Welcome!

ELEC 8560 – Computer Networks

Introduction

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Outline

- What is the Internet?
- Internet structure
- Protocol layers models

- Recommended reading: Forouzan – Chapter 1
- Extra reading: Kurose and Ross – Chapter 1

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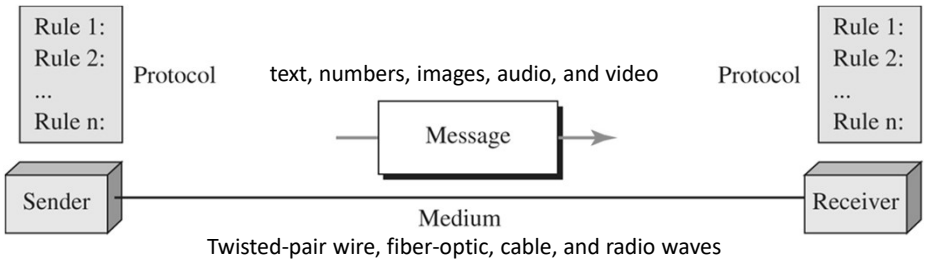
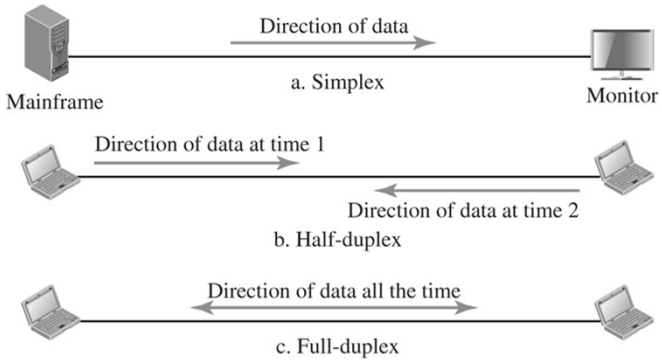
Data Communication

- Data communication is the exchange of data between two devices via some form of transmission media
- A data communications system has five components: sender, receiver, message, transmission medium, and protocol (set of rules)



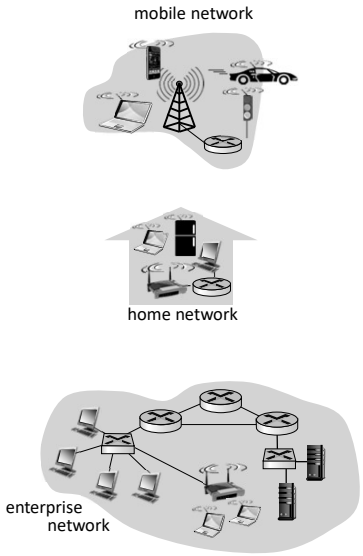
Data Flow

- Simplex: Only one of the two connected devices can send or receive
- Half-duplex: Each station can send or receive, not at the same time
- Full-duplex: Both stations can send or receive at the same time

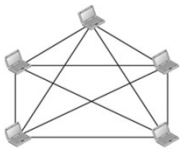


Networks

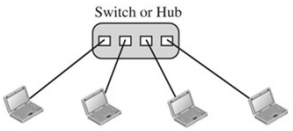
- A network is the interconnection of a set of devices capable of communication
- Devices can be:
  - Host: a large computer, desktop, laptop, workstation, cellular phone, printer, etc.
  - Connecting device to forward data: a router, switch, etc.
- Devices are connected by communication links
- Networks must meet certain criteria:
  - Performance: delay, throughput, etc.
  - Reliability: packet losses, robustness, etc.
  - Security

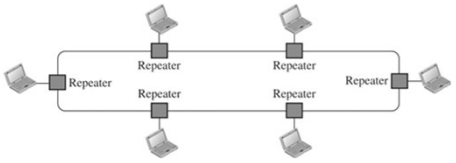


Physical Topology



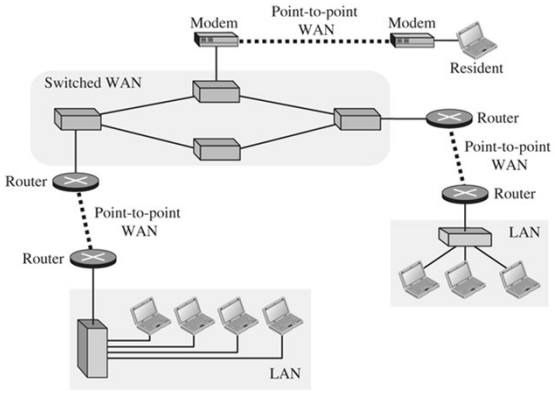
- Topology of a network is the geometric representation of the relationship of all the links and devices (nodes) to one another
- Basic topologies:
  - Mesh: fully-connected, every device has a dedicated point-to-point link to every other device (i.e., *n(n-1)* links)
  - Star: every device has a dedicated point-to-point link to a central controller
  - Bus: multipoint connection, all nodes are connected to a (backbone) bus cable
  - Ring: every device has a dedicated point-to-point link to two devices on either sides





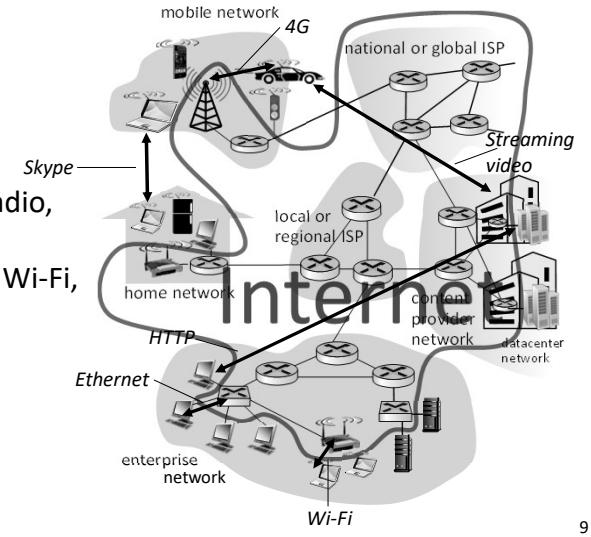
Network Types

- A network can be of two types:
  - Local area network (LAN): usually privately owned and connects some hosts in a single office, building, or campus (i.e., limited in size)
  - Wide area network (WAN): has a wider geographical span, spanning a town, a state, a country, or even the world
- It is rare to see a LAN or a WAN in isolation today; they are connected to one another
  → an internetwork or internet



The Internet

- Network of networks: Interconnected Internet Service Providers (ISPs)
- Billions of connected devices
  - Hosts: end systems
  - Packet switches: forward packets
  - Communication links: fiber, copper, radio, satellite, etc.
  - Protocols: HTTP, Skype, Ethernet, 4G, Wi-Fi, TCP, IP, etc.

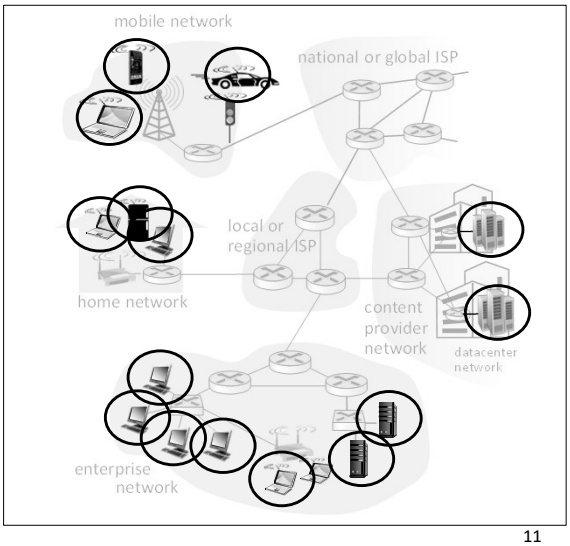


Outline

- What is the Internet?
- Internet structure
- Protocol layers models

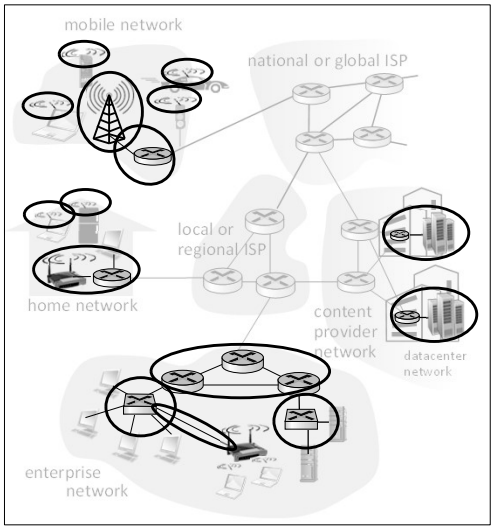
Internet Structure

- Network edge:
  - Hosts: clients and servers
  - Servers often in data centers



Internet Structure

- Network edge:
  - Hosts: clients and servers
  - Servers often in data centers
- Access networks and physical media:
  - Wired and wireless communication links
  - Home (DSL, cable, FTTH), cellular (3G, 4G, 5G), or enterprise (Ethernet, Wi-Fi) networks



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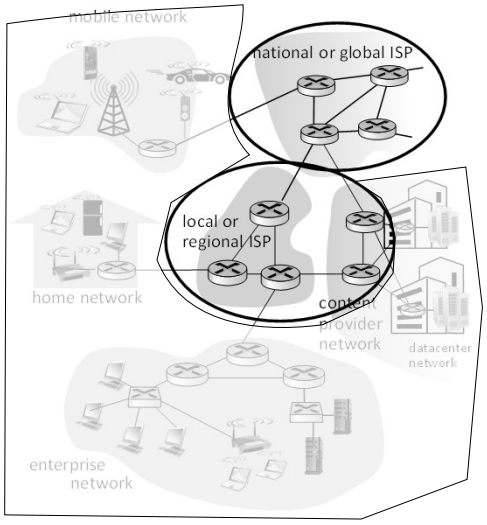
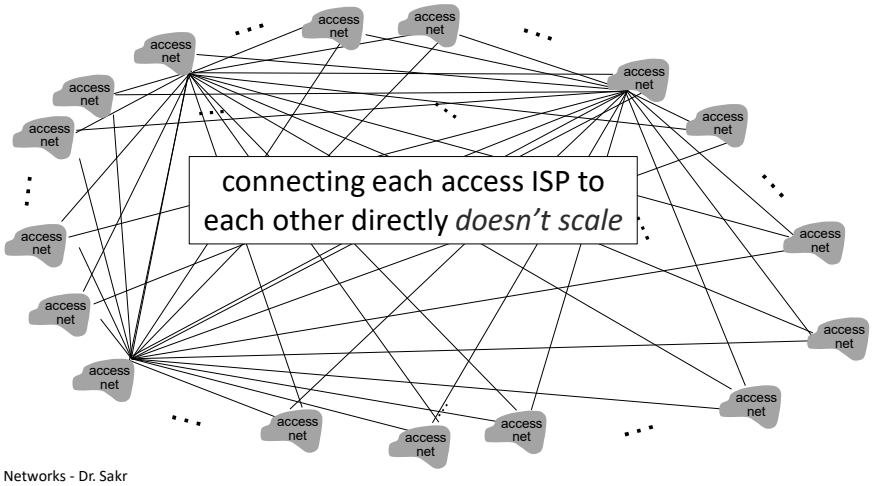
- Network core:
  - Interconnected routers
  - Forwards packets from one router to the next, across links on path from source to destination



Internet Structure (cont.)

Given millions of access ISPs, how to connect them together?



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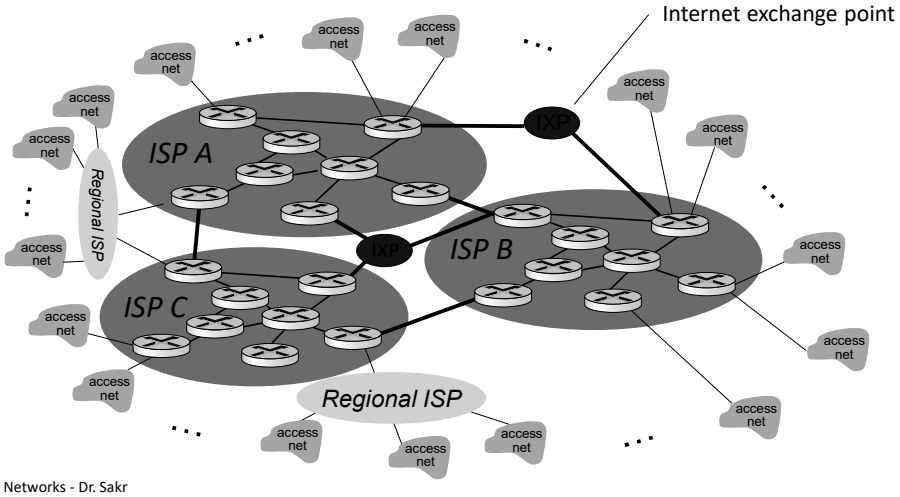
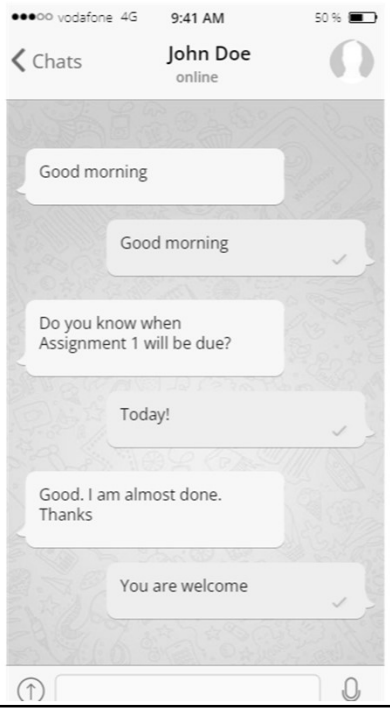


Outline

- What is the Internet?
- Internet structure
- What is a protocol?
- Protocol layers models

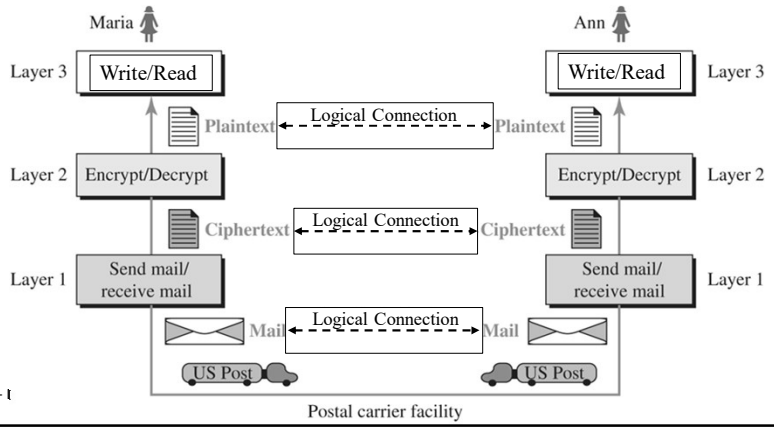
What is a Protocol?

- A protocol is a set of rules that governs data communication
- It define the format, order of messages sent and received among nodes, and actions taken on message transmission and reception
- Sender, receiver, and all intermediate devices need to follow to be able to communicate directly



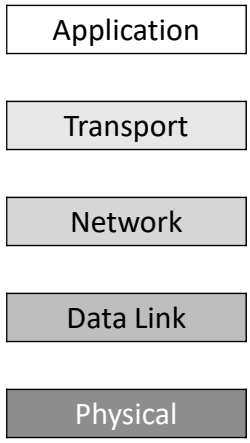
Example: A Three-layer Protocol

- Each layer perform two opposite task in each direction
- Notice the logical connection between each peer layers:
  - An imaginary direct connection through which they can send and receive messages

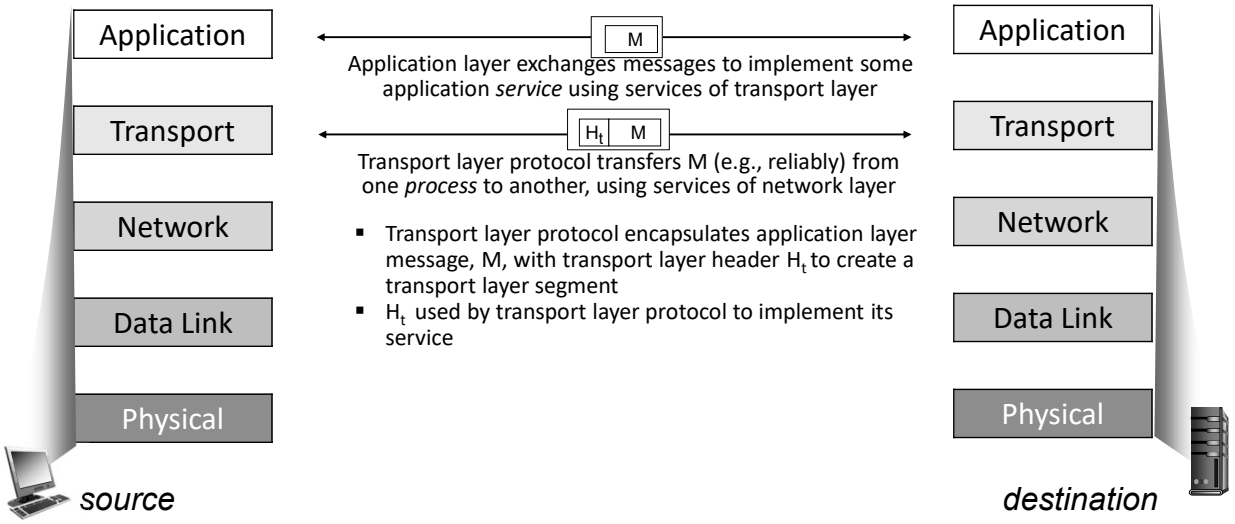


TCP/IP Protocol Stack

- Transmission Control Protocol/Internet Protocol
- A 5-layer protocol used in the Internet today
  - **Application**: supporting network applications
    - HTTP, IMAP, SMTP, DNS
  - **Transport**: process-process data transfer
    - TCP, UDP
  - **Network**: routing of datagrams from source to destination (host-to-host connection)
    - IP, routing protocols
  - **Data Link**: data transfer between neighboring network elements
    - Ethernet, 802.11 (Wi-Fi)
  - **Physical**: puts bits "on the wire"

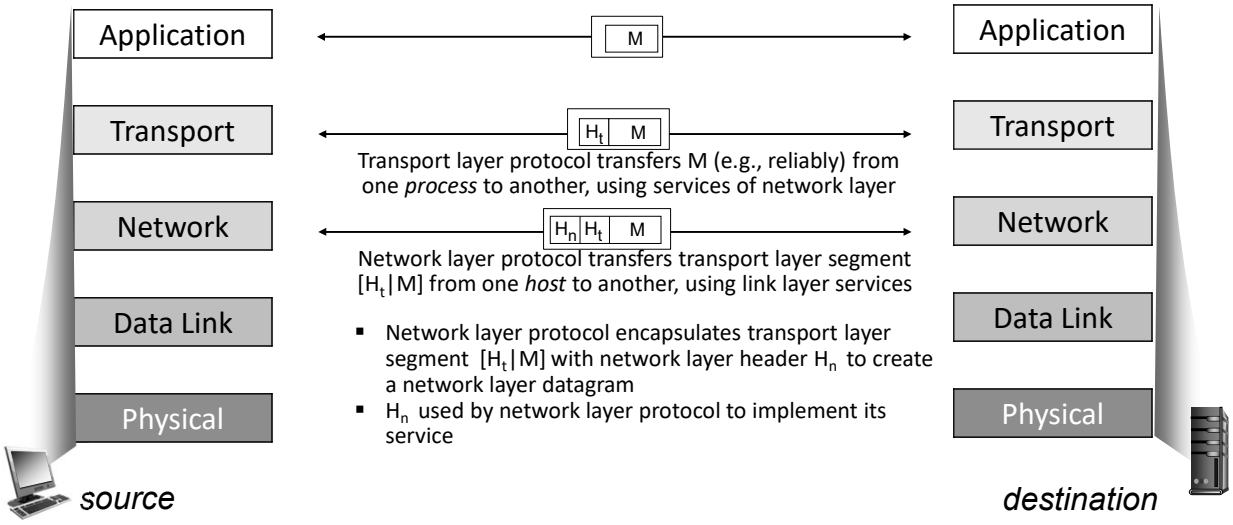


Services, Layering, and Encapsulation



- Transport layer protocol encapsulates application layer message, M, with transport layer header H_t to create a transport layer segment
- H_t used by transport layer protocol to implement its service

Services, Layering, and Encapsulation

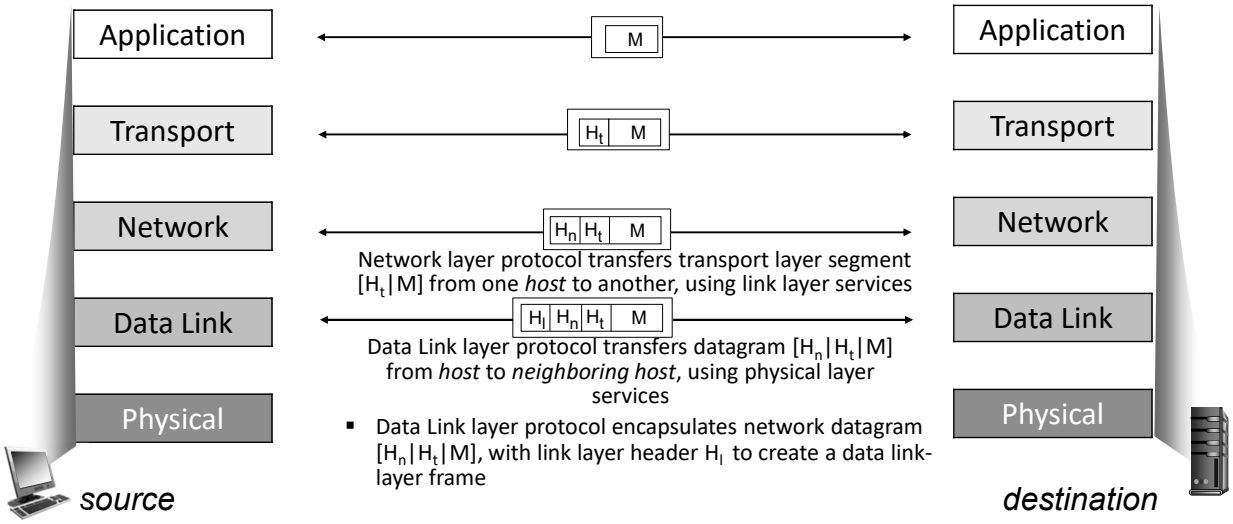


Transport layer protocol transfers M (e.g., reliably) from one *process* to another, using services of network layer

Network layer protocol transfers transport layer segment $[H_t|M]$ from one *host* to another, using link layer services

- Network layer protocol encapsulates transport layer segment $[H_t|M]$ with network layer header H_n to create a network layer datagram
- H_n used by network layer protocol to implement its service

Services, Layering, and Encapsulation

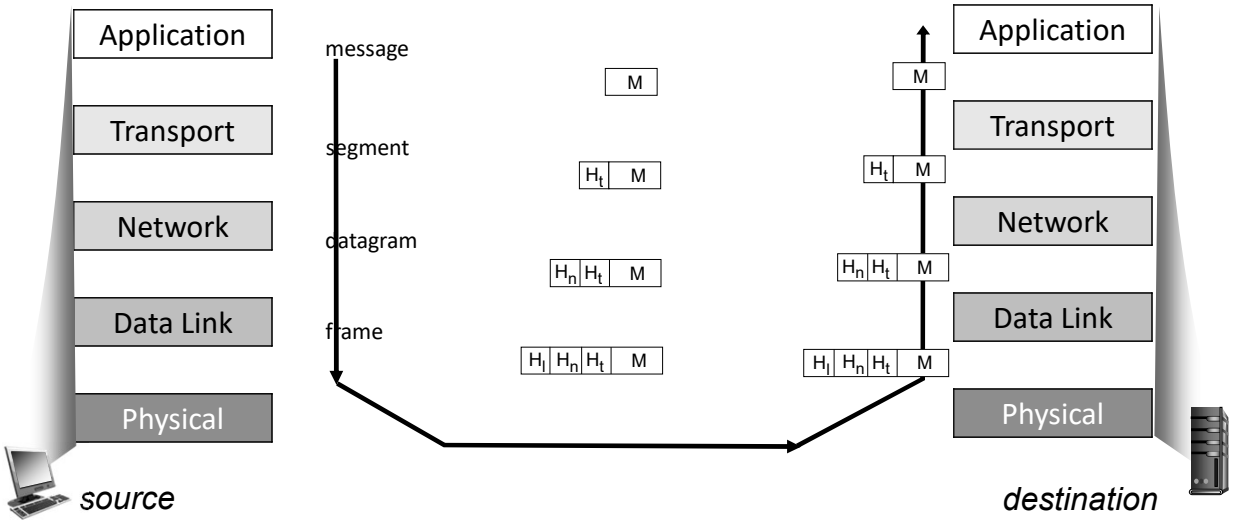


Network layer protocol transfers transport layer segment $[H_t|M]$ from one *host* to another, using link layer services

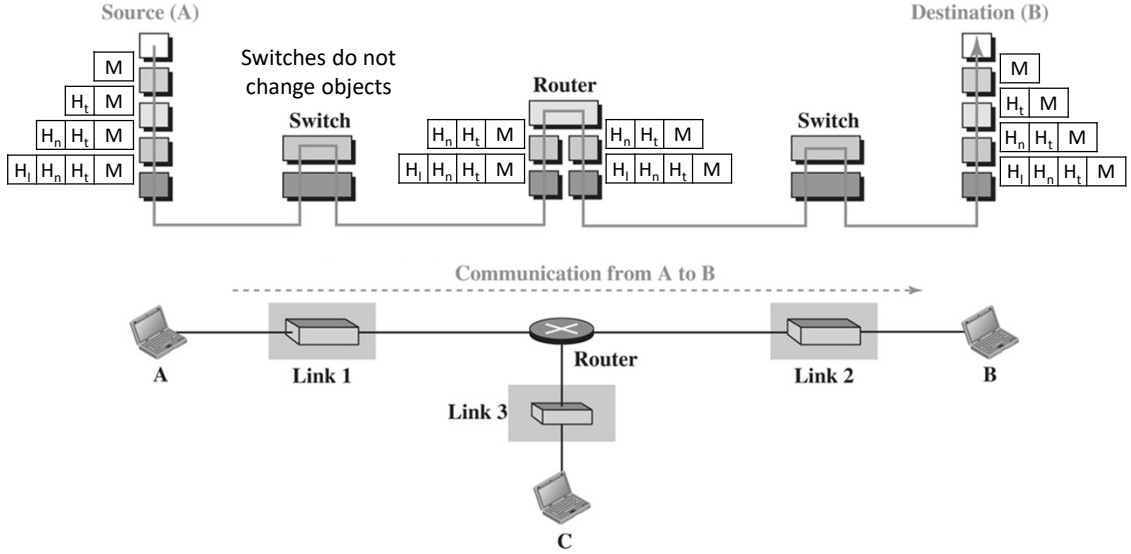
Data Link layer protocol transfers datagram $[H_n|H_t|M]$ from *host* to *neighboring host*, using physical layer services

- Data Link layer protocol encapsulates network datagram $[H_n|H_t|M]$, with link layer header H_l to create a data link-layer frame

Services, Layering, and Encapsulation

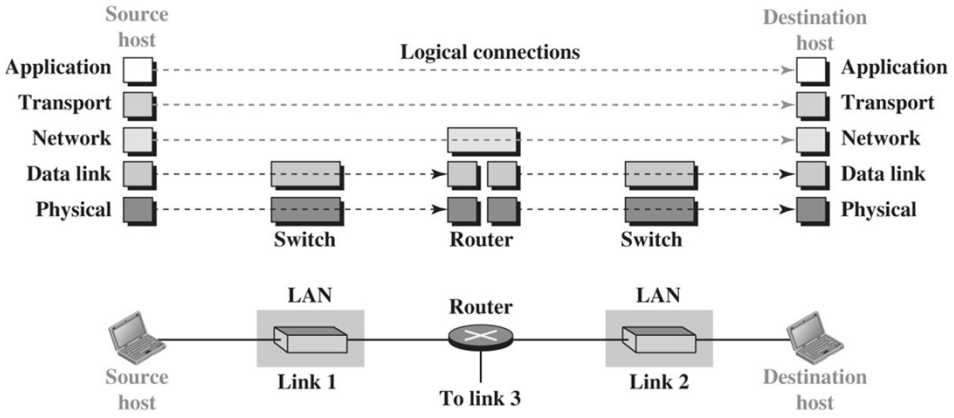


Example: End-to-End Communication via Internet



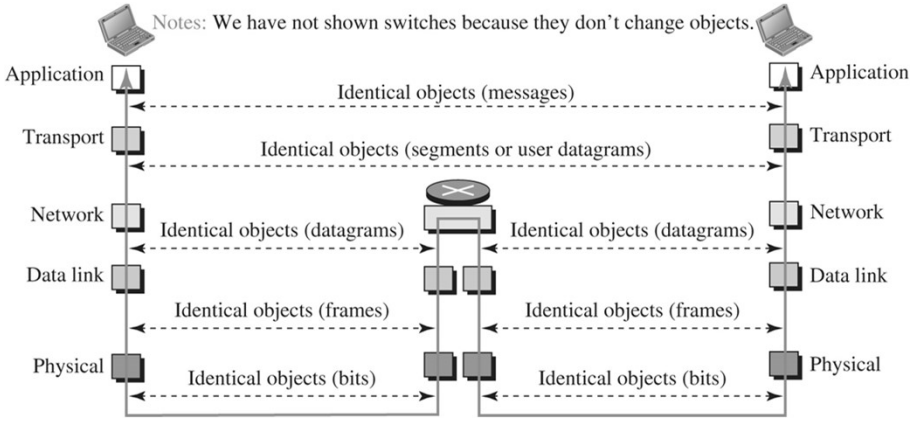
Example: End-to-End Communication via Internet (cont.)

- Notice the logical connections between layers
  - The imaginary direct connection through which they can send and receive messages



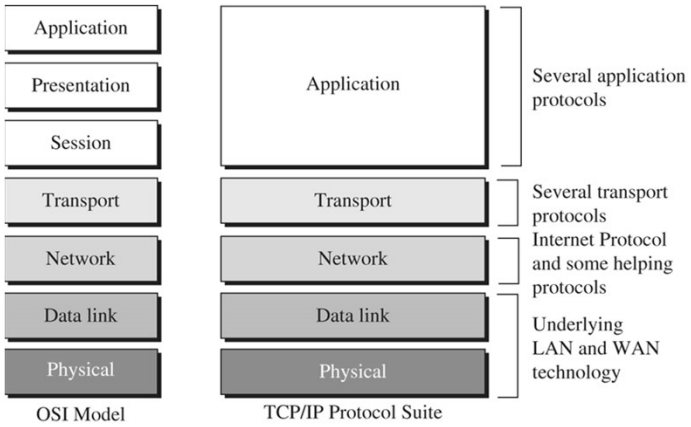
Example: End-to-End Communication via Internet (cont.)

- Notice identical objects at peer layers
- Switches are not shown because they do not change objects



OSI Model

- Open Systems Interconnection (OSI) by the International Organization for Standardization (ISO)
- Was expected to replace TCP/IP but did not happen



Summary

- We covered:
  - Network elements
  - Internet structure
  - What is a protocol?
  - Layering and service models