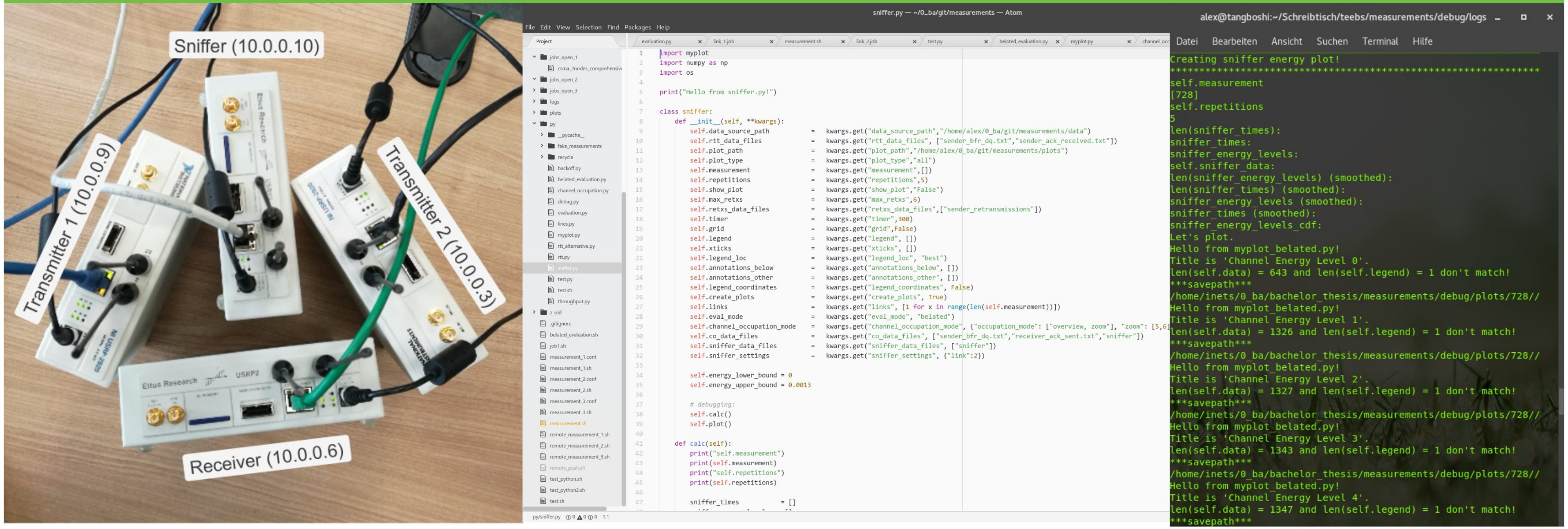

Coexistence Study of Different Medium Access Mechanisms Using a Software Defined Radio Testbed

Bachelor Thesis Talk

Alexander Pastor - December 18th, 2017

iNETS
Institute for **Networked Systems**
RWTH Aachen University

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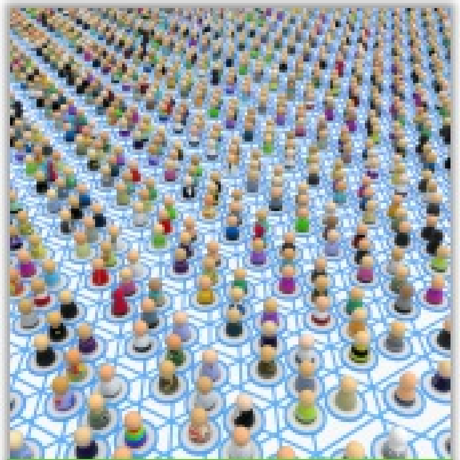
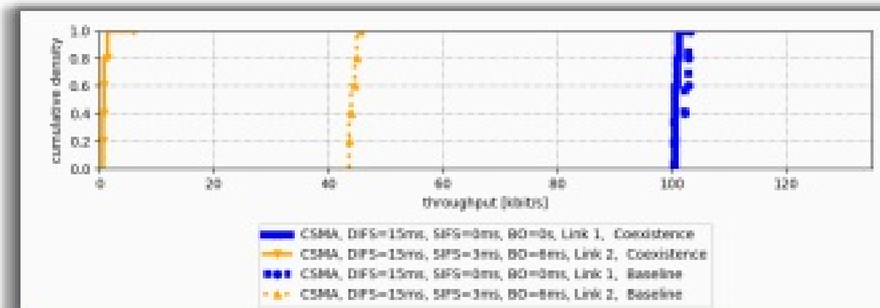
Contents

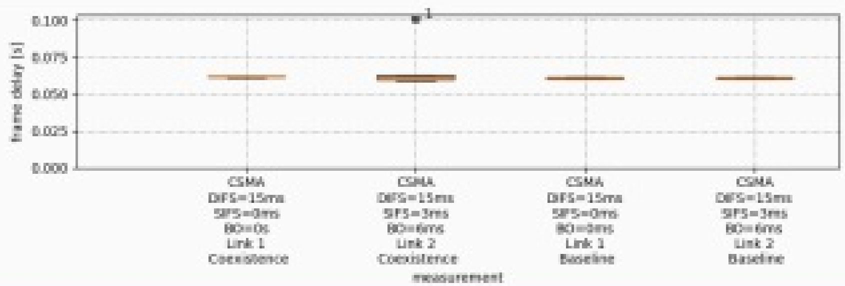


Motivation

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

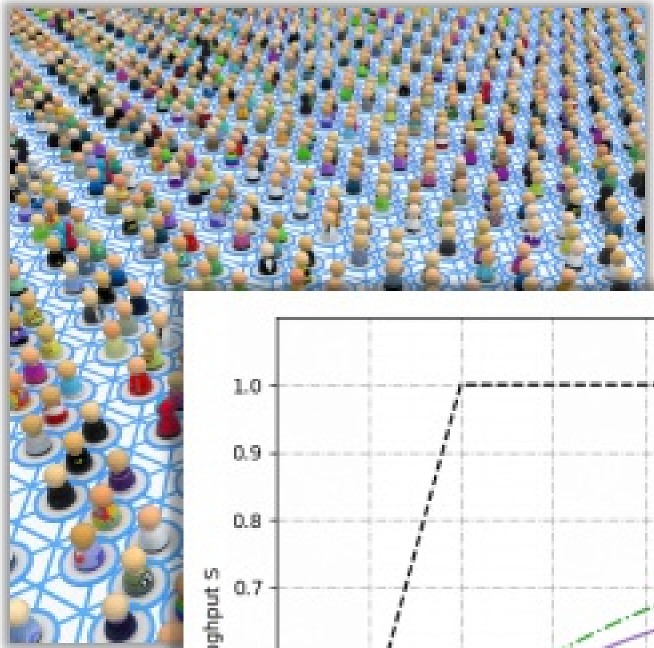
Methodology

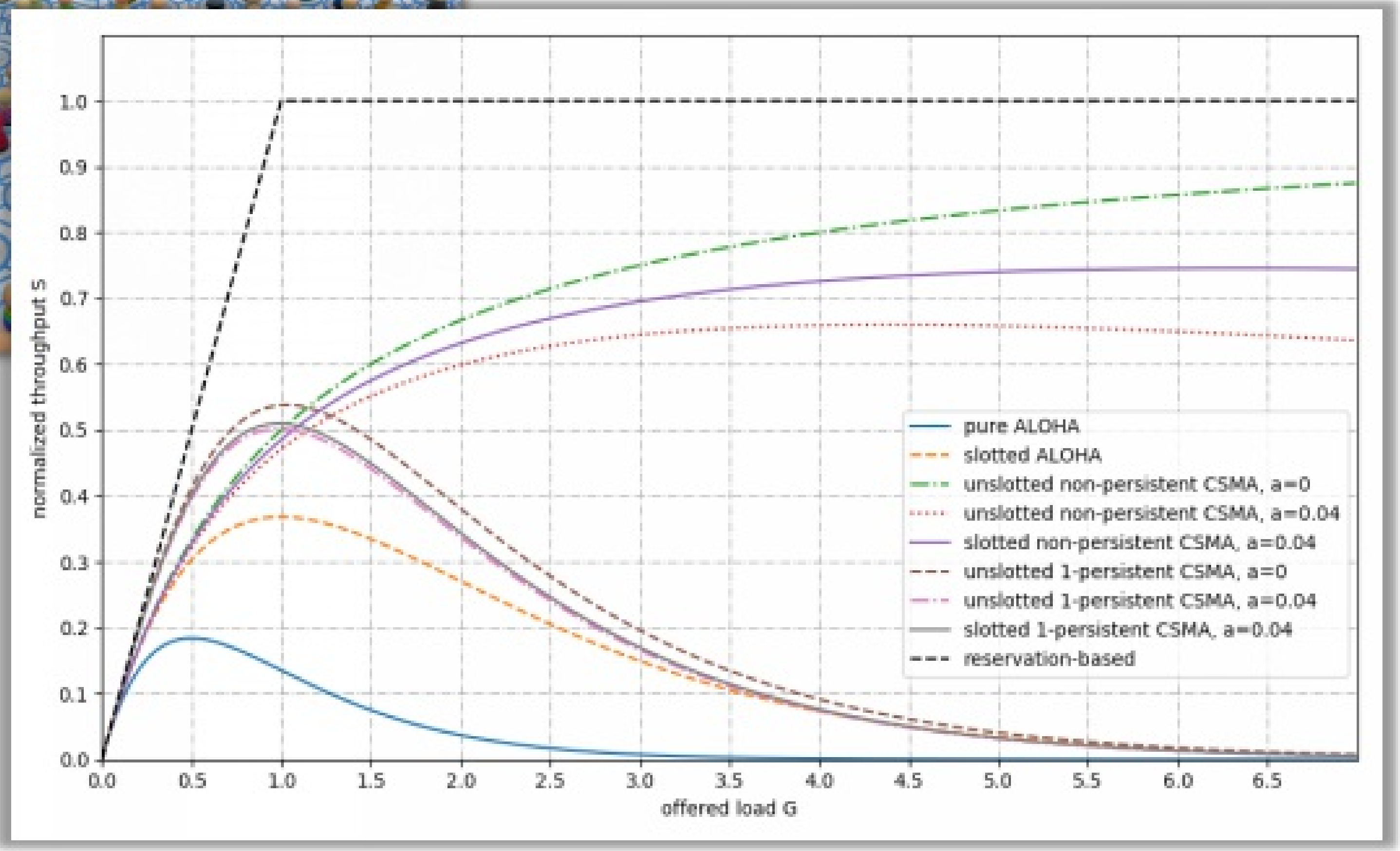




Results

Motivation




normalized throughput S
offered load G
0.0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
pure ALOHA
slotted ALOHA
unslotted non-persistent CSMA, a=0
unslotted non-persistent CSMA, a=0.04
slotted non-persistent CSMA, a=0.04
unslotted 1-persistent CSMA, a=0
unslotted 1-persistent CSMA, a=0.04
slotted 1-persistent CSMA, a=0.04
reservation-based

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

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

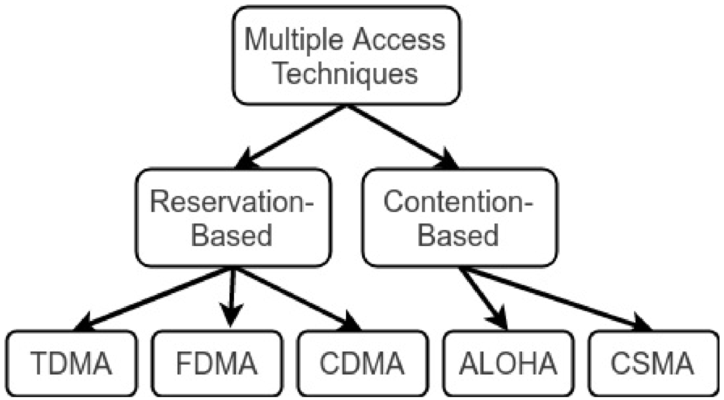
Operating Conditions

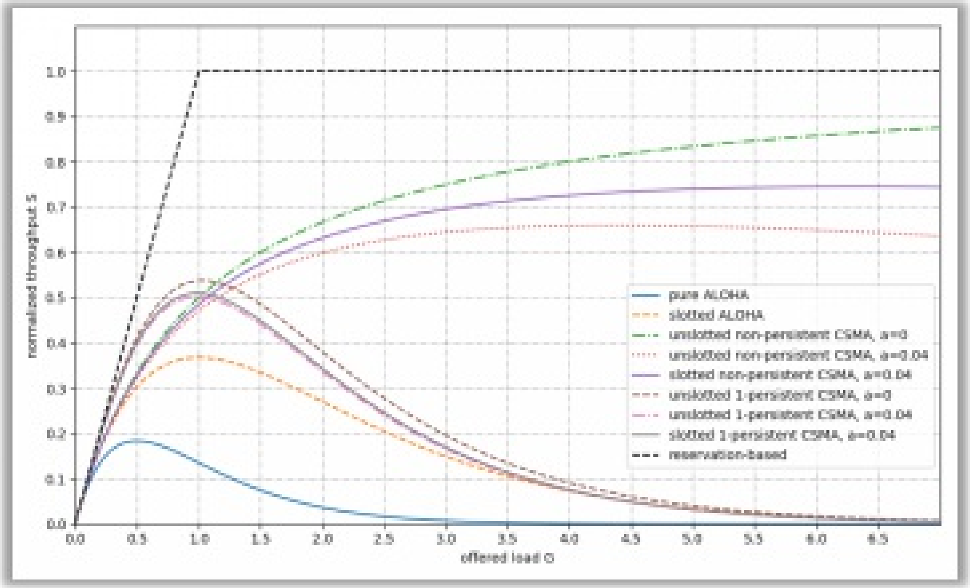
- **Intertechnological Coexistence**
- Traffic Patterns
- Directional Traffic

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

Motivation

Protcol Classification





MAC Mechanisms

Coordinator
- Time Domain
- Frequency Domain
- Code Domain

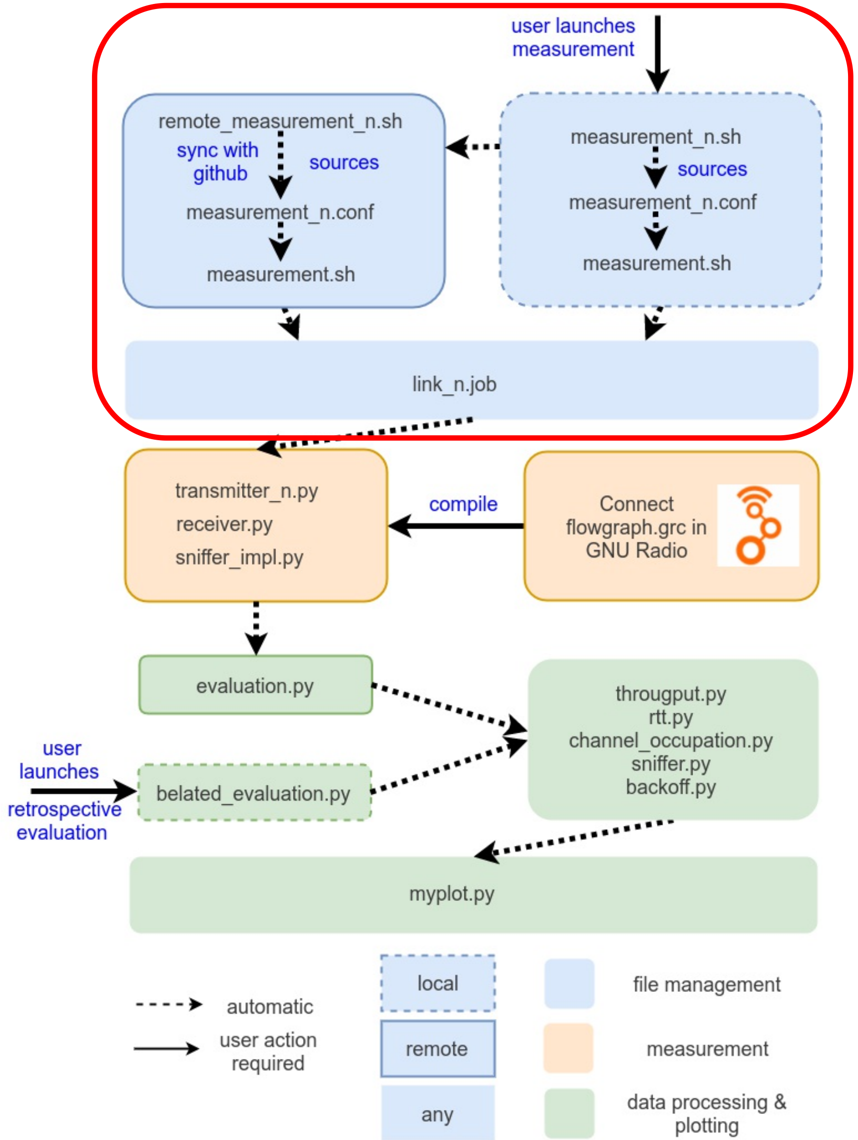
Carrier Sensing
- Thresholding
- Preamble Sampling
- Outlier Detection

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

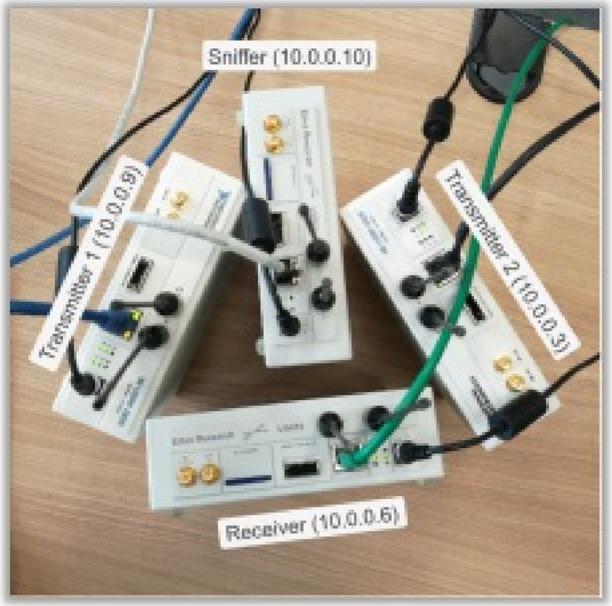
Random Backoff
- Minimium CW
- CW Growth

Duty Cycles
- Fixed Length
- Adaptive Length

Methodology




```
./measurement_2.sh
export link=2
export timer=100
export measurement_repetitions=5
measurement_scripts=( theoretical_aloha_III.py theoretical_aloha_I.py csma_80211_
IV.py )
#measurement_scripts=( theoretical_aloha_I.py theoretical_aloha_III.py csma_80211
_IV.py )
plot_scripts=( evaluation.py )
export throughput_data_files="receiver_data_received,sender_ack_received"
export rtt_data_files="sender_bfr_dq,sender_ack_received"
export rtt_mode="rtt"
export retxs_data_files="sender_retransmissions,sender_max_retransmissions"
export retxs2_data_files="receiver_retransmissions,receiver_max_retransmissions"
export co_data_files="sender_bfr_dq,receiver_ack_sent,sender_ack_received"
export sniffer_data_files="sniffer"
export plot_type="boxplot,cdf"
export show_plot_after_measurement=0
export receiver_mode="single"
```



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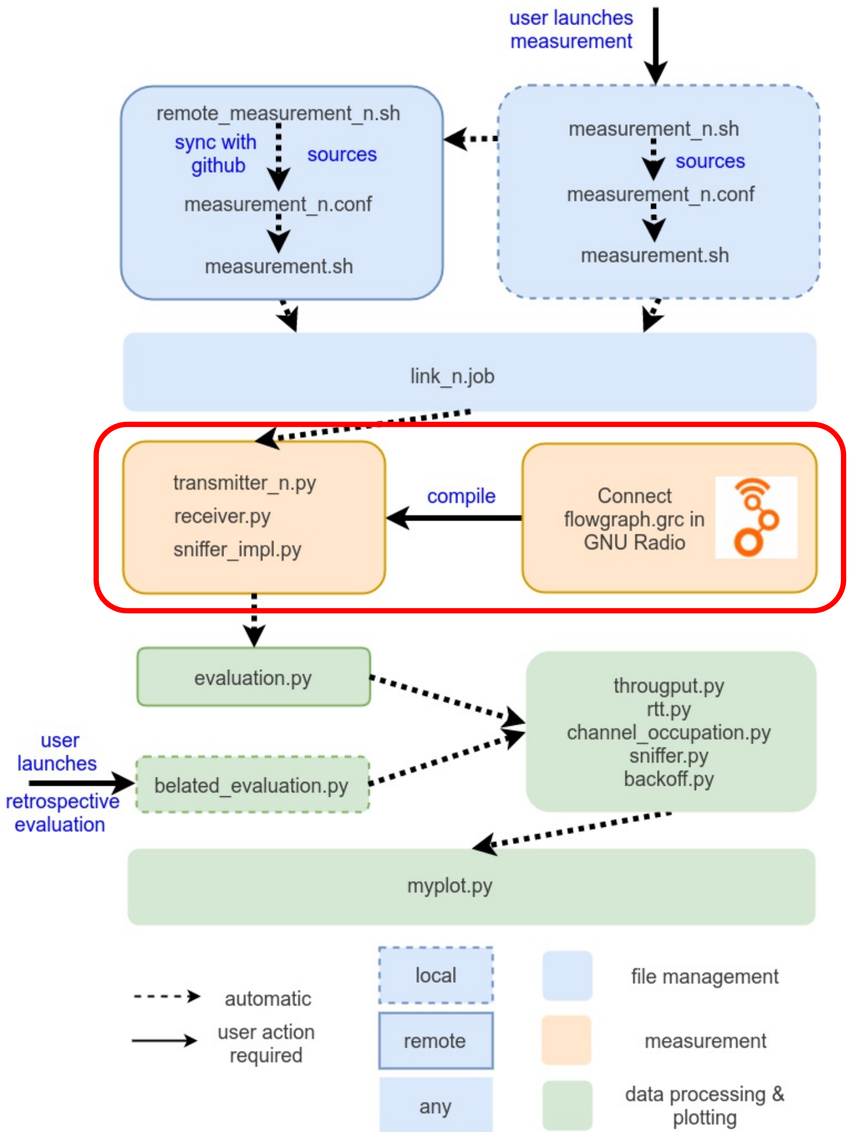
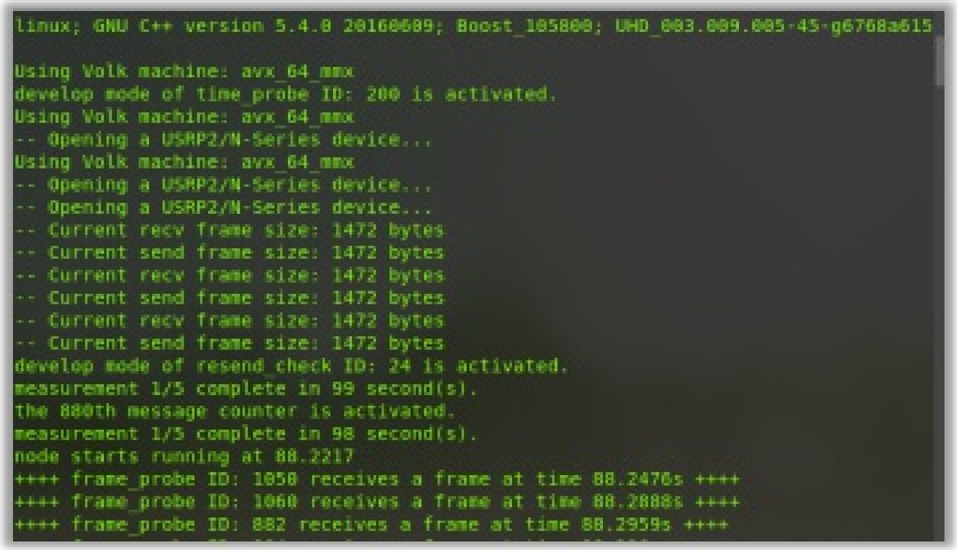
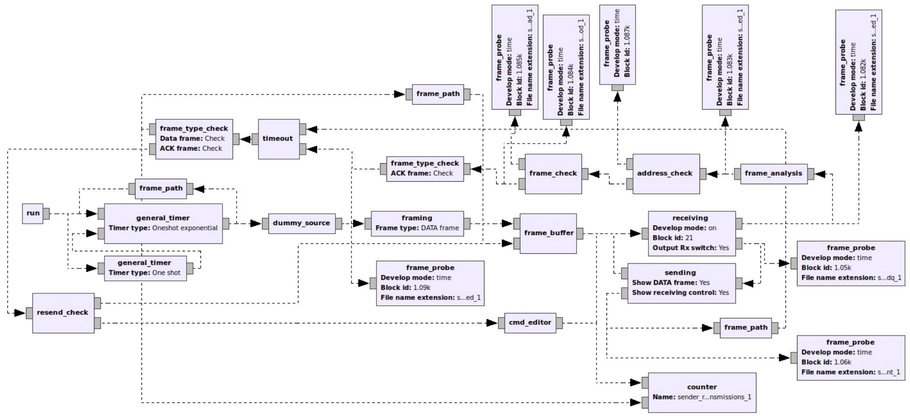
Methodology

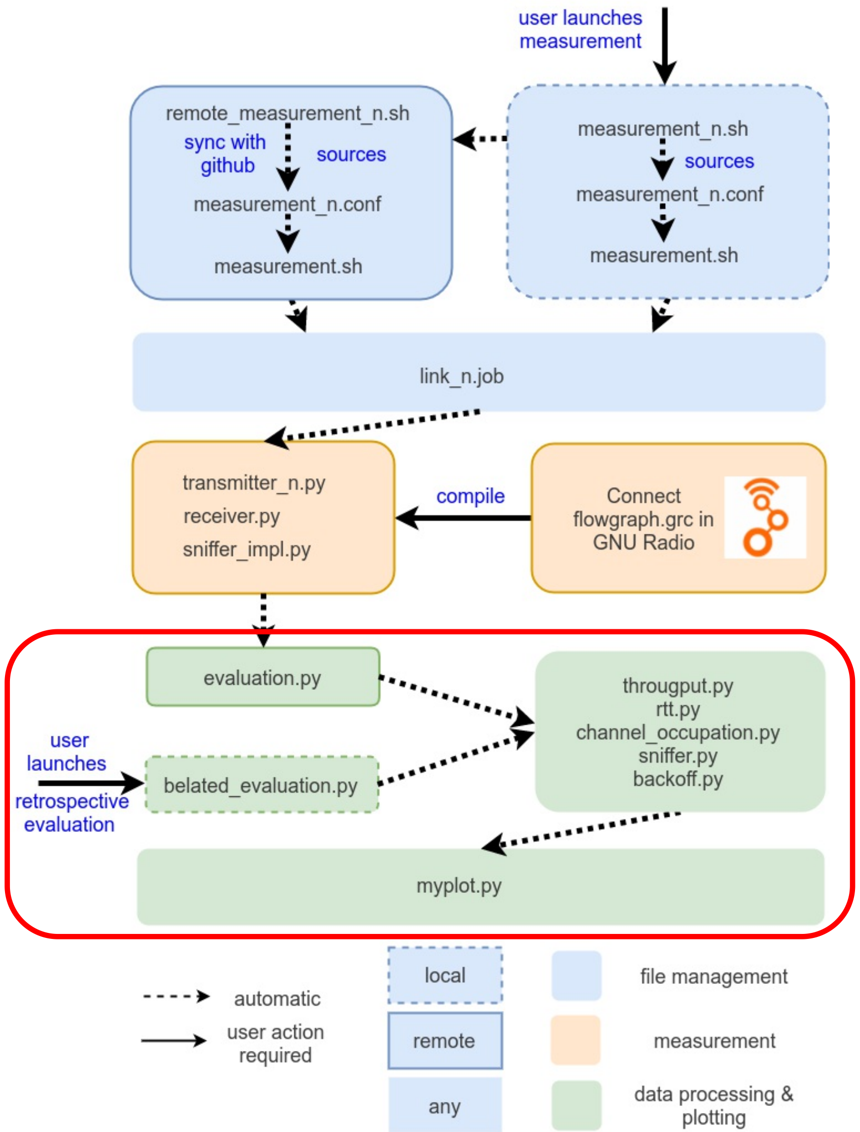


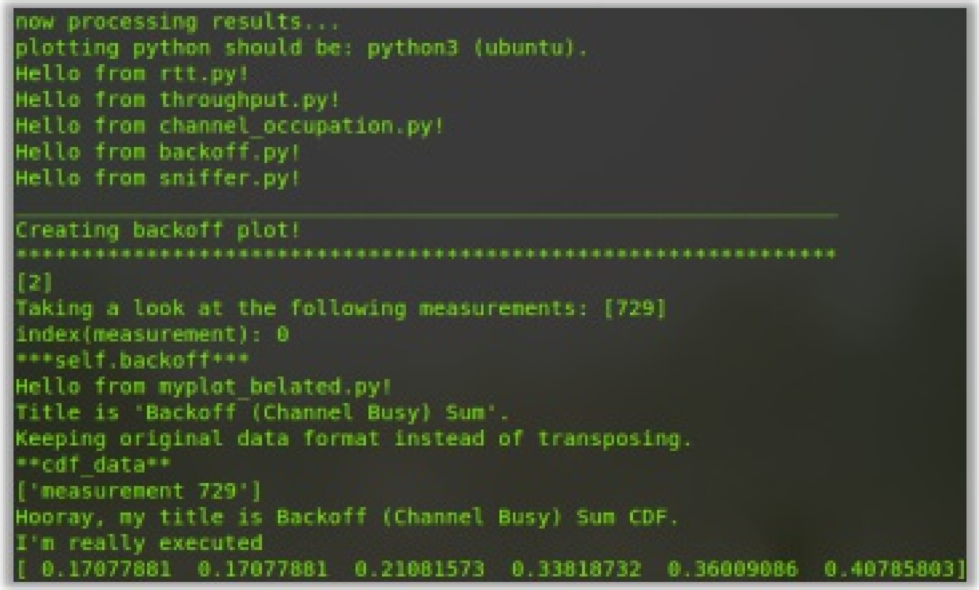


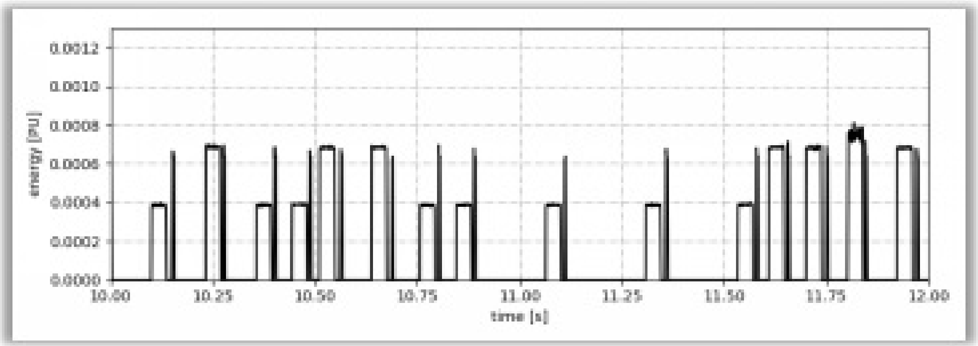


iNETS

Methodology







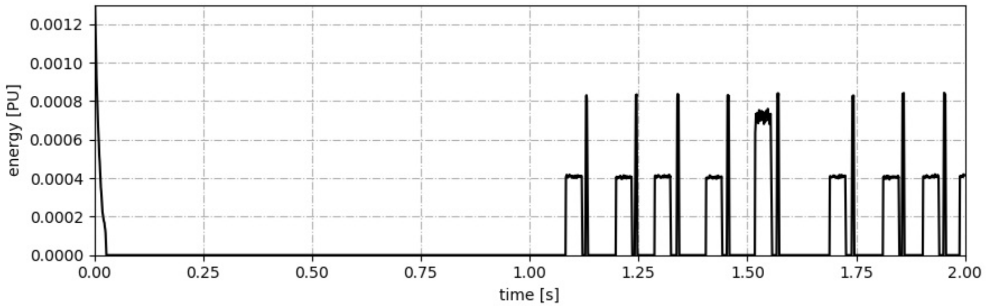
matplotlib

Methodology

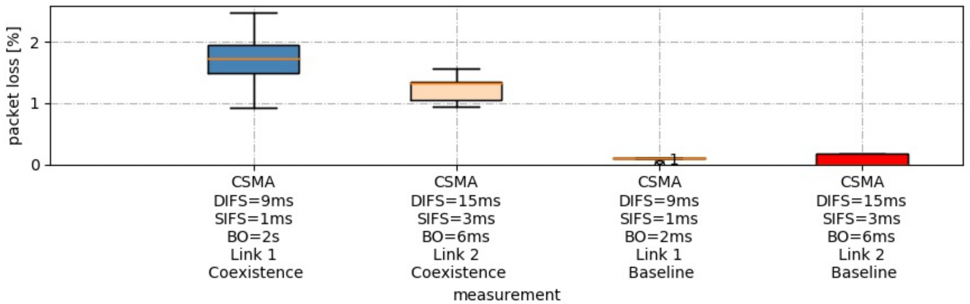
Scenario Type	Link 1	Link 2
Same MAC	ALOHA CSMA/CA (3 variants) 1-persistent CSMA	
Different MAC	ALOHA unsaturated ALOHA CSMA/CA 1-persitent CSMA 1-persistent CSMA	CSMA/CA CSMA/CA CSMA/CA unsaturated ALOHA CSMA/CA

Scenarios

- Same MAC scenarios
- Different MAC scenarios



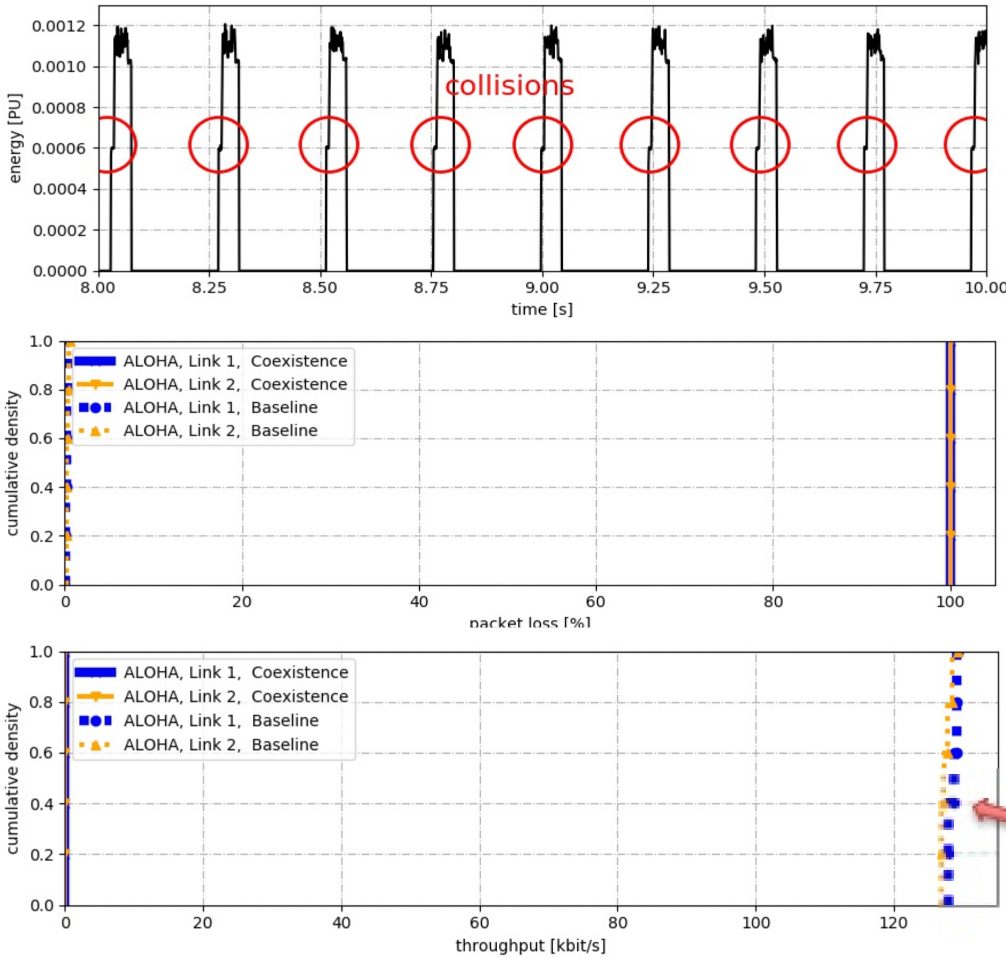
1.1 s delay



<= 0.2% baseline packet loss

Results

Same MAC protocol on the two links - Pure ALOHA



Each and every frame collides …

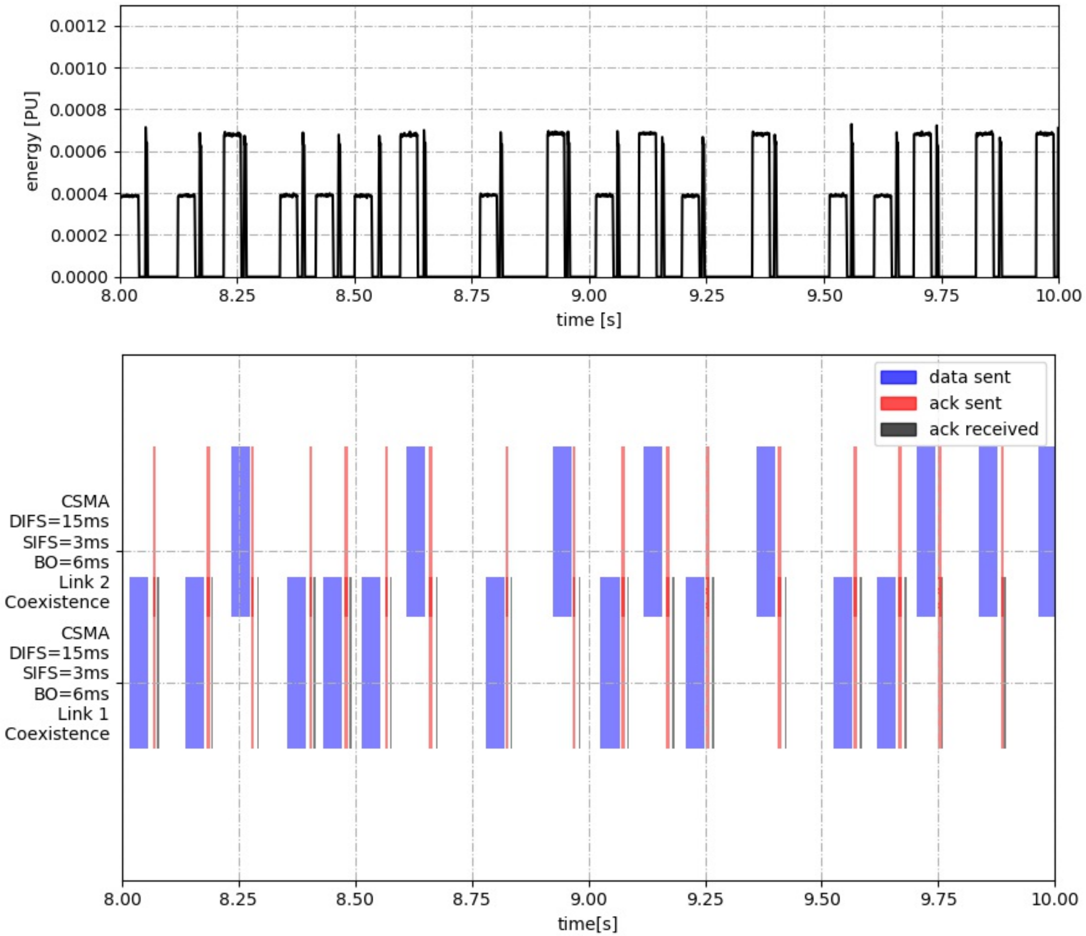
… leading to 100% packet loss …

… and thus 0 throughput.

max. ≈ 135 kbps

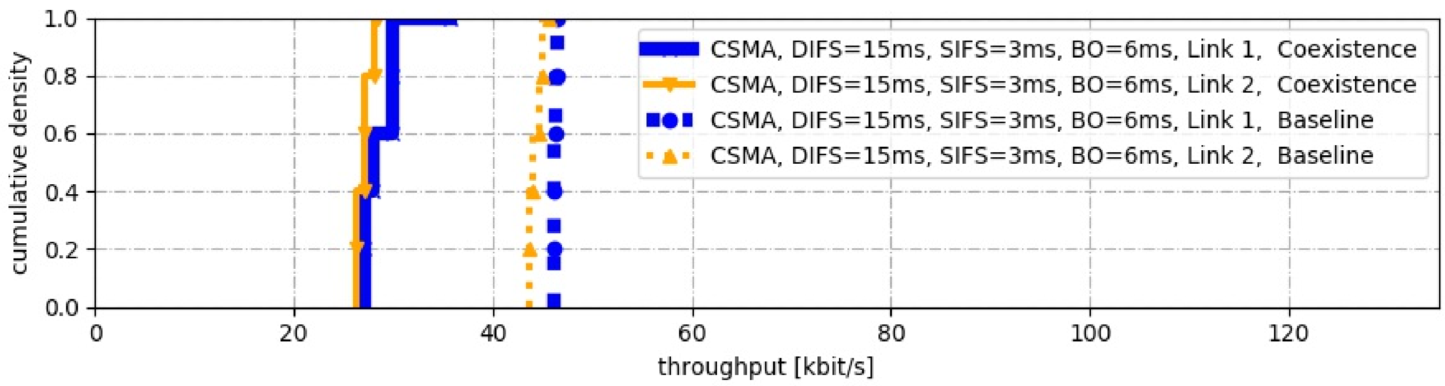
Results

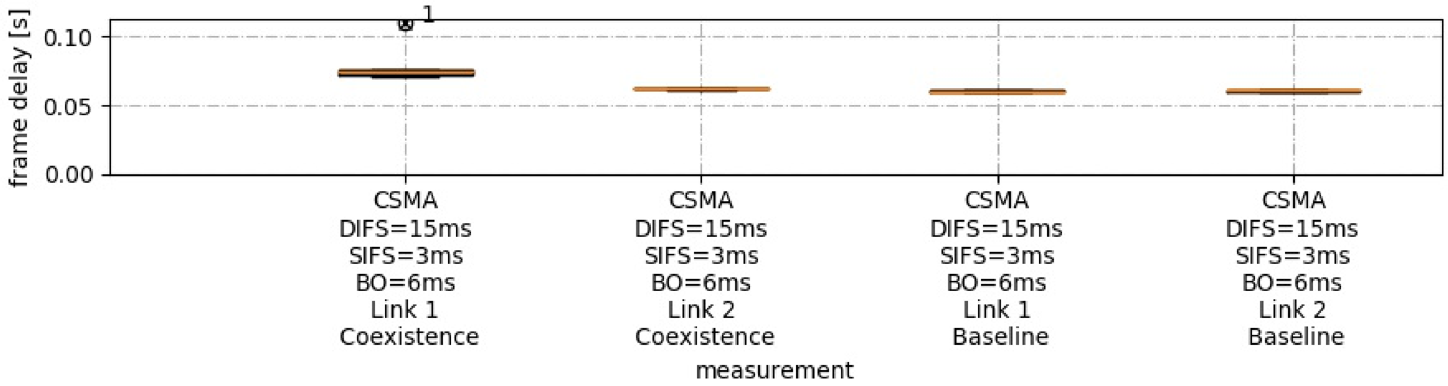
Same MAC protocol on the two links - CSMA/CA high parameter values



Results

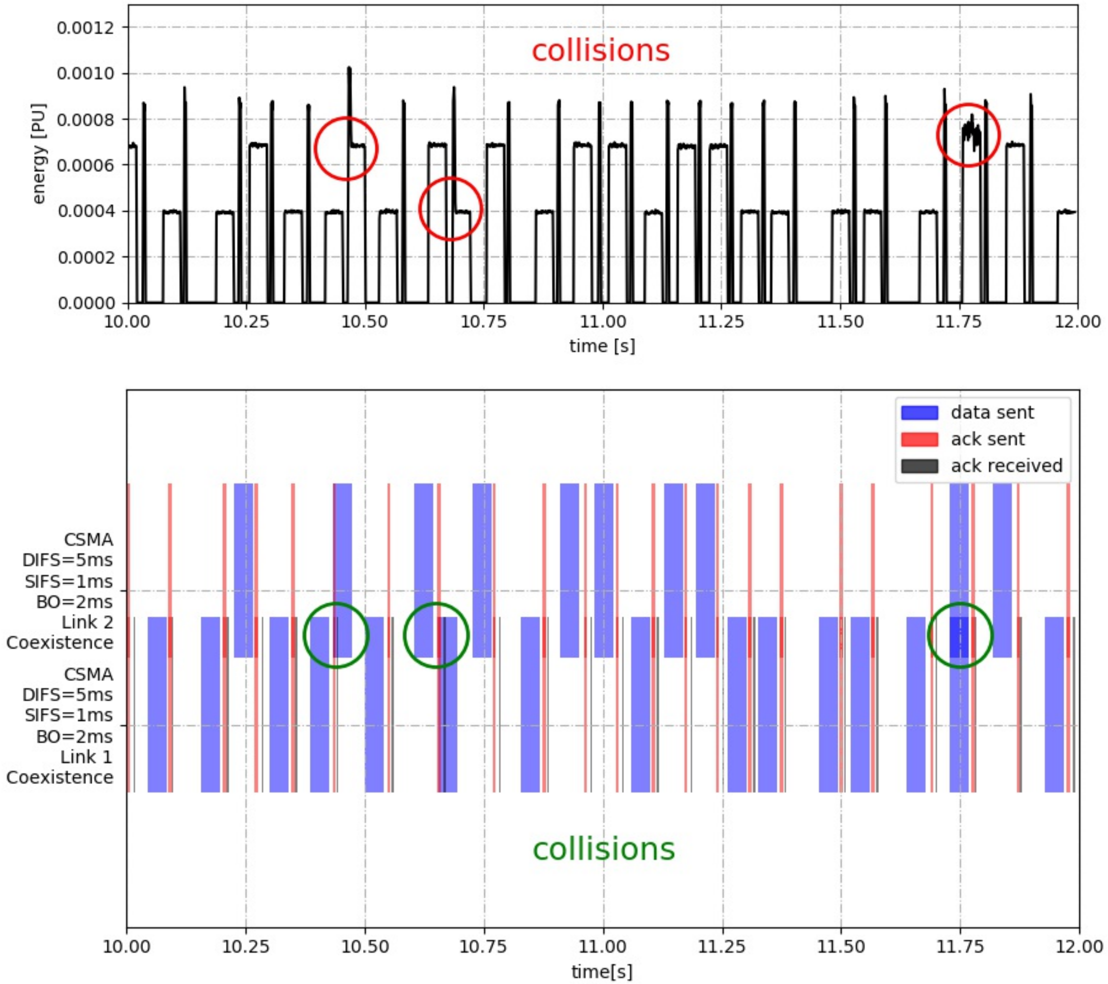
Same MAC protocol on the two links - CSMA/CA high parameter values





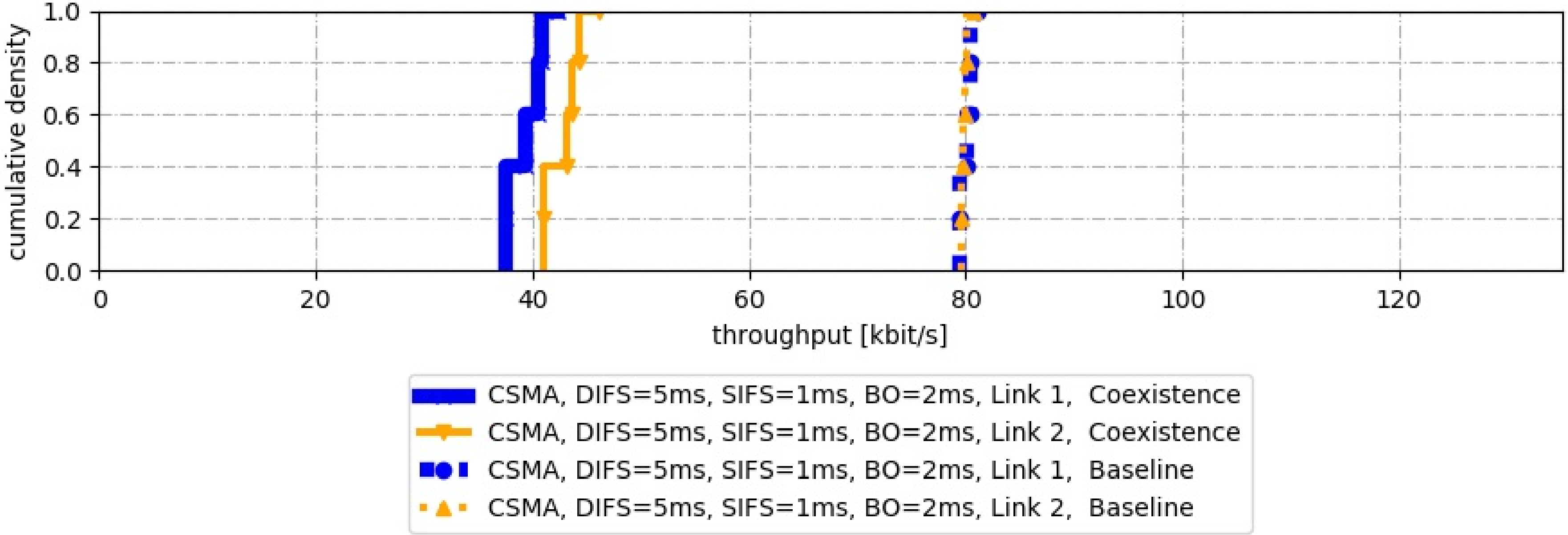
Results

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



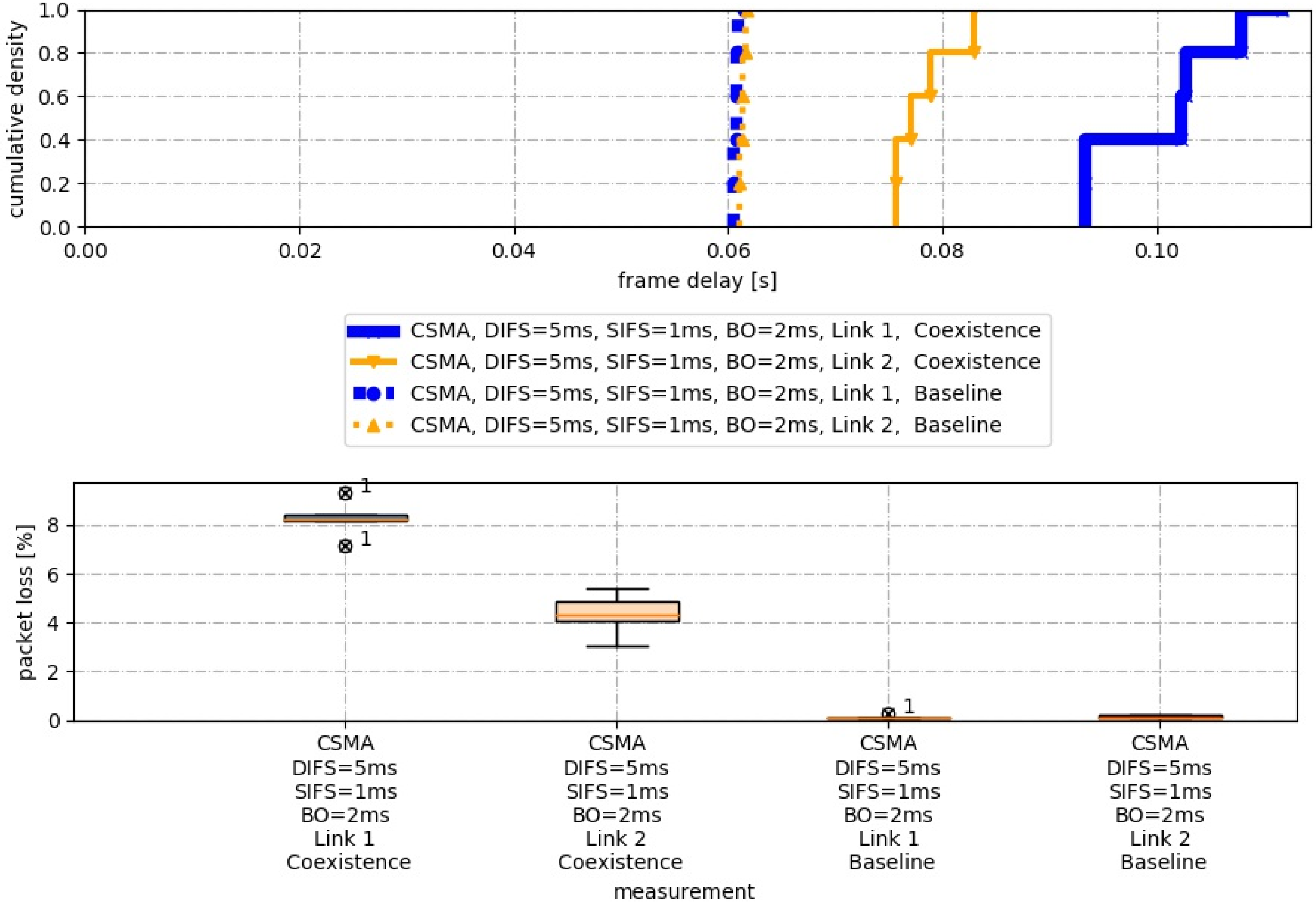
Results

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



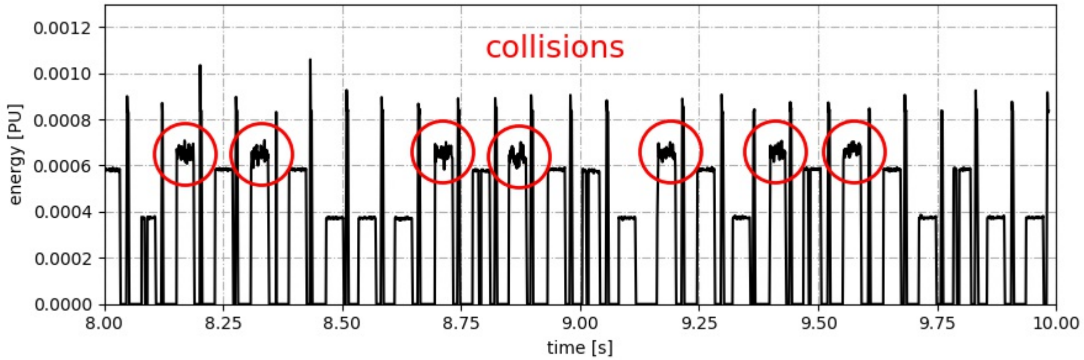
Results

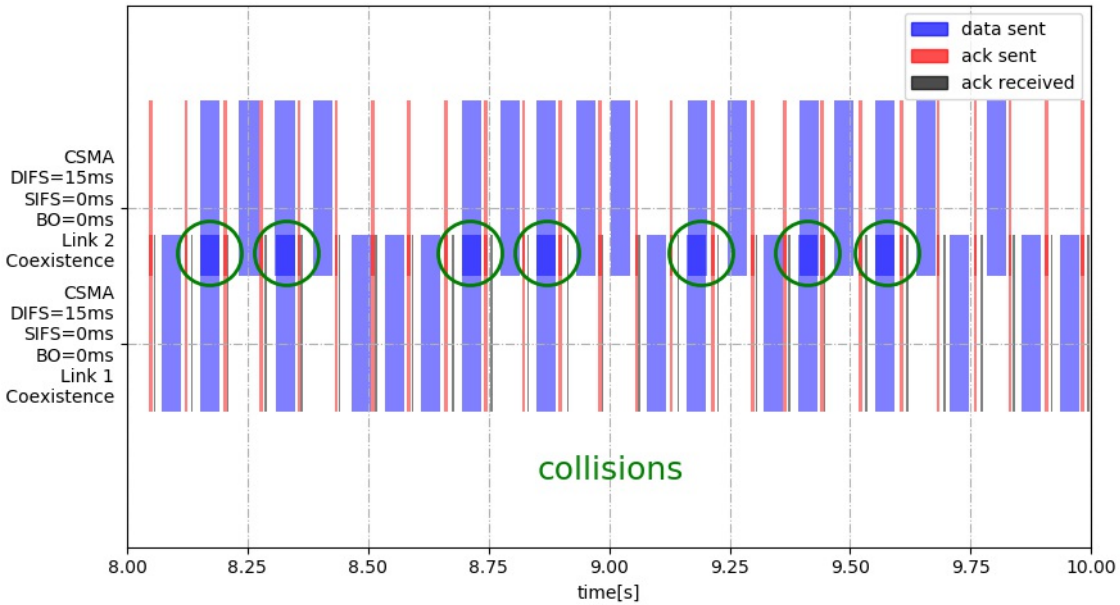
Same MAC protocol on the two links - CSMA/CA low parameter values



Results

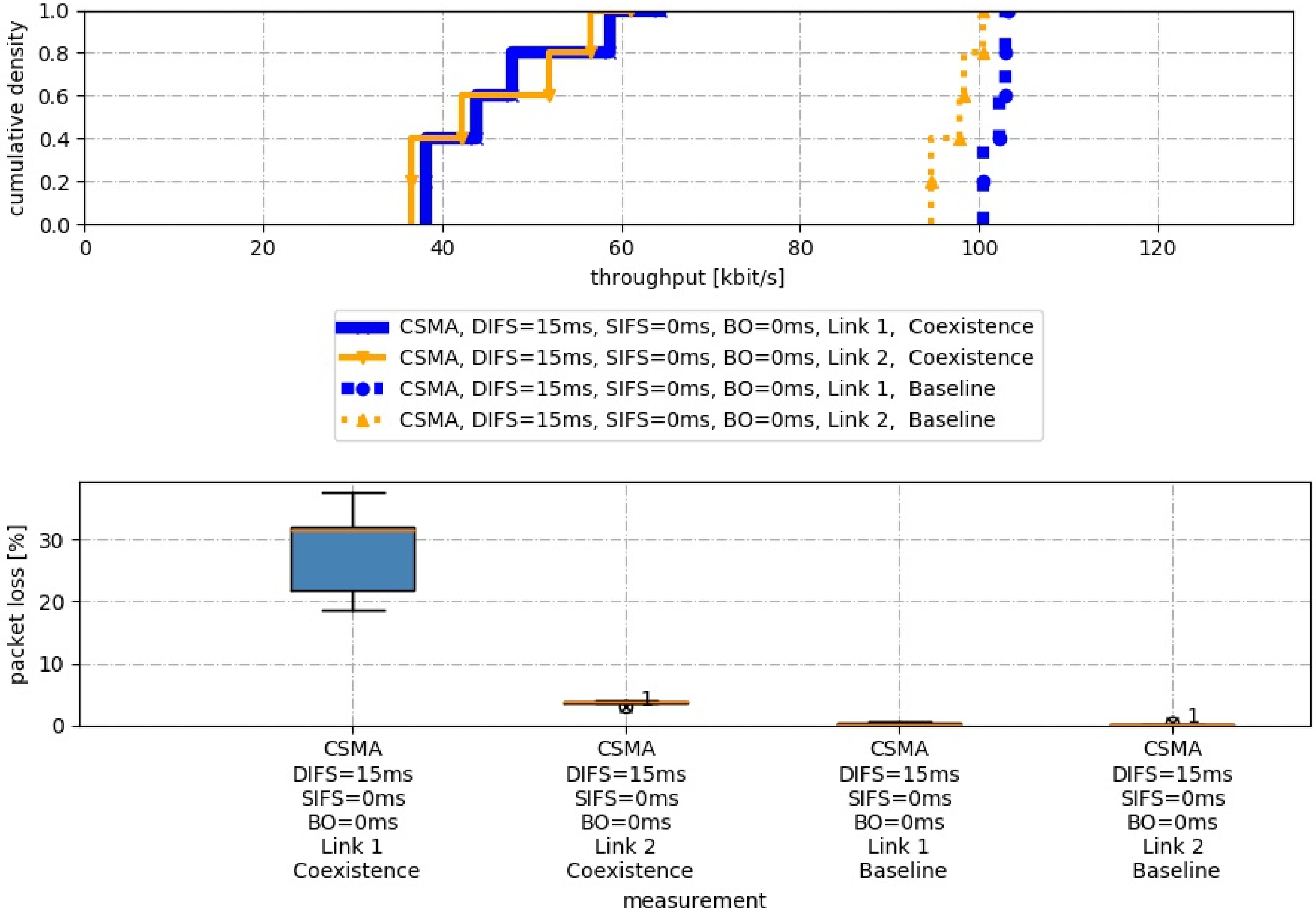
Same MAC protocol on the two links - 1-persistent CSMA





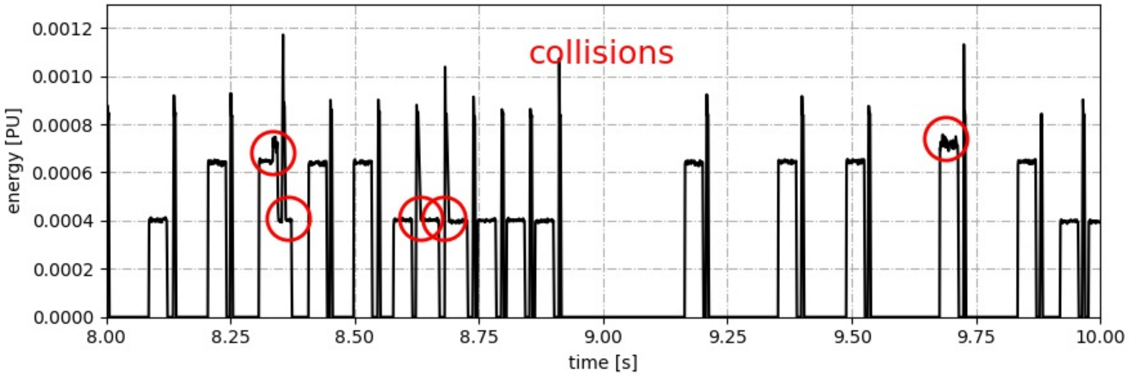
Results

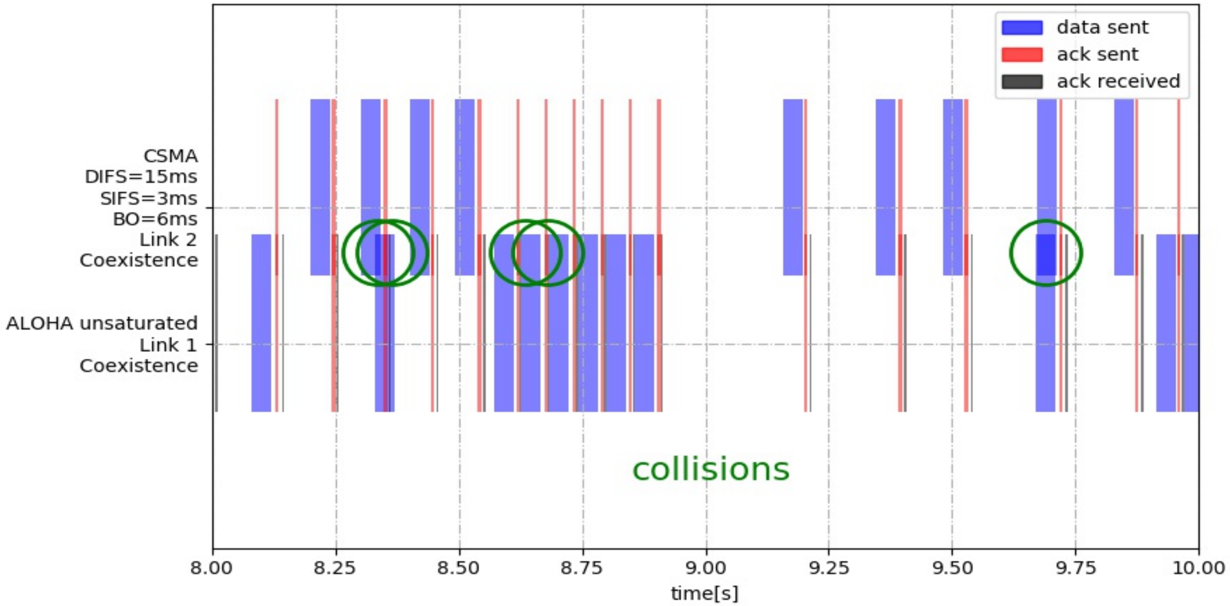
Same MAC protocol on the two links - 1-persistent CSMA



Results

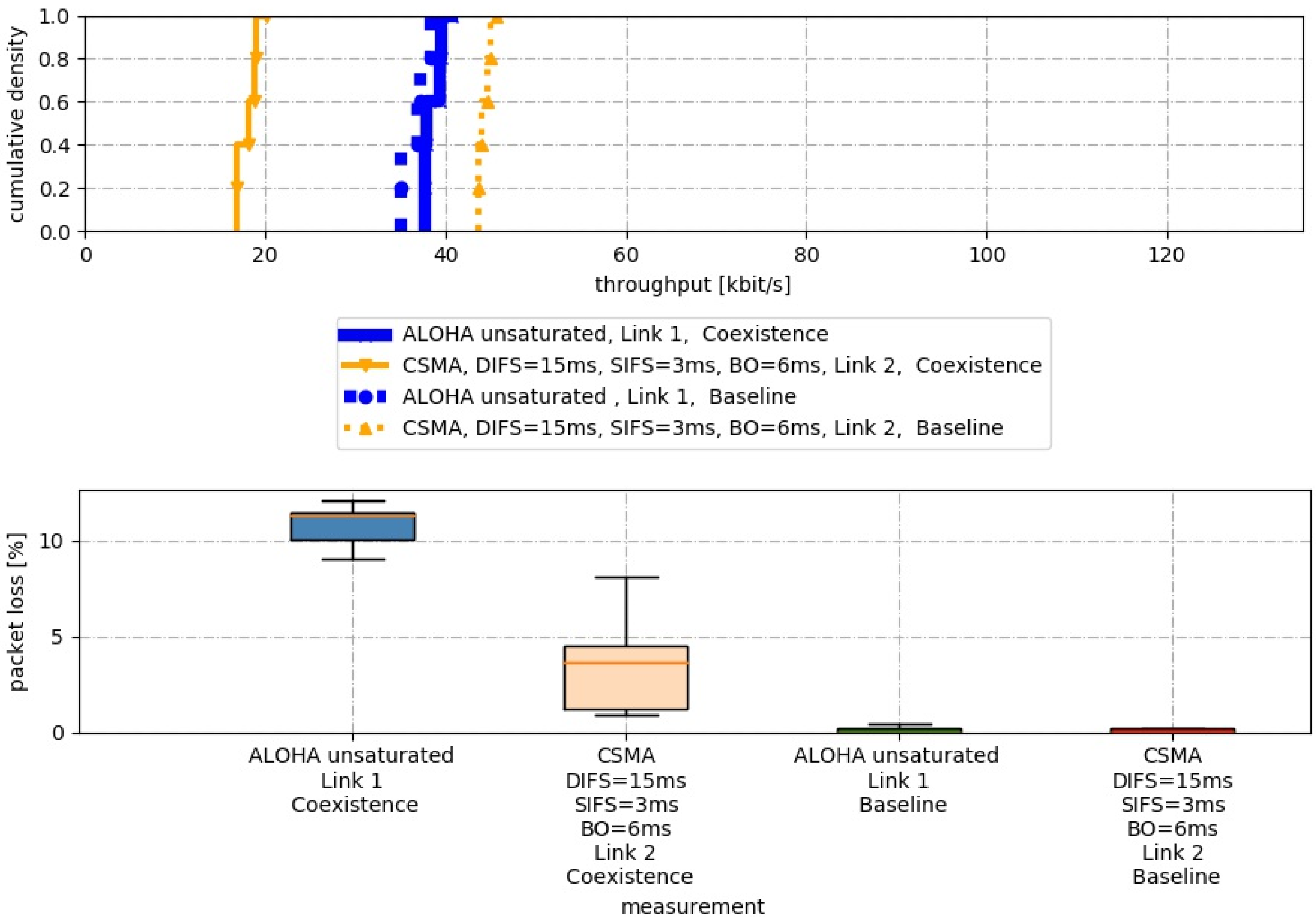
Different MAC protocol on the two links - unsaturated ALOHA + CSMA/CA





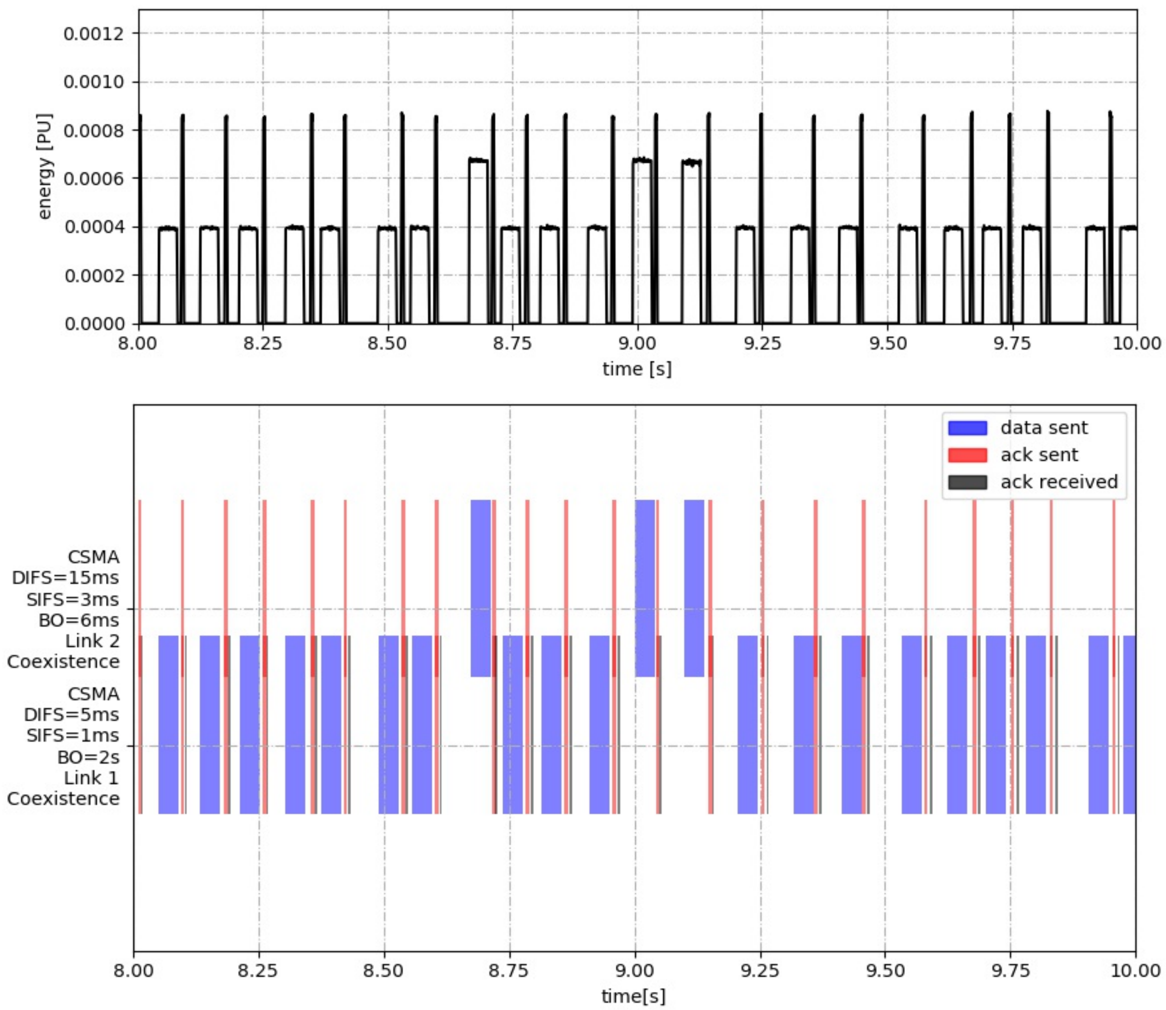
Results

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



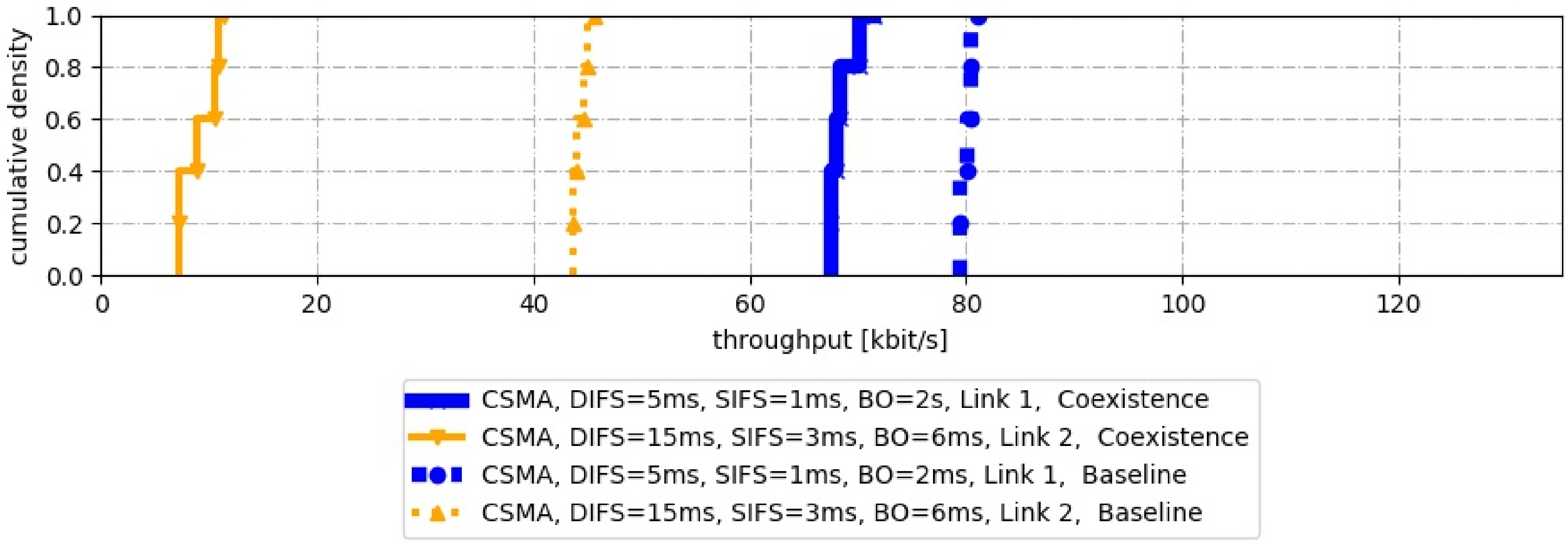
Results

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



Results

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



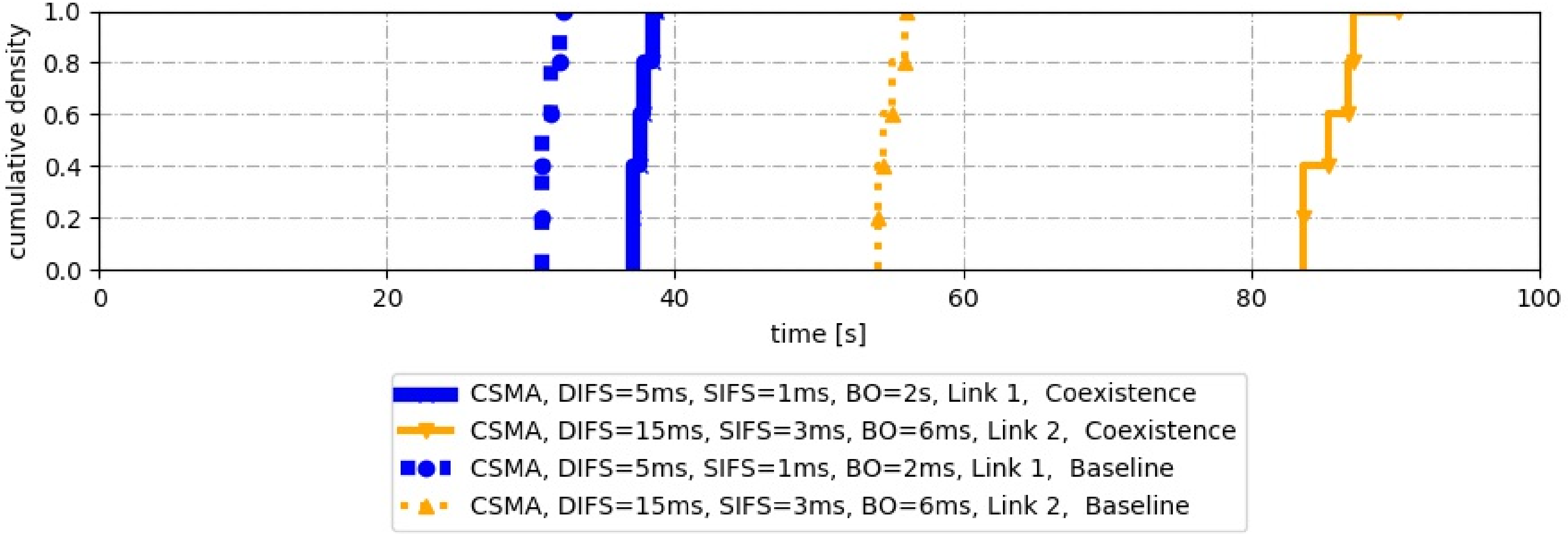
Baseline

$$\frac{S_{\mathrm{CL}}}{S_{\mathrm{CH}}} = \frac{DIFS_{CH} + SIFS_{CH} + 16 \cdot BO_{CH} + ACK + DATA}{DIFS_{CL} + SIFS_{CL} + 16 \cdot BO_{CL} + ACK + DATA}$$

theoretical ≈ 1.85
measured ≈ 1.77

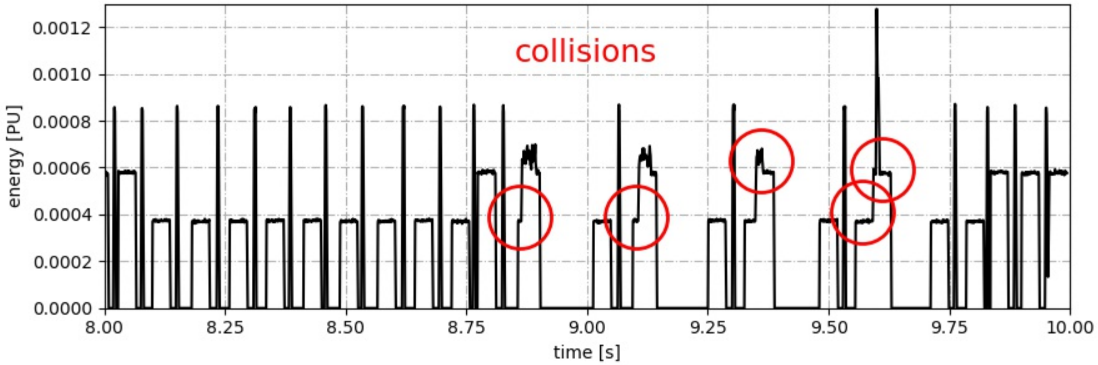
Results

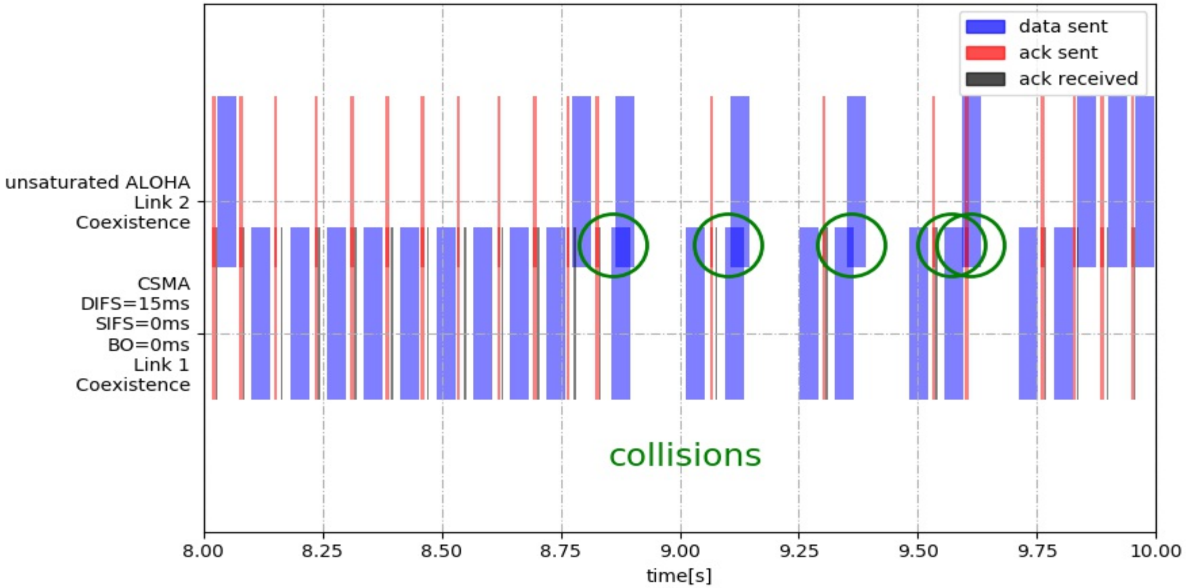
Different MAC protocol on the two links - different CSMA/CA variants



Results

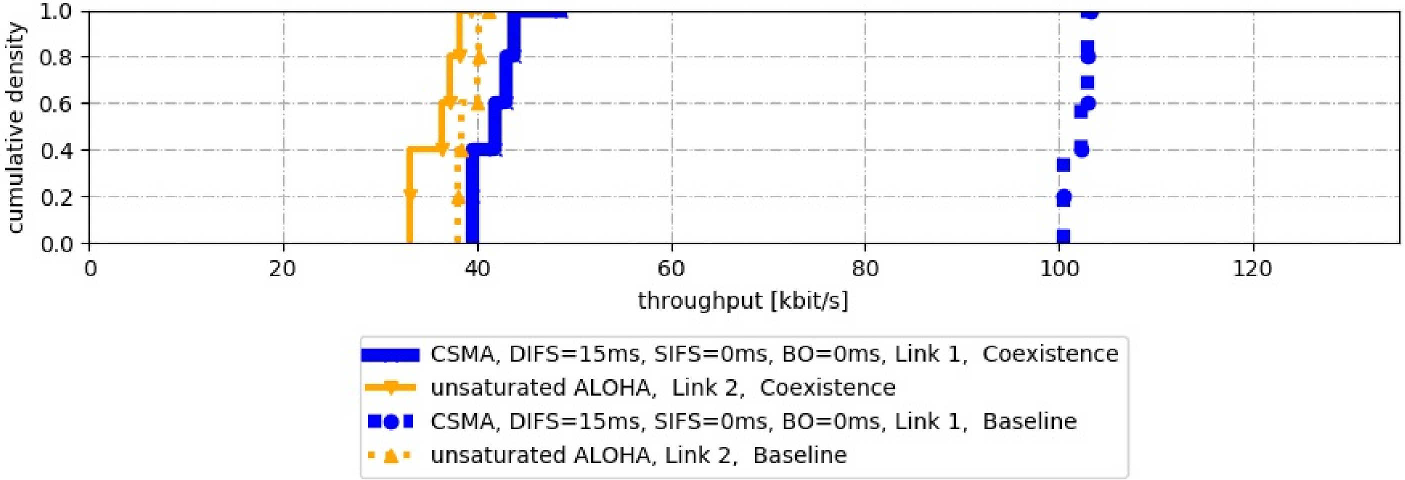
Different MAC protocol on the two links - 1-persistent CSMA/CA + unsat. ALOHA

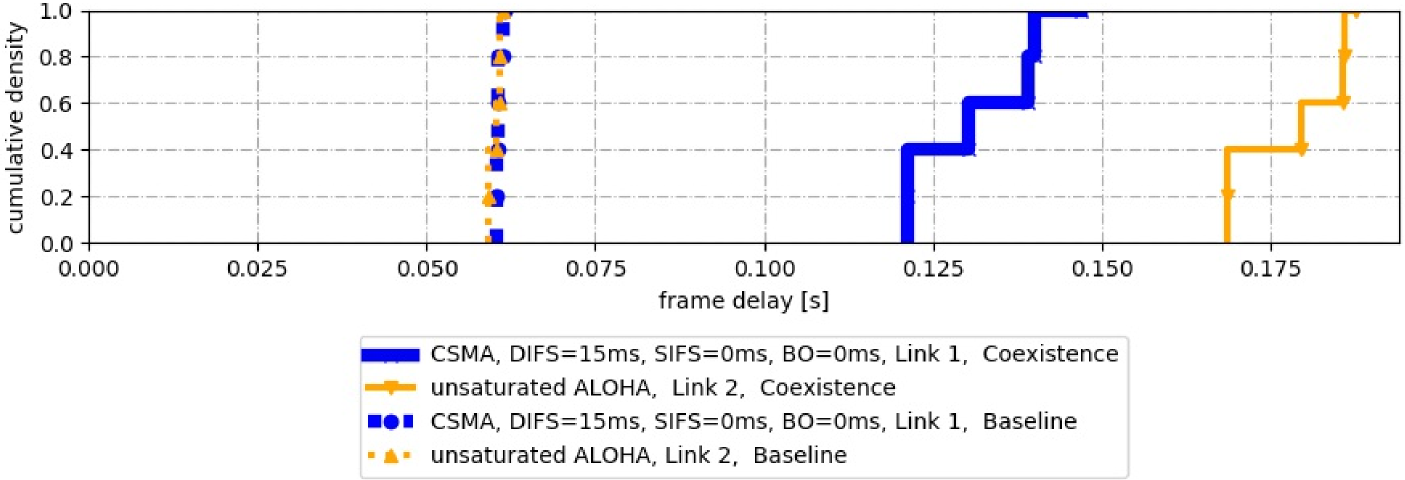




Results

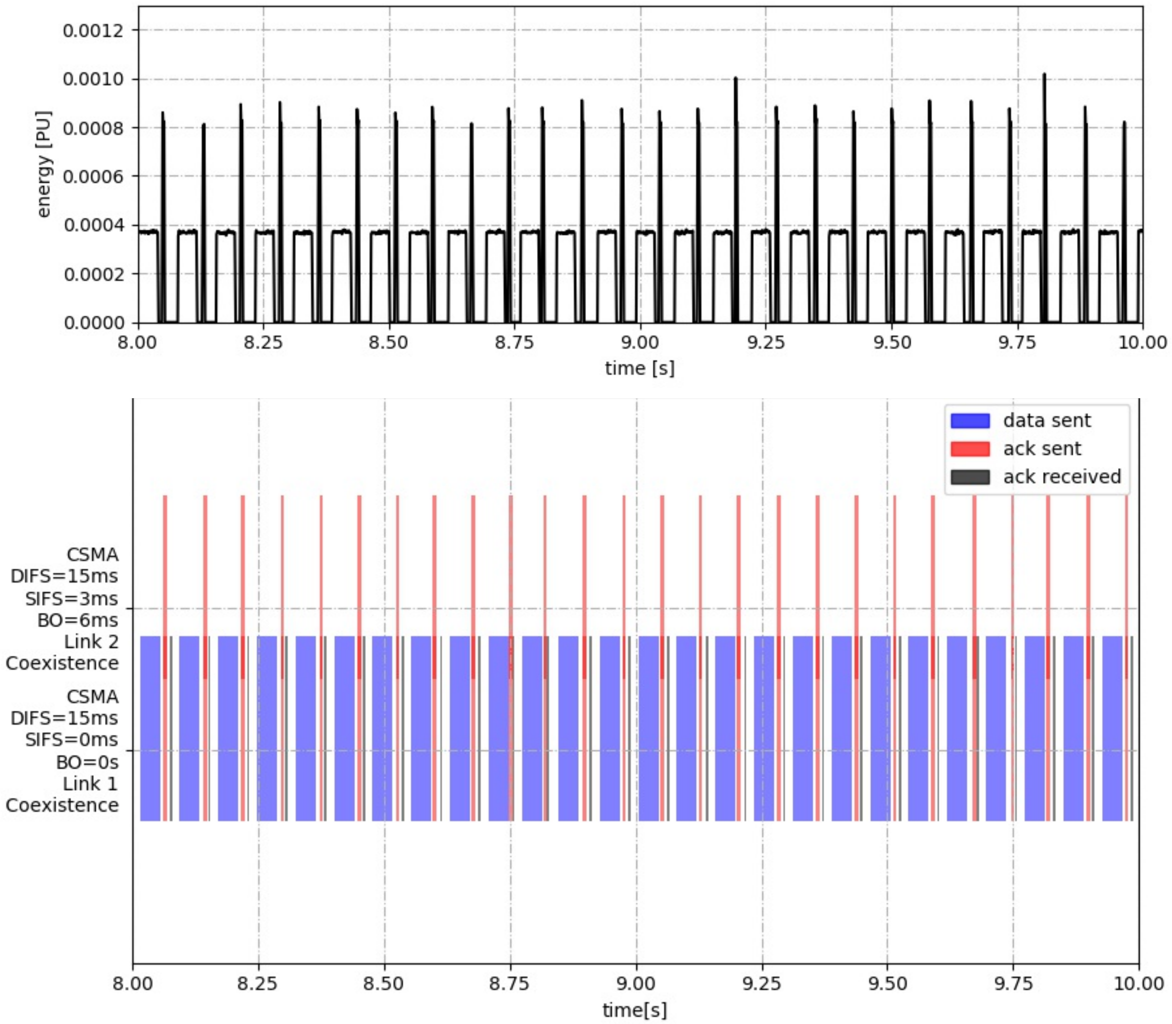
Different MAC protocol on the two links - 1-persistent CSMA/CA + unsat. ALOHA





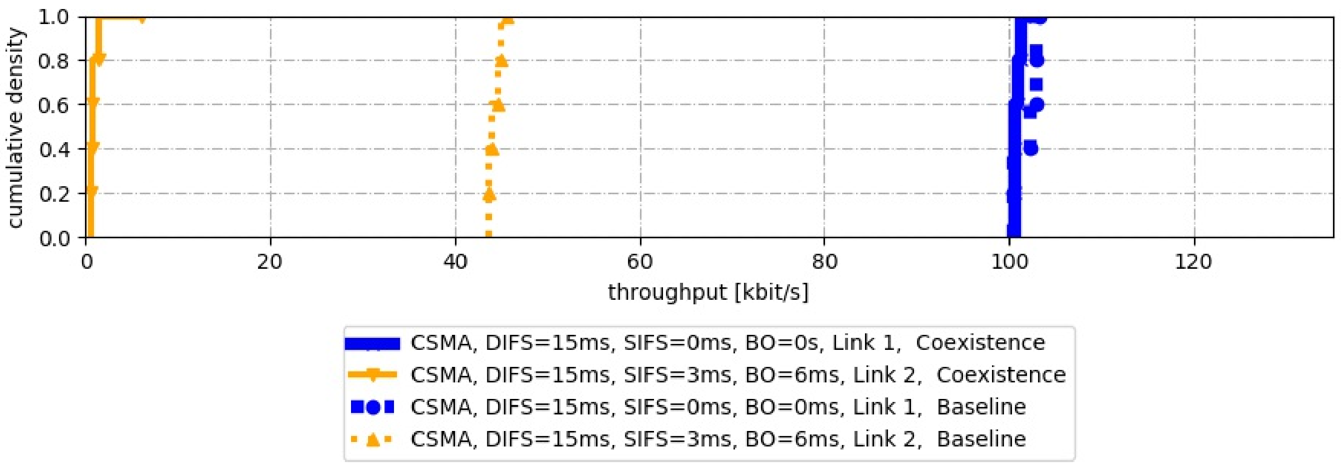
Results

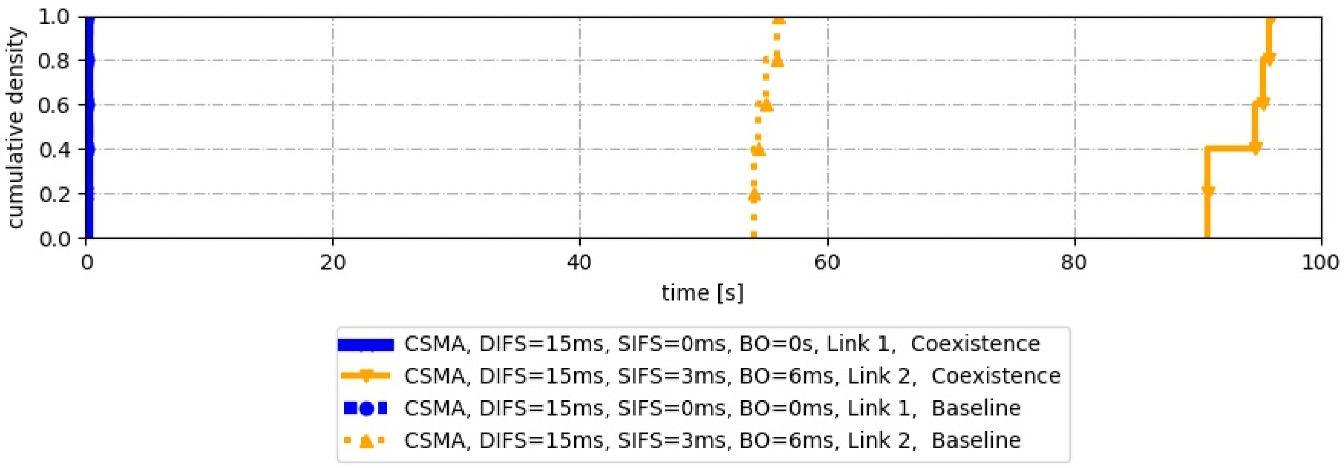
Different MAC protocol on the two links - 1-persistent CSMA/CA + unsat. CSMA/CA



Results

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





You with the interesting question!

Backup Slides

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 alive

Interrogation Attack

Attacker: Repeated RTS to target neighborhood node

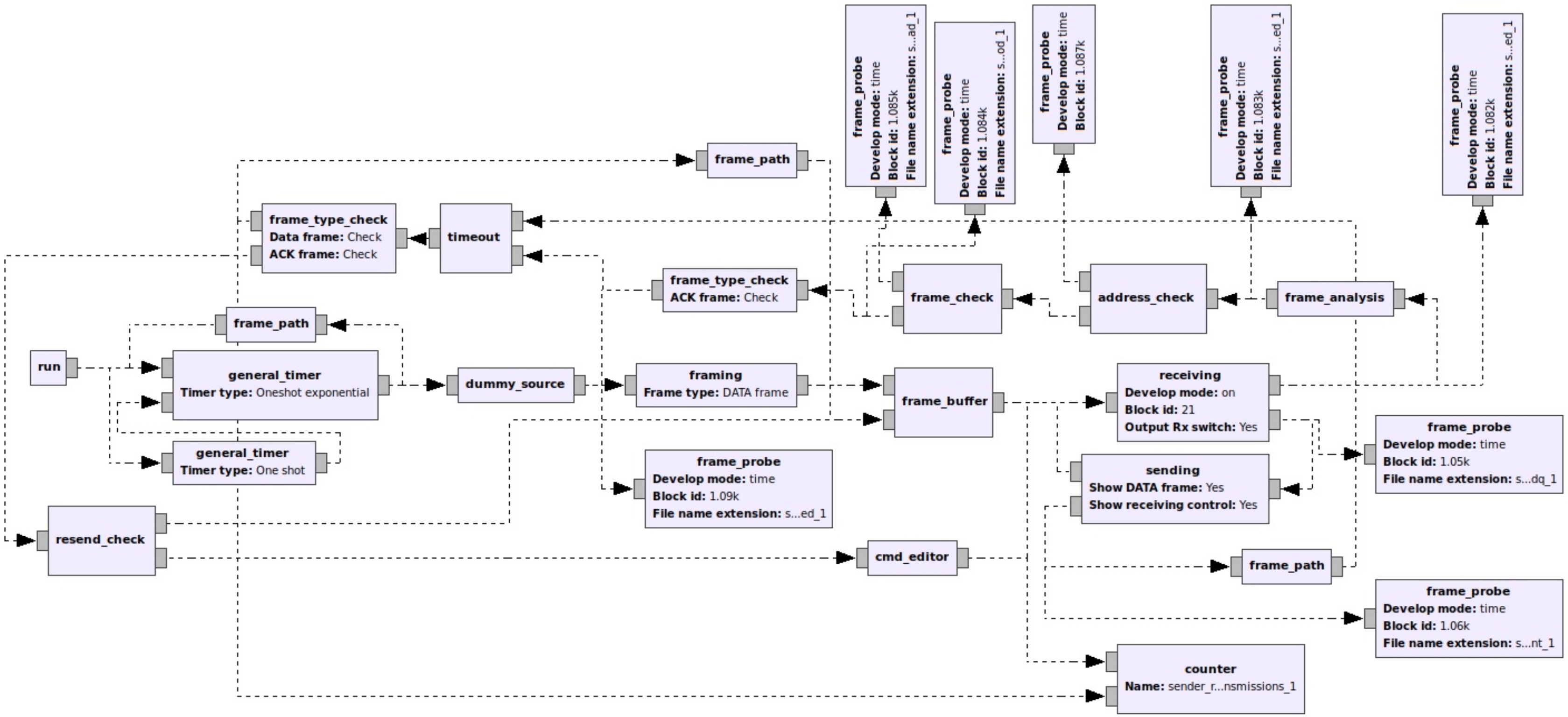
Testbed Setup Parameters

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

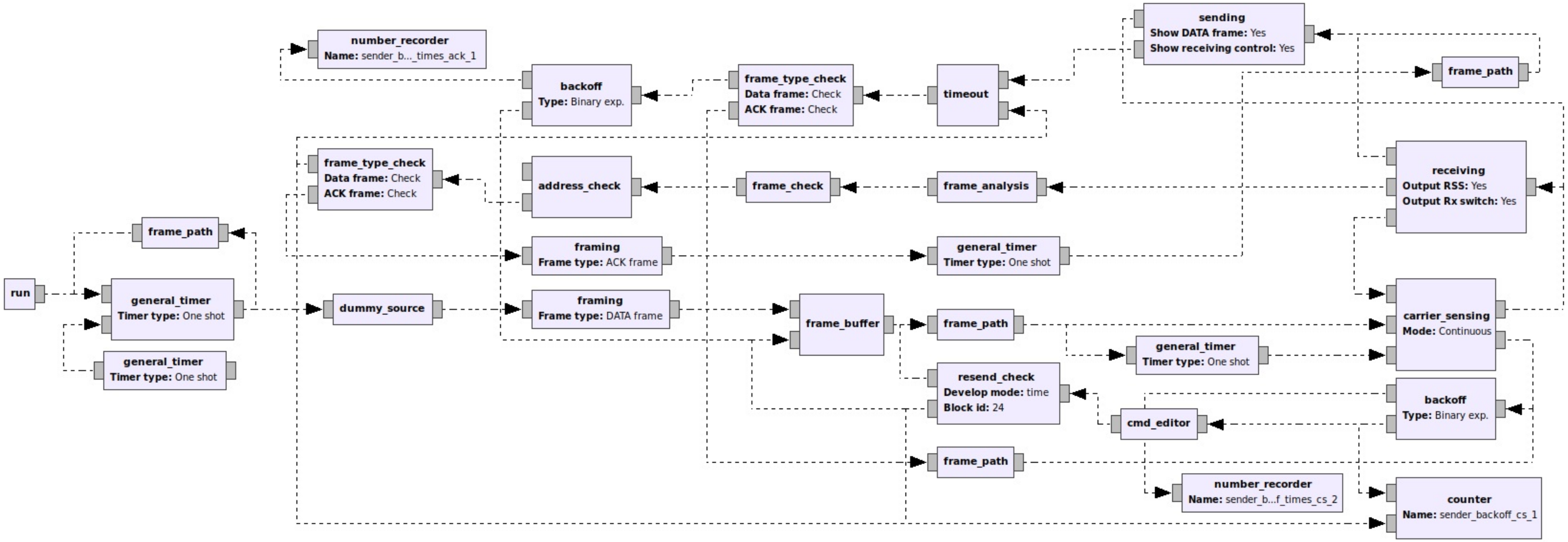
Methodology

Sender (ALOHA) Flowgraph



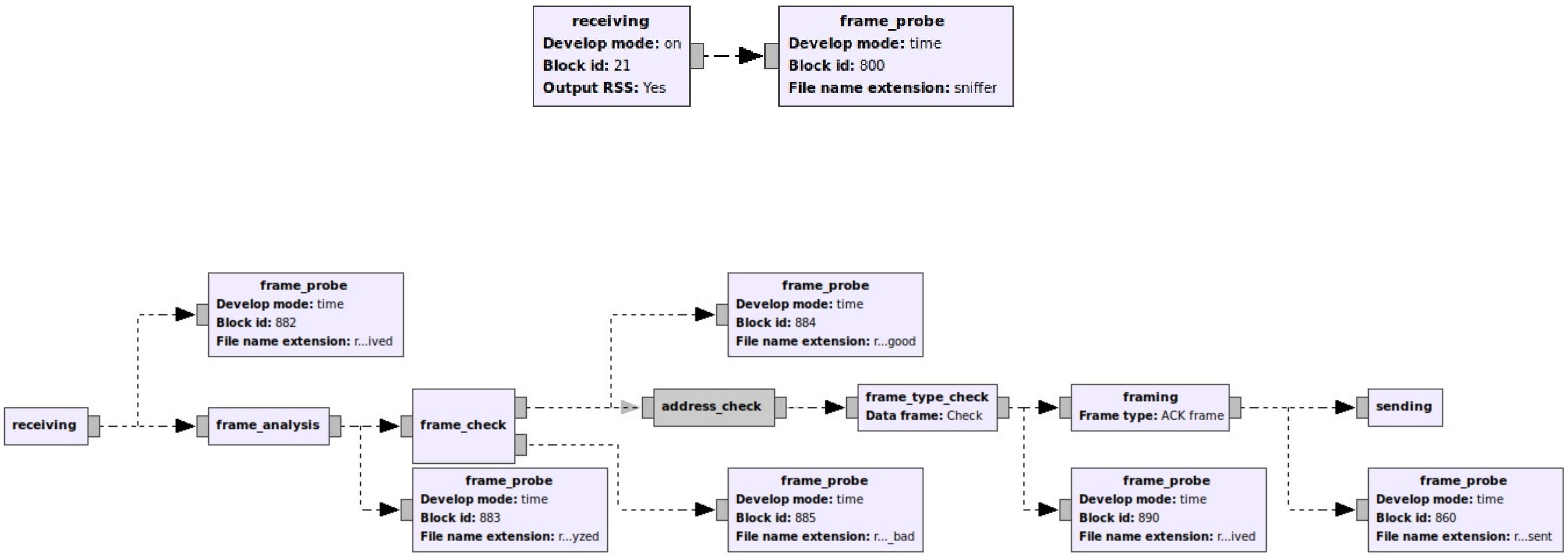
Methodology

Sender (CSMA) Flowgraph



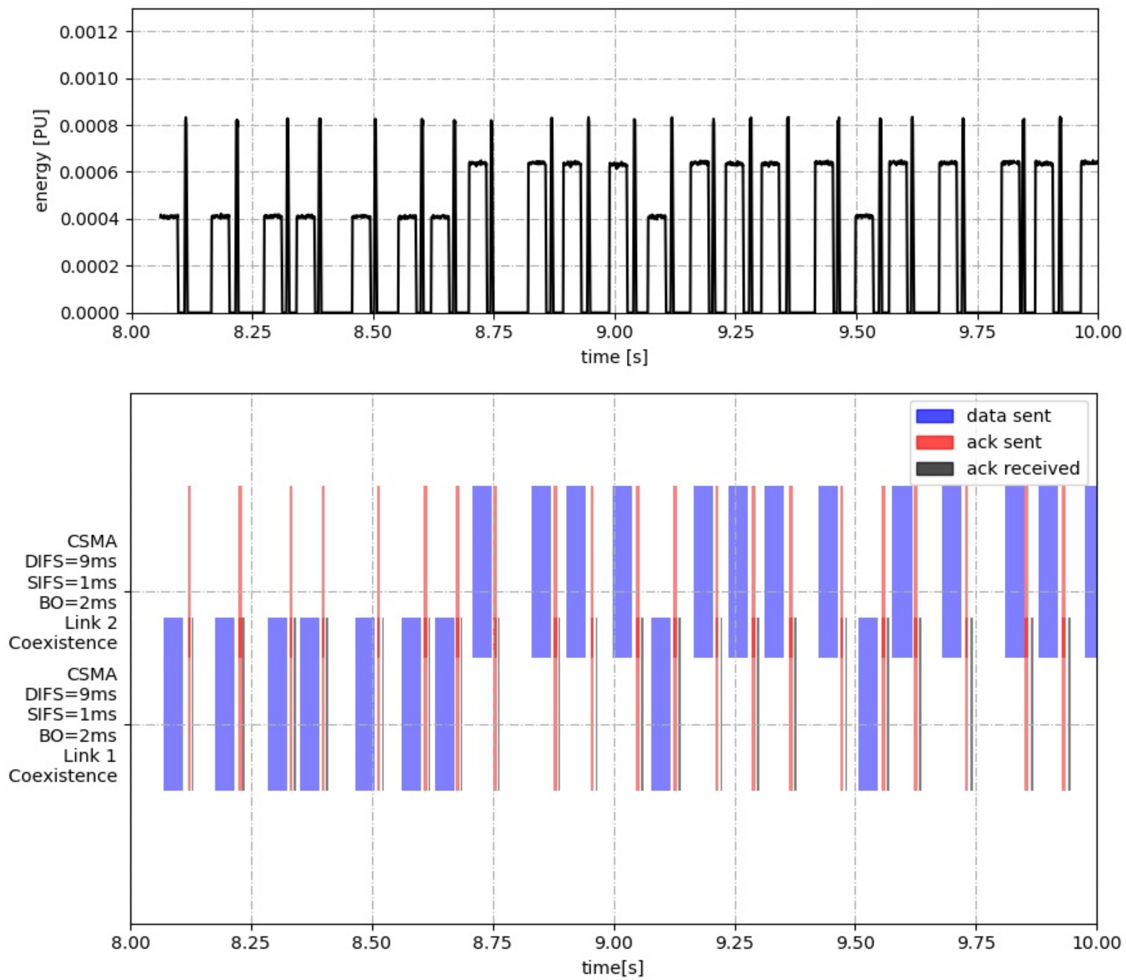
Methodology

Sniffer+Receiver Flowgraph



Results

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



Results

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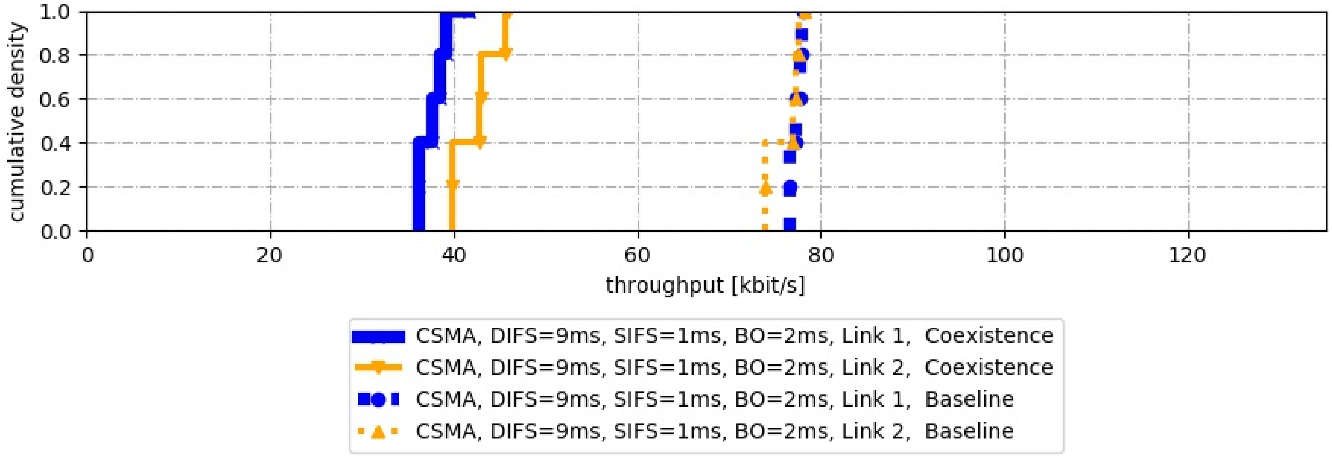

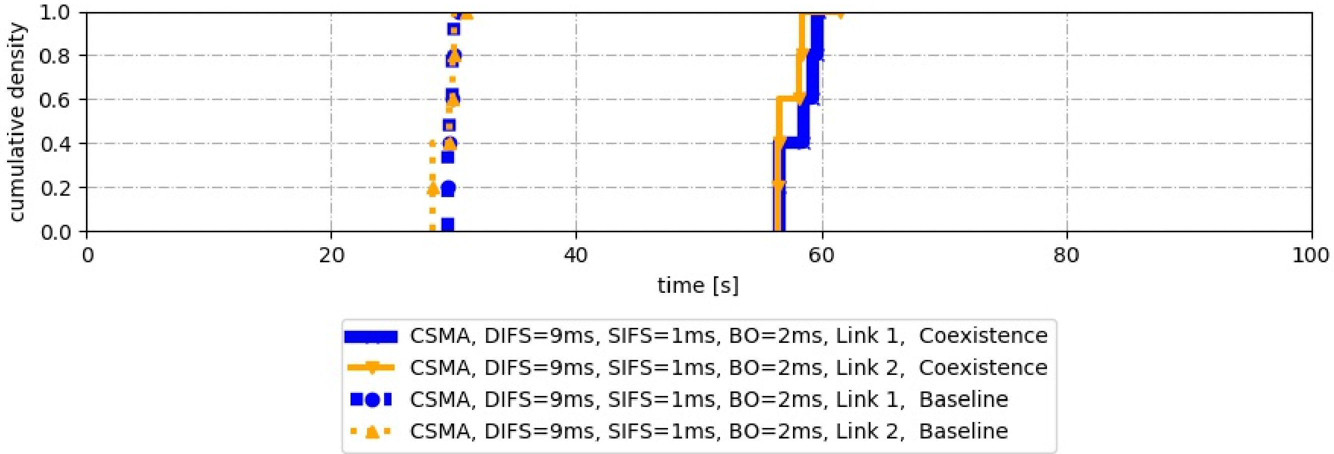

Different MAC protocol on the two links - saturated ALOHA + CSMA/CA