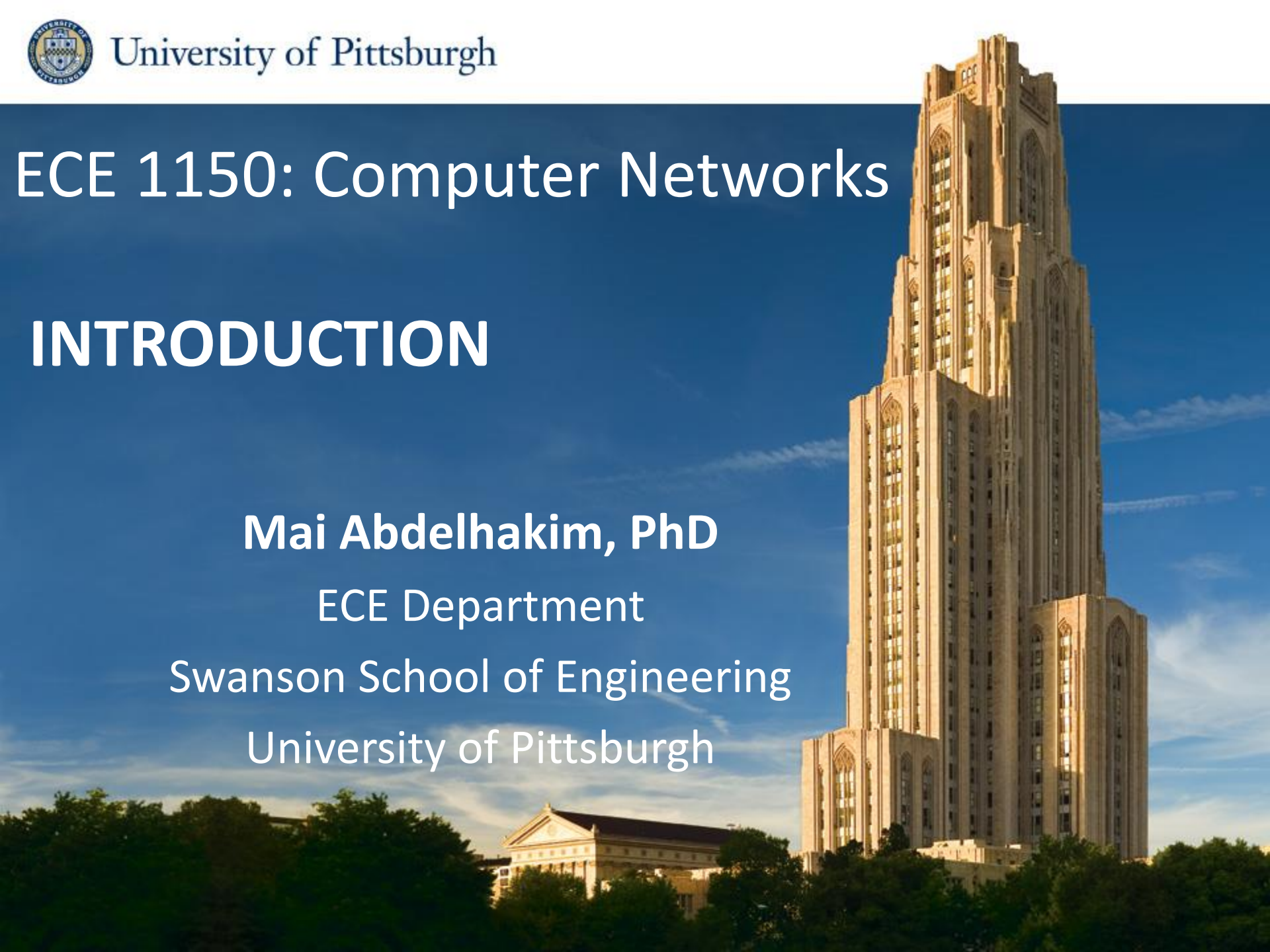


University of Pittsburgh

ECE 1150: Computer Networks

INTRODUCTION

Mai Abdelhakim, PhD

ECE Department

Swanson School of Engineering

University of Pittsburgh

Course Objectives

- Provides **essence and fundamentals of communication networks**
  - Learn terminology
  - Learn system context
  - Learn basics about underlying technologies

- Learn how **Internet** works

Course Objectives

- Perform **analysis** of communications systems
  - Key parameters: Rate (speed), throughput (effective speed), delay
- Relate requirements to network design, system capabilities and characteristics

Objectives of This Unit

- Course logistical information
- Applications of telecommunication networks
- Networks basics

Course Logistics

- Instructor: **Mai Abdelhakim, PhD**
- Contact me if you for question or need to discuss anything
  - E-mail address: maia@pitt.edu
- Graduate teaching Assistant: **Mr. Xiangyu Yin**
  - Contact: eric.yin@pitt.edu
- Office hours & Zoom rooms ==check Canvas

Course Logistics

- Class meetings:
  - Time: Mon & Wed 1:15pm-2:30pm
  - Location:
    - Mainly Zoom
    - In-person option to be announced: 152 Chevron Science Center - pending arrangements, based on risk postures
  - Survey due by next lecture: ECE 1150: https://pitt.co1.qualtrics.com/jfe/form/SV_8e8alxLFOjplSHY

Risk postures

- Current status: Elevated risk posture
  - University policy and instructions
    - https://www.policy.pitt.edu/sites/default/files/covid/Instruction%20REVISED.pdf
- Gathering capacity
  - Elevated risk: capacity any location 25

Canvas

- Syllubus, Course material, assignments will be on Canvas
- Please update notification to be “notify me right away”
- Any changes will be announced on Canvas

Course Requirements

- Participation (Top Hat)
- Assignments (homeworks and term report)
- Periodic quizzes (~ every other week)
  - On Canvas
- Midterm and Final exams
  - Online

• Assignments (homework, reading, term-report ~10%) & Participation: 40%
• Quizzes: 15%
• Midterm: 20%
• Final: 25%

Policy

- Academic integrity: Your work is your own!
- No credits for vague answers
- It is your responsibility to make sure that you uploaded your correct submissions
- Late submission not accepted without permission

References

- [Textbook] Computer Networks, A. S. Tanenbaum and D. J. Wetherall, 5th Ed.
- Queuing Theory and Telecommunications: Networks and Applications, Giovanni Giambene, 2014, 2nd ed. (available online through library.pitt.edu)
- Computer Networking - A Top-Down Approach, Jim Kurose and Keith W. Ross, Addison-Wesley
- Business data communications and IT infrastructures, 2nd Edition, by Agrawal & Sharma
- Wireless Communications Network & Systems, C. Beard and W. Stallings.
- Business Data Communications and Networking, J. FitzGerald et al

Comments

- My slides are from a lot of places and derived from many textbooks
  - Author's of references (e.g. Agrawal, Tanenbaum, Kurose, Stallings), Dr. Weiss, Dr. Krishnamurthy,..

Strategies for Success

- It is recommended to **take notes** that you can review before exams

- In lecture feel free to **ask** questions via speaking up or chat
  - You can send message private to me if you wish
  - In chat, take sure to use appropriate language and refrain form using acronyms that some may not understand

- Ask questions on **discussion** on canvas, in lecture, join office hours

- Time Management – don't start assignment last min

Why Networks are Important?

- Use network at work, home, and on-the-go

- The information ***exchange*** industry is one of the world's **largest industries** by revenue

Internet is used for everything

- Easy access to knowledge

- Sharing information

- Online banking & paymemt systems

PayPal

- Electronic commerce

amazon

- Social networks

facebook

- Online virtual meetings (Zoom)

zoom

- In 2016, Cisco estimates that over 3,000 Petabytes of information transferred over the Internet **DAILY**!

  Petabytes = Million Gigabyte!

- Netflix accounts for around 1/3 of primetime downstream traffic

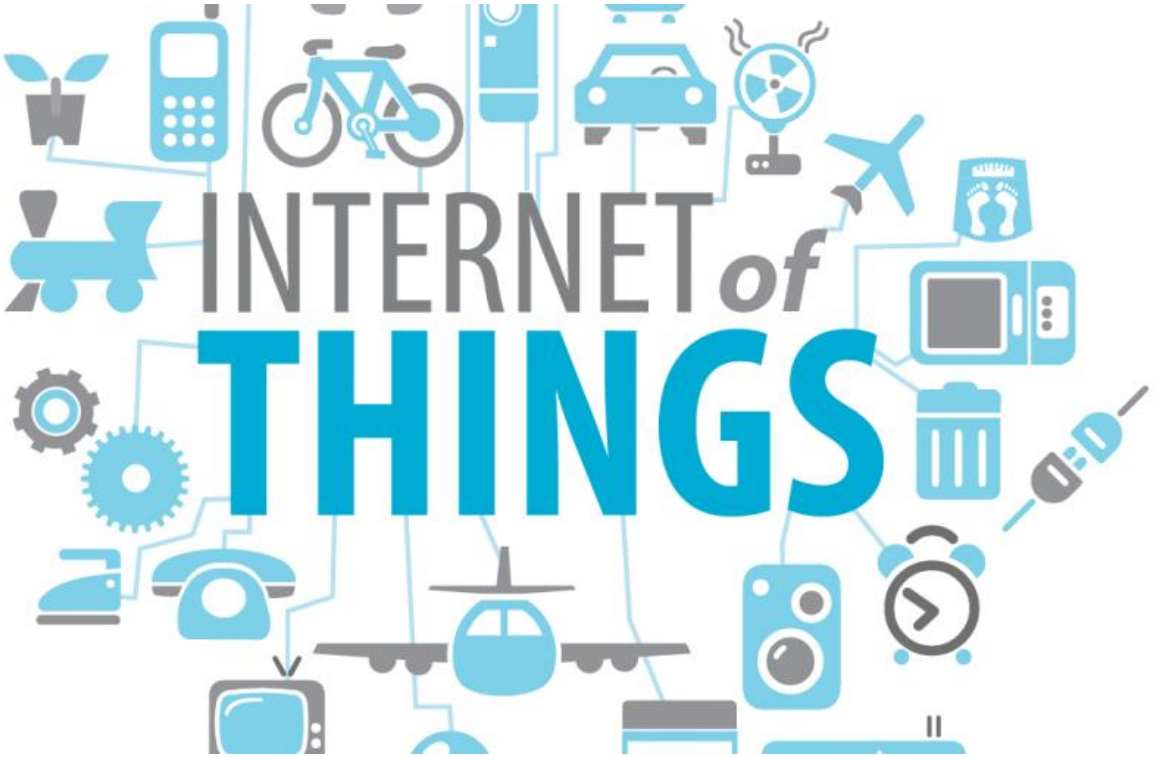
- As of 2012, every **DAY** on Facebook there are:
  - 2.7 Billion Likes
  - 300 Million Photos uploaded
  - >500 Terabytes of data transmitted

Giga=10^9
Terra=10^{12}

Source: Business Data Communications and Networking

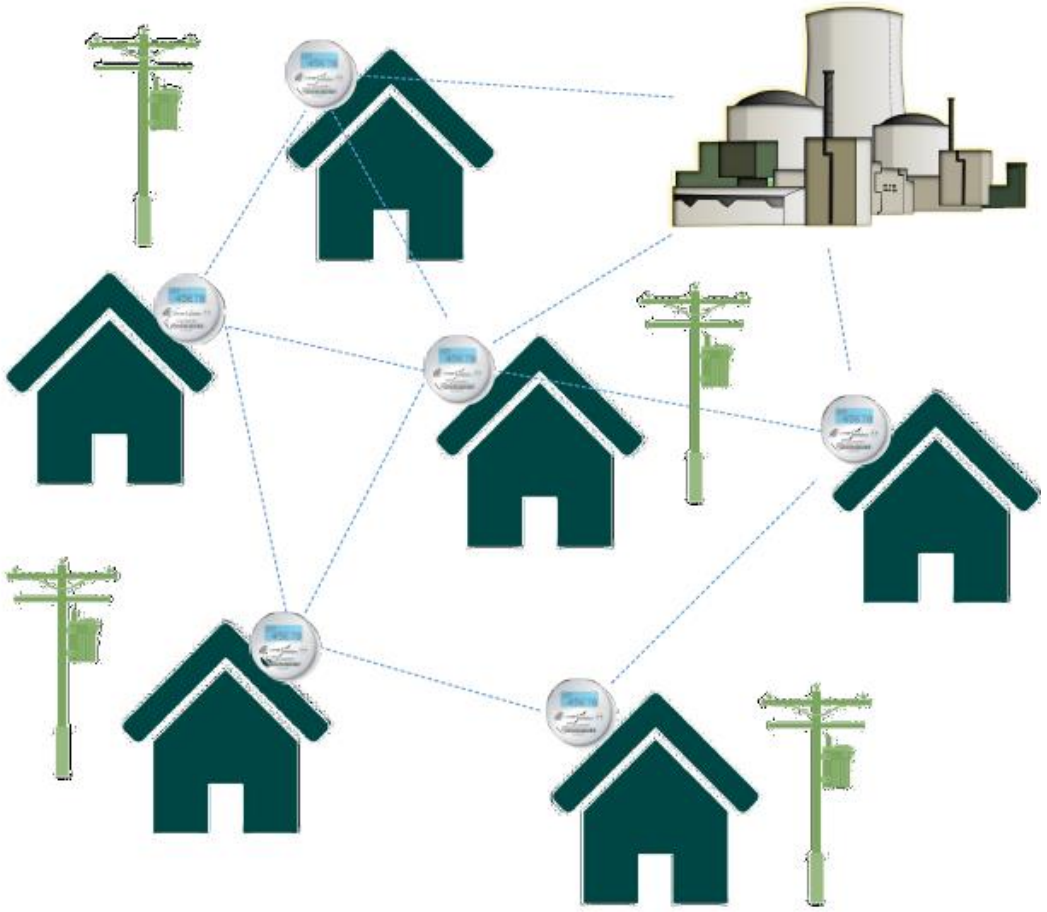
Why is networks getting even more important?

- Internet of Things concept
  - Connecting ‘things’ together and to the Internet



IoT Application – Smart Energy Grid

Efficient distribution of power resources

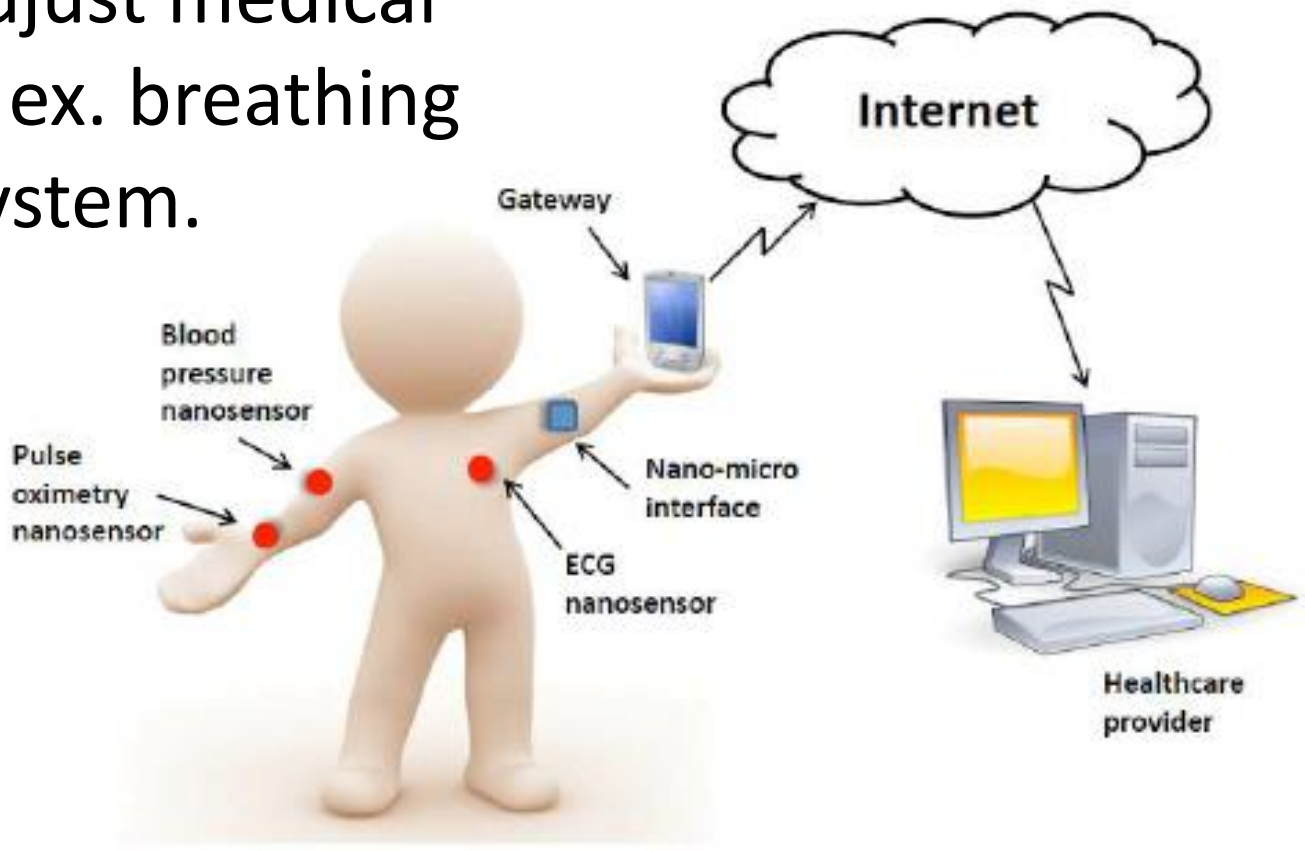


IoT Application – Smart Home

Connected devices in home can be accessed remotely through the internet.
e.g. turn on the sprinkler while you are away, control lighting, heating

IoT Application - Healthcare

- Monitor patients remotely
- Remotely adjust medical equipment, ex. breathing ventilator system.



IoT Application - Manufacturing

- Parts in the production process are connected and can be managed and analyzed through the Internet
  - Create automated and self-running factories

IoT Application – Smart Cities

- Autonomous vehicles, smart parking, intelligent traffic management

Impact of Communication Networks

Numerous Applications: autonomous vehicles, smart cities, smart home, energy systems, healthcare, military, cyber-manufacturing, agriculture, …

- Billions of devices!

- Huge impact on the economy
  - IoT could generate up to $11.1 trillion a year in economic value by 2025.

Reference: McKinsey

Broad Course Contents

- Application
  - Web browsing
- **Internet Protocol Stack**
  - 5 Layers
  - Application Protocols
    - HTTP
  - Transport (TCP, UDP)
  - Internet Protocol (IP)
  - Helpers – Address Resolution (ARP)
  - DHCP, DNS
- Lower Layers (**Main focus**)
  - Medium Access layer (MAC)
    - Fixed, Random, Hybrid access
    - Ethernet, WiFi, Cellular
  - Physical Layer (PHY)
    - Signal Constellation, modulation, data rates
- Performance
  - Throughput, delay, jitter
  - Reliability
- Management Issues

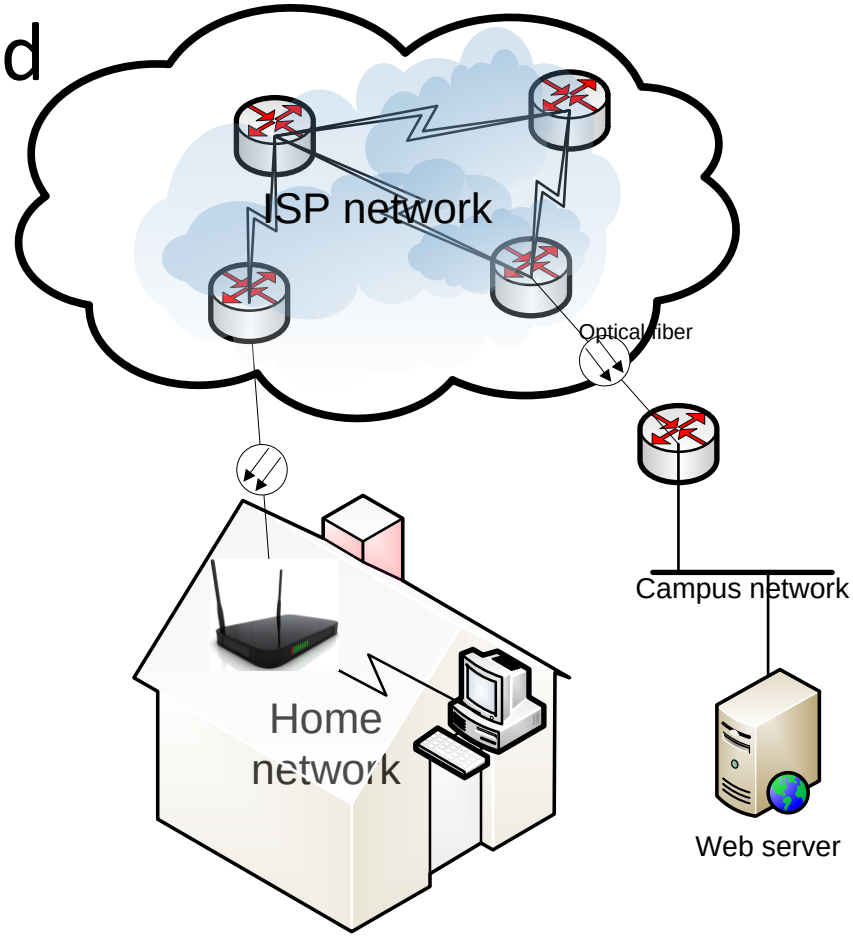
Acronyms!

Generic Approach

- Description (What is X?)
  - What problems it solves?
- Context
  - Where does X fit in a system?
- Evaluation
  - How well does X work?
  - What are X's limitations?

What is Computer Network?

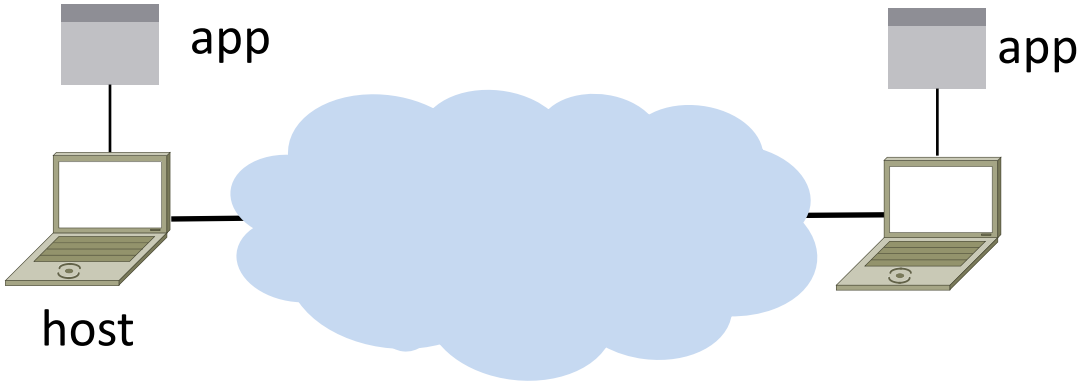
- System of interconnected devices
- Enables exchange of information



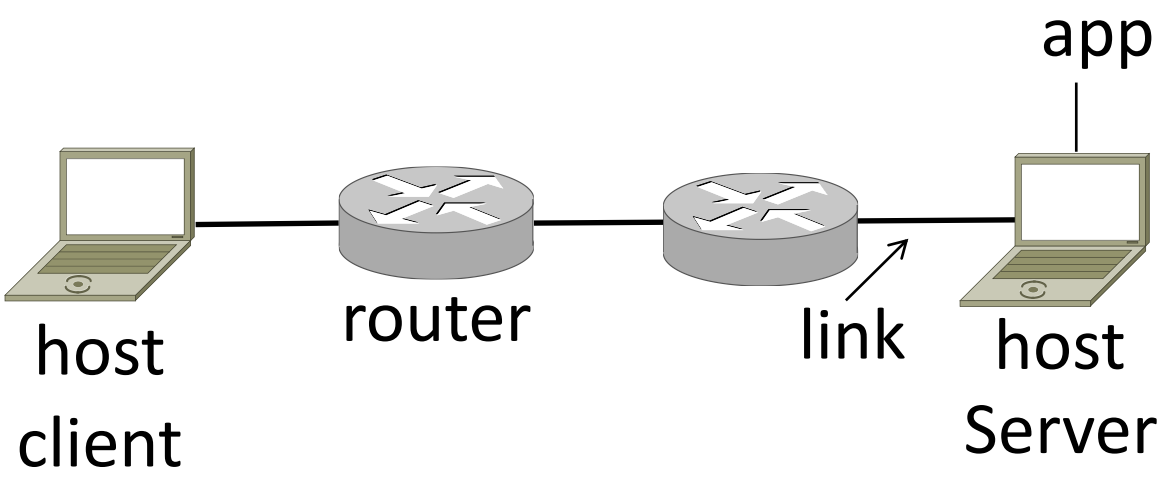
Source: Agrawal et al.

Representation

- Cloud as a generic network

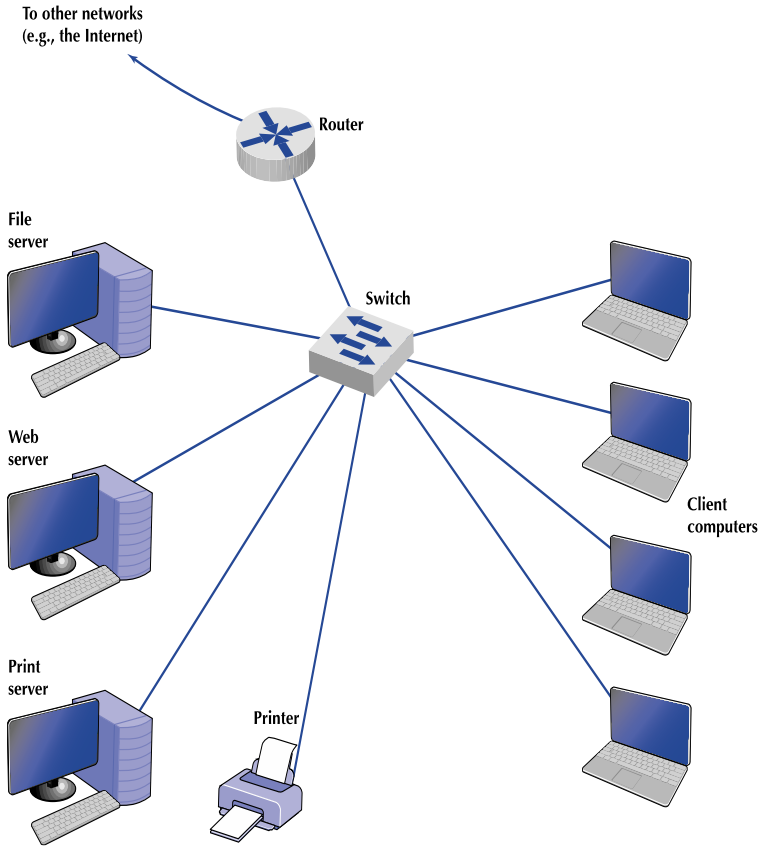


Parts of a Network



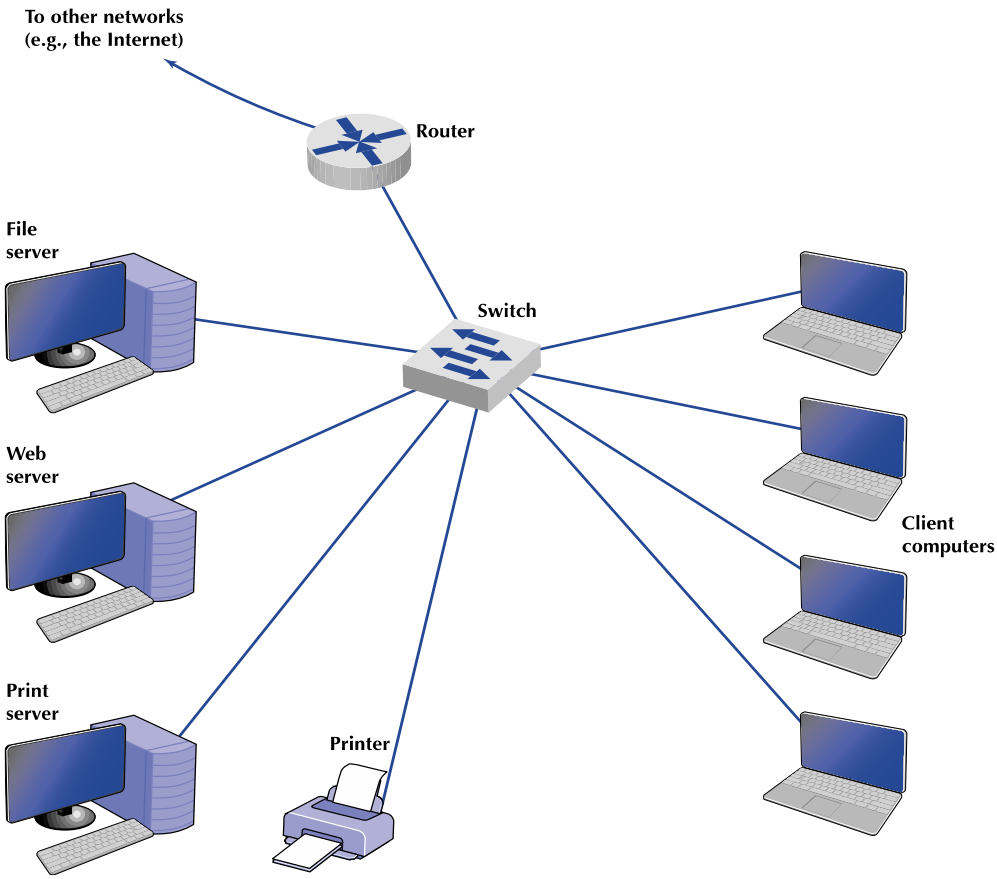
Abstract Model

- Network is composed of
  - **Nodes:**
    - End devices
    - Interconnecting devices
  - **Links:**
    - Wired or wireless



End Devices

- **End devices** can be
  - **Clients**: a user device that access network
    - Desktops, laptops, tablets, phones, etc.
  - **Servers**: stores and transmits data to clients
    - Web server, mail server, file server



Component Names

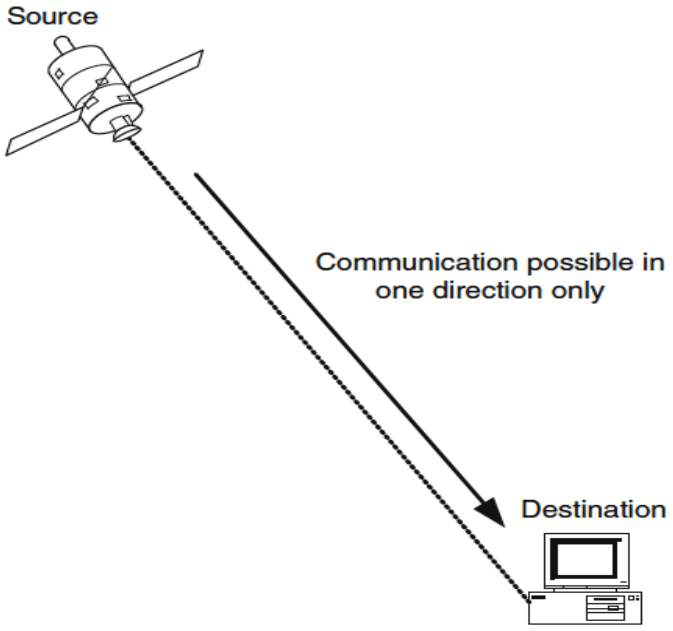
Component	**Function**	**Example**
Application, or app, user	Uses the network	Skype, iTunes, Amazon
End-device, Host, , edge device, node, source, sink	Supports apps	Laptop, mobile, desktop
Interconnecting device, Router, or switch, node, hub, intermediate system	Relays messages between links	Access point
Link, or channel	Connects nodes	Wires, wireless

Classification Based on Direction of Communications

- Simplex
- Half-duplex
- Full-duplex

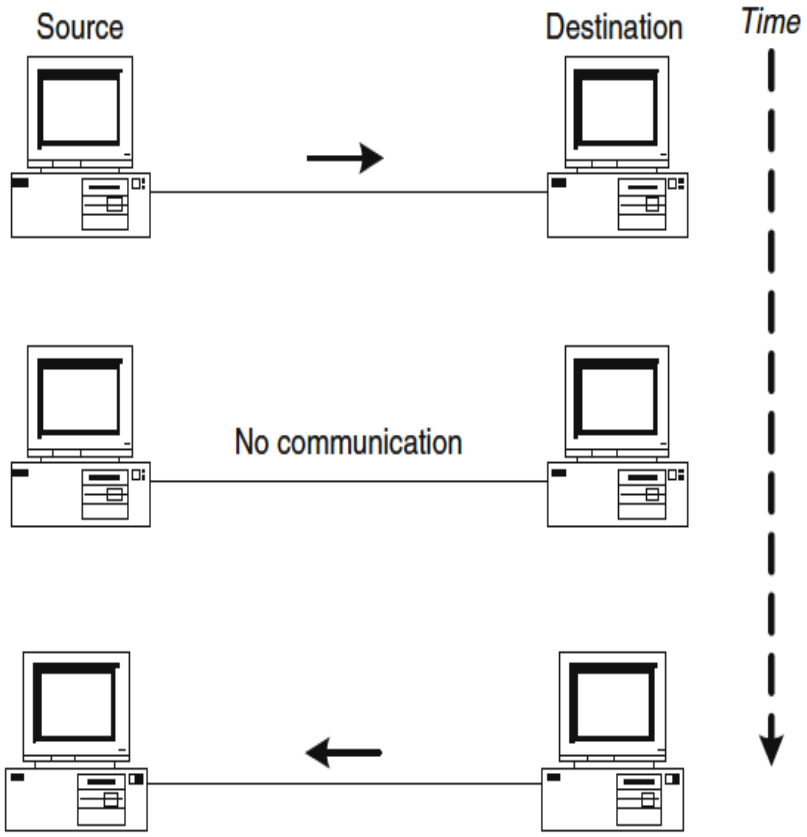
Simplex Communications

- Communication in **one direction (unidirectional)** only at all time:
  - e.g. broadcast **radio**, some **satellite** services



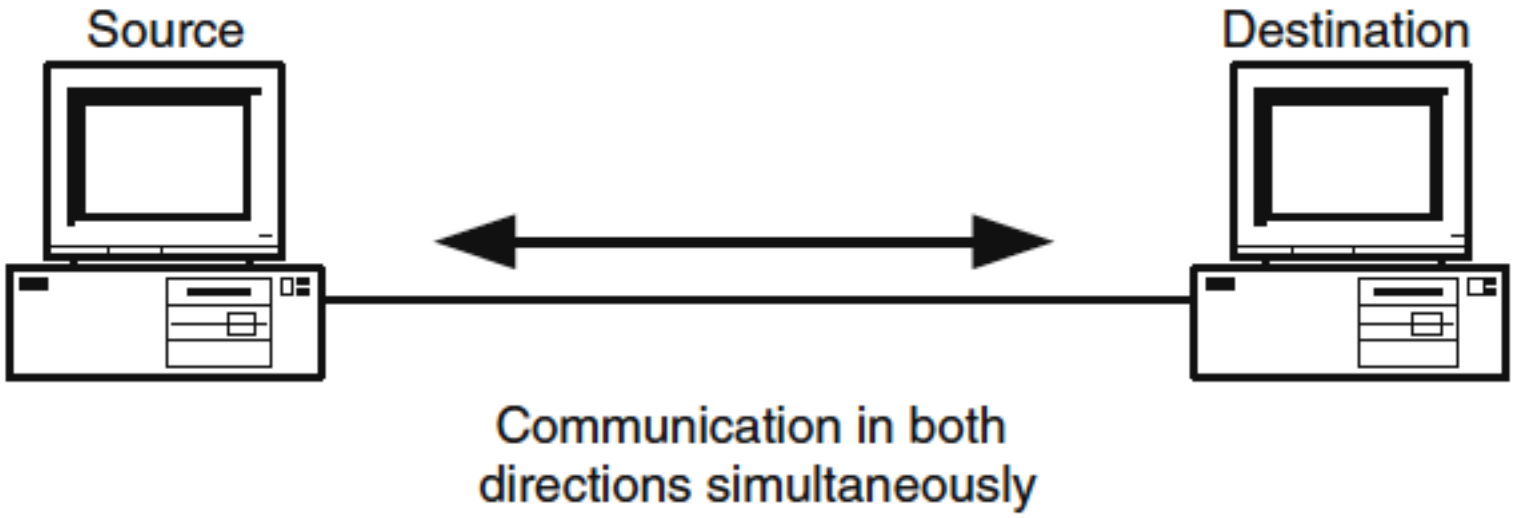
Half Duplex

- Communication is bidirectional, but only one direction possible at a time
  - **Can't talk and hear at the same time**
  - E.g. Walkie-talkie, local network with a hub, some Bluetooth devices



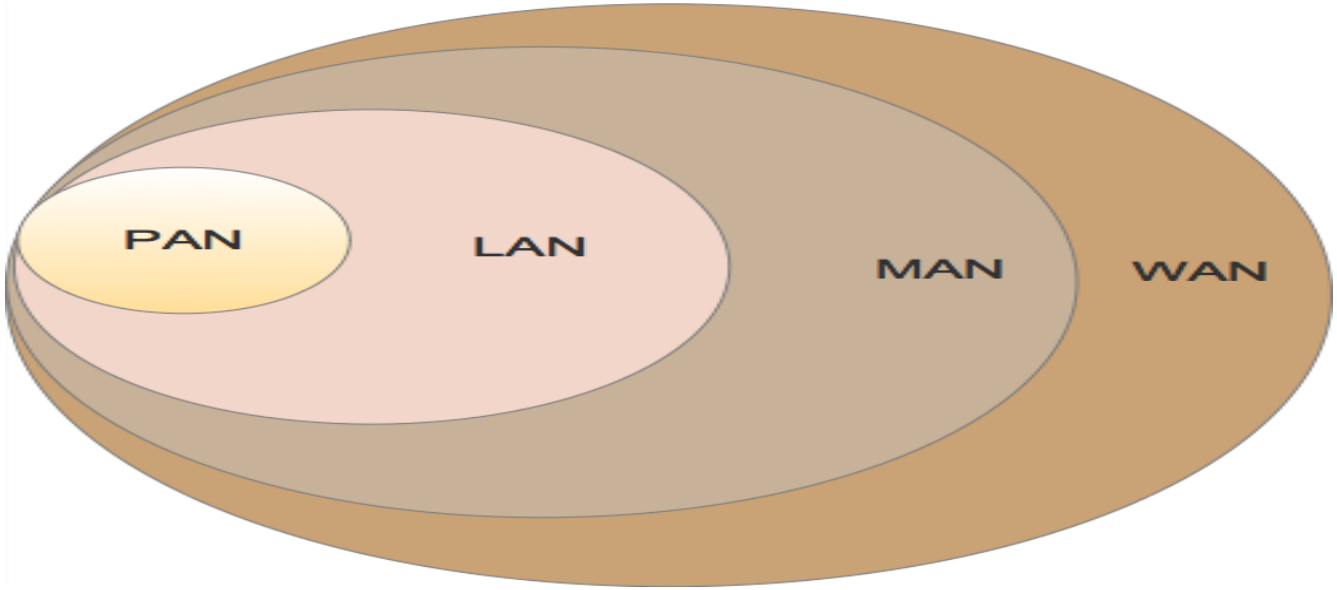
Full Duplex

- Communications possible is both directions (bidirectional) at the same time
- E.g. Cell phone



Network Classification

- Based on size:
  - Personal Area Network (PAN)
  - Local Area Network (LAN)
  - Metropolitan Area Network (MAN)
  - Wide Area Network (WAN)

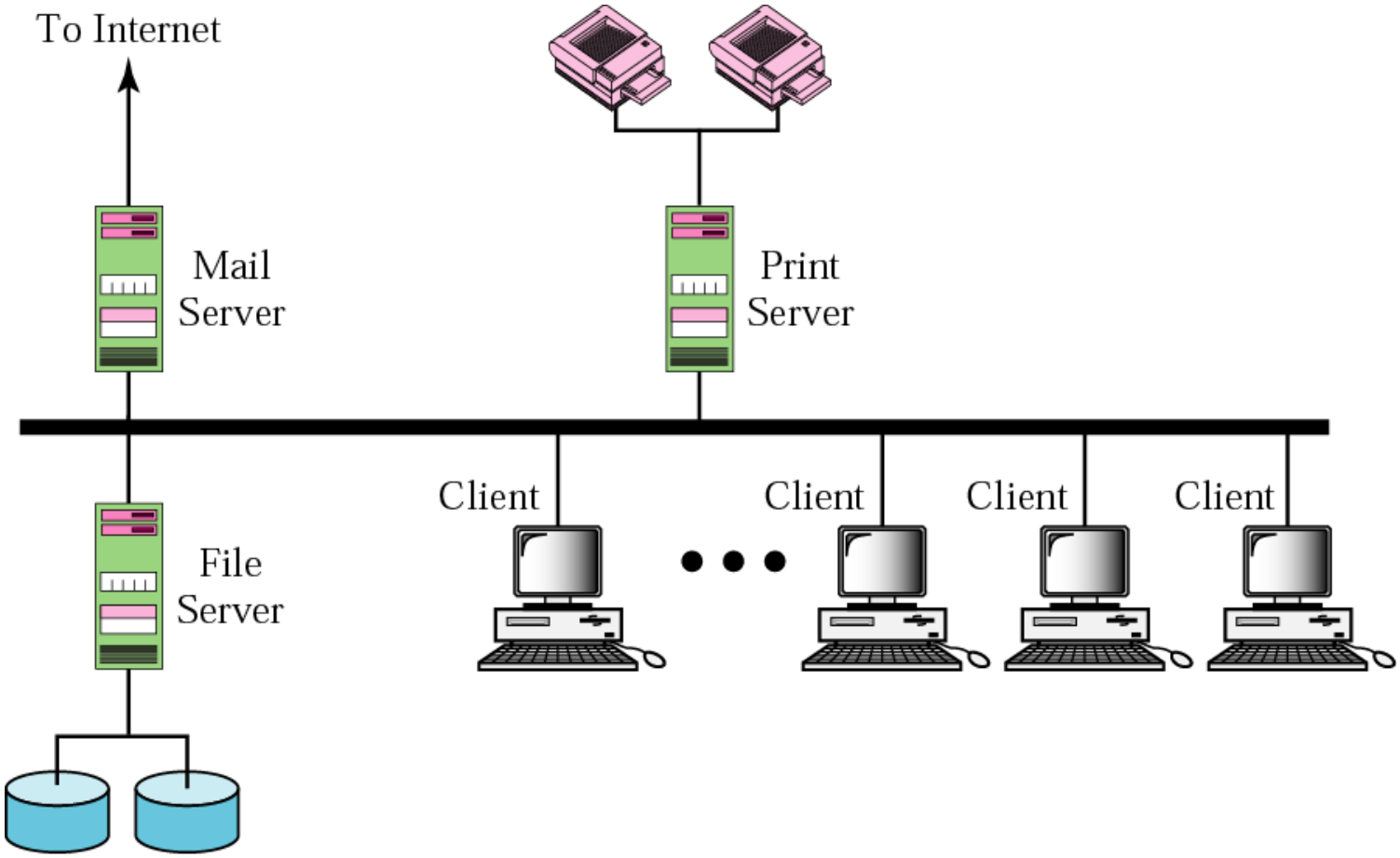


Network names by scale

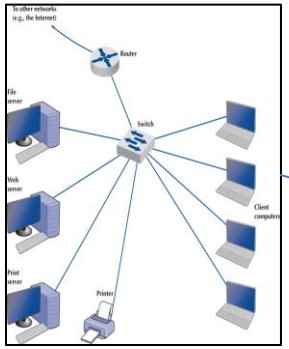
Type	**Example**
PAN (Personal Area Network)	Bluetooth (e.g., headset)
LAN (Local Area Network)	WiFi, Ethernet
MAN (Metropolitan Area Network)	Cable, DSL
WAN (Wide Area Network)	Large ISP
The Internet (network of all networks)	The Internet!

Internet can be considered as a large WAN

Local Area Network (LAN)

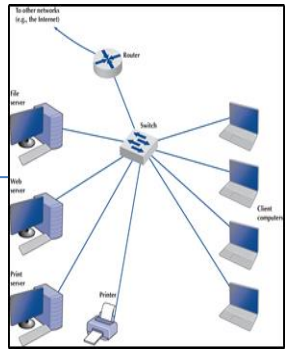


Metropolitan Area Network (MAN)

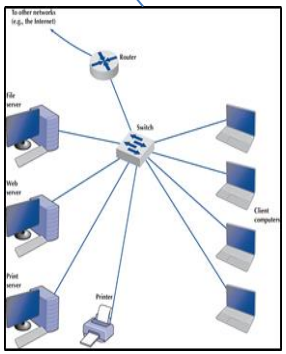


Oakland

Metro Ethernet service

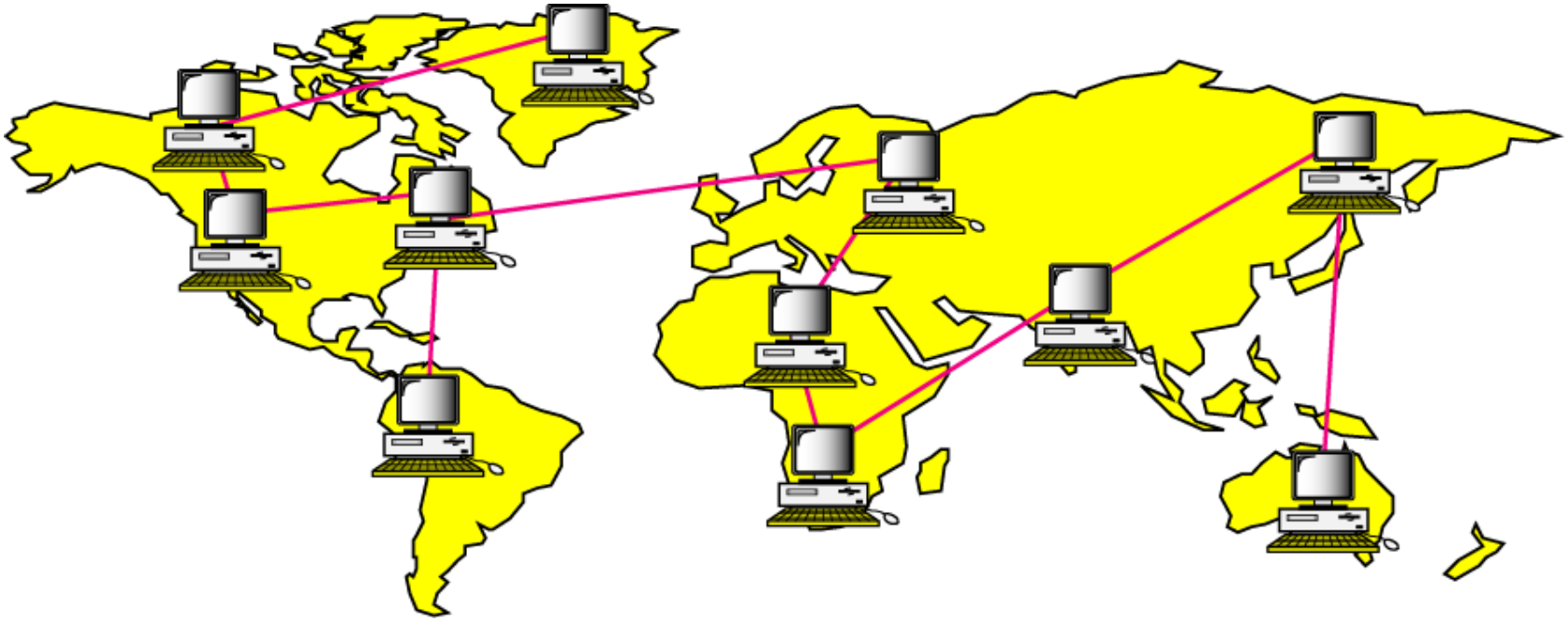


Wexford

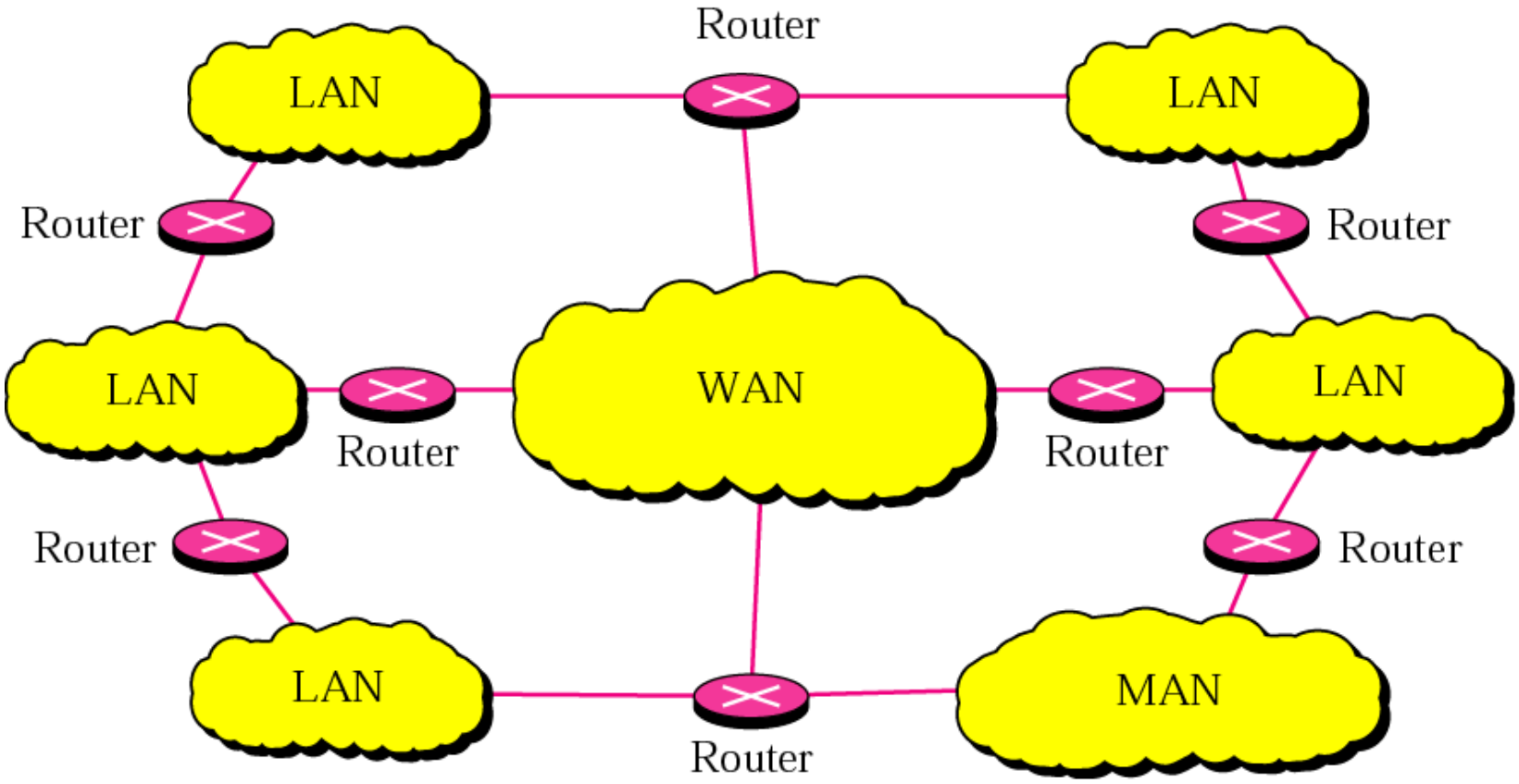


Southside

Wide Area Network (WAN)



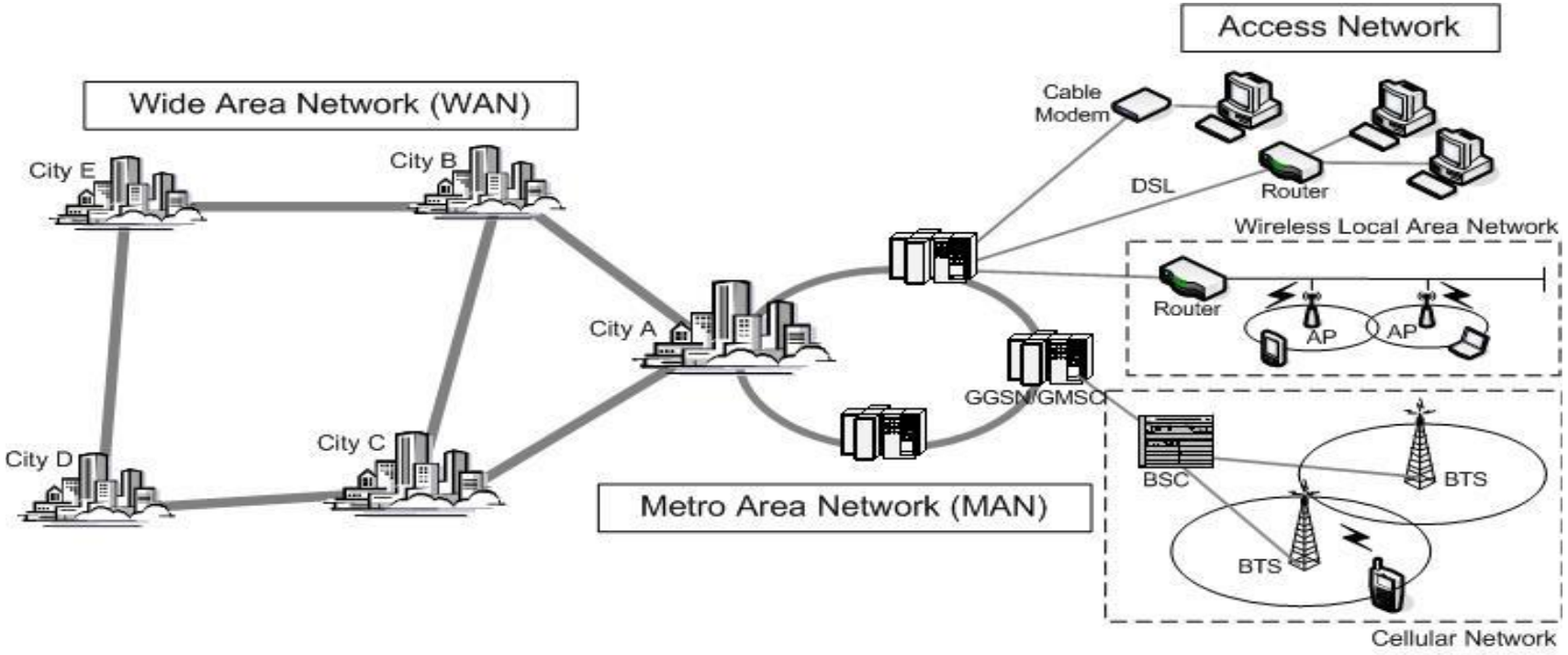
Internet



Backbone network/Core network: connects various smaller networks together forming a larger network

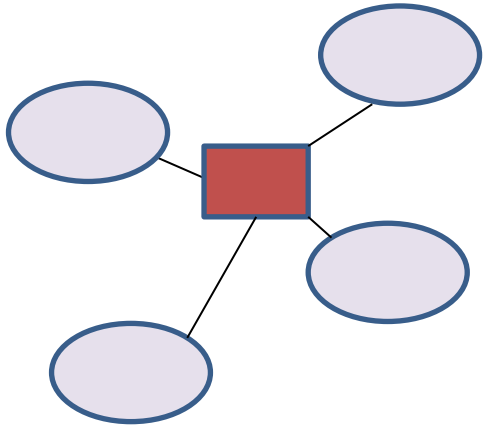
Network Types

Different architecture, technologies and protocols depending on size and application!

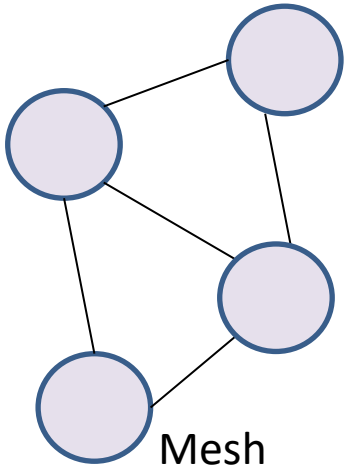


Network Classification: Based on Topology

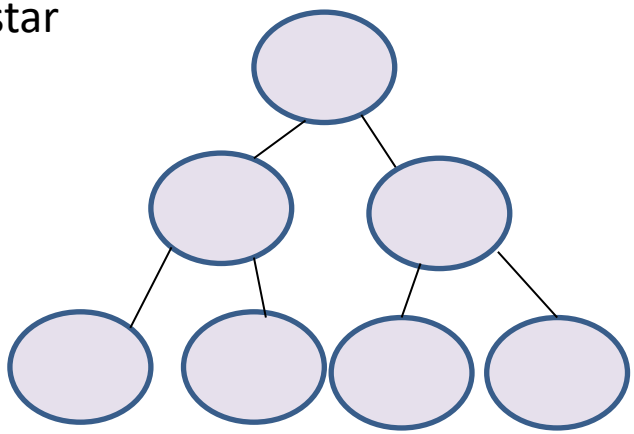
- Topology defines how nodes are connected
- Possible topologies: Star, Tree, Mesh, Ring



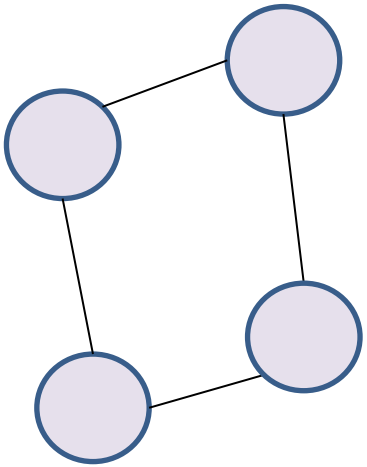
star



Mesh



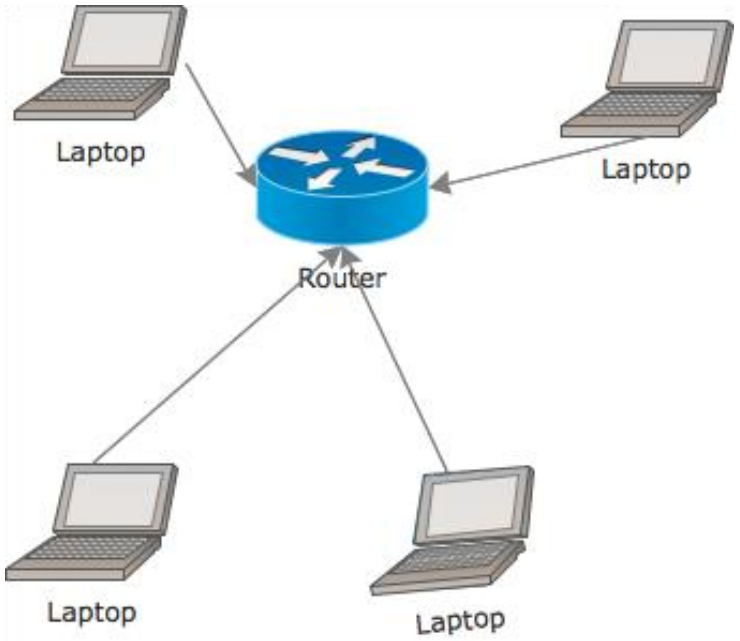
Tree



Ring

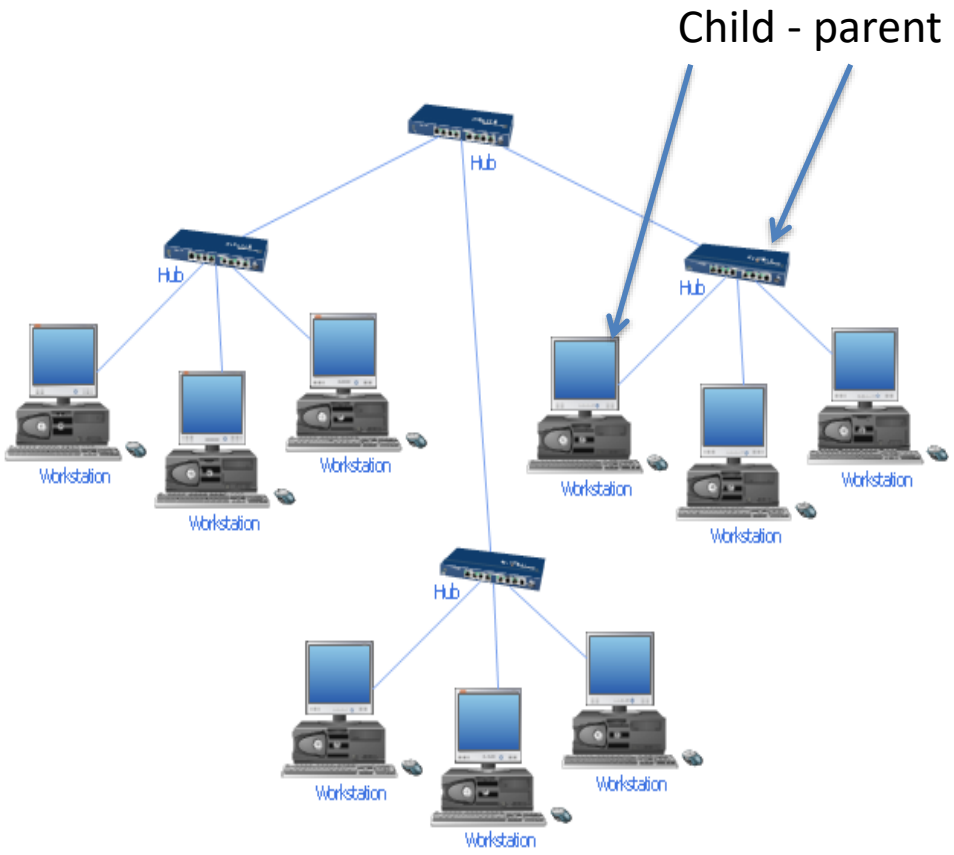
Star Topology

- All nodes are connected to a central node
- Advantages:
  - Simpler management
- Disadvantages
  - Susceptible to traffic problems
  - Failure of the central entity causes complete network failure



Tree Topology

- Tree topology:
  - Interconnecting node can be a parent of one or more child nodes
  - **End device** can only be a **child** node in the tree
  - Extend network coverage over star

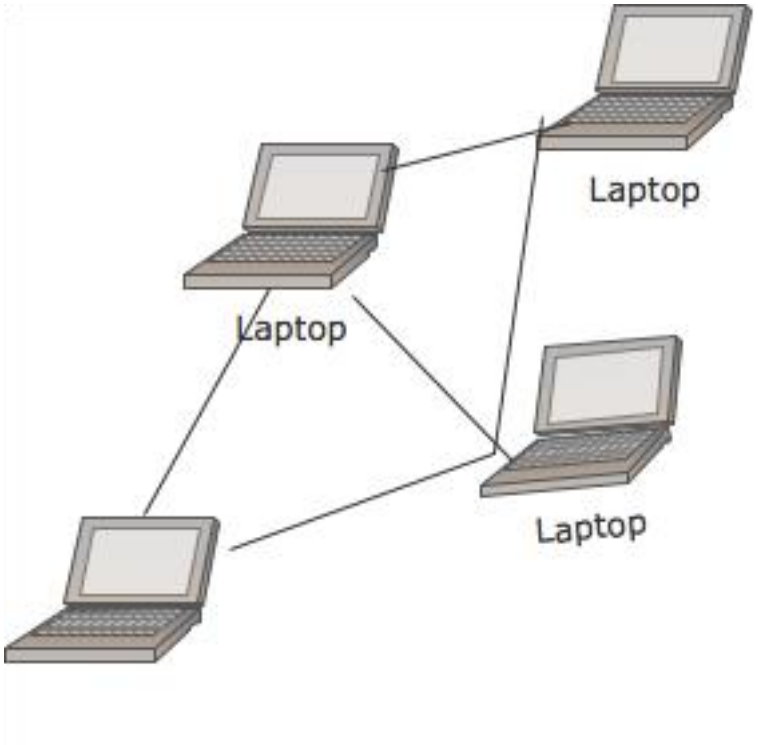


Ring Topology

- All devices are connected in a loop
- **Disadvantage**: **communication latency** for long routes

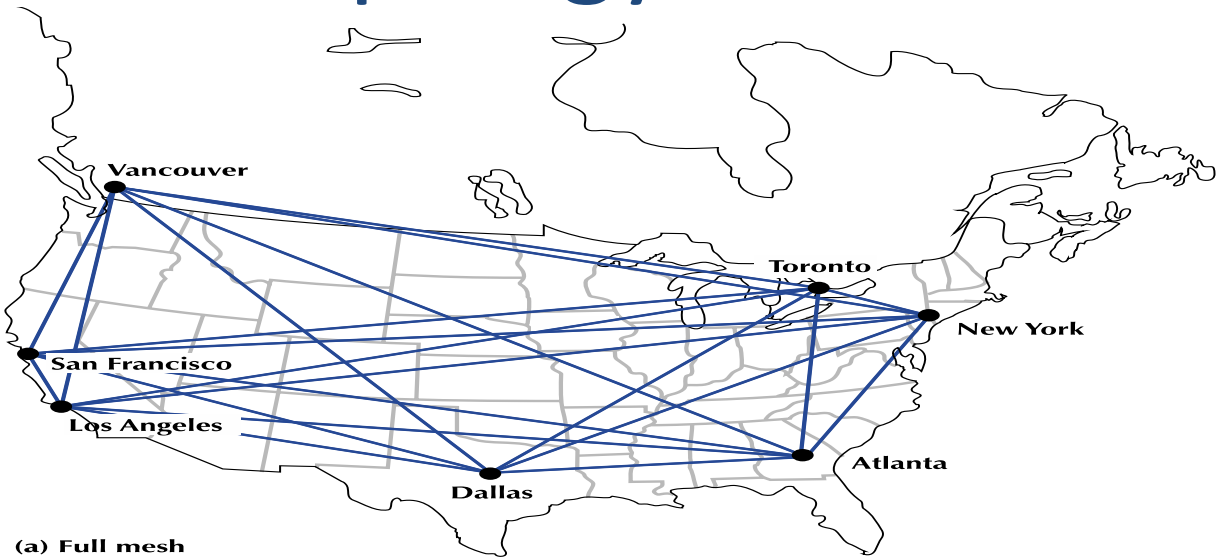
Mesh Topology

- Nodes establish links directly with each other
- Advantage: Flexible, more reliable
- Disadvantage: Expensive, harder to manage



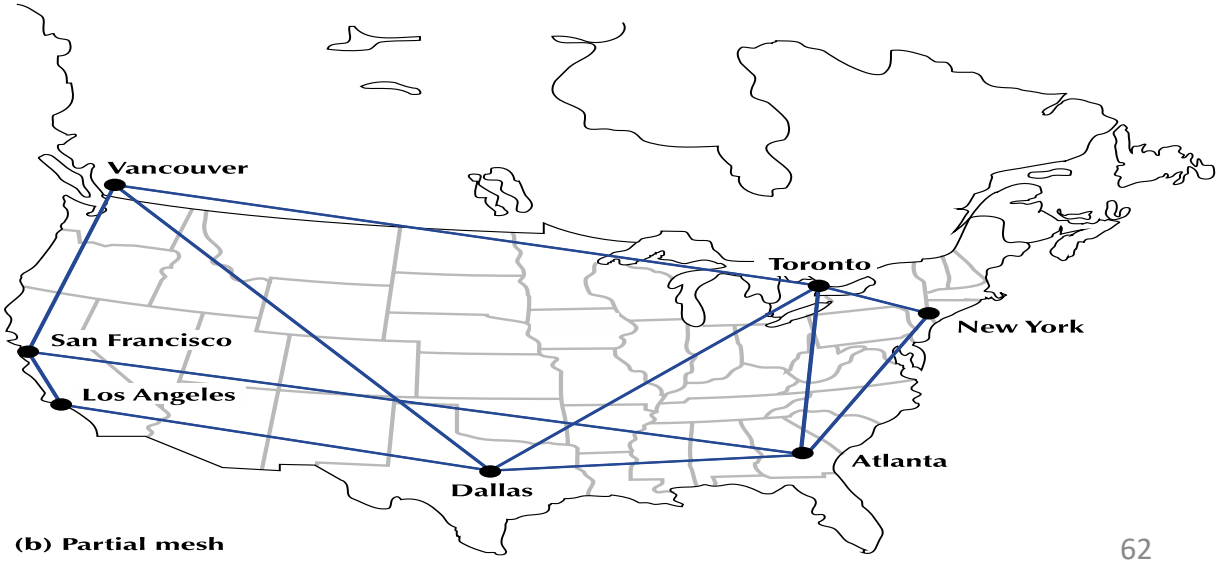
Mesh Topology

- Full mesh



(a) Full mesh

- Partial mesh



(b) Partial mesh

Top Hat: Q_Network topology

- Choose correct answer:

A key advantage of the mesh topology is that

A) It is easier to manage and troubleshoot

B) It enables low power consumption at all devices

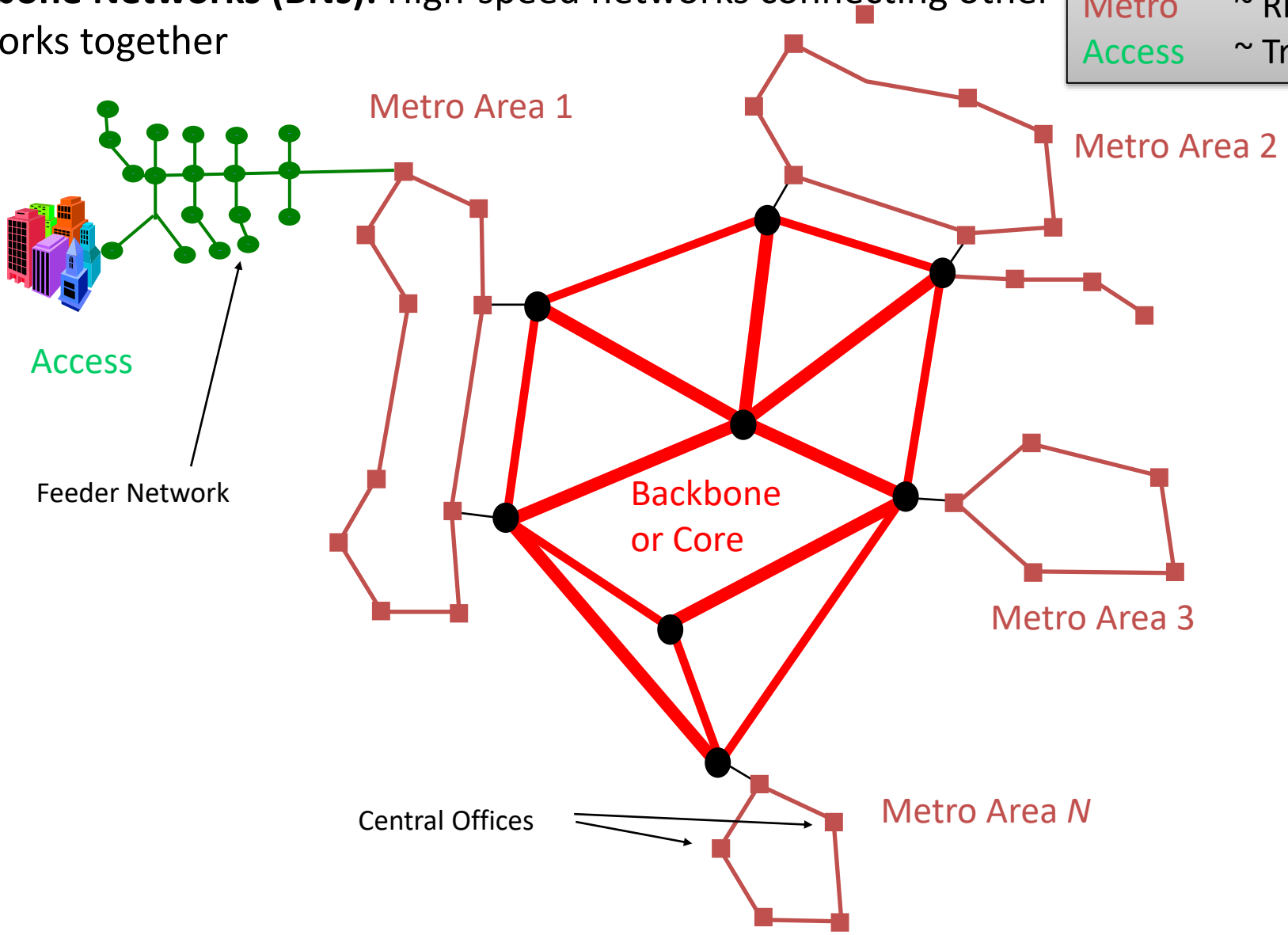
C) There is no single point of failure

Typical Wired Network Structure

Access network: connects subscribers to their immediate service providers

Backbone Networks (BNs): High-speed networks connecting other networks together

Current Trends	
Core	~ Mesh
Metro	~ Ring
Access	~ Tree



Key Takeaways

- Numerous applications
- Abstract model: Network is composed of devices and links
- Based on direction of communications, network can be
  - Simplex, half duplex, full duplex
- Networks can be classified based on geographical coverage
  - PAN, LAN, MAN, WAN
- Network has a topology, which defines how devices are connected
  - Star, tree, mesh, ring