CPE314 Data Communication and Computer Networks

Lecture 3: Network Architecture, Layering and Encapsulation

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Lecture Agenda

1. Network Architecture and Layering Motivation
2. TCP/IP Architecture
3. OSI vs TCP/IP
4. Encapsulation and Decapsulation
5. Addressing
6. Example and Discussion

What is Network Architecture?

Definition

A set of layers and protocols is called a **network architecture**.

- Specifies rules for communication
- Must allow implementers to build hardware/software
- Implementation details are hidden
- One protocol per layer $\rightarrow$ **Protocol Stack**

Key Idea

Architecture defines behavior, not implementation.

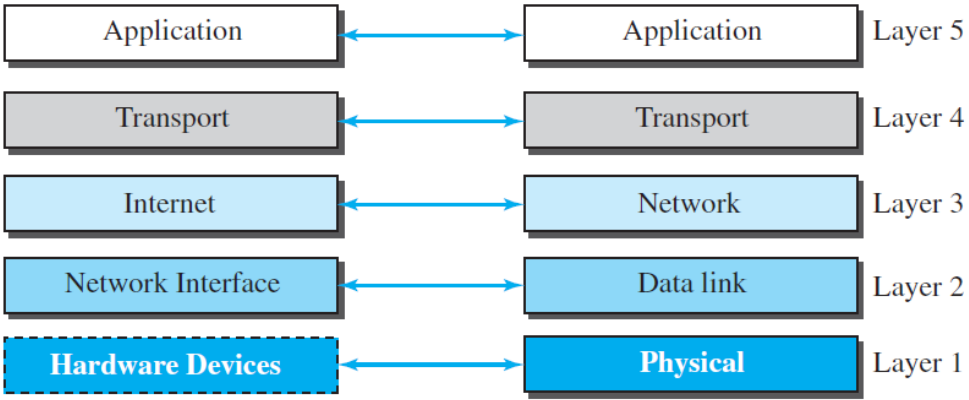
Why Layering?

- Reduces system complexity
- Enables modular design
- Allows independent development
- Simplifies troubleshooting

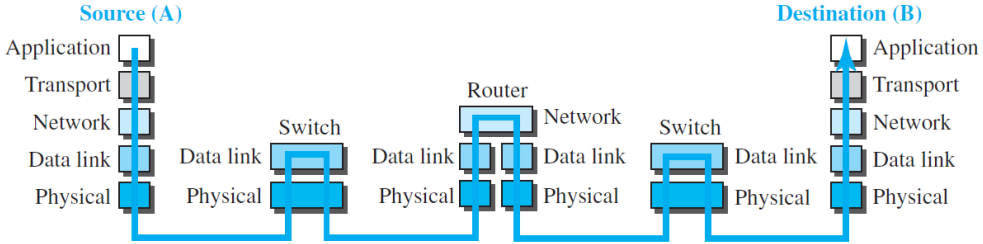
Service Model

Each layer provides services to the layer above it.

TCP/IP Layered Model



Internet Communication using TCP/IP



Application Layer

- Network applications reside here
- Protocol examples:
  - HTTP
  - SMTP
  - FTP
  - DNS

Data Unit

Application-layer packet is called a **Message**.

Transport Layer

- End-to-end communication
- Protocols:
  - TCP – reliable, connection-oriented
  - UDP – connectionless, best-effort
- Flow control and congestion control

Data Unit

Transport-layer packet is called a **Segment**.

Network Layer (IP Layer)

- Responsible for routing
- Moves packets across networks
- Uses IP protocol
- Includes routing protocols

Data Unit

Network-layer packet is called a **Datagram**.

Link and Physical Layers

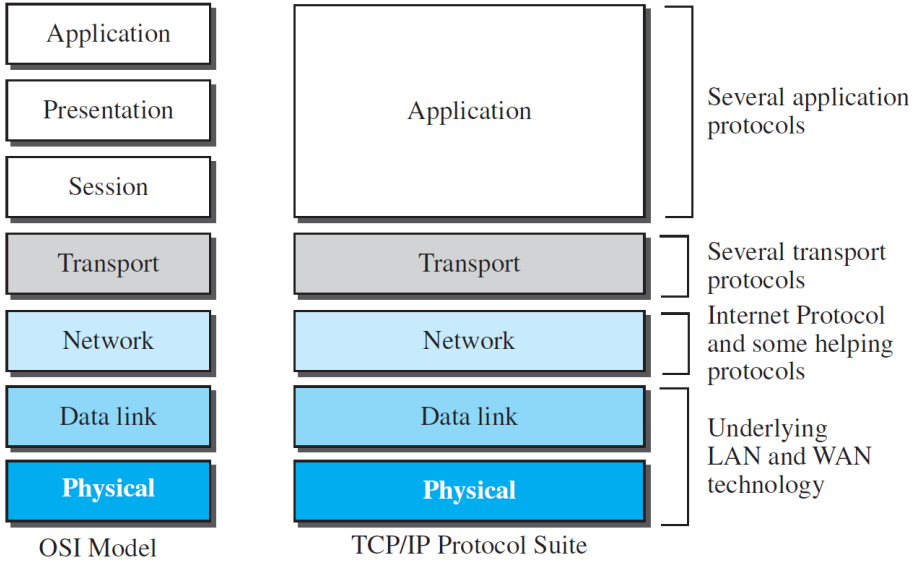
Link Layer

- Moves datagram to next hop
- Examples: Ethernet, WiFi, PPP
- Data unit: **Frame**

Physical Layer

- Moves individual bits
- Medium dependent
- Data unit: **Bit**

OSI vs TCP/IP


Application
Presentation
Session
Transport
Network
Data link
Physical
OSI Model
Application
Transport
Network
Data link
Physical
TCP/IP Protocol Suite
Several application protocols
Several transport protocols
Internet Protocol and some helping protocols
Underlying LAN and WAN technology

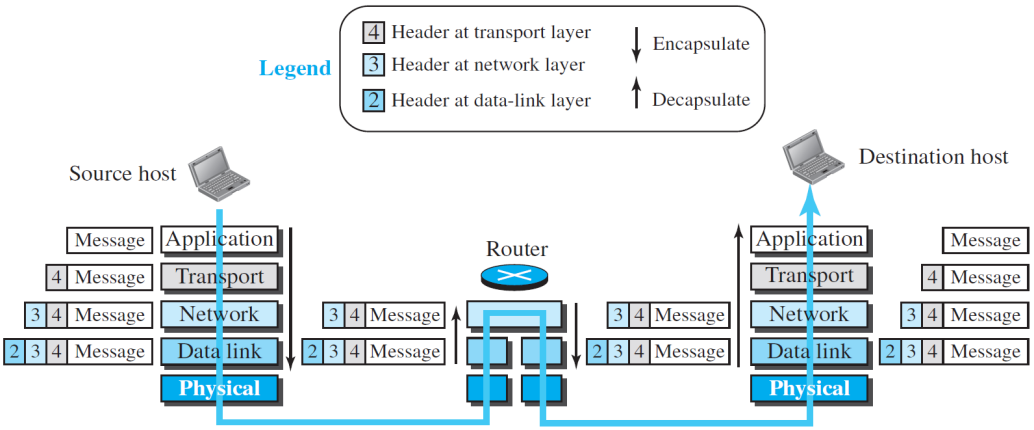
Conceptual Comparison

- OSI: 7-layer conceptual model
- TCP/IP: 4/5-layer practical Internet model
- TCP/IP collapses:
  - Presentation + Session $\rightarrow$ Application
  - Physical + Data Link $\rightarrow$ Link

Practical Note

TCP/IP is implemented in real networks. OSI is primarily pedagogical.

Encapsulation



Encapsulation at Source Host

1. Application creates **Message**
2. Transport adds header $\rightarrow$ **Segment**
3. Network adds header $\rightarrow$ **Datagram**
4. Link adds header $\rightarrow$ **Frame**
5. Physical transmits bits

Important

Each layer adds its own header.

Decapsulation

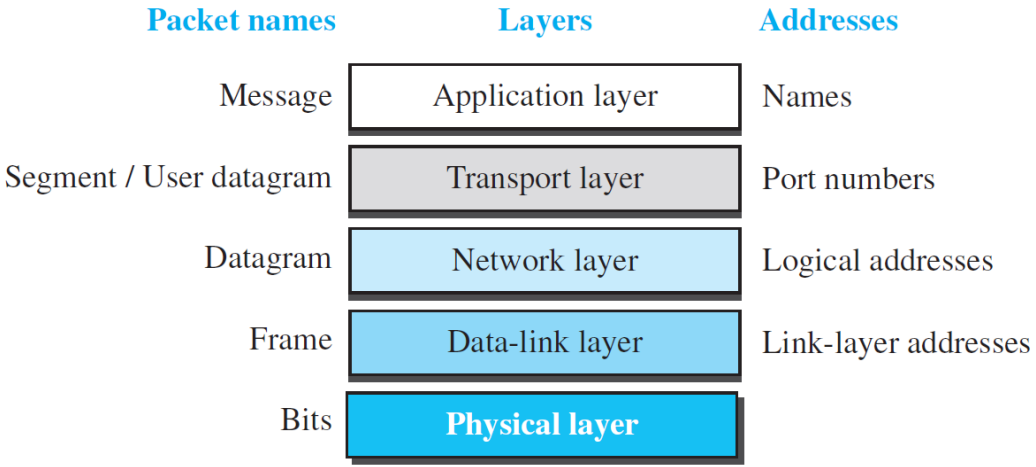
At Router

- Remove frame header
- Inspect IP header
- Forward to next hop
- Re-encapsulate in new frame

At Destination

- Frame $\rightarrow$ Datagram
- Datagram $\rightarrow$ Segment
- Segment $\rightarrow$ Message

Addressing Across Layers



Types of Addresses

- Application Layer $\rightarrow$ Names (e.g., www.example.com)
- Transport Layer $\rightarrow$ Port Numbers
- Network Layer $\rightarrow$ IP Address (Global)
- Link Layer $\rightarrow$ MAC Address (Local)
- Physical Layer $\rightarrow$ No Address

Observation

Logical communication requires source and destination addresses at each relevant layer.

Example: Sending an Email

- Application: SMTP Message
- Transport: TCP Segment
- Network: IP Datagram
- Link: Ethernet Frame
- Physical: Bits transmitted

Discussion

What changes at each router?

Summary

- Network architecture = layers + protocols
- TCP/IP is hierarchical
- Encapsulation adds headers layer by layer
- Routers forward using IP
- Addressing exists at four logical layers