Effect of Channel Prediction Errors on Adaptive Modulation Systems for Wireless Channels

CHALMERS

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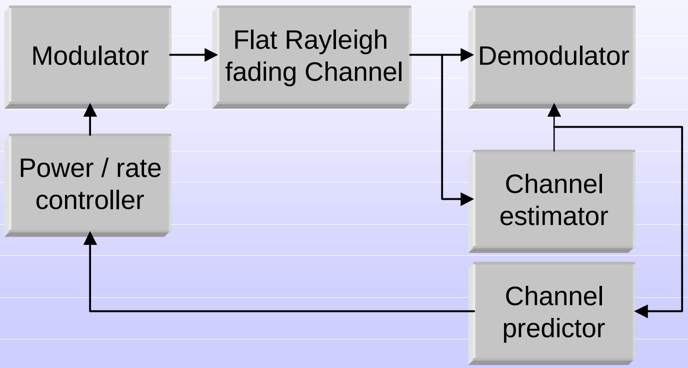
Problem statement:

Optimum design of an adaptive modulation scheme based on M-QAM modulation assisted by channel prediction for the flat Rayleigh fading channel.

System model:



Notations:

Number of constellations	N
Constellation sizes	$\{M_i\}_{i=0}^{N-1}$
Number of bits per symbol	$\{k_i\}_{i=0}^{N-1}$
Rate region boundaries	$\{\hat{\gamma}_i\}_{i=0}^{N-1}$
Average received SNR	$\bar{\gamma}$
Instantaneous predicted SNR	$\hat{\gamma}$
Average transmit power	$\bar{S}$

Channel prediction:

- Channel gain is modelled as a correlated complex Gaussian random process.
- The instantaneous SNR is proportional to the channel gain power.
- An MSE unbiased quadratic filter is used to predict the channel gain power.
- The pdf of the predicted SNR, $f(\hat{\gamma})$, is found to be exponentially distributed.

Rate and power adaptation:

- The data rate and transmit power are adapted to maximize the spectral efficiency

$$\eta_B = \sum_{i=0}^{N-1} k_i \int_{\hat{\gamma}_i}^{\hat{\gamma}_{i+1}} f(\hat{\gamma}) d\hat{\gamma} \, ,$$

subject to the average power constraint

$$\int_0^{\infty} S(\hat{\gamma}) f(\hat{\gamma}) d\hat{\gamma} \leq \bar{S}$$

and the instantaneous BER constraint

$$\mathrm{BER}(\hat{\gamma}) = P_b .$$

- Based on the BER constraint, the transmit power is obtained from the instantaneous predicted SNR.

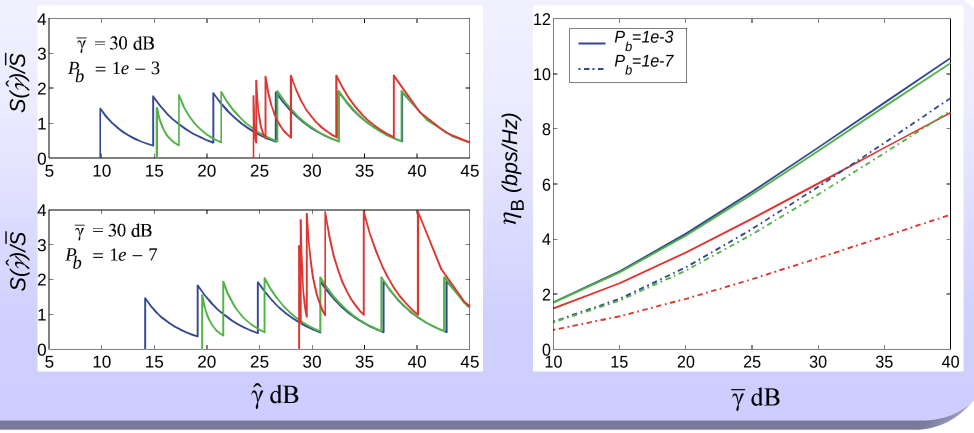
Thus, the optimization problem is simplified to finding the optimal region boundaries.
- The solution is found based on the Lagrange function.
- When $\hat{\gamma} \in [\hat{\gamma}_i, \hat{\gamma}_{i+1})$, k_i bits per symbol are transmitted.

Results:

Adaptive modulation scheme based on:
4QAM, 16QAM, 64QAM, 256QAM, 1024QAM, 4096QAM

σ_ε^2 : MMSE of the power prediction error

$\sigma_\varepsilon^2 = 0.001$
$\sigma_\varepsilon^2 = 0.01$
$\sigma_\varepsilon^2 = 0.1$



Conclusions:

- Optimum solutions for the adaptive rate and transmit power are derived.
- The spectrum efficiency loss due to the prediction errors or low BER requirement, is reduced by using a good predictor.