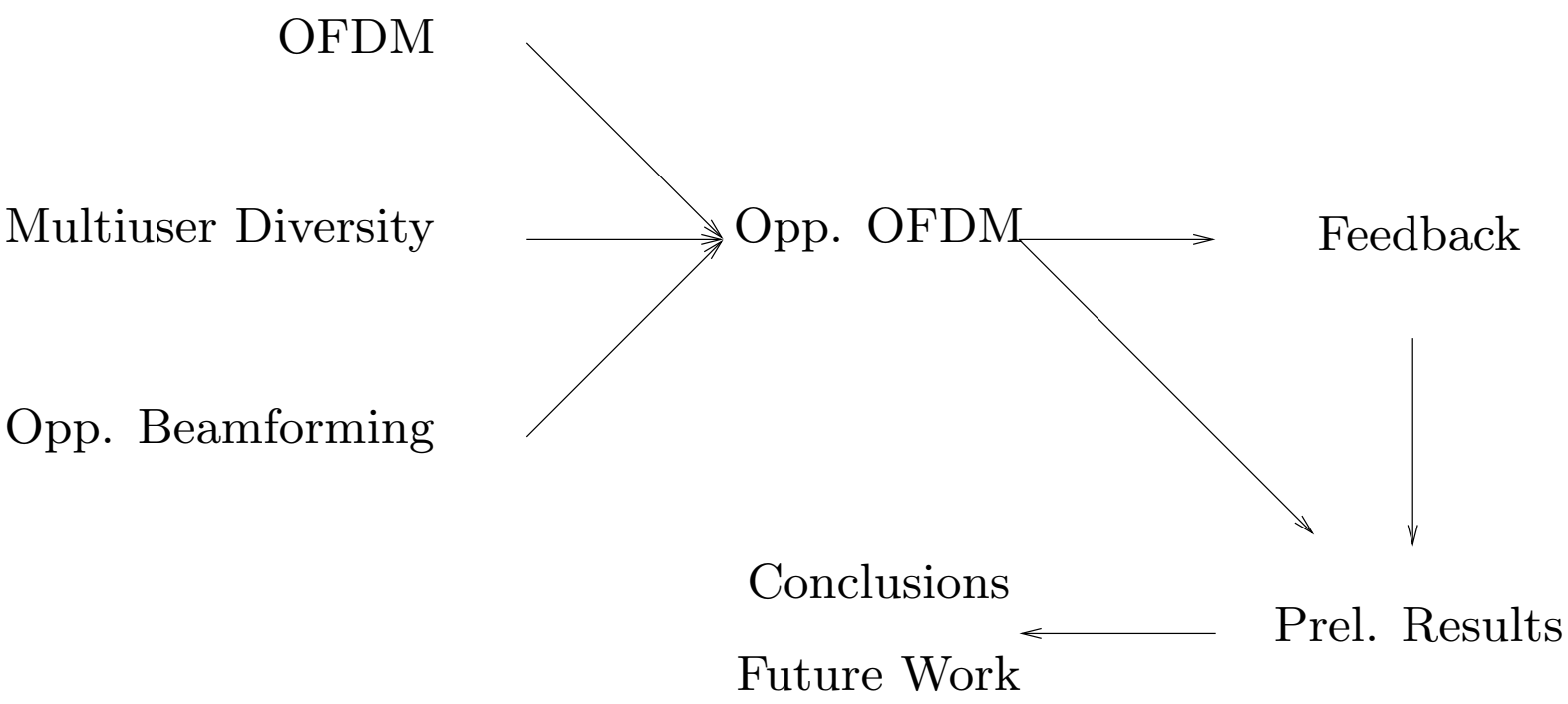
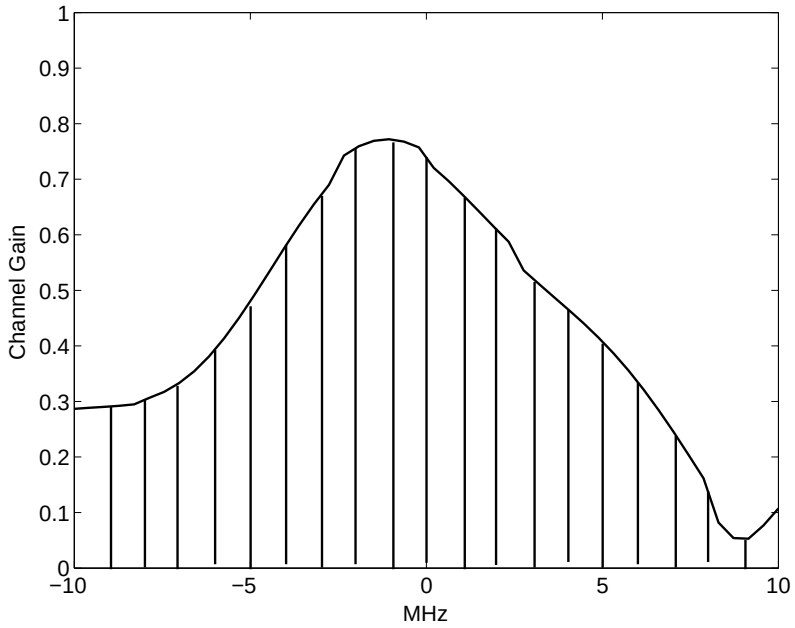
Opportunistic Beamforming with Dumb Antennas for Clustered OFDM

Outline


OFDM
Multiuser Diversity
Opp. Beamforming
Opp. OFDM
Feedback
Prel. Results
Conclusions
Future Work

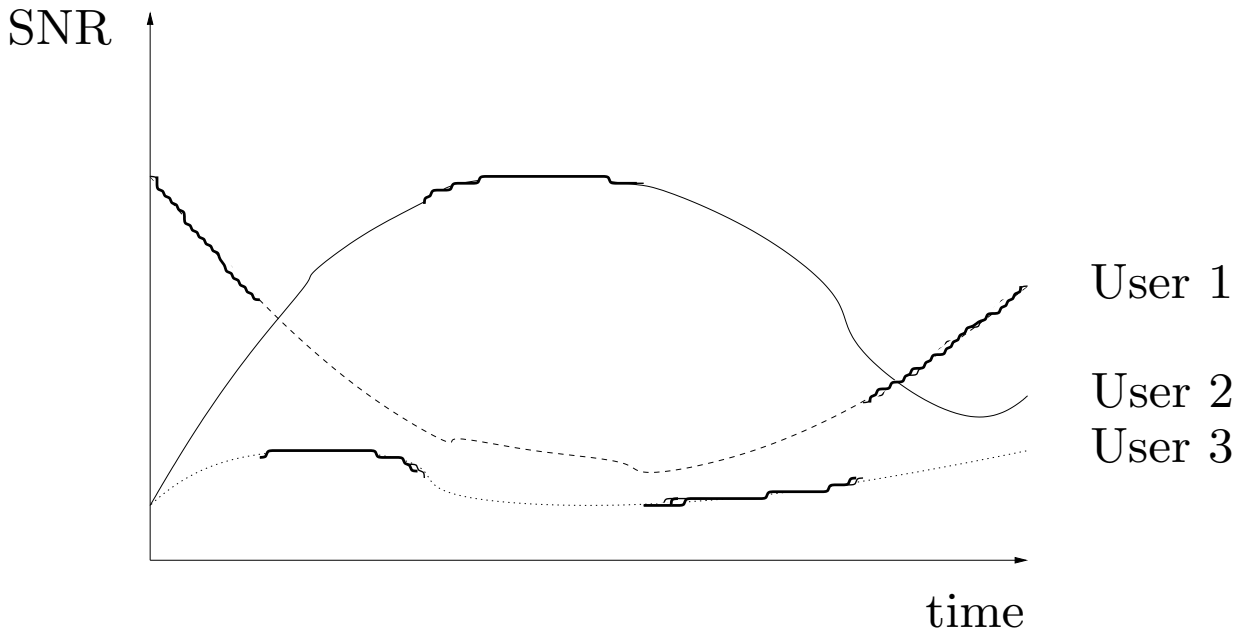
Orthogonal Frequency Division Multiplexing

- Instead of equalizing the fading channel, divide the channel into sub-channels, which can be considered as flat.



Multiuser Diversity

- Uncorrelated (time-varying) channels of different users $\Rightarrow$ the users can be scheduled in a favourable way.
- Schedule a user when his channel is "relatively strong".



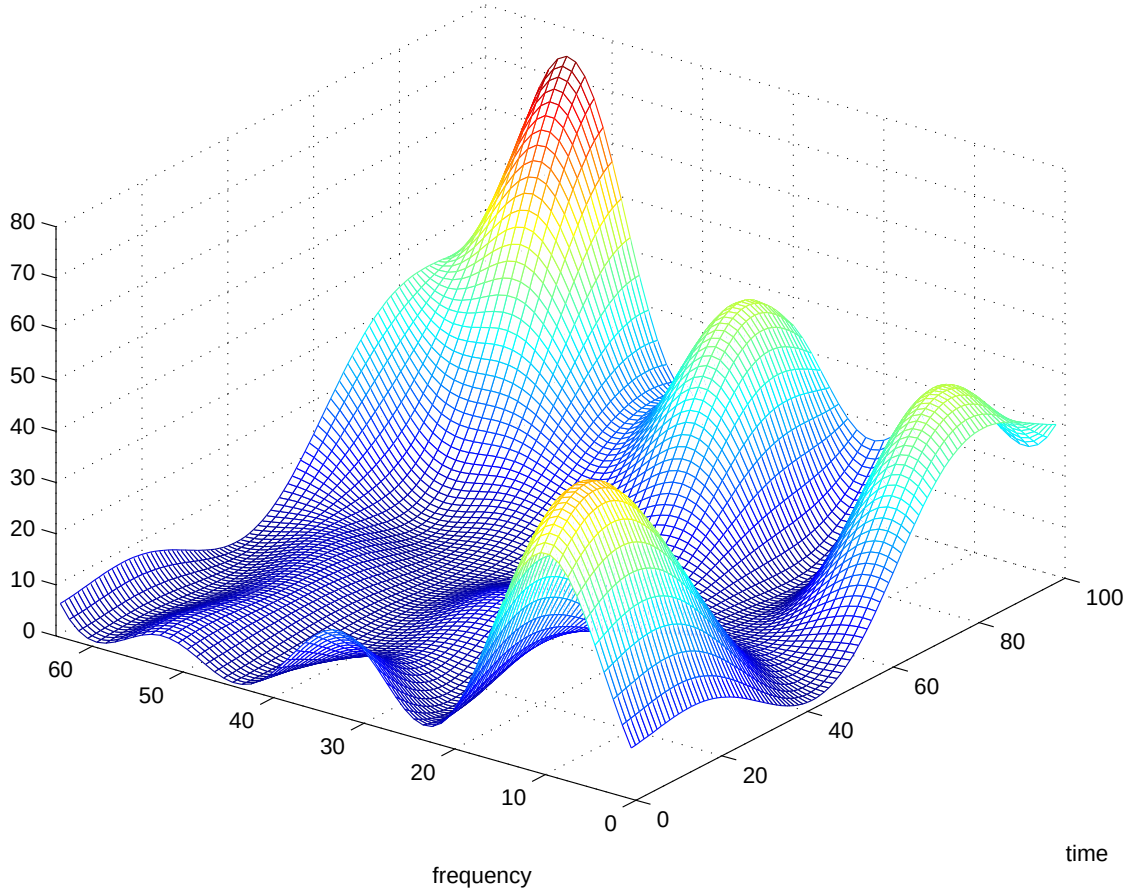
Opportunistic Beamforming

- Traditionally, multiple antennas have often been used to combat fading (e.g. space-time block coding).
- Opportunistic beamforming using dumb antennas: randomly form the beams for each data block to *increase* the fading of the users! $\Rightarrow$ Also stationary users will experience temporal fading!
- C.f. Viswanath, Tse and Laroia "Opportunistic Beamforming Using Dumb Antennas" IEEE Trans. Inform. Theory, vol 48, pp. 1277-1294, June 2002.

Opportunism for an OFDM downlink

- In an OFDM downlink, different users can be scheduled on different subcarriers.
- This introduces another dimension on which the users can be scheduled!
- What if the users experience relatively flat channels? More frequency fading can be induced by having different beamforming weights on different subcarriers.

Time-frequency grid of one user



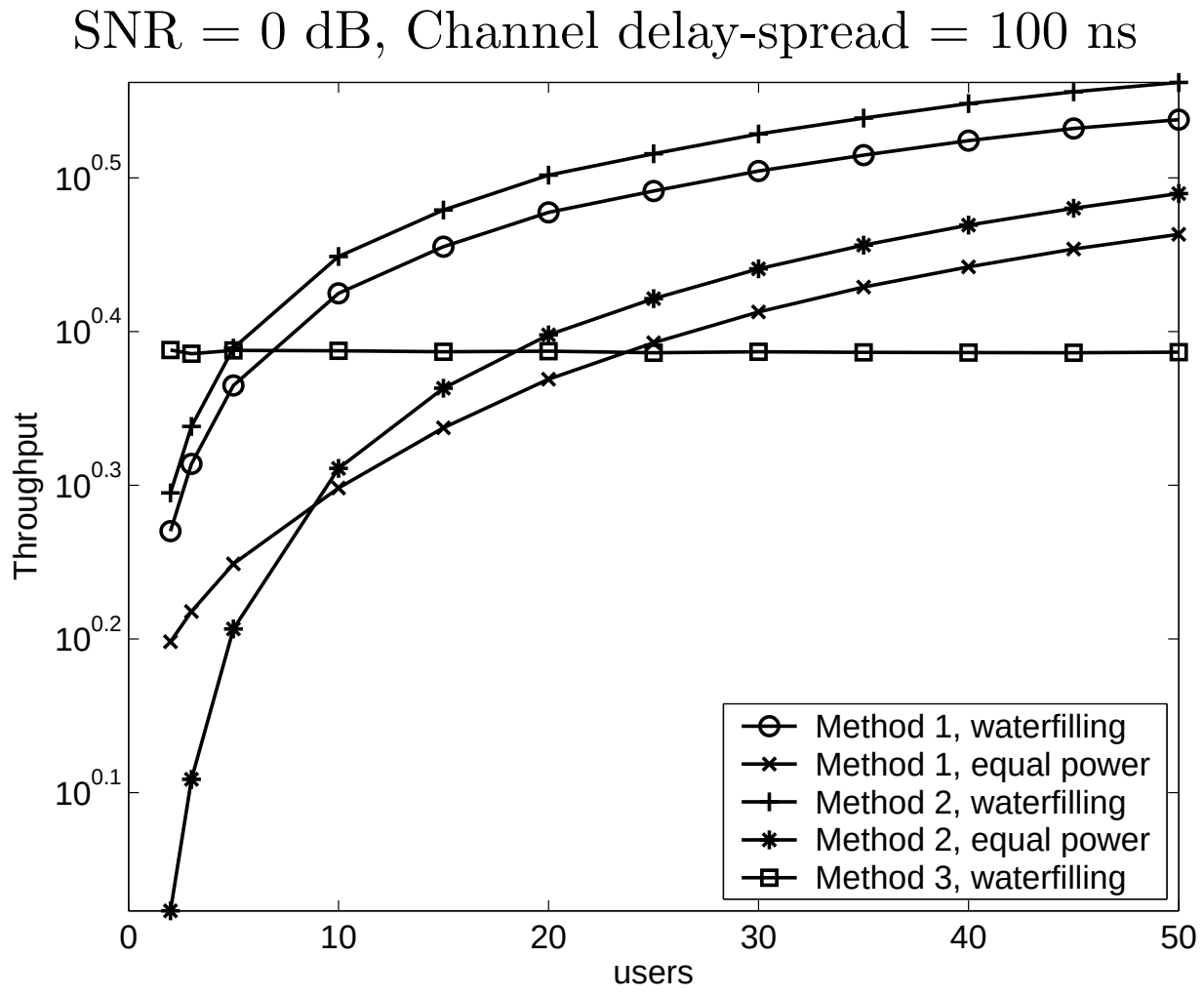
What about feedback?

- The scheduler requires knowledge of the frequency responses of all users ⇒ much feedback
- Improvement 1: Clustered OFDM
  - Divide the subcarriers into clusters (of adjacent subcarriers). If the cluster-size is appropriate, the correlation between the sub-carriers in one cluster is high.
- Improvement 2: Feed back information only about the strongest clusters. The weakest will not be scheduled anyway! ⇒ much less feedback.

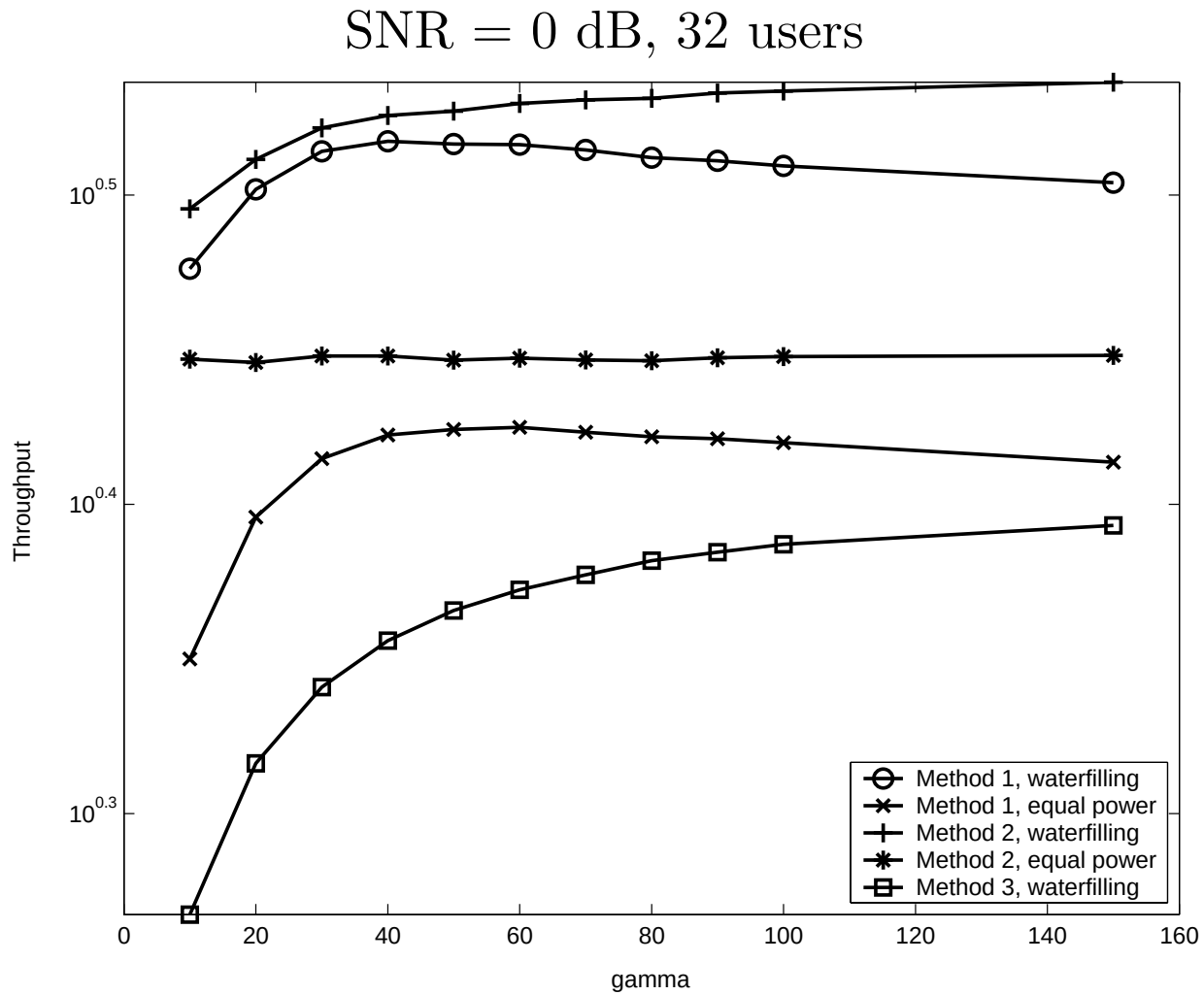
Preliminary Simulation Results

- Comparison between
  1. Opportunistic OFDM with clustering and reduced feedback
  2. Opportunistic OFDM with full feedback
  3. A smart antenna solution (beamforming on the largest eigenvalue), with round-robin scheduling
- Simple scenario
  - HIPERLAN/2 channel model (64 sub-carriers)
  - Equally distributed users
  - Maximum system throughput considered
  - Fairness not considered yet

Throughput vs Number of Users:

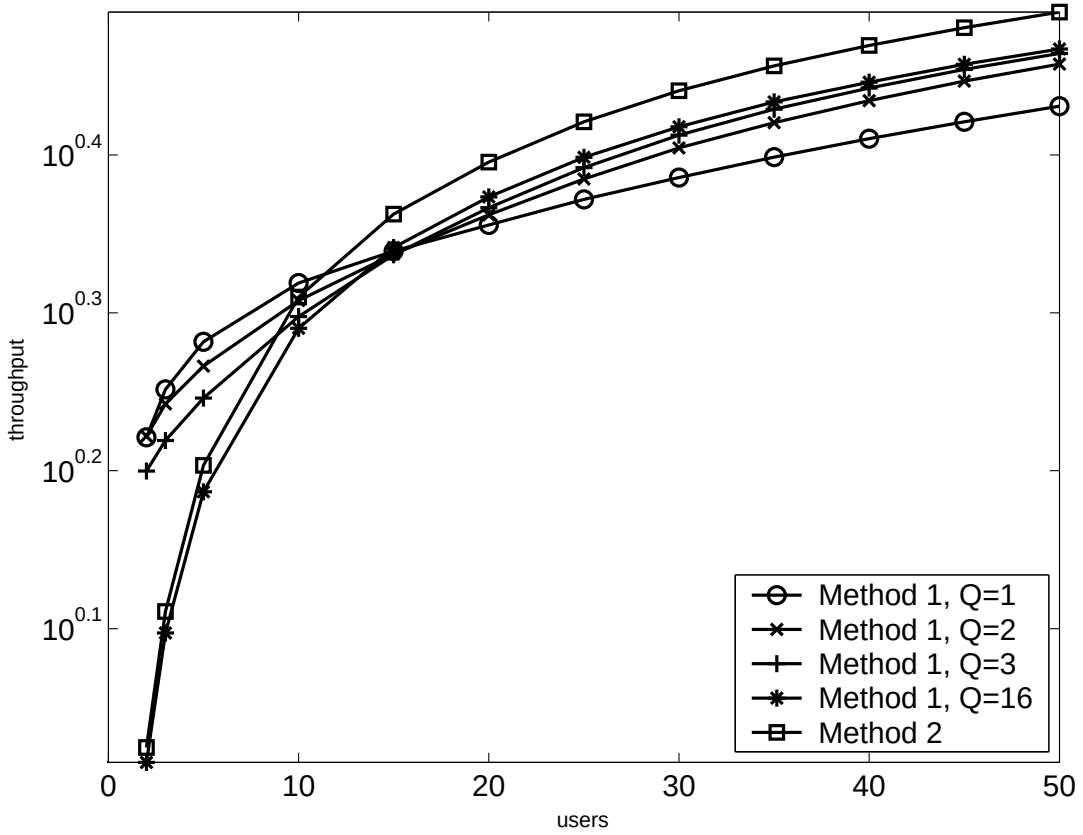


Throughput vs Channel Delay-spread:

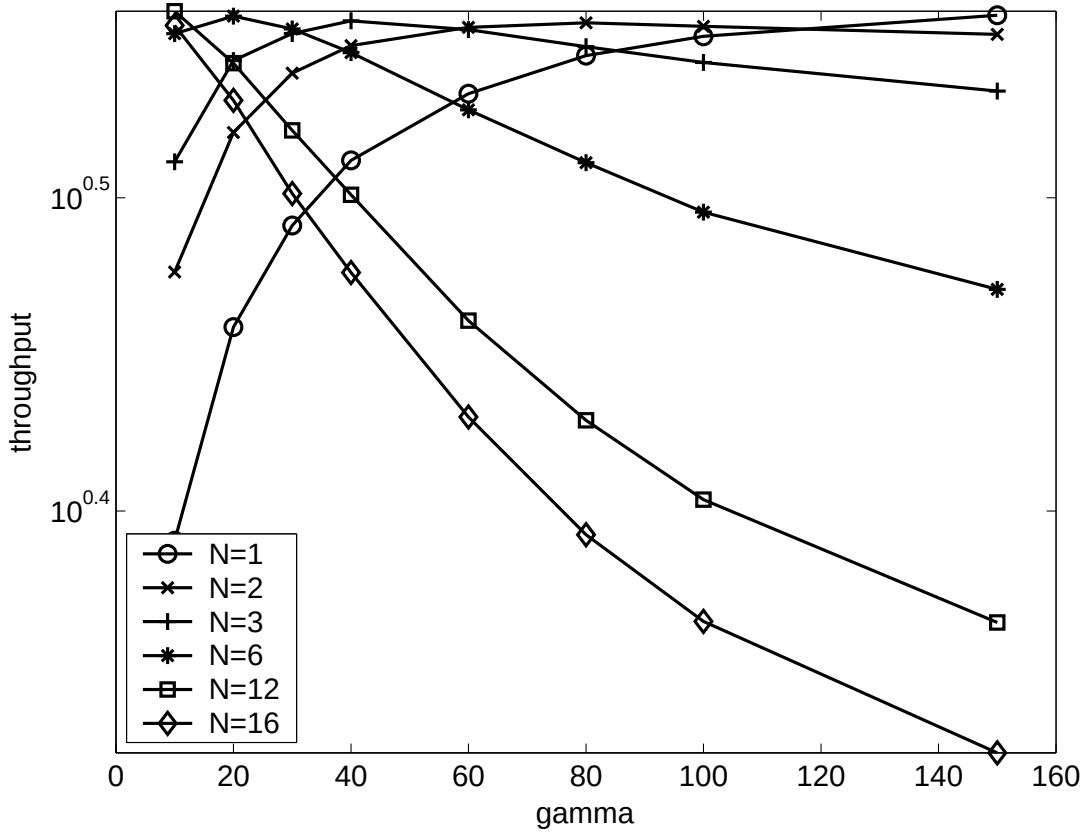


Throughput vs amount of feedback information Q:

SNR = 0 dB, Channel Delay-spread = 100 ns



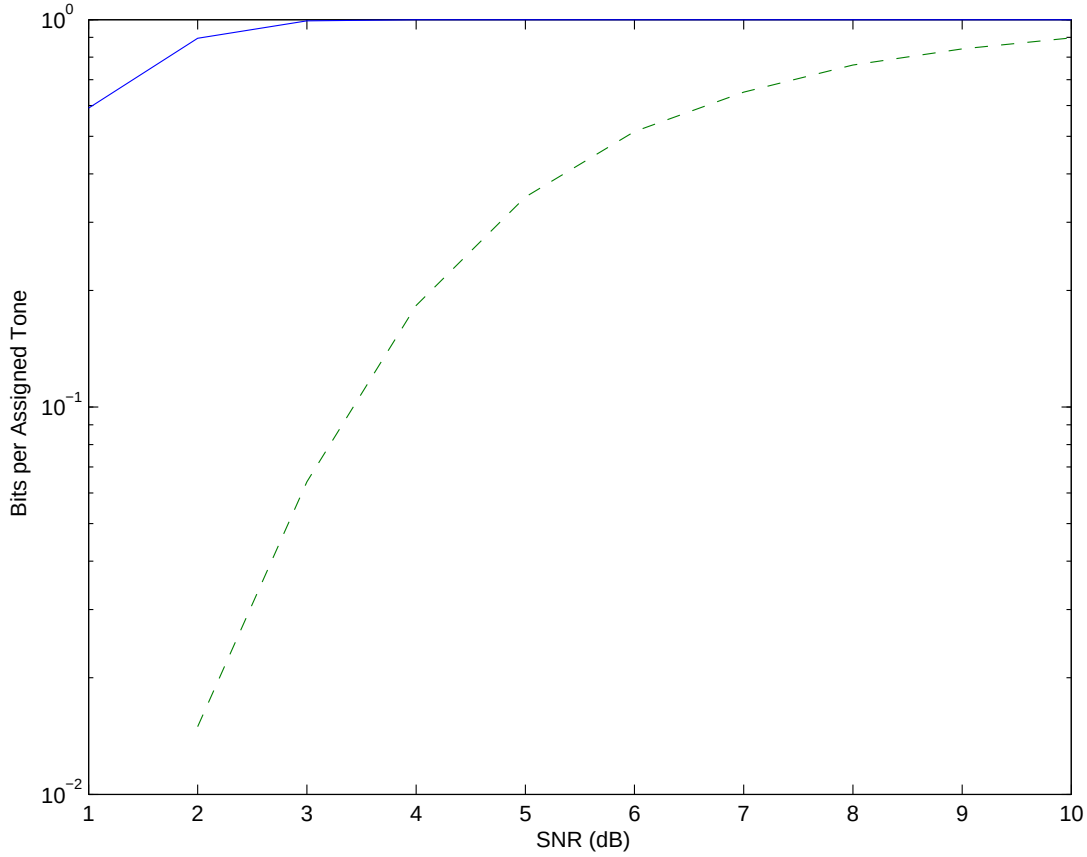
Throughput vs cluster-size N:



SNR = 0 dB, 32 users

One User, on-off waterfilling

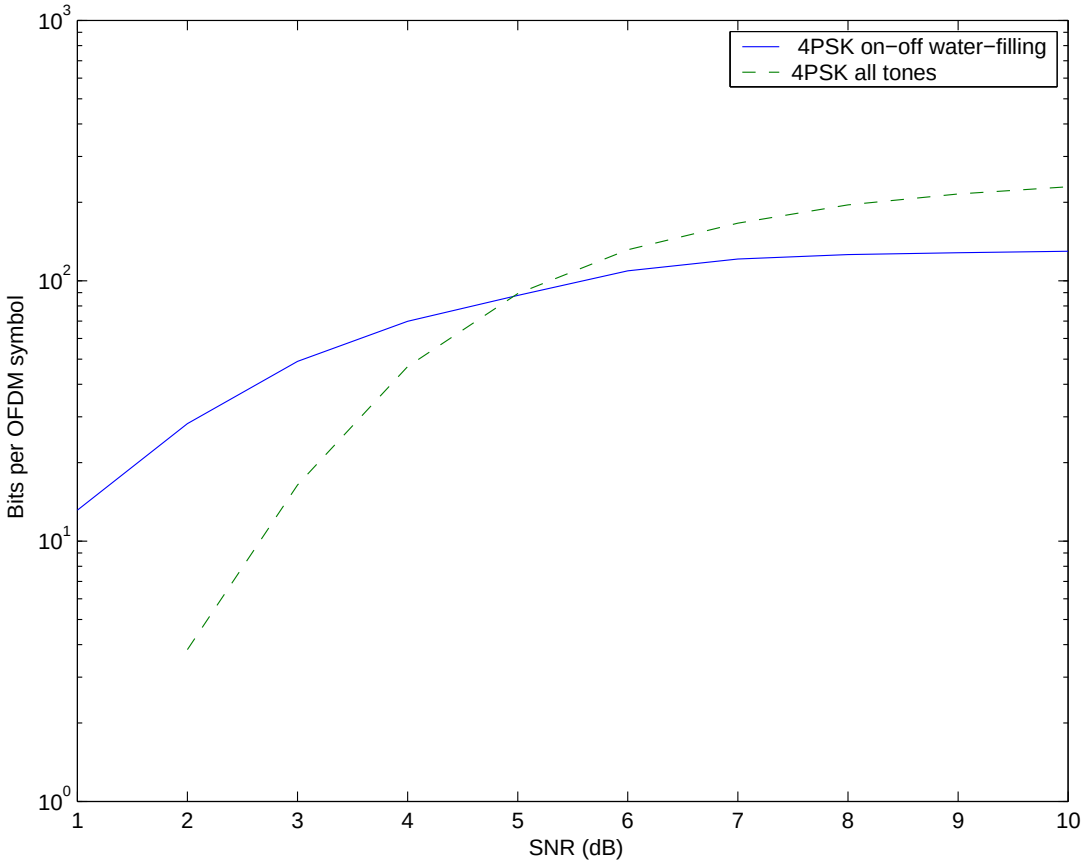
Relative Doppler 1%, OFDM symbol with 256 tones, 4PSK



modulation

One User, on-off waterfilling

Relative Doppler 1%, OFDM symbol with 256 tones, 4PSK



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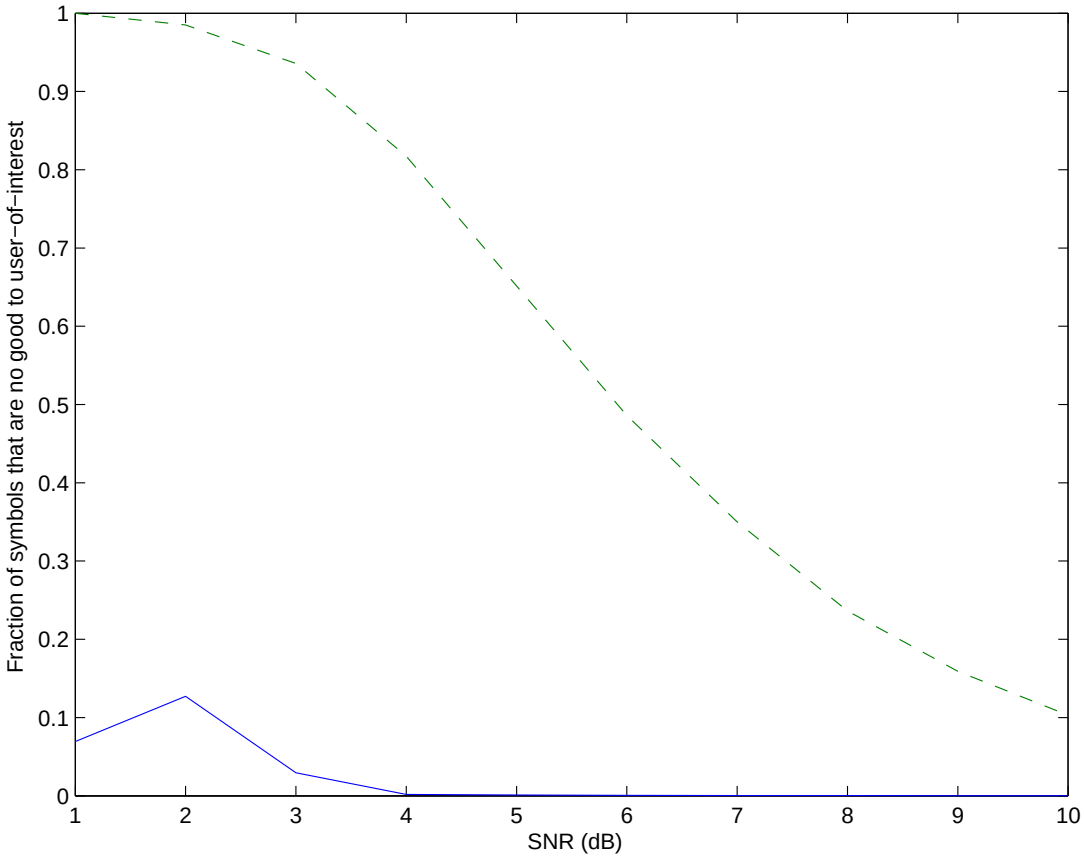

modulation

- Conclusions:
  - Opportunistic beamforming with clustered OFDM promises throughput on par with a smart antenna solution, with little feedback and possibly a lower complexity basestation.
- Future work:
  - Design of a *fair* scheduler
  - Analysis of the impact of channel estimation and feedback error/delay
  - More realistic simulations, especially regarding the channel models
  - and more