Final Project Description

Wireless Communication Systems

The main purpose of the final project is for you to apply the concepts learned from the lectures and the tools learned from the lab assignments to solve real-world problems. You will have the freedom of selecting the topic of your final project. The only requirement is that your system should be built using wireless signals, such as WiFi, USRPs, Bluetooth, RFID or audio signals. For most topics, you can choose to implement the same system as described in the related paper. However, we encourage you to also consider additional improvements over the original design. Teams with such considerations would receive higher grades.

- **Project topics:** Some potential topics include but not limited to the following:

1. Interference nulling: http://people.csail.mit.edu/fadel/papers/wivi-paper.pdf

Interference nulling is a technique leveraging multiple transmit antennas to precode their signals such that their signals can be nulled out at a particular receive antenna. The simplest setting is to have two transmit antennas cancel their signals at one receive antenna, which is exactly the same setting with WiVi. We will implement it using USRP, and you can observe how the receiving power at the receiver changes with/without interference nulling.

2. ZFBF: http://www.thlab.net/~thsalon/papers/aryafar10Design.pdf

Zero-forcing beamforming allows a multi-antenna AP to send packets to multiple single-antenna clients simultaneously. In this project, we will implement ZFBF in a 2-antenna AP scenario using USRP. We will evaluate using USRP how this ZFBF improves the aggregate throughput, as compared to single-user transmission w/ and w/o using transmit diversity.

3. Device-free localization:
   http://web.stanford.edu/~skatti/pubs/sigcomm15-spotfi.pdf

SpotFi leverages the CSI provided by commodity WiFi cards (Intel 5300) to achieve accurate device free indoor localization. It combines the ToF and AoA to improve the

localization accuracy. It might be challenging to implement the whole system and get the final localization results within this limited timing. However, you could start by trying to estimate the ToF and AoA using the approach proposed in SpotFi.

4. People Counting:

http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=6847958

FrogEye leverages the variation of the CSI to infer the number of mobile users in an indoor environment. It proposes an algorithm to estimate the short-term channel variation, which can be used to accurately predict the number of users (though the system is limited to <10 users). You can try to implement this system, and try whether you can have your solutions to even detect static users.

5. Full-Duplex Radio:

   http://web.stanford.edu/~skatti/pubs/mobicom10-fd.pdf

   https://www.usenix.org/system/files/conference/nsdi16/nsdi16-paper-qiao.pdf

Full-duplex radio enables bidirectional transmissions by cancelling its strong self-interference. Typically, self-interference should be performed by the combination of analog cancellation, digital cancellation and antenna cancellation. However, analog cancellation and antenna cancellation require hardware modification or specific deployment. Hence, you only need to practice digital cancellation using USRPs. The remaining self-interference can be eliminated by equipping absorber in between Tx/Rx antenna. You will experimentally learn how much power can be removed via digital cancellation. You are also encouraged to come up with some interesting applications, such as passive monitoring or sniffing, by utilizing the capability of full-duplex transmissions.

6. Camera Communications

UFSOOK: http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=6676454

RollingShutter Sampling:

http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=6477759

Camera Communications is a form of visible light communications (VLC) that uses a camera as the receiver. The main benefit of the paradigm is that there is already a pervasive existence of cameras in our daily life; mobile devices, laptops, cars, or, more recently, glasses (Google glass), all have built-in cameras nowadays, and thus it

is possible to receive a small amount of information from LED lights, which are also installed pervasively in the environment for illumination, from virtually every IT device, creating a new communication infrastructure. The above two papers are some of the simpler implementations of camera communications. We encourage you to take additional considerations to make the system suitable for a wider range of scenarios. You can ask for initial setup tips if you want to select CamCom as your final project.

A few possible topics:

1) Create a modulation format that can be received by cameras with different settings, that works in different lighting conditions (since the camera would be taking the picture with a longer shutter time), and that works when the transmitting light and the receiving camera have different frame rates (synchronization issues). You can also try to include designs that could boost the data rate (such as utilizing the color).
2) LED-array-to-camera communications: Using a large number of LEDs to transmit at the same time to boost the data rate. We do have an arduino-compatible LED array – peggy2 board that you can use as a transmitter. Let us know if you'd like to use it for your project.
   http://www.winlab.rutgers.edu/~aashok/visualmimo/aashok_secon2011.pdf
   http://www.winlab.rutgers.edu/~aashok/visualmimo/mvarga_mobisys11.pdf
   Peggy2: http://wiki.evilmadscientist.com/Peggy_2
3) Vehicle-to-Vehicle CamCom: building on top of your lab 1, instead of using a small LED, we can lend you a set of hardware components that would allow you to modulate a real car or scooter taillight module. Then the goal is to be able to show that when the scooter/car are moving, a camera that takes images of the transmitting taillight can receive messages with high reliability. This CamCom system can enable a large number of safety applications, since the car would be able to report its current speed, location, steering angle, etc., via the taillight to surrounding vehicles.

We understand that you might not understand the proposed topics completely from the short description in this document. We hence reserve a week (probably at 11/17 and 11/22) for arranging individual meeting to discuss your proposal. Each team should sign up a slot with Kate to discuss what you'd like to do for your final project. This is for making sure that your proposal meets do help you learn some

techniques and even train your research ability.

- **Items to be submitted, grade contribution, and deadlines for each team:**

1. **Project proposal**: (20%)

   A single-column one-page summary describing the objectives of your project. The purpose of this summary is for us to evaluate the scope and the topic is appropriate for the final project. In the proposal, you should mention: 1) the problem you want to solve, 2) the related work, 3) the possible solutions you plan to try, and 4) the results you expect to see. Please send the summary, as a PDF file, by the due date to msn.nctu@gmail.com. We will arrange a poster session in our lecture to present your proposal and stimulate discussion.

   Due date: 11/24 (Thu.) 23:59

2. **Final project presentation:** (40%)

   Each team will present their project in a poster session. The presentation should report the problem you are trying to solve, the experimental setup, and the results. You are encouraged to demo your system or prepare a short video demonstrating your working system.

   Presentation dates: 1/3 (Tue.)

3. **Final report:** (40%)

   The final report should be in standard ACM conference paper format. The report should at least have the following: abstract, introduction, related works, experimental setup and results, conclusion, and references listed at the end of the paper. The report should have at least 4 pages and no more than 5 pages. Please send the report as a PDF file to msn.nctu@gmail.com by the due date.

   Due date: 1/12 (Tue.) 23:59

The template for the report can be downloaded from here:
http://www.acm.org/sigs/publications/proceedings-templates (option 2)