Adaptive MIMO Beamforming/Multiplexing Switching Scheme

Group Members: To Ka Lok, Nick Lam Yue Shek, Edmund

Supervisor: Prof. Matthew Mckay
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Overview

For the immediate future, a remarkable advance has been made in the wireless technology called **MIMO**, short for multiple-input, multiple-out, which makes use of two or more antennas at both transmitters and receivers to bring us a huge improvement in the system performance. For example, such technique has been employed in Wi-Fi and WiMAX to enjoy advantages in data rate, throughput and coverage. In this project, we are going to efficiently utilize the benefits of different MIMO techniques and come up with an efficient new design which can intelligently select and switch among them to improve the system capacity and reliability.

MIMO Techniques

The original SISO technique which makes use of only one transceiver at both the transmitter and receiver can neither give a robust system nor a system with a high data rate. A SIMO system can achieve a more reliable system. However, still no improvement in data rate can be made.

![Diagram showing differences between SISO and MIMO systems](image)

- **Beamforming (BF)**, **Spatial Multiplexing (SM)** and **Space-Time Block Code (STBC)** are three important techniques employed in the MIMO system. We may choose to improve the transmission bit error rate (by making use of BF or STBC) or increase the capacity (by making use of SM). Figure 1. shows the structure of an MIMO system.

We simulated and verified a 2x2 MIMO system using the above techniques. Below are the results compared with a SISO system of the same modulation scheme.

- **Space-Time Block Code**: BER decreases, same data rate
- **Spatial Multiplexing**: Data rate increases, BER increases
- **Beamforming**: BER decreases, same data rate

Simulation results of each individual scheme are not shown here due to the limited space.
Simulation Results
SM/STBC Switching Scheme

Bandwidth efficiency (SM): It can achieve the highest possible data rate as long as its transmission error (or BER) is under the system that can tolerated. Therefore, a higher data rate transmission is possible in a good channel.

Diversity gain (STBC): BER can be reduced to meet the requirement of the system and to have a more reliable transmission. The system can still function in a bad channel.

Figure 2. SM/STBC BER performance

Figure 3. SM/STBC throughput curve & switching curve

SM/STBC Switching Scheme

Diversity gain (STBC/BF):
When the feedback of BF is perfect or with little error, BF outperforms STBC. When the feedback is imperfect, BF starts to deteriorate and there is a need to switch from BF to STBC to achieve a more reliable transmission.

Figure 4. BER of STBC and BF with feedback error
SM/STBC/BF Switching Scheme

Diversity gain (STBC/BF) : It can achieve the lowest possible BER especially when the feedback of BF is good. BER can be reduced to meet the requirement of the system and to have a more reliable transmission. The system can still function in a bad channel.

Bandwidth efficiency (SM) : It can achieve the highest possible data rate as long as its transmission error (or BER) is under the system that can tolerated. Therefore, a higher data rate transmission is possible in a good channel.

**Figure 6. SM/STBC/BF BER performance**
BF feedback error variance = 0.00

**Figure 7. SM/STBC/BF BER performance**
BF feedback error variance = 0.03

Conclusion

The final adaptive scheme is more capable to operate at different SNR values by making use of both BF and STBC. Moreover, data rate can increase as long as the channel environment is good. The other advantages of this scheme are:

1. very low complexity with low cost and short construction time
2. diversity gain that can reward from constant transmission power
3. high data rate to compensate the insufficient transmission bandwidth in real environment