Comparison of Precoding Methods for Broadband MIMO Systems

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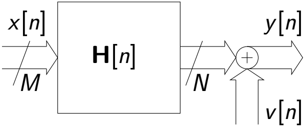
Overview

Motivation

- With the increased demand for high-quality wireless communication services
- And the scarcity of available radio spectrum
- Wireless Comm. with MIMO broadband channels is emerged
- Aim — high data throughput transceiver design with better QoS

Introduction



The broadband MIMO system can be described by a polynomial channel matrix

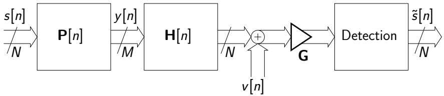
$$\mathbf{H}(z) = \sum_{l=0}^{L} z^{-l}\mathbf{H}_l \,, \qquad (1)$$

- OFDM-based solutions—narrowband subsystems
- Block precoding/equalisation—[Scaglione-1999]

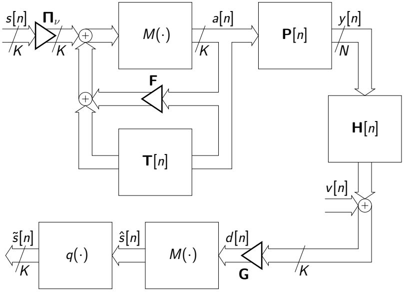
Drawbacks—extra redundancy, lower data throughput

Existing Non-block-Based Approaches

- V-BLAST approaches [Lozano-2002, Choi-2004]
- Linear & THP [Joham-2007] — used as a benchmark



Linear precoding



THP precoding

Problem Formalisation

The approach of this paper is done in two stages:

- Stage (1) — *CCI Mitigation*

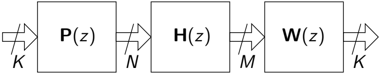
The system in (1) can be diagonalised using a novel broadband SVD (BSVD) [McWhirter-2007] such that

$$\mathbf{H}(z) = \mathbf{U}(z)\mathbf{D}(z)\tilde{\mathbf{V}}(z) \qquad (2)$$

where $\mathbf{U}(z)$ and $\mathbf{V}(z)$ are paraunitary matrices, i.e.,

$$\tilde{\mathbf{U}}(z)\,\mathbf{U}(z) = \mathbf{U}(z)\,\tilde{\mathbf{U}}(z) = \mathbf{U}(z)\,\mathbf{U}^H(z^{-1}) = \mathbf{I} \qquad (3)$$

Defining a precoder $\mathbf{P}(z) = \mathbf{V}(z)$ and an equaliser $\mathbf{W}(z) = \tilde{\mathbf{U}}(z)$, the overall MIMO broadband system $\mathbf{H}(z)$ can be reduced to a diagonalised system $\mathbf{D}(z)$



Problem Formalisation (Contd.)

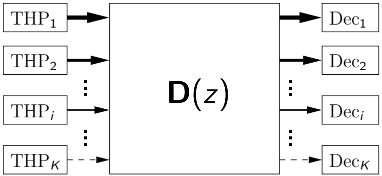
- Stage (2) — *ISI Mitigation*

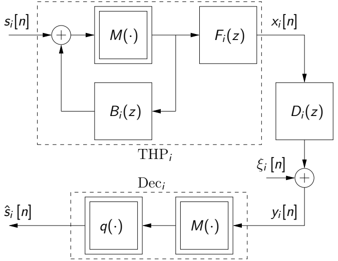
$\mathbf{D}(z)$ is a diagonalised and spectrally majorised system such that

$$\mathbf{D}(z) = diag\,\{D_0(z), D_1(z), \cdots D_{K-1}(z)\} \quad (3a)$$

$$D_0(e^{j\Omega}) \geq D_1(e^{j\Omega}) \geq \cdots \geq D_{K-1}(e^{j\Omega}) \;\forall\Omega \quad (3b)$$

where $K = \min(M, N)$

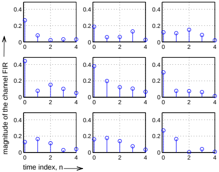


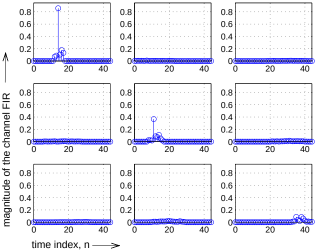


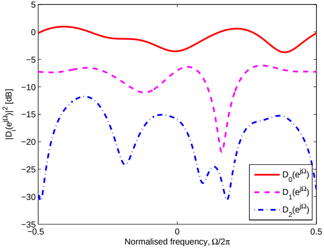
$F_i(z)$, and $B_i(z)$ are computed using the spectral factorisation theorem [Fisher-2005]

An Illustrative BSVD example

A 3x3 MIMO channel instance with exponentially power delay profile and $L = 4$ is shown to illustrate the BSVD algorithm







Same Throughput Bit Loading

Table: BSVD-SISO for Same Throughput as a 4x4 MIMO System

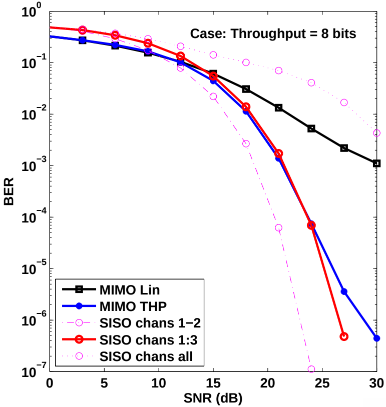
Throughput	Case1: 8-bits	Case2: 16-bits	Case3: 24-bits
MIMO	**QPSK**	**16-QAM**	**64-QAM**
SISO-1	16-QAM	64-QAM	256-QAM
SISO-2	QPSK	64-QAM	256-QAM
SISO-3	QPSK	16-QAM	64-QAM
SISO-4	QPSK	QPSK	QPSK

Performance Evaluation

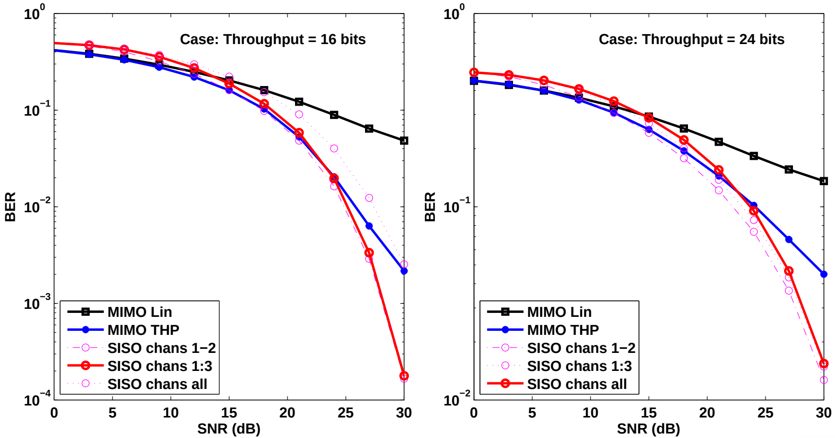
simulation parameters

A 4x4 MIMO system with the following:

- $\mathbf{H}_l \in \mathcal{CN}(0, -2\text{dB} \times I)$
- $L = 5, \ L_f = 10$
- $L_f^{(i)} = 2 \times \text{order}\{D_i(\text{z})\}$
- $L_b^{(i)} = \text{order}\{D_i(\text{z})\}$
- 300 different channel realisations



Performance Evaluation (Contd.)



Conclusions

- A BSVD-based solution with variable transmission rates is proposed
- This is resulting in a number of independent SISO subchannels with ordered qualities
- SISO-THP precoding algorithm with variable rates is applied to combat ISI
- This method is compared with a MIMO-THP incorporating spatio/temporal ordering
- Better BER performance is achieved for same target throughputs and transmit power

Questions

Thank You — Any Questions