

# Basic Concepts in Computer Networking

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Peerapon S.

CPE 314: Computer Networks (2/63)

<https://classroom.google.com>  
Google classroom code: rwxqggp

## Learning Objectives

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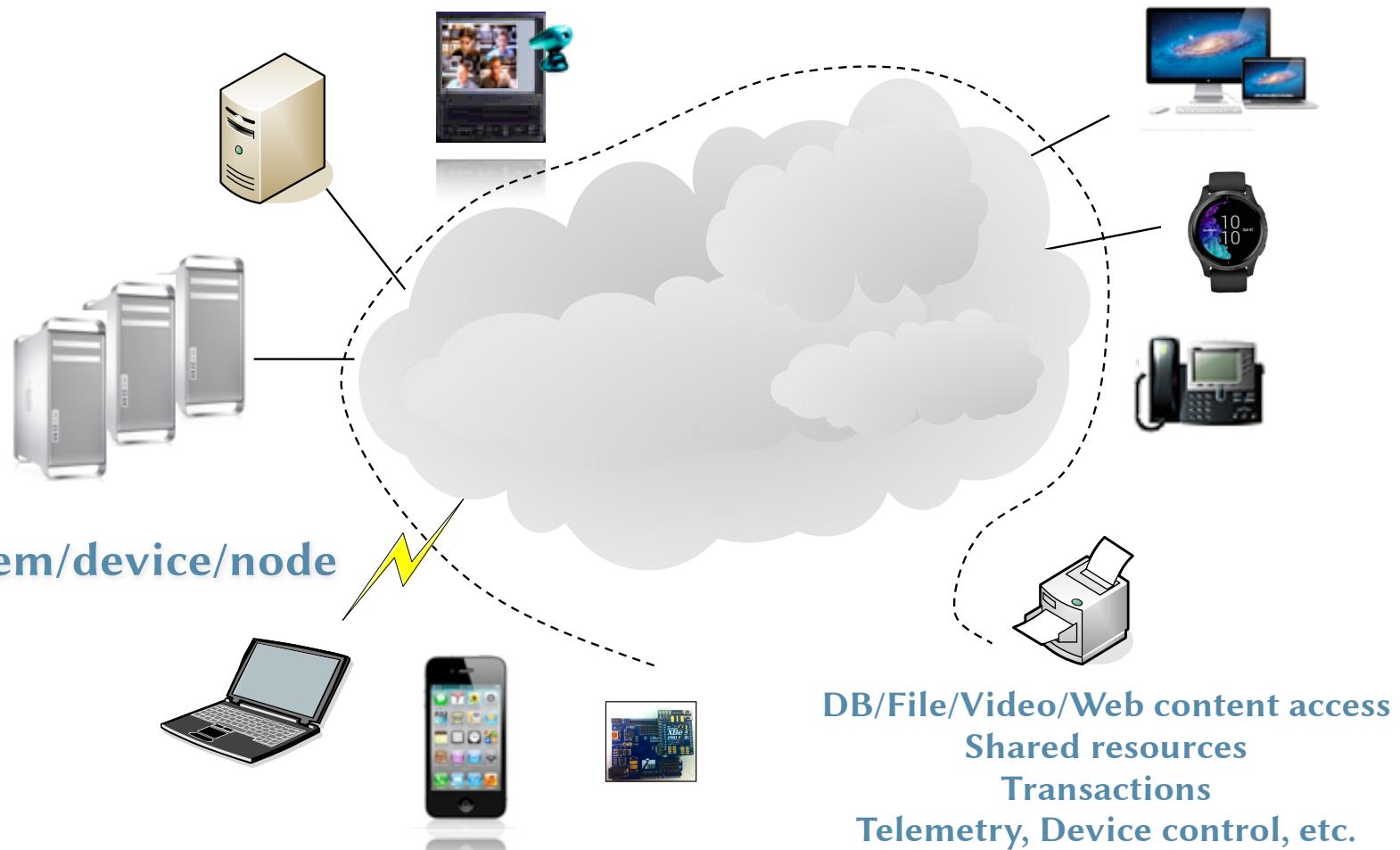
- List the needs for computer networks.
- Explain the roles and elements of a network protocol.
- Explain the differences between switch and router, what they do, and why they are needed.
- Explain how and why network protocols are organized into layers.

## Topics

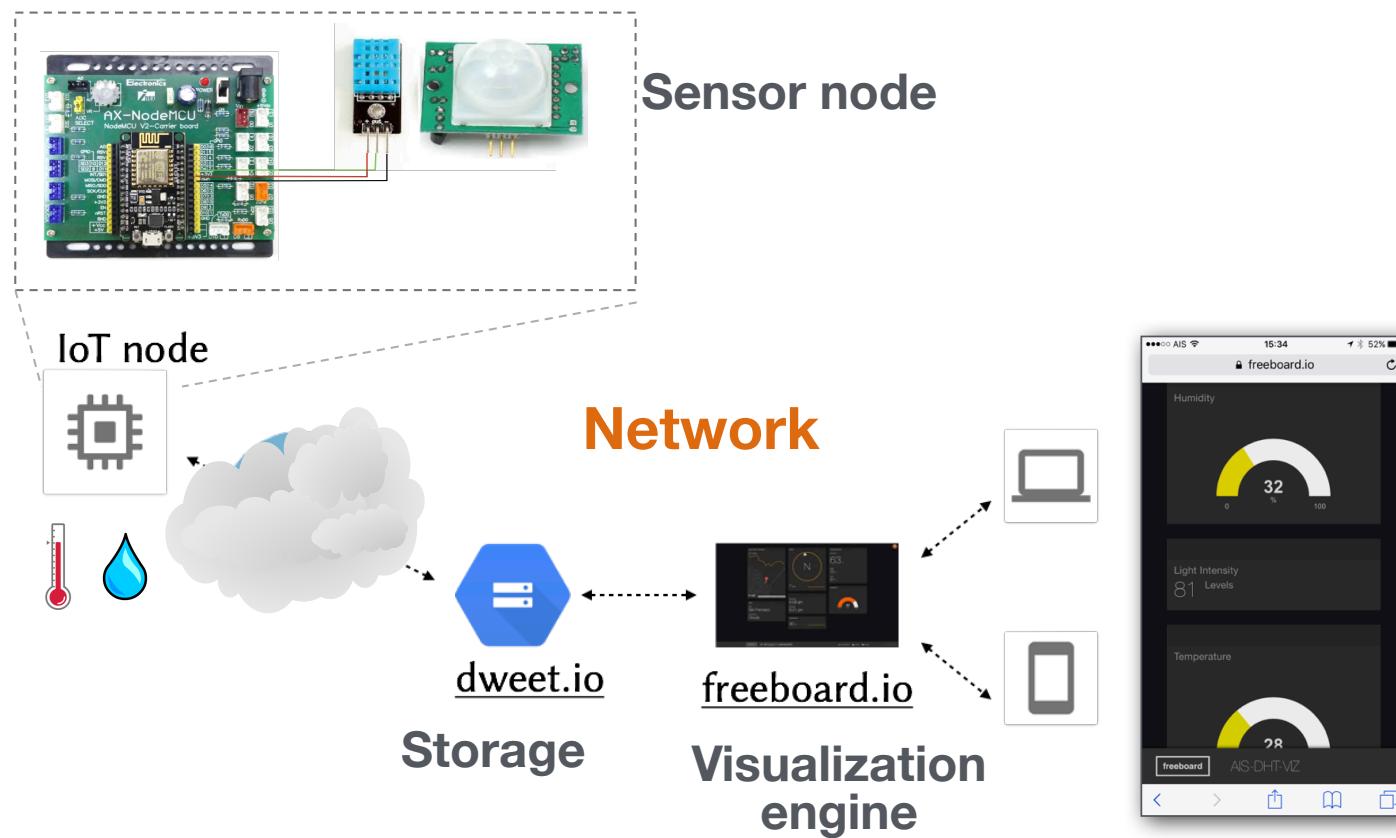
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- Motivation
  - Protocols and layered architectures
  - Network infrastructure
  - TCP/IP protocol stack
  - Lab session information
- 
- Reading
    - ◆ Forouzan text: Chapters 1, 2.1 - 2.3
    - ◆ Kurose text: Chapter 1

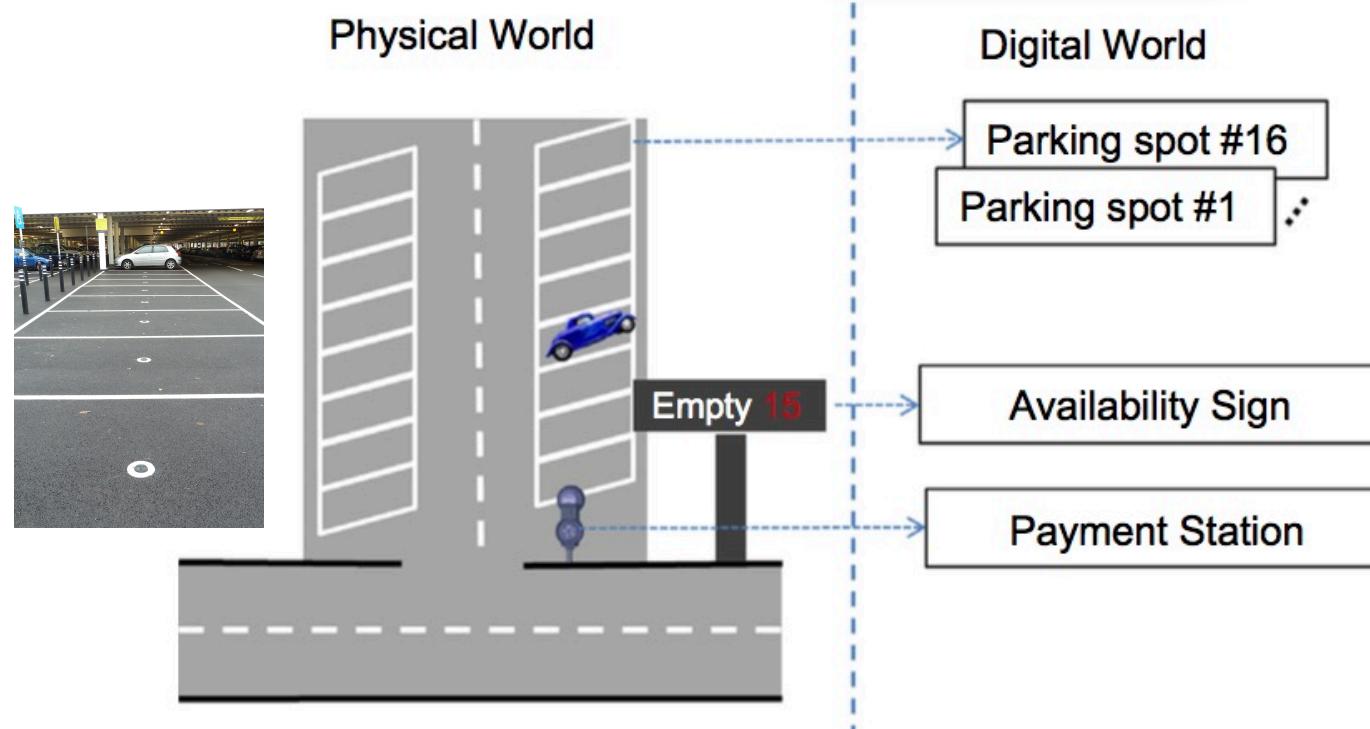
## Motivation



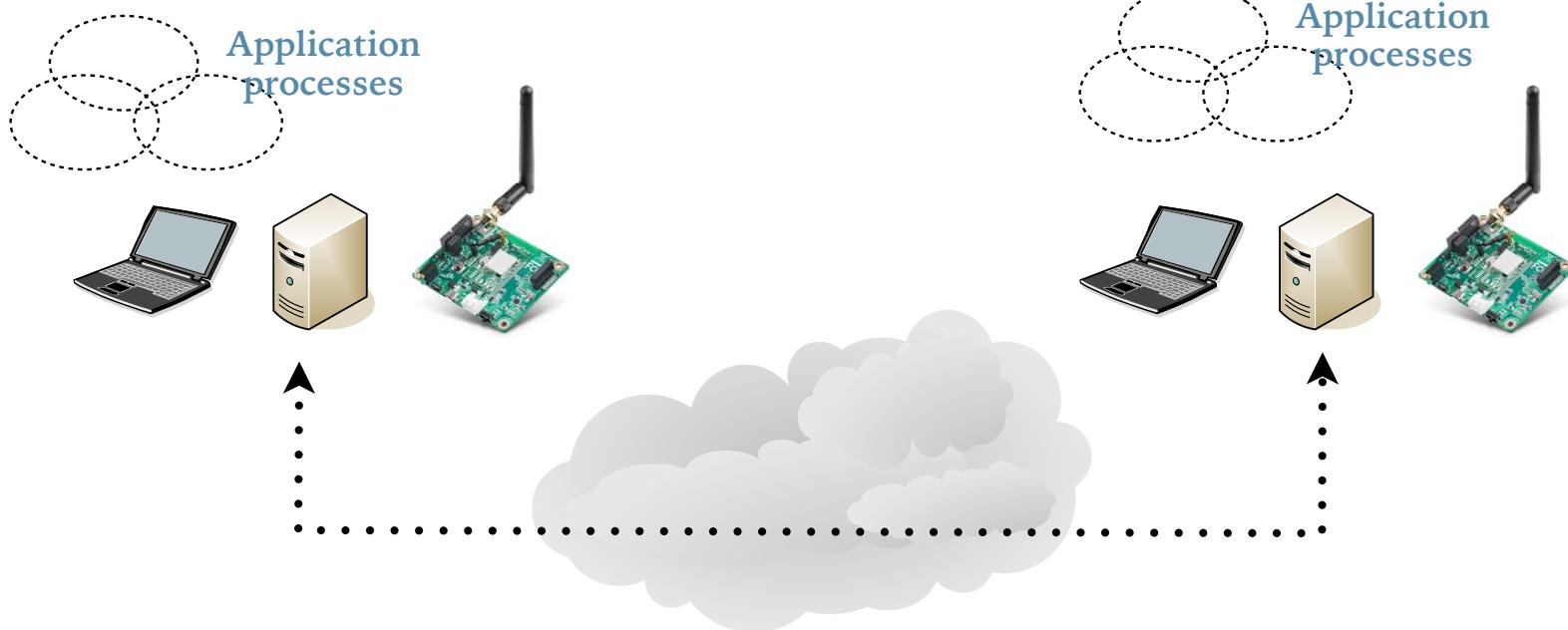
## Ex: IoT Environment Monitoring



## Ex: IoT Smart Parking



## What do we study in this course ?



**Software-based part -- Protocols and App software**

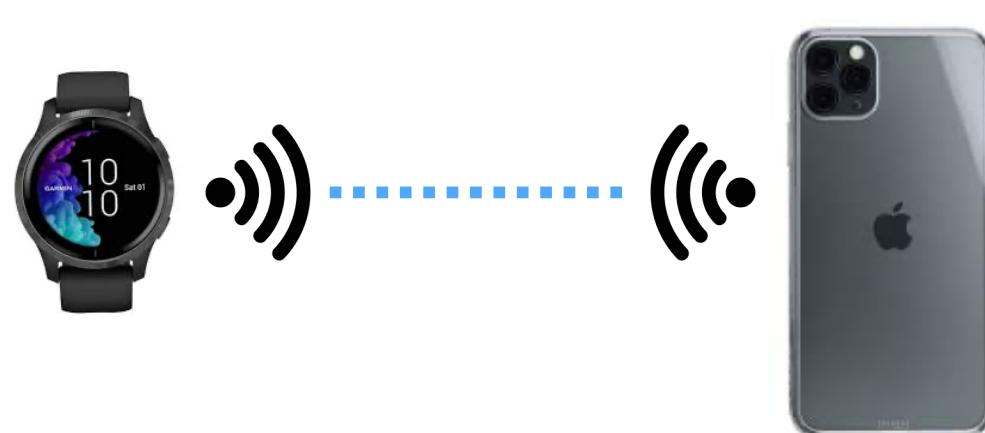
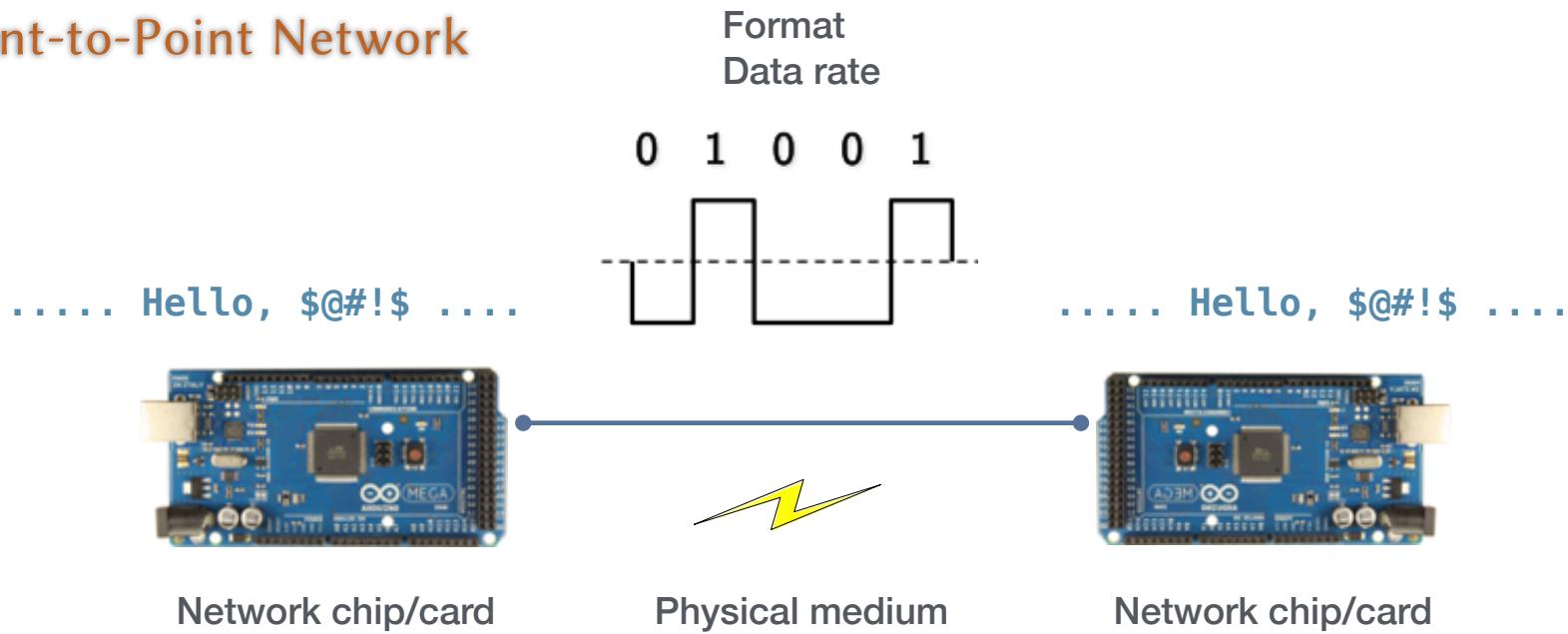
**Hardware-based part -- Networking devices,  
Transmission medium**

What does it do ?  
Why uses it ? Limitations ?  
When/where to use?  
How it works ?  
How to set up and troubleshoot ?

## Protocols and Layered Architecture

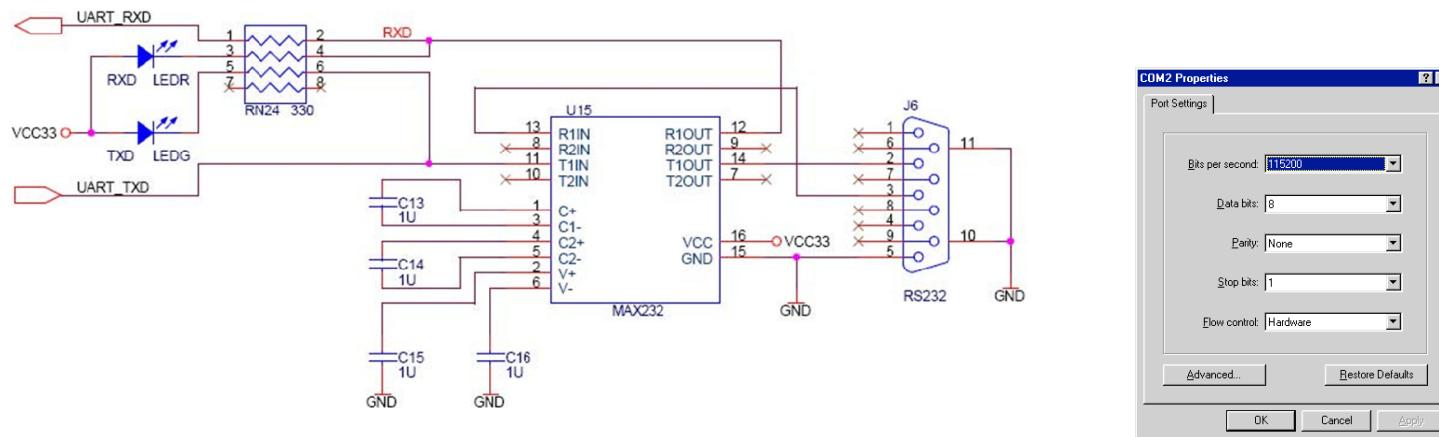
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## Simple Point-to-Point Network



# Physical (Bit-Level) Transmission

- What power, signal representation to use ?
  - What is the **bit rate**?
  - Which type of connector is used?



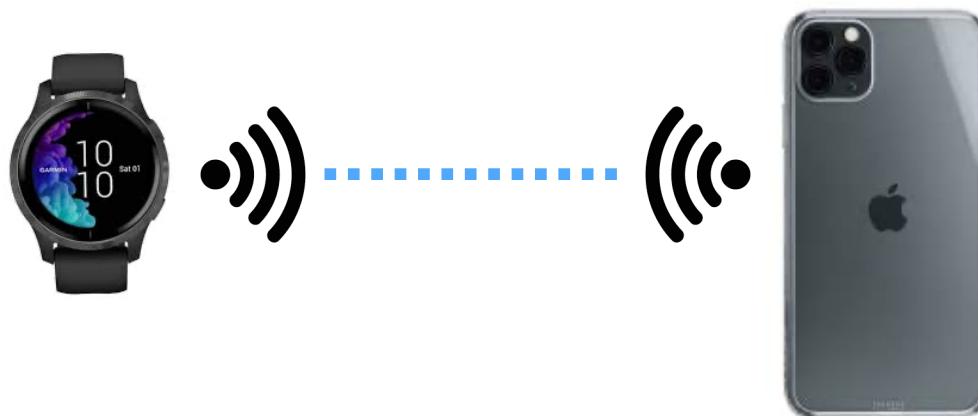
**Recovering bits from (corrupted) signal ?  
Largest distance between the two?  
How much power is needed ?**

## Basic Tasks in Data Transmission

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- Suppose you are asked to write a software to sync data on a fitness watch to a mobile phone when they are in range.

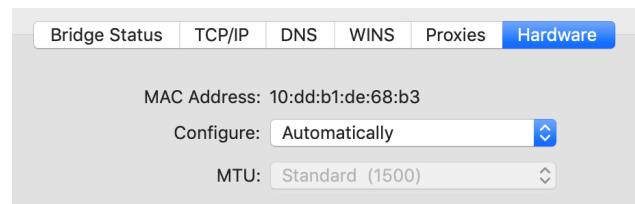
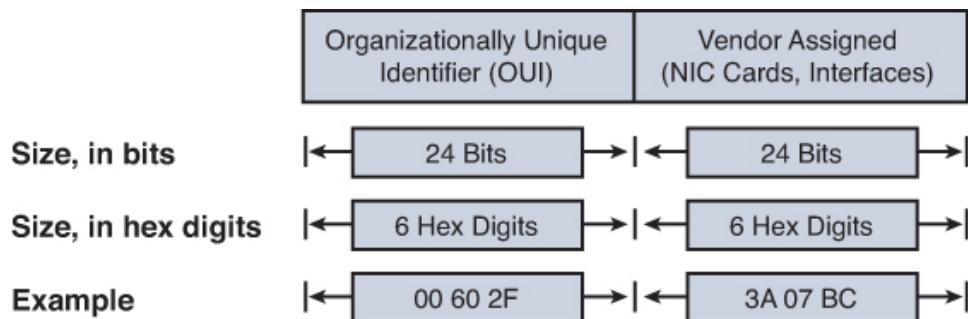
Regarding the data transfer, what issues you need to consider when writing the software to make sure that the data is correctly transferred ?



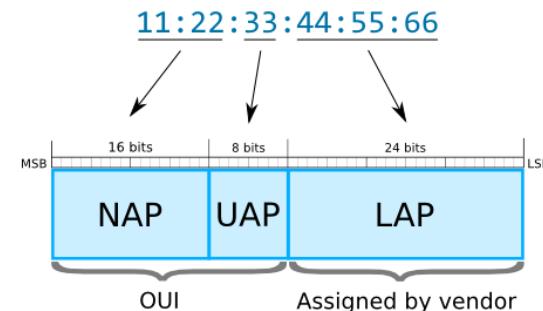
## Addressing Examples



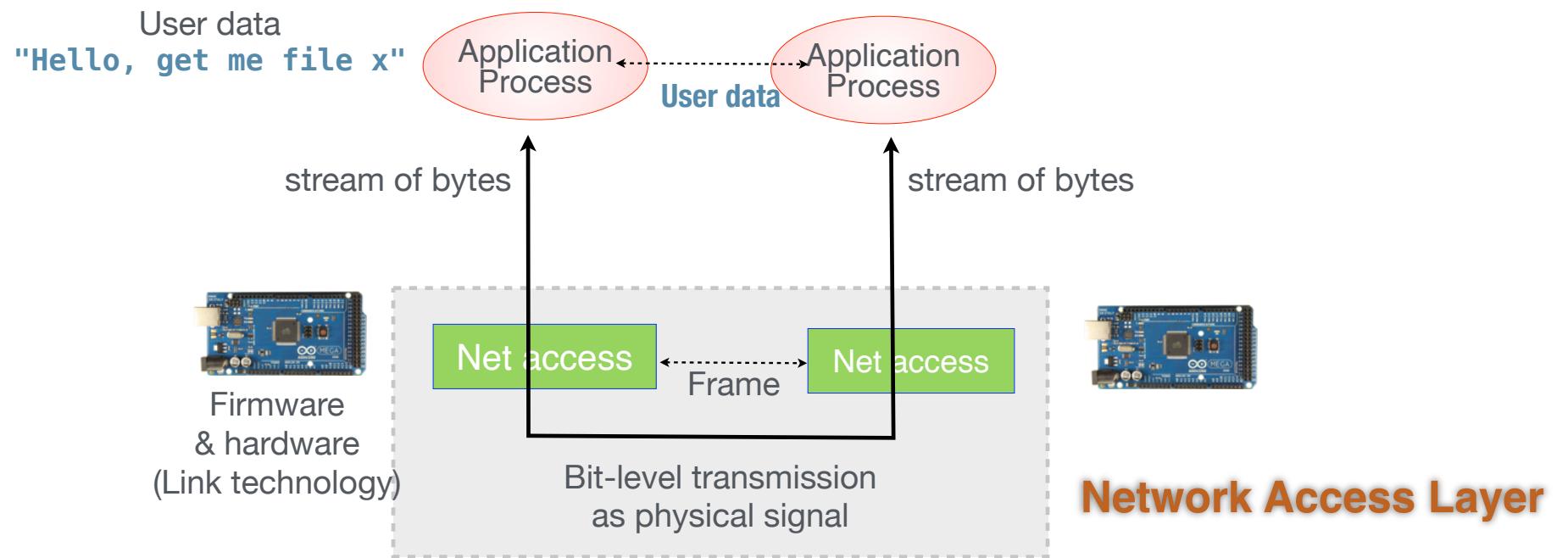
Ethernet/MAC/Physical address



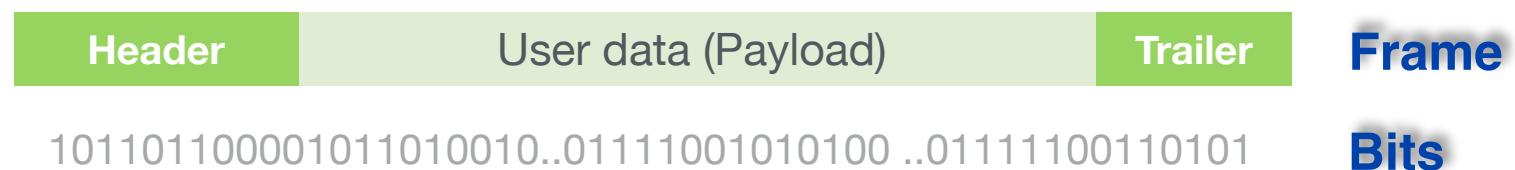
Bluetooth Address (BD\_ADDR)



- Look up your card vendor from MAC address at <https://www.wireshark.org/tools/oui-lookup.html>



**What are in the header and trailer ?**

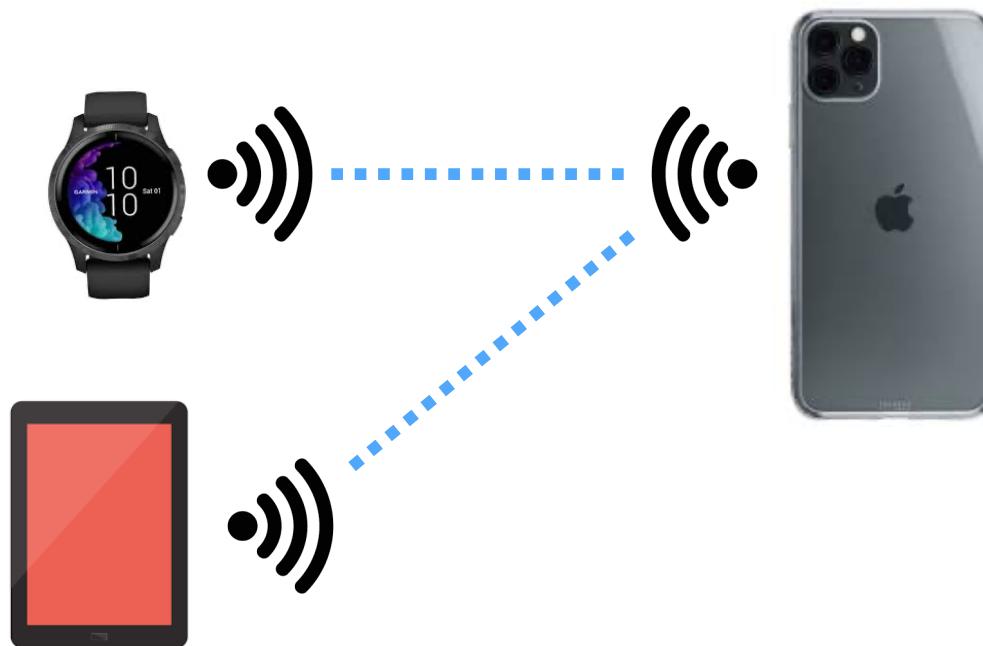


For non-zero payload,

$$\text{Percentage of overhead (\%)} = \frac{\text{Non-payload bits}}{\text{Total bits}} \times 100 \%$$

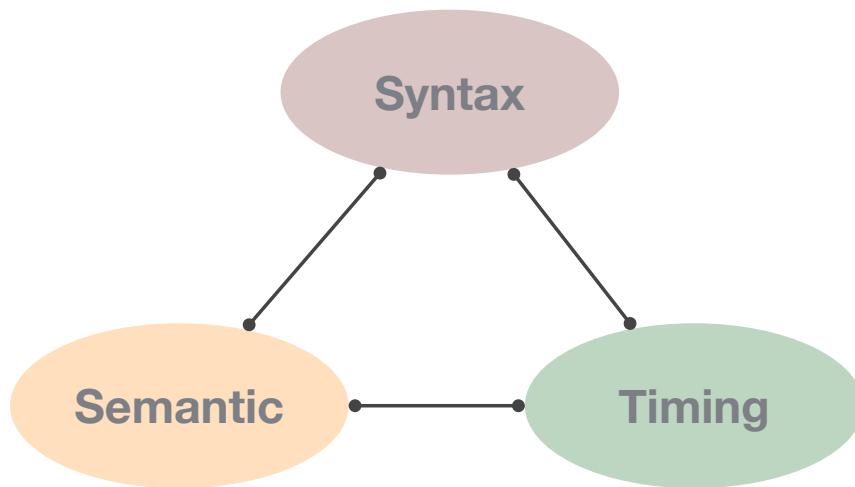
## Question

- Suppose a mobile phone connects to iPad and Smart watch simultaneously to exchange data. Regarding the data transfer, what issues you need to consider when writing the software to make sure that the data is correctly transferred among them ?



## Network Protocol

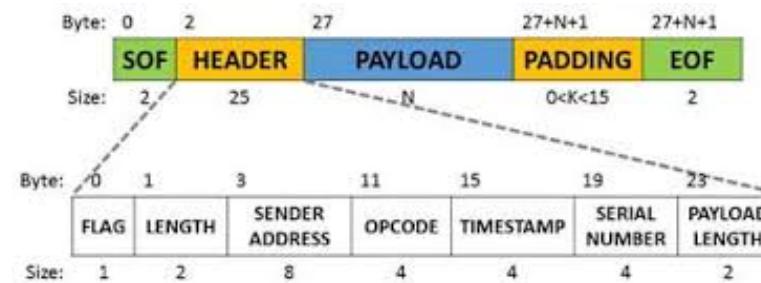
- A set of rules governing communication among entities
- Computer networks are built upon a collection of either **open** or **proprietary** protocols.



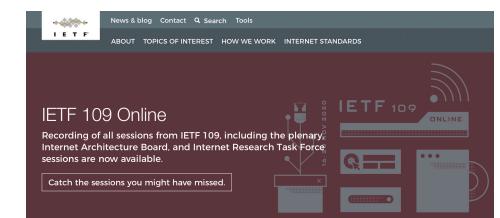
### Human protocol

A: Hello, how are you ?

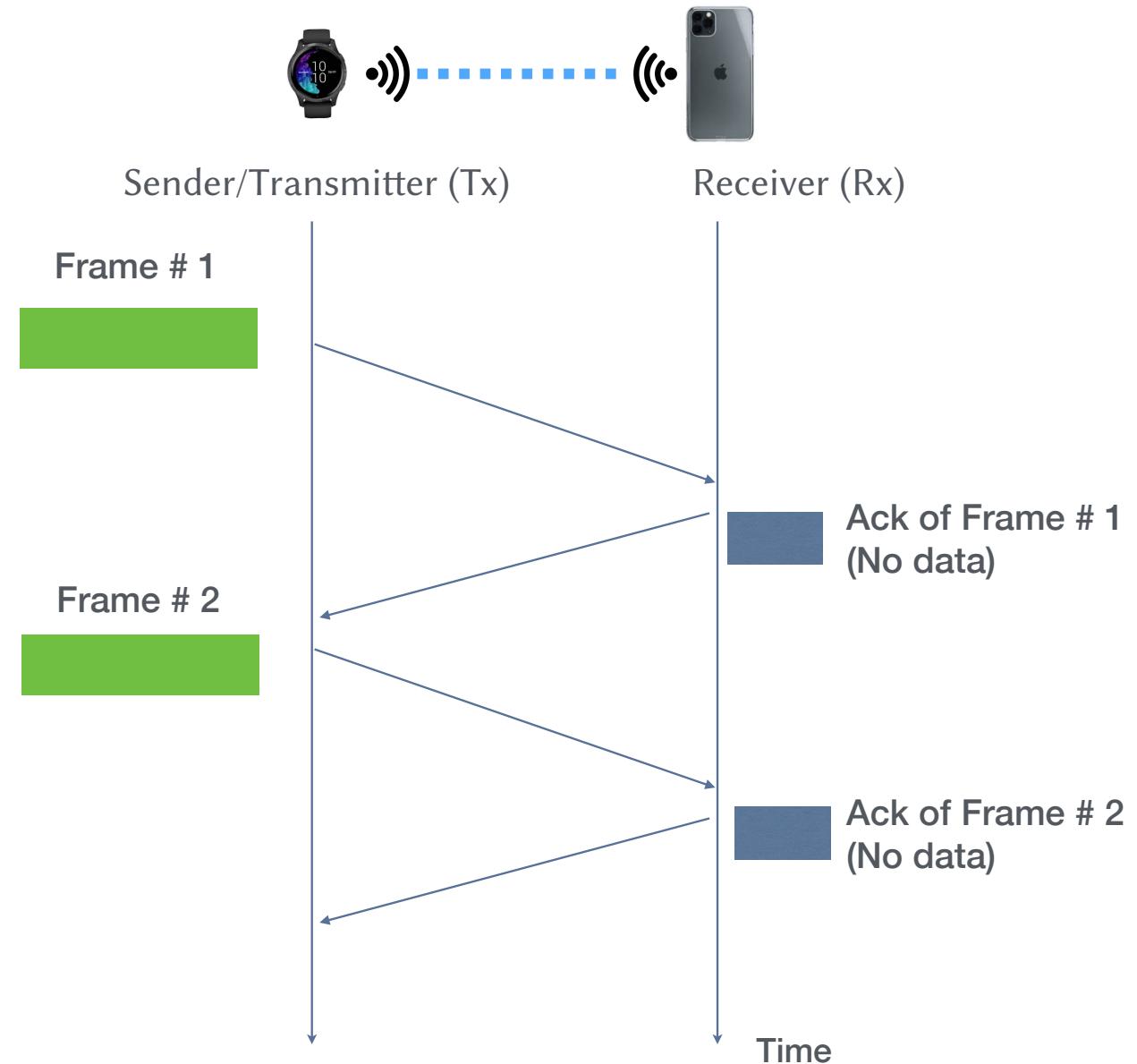
B: I'm all right. What about you ?



Syntax = ?  
Semantic = ?



## Timing Diagram



## Quick Questions

What is the protocol element of the following ?

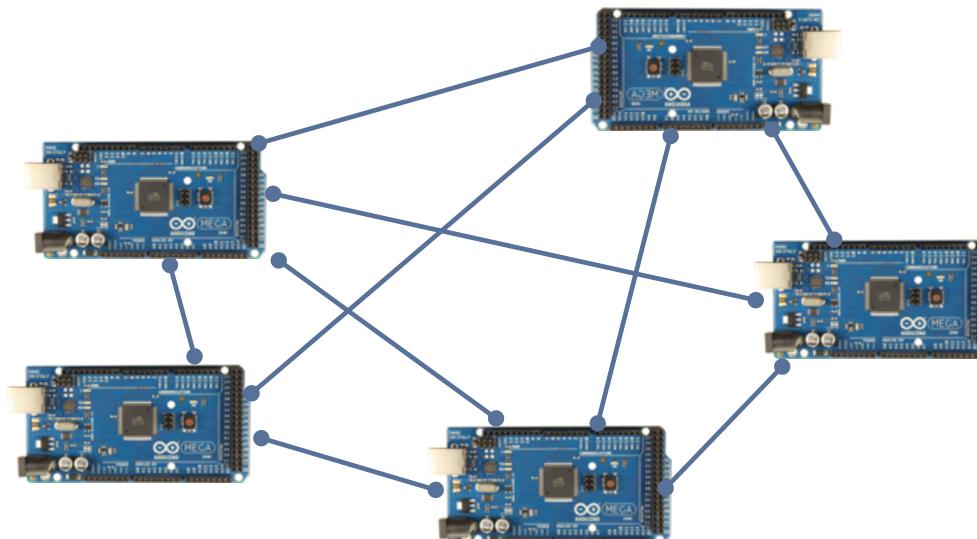
- The Error Flag field equal to 0 means the previous frame is received incorrectly.
- The Address field has 24 bits.
- The Address field comes right before the Sequence number field
- The maximum frame payload is 1500 bytes
- The frame is retransmitted if the sender does not receive an Ack within 5 seconds.

- A. Syntax
- B. Semantic
- C. Timing

## Scaling up Network

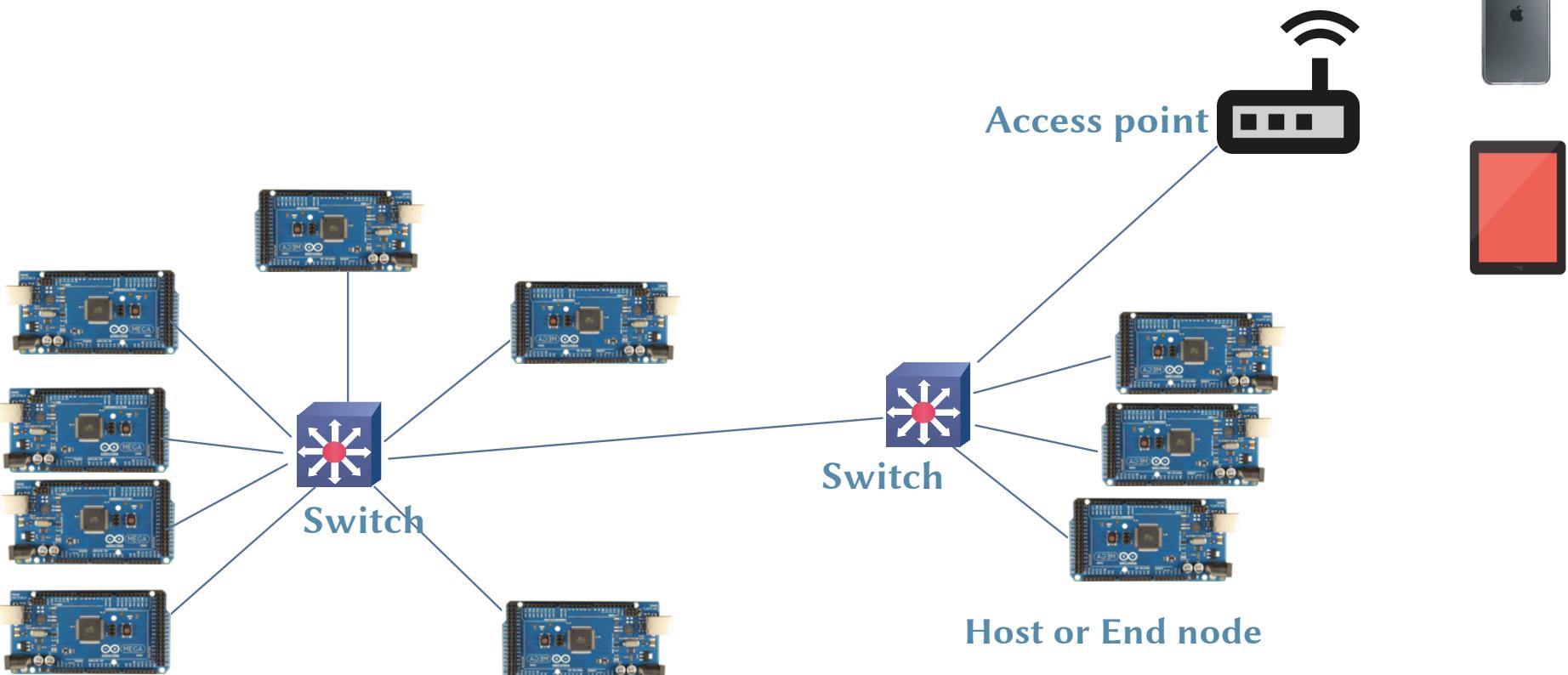
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- Each node generally exchanges data with many others.
- Questions: Can we do a full mesh? Why or why not?



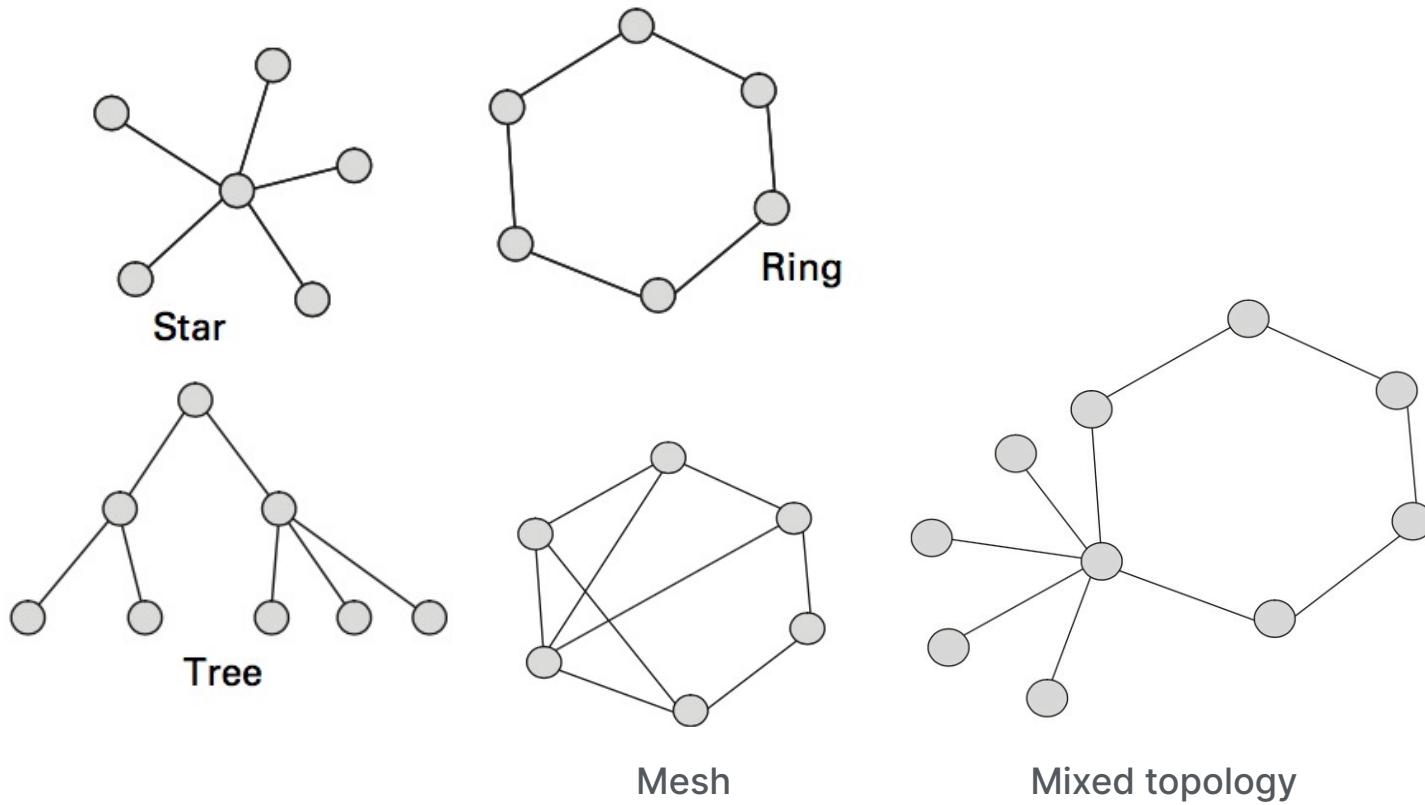


- Use networking device called "switch" or "access point" as intermediate nodes.
- Intermediate node needs to know how to handle incoming frames -- **Routing** algorithm and protocol

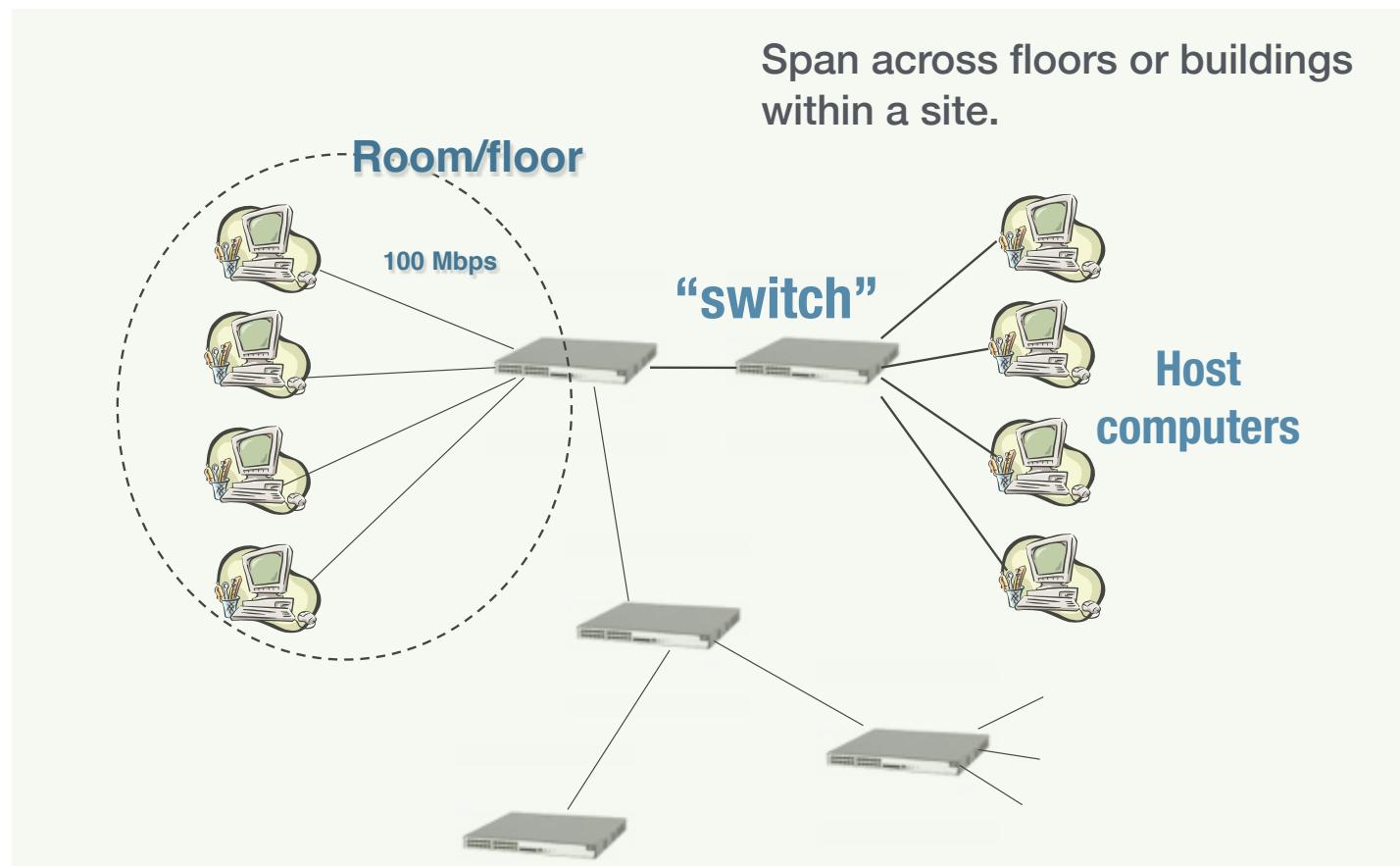


## Network Topology

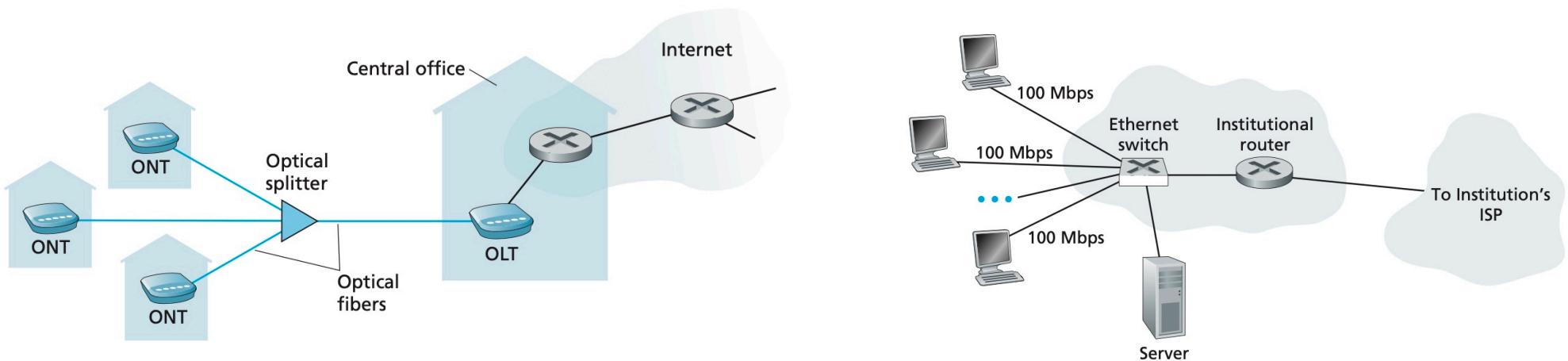
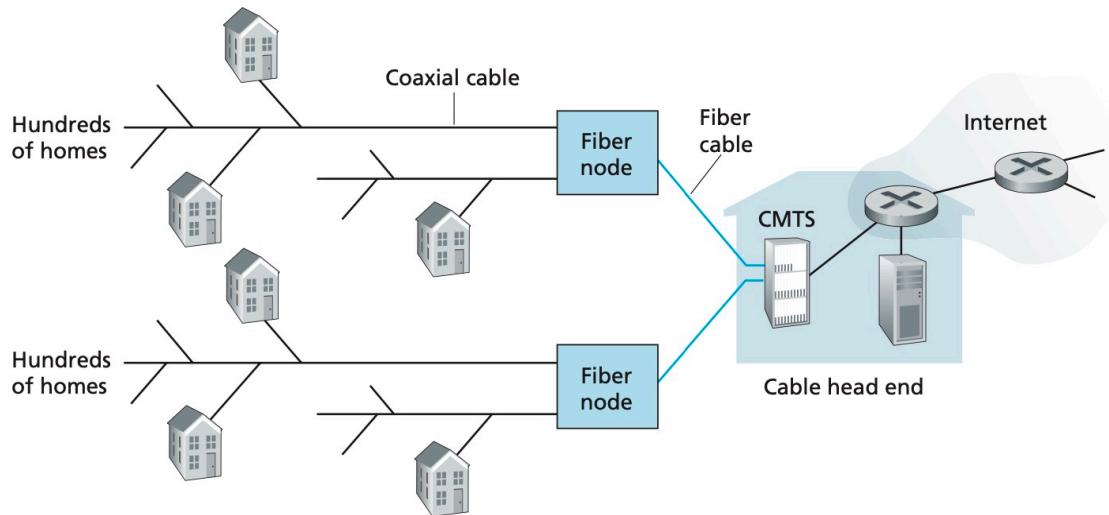
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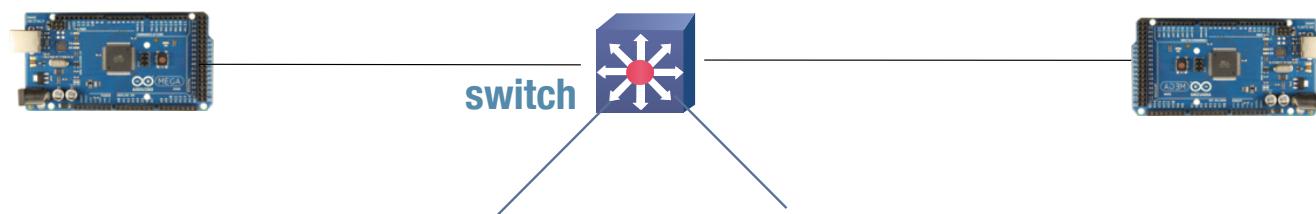
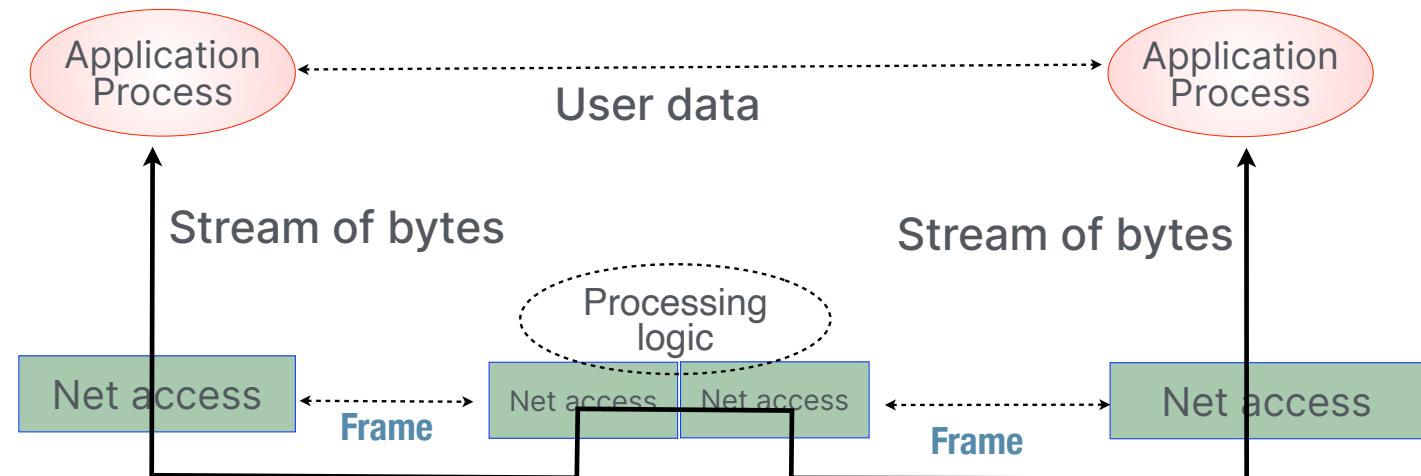


## Ex: Local Area Network (LAN)



## Access Networks

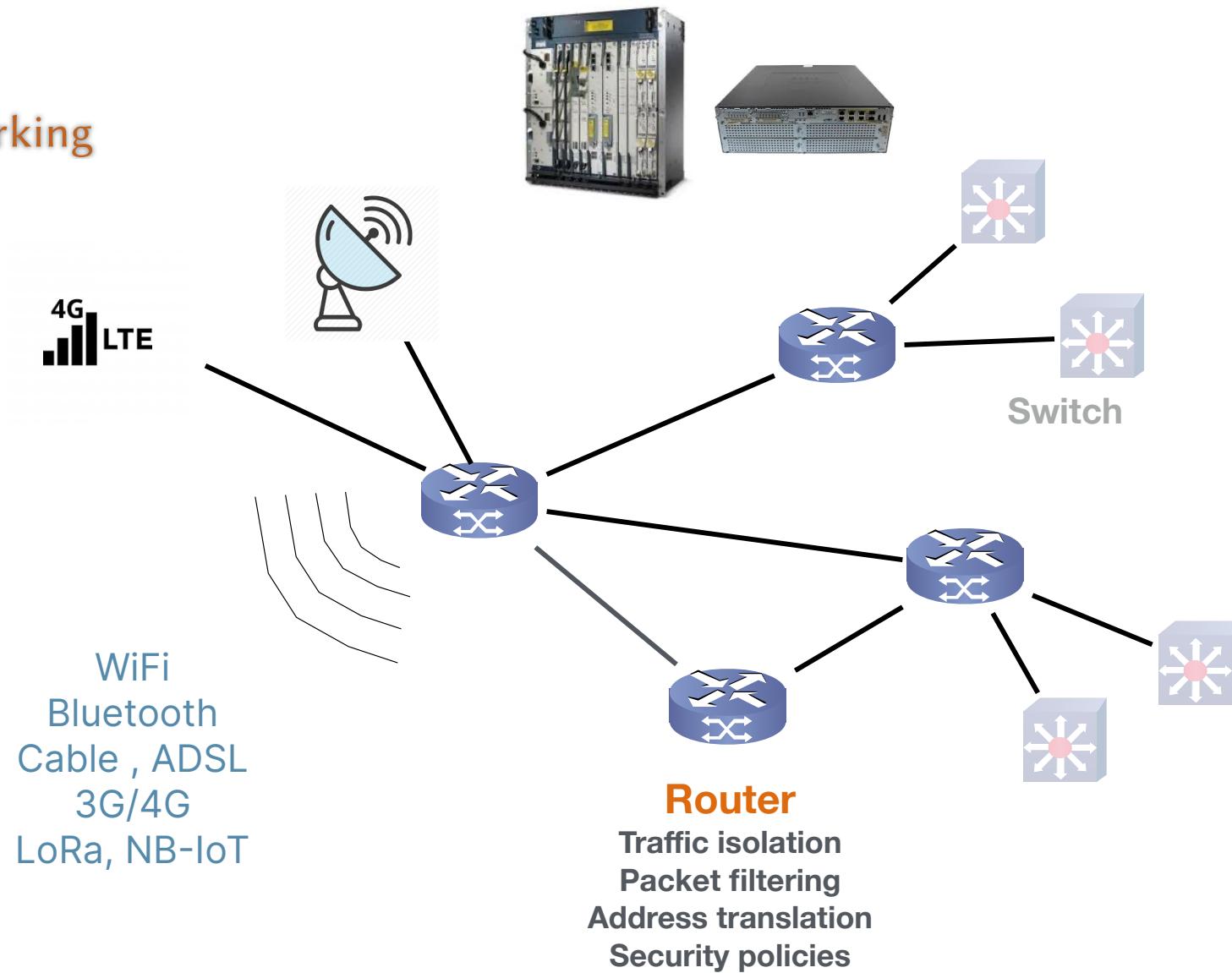


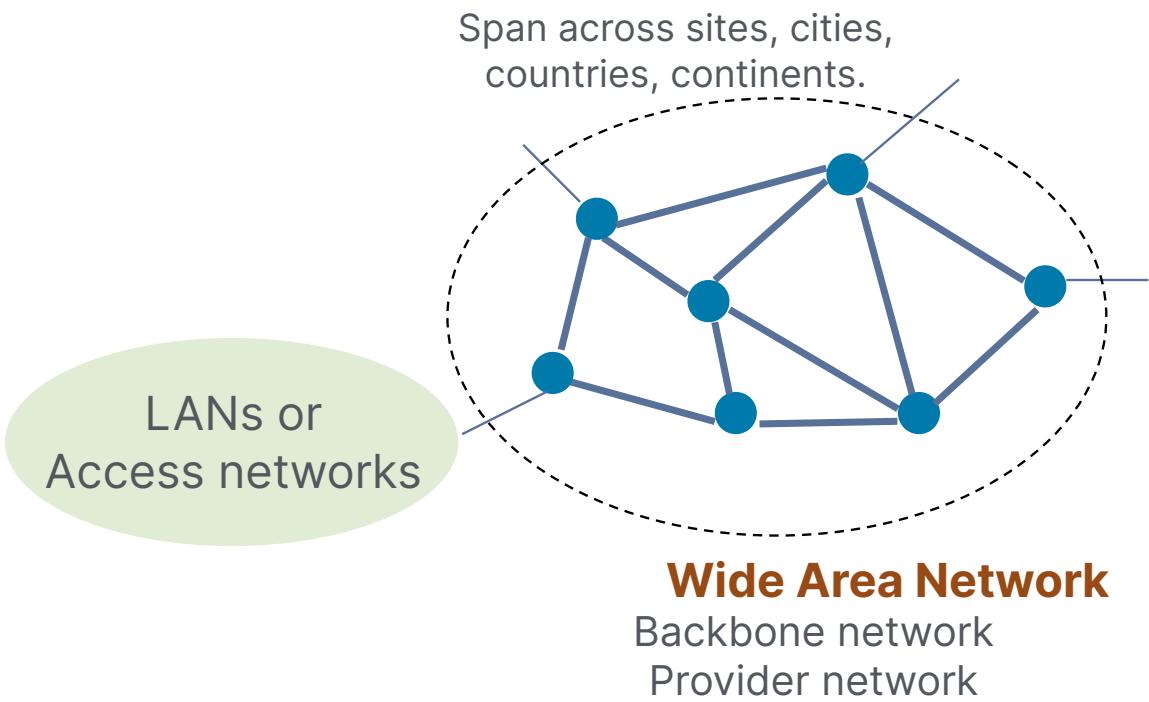


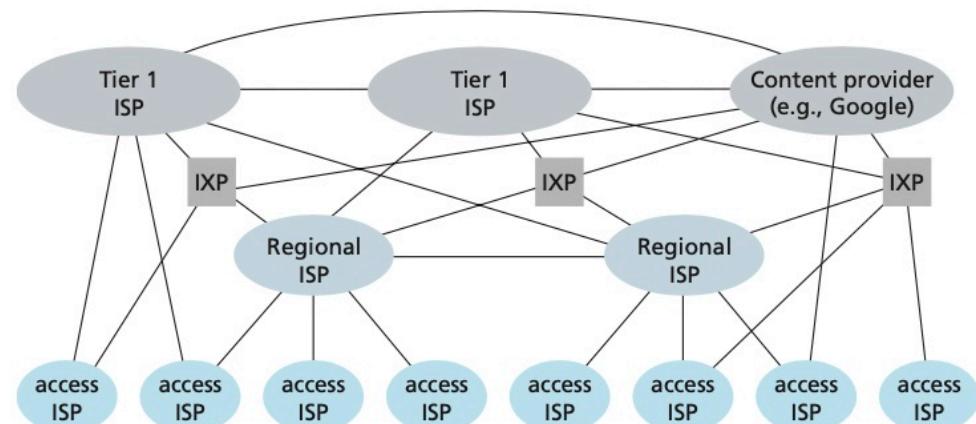
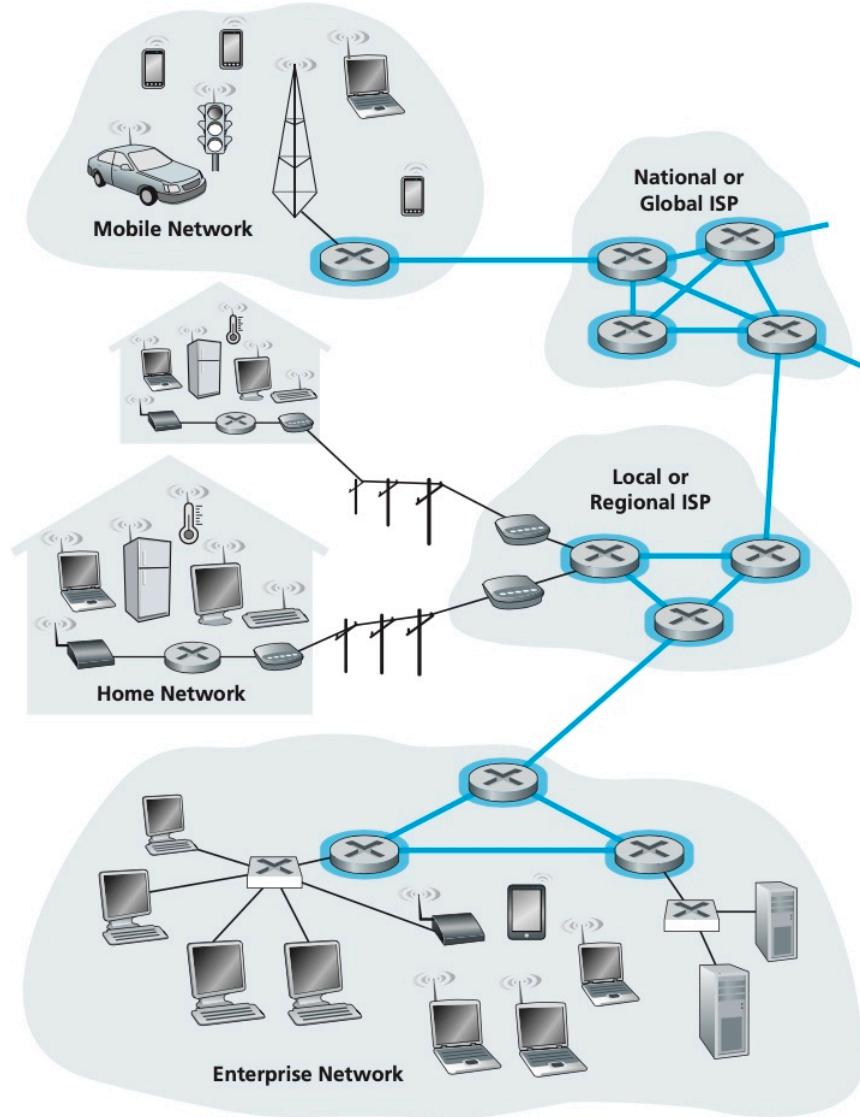
Frame header	User data (Payload)	Trailer	<b>Frame</b>
--------------	---------------------	---------	--------------

101101100001011010010..01111001010100 ..01111100110101	Bits
--	------

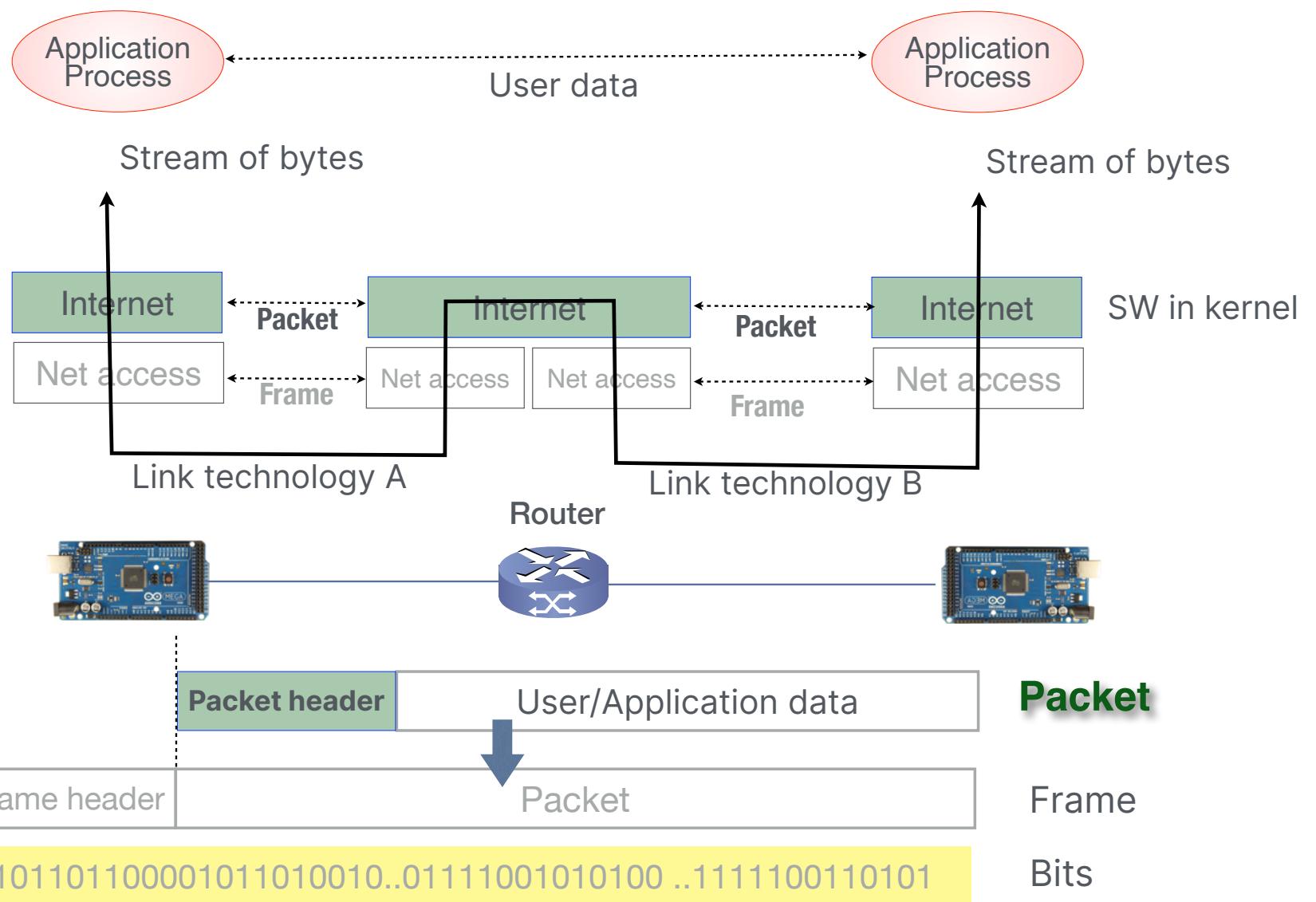
## Internetworking







## Internet Layer



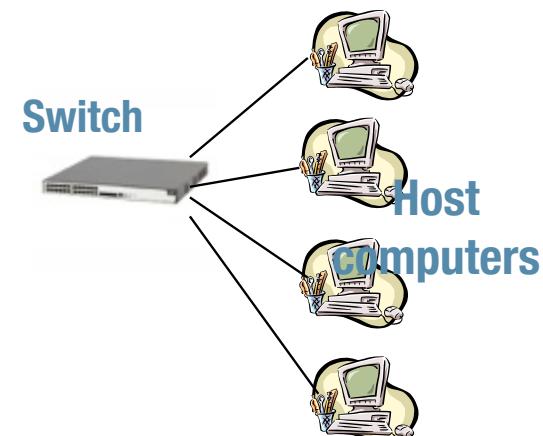
## Ex: IP Addressing

- IP address is a **logical identifier** of a network interface

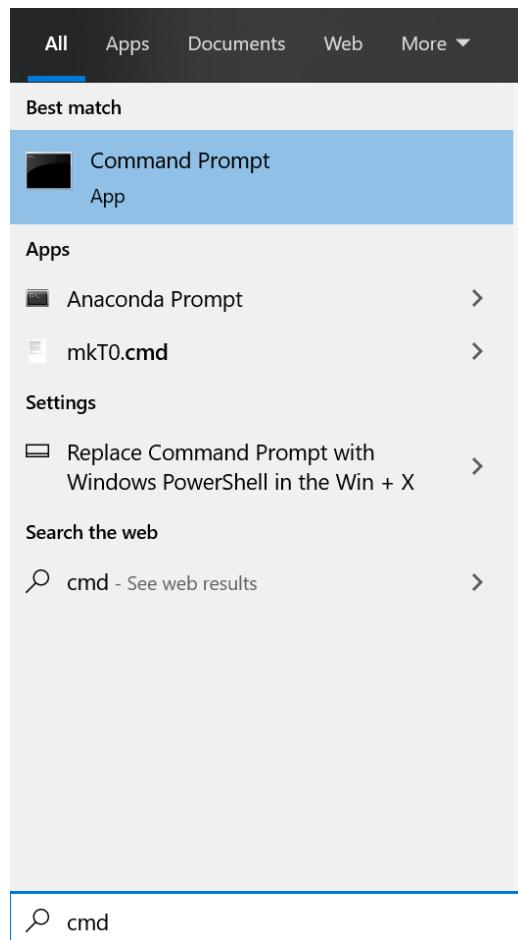
**32 bits**

```
10010100 00000001 10110100 01011110
```

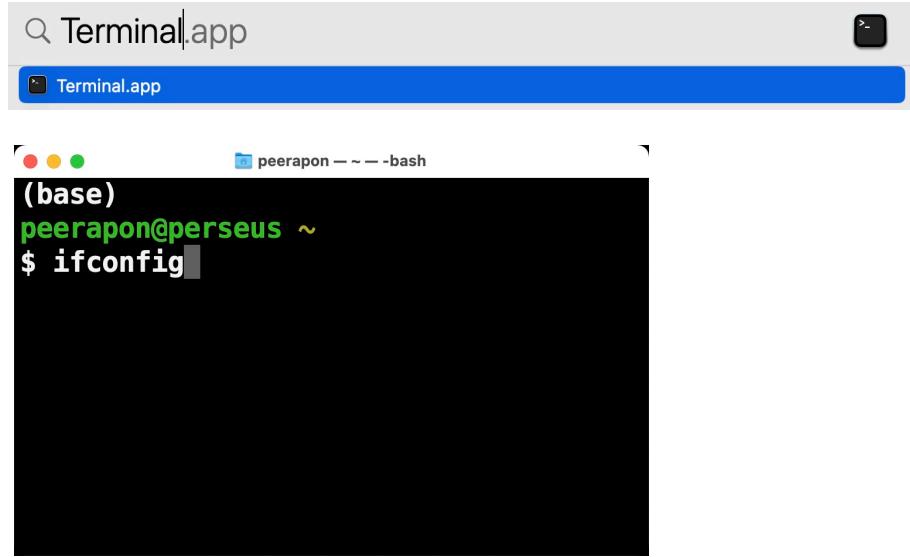
**Dotted decimal notation:**  
148.1.180.94



## Discovering Address Information

A screenshot of a Microsoft Windows Command Prompt window. The window title is 'Command Prompt' and the subtitle is 'Microsoft Windows [Version 10.0.18362.1016] (c) 2019 Microsoft Corporation. All rights reserved.'. The command entered in the prompt is 'C:\Users\peera>ipconfig /all'. The rest of the window is black, indicating no output has been displayed yet.

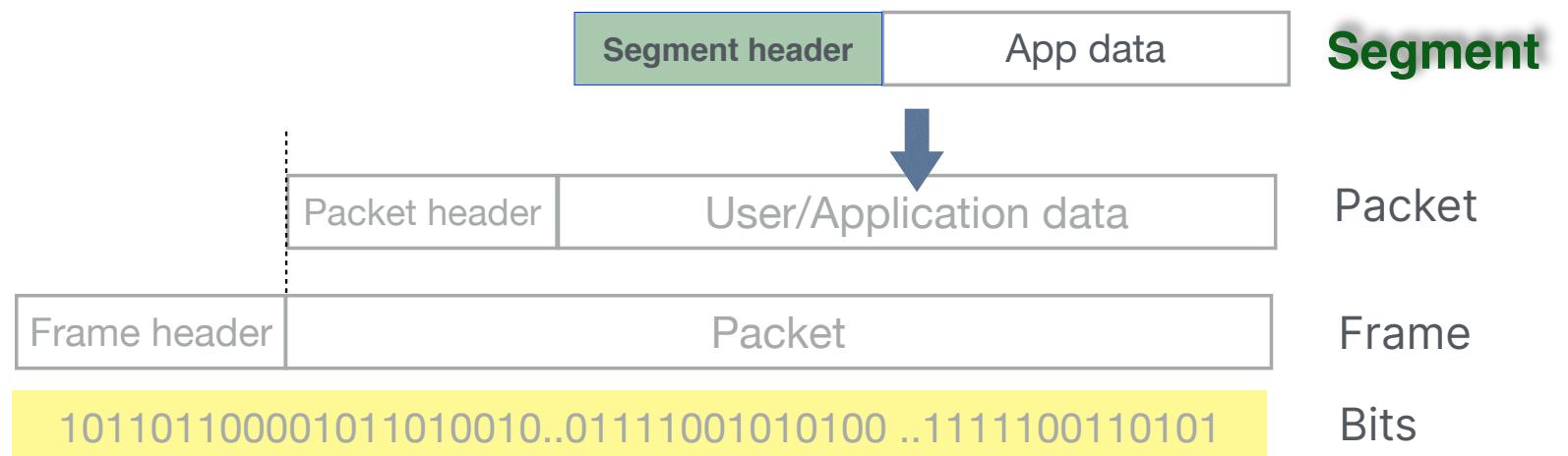
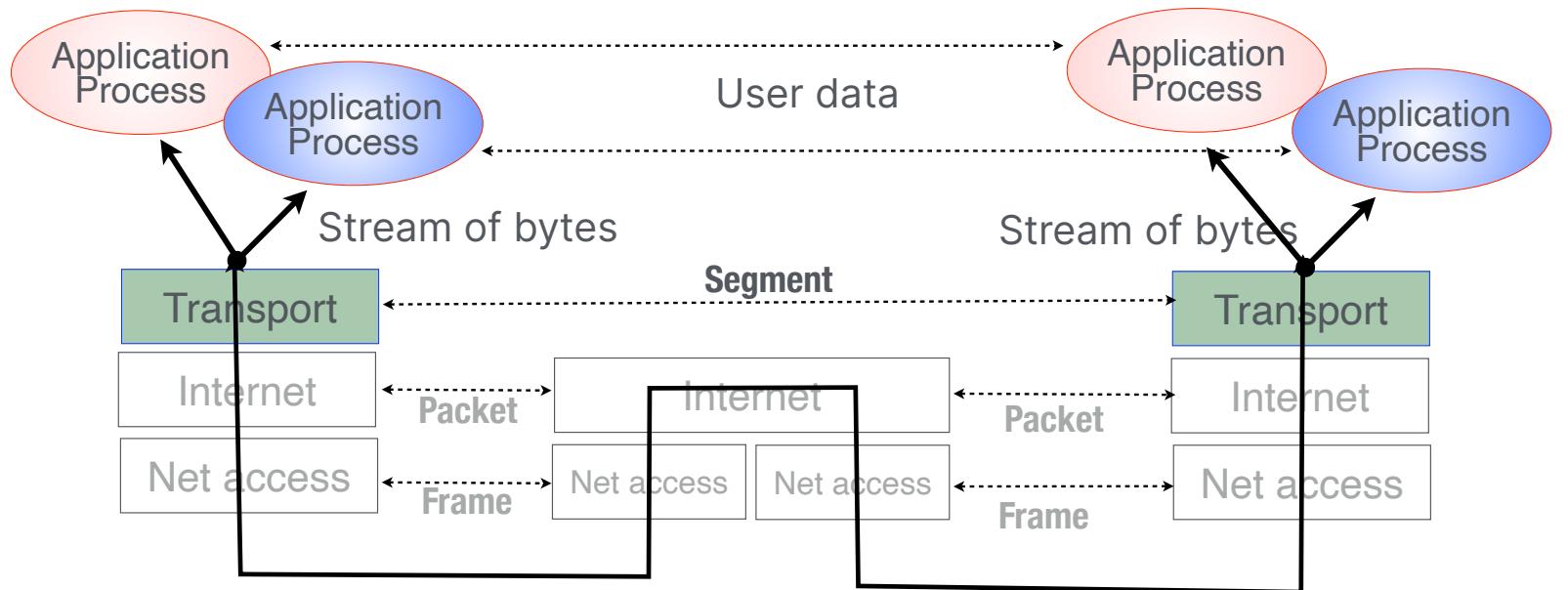
How many network interfaces your computer have ?  
Which ones have MAC (Physical) addresses ? What are they ?  
Which ones have IP addresses ? What are they ?  
Which interfaces are active ?



Spotlight

How many network interfaces your computer have ?  
Which ones have MAC (Physical) addresses ? What are they ?  
Which ones have IP addresses ? What are they ?  
Which interfaces are active ?

## Transport Layer



**GET /~peerapon.sir/index.html HTTP 1.1**

Application  
Process



Application  
Process



**HTTP/1.1 200 OK**  
**Content-Length: 11308**  
**<html><head> ... </head>**  
**<body> My contents here </body>**  
**</hmtl>**

**publish /room1/light value=on**

Application  
Process



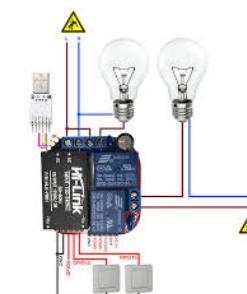
Application  
Process

**Success**

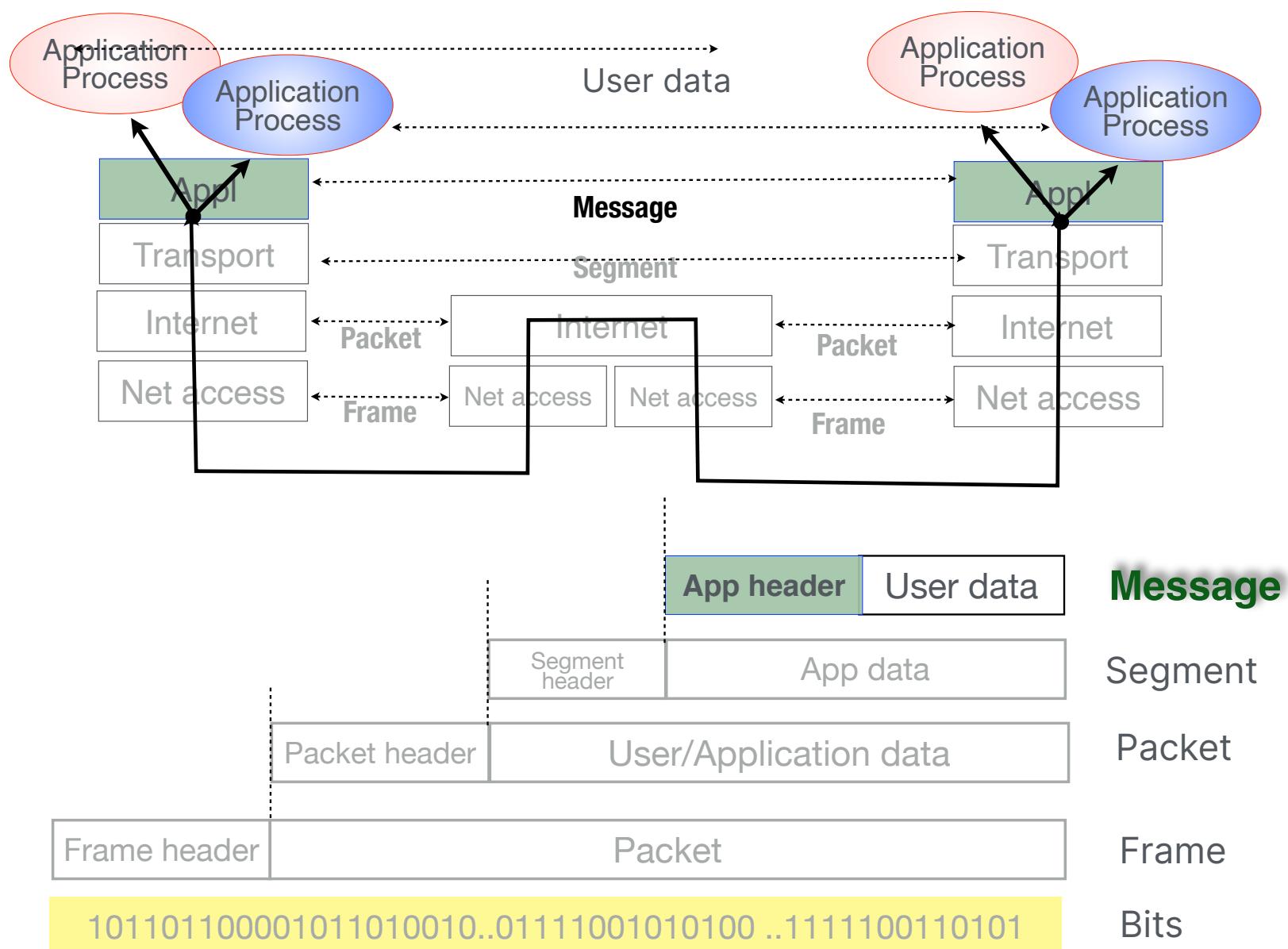
**publish /room2/light value=off**



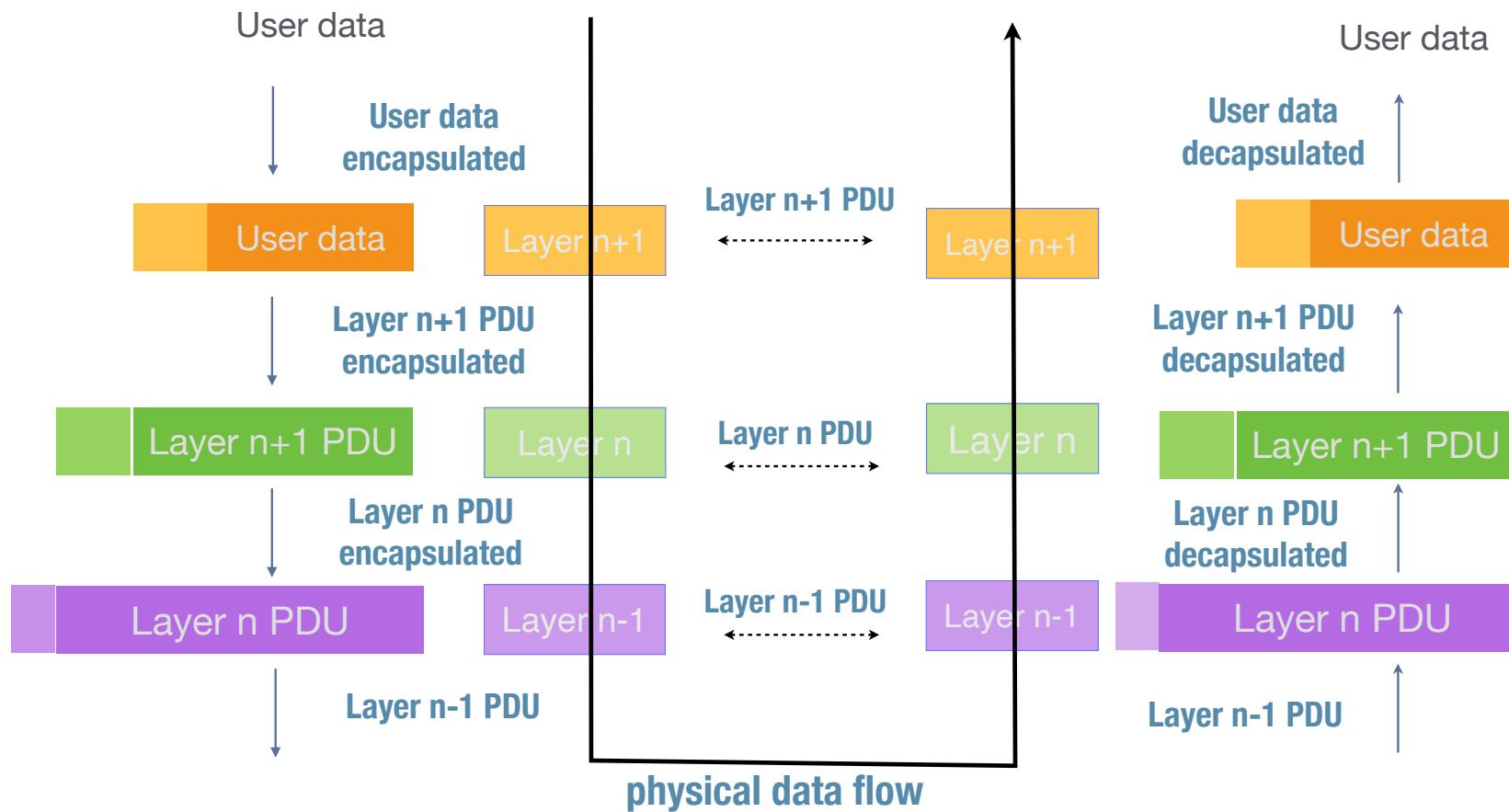
**Failed**



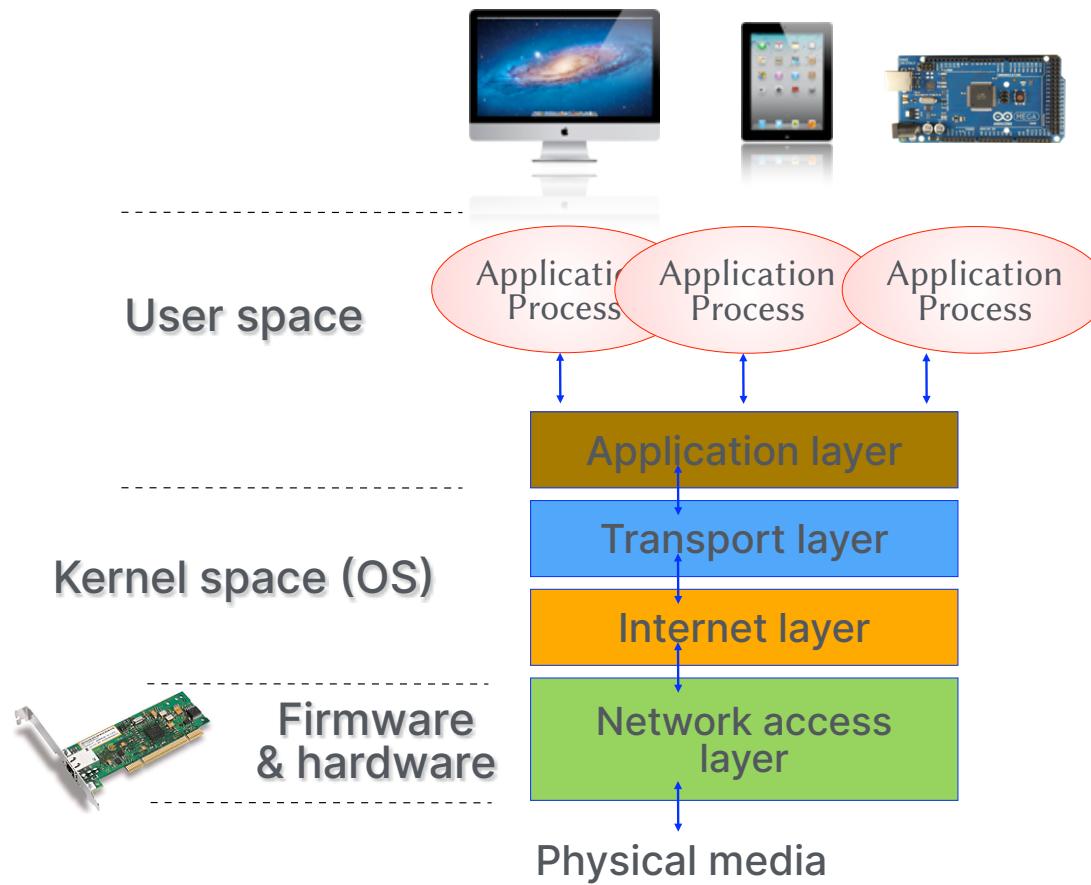
## Application Layer

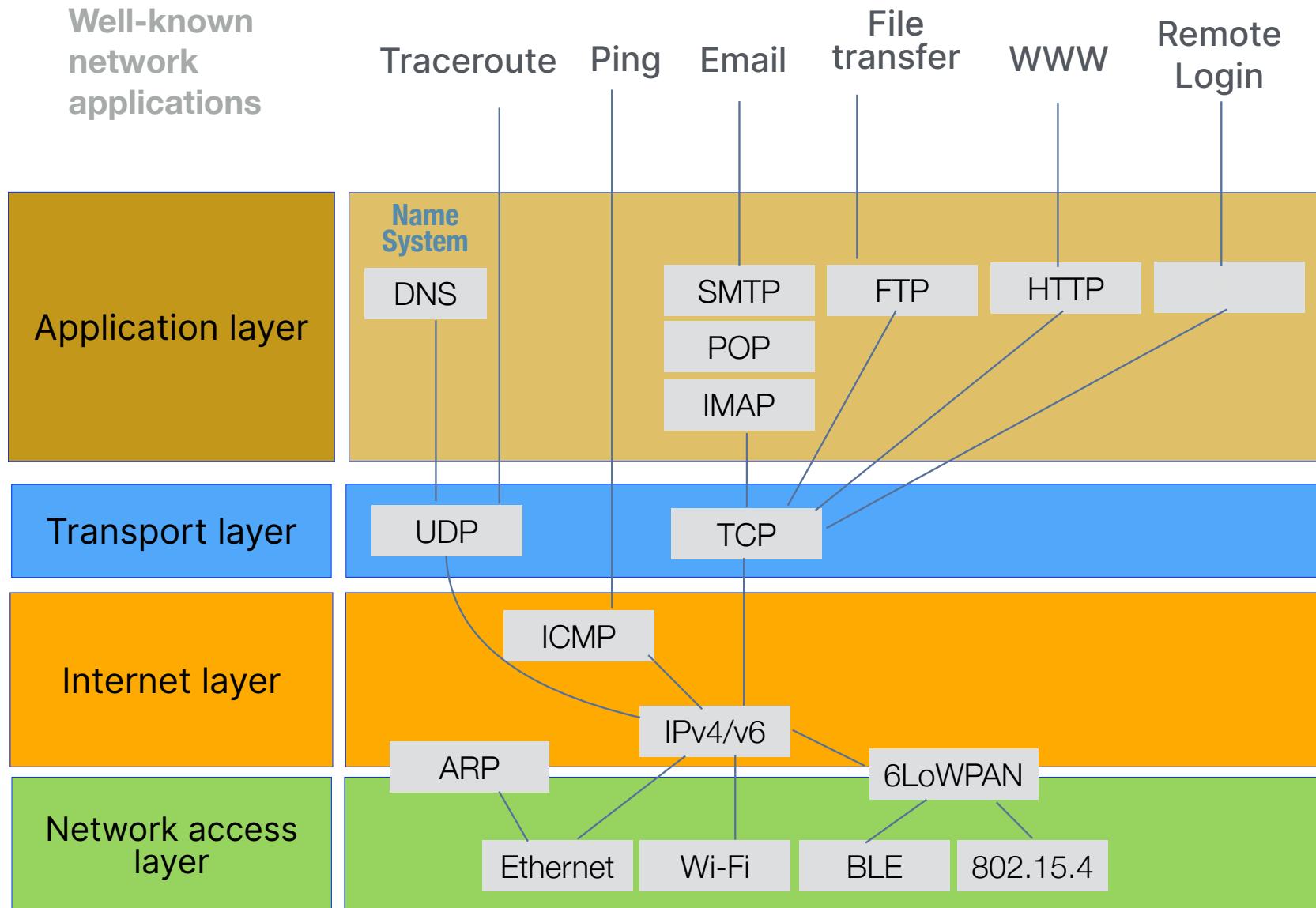


## Layered Protocol Architecture

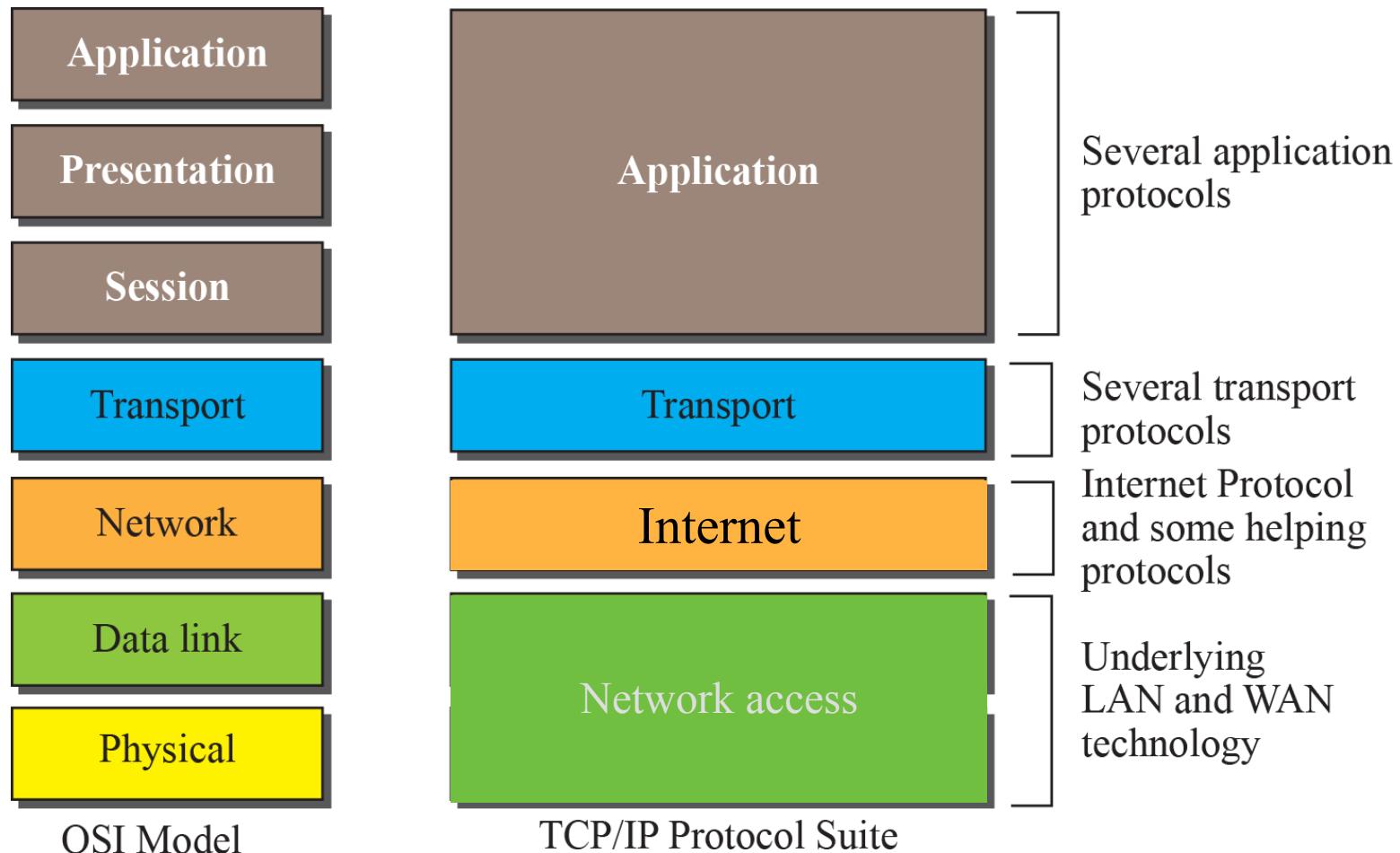


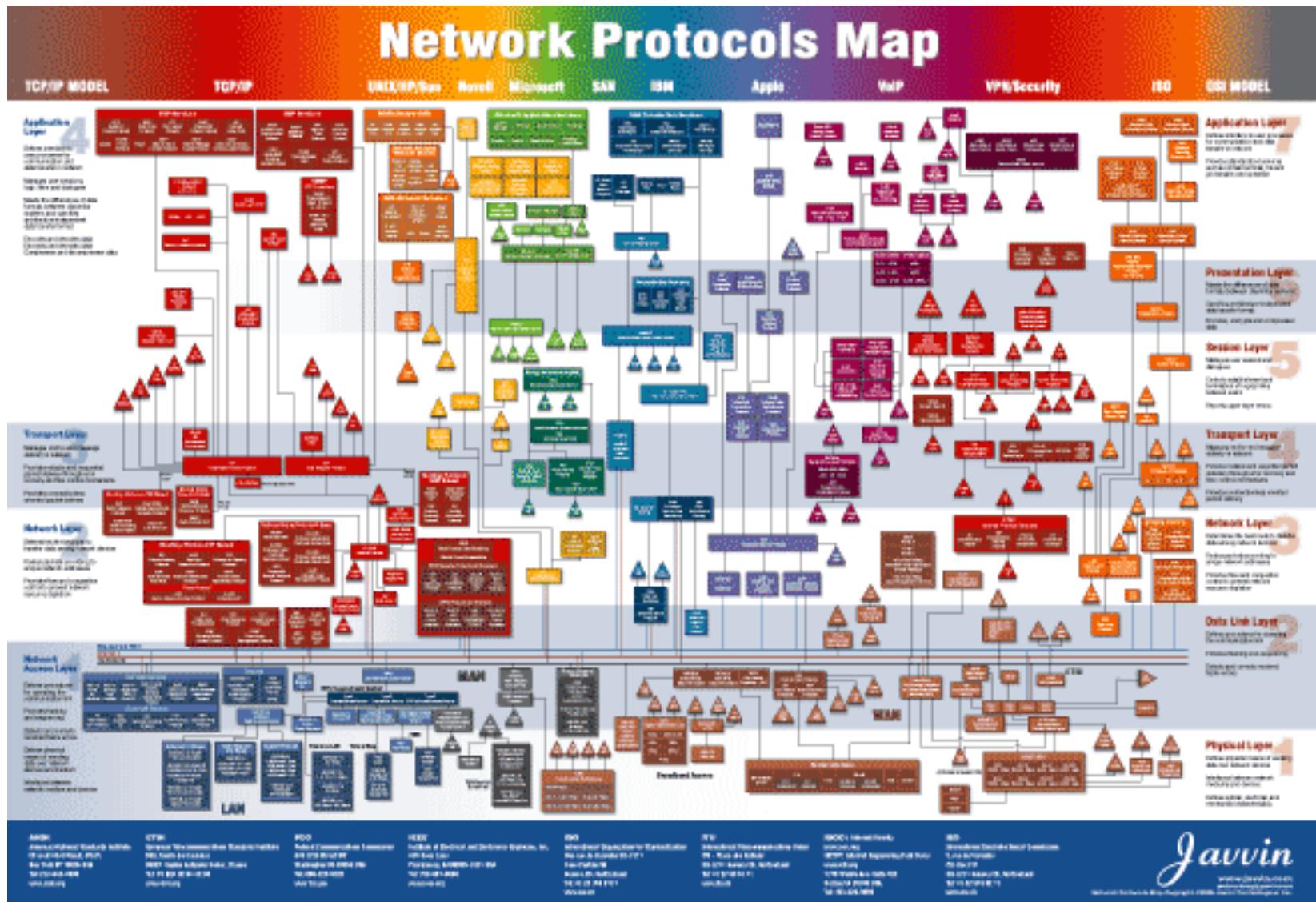
## TCP/IP Reference Model





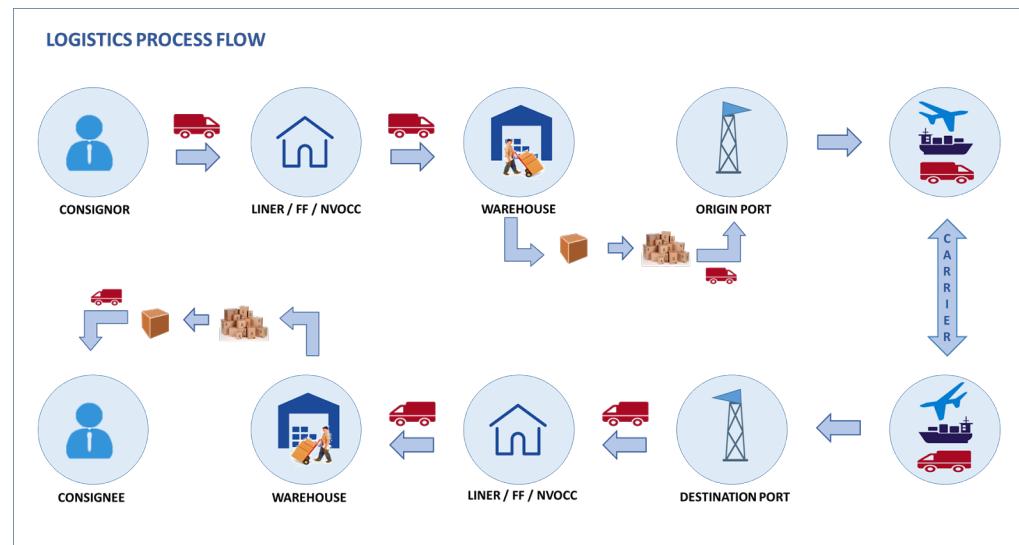
## OSI Model and TCP/IP Model





# Activity: Packet Delivery Analogy

- Package delivery carrier delivers packages from sender to recipient along one or more local/transit hubs, possibly with different kinds of transportations (e.g., trucks, ships, planes, vans, trains, motorbikes, etc.)
  - Can you map functions of layers TCP/IP reference models to those in package delivery service ?





Shipping logistics	Analogous elements in computer networks
Sender / Recipient	
Mailing addresses	
Sender/Recipient home	
Trucks, Planes, Trains, Ships	
Distribution centers	
Transit hubs	

## Conclusion

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- Network for information exchange, resource sharing, device control and monitoring
- Large and highly complex system !
  - ◆ Specialized network devices -- Switch, Access point, and Router
  - ◆ Network protocol (Syntax + Semantic + Timing) as elementary building blocks
- Network protocols organized into layers to gain benefits of modularity.
  - ◆ Data units exchanged: Bits, Frames, Packets, Segments, Messages
  - ◆ Many protocols in each layer -- TCP/IP protocol suite

## Next Week

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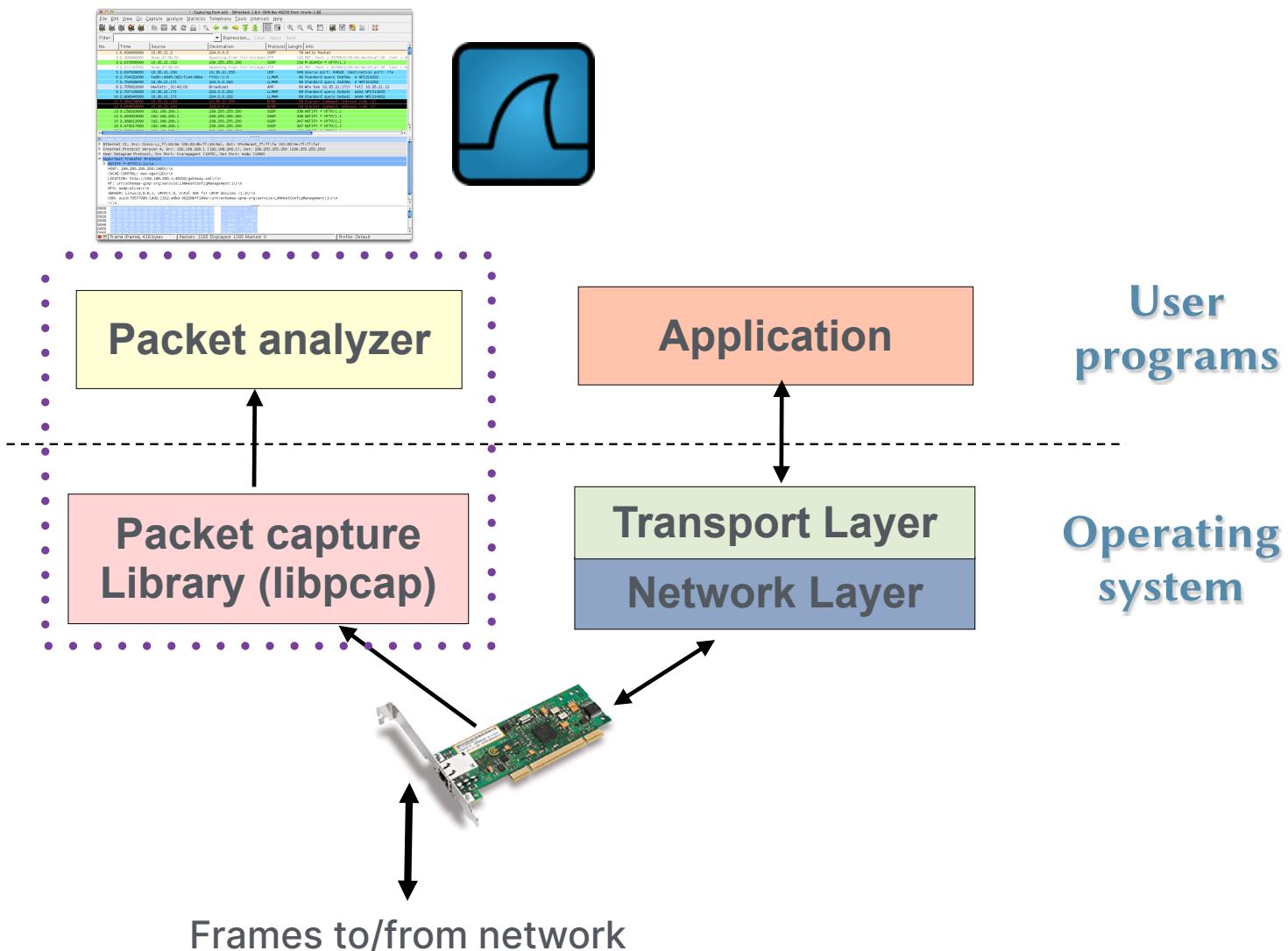
- Install Anaconda Python 3 distribution in your labtop from  
<https://www.anaconda.com/products/individual>
- Read how to create and run a python program from
  - <https://docs.python.org/3/tutorial/index.html>
  - <https://github.com/zhiyuzuo/python-tutorial>

<https://www.wireshark.org/download.html>

## Wireshark Hands-on

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# Packet Capture Tool: Wireshark



2



Select interface

1

Welcome to Wireshark

### Capture

...using this filter:  All interfaces shown

Wi-Fi: en0  
p2p0  
awdl0  
llw0  
utun0  
utun1  
utun2  
utun3  
utun4

### Learn

[User's Guide](#) · [Wiki](#) · [Questions and Answers](#) · [Mailing Lists](#)

You are running Wireshark 3.4.2 (v3.4.2-0-ga889cf1b1bf9). You receive automatic updates.



Stop capture

Click column to sort listing

Display filter →

Listing of captured packets {

Header detail of selected packet

Header of selected packet in HEX and ASCII

Size of highlighted header

Capturing from Wi-Fi: en0

No.	Time	Source	Destination	Protocol	Length	Info
75	9.257218	74.125.24.95	192.168.0.135	TCP	112	[TCP Retransmission] 443 → 58632 [PSH, ACK] Seq=1377 A...
76	9.257286	192.168.0.135	74.125.24.95	TCP	66	58632 → 443 [ACK] Seq=2762 Ack=1423 Win=130432 Len=0 T...
77	9.257336	192.168.0.135	74.125.24.95	TCP	78	[TCP Dup ACK 76#1] 58632 → 443 [ACK] Seq=2762 Ack=1423...
78	9.258645	192.168.0.135	74.125.24.95	TLSv1...	112	Application Data
79	9.294843	74.125.24.95	192.168.0.135	TCP	66	443 → 58632 [ACK] Seq=1423 Ack=2808 Win=75264 Len=0 TS...
80	9.558872	192.168.0.135	17.248.157.41	TCP	143	[TCP Retransmission] 58518 → 443 [FIN, PSH, ACK] Seq=1...
81	9.816364	192.168.0.135	40.90.189.152	TCP	68	58049 → 443 [PSH, ACK] Seq=1 Ack=1 Win=4096 Len=14 [TC...
82	9.916164	40.90.189.152	192.168.0.135	TCP	54	443 → 58049 [ACK] Seq=1 Ack=15 Win=6851 Len=0
83	9.916287	192.168.0.135	40.90.189.152	TLSv1...	83	Application Data
84	9.950732	40.90.189.152	192.168.0.135	TLSv1...	228	Application Data
85	9.950863	192.168.0.135	40.90.189.152	TCP	54	58049 → 443 [ACK] Seq=44 Ack=175 Win=4093 Len=0
86	10.336238	192.168.0.135	216.58.203.68	TCP	66	[TCP Retransmission] 58527 → 443 [FIN, ACK] Seq=1 Ack=...

> Frame 13: 104 bytes on wire (832 bits), 104 bytes captured (832 bits) on interface en0, id 0  
> Ethernet II, Src: D-LinkIn\_d8:28:12 (ec:ad:e0:d8:28:12), Dst: Apple\_5b:89:c0 (8c:85:90:5b:89:c0)  
  Internet Protocol Version 4, Src: 74.125.200.189, Dst: 192.168.0.135  
    0100 .... = Version: 4  
    .... 0101 = Header Length: 20 bytes (5)  
  > Differentiated Services Field: 0x68 (DSCP: AF31, ECN: Not-ECT)  
    Total Length: 90  
    Identification: 0x3b9e (15262)  
    E...  
0000 8c 85 90 5b 89 c0 ec ad e0 d8 28 12 08 00 45 68 ...[..... .(....Eh  
0010 00 5a 3b 9e 00 00 33 06 77 2e 4a 7d c8 bd c0 a8 .Z;....3. w.J}....  
0020 00 87 01 bb e2 cf 15 5c 3b 58 e3 23 13 74 80 18 .....\\ ;X.#.t..  
0030 01 4a f0 78 00 00 01 01 08 0a d6 5d 3d ea 28 60 .J.x.... .]=.C`

Ethernet (eth), 14 bytes      Packets: 86 · Displayed: 86 (100.0%)      Profile: Default

- Start Wireshark packet capture and let it run for 10 seconds before stopping.
  - ◆ List up to 7 different protocols you see in the protocol column
  - ◆ What is the largest and smallest packet sizes in the capture ?
- Start Wireshark capture and enter 'http' (without quote) in the display filter.
- In your web browser, go to your favorite website and stop Wireshark capture when the web page is loaded.
  - ◆ How many packets do you see in the listing ? What are they ?
  - ◆ What are the source and destination IP addresses in the packets ?