Name: *Alon S. Levin*
Date: *March 4, 2020*
Paper Title: A Simple Transmit Diversity Technique for Wireless Communications
Author Names: *Siavash M. Alamouti*
Year Published: *October 1998*

Open questions for discussion in class:

1. Alamouti mentions space-frequency coding as a possible alternative for space-time coding. What would a system that is a combination of the two (space-time-frequency) look like?
2. What would happen to the model in the case of a channel with non-constant fading over adjacent symbols? Are there mechanisms to counteract this effect?

The topic areas covered by the paper are:

- Spatial diversity schemes
- Maximal-ratio receiver combining (MRRC)

The previous approaches to this problem were:

- Maximal-ratio receiver combining (MRRC)
- Other transmit diversity approaches, including
    - Base station simulcasting
    - Artificial multipath distortion through symbol repetition across different antennas

Outline the basic new approach or approaches to this problem:
Rather than using a system with multiple receive antennas, which in the case of a mobile receiver is often infeasible for multiple reasons, the author proposes a system with multiple transmit antennas instead. Consider a two-antenna system:

1. Two signals (s_0 and s_1) are simultaneously transmitted from the two antennas during the first symbol period; in the next symbol period, the antennas transmit each other's conjugated signals, with the first negated; that is, $-s_1^*$ and s_0^*. This ensures that the signals are space-time coded, although a space-frequency coding scheme is possible as well.
2. The signals are passed through the channel and noise is added at the receiver end. The channels h are estimated, and the received signals r are combined in order to obtain estimates for the signals as follows:

$$\tilde{s}_0 = h_0^* r_0 + h_1 r_1^*$$
$$\tilde{s}_1 = h_1^* r_0 - h_0 r_1^*$$

3. The MRRC decision rule is employed, in which the legitimate signal with the smallest squared Euclidean distance from the estimate is chosen, accounting for symbol energy; when using a PSK modulation scheme, only the squared Euclidean distances need to be considered as symbol energy is constant across all symbols.

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Critical assumptions made include:
One major assumption is that channel fading is constant across two consecutive symbols. As well, in the simulation portion, the following conditions were placed to compare the different methods:

- Total transmit power from the two antennas in the new scheme is the same as the transmit power for the single antenna MRRC.
- Amplitudes of fading are mutually uncorrelated Rayleigh distributed
- Average signal powers at each receive antenna are the same
- Receiver has perfect knowledge of the antenna
- The transmitted signals are uncoded and coherent BPSK modulated.

The performance of the techniques discussed in the paper was measured in what manner:
The bit error rate (BER) performance for five different systems (no diversity, MRRC with two receivers, MRRC with four receivers, new scheme with one receiver, new scheme with two receivers) are compared under the assumptions listed above.

What background techniques are used in the paper that you are not familiar with:

- Spatial diversity techniques – I am familiar with them, but this paper enhanced my understanding with respect to mobile systems.

The following terms were defined:

- Maximal-ratio receiver combining (MRRC)
- Space-time coding

I rate and justify the value of this paper as:
I enjoyed this paper a lot. It was relatively easy to read, and very clear on both the previous system and the system being proposed.