

CPSC 317 – Winter 1 2025

Introduction to Computer Networking

Design of the Internet

Module 1.1

Norm & Ibtissem

READING

- Reading: Chapter 1 Intro, 1.1, 1.2, 1.3, 1.5, 1.7

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

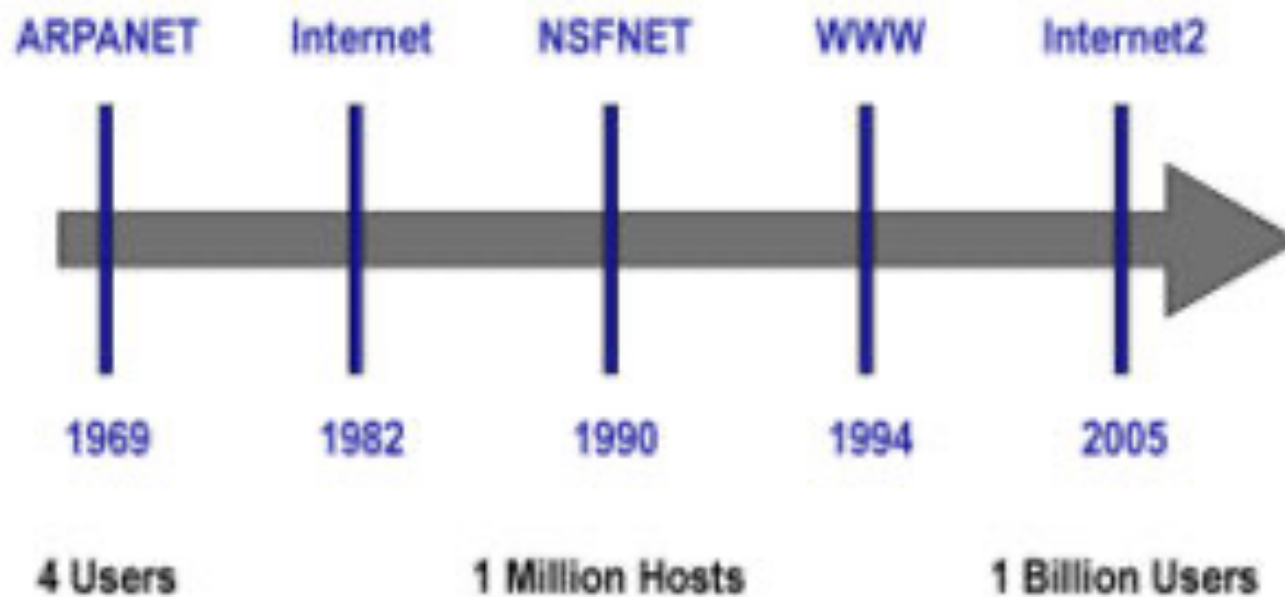
What is the Internet?

The Internet is the **global system** of interconnected computer networks that use the **Internet protocol suite** (TCP/IP) to communicate between networks and devices. It is a **network of networks** that consists of **private, public, academic, business, and government networks** of local to global scope, linked by a broad array of electronic, wireless, and optical networking technologies. The Internet carries a vast **range of information resources and services**, such as the inter-linked hypertext documents and applications of the World Wide Web, electronic mail, telephony, and file sharing.

Network of Networks

Wikipedia 2024

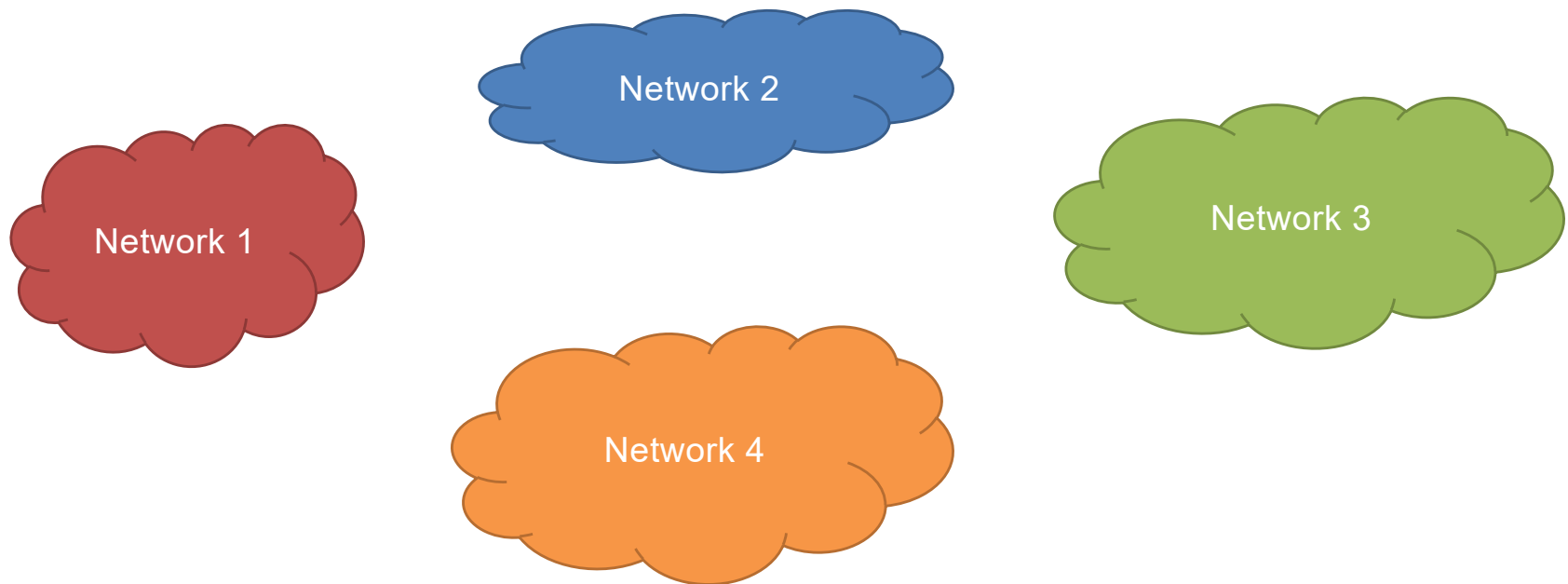
History of the Internet (American)



The number of connected devices in 2021 was 46 billion and in 2025, it will be 80 billion.

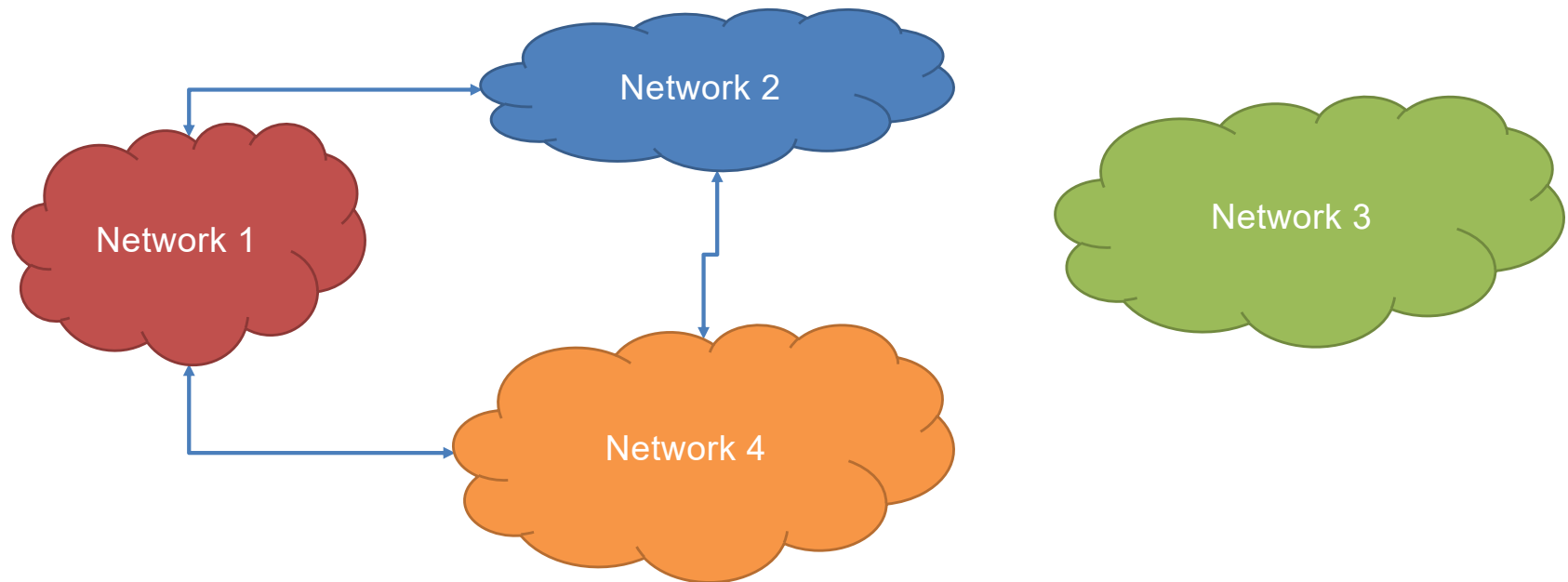
In the Beginning...

- Imagine a bunch of private networks



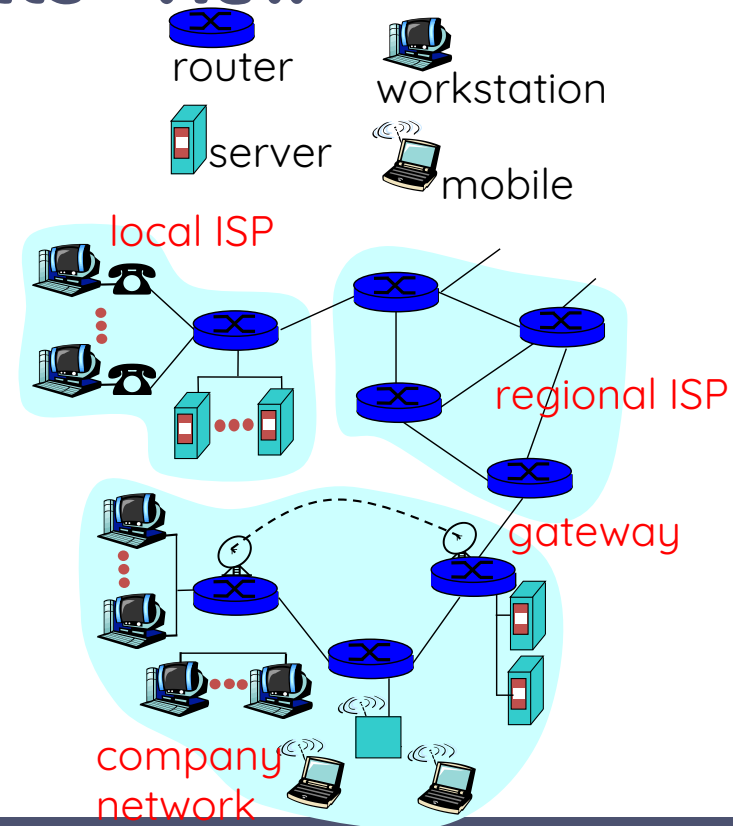
Networks start to Interconnect

- Internet: Network of networks



The Internet: “nuts and bolts” view

- ❑ billions of connected computing devices:
 - hosts, end-systems*
 - ❑ PCs workstations, servers
 - ❑ smartphones, toasters, IoT
 - ❑ running *network apps*
- ❑ *communication links*
 - ❑ fiber, copper, radio, satellite
 - ❑ varying *bandwidth/latency*
- ❑ *routers*: forward packets (chunks of data)
- ❑ regional, local, company networks



Internet Goals

- Main goal:
 - integrating a number of separately administrated entities into a common entity
- Secondary goals:
 - Must continue despite loss of the network or gateway
 - Must support multiple types of services (applications)
 - Must support multiple types of networks
 - Distributed management of resources
 - Cost effective
 - Easy host attachment
 - Resources must be accountable

Communication

Necessary conditions:

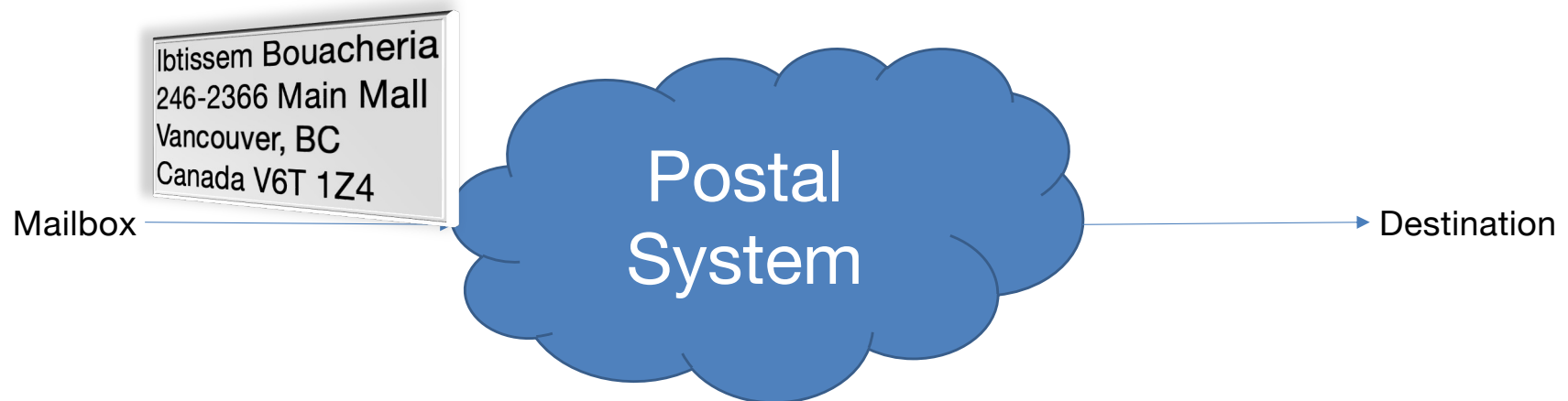
- a communication **medium**: modulation of some medium (e.g., air, wire, fibre)
- **source(s)** and **destination(s)**
- **protocol**: shared information (language)
- **message**: information sent from source to destination on a medium using a protocol

Large Scale “Communication” Systems

- Telephone / Telegraph
- Mail
- Package delivery (Canada Post, DHL, Amazon)

An Analogy: Mail Delivery

- What makes up a postal address?
 - What needs to be listed in the envelope?



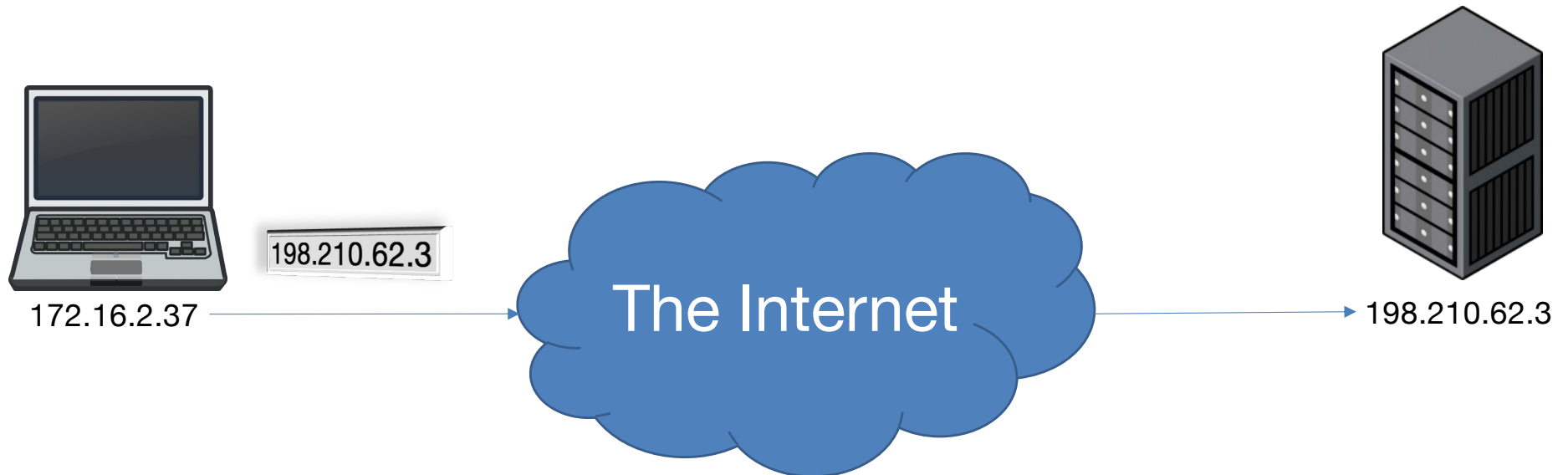
Another Analogy: Phone SYSTEM

- What makes up a phone system address?



How does this Translate to the Internet?

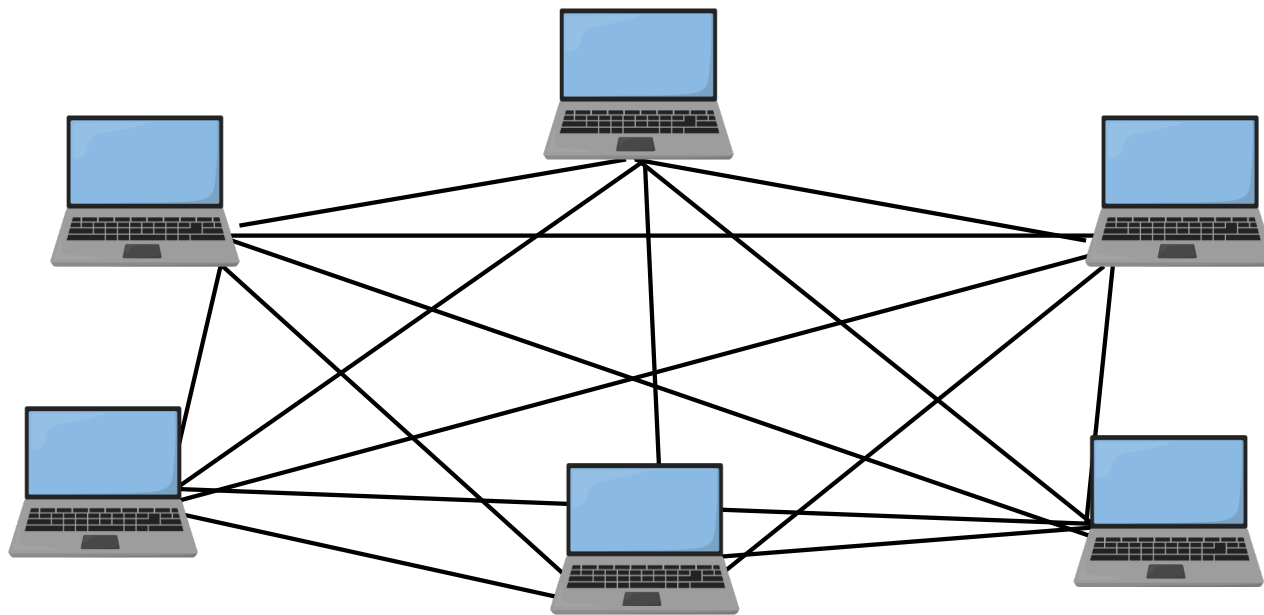
- What makes up an Internet Address?



Clicker Question

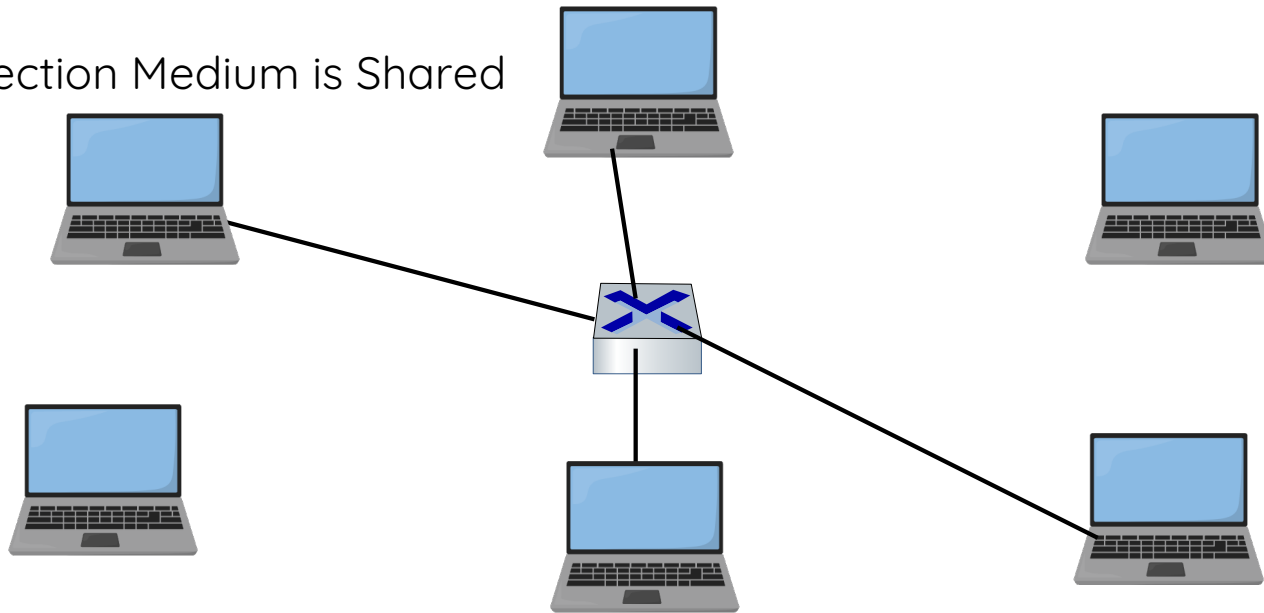
How do you think IP addresses are organized? Or in other words, how are A.x.y.z and A.u.v.w or (A.B.C.x and A.B.C.y) close together? [A,B,C: constants; u,v,w,x,y,z: variables]

- A. Geographically
- B. By organization (company, university, government, etc.)
- C. By Fully-Qualified Domain Name (thetis.cs.ubc.ca, www.amazon.com, etc.)
- D. There is no organization, it is essentially random



A Switched network

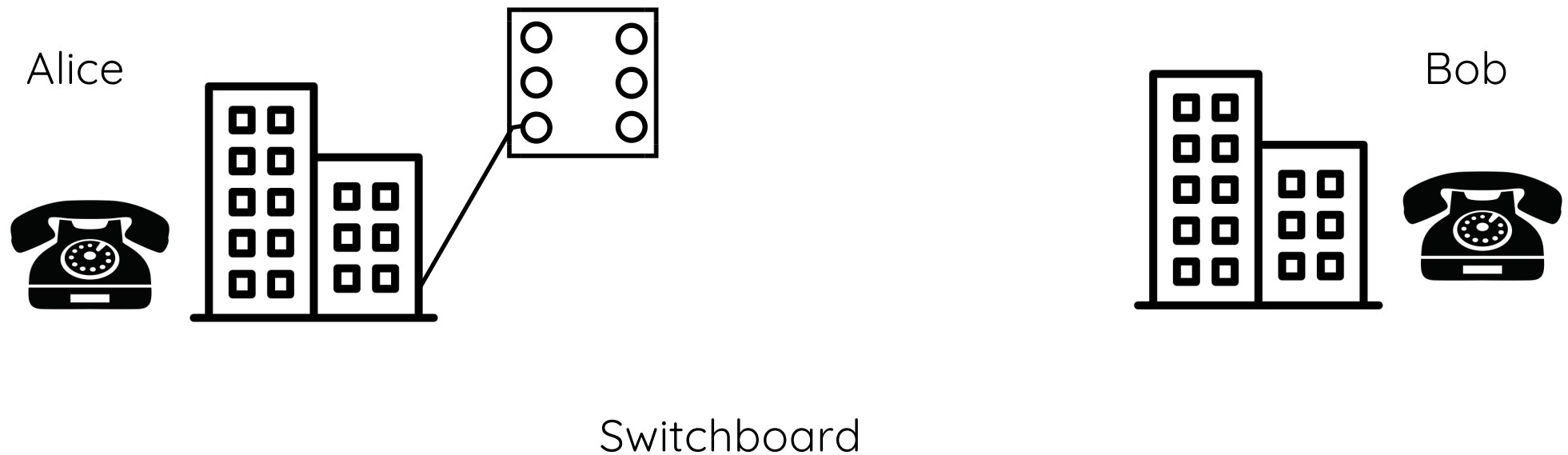
The Connection Medium is Shared

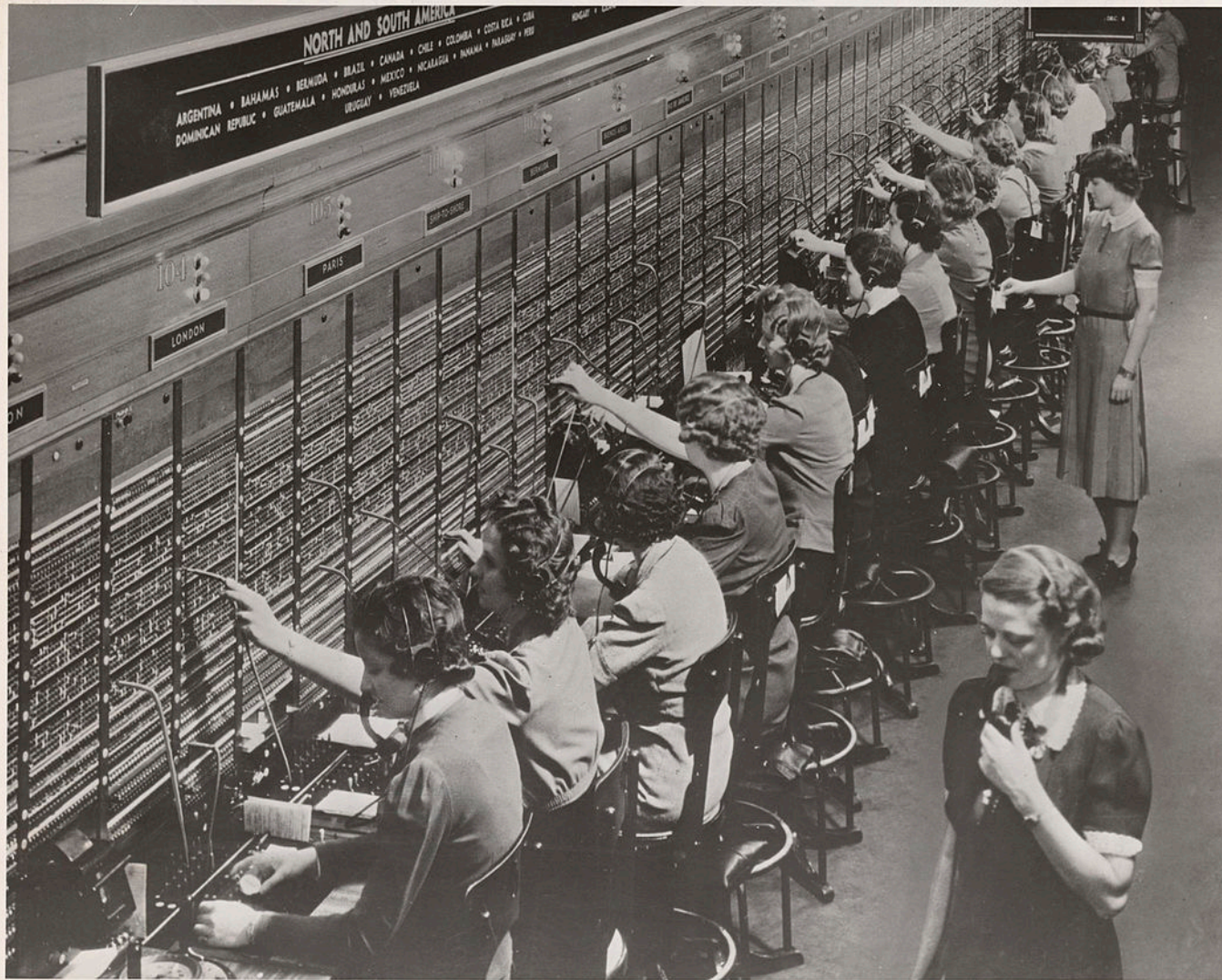


Multiplexing

- Data flows need to be “multiplexed”
 - Multiple input streams must share the medium
 - It must be possible to “demultiplex” at the destination

How is Data Sent? Option 1: Circuit switching



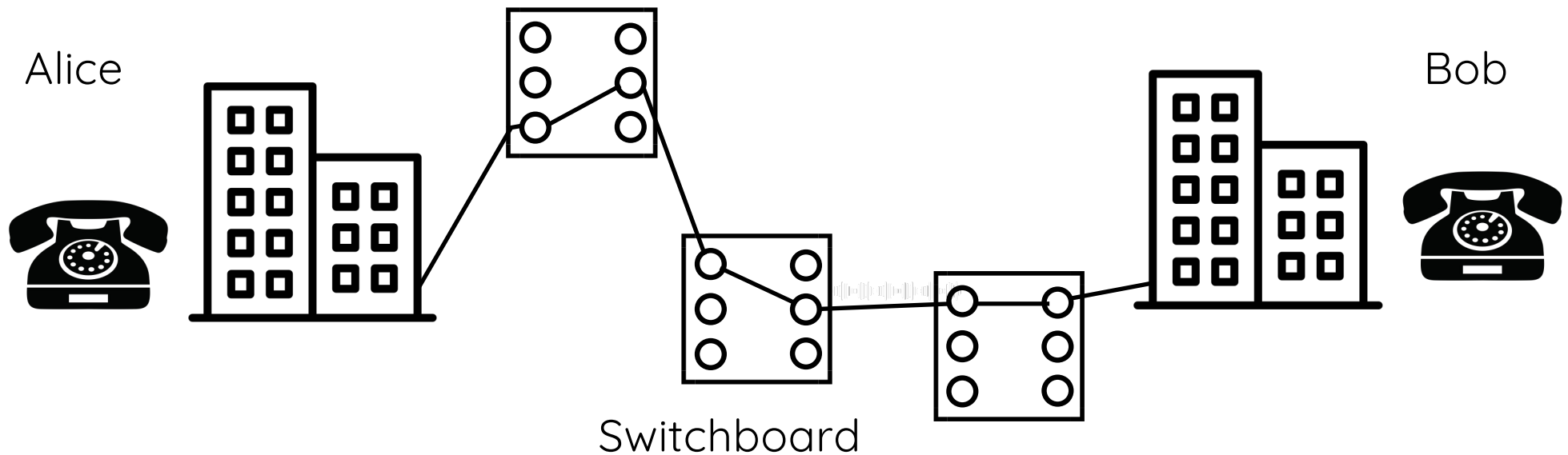


Circuit Switching

By The U.S. National Archives
- Photograph of Women Working at a Bell System Telephone Switchboard This media is available in the holdings of the National Archives and Records Administration, cataloged under the ARC Identifier (National Archives Identifier)

1. Circuit switching

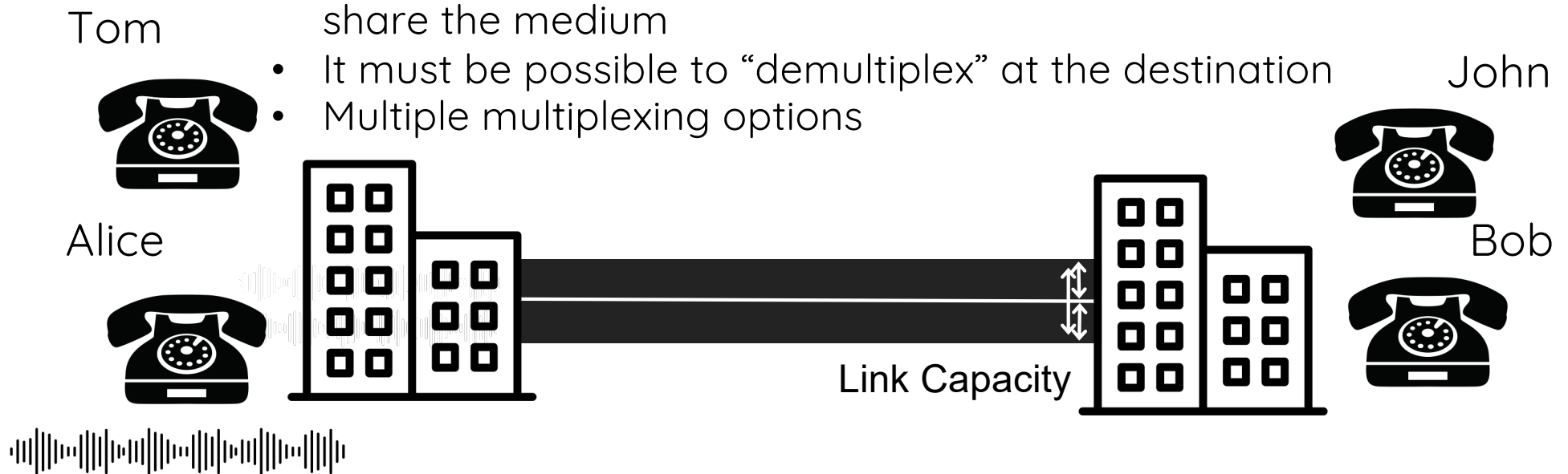
- Dedicated path between source and destination
- The path the data will take is determined when the connection is established





Circuit switching

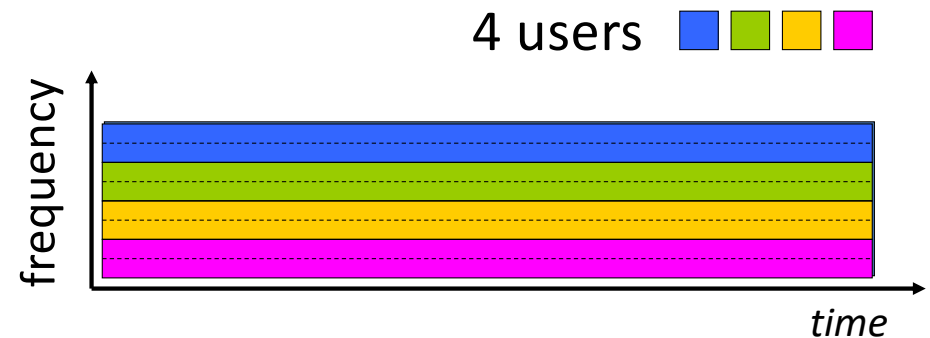
- Single stream of information per path
- Data flows need to be “multiplexed”, Multiple input streams must share the medium
- It must be possible to “demultiplex” at the destination
- Multiple multiplexing options



Multiplexing – Circuit switching: FDM and TDM

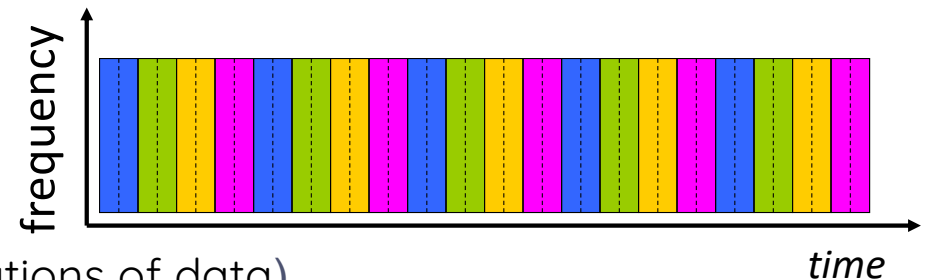
Frequency Division Multiplexing (FDM)

- optical, electromagnetic frequencies divided into (narrow) frequency bands
- each call allocated its own band, can transmit at max rate of that narrow band



Time Division Multiplexing (TDM)

time divided into slots



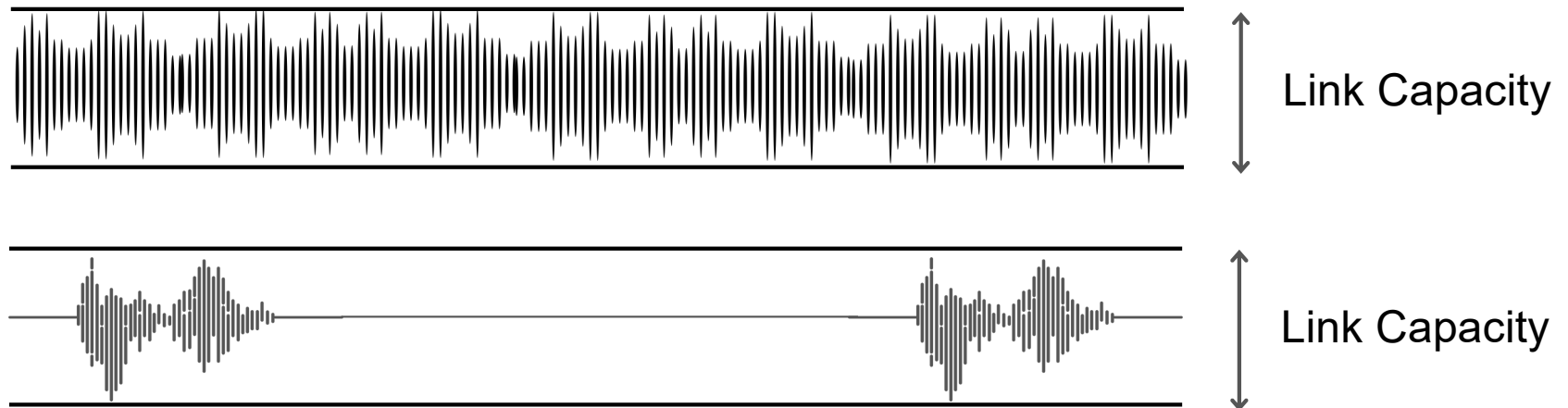
Code division multiplexing (different representations of data)

Orthogonal multiplexing (combination of techniques)

Circuit switching

- Pros
 - Guaranteed performance once the circuit was established.
 - Immediate data transmission once the call began. No delay for each message
- Cons

Circuit switching

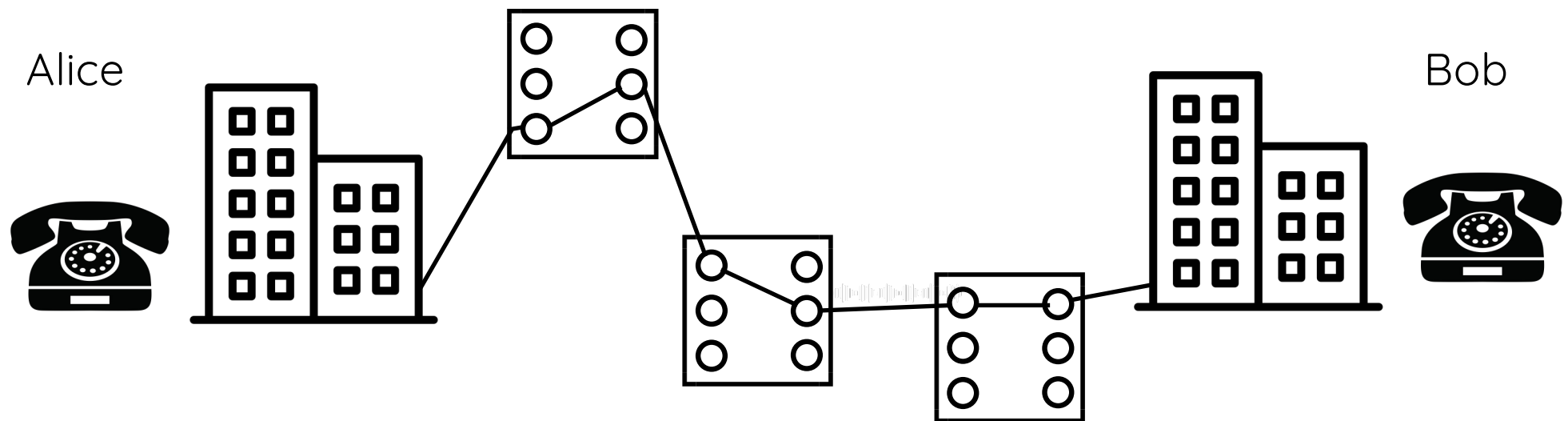


How about bursty traffic ?

Circuit switching

- Pros
 - guaranteed performance
 - fast transfers (once circuit is established)
- Cons
 - wastes bandwidth if traffic is “bursty”

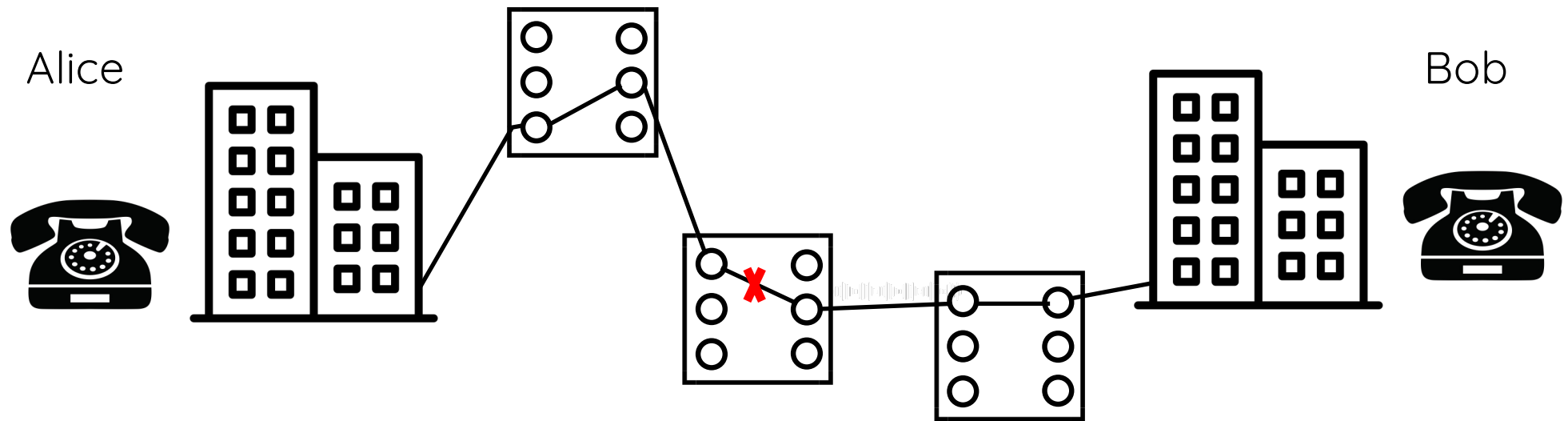
Circuit switching



Circuit switching

- Pros
 - guaranteed performance
 - fast transfers (once circuit is established)
- Cons
 - wastes bandwidth if traffic is “bursty”
 - connection setup time is overhead

Circuit switching

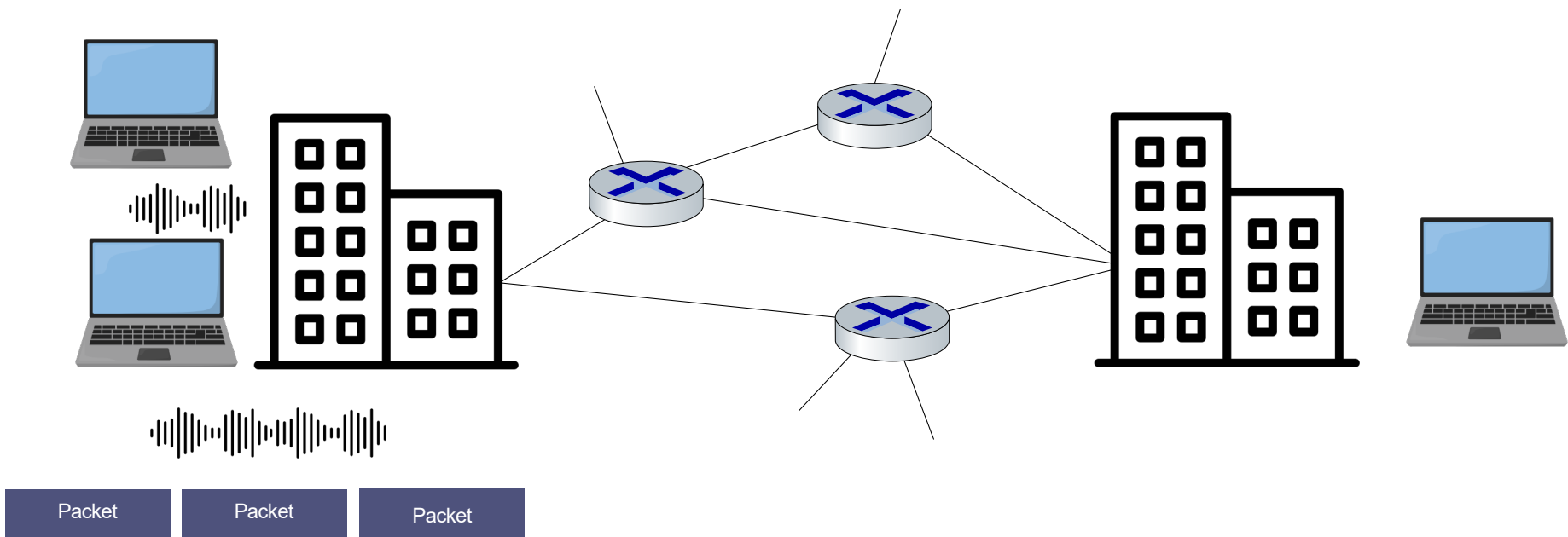


Circuit switching

- Pros
 - guaranteed performance
 - fast transfers (once circuit is established)
- Cons
 - wastes bandwidth if traffic is “bursty”
 - connection setup time is overhead
 - Poor fault tolerance

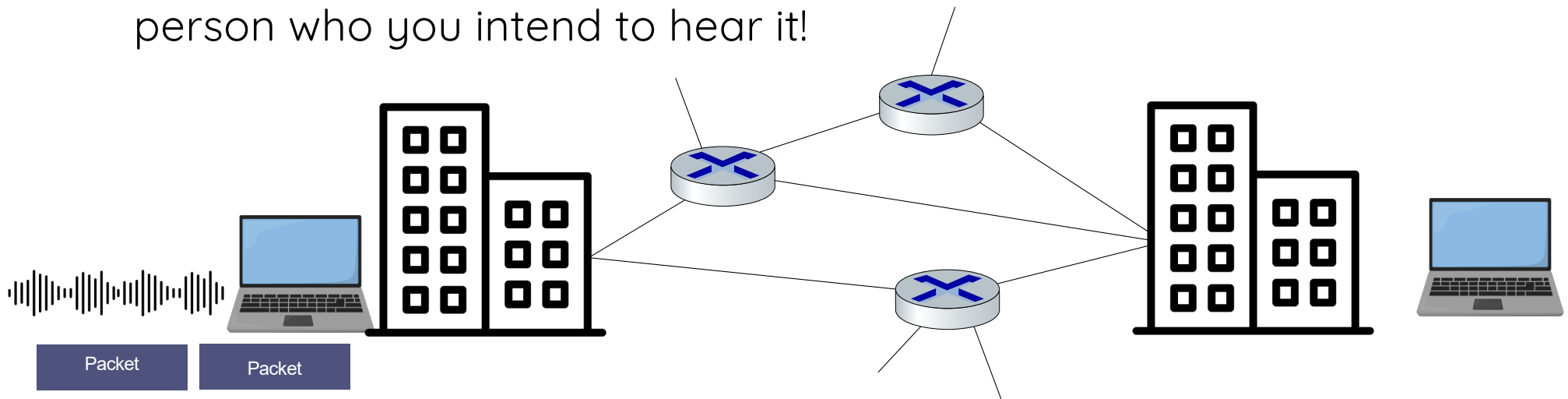
How is Data Sent? Option 2: Packet switching

- Data is divided in packets (small chunks of data) that are sent individually



2. Packet switching

- A much less “obvious” option
 - Initially, many people thought it wouldn’t work at all
 - Imagine if each word you speak had to be addressed to the person who you intend to hear it!

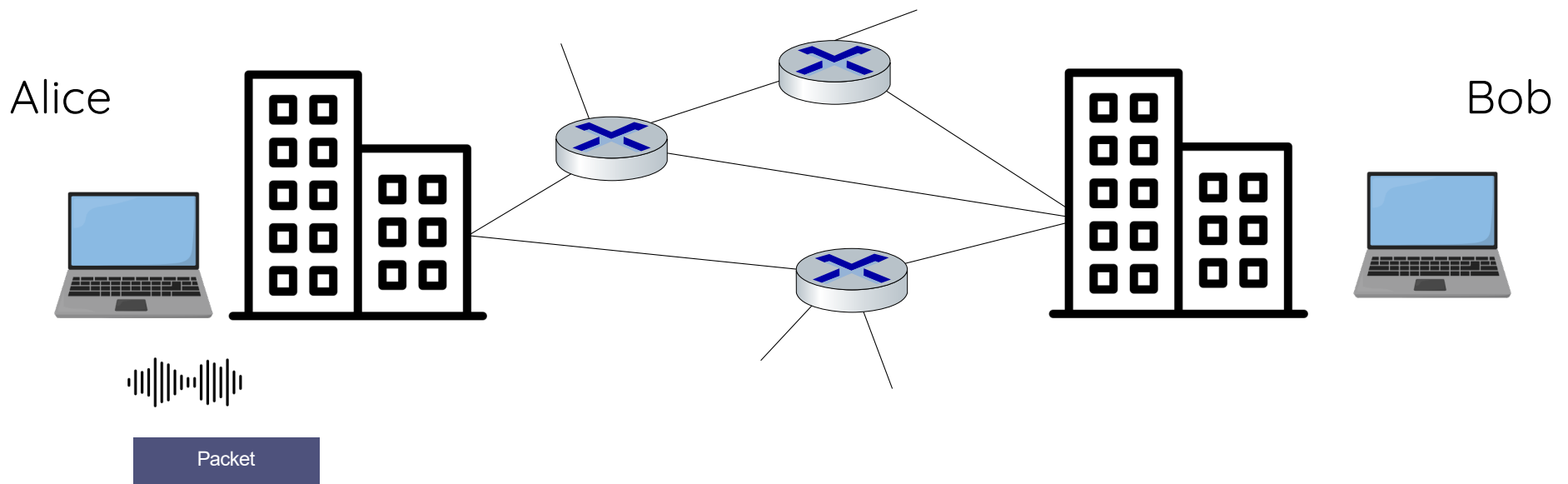


IClicker Question

- Which of the following DOES NOT need to be included in a self contained Internet packet?
 - A. Its source address
 - B. Its destination address
 - C. The route it needs to take to get to the destination
 - D. An indication of ordering (for data with multiple parts)
 - E. All of the above need to be included

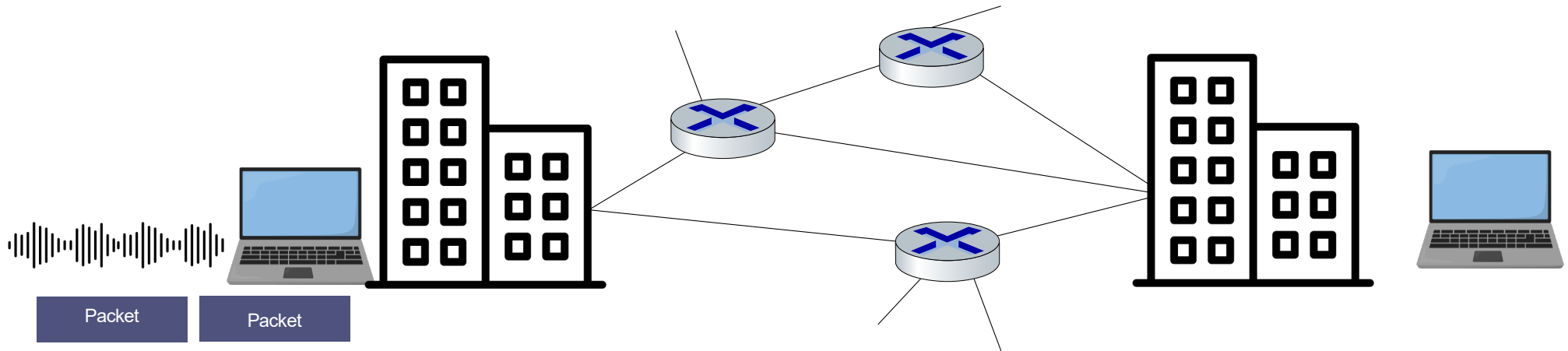
2. Packet switching

- Each packet is self-contained: it contains a header as well as payload (data)
- Independently routed from source to destination



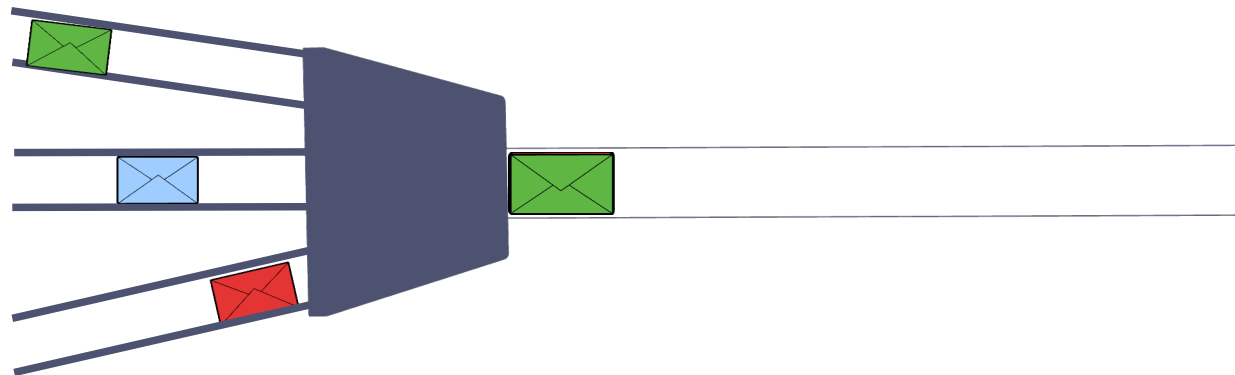
2. Packet switching

- Works well when
 - Statistically good performance is good enough

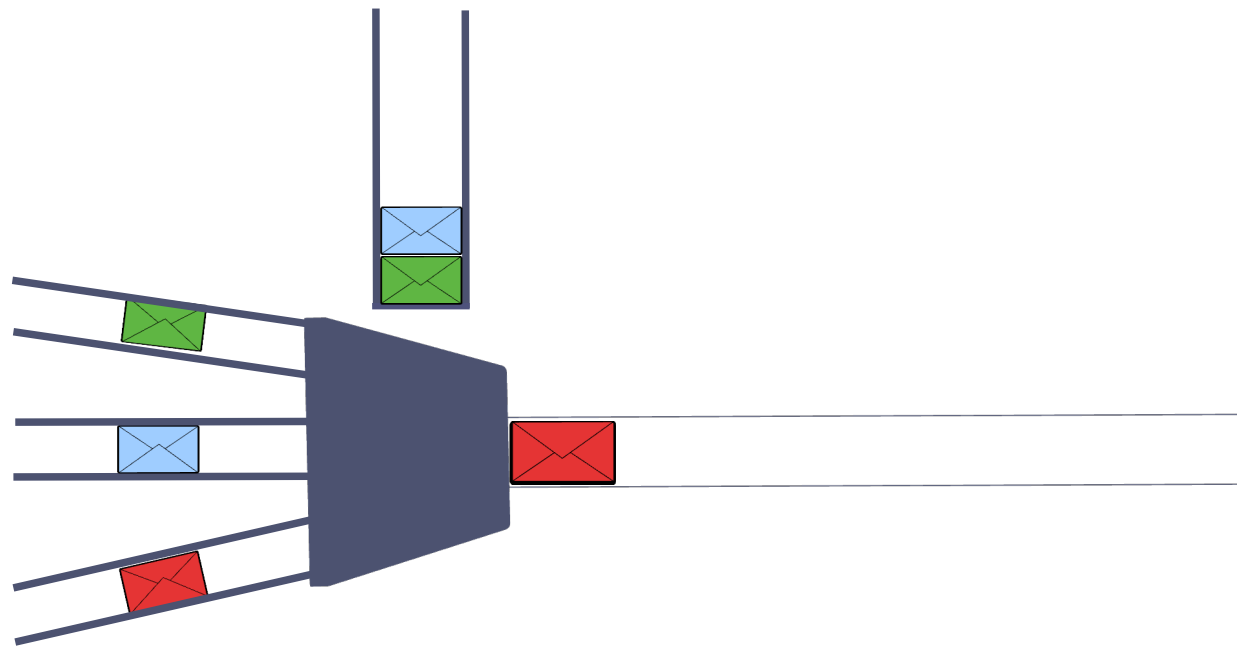


2. Packet switching

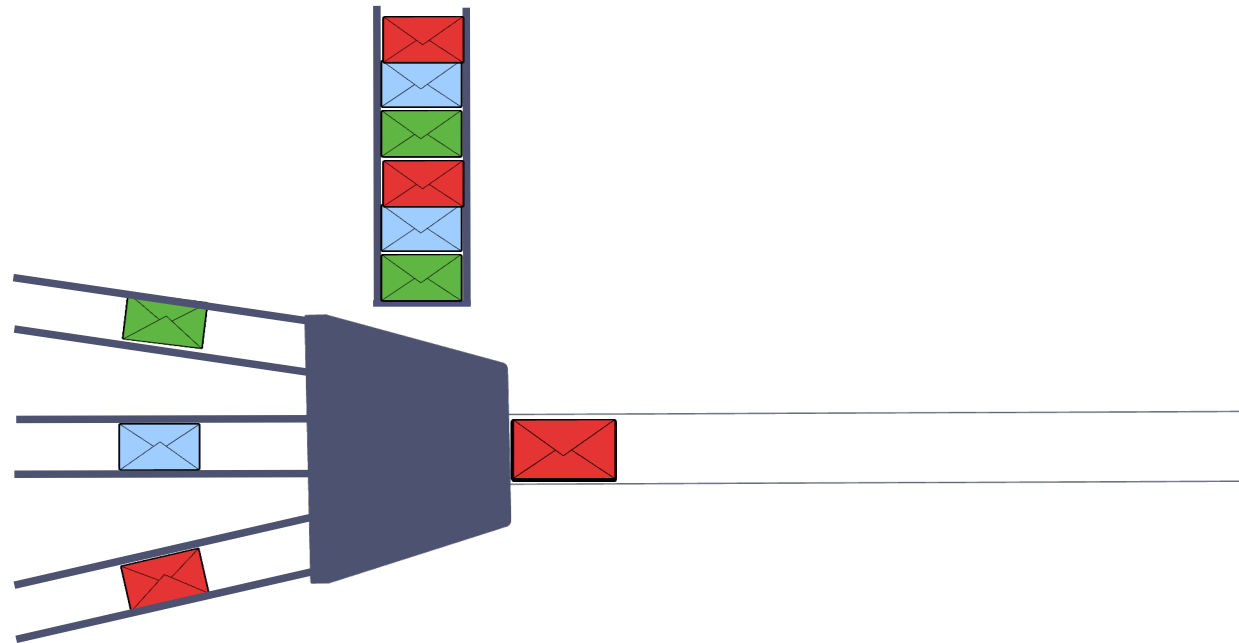
- Works well when
 - Statistically good performance is good enough
 - Demand is bursty (rapidly changing rate)
 - Starting a new conversation is frequent



2. Packet switching



2. Packet switching



Overall, allows more conversations and better utilization of the medium

Summary

- The Internet is a network of networks
- Its design goals include: reliability, flexibility, decentralized management, cost effectiveness, accountability
- Circuit switching vs packet switching

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 ICA11 assessment (Circuit vs Packet Switching)
- Talk in your group about the answers
 - Hearing other students ideas
 - Explaining your ideas to others

Next Topic: Switching and Protocols