Iterative Spatial Sequence Estimator for Multi-Group Space Time Trellis Coded Systems

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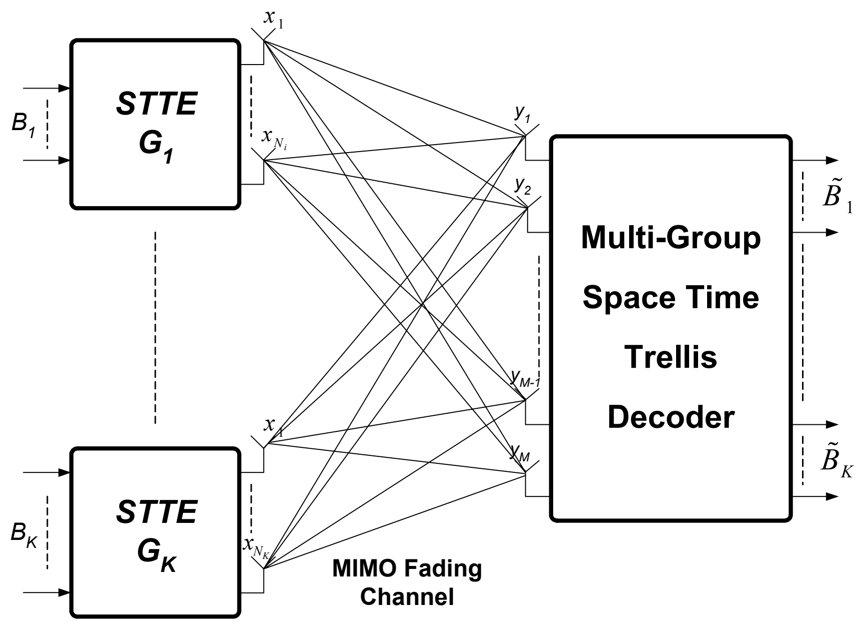

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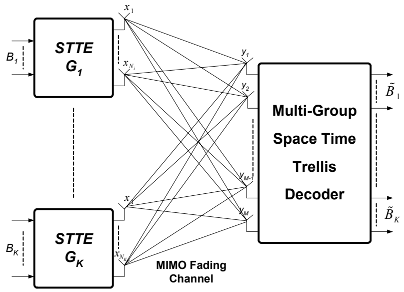
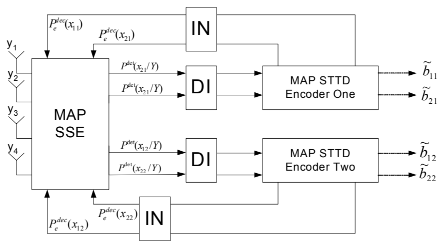
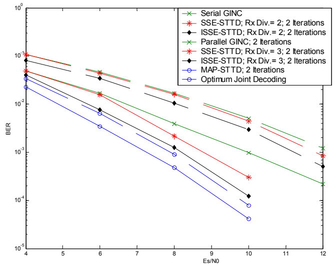
Iterative spatial sequence estimation algorithm is proposed for decoding Multi-Group STTC systems



Architecture, system model and background



ISSE algorithm description



Simulation results

This is a single user system that combines transmit diversity and spatial multiplexing, the transmitter consists of *K* parallel synchronous space-time trellis encoders

Advantages:

high data rates,

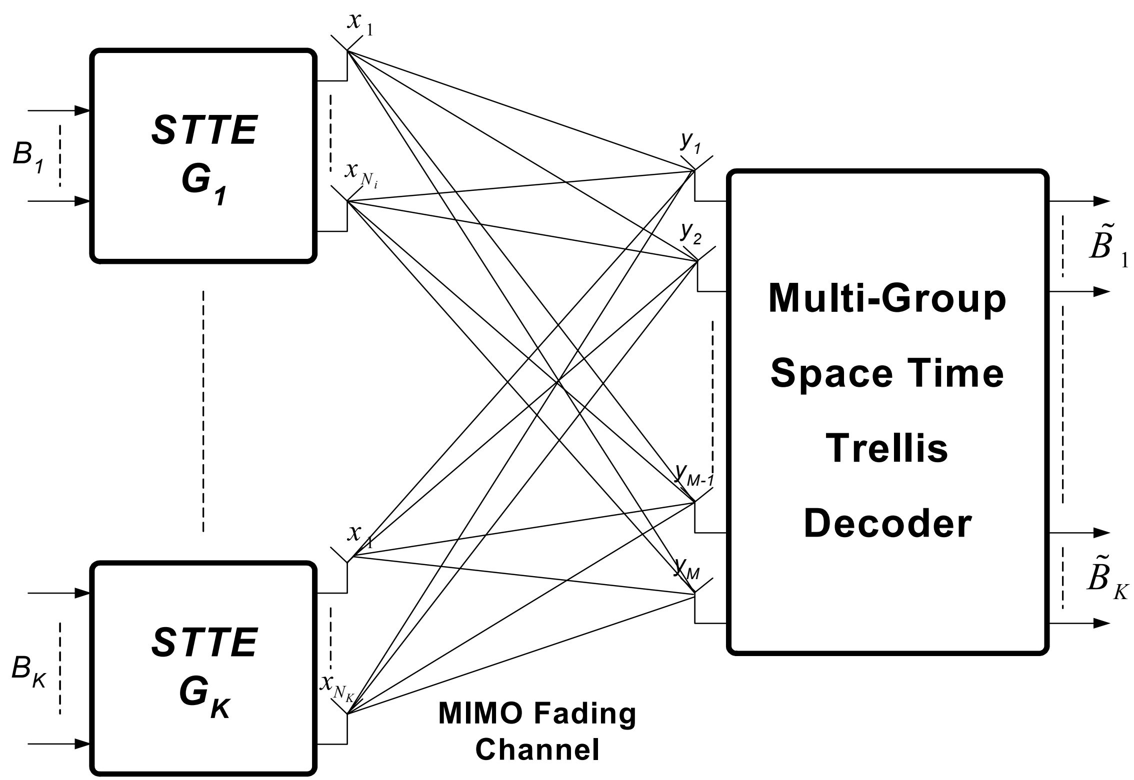
transmit diversity,

and coding gains

without any bandwidth expansions or extra power

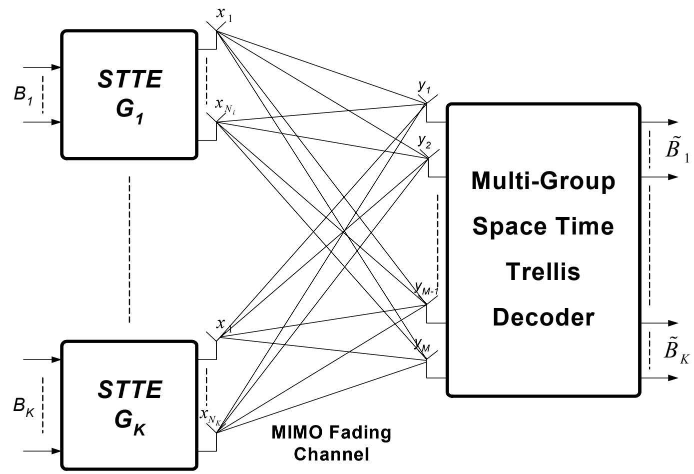
Disadvantage:

more decoding complexity



At the receiver, the discrete received vector is

$$\mathbf{y}^t = \mathbf{H}\mathbf{x}^t + \boldsymbol{\eta}^t$$



Where,

$$\mathbf{x}^t = \left[(\mathbf{x}_1^t)^T \quad \cdots \quad (\mathbf{x}_K^t)^T \right]^T$$

$$\mathbf{H} = \begin{bmatrix} h_{11} & \cdots & h_{1n_1} & h_{1(n_1+1)} & \cdots & h_{1N_T} \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ h_{N_R 1} & \cdots & h_{N_R n_1} & h_{N_R (n_1+1)} & \cdots & h_{N_R N_T} \end{bmatrix}_{N_R \times N_T}$$

$$\mathbf{H} = \left[\mathbf{H}_1 \quad \mathbf{H}_2 \quad \cdots \quad \mathbf{H}_K \right]_{N_R \times N_T}$$

$\boldsymbol{\eta}^t$ **Is the AWGN vector of zero mean and** $N_0/2$ **variance**

Previous detection algorithms were studied earlier in [samir et. al 04]

- **Group interference nulling and cancellation (GINC)**
  - **Serial**
  - **Parallel**
- **Joint Detection**
  - **Optimum**
  - **Suboptimum iterative joint detector.**

Background : group interference nulling and cancellation

Group interference nulling:

$$\mathbf{y} = \begin{bmatrix} \mathbf{H}_1 & \mathbf{H}_2 & \cdots & \mathbf{H}_K \end{bmatrix} \mathbf{x} + \boldsymbol{\eta}$$

-To detect group *k*, find the orthonormal bases $(\boldsymbol{\Theta}_k)$ of the null space of H-{H_k}, then project y into this null space

$$\tilde{\mathbf{y}}_k = \boldsymbol{\Theta}_k \mathbf{y} = \tilde{\mathbf{H}}_k \tilde{\mathbf{a}}_k + \tilde{\boldsymbol{\eta}}_k$$

source of Rx diversity reduction

Group interference cancellation:

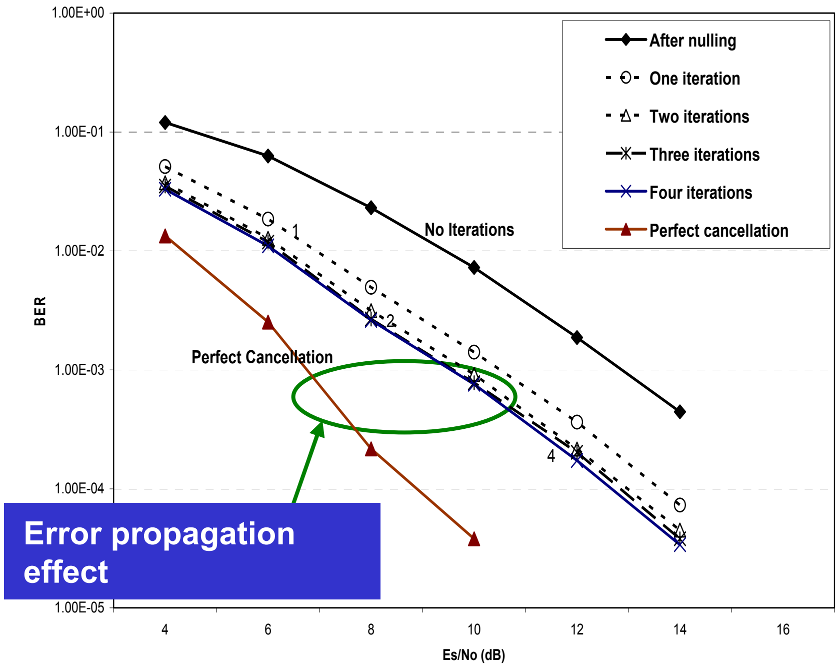
$$\tilde{\mathbf{y}} = \mathbf{y} - \mathbf{H}_k \tilde{\mathbf{x}}_k$$

source of error propagation

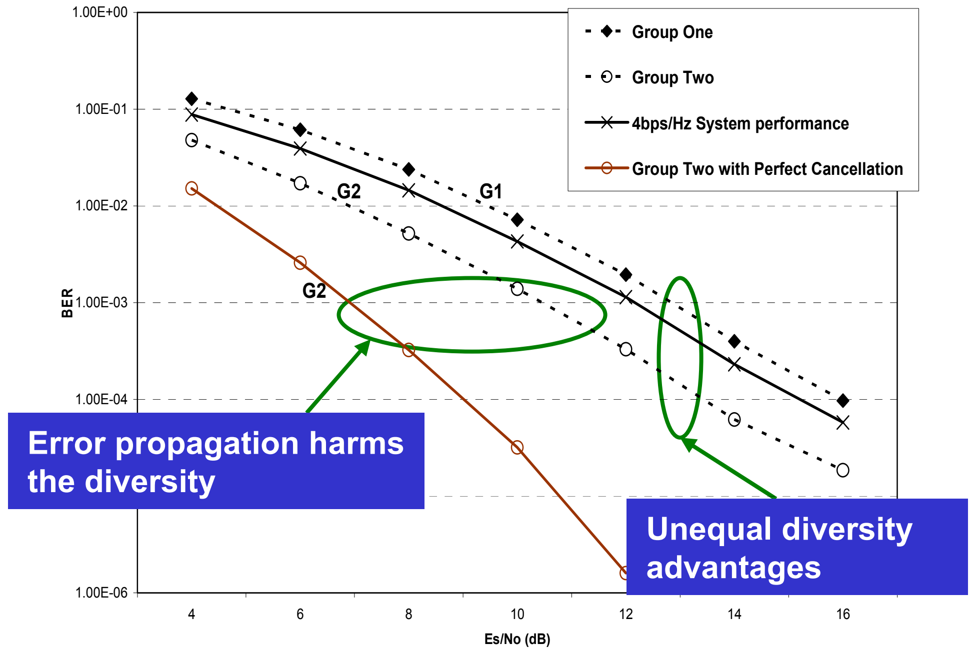
Disadvantages of GINC

Error propagation, Reduced receive diversity

Parallel



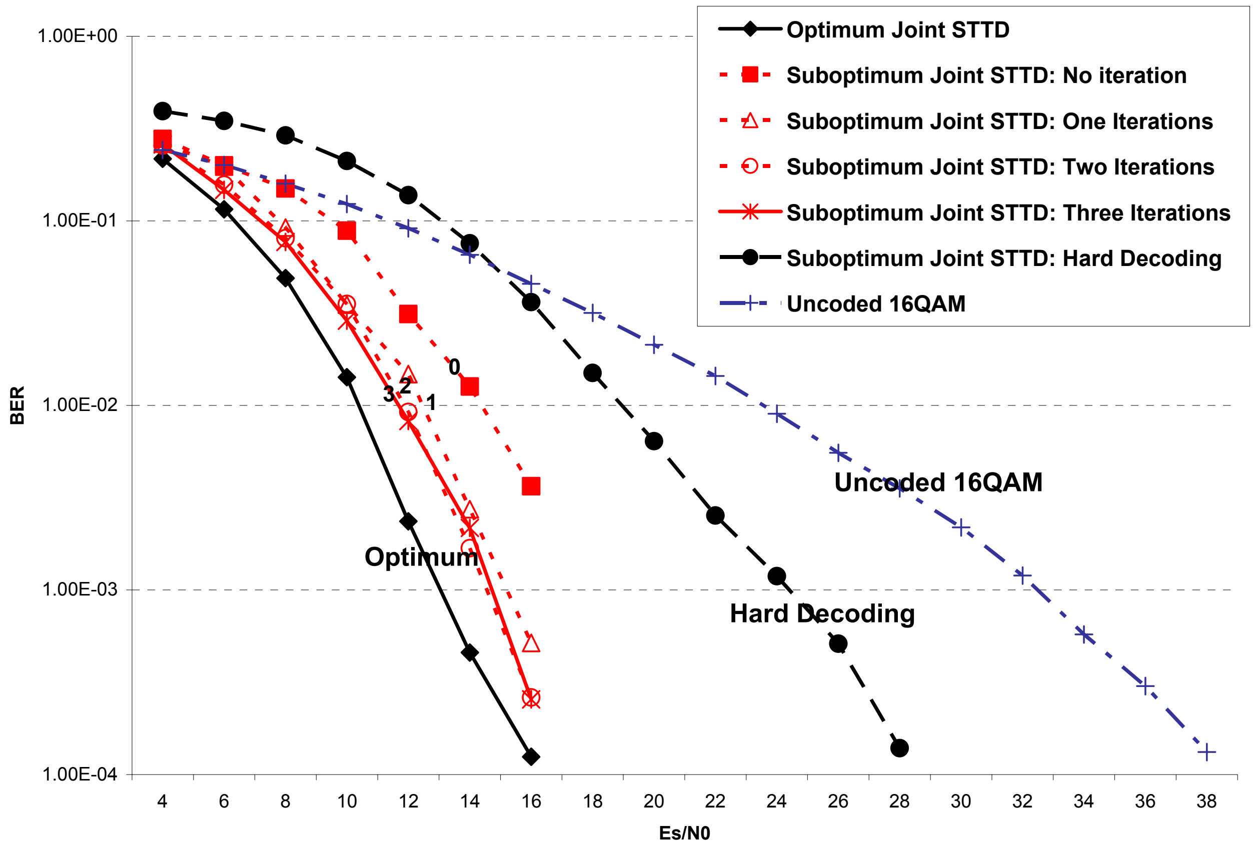
Serial [Tarokh99]



Two GSTTCs, $N_T = N_R = 4$

Joint detection is provides full diversity and doesn't suffer form error propagation but with exponential complexity per group

Two STTEs
8-states QPSK
N_T =4
N_R=2

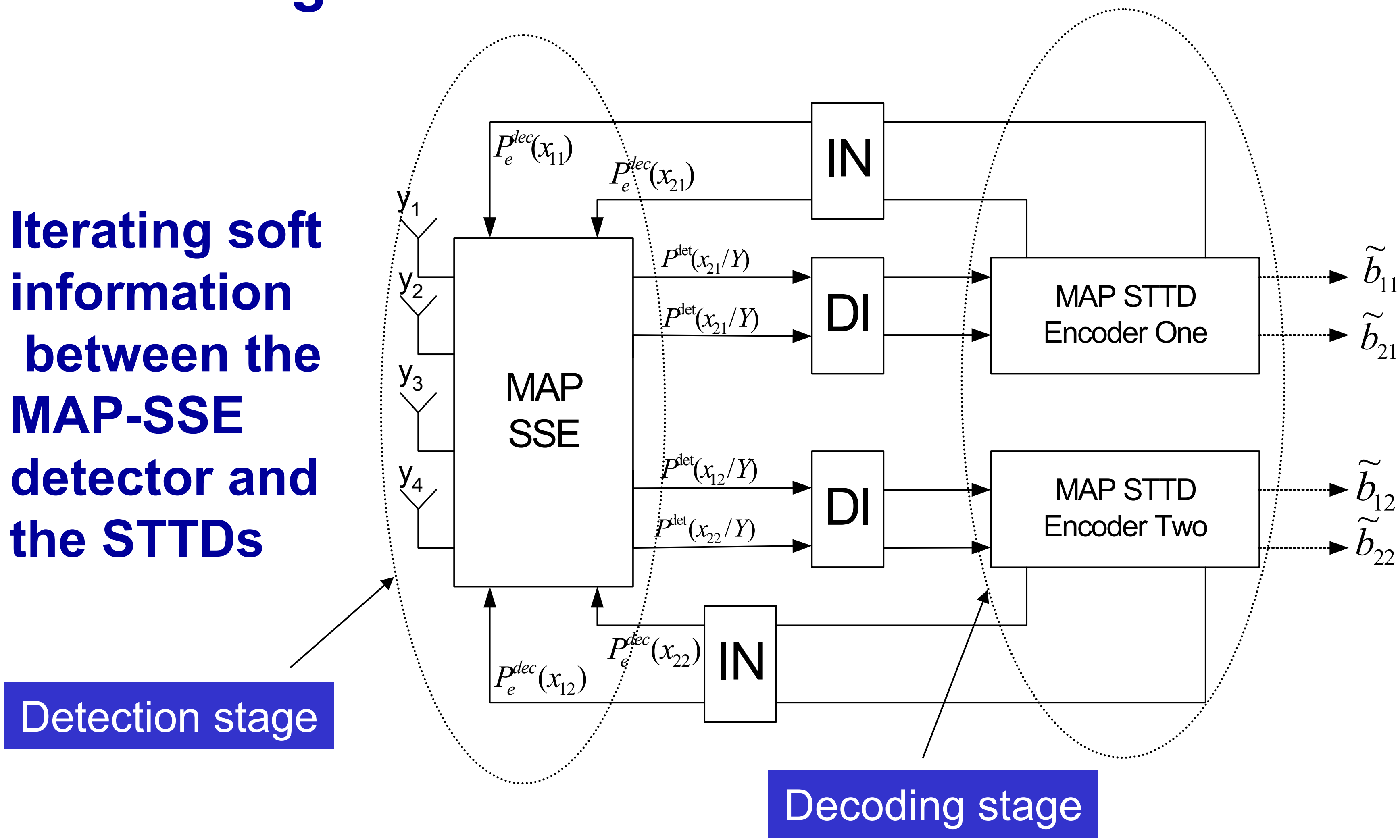


Our proposal in this work is a new multi-group detector that is based on the spatial sequence estimator (SSE) [Maruf et al session 3.4.4 today].

- **The algorithm combines joint detection and interference nulling in away that permits complexity / performance tradeoffs -inherent in the algorithm- and avoids error propagation among the groups.**
- **To minimize information loss, soft input soft output algorithm is built onto the SSE to detect the MGSTTC systems.**

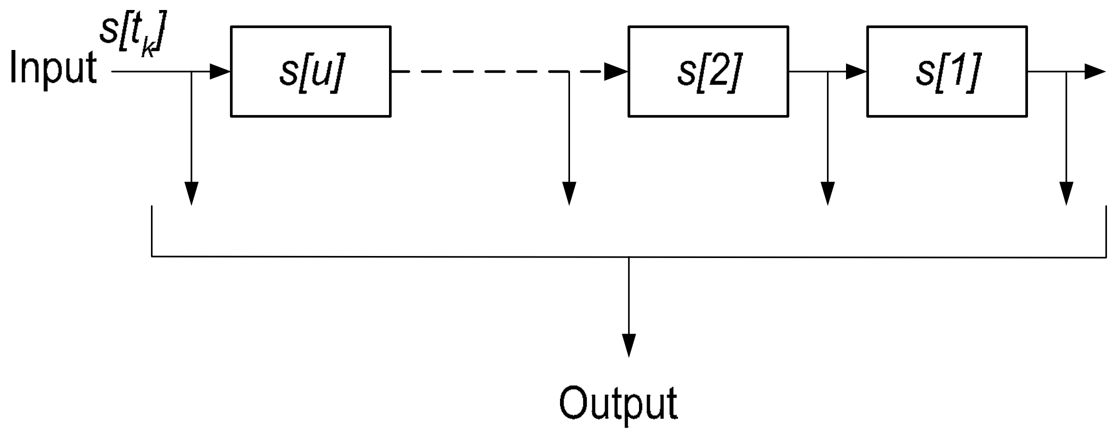
Block diagram for 2GSTTC

Iterating soft information between the MAP-SSE detector and the STTDs



Trellis formulation for the spatial sequence estimator is based on introducing memory into spatially transmitted symbols

Spatial state machine: group of *L* antennas, *u*=*L*-1



Window length = N_T+1

# of states at each stage = M^{L-1}

each state will have M transitions

Next symbol index is found by

$$t = \mathrm{mod}(\mu + k - 1, N_T + 1) + \left\lfloor (\mu + k - 1)/(N_T + 1) \right\rfloor$$

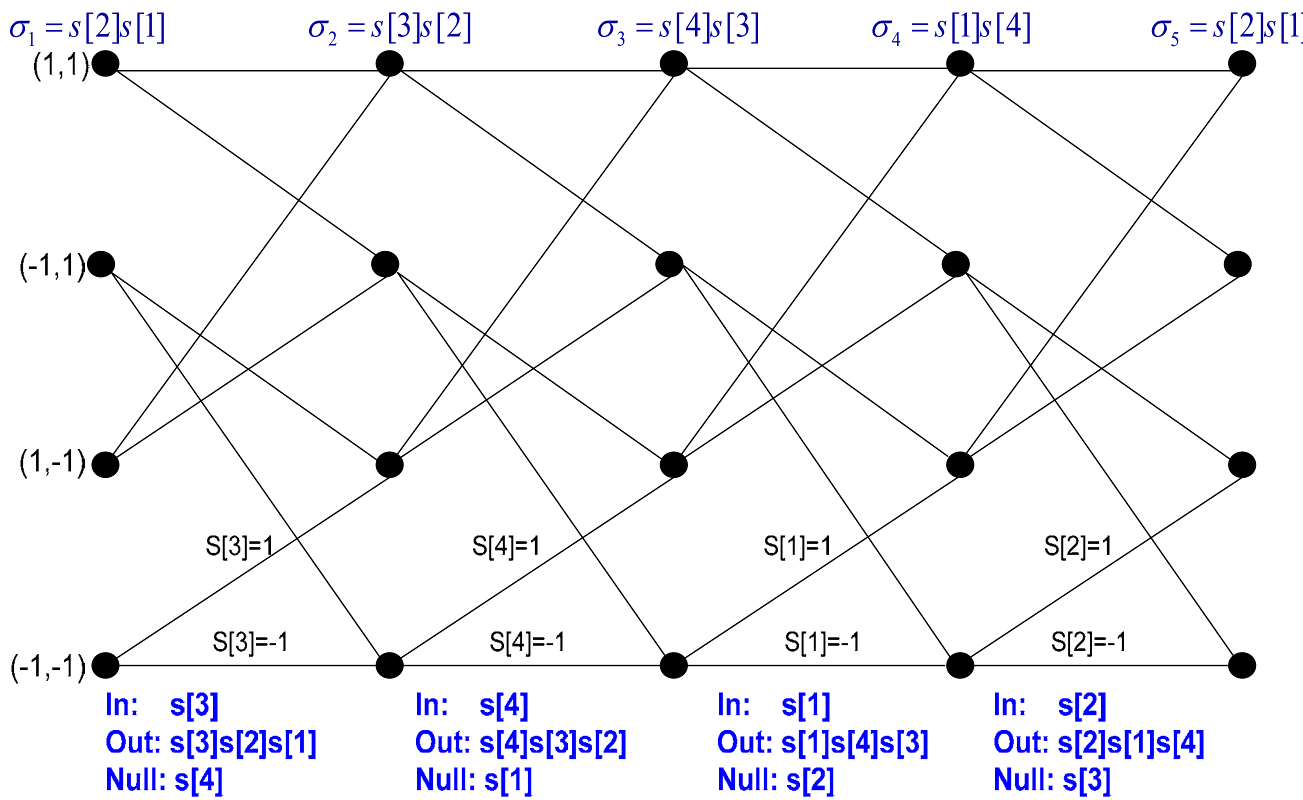
Receive diversity is equal for each group, Rx Div.= $N_R - N_T + L$

Example: N_T=4, BPSK symbols and L=3

Window length =5

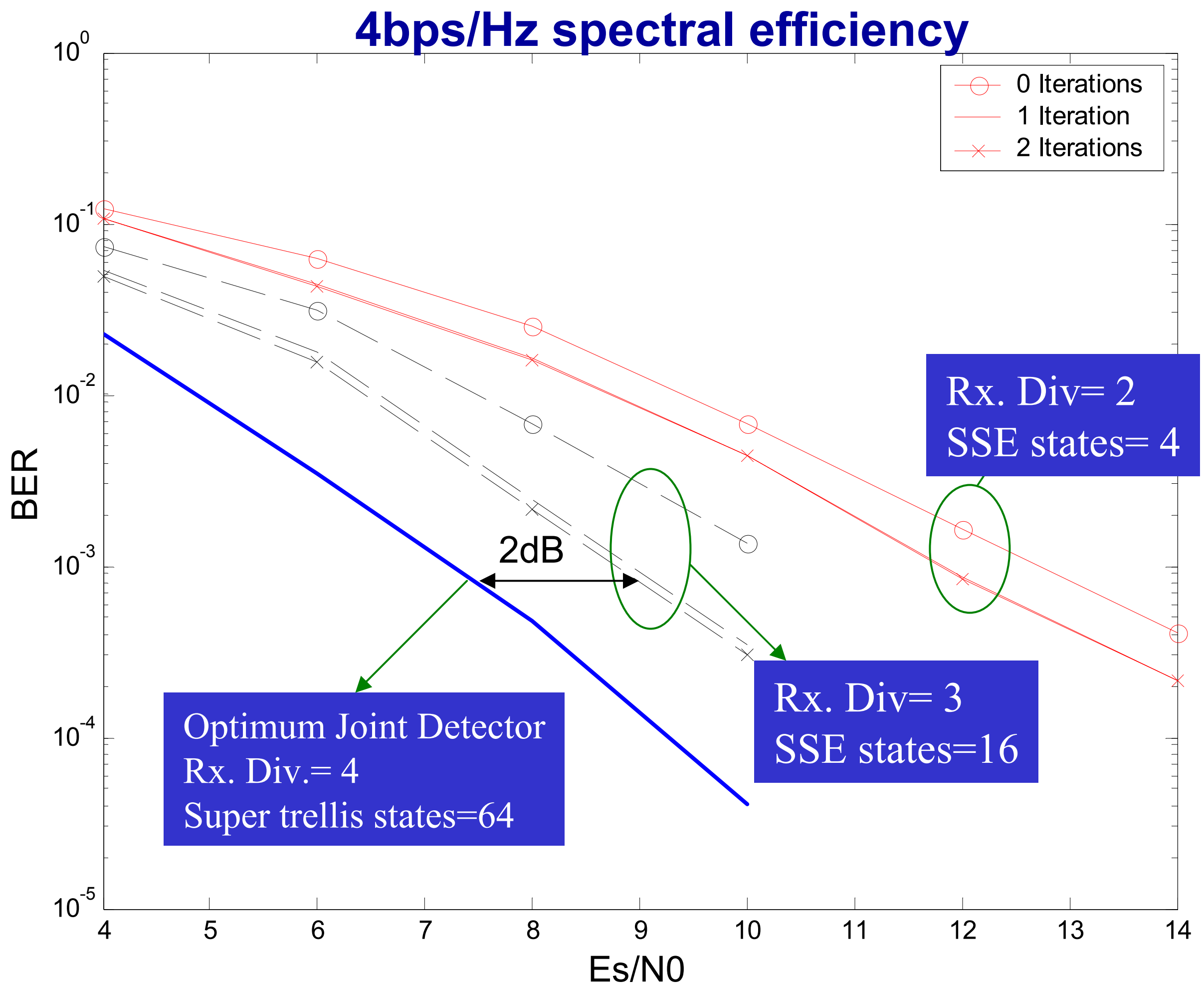
states =4

First stage is equal to the last stage, enables the use of tail biting



SSE performance for 2GSTTCs

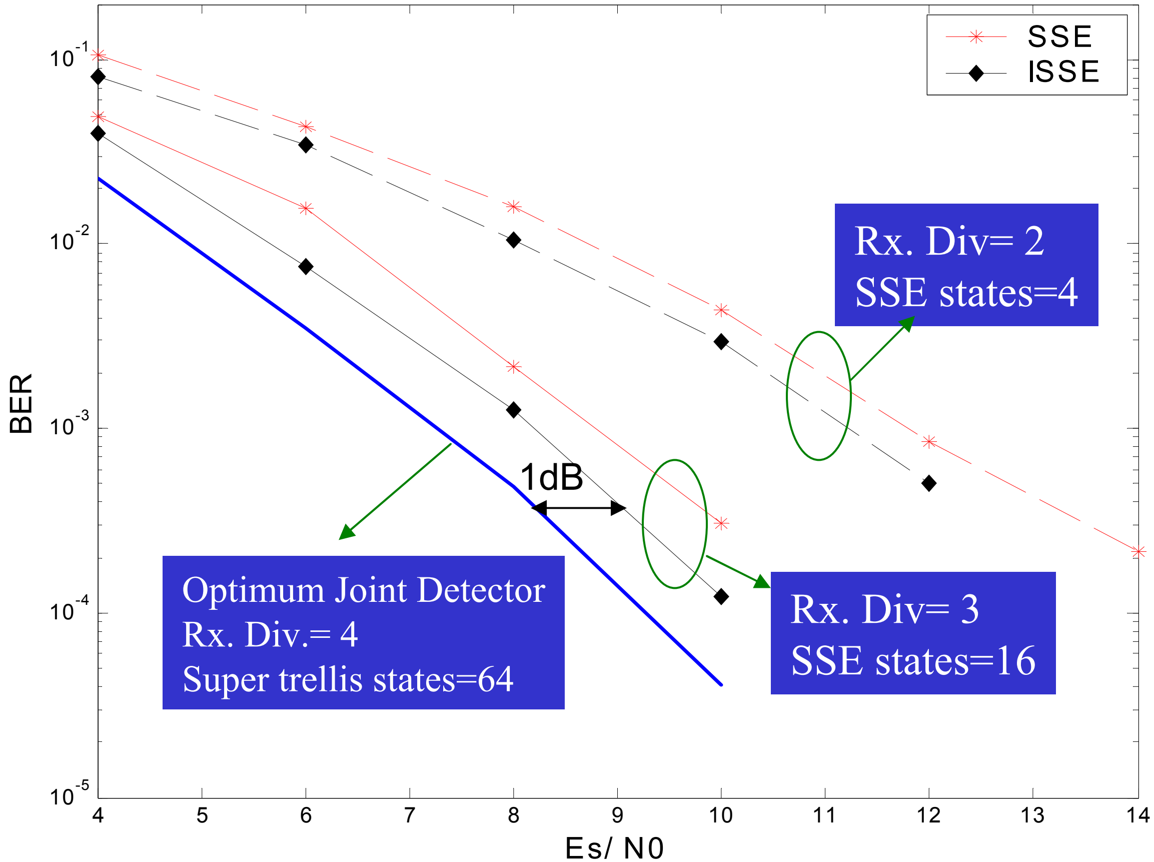
Two Groups
8-states QPSK STTC
N_T=4
N_R=4
Tx Div.=2
Rx Div.=*L*
States=4^(*L*-1)



Further iterations within the estimator itself improves the performance (utilizing tail biting technique)

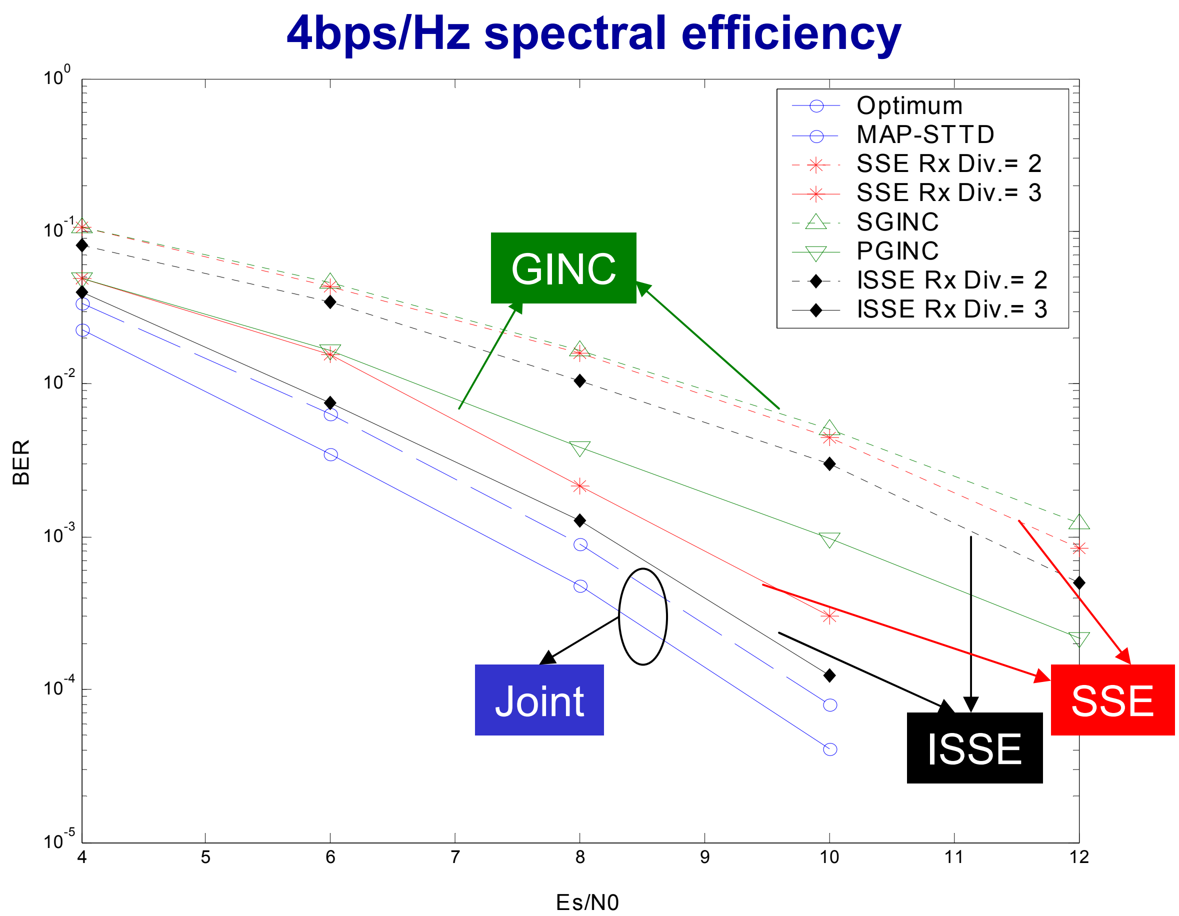
4bps/Hz spectral efficiency

2 iterations within SSE
Two Groups
8-states QPSK STTC
N_T=4
N_R=4
Tx Div.=2
Rx Div.=L
States=4^(L-1)



2GSTTC decoding algorithms comparison

Two Groups
8-states QPSK STTC
N_T**=4**
N_R**=4**



In summary, we have presented and evaluated the performance of a novel multi-group detector (SSE).

- The algorithm combines joint detection and interference nulling to formulate the spatial trellis description of the transmitted symbols.
- The design parameter of SSE is the number of grouped antennas, L, which sets the trade-off between complexity and performance.
- The receive diversity achieved by all groups is N_R-N_T+L.
- Cleary as more transmit antennas are grouped, the diversity advantage increases and the number of states increases (M^{L-1}), and thus the complexity also increases exponentially.