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Uplink Scheduling Criteria Comparison for V-BLAST Users

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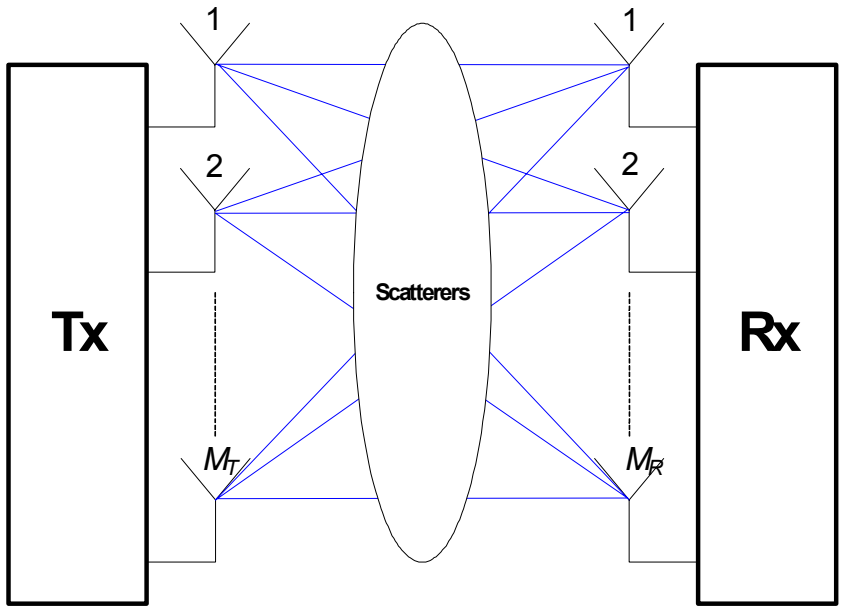
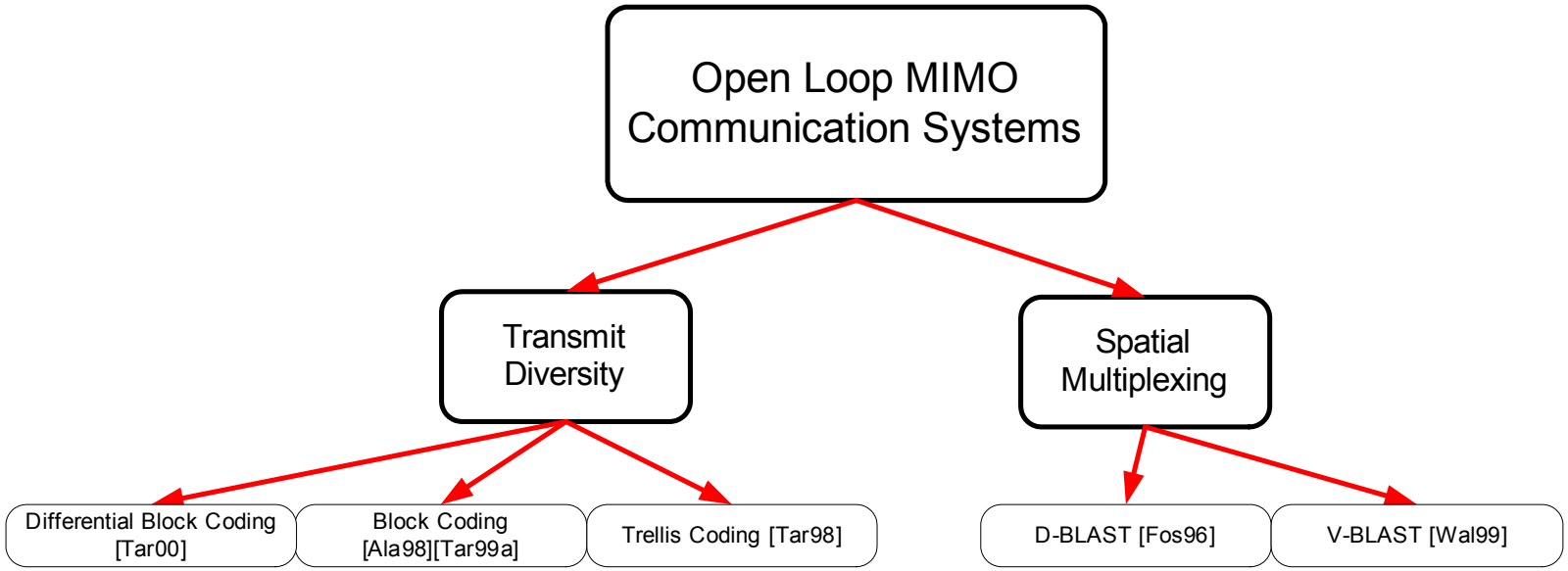
Introduction: Multiple Input Multiple Output (MIMO) Channels

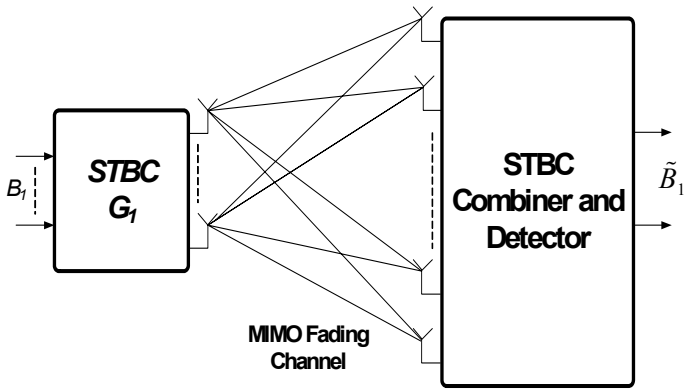
- A MIMO channel is a wireless link between *MT* transmit and *MR* receive antennas.
- MIMO channels boost the information capacity of wireless systems by order of magnitude [Telater95][Foschini98].

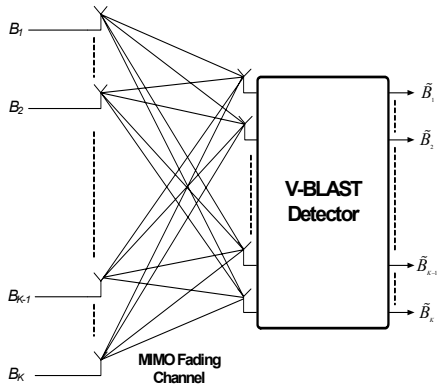


$$\mathbf{H}(t) = \begin{pmatrix} h_{11}(t) & \cdots & h_{1M_T}(t) \\ \vdots & \ddots & \vdots \\ h_{M_R 1}(t) & \cdots & h_{M_R M_T}(t) \end{pmatrix}$$

Introduction: Open Loop MIMO Communication Systems







Uplink Scheduling for Multiuser Systems with Spatial Multiplexing

- In a multiuser environment, each user has different channel statistics.
- Scheduling transmission to the user with the best channel condition at each time leads to a form of selection diversity known as multiuser diversity.
- In SISO, MaxSNR scheduling maximizes the capacity of the uplink [Kno95] and downlink [Tse97].

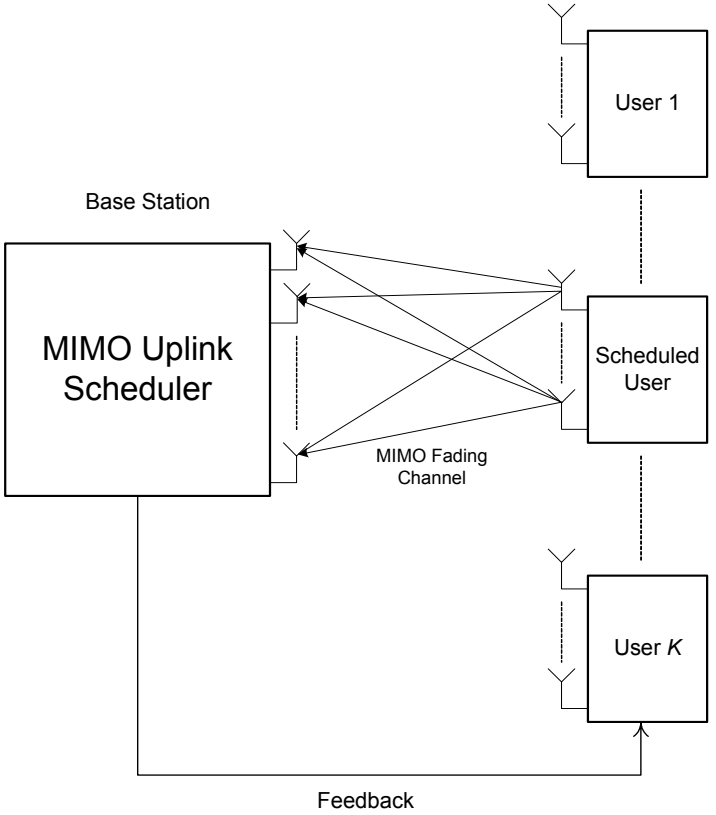
Our focus is on

- Scheduling for uplink MIMO system.
- Scheduling and STBC aren't a good match [Gozali03].
- We focus on scheduling for spatial multiplexing systems selecting a single user at a time and we focus on practical detection algorithms, such as V-BLAST, SMZF and SMSD.

System Model

- Average SNR is assumed to be the same for all users.
- The base station scans the uses.
- The user with the best channel condition is allowed to transmit.
- The received signal from user *k* is:

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



Scheduling Algorithms

- Optimal MIMO capacity maximizing scheduler

$$C_{\max} = \max_{k=1,2,\ldots,K} C_k \ ; \text{where}$$

$$C_k = \log_2\left(\det\left(\mathbf{I}_{M_R} + \frac{SNR}{M_T}\mathbf{H}_k\mathbf{H}_k^H\right)\right)$$

- MaxSNR scheduler selects the user with maximum MIMO channel power $\left(trace\left(\mathbf{H}_k\mathbf{H}_k^H\right)\right)$

- RR: Round robin scheduling allows each user to transmit in a time-division fashion regardless of their channel condition.

Scheduling Algorithms

- V-BLAST capacity maximizing scheduler

  V-BLAST capacity is dominated by the weakest layer [Pap02]

$$C_{VBLAST}^{ZF} = M_T \cdot \min_{i=1,2,\ldots,M_T} \left\{ \log_2 \left(1 + \frac{SNR}{M_T \left\| \mathrm{W}_{ZF,i} \right\|^2} \right) \right\}$$

  Thus, the scheduler selects the user with $\min_{k=1,\ldots,K} \{w_k\}$ where

$$w_k = \max_{i=1,2,\ldots,M_T} \left\{ \left\| \mathrm{W}_{ZF,i}^{k} \right\|^2 \right\}$$

Scheduling Algorithms

- MinES: Minimum Eigenspread

$$k = \arg \min_{k=1,\ldots,K} \left\{ s_k = \frac{\lambda_{\max,k}}{\lambda_{\min,k}} \right\}$$

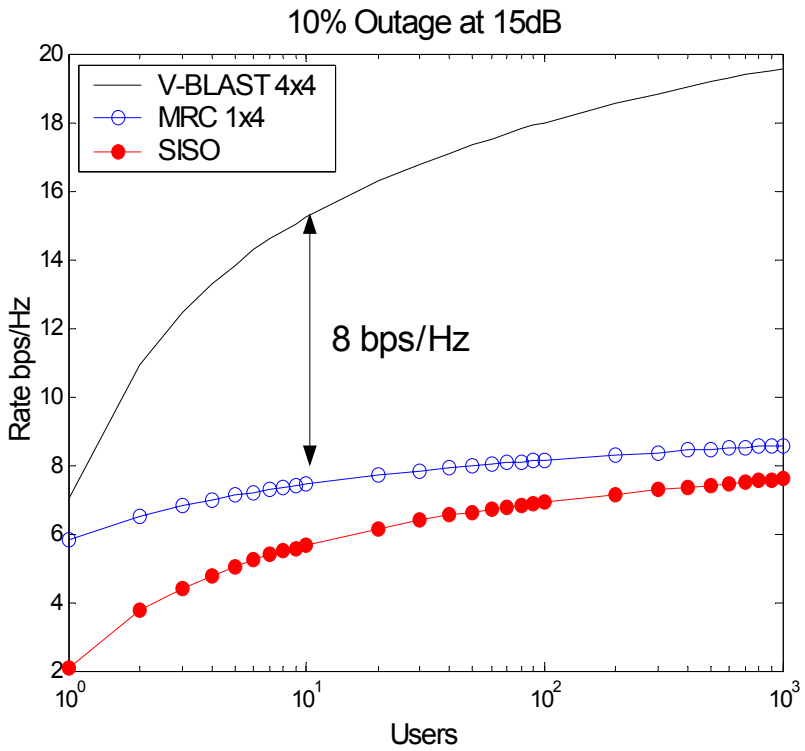
$\lambda_{\max}$ and $\lambda_{\min}$ are the largest and smallest eigenvalues of $\mathbf{H}_k \mathbf{H}_k^H$

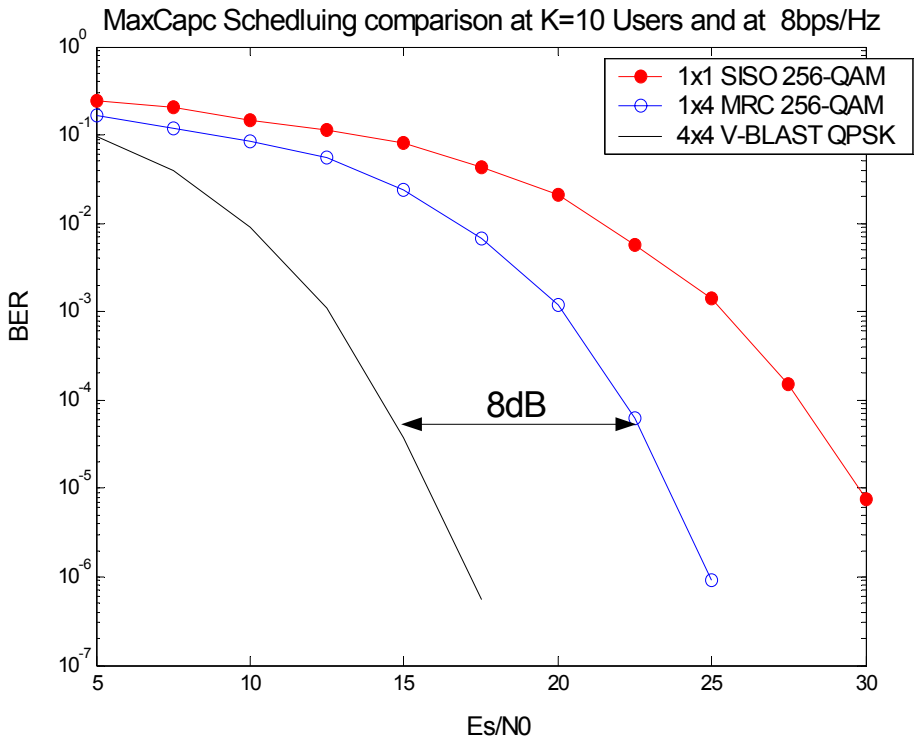
- MaxMinSV: Maximum Minimum Singularvalue

$$k = \arg \max_{k=1,\ldots,K} \left\{ \rho_{\min,k} \right\} \qquad \text{where} \qquad \rho_{\min} = \frac{\rho_{\max}}{\sqrt{s}}$$

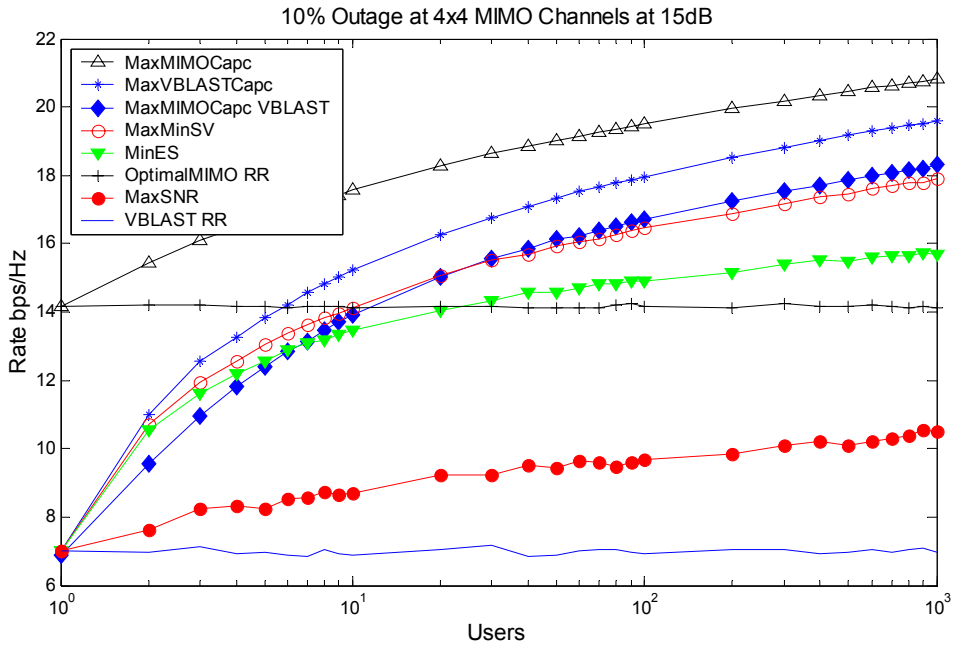
$\rho_{\min}$ is the smallest singularvalue of $\mathbf{H}_k$

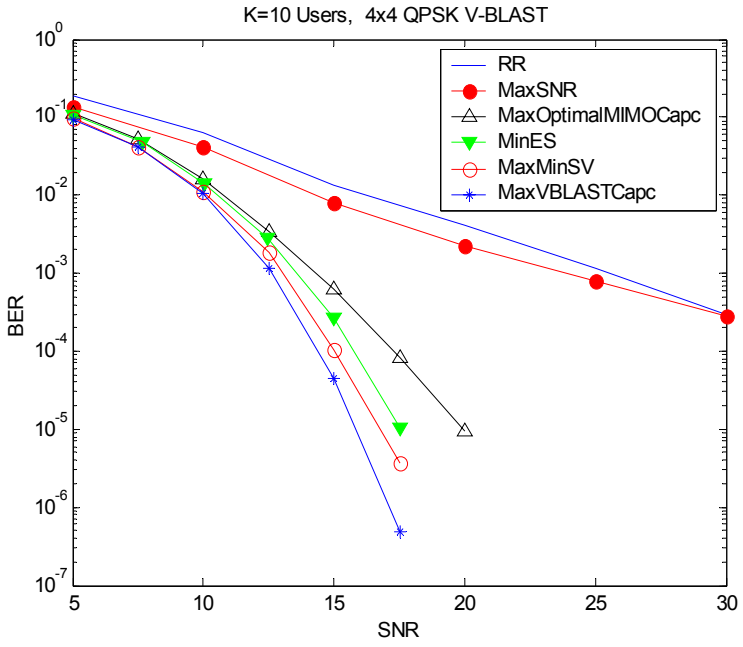
Advantage of V-BLAST compared to SISO and SIMO systems



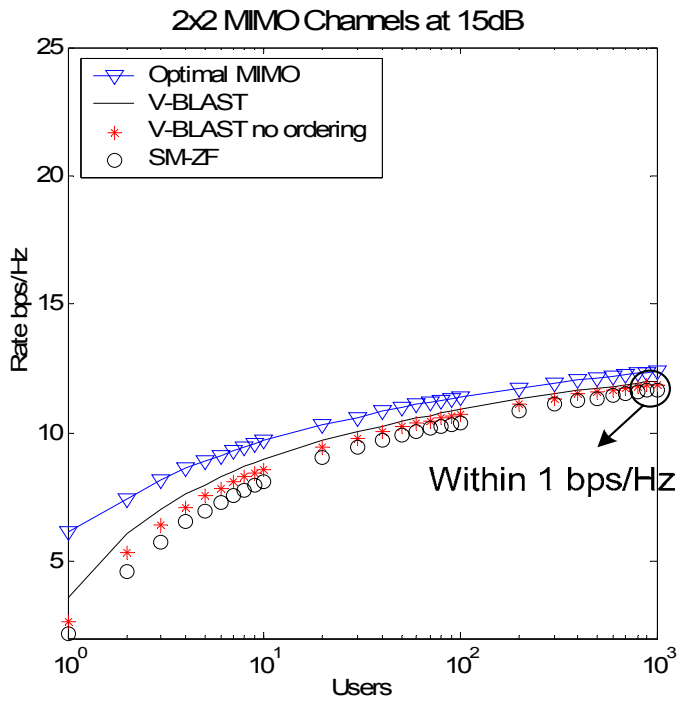


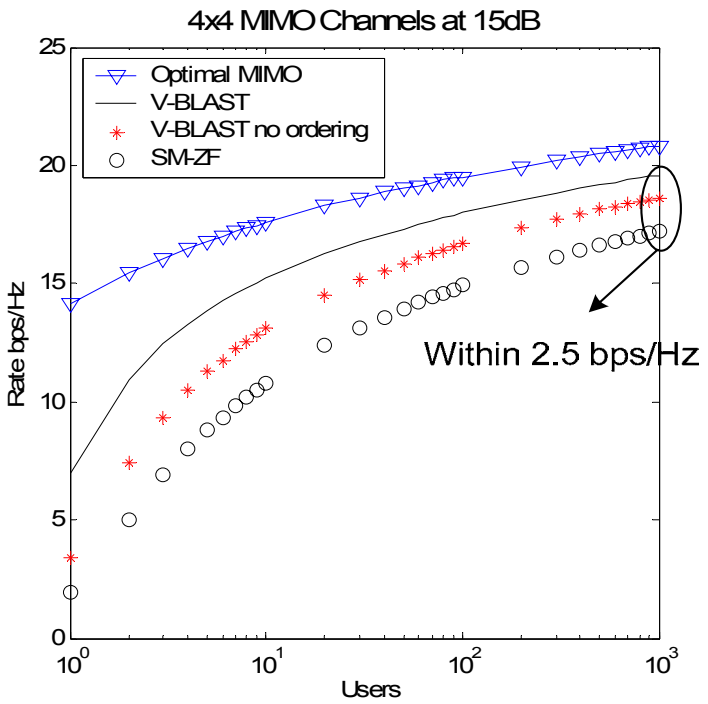
Simulation results of V-BLAST uplink scheduling



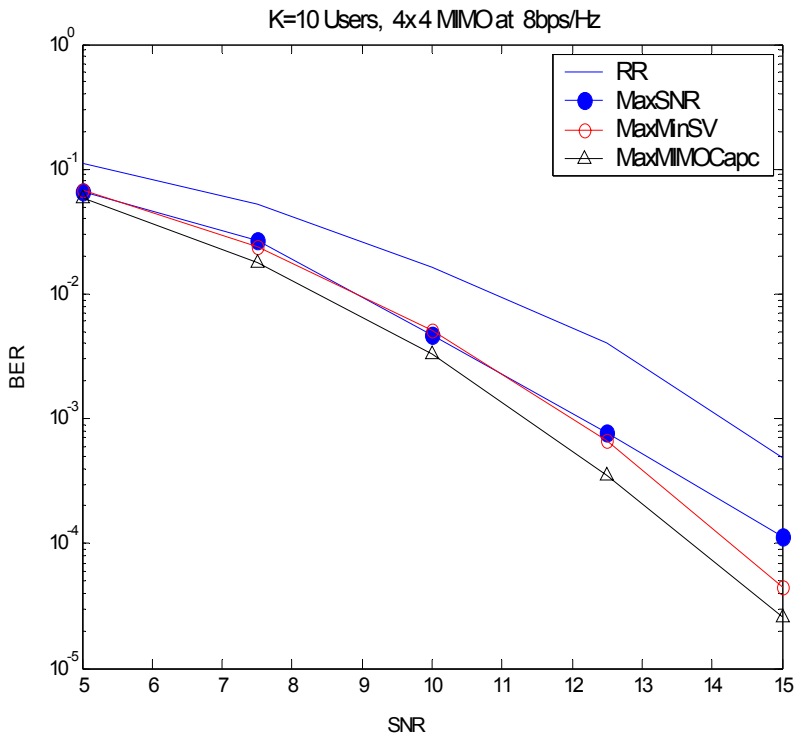


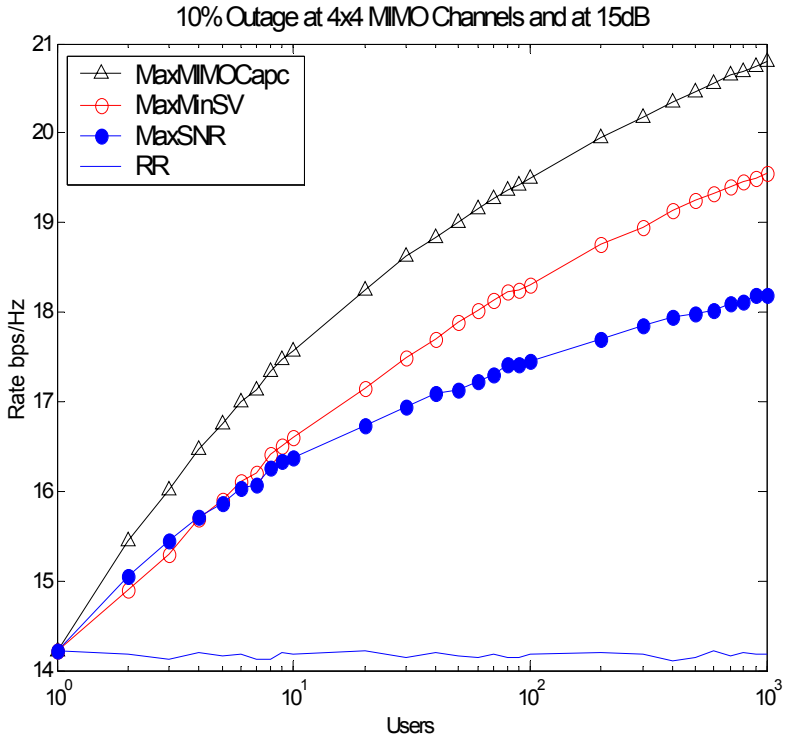
Effect of Suboptimal Detection





Scheduling for Spatial Multiplexing with Sphere Decoder





Uplink MIMO Scheduling Conclusions

- We found the V-BLAST capacity maximizing scheduler.
- We showed that scheduling based on maximum MIMO capacity doesn't work well for a V-BLAST system.
- We compared several scheduling algorithms and found that MaxMinSV scheduling performs close to MaxVBLAST capacity scheduler.
- The difference between V-BLAST and SMZF performance is not substantial, especially at low number of antennas and large number of users.