CPSC 317 – Winter 1 2025   Introduction to Computer Networking

Design of the Internet
## Module 1.2 – Switching and Protocols

Norm & Ibtissem

Learning Goals

A. Explain what the Internet is, and how (generally) it is put together

B. Describe the advantages and disadvantages of packet vs circuit switching

C. Define the term protocol in the context of a computer network

D. Explain why protocols are modeled using finite state machines and what states, actions, and events are

E. List the layers of the Internet protocol stack, in their proper order, and what functions each layer performs

F. Explain encapsulation and the structure of packets flowing in the Internet

As a network of networks, the internet has many routers

router
workstation
server
mobile

local ISP

regional ISP

gateway

company network
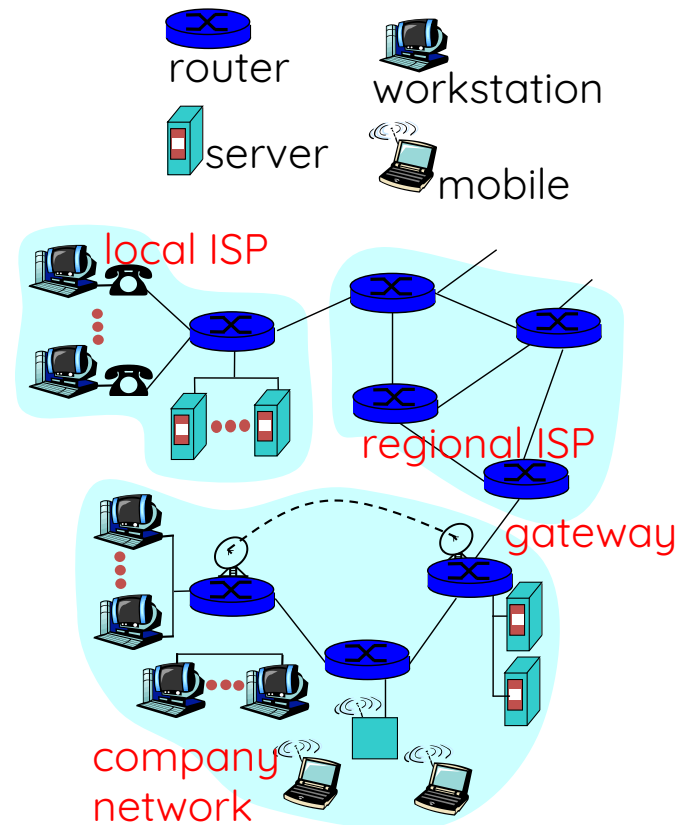
Packet Switching and Routers

- Packet is sent to the router that is believed to be closest to the destination
- Router looks up destination address in a forwarding table to determine next hop
- There may be several possible paths to take

Alice

Bob

Destination	Next hop
Alice	1
Bob	2
x	3
y	4

Check the header
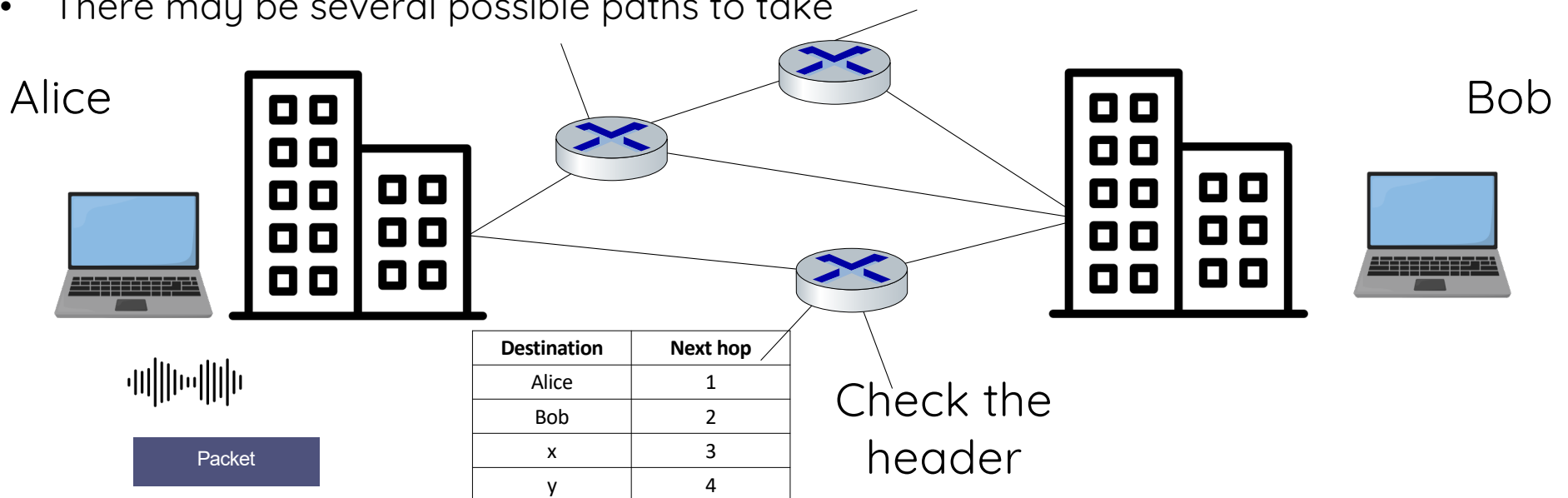
Packet

Circuit vs packet switching revisited

- When using circuit switching, the decision about the route that the data will take from source to destination is made once when the connection is established
- When using packet switching, this decision is made for every packet
- Does this have any impact on reliability?
- Does this have any impact on performance?

Clicker Question

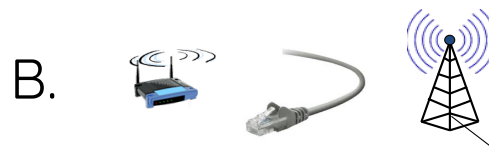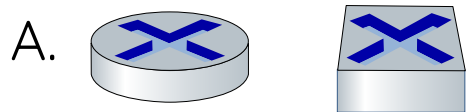- Assume A creates a 100kbps circuit to B, and A sends data at an average rate of 25kbps.

What is A's utilization of the network resources? Express your answer as a percent.

Clicker Question

- Assume A creates a 100kbps circuit to B, and A sends data at an
- average rate of 25kbps.

- Can the network use these idle resources for other traffic?
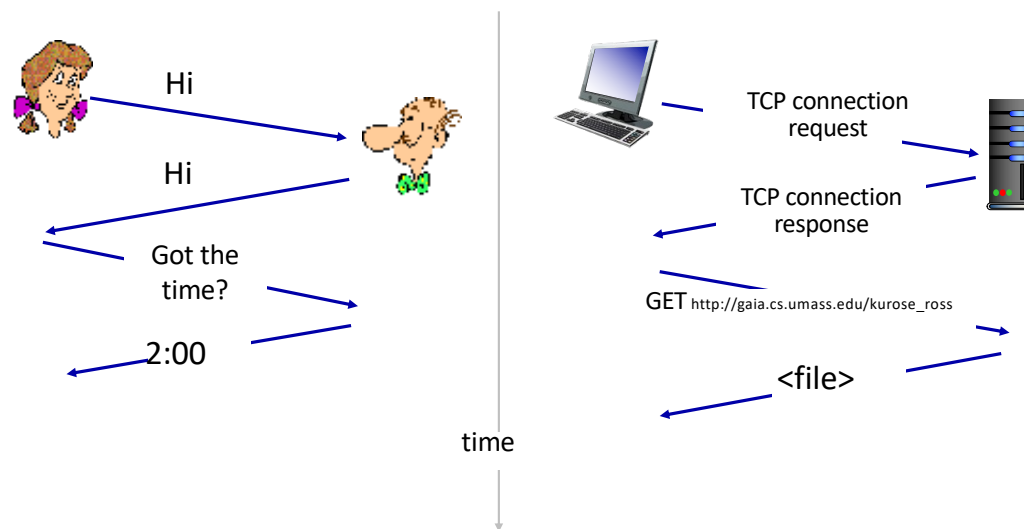
  – A. Yes
  – B. No

IClicker Game

A-B-C game:

A.

B.

C.

What's a protocol?

A human protocol   and   A computer network protocol:

Hi

Hi

Got the time?

2:00

time

TCP connection request

TCP connection response

GET http://gaia.cs.umass.edu/kurose_ross

Protocols

- A protocol defines:
  - Roles of communicating entities
  - Format of messages
  - Order of messages
  - Actions taken on the transmission, receipt of a message, or other event
- A fully-defined protocol must provide a proper action for any event in any state

Request-Response Protocols

- Many protocols on the Internet are request-response protocols
  - Requestor (usually client) sends a request
  - Receiver (usually server) sends a response
  - Well-defined rules for whose turn it is

- Some rules can be complicated
  - Server is slow to respond
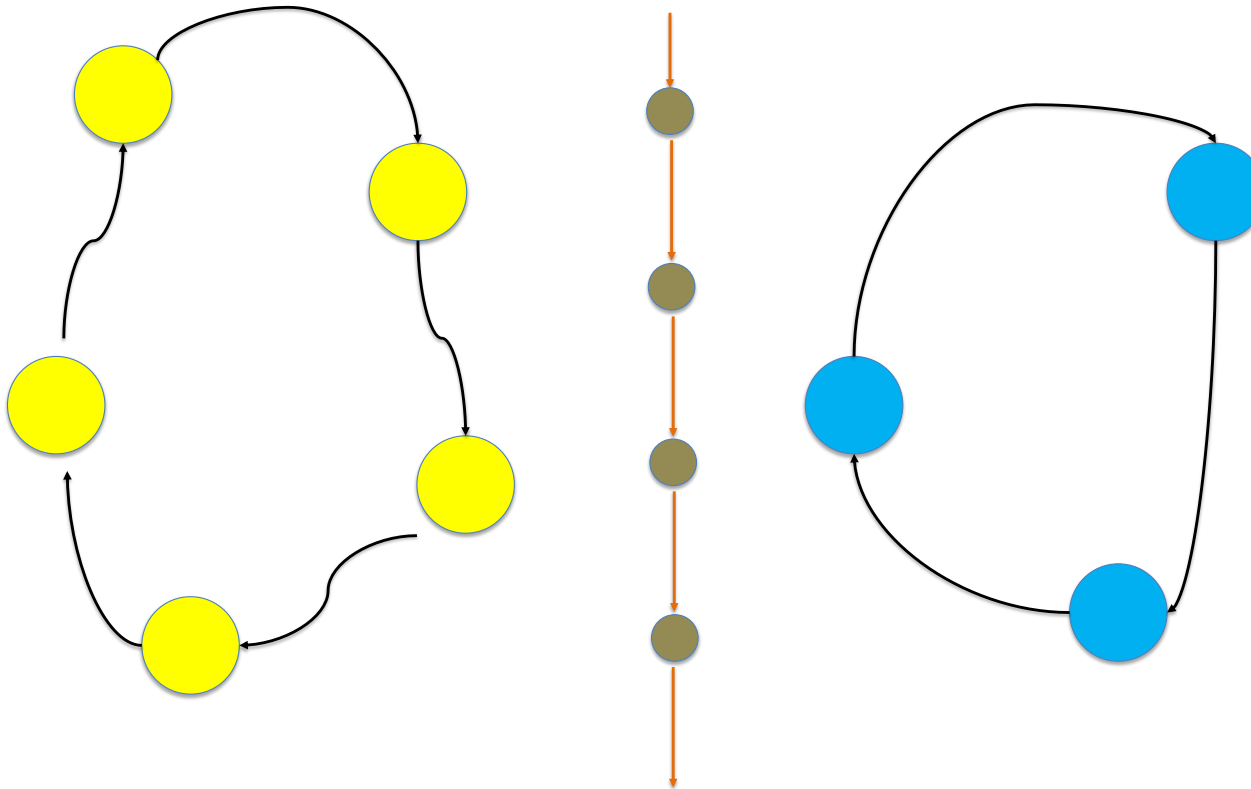 - Size of request or response can vary
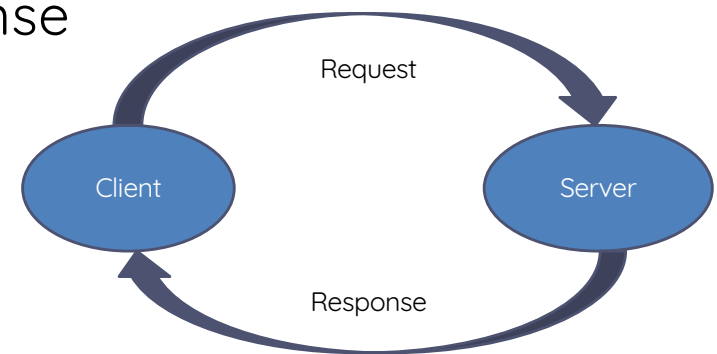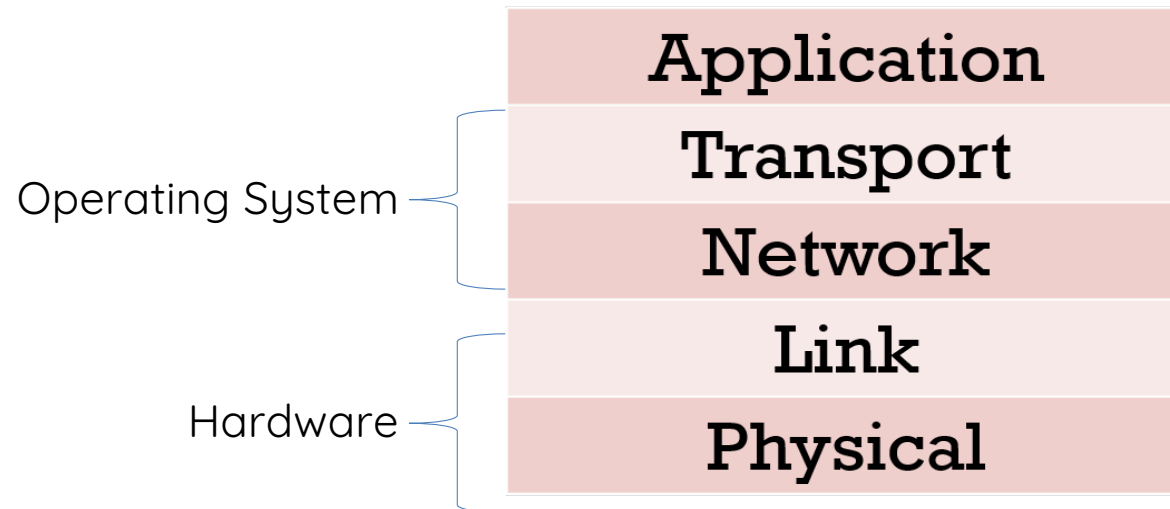
MODELLING protocols: Finite State Machines
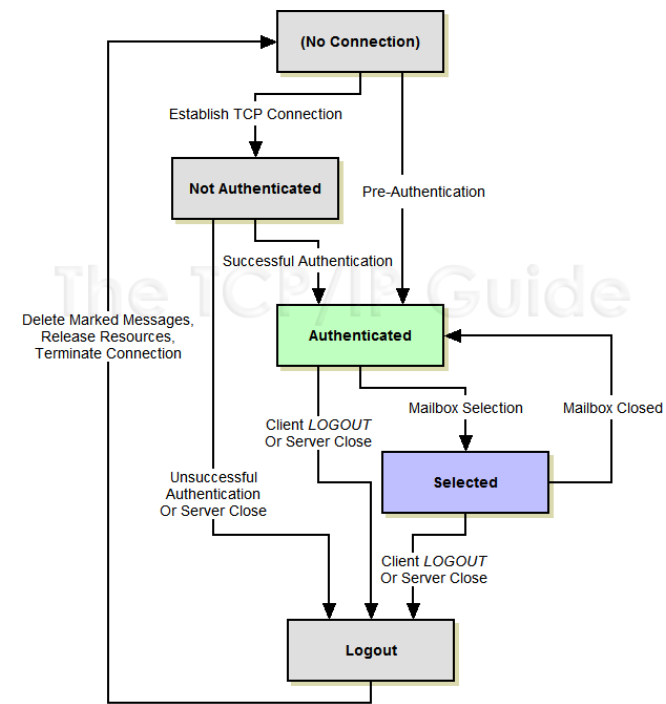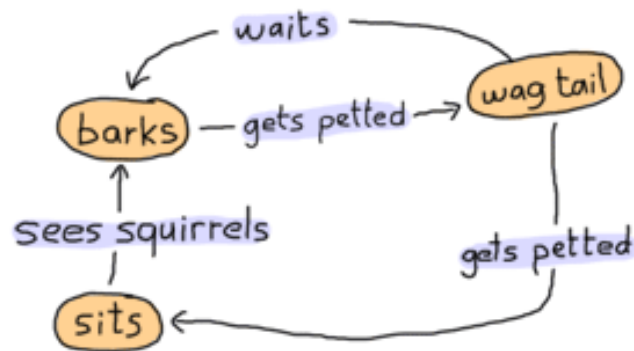
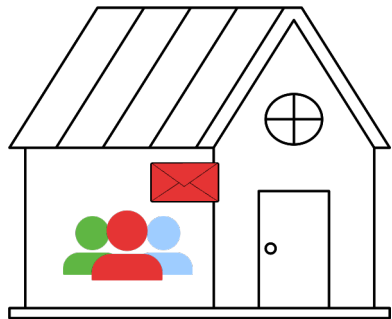Mail

LINKED FINITE STATE MACHINES

Protocol Stack

Operating System

Application
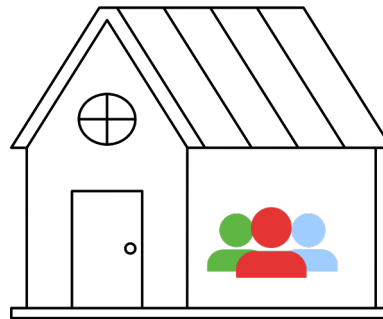Transport
Network
Link
Physical

Hardware

Daily Life Analogy

Application Layer Protocol

HTTP (Web), Email, File Transfer, Multimedia, etc.

Process

Process

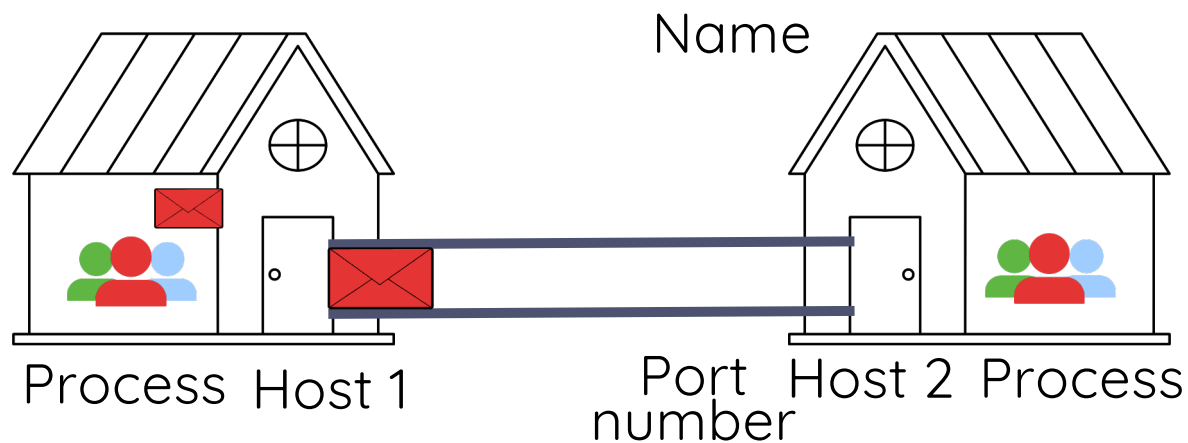Writing a letter using the proper format expected by the recipient.

Application
Transport
Routing
Link
Physical

Daily Life Analogy

Transport Layer Protocol

TCP, UDP

Name

Process Host 1

Port number Host 2 Process

Handling reliability and making sure the message reaches the correct person.

Application

Transport

Routing

Link

Physical
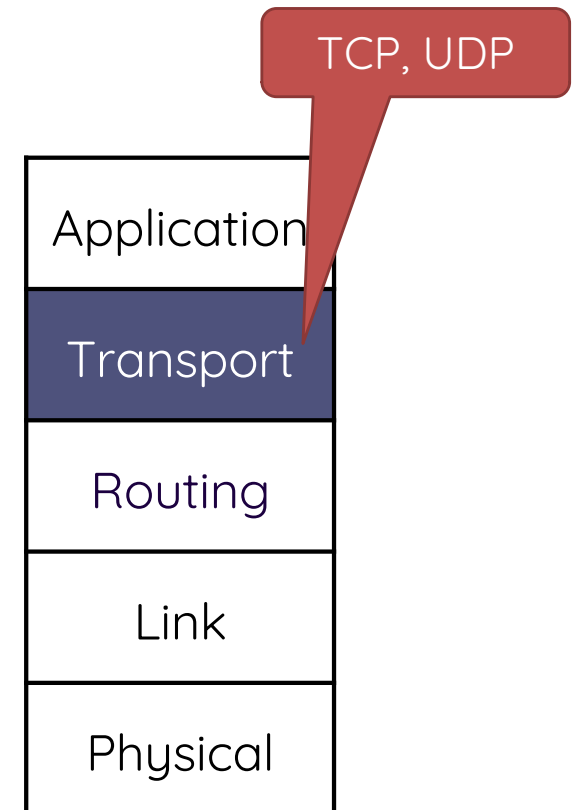
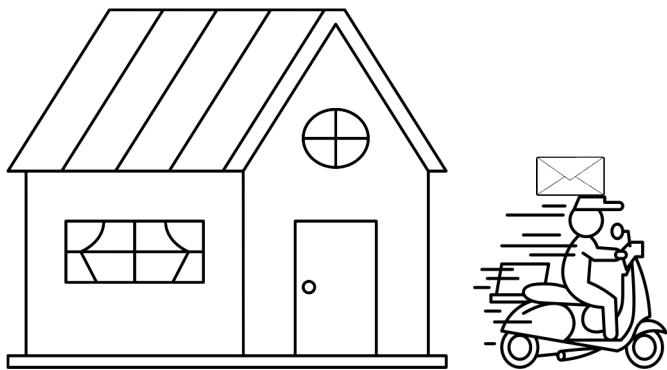# Daily Life Analogy

Network Layer Protocol

IP Adress

IP

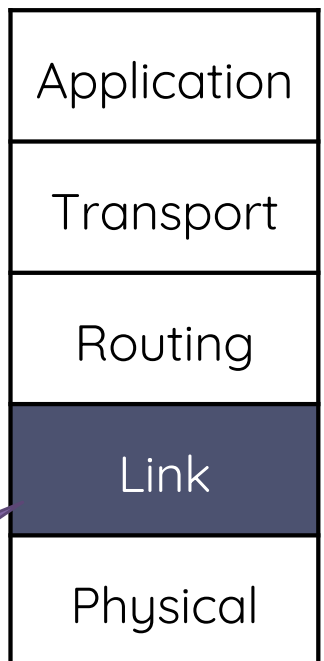| |
|---|
| Application |
| Transport |
| Routing |
| Link |
| Physical |
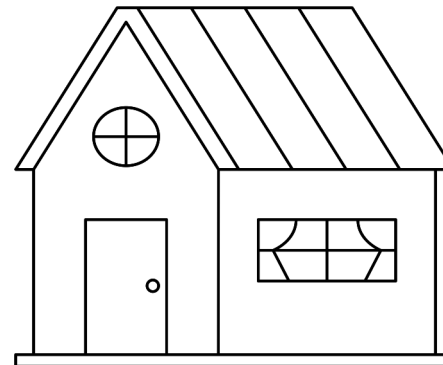
Like a routing officer at a post office or logistics center who decides the best sequence of roads, cities, or hubs to move the letter toward its goal.
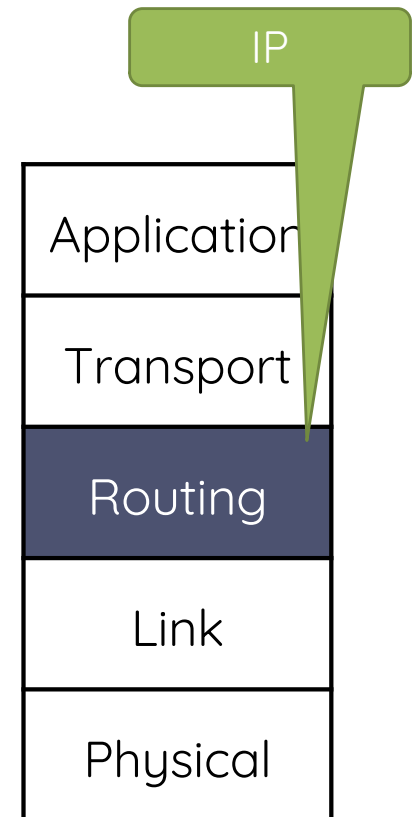
Daily Life Analogy

Link Layer Protocol

Mac Adress

Each Local Delivery

Ethernet

Application
Transport
Routing
Link
Physical
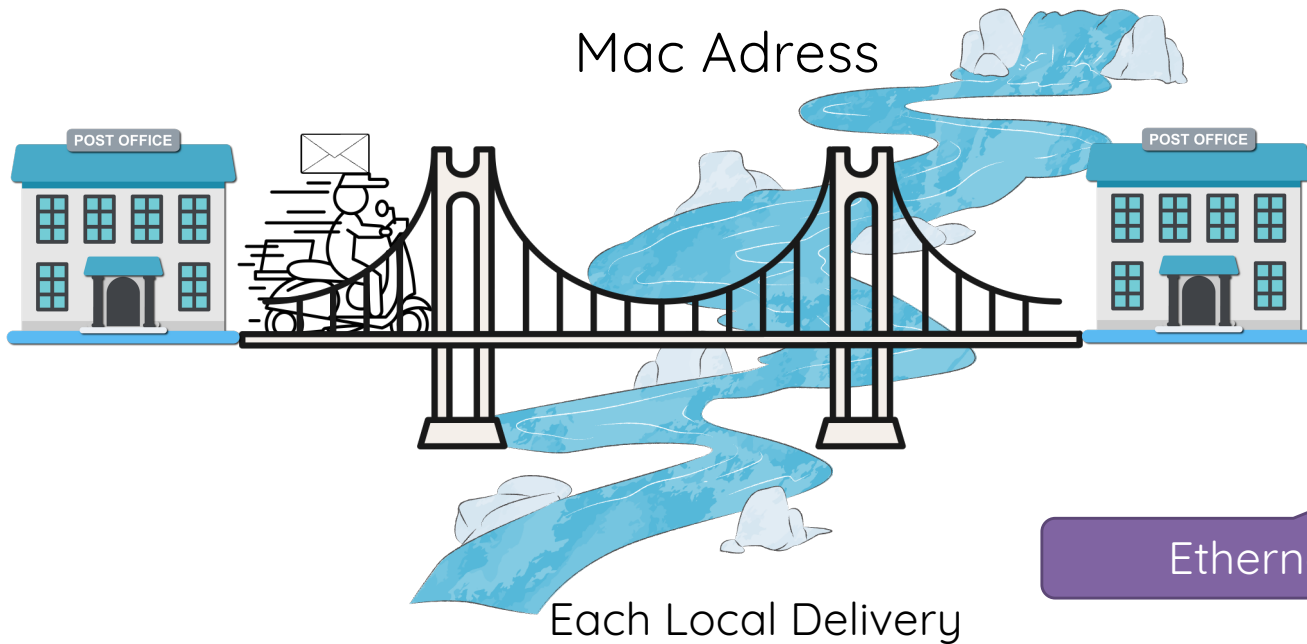
Daily Life Analogy

Physical Layer Protocol

Make sure the letter is in the right container suitable for transport medium.

Application
Transport
Routing
Link
Physical

802.11b/g/n
1000BASE-T

Sending Data through the Stack

As a network of networks, the internet has many routers

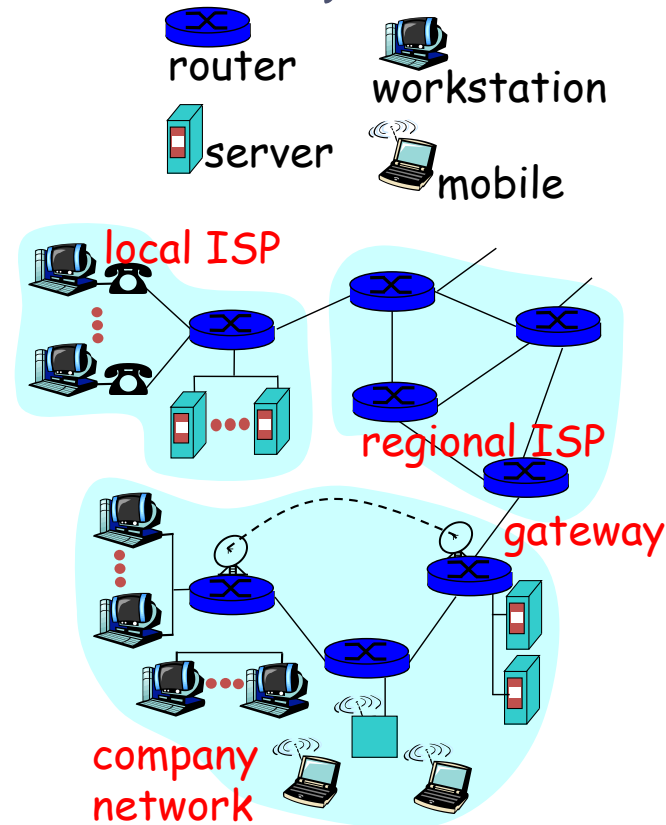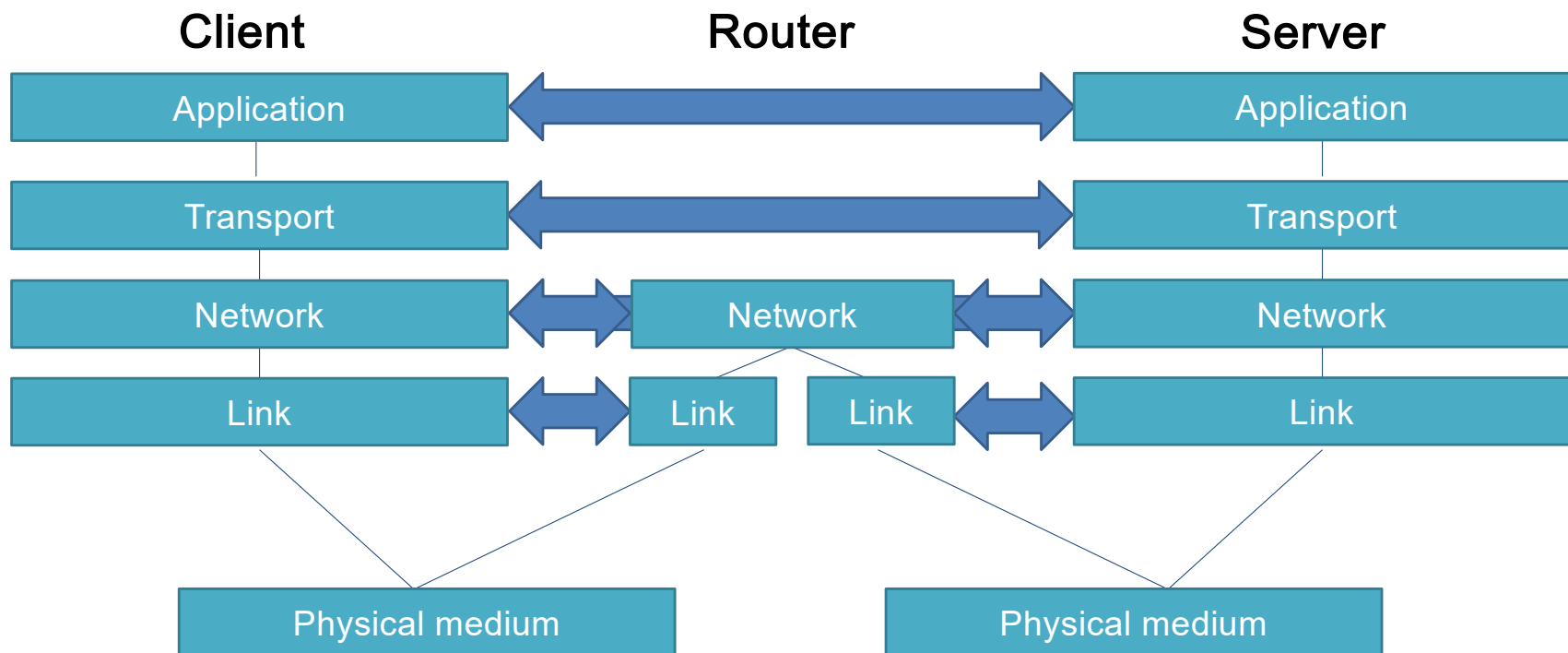# Sending Data through the Stack

Encapsulation

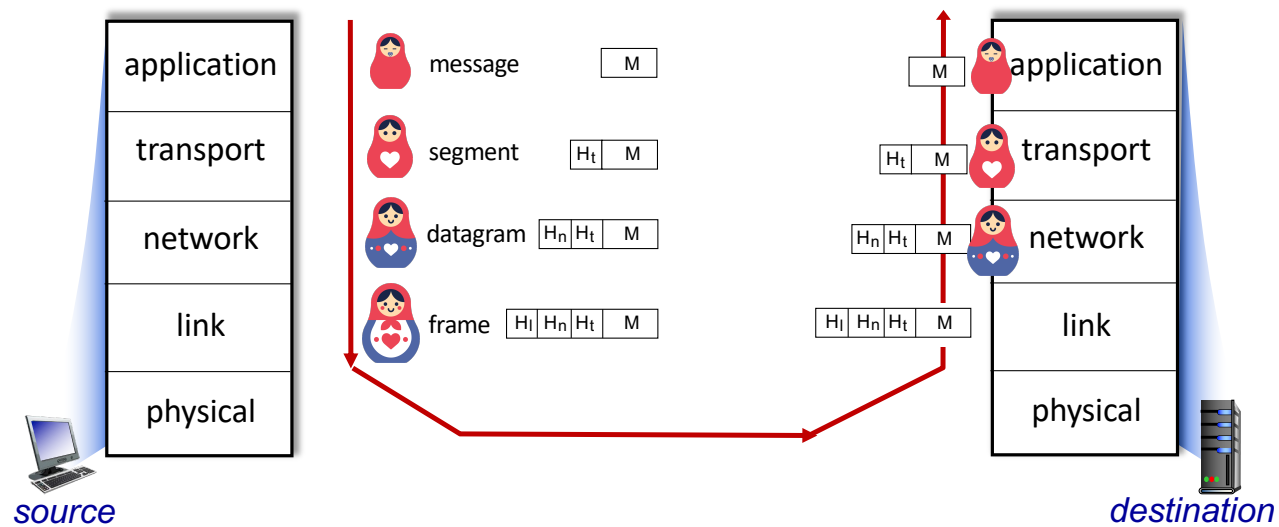Matryoshka dolls (stacking dolls)

message   segment   datagram   frame
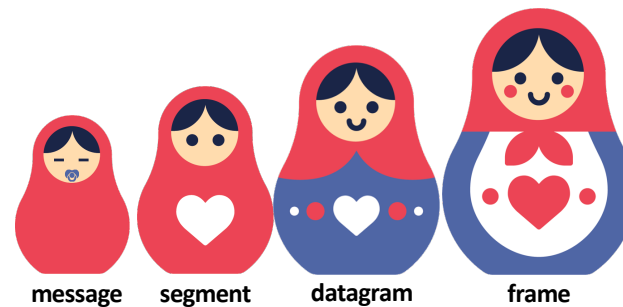
Protocol Layering and Data

- Each layer takes data from above
  - Adds header information to create new data unit
  - Passes new data unit to layer below

Encapsulation

Source

Message			M
Segment		H_t	M
Datagram	H_n	H_t	M
Frame	H_l	H_n	H_t	M

Application
Transport
Network
Link
Physical

Link
Physical

Switch

Destination

			M
		H_t	M
	H_n	H_t	M
H_l	H_n	H_t	M

Application
Transport
Network
Link
Physical

| H_n | H_t | M |
| H_l | H_n | H_t | M |

Network
Link
Physical

| H_n | H_t | M |
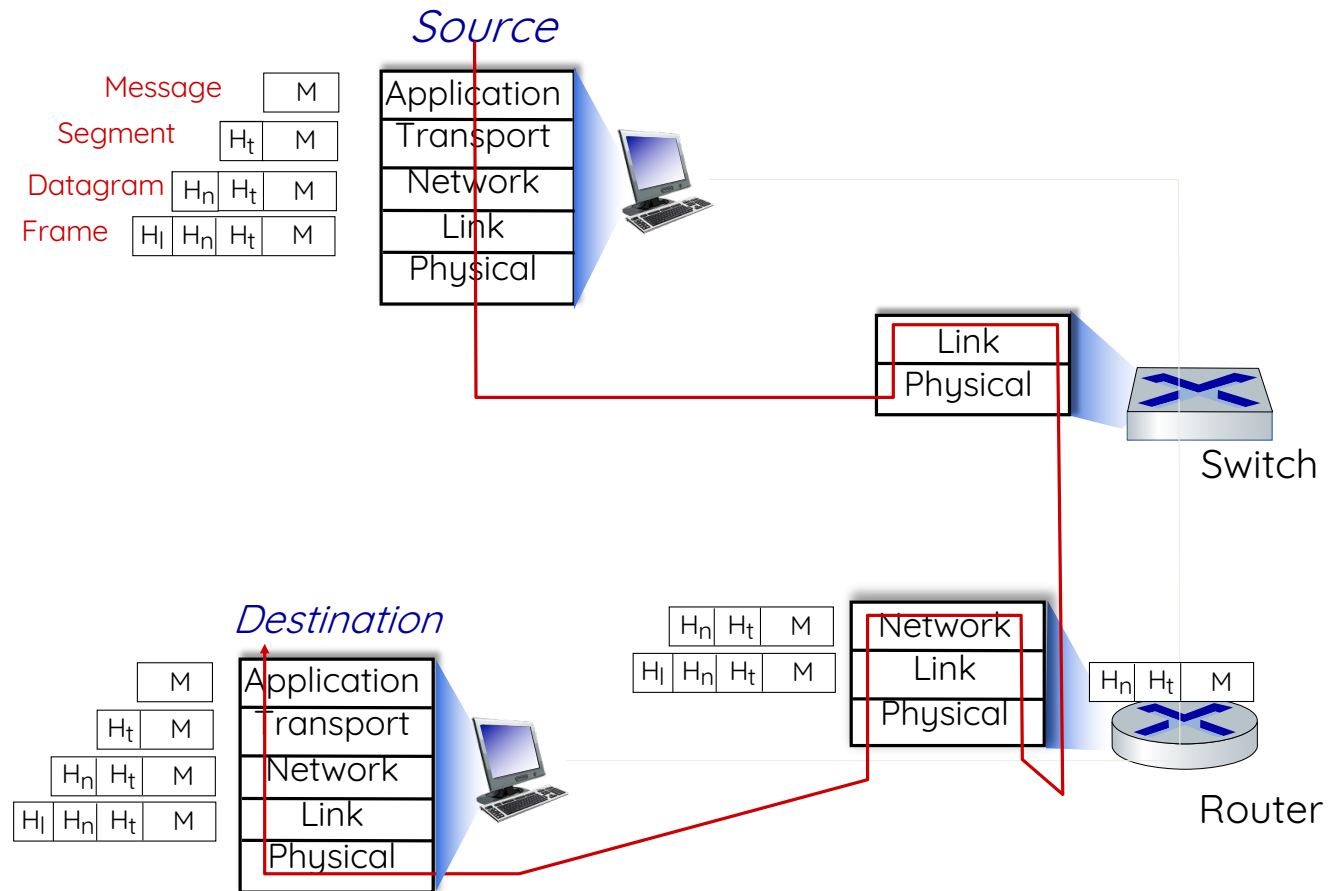
Router

Protocol Stack: Responsibilities

- Transport layer:
  - Identifies process on machine
    - Maybe resource within process (e.g., browser tab)
  - Ensures data arrives in order (if required)
  - Recovers lost data (if required)
- Network layer:
  - Routes datagrams through routers to destination machine
- Link layer:
  - Routes frames to adjacent machines ("direct" connection)
- Physical layer:
  - Encodes data appropriately for the physical medium

Summary of Module 1

- The Internet is a network of networks
  - End systems and routers
- How is data sent?
  - Data is chopped into packets
  - Each packet has its destination address
- Protocol stack
  - Each layer is responsible for a function
  - A protocol layer, in an abstract way, "talks" to a corresponding layer in another machine at the same level
  - Each layer requests services from the layer below it

In-class activity

- Form yourselves into groups (1 – 9 students per group)
- You should be able to chat conveniently in your group
- Go to PrairieLearn
- Click on Assessments
- Start the ICA12 assessment (Protocol Layers)
- Talk in your group about the answers
  - Hearing other students ideas
  - Explaining your ideas to others

Next Topic:
Internet Performance