Aspects of Macrodiversity MIMO Transceivers

1

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Introduction

2

- **What is it?**

  A wireless access architecture

- **What does macrodiversity mean?**

  Any scenario where both sources and receivers are geographically distributed

  e.g. A cooperative base station topology with distributed users

Introduction

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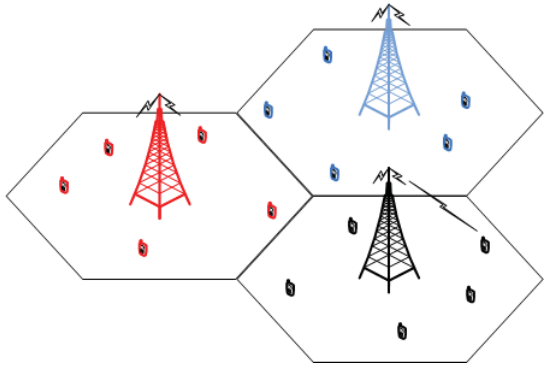

Fig. 1 Usual cellular wireless access system

Introduction (This example is used throughout)

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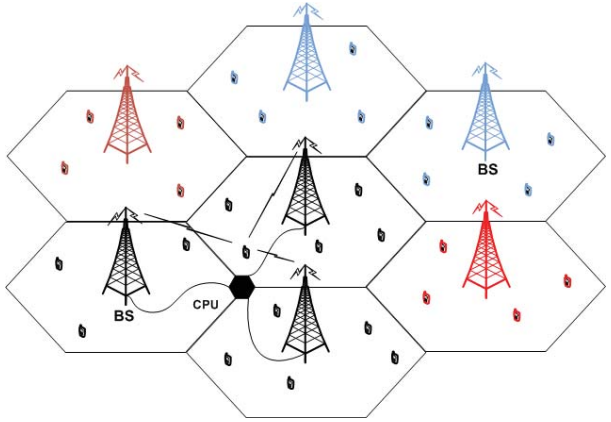


Fig. 2 Macrodiversity cellular wireless access system

Introduction

- **How does it differ from a micro-diversity system?**

  Antennas are widely separated at different BS locations.

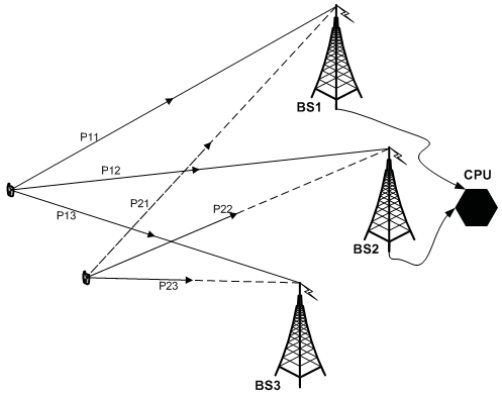
- **How does it form a MIMO system?**

  The BSs are connected by means of a backhaul network and joint processing is allowed. BSs may have 1 or more antennas.

Multiple access channel

- **This is the channel from the mobiles to the BS.**

Uplink channel



State-of-the-art in Macrodiversity

- **There are simulation results available.**
- **In order to get a good understanding of the system, allow efficient computation and gain insights into performance, we need analytical results.**
- **No analytical results are currently available except very simple approximations that do not match the reality of macrodiversity.**

Achievements

- **Dual user system with arbitrary number of receive antennas (linear combiners)**

ZF : exact CDF of output SNR.
high SNR approximation of SER.

MMSE : exact CDF of output SINR.
high SNR approximation of SER.

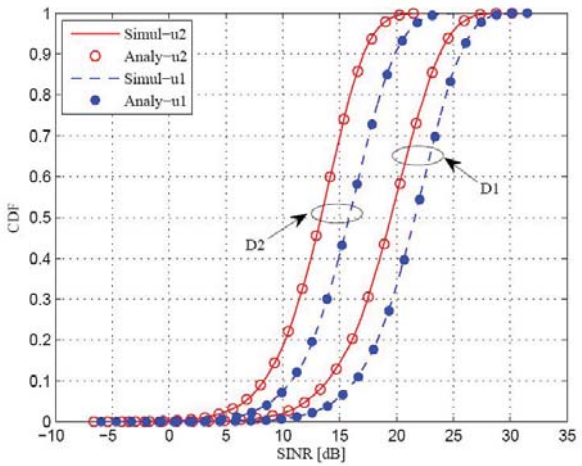


Fig. 2. Analytical and simulated cdfs of the output SINR of an MMSE receiver with D1: $\mathrm{SNR}_{av} = 7.8499$ dB, D2: $\mathrm{SNR}_{av} = 3.0423$ dB.

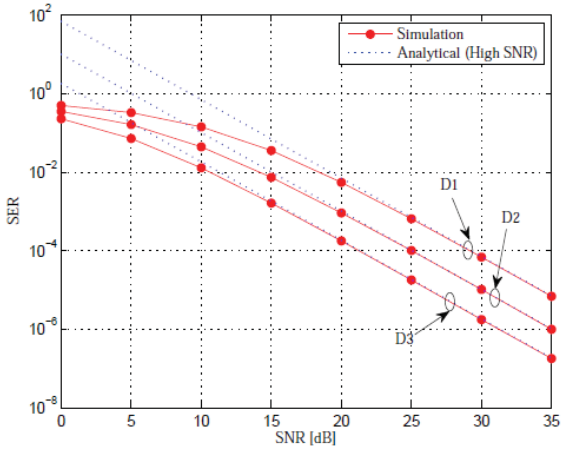


Fig. 2. SER of ZF receiver for QPSK modulation in Rayleigh flat fading with D1: $\mathrm{SNR}_{av} = -4.8219$ dB, D2: $\mathrm{SNR}_{av} = -2.8800$ dB, D3: $\mathrm{SNR}_{av} = -0.3875$ dB

Achievements

- **Arbitrary number of users and receive antennas**

ZF
MMSE } high SNR approximation of SER. Approximate CDF.

Possible patent in the area.

MRC: Exact SER

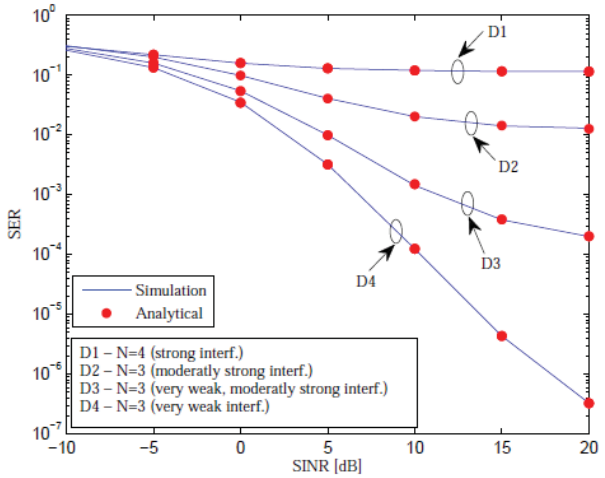


Fig. 2. Analytical and simulated SER of MRC receiver with BPSK modulation in Flat Rayleigh Fading with $n_R = 4$.

Achievements

- **Exact pair-wise error probability of an MLE receiver in uncoded transmission.**
- **Exact ergodic sum capacity of the dual user macrodiversity system with arbitrary number of receive antennas.**
- **Approximate sum capacity of the general user & antenna system (in progress)**

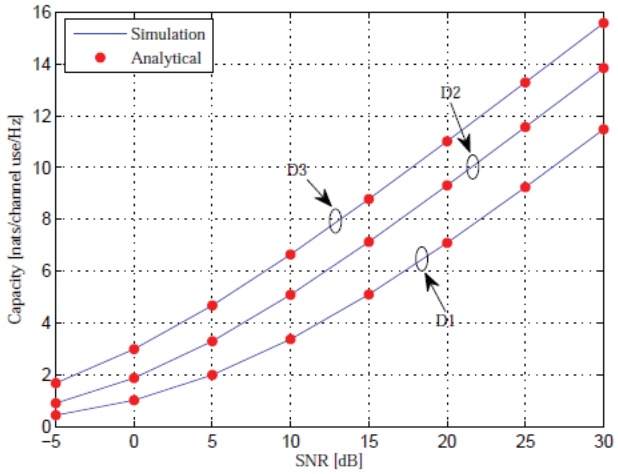


Fig. 3. Dual User analytical and simulated ergodic sum-rate capacity in Flat Rayleigh Fading with D1: SNR_{av}= -3.4813 dB, D2: SNR_{av}= 0.3917 dB and D3: SNR_{av}= 4.8153 dB.

Approaches

- **What makes this progress possible?**

  Many people believed that analytical solutions were not possible (including my supervisor)

- **We exploit some integrals and use elementary mathematical techniques.**

  In the 2-user case, matrix versions were converted to scalar forms.

  Laplace-type approximation.

  Exponential identities for ratios