Wireless Communication Systems
@CS.NCTU

Lecture 0: Introduction to Wireless Networks

Instructor: Kate Ching-Ju Lin (林靖茹)

Wireless Courses @ CS, NCTU

- 有線/無線網路技術整合及應用
- 行動無線網路安全
- 無線多媒體網路
- 無線區域網路
- 無線通訊最佳化
- 無線感測網路及射頻識別技術
- 無線網路與行動計算
- 無線網際網路
- 無線隨意及感測網路技術與應用
- 雲端架構之4G/LTE網路和應用
- 行動通訊網路與應用
- 新世代無線網路協定與技術
- ……

What's new here?

Wireless

Use wireless signals




Communication

To communicate or interact

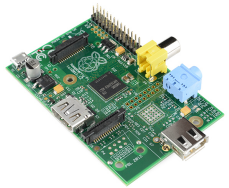
- MIMO, full-duplex, mmWave, localization, action recognition, ….

Systems

Via prototyping or application


Software Defined Radio

Aduino



Pi

iOS App

Main Purposes of This Class

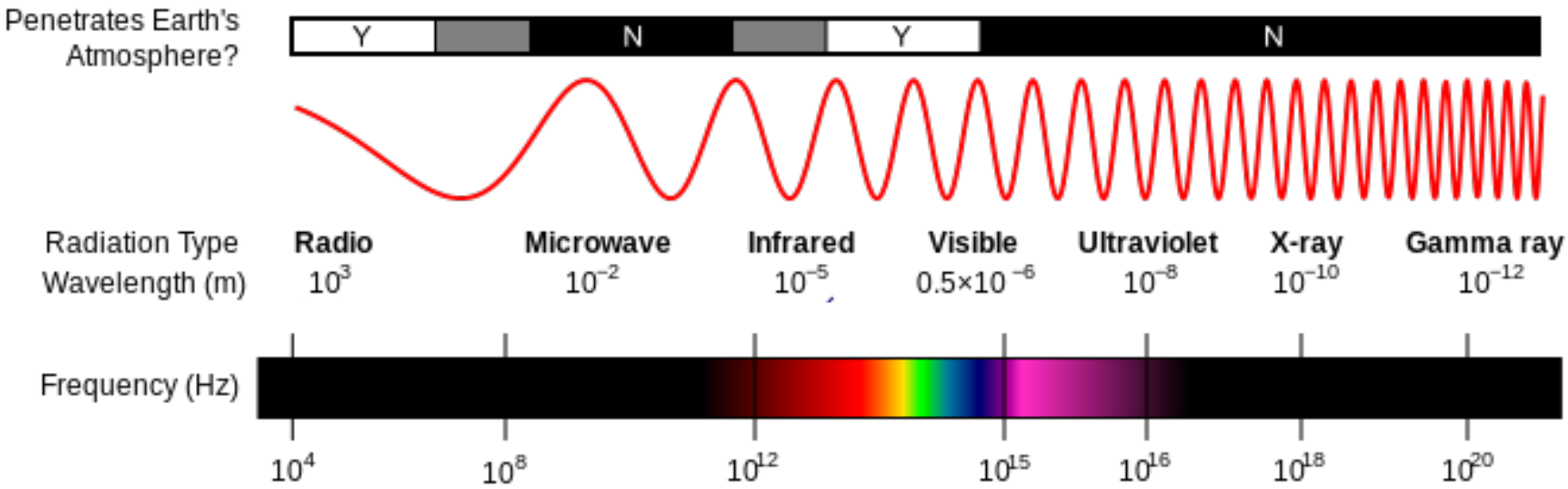
- Train hand-on experiences
  - Four labs
- Broaden your knowledge base for mobile and wireless research
  - Introduce most emerging wireless technologies in recent 5 years
  - Introduce possible applications
- Learn how to do presentation
  - One paper presentation
- Improve your English

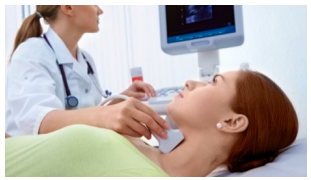
Syllabus

- Introduction
- Medium Access Control
- Modulation
- Bit-Rate Adaptation
- Soft Information and Error Recovery
- OFDM
- Successive Interference Cancellation
- RFID
- MIMO 1: Multiplexing, Diversity, and Detection
- MIMO 2: Interference Alignment, Interference Nulling, and Virtual MIMO
- Wireless Localization
- Wireless HCI
- Visible Light Communications
- Full-Duplex Communications
- mmWave

Introduce 1-3 famous papers for each topic!

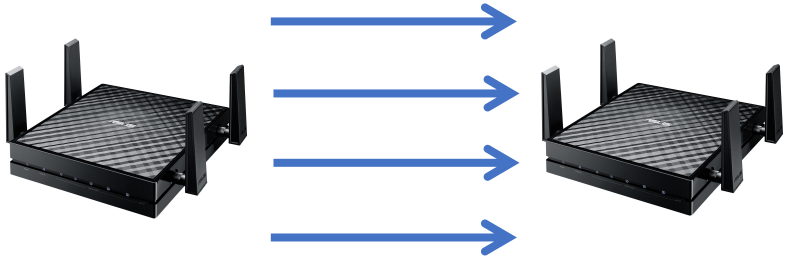
What wireless signals we can use?



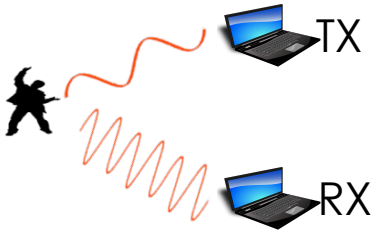
20–20kHz	20kHz – GHZ	3kHz – 300GHZ	430–770 THz
			
Audio signal	Ultrasound	Radio frequency (WiFi, LTE, Bluetooth, RFID)	Visible light

What topics we will cover?

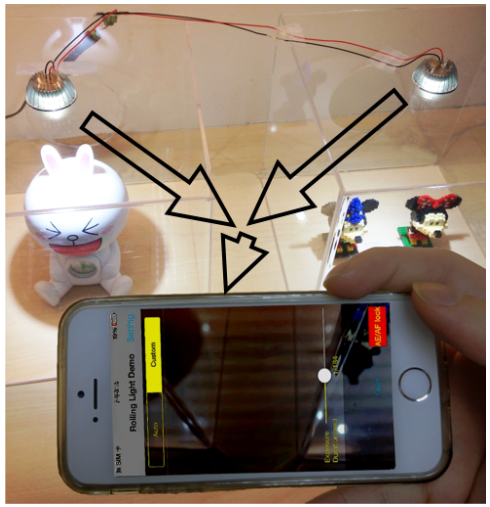
Multi-antenna (MIMO) systems



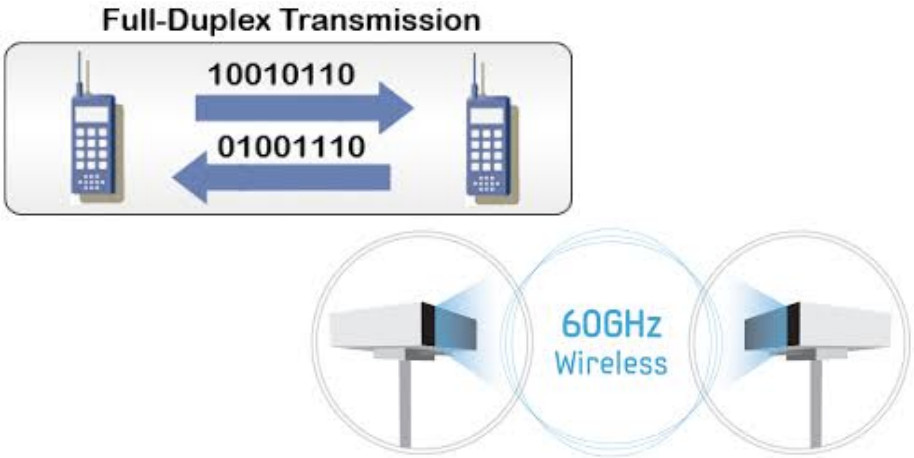
Device-free / wearable localization and action recognition



Visible light applications



Next-generation communications (5G)



What you will NOT learn from this class?

- Standards, such as 3GPP, 802.11ac, ZigBee
- Top-down or bottom-up network design
- Optimization and algorithm designs
  - Advanced algorithm, combinatorial optimization, etc
- Performance modeling and analysis
  - Random process, queueing theory, etc

What you WILL learn from this class?

- How to ***design*** a wireless system/application using
  - Existing signal processing skills
  - Cross-layer designs
  - Various wireless spectrum, such as radio frequency (RFID, WiFi, mmWave, etc), ultrasound and visible light
- How to ***build*** a wireless system/application using
  - Software designed radio, such as USRP and WARP
  - Commodity NIC with the modified driver
- How to ***evaluate*** your wireless system, using
  - Well known performance metrics
  - Testbed experiments

General Information

- http://people.cs.nctu.edu.tw/~katelin/courses/wcs18/
- Other information
  - Facebook group: NCTU WCS
- Instructor
  - Kate Ching-Ju Lin (林靖茹), EC-538
  - Office hours: Fri. after class
- TA
  - 蔡一嘉, EC-522, richard.yctsai@gmail.com
- Schedule
  - 16:30 — 17:20, Tue.
  - 10:10 — 12:00, Fri.

Course Details

- Materials
  - Mainly research papers
  - Additional tutorials/notes/slides
- Reference textbook
  - David Tse and Pramod Viswanath. 2005. Fundamentals of Wireless Communication. Cambridge University Press, New York, NY, USA. https://people.eecs.berkeley.edu/~dtse/book.html
  - Andrea Goldsmith. 2005. Wireless Communications. Cambridge University Press, New York, NY, USA.
- Prerequisites
  - Undergraduate network class
  - Basic math: probability, Fourier, …
  - Programming required in wireless labs and projects (Python, C and Matlab)

Grading

- Four Labs 60%
  - Matlab simulation
  - Use USRP software defined radios
  - Develop in UHD (USRP hardware driver, written in C)
- Quiz 20%
  - After lab2
  - OFDM Matlab code
- Presentation 20%
  - In the last two weeks
  - Each team with 2-3 members

Labs

- Lab1: OFDM simulation (Matlab)
- Lab2: OFDM on USRP
- Lab3: Interference cancellation simulation (Matlab)
- Lab4: interference cancellation on USRP

- Lab1, Lab3: Each student works individually
- Lab2, Lab4: 2-3 students a group

https://warpproject.org/trac/wiki/WARPLab/Examples/OFDM

Schedule

- 3/25 (Sun): Lab1 due
- 4/15 (Sun): Lab2 due
- 4/20 (Fri): Quiz
- 5/13 (Sun): Lab3 due
- 5/8 (Fri): Lab4 demo
- 5/10 (Sun): Lab4 due
- Last two weeks: presentation

- 3/16 (Fri): no class
- 4/6 (Fri): no class
- 5/8 (Tue): no class

In this class, you will

- Learn how the interaction between PHY and MAC can improves network performance
- Leverage wireless signals to develop potential applications
  - Localization
  - Human interaction
  - Smart home
  - Visible light communications
- Learn how to do networking research
  - Paper reading
  - Logical thinking
  - Prototyping and evaluation

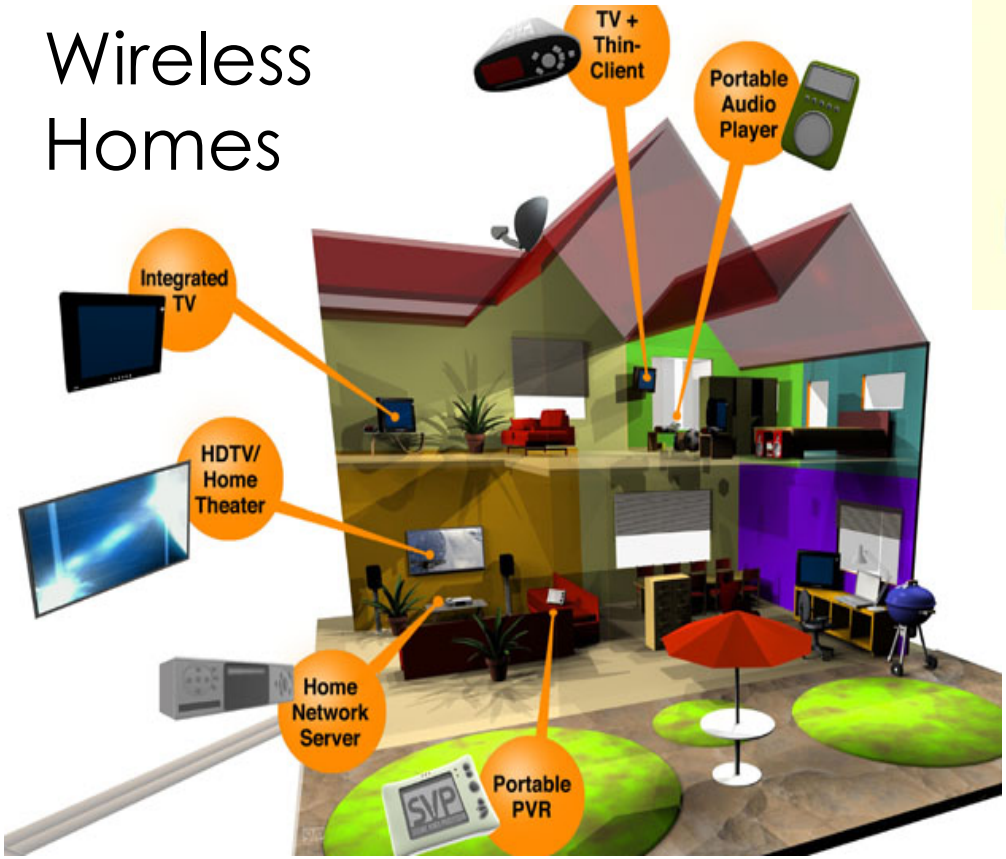
Class Policy

- Don't be shy!
- Feel free to stop me if you have ANY question
- Feel free to ask (partially) in Chinese
- Feel free to request for repeating again if you didn't get it
- Feel free to discuss offline (office hour, e-mail, facebook)
- Engage even if the assignments are group-based
- Correct me if I said anything wrong

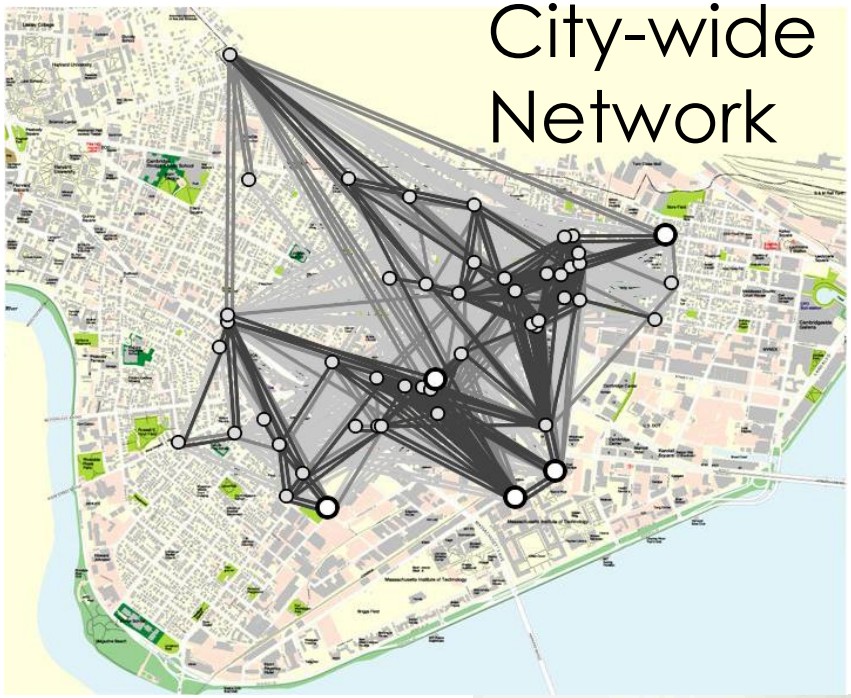
Introduction to Wireless Networks

Wireless networks are increasingly prevalent

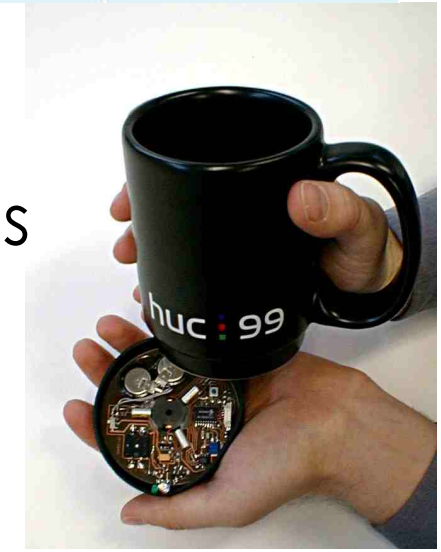
Wireless Homes



City-wide Network



IOT devices



Introduction to Wireless Networks

- Wireless networks provide advantages
  - Mobility
  - Eliminate wires at home and office
- But wireless networks present different challenges
  - The medium is shared
    - Nearby transmitters can interfere
    - Need medium access protocols
    - Throughput is relative low particularly in a dense environment
  - Channel quality could be bad and/or unpredictable
    - High bit errors which could result in dead spots

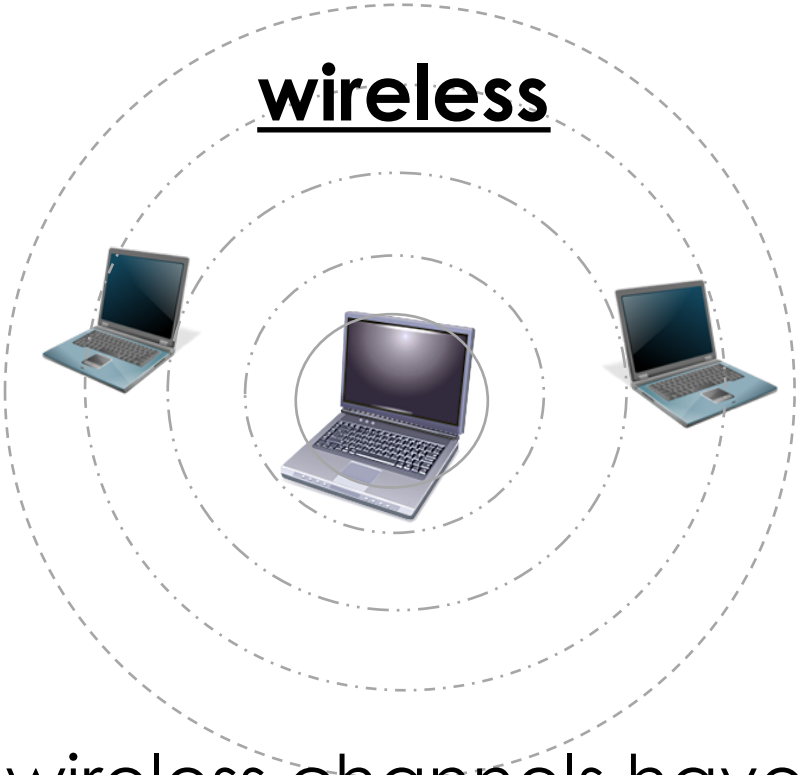
Traditional Design of Wireless Networks

- Traditional design of wireless networks mimics wired networks

wired

assume links are point-to-point

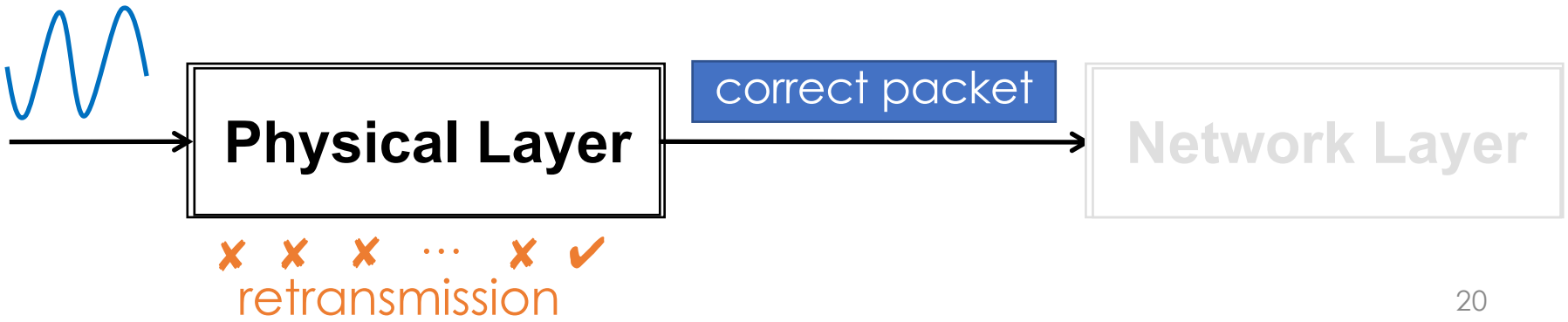
wireless



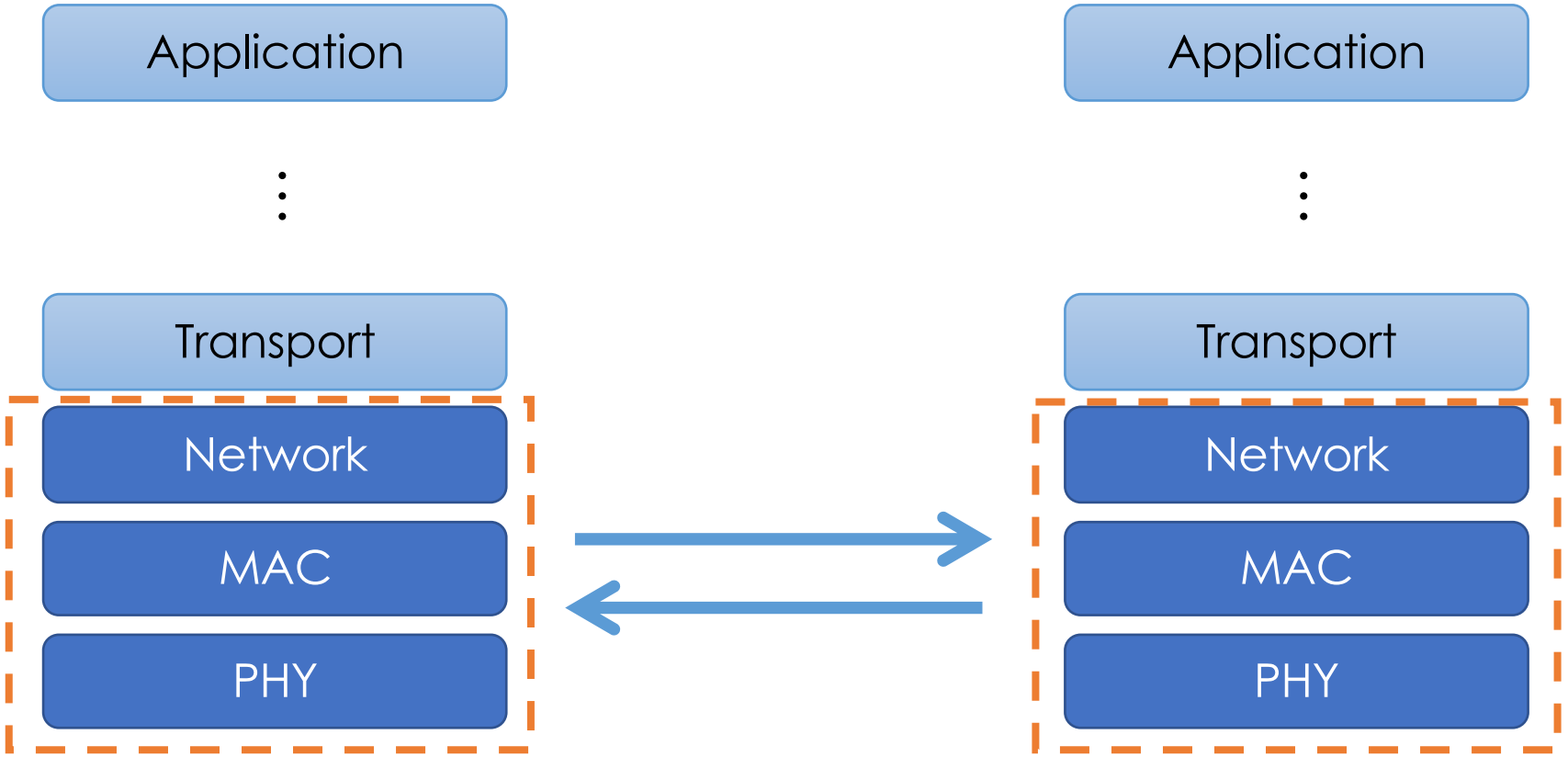
wireless channels have a broadcast nature

Traditional Design of Wireless Networks

- Traditional design of wireless networks mimics wired networks
  - Divide the network stack into separate layers
  - But separation reduces spectrum efficiency because one can optimize only within a layer, without considering the properties of other layers
  - E.g., assumes the PHY and lower layers deliver fully correct packets, but the errors in wireless channel are high and PHY keeps retransmitting until succeed



Cross-layer Design



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TODO

- Install Matlab
- Bring your laptop (if you have) to the class next week