Hybrid Beamforming

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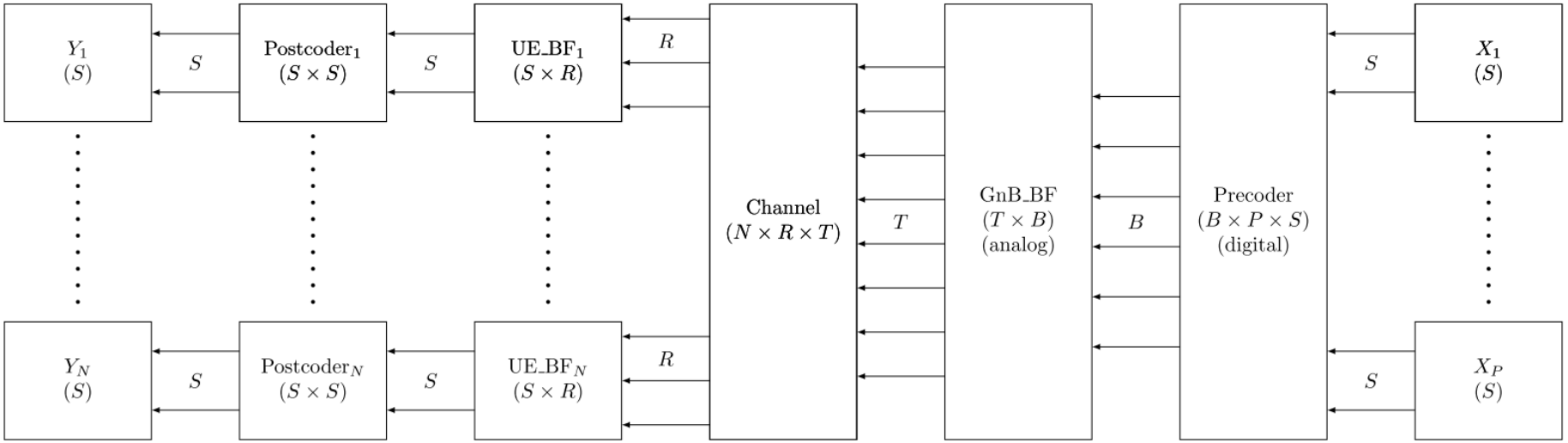
Overall project: Simulator

- B GnB beamformers, N users, P selected users at current time slot, R receiving antennas per user, S independent streams per user, T transmitting antennas.
- Long term performance: typically, proportional fairness.
- N.B.: The block diagram is displayed from right to left in order to match with tensor multiplication notation.



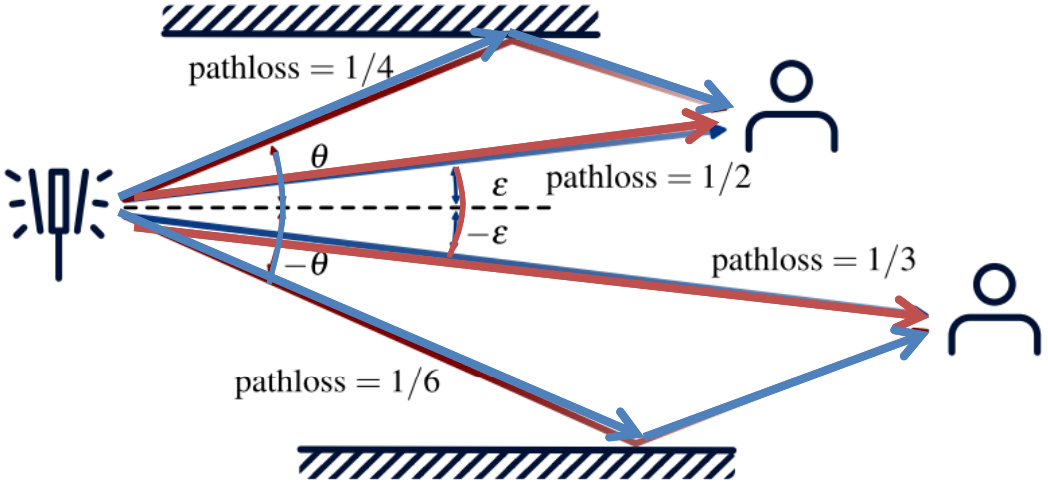
In Einstein notation (with $n \in \{1, \ldots, N\}$, etc):

$$Y_{ns} = \text{Postcoder}_{ns}{}^{s'} \cdot \text{UE\_BF}_{ns'}{}^{r} \cdot \text{Channel}_{nr}{}^{t} \cdot \text{GnB\_BF}_{t}{}^{b} \cdot \text{Precoder}_{b}{}^{ps''} \cdot X_{ps''}.$$

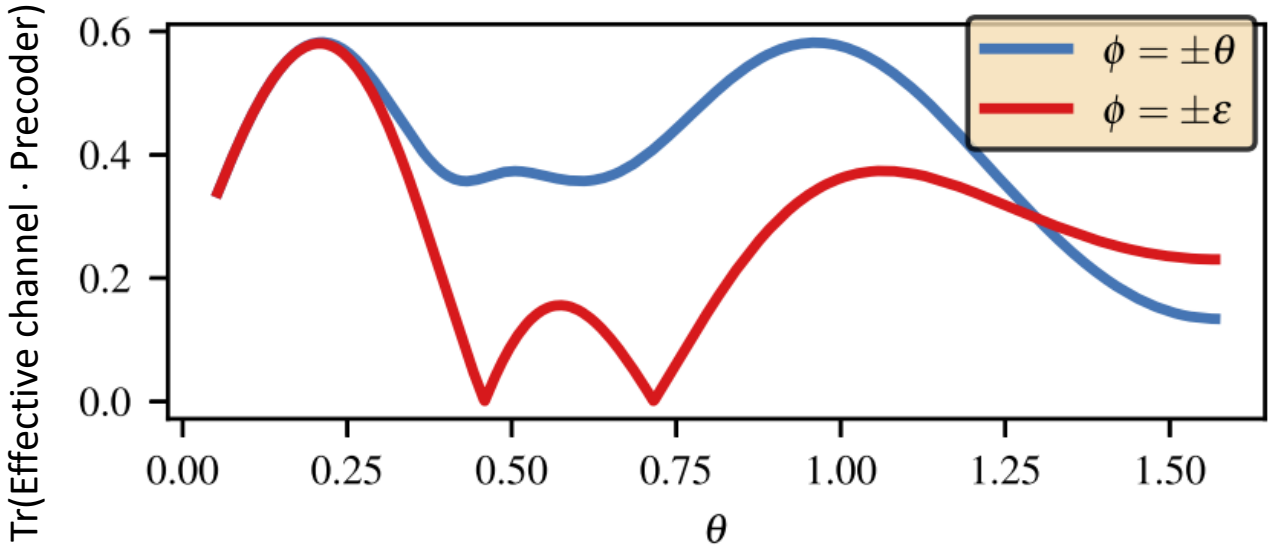
Rest of the talk:
An example of question

- Typically:
  1. We compute analog beams (every once in a while).
  2. We acquire the channel matrix (at each time slot).
  3. We compute user selection & precoder (at each time slot).
- What is the difference if we recompute the analog beams (and the precoding) once the users are selected?
- Of course this would be expensive, so we would prefer to avoid it… Reformulated question: Do we lose something by **not** recomputing the beams after user selection?

Example: Potential benefits of beam recomputation after user selection



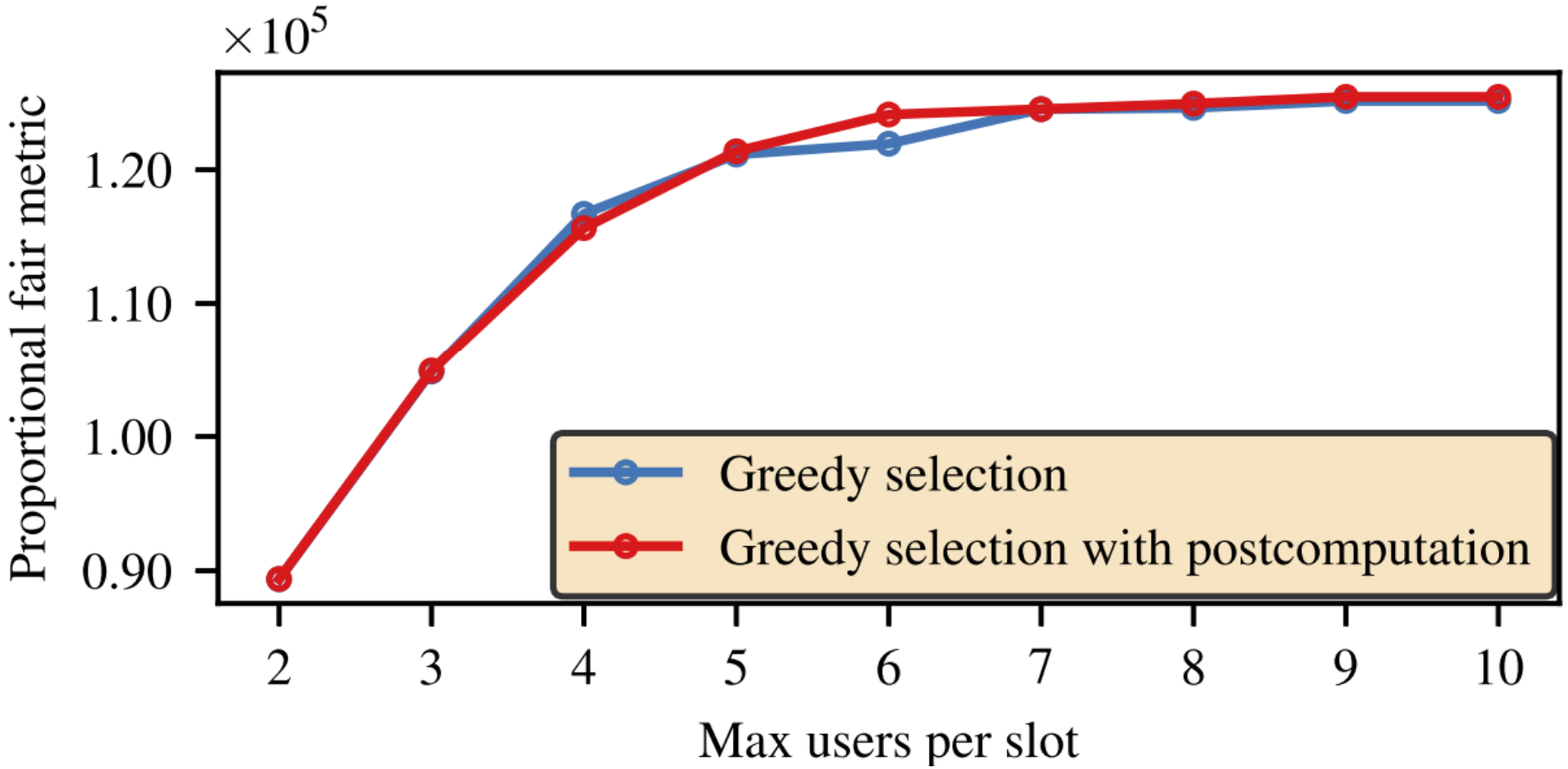
Assumptions:
- 4 physical antennas.
- 2 RF chains.
- For each user, the channel can be modeled as two rays (LOS and NLOS) as shown in the diagram.
- Both users are selected at current time slot.



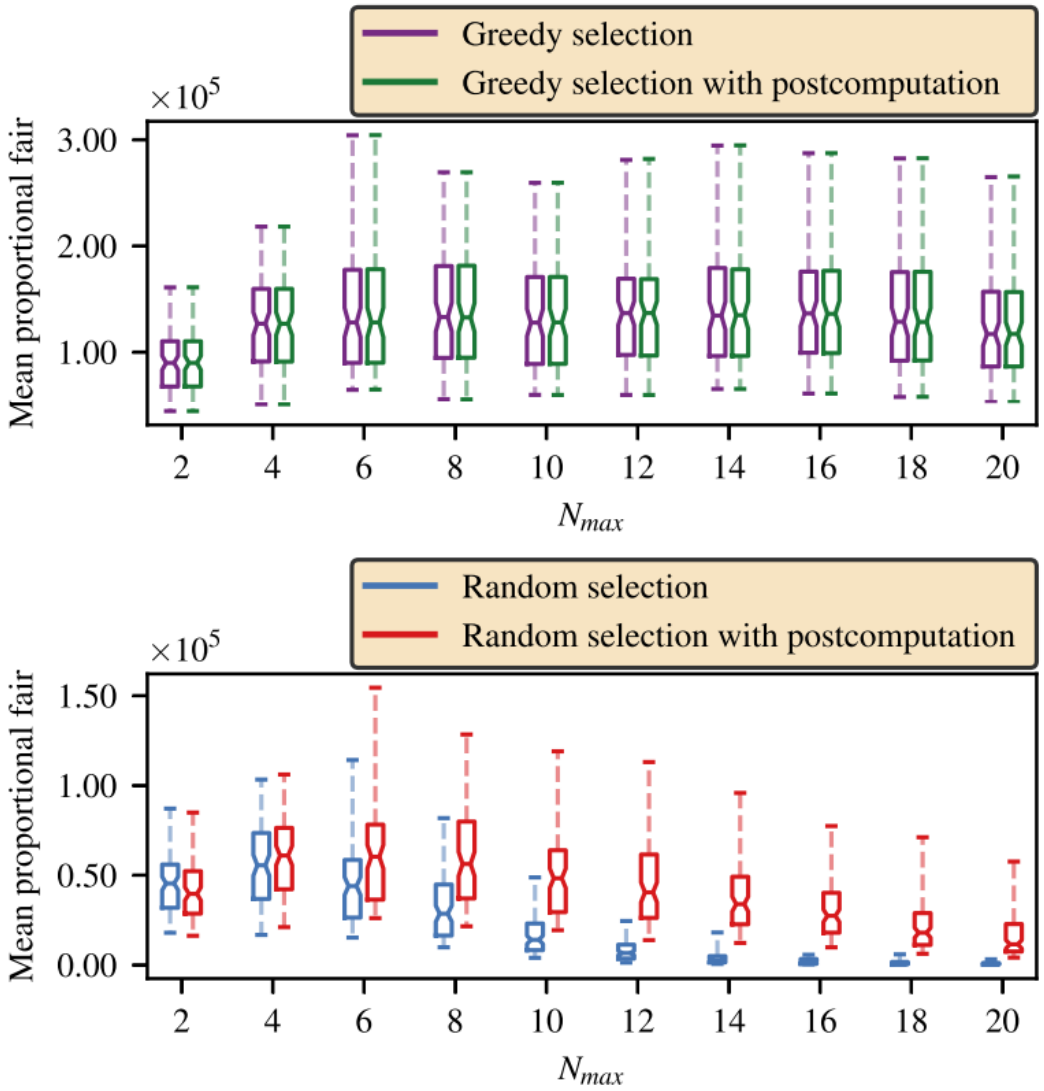
Greedy user selection (for a given time slot)

- Start with selected users = {}.
- While |selected users| < maximum allowed:
  - Find the best user to add (with what-if computation on the precoder).
  - If it improves the performance, add her to the selected users.
  - If it degrades the performance, do not add her and stop the algorithm.

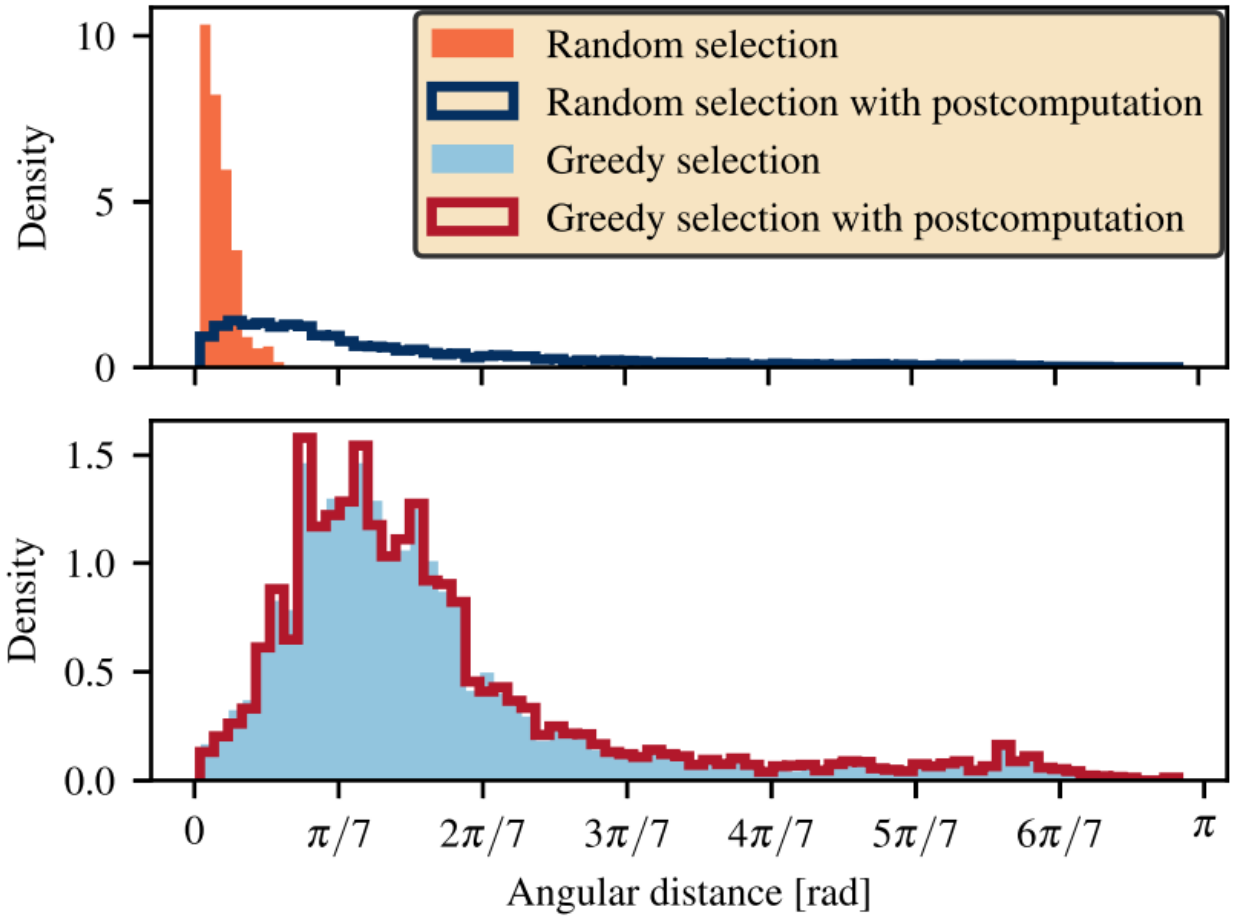
Does beam post-computation help when using greedy user selection?



Comparison with random selection of users



Angular distance of the beams



Distribution of minimum angular distance between selected user beams for post-computation (stepped) and user selection only (filled) for random (top) and greedy (bottom) user selection variants

Conclusion on beam post-computation

- For specific configurations of selected users, beam post-computation can lead to significantly better performance.
- However, in a full simulation, the gains are marginal.
- Intuition: The user selection step typically selects users that are far apart in beam space, and hence have the least interference.

➔ The extra computational effort associated with the post-computation of analog beams can be avoided without affecting system performance.

General conclusion

- The question of beam post-computation exploits only a small fraction of the possibilities of the simulator.
- Many other things could be done!