SEOULTECH

Lecture 01
Introduction to Course & Data Communication

09/05/2022 & 09/08/2022

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CIEL Communication & Intelligence Laboratory 통신및지능연구실

OUTLINES

- Orientation
  - Course information, description, grading etc
- Overview of the class issues
  - Brief introduction to network protocols & software
  - Recent hot issues: 5G networks & vision
- Ch 1 Introduction
- Summary & Next class

Orientation

: Course information, description, logistics, grading etc.

- Orientation
- Overview of the class issues
- Ch 1 Introduction
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Course Information

- Lecture: Flipped learning
  - Monday/Thursday 9 am to 11:50 pm
    - 10:10am~11am (before 11:50)
    - Until 10:10am, watch the lecture videos
  - Online recorded video + F2F Lecture (Summary & QnA)

- Instructor: Prof. Taesoo Kwon
  - Office: Rm. 330, Mirae hall
  - Email: tskwon@seoultech.ac.kr, Phone: 02-970-9716
  - Office hours: By appointment

- Teaching assistant: Dongyun Joo, Hyunjeong Lee, Hyorin Lee
  - Office: Rm. 124, Mirae hall
  - Email: miclejoo@naver.com, fineimagination@naver.com, hyorish03@naver.com

- Web page
  - Linked through http://eclass.seoultech.ac.kr
  - All notices (assignment, lecture slides etc.) are posted on this class web page

Course Goal

- Through this course, students can understand
  - Basic models and functionalities of communication networks
  - Basic principles of physical layers for signal transmission/receiving
  - Data link layer protocols
  - Basic operations of recent (data) communication systems

Course Description

- This course provides
  - Fundamental principles of data communication which enables us to exchange information remotely.

- Via this course, students learn
  - Standard models for data communications
  - More details on physical and data link layers, which are backgrounds to learn wired and wireless networks in future.

- Through briefly introducing recent systems such as Ethernet, Wi-Fi, LTE, and 5G networks,
  - Becoming more familiar with how data communication technologies work in real life.

Prerequisite

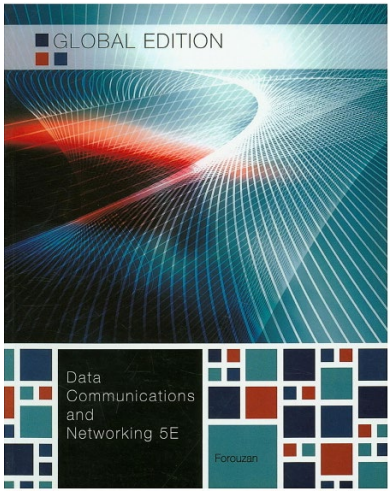
- None

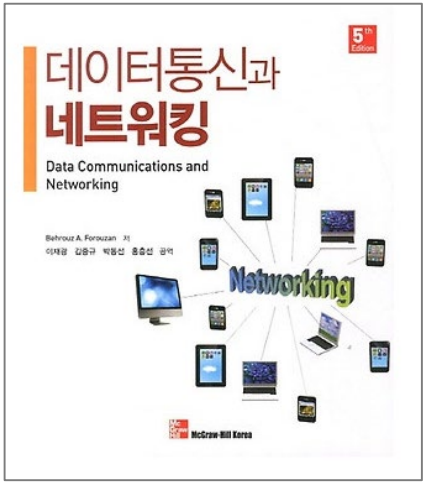
- Recommended (strongly)
  - Engineering mathematics (for Laplace & Fourier transform)
  - Probability & statistics
  - Linear algebra
  - Programming (C, C++ etc.)

- In general, for communication networks
  - Programming for implementation or simulations (C, C++, Linux, Unix)
  - Mathematics such as linear algebra, probability, engineering math
  - Algorithm
  - English for reading & writing standard document
  - These are not only for communication networks, but also for any issues in vogue such as machine learning, data science etc.

Textbook

- No official textbook
  - Forouzan, Data Communications and Networking 5E, McGraw-Hill, 2013.





  - Not 6E!!
  - Korean-translated book NOT recommended!!
- References
  - James F. Kurose and Keith W. Ross, Computer Networking: A Top-Down Approach, 6th ed., Pearson, 2013
  - William Stallings, Data and Computer Communications, 10th ed., Pearson, 2014

Course Grading

- Midterm exam 35%, Final exam 35%
- Assignment & Participation 20%
  - Late penalty: not allowed
  - Upload your answer sheet on eClass website
- Bonus points
  - Volunteer student
  - Surveys etc.
- Attendance 10%
  - Absences more than five: F

About Assignment

- **Solve Assignment # problems posted on eClass website exercise**
  - eClass → Data Communication → Assignment
- **Upload your answer sheet** on eClass **until the dealine**
  - **Firm deadline!!**: **late** submission is **not accepted**
  - Only **docx, hwp, pdf** format allowed (**NOT any figure format including jpg, bmp, png** etc.)
  - eClass → Data communication → Assignment
  - Don't forget to write your **name**, **student ID number**.
  - It is not important whether or not your answers are correct. That is, if you **just try to write an answer**, you can **get the perfect scores**.
  - Exams will rigorously check your efforts on solving the assignment and practice problems by yourself.
- In order to inquire about the assignment (problem or scoring), please contact to the teaching assistant

Course Schedule (Tentative)

- FL: Flipped learning
- **Rec: Recorded video for makeup class**

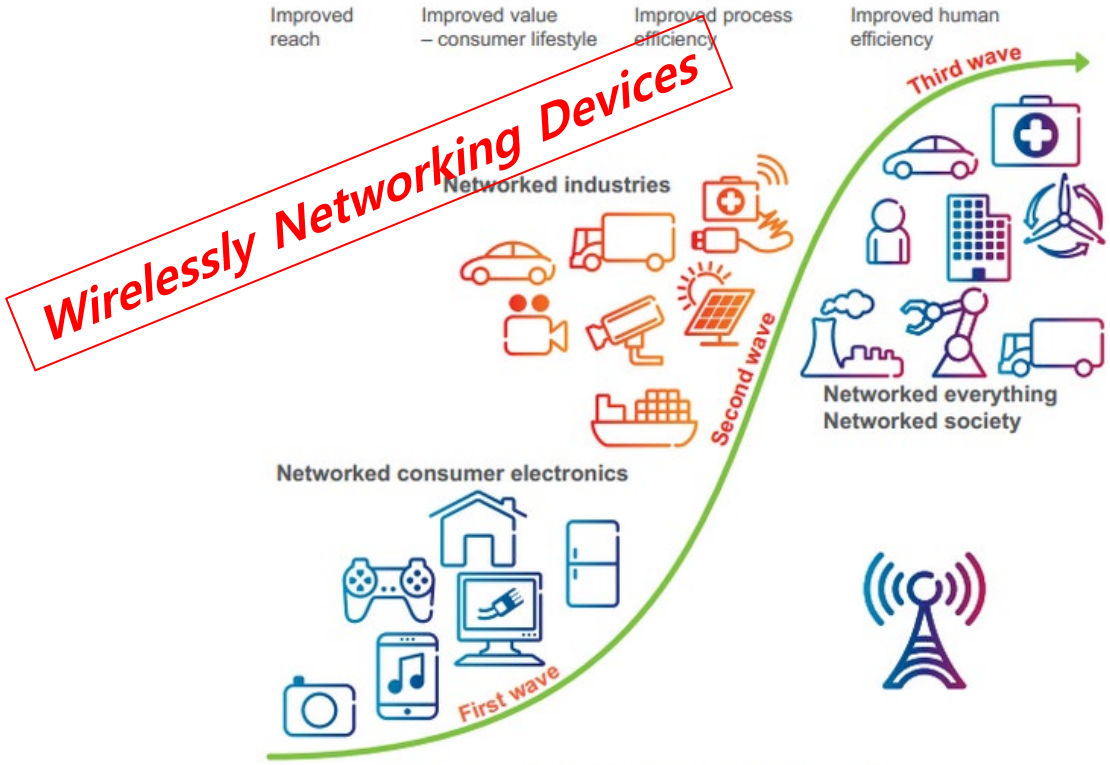
No	Topics	Date-M		Date-Th	
1	Introduction to course and data communications (Ch1)	09/05	FL (**Zoom**)	09/08	FL
2	Intro. to data communications (Ch1) & Network models (Ch2)	09/12	**Rec**	09/15	FL
3	Intro. to physical layer (Ch3)	09/19	FL	09/22	FL
4	Digital transmission (Ch4)	09/26	FL	09/29	FL
5	Analog transmission (Ch5) & Bandwidth utilization: multiplexing (Ch6.1)	10/03	**Rec**	10/06	**Rec**
6	Bandwidth utilization: spread spectrum (Ch6.2) Transmission Media (Ch7)	10/10	**Rec**	10/13	FL
7	Switching (Ch8) Introduction to Data-Link Layer (Ch9)	10/17	FL	10/20	FL
8	**Midterm exam**	**10/24**	**Evening**	**10/24**	**Evening**
9	Error detection and correction (Ch10)	10/31	FL	11/03	FL
10	Data link control (Ch11)	11/07	FL	11/10	FL
11	Media Access Control (Ch12)	11/14	FL	11/17	FL
12	Wired LAN (Ethernet) (Ch13) & Other wired network (Ch14)	11/21	**Rec**	11/24	FL
13	Wireless LAN (Ch15)	11/28	FL	12/01	FL
14	Other wireless networks (Ch16) Connecting devices and virtual LANs (Ch17)	12/05	FL	12/08	FL
15	**Final exam**	**12/12**	**Evening**	**12/12**	**Evening**

Brief Introduction to Network Protocols & Software

- Orientation
- Overview of the class issues
  - Brief introduction to network protocols & software
  - Recent hot issues: 5G networks & vision
- Ch 1 Introduction
- Summary & Next class

Future Everything Connected Society

- Moving towards *everything connected* society
  - According to ABI research, over 50 billion wireless connected devices by 2020
  - 75% of this growth will come from non-hub devices: sensor nodes and accessories



The three waves of connected device development.

Protocols & Software

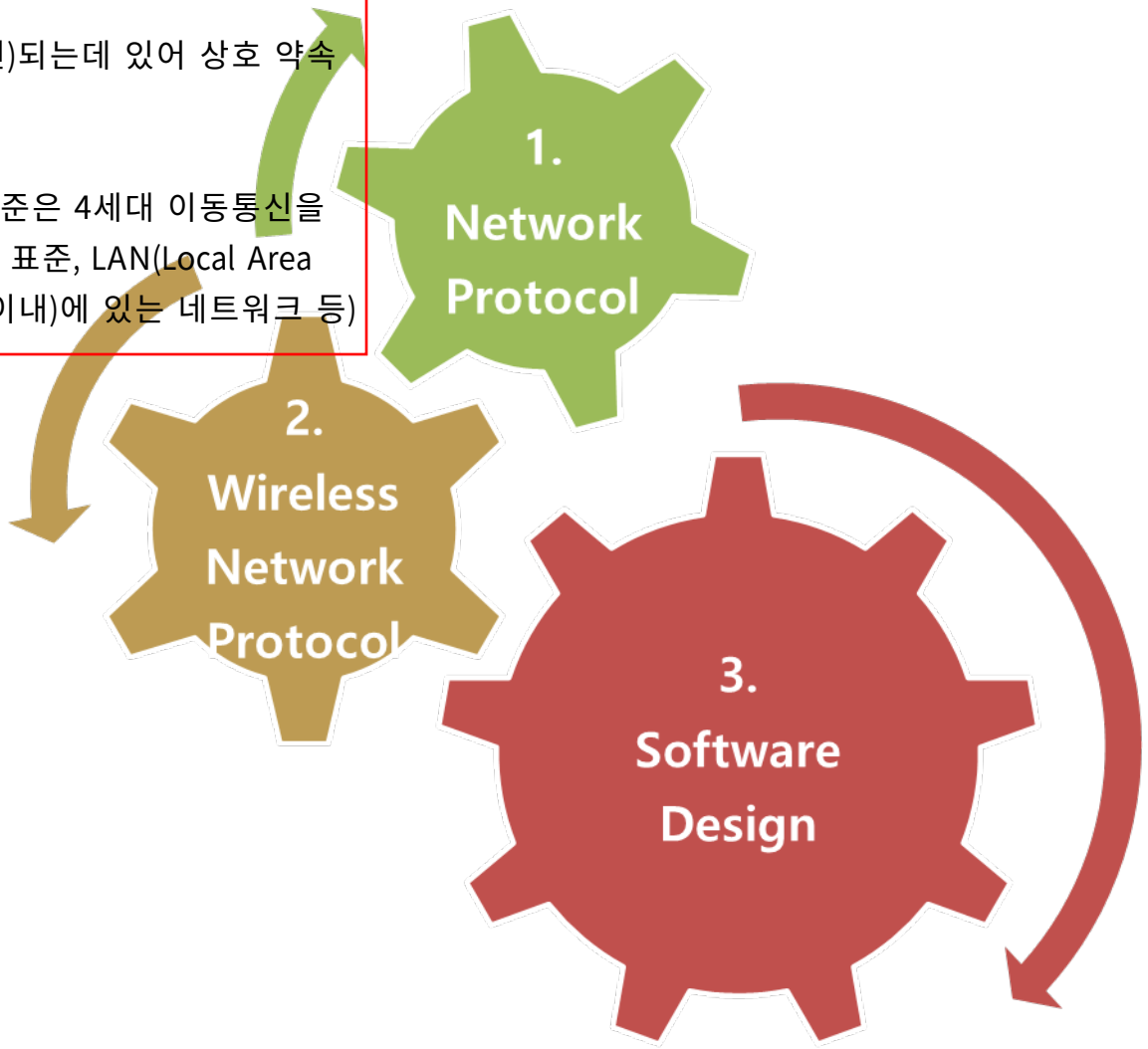
Software Design for Wireless Data Network Protocols

프로토콜

두 개의 기기가 서로 연결(통신)되는데 있어 상호 약속된 규약

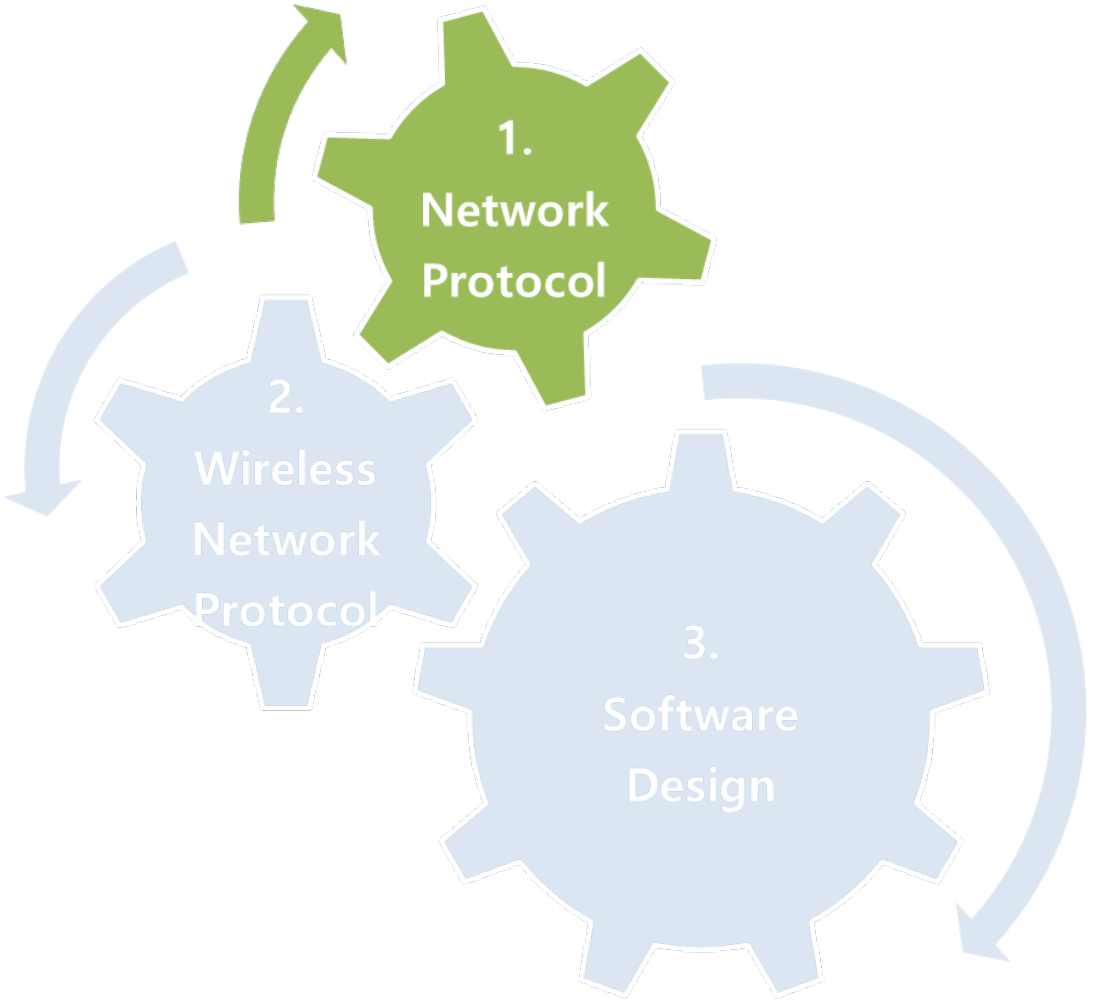
주로 소프트웨어로 구현

표준 문서로 나옴 (예시: LTE표준은 4세대 이동통신을 위한 표준, 5G는 5세대를 위한 표준, LAN(Local Area Network)은 각은 영역(100m 이내)에 있는 네트워크 등)



Protocols & Software

Software Design for Wireless Data Network Protocols



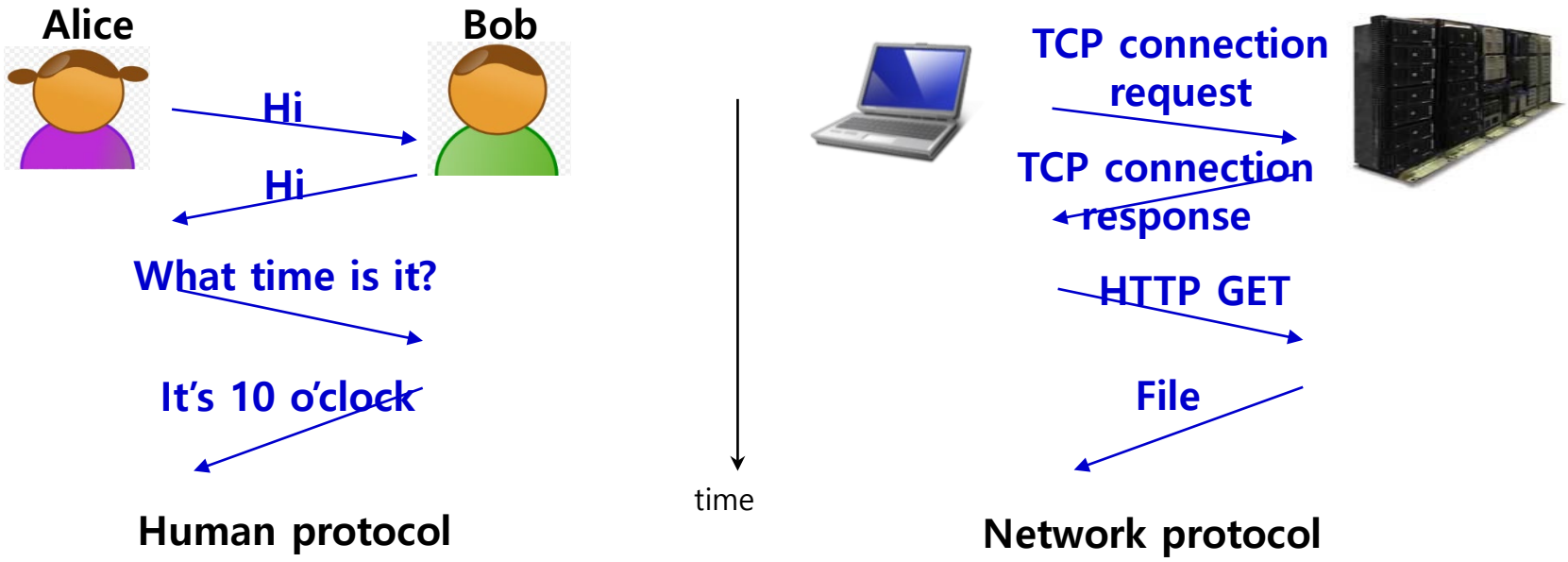
1. What is a Protocol?

Communication protocol
멀리 떨어진 것과의 상호소통(telecommunication)과 컴퓨터 네트워킹(computer networking)에서 전송데이터가 어떻게 전송되는지를 결정하는 규칙 또는 규정의 정의 되어있는 set이다 -> 통신규약

WIKIPEDIA
The Free Encyclopedia

- *Communications protocol* : a defined set of **rules and regulations** that determine how data is transmitted in telecommunications and computer networking

Communicating between two devices is similar to human communication



1. Network Protocol

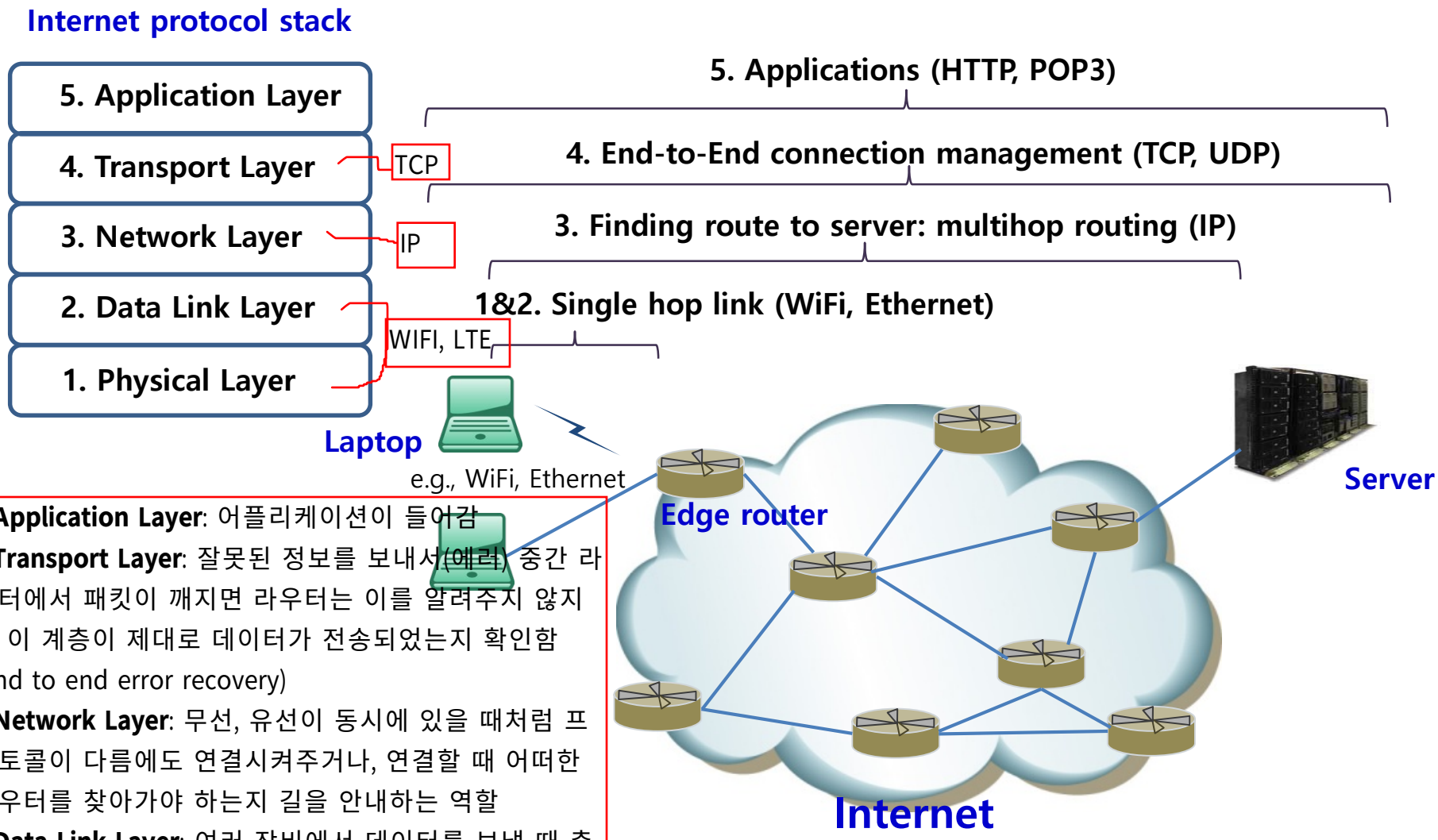
- Devices much more than two (tens of billions by 2020)
- Devices far apart

네트워크 프로토콜을 통해 만약 한국에서 미국 서버로 접속을 한다면 한 번에 접속하는 것이 아닌 그 중간에 라우터(**router** 또는 **gateway**)들이 존재함. 이처럼 여러 번 거치는 방식을 **multihop** 방식이라 함

(전체 1~5계층 중 1~3계층만 포함하면 **router**, 그 이상의 계층까지 포함하면 **gateway**)

- Need of building and coordinating many links, and extending those links in a multihop way

1. Network Protocol & Layered Architecture



5.**Application Layer**: 어플리케이션이 들어감

4.**Transport Layer**: 잘못된 정보를 보내서(예러) 중간 라우터에서 패킷이 깨지면 라우터는 이를 알려주지 않지만 이 계층이 제대로 데이터가 전송되었는지 확인함 (end to end error recovery)

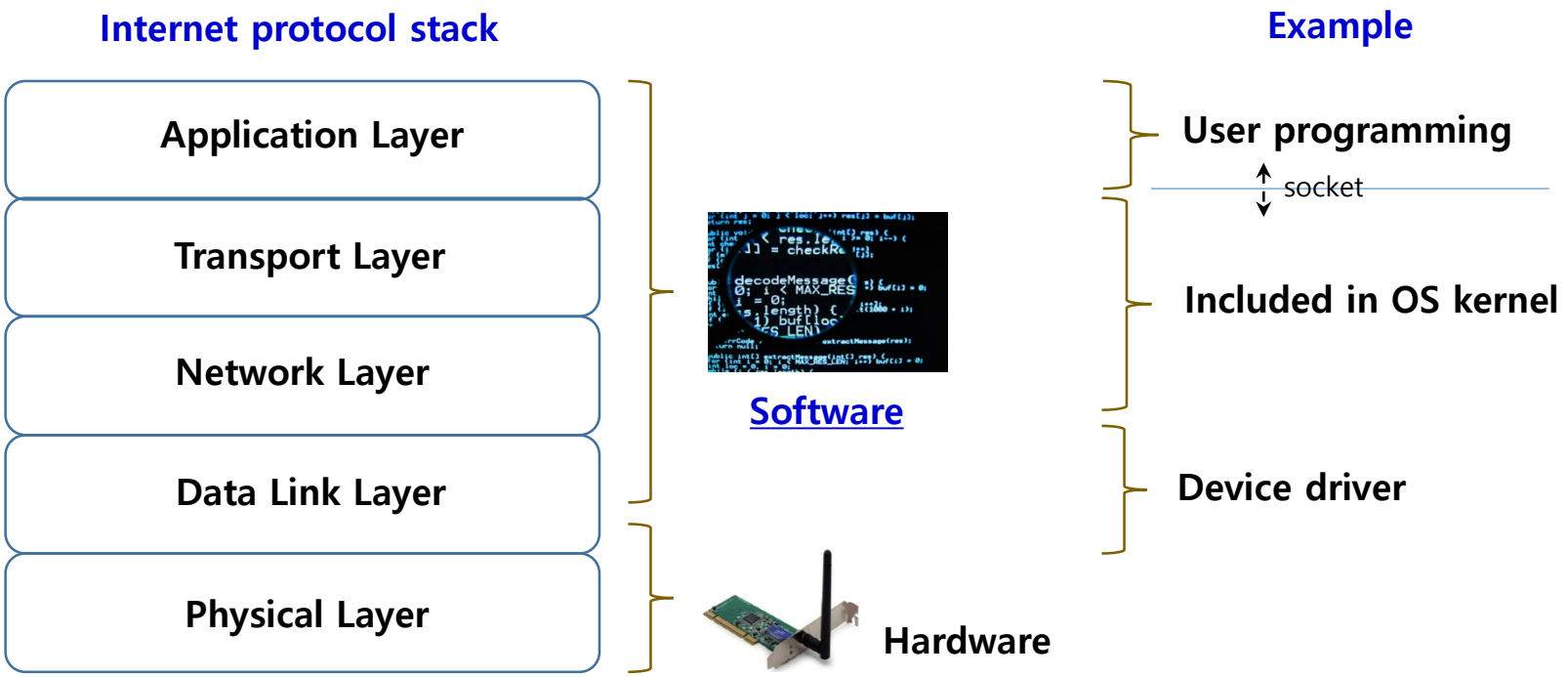
3.**Network Layer**: 무선, 유선이 동시에 있을 때처럼 프로토콜이 다름에도 연결시켜주거나, 연결할 때 어떠한 라우터를 찾아가야 하는지 길을 안내하는 역할

2.**Data Link Layer**: 여러 장비에서 데이터를 보낼 때 충돌을 조율해 줌

1.**Physical Layer**: 0,1의 비트 정보, 하드웨어 관련

1. Protocol Stack Implementation

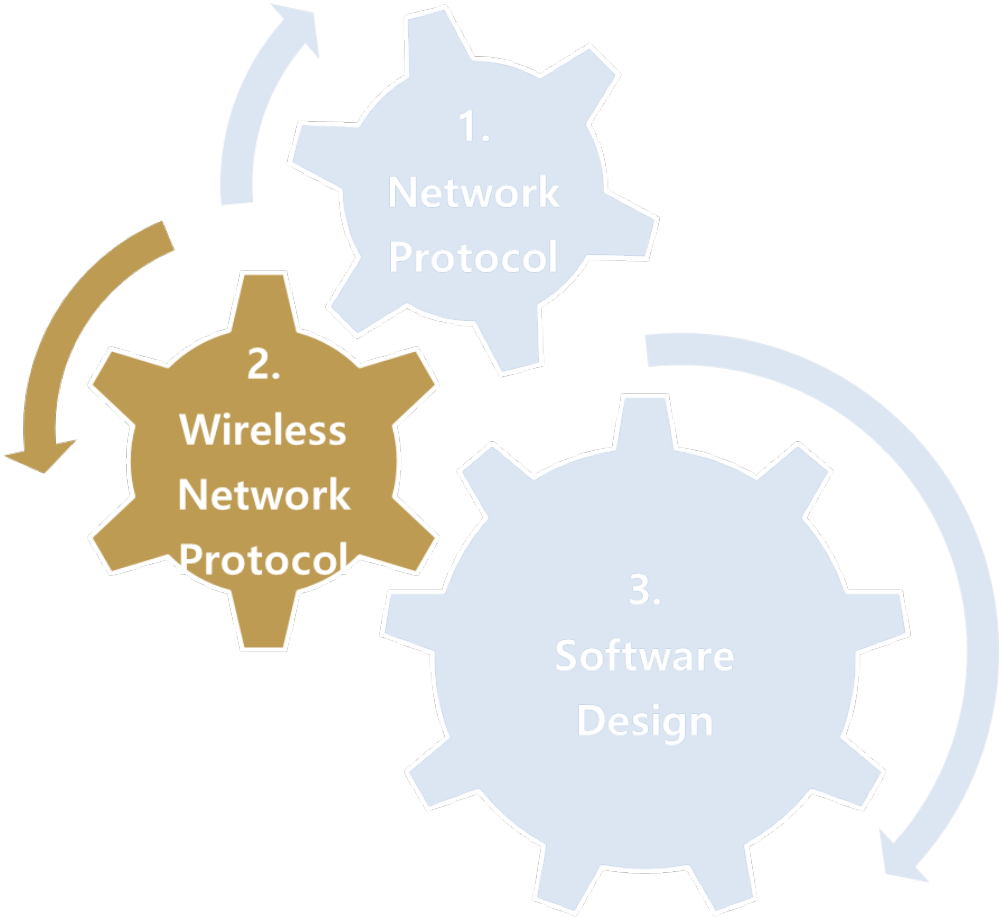
- Typically, except for physical layer and a part of data link layer, **data link to application layers are implemented by software**



Protocols & Software

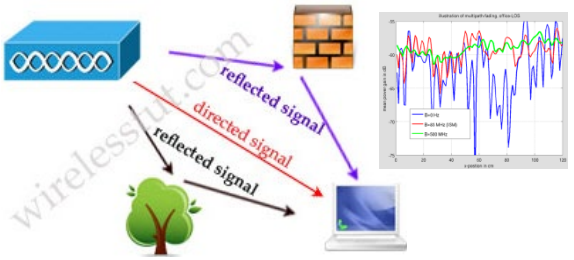
Software Design for Wireless Data Network Protocols

How does *wireless* affect protocol design?

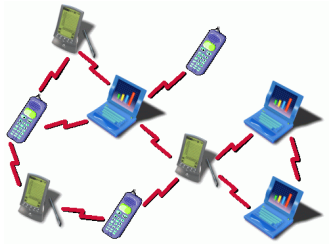


2. Wireless Protocols

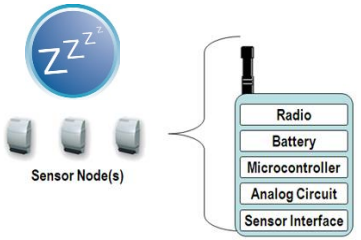
- **Unreliable and time varying wireless channels**
  - Wireless TCP, Channel aware resource allocation, Hybrid Automatic Repeat Request (HARQ)



- **Dynamic topology**
  - Ad hoc routing, Neighbor discovery, Location management



- **Battery powered**
  - Sleep mode design



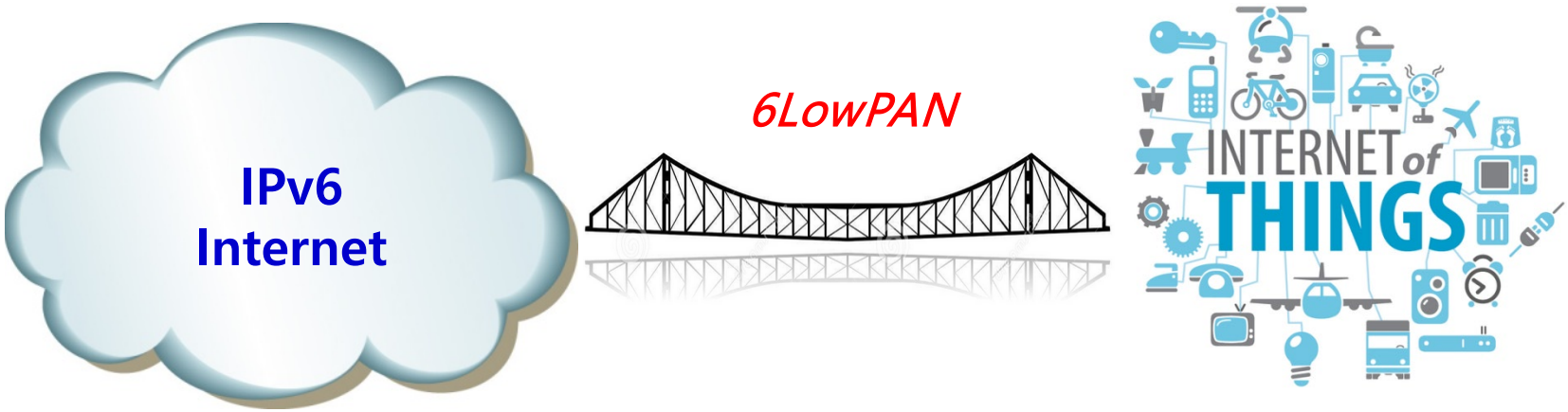
Fully affecting both protocol design and software implementation

2. Wireless Protocols

- An interesting example
  - Explicitly revealing the difference between wired and wireless protocols
  - Helping us to set the software design constraints for wireless protocols

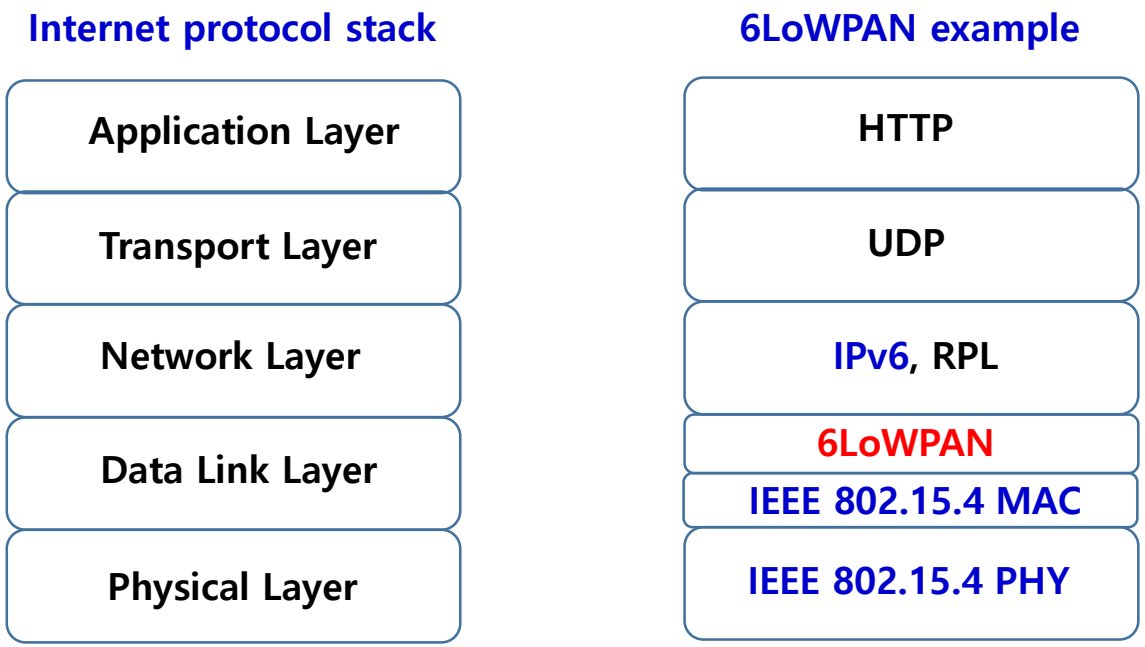
6LowPAN
(IP version **6** over **Lo**w Power **W**ireless **P**ersonal **A**rea **N**etworks)

IPv6 will be a key enabler to connect 50 billion devices to the Internet



2. 6LoWPAN

- 6LoWPAN
  - IPv6 modification for networking low power and low cost wireless devices
    - **Enabling to use IPv6 over IEEE 802.15.4**



2. IEEE 802.15.4 & IPv6

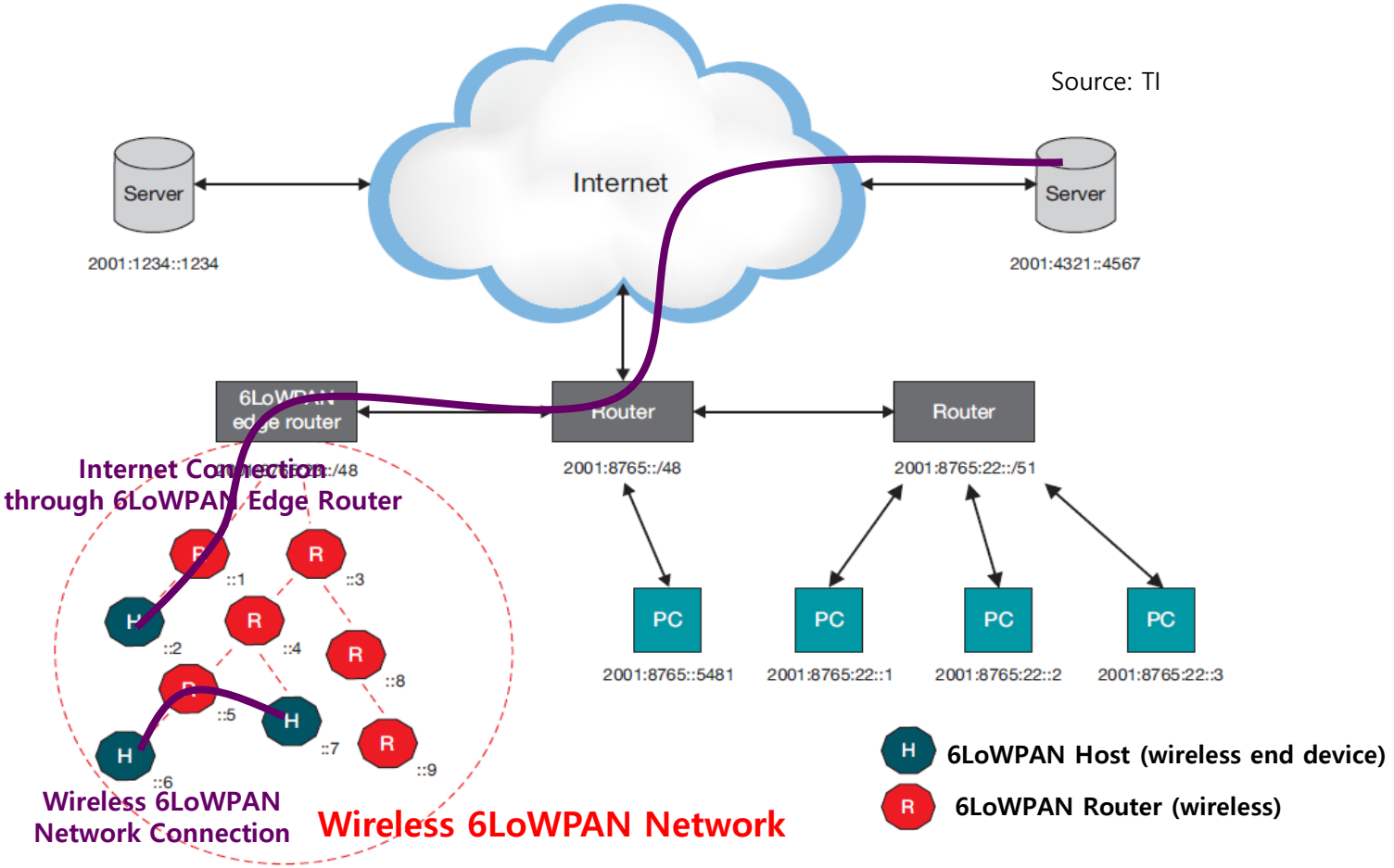
6LoWPAN allows IPv6 packets to be carried with small link layer frames

- **IEEE 802.15.4 standards**
  - MAC (medium access control; data link layer) and physical layers
  - *Low power and low cost wireless networking*
  - Industrial control and monitoring, wireless sensor network, smart grid

- **IPv6 (Internet Protocol version 6)**
  - Extension of wired Internet protocol IPv4
  - *128 bit IPv6 addresses (~10^{29} billion)*
    - 50 billion devices connected to the Internet by 2020
  - *Not adequate to low power and low cost wireless devices*

2. IPv6 Netw w/ Wireless 6LoWPAN Netw

- A 6LoWPAN device can be connected *not only to the wireless 6LoWPAN network but also to the Internet*



2. 6LoWPAN for Wireless Networking

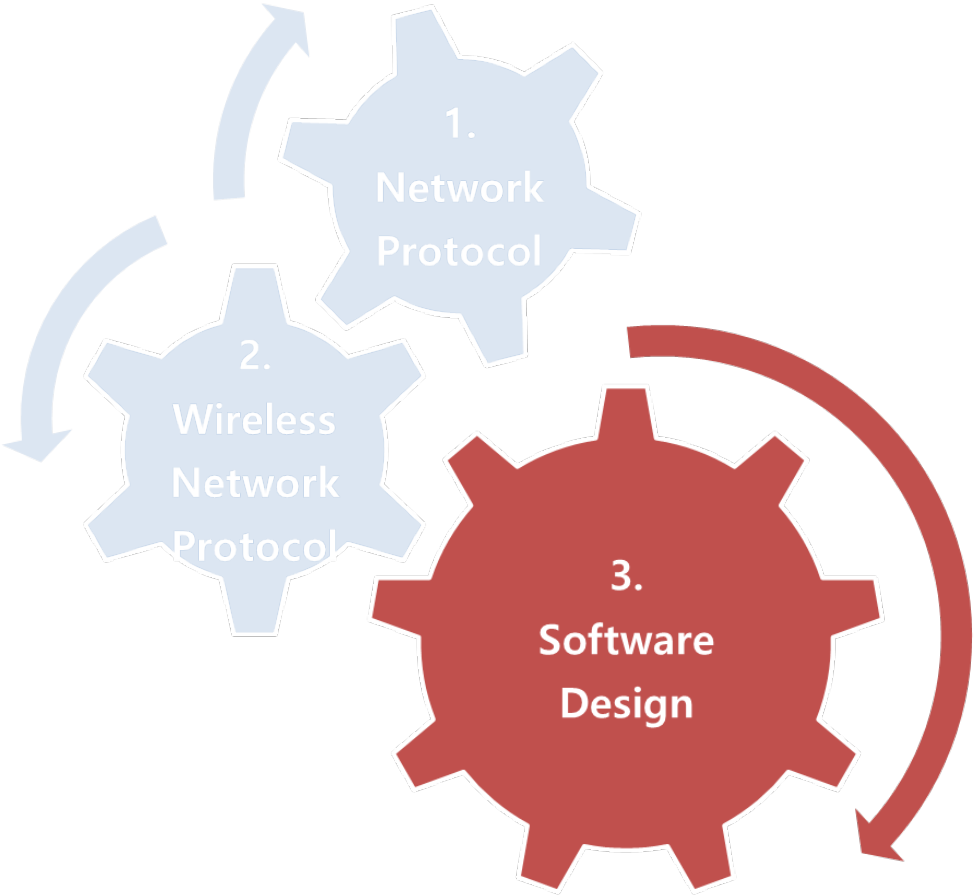
- **Header compression**
  - Reducing IP/UDP header size
  - Max. 48 byte IP/UDP header → 6 byte 6LoWPAN header
- **Packet fragmentation below network layer**
  - Supporting the short IEEE 802.15.4 frame length (127 bytes)
  - C.f. IPv6 requires a minimum MTU of 1280 bytes
- **Mesh routing support**
  - Mesh forwarding transparent to the Internet Protocol

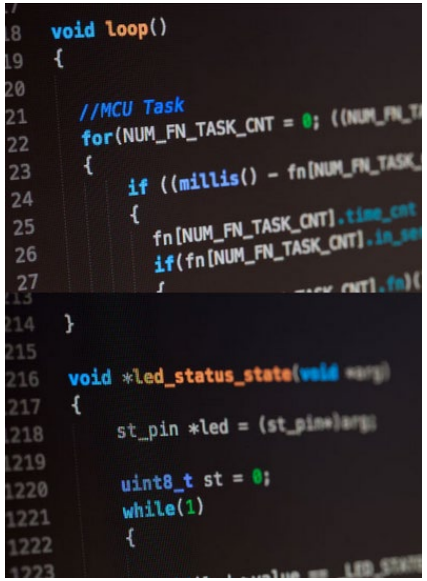
→ *Reducing the amount* of transmit power, wireless resources, and required memory

→ Wireless packet transmission *more adaptive and responsive* to wireless channel environment

Protocols & Software

Software Design for Wireless Data Network Protocols





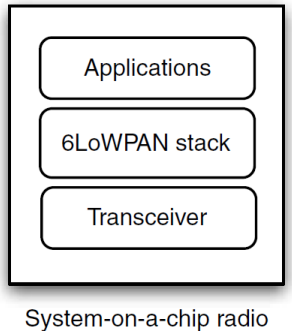
3. Embedding 6LowPAN Protocol Stack

- 6LoWPAN implementation
  - Designed for low cost, low power, and compact wireless devices
  - **Embedded on a microcontroller** somewhere in a wireless embedded device

3. Embedding 6LowPAN Protocol Stack

- Three models used to embed a wireless protocol stack

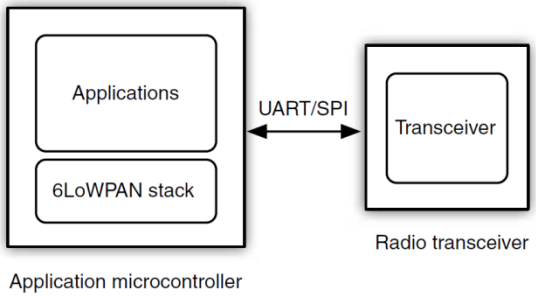
Single-chip solution



Minimizing cost and size

Limited reusability

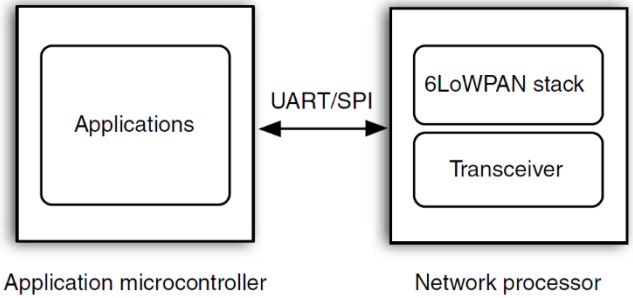
Two-chip solution



More complex applications

Extensive engineering and test

Two-chip netw. processor solution



Easy to integrate with OS (e.g., edge router)

Not extremely cost effective

6LoWPAN *implemented through microprocessor software*

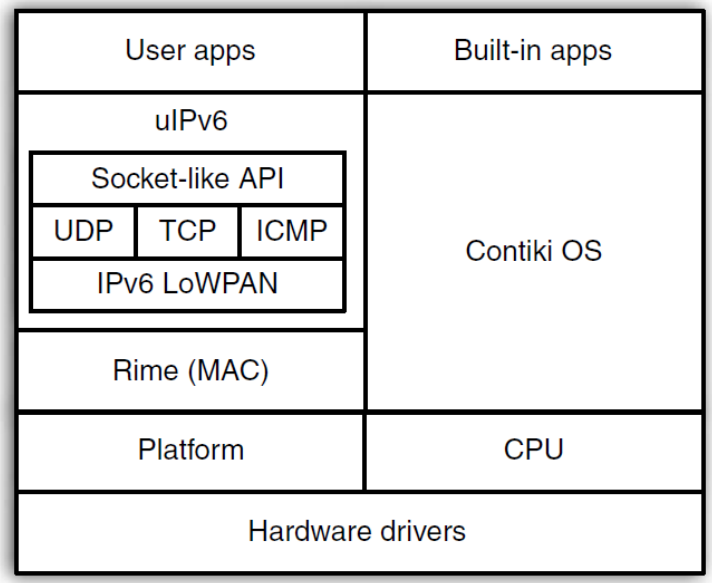
3. Software Design for Wireless Netw Protocols

- uIPv6
  - Very small implementation of 6LowPAN protocol stack included in Contiki

- Contiki
  - Open source operating system for the Internet of Things (IoT)
  - Connecting tiny low-cost, low-power microcontrollers to the Internet

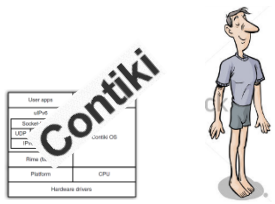
Contiki

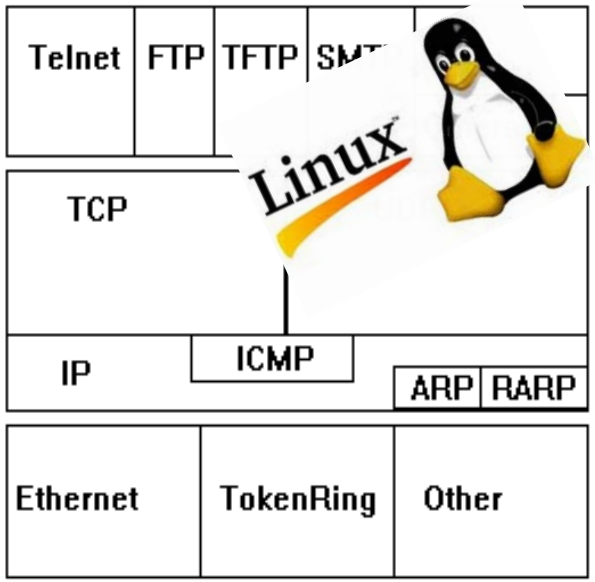
The Open Source OS for the Internet of Things



3. uIPv6 Implementation

- Extremely small code size and low RAM usage
  - Total code size of uIPv6 ~ 11 kB, RAM usage ~ 2 kB
  - Ordinary IP stack in Linux ~ one MB (1000 kB)





uIPv6 is very *suitable for memory constrained devices*

Summary on Examples for Software & Protocol

- Software Design for Wireless Data Network Protocols
  - *Embedded* on a microcontroller and implemented through microprocessor software
  - Specialized & *resource constrained* rather than general purposed
  - Becoming increasingly important as the *age of IoT* comes

Recent Hot Issues: 5G Networks & Vision

- Orientation
- Overview of the class issues
  - Brief introduction to network protocols & software
  - Recent hot issues: 5G networks & vision
- Ch 1 Introduction
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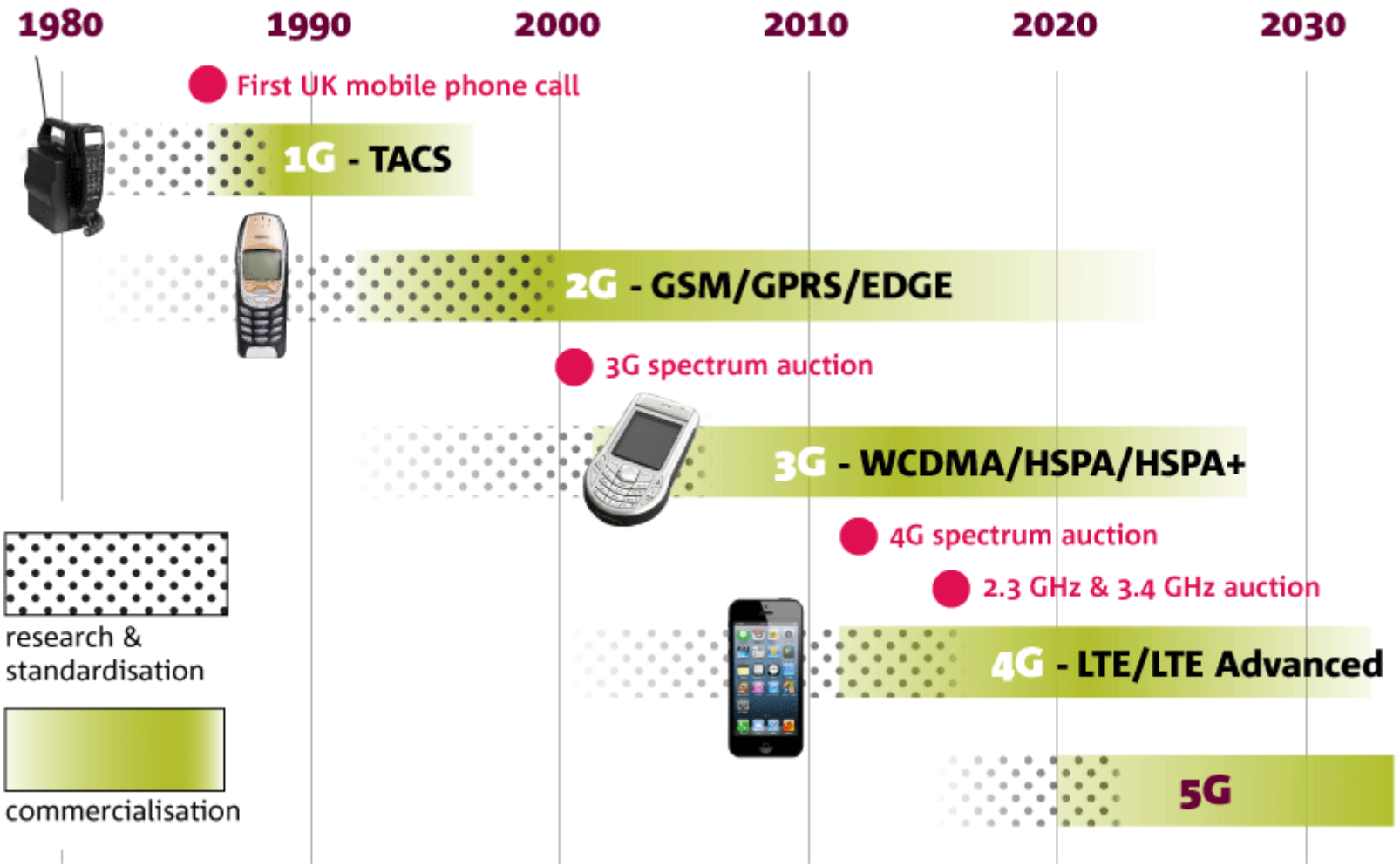
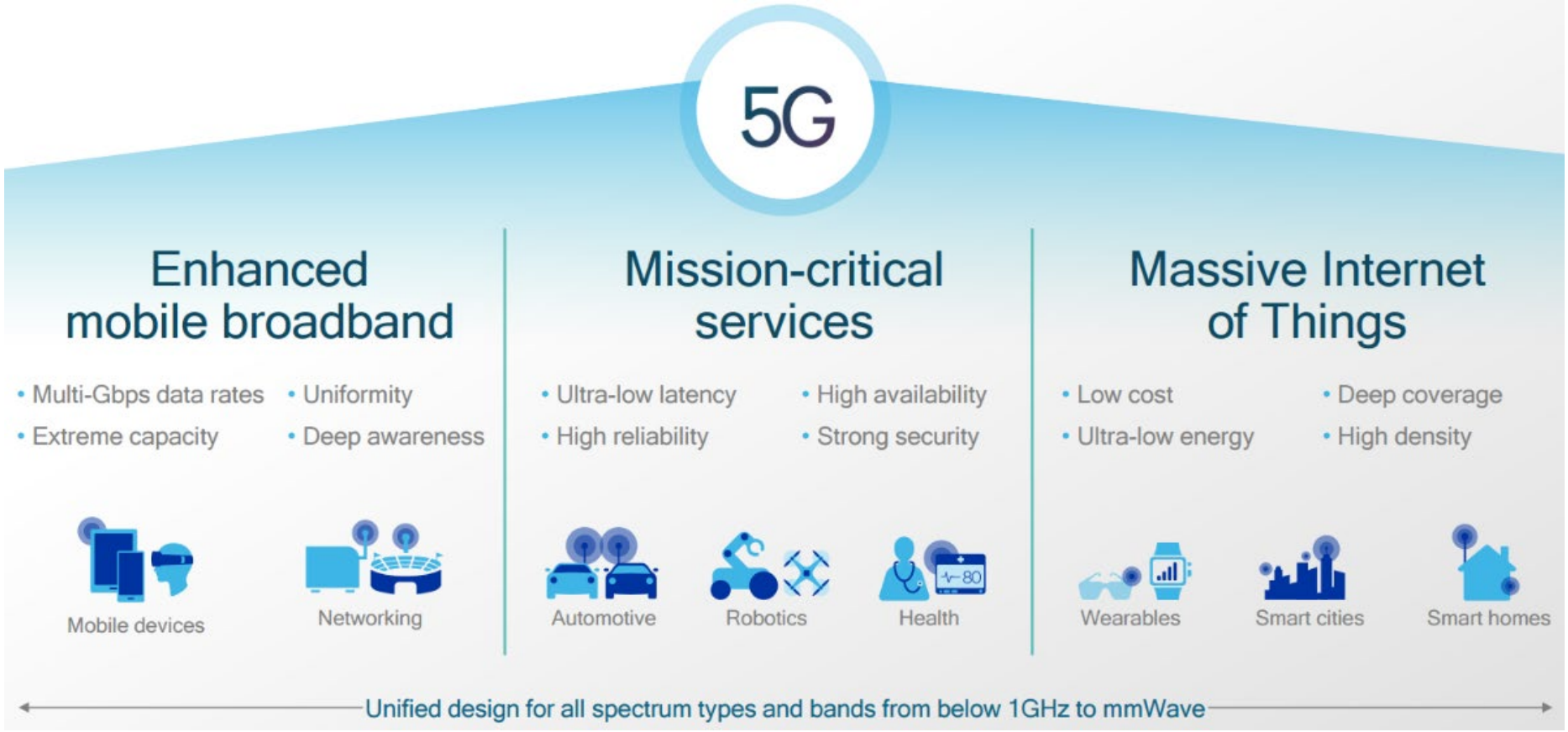
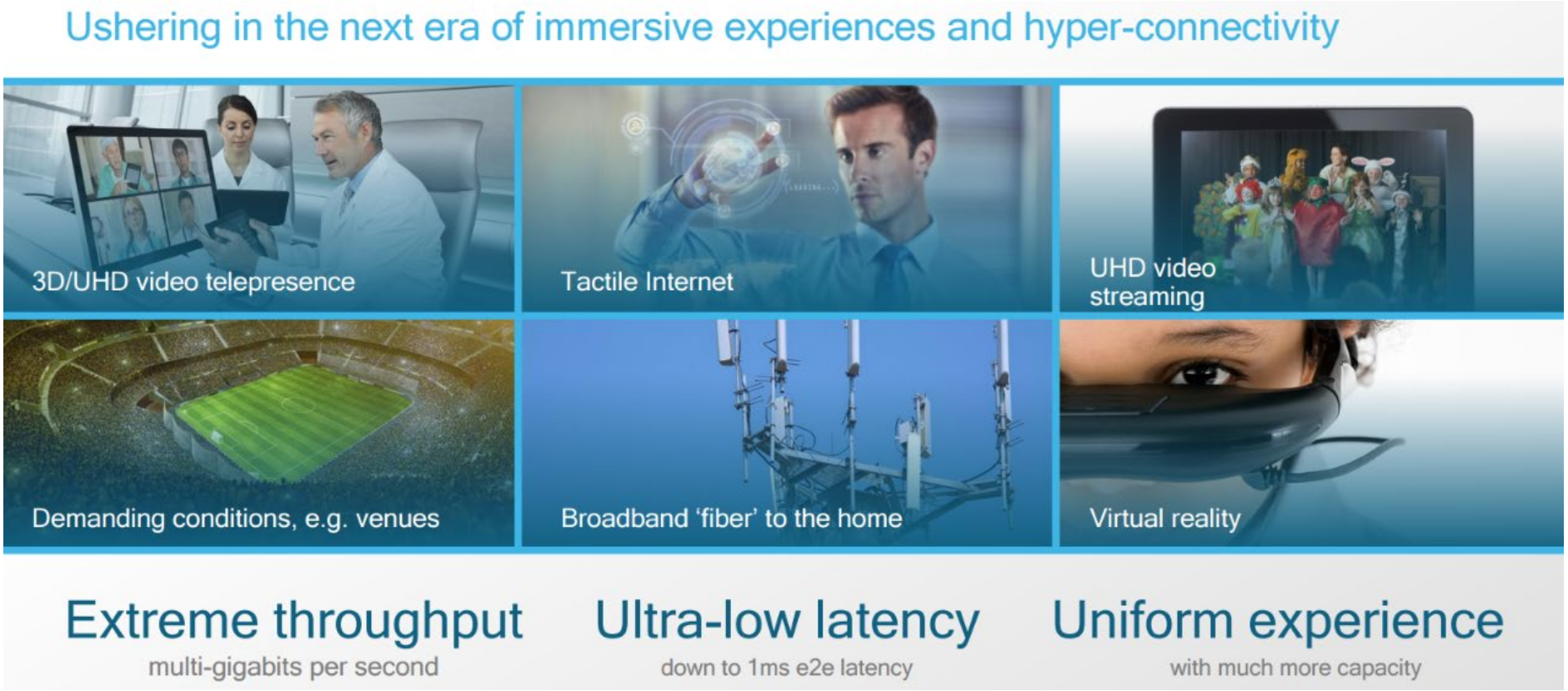
Evolution of Mobile Communications



5G Vision: a Unifying Connectivity Fabric

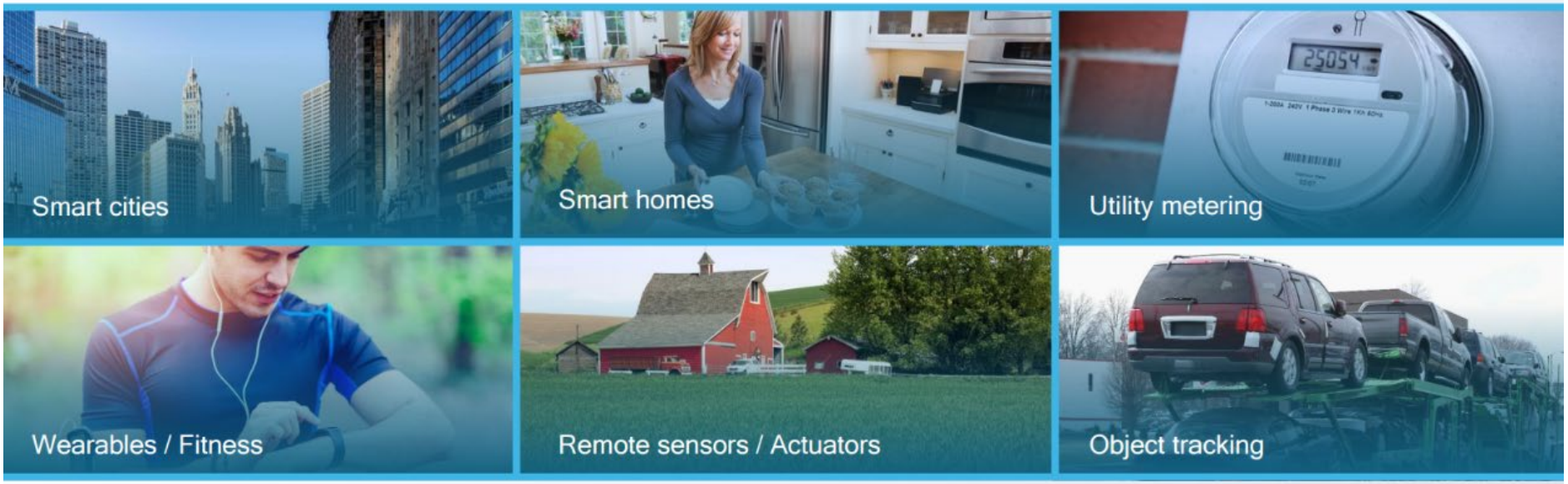


Enhancing Mobile Broadband



Connecting the Massive Internet of Things

Optimizing to connect anything, anywhere with efficient, low cost communications



Power efficient
Multi-year battery life

Low complexity
Low device and network cost

Long range
Deep coverage

Enabling New Mission-Critical Control Services

With ultra-reliable, ultra-low latency communication links

High reliability
Extremely low loss rate

Ultra-low latency
Down to 1ms e2e latency

High availability
Multiple links for failure tolerance & mobility

Introduction (Ch 1)

- Orientation
- Overview of the class issues
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- Summary & Next class

Ch 1 Contents

Ch 1 Objective

- The first section: Data Communications
  - Introduces data communications and defines their components and the types of data exchanged. It also shows how different types of data are represented and how data is flowed through the network.
- The second section: Networks
  - Introduces networks and defines their criteria and structures. It introduces four different network topologies that are encountered throughout the book.
- The third section: Network Types
  - Discusses different types of networks: LANs, WANs, and internetworks (internets). It also introduces the Internet, the largest internet in the world. The concept of switching is also introduced in this section to show how small networks can be combined to create larger ones.

Ch 1 Objective

- The fourth section: Internet History
  - Covers a brief history of the Internet. The section is divided into three eras: early history, the birth of the Internet, and the issues related to the Internet today. This section can be skipped if the reader is familiar with this history.
- The fifth section: Standards and Administration
  - Covers standards and standards organizations. The section covers Internet standards and Internet administration. We refer to these standards and organizations throughout the book

1-1 Data Communications

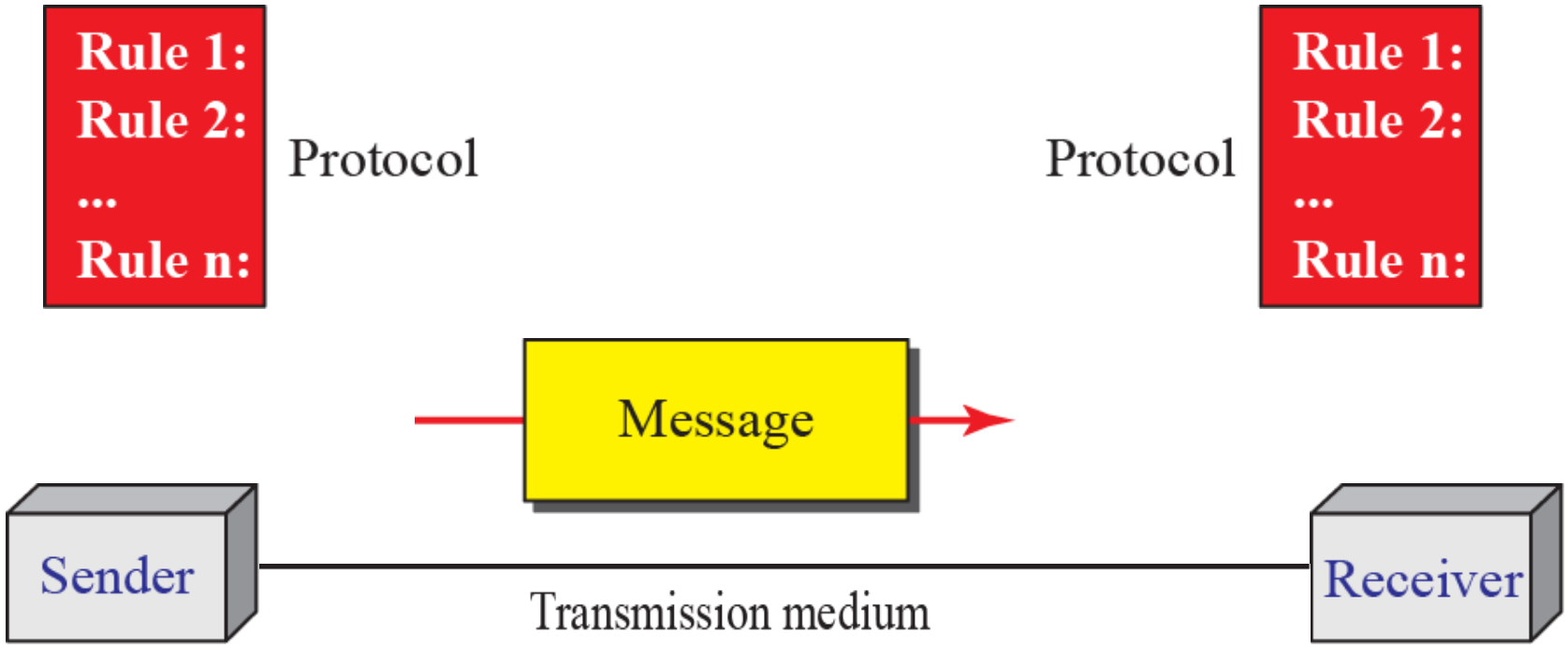
- When we communicate, we are sharing information.
  - This sharing can be local or remote.

- The term telecommunication, which includes telephony, telegraph, and television, means communication at a distance.

- Data communications are the exchange of data between two devices via some form of transmission media.

1.1.1 Components

- A data communications system has five components (see Figure 1.1).

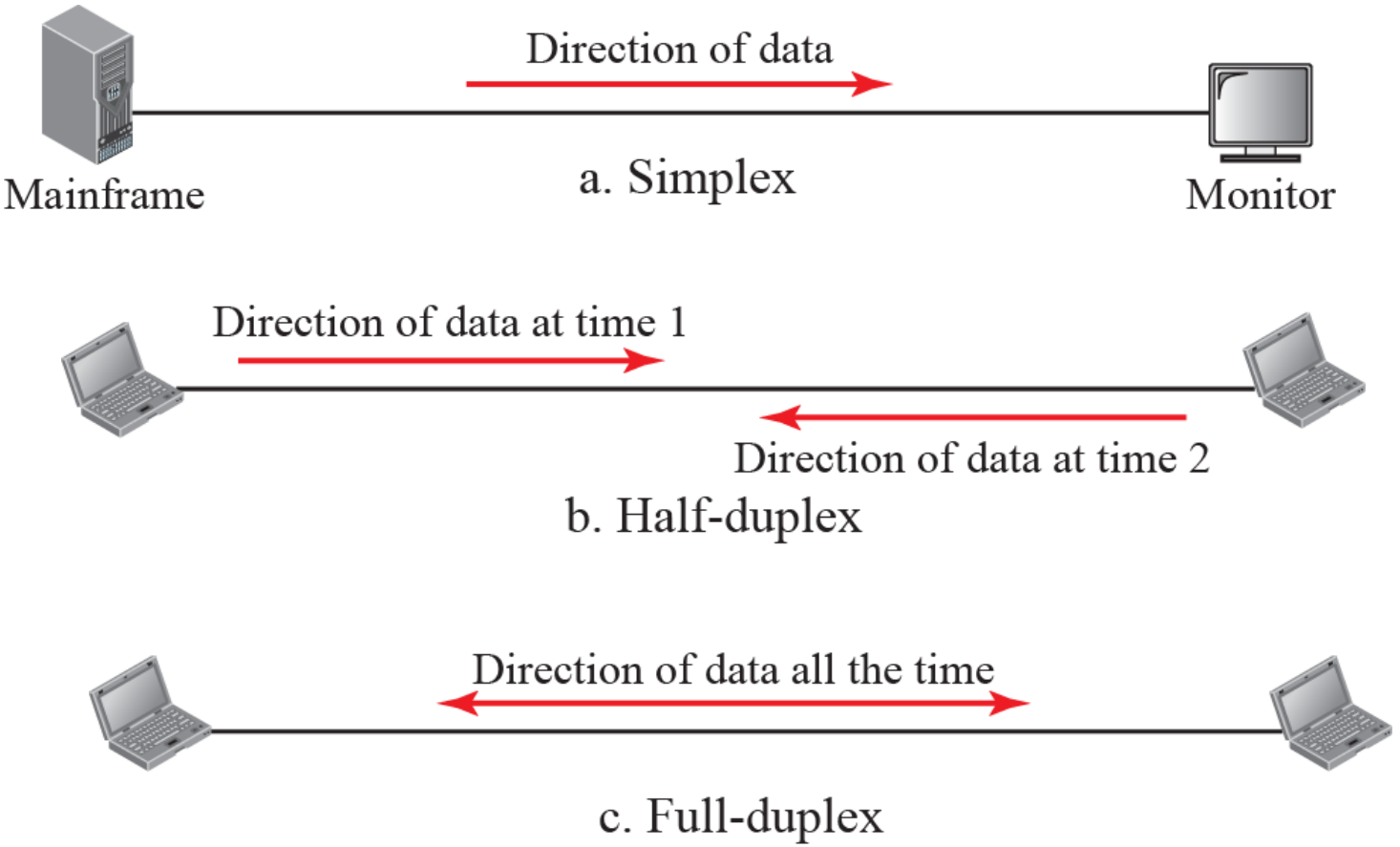


1.1.2 Data Representation

- Information today comes in different forms such as
  - Text
    - Unicode: using 32 bits to represent a symbol or character used in any language in the world
    - ASCII (American Standard Code for Information Interchange): developed some decades ago in the US, now, the first 127 characters in Unicode
  - Numbers
    - Directly converted to a binary number
  - Images
    - Represented by bit patterns; resolution
    - RGB (red, green, blue), YCM (yellow, cyan, magenta)
  - Audio
    - Recording or broadcasting of sound or music
  - Video
    - Recording or broadcasting of a picture or movie

1.1.3 Data Flow

- Communication between two devices can be simplex, half-duplex, or full-duplex as shown in Figure 1.2.



1-2 Networks

- A network is the interconnection of a set of devices capable of communication.
  - In this definition, a device can be a host such as a large computer, desktop, laptop, workstation, cellular phone, or security system.
  - A device in this definition can also be a connecting device such as a router a switch, a modem that changes the form of data, and so on.

Summary & Next Class

- Orientation
- Overview of the class issues
- Ch 1 Introduction
- Summary & Next class

Summary

- Orientation
  - Midterm exam 35%, Final exam 35%, Assignment 20%, Attendance & participation 10%, Bonus points
  - Recall course policies about participation, late policy, attendance
  - Important ones: don't copy, carefully read the textbook, link our class to practical systems
- Overview of the class issues
  - Brief introduction to network protocols & software
  - Recent hot issues: 5G networks & vision
- A part of ch 1: introduction
  - Data communications: transfer of data from one device to another via some form of transmission medium
  - Network: a set of communication deices connected by media links

Course Schedule (Tentative)

- FL: Flipped learning
- **Rec: Recorded video for makeup class**

No	Topics	Date-M		Date-Th	
1	Introduction to course and data communications (Ch1)	09/05	FL (**Zoom**)	09/08	FL
2	Intro. to data communications (Ch1) & Network models (Ch2)	09/12	**Rec**	09/15	FL
3	Intro. to physical layer (Ch3)	09/19	FL	09/22	FL
4	Digital transmission (Ch4)	09/26	FL	09/29	FL
5	Analog transmission (Ch5) & Bandwidth utilization: multiplexing (Ch6.1)	10/03	**Rec**	10/06	**Rec**
6	Bandwidth utilization: spread spectrum (Ch6.2) Transmission Media (Ch7)	10/10	**Rec**	10/13	FL
7	Switching (Ch8) Introduction to Data-Link Layer (Ch9)	10/17	FL	10/20	FL
8	**Midterm exam**	**10/24**	**Evening**	**10/24**	**Evening**
9	Error detection and correction (Ch10)	10/31	FL	11/03	FL
10	Data link control (Ch11)	11/07	FL	11/10	FL
11	Media Access Control (Ch12)	11/14	FL	11/17	FL
12	Wired LAN (Ethernet) (Ch13) & Other wired network (Ch14)	11/21	**Rec**	11/24	FL
13	Wireless LAN (Ch15)	11/28	FL	12/01	FL
14	Other wireless networks (Ch16) Connecting devices and virtual LANs (Ch17)	12/05	FL	12/08	FL
15	**Final exam**	**12/12**	**Evening**	**12/12**	**Evening**