GSCI1801A

Information Science

Lecture 5: Data Communication and Computer Networks

Asst. Prof. Chawanat NAKASAN | 2020-11-02

Class Announcement

Report 1 is due next week.
レポート1の締め切りは来週です。

Submission closes 2021-11-09 11:59:59 JST.
Late submissions lose 20% points per day.

Agenda

- Data Communication
- Network Concepts
- Exploring the TCP/IP Protocol Model

⚠ Please save the slides! ⚠

- Content presented here is more detailed than the 情報の科学 official textbook.
- Slides can be downloaded from the LMS.
- Content from the slide may be on exam.

Data Communication

share or exchange information, or express ideas

with someone else

by speaking, writing, moving your body, using equipment, or signals

Communication Model
(Modified and Interpreted for Data Communication)

Signal = Signaling method, etc.
Channel = Usually physical media + bandwidth, etc.

M   S   S'   M'

S → E → C → D → R

Sender   Message   Encoder   Signal   Received   Decoder   Received   Recipient
                     (modulator)   Signal   (demodulator) Message

Noise

Noise Source

Message =
- Content
- Structure
- Code

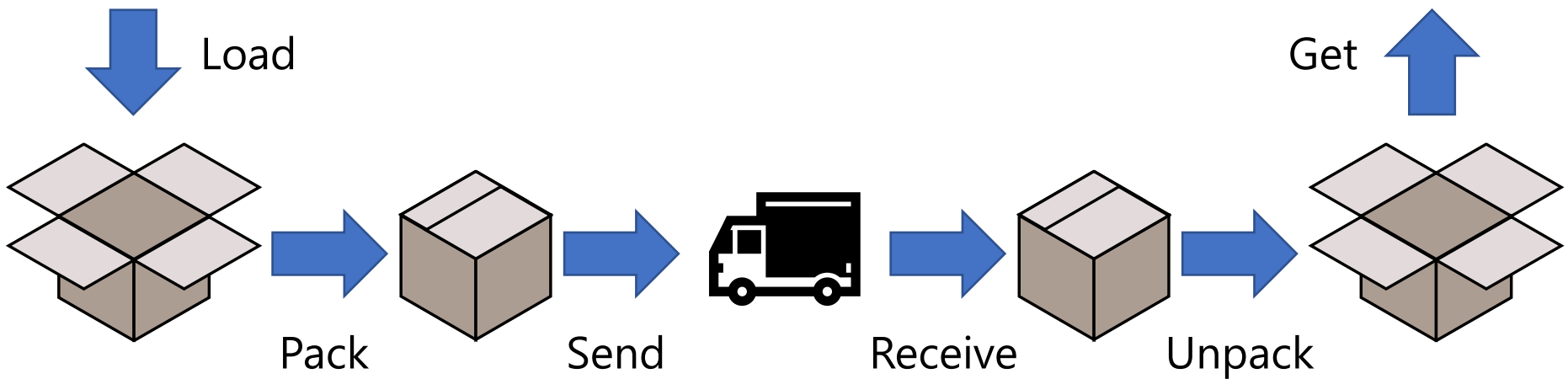This model is based on Shannon Model and Berlo's SMCR Model.
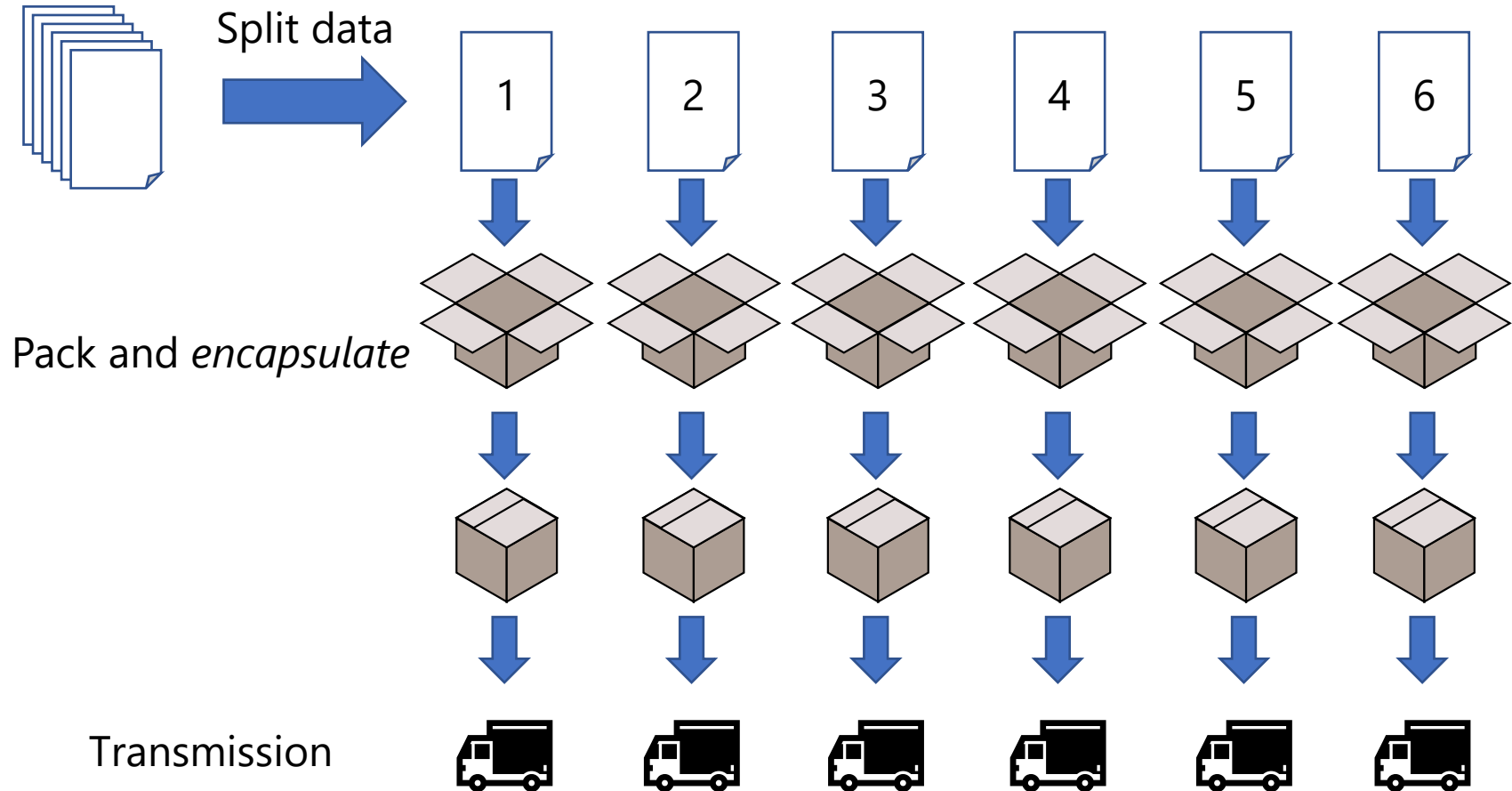
7
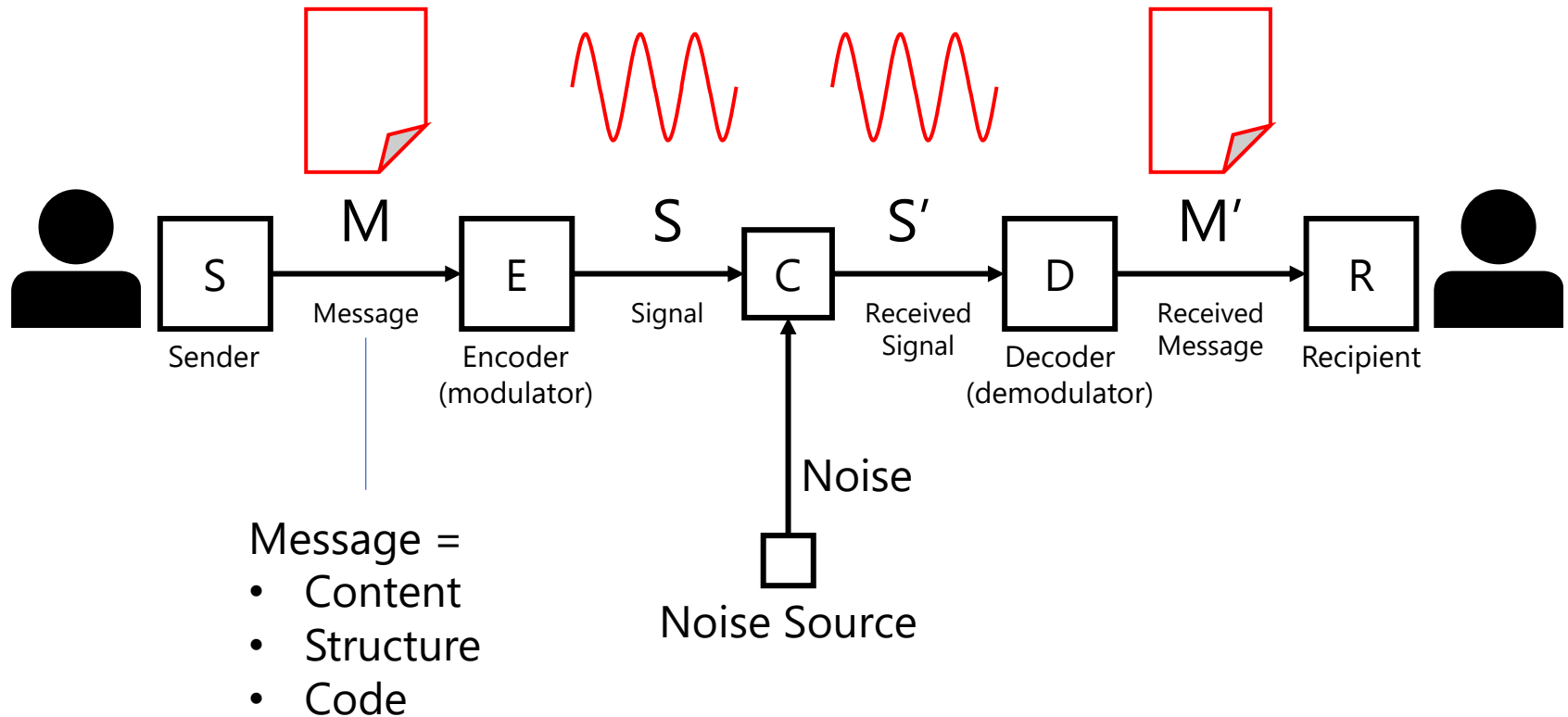
Network Concepts

The Post/Mail/Courier Model

Human Communication, Data Communication, sending things, all the same.
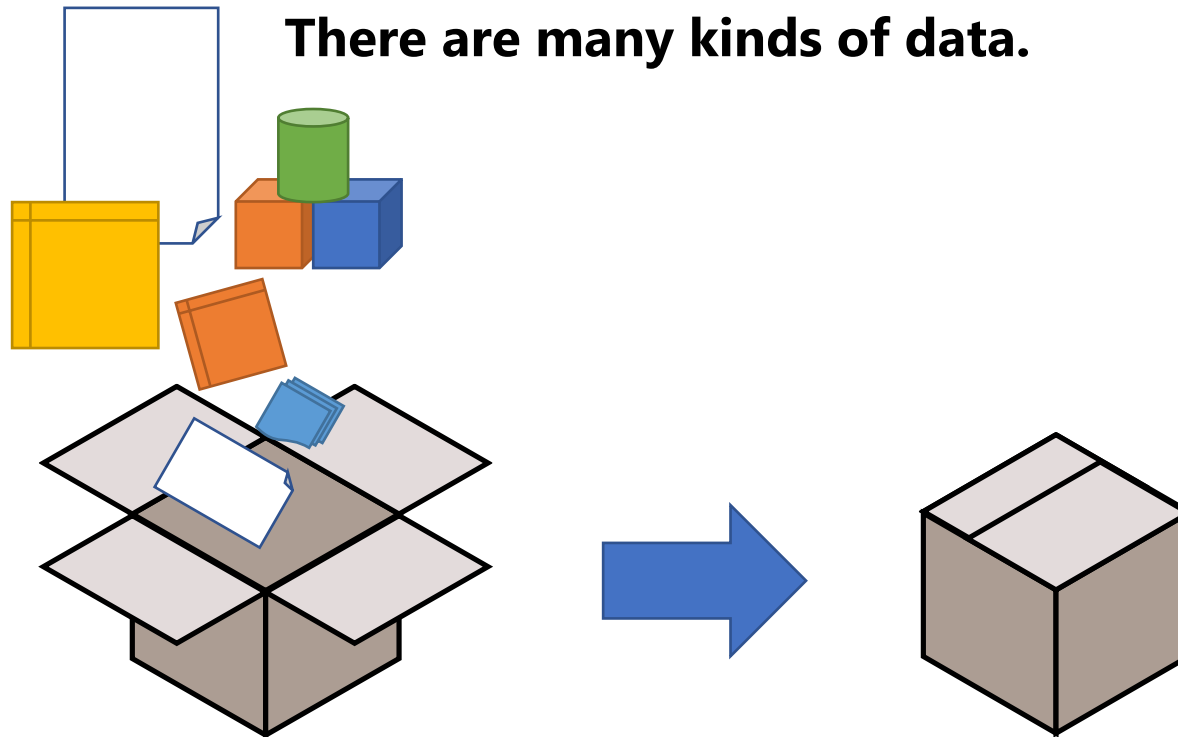(Use whichever word you remember.)

Load

Get

Pack   Send   Receive   Unpack

The Packet Model:
Handling Large Data Sizes

Split data

1   2   3   4   5   6

Pack and *encapsulate*

Transmission

The Packet Model:
Handling Different Data Formats

There are many kinds of data.

A **packet** containing data.
All packets look and behave the same.

Abstraction

Death Stranding / Kojima Productions, via Gosunoob

You can sleep easy!   It's his problem now.

- Once the item leaves your hands, you can rest assured it will arrive. The delivery is someone else's problem.
- You can assume that the delivery **will somehow complete**.

Cat Photo: Own Work, Cat is owned by Mikan Neko Cat Cafe, Kurashiki

The Network Stack

- Therefore, the network is all about processes:

Receiving input

Processing it for transmission

Passing it along

(Sending side)

Passing it along

Processing it for reception

Receiving input

(Receiving side)
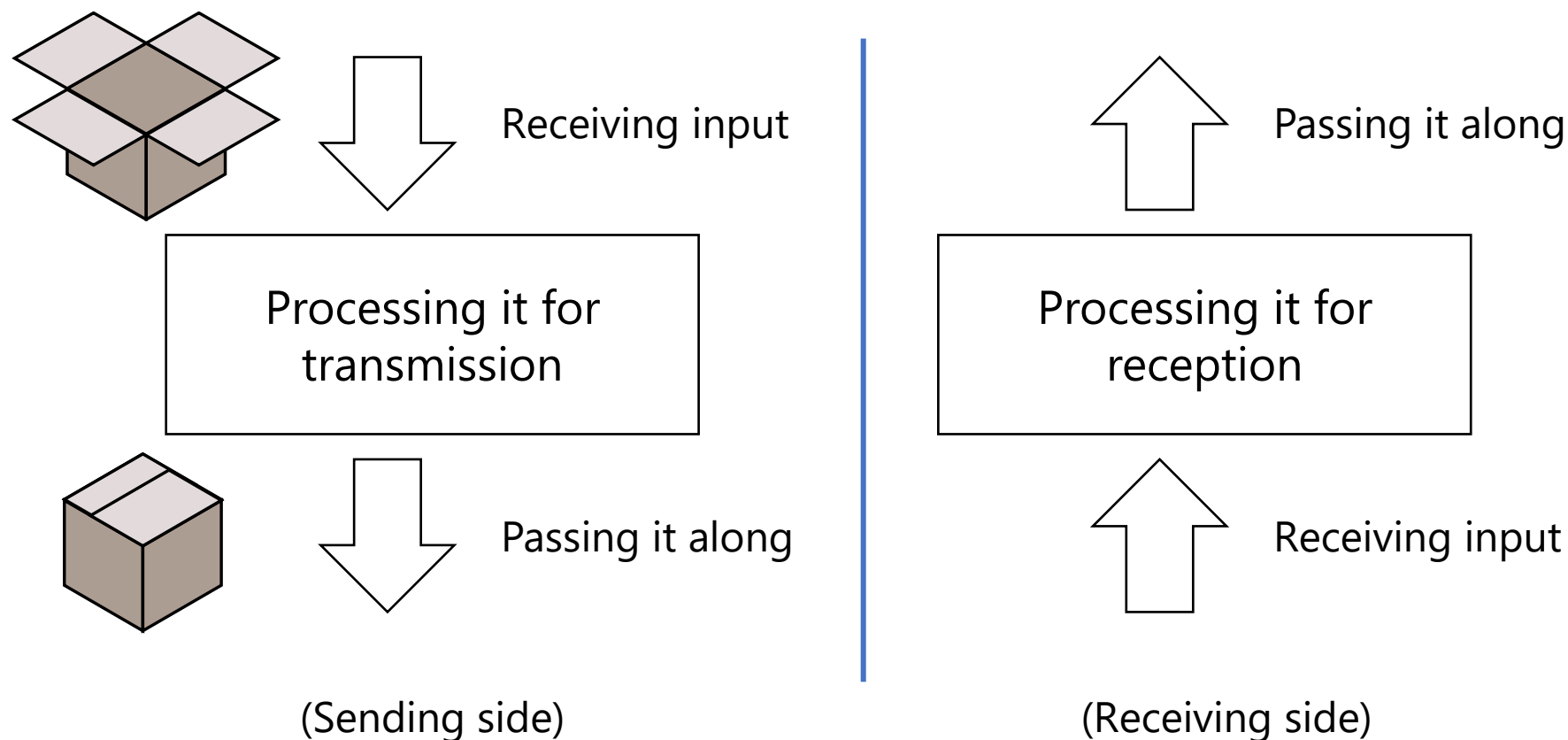
The Network Stack

- Since communication creates multiple levels of information processing, this results in a "stack" of many layers.

Layer 5	←L5-Protocol→	Layer 5
Layer 4	←L4-Protocol→	Layer 4
Layer 3	←L3-Protocol→	Layer 3
Layer 2	←L2-Protocol→	Layer 2
Layer 1	←L1-Protocol→	Layer 1

Vertical compatibility: Protocols work with other protocols in nearby layers of the same machine.
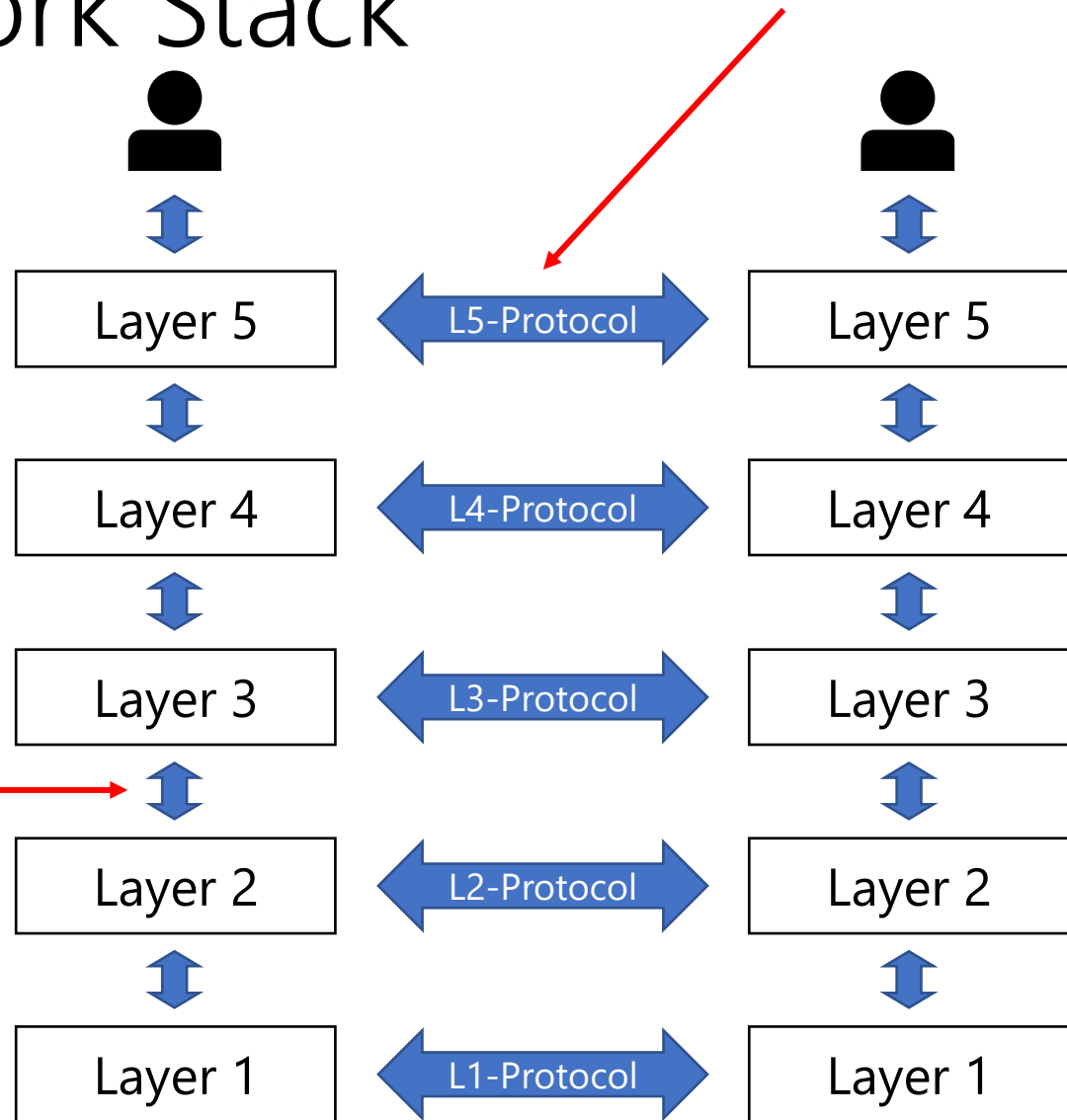
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Open Systems Interconnection (OSI) Model

OSI-L7	Application Layer
OSI-L6	Presentation Layer
OSI-L5	Session Layer
OSI-L4	Transport Layer
OSI-L3	Network Layer
OSI-L2	Data Link Layer
OSI-L1	Physical Layer

- This concept of a network stack is formalized into a global standard.

- The ISO (International Organization for Standardization) defines the OSI Model (Open Systems Interconnection Model) as a 7-layer system of computer network elements.

Open Systems Interconnection (OSI) Model

OSI-L7	**Application Layer**	Provides functional utility to the user or system operations, such as web content (HTTP), email (SMTP), and network configuration (DHCP).
OSI-L6	**Presentation Layer**	Data encoding and translation, such as data type definition (MIME types), character systems (ASCII), etc.
OSI-L5	**Session Layer**	Provides session creation and maintenance ("logging in") and manages long-term connections e.g. SOCKS and PAP.
OSI-L4	**Transport Layer**	Provides abstraction of applications into port numbers (multiplexing) and provides consistency (packet in-order) and speed (congestion) control.
OSI-L3	**Network Layer**	Provides addressing and routing between networks (across the Internet) on an individual packet basis.
OSI-L2	**Data Link Layer**	Provides communication within same network. Provides abstraction of physical layer properties.
OSI-L1	**Physical Layer**	Defines how data is physically sent across the network, such as by wire and radio signals.

Don't worry for now. Just keep this for your reference.

The TCP/IP Protocol Model

- The TCP/IP Protocol Suite reduces some layers from the OSI model and changes some definitions.

- It is considered more practical for general, research, and educational use.

- There are many forms of TCP/IP Protocol Models, but in this class, we will use this model.
  - Kanazawa University official textbook uses a 4-layer model.

Application Layer
Transport Layer
Network Layer
Data Link Layer
Physical Layer
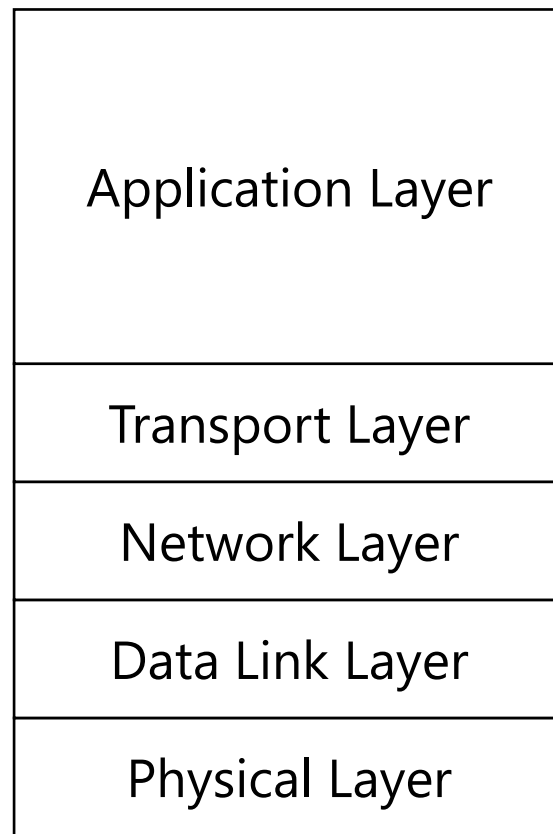
Comparison between OSI and TCP/IP Protocol Model

	OSI Model		TCP/IP Protocol Model
OSI-L7	Application Layer		Application Layer
OSI-L6	Presentation Layer		
OSI-L5	Session Layer		
OSI-L4	Transport Layer		Transport Layer
OSI-L3	Network Layer		Network Layer
OSI-L2	Data Link Layer		Data Link Layer
OSI-L1	Physical Layer		Physical Layer

OSI Model   TCP/IP Protocol Model

Addressing

- Addressing allows the network elements to send to the correct destination.

- It's very similar to writing an address.

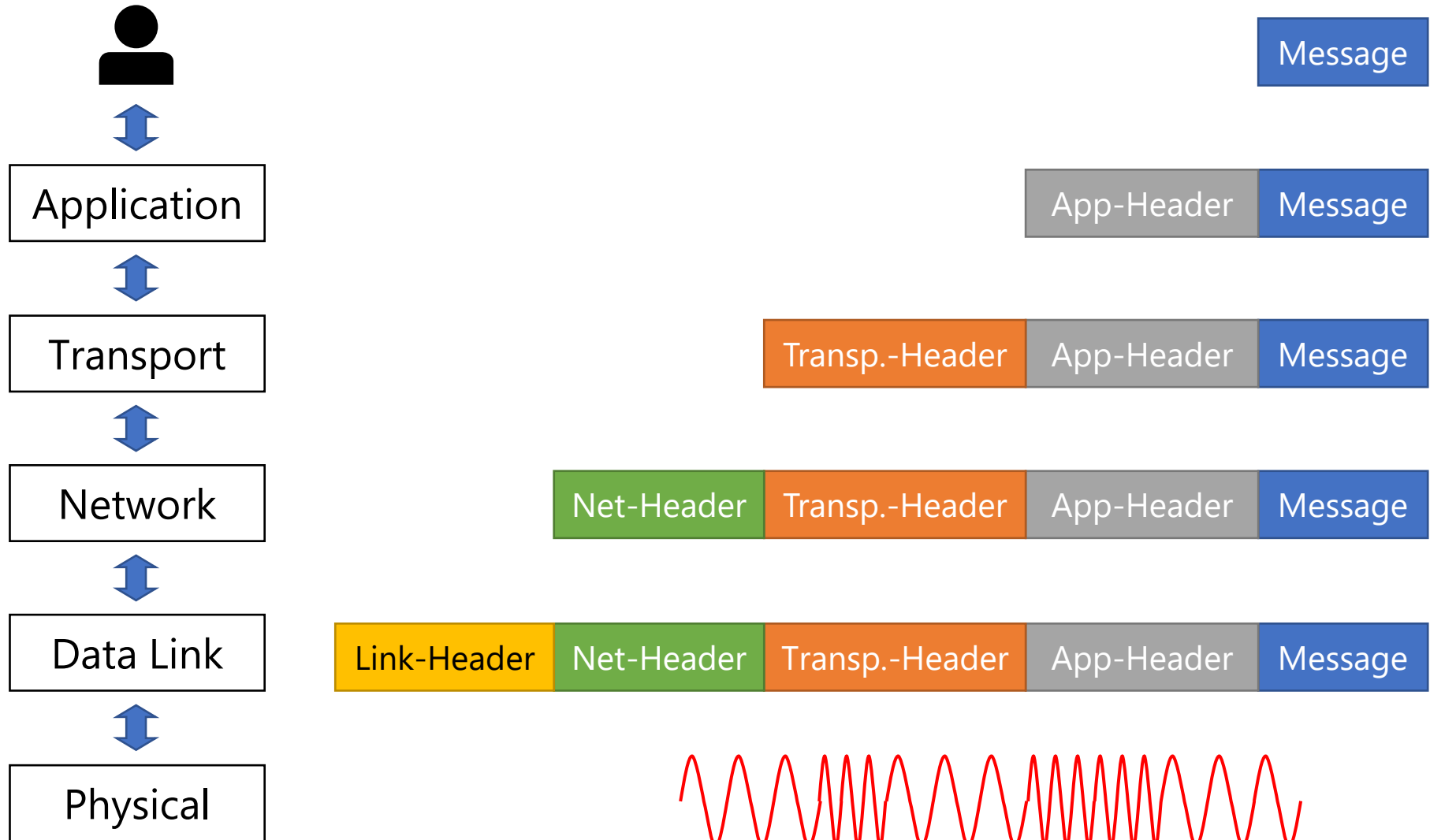- Different protocols use different kinds of addresses.

Postal addressing

920-1192

石川県金沢市角間町
金沢大学　学術メディア創成センター

角間　あざみ　様

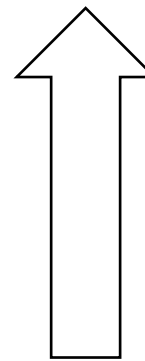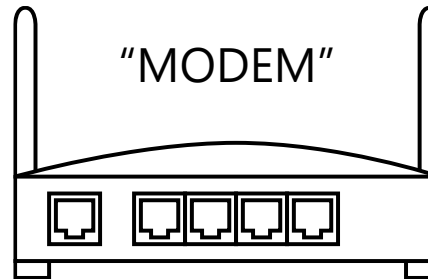Locally (in-campus) addressed envelope

EMI　角間あざみ　様

Encapsulation

Signal Modulation

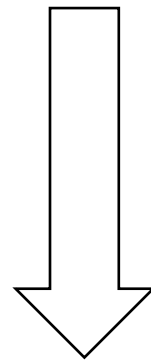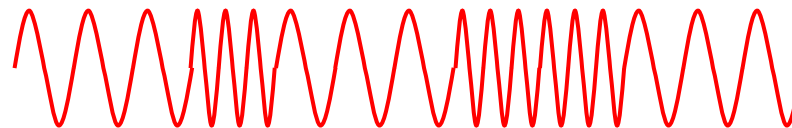| Link-Header	Net-Header	Transp.-Header	App-Header	Message

(Data sequence)

$= [01]*$

"MODEM"

Modulation

Demodulation

(Signal)

Hey, we're at the bottom of the stack!
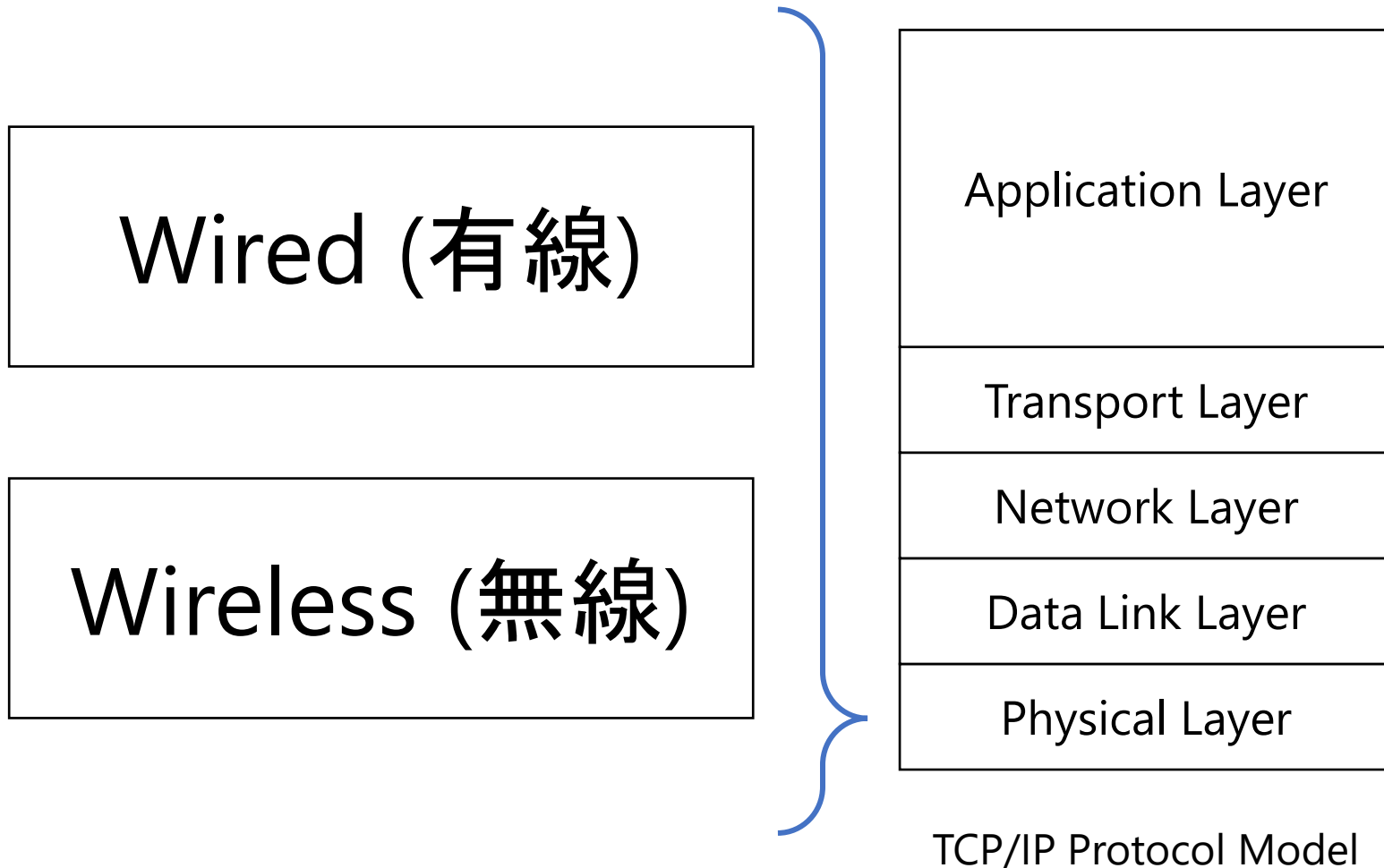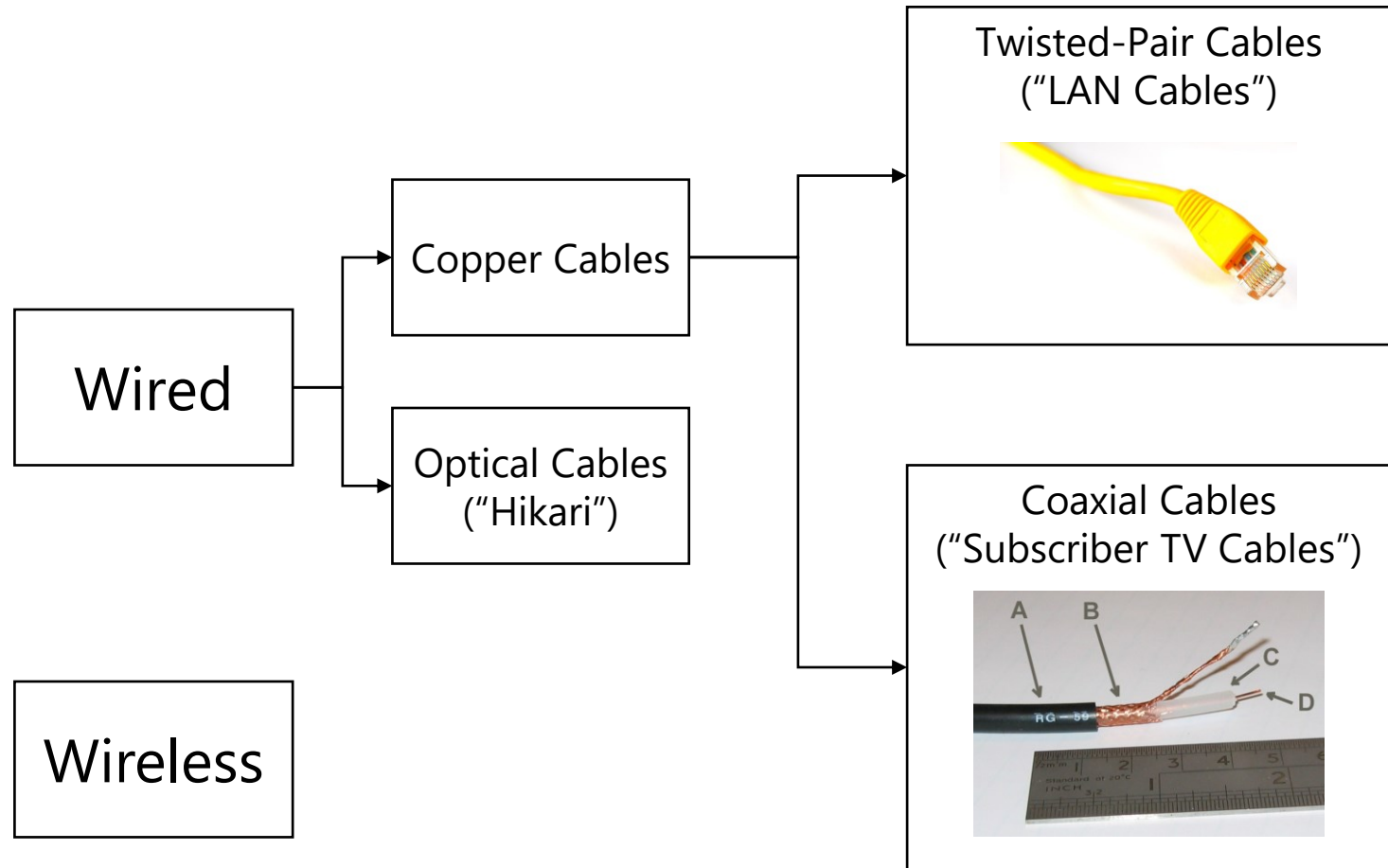
Wired (有線)

Wireless (無線)

Application Layer
Transport Layer
Network Layer
Data Link Layer
Physical Layer

TCP/IP Protocol Model

Types of Wired Media

Copper Cables → Twisted-Pair Cables ("LAN Cables")

Wired → Copper Cables, Optical Cables ("Hikari")

Wireless

Coaxial Cables ("Subscriber TV Cables")

Twisted Pair Cables

Image Source: Baran Ivo / Wikipedia
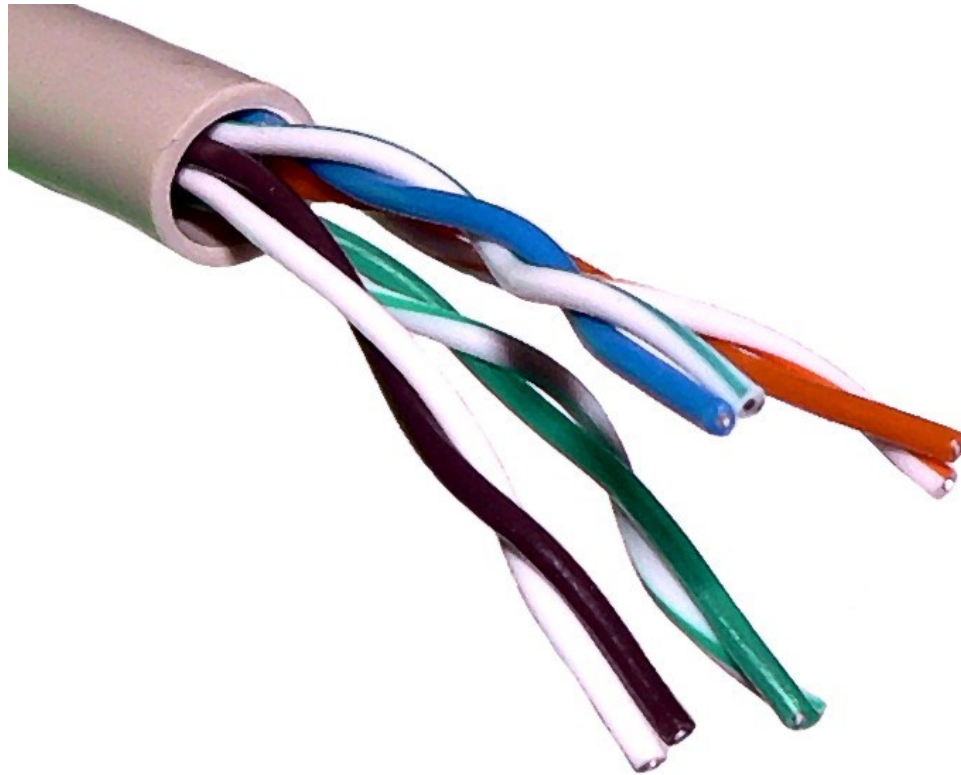
How to choose cables?

- Formally called Ethernet Cables, there are two popular ways to indicate a cable.

"Cat" System
(Common "market" language)

Cat 5e = Supports Gigabit Ethernet
Cat 6 = Supports 10Gig Ethernet

etc.

"Specification" System

Max Data Rate	"Baseband"	"Cable Class"
10 100 1000 10G	BASE	2 = up to 200 m 5 = up to 500 m T = Twisted Pair X = only 2 pairs used F = Fiber Optic

Example: 1000BASE-T = 1 Gigabit Twisted-Pair Cable

Pros:
- Easy to understand by consumers
- Higher number is always more modern

Cons:
- Does not reflect actual specification of the cable
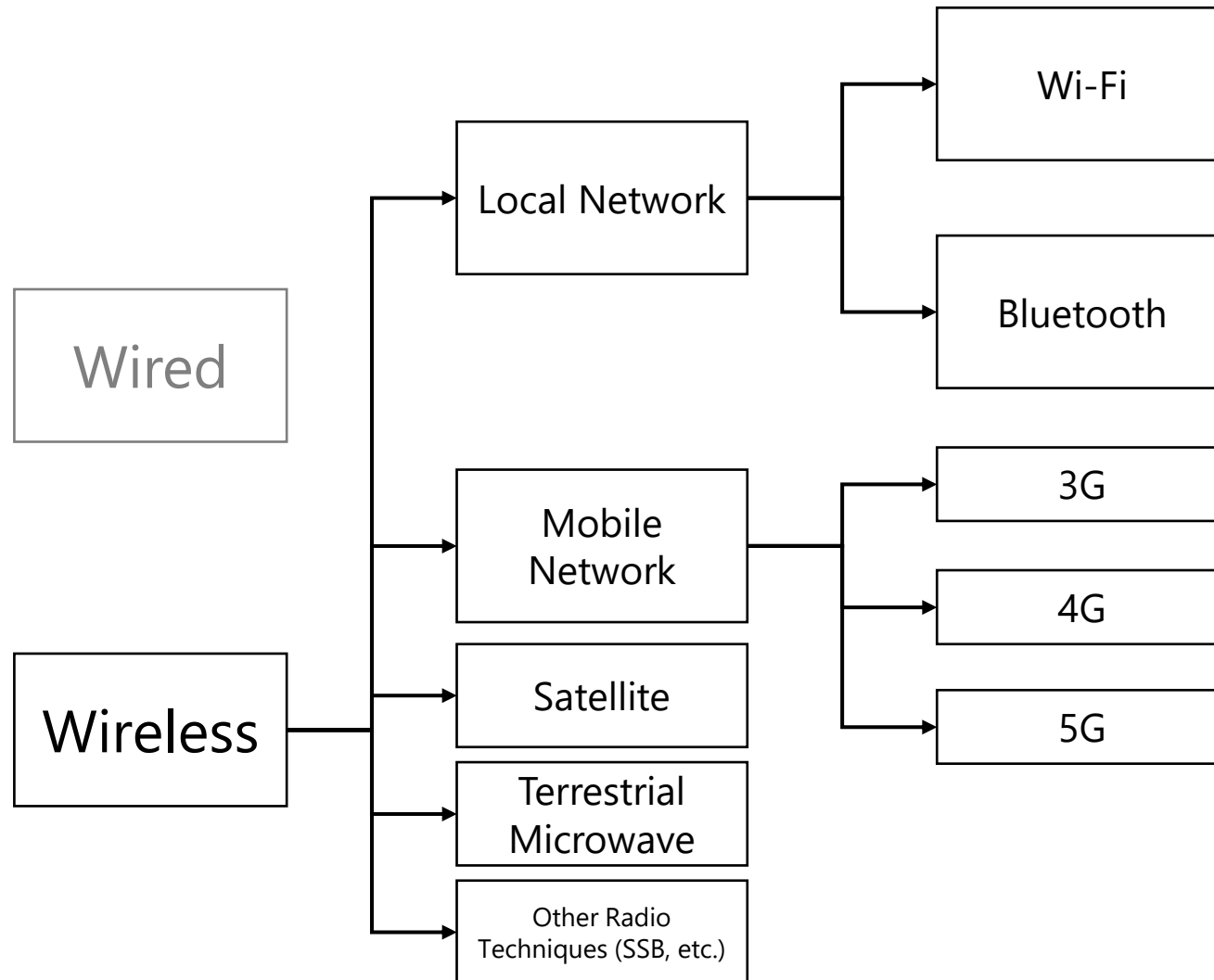
Pros:
- Very specific and you're likely to get what you want if you order by this specification system.

Cons:
- Most consumers don't understand this system.

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Wireless Communication

Wi-Fi

IEEE 802.11
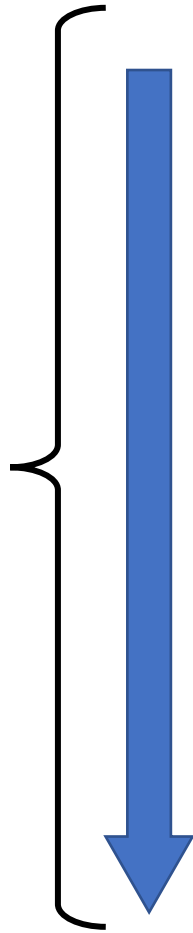
More Recent

Standard	Max Data Rate	Frequency Band	Going through walls
a	54 Mbps	5 GHz	△
b	11 Mbps	2.4 GHz	○
g	54 Mbps	2.4 GHz	○
n	600 Mbps	2.4 GHz	○
		5 GHz	△
ac	6.9 Mbps	2.4 GHz	○
ax	9.6 Mbps	2.4 GHz	○
		5 GHz	△

This is "Wi-Fi 6"

5G Emerging Tech:
mmWave vs Sub6 … what's going on?
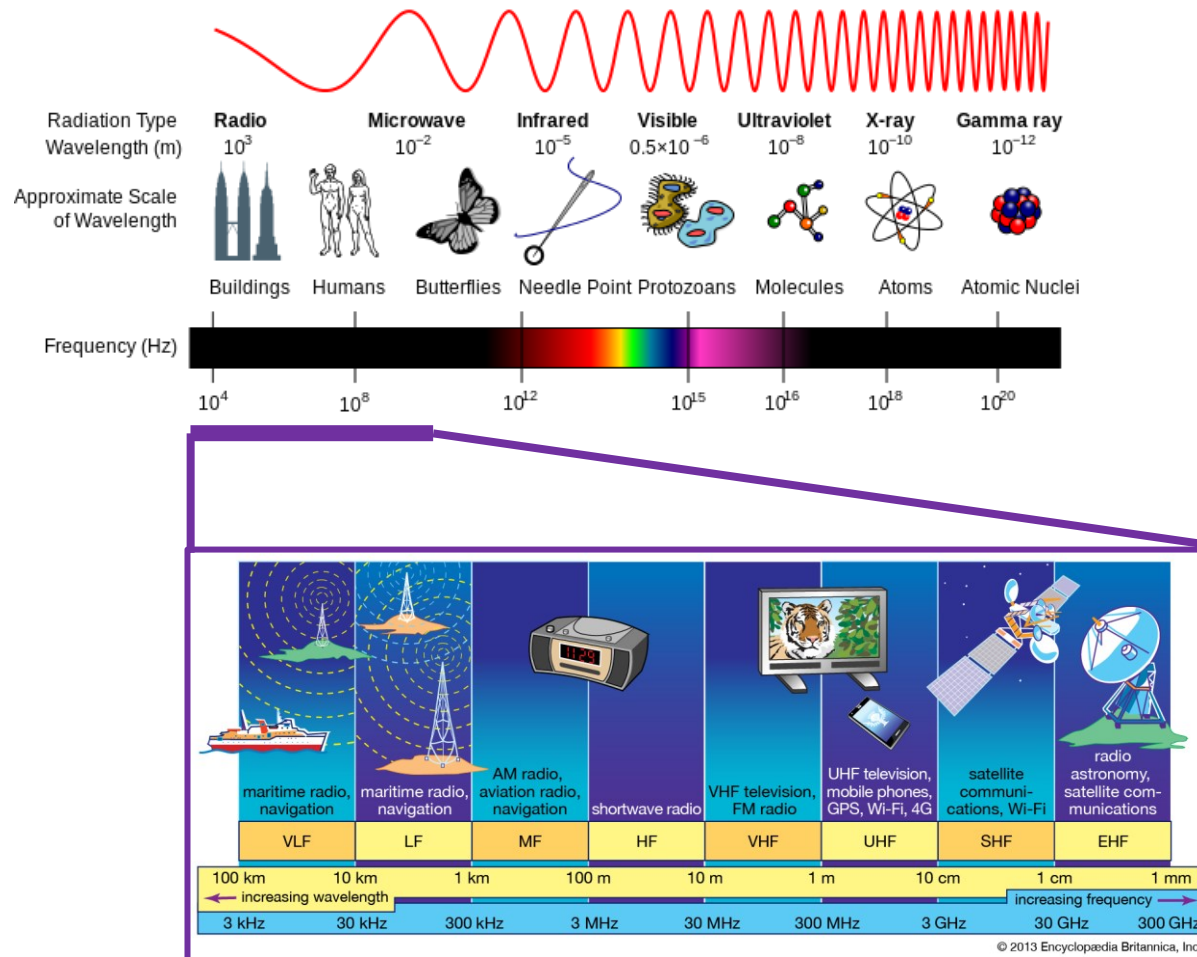
mmWave vs Sub6

mmWave

- Higher frequency (30-300 GHz)

- Harder to go through buildings ("line-of-sight")

- Less coverage

- Requires specific phone models (as of 2021)

Sub6

- Lower frequency (Sub6 = "less than 6 GHz")

- Easier to go through buildings

- Better coverage

Data Link Layer

Application Layer	
Transport Layer	
Network Layer	
Data Link Layer	
Physical Layer	

TCP/IP Protocol Model

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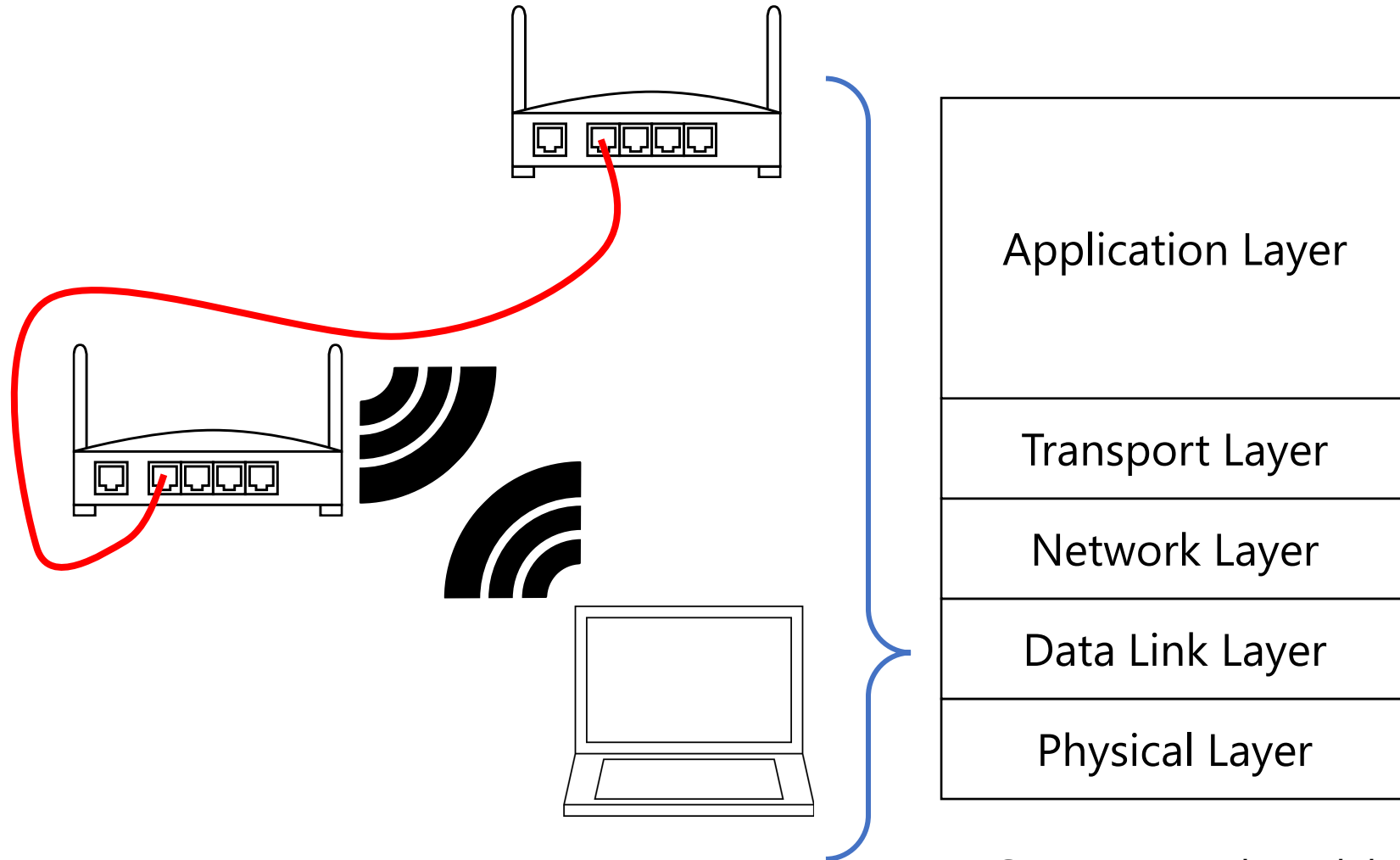
Roles of the Data Link Layer

Lowest abstraction level possible

Collision detection
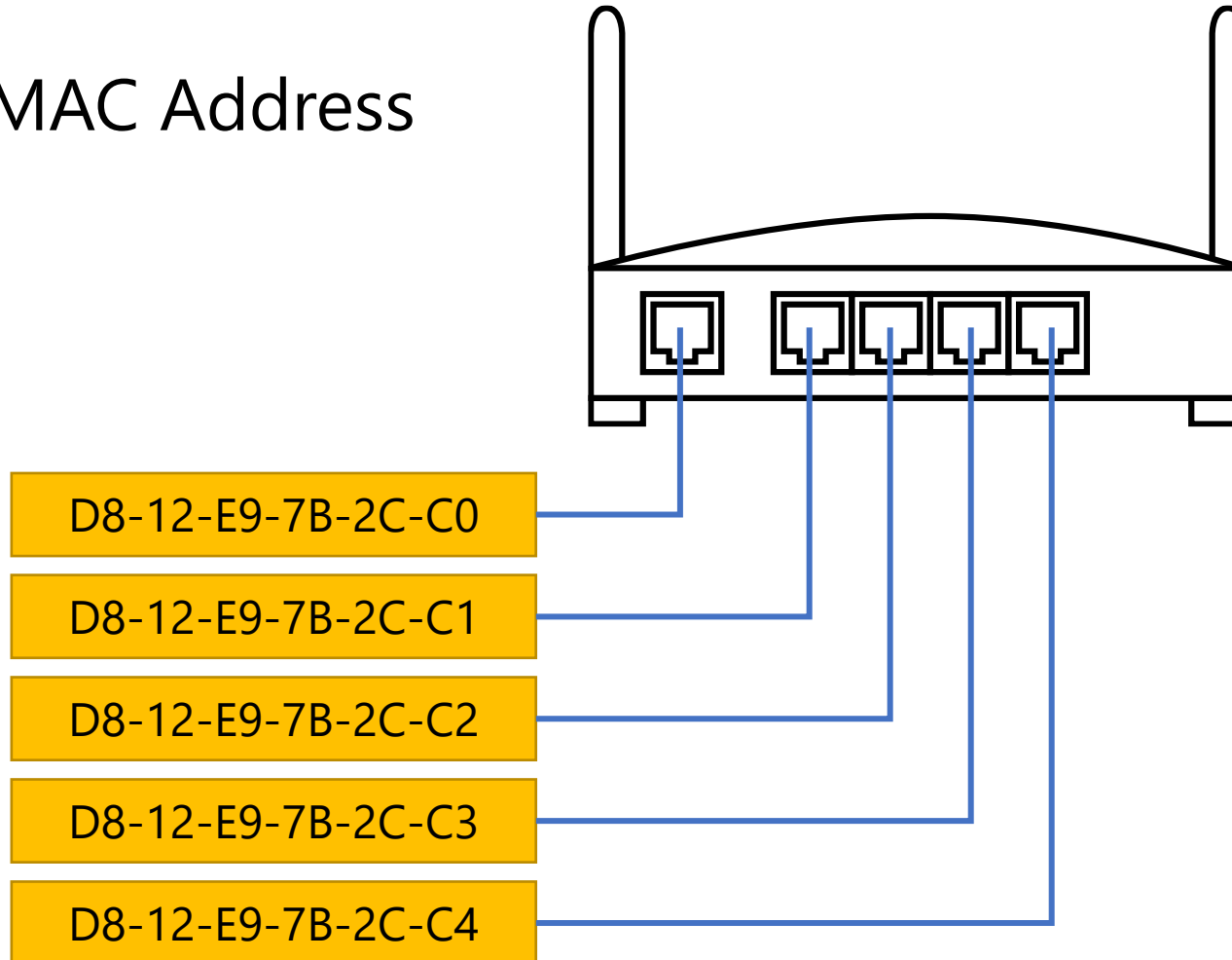
- Stop sending when others are sending

Error detection

Packet Switching

More things in Data Link Layer

- MAC Address

D8-12-E9-7B-2C-C0

D8-12-E9-7B-2C-C1

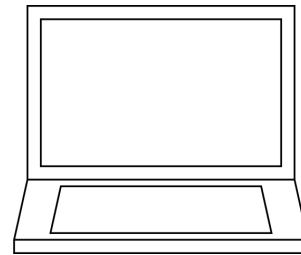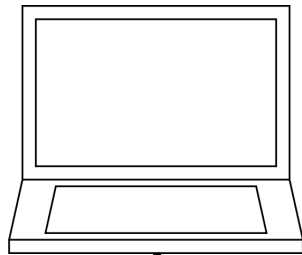D8-12-E9-7B-2C-C2

D8-12-E9-7B-2C-C3

D8-12-E9-7B-2C-C4

Your device may have more than one MAC address.

2D-3B-8D-20-A4-AC

One MAC address is (supposed to be) globally unique.

00-18-C2-6C-40-8D

Network Layer: The Internet Protocol

158.108.8.7

Application Layer
Transport Layer
Network Layer
Data Link Layer
Physical Layer

163.221.222.222

TCP/IP Protocol Model

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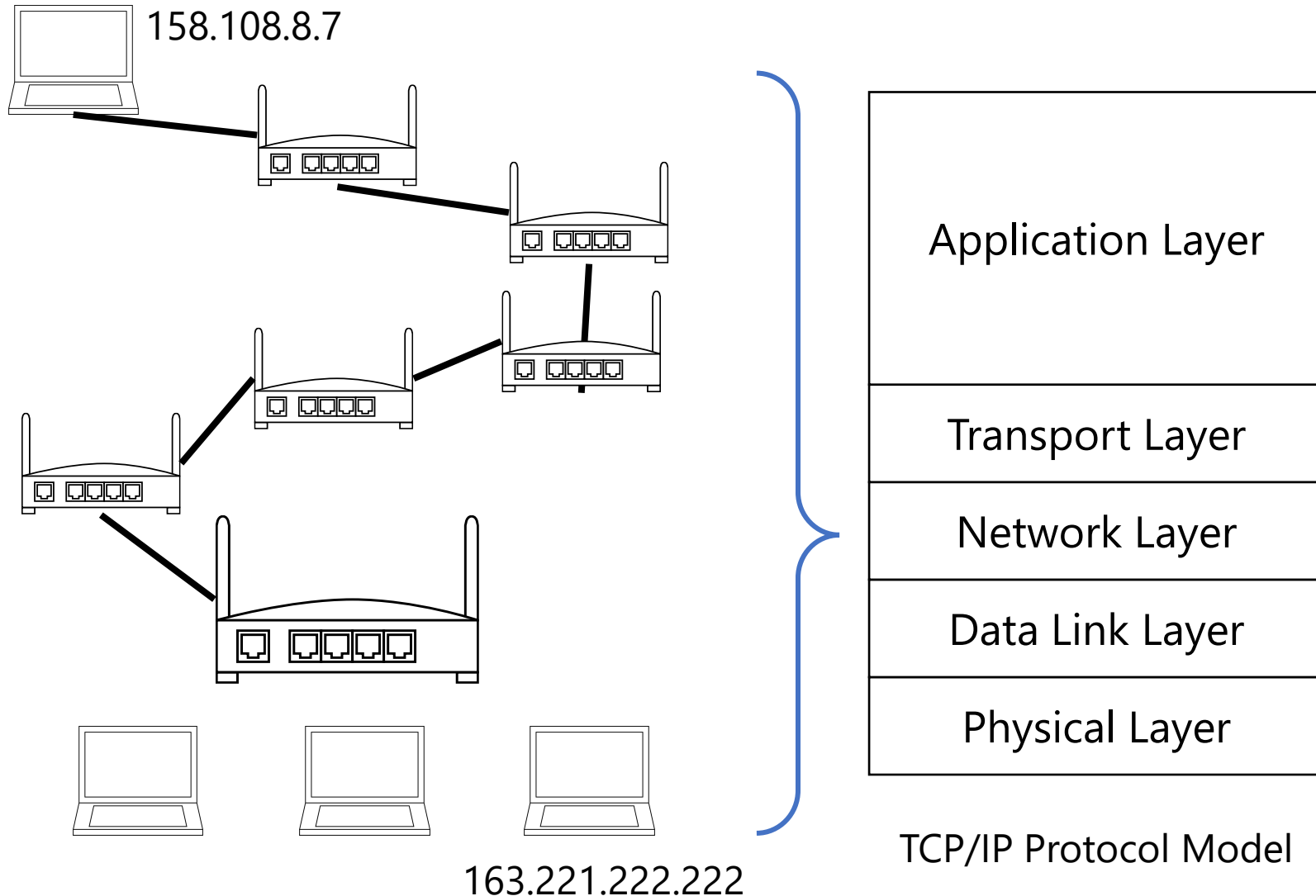
Key roles of the Internet Protocol

Internetwork Routing

- Internetwork = Between the networks.
- IP is the basis of the *Internet* itself.

IP Address as Globally Unique Address System

- There are no repeated IP addresses on the global scale.

Provides a common format for packets

- Pretty much all protocols in the world rely on IP.

How to check your MAC and IP addresses (Windows)

```
Ethernet adapter Ethernet 2:

   Connection-specific DNS Suffix  . :
   Description . . . . . . . . . . . : Intel(R) Ethernet Connection (7) I219-V
   Physical Address. . . . . . . . . : A8-A1-59-03-XX-XX
   DHCP Enabled. . . . . . . . . . . : Yes
   Autoconfiguration Enabled . . . . : Yes
   Link-local IPv6 Address . . . . . : fe80::5886:7093:b8a2:7608%14(Preferred)
   IPv4 Address. . . . . . . . . . . : 172.16.20.2(Preferred)
   Subnet Mask . . . . . . . . . . . : 255.255.0.0
   Lease Obtained. . . . . . . . . . : Sunday, October 24, 2021 18:36:39
   Lease Expires . . . . . . . . . . : Tuesday, November 2, 2021 11:17:16
   Default Gateway . . . . . . . . . : 172.16.0.1
   DHCP Server . . . . . . . . . . . : 172.16.0.1
   DHCPv6 IAID . . . . . . . . . . . : 195600729
   DHCPv6 Client DUID. . . . . . . . : 00-01-00-01-28-03-18-C5-A8-A1-59-03-XX-XX
   DNS Servers . . . . . . . . . . . : 172.16.0.1
                                       8.8.8.8
                                       8.8.4.4
   NetBIOS over Tcpip. . . . . . . . : Enabled
```

- Start command prompt
- Type "ipconfig /all"
- Do not share this information without technical need.

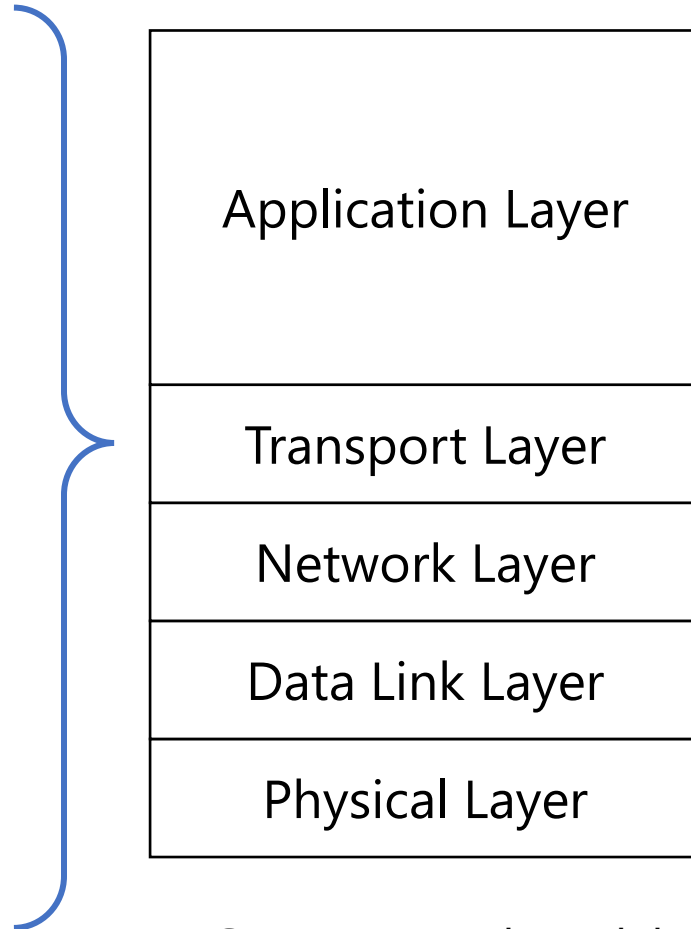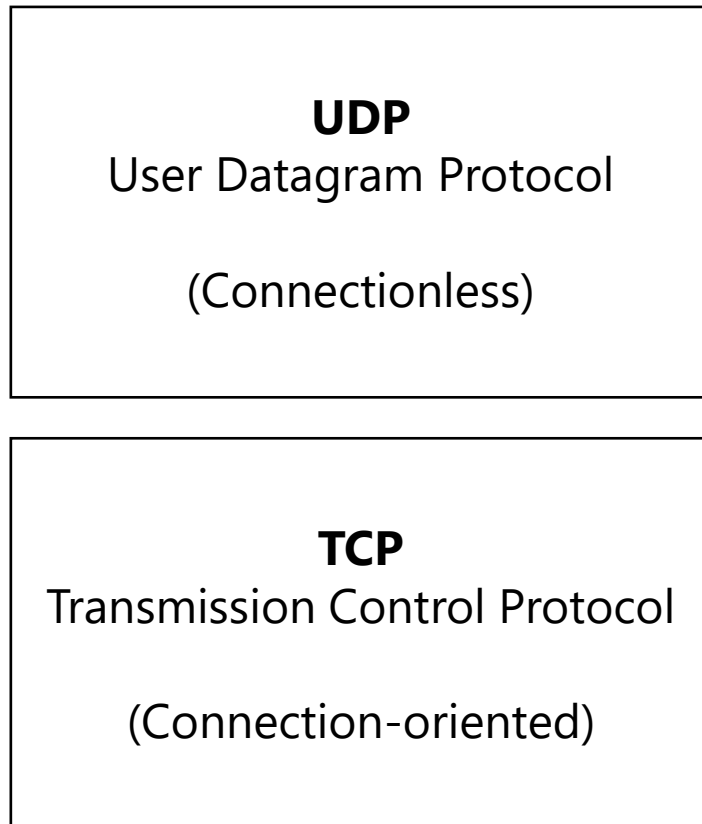# Difference between MAC and IP addresses

MAC Address

- Address for data link layer

- Used for routing within network

- Hardware-specific, cannot be changed (conventionally).

IP Address

- Address for network layer

- Used for routing across networks

- Can be configured by the OS.

Usually, one interface has one MAC address and one IP address.
In more advanced network configurations, this may change.

Transport Layer

UDP
UDP
User Datagram Protocol
(Connectionless)

TCP
TCP
Transmission Control Protocol
(Connection-oriented)

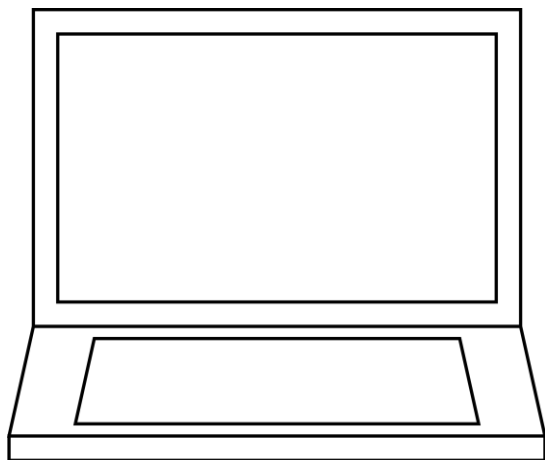| |
|---|
| Application Layer |
| Transport Layer |
| Network Layer |
| Data Link Layer |
| Physical Layer |

TCP/IP Protocol Model

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This is where port numbers are!

Each computer can run multiple processes at a time.
Port numbers allow you to guide network traffic to each process.

:22 = ssh (remote control)

:68 = bootp/dhcp (network configuration)

:80 = web server

:8080 = another web server

IP Address: 10.0.0.8

If you want to connect to this computer using ssh, you should access "10.0.0.8:22".
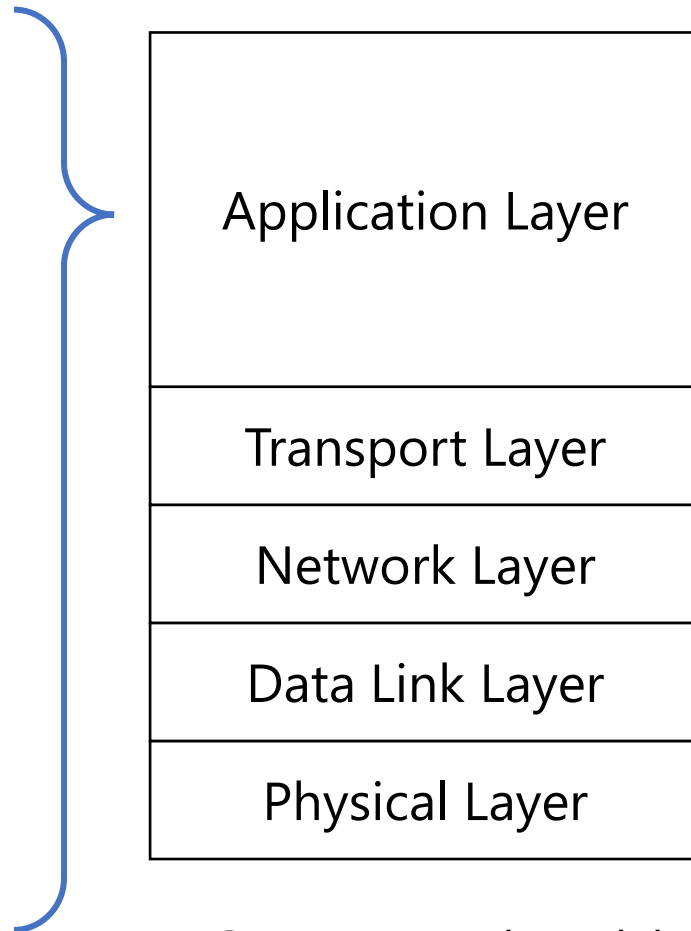
What TCP does that UDP doesn't?

- Congestion control
- Connections
- Packet ordering

Finally, we're at the application layer!

- Lots of functionality is provided here, and this layer has the greatest variety of protocols and applications.

Application Layer
Transport Layer
Network Layer
Data Link Layer
Physical Layer

TCP/IP Protocol Model

Examples of Application-Layer Protocols

```
>nslookup kanazawa-u.ac.jp
Server:  UnKnown
Address:  172.16.0.1

Non-authoritative answer:
Name:     kanazawa-u.ac.jp
Address:  133.28.0.180
```

Domain Name Services (DNS)

Hypertext Transfer Protocol (HTTP)
The main protocol for the World Wide Web

Message Queue Telemetry Transport (MQTT)
Very prominent in Internet of Things

Extensible Messaging and Presence Protocol (XMPP)
Some chat apps use this protocol.

Examples of Application-Layer Protocols

Dynamic Host Configuration Protocol (DHCP)

And so on!

- There are hundreds of application layer protocols. More are being developed every day.
- You don't have to remember the details. The most important thing today is to **understand the context of things** so it's easier for you to learn in the future.

What can you learn further in single sentences?

- Virtual Private Network (VPN)
  - Encapsulate and encrypt *total* data transmission to achieve privacy.

- Internet of Things (IoT)
  - Many small devices communicate and provide useful functionality in physical world.

- Personal Area Network (PAN)
  - Things around your body that communicate with each other.

- Blockchain
  - Using concepts in computer networks, computation, and security to create a tamper-proof public record system.
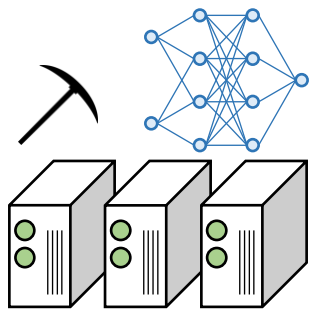 - We'll talk about this later!

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