Grouping and Partner Selection in Cooperative Wireless Networks

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Outline

- Introduction
- System model
- Proposed protocol
- Simulation
- Conclusion

Introduction

- In cooperative networks, how to make groups and select partners?
  - Consider non-altruistic cooperation.
    - Each node has data of its own to transmit
  - Allow non-reciprocal cooperation.
    - Node A helps node B, but node B may not help node A.

Introduction

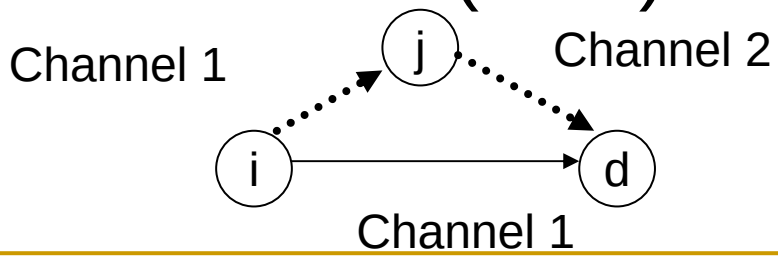
- Distributed scenarios:
  - Each node can help *n* other nodes, but makes decisions individually.
  - Assume each node has **receive-side** channel state information (CSI), but **no transmit-side** CSI.
  - No feedback or handshake in PHY.

Introduction

- Centralized scenarios:
  - Intuitively, a centralized protocol should provide better performance than the distributed protocol.
  - Different amount of information that the centralized controller has may affect performance.
  - The goal is to consider a centralized protocol that minimizes the outage across the network.

System model

- Each of the users is assigned an orthogonal multiple access channel.
- The signal-to-noise ratio (SNR) of node *i* to node *j* , $\gamma_{i,j}$, is related to transmit power, path loss, shadowing, and distance.
- We assume the cooperating nodes use decode-and-forward (DAF).



System model

- This paper evaluates performance based on outage probability, i.e., that probability that the channel capacity cannot support the desired rate.
- The outage probability is related to SNR and transmission rate.

Distributed partner selection

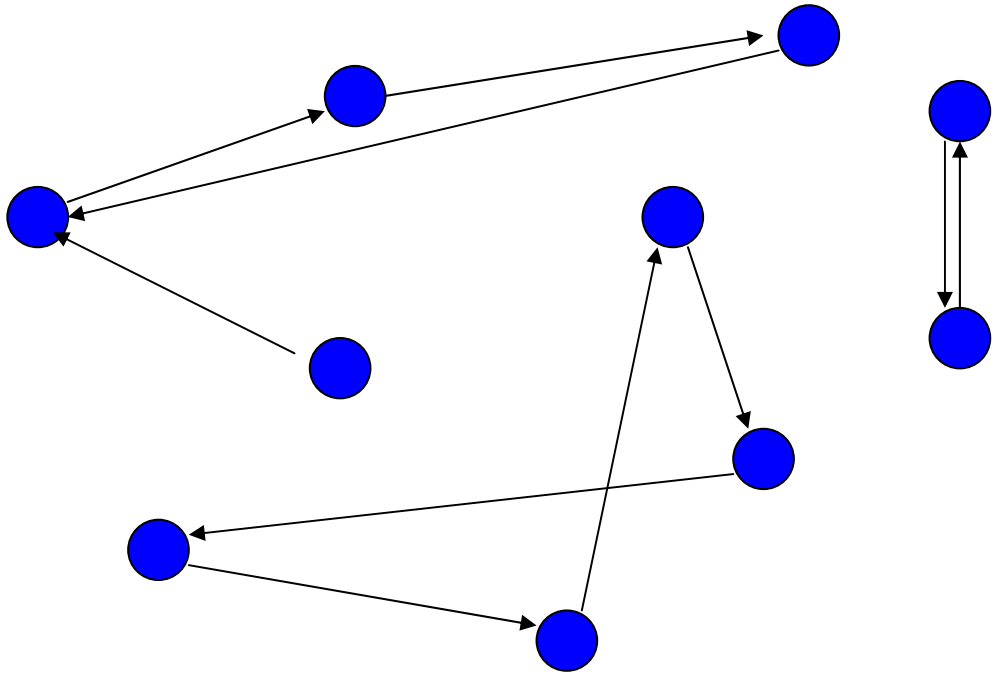
- Suppose S_i means the partner set that assist node *i*, and *n* means maximum partner number.
- When n = 1, to achieve full diversity (no isolated node), it is required that $\Pr\{ |S_i| = 0 \} \rightarrow 0$ at high SNR.
  - Random selection
  - Received SNR selection
  - Fixed priority selection

Distributed partner selection

- Random selection
  - Each node randomly selects a node to assist.
- Received SNR selection
  - Each node assists a node with the highest SNR.
- Fixed priority selection
  - Each node maintains a priority vector {i+1,i+2,…,M,1,2,…,i-1} , where *i* is its ID.
  - Node *i* assists first *n* nodes.

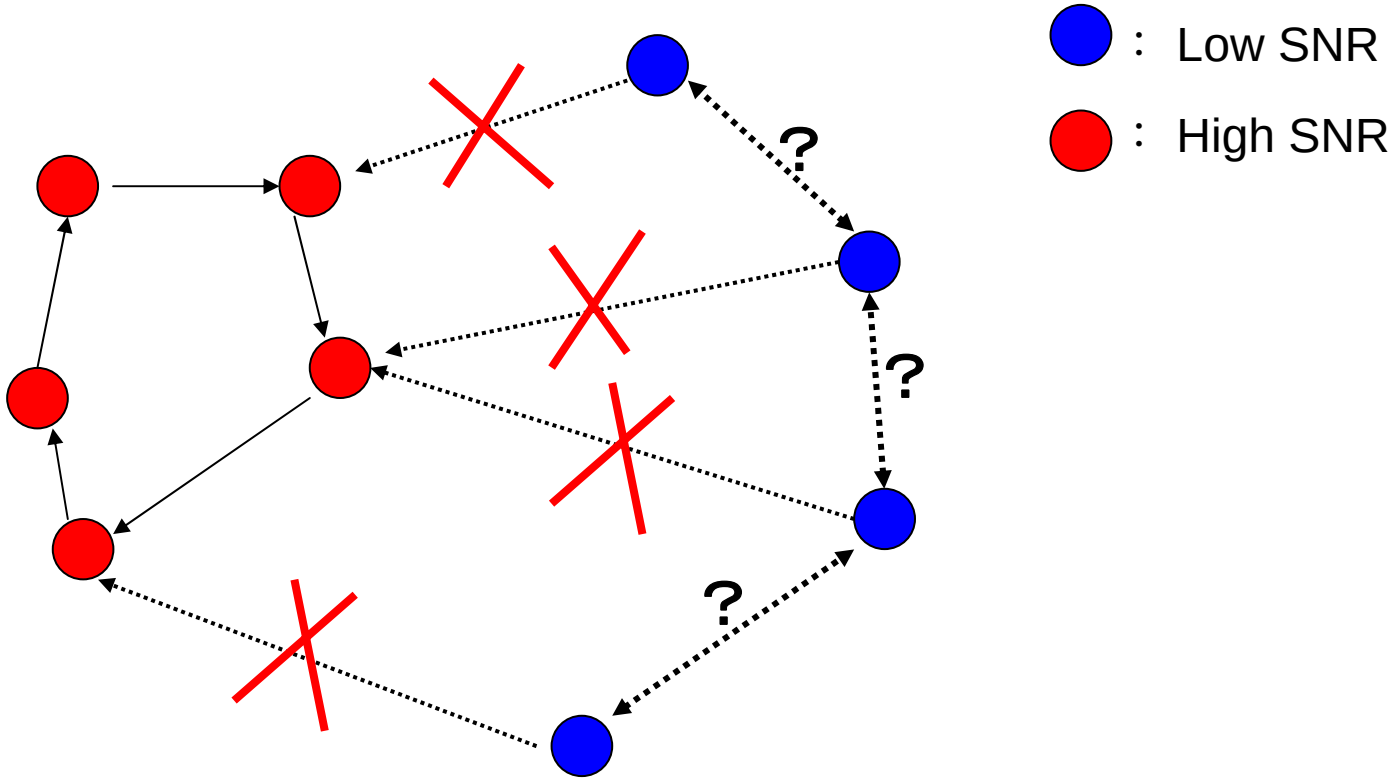
Distributed partner selection

- Random selection (n=1)



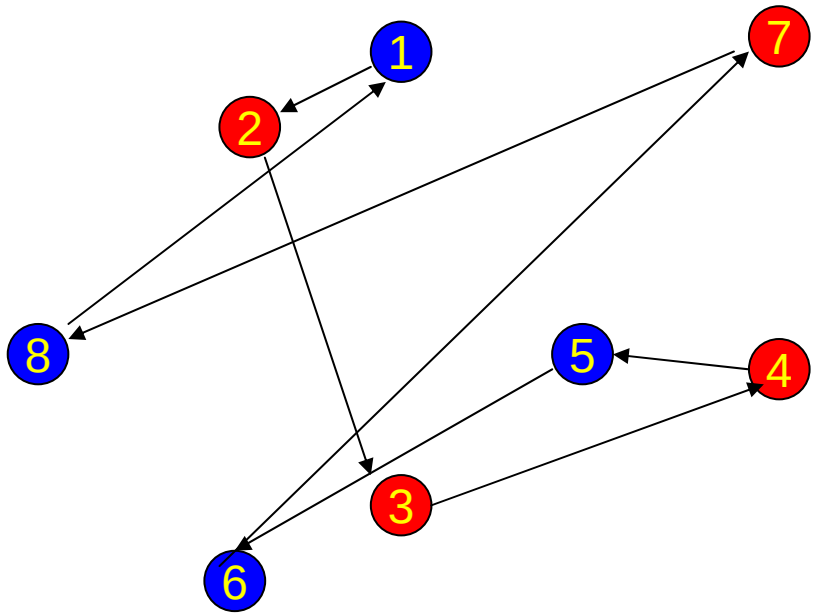
Distributed partner selection

- Received SNR selection (n=1)



Distributed partner selection

- Fixed priority selection (n=1)

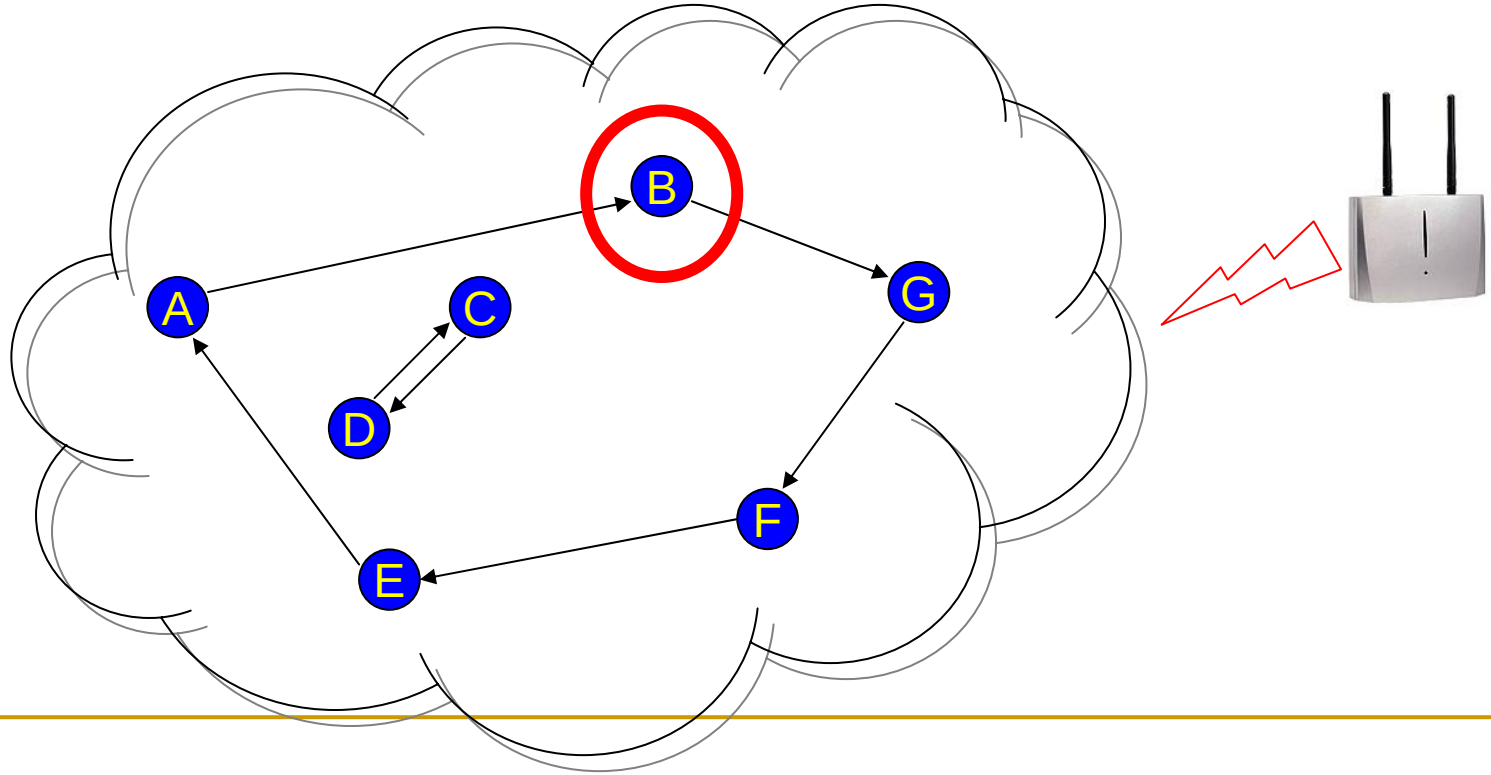


Centralized partner selection

- Consider a centralized controller for assigning cooperation partners.
- The distinction between distributed and centralized algorithm is that the latter would pick the **best** solution.

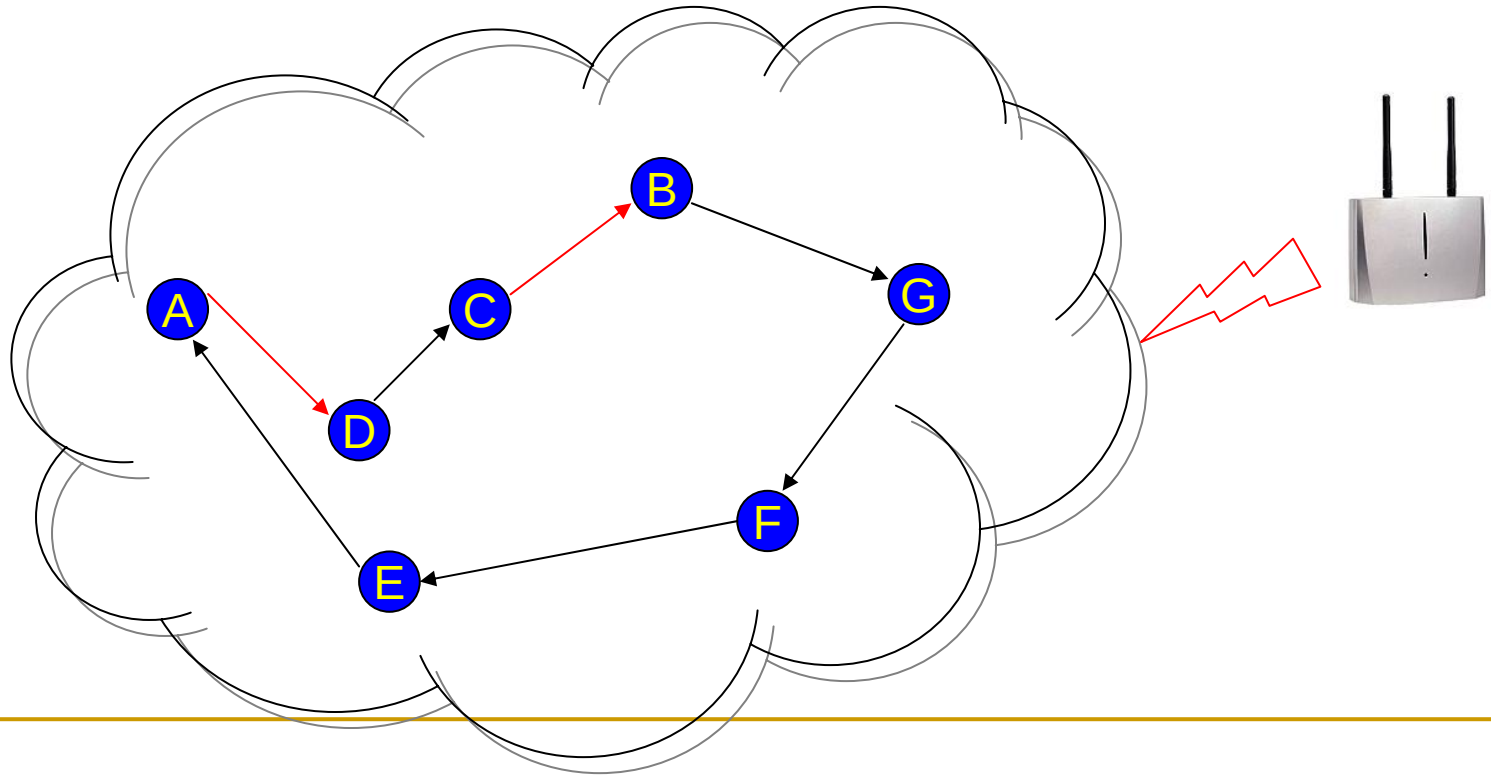
Centralized partner selection

- Step1: randomly assign partners
- Step2: compute overall outage probability



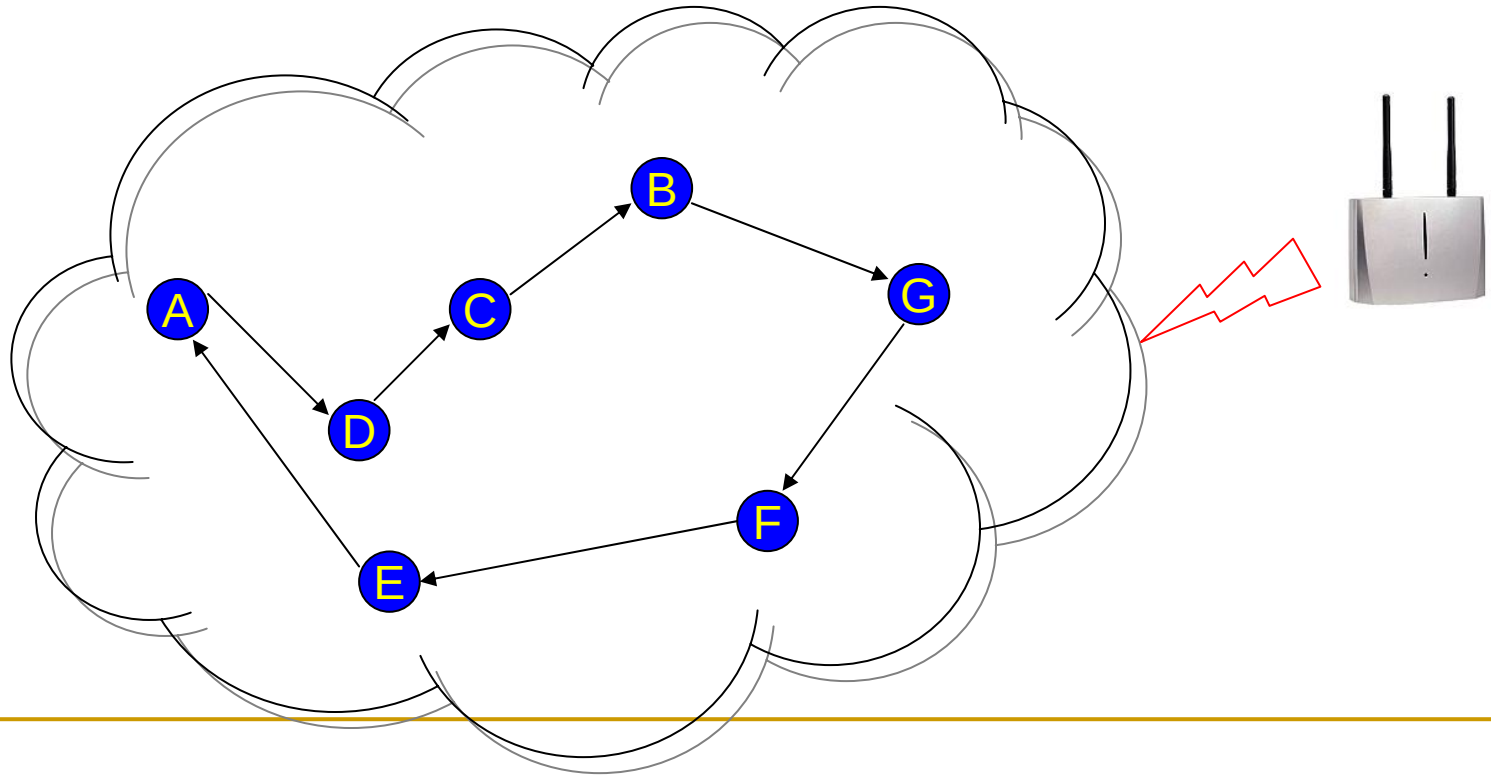
Centralized partner selection

- Step3: find candidate partners, and exchange. If outage probability is lower, do it.



Centralized partner selection

- Step4: repeat step3 for all nodes.



Centralized partner selection

1) Randomly assign partners, and ensure that each node has only one partner.
2) Compute average outage probability over all nodes based on available channel knowledge.
3) If A assists B, find candidate partners of B, ex: C, and C assists D now. Check if exchanging A and C has lower outage probability.
4) Repeat step.3 for all M users until no exchange.

Simulation

- Distributed protocol

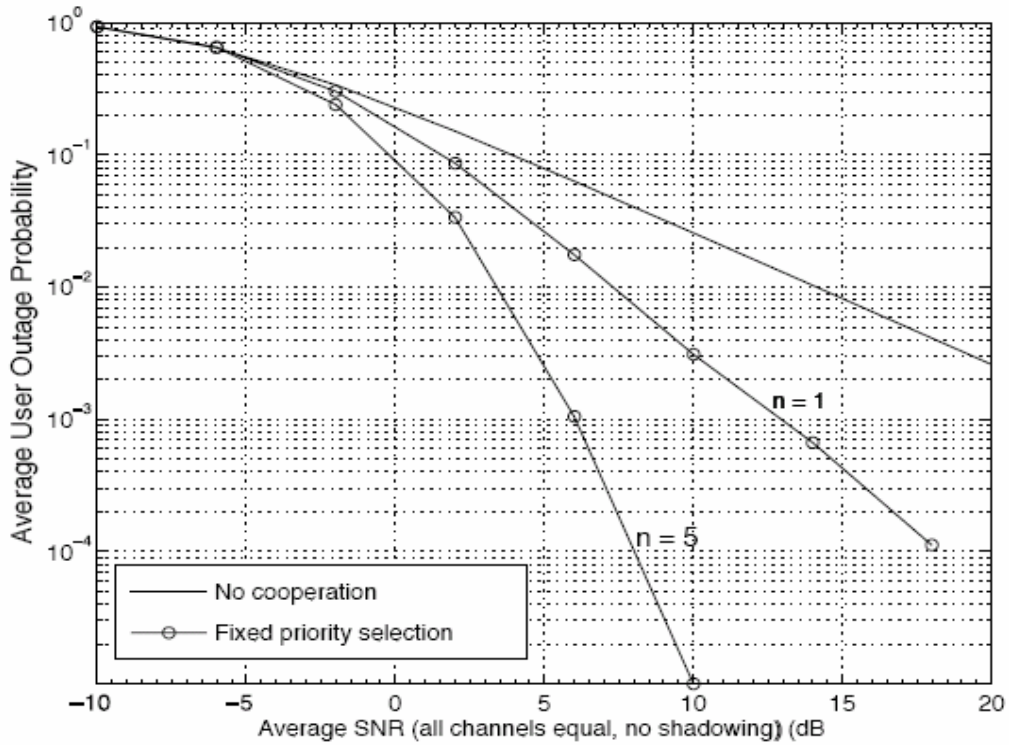


Fig. 4. Fixed priority protocol under Rayleigh fading without path loss or shadowing. Users make $n = 1, 5$ decoding attempts.

Simulation

- Distributed protocol

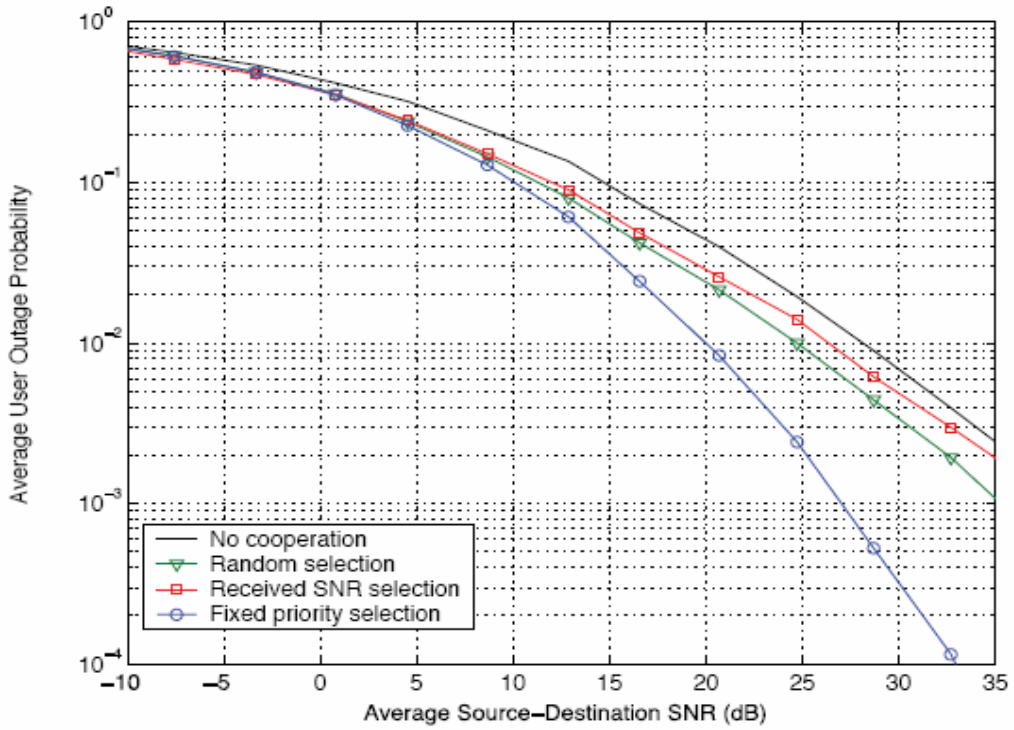


Fig. 5. Distributed protocols for $M = 10$ users, $n = 1$ decoding attempts per user, path loss $\beta = 4$, $K = -60$dB, shadowing $\sigma_S = 8$. For $M = 50$ users the curves are virtually identical.

Simulation

- Distributed protocol

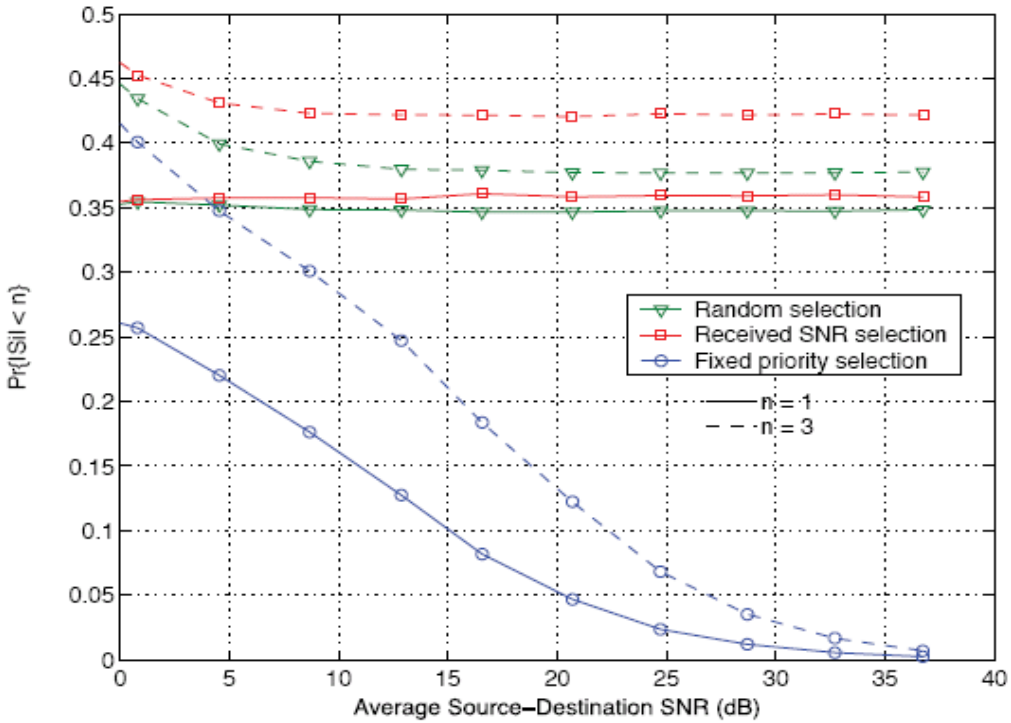


Fig. 6. $\Pr\{|\mathcal{S}_i| < n\}$ vs. average source-destination SNR for $M = 10$ users, and $n = 1, 3$, path loss $\beta = 4$, $K = -60$dB, and shadowing $\sigma_S = 8$.

Simulation

- Centralized protocol

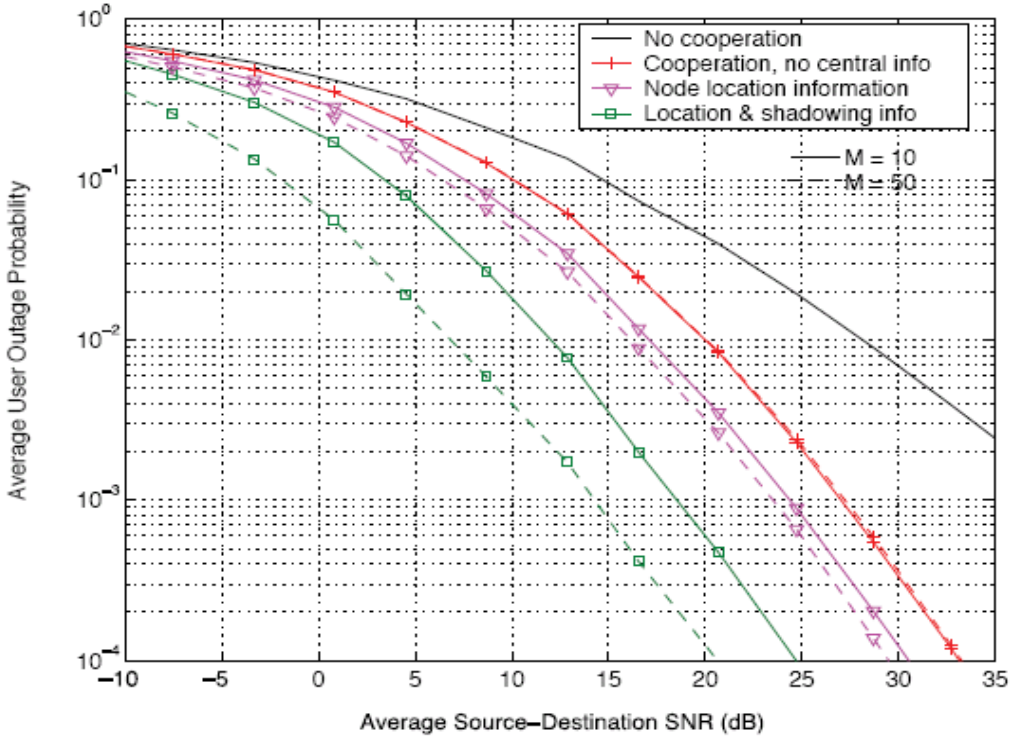


Fig. 9. Showing the effect of various amounts of information available to the centralized controller. Network has $M = 10, 50$ users, path loss $\beta = 4$, $K = -60$dB, and shadowing $\sigma_S = 8$.

Simulation

- Centralized protocol

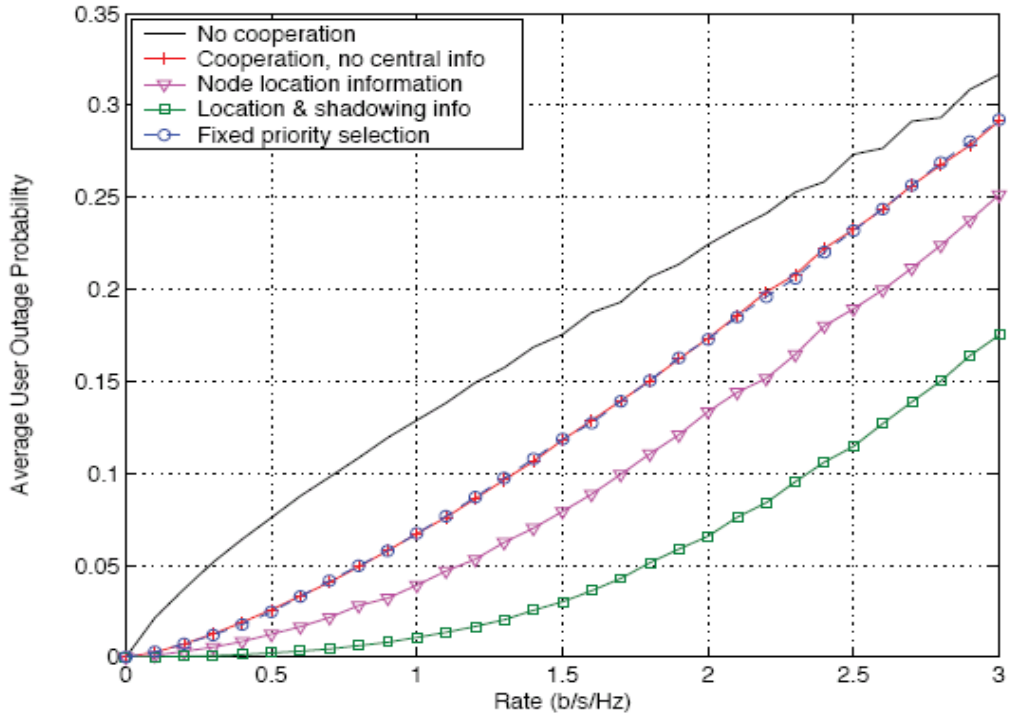


Fig. 10. Comparison of centralized and distributed protocols. Network has $M = 10$ users, path loss $\beta = 4$, $K = -60$dB, and shadowing $\sigma_S = 8$. Source-destination SNR is fixed at 20dB to see the effect of varying rate.

Conclusion

- Distributed protocol
  - Fixed priority selection can achieve full diversity and improve performance.
- Centralized protocol
  - If centralized controller has enough channel state information (CSI), it will perform better than distributed protocol.