Final Project Description
Wireless Networking: Fundamentals and Applications
2015 Fall

wn@csie.ntu.edu.tw

The main purpose of the final project of this course 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 from a number of different topics for your final project. Most topics are related to the tools with which you are already familiar, such as software defined radio (USRP), and Arduino/Zigduino boards. 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.

We understand that you might not understand the proposed topics completely from the short description in this document. If you have any question, please feel free to send us e-mails, or schedule an appointment with Michael to discuss what you'd like to do for your final project.

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

1. **Project proposal: (10%)**
   A 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. Please send the summary in standard ACM conference format, as a PDF file, by the due date to wn@csie.ntu.edu.tw. You will receive our comments about your proposal after we read your proposals.
   Due Date: 5/14(Thu) 23:59
2. **Final Project Presentation: (40%)**
   Each team will give a 15-minute presentation. The presentation should report the problem you are trying to solve, the experimental setup, and the results. You are encouraged to prepare a short video that can demonstrate your working system and play the video during your presentation.
   Presentation dates: 6/26 (Fri), during the usual lecture time in the final exam week
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 can be up to 8 pages. Please send the report as a PDF file to wn@csie.ntu.edu.tw
   Due date: 6/27(Sat) 23:59
   http://www.acm.org/sigs/publications/proceedings-templates (Option 2)
4. **Peer Assessment: (10%)**
   As lab 1-4 you did, you have to do the peer assessment for the final project on the end of the presentation day 6/26(Fri).

- **Project Topics:**

1. **Interference Nulling and Alignment**
   In this project, you will need to implement interference nulling and alignment for a 2x2 MIMO link. The 2x2 MIMO link is built by connecting two USRPs as a two-antenna transmitter and connecting another two USRPs as a two-antenna receiver. In the first part, the two-antenna transmitter nulls its signal at the first antenna of the receiver. In the second part, the two-antenna transmitter aligns its signal along any given direction.
   Reference: http://nms.citi.sinica.edu.tw/n+/n+.pdf

2. **Full-Duplex Node**
   In this project, you are asked to build a full-duplex node using two USRPs. A full-duplex node is typically realized by enabling three components: analog self-interference cancellation, digital self-interference cancellation, and antenna placement. In this project, we will replace analog cancellation by placing a RF absorber between the Tx/Rx antennas. As a result, you only need to implement digital self-interference cancellation, and measure the residual interference.
   Reference:
   (1) http://web.stanford.edu/~skatti/pubs/mobicom10-fd.pdf
   (2) http://web.stanford.edu/~skatti/pubs/sigcomm13-fullduplex.pdf

3. **Doppler Effect within WiFi Signals**
   The Doppler effect is the change in frequency of a wave when the observer and the signal source have relative movement. WiFi signals are transmitted in radio wave, and would also have the Doppler effect. In this project, you will use two USRPs, one as a transmitter and the other as a receiver at fixed locations, facing the subject, to observe the Doppler pattern when the subject performs different gestures with different speeds.
   Reference: https://wisee.cs.washington.edu/wisee_paper.pdf

4. **Camera Communications**
   UFSOOK:
   http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=6676454
   Manchester coding+ on-off keying (OOK):
   http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=6477759
   RollingLight:
   http://www.csie.ntu.edu.tw/~hsinmu/wiki/_media/paper/mobisys15.pdf
   Visible Light Landmark:
   http://wise.ece.cmu.edu/resources/publications/ipsn-14-vlc.pdf

   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 few papers describe some existing implementations of camera communications. We encourage you to take additional considerations to make the system suitable for a wider range of scenarios. Note that since in lab 1 you have implemented a similar system, teams that select this topic have to implement additional functionalities for the 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) **Screen-Camera Communications**: Use the display of the smartphone or a TV as the transmitter. Due to the large number of pixels, the achievable throughput for screen-camera communications is usually quite high, in the range of tens or even hundreds of kilobits per second. Design your system and implement a pair of working transmitter and receiver.
   Reference:
   2)-1. Inframe:
   http://conferences.sigcomm.org/hotnets/2014/papers/hotnets-XIII-final60.pdf
   2)-2. HiLight:
   http://dl.acm.org/citation.cfm?id=2643171&CFID=671669613&CFTOKEN=26707089

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.

4) **Visible Light Positioning**: each transmitting light can send out an ID. Assuming the positions of all lights are known, then the camera receiver (on a smartphone) can use the position of the light in the image to estimate its own location. This is perfect for indoor positioning or navigation system.
   Visible Light Landmark: See the link at the beginning of this topic
   Reference:https://web.eecs.umich.edu/~prabal/pubs/papers/kuo14luxapose.pdf

5. **GEMV^2: Geometry-based Efficient propagation Model for V2V communication (http://vehicle2x.net)**
GEMV^2 is a propagation model for vehicle-to-vehicle communications. The propagation model takes into consideration many different aspects, including free-space path loss, shadowing caused by other cars or surrounding buildings, as well as small-scale fading caused by the environment and the velocity of the vehicle. The author of the model has an implementation of the model in MATLAB (which is quite cool; see the screenshot of its integration with Google Earth on the website). Michael is familiar with the author of the model so it is possible to directly ask him questions via e-mails.

A few possible topic to utilize GEMV^2 MATLAB implementation:

1) **Implementing the propagation model for vehicle-to-vehicle VLC**.
The Vehicle-to-Vehicle VLC propagation model is slightly different from the RF propagation model; the most important two aspects are: (1) there is only a link if the transmitter and the receiver have line-of-sight (2) free-space path loss depends not only on the distance between the transmitter and the receiver, but also the respective angle between them. For this topic, you need to modify the original MATLAB code to incorporate this new VLC propagation model. Then, we would ask you to evaluate the performance of this new VLC-based vehicular network with realistic traffic traces generated by SUMO, a traffic simulator (the current implementation already supports that).
Vehicle-to-vehicle VLC propagation model:
http://www.csie.ntu.edu.tw/~hsinmu/wiki/_media/paper/vnc2013.pdf
SUMO: http://sumo-sim.org

2) **Modify the model to take human body shadowing into consideration**.
Scooter is very popular in Taiwan as well as several other Asian countries. Recent research results show that human bodies of the scooter driver and the passenger can create shadowing effect which attenuates the signal by up to 18 dB, when it blocks the line-of-sight. For this topic, you need to modify the original MATLAB code to consider this effect in the received power calculation. Then, we would also ask you to evaluate the performance of the vehicular network with realistic traffic traces.

3) If you feel that you are already familiar with NS-2, you can also choose to implement GEMV^2 entirely from scratch in NS-2 and perform simple evaluation to show that it actually works.