

Wireless Communication Systems

@CS.NCTU

USRP Lab 3

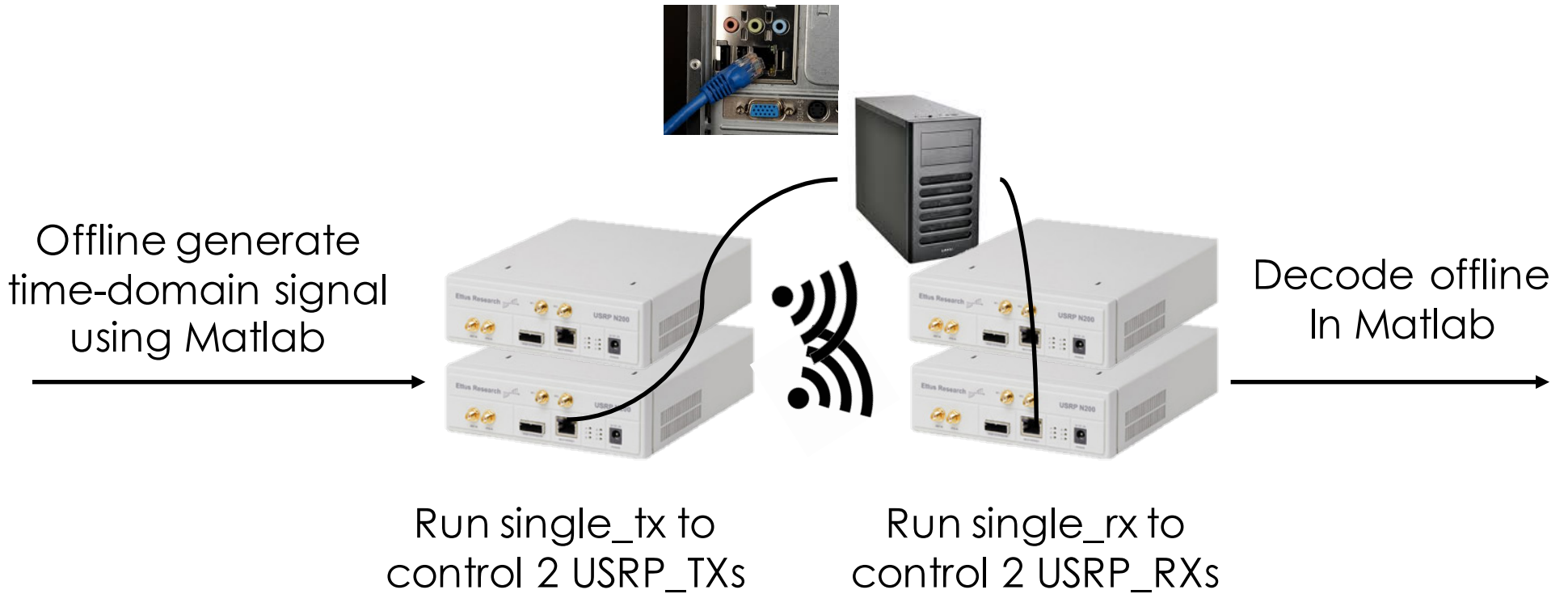
Yu-Lin Wei

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Outline

- Intro
 - Environment
- Tasks
 - OFDM signal generator (MATLAB)
 - Tx / Rx (C++ for USRP)
 - Decoding (MATLAB)
- Grading Criteria

Environment



- USRP Testbed in LAB / office
- Access through ssh (test your `single_tx` / `single_rx`)
- Run Matlab in your own machine

Build MIMO Using USRPs

- Connect two USRPs using an external clock



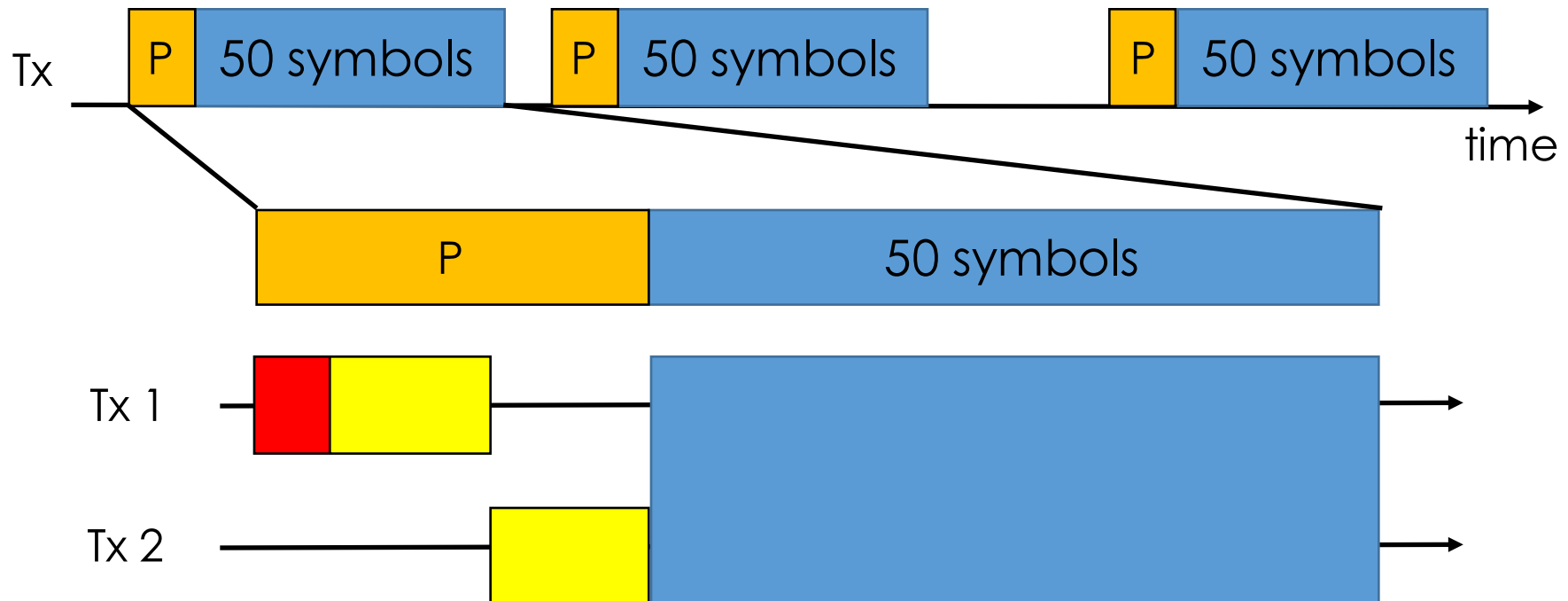
- Configure clock info in tx.cpp and rx.cpp (have implemented in the example files)
 - `usrp1->set_clock_config(uhd::clock_config_t::external());`
`usrp1->set_time_next_pps(uhd::time_spec_t(0.0));`

USRP Server

- ssh [wcs-g#@140.113.203.6](ssh:wcs-g#@140.113.203.6)
ssh [wcs-g#@140.113.207.100](ssh:wcs-g#@140.113.207.100)
 - e.g., [wcs-g1@140.113.203.6](ssh:wcs-g1@140.113.203.6) default password:
- Please refer to lab1_info.pptx for compile details

TODO

- Tx repetitively sends 50 symbols
- Rx receives at least one batch of 50 symbols
- Matlab offline decoding



Legacy preamble for packet detection



MIMO preamble for calculating the channel matrix

Sample Code

- WARP (Wireless Open Access Research Platform)
- 2x2 OFDM example:
https://warpproject.org/trac/wiki/WARPLab/Examples/MIMO_OFDM
 - OFDM symbol generation
 - OFDM Tx/ Rx
 - Decoding
- Default setting
 - `USE_WARPLAB_TXRX = 0` to see the simulation result
 - Set `MOD_ORDER = 2` to use BPSK modulation

Task 1: OFDM Symbol Generator

- This time generator code is given as sample code
- `gen_signal.m`
 - `signal_gen.m` outputs the time-domain signal to be transmitted as `tx1_signal.bin`, `tx2_signal.bin` and `src_data.mat`
 - `tx1_signal.bin` / `tx2_signal.bin` – will be fed into `single_tx` for USRP transmission
 - `src_data.mat` – ground truth for decoding / plotting

Task 2: USRP Transmitter

- Compile the example code and test
- Sample code provided by the TA
 - Similar to Tx in Lab1
 - Call “connecting to external clock”
 - Declare two USRP variables
 - Add comments to show your “TODO” tasks
- TODO (`2ant_tx.cpp/ 2ant_tx.h`)
 - Modify `2ant_tx.cpp/ 2ant_tx.h` to transmit the message you just generated
 - Two variables: `usrp1` and `usrp2`, each represents an antenna
 - Now `2ant_tx.cpp` only implements the code for the first antenna (`usrp1`). Do the same thing for `usrp2`
 - Search “// TODO: add usrp2”

Task 3: USRP Receiver

- Sample code provided by the TA
 - Receive the upcoming signal
 - Save the data at `wcs_trace/rx1_signal.bin` and `wcs_trace/rx2_signal.bin`
 - Launch `2ant_rx` after `2ant_tx`
 - `./2ant_rx --f=2.49 --i=128`
- TODO (`2ant_rx.cpp`)
 - Modify `2ant_rx.cpp` to add the code for `usrp2`

Task 4: Decoding

- Read the WARP code
- TODO (decode.m)
 - Modify the decoder
 - originally in line 505: $x = \text{inv}(H)*y;$
 - Implement using the ZF decoder shown in slide 8 of L4_MIMO.pptx

Task 5: Check Channel Correlation

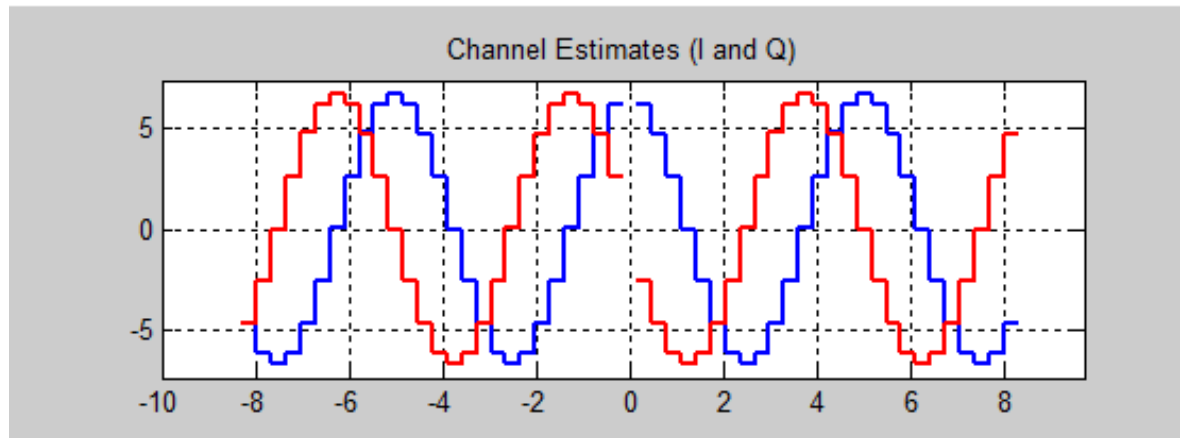
- TODO (decode.m)
 - Check the angle between channel vector 1 (h_{11}, h_{12}) and channel vector 2 (h_{21}, h_{22})
- Hint: how to calculate the angle of two complex vectors?

$$\theta = \arccos \left(\frac{\operatorname{Re}(u \cdot v)}{\|u\| \|v\|} \right)$$

$$u \cdot v = \sum_{k=1}^n u_k \bar{v}_k$$

Required figures

- Figure 1: 2x2 Channel estimation (There should be four figures)

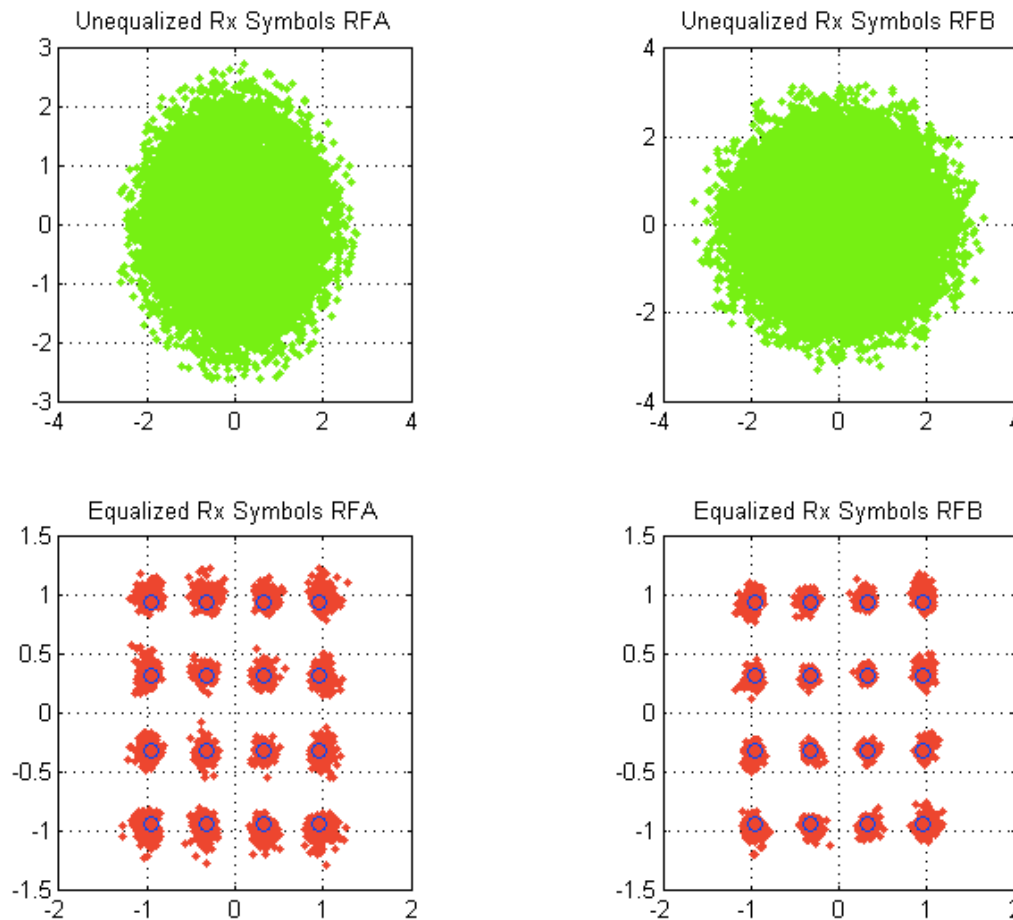


Required figures

- Figure 2: subcarrier SNR of two streams
 - For each stream, plot the average SNR of each data subcarrier among all symbols (bar graph)

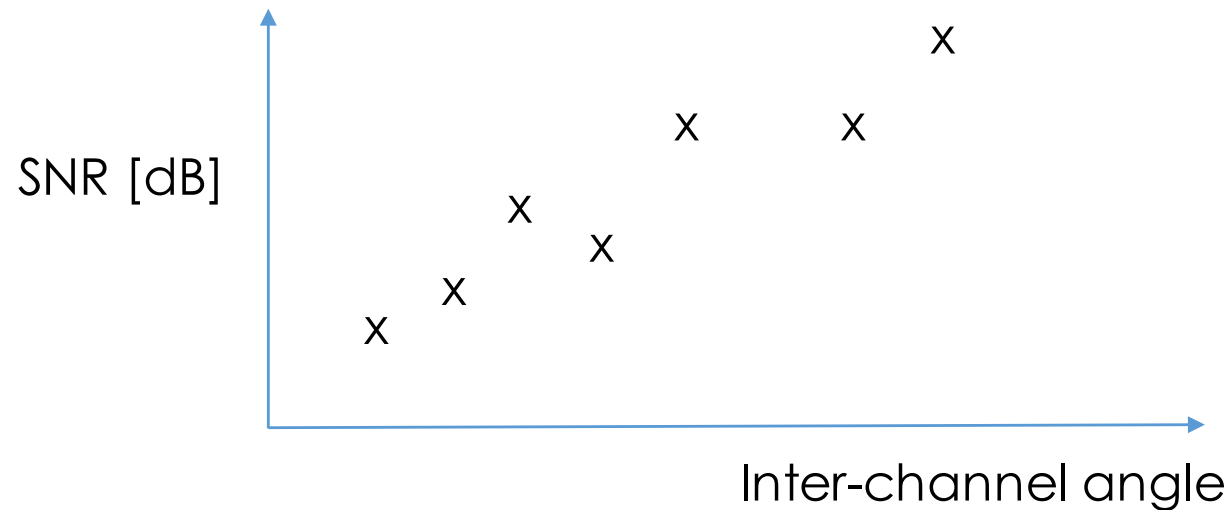
Required figures

- Figure 3: constellation points (WARP figure 6)



Required figures

- Figure 4: channel correlation vs. average SNR of a subcarrier (scatter plots)
 - Collect 10-20 Rx traces
 - Randomly pick three data subcarriers. For each selected subcarrier, plot the following figure.



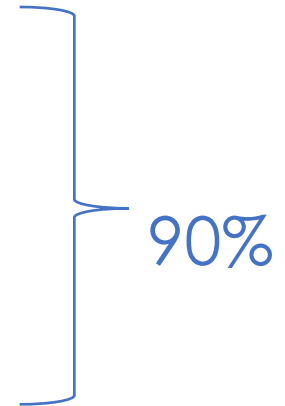
Demo

- Time/Location
 - Dec. 2 (Fri.) 10:00~12:00 in EC-538
 - Or by appointment
 - Contact with TX (張威竣) to sign up the time slot

Grading

- Tx/Rx: 30%
- decode.m: 30%
- Figure: 20%
- Code readability: 10%

- Peer review: $\pm 15\%$



90%

Peer Review

- 15% group member peer review
 - Anonymous
 - Range from -15 ~ 15
 - Grade for each peer, excluding yourself
 - Zero mean

	Alice	Bob	Chris	David
Alice	N/A	-10	-5	+15

- Total score: up to 105

Code Submission

- Deadline: Dec. 2 (Fri.) 23:59
- Email to
 - msn.nctu@gmail.com
 - Email subject: [WCS] lab3_gX
 - WCS_lab3_gX.zip
 - source code (2ant_tx.cpp/ 2ant_rx.cpp/ decode.m/ signal_gen.m)
 - Report (.pdf): include all figures along with captions and **short** discussion

Q&A