# CSCE 463/612
# Networks and Distributed Processing
# Spring 2024

## Introduction

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January 24, 2024

# Updates

- Recv loop reminder
  - timeout.tv_usec must be initialized to zero
  - NULL-terminate buf before searching with strchr or strstr

```
while (true) {
  if ((ret = select (0, &fd, ..., &timeout)) > 0)
  {
    // new data available; now read the next segment
    int bytes = recv (sock, buf + curPos, allocatedSize – curPos, ...);
    if (errors)
          // print WSAGetLastError() & return false;
    if (connection closed)
    {
          buf[curPos] = NULL;
          return true; // normal completion
    }
    curPos += bytes;          // adjust where the next recv goes
    if (allocatedSize – curPos < THRESHOLD)
          // realloc() buf to double its size
  }
  else if (timeout)
          // report timeout & return false;
  else
          // print WSAGetLastError() & return false;
}
```

commonly forgotten

# Chapter 1: Roadmap

1.1 What *is* the Internet?

1.2 Network edge

1.3 Network core

1.4 Network access and physical media

1.5 Internet structure and ISPs

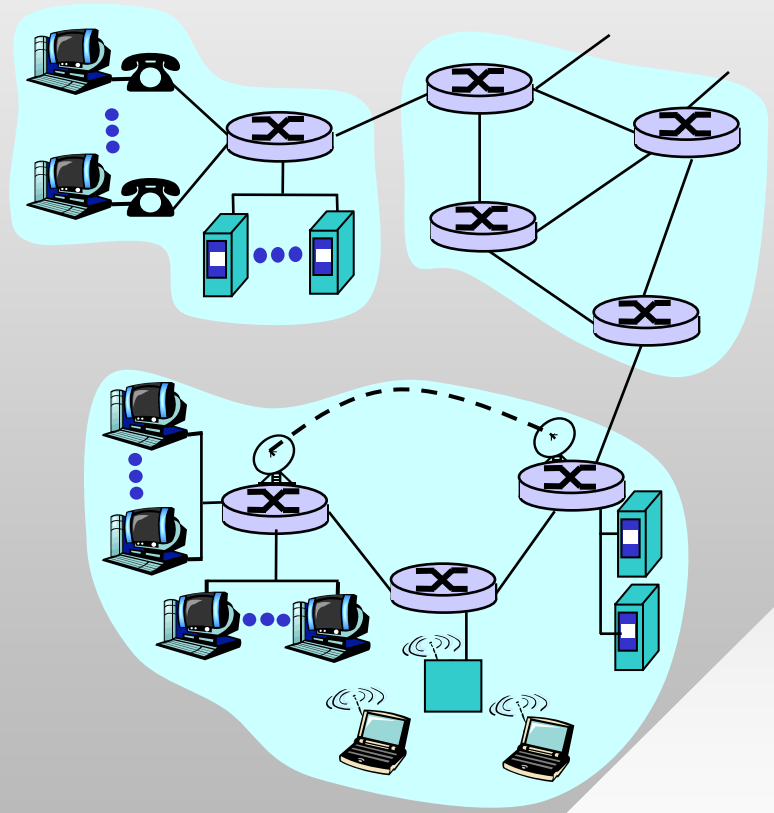
1.6 Delay & loss in packet-switched networks

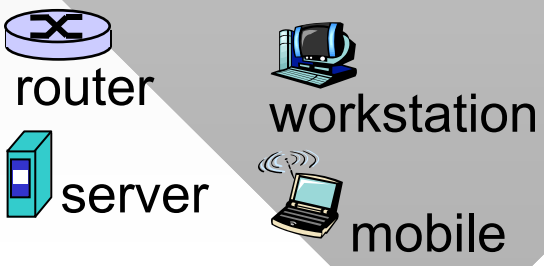
1.7 Protocol layers, service models

1.8 History

# The Internet: "Nuts and Bolts" View

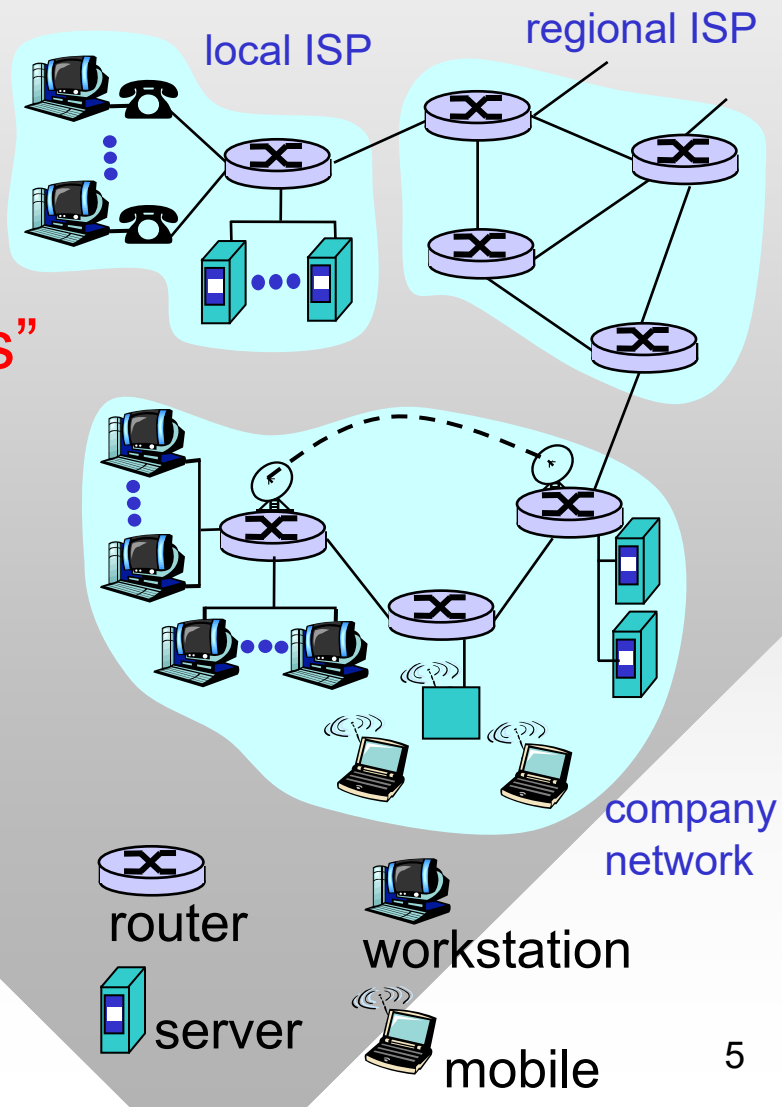
- 1) Hosts (end systems)
  - Computing devices (servers, desktops, phones, laptops)
  - Run network apps
- 2) Routers
  - Forward packets (chunks of data) to destinations
- 3) Communication links
  - Connect hosts & routers
  - Fiber, copper, radio, satellite
  - Transmission rate = bandwidth





# The Internet: "Nuts and Bolts" View

- 4) Protocols
  - Control sending/receiving of messages (e.g., TCP, IP, HTTP, FTP, SMTP)
- *Internet:* "network of networks"
  - Loosely hierarchical
- Who rules the Internet?
  - No single authority, mostly decentralized
- Internet standards
  - IETF: Internet Engineering Task Force
  - RFC: Request for comments



# What's a Protocol?

Human protocols:

- "What's the time?"
- "I have a question"
- Introductions

… specific msgs sent

… specific actions taken when msgs received or other events take place

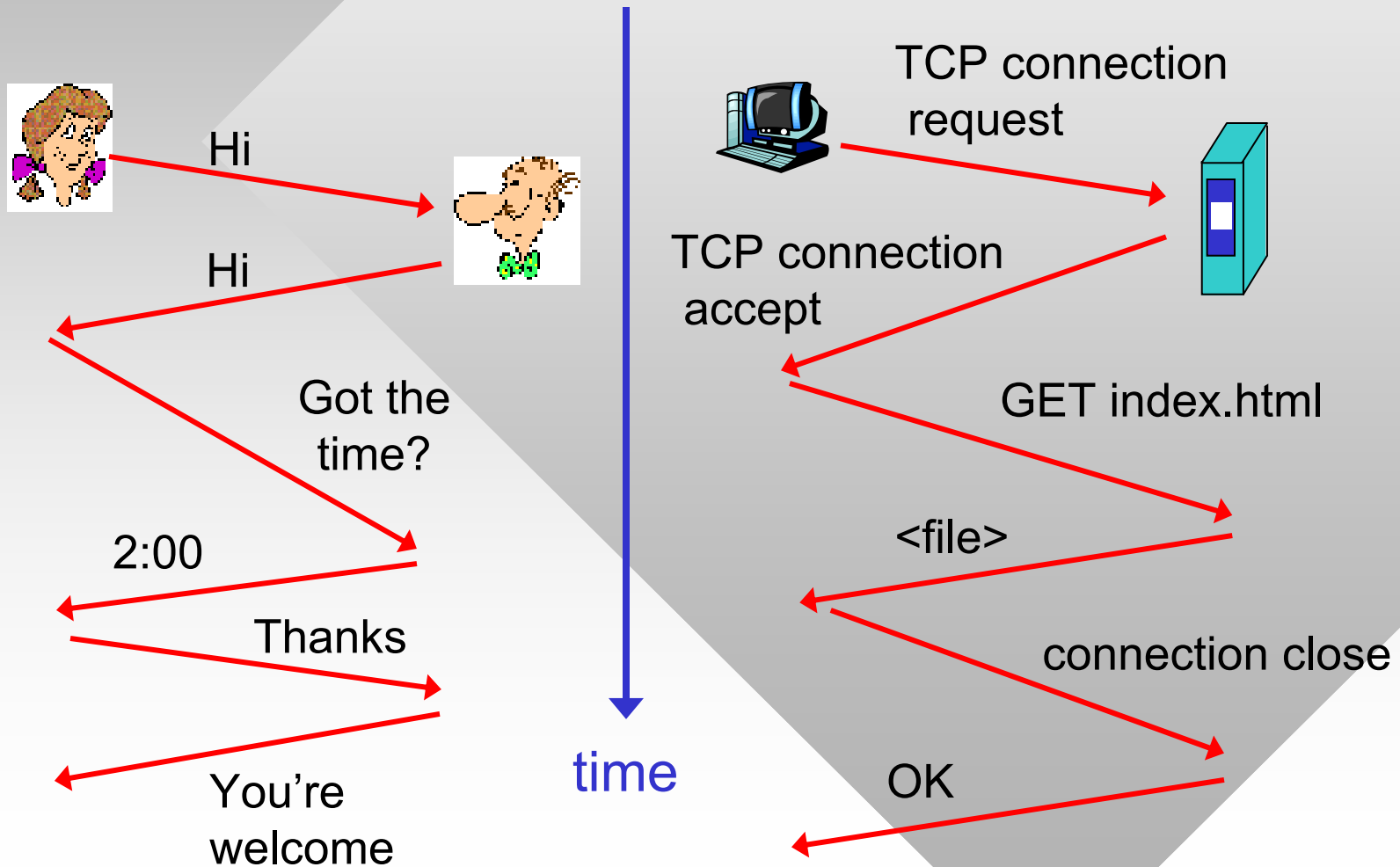
Network protocols:

- Machines rather than humans
- All communication activity in the Internet governed by protocols

*Protocols define format, order of messages sent and received among network entities, and actions taken on message transmission/receipt*

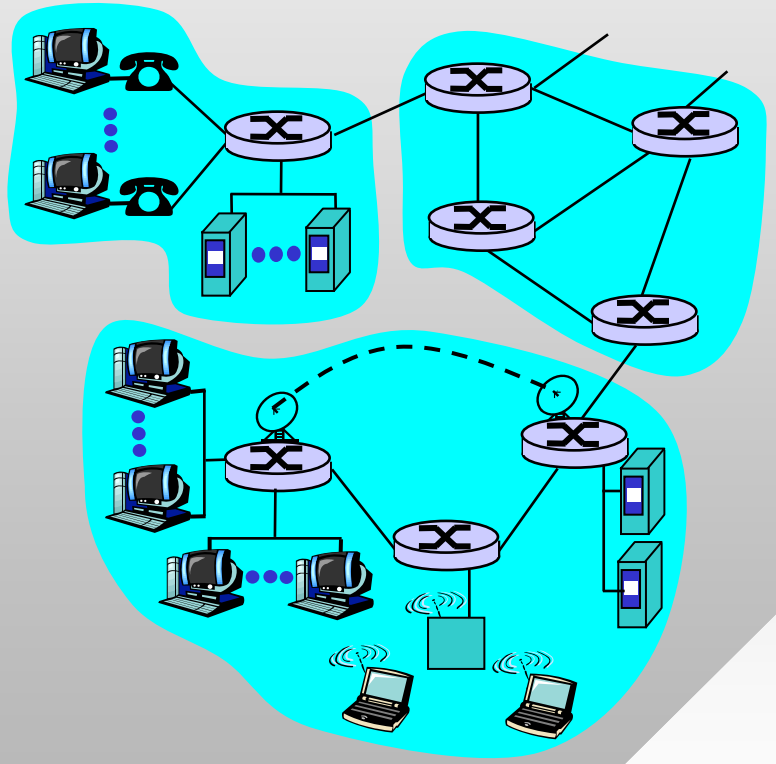
# What's a Protocol?

A human protocol and a computer network protocol:



# Closer Look at Network Structure

- Network edge:
  - Applications and hosts
- Network core:
  - Routers
  - Links
- How large is the edge?
  - Billions of hosts, trillions of web pages, zettabytes of information
- Large ISPs form the Internet backbone
  - Terabits per second router speed



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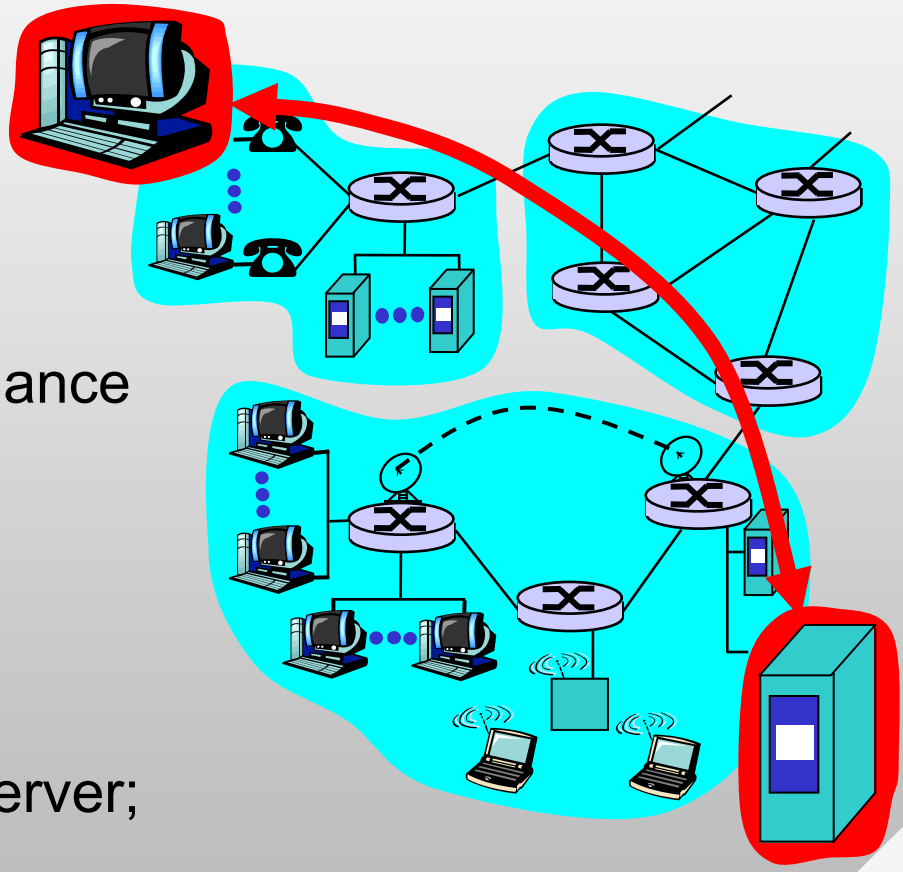
# Network Edge

- The edge:
  - Responsible for almost all data supply/demand
  - Protocols impact performance
- Client/server model
  - Client host requests, receives service from always-on server
  - Example: web browser/server; email client/server
- Peer-to-peer (P2P) model:
  - Minimal use of dedicated servers; user hosts talk to each other
  - Example: BitTorrent



# Network Edge: Reliable Service

- Goal: data transfer between sockets
- TCP – Transmission Control Protocol
  - Internet's reliable service
- Connection-oriented
  - *Handshaking:* send connection messages (prepare) for data transfer ahead of time
  - Set up *state* in two communicating hosts

TCP service [RFC 793]

- *Reliable, in-order* byte-stream data transfer
  - Packet loss handled through acknowledgements and retransmissions
- *Flow control:*
  - Sender won't overwhelm receiver
- *Congestion control:*
  - Senders reduce transmission rate when network becomes congested

# Network Edge: Unreliable Service

- Goal: data transfer between sockets
  - Same as before!
- UDP – User Datagram Protocol [RFC 768]:
  - Connectionless
  - Unreliable data transfer
  - No flow control
  - No congestion control
- Less overhead and delay
  - TCP connection setup & termination is 7 packets
  - TCP retransmission delay is potentially unbounded

Apps using TCP:

- HTTP (Web), FTP (file transfer), SSH (remote login), SMTP (email)

Apps using UDP:

- DNS, SNMP
  - Short (single-packet) transfers
  - No need for congestion management
- Streaming media, online games, IP telephony
  - More sensitive to delay than packet loss

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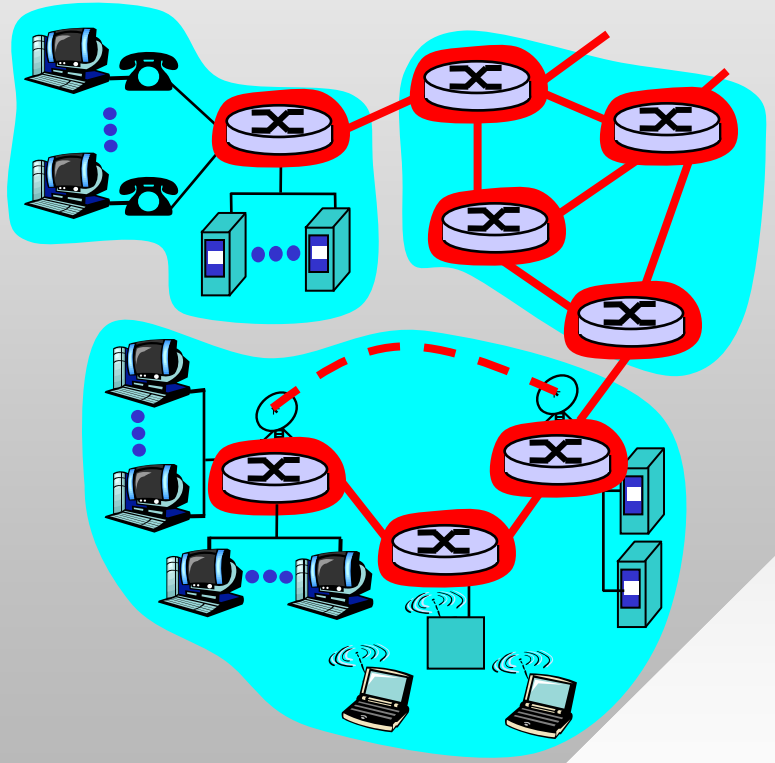
# The Network Core

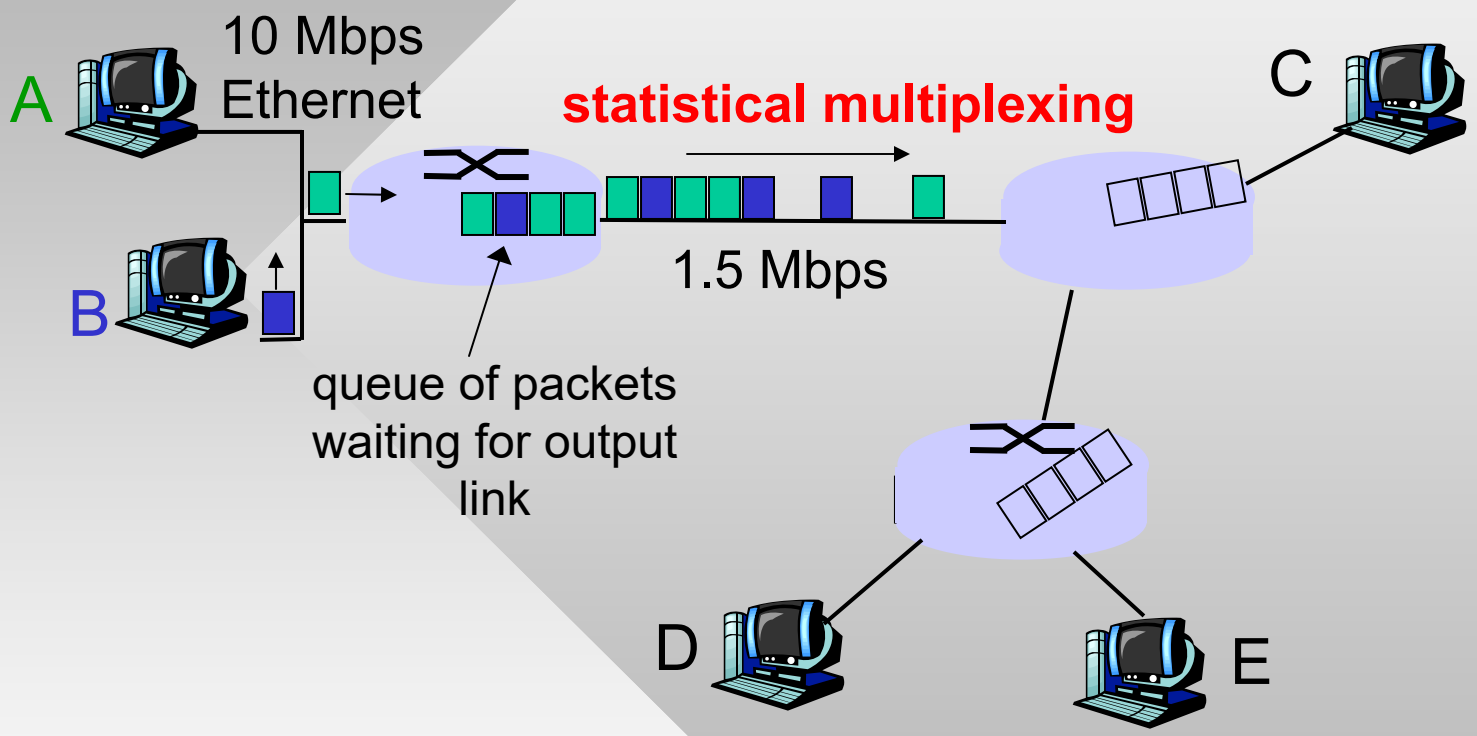
- Supports end-host communication
- Fundamental question: how is data transferred through the network?
  - Circuit switching: dedicated circuit per call (telephone network, origin 1800s)
  - Packet-switching: data sent in discrete “chunks” (1960s)
- Notation
  - Call = connection = flow



# Network Core: Packet Switching

- End-to-end data stream divided into *packets*
  - Packets of users A and B *share* network resources
  - Each packet uses full link bandwidth
- Resource contention:
  - Aggregate resource demand can exceed amount available
  - Congestion: packets queue, wait for link use
- Store-and-forward:
  - Packets move one hop (router) at a time
  - Node receives complete packet before forwarding

# Packet Switching: Statistical Multiplexing

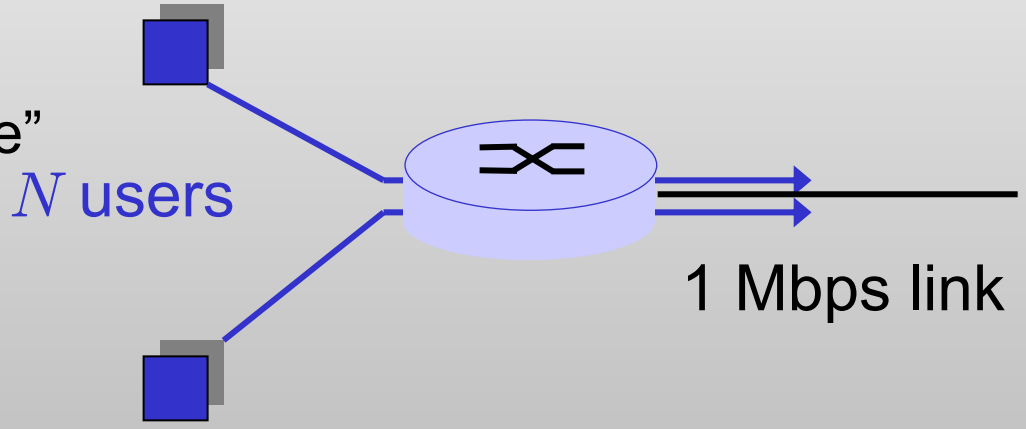



- Sequence of A's and B's packets does not have a fixed pattern ➔ ***statistical multiplexing***

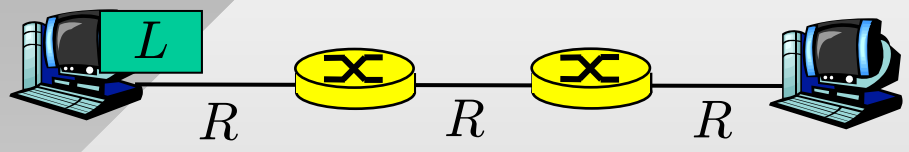
# Packet Switching vs. Circuit Switching

Packet switching allows more users than circuit switching

- 1 Mbps link
- Each user:
  - 100 Kbps when “active”
  - Active 10% of time
- Circuit-switching:
  - Supports 10 users
- Packet switching:
  - With 35 users, probability that more than 10 are active is 0.0424%; with 50 users – 0.94%
  - Max 100 users (if perfectly interleaved)



# Packet Switching: Store-and-Forward




- Takes $L/R$ seconds to transmit (push out) packet of $L$ bits on to link of $R$ bps
- Entire packet must arrive at router before it can be transmitted on next link: *store and forward*
- Path delay $= 3L/R$

Example:

- $L = 7.5$ Mbits
- $R = 1.5$ Mbps
- End-to-end delay $=$ $15$ sec