Enhancing IEEE 802.11 MAC in congested environments

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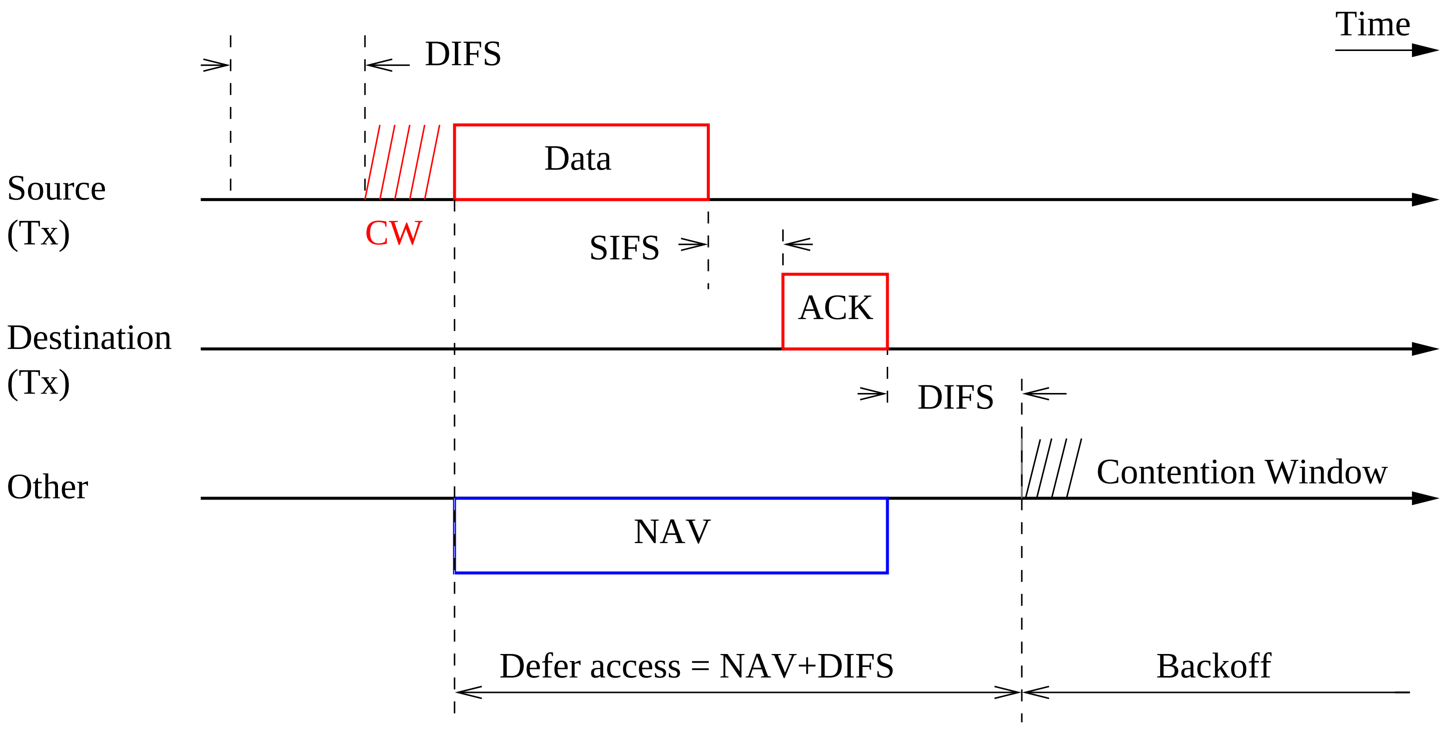
Outline

- IEEE 802.11
  - Very brief description
  - Mathematical model description
- Enhacement
  - Related work
  - Slow decrease (SD)
- Performance Evaluation

MAC sub-layer



MAC sub-layer

$backoff = rand() \times CW$

Collision $\rightarrow$ equal backoffs $\rightarrow$ too many nodes

$\rightarrow$ Should increase CW !!

at the i^{th} retransmission: $CW(i) = CW_{min} \times 2^i$

at a successful transmission: $CW = CW_{min}$

MAC Throughput Model [Bianchi]

$$S = \frac{E[payload{-}information{-}transmitted{-}in{-}a{-}slot{-}time]}{E[length{-}of{-}a{-}slot{-}time]}$$

MAC Throughput Model [Bianchi]

$$S = \frac{E[payload-information-transmitted-in-a-slot-time]}{E[length-of-a-slot-time]}$$

$$S = \frac{P_s P_{tr} E[P]}{(1-P_{tr})\sigma + P_{tr} P_s T_s + P_{tr}(1-P_s) T_c}$$

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$$P_s = \frac{n\tau(1-\tau)^{n-1}}{P_{tr}} = \frac{n\tau(1-\tau)^{n-1}}{1-(1-\tau)^n}$$

$$P_{tr} = 1 - (1-\tau)^n$$

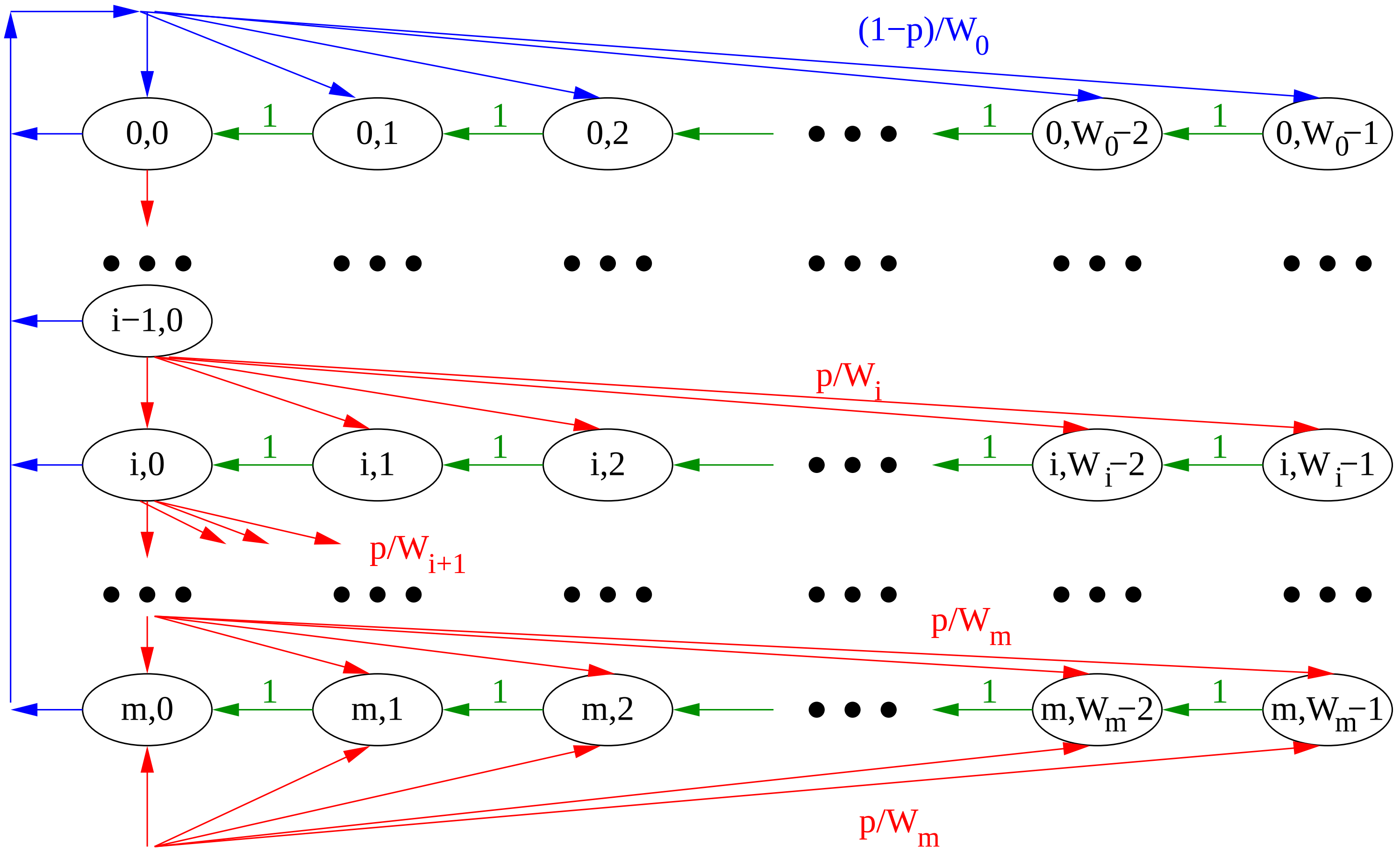
MAC Throughput Model [Bianchi]

To find τ, 2 nonlinear equations to solve, 1:

- $p = 1 - (1 - \tau)^{n-1}$

MAC Throughput Model [Bianchi]

To find τ, 2 nonlinear equations to solve, 2:



MAC Throughput Model [Bianchi]

To find τ, 2 nonlinear equations to solve:

- $p = 1 - (1 - \tau)^{n-1}$
- $\tau = \frac{2(1-2p)}{(1-2p)(W+1)+pW(1-(2p)^m)}$

MAC Throughput Model [Bianchi]

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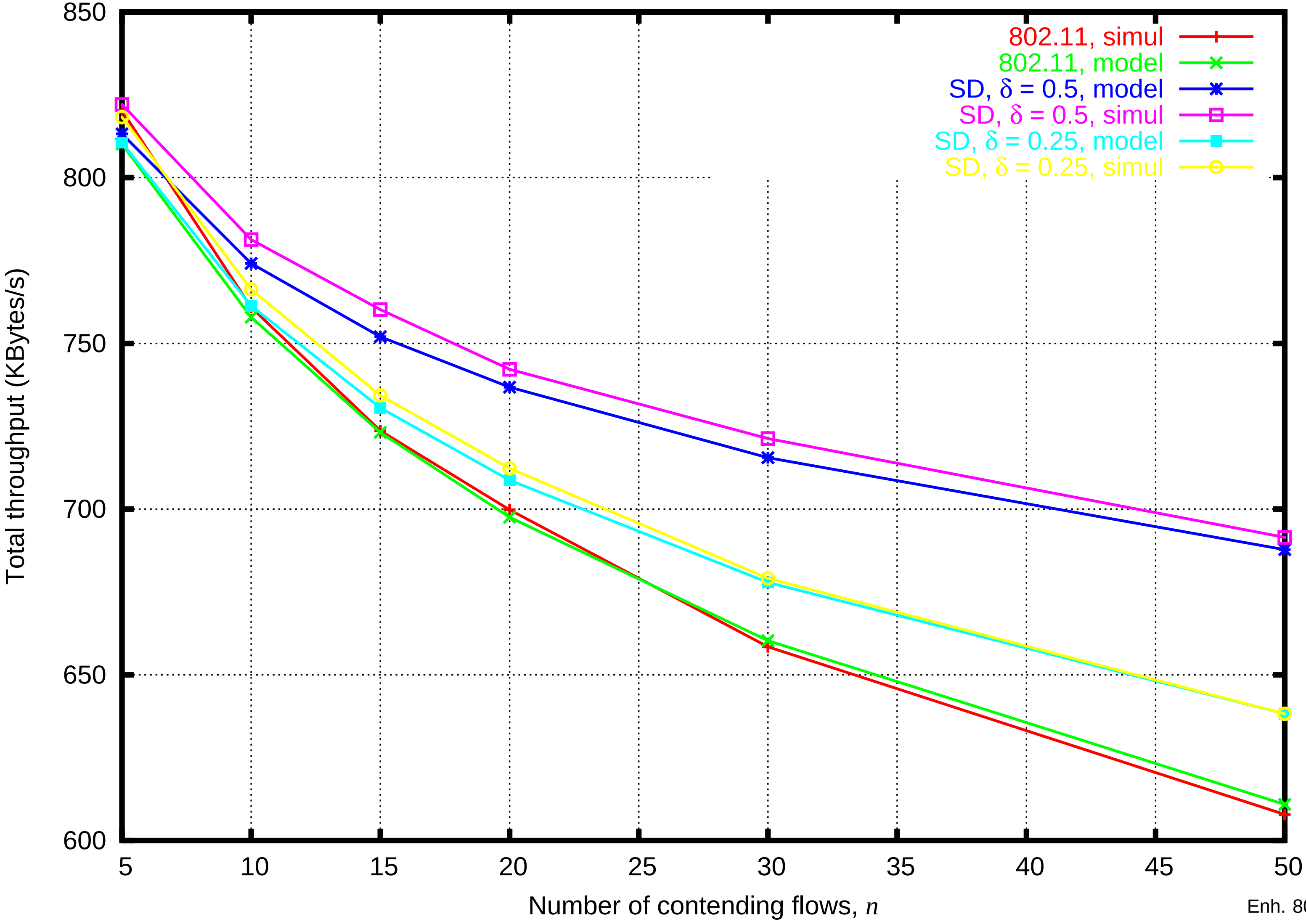
- $p = 1 - (1 - \tau)^{n-1}$
- $\tau = \frac{2(1-2p)}{(1-2p)(W+1)+pW(1-(2p)^m)}$
- $\rightarrow$ Matlab $\rightarrow$ very close to simulations

MAC Throughput Model [Bianchi]



Outline

CW slow decrease

- After each collision, CSMA/CA increases CW
- Upon a successful transmission, reset CW
- BUT! congestion did not “reset”!

CW slow decrease

To reset or not to reset, that is the question!

Related work

In 1994, Bharghavan *et al. proposed MACAW:*

MILD: Multiplicative Increase ($CW = CW \times 1.5$)
Linear Decrease ($CW = CW - 1$)

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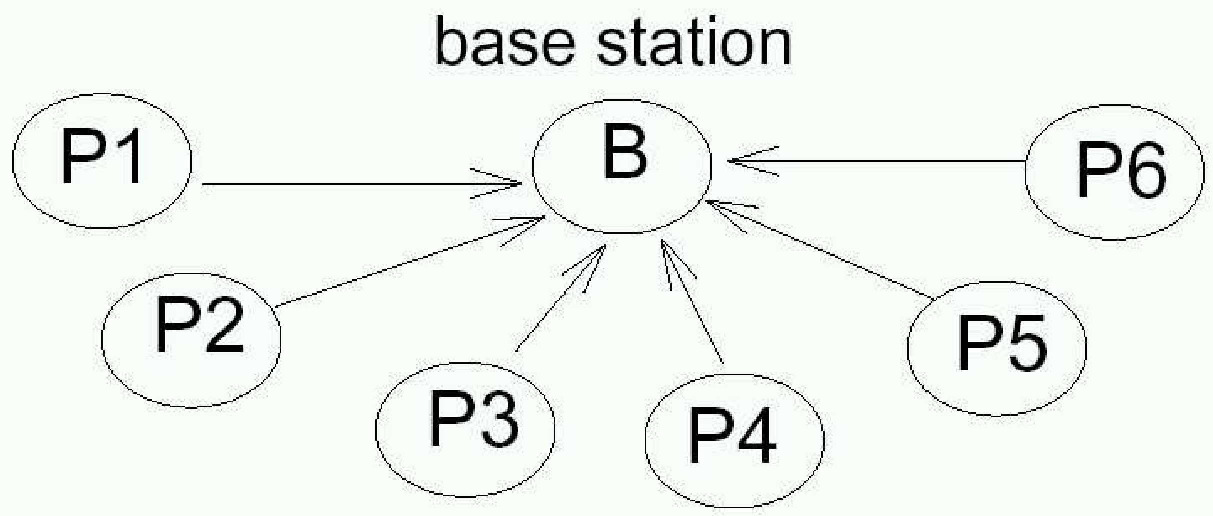


Figure 3: A single cell configuration where all stations are in range of each other. All six pads are sending data to the base station. Each stream is generating data at a rate of 32 packets per second and using UDP for transport.

Related work

In 1994, Bharghavan *et al. proposed MACAW:*

	BEB copy	MILD copy
P1-B	2.96	6.10
P2-B	3.01	6.18
P3-B	2.84	6.05
P4-B	2.93	6.12
P5-B	3.00	6.14
P6-B	3.05	6.09

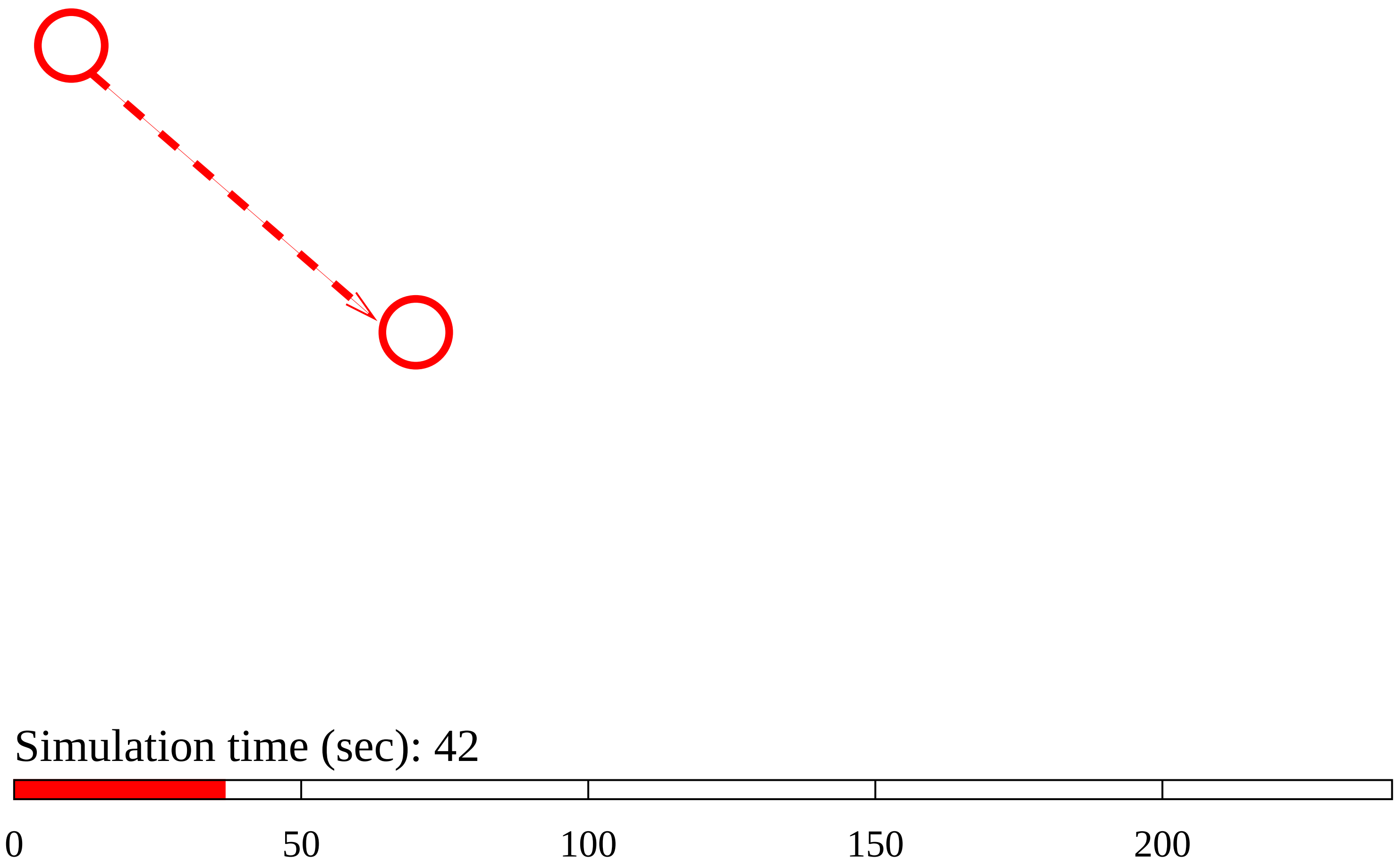
Table 2: The throughput, in packets per second, achieved by the streams in Figure 3.

Our approach

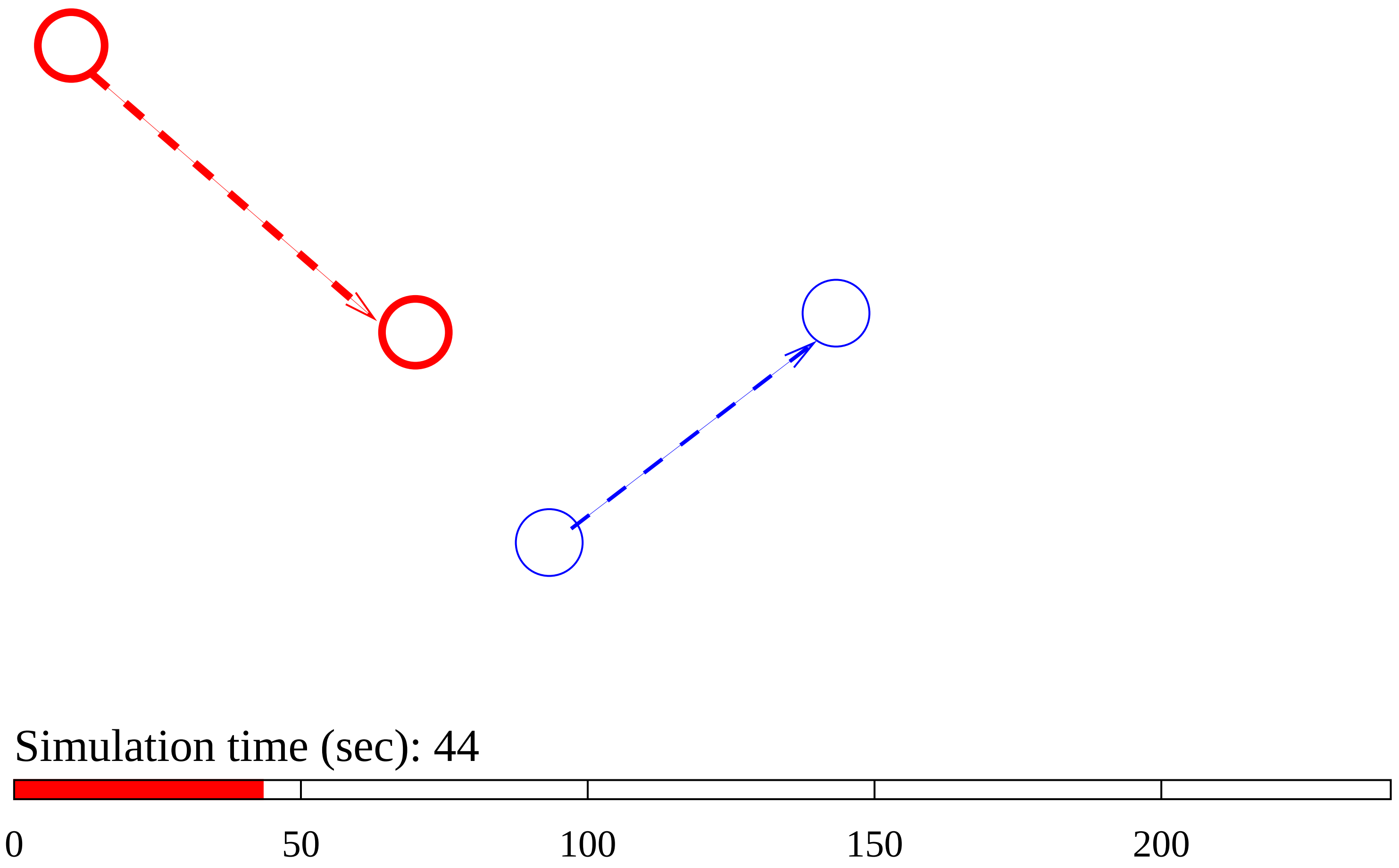
We propose a slow CW decrease mechanism (SD), e.g.

$$CW = 0.9 \times CW$$

Simulation scenario



Simulation scenario



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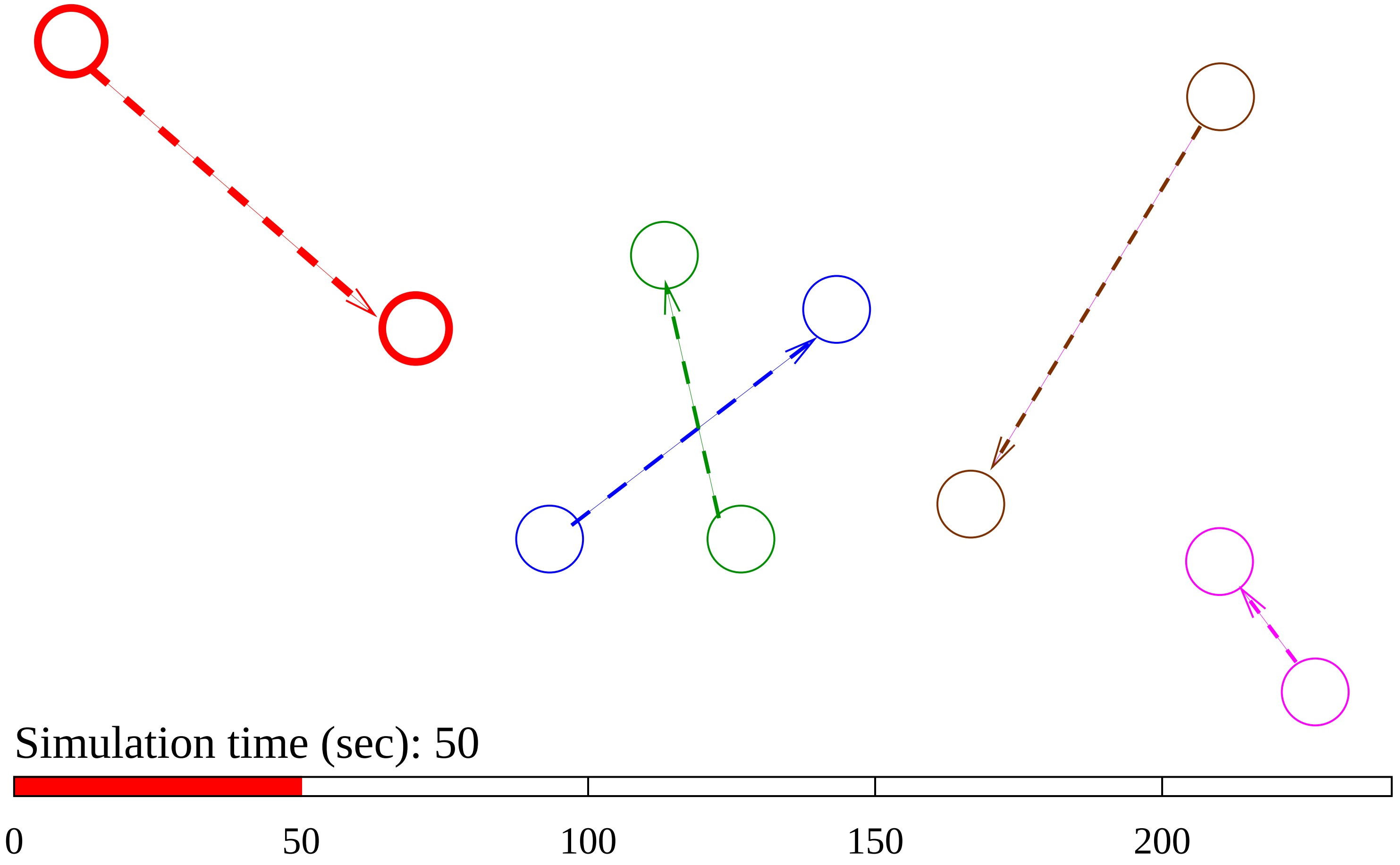

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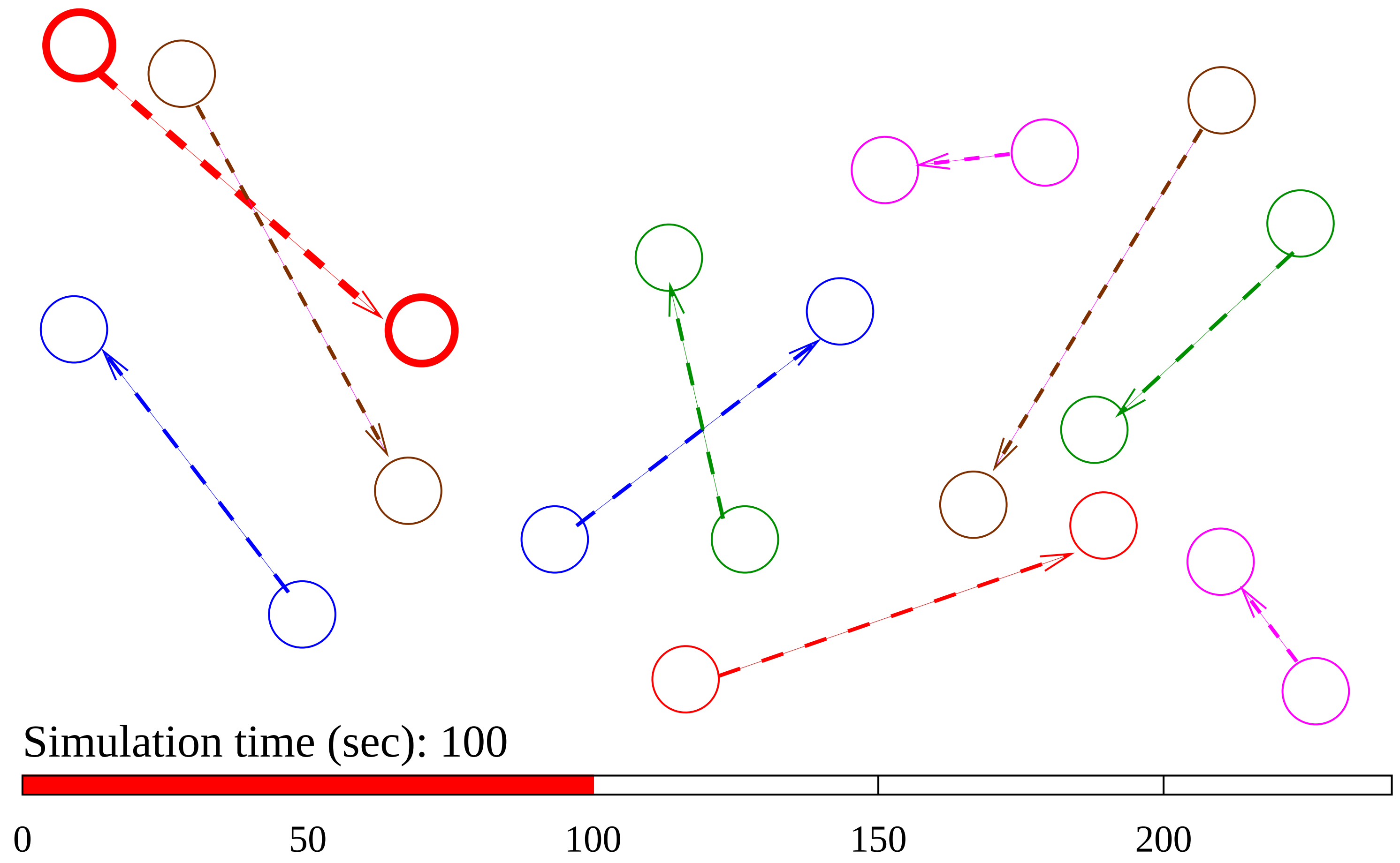

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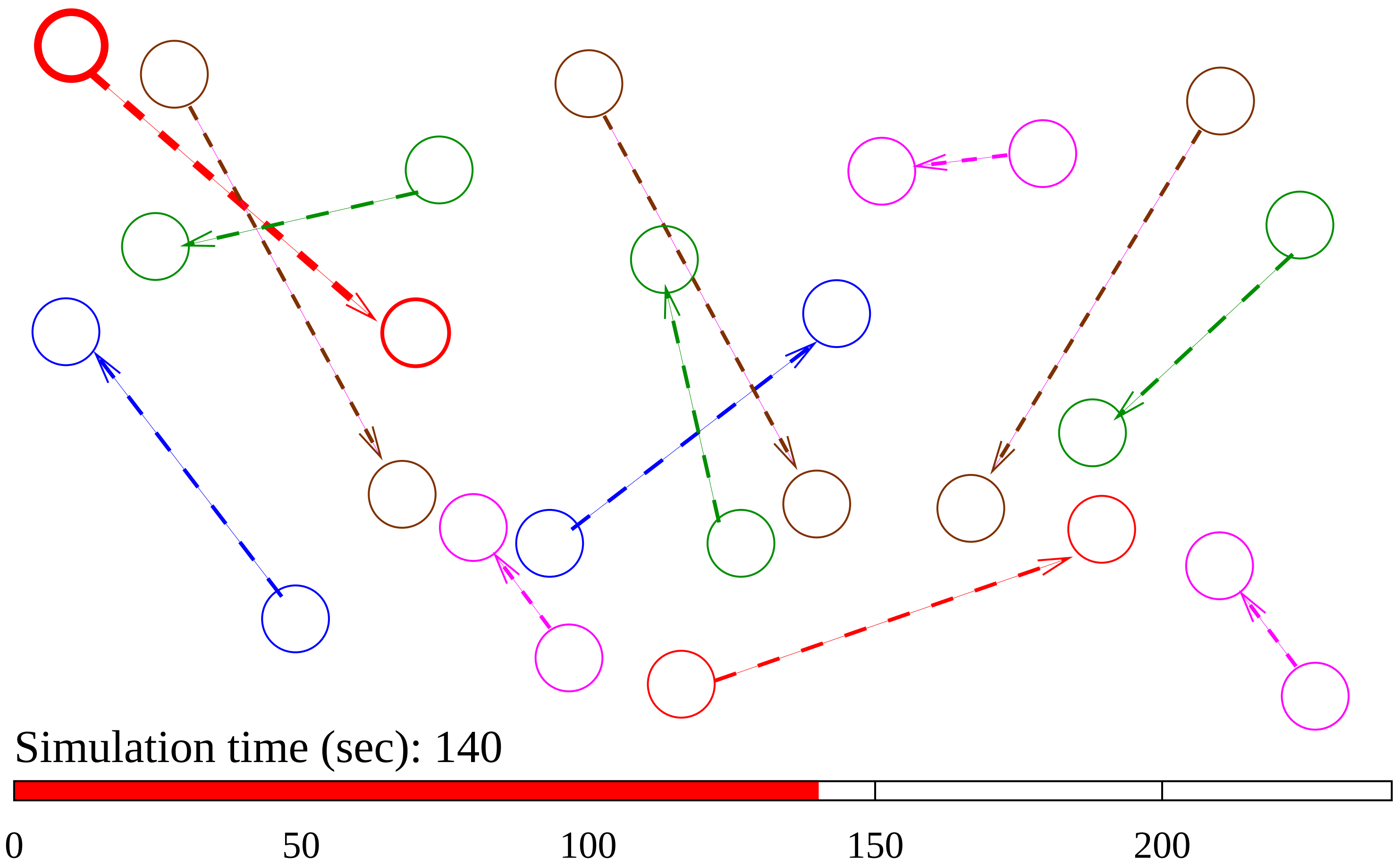

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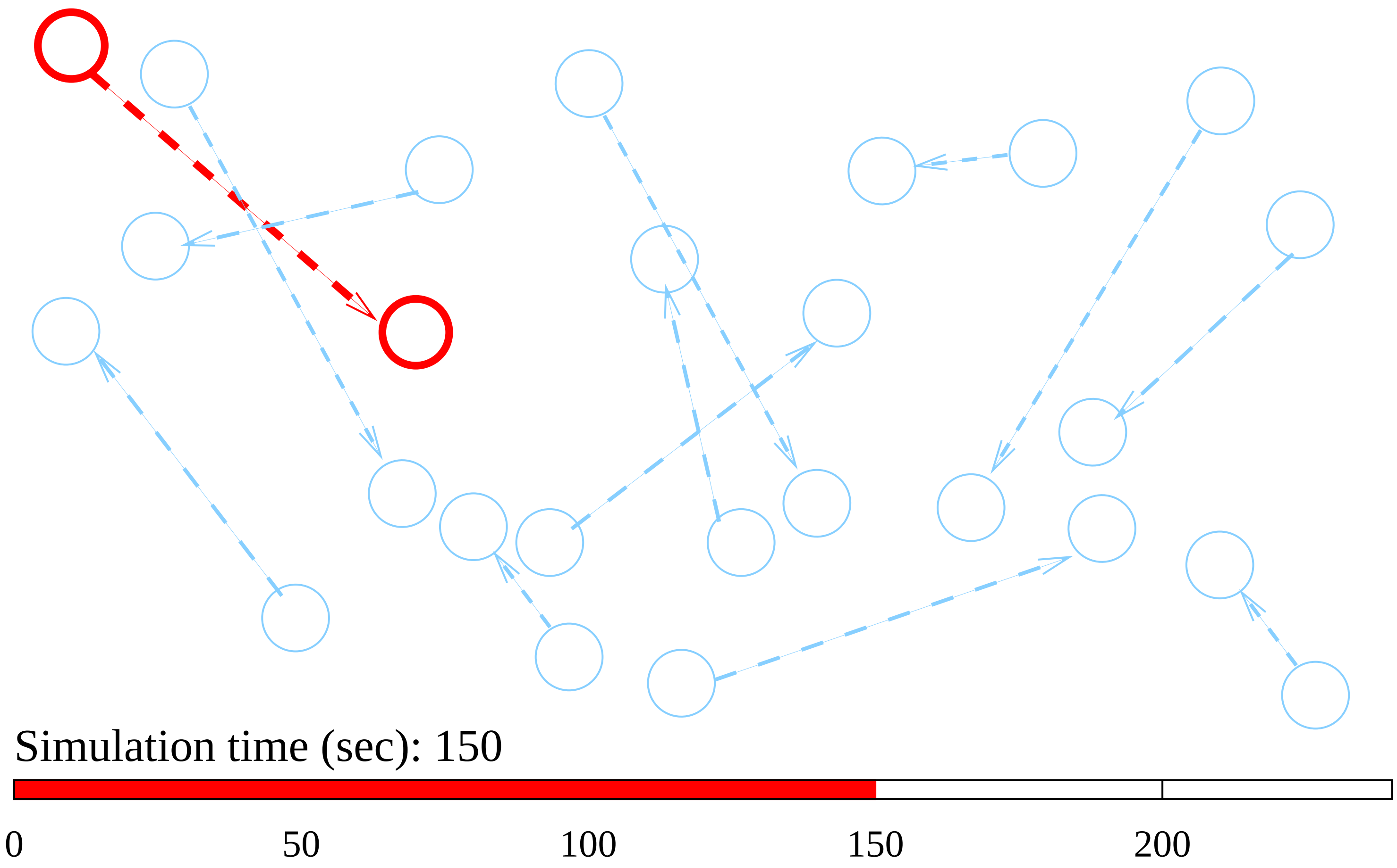
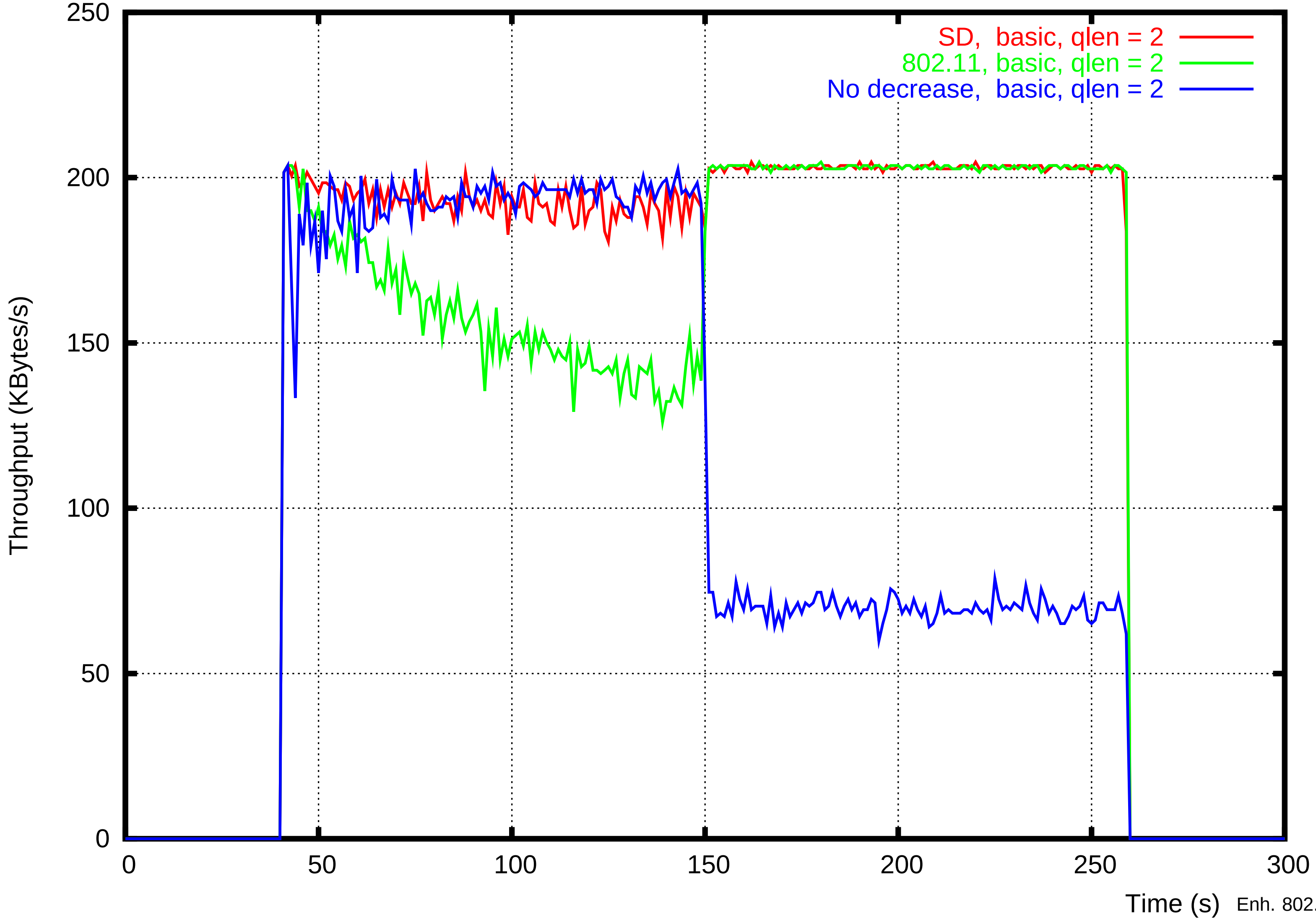
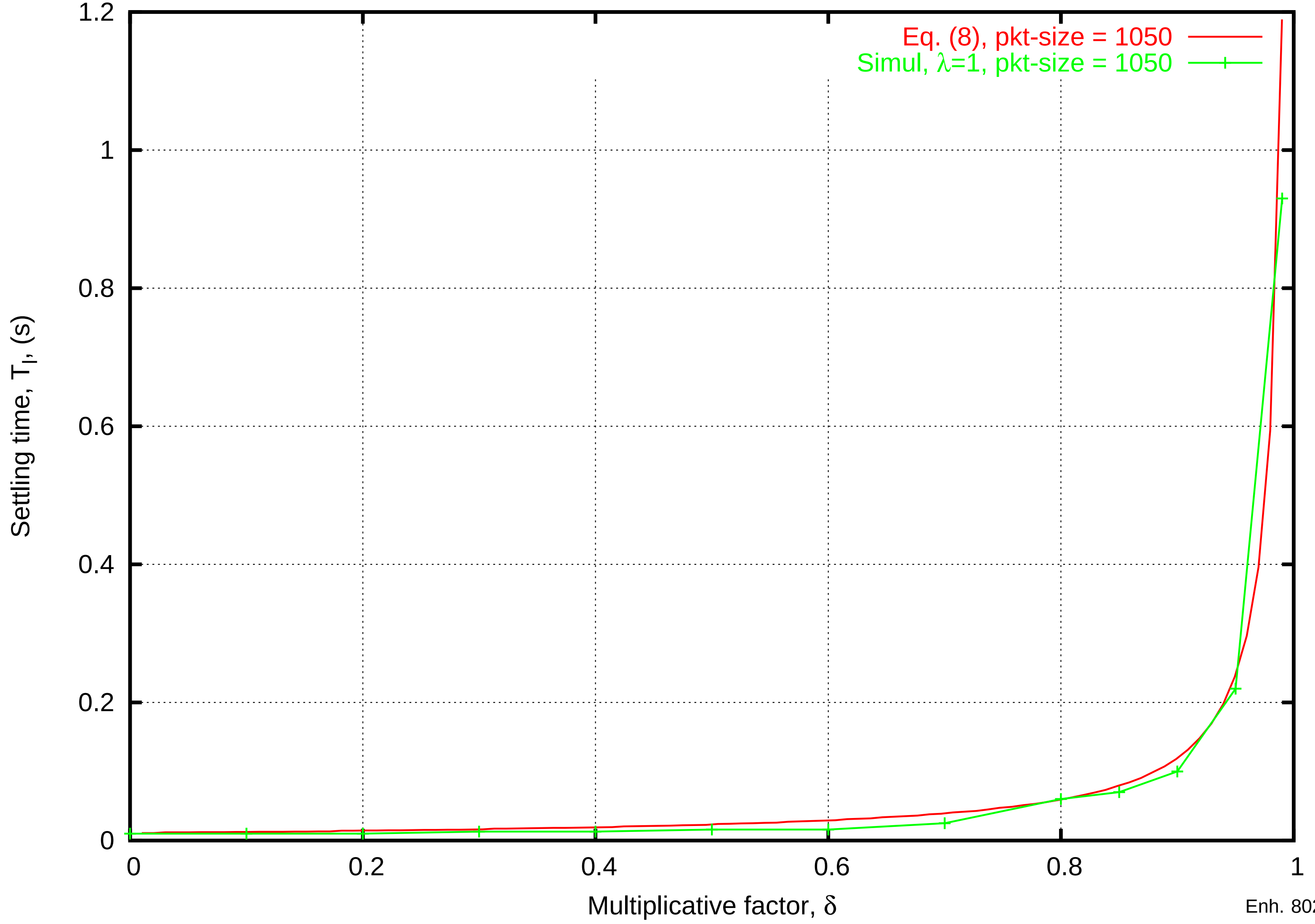


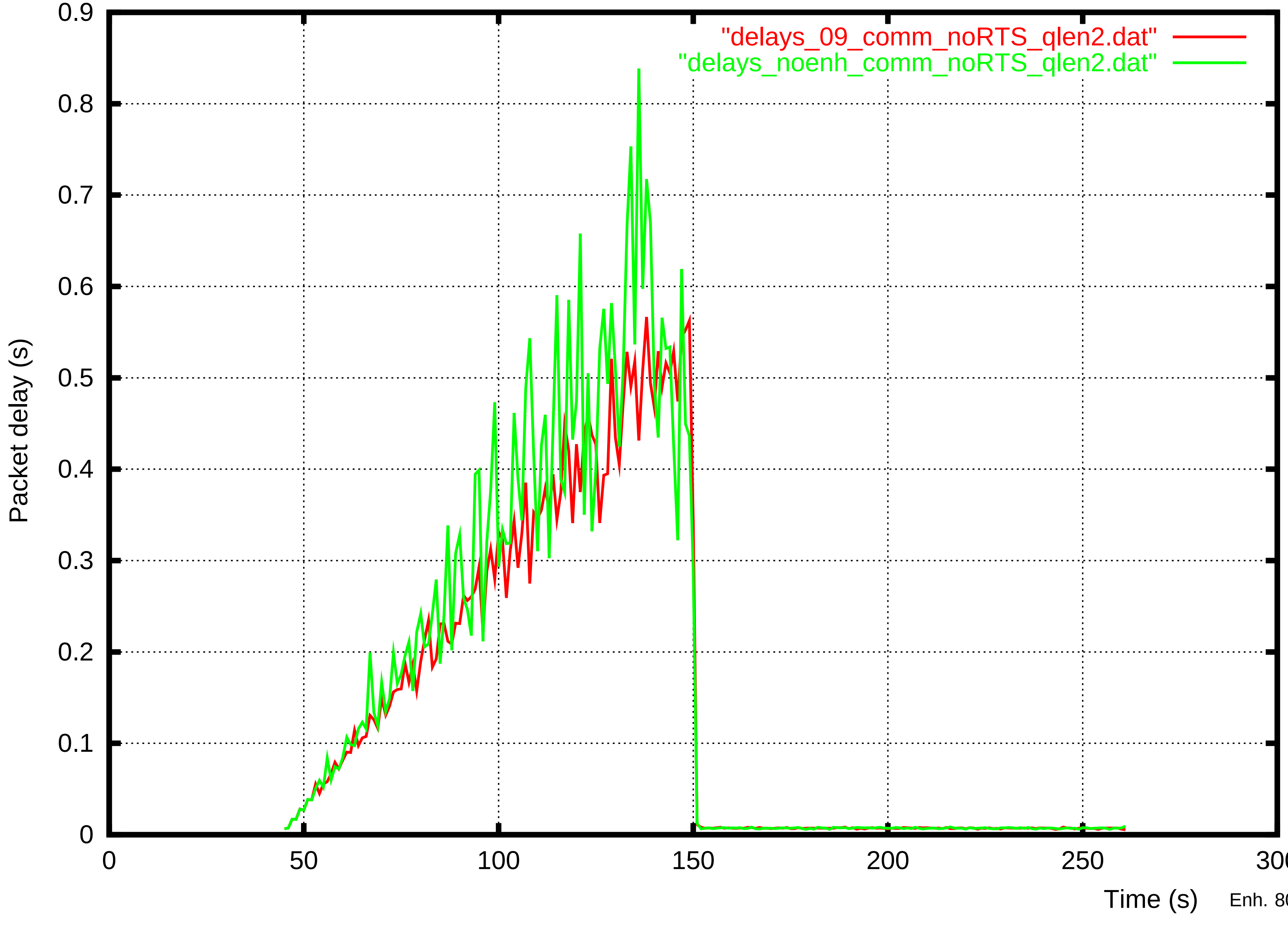
Throughput vs. n



Settling time vs. δ

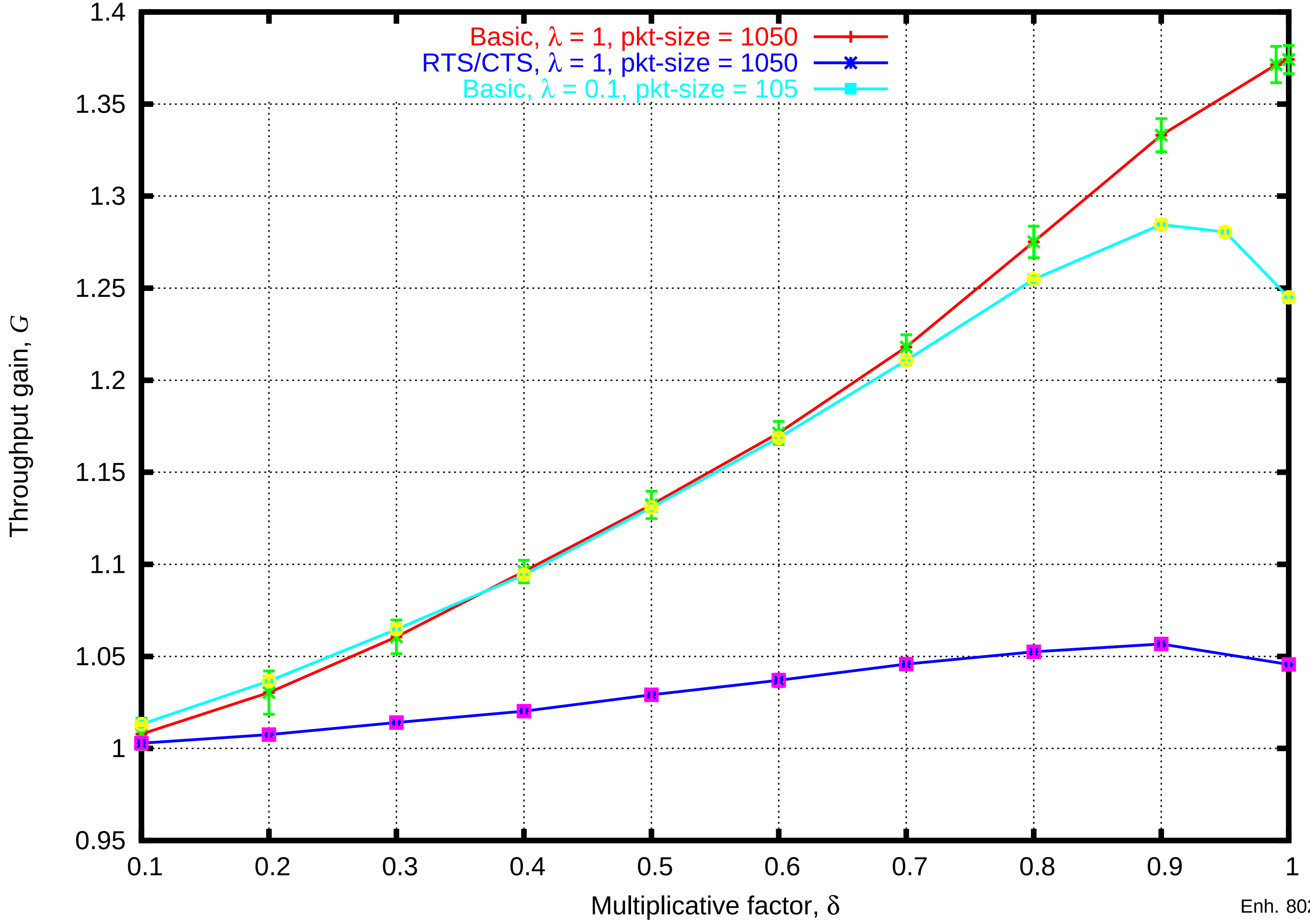


Delays vs. n

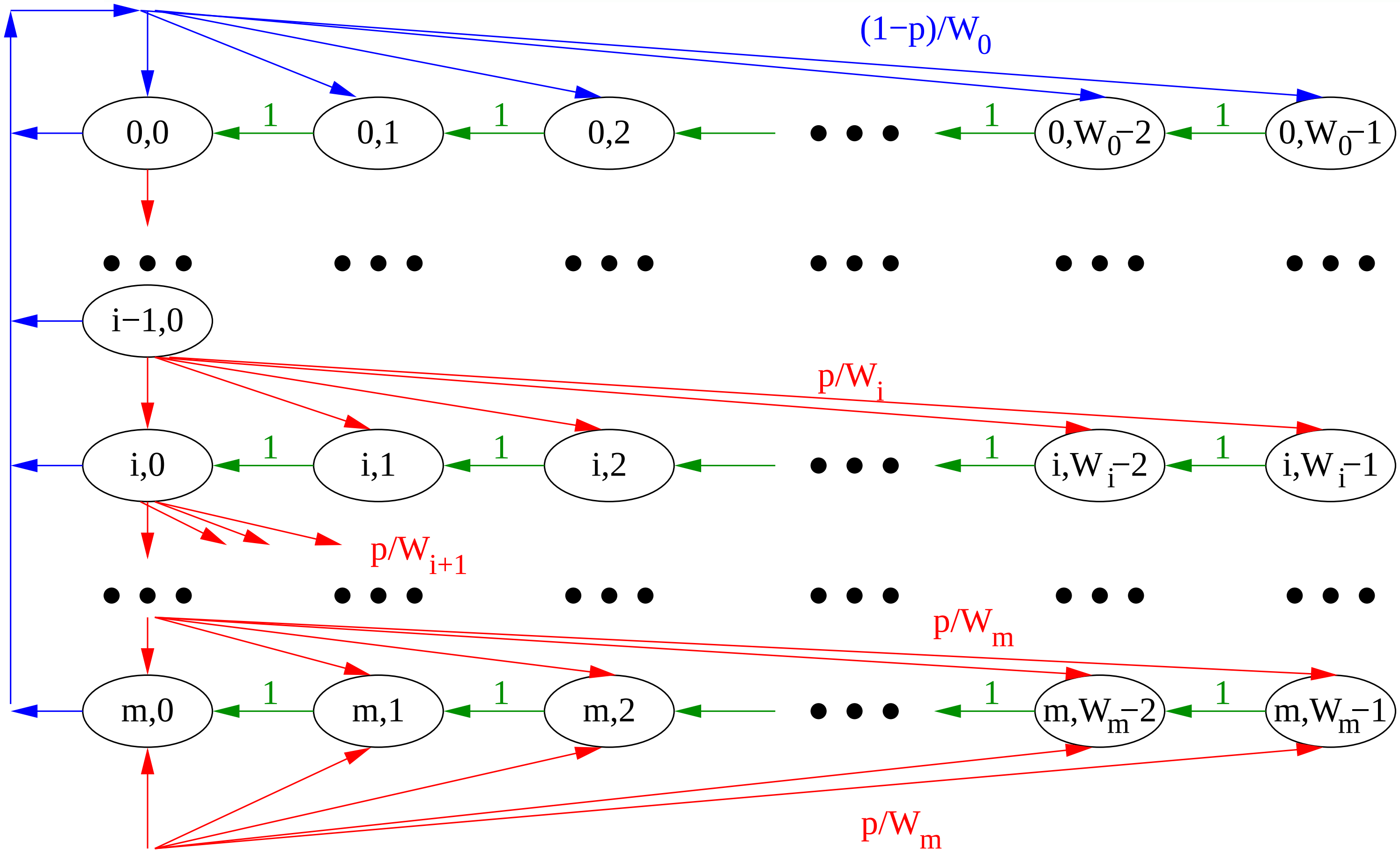


"delays_09_comm_noRTS_qlen2.dat"
"delays_noenh_comm_noRTS_qlen2.dat"
Packet delay (s)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
0
50
100
150
200
250
300
Time (s)

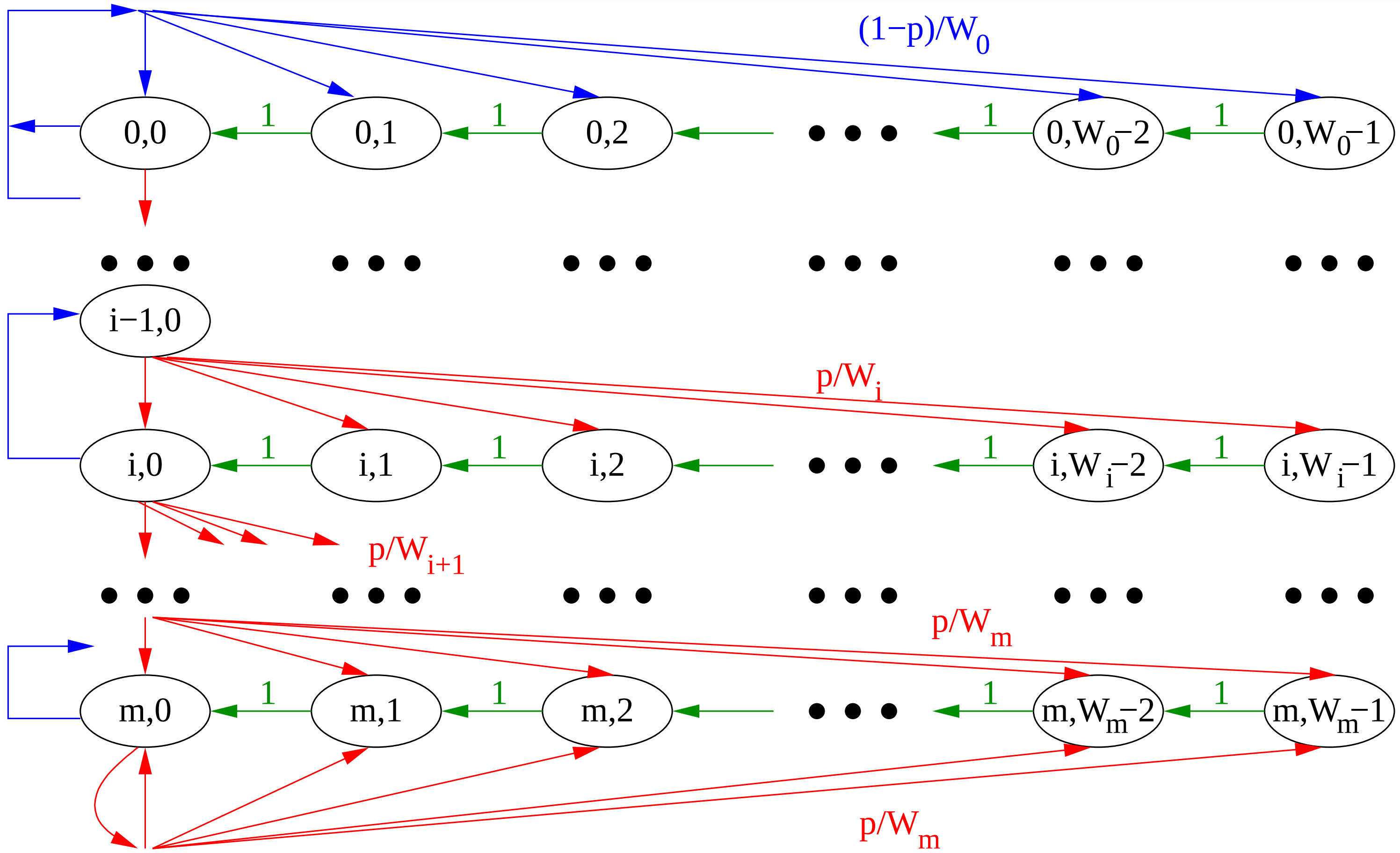
Throughput gain vs. δ



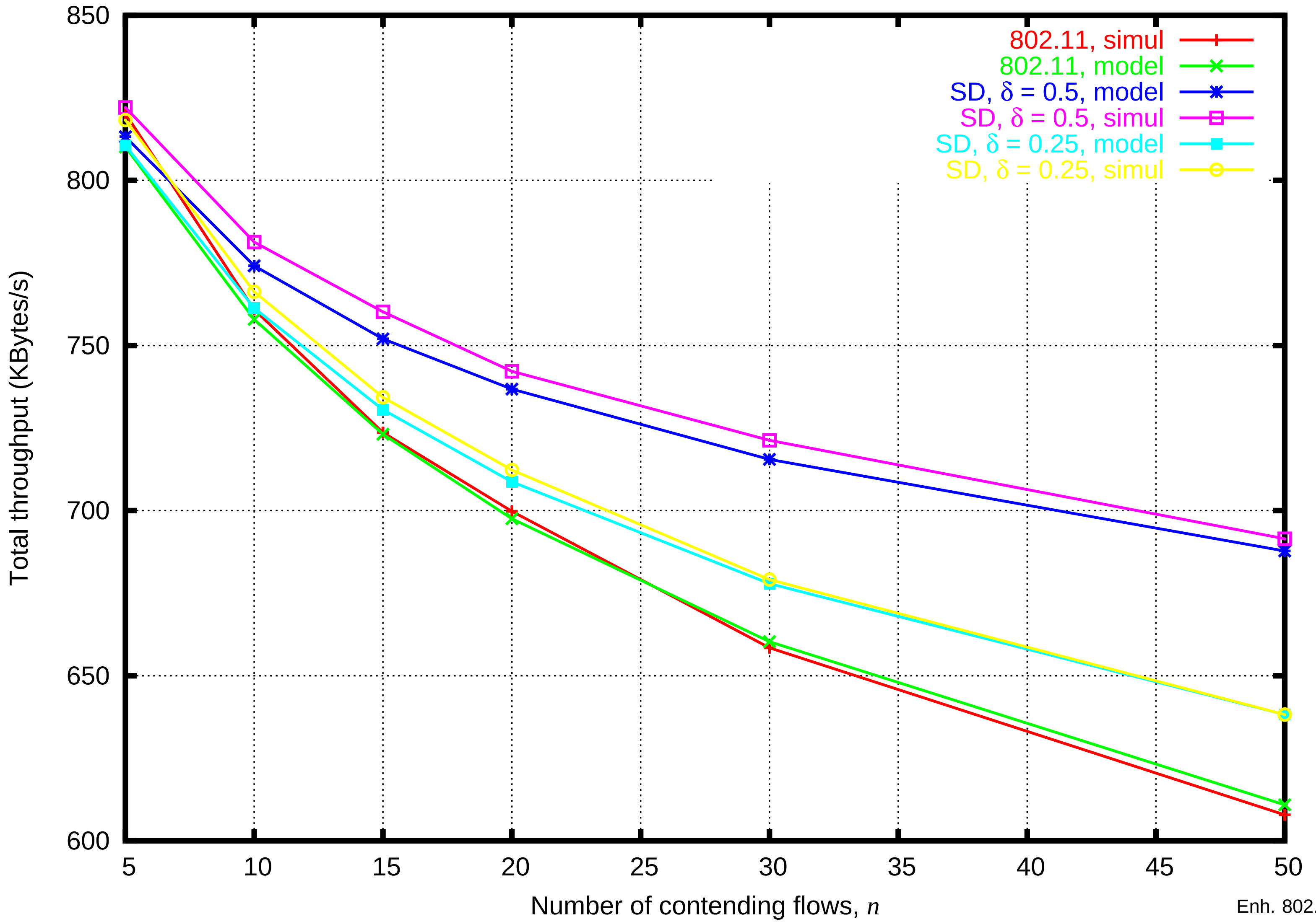
802.11 throughput model



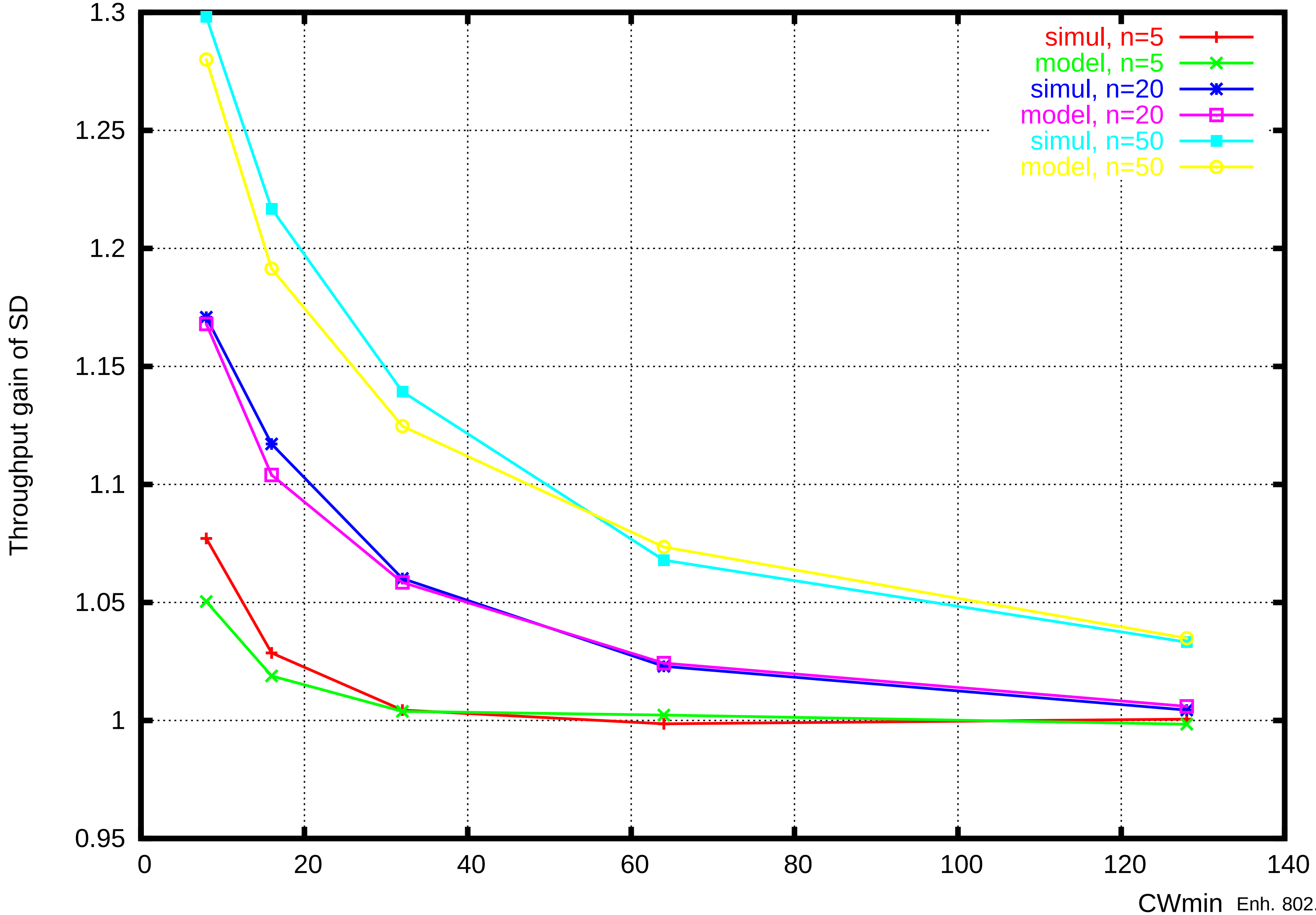
SD throughput model



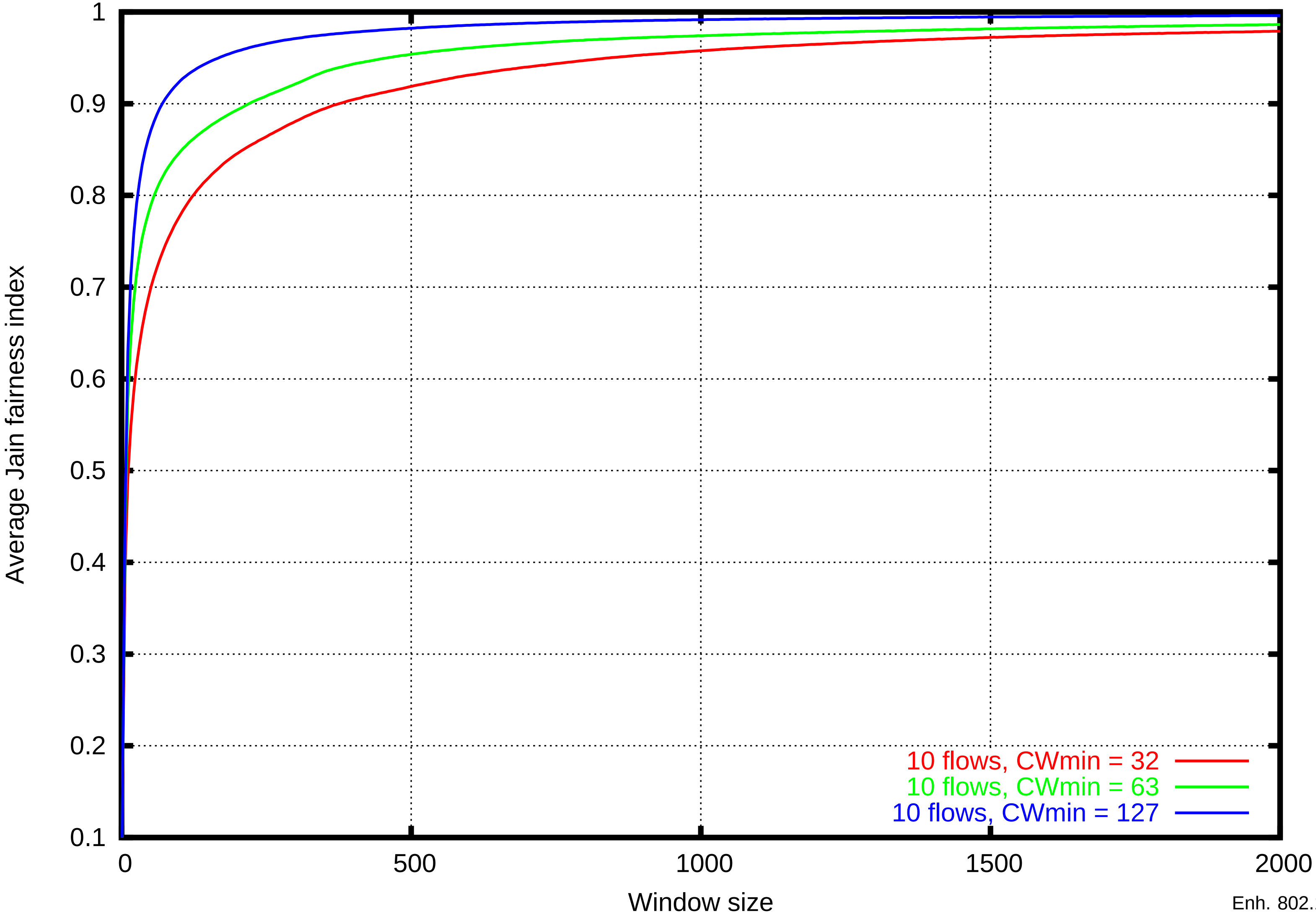
Throughput vs n



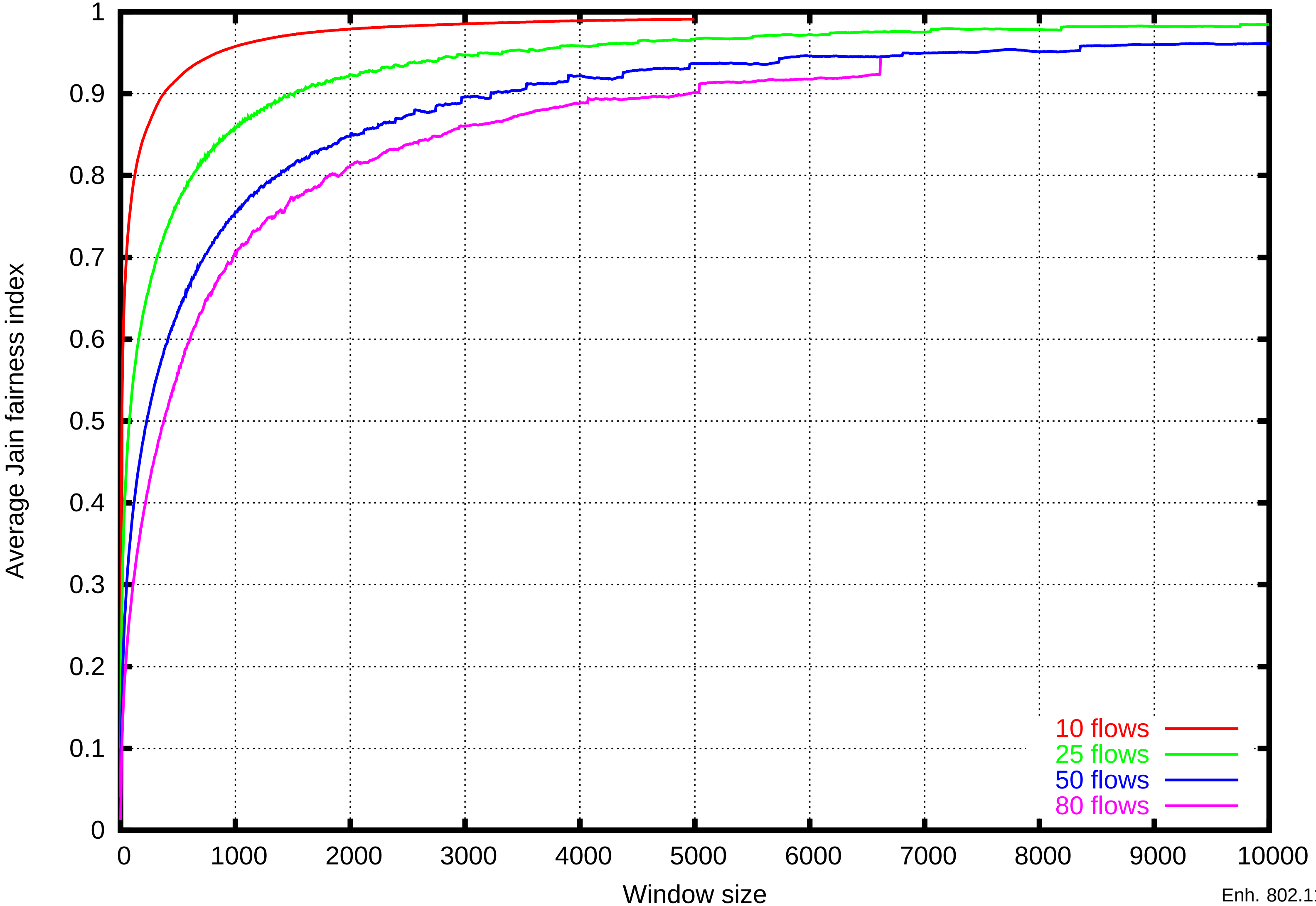
Throughput Gain vs. CW_{min}



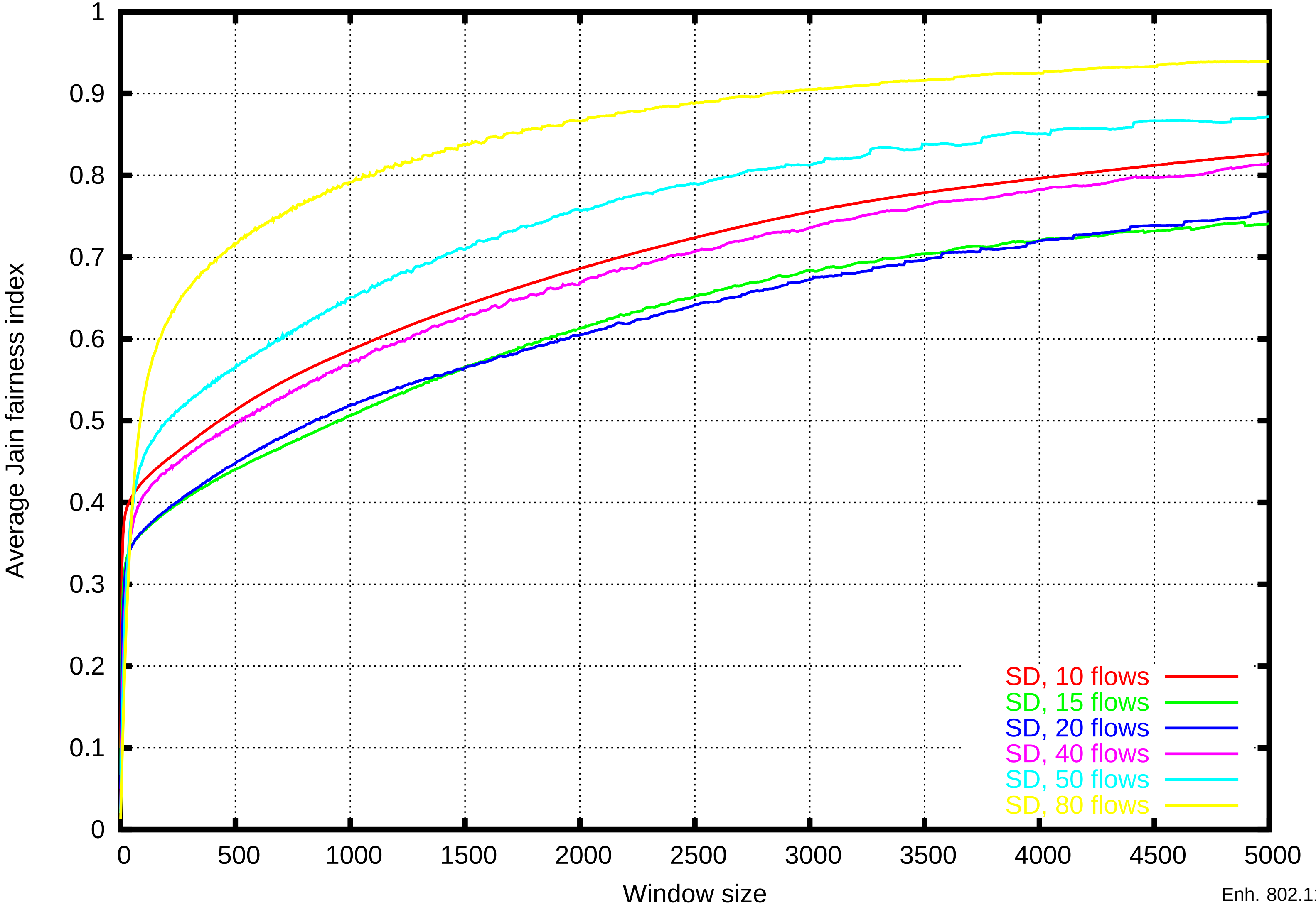
802.11 Fairness, varying CW_{min}



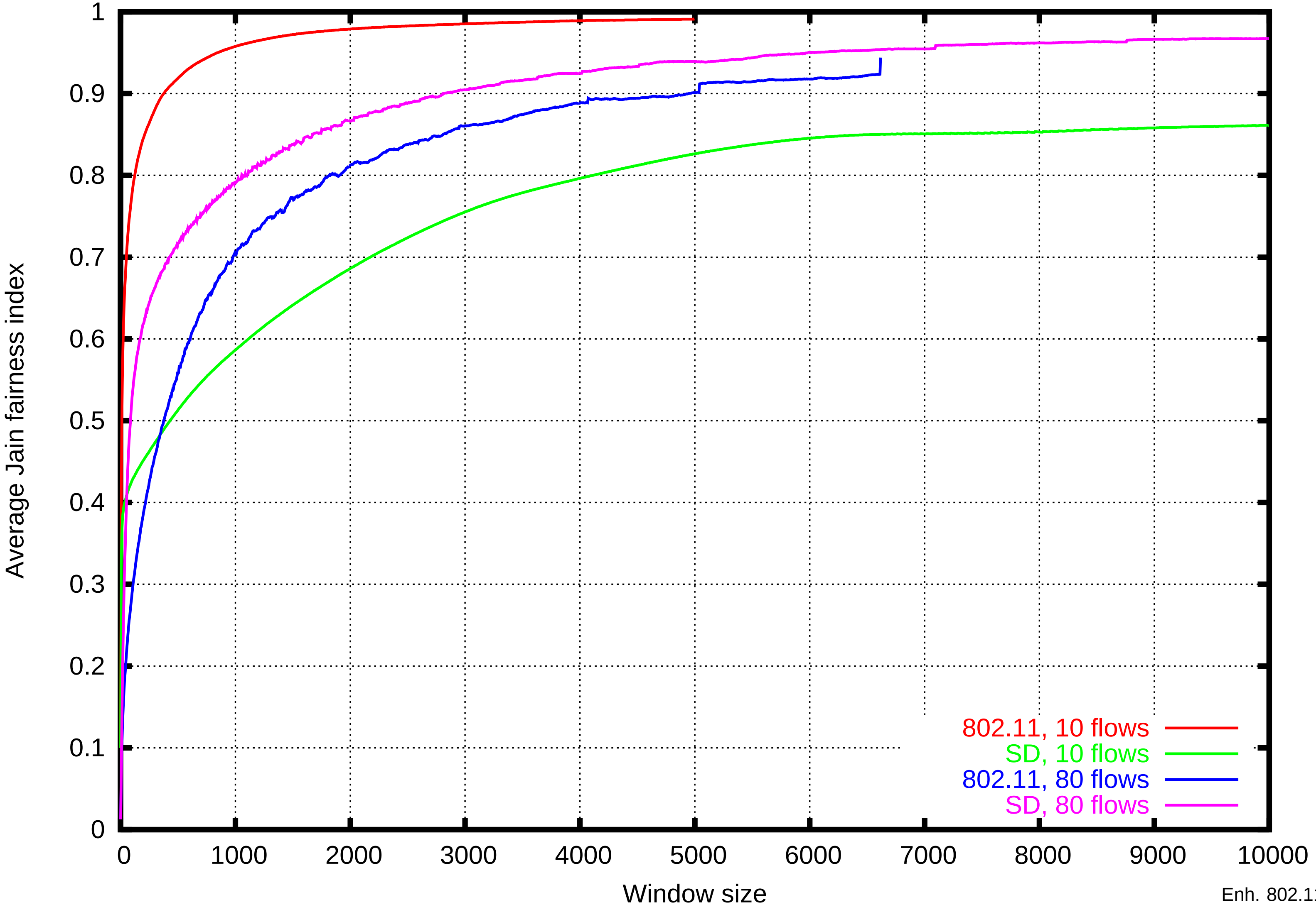
802.11 Fairness, varying n



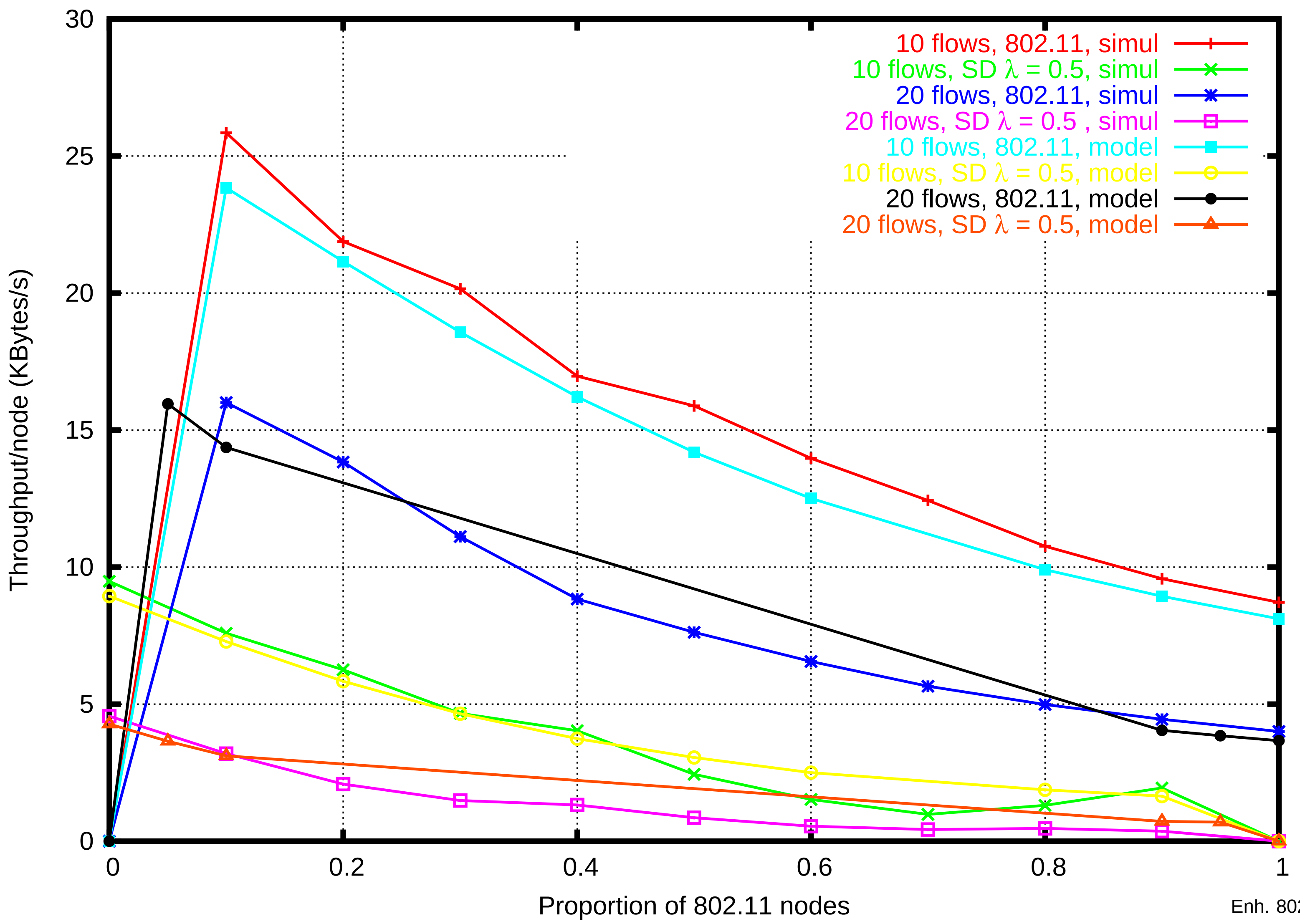
SD Fairness, varying n



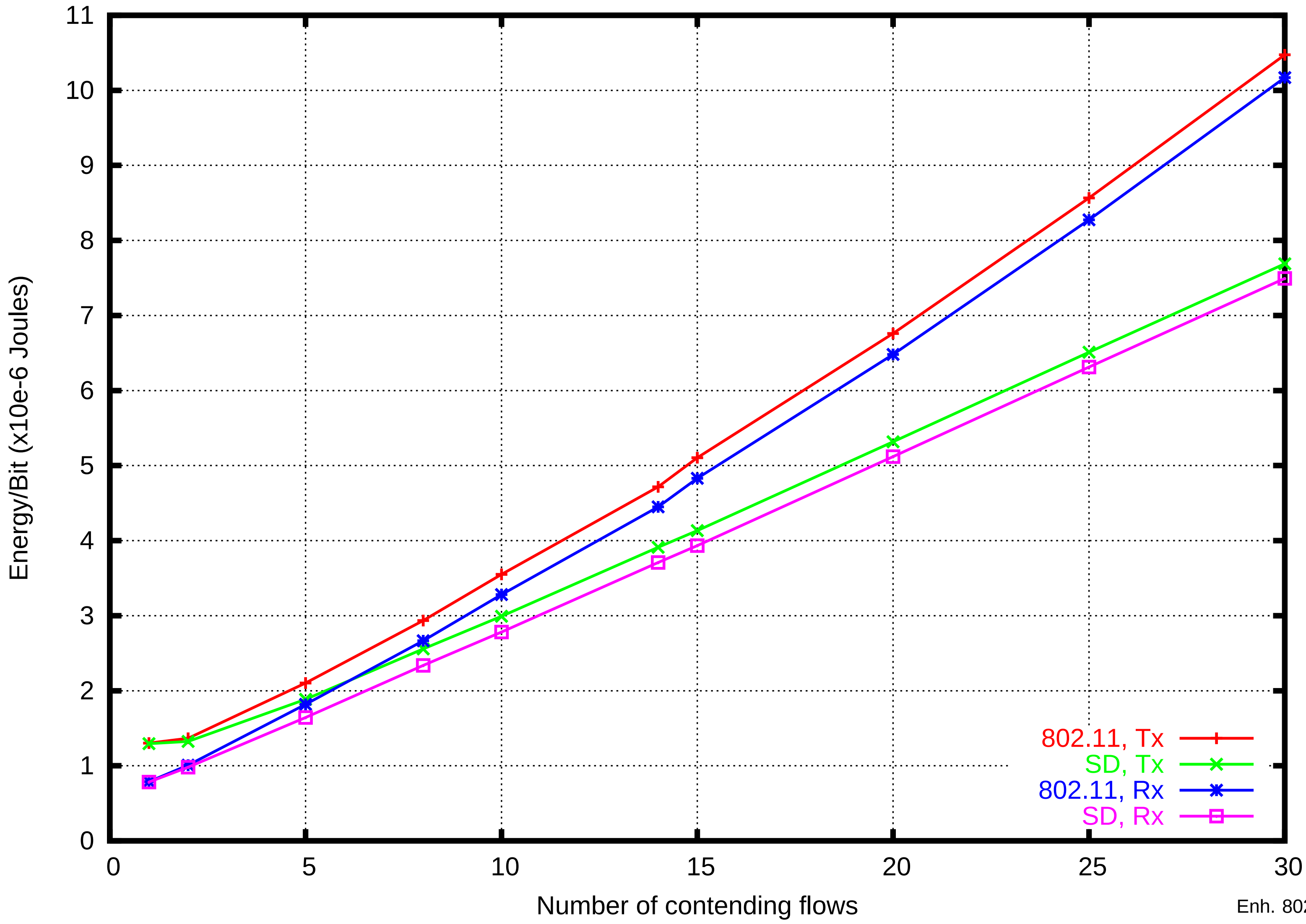
Fairness comparison



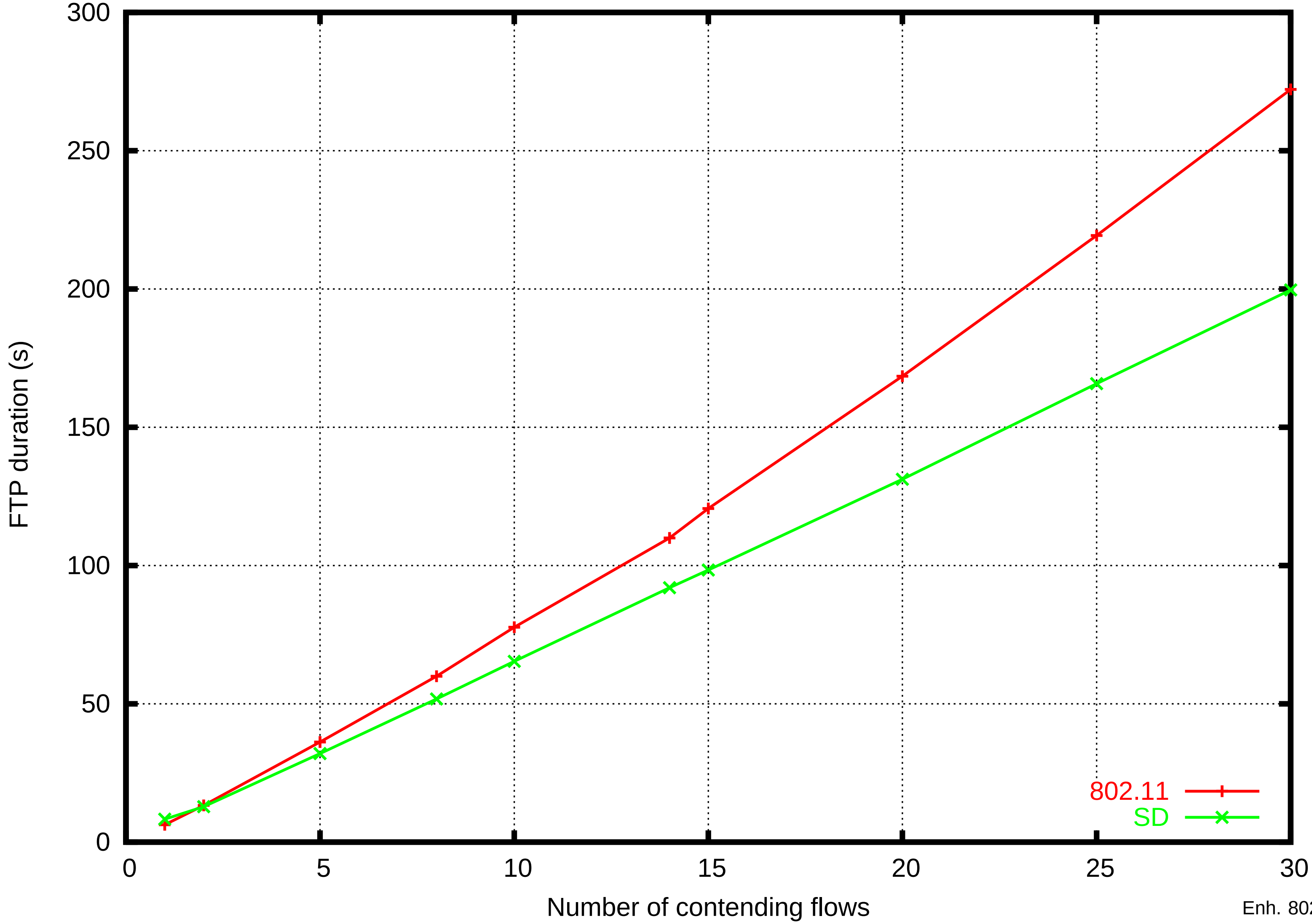
Coexisting SD and 802.11



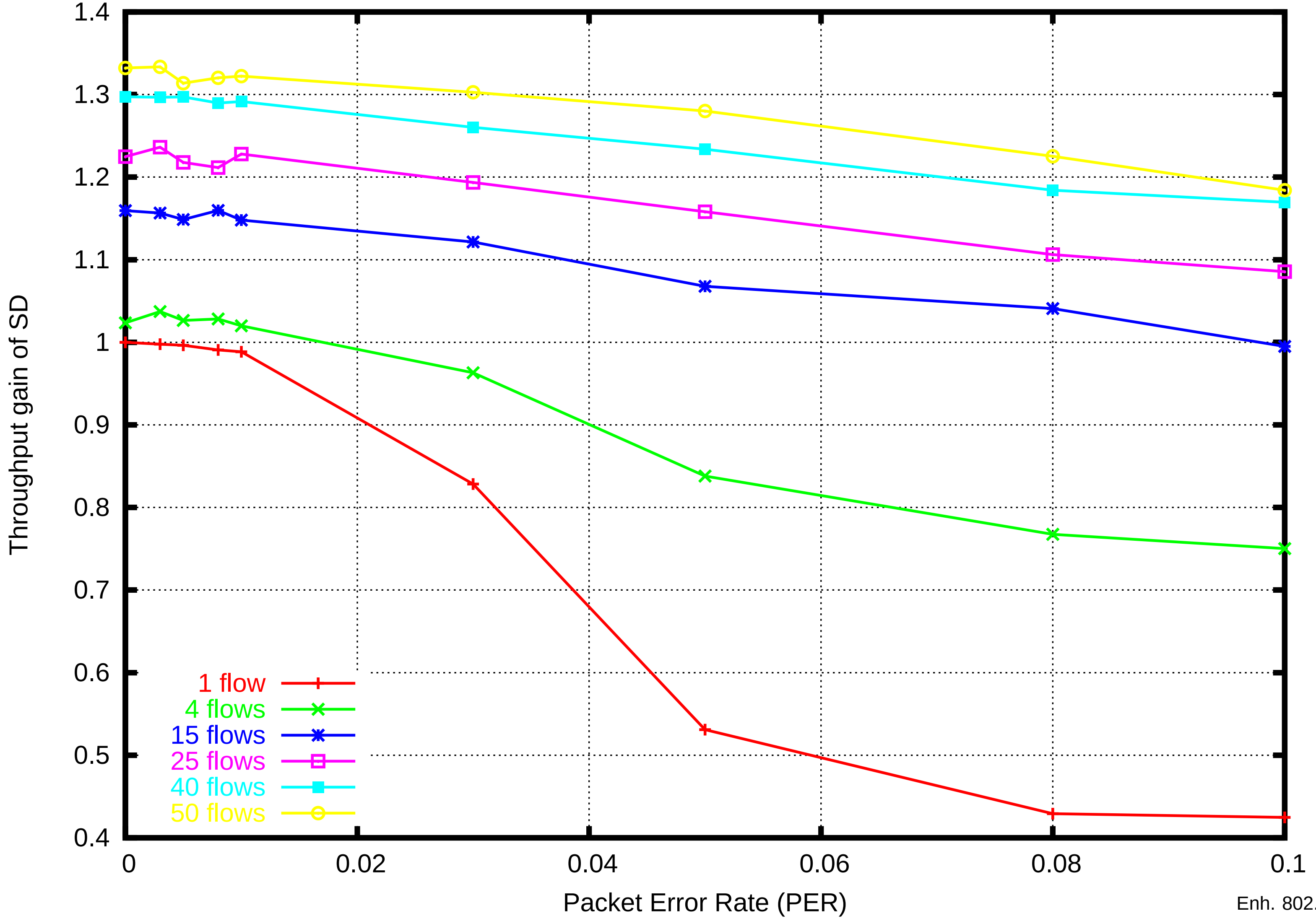
Energy consumption



On the application layer, FTP



Noisy channel



Conclusion

- Deep analysis of simple Slow Decrease (SD) functions
- SD outperforms 802.11 in:
  - throughput
  - delay
  - fairness (if congested)
  - battery consumption
  - etc.
- 802.11 outperforms SD if channel is severely noisy

The End

Thank you! ... questions ?

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