HUMBOLDT-UNIVERSITÄT ZU BERLIN

Superpositioncoding for Wireless Mesh Networks

diploma thesis
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agenda

- goal
- protocol design
- (first) simulation results
- TODOs

Goal

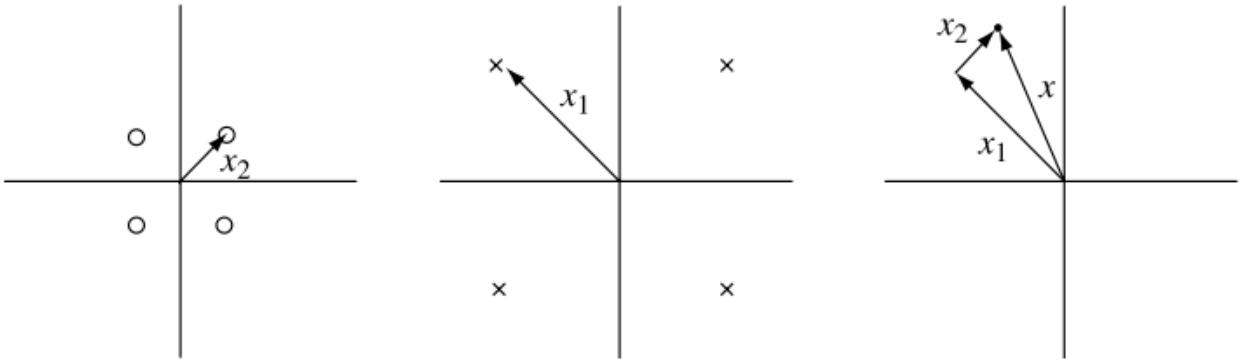
- Superposition-Coding is a promising technology providing coding gain in cellular networks.

- Opportunistic Protocols are proven to provide performance gain in wireless mesh networks by multi-user diversity.

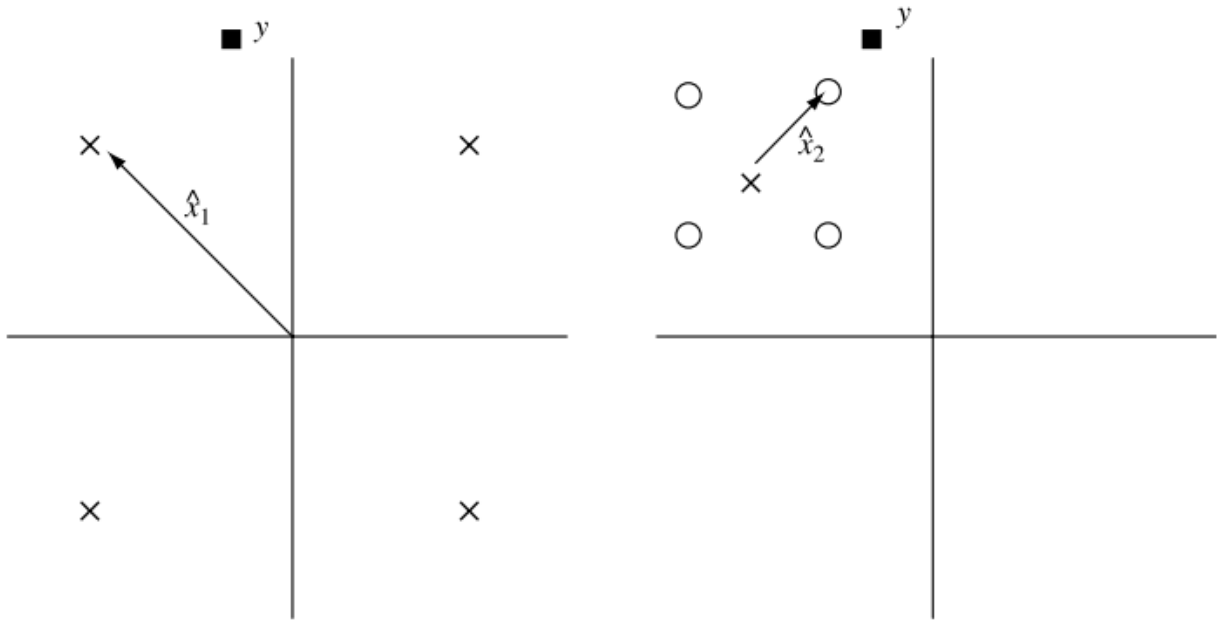
- **Q.: Is it possible to combine both technologies to get both a coding and an opportunistic gain?**

what is SC

Superposition encoding example. The QPSK constellation of user 2 is superimposed on that of user 1.



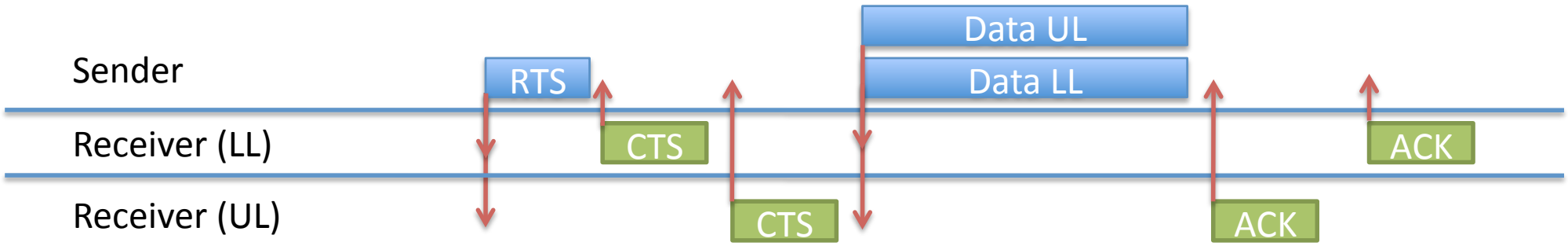
Superposition decoding example. The transmitted constellation point of user 1 is decoded first, followed by decoding of the constellation point of user 2 (SIC).



challenges in protocol design

- Robust MAC Layer (RTS/CTS; ACK)
- Efficient SP-Coding
  - selecting possible/optimal node-pairs
  - order of nodes (assignment upper/lower layer)
  - fairness
- radio modifications (spc)

medium access



medium access

- ACK
  - slotted ACK

  - SPC ACK

medium access

- RTS
  - slotted

  - SPC RTS

medium access

- power split (CTS/ACK):
  - LL may only decoded by sender
  - UL signal range reduced
  - BER/PER worse
  - sender’s behavior if CTS lost

efficient SP-coding

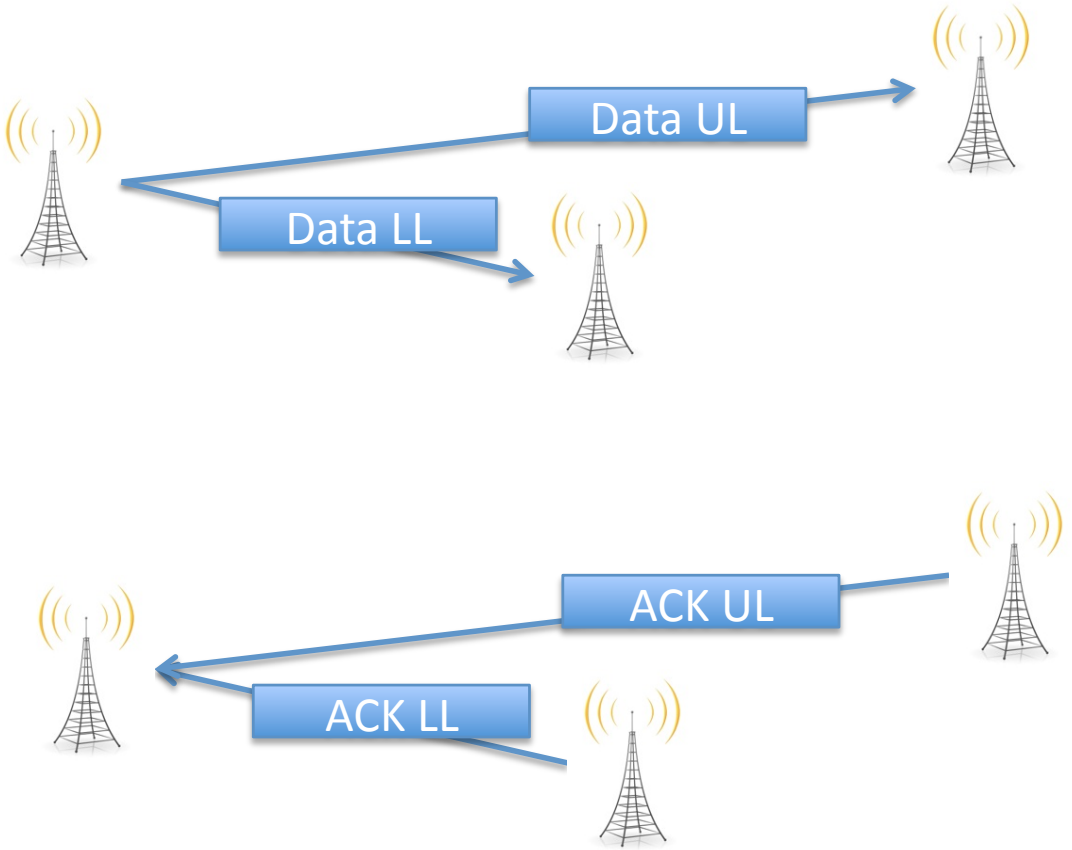
- mac holds a queue for every destination
- all non-empty queues considered
- RR scheduler

node selection

$best\_n_{UL} \leftarrow 0, best\_n_{LL} \leftarrow 0, best\_p \leftarrow 0, optTput \leftarrow 0$
for $n_{UL}, n_{LL} \in nodes$ **do**
  for $p \in (0, 1)$ **do**
    $per_{UL} = per(sig(1-p)@PL(n_{UL}), sig(p)@PL(n_{UL}) + noise)$
    $per_{LL1} = per(sig(1-p)@PL(n_{LL}), sig(p)@PL(n_{LL}) + noise)$
    $per_{LL2} = per(sig(p)@PL(n_{LL}).noise)$
    $per_{LL} = 1 - (1 - per_{LL1}) \cdot (1 - per_{LL2})$
    $vTput = tput(per_{UL}, perLL)$
    if $(vTput > optTput)$
      $best\_n_{UL} \leftarrow n_{UL}, best\_n_{LL} \leftarrow n_{LL}, best\_p \leftarrow p, optTput \leftarrow vTput$
    endif
  endfor
endfor
return $(best\_n_{UL}, best\_n_{LL}, best\_p)$

radio

- handle Uplink & Downlink spc transmission

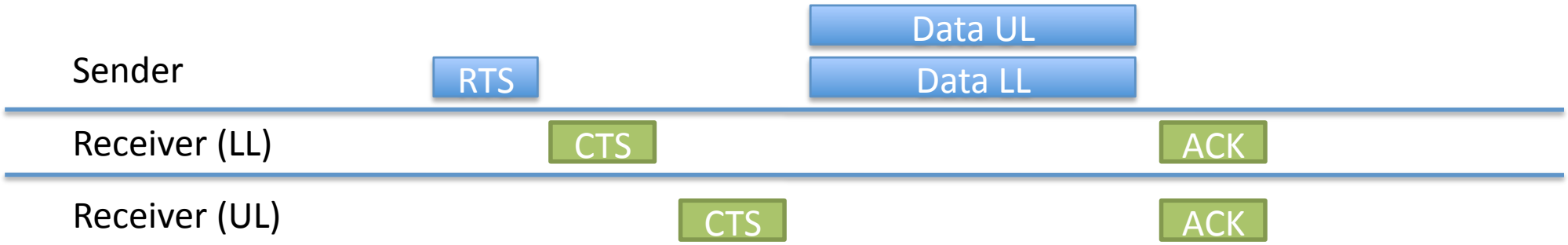


UL and DL powersplit

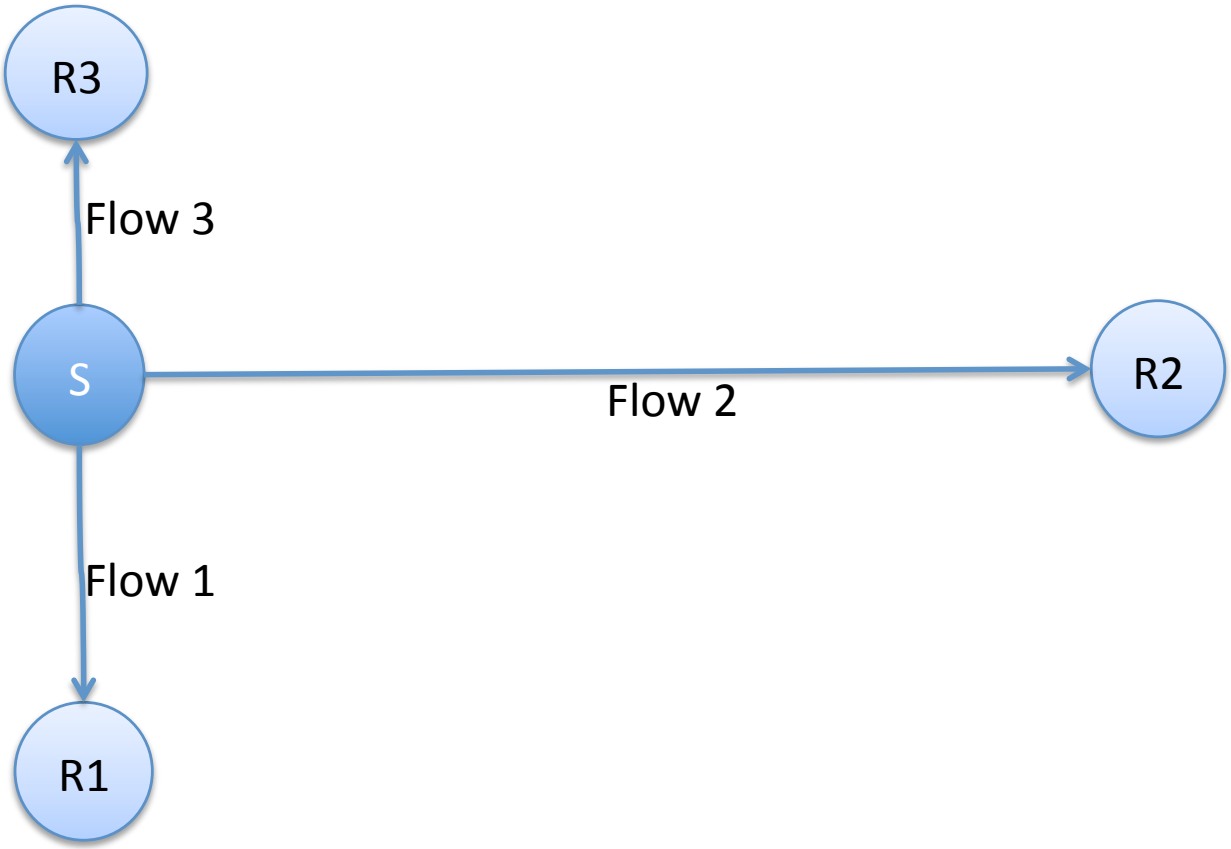
- DL: $$SINR = \frac{p|h_1|^2}{(P-p)|h_1|^2 + N_0}$$
- UL: $$SINR = \frac{p|h_1|^2}{(P-p)|h_2|^2 + N_0}$$

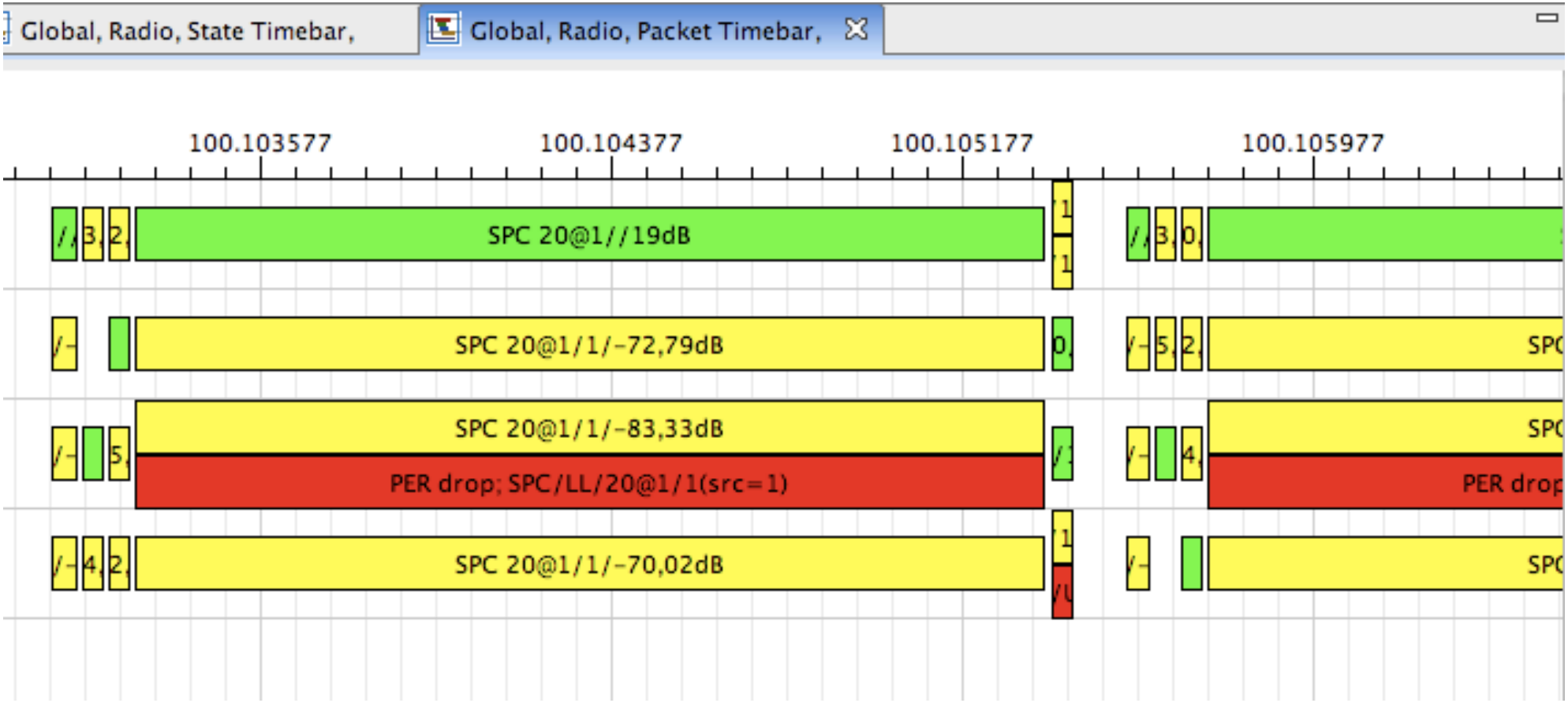
simulations

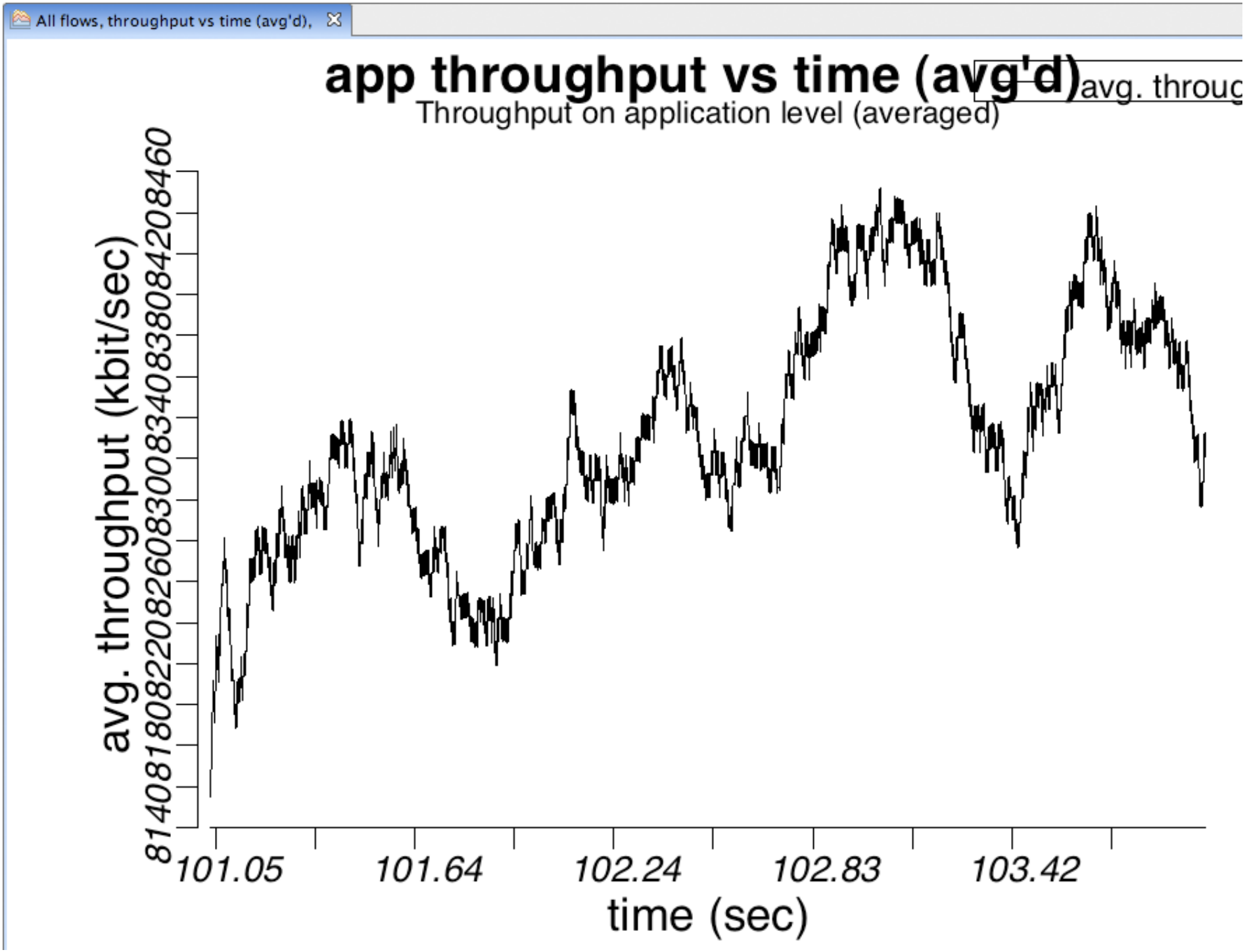
current implementation state



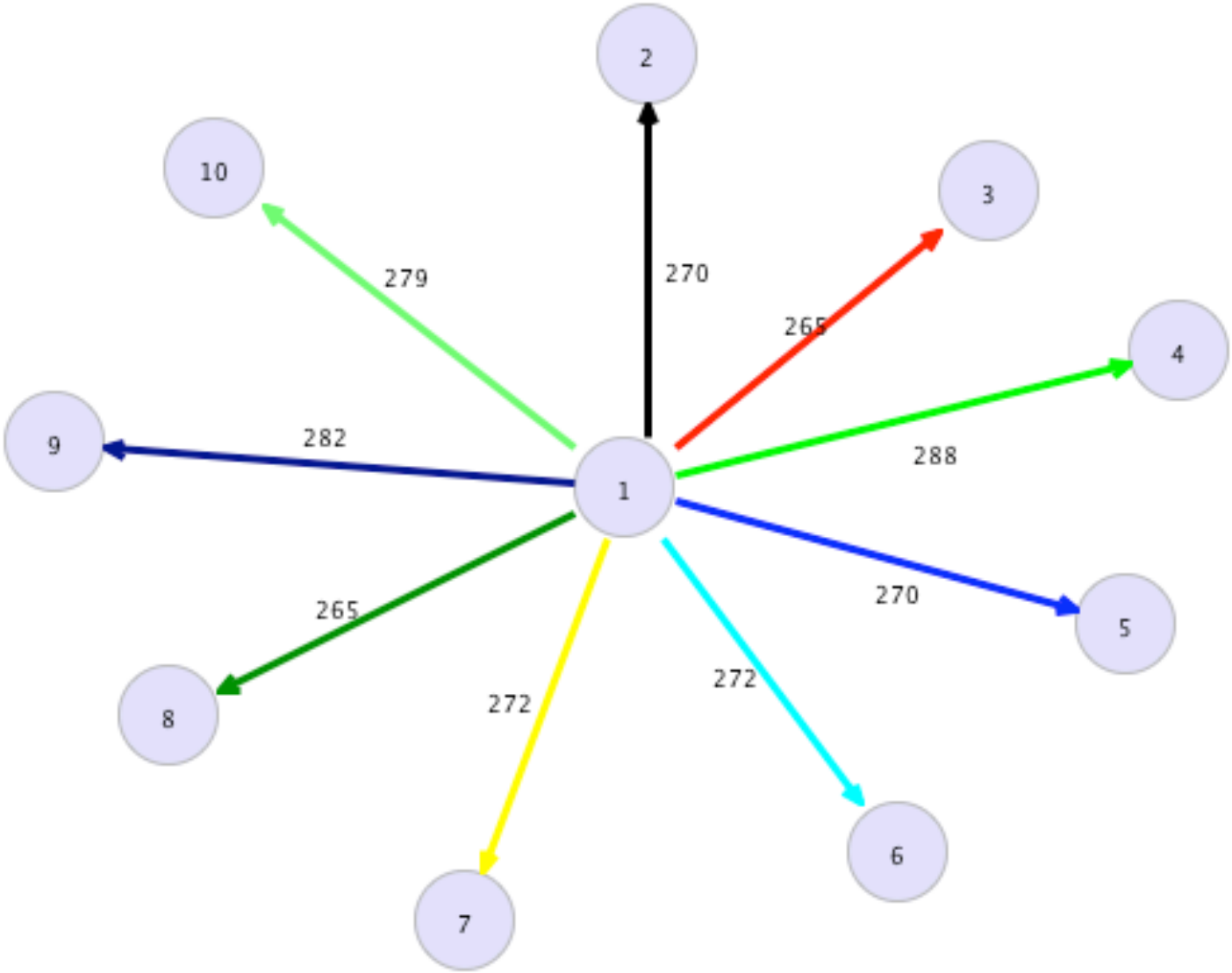
setup, 4 nodes, 6 MBit radio

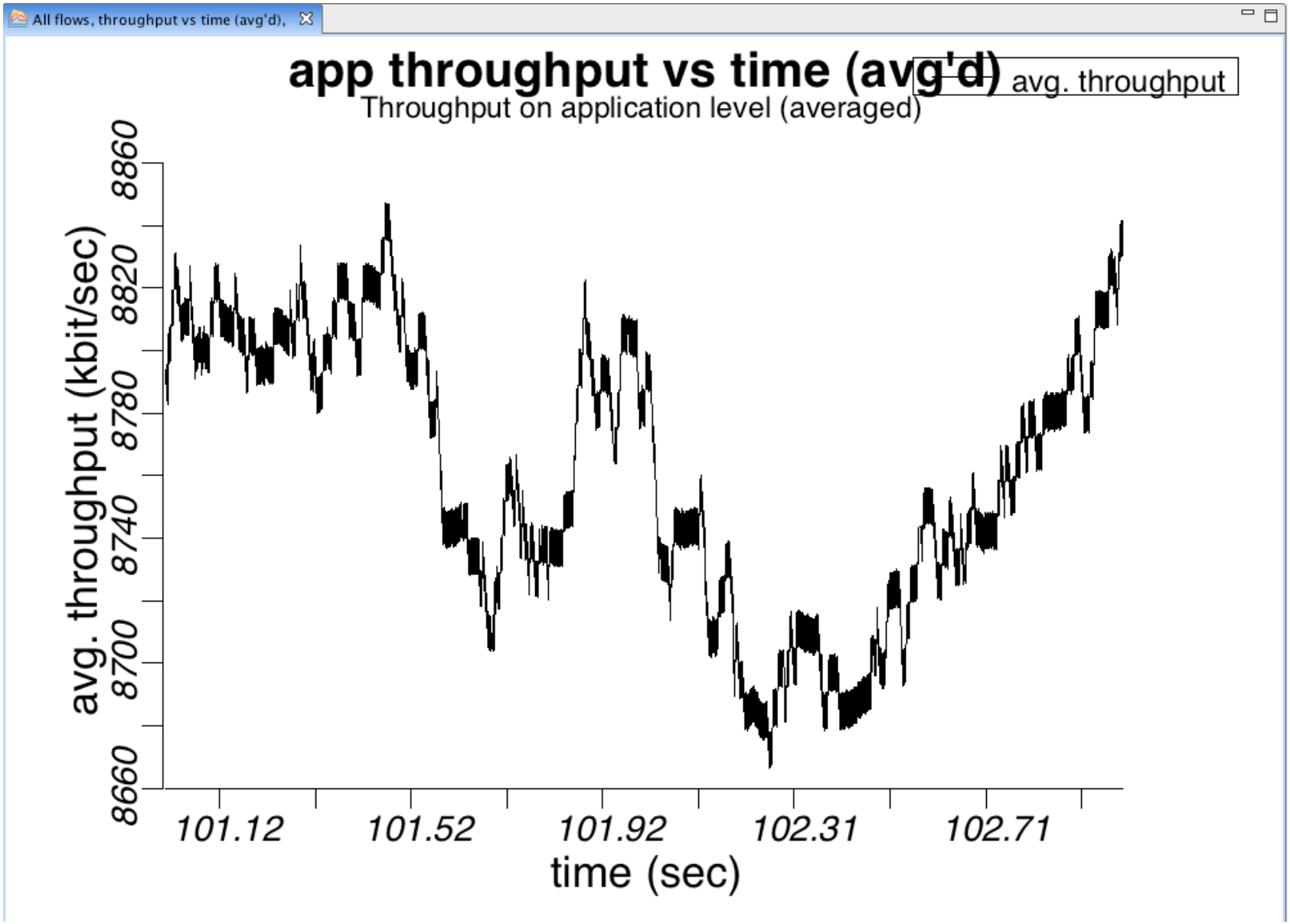



Global, Radio, State Timebar,
Global, Radio, Packet Timebar,
100.103577
100.104377
100.105177
100.105977
SPC 20@1//19dB
SPC 20@1/1/-72,79dB
SPC 20@1/1/-83,33dB
PER drop; SPC/LL/20@1/1(src=1)
SPC 20@1/1/-70,02dB


All flows, throughput vs time (avg'd),
app throughput vs time (avg'd)
avg. throuc
Throughput on application level (averaged)
avg. throughput (kbit/sec)
814081808220826083008340838084208460
101.05
101.64
102.24
102.83
103.42
time (sec)

fairness, 10 nodes, 6 MBit radio




All flows, throughput vs time (avg'd),
app throughput vs time (avg'd)
Throughput on application level (averaged)
avg. throughput
avg. throughput (kbit/sec)
8660
8700
8740
8780
8820
8860
101.12
101.52
101.92
102.31
102.71
time (sec)

“stats”

- failed 13
- LL failed 52
- UL failed 1425
- double success 18328
- success 50711

- approx. 1 MBit per Flow

TODOs

- implement (spc) CTS, (slotted) ACK
- optimize power control algorithm
- how to handle broadcasts
- multi-hop scenario
- opportunistic component?
- simulations
- write everything down

the end

- questions?