

[2015-Fall] WNFA lab3 – USRP

Wireless System

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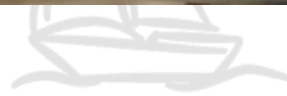
The background features a network diagram with various icons connected by dashed lines. The icons include two satellites at the top, a mobile phone, a satellite dish, a server tower, a person at a computer, a sailboat, a car, a truck, and a navigation device. The navigation device displays '60km' and '19:30'.

USRP INTRODUCTION

- What is USRP?
 - Used for software-defined radio experiment
 - For example, MIMO experiment
- Official website
 - http://www.ettus.com/content/files/07495_Ettus_N200-210_DS_Flyer_HR.pdf



USRP N200 & External Clock



- UHD
 - USRP Hardware Driver
 - C++ Program
- UHD Tool
 - uhd_find_devices
 - This program scans the network for supported devices and **prints out a list of discovered devices and their IP addresses.**
 - uhd_usrp_probe
 - This program constructs an instance of the device and prints out its properties, such as detected daughterboards, **frequency range, gain ranges**, etc...
- Reference: http://files.ettus.com/manual/page_coding.html

- How to compile a UHD program?
 - Files Directory
 - uhd/host/examples
 - Put your files here
 - Add your file in the Cmakelist.txt
 - compile Directory:
 - uhd/host/**build**/examples
 - sudo make
- The detail guideline for UHD program can see:
<http://goo.gl/TcR8Do>



WHAT WILL WE DO

- What is the purpose of lab3?
 - Implement a small wireless system
 - Be familiar with USRP
 - USRP Tx & Rx
 - Understand the principle of wireless system
 - Packet Detection
 - Phase Tracking
 - Analysis
 - Average SNR of each subcarrier
 - Average SNR of each symbol

- wn_lab3 directory introduction
 - matlab
 - `decode.m`, `phaseTrack.m`, `pkt_detection.m`
 - `read_complex_binary.m`, `signal_generator.m`
 - usrp
 - `single_tx.cpp`, `single_tx.h`, `single_rx.cpp`, `single_rx.h`
 - trace
 - `src_data_1.bin`, `src_data_1.mat` (both are generated by `signal_generator.m`)
 - Put your data received by USRP here you can run `decode` directly

- Data

- 1 preamble
- 50 symbols
- Generated by signal_generator.m

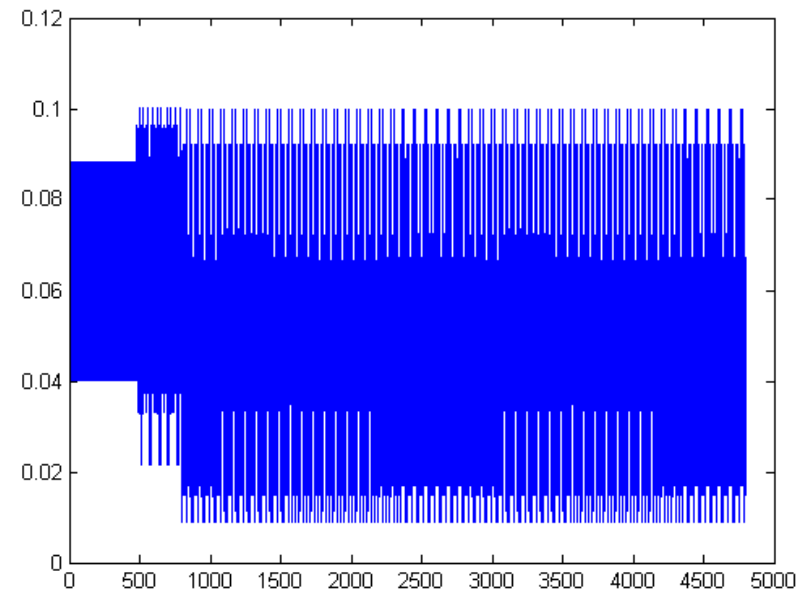
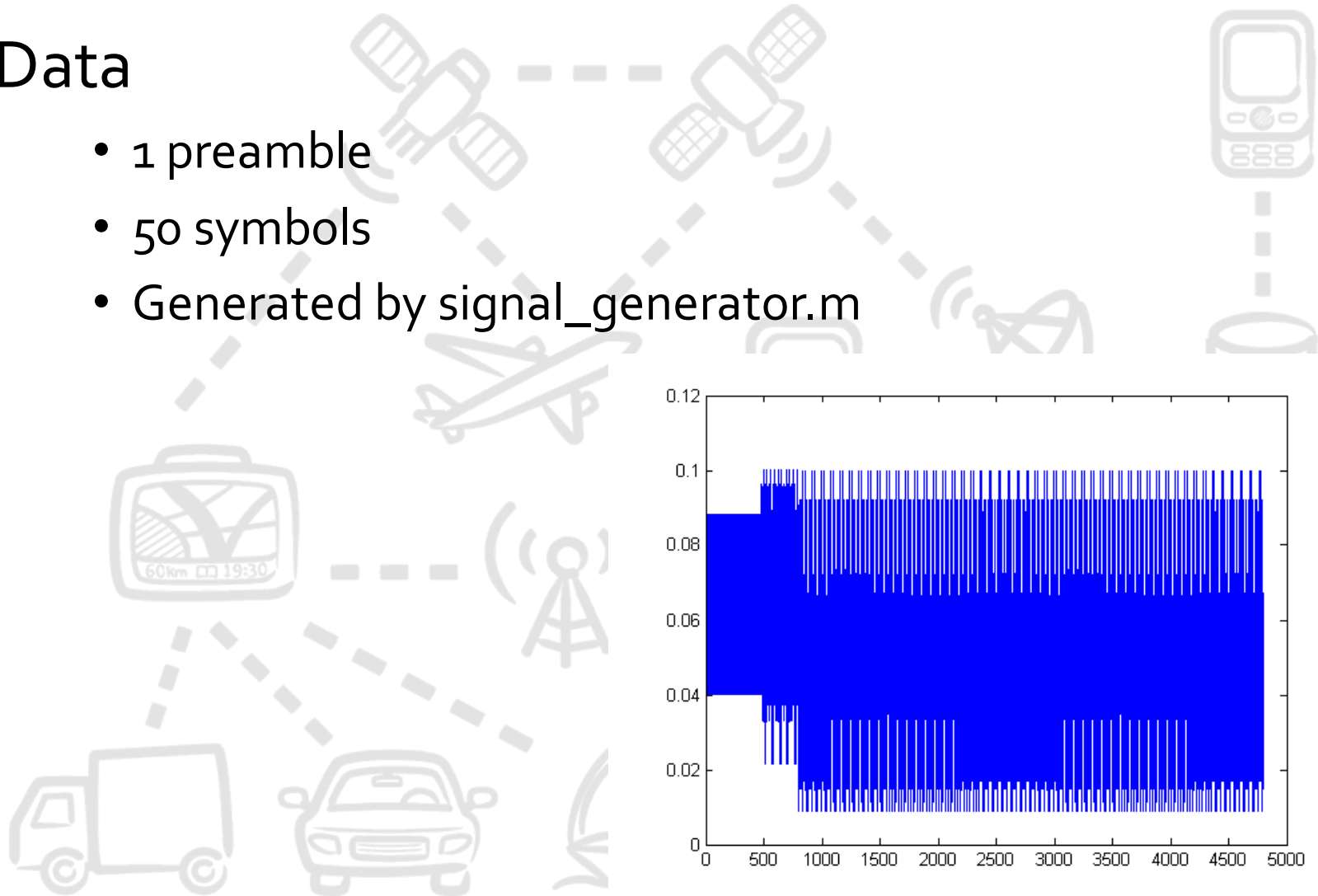


Fig. Raw signal

- Todo

- UHD

- single_tx.cpp
 - single_rx.cpp

- Decoder

- decode.m
 - phaseTrack.m
 - pkt_detection.m

- Analysis

- Average SNR of each subcarrier
 - Average SNR of each symbol



- Using UHD API to **transmit/receive** signal
 - Transmit: single_tx.cpp
 - Receive: single_rx.cpp
- How to execute your program?
 - Directory: uhd/host/build/examples
 - Tx `./single_tx --ro="addr=192.168.10.3" --f=2.49 --i=128 --in="./src_data_1.bin"`
 - Rx `./single_rx --ro="addr=192.168.10.4" --f=2.49 --i=128 --out="./recv_signal.bin"`



USRP Tx&Rx(cont)

- Todo

- UHD

- single_tx.cpp
 - single_rx.cpp

- Decoder

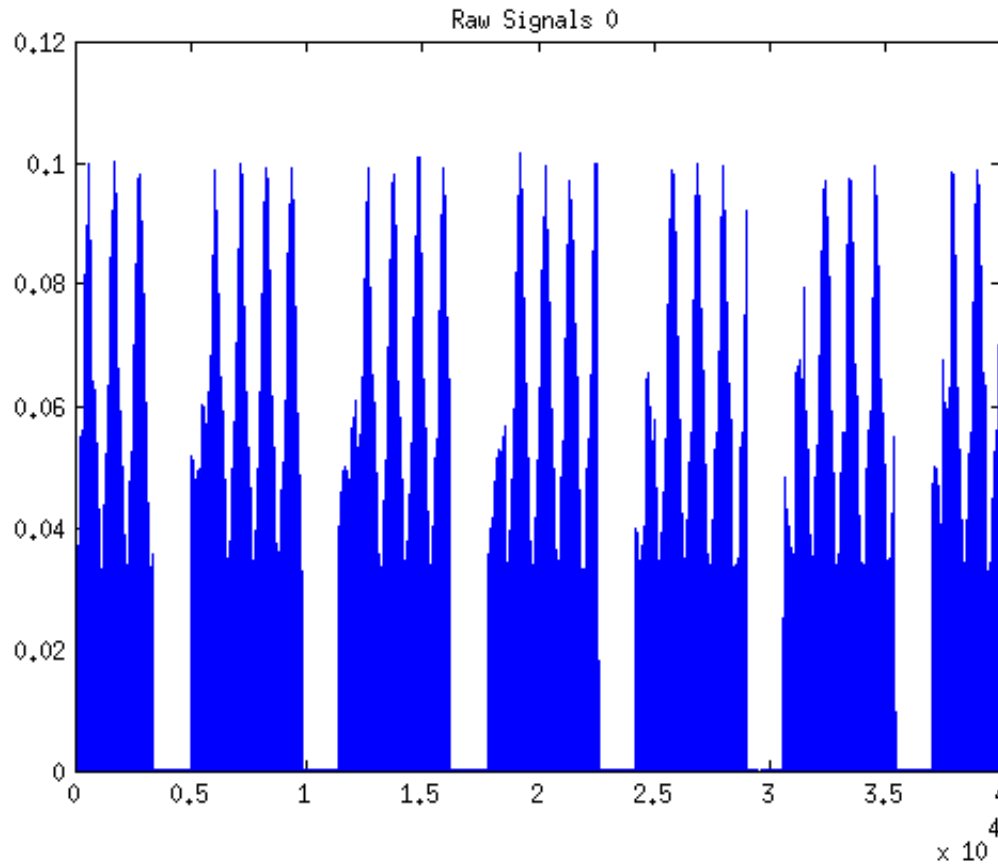
- decode.m
 - phaseTrack.m
 - pkt_detection.m

- Analysis

- Average SNR of each subcarrier
 - Average SNR of each symbol

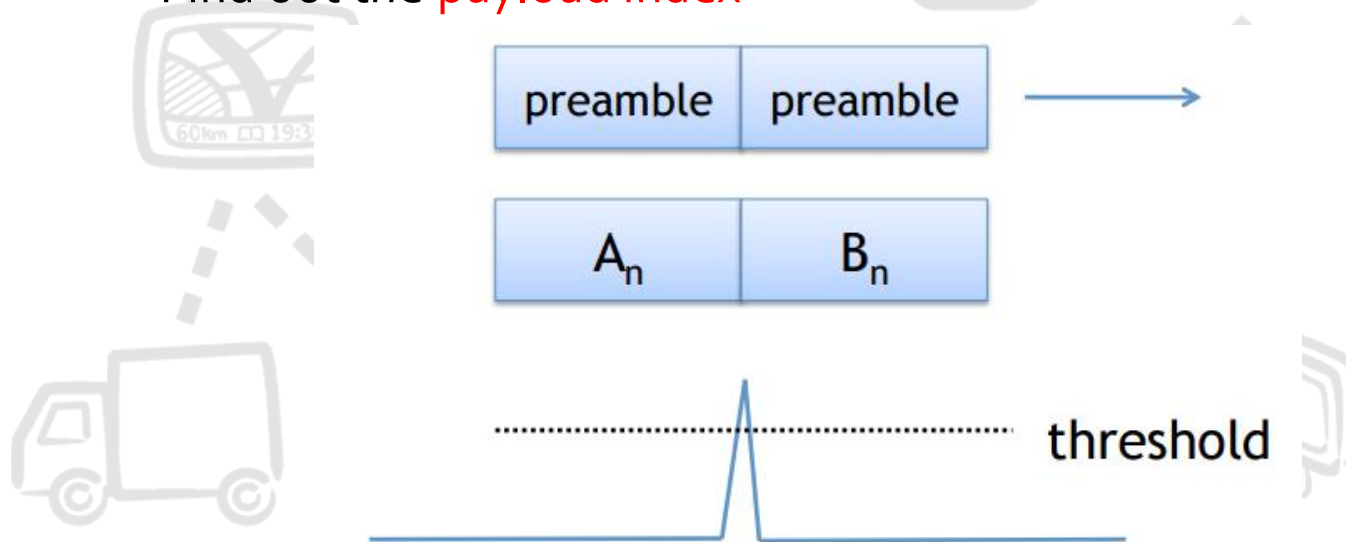


Decoder



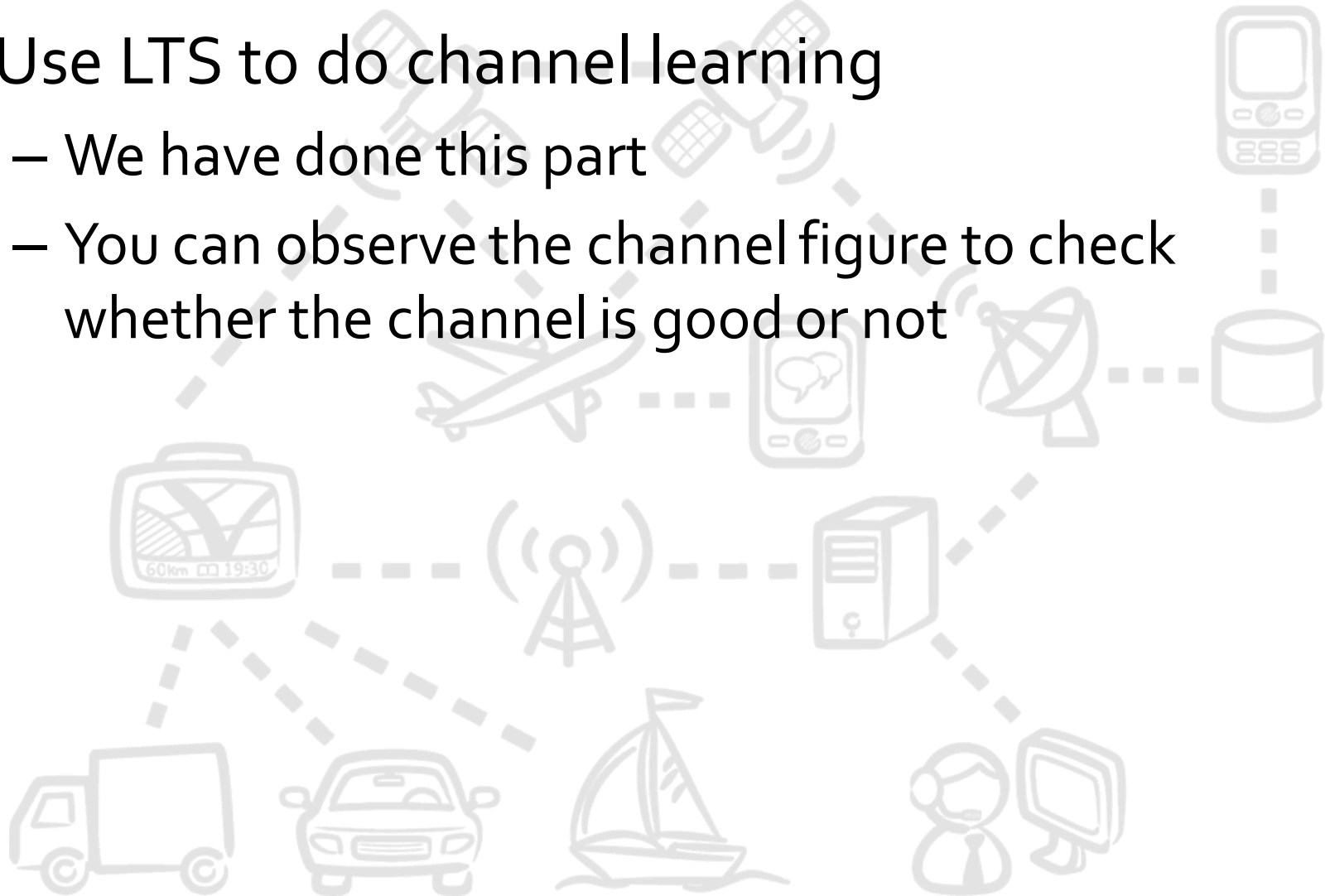
Packet Detection

- Preamble
 - $lts = [lts_t(33:64) \ lts_t \ lts_t \ lts_t \ lts_t \ lts_t(1:32)];$
 - Preamble = [sts, lts];
- Packet Detection
 - Use **cross-correlation** to detect the preamble
 - Find out the **payload index**



Channel Learning

- Use LTS to do channel learning
 - We have done this part
 - You can observe the channel figure to check whether the channel is good or not



Channel Learning

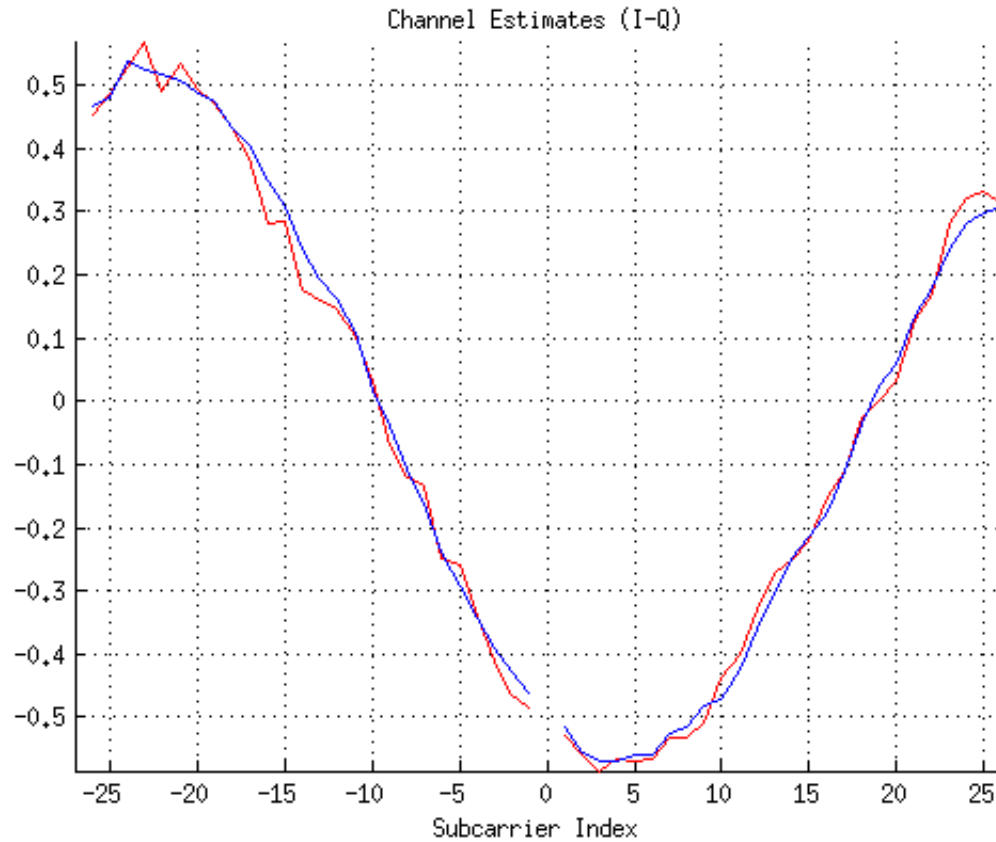


Fig. Channel Estimation(Good)

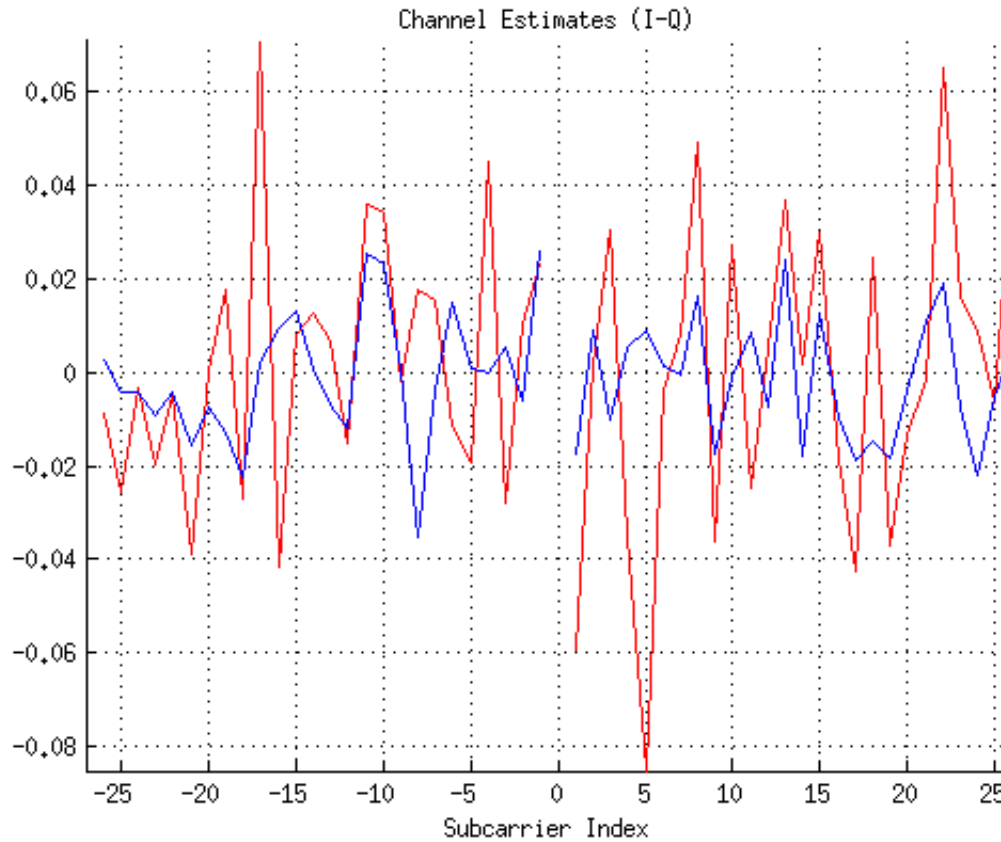
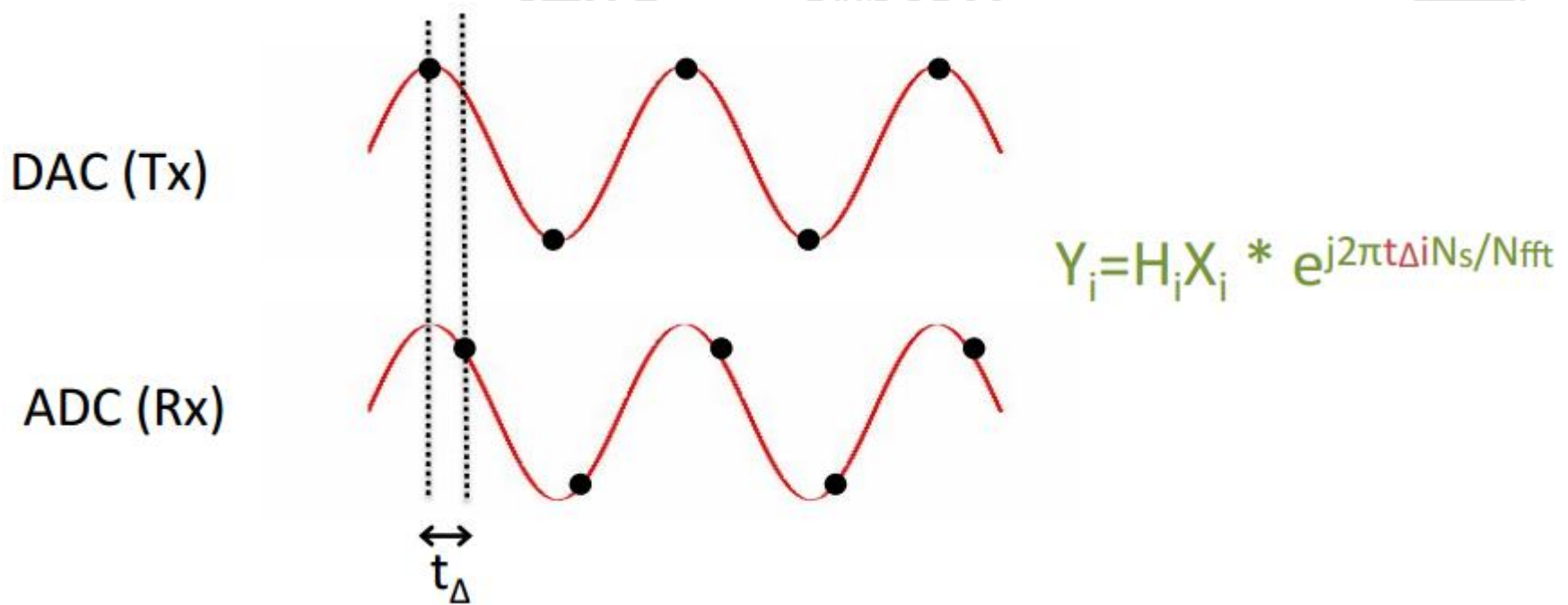


Fig. Channel Estimation(**bad**)

Phase Tracking

- Sampling Frequency Offset(SFO)

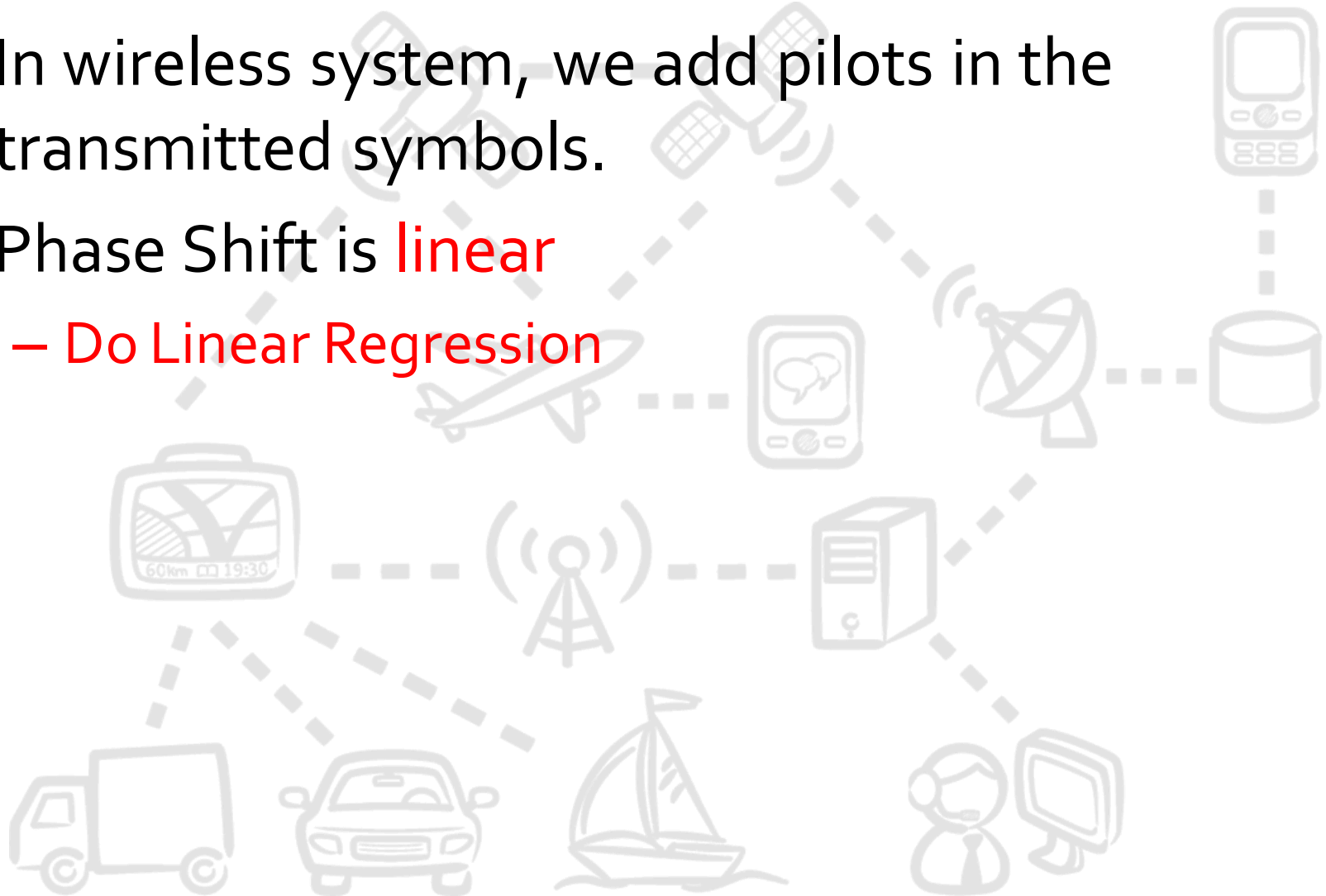


Sampling delay **rotate** the signal at slight different offset



Phase Tracking(cont)

- In wireless system, we add pilots in the transmitted symbols.
- Phase Shift is **linear**
 - Do Linear Regression



Phase Tracking(cont)

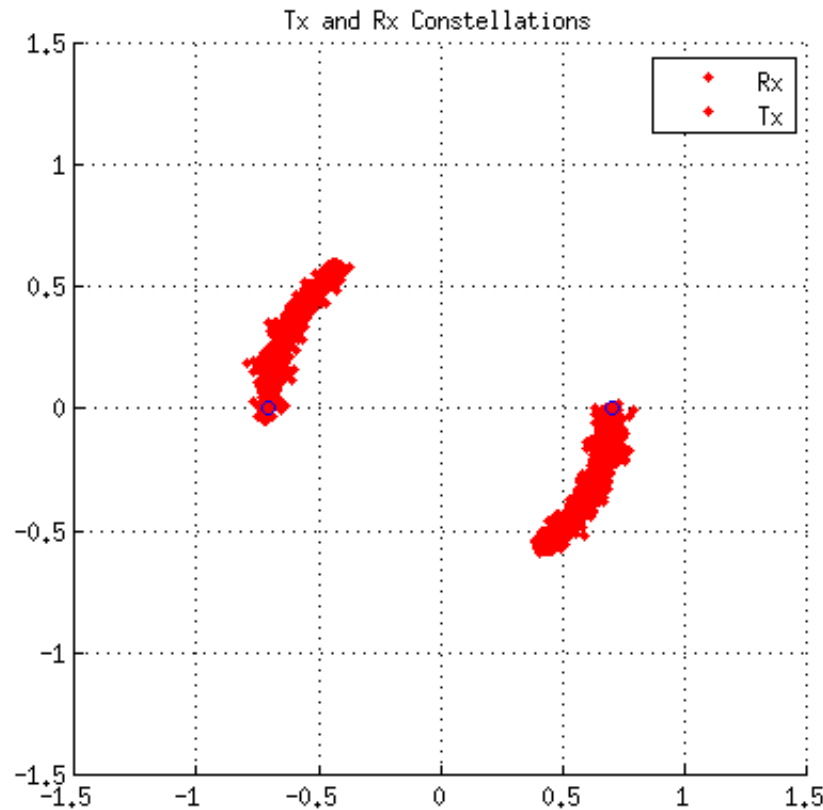


Fig. Without Phase Tracking

Phase Tracking(cont)

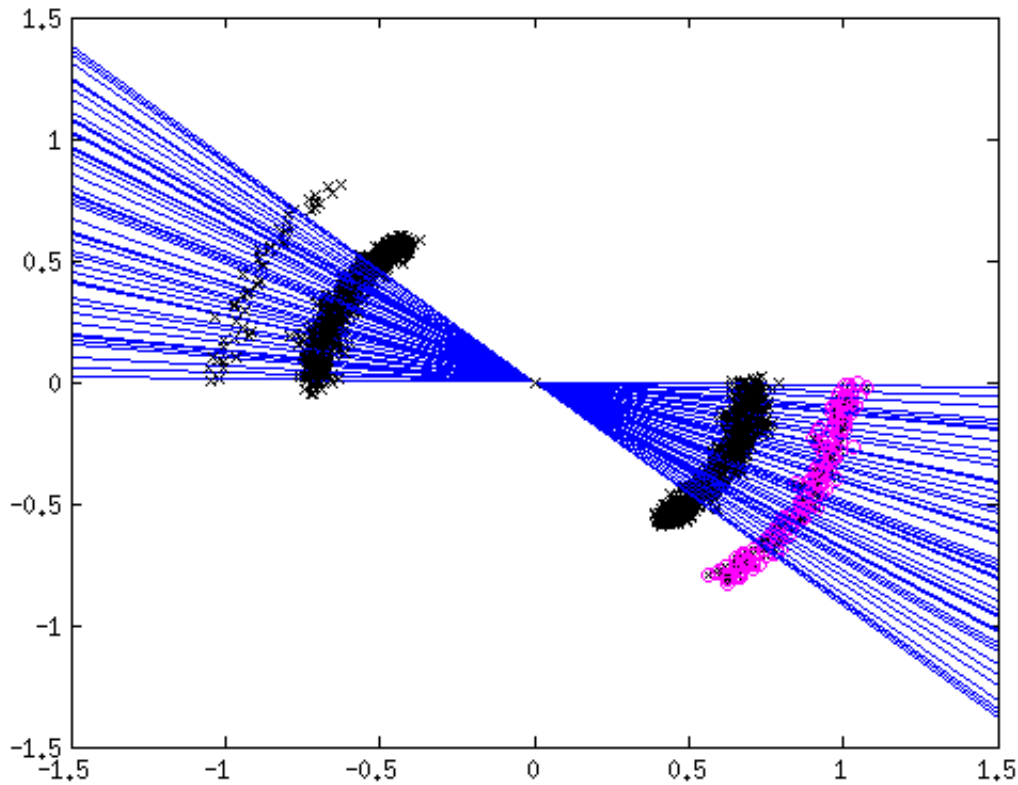


Fig. Without Phase Tracking

Phase Tracking(cont)

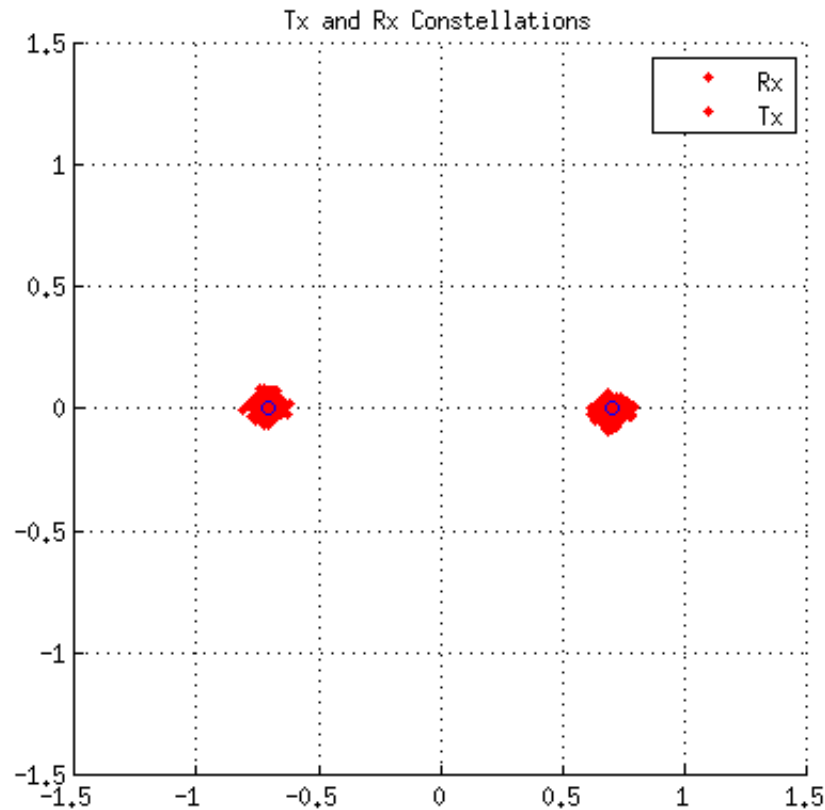


Fig. With Phase Tracking

- **Todo**

- UHD

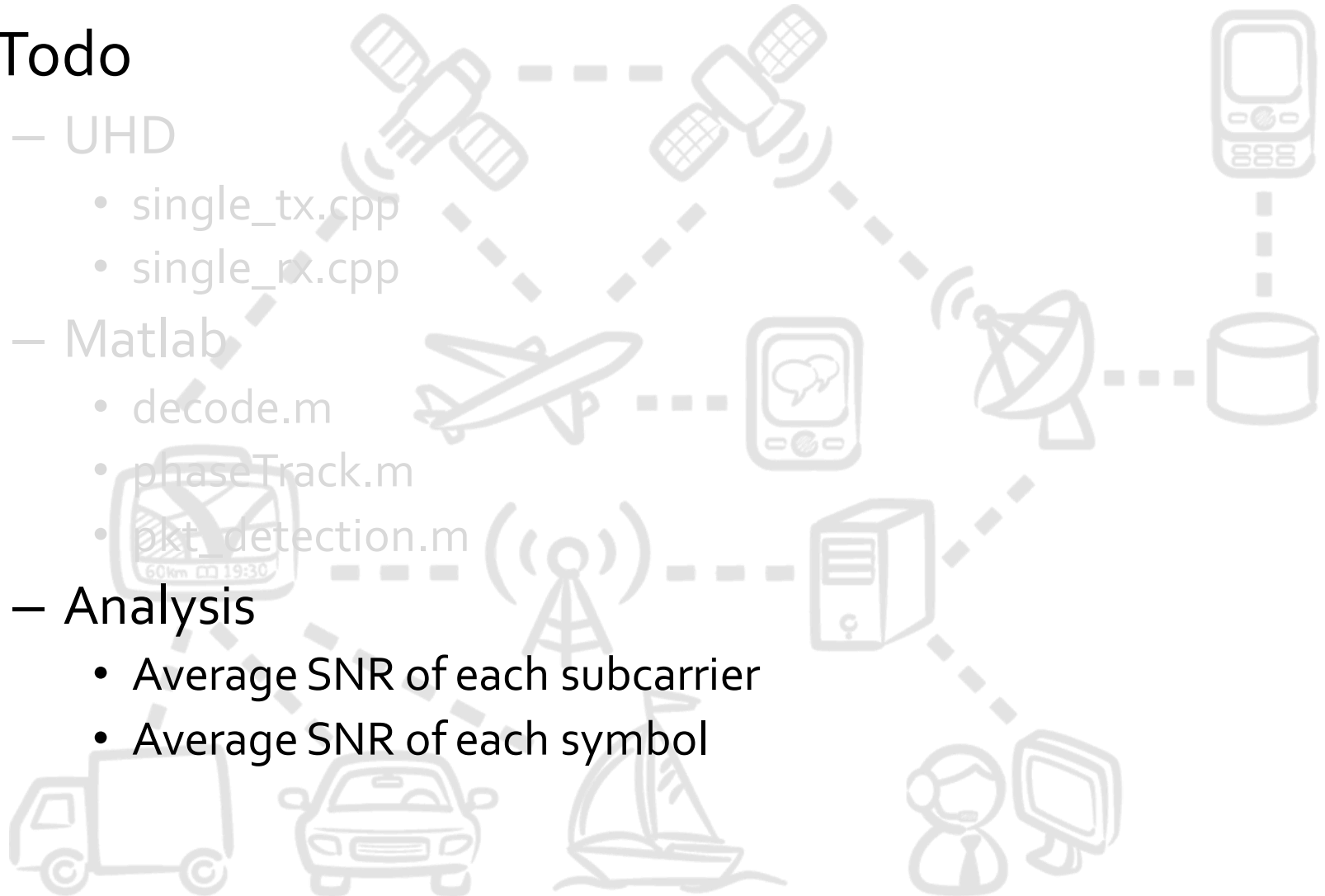
- single_tx.cpp
 - single_rx.cpp

- Matlab

- decode.m
 - phaseTrack.m
 - pkt_detection.m

- **Analysis**

- Average SNR of each subcarrier
 - Average SNR of each symbol



- Output the SNR of each Symbol
- Output the average SNR of each sub-carrier

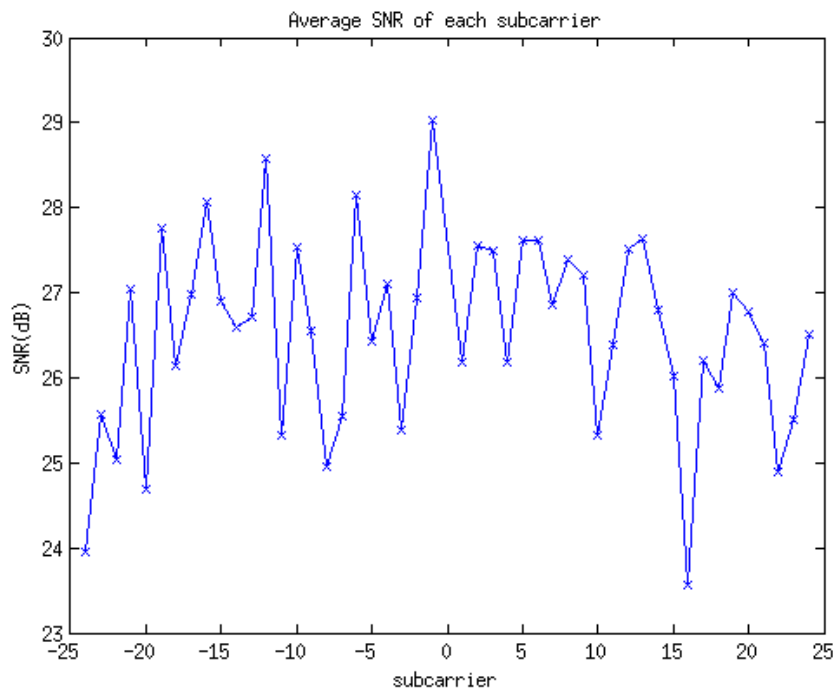


Fig. Avg. SNR of each subcarrier

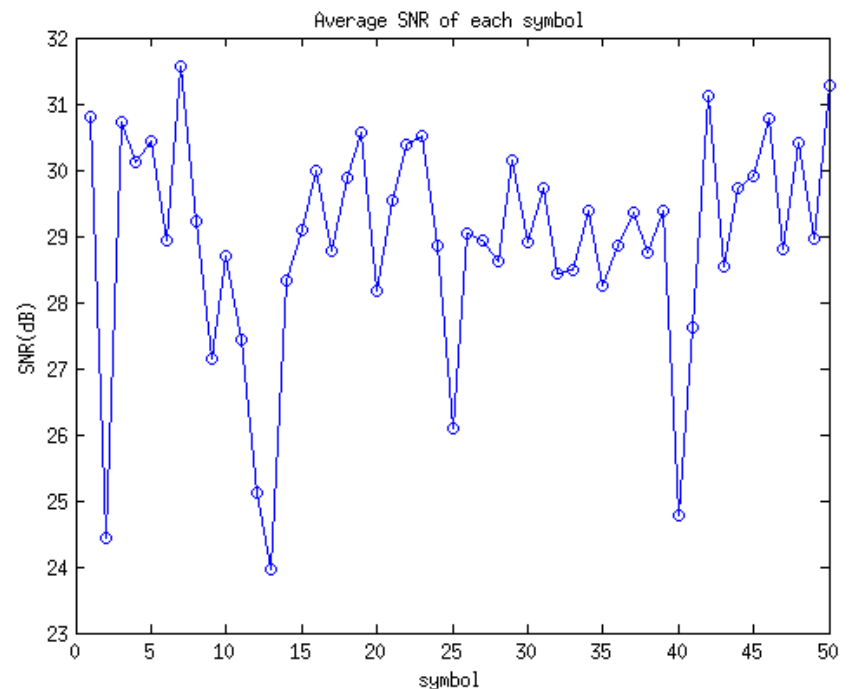
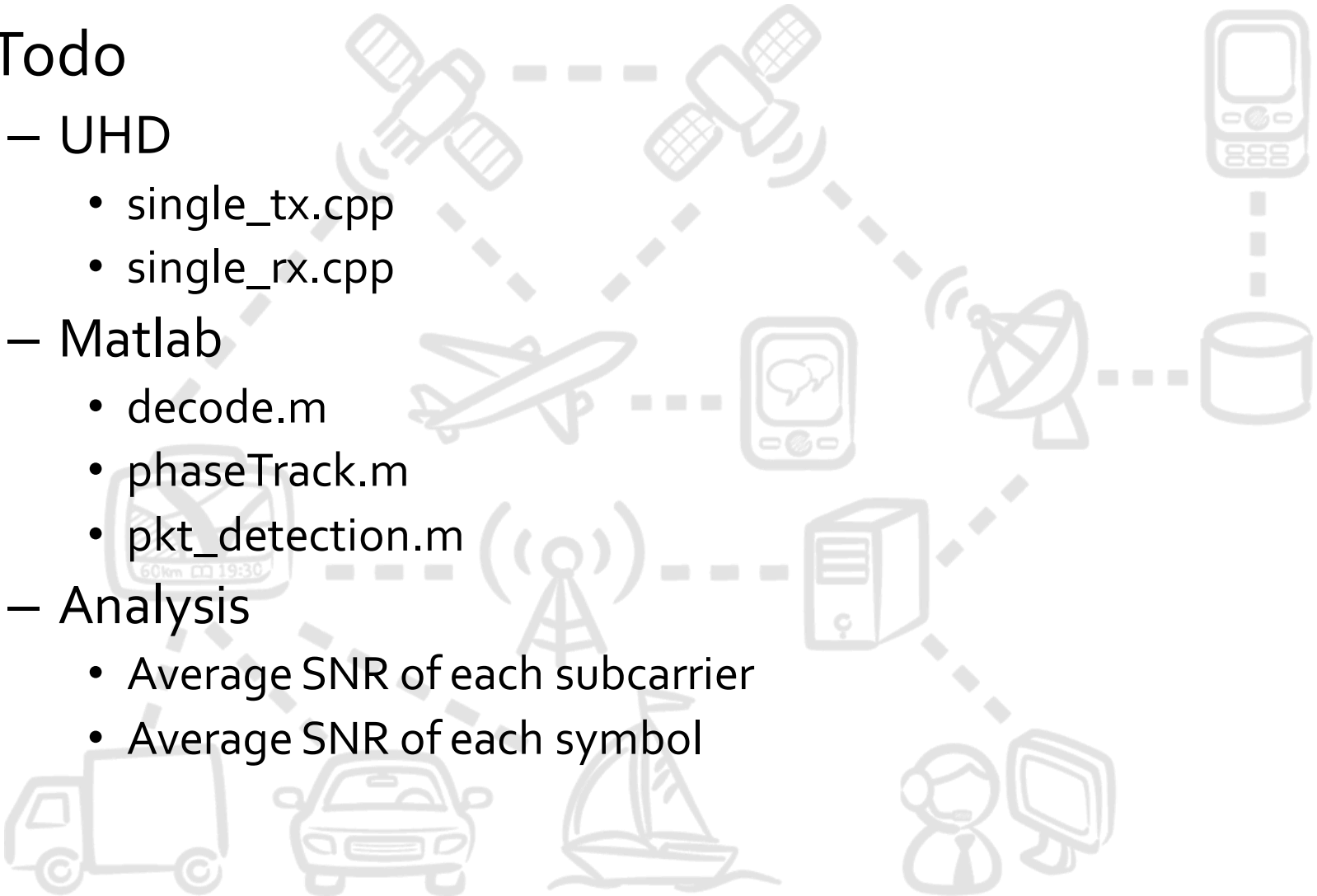


Fig. Avg. SNR of each symbol

What will we do

- Todo
 - UHD
 - single_tx.cpp
 - single_rx.cpp
 - Matlab
 - decode.m
 - phaseTrack.m
 - pkt_detection.m
 - Analysis
 - Average SNR of each subcarrier
 - Average SNR of each symbol





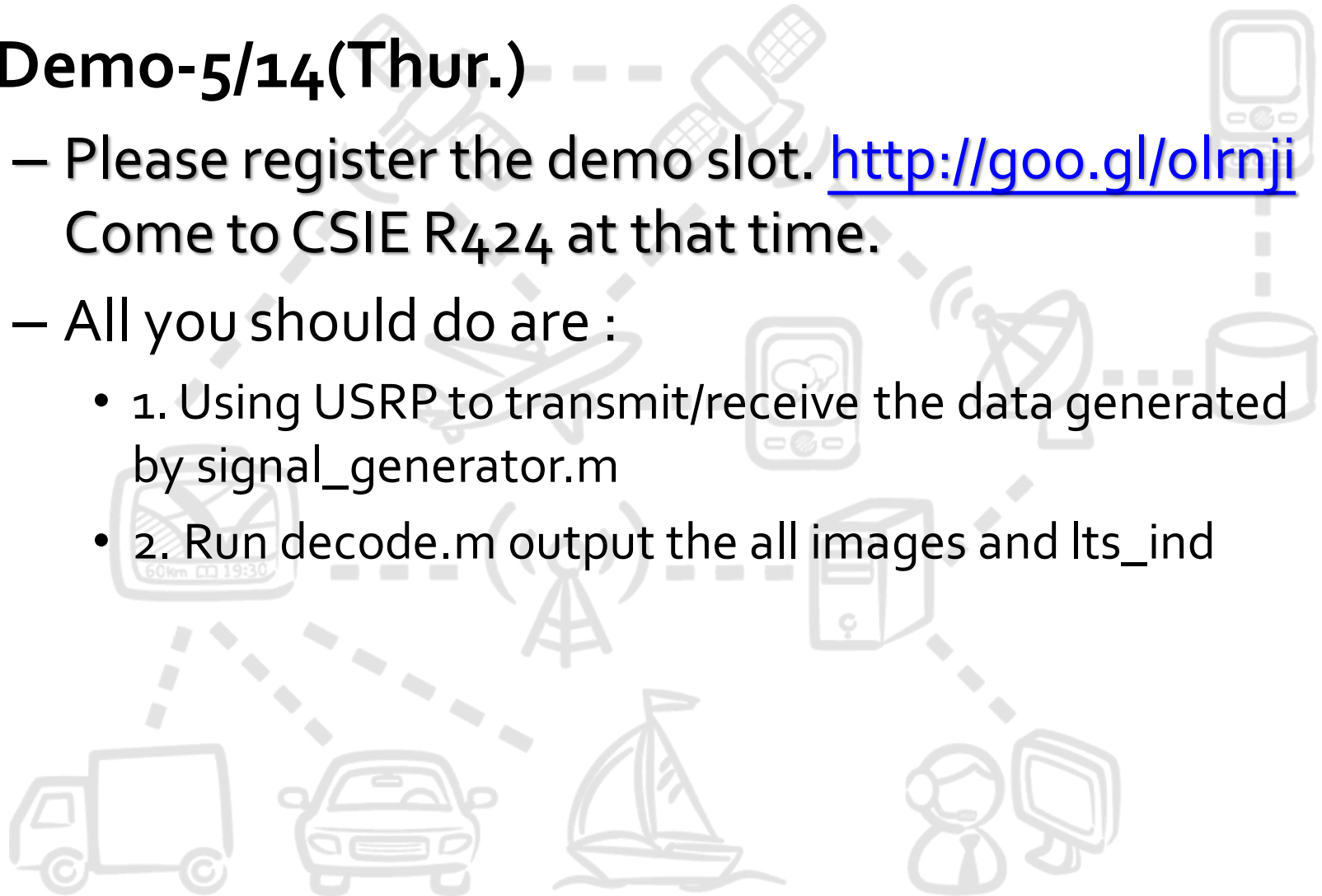
- **Deadline: 5/14 (Thur.) 23:59**
 - **Email** to wn@csie.ntu.edu.tw
 - **Subject:** [WN]lab3_teamXX
 - **Filename:** lab3_teamXX.zip
 - source code
 - UHD: single_tx.cpp/single_rx.cpp
 - Matlab: decode.m/pkt_detection.m/phaseTrack.m
 - Report(.pdf)
 - Describe what team members have done (**in detail**)
 - What kinds of problems you encountered & how to solve?
 - Analysis output image including received raw signal, channel estimate, avg. SNR of each subcarrier and avg. SNR of each symbol.
 - Image with phase tracking/without phase tracking

- **Demo-5/14(Thur.)**

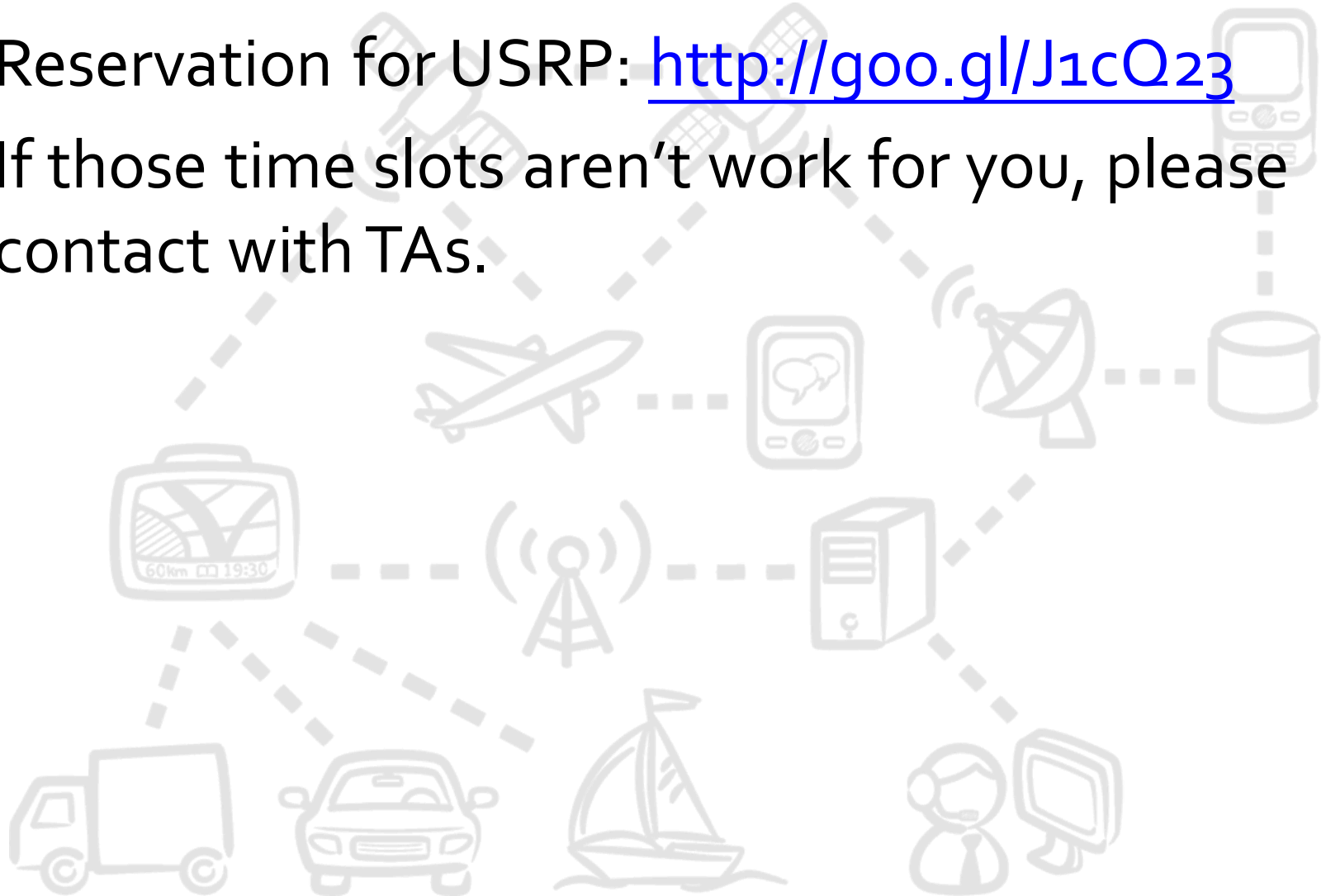
- Please register the demo slot. <http://goo.gl/olrnji>
Come to CSIE R424 at that time.

- All you should do are :

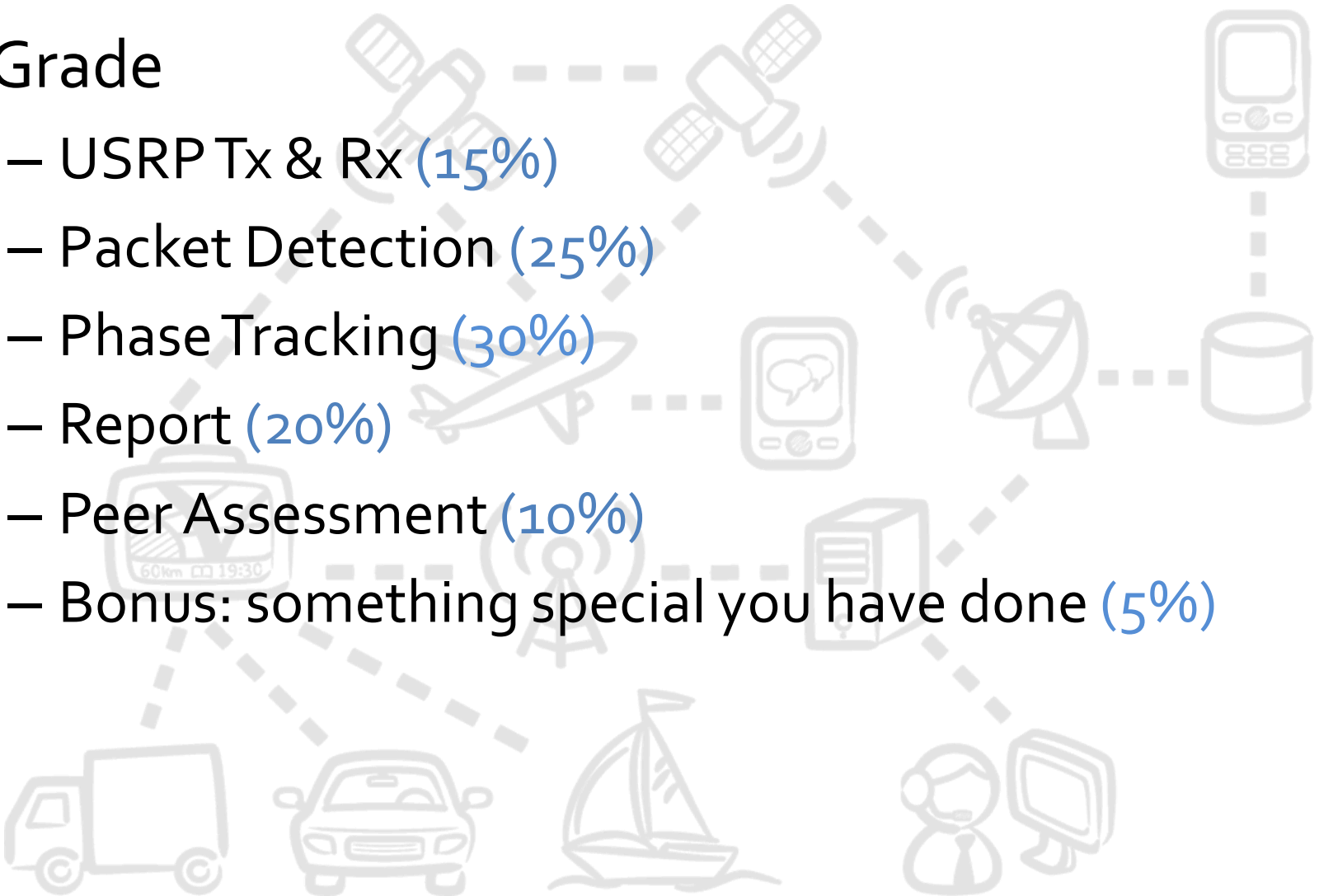
- 1. Using USRP to transmit/receive the data generated by signal_generator.m
 - 2. Run decode.m output the all images and Its_ind



- Reservation for USRP: <http://goo.gl/J1cQ23>
- If those time slots aren't work for you, please contact with TAs.



- Grade
 - USRP Tx & Rx (15%)
 - Packet Detection (25%)
 - Phase Tracking (30%)
 - Report (20%)
 - Peer Assessment (10%)
 - Bonus: something special you have done (5%)



- Contact to TAs :
 - Facebook
<https://www.facebook.com/groups/wn15spring/>
 - Email : wn@csie.ntu.edu.tw
 - Office hour : Thur. 16:00~17:00@ CSIE R424

