

One-Bit Feedback Selection Schemes for Power-Efficient Multiuser and Multirelay Systems



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MOTIVATION

■ Cooperative communication

- Single user and single amplify-and-forward relay:
Emamian *et al.* [3] and Hasna *et al.* [6, 7]
- Exploiting CSI to save transmit power:
Ahmed *et al.* [1, 2] and Hasna [5]

■ Multiuser and multirelay network

- User and relay scheduling or selection based on maximum SNR scheduling: *Kim et al.* [8]
- Perfect CSI and feedback

MOTIVATION

- A selection scheme with:
 - Reduced feedback
 - Threshold-based relay and user selection
 - One-bit feedback
 - Transmit power savings
 - Select one two-hop link with SNR(s) above the threshold
 - Switch off transmission when leading to system outage

AGENDA

■ Introduction

- Multiuser and multirelay system model
- Two-hop channel model
- Useful observations

■ Threshold-based selection schemes

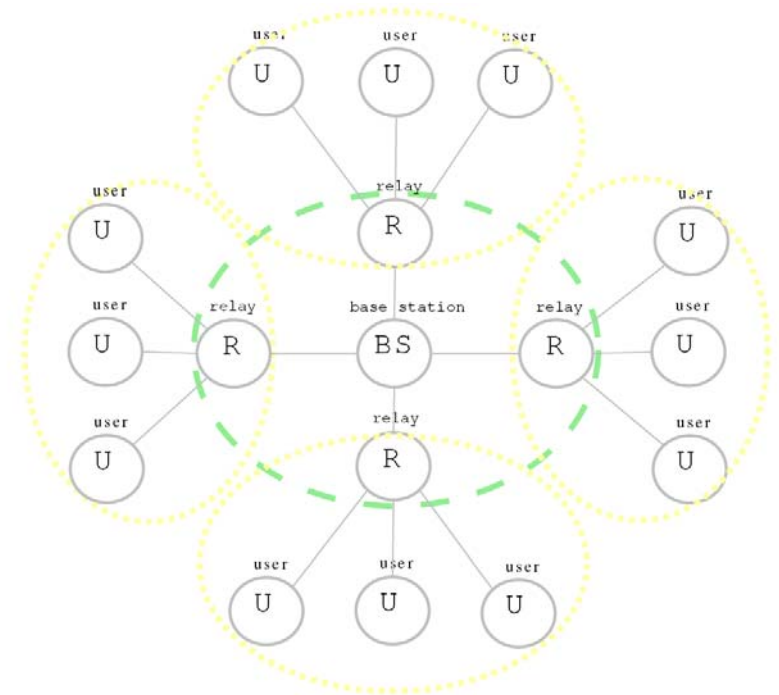
- Decentralized scheduling: DS, simplified DS: DSS
- Centralized scheduling: CS

■ Discussion

INTRODUCTION

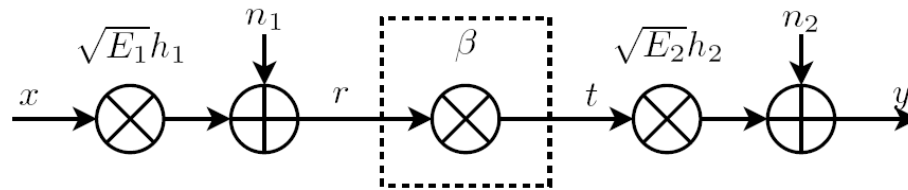
■ Multiuser and multirelay system model

- N users, M relays
- 1 BS partition
- M relay partitions
- Rayleigh fading



INTRODUCTION

■ Two-hop channel model



□ Equivalent end-to-end SNR

$$\gamma_{eq} = \frac{E_1 E_2 |h_1 \beta h_2|^2}{E_2 |\beta h_2|^2 \sigma_1^2 + \sigma_2^2}$$

□ Outage probability

$$P_{out} = \int_0^{\gamma_{th}} p_\gamma(\gamma) d\gamma$$

INTRODUCTION

- Observations on lower-bound values for the thresholds on the first-hop and second-hop SNRs
 - *Observation 1:* In a generic dual-hop AF communication channel with gain β , if the first-hop SNR drops below the outage threshold, the system will be in outage
 - Proof:

$$\gamma_{eq} = \frac{E_1 E_2 |h_1 \beta h_2|^2}{E_2 |\beta h_2|^2 \sigma_1^2 + \sigma_2^2} \leq \frac{E_1 E_2 |h_1 \beta h_2|^2}{E_2 |\beta h_2|^2 \sigma_1^2} = \gamma_1$$

INTRODUCTION

- *Observation 2:* Given a dual-hop communication channel with gain $\beta = \frac{1}{\sqrt{E_1|h_1|^2}}$, if the first-hop SNR or the second-hop SNR drops below the outage threshold, the system will be in outage
- *Proof:*

$$\gamma_{eq} = \frac{E_1 E_2 |h_1 \beta h_2|^2}{E_2 |\beta h_2|^2 \sigma_1^2 + \sigma_2^2} \leq \frac{E_1 E_2 |h_1 \beta h_2|^2}{\sigma_2^2} \stackrel{\uparrow}{=} \gamma_2$$
$$\beta = \frac{1}{\sqrt{E_1 |h_1|^2}}$$

Threshold-based selection schemes

■ Distributed selection

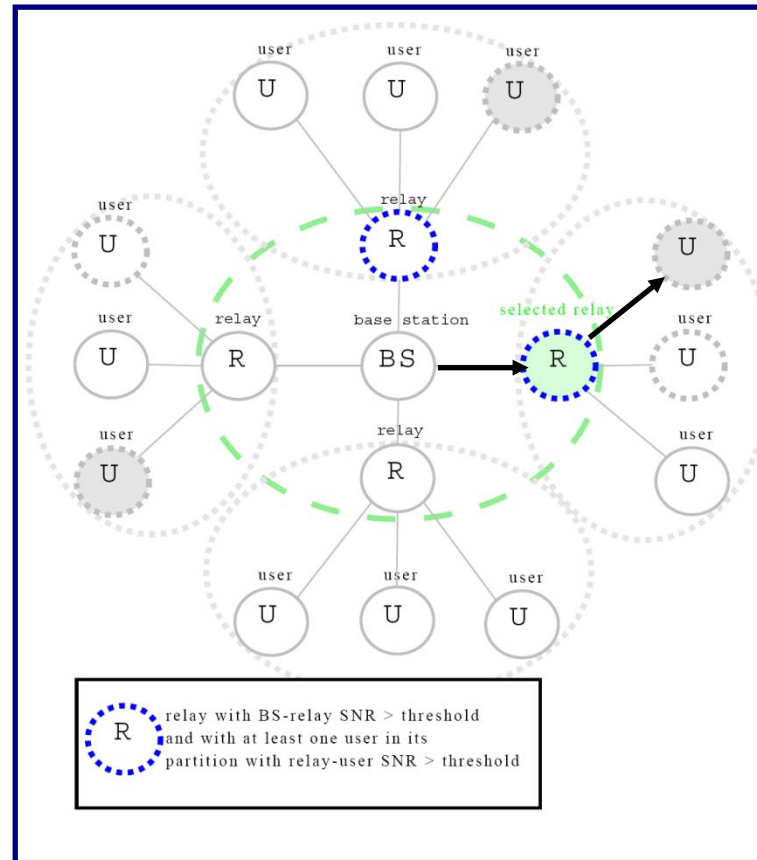
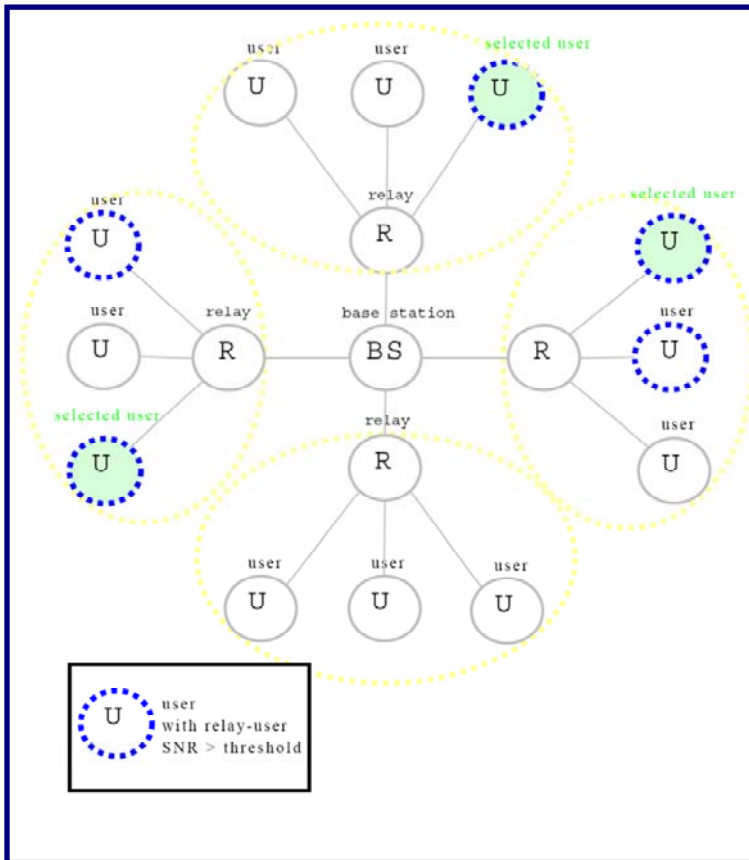
- Receiver (relay, user) selection is performed within the transmitters' partitions
- DS
- DSS

■ Centralized selection

- Selection is performed at the BS
- CS

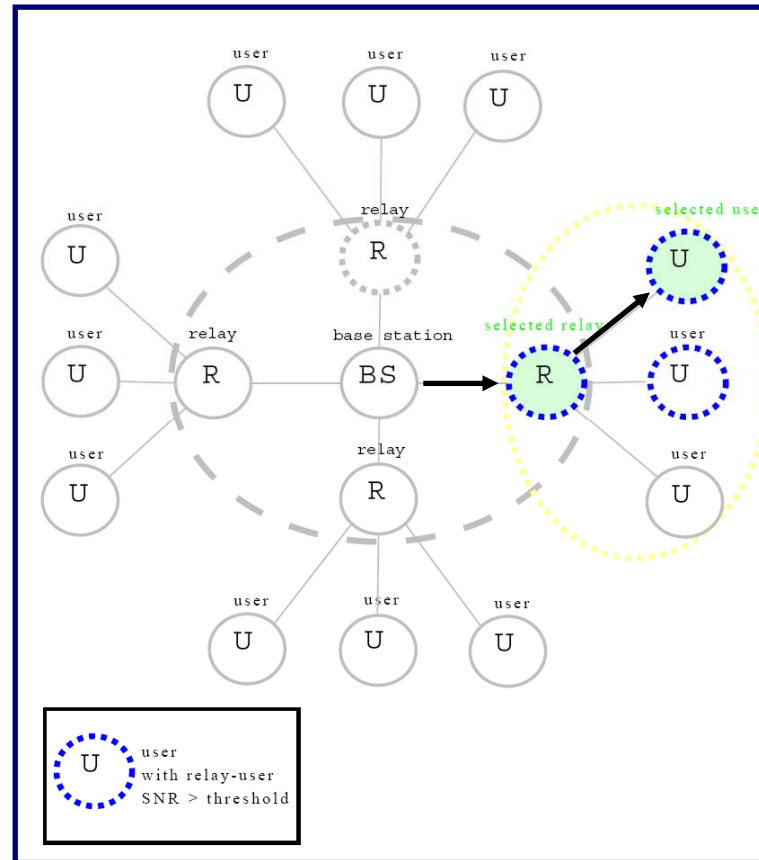
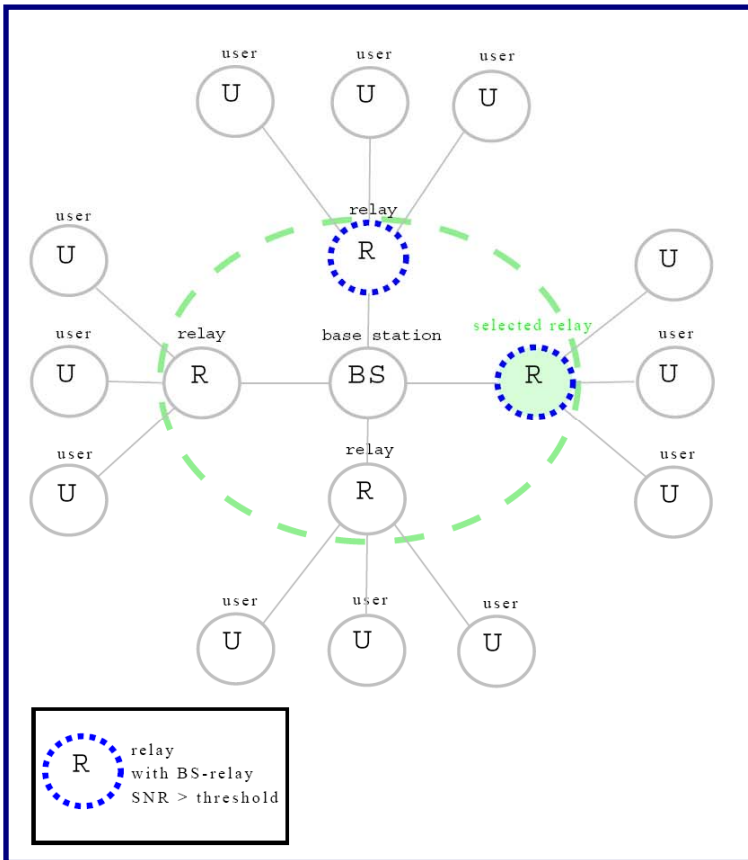
Distributed selection: DS

- User selection and relay selection are not done independently



Distributed selection: DSS

- Relay selection is done independently of user selection



OUTAGE PROBABILITY

- DS
$$P_{stop,DS} = \left[e^{-\frac{\gamma_{th}}{\bar{\gamma}_1}} \cdot \left(1 - e^{-\frac{\gamma_{th}}{\bar{\gamma}_2}}\right)^{\frac{N}{M}} + \left(1 - e^{-\frac{\gamma_{th}}{\bar{\gamma}_1}}\right) \right]^M$$

$$P_{out,DS}^{M,N} = (1 - P_{stop,DS}) \cdot P_{out,DS}^{\infty} + P_{stop,DS}$$

- DSS
$$P_{transmit,DSS} = (1 - P[\gamma_{BS-R} < \gamma_{th}]^M) \left(1 - P[\gamma_{R-U} < \gamma_{th}]^{\frac{N}{M}}\right)$$

$$P_{out,DSS}^{M,N} = P_{transmit,DSS} \cdot P_{out,DS}^{\infty} + (1 - P_{transmit,DSS})$$

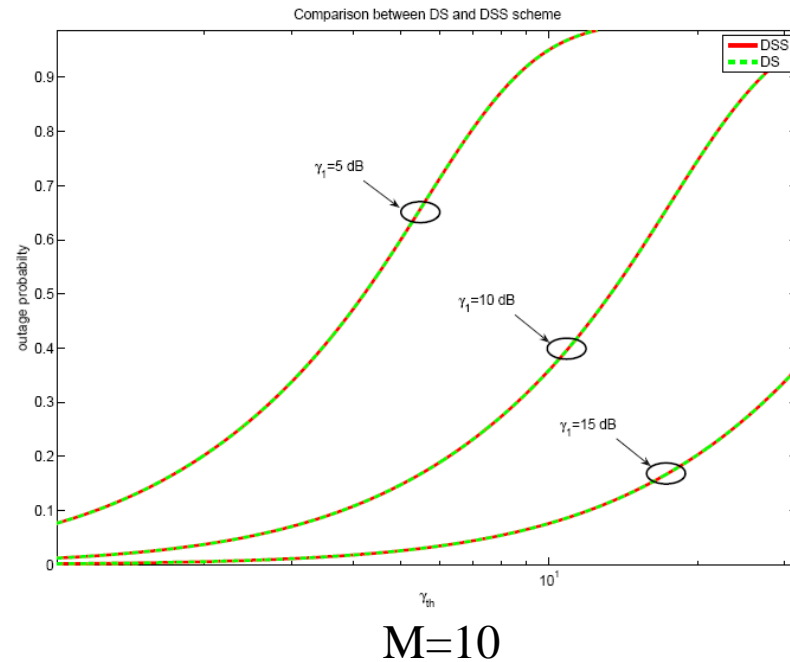
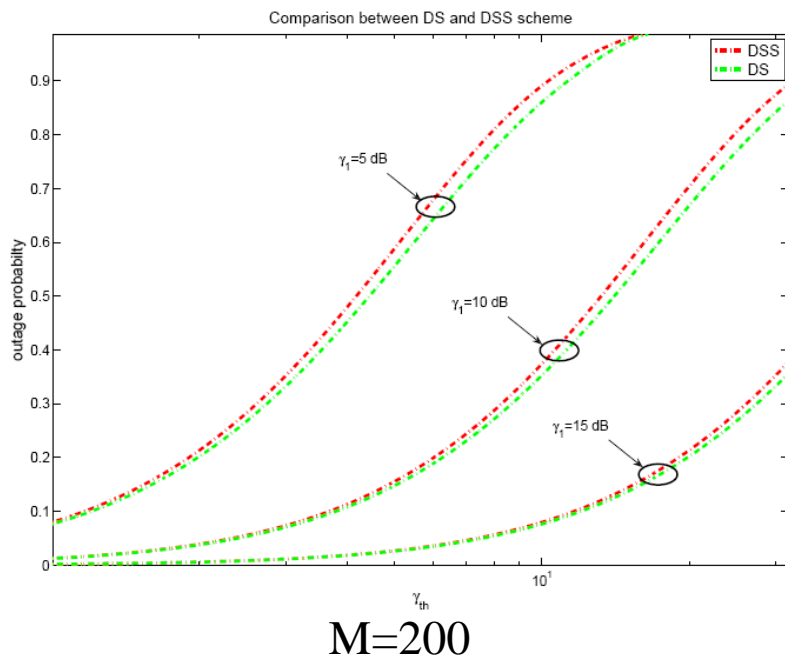
- where

$P_{out,DS}^{\infty}$ is the conditional outage probability given that $\gamma_1 > \gamma_{th}$ and $\gamma_2 > \gamma_{th}$

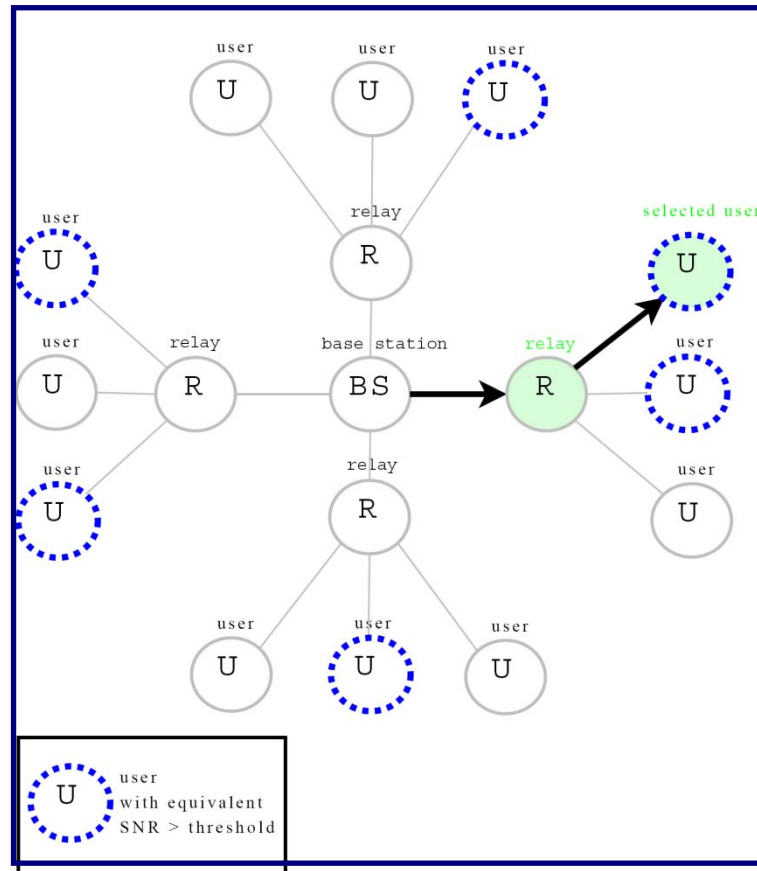
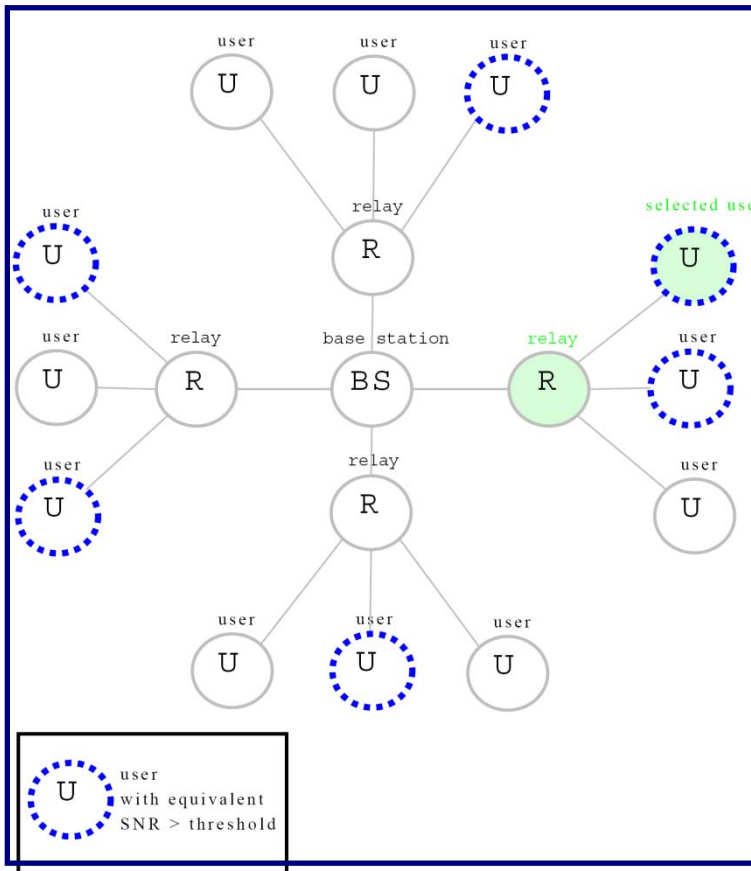
$$P_{out,DS}^{\infty} = 1 - \frac{2\gamma_{th}}{\sqrt{\bar{\gamma}_1\bar{\gamma}_2}} K_1 \left(\frac{2\gamma_{th}}{\sqrt{\bar{\gamma}_1\bar{\gamma}_2}} \right)$$

DS AND DSS

■ N=400



Centralized selection: CS



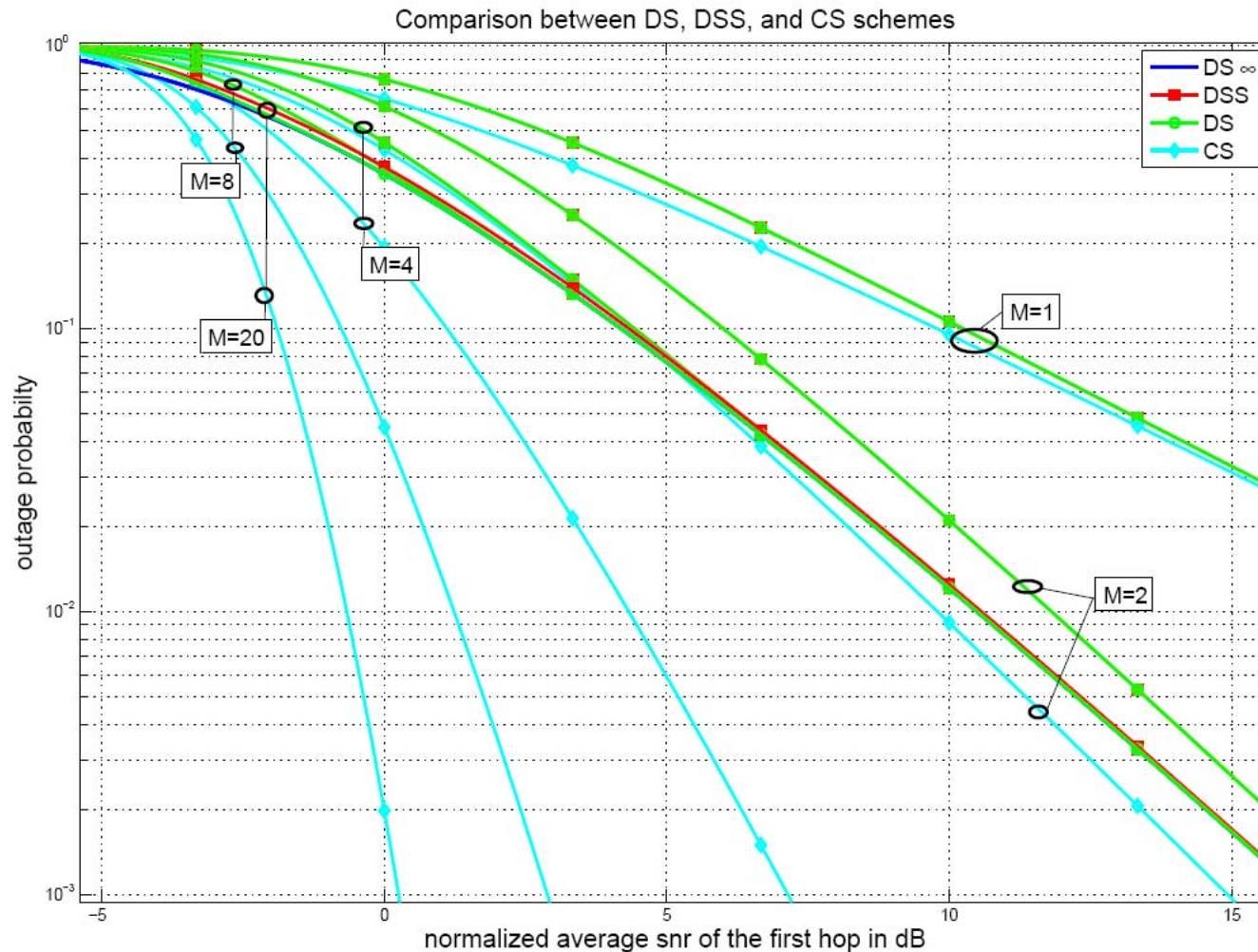
OUTAGE PROBABILITY

■ CS

$$P_{out,CS}^{M,N} = \left[1 + \sum_{k=1}^{\frac{N}{M}} \binom{\frac{N}{M}}{k} (-1)^k e^{-\frac{k\gamma_{th}}{\bar{\gamma}_2} - \frac{\gamma_{th}}{\bar{\gamma}_1}} 2 \sqrt{\frac{\gamma_{th}^2 k}{\bar{\gamma}_1 \bar{\gamma}_2}} K_1 \left[2 \sqrt{\frac{\gamma_{th}^2 k}{\bar{\gamma}_1 \bar{\gamma}_2}} \right] \right]^M$$

- $K_1(\cdot)$ is the first-order modified Bessel function of the second kind

COMPARISON BETWEEN DSS, DS, AND CS WITH N=40



CONCLUSIONS

- New selection schemes CS, DS, and DSS
- One-bit feedback that is obtained by comparing the SNR of the assessed link to a predefined threshold
- Thresholds are chosen such that the transmission can be switched off to save power during outage
- Closed-form expressions of outage probability are derived

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THANK YOU