Principles of Wireless Networks

Over the past few years, a new understanding of wireless networks is emerging by focussing on signal interactions arising due to the broadcast nature of wireless channels. This allows some approximate characterizations of information flow over wireless networks. Underlying these developments are deterministic modeling techniques that approximately capture these interactions. This doctoral school class develops these ideas and applies them to (practical) methods of communication over wireless networks. It develops many of the underlying principles of communication of wireless networks from this viewpoint, with the goal of introducing these ideas to advanced students in the School of Computer and Communication Sciences. A brief outline of the class is as follows.

1. **Wireless channel: propagation effects**
    - Mobility and multipath fading: delay spread and Doppler spread.
    - Multiple antenna (spatial) propagation models: angle spread.
2. **MIMO channels: capacity, degrees of freedom and outage**
    - MIMO performace gains: capacity, degrees of freedom.
    - Slowly fading channels: non-ergodic regime, outage probability.
    - Diversity order: high-SNR regimes.
3. **MIMO channels: diversity-multiplexing trade-off**
    - Diversity-multiplexing trade-off MIMO channel.
    - Universal code designs.
4. **Deterministic models for wireless networks**
    - Gaussian broadcast and multiple access channels.
    - Deterministic models for broadcast, multiple access channels and relay networks.
    - Conversion between Gaussian and deterministic models.
5. **Capacity of deterministic and Gaussian relay networks**
    - Information-theoretic cut-set bounds.
    - Capacity of linear deterministic relay networks.
    - Extension to arbitrary deterministic networks.
    - Approximate characterization of Gaussian relay networks.
6. **Gaussian interference channel**
    - Achievable rates for interference channels.
    - Deterministic approach to interference channels.
    - Approximate characterization of Gaussian interference channels.
7. **Wireless network secrecy**
    - Wiretap channel.
    - Wireless relay network secrecy.
    - Interactive secrecy.