3 Information Theory

Exercise 3.1 **Capacity without CSI at the transmitter**

Consider the equivalent baseband model for transmission over a flat fading channel given by

$$\mathbf{y} = \sqrt{\frac{\mathcal{P}}{N_t}}\mathbf{H}\,\mathbf{x} + \mathbf{n}\ ,$$

where $\mathbf{x}\in\mathcal{C}^{N_t\times 1}$ is the transmit signal, $\mathbf{y}\in\mathcal{C}^{N_r\times 1}$ is the receive signal, $\mathbf{n}$ is complex Gaussian noise, $\mathbf{H}\in\mathcal{C}^{N_r\times N_t}$ is the Rayleigh fading channel coefficient with variance 1 and $\mathcal{P}$ is the transmission power. The power of the transmit signal and the noise are normalized to be 1. The receiver has perfect channel state information (CSI) while the transmitter has no CSI.

a) plot the capacity of AWGN channel for the following channels for the signal to noise ratio from $E_s/N_0 = 0$ dB to 20 dB.

   (1) SISO; (2) SIMO; (3) MISO; (4) MIMO.

   The transmission power $\mathcal{P}$ is the same for all cases. Note that AWGN channel means the channel without fading, e.g., $\mathbf{H}$ is assumed to be a identity matrix.

b) plot the ergodic capacity of the Rayleigh fading channel for the signal to noise ratio from $E_s/N_0 =$ 0 dB to 20 dB.

c) plot the outage probability.

Exercise 3.2 **Capacity and Waterfilling**

If the transmitter has perfect channel state information (CSI@T), re-consider the ergodic capacity done at the previous exercise.

a) plot the ergodic capacity if the Waterfilling algorithm is applied at the transmitter. Compare the results to the case without CSI at the transmitter.

b) Fig. 3 shows ergodic capacities for a SIMO, MISO, and MIMO system without and with perfect CSI at the transmitter, respectively. Add the corresponding markers to the legend.

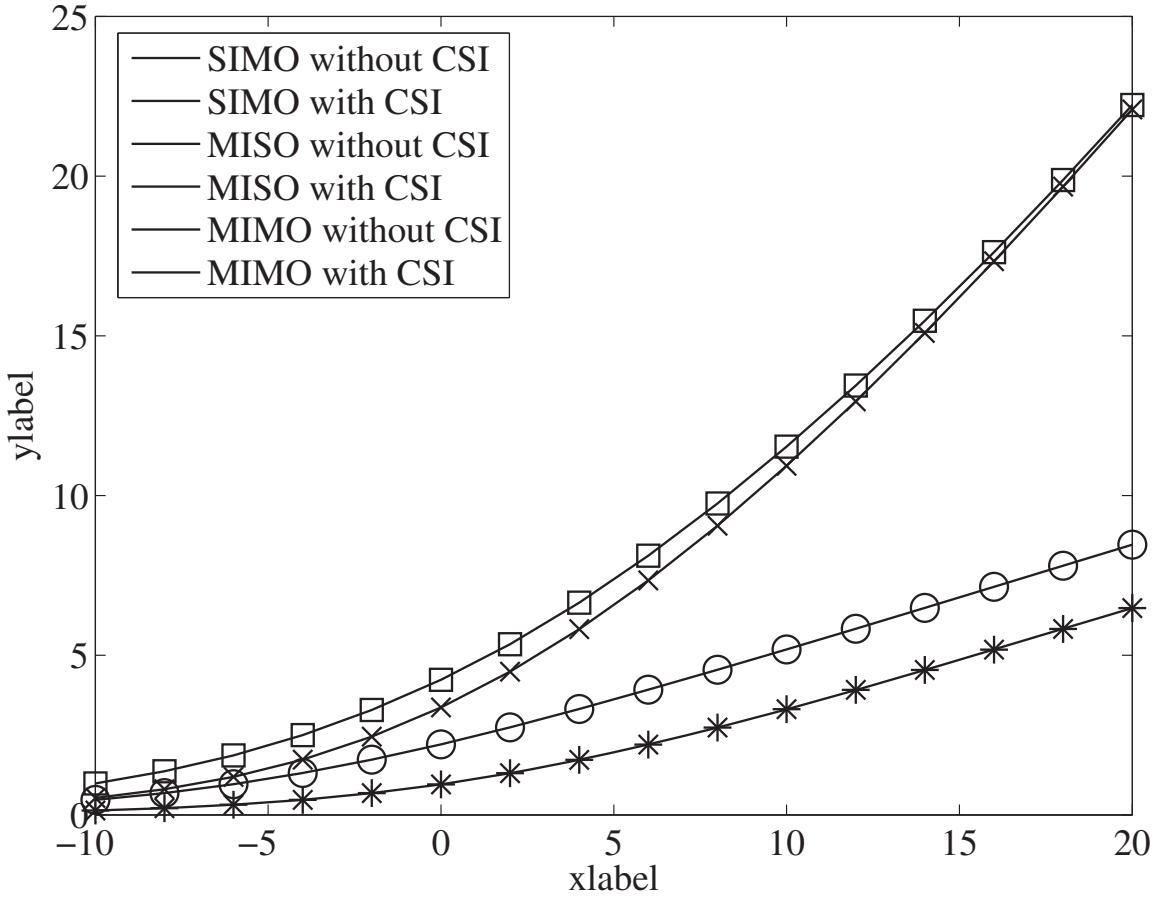

Fig. 3: Ergodic channel capacities of SIMO, MISO, and MIMO without and with perfect CSI at the transmitter