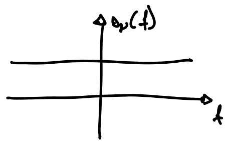
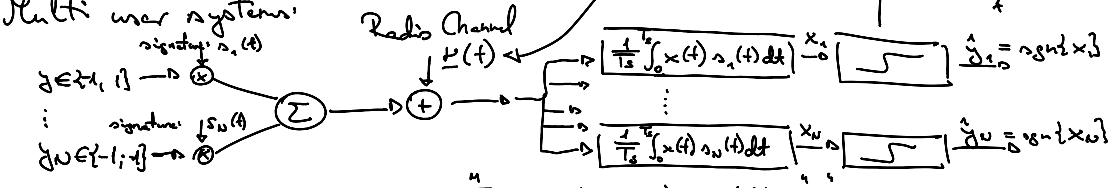
2016. december 7., szerda 16:22

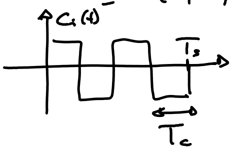


Multi user systems:



$$x(t) = \sum_{i=1}^{M} y_i\, s_i(t) + \nu(t) \rightarrow \text{user "}l\text{"}\ y_l$$

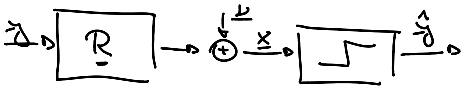
code: $\underline{c}^{(i)} = (1; -1; 1; -1)$



more precise modell: $x(t) = \sum_{i=1}^{M} y_i\, a_i\, s_i(t - T_i) + \nu(t)$

most precise modell: $x(t) = \sum_{i=1} y_i\, h_i(t - T_i) * s_i(t) + \nu(t)$

$$\left.\begin{array}{l} \frac{1}{T_s} \rightarrow \text{dataspeed} \\ T_c : \text{hardware} \end{array}\right\} N = \frac{T_s}{T_c} = \frac{\text{service}}{\text{HW}}$$



$$\underline{x} = \underline{\underline{R}}\,\underline{y} + \underline{\nu}\ ;\quad R_{li} = \frac{1}{T_s}\int_0^{T_s} s_l(t)\, s_i(t)\,dt = \frac{1}{N}\sum_{m=1}^{N} c_m^{(l)} c_m^{(i)} = \frac{1}{N}\,\underline{c}^{(l)T}\underline{c}^{(i)}$$

$$R_{ll} = 1 \quad \forall l$$

$$x_l = \sum_{i=1}^{M} R_{li}\, y_i + \nu_l = R_{ll}\, y_l + \sum_{\substack{i=1 \\ l \neq i}}^{M} R_{li}\, y_i + \nu_l = y_l + \underbrace{\sum_{\substack{i=1 \\ i \neq l}}^{M} R_{li}\, y_i}_{\text{Multi User Interference MUI}} + \nu_l$$

Best case: $MUI = 0 \Rightarrow R_{li} = 0 \quad \forall i = 1 \ldots M,\ i \neq l$

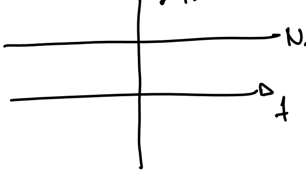
$\underline{c}^{(l)},\ l = 1 \ldots M \rightarrow$ orthogonal vector set $\rightarrow \dim(\underline{c}^{(l)}) = N > M \overset{\lightning}{\Longleftrightarrow} M > N$

$\Rightarrow$ Because of that contravene, it <u>is impossible to set MUI to 0</u>

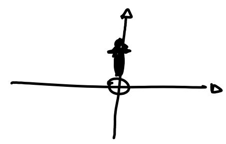
$$\underline{\nu};\ \nu_l = \frac{1}{T_s}\int_0^{T_s} \nu(t)\, s_l(t)\,dt,\quad l = 1 \ldots M \rightarrow \underline{\nu} \sim \mathcal{N}(\underline{0}, \underline{\underline{K}})$$

$$K_{li} = E\{\nu_l \nu_i\} = E\left\{\frac{1}{T_s}\int_0^{T_s} \nu(t)\, s_l(t)\,dt \cdot \frac{1}{T_s}\int_0^{T_s} \nu(\tau)\, s_i(\tau)\,d\tau\right\} = E\left\{\frac{1}{T_s^2}\iint_0^{T_s} \nu(t)\,\nu(\tau)\, s_l(t)\, s_i(\tau)\,dt\,d\tau\right\} =$$

$$= \frac{1}{T_s^2}\iint_0^{T_s} E\{\nu(t)\,\nu(\tau)\}\, s_l(t)\, s_i(\tau)\,dt\,d\tau = \frac{1}{T_s^2}\iint_0^{T_s} \underbrace{R_\nu(t-\tau)}_{\text{autocorrelation-function}}\, s_l(t)\, s_i(\tau)\,dt\,d\tau = (*)$$



$$\xrightarrow[\text{inverse Fourier transform}]{\mathcal{F}^{-1}} R_\nu(u) = N_0\,\delta(u)$$



$$(*) = \frac{N_0}{T_s}\frac{1}{T_s}\int_0^{T_s} s_l(t)\, s_i(t)\,dt = N_0'\, R_{li}$$

$$p_\nu(u) = \frac{1}{\sqrt{(2\pi)^M \det(N_0' R)}}\, e^{-u^T N_0'^{-1} R^{-1} u}$$

$$e^{-u^T N_0'^{-1} \underline{\underline{R}}^{-1} u}$$

Recieve $\underline{x}$

$$\hat{\underline{y}} = \max_{y\in\{-1,1\}^M} P(\underline{y}|\underline{x}) \sim \max_{\underline{y}\in\{-1,1\}^M} \frac{P(\underline{x}|\underline{y})\overbrace{\cancel{P(\underline{y})}}^{\frac{1}{2^M}}}{\cancel{P(\underline{x})}} \sim \max_{y\in\{-1,1\}^M} P(\underline{x}|\underline{y})$$

just a constant...

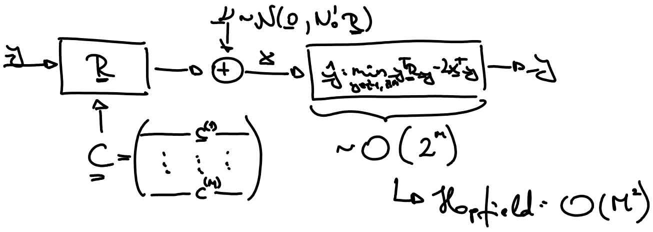
$$\hat{\underline{y}} = \max_{y\in\{-1,1\}^M} \cancel{\frac{1}{\sqrt{(2\pi)^M \det(N_0' \underline{\underline{R}})}}}\, e^{-\frac{1}{2}(\underline{x}-\underline{\underline{R}}\underline{y})^T N_0'^{-1} \underline{\underline{R}}^{-1} (\underline{x}-\underline{\underline{R}}\underline{y})} \sim \max_{y\in\{-1,1\}^M} -\frac{1}{2}(\underline{x}-\underline{\underline{R}}\underline{y})^T \cancel{N_0'^{-1}} \underline{\underline{R}}^{-1} (\underline{x}-\underline{\underline{R}}\underline{y}) \sim$$

$$\sim \min_{y\in\{-1,1\}^M} (\underline{x}-\underline{\underline{R}}\underline{y})^T \underline{\underline{R}}^{-1} (\underline{x}-\underline{\underline{R}}\underline{y}) \sim \min_{y\in\{-1,1\}^M} \underline{x}^T \underline{\underline{R}}^{-1} \underline{x} - \underline{y}^T \underbrace{\underline{\underline{R}}^T \underline{\underline{R}}^{-1}}_{\underline{\underline{I}}} \underline{x} - \underline{x}^T \underbrace{\underline{\underline{R}}^{-1} \underline{\underline{R}}}_{\underline{\underline{I}}} \underline{y} + \underline{y}^T \underbrace{\underline{\underline{R}}^T \underline{\underline{R}}^{-1}}_{\underline{\underline{I}}} \underline{\underline{R}}\, \underline{y} \sim$$

$$\sim \min \underline{y}^T \underline{\underline{R}}\, \underline{y} - 2\underline{x}^T \underline{y} \quad \Rightarrow \text{Multi User Detection Problem}$$

↙ beyond 3G

B3G mobile communication:



$$R_{ij} = \frac{1}{N} \underline{c}^{(i)T} \underline{c}^{(j)}$$