ECE 463: Digital Communications Lab.

Lecture 1: Introduction Digital Communications

Haitham Hassanieh

Digital Communication Is Everywhere!

THE INTERNET

Digital Communication Is Everywhere!

OTHER APPLICATIONS

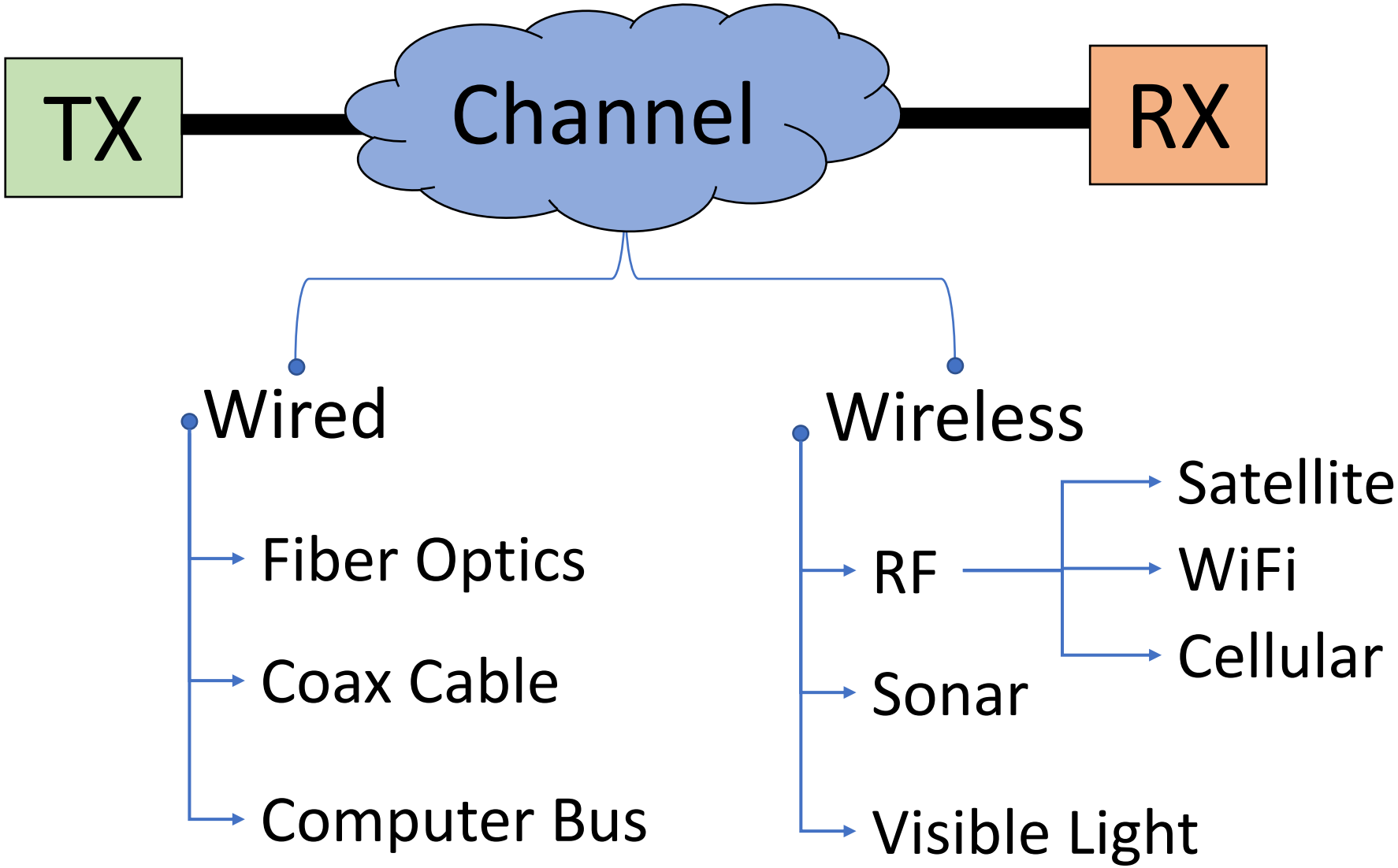
Digital TV

GPS

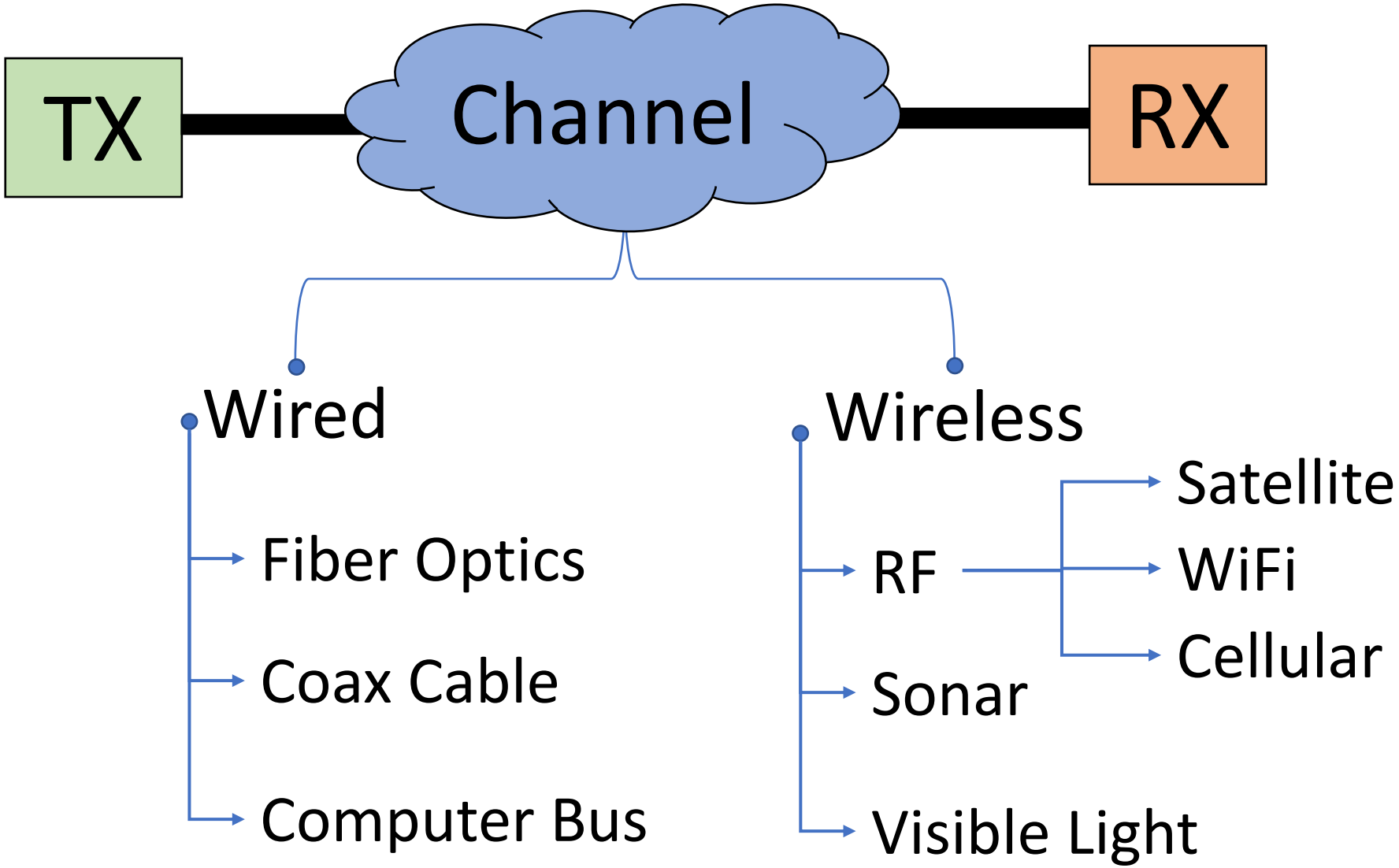
Mobile Payment (NFC)

Bluetooth

Digital Communication System

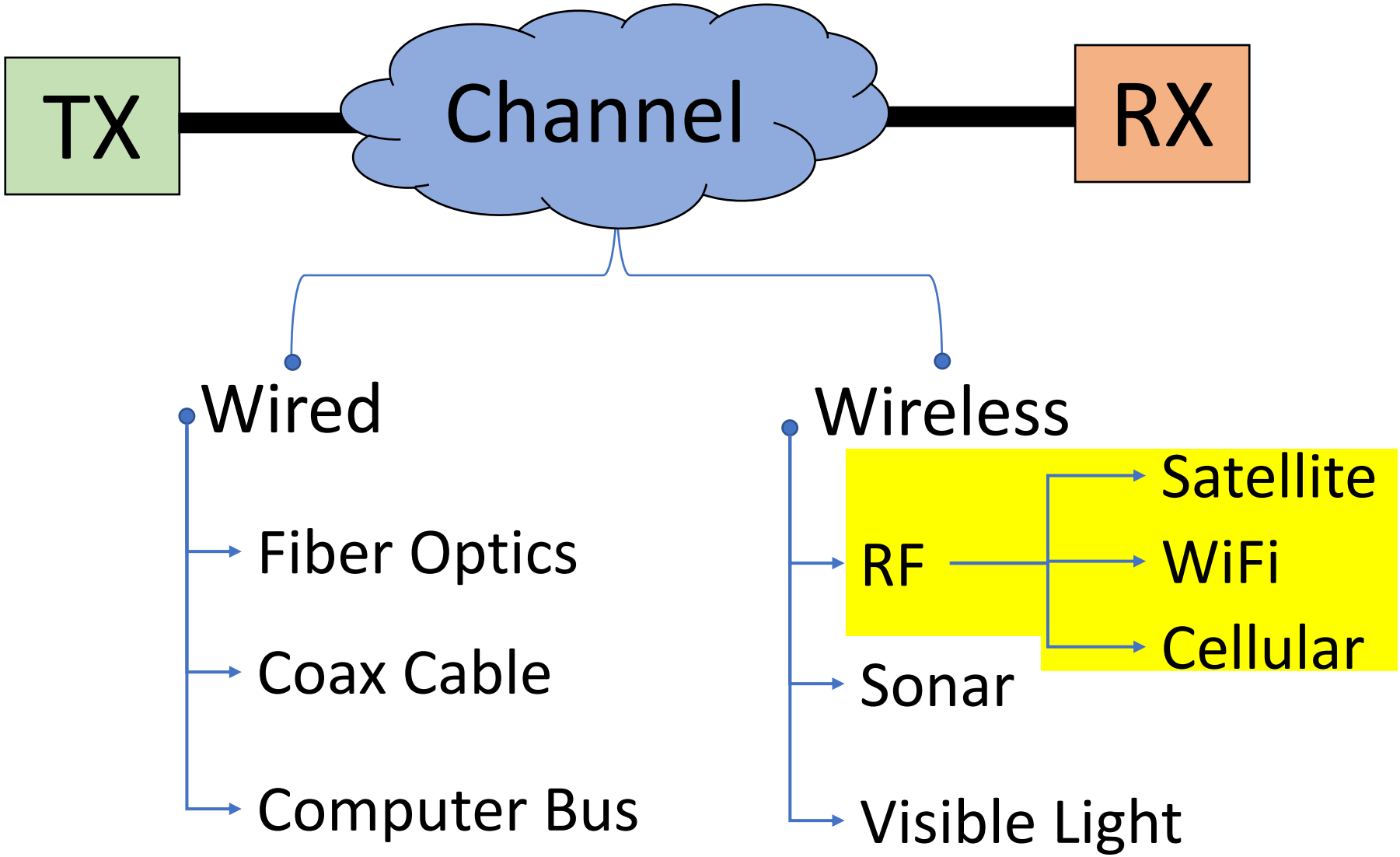


Digital Communication System



This class is not about the channel!
In this class, we will mainly focus on the TX and RX.

Digital Communication System



Learn how to design TX and RX in the context of RF

Digital Communication System

- Wired
  - Fiber Optics
  - Coax Cable
  - Computer Bus
- Wireless
  - RF
    - Satellite
    - WiFi
    - Cellular
  - Sonar
  - Visible Light

Learn how to design TX and RX in the context of RF

Digital Communication System

Digital Communication System

In this class:

- Learn the design of a basic digital communications transceiver.

Different Applications

- Need different data rates
- Have different power budget
- Require different form factor
- Require different mobility range
- Demand the use of different channel
- Have different cost limitations

} Different Communication Technologies

Digital Communication System

In this class:

- Learn the design of a basic digital communications transceiver.

- Learn about some of digital communication technologies (especially for IoT)

Digital Communication System

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- Learn the design of a basic digital communications transceiver.
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HOW?

Digital Communications Lab

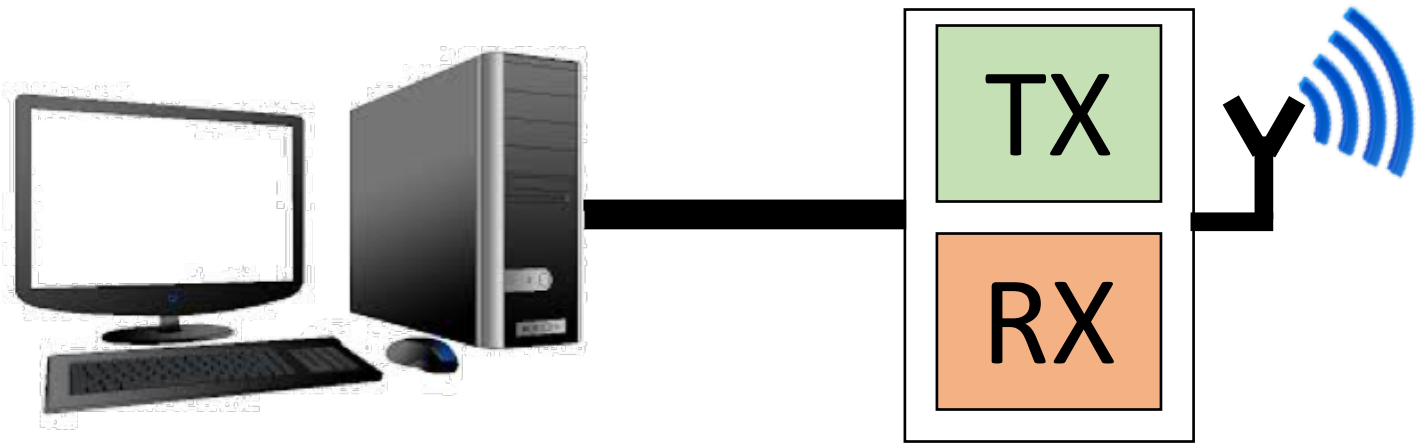
In this class:

- Work with hardware.
- Perform practical experiments.

However, we will not build transceiver from scratch! → Not a circuits course!

We will use Software Defined Radios (SDRs)!

Software Defined Radio



- Flexible radio frontend with ADC & DAC connected to machine
- Streams digital samples to/from the machine
- Machine controls radio parameters

Software Defined Radio

- Can control hardware parameter from software:
  - Change frequency
  - Change bandwidth
  - Change amplifier gain
  - Change the sampling rate
  - …

- Can design all digital processing in software:
  - Filters
  - Modulation
  - Synchronization
  - …

Software Defined Radio

- In this class we will use USRP X310
  - 2 Channels
  - Wide bandwidth up to 160 MHz
  - ADC up to 200 MS/s and DAC up to 400 MS/s
  - Wide frequency range 10MHz- 6GHz

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More on Software defined Radio→ Next Lecture

Digital Communication System

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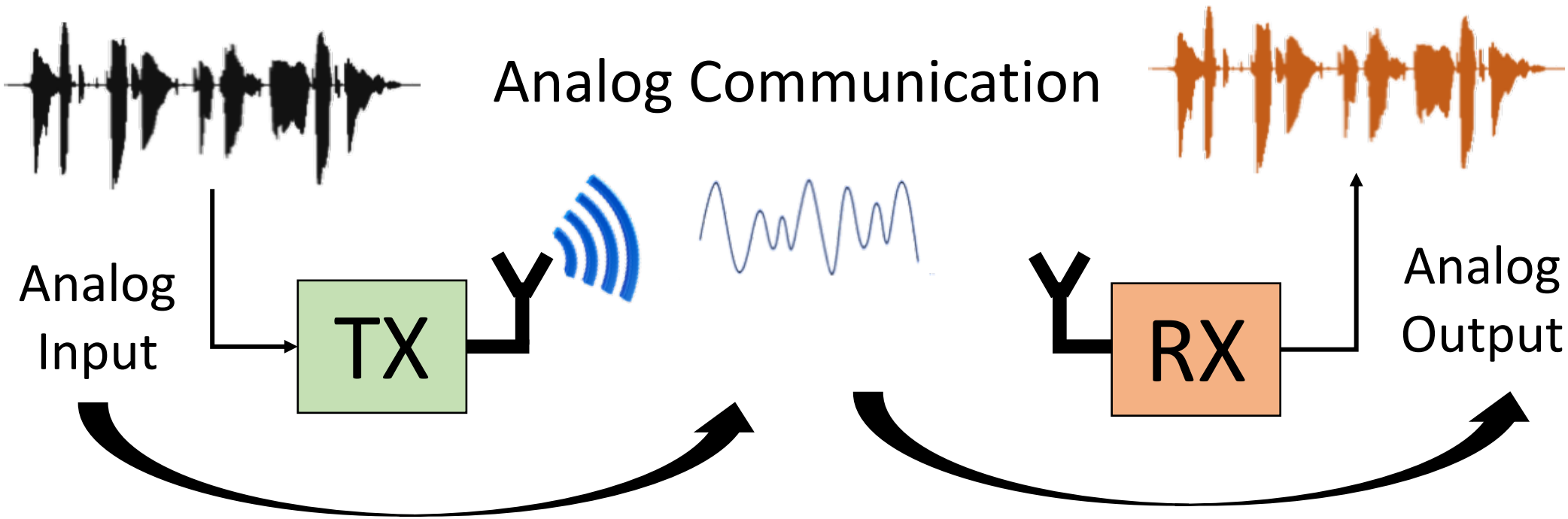
Why Digital?

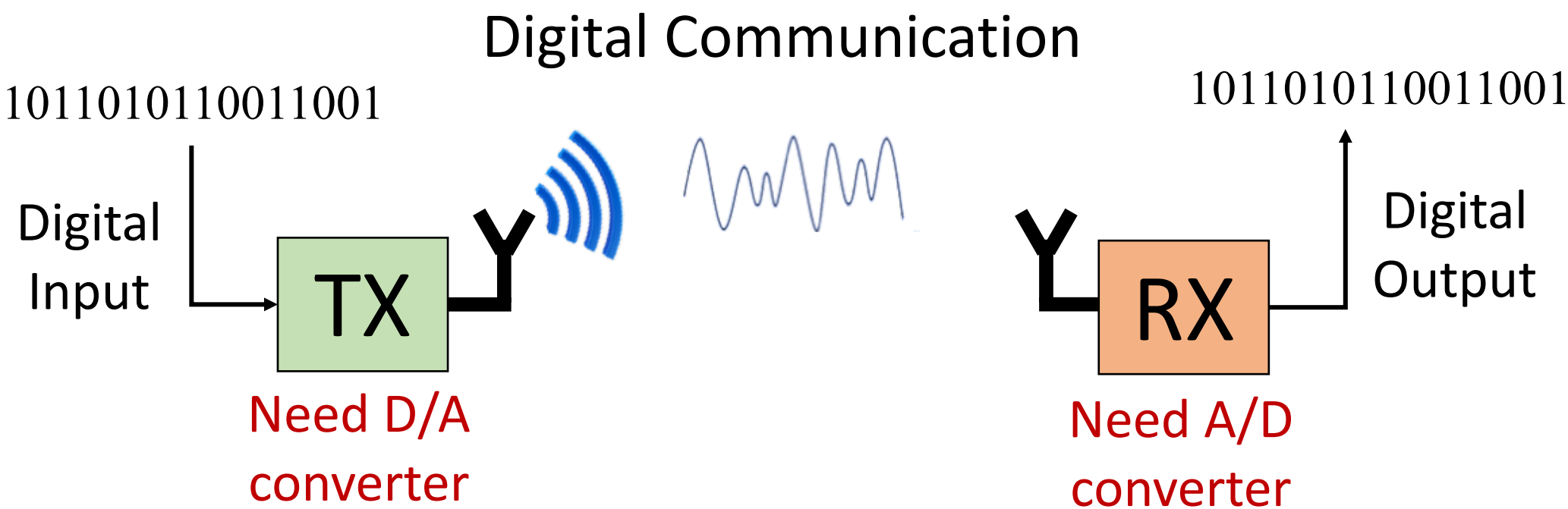
Analog vs. Digital Communication System



Amplitude modulation (AM) : $x(t) = A\, s(t) \cos 2\pi f_c t$

Frequency modulation (FM) : $x(t) = A \cos\left(2\pi f_c t + 2\pi \int_0^t s(\tau) d\tau \right)$

Analog vs. Digital Communication System



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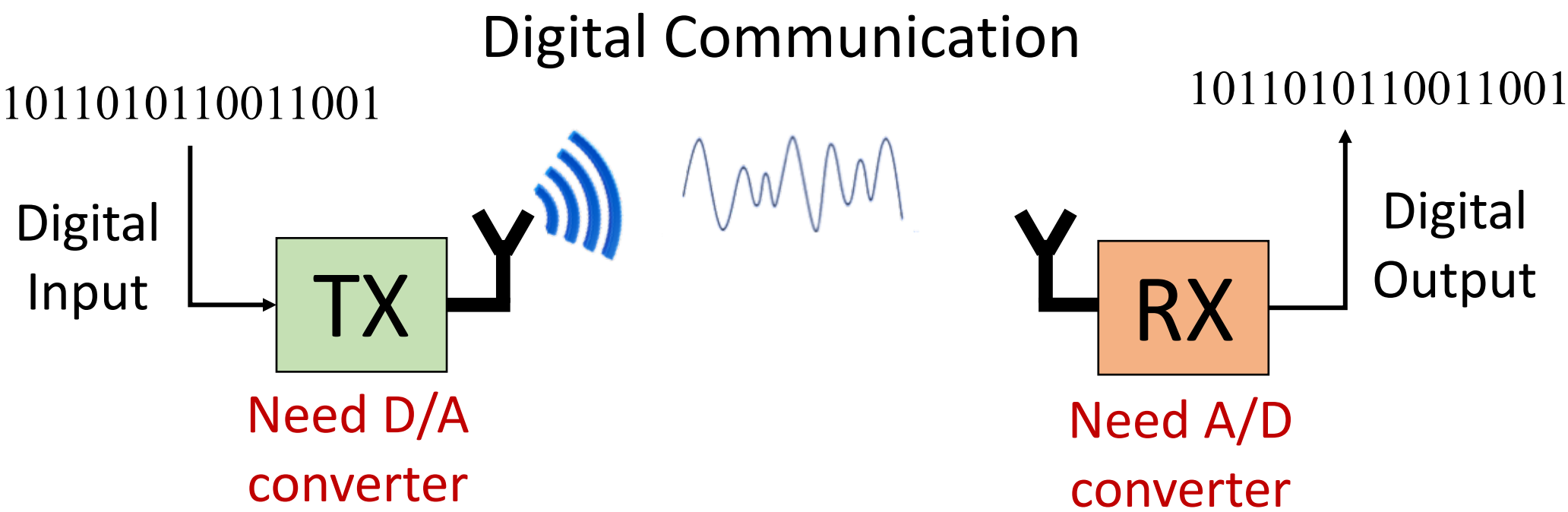

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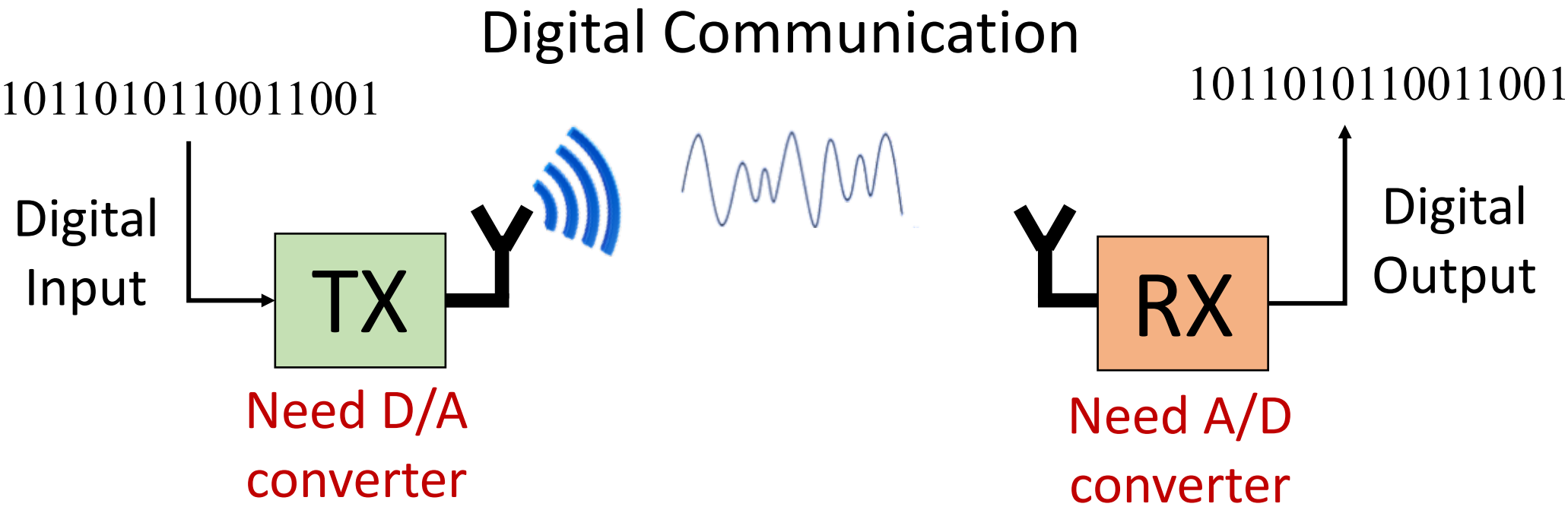
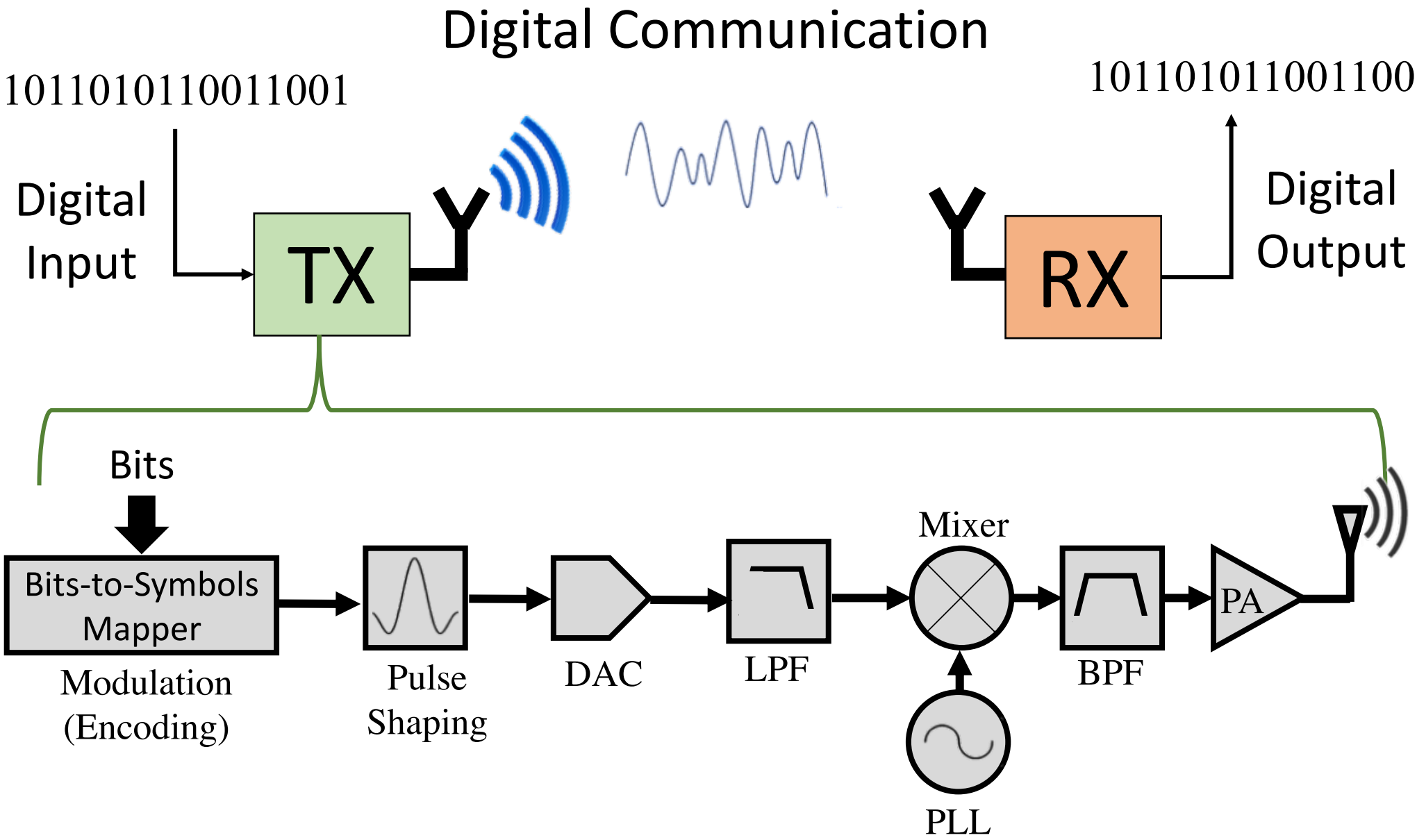


Why digital?

- Better quality!
- Data is already digital.
- Optimized hardware form factor.

Analog vs. Digital Communication System



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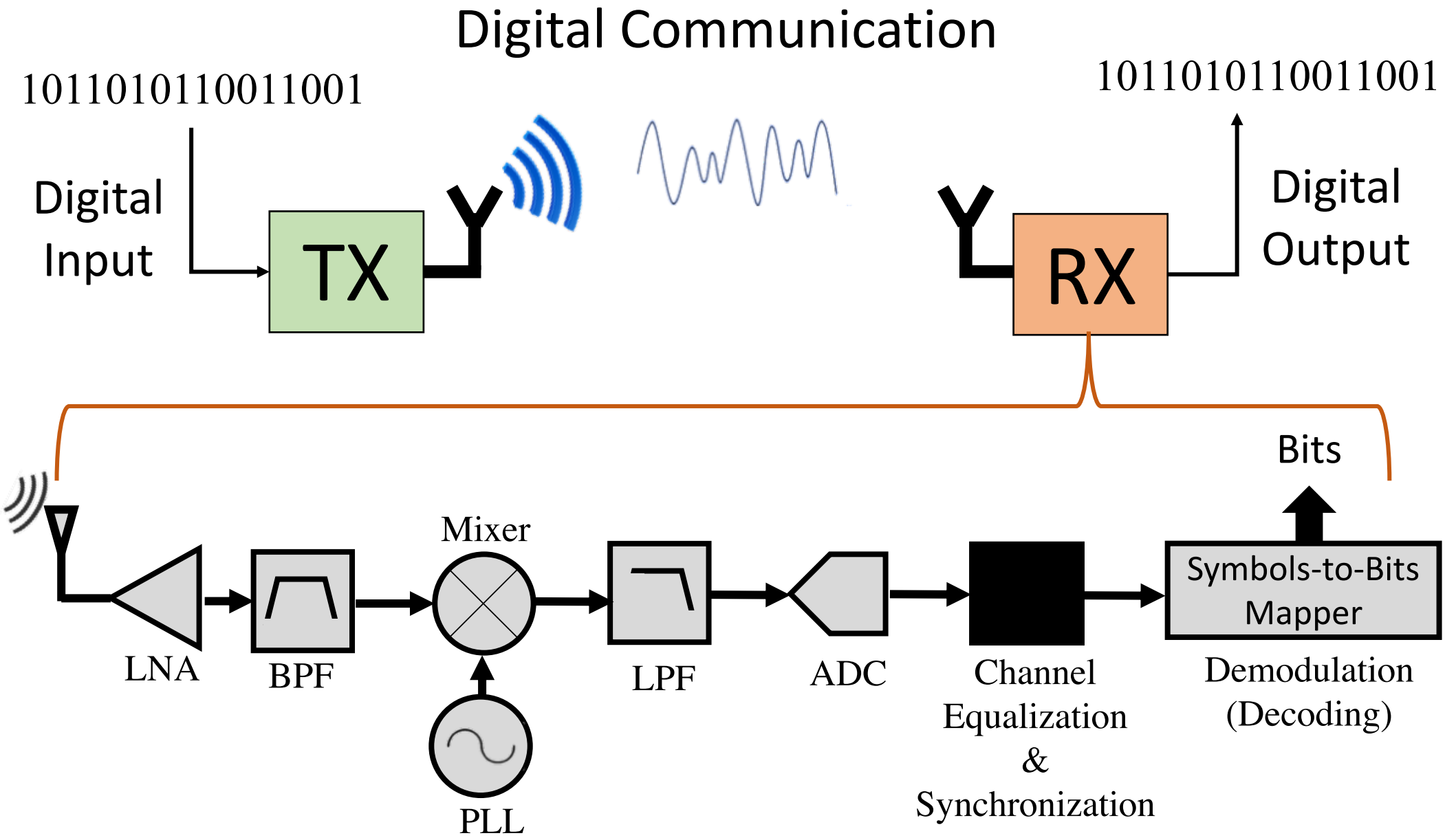
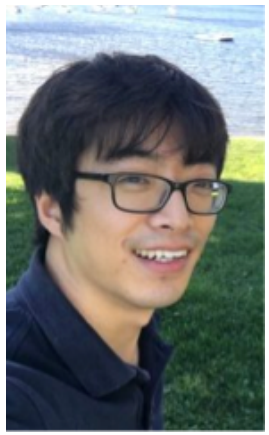


Course Information

- Class:
  - Lecture: Wednesdays 2-2:50pm in **ECEB 2013**
  - Lab: Monday, Thursday, Friday 1-3:50pm, Wednesday 9- 11:50am in **ECEB 5080**
  - Must go to your own lab session.
  - First Lab on Thursday.

- Staff
  - Lecturer: Haitham Hassanieh, haitham@illinois.edu
  - Lab Instructor: Thomas Moon, tmoon@Illinois.edu
  - Lab TA: Junfeng Guan (aka. Jayden), jguan8@Illinois.edu

Thomas



Jayden

Course Information

- Material
  - Lecture Slides (Posted on class webpage)
  - Class Notes (Take notes in class)
- Books
  - No Required Textbook
  - Recommended Textbooks:
    - **Signal Processing Techniques for Software Radio** by Behrouz Farhang-Boroujeny. 2nd Edition.
    - **Software Receiver Design: Build your Own Digital Communication System in Five Easy Steps,** 1st ed., by Johnson, Sethares & Klein, Cambridge Univ. Press publisher.
- Prerequisites
  - Basic knowledge of communications
  - Any one of the following classes: ECE 361, 361, 438, 439, 459

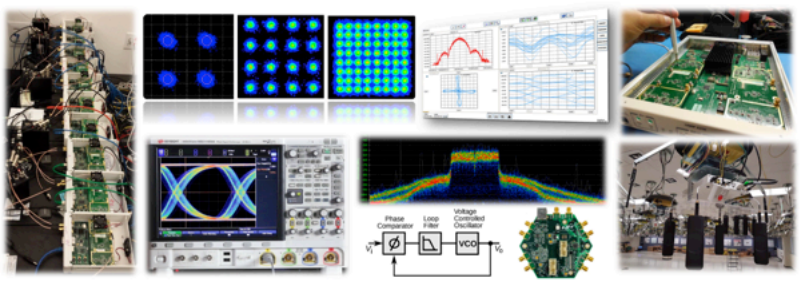
Course Information

- Grading
  - 20% Participation & Attendance
    - Come to lab in your own lab session.
    - Do the lab in the lab & not at home.
    - Come to lectures & ask questions.
  - 50% Lab Reports
    - Write a Lab report after each lab. (Some labs span multiple weeks)
    - Submit report as hard copy at the beginning of next lab session.
    - Work in groups of 2. Submit 1 report per group.
    - Approximately 10 ± 1 Lab reports
  - 30% Quizzes
    - Two quizzes covering both Lab and Lectures.
    - Tentative Dates: Oct. 30th & Dec. 12th
    - Time & Location: During Class.

Class Webpage

https://courses.engr.illinois.edu/ece463/fa2018/

ECE 463: Digital Communications Laboratory - Fall 2018



Course Description:

The goal of this course is to give students hands-on experience in the design, configuration and evaluation of digital communication systems through software defined radios. The course will introduce students to various components of a digital transceiver. It will also cover various Internet of Things (IoT) communication technologies used today. Students will learn through lab driven experiments on USRP software defined radios.

Lecture Time & Location: Wednesday 2:00pm - 2:50pm in ECEB 2013

Lab Time & Location: Monday, Thursday or Friday 1:00pm - 3:50pm or Wednesday 9:00am - 11:50am in ECEB 5080

Instructor: Haitham Hassanieh (haitham@illinois.edu)

Office Hours: Wednesday 3:00pm - 4:00pm or by appointment.

Lab Instructor: Dr. Thomas Moon

Lab TA: Junfeng Guan

Prerequisites: Basic knowledge of communications or ECE 361 or 461 or 459

Topics:

► Software Defined Radios

- USRP X310
- LabVIEW Communications

► TX/RX Trasceivers

- Up/Down Conversion
- Pulse Shaping Filers, Matched Filters
- Bandwidth & Spectral Efficiency

► Modulation

- Coherent Modulation
- Non-Coherent Modulation

► Internet of Things (IoT)

- Bluetooth & Frequency Hoping
- LoRa & Chirp Spread Spectrum
- RFIDs & Battery Free Communicaion
- Direct Sequency Spread Spectrum

► Synchronization

- Frame synchronizaiton & PN sequences
- Phase Locked Loops (PLLs)
- Carrier/Timing Recovery

► Channel

- AWGN Channel
- Flat Fading vs Frequency Selective

Schedule:

#	Date	Lectures	Labs
1	Aug. 29	**Lec 1:** Introduction: Overview & Logistics	**Lab 1:** Introduction to LabView **Documentation:** [Lab1.pdf]
2	Sep. 5	**Lec 2:** Software Defined Radios	