

# CSC0056: Data Communication

## Lecture 02: Layered Network Architecture

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**NATIONAL TAIWAN NORMAL UNIVERSITY**

# Course information



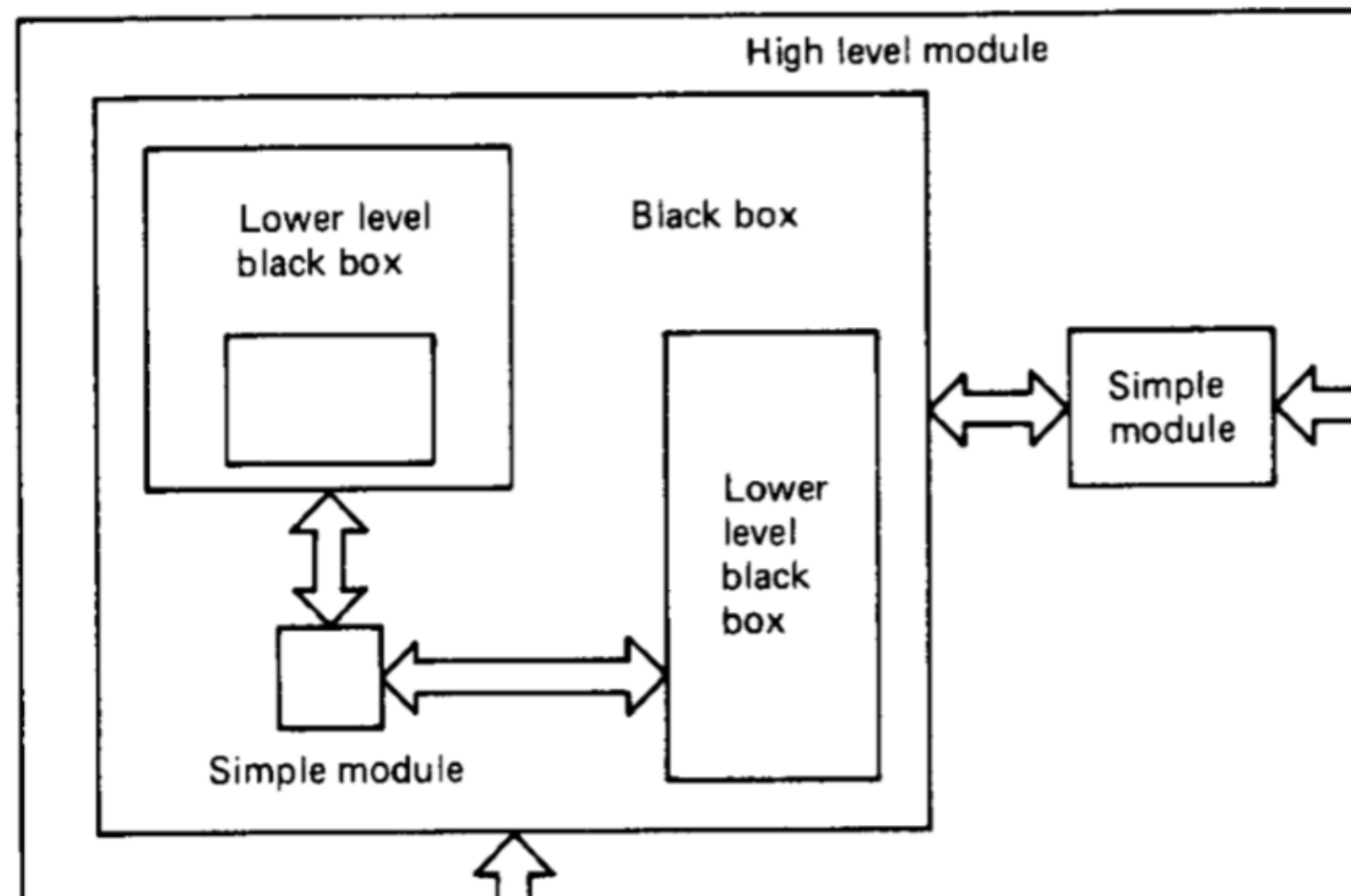
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- Course website: <https://wangc86.github.io/csc0056/>
  - Homework submission: via NTNU Moodle (<https://moodle.ntnu.edu.tw/>)
- Course meetings: Mondays 9:10-12:10 in C007, Gongguan Campus

Acknowledgement: Some slides' materials in this course are borrowed with permission from the 2014 edition of the course taught by Prof. Yao-Hua Ho 賀耀華

Figures are obtained from the textbook available at <http://web.mit.edu/dimitrib/www/datanets.html>

# Layered system architecture

- Module: a device/process that perform a function
- Black-box view of modules
- Communication between modules
  - Protocol
  - Interface



# Layered system architecture (cont.)

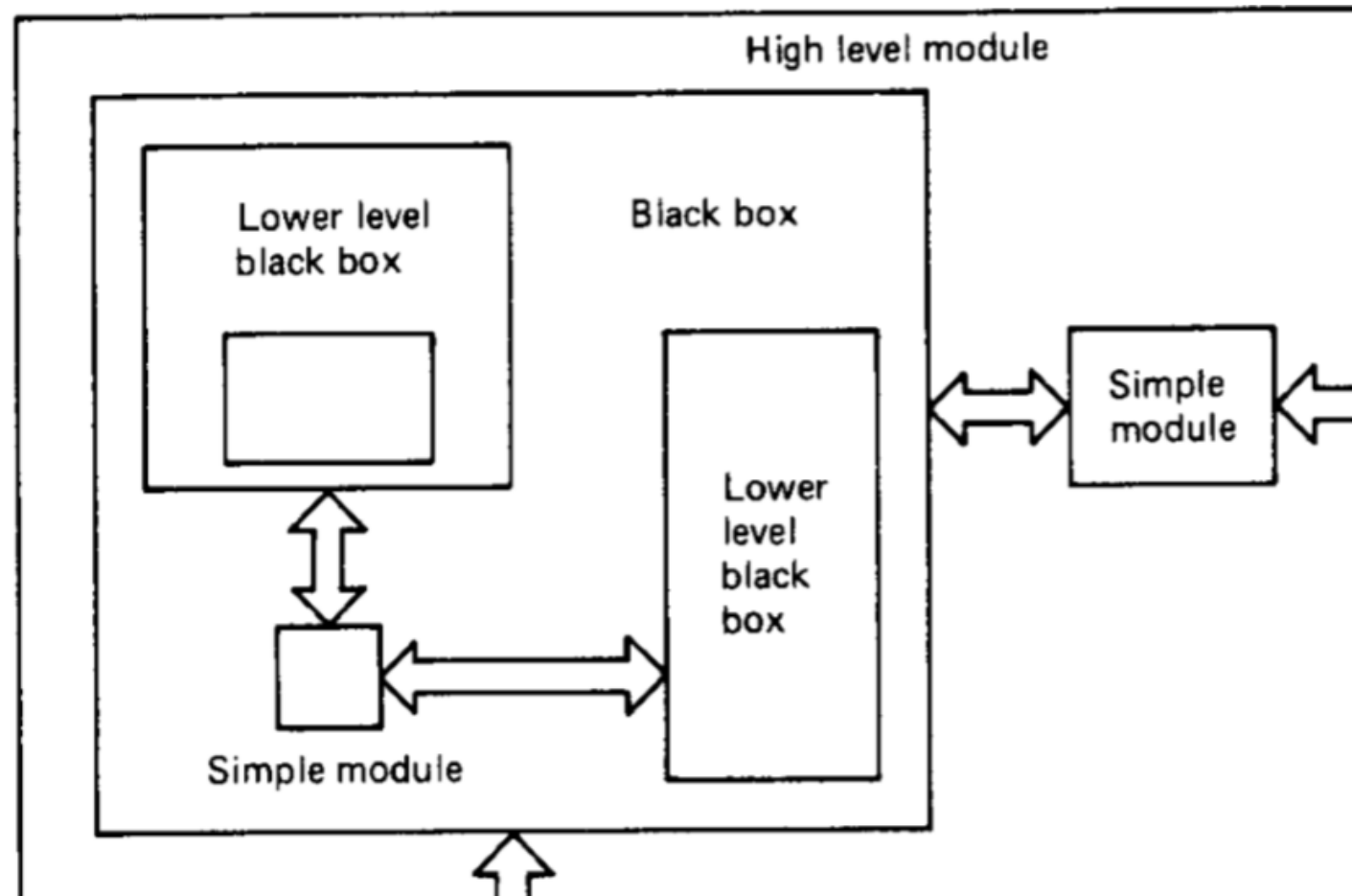
- Advantage

- Simplicity of design
- Easy to understand
- Standard, interchangeable modules

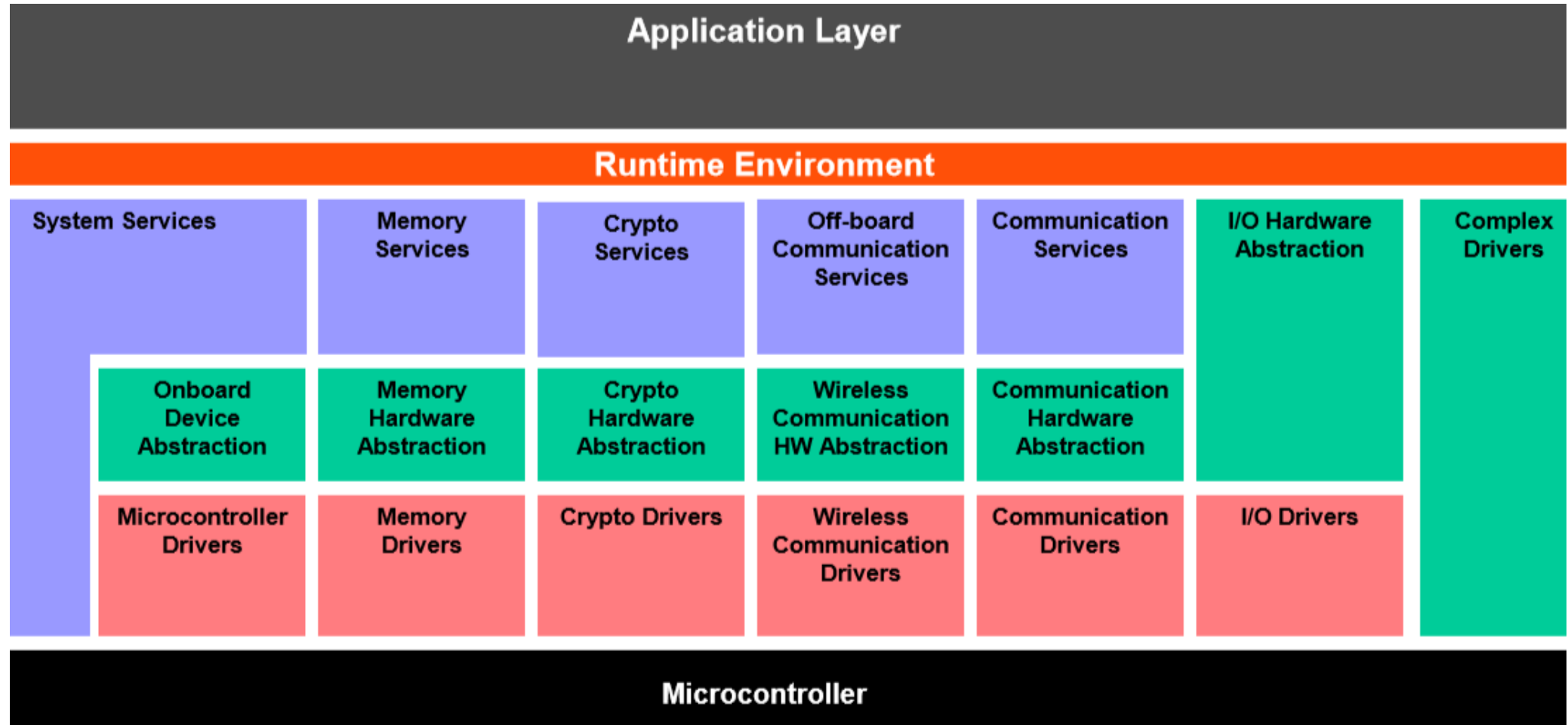
- Disadvantage

(if too many layers)

- Duplicated functionality
- Additional latency



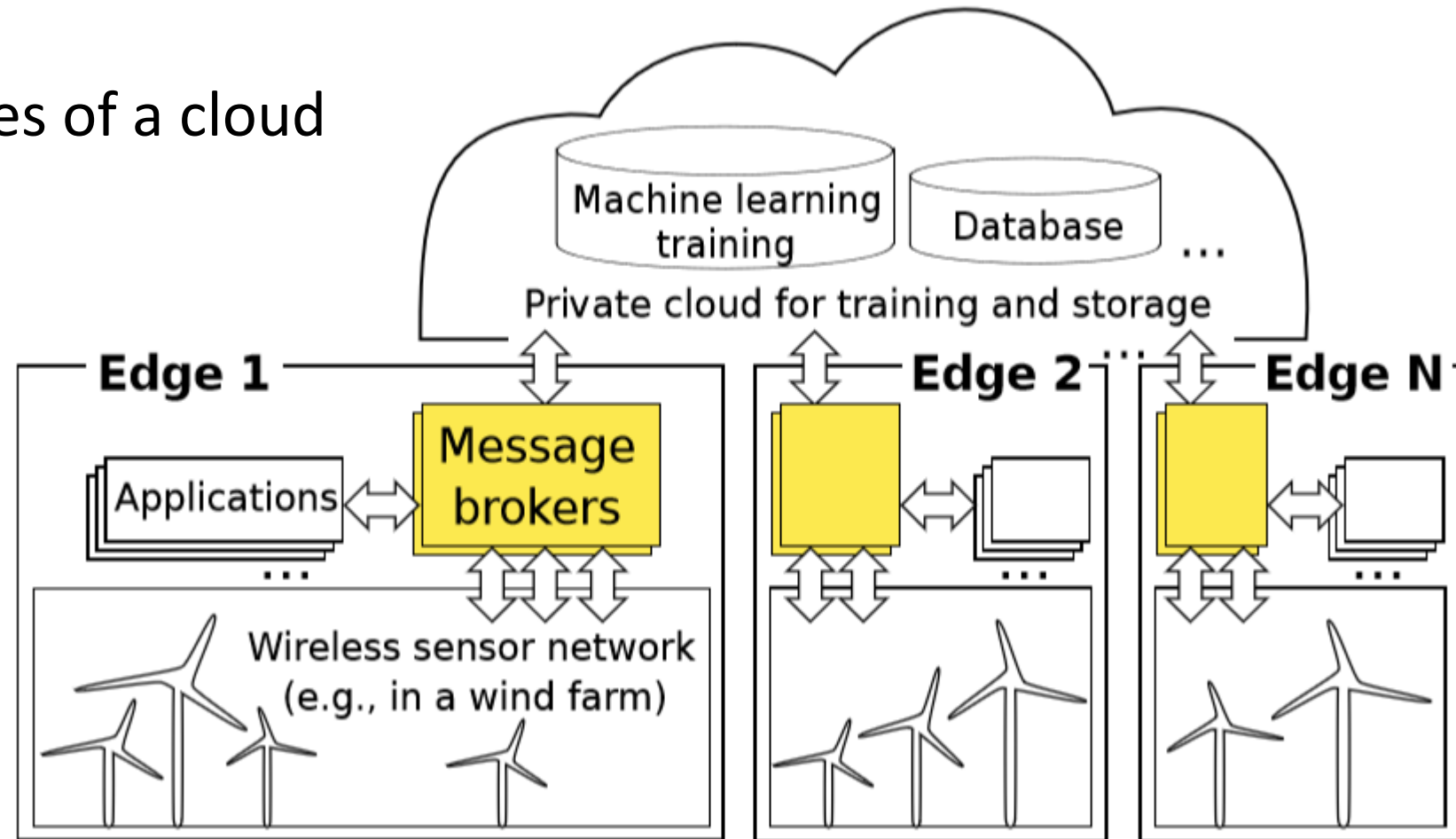
# Modern example: AUTOSAR (Automotive Open System Architecture)



[https://autosar.org/fileadmin/user\\_upload/standards/classic/4-3/AUTOSAR\\_EXP\\_LayeredSoftwareArchitecture.pdf](https://autosar.org/fileadmin/user_upload/standards/classic/4-3/AUTOSAR_EXP_LayeredSoftwareArchitecture.pdf)

# Modern example: Industrial IoT Systems

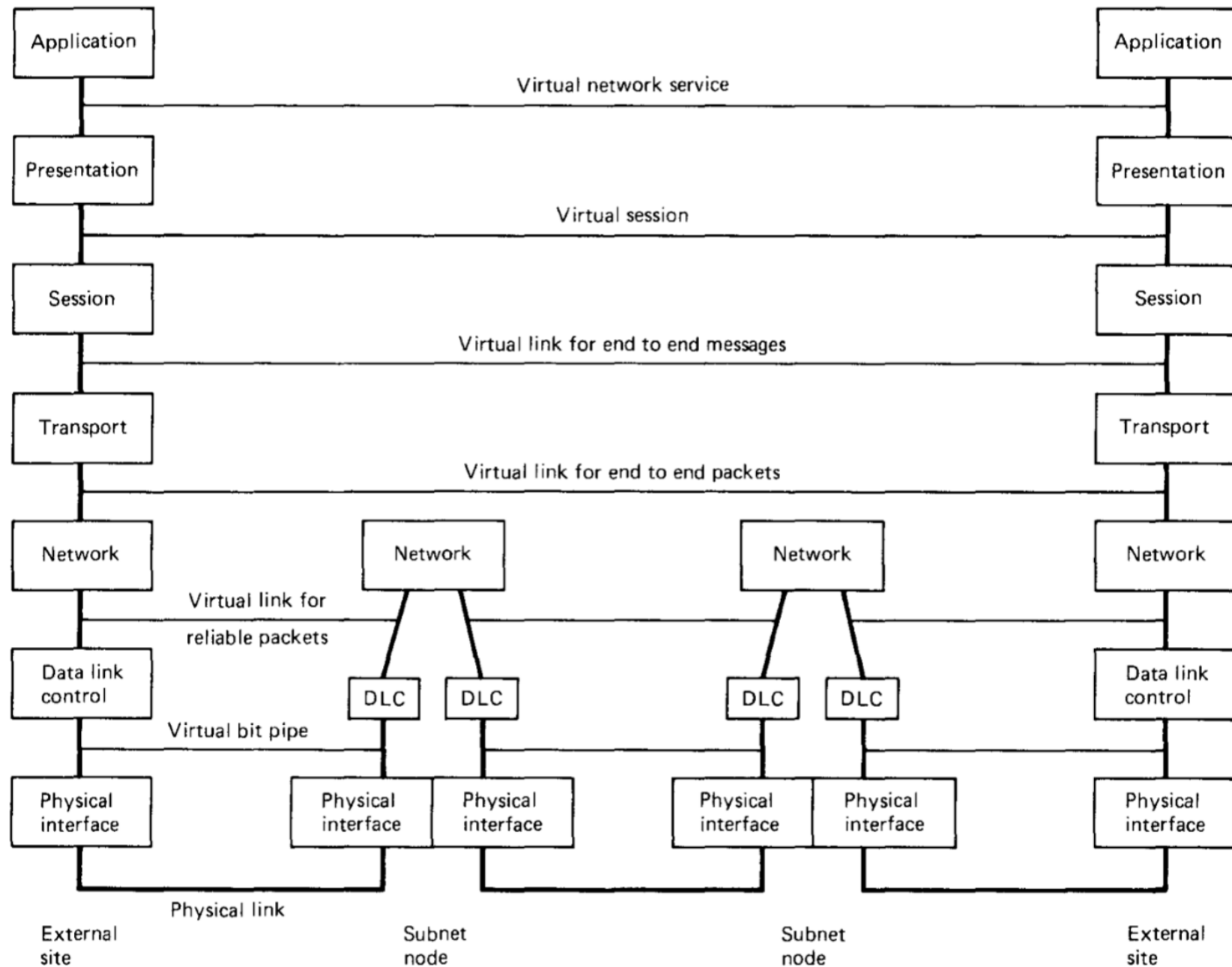
- Cloud + edges of a cloud



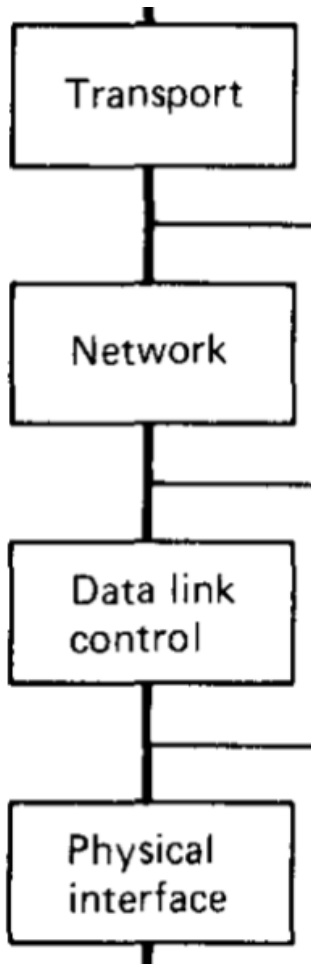
Chao Wang, Christopher Gill, Chenyang Lu. FRAME: Fault Tolerant and Real-Time Messaging for Edge Computing. IEEE International Conference on Distributed Computing Systems (ICDCS), accepted, 2019.

# Data communication

- The OSI model
  - Seven layers
  - In this course, we focus on layers beneath Session



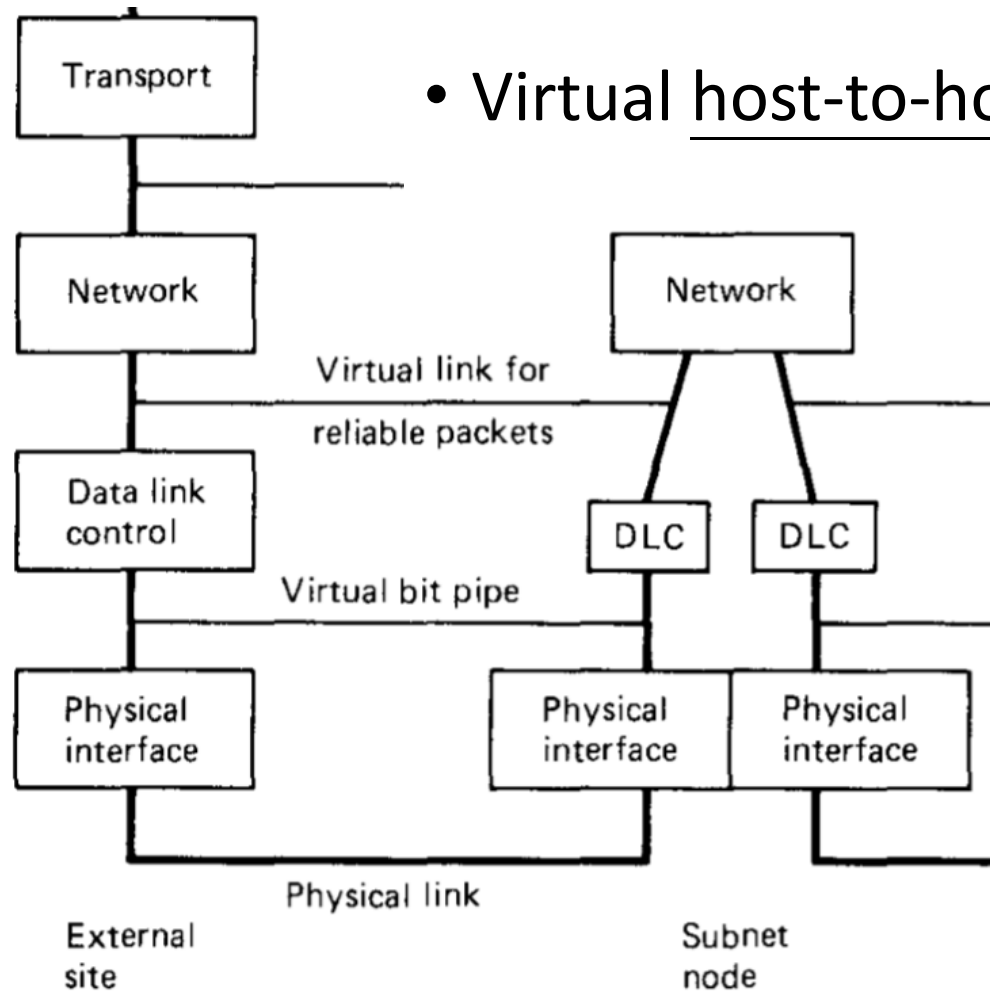
# Transport layer



- Virtual end-to-end message service to the higher layers
- Functions
  - Break messages into packets (at the transmitting end)
  - Reassemble packets into messages (at the receiving end)
  - Re-sequence packets at destination
  - Recover from residual errors and failures
  - Provide end-to-end flow control



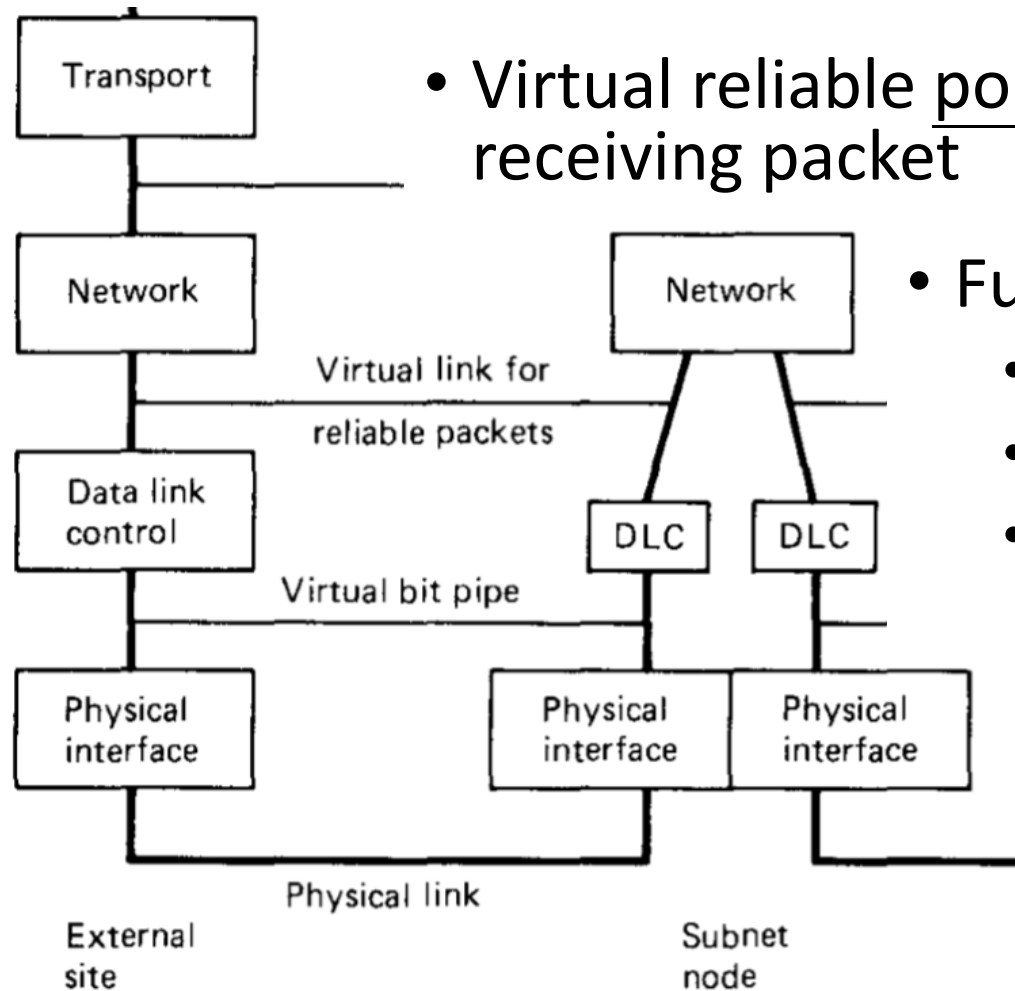
# Network layer



- Virtual host-to-host packet service to the higher layers

- Each host (node) contains one network layer module
- Provide routing and flow control for the network

# Data link control layer



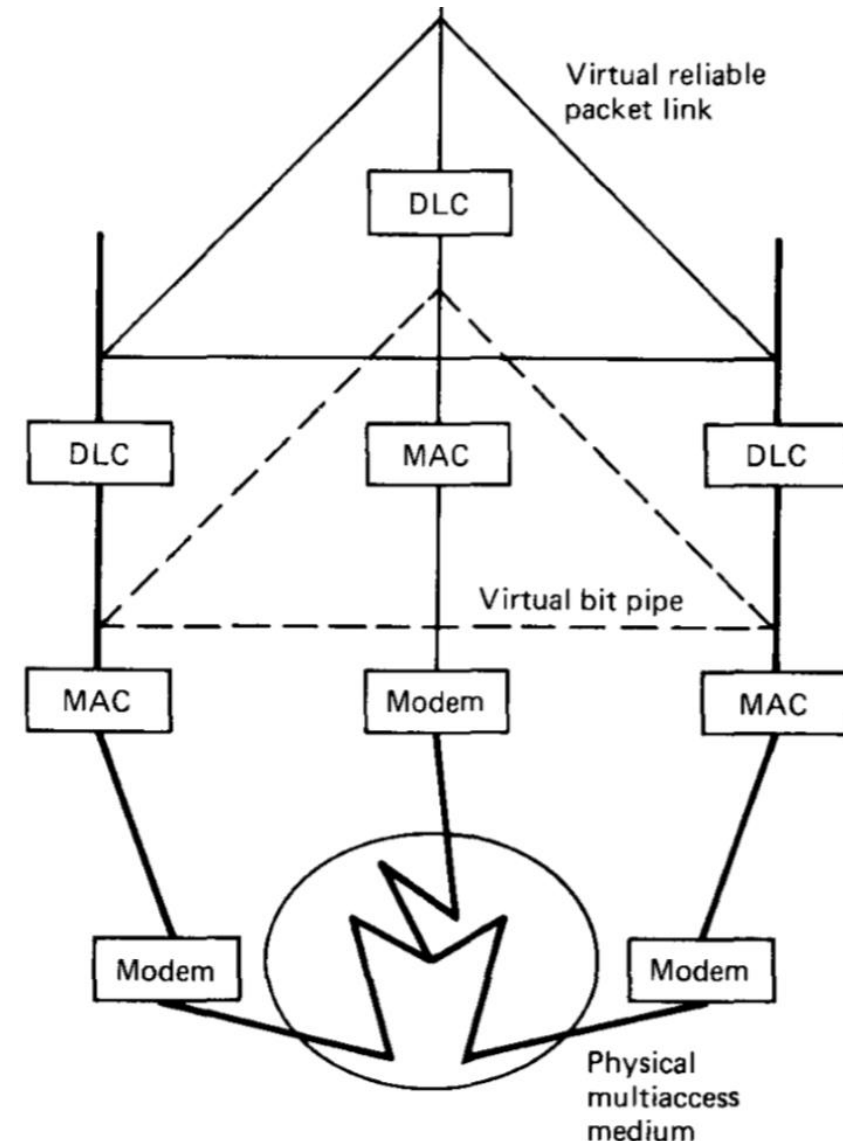
- Virtual reliable point-to-point link for sending and receiving packet

## • Functions

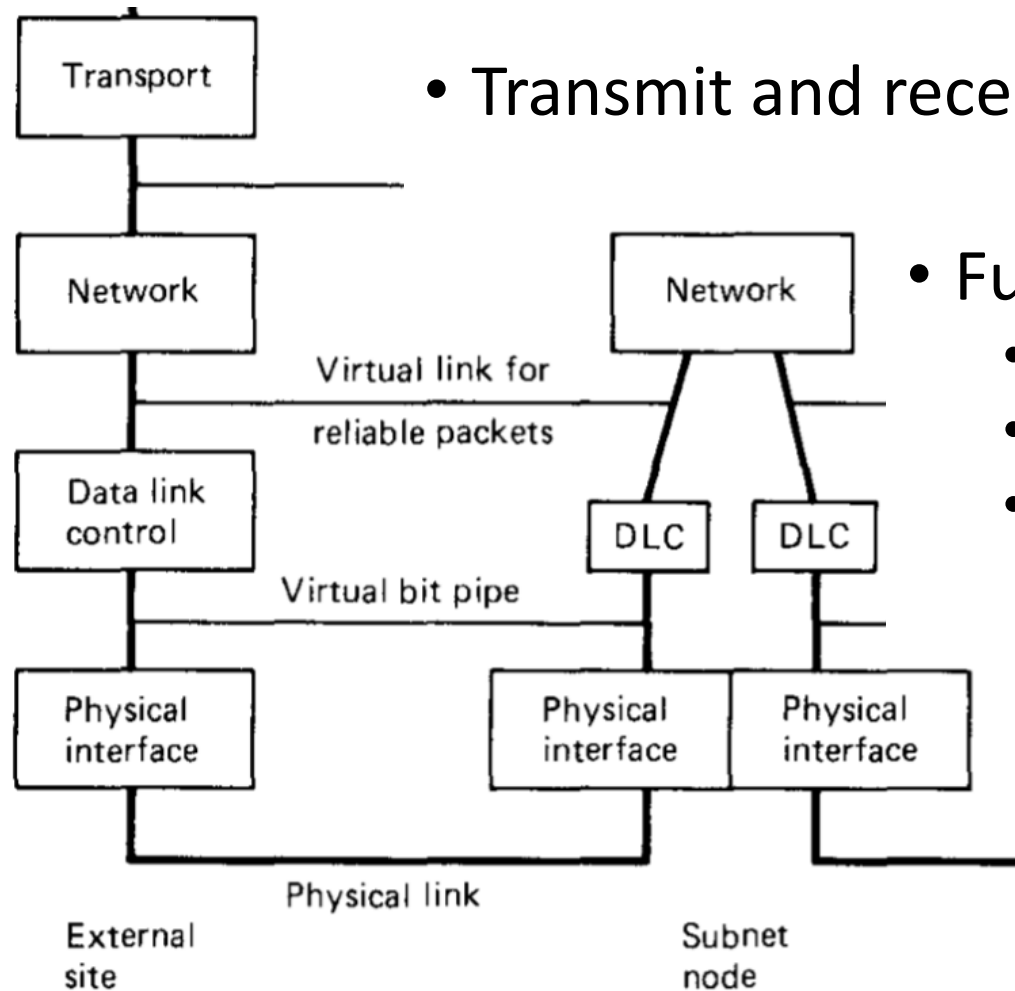
- Framing – determine the start and end of packets
- Error detection – identify corrupted packets
- Error correction – correct or retransmit packets

# The MAC sublayer

- MAC (Medium access control)
- Function
  - Allocate the multi-access channel so that each node can successfully transmit its frames without undue interference from the other nodes



# Physical layer

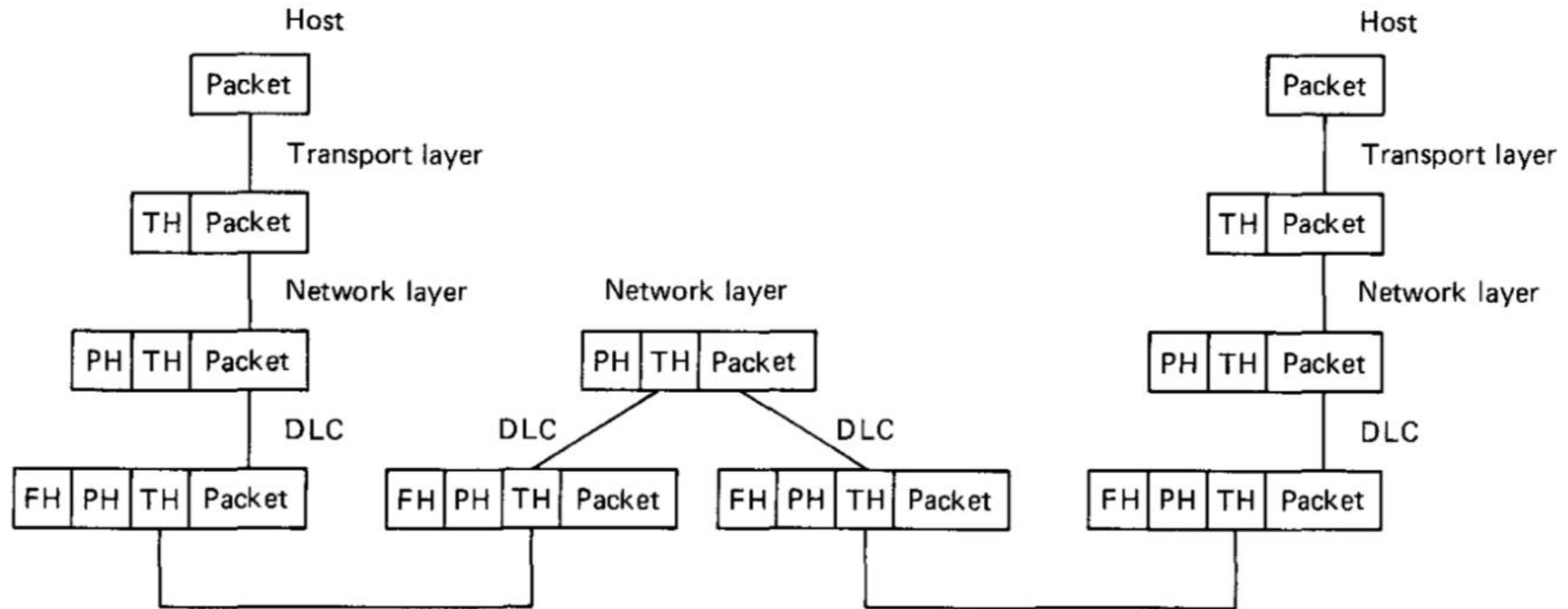


- Transmit and receive bits over a link

- Functions

- Encoding – transform bits into signals
- Filtering – reduce signal noises
- Modulation – reduce noise, increase transmission range, etc.

# Encapsulation of data



- What happen if there are too many layers?

# Take a break

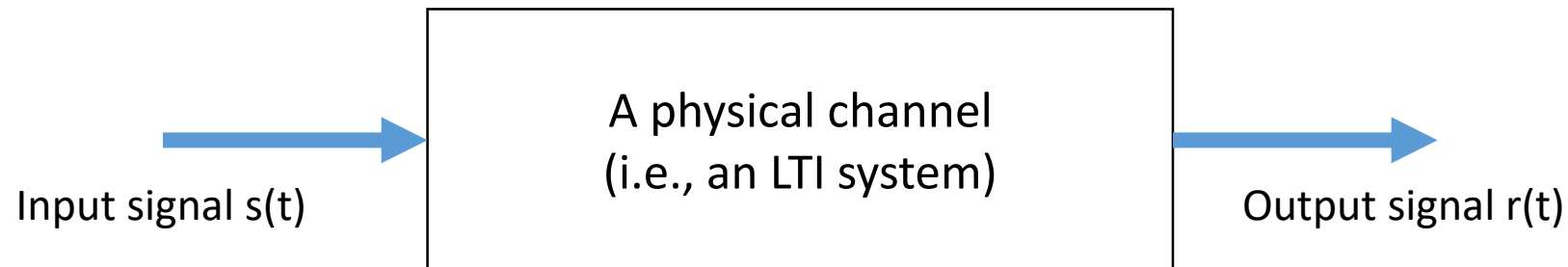
- Wireless technology?



# Into the physical layer

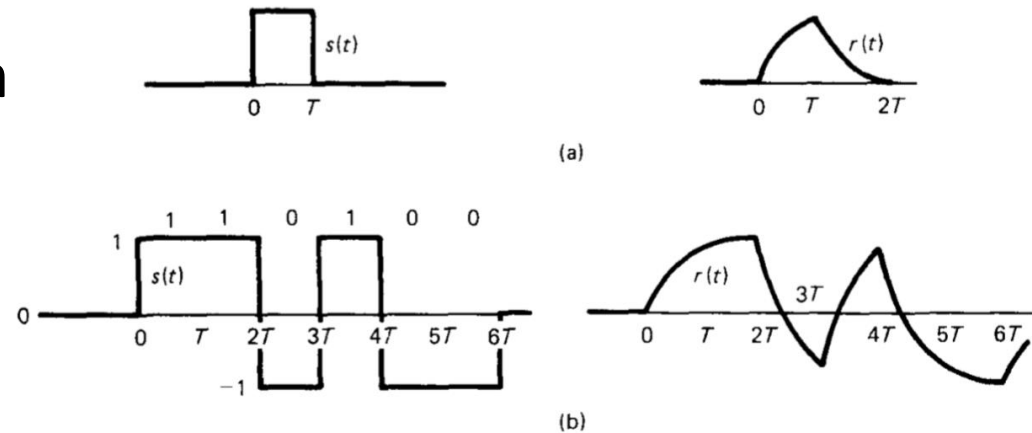
- Linear time-invariant (LTI) systems:

1. If input  $s(t)$  yields output  $r(t)$ , then for any  $\tau$ , input  $s(t - \tau)$  yields output  $r(t - \tau)$ .
2. If  $s(t)$  yields  $r(t)$ , then for any real number  $\alpha$ ,  $\alpha s(t)$  yields  $\alpha r(t)$ .
3. If  $s_1(t)$  yields  $r_1(t)$  and  $s_2(t)$  yields  $r_2(t)$ , then  $s_1(t) + s_2(t)$  yields  $r_1(t) + r_2(t)$ .

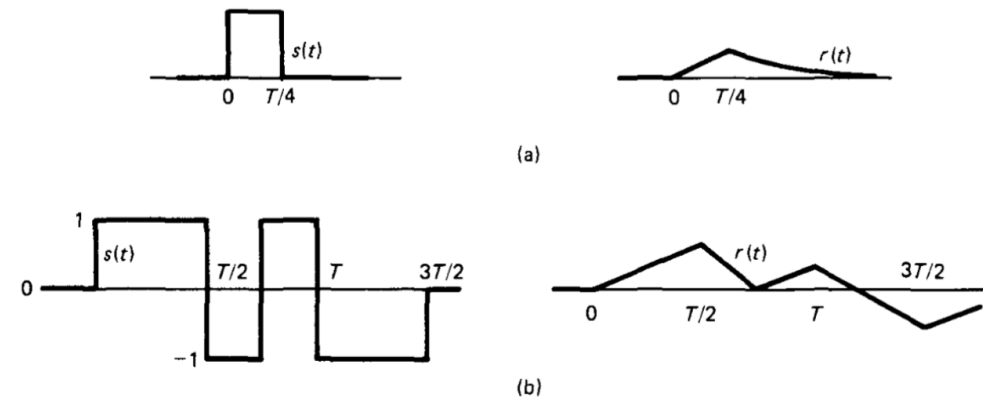


# Communication channel with filtering

- Signal distortion



- Intersymbol interference



(read the note of lecture02 at  
<https://wangc86.github.io/csc0056/lec2note.pdf> )



# Summary of lecture 02



- Layered network architecture
- The physical layer: channels and modems
  - See the note at <https://wangc86.github.io/csc0056/lec2note.pdf>
- Next lecture: Error detection at the data link layer
- Course logistics
  - Remember to visit and view the course website (e.g., via this QR code)
  - Submit your homework assignments and view scores via NTNU Moodle