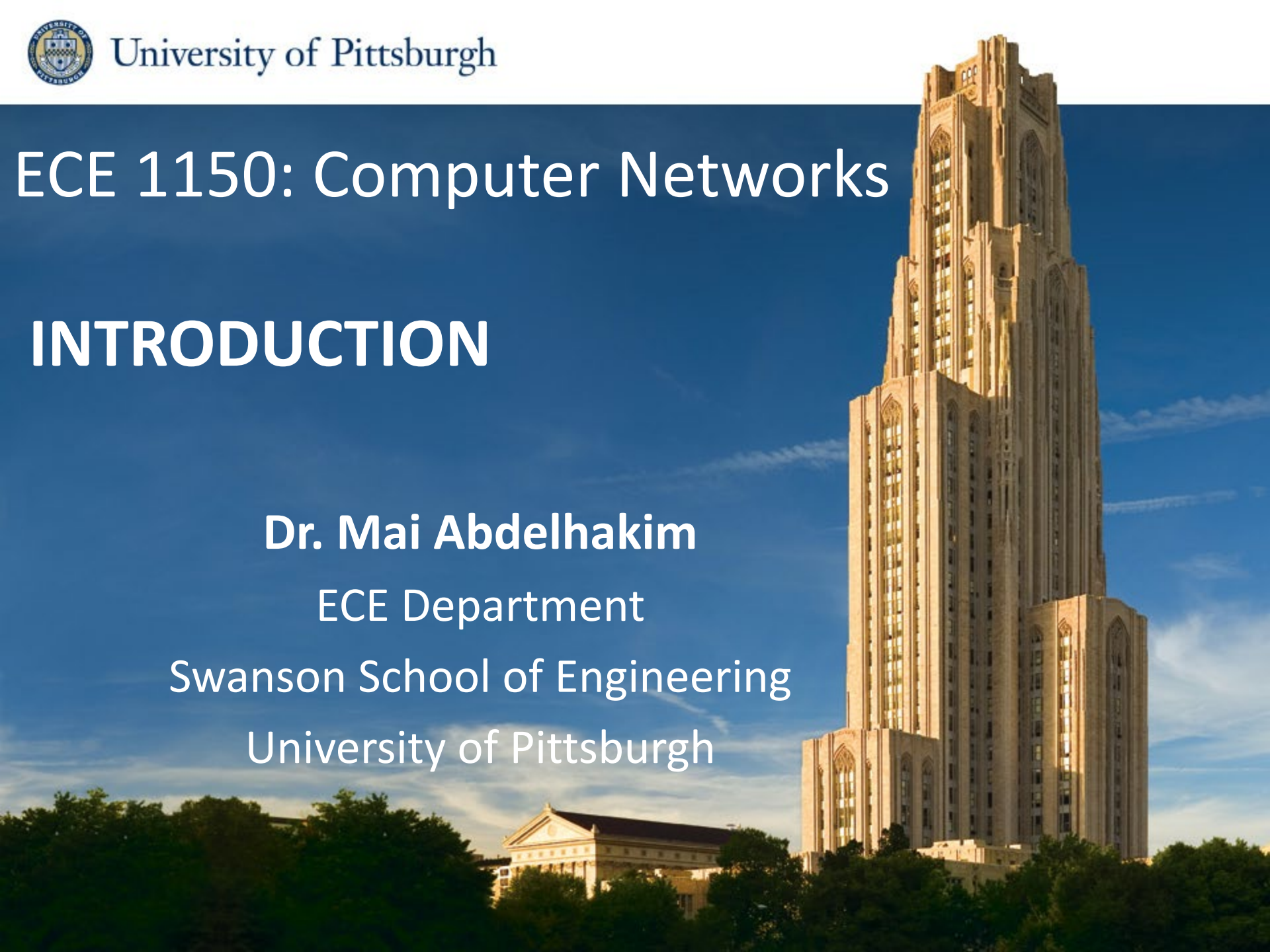

University of Pittsburgh
ECE 1150: Computer Networks
INTRODUCTION
Dr. Mai Abdelhakim
ECE Department
Swanson School of Engineering
University of Pittsburgh

Instructor and Teaching Assistant Contact

- Instructor: **Dr. Mai Abdelhakim - (Dr. Mai)**
  - E-mail: maia@pitt.edu
  - Office hours via Zoom: check Canvas
- Graduate teaching Assistant: **Mr. Lichang Chen** PhD student at Pitt
  - Email: **(LIC138@pitt.edu)**
  - Office hours via Zoom: Friday 6-7:30pm & by appointment
- Please Check Canvas for any updates in office hours info.

Class Meeting

- Class meetings:
  - Time: Tu & Th 1:00pm-2:15pm
  - Location:
    - 404 IS building
  - Check Pitt Heath Guidelines if masks are required!

Objectives of This Unit

- Course objectives & syllabus
- Applications of telecommunication networks
- Networks basics

Course Objectives

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

- Learn how **Internet** works

Course Objectives

- Perform **analysis** of communications systems
  - Key parameters: Rate (speed), throughput (effective speed), delay, error rate

- Relate requirements to network design, system capabilities and characteristics

Learning Objectives

- Evaluate switching (circuit and packet switching) technologies
- Analyze the performance of connections, as well as processes of the physical layer and data link layer of the TCP/IP stack
- Demonstrate how different multiplexing and multiple access systems **share network resources**.
- Examine functions of IP layer in the protocol stack, including **addressing** and **routing** techniques
- Describe application layer functions (e.g. HTTP) and network support services (DNS, DHCP).

Course Requirements

- Participation (Top Hat – Join Code **433266**)
- Assignments (homeworks and term report)
  - Theoretical/problem solving
  - Analyze Internet packets using Wireshark.
  - Matlab/Simulink
- Quizzes
- Midterm and Final exams

- Assignments & participation: 30%
- Term report + presentation: 10%
- Quizzes: 10%
- Midterm: 25%
- Final: 25%

Term report

- Groups of 2- 3 members
- Suggested topics on Canvas
- **Simulation** must be part of the report
- Assessment: Independently acquire and apply new knowledge

Milestones:
Oct (1st week): Abstract of your report.
Nov (1st week): Progress report
Nov. (last week): Complete report & short recorded presentation

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
  - Only for legitimate reason, please ask for extension (requested and granted prior to the due date)

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

Strategies for Success

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

- In lecture feel free to **ask** questions

- **Time Management** - Don't start assignments late
  - We try to respond to emails within 24 hours (don't expect response same day as due date of any assignment/exam)

Canvas

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

Objectives of This Unit

- Course Objective & Syllabus
- Applications of telecommunication networks
- Networks basics

We rely on computer networks

- 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 – Common/Traditional Apps

- Easy access to knowledge
- Sharing information
- Online banking & payment systems
- Electronic commerce
- Social networks
- Online virtual meetings (Zoom)

PayPal

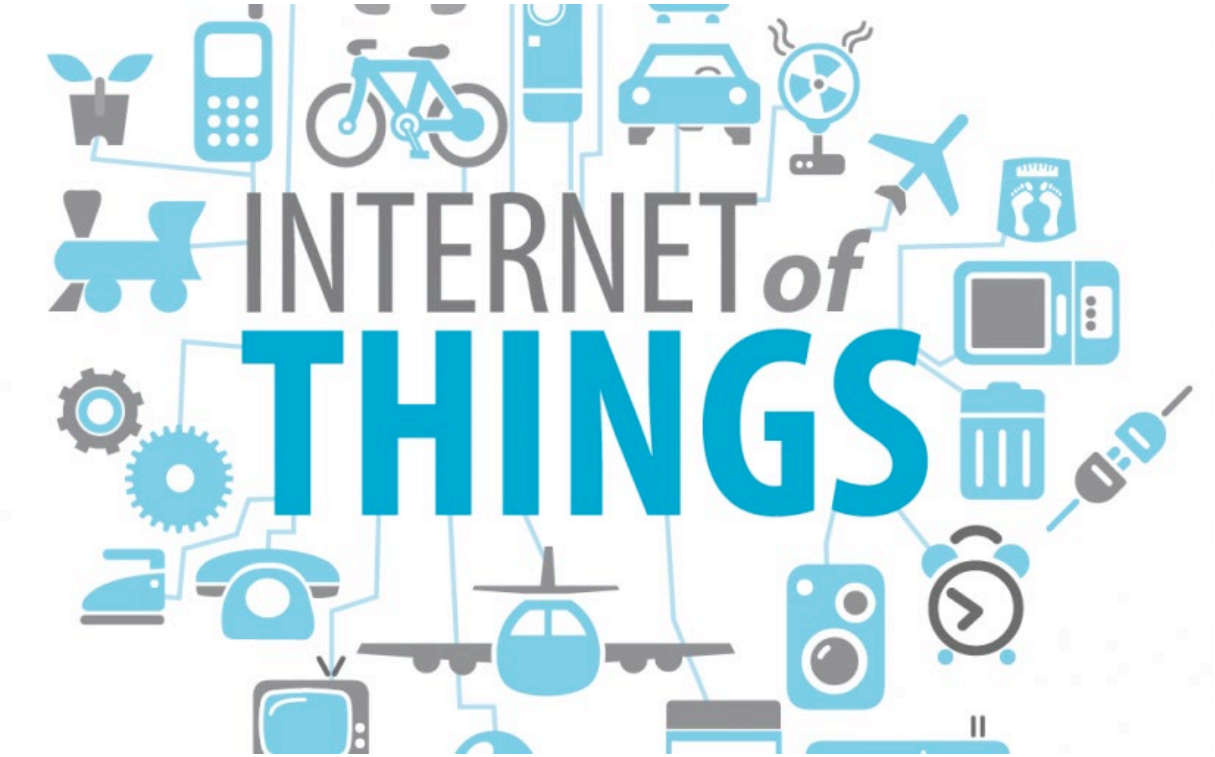
amazon

facebook

zoom

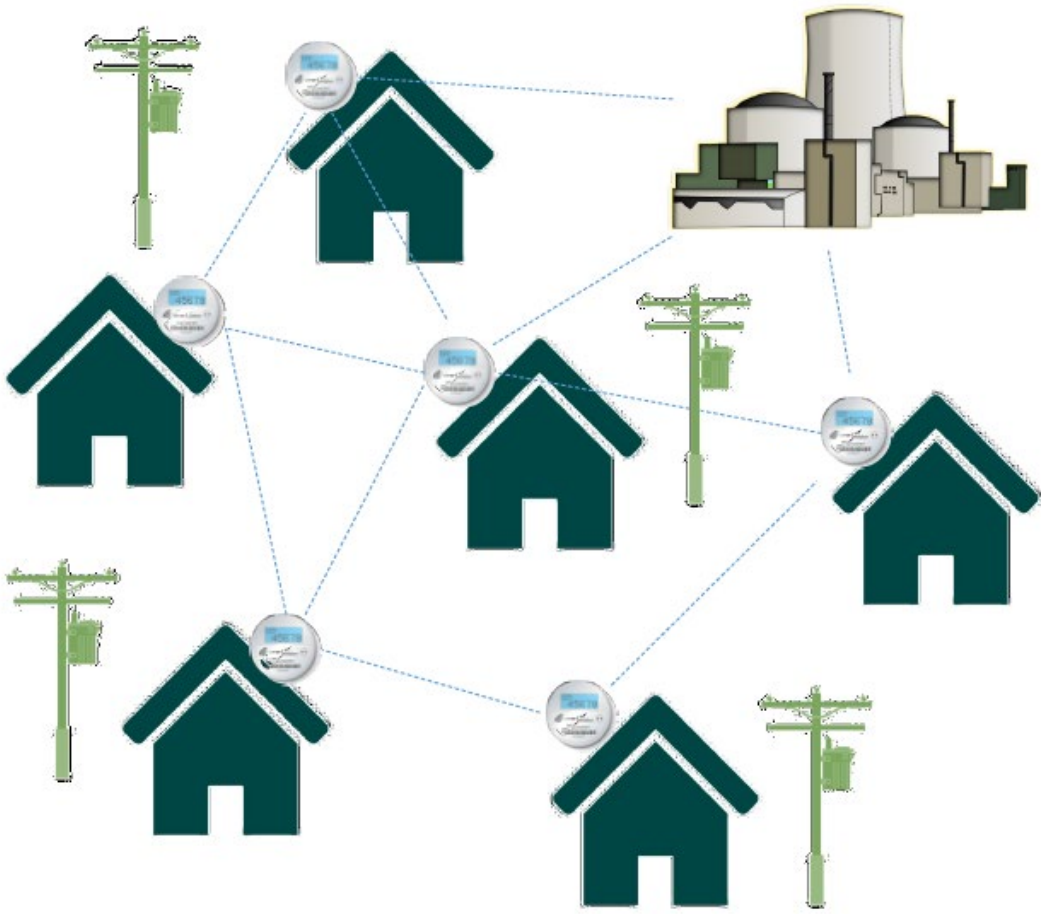
More Recent Applications on Internet of Things (IoT)

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



IoT Application – Smart Energy Grid

Efficient distribution of power resources

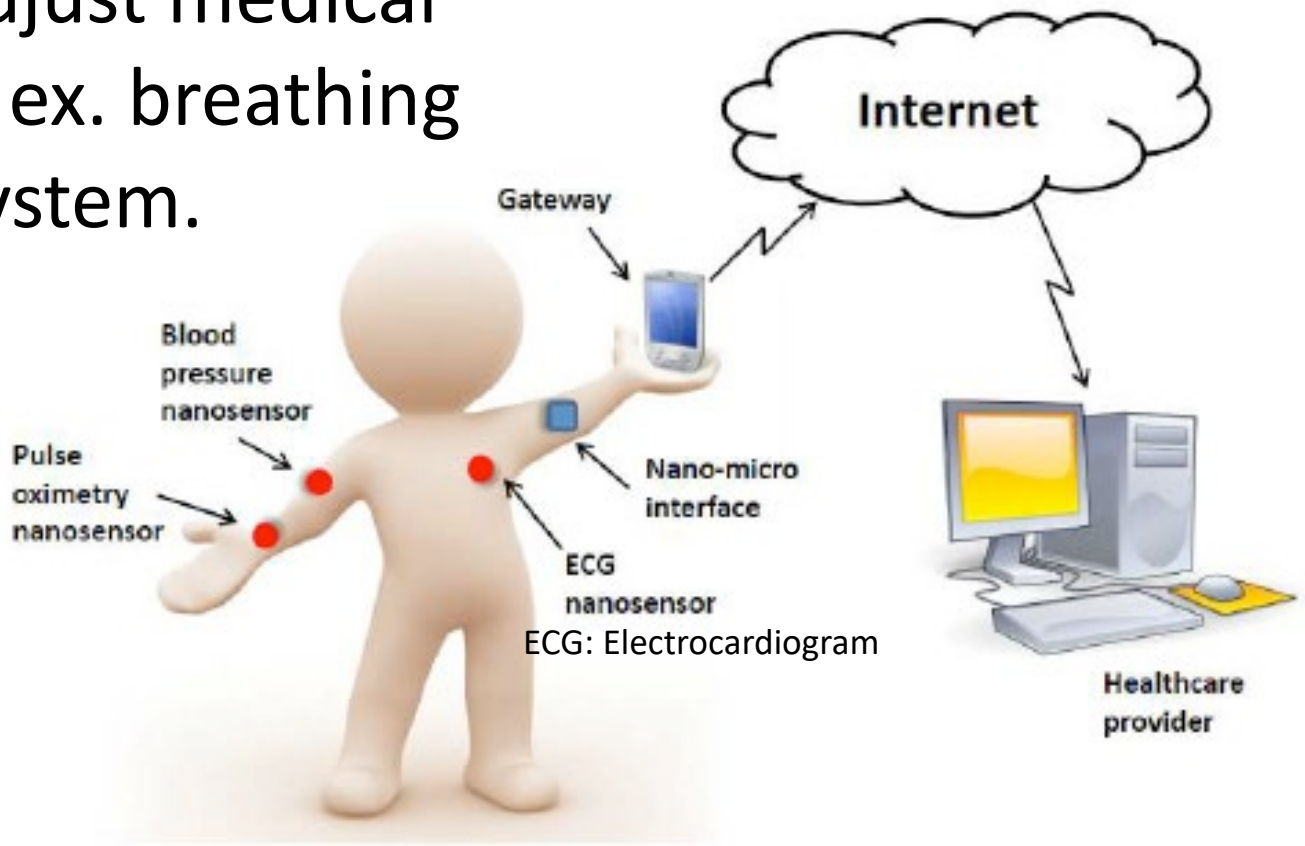


IoT Application – Smart Home

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.



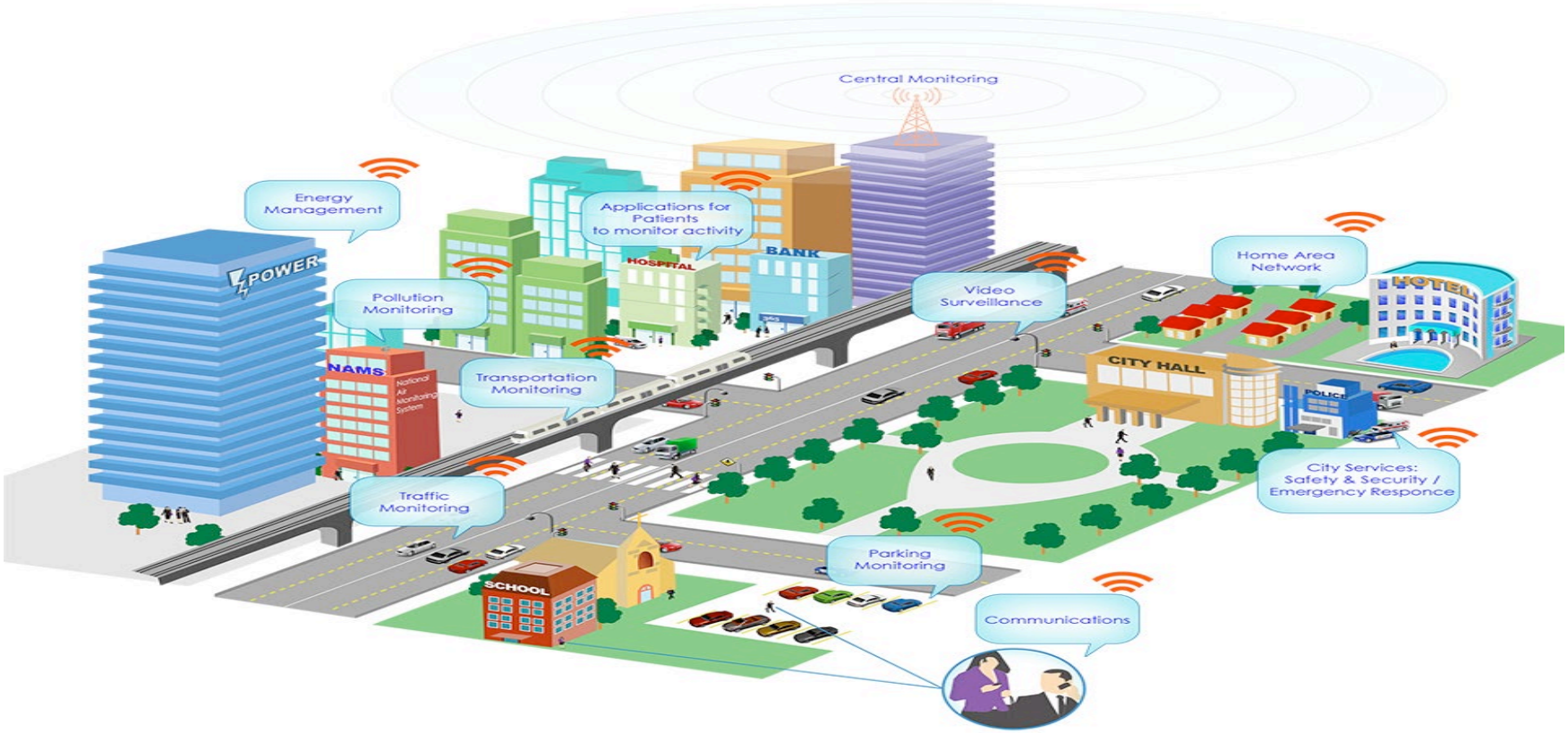
ECG: Electrocardiogram

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

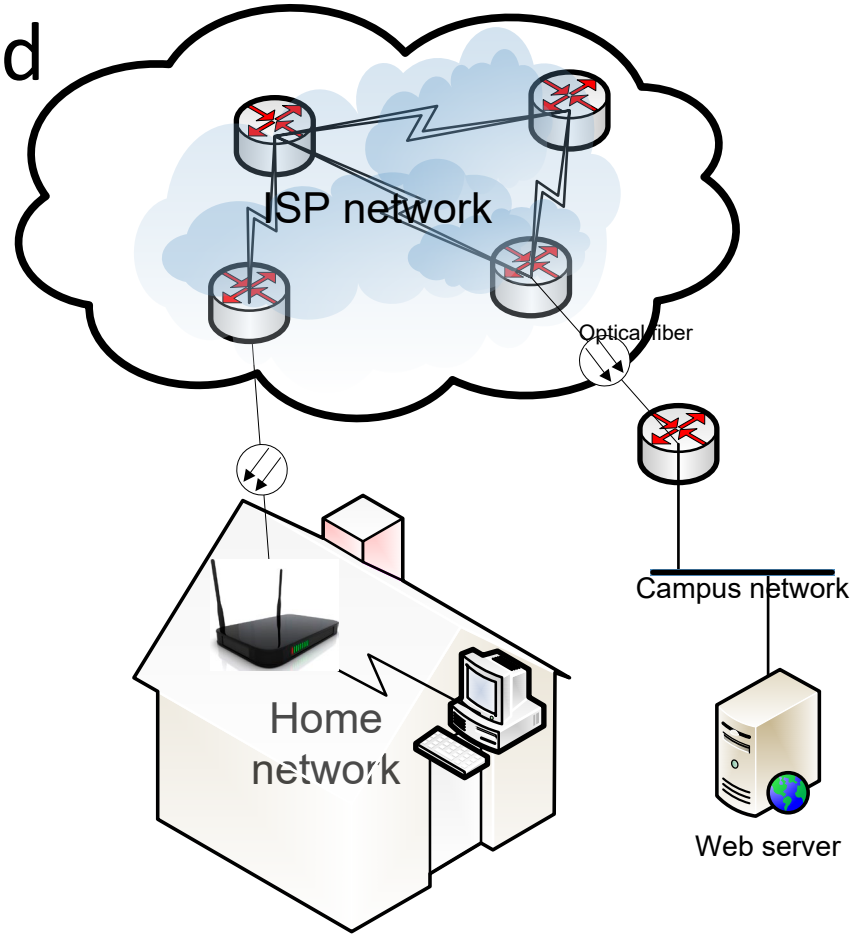
Acronyms!

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?

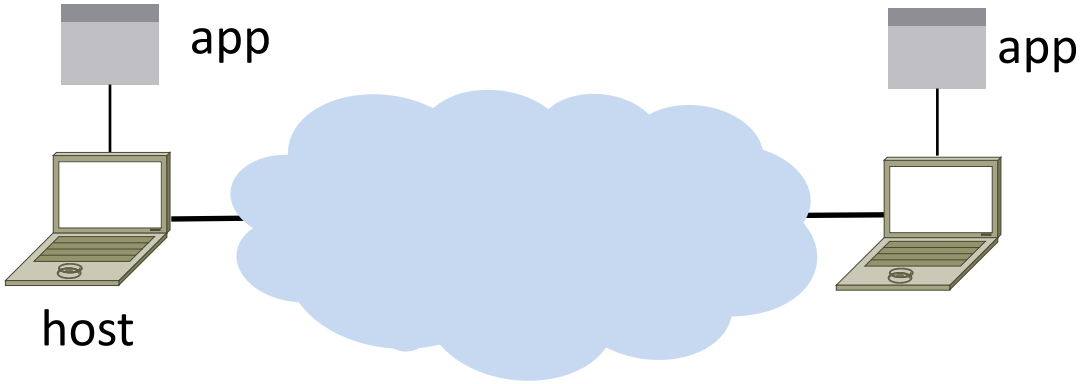
- System of interconnected devices
- Enables exchange of information



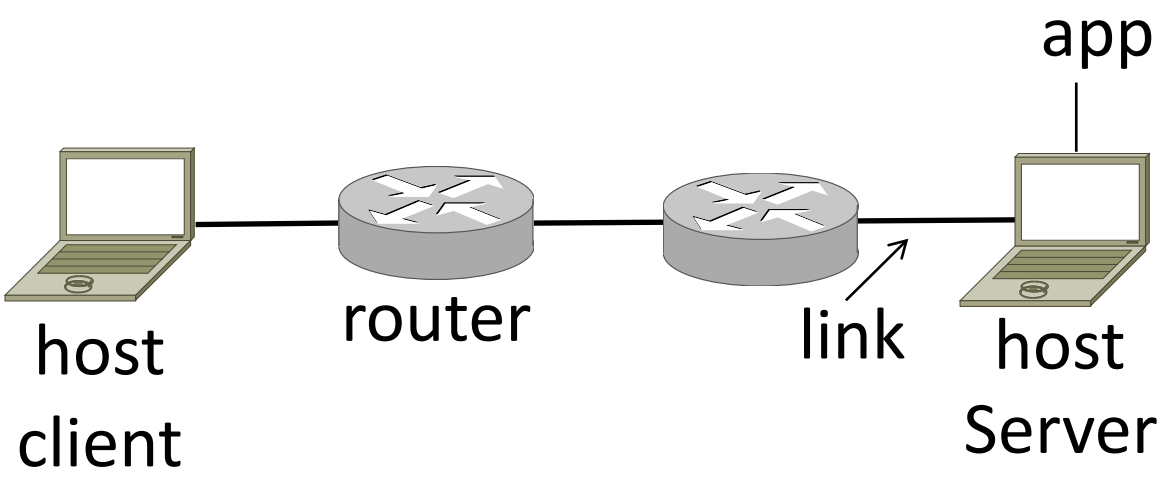
Source: Agrawal et al.

Representation

- Cloud as a generic network

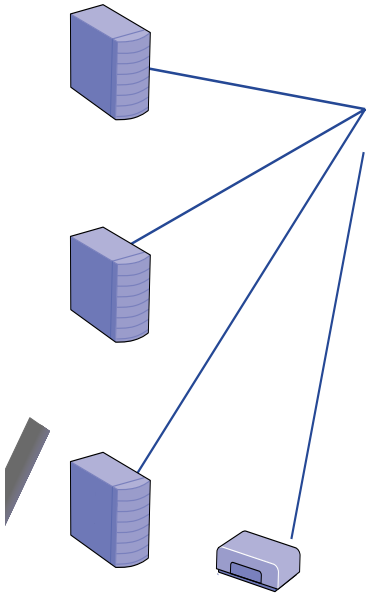


Parts of a Network



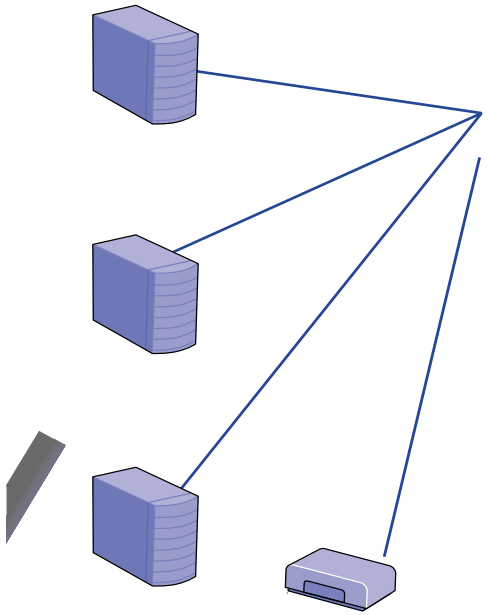
Abstract Model

- 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

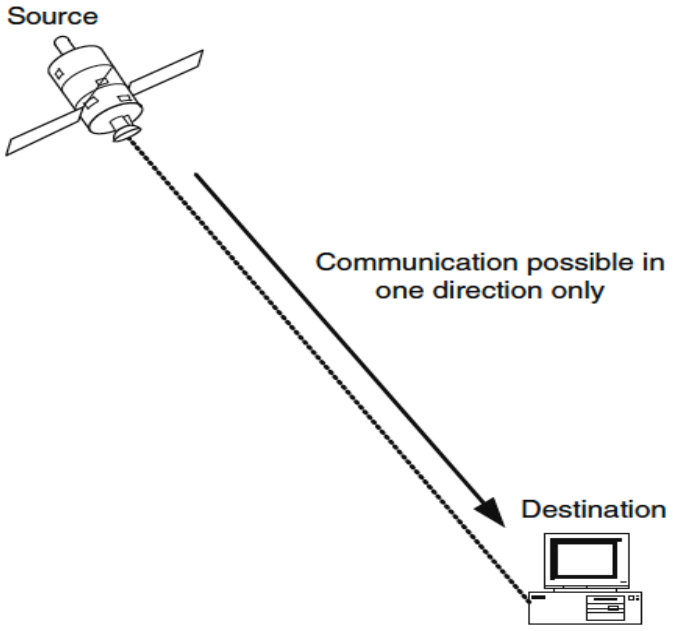
Component	**Function**	**Example**
Application, or app, user	Uses the network	Skype, iTunes, Amazon
End-device, Host, , edge device, node, source, sink	Supports apps	Laptop, mobile, desktop
Interconnecting device, Router, or switch, node, hub, intermediate system	Relays messages between links	Access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

Classification Based on Direction of Communications

- Simplex
- Half-duplex
- Full-duplex

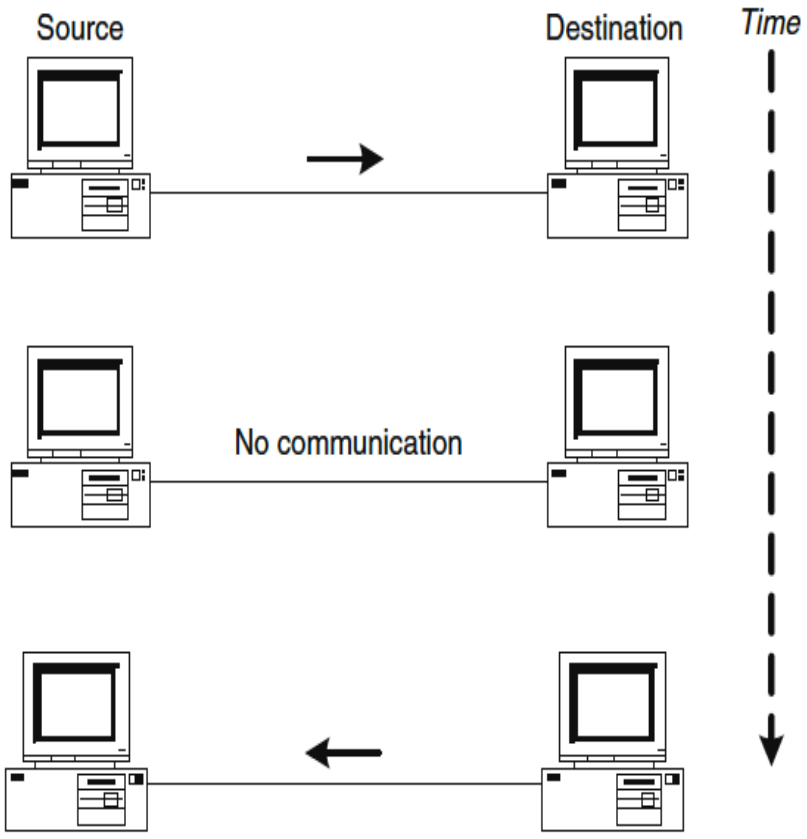
Simplex Communications

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



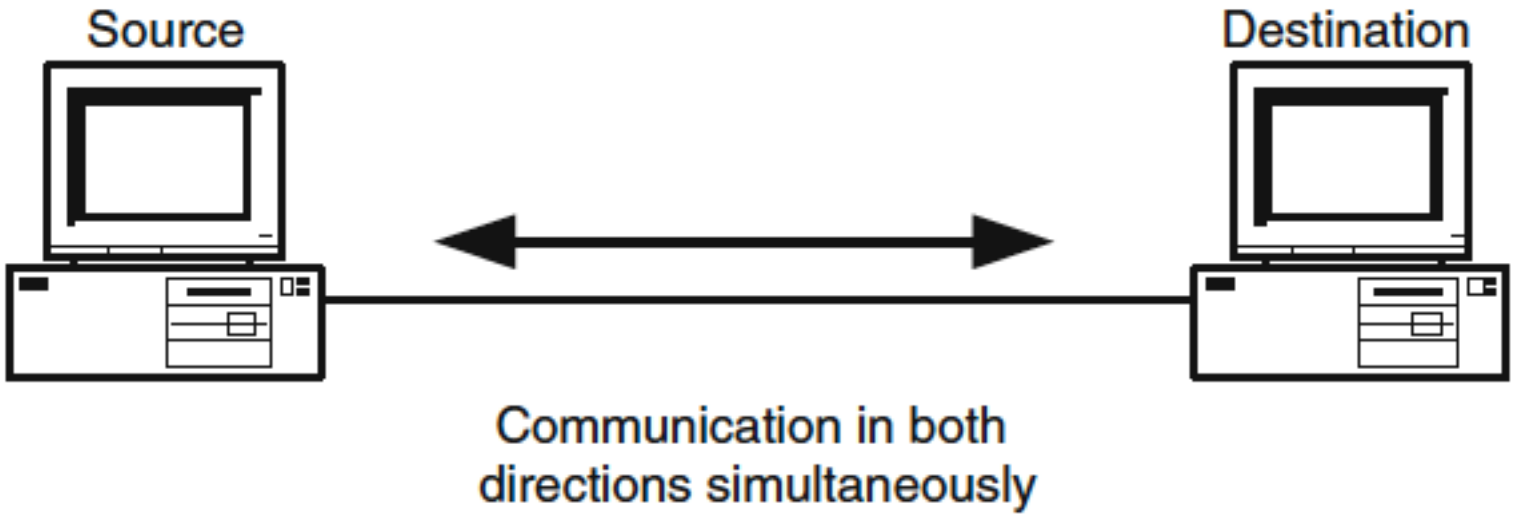
Half Duplex

- 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



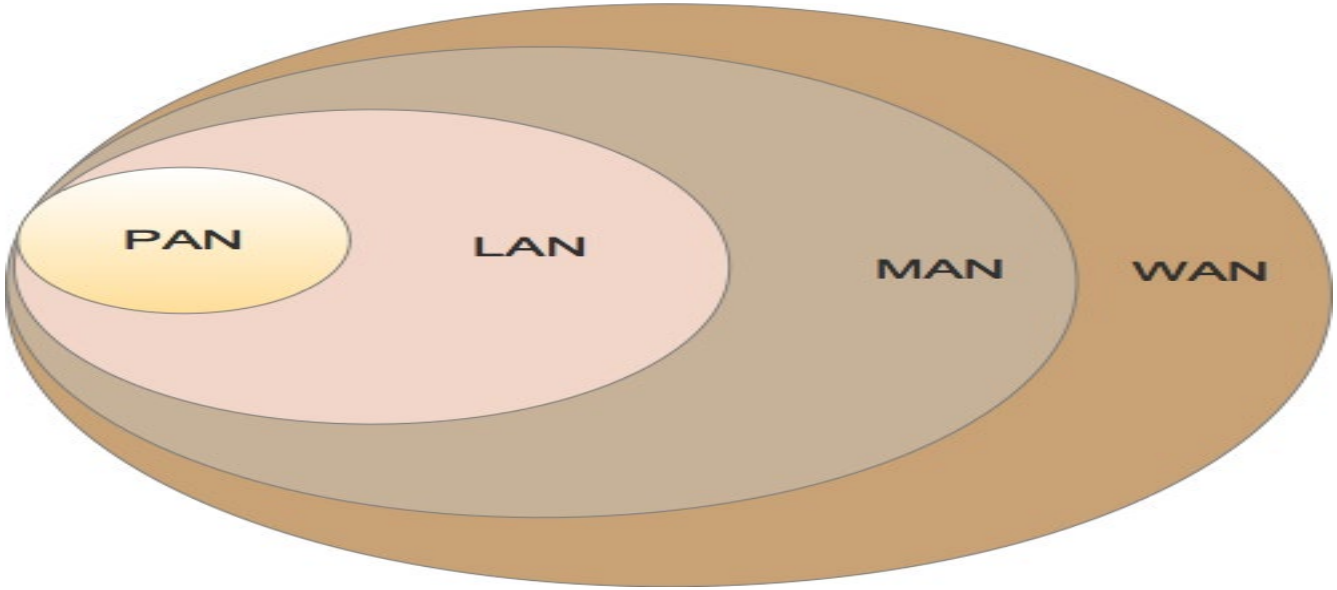
Full Duplex

- 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)

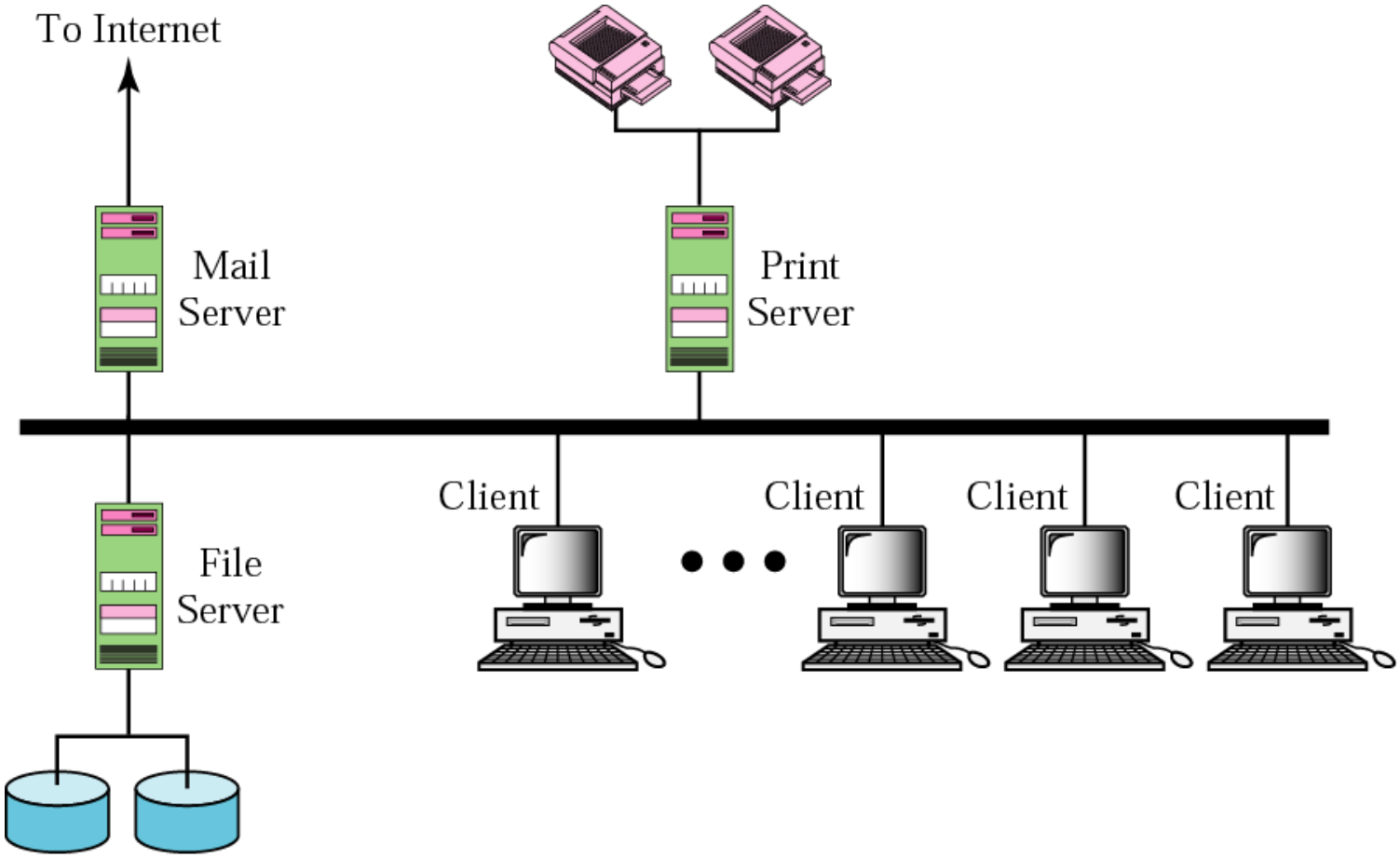


Network names by scale

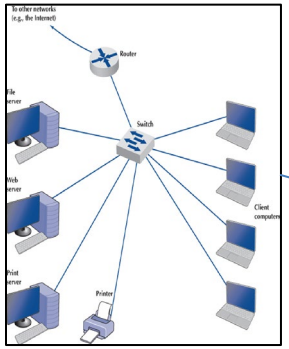
Type	**Example**
PAN (Personal Area Network)	Bluetooth (e.g., headset)
LAN (Local Area Network)	WiFi, Ethernet
MAN (Metropolitan Area Network)	Cable, DSL
WAN (Wide Area Network)	Large ISP
The Internet (network of all networks)	The Internet!

Internet can be considered as a large WAN

Local Area Network (LAN)

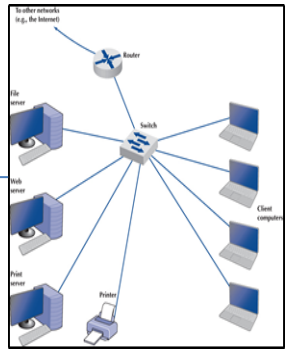


Metropolitan Area Network (MAN)

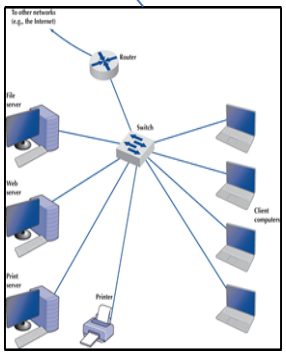


Oakland

Metro Ethernet service

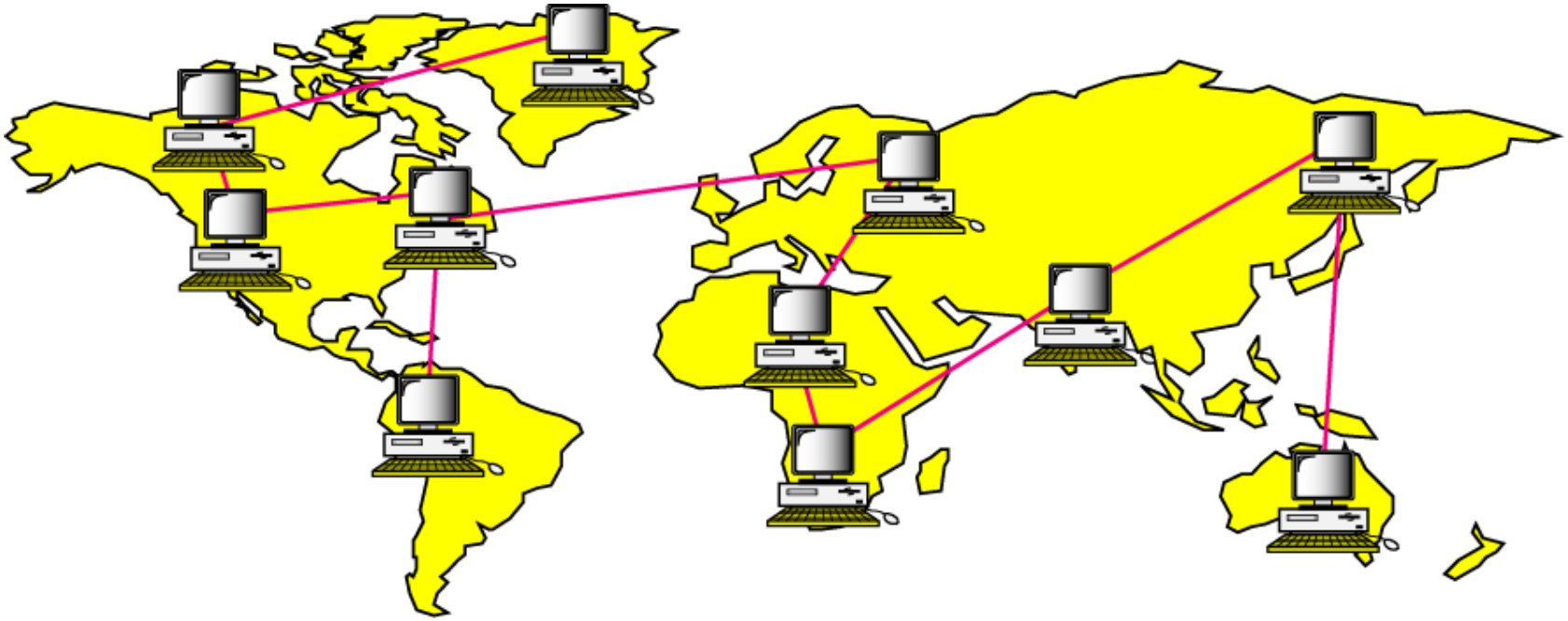


Wexford

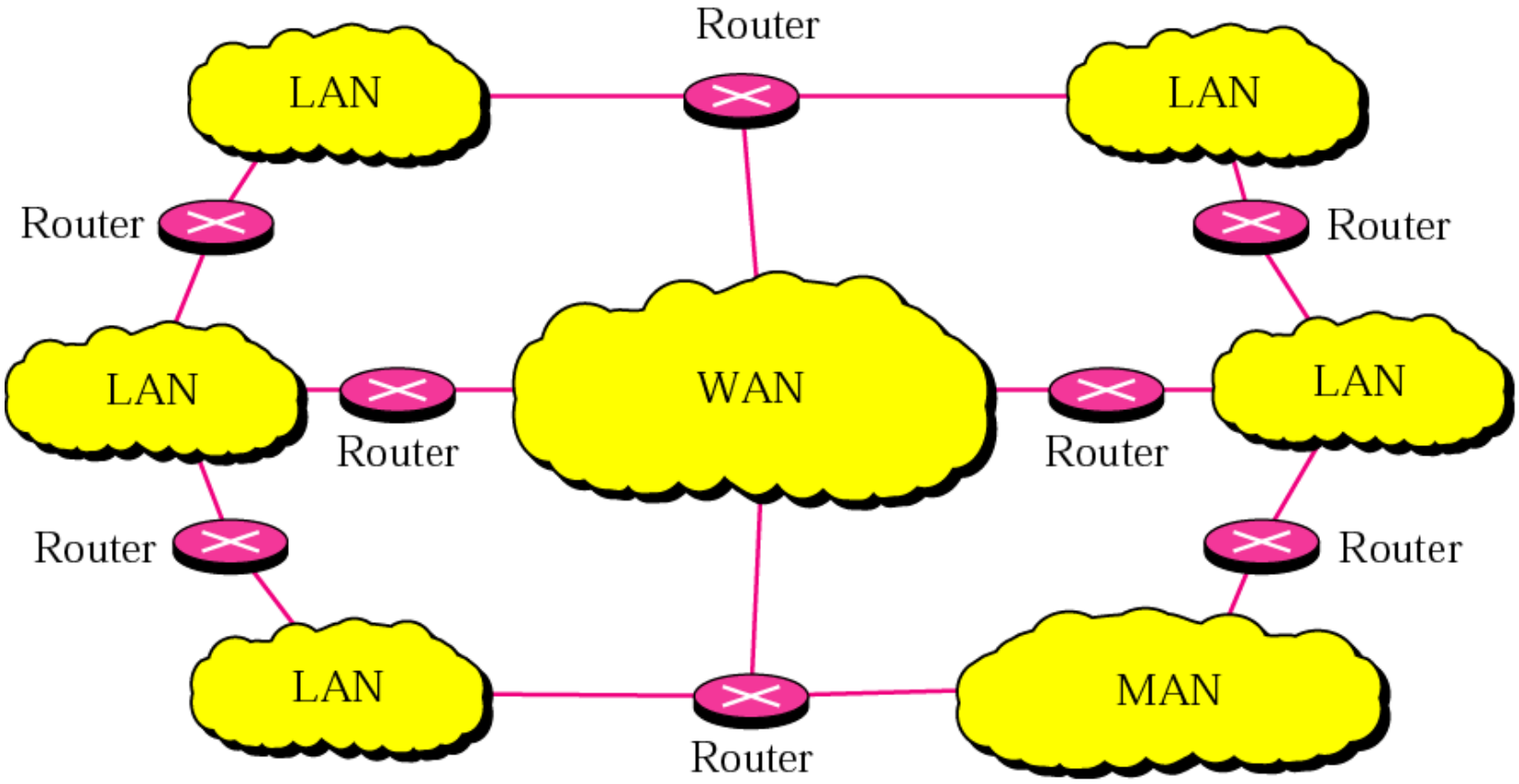


Southside

Wide Area Network (WAN)



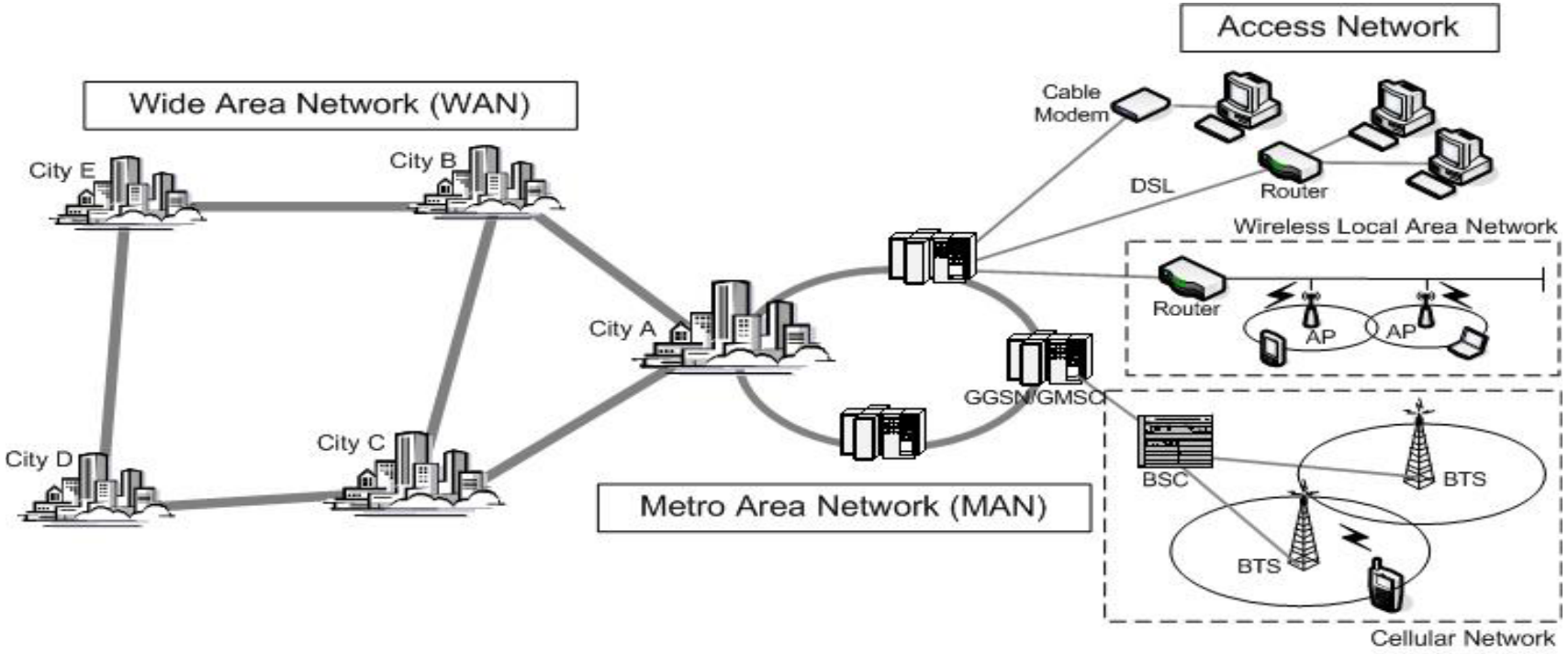
Internet



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

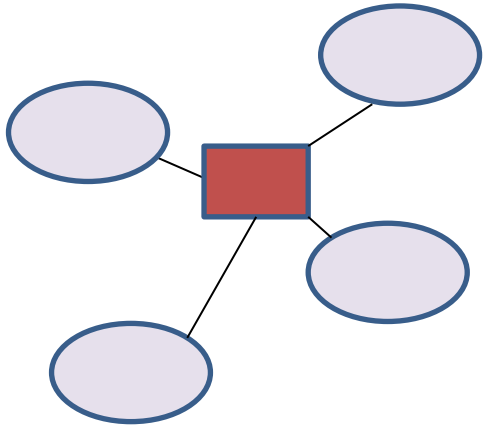
Network Types

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

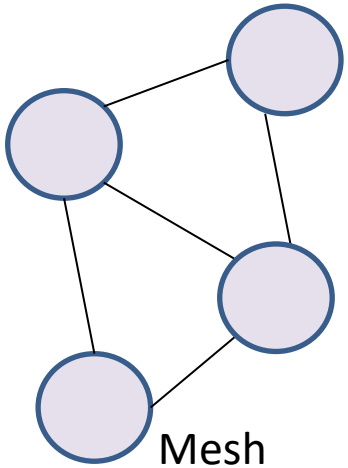


Network Classification: Based on Topology

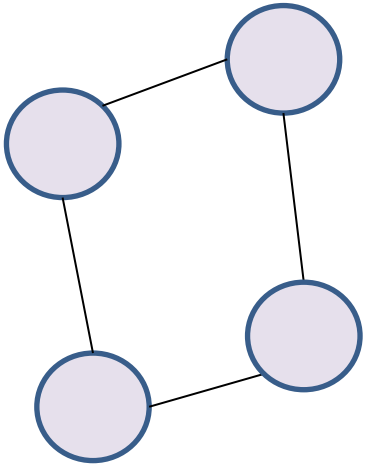
- Topology defines how nodes are connected
- Possible topologies: Star, Tree, Mesh, Ring



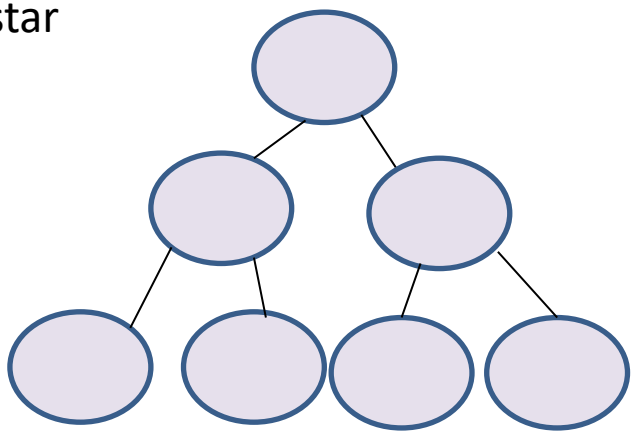
star



Mesh



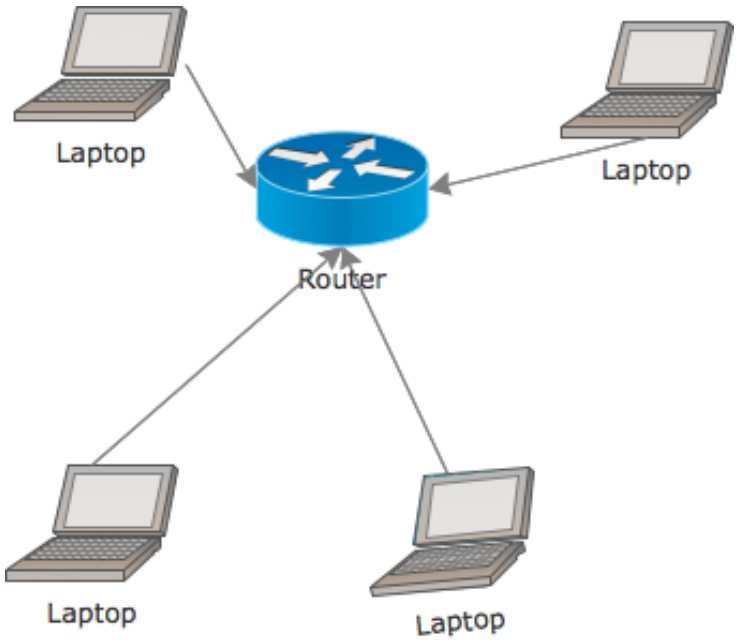
Ring



Tree

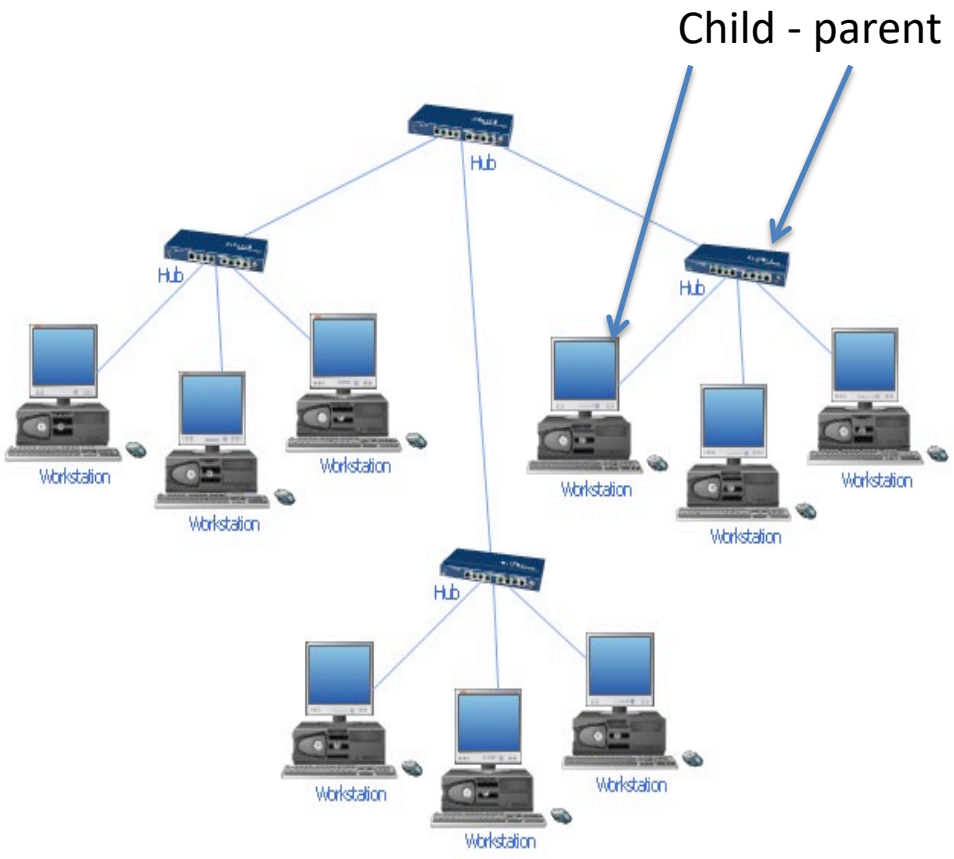
Star Topology

- 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

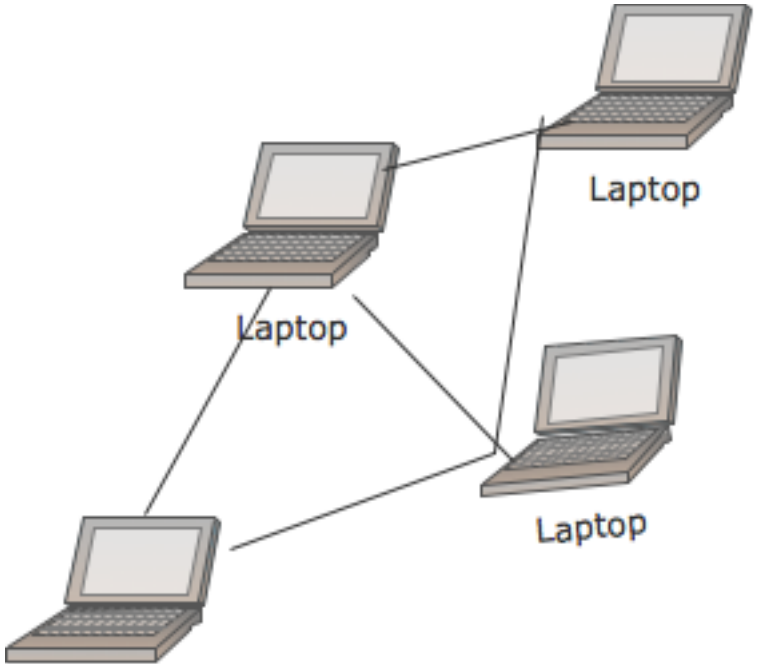


Ring Topology

- All devices are connected in a loop
- Traffic can be unidirectional or bidirectional:
  - Bidirectional could be faster
- **Disadvantage: communication latency** for long routes

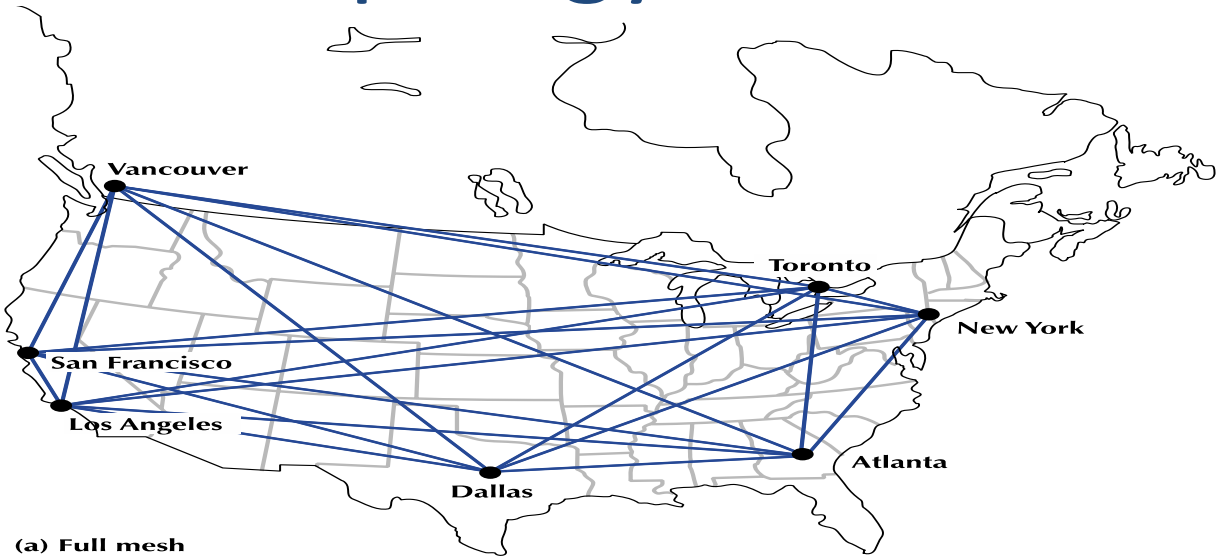
Mesh Topology

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



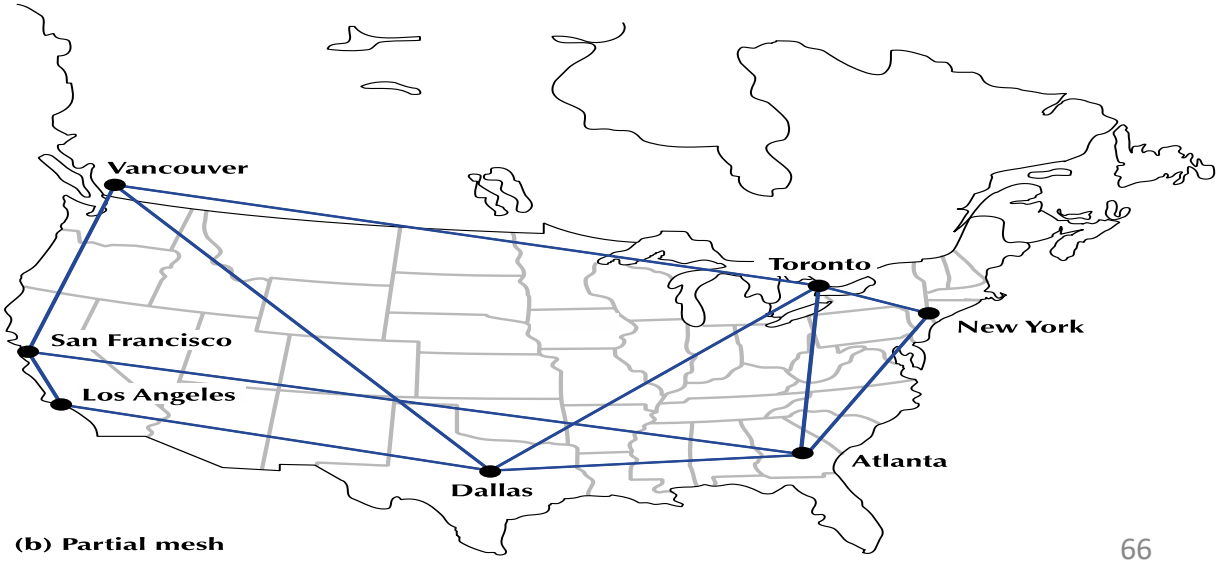
Mesh Topology

- 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

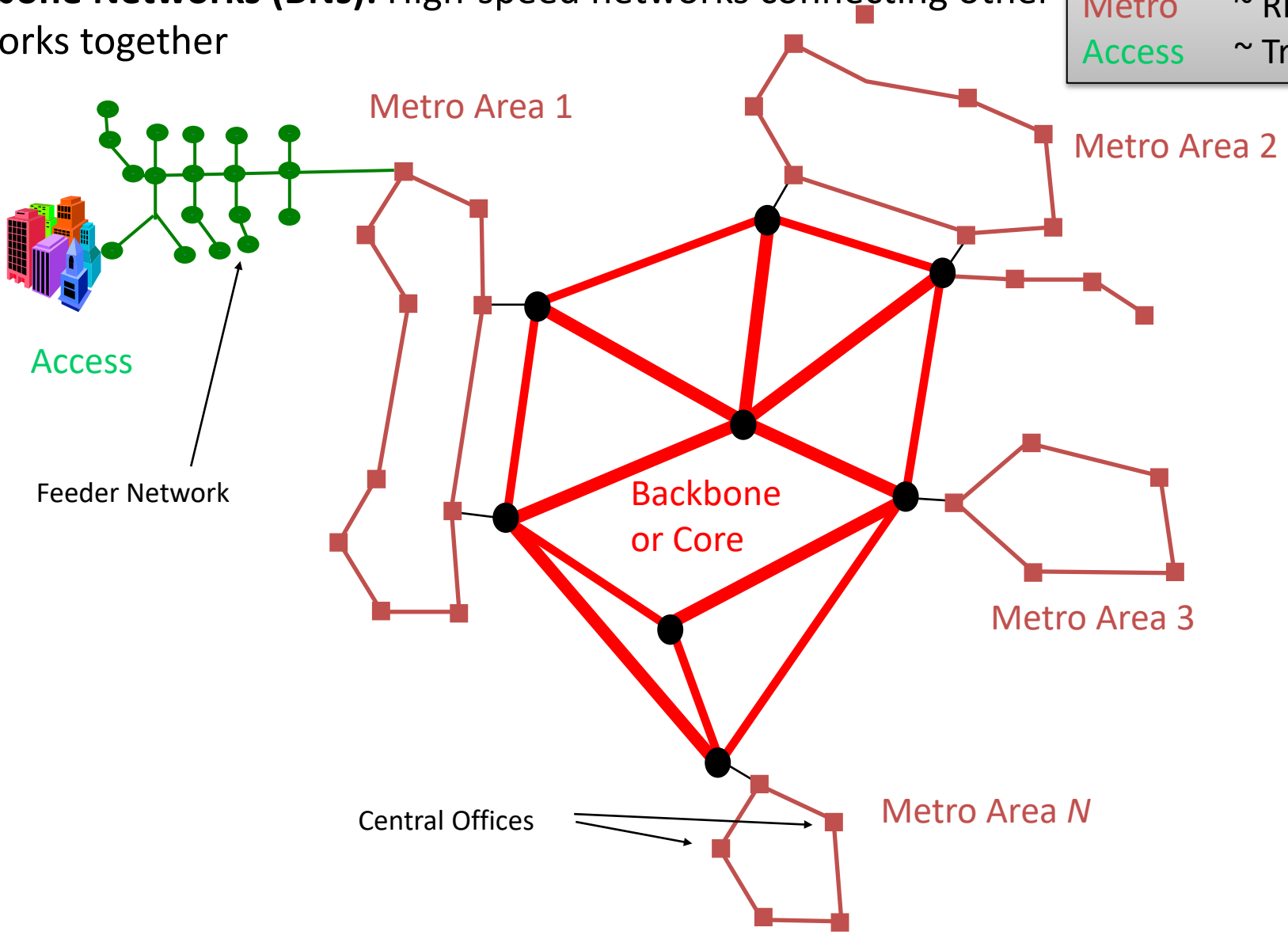
C) There is no single point of failure

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