Cooperative Communications and Networks

Instructor: Kuang-Hao Liu, EE Room 92A15, x62424, email: khliu@mail.ncku.edu.tw
Lectures: Wednesday 9:10am - 12:00pm, Room 92926
Office Hour: 3:00pm-4:00pm, Tuesdays
Web Site: `http://moodle.ncku.edu.tw/`
Suggested Prerequisite: Probabilities and Random Processes, Digital Communications
Grading Policy: midterm=20%, project=40%, assignments=40%

References:

1. Theodore S. Rappaport, Wireless Communications: Principles and Practice, Pearson Education, 2009, ISBN: 9788131728826.

2. Y.-W. Hong, W.-J. Huang, C.-C. Kuo, *Cooperative Communications and Networking: Technologies and System Design*, Springer, 2010, ISBN: 9781441971944.

Overview:

While most of the end users are eager to try new smart phone products, a new era of wireless communications has just arrived that fundamentally changes the way that a device communicates to the distant base station. Among numerous upcoming technology breakthroughts, this course will focus on the so-called "cooperative communications" and its applications in networking devices.

Expected audiences are graduate students who know the basics of digital communications and will pursue their graduate studies in the area of wireless communications. Although the course has a specific focus on cooperative communications, it will cover the basic principles of wireless communications and thus it is particularly suitable to fresh graduate students. Besides theoretical development, this course is featured by delivering computer simulation skills required for studying wireless communication systems that will benefit graduate students in terms of their research work and thesis preparation.

With the foundations established in the first few weeks, the course will move on to introduce existing cooperative protocols, which serve as the key enabler for cooperation among wireless nodes. To assess the pros and cons of different cooperative protocols, methods for analyzing the performance of cooperative networks will be addressed. By developing both closed-form and asymptotic expressions for various performance metrics, students can get more insights into cooperative communications. Meanwhile, simulation framework built in the first part of this course will be reused and extended to validate the analysis accuracy and also to facilitate performance evaluation.

Finally, some important applications of cooperative communications will be discussed. Tentative topics include packet-level cooperation (a.k.a. network coding), cooperative networks between base stations, cooperative message dissemination in vehicular networks, and cooperative spectrum sensing. By discussing the related applications, students may find the usefulness of cooperative communications in their own research.

Lectures will be based on the handouts and slides. Active class participation is mandatory. In-class time will be divided between lectures, student presentations, and group discussions. The course grade will be based on class presentation and participation, four to five homework assignments, and a final project (details will be given in the first lecture).

Course Outline:

- Introduction
  - Why Cooperation
  - Cooperative Relaying
- Characteristics of Wireless Channels
  - Large-scale (long-term) impairment: path loss, shadowing
  - Small-scale (short-term) impairment: fading
  - Mathematical model for fading
  - Fading channel parameters
  - Fading channel classifications: flat vs. selective
  - Statistical model for frequency-flat fading
  - Statistical model for frequency-selective fading
  - Measurements for fading channel: level cross rate and average fade duration
- Receiver Techniques for Fading Channels
  - Optimum receiver for fading channels
  - Example: BPSK over fading channels
  - Example: DPSK over fading channels
  - Diversity techniques for fading channels
    - Receive diversity
    - Maximum ratio combining
    - Selection combining
    - Equal gain combining
  - Transmit diversity
- Cooperative Communications with Single Relay
  - Amplify-and-forward (AF)
  - Decode-and-forward (DF)
  - Demodulate-and-forward (DmF)
- Cooperative Communications with Multiple Relays

  - Orthogonal cooperation for AF relays
  - Orthogonal cooperation for DF relays
  - Relay selection
    * Opportunistic Relaying
    * Partial relay selection
    * Buffer-aided relaying
- Base station cooperation
  - Signal enhancement
  - Interference cancellation
- System-level simulations
  - Physical layer abstraction
  - Introduction to WiSE simulator