MIMO multiple-input multiple-output Channel.

multiple TX antenna — multiple Rx antennas

TX 1 s_1 RX 1

TX 2 s_2 RX 2

. .

. .

TX_M s_M RX N

M: # of tx antennas

N: " RX "

$$Y = HS + n$$

Y: RX signal vector $\mathbb{C}^{N\times 1}$

H: channel matrix $\mathbb{C}^{N\times M}$

h_{ij}: channel gain between i-th RX antenna and j-th Tx antenna

$$h_{ij} = \underbrace{h_{ij,I}}_{N(0,\frac{1}{2})} + \boxed{j}\, \underbrace{h_{ij,Q}}_{N(0,\frac{1}{2})}$$

$j^2 = -1$

standard normal dist.

$$E(|h_{ij}|^2) = 1$$

S: transmitted signal vector $S \in \mathbb{C}^{M\times 1}$

n: noise vector. $n \in \mathbb{C}^{N\times 1}$ $n_i = n_{i,I} + j n_{i,Q}$

$n_{i,I} \sim N(0, \sigma^2)$, $n_{i,Q} \sim N(0,\sigma^2)$

σ^2 related to $\frac{E_b}{N_0}$ value, needs to be adjusted!

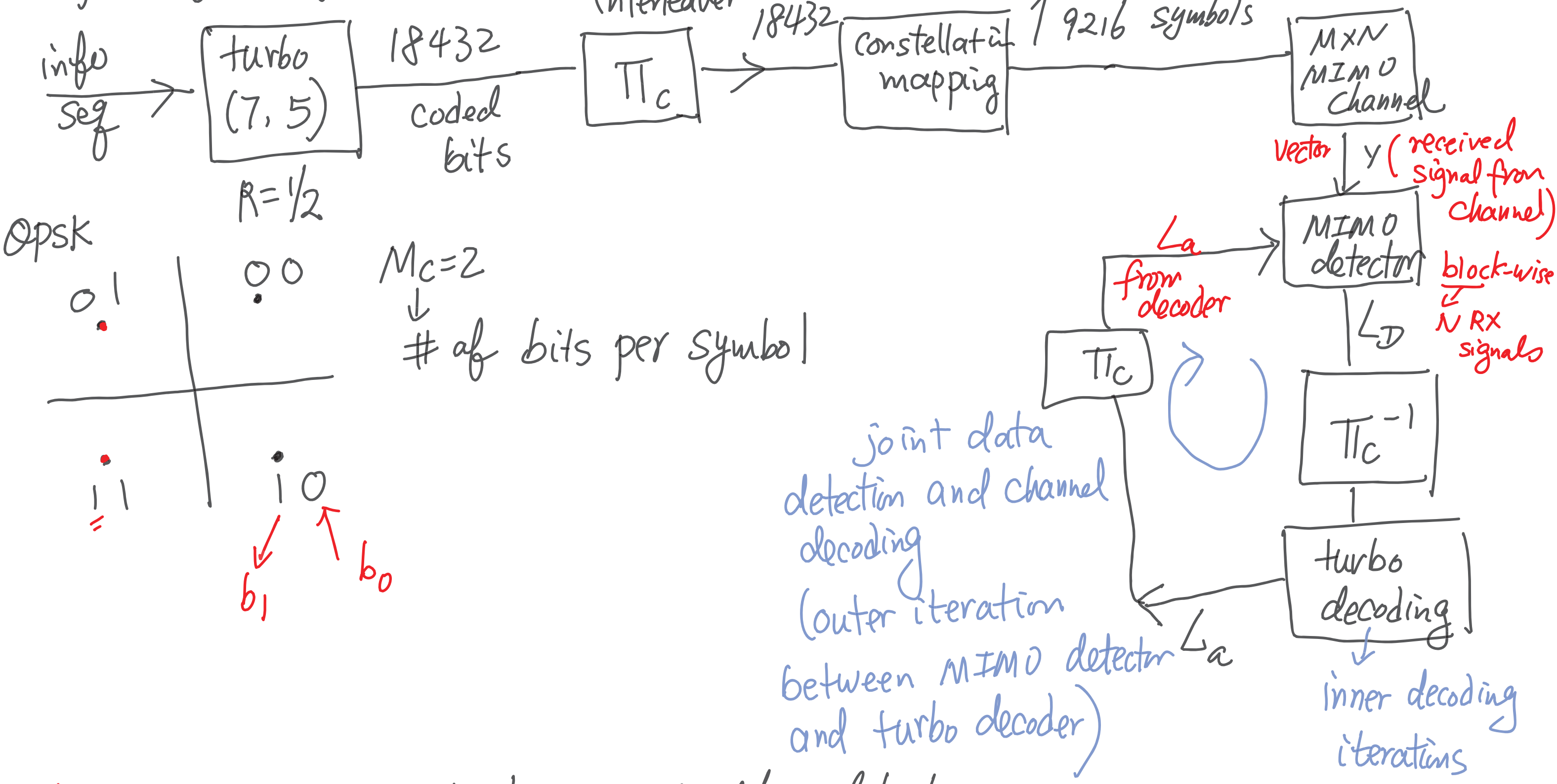
Average power constraint: $E[|s_i|^2] = \frac{E_s}{M}$

$$\boxed{Y = HS + n}$$

$$y_i = \sum_{j=1}^{M} h_{ij} s_j + n_i$$

i-th Rx antenna

info seq length 9216



Assume H is perfectly known at the detector.

Input to the MIMO detector

① $\underline{Y} \in \mathbb{C}^{N\times 1}$ RX vector, $\quad Y = H\underline{s} + n$

② L_A from decoder: $M \times M_c$ real-valued $\qquad M_c = 2 \Rightarrow$ QPSK

Each symbol consists of M_c bits

$\underline{s}$: $\underline{M\times 1}$ transmitted vector

x: bit vector $(x_0, x_1, x_2, \dots x_{M\times M_c - 1})$

$x_k = \pm 1 \qquad$ turbo code (same as in the paper)

$0 \to -1 \quad$ (reverse it for LDPC)

$1 \to +1$

$$L_D(x_k|_{Y, H, L_A}) = \ln \frac{P(x_k = +1 | Y, H, L_A)}{P(x_k = -1 | Y, H, L_A)}$$

"$x_k = +1$" total $\boxed{2^{M \cdot M_c - 1}}$ many possible X (bit vector) such that $\boxed{x_k = +1}$.

Baye's formula

$$P(x_k = +1 | y, H, L_A) = \sum_{X:\, x_k = +1} P(X|_{Y, H, L_A}) = \sum_{X:\, x_k = +1} \frac{f(Y|_{X,H}) \cdot P(X|_{L_A})}{f_Y(y)}$$

$$P(X|_{L_A}) \overset{\text{approx}}{=} P(x_k|_{L_A}) \cdot \prod_{j \neq k} P(x_j|_{L_A})$$

$$L_D(x_k|Y,H,L_A) = \underbrace{\boxed{\ln\frac{p(x_k=+1|L_A)}{p(x_k=-1|L_A)}}}_{=\,L_A(x_k)} + \ln\frac{\sum_{X:\,x_k=+1} f(Y|X,H)\prod_{j\neq k} p(x_j|L_A)}{\sum_{X:\,x_k=-1} f(Y|X,H)\prod_{j\neq k} p(x_j|L_A)}$$

$$\sum_{X:\,x_k=+1} f(Y|X,H)\prod_{j\neq k} p(x_j|L_A) = \sum_{X:\,x_k=+1} e^{\ln f(Y|X,H)+\sum_{j\neq k}\ln p(x_j|L_A)}$$

$$\ln p(x_j|L_A) = \frac{x_j\cdot L_A(x_j)}{2}\ ; \quad x_j=\pm 1$$ eqn (7) reference paper.

$$Y = \boxed{HS} + n$$

$$f(Y|\underline{\underline{X}},H) = \frac{1}{(\sqrt{2\pi\sigma^2})^N}\, e^{-\frac{1}{2\sigma^2}\|Y-HS\|^2}$$

$\updownarrow$ X

$X \to S$

$$\ln f(Y|X,H) = \ln\frac{1}{(\sqrt{2\pi\sigma^2})^N} - \frac{1}{2\sigma^2}\|Y-HS\|^2$$

$$\begin{cases} L_D(x_k|Y,H,L_A) = L_A(x_k) + \max^*_{X:\,x_k=+1}\left(-\frac{1}{2\sigma^2}\|Y-HS\|^2 + \frac{1}{2}\sum_{j\neq k} x_j L_A(x_j)\right) \\ \qquad\qquad - \max^*_{X:\,x_k=-1}\left(\qquad\qquad\qquad\qquad\qquad\right) \end{cases}$$

same

$L_D^e = L_D - L_A$ get extrinsic LLR going to decoder