Ming Hsieh Department of Electrical Engineering

USC Viterbi School of Engineering

Capacity and Power Allocation for Degraded Decode-and-Forward Relay Channel with ISI

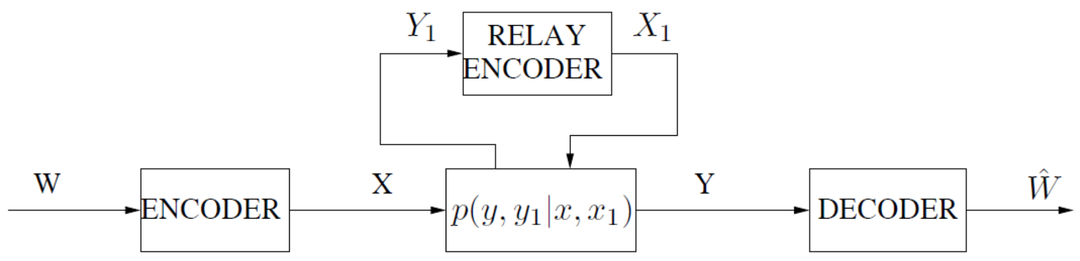
Chien-Lun Chen, Urbashi Mitra
Electrical Engineering/Communications

Degraded Relay Channel

•Definition:

A Relay Channel is said to be degraded if $p(y, y_1|x, x_1)$ can be written in the form

$$p(y, y_1|x, x_1) = p(y_1|x, x_1)\,p(y|y_1, x_1)$$



•Capacity:

From the definition, since y depends on x only through y_1 and x_1, we can define

$$X = \sqrt{(1-\alpha)P_S / P_R}\,X_1 + X_{10}$$

and therefore the capacity for a degraded channel is

$$C^* = \max_{0\le\alpha\le1} \min\left\{\frac{1}{2}\log\left(1+\frac{P_S+P_R+\sqrt{2(1-\alpha)P_SP_R}}{N_D}\right), \frac{1}{2}\log\left(\frac{\alpha P_S}{N_R}\right)\right\},$$

where $X_1 \sim N(0, P_R)$ and $X_{10} \sim N(0, \alpha P_S)$.

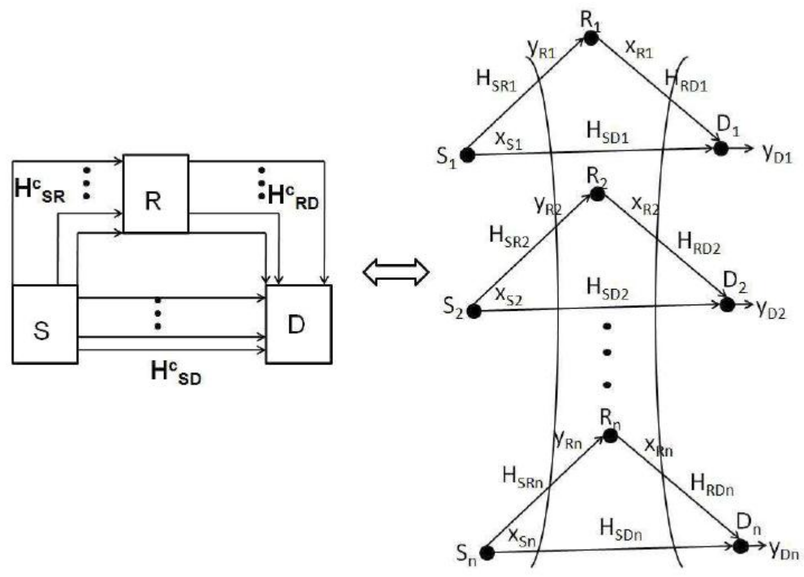
Degraded Relay Channel with ISI

•Capacity

The capacity region of circular Gaussian relay channel (CGRC) and linear Gaussian relay channel (LGRC) is the same when the input block size N goes to infinity.

•By DFT, a multi-path relay channel can be decomposed as a set of N parallel and independent scalar relay channels and is optimal for the computation of DF rate.

Decomposition



Power Allocation for Parallel Channels

•Why?

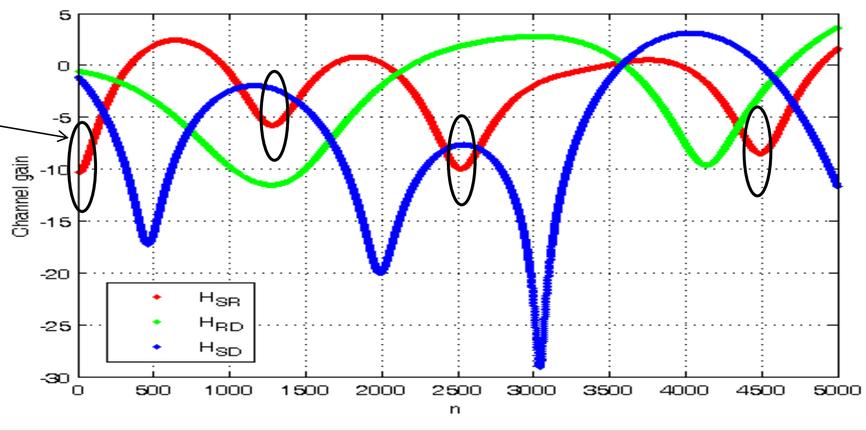
- To appropriately assign power on the sub-bands that can provide higher rates.
- To design codes with rates approaching capacity of multi-path relay channel

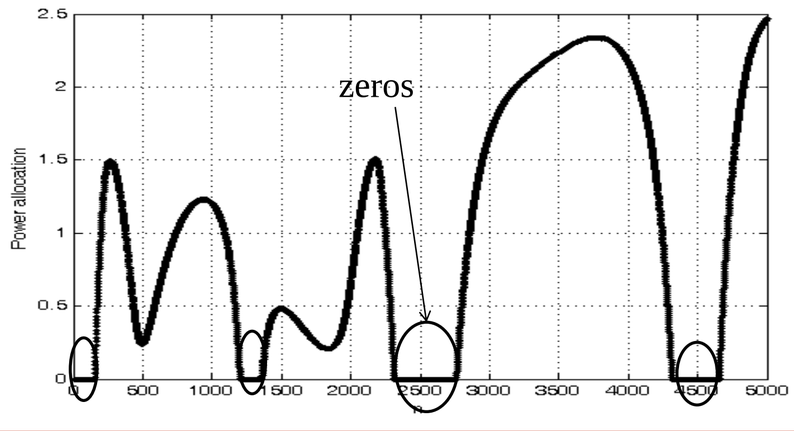
•How?

1. Find the capacity of each sub-band under equal power allocation.
$$C_n^* = \max_{0\le\alpha_n\le1} \min\{C_{1,n}, C_{2,n}\}$$
2. Find the corresponding SNR γ_n^* by
$$C_n^* = 1/2\log(1+\gamma_n^*),$$
3. Equivalent to power allocation issue on OFDM
$$P_{S,n} = P_{R,n} = (\nu_t - 1/\gamma_n^*)^+$$

Simulation Results

Deep fades





NOTE:
Since H_{SD} is degraded, when H_{SR} is in a deep fade, capacities of both paths are low and thus zero power is assigned.

Ming Hsieh Institute
Ming Hsieh Department of Electrical Engineering