturated ALOHA
	1-persistent CSMA	CSMA/CA

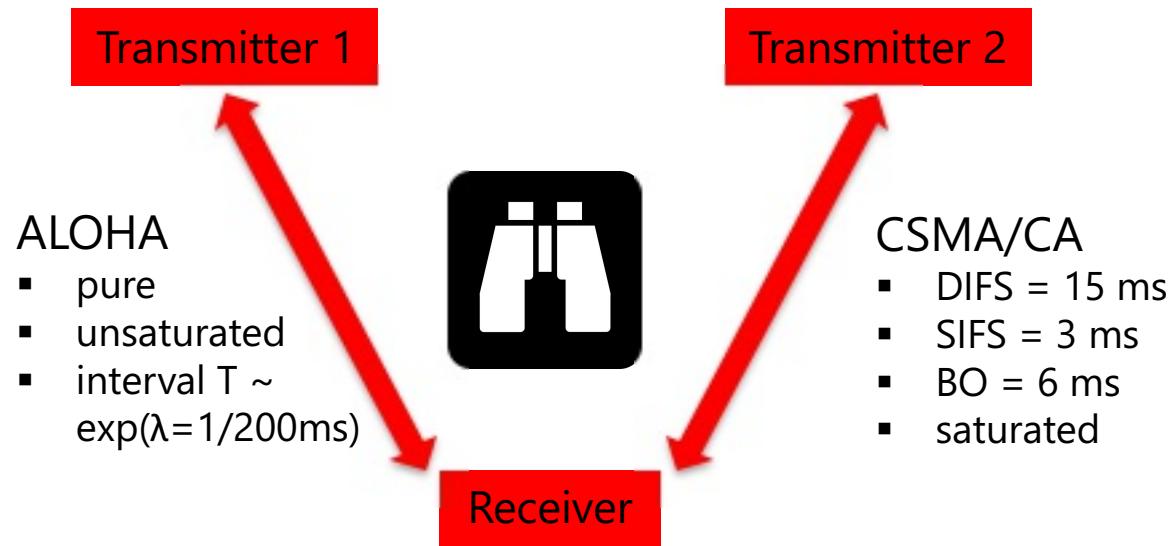
Results

Same MAC protocol on the two links - 1-persistent CSMA



Results

unsaturated ALOHA + CSMA/CA (high parameters)



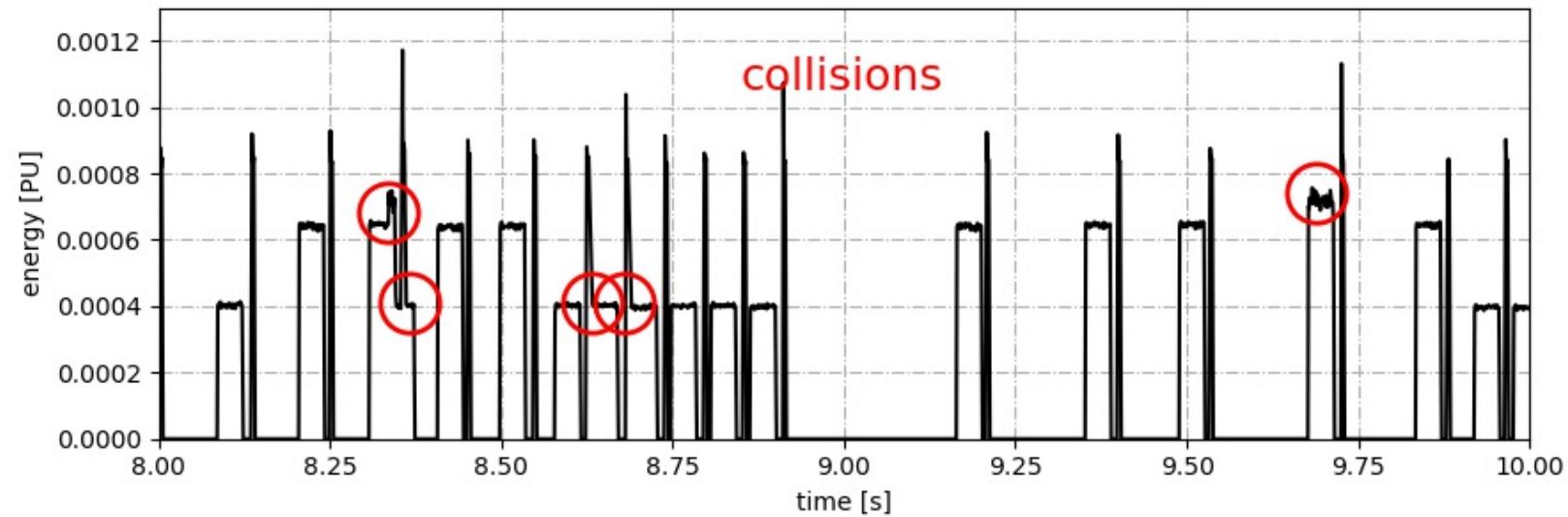
Expectations:

- Some collisions
- Low channel utilization
- Low throughput

Scenario Type	Link 1	Link 2
Same MAC	ALOHA	CSMA/CA (3 variants)
		1-persistent CSMA
Different MAC	ALOHA	CSMA/CA
	unsaturated ALOHA	CSMA/CA
	CSMA/CA	CSMA/CA
	1-persistent CSMA	unsaturated ALOHA
	1-persistent CSMA	CSMA/CA

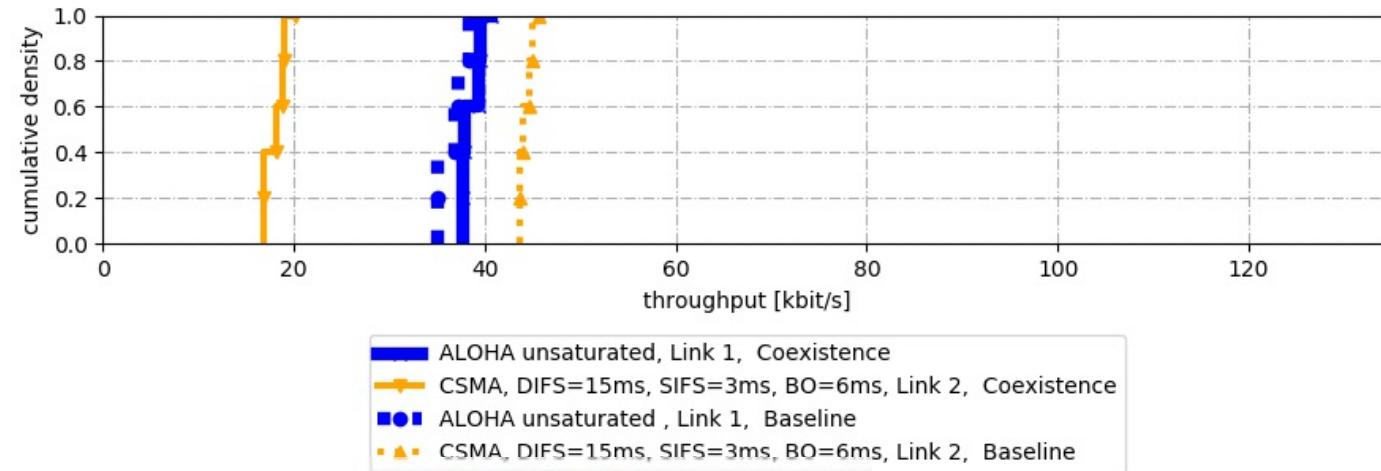
Results

Different MAC protocol on the two links - unsaturated ALOHA + CSMA/CA

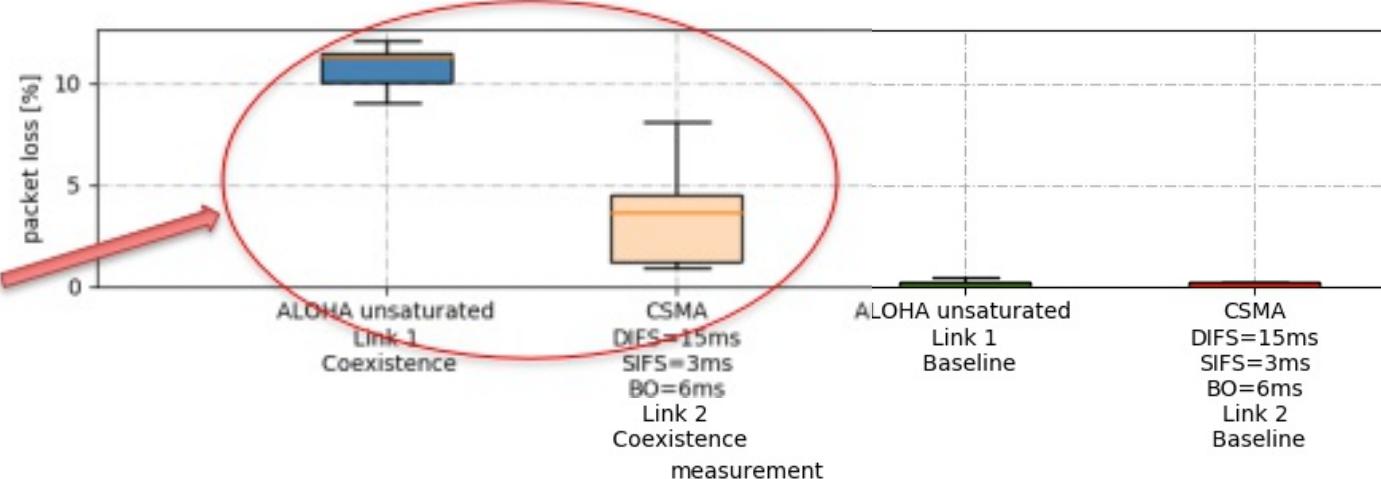


Results

Different MAC protocol on the two links - unsaturated ALOHA + CSMA/CA

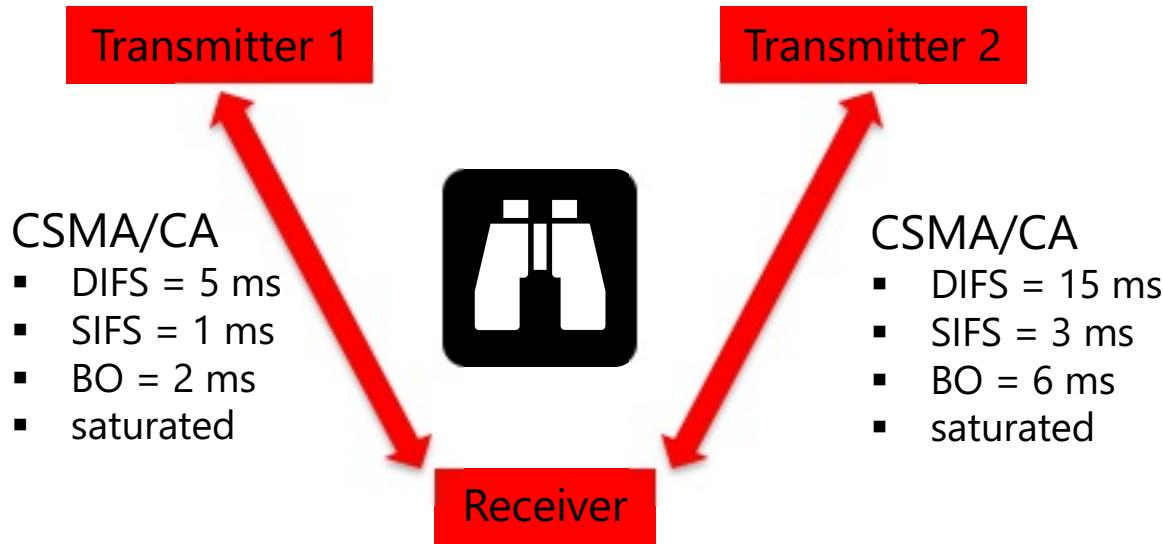


LBT
versus
no LBT



Results

2x CSMA/CA (high+low)



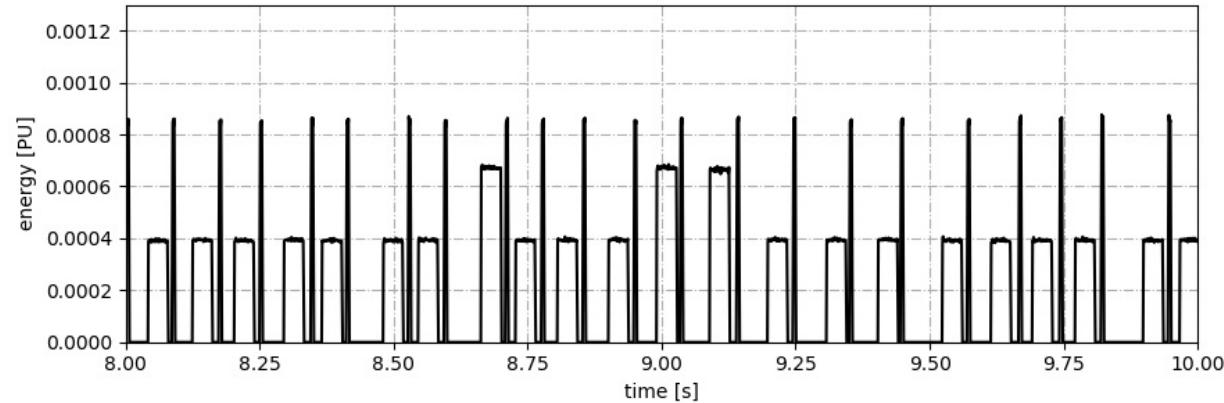
Expectations:

- Few collisions
- Medium channel utilization
- Medium throughput

Scenario Type	Link 1	Link 2
Same MAC	ALOHA	
	CSMA/CA (3 variants)	1-persistent CSMA
Different MAC	ALOHA	CSMA/CA
	unsaturated ALOHA	CSMA/CA
	CSMA/CA	CSMA/CA
	1-persistent CSMA	unsaturated ALOHA
	1-persistent CSMA	CSMA/CA

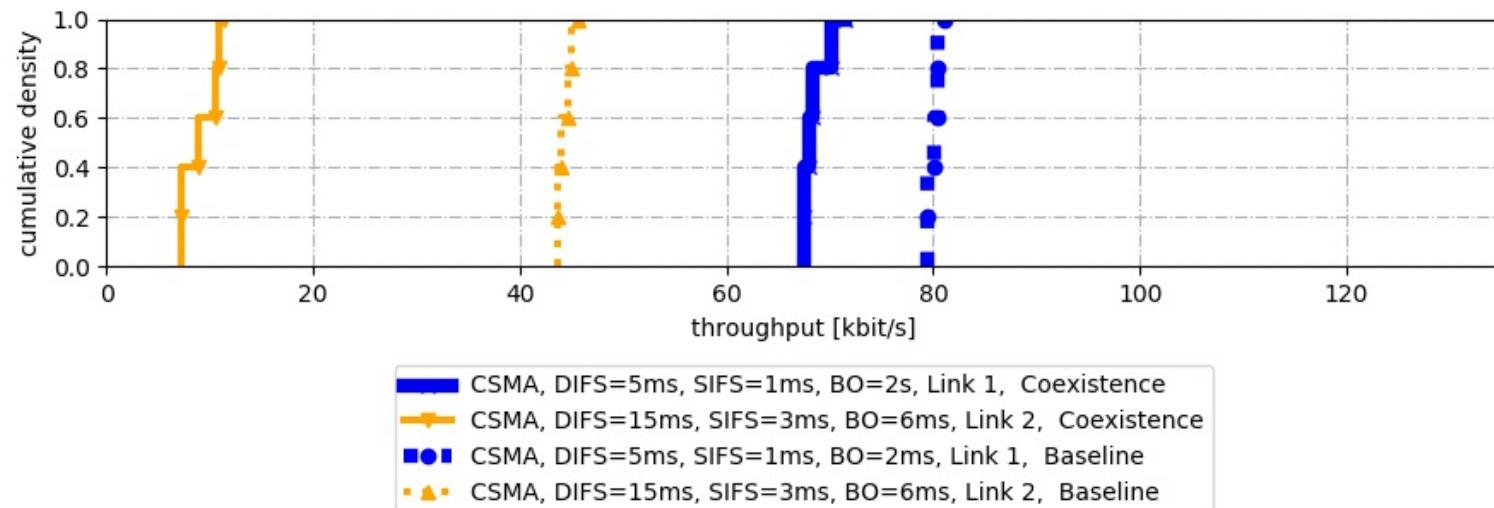
Results

Different MAC protocol on the two links - different CSMA/CA variants



Backoff (slot) duration
decisive factor in
channel share...

... and thus throughput



Conclusions

- Even low loads of ALOHA have strong, negative impact on all other nodes within reach.
- The LBT mechanism of CSMA/CA enables fair, (almost) collision-free traffic.
- CSMA/CA parameters have a major impact on the performance
 - High values \Rightarrow excessive idle periods
 - Low values \Rightarrow possibly below system time granularity
 - $SIFS = 0, BO = 0, DIFS > 0 \Rightarrow$ 1-persistent CSMA
 - Backoff slot duration is the decisive factor in (our) transmission cycle
 - "Ideal" backoff would be t/n
- Capture effect



Q&A Time!



Backup Slides



Motivation

Security Aspects in MAC Design

Characteristic	Mica2*	TMote Mini†
RAM (Kbytes)	4	10
Program flash memory (Kbytes)	128	48
Maximum data rate (Kbps)	76.8	250
Power draw: Receive (mW)	36.81	57.0
Power draw: Transmit (mW)	87.90	57.0
Power draw: Sleep (mW)	0.048	0.003

Denial of
Sleep Attack

Targetting: service availability and data integrity
Example attack against S-MAC: Bogus SYNC
packets to keep clusters awake

Attacker: Repeated RTS to target neighborhood node

Interrogation
Attack

Methodology

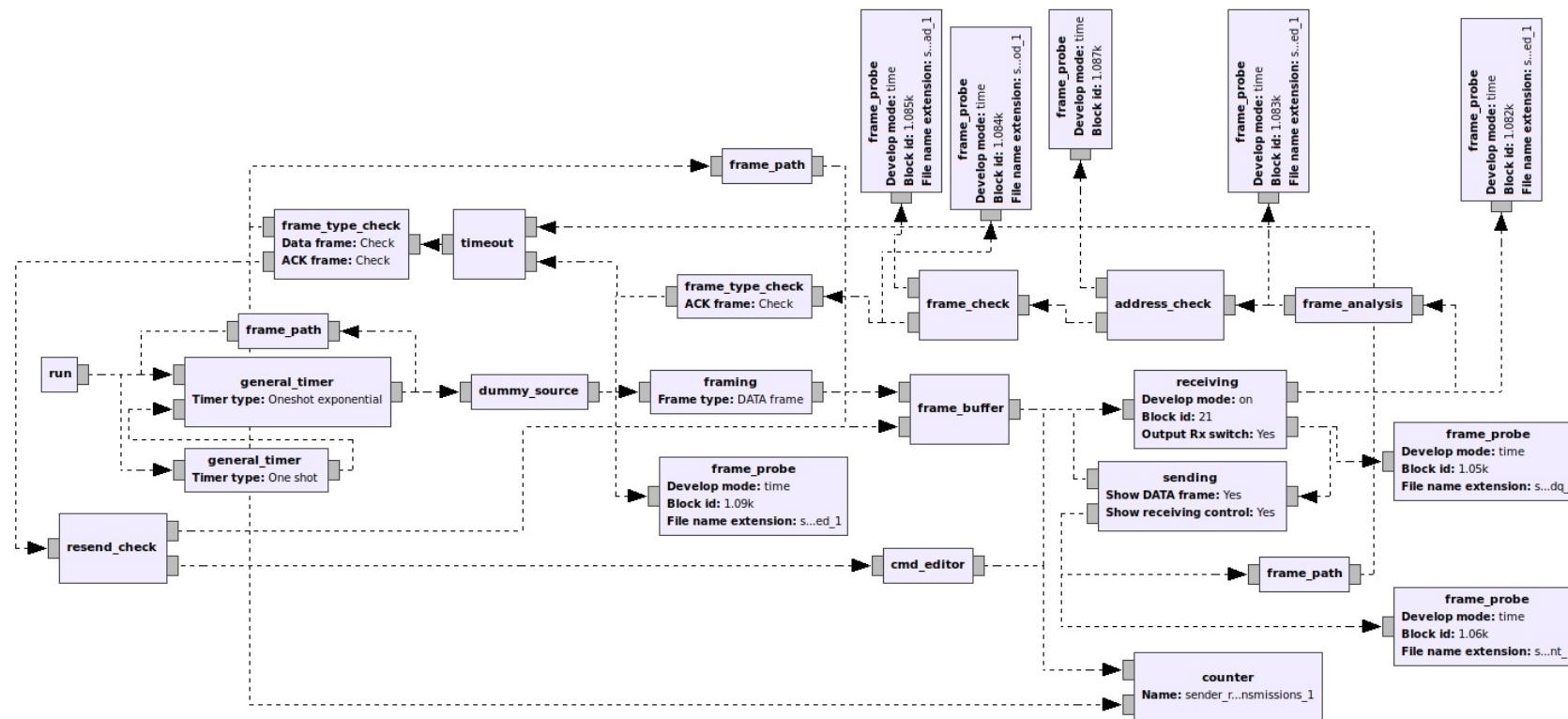
Testbed Setup Parameters

Layer	Parameter	Value	Comment
PHY Layer	MCS	QPSK	BPSK optional, unused
	Carrier frequency	450 MHz	420 MHz - 480 MHz work as well
	Sampling rate	400 k/s	
MAC Layer	Frame size	1000 bytes	max. supported by OS
	Payload size	837 bytes	
	Timeout	100 ms	RTT \leq 68 ms
	CSMA CS threshold	0.001 PU	for RX/TX gains as in Table 4.1
	Max. retransmissions	6	

Function	TX Gain	RX Gain	Source Address	Dest. Address	IP Address
Receiver	4 dB	10 dB	X	any	10.0.0.6
Sniffer	0	0	any	any	10.0.0.10
Transmitter 1	5 dB	0	Y	X	10.0.0.9
Transmitter 2	9 dB	0	Z	X	10.0.0.3

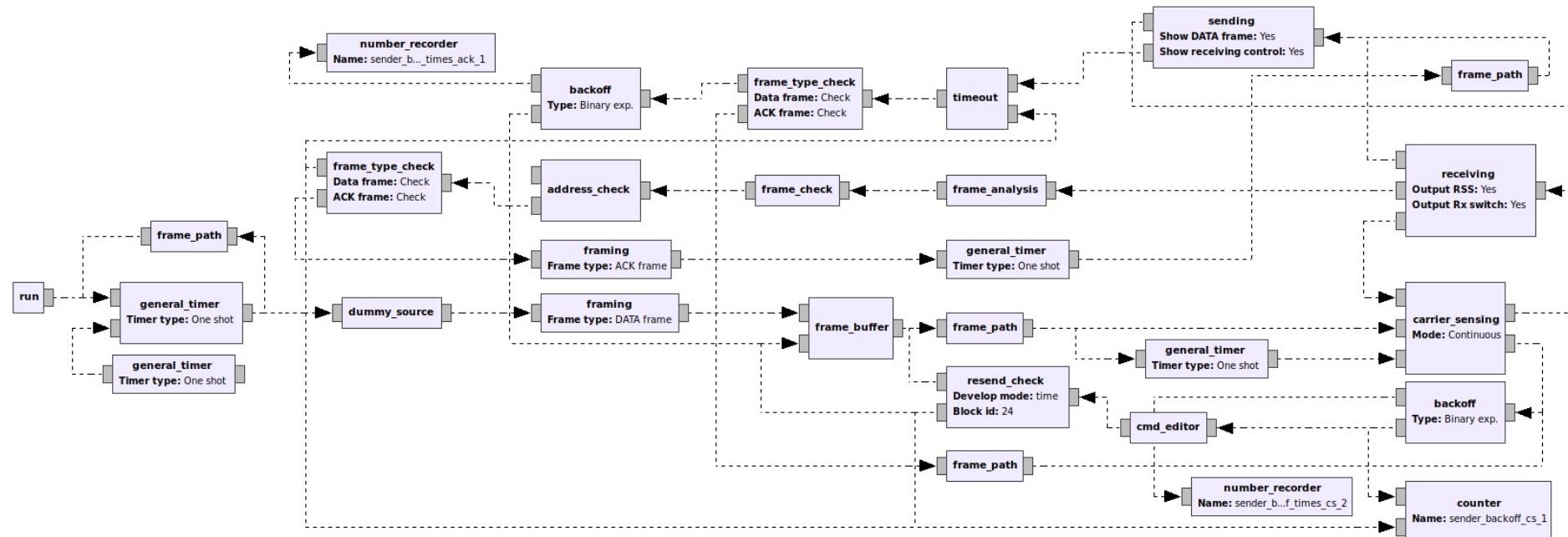
Methodology

Sender (ALOHA) Flowgraph



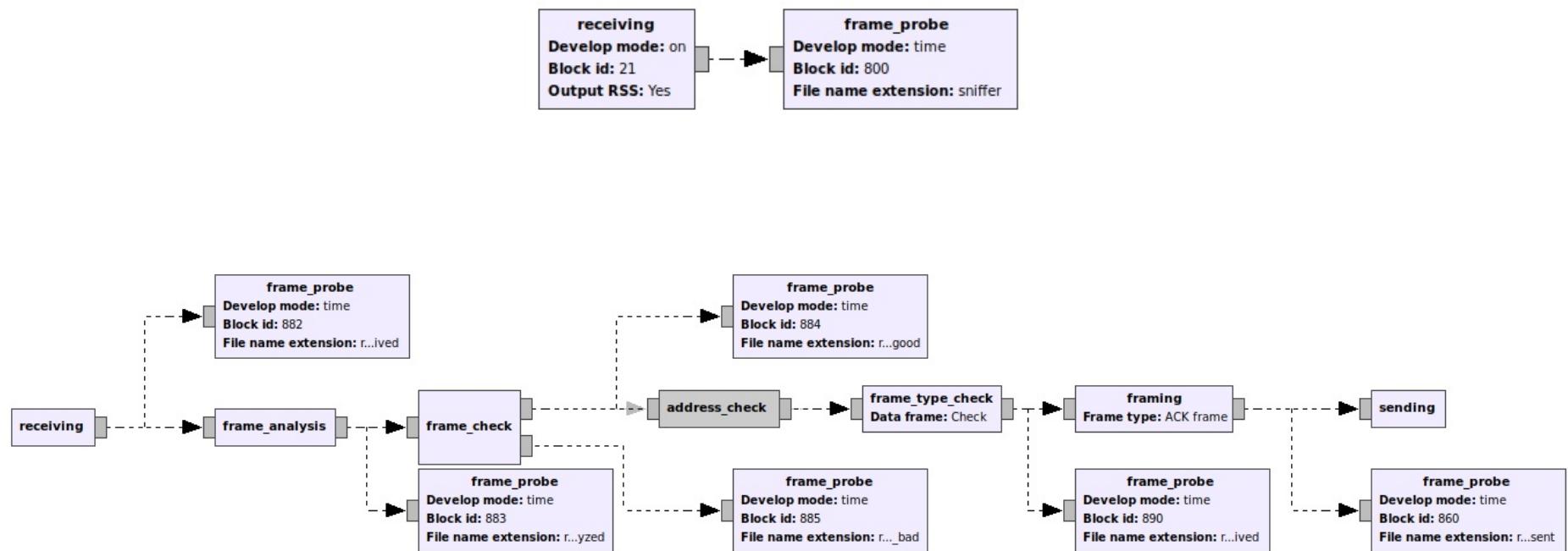
Methodology

Sender (CSMA) Flowgraph



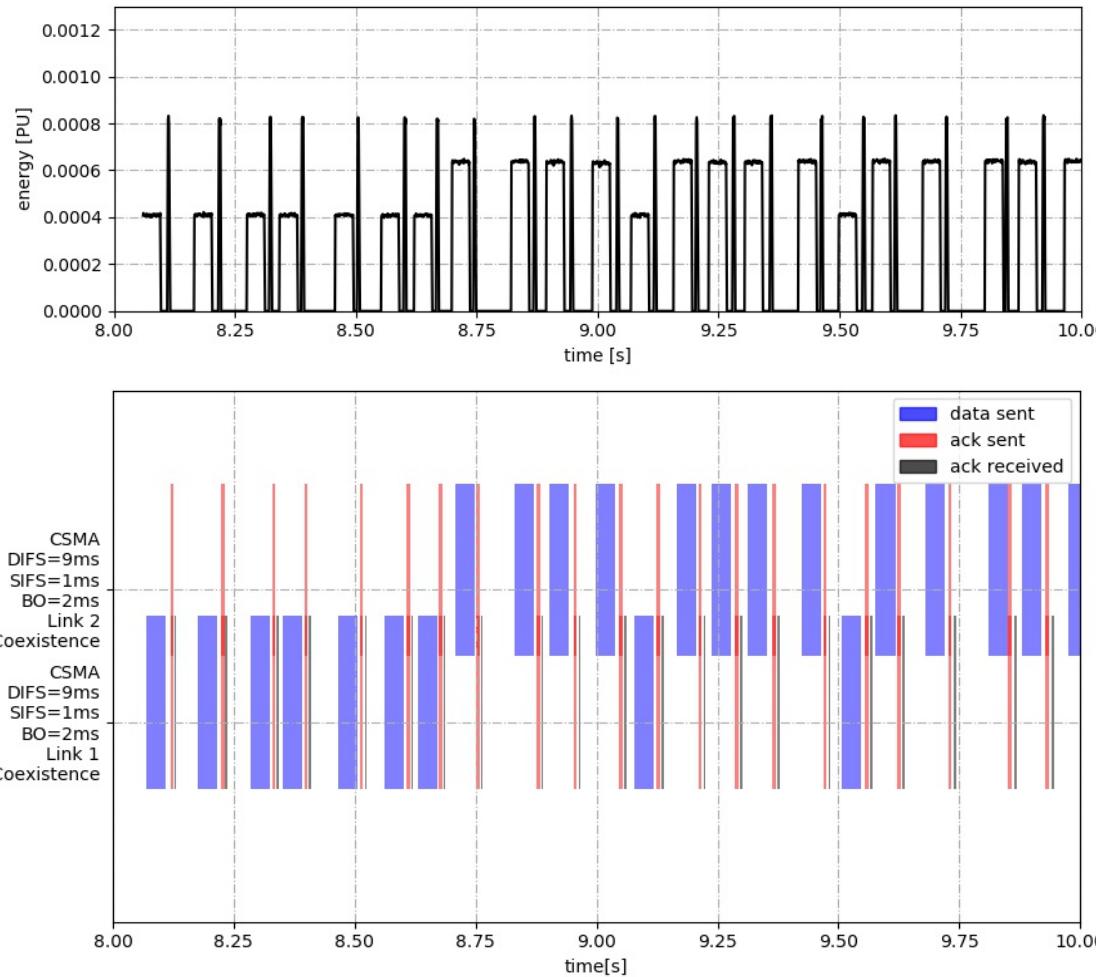
Methodology

Sniffer+Receiver Flowgraph



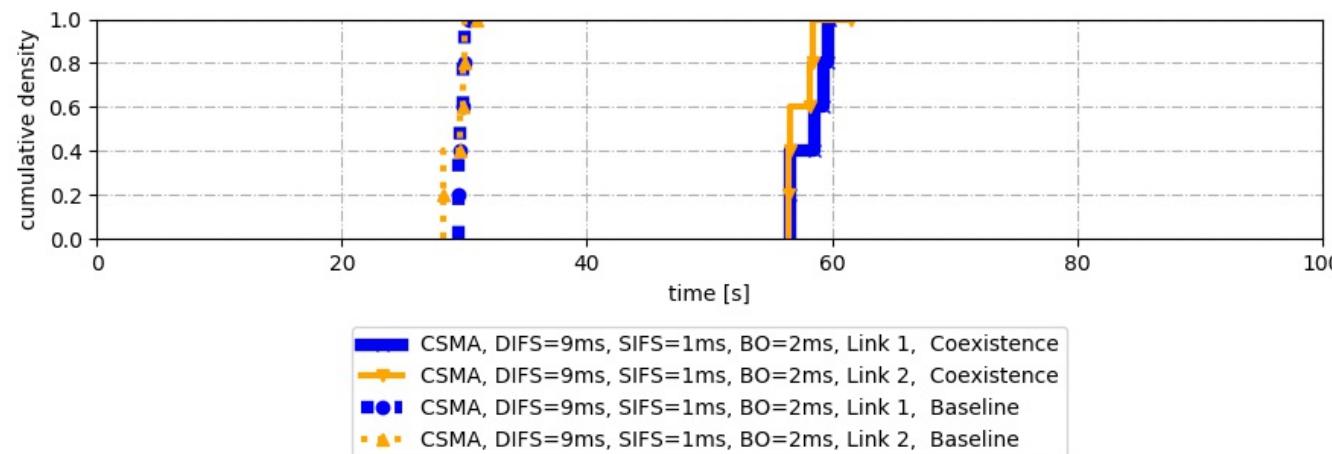
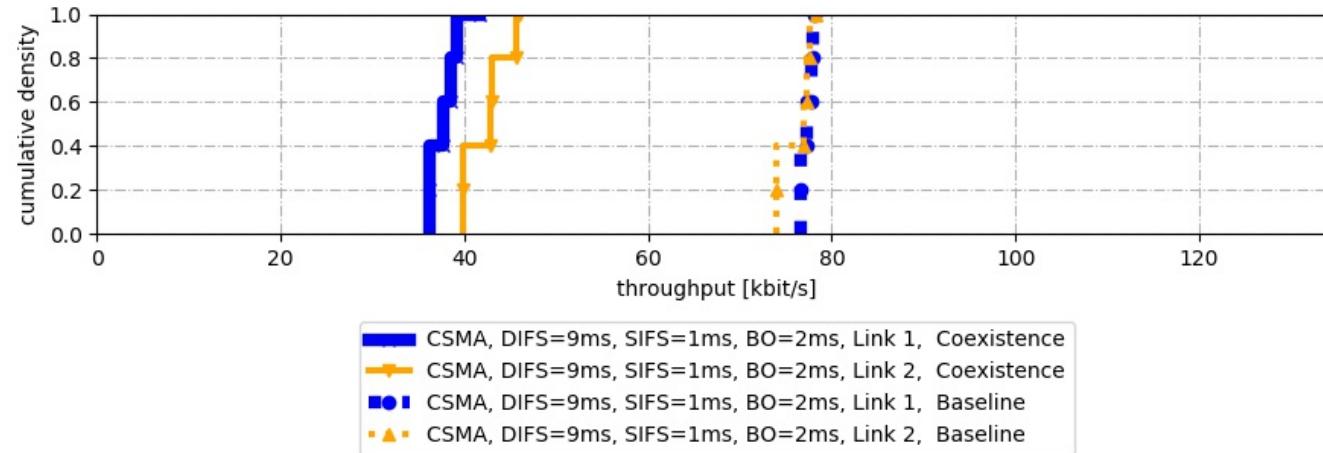
Results

Same MAC protocol on the two links - CSMA/CA with medium parameter values



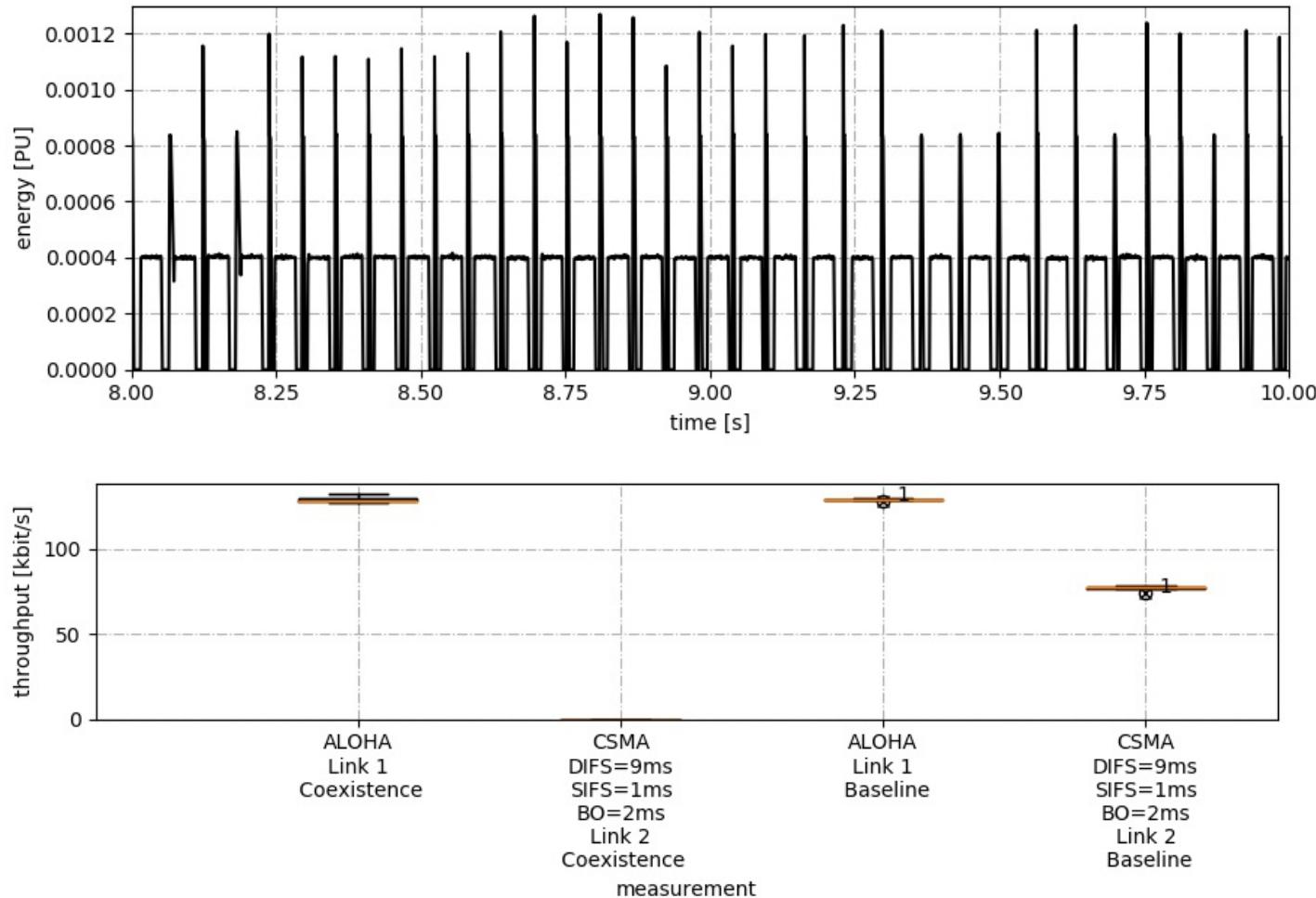
Results

Same MAC protocol on the two links - CSMA/CA with medium parameter values



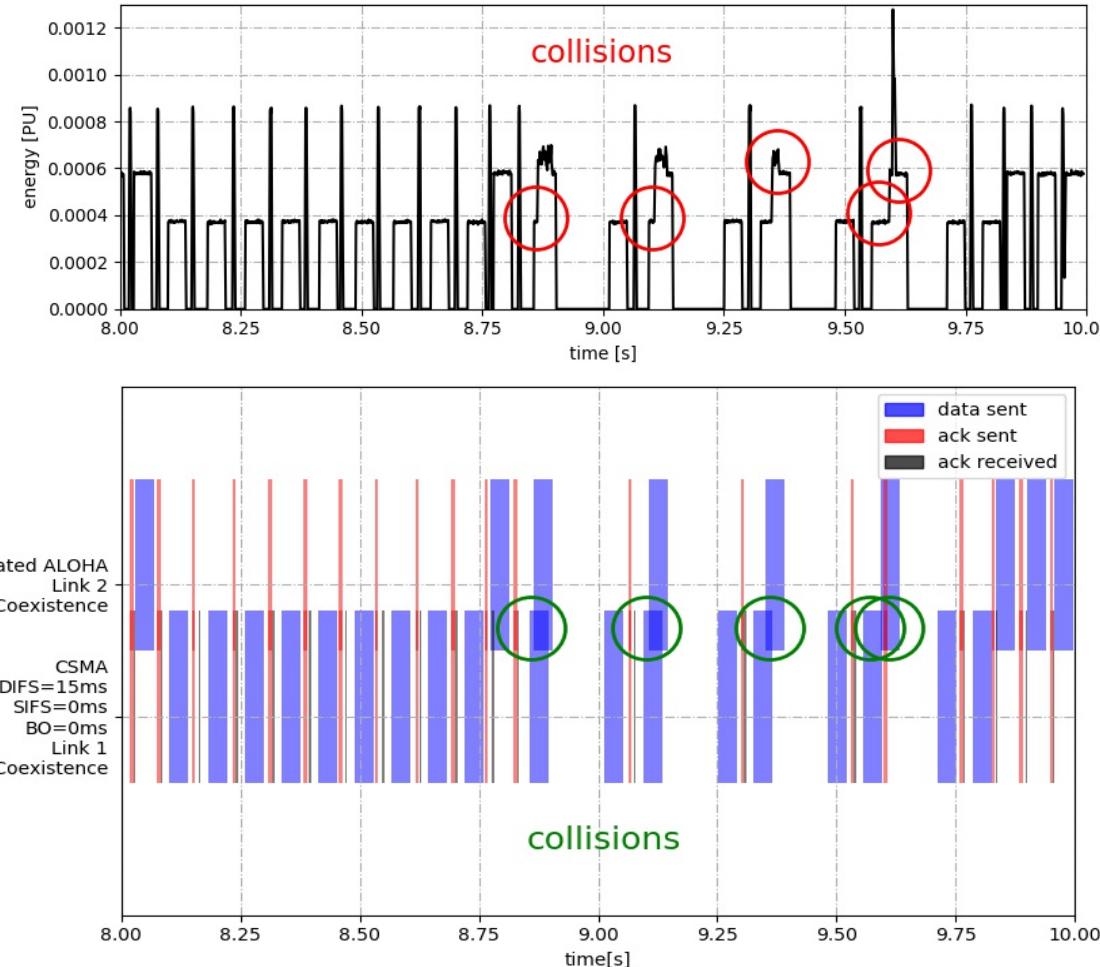
Results

Different MAC protocol on the two links - saturated ALOHA + CSMA/CA



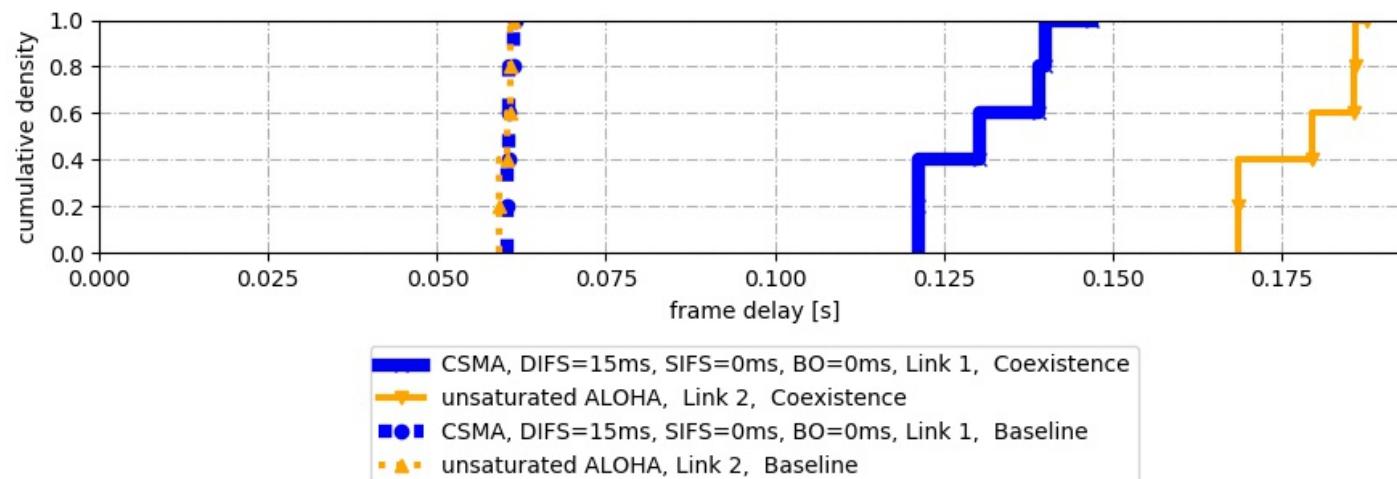
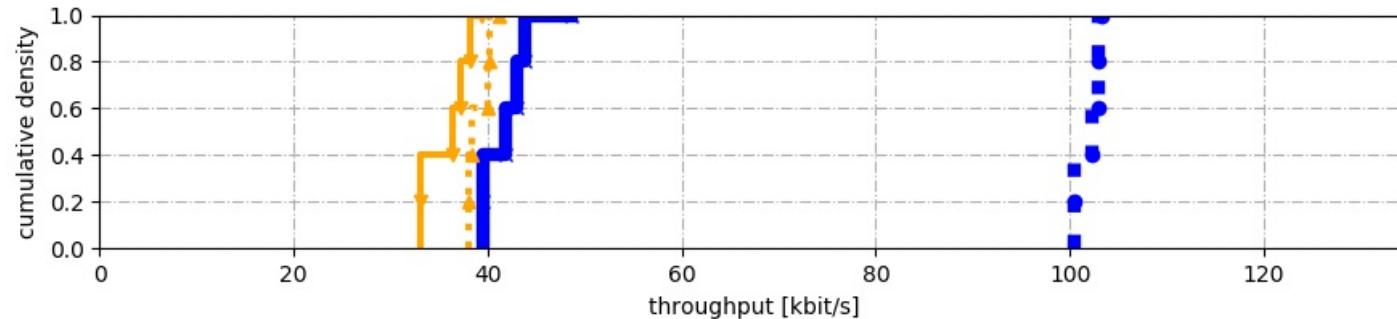
Results

Different MAC protocol on the two links - 1-persistent CSMA/CA + unsat. ALOHA



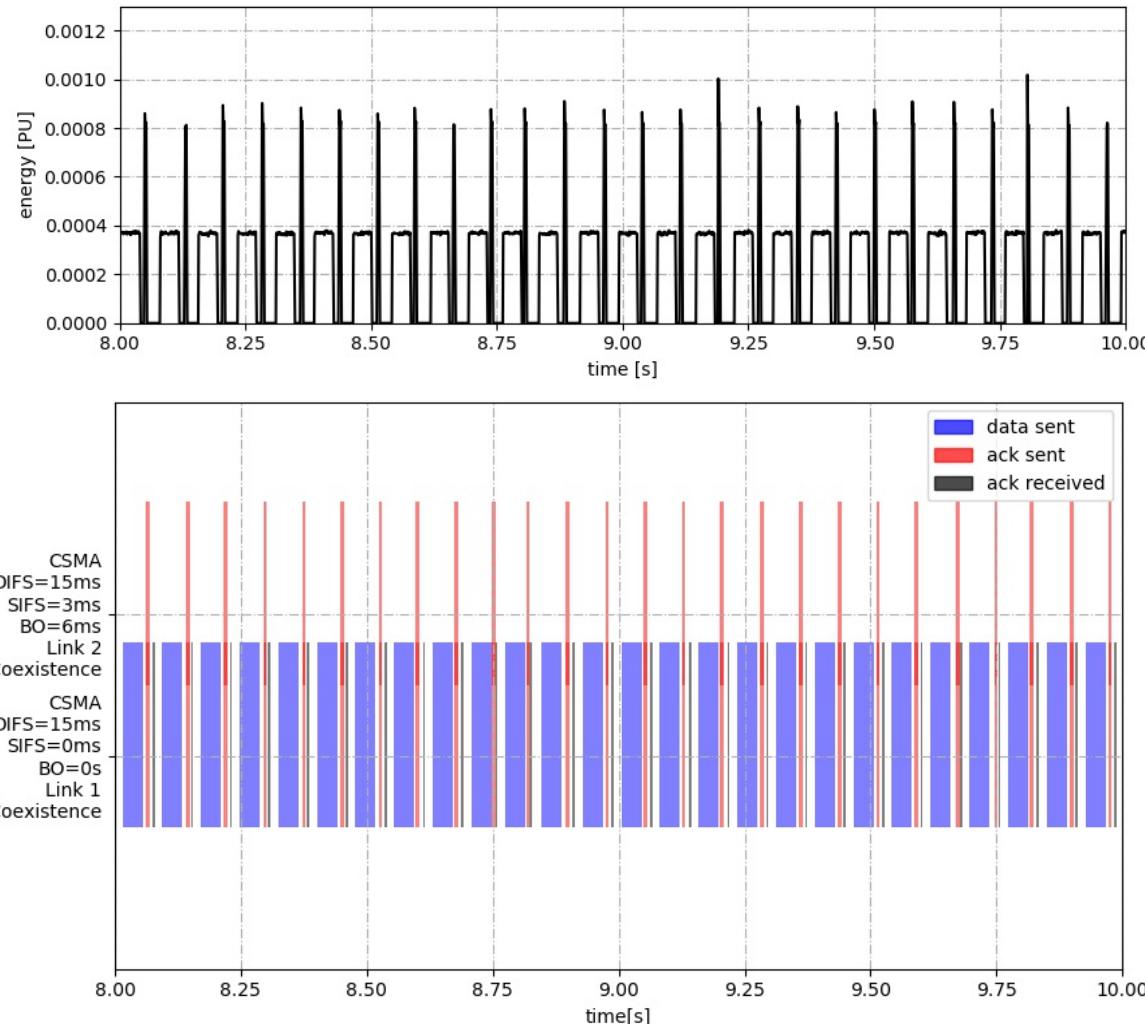
Results

Different MAC protocol on the two links - 1-persistent CSMA/CA + unsat. ALOHA



Results

Different MAC protocol on the two links - 1-persistent CSMA/CA + unsat. CSMA/CA



Results

Different MAC protocol on the two links - 1-persistent CSMA/CA + unsat. CSMA/CA

