**MIMO and Diversity**

**Theoretical Laboratory Session**

Wireless Communications 371-1-1903

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# Part 1 – General Theoretical Information

**Receiver Diversity**

Antenna diversity, also known as space diversity or spatial diversity, is any one of several wireless diversity schemes that uses two or more antennas to improve the quality and reliability of a wireless link. Often, especially in urban and indoor environments, there is no clear line-of-sight (LOS) between transmitter and receiver. Instead the signal is reflected along multiple paths before finally being received. Each of these bounces can introduce phase shifts, time delays, attenuations, and distortions that can destructively interfere with one another at the aperture of the receiving antenna.

Antenna diversity is especially effective at mitigating these multipath situations. This is because multiple antennas offer a receiver several observations of the same signal. Each antenna will experience a different interference environment. Thus, if one antenna is experiencing a deep fade, it is likely that another has a sufficient signal. Collectively such a system can provide a robust link. While this is primarily seen in receiving systems (diversity reception), the analog has also proven valuable for transmitting systems (transmit diversity) as well. Signal reliability is paramount and using multiple antennas is an effective way to decrease the number of drop-outs and lost connections.

A positive side effect of the receiver diversity is the increase of the signal-to-noise ratio (SNR) when combining the different reception signals coherently. This SNR enhancement is called **array gain.**

**Processing Techniques**

**Switching**: In a switching receiver, the signal from only one antenna is fed to the receiver for as long as the quality of that signal remains above some prescribed threshold. If and when the signal degrades, another antenna is switched in. Switching is the easiest and least power consuming of the antenna diversity processing techniques but periods of fading and desynchronization may occur while the quality of one antenna degrades and another antenna link is established.

**Selecting**: As with switching, selection processing presents only one antenna’s signal to the receiver at any given time. The antenna chosen, however, is based on the best signal-to-noise ratio (SNR) among the received signals. This requires that a pre-measurement take place and that all antennas have established connections (at least during the SNR measurement) leading to a higher power requirement. The actual selection process can take place in between received packets of information. This ensures that a single antenna connection is maintained as much as possible. Switching can then take place on a packet-by-packet basis if necessary.

**Combining**: In combining, all antennas maintain established connections at all times. The signals are then combined and presented to the receiver. Depending on the sophistication of the system, the signals can be added directly (equal gain combining) or weighted and added coherently (maximal-ratio combining). Such a system provides the greatest resistance to fading but since all the receive paths must remain energized, it also consumes the most power.

**Dynamic Control**: Dynamically controlled receivers are capable of choosing from the above processing schemes for whenever the situation arises. While much more complex, they optimize the power vs. performance trade-off. Transitions between modes and/or antenna connections are signaled by a change in the perceived quality of the link. In situations of low fading, the receiver can employ no diversity and use the signal presented by a single antenna. As conditions degrade, the receiver can then assume the more highly reliable but power-hungry modes described above.

<https://en.wikipedia.org/wiki/Antenna_diversity>

<https://en.wikipedia.org/wiki/Diversity_scheme>

<https://en.wikipedia.org/wiki/Diversity_combining>

<https://mimognuradio.wordpress.com/2018/05/11/week-0-diversity-combining/>

# Part 2 – MIMO Combining

In this part, we focus on linear combining techniques, meaning that the output of the combiner is a linear combination of the input branches. The general signal processing of a linear combining block is therefore a simple weighted sum:

describes a sample that results out of a combination of received input signals , each weighted by a complex coefficient .