Cooperative Transmit Diversity Based on Superposition Modulation

The cooperative relay channel is a recent model for the exploitation of the spatial channel. One user node relays information from the source to the destination which in turn improves the error rate performance due the multiple receive copies i.e. diversity gain. Relays typically take turns transmitting their information in blocks.

Superposition modulation describes how one transmitter will superimpose its information on top of the reconstructed information from its partner relay. The transmitted signal from relay A is:

$$x_A(t) = \epsilon \cdot s_B'(t-1) + s_A(t),$$

where $x_A(t)$, $s_B'(t-1)$ and $s_A(t)$ are the transmitted signal from transmitter A from block $t$, the estimated signal from transmitter B from the previous block $(t-1)$, and the information from transmitter A at time $t$ respectively. $\epsilon$ is a power scaling factor for the system.

Transmitter B receives

$$r_B(t) = h(\epsilon \cdot s_B'(t-1) + s_A(t)) + \eta(t).$$

If the channel attenuation $h$ can be measured, transmitter B can subtract the signal $y_B(t) = r_B(t) - h \cdot \epsilon \cdot s_B(t-1)$ i.e. $s_B(t-1)$ is known exactly at transmitter B, because it was the source of the original signal. The remaining unknowns in $y_B(t)$ are the signal $s_A(t)$ and the noise $\eta(t)$. Standard demodulation/decoding techniques can be done to estimate $s_A'(t)$.

Investigations will introduce coding into the basic system, and consider some optimal and sub optimal decoding strategies. The power scaling factor will be extended to give $\epsilon \cdot e^{j\theta}$ which includes both a scaling and phase factor. The effect of varying these parameters on the error performance probability will also be investigated.

Basic knowledge of Matlab or C/C++ is suggested, as well as an interest in signals & systems, probability and coding theory.

1 project/2 people

1 Project Milestones

Stage 1: Generation of channel statistics

a) AWGN noise variables

b) Binary data

c) Rayleigh channel statistics
**Stage 2: Single antenna transmission of BPSK signals**

a) Modulation of data to BPSK signals

b) Construction of a transmission chain including information source, modulation, channel, demodulation, and bit recovery for an AWGN channel. Verification of the probability of bit errors as a function of the system signal to noise ratio with theory calculations.

c) Adaptation of transmission chain to a Rayleigh fading channel.

**Stage 3: Relay channel model**

a) Adapt the single antenna transmission scheme to the relay channel scenario, where each user transmits at an orthogonal time slot.

b) Include the following control variables:
   - SNR among source 1 and source 2 and the receiver.
   - Power of the superimposed signal
   - Phase of the superimposed signal

c) Select meaningful parameters for a fair comparison of the uncoded relay channel model.

**Stage 4: Channel Coding**

a) Implement the Hamming code with soft/hard decision decoding. Comparison of optimum/sub-optimum performance loss.

b) Implement a convolutional code with quantized-soft/hard decoding. Investigate the effect of having different quantization levels on the BER performance.

**Stage 5: Extended Topics**

a) QPSK modulation

b) Different codes and code rates

c) Channel estimation errors

**Stage 6: Report writing**