



HOKKAIDO UNIVERSITY

Title	Advanced MIMO-OFDM in Wireless Communications
Author(s)	Shi, Xiaonan Nicole; Siriteanu, Constantin Costi; Yoshizawa, Shingo et al.
Relation	グリーン回路とシステムに関する国際ワークショップ = International Workshop on Green Circuits and Systems. 2010年10月25日 (月). 北海道大学大学院情報科学研究科大会議室 (11階17号室), 札幌市.
Issue Date	2010-10-25
Doc URL	https://hdl.handle.net/2115/44301
Type	conference presentation
File Information	Xiaonan (Nicole) Shi.pdf



Advanced MIMO-OFDM in Wireless Communications

- Xiaonan (Nicole) Shi,
Constantin (Costi) Siriteanu, Shingo Yoshizawa, Yoshikazu Miyanaga

Graduate School of Information Science and Technology
Hokkaido University, Sapporo, Japan

Presented at: Green Circuits and Systems, IST, Hokkaido Univ.

Oct. 25th, 2010

Motivation (Why)

Unrealistic channel fading (typical research) assumptions significantly distort performance indications.

1. Unrealistic:

- Rayleigh fading
- Rician fading with K fixed to typical value, or with uncorrelated AS and K -factor
- Perfect channel knowledge.

2. Realistic:

- Rician fading with correlated azimuth spread (AS) and K -factor
- Existing channel estimation error.

Approach (How)

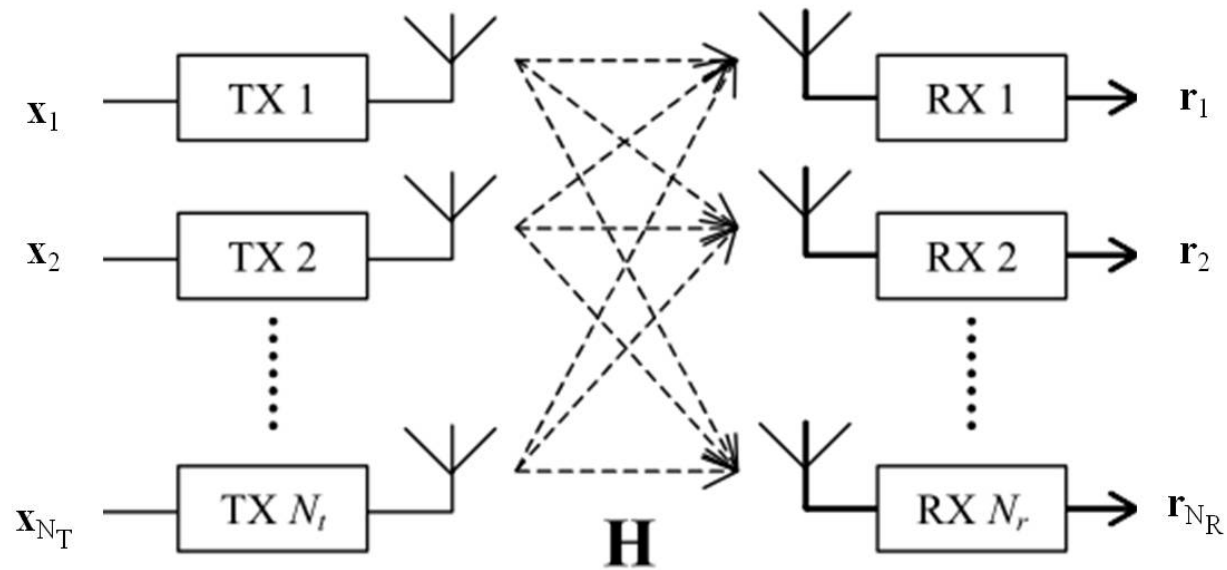
How we approach:

- Unrealistic – realistic: Study performance of MIMO systems for un/realistic assumptions with estimated ICSI
- Accuracy: Derive new error probability analysis for zero-forcing detected symbols with estimated ICSI
- Efficiency: Implement channel coding (LDPC code achieves Shannon limit performance)
- Reliability: Design soft iterative interference cancelation.

Presentation Outline

- MIMO system models
- Correlated AS and K -factor statistical models
- Zero-forcing detection
- MIMO-OFDM, iterative receiver.

MIMO Systems Models



- Multiple input multiple output (MIMO)
- Higher spectral efficiency and diversity
- Key technology for next-generation wireless communications.

Signal Models

MIMO with N_T transmit and N_R receive antennas can represent the received signals as:

$$\mathbf{r} = \sqrt{\frac{E_s}{N_T}} \mathbf{H} \mathbf{x} + \mathbf{n}, \quad \mathbf{n} \sim \mathcal{N}_c(\mathbf{0}, N_0 \mathbf{I}) \quad (1)$$

- \mathbf{x} : N_T -dimensional complex-valued vector
- \mathbf{r} : N_R -dimensional complex-valued vector
- $\frac{E_s}{N_T}$: energy transmitted per symbol and per antenna element.

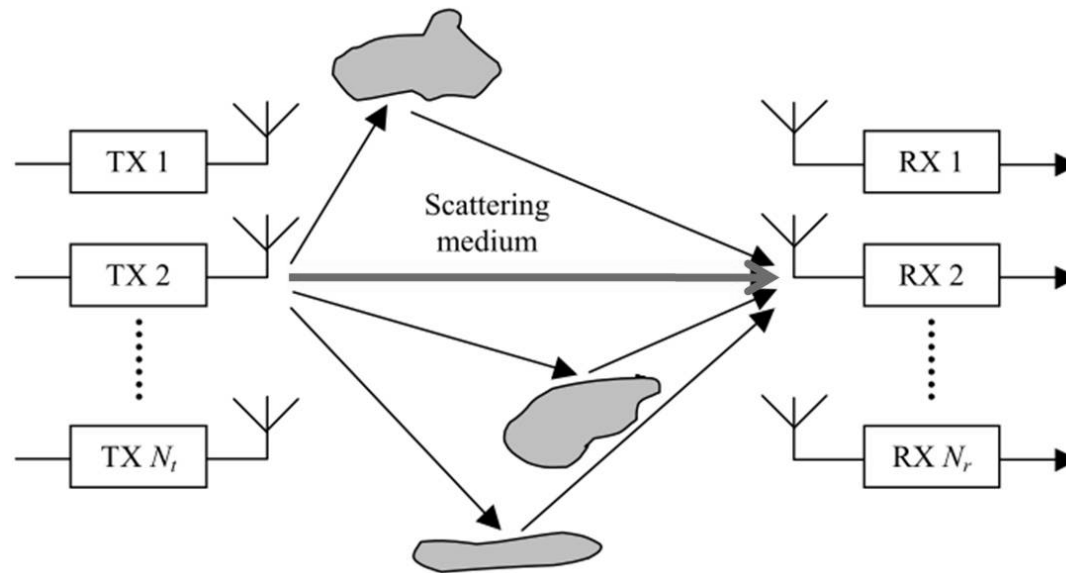
Channel Models

\mathbf{H} is the $N_T \times N_R$ channel matrix with complex-valued Gaussian distributed elements with unit variance:

$$\mathbf{H} = \sqrt{\frac{K}{K+1}} \mathbf{H}_{d,n} + \sqrt{\frac{1}{K+1}} \mathbf{H}_{r,n}. \quad (2)$$

- $\mathbf{H}_{d,n}$: normalized deterministic components of the channel matrix (rank-one case/full-rank case)
- $\mathbf{H}_{r,n}$: normalized random components of the channel matrix ($\mathbf{H}_{r,n} = \mathbf{H}_w \mathbf{R}^{\frac{1}{2}}$)
- Rician K -factor: The power ratio of corresponding elements from $\mathbf{H}_{d,n}$ and $\mathbf{H}_{r,n}$ ($K = \frac{|[\mathbf{H}]_{i,j}|^2}{\mathbb{E}\{|[\mathbf{H}]_{i,j}|^2\}}$).

Channel Models



$K = 0$, channel fading is described by the Raleigh distribution

$K \neq 0$, channel fading is described by the Rician distribution.

Presentation Outline

- MIMO system models
- Correlated AS and K -factor statistical models
- Zero-forcing detection
- MIMO-OFDM, iterative receiver.

AS and K -factor statistical models

Table 1: Base-station AS and K statistics, WINNER II

Scenario	AS [$^{\circ}$]	K	ρ
A1: indoor office/residential	$10^{1.64+0.31\chi}$	$10^{0.1(7+6\psi)}$	-0.6
B1: typical urban microcell	$10^{0.40+0.37\chi}$	$10^{0.1(9+6\psi)}$	-0.3
B3: large indoor hall	$10^{1.22+0.18\chi}$	$10^{0.1(2+3\psi)}$	+0.2
C1: suburban	$10^{0.78+0.12\chi}$	$10^{0.1(9+7\psi)}$	+0.2
C2: typical urban macrocell	$10^{1.00+0.25\chi}$	$10^{0.1(7+3\psi)}$	+0.1
D1: rural macrocell	$10^{0.78+0.21\chi}$	$10^{0.1(7+6\psi)}$	+0.0
D2a: rural, high-speed	$10^{0.70+0.31\chi}$	$10^{0.1(7+6\psi)}$	+0.0

Correlation coefficient Eqn.

$$\psi = \rho \cdot \chi + \sqrt{1 - \rho^2} \cdot \omega; \quad \omega \sim \mathcal{N}(0, 1). \quad (3)$$

Presentation Outline

- MIMO system models
- Correlated AS and K -factor statistical models
- Zero-forcing detection
- MIMO-OFDM, iterative receiver.

Zero-forcing detection

- Conventional ZF detection approach: given the estimate \mathbf{G} of \mathbf{H}

$$[\mathbf{G}^{\mathcal{H}} \mathbf{G}]^{-1} \mathbf{G}^{\mathcal{H}} \mathbf{r} = \mathbf{x} + [\mathbf{G}^{\mathcal{H}} \mathbf{G}]^{-1} \mathbf{G}^{\mathcal{H}} \mathbf{n}. \quad (4)$$

- Employs the channel matrix estimate as if it were the true channel matrix
- Does not use the channel and noise statistics.

Zero-forcing detection

- Channel matrix is re-written as:

$$\mathbf{H} = \mathbf{H}_m + \mathbf{H}_e, \quad (5)$$

- The received signal vector becomes:

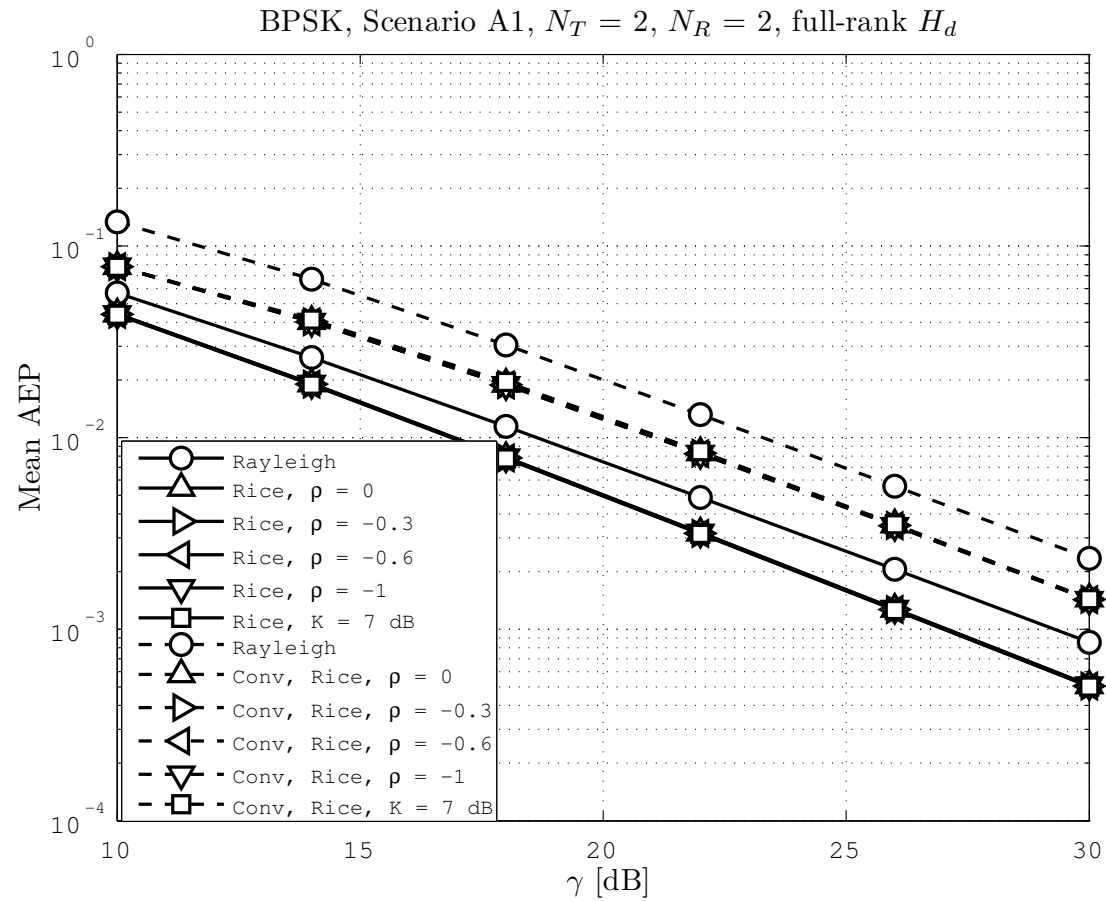
$$\mathbf{r} = \sqrt{\frac{E_s}{N_T}} \mathbf{H}_m \mathbf{x} + \underbrace{\sqrt{\frac{E_s}{N_T}} \mathbf{H}_e \mathbf{x} + \mathbf{n}}_{\boldsymbol{\nu}}, \quad (6)$$

where $\boldsymbol{\nu}$ denotes the effective noise, comprising channel estimation error and actual noise.

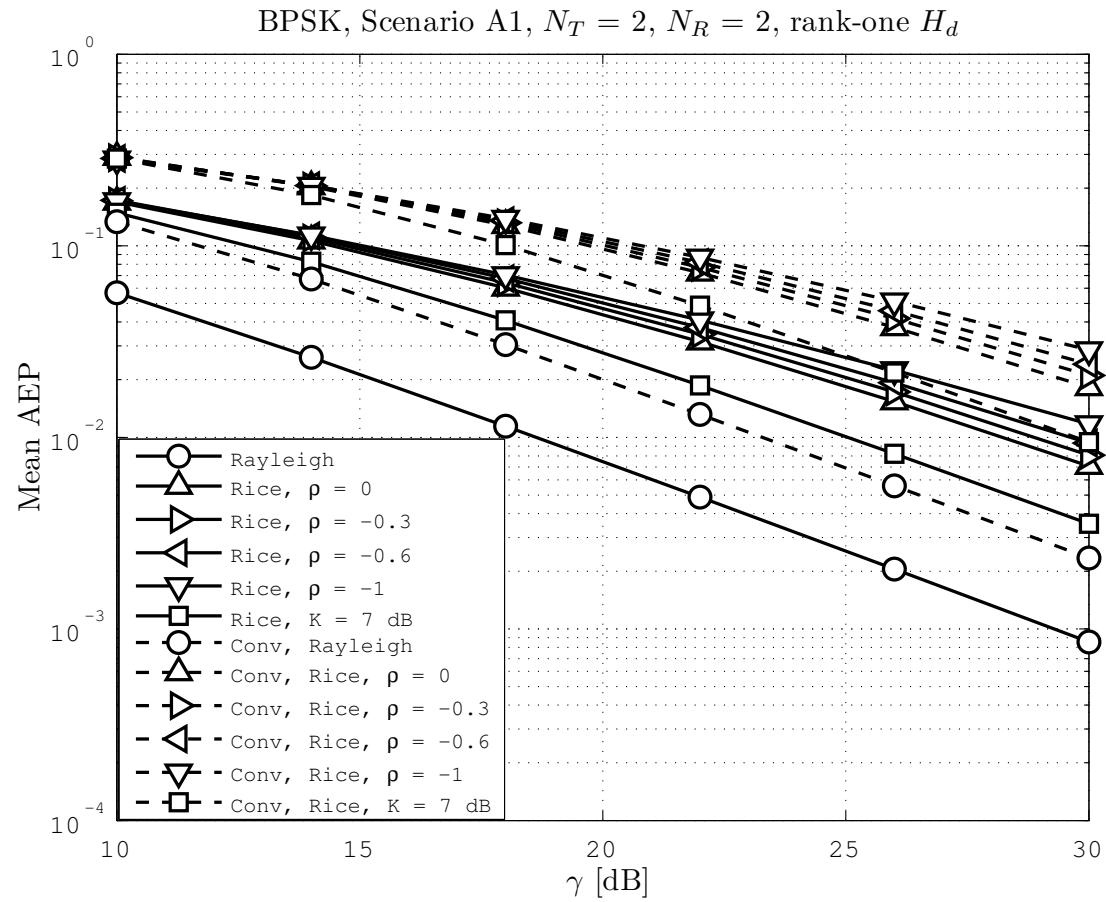
- New ZF detection approach: replace \mathbf{G} with \mathbf{H}_m

$$\left[\mathbf{H}_m^{\mathcal{H}} \mathbf{H}_m \right]^{-1} \mathbf{H}_m^{\mathcal{H}} \mathbf{r} = \mathbf{x} + \left[\mathbf{H}_m^{\mathcal{H}} \mathbf{H}_m \right]^{-1} \mathbf{H}_m^{\mathcal{H}} \boldsymbol{\nu}. \quad (7)$$

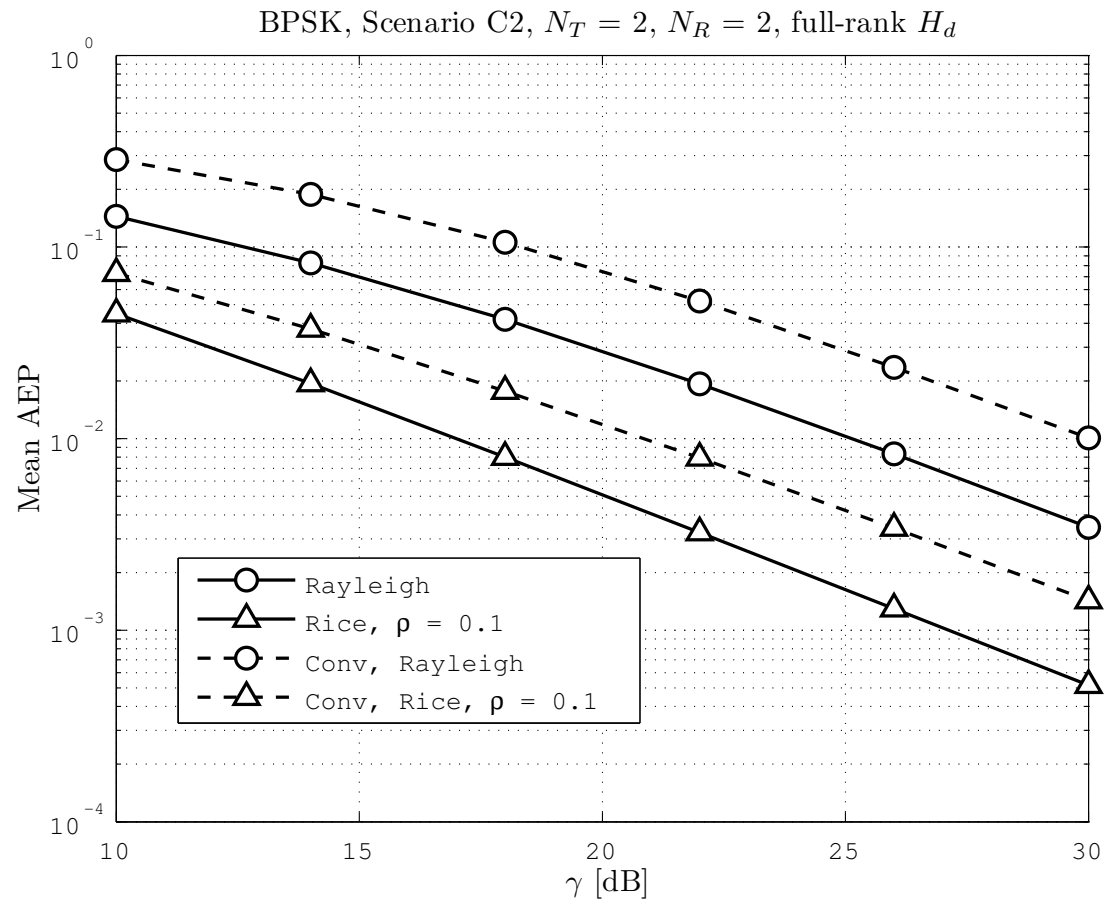
Performance for 2×2 MIMO (Indoor office/Residential, full-rank)



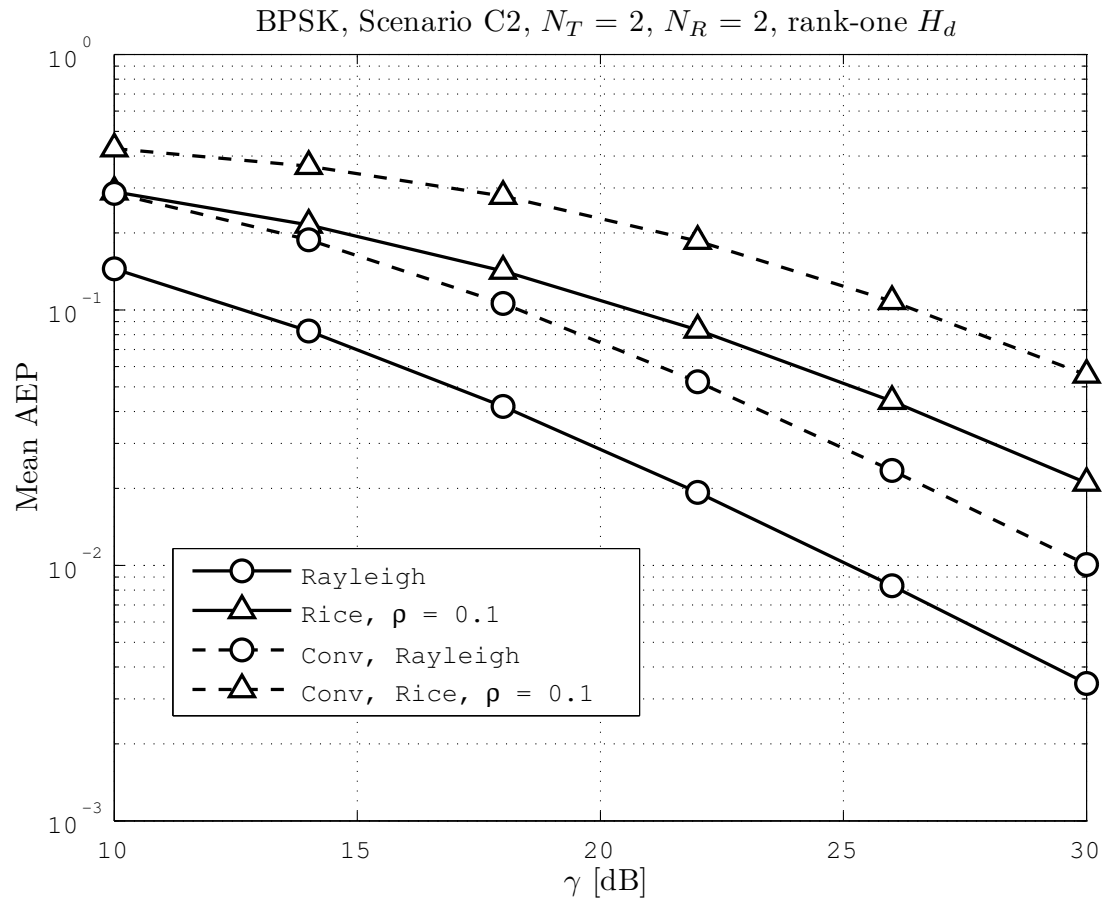
Performance for 2×2 MIMO (Indoor office/Residential, rank-one)



Performance for 2×2 MIMO (Typical urban macrocell, full-rank)



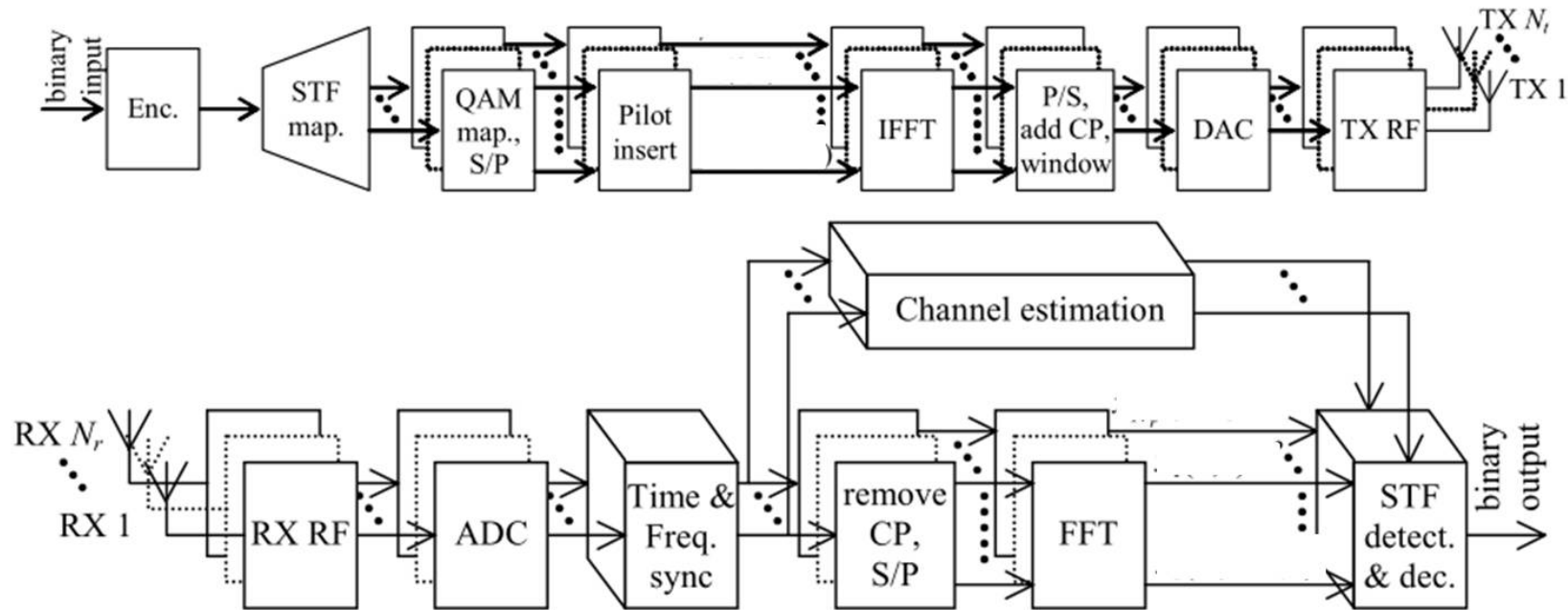
Performance for 2×2 MIMO (Typical urban macrocell, rank-one)



Presentation Outline

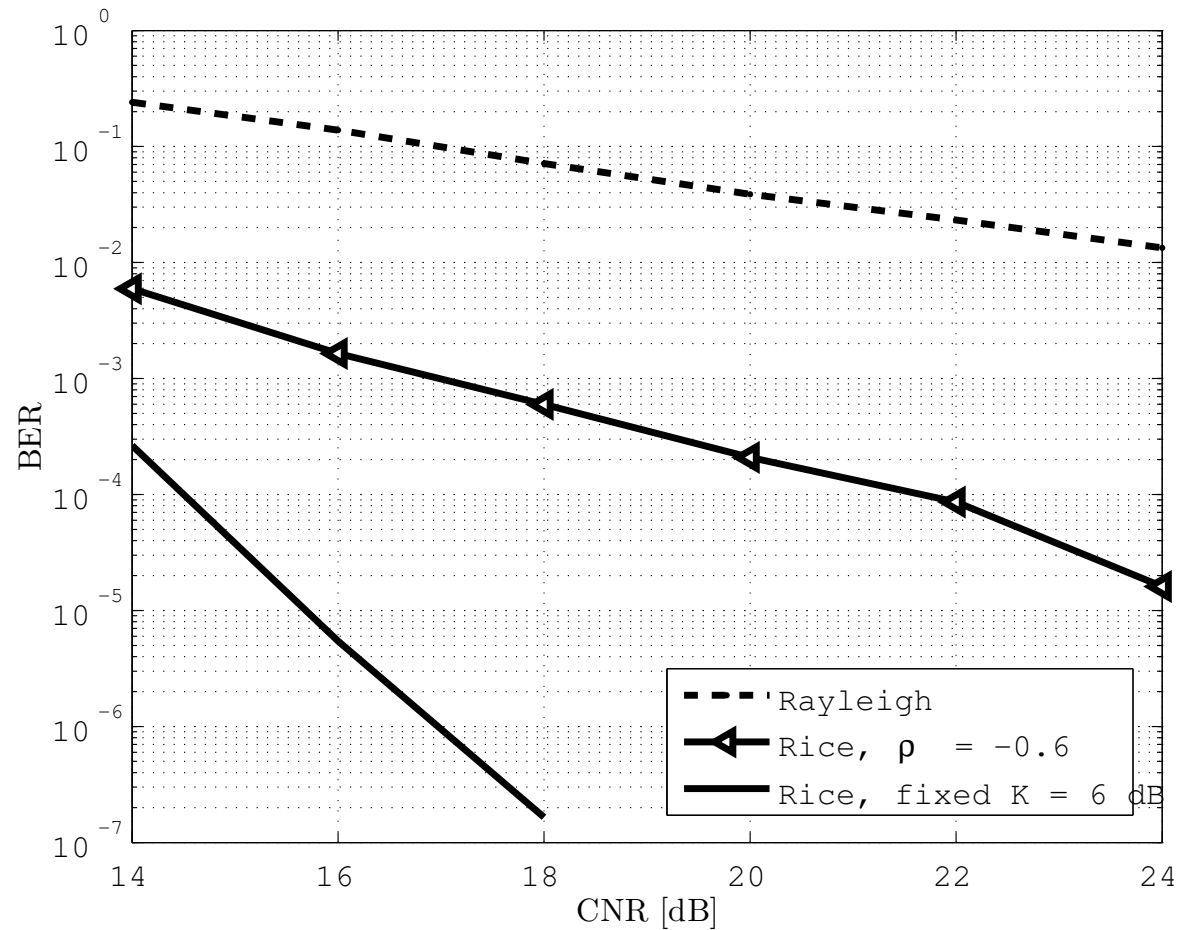
- MIMO system models
- Correlated AS and K -factor statistical models
- Zero-forcing detection
- MIMO-OFDM, iterative receiver.

MIMO-OFDM

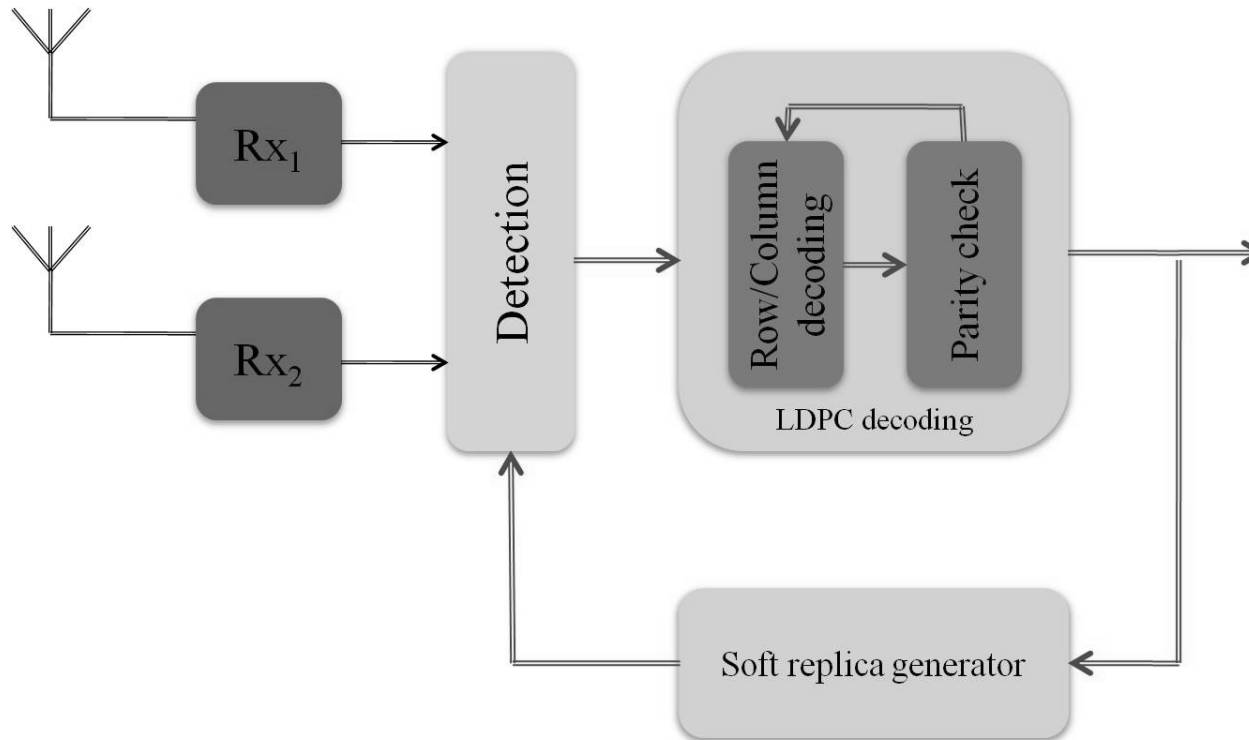


- OFDM: specific orthogonality constraints between multi-carrier ; achieves high spectral efficient
- MIMO-OFDM: Provide basis for next-generation wireless communications systems (Potential application areas–WLANs).

Performance for 4×4 MIMO-OFDM Iterative Receiver (Indoor office/Residential)

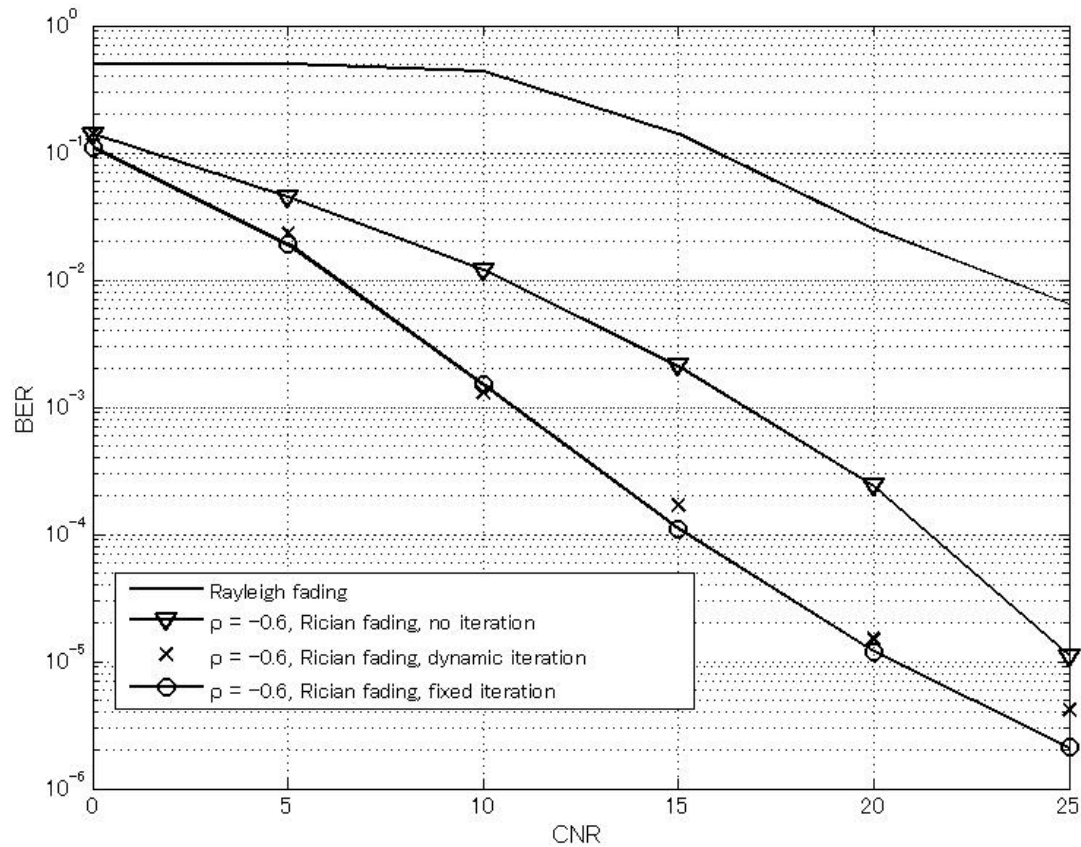


Iterative receiver



- Iterative receiver: Feasible to approach BER performance

Performance for 4×4 MIMO-OFDM Iterative Receiver (Indoor office/Residential)



Future Work – Multi-user MIMO(OFDM)

- Construct multi-user MIMO(OFDM) system by explored knowledge for realistic channel model
- Capture the serious effect of AS and K -factor correlation on the performance indications
- Optimal (mobile) receiver design with obtained channel information
- Feedback complexity reduction with reliability channel conditions information.