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“Recursive Least-Squares Adaptive Channel Estimation for Spatial Modulation Systems”

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Outline

- Introduction
- Spatial Modulation
- Optimal Detection
- Recursive Least-Squares Adaptive Channel Estimation
- Simulation Results
- Conclusions

Introduction

- The necessity for higher data rate and higher spectral efficiency are the key elements that are driving research in future wireless communication systems.

- Multiple-input-multiple-output (MIMO) transmission scheme is one solution to achieve this by transmitting multiple data streams from multiple antennas.

- The capacity gain resulting from MIMO transmission is dependent on transmit and receive antenna spacing, transmit antenna synchronization, and the algorithm employed to combat the interchannel interference (ICI) at the receiver.

Introduction contd.

- Many ICI reduction algorithms have been reported in the literature and among them is the vertical Bell Labs layered space-time (V-BLAST), which is considered as one of the most promising MIMO detection algorithms.

- In this work, we consider spatial modulation (SM) scheme with practical channel estimation based on recursive least-squares adaptive channel estimation for over block fading MIMO channels.

Spatial Modulation

- In spatial modulation system, a block of information bits are mapped into two information carrying units: a symbol that was chosen from a constellation diagram, and a unique transmitter antenna number that was chosen from a set of transmitter antennas, which increases the overall spectral efficiency of the spatial modulation system by the base-two logarithm of the number of transmitter antennas.

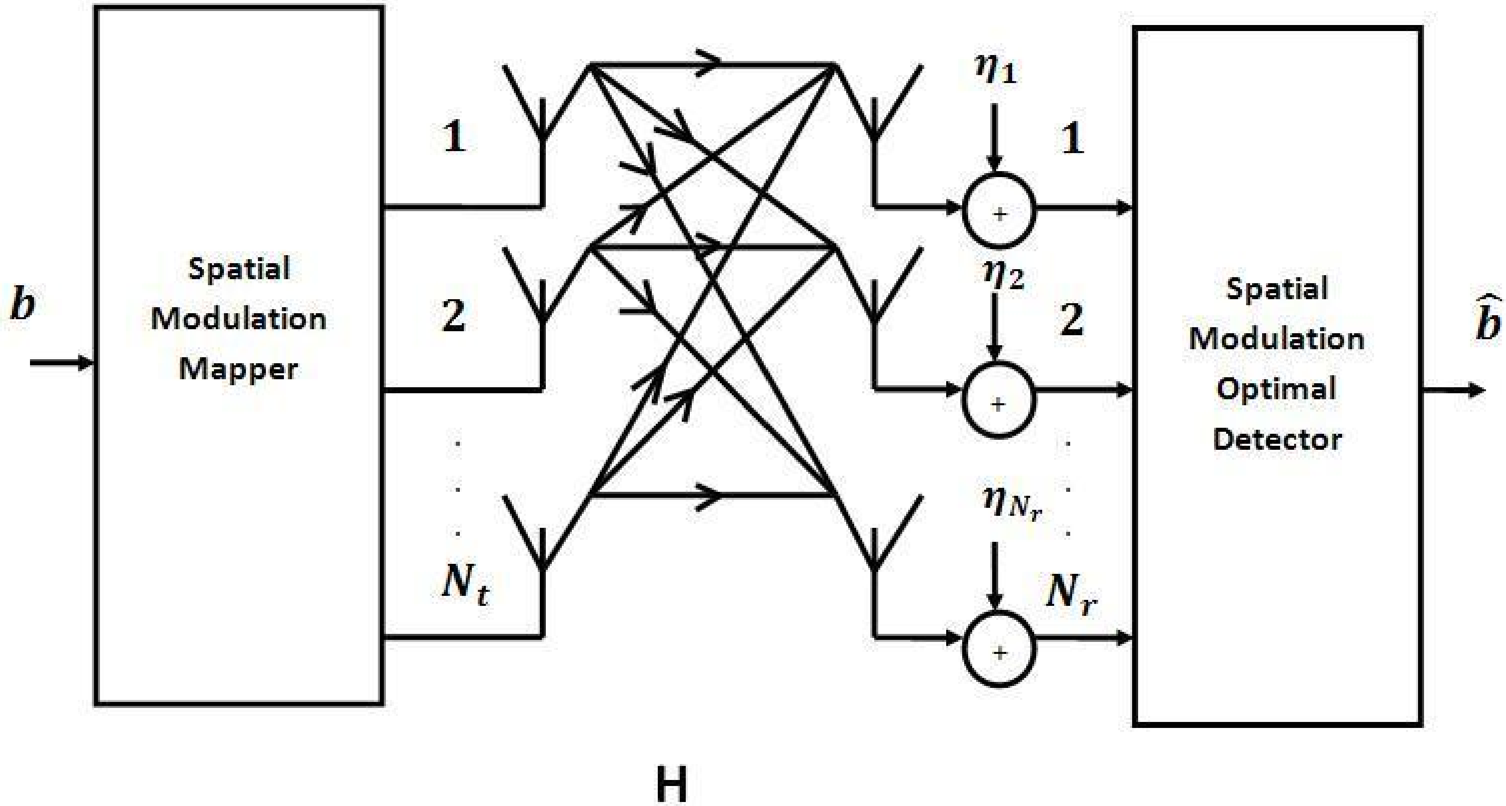
- In general, the number of bits that can be transmitted using spatial modulation system is given as follows:

$$n = \log_2(N_t) + m.$$

- For M-QAM modulation, *m* is the number of bits/symbol and is given by:

$$m = \log_2(M).$$

Spatial Modulation contd.



Spatial Modulation contd.

Some of the advantages of SM over other transmission schemes like V-BLAST here:

- ICI is completely avoided.
- Inter-antenna synchronization (IAS) is not needed.
- Provides high spectral efficiency.
- Results in a significant reduction in receiver complexity.
- Does not suffer from the error propagation problem that exists in V-BLAST.

Optimal Detection

- The receiver estimates both the transmitted symbol and the transmitter antenna number and uses these two pieces of information to de-map the block of information bits.

- The optimal detector is based on the maximum likelihood (ML) principle:

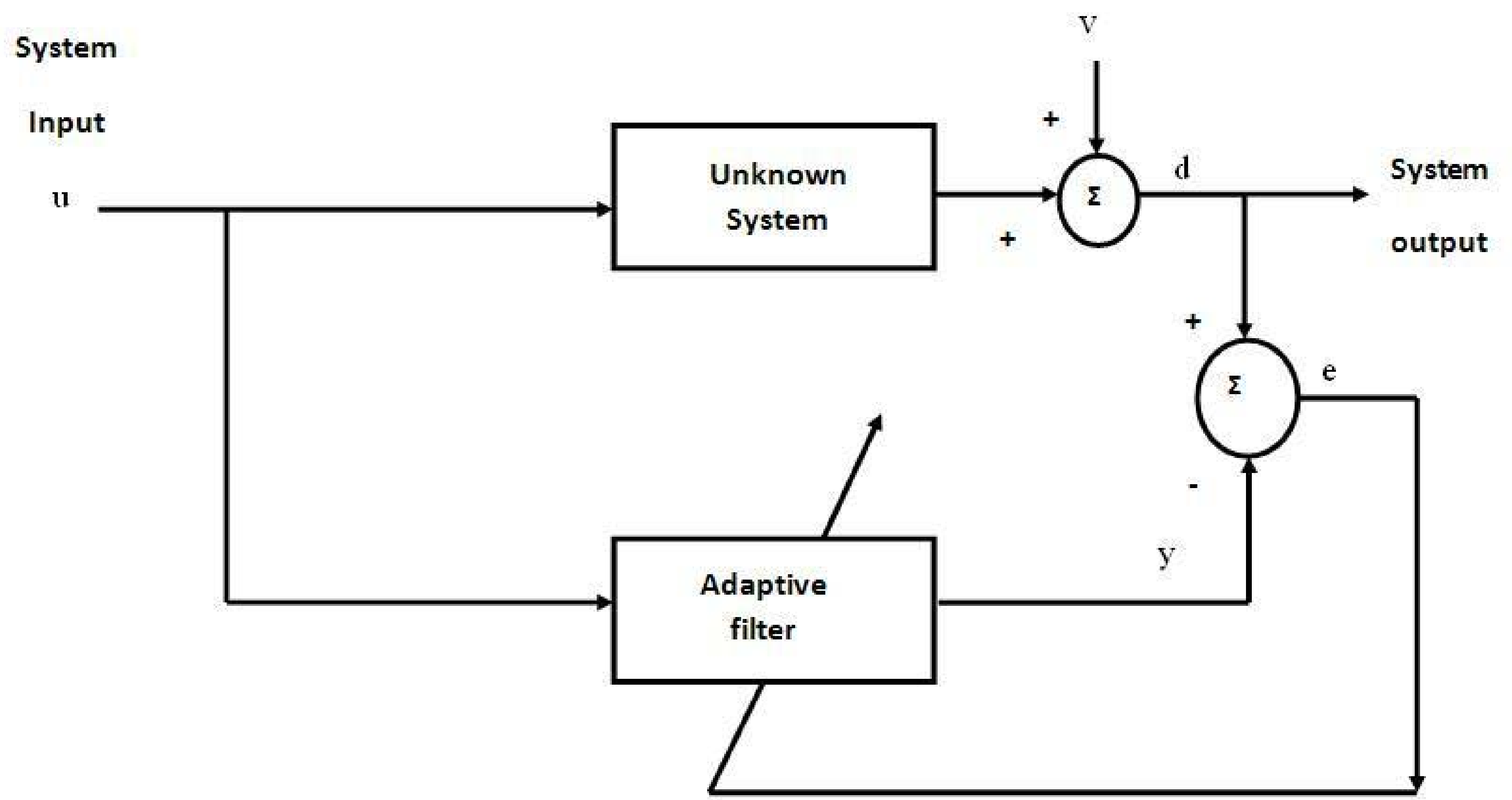
$$[\hat{j}_{\mathrm{ML}}, \hat{q}_{\mathrm{ML}}] = \arg_{j,q} \min \sqrt{\rho} \, \| g_{jq} \|_{\mathrm{F}}^2 - 2\mathrm{Re}\{ \mathrm{y}^H \mathrm{g}_{jq} \},$$

$$\text{where } \mathrm{g}_{jq} = h_j x_q, \qquad 1 \le j \le N_t, \qquad 1 \le q \le M,$$

and ρ is the average signal-to-noise ratio (SNR) at each receiver antenna.

- Both the transmitted symbols and the transmitter antenna numbers are detected jointly in optimal detection.

Recursive Least-Squares Adaptive Channel Estimation



Recursive Least-Squares Adaptive Channel Estimation contd.

where

- u is the system input.
- v is the additive noise.
- d is the unknown system output or the desired signal.
- y is the adaptive filter output.
- e is the error signal.

Recursive Least-Squares Adaptive Channel Estimation contd.

- Given an $N\times 1$ measurement vector y, an $N\times M$ data matrix H and an $M\times M$ positive-define matrix $\prod$, the $M\times 1$ solution w_i to the following regularized least-squares problem:

$$\min_{\mathrm{w}}[\mathrm{w}^* \prod \mathrm{w} + \| \mathrm{y}_i - \mathrm{H}_i \mathrm{w} \|^2],$$

can be computed recursively as follows. Start with $\mathrm{w}_{-1} = 0, \mathrm{P}_{-1} = \prod^{-1}$ and iterate for $i \geq 0$:

$$\gamma_i = \frac{1}{(1 + \mathrm{u}_i \mathrm{P}_{i-1} \mathrm{u}_i^*)},$$

$$\mathrm{g}_i = \mathrm{P}_{i-1} \mathrm{u}_i^* \gamma_i,$$

Recursive Least-Squares Adaptive Channel Estimation contd.

$$\mathrm{w}_i = \mathrm{w}_{i-1} + \mathrm{g}_i[d_i - \mathrm{u}_i \mathrm{w}_{i-1}],$$

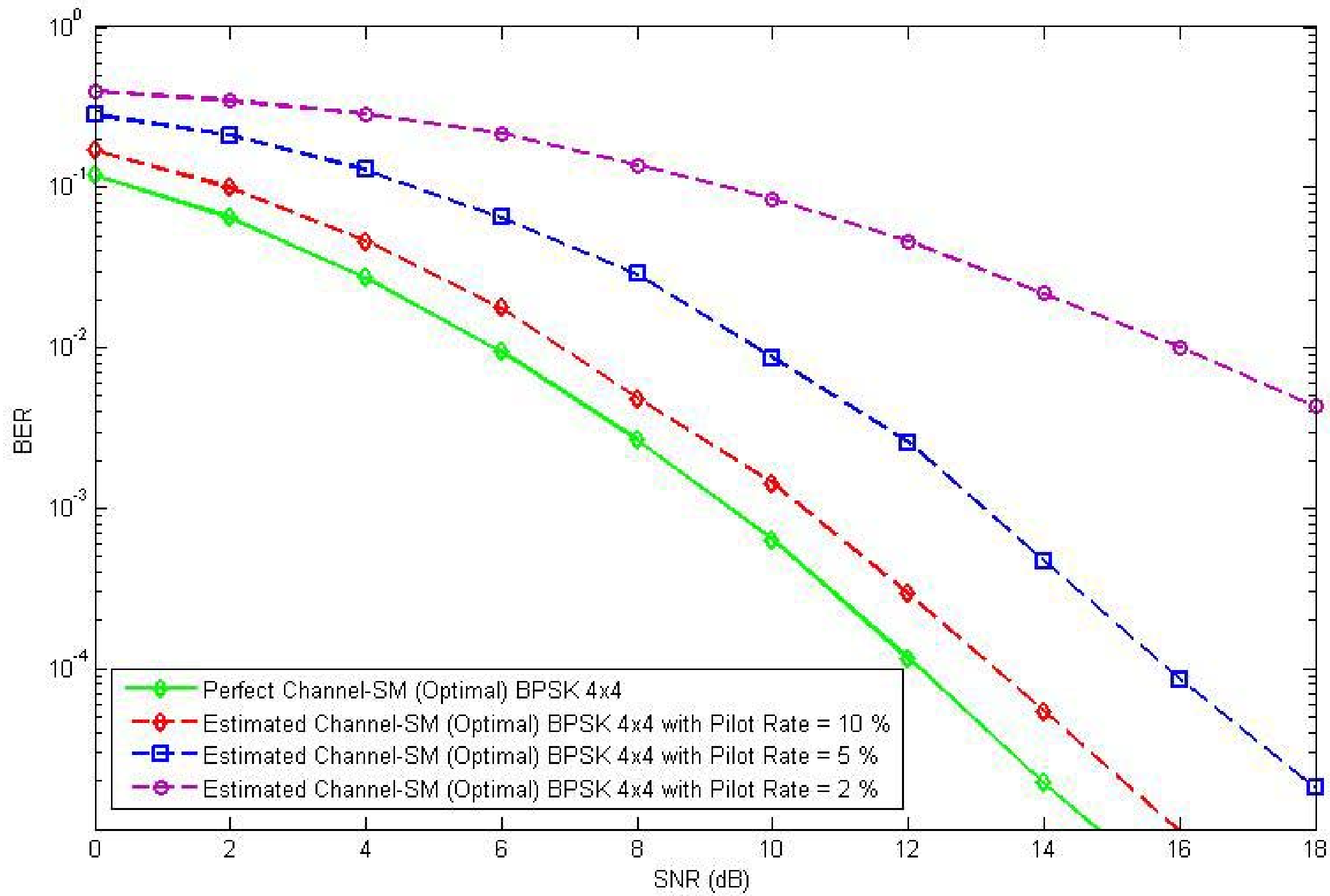
$$\mathrm{P}_i = \mathrm{P}_{i-1} - \frac{\mathrm{g}_i \mathrm{g}_i^*}{\gamma_i}.$$

- At each iteration, the matrix P_i has the following interpretation:

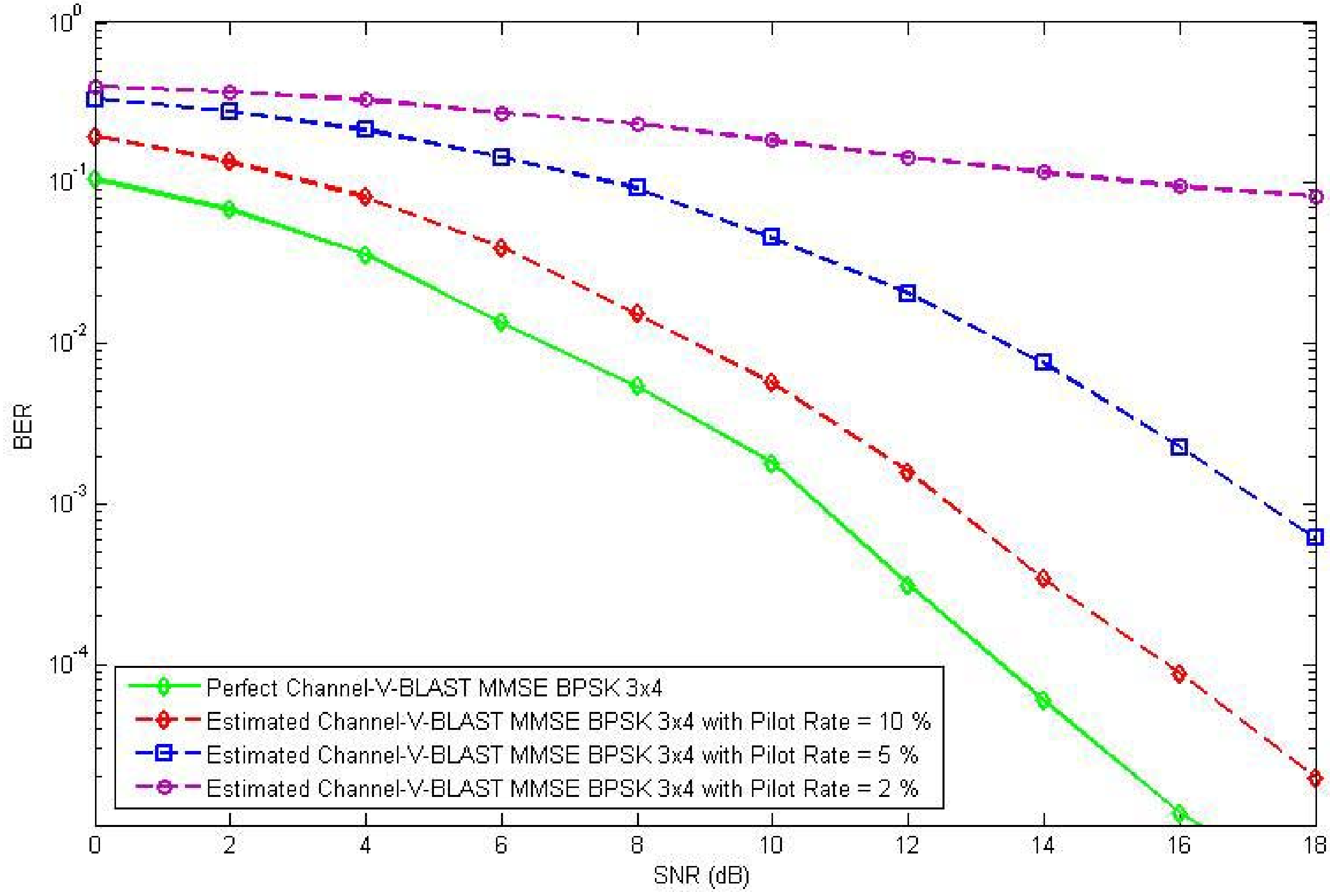
$$\mathrm{P}_i = (\Pi + \mathrm{H}_i^* \mathrm{H}_i)^{-1}.$$

Simulation Results

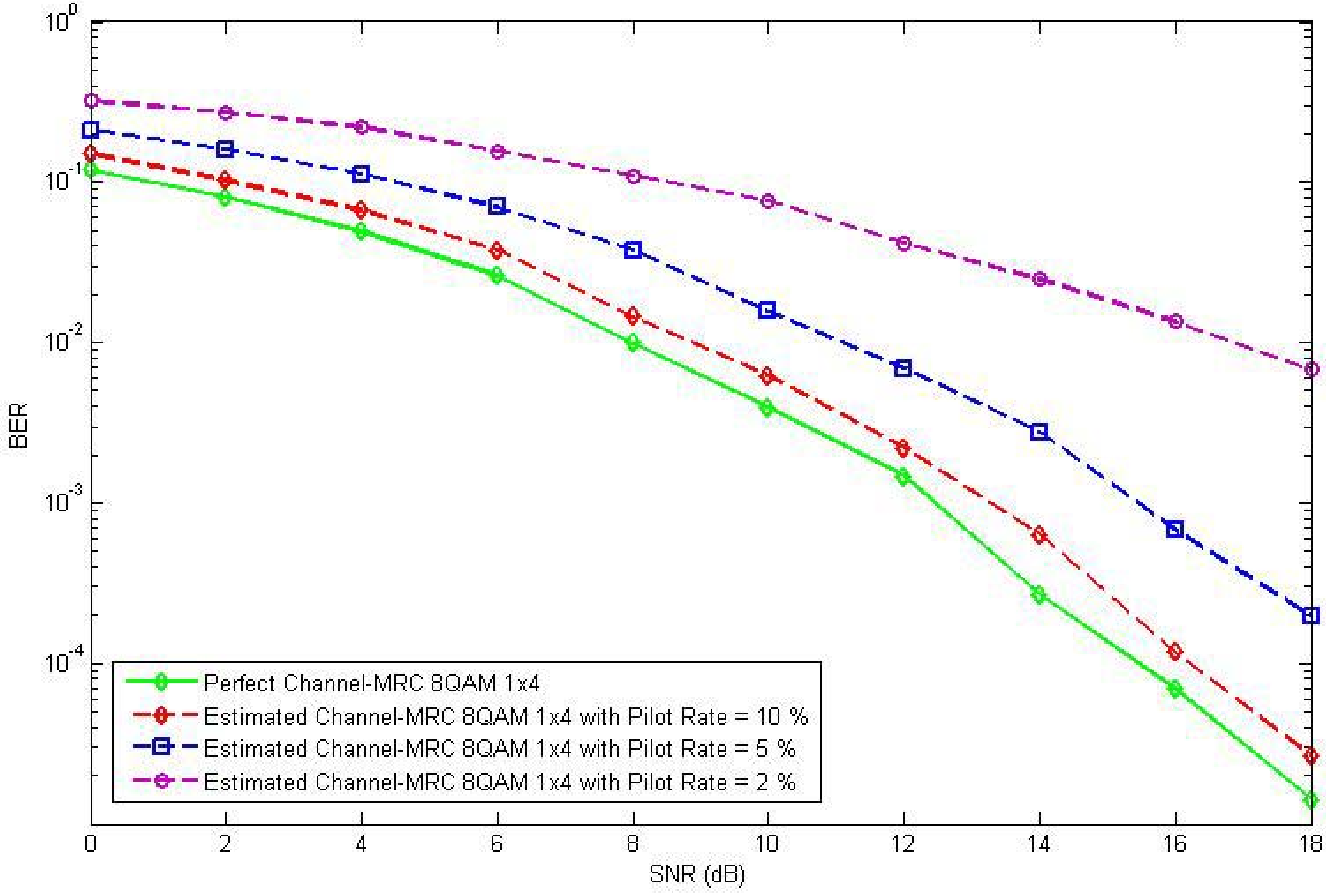
Performance of the RLS channel estimator for pilot rates=10%, 5%, and 2% over a block fading channel at 3-b/s/Hz using **spatial modulation**.



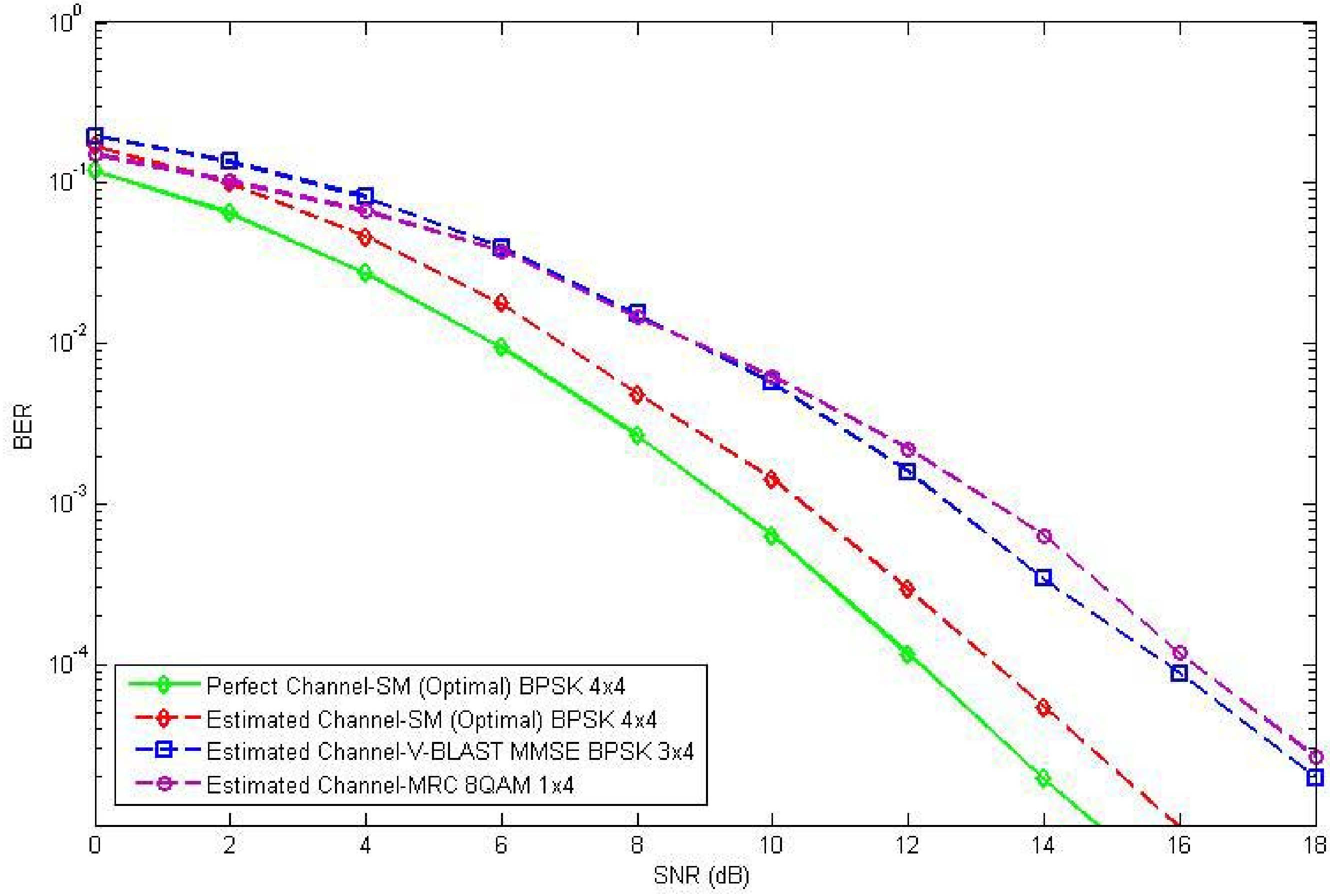
Performance of the RLS channel estimator for pilot rates=10%, 5%, and 2% over a block fading channel at 3-b/s/Hz using **V-BLAST**.



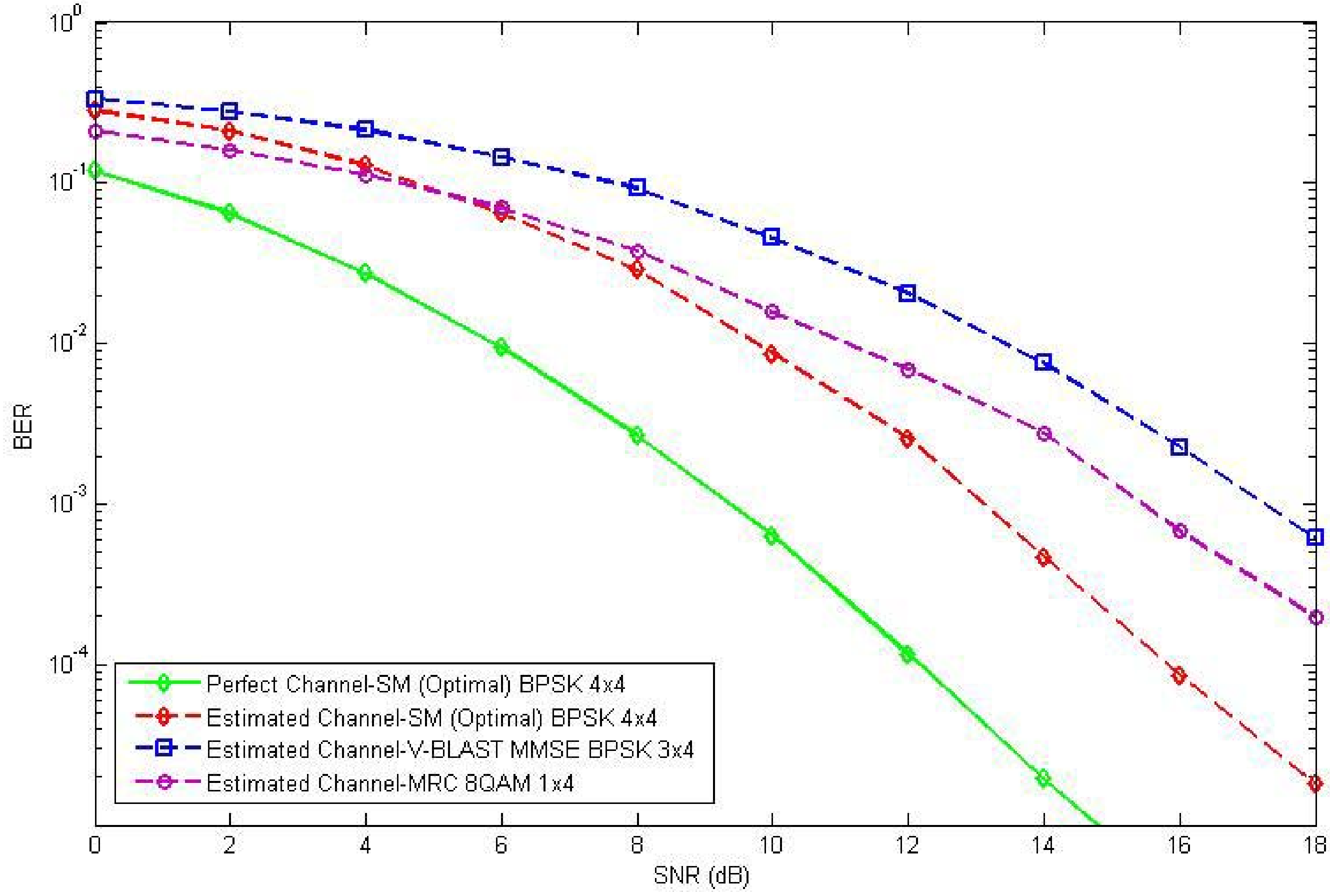
Performance of the RLS channel estimator for pilot rates=10%, 5%, and 2% over a block fading channel at 3-b/s/Hz using **MRC**.



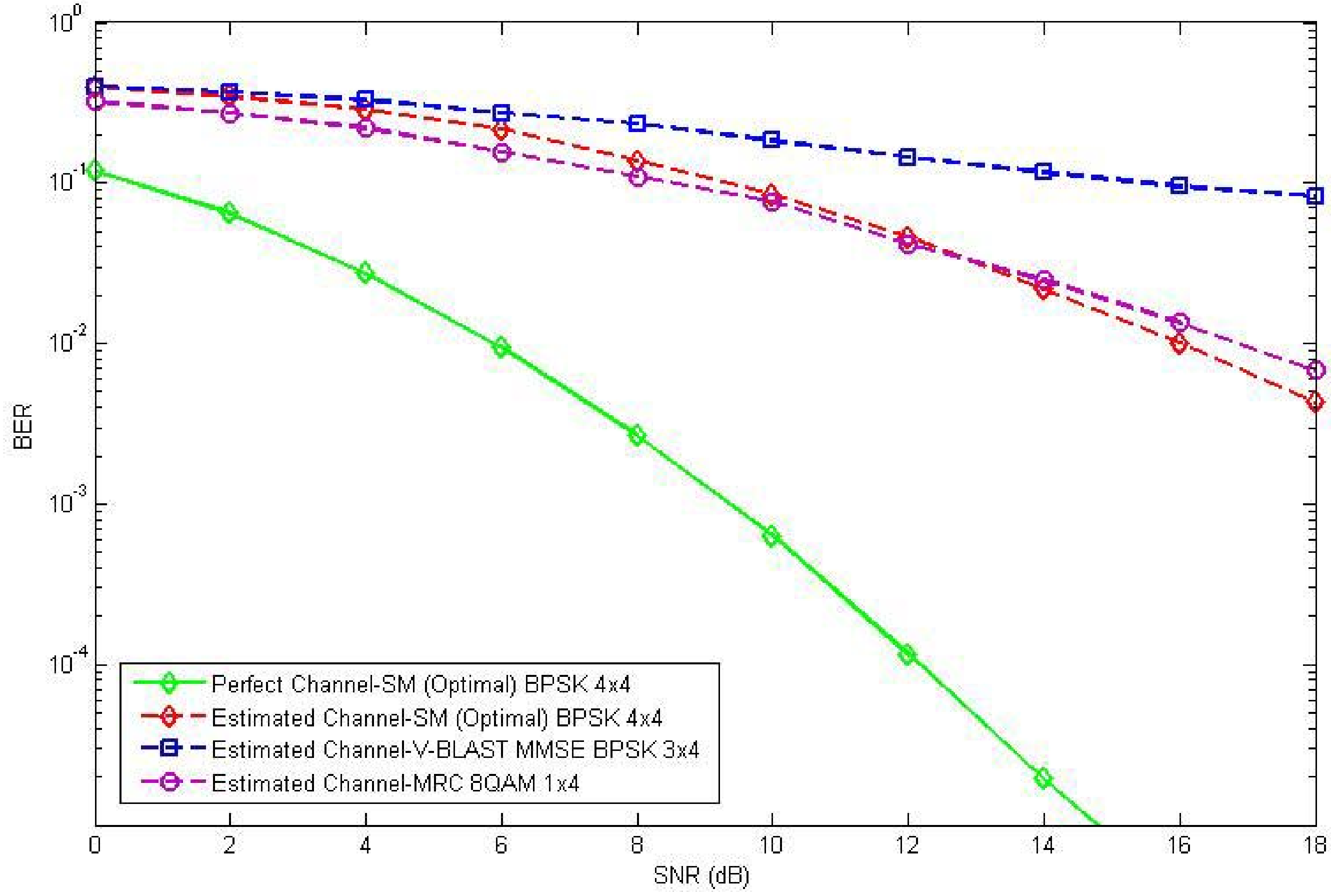
Performance of the RLS channel estimator for pilot **rate=10%** over a block fading channel at 3-b/s/Hz using **spatial modulation, V-BLAST, and MRC**.



Performance of the RLS channel estimator for pilot **rate=5%** over a block fading channel at 3-b/s/Hz using **spatial modulation, V-BLAST, and MRC**.



Performance of the RLS channel estimator for pilot **rate=2%** over a block fading channel at 3-b/s/Hz using spatial modulation, V-BLAST, and MRC.



Conclusions

- In this paper, we applied recursive least-squares adaptive channel estimator for spatial modulation system with optimal detection over a block fading MIMO channel.

- The simulation results indicate that SM with optimal detection and RLS channel estimation achieves performance gains of approximately 2.1 dB over V-BLAST and approximately 2.6 dB over MRC for BER equal to 10^{-3} and pilot rate equal to 10%.

- In addition, the results show that SM is more robust with practical channel estimation than V-BLAST.

Thank You !