

Lecture 1 - An Introduction

Computer Communication Networks
CS35201 - (001/ 002)
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Kent State University



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Outline I

1 Overview

- Business Application
- Home Applications
- Mobile Applications
- Social Networks

2 Network Hardware

- Personal Area Networks
- Local Area Networks
- Metropolitan Area Networks
- Wide Area Networks

3 Network Software Protocols

- Connection-oriented vs. Connection-less Service
- Service Primitives
- The Relationship of Services to Protocols
- Reference Models

Outline II

4 Network Examples

- ARPNET
- NSFNET
- Architecture of the Internet
- Third-Generation Mobile Phone Networks

5 Wireless LANs

- Network Standardization

6 What's Next?

7 References

Computer Networks Applications

Application Classification

- ① Business Applications
- ② Home Applications
- ③ Mobile Users
- ④ Social networks

Other classifications based on their range, technology, etc.

- Wired vs. wireless (1G, 2G, ..., 6G)
- LAN, MAN, WAN, ...
- Terrestrial, satellite, space, ...
- Cellular, ad hoc, sensor, mesh ...

Classification Based on Applications

Computer Networks Applications

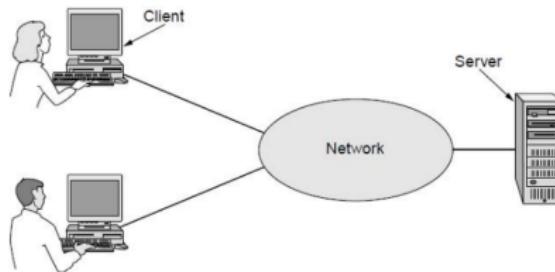
Business Applications

- Resource Sharing
- VPNs
- Client-Server Model
- VoIP
- Desktop Sharing
- e-Commerce

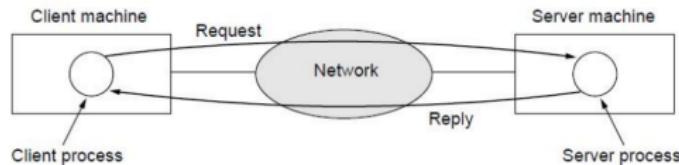
Computer Networks Applications

Business Applications

Example 1: A network with two clients and one server



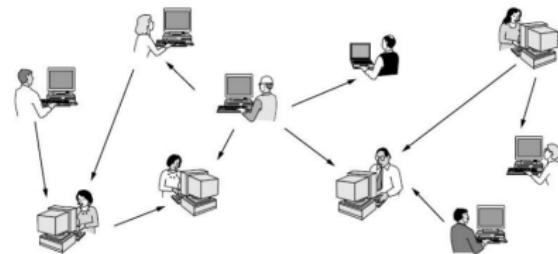
Example 2: The client-server model involves requests and replies



Computer Networks Applications

Home Applications

Example 1: In a Peer-to-Peer (P2P) system there are no fixed clients and servers



Example 2: Some forms of e-commerce

- Business-to-consumer ⇒ Ordering books online
- Business-to-business ⇒ Car manufacturer ordering tiers from supplier
- Government-to-consumer ⇒ IRS distributing tax forms electronically
- Consumer-to-consumer ⇒ Auctioning second-hand products online
- Peer-to-peer ⇒ Music sharing

Computer Networks Applications

Mobile Applications

- Mobile Users

- Mobility vs. Wireless ⇒ Not the same

Why?

Example 1: Combinations of wireless networks and mobile computing

Wireless	Mobile	Typical applications
NO	NO	Desktop computer in offices
NO	YES	A notebook computer is used in a hotel room
YES	NO	Networks in unwired building
YES	YES	Store inventory with a handheld computer

Computer Networks Applications

Mobile Applications

- Network neutrality
 - No restrictions by Internet Service Provider (ISP)/Governments on contents, sites, platforms, equipment, and mode of communication
 - ISPs should not be able to play favorites with the content that goes over the network
- Digital Millennium Copyright Act
 - Treaties of the World Intellectual Property Organization (WIPO)
- Profiling users
 - Explicit digital representation of a person's identity ⇒ LinkedIn
- Phishing
 - Criminally fraudulent process of attempting to acquire sensitive information such as usernames, passwords, and credit card details by masquerading as a trustworthy entity in an electronic communication

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Computer Networks Hardware

Transmission Technologies

- Broadcast
 - Broadcasting
 - Multicasting (Transmission to a subset of machines)
- Point-to-Point
 - Unicasting

Computer Networks Hardware

Range, Size and Scale

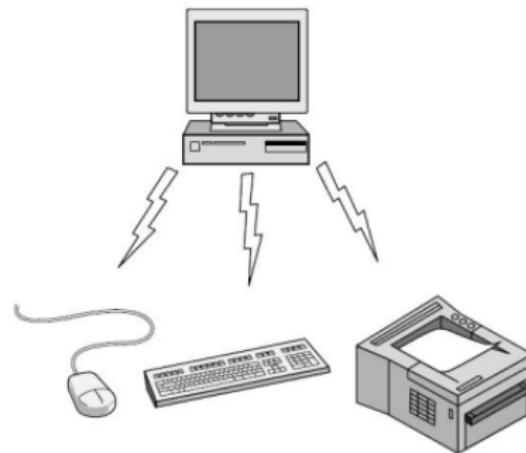
- ① Personal Area Networks
- ② Local Area Networks
- ③ Metropolitan Area Networks
- ④ Wide Area Networks
- ⑤ The Internet

Interprocessor distance	Processors located in same	Example
1 m	Square meter	Personal area network
10 m	Room	
100 m	Building	Local area network
1 km	Campus	
10 km	City	Metropolitan area network
100 km	Country	
1000 km	Continent	Wide area network
10,000 km	Planet	The Internet

Computer Networks Hardware

Personal Area Networks

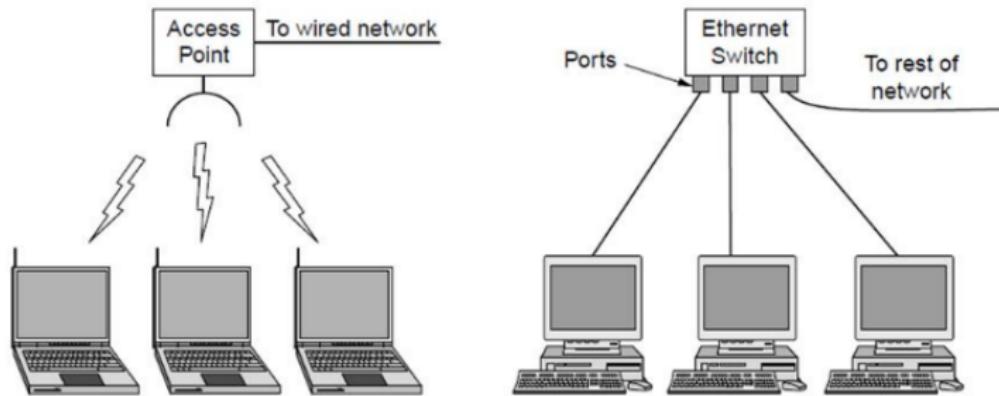
Bluetooth PAN configuration



Computer Networks Hardware

Local Area Networks

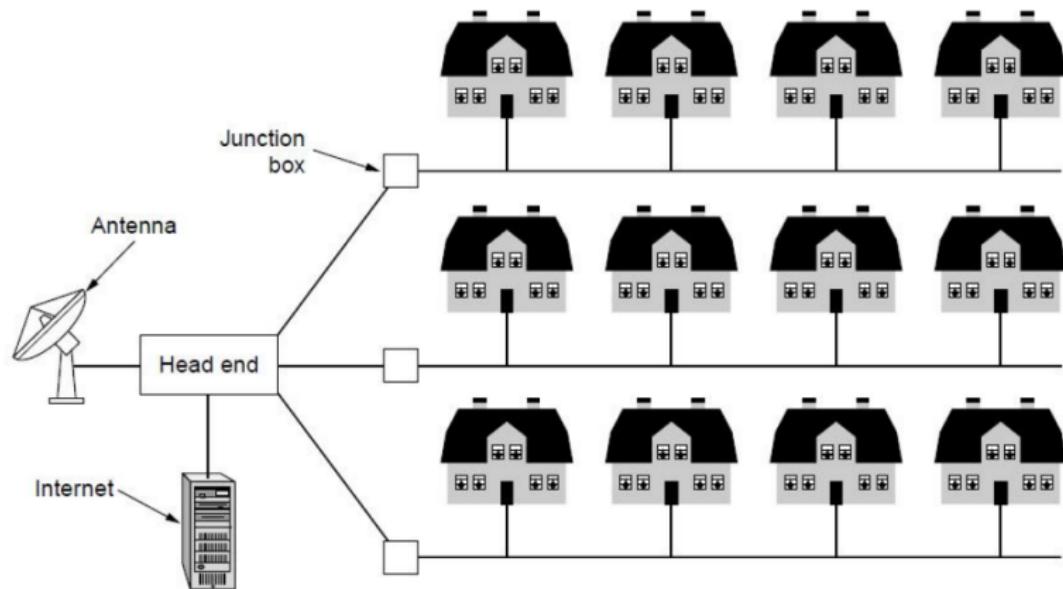
802.11 and Switched Ethernet



Computer Networks Hardware

Metropolitan Area Networks

Cable TV

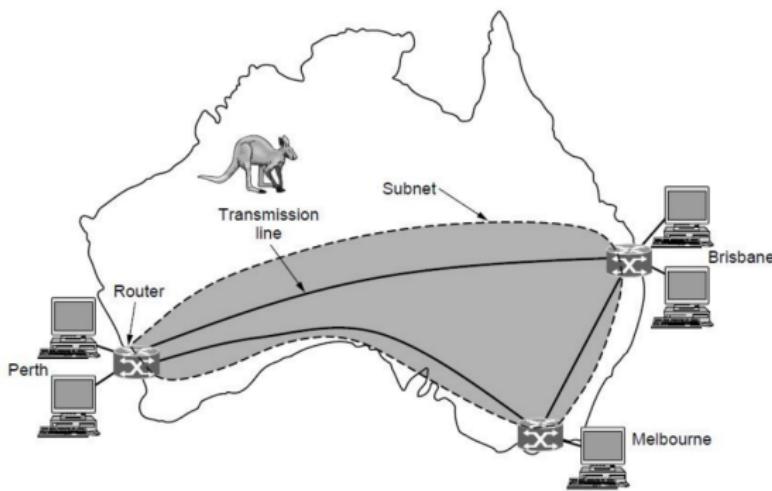


Computer Networks Hardware

Wide Area Networks

Three Branch Offices in Australia

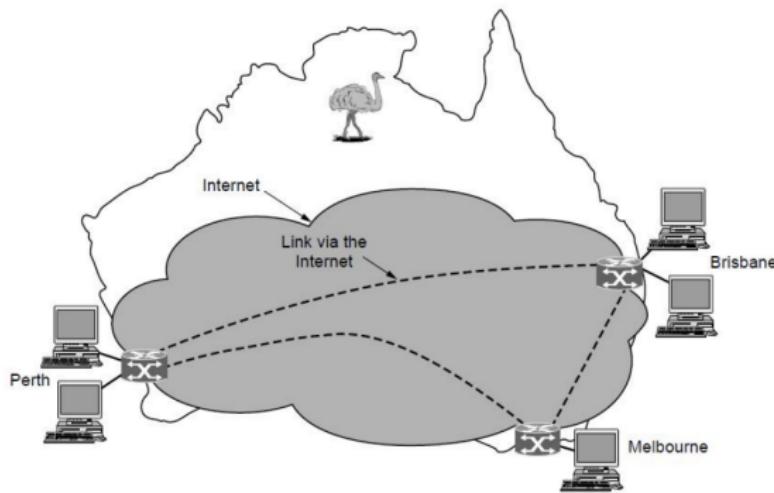
- Wide Area Network (WAN) that connects three branch offices in Australia



Computer Networks Hardware

Wide Area Networks

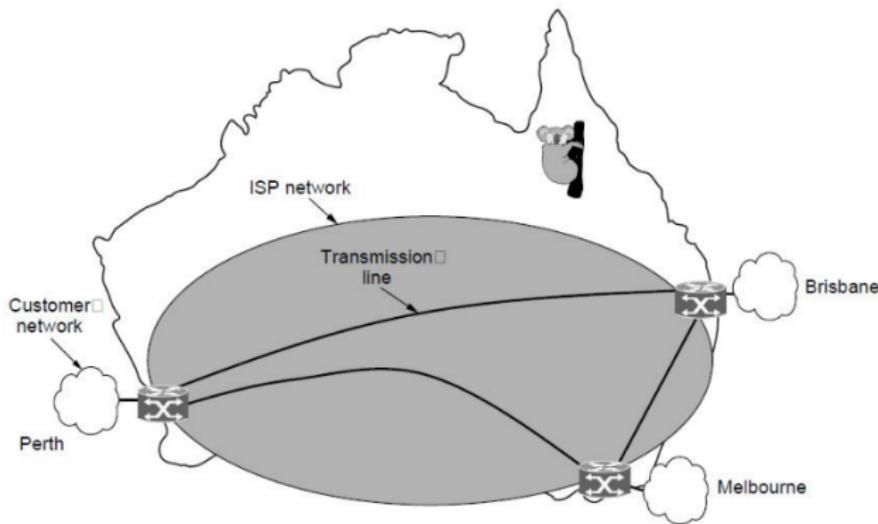
WAN Using a Virtual Private Network



Computer Networks Hardware

Wide Area Networks

WAN Using an ISP Network



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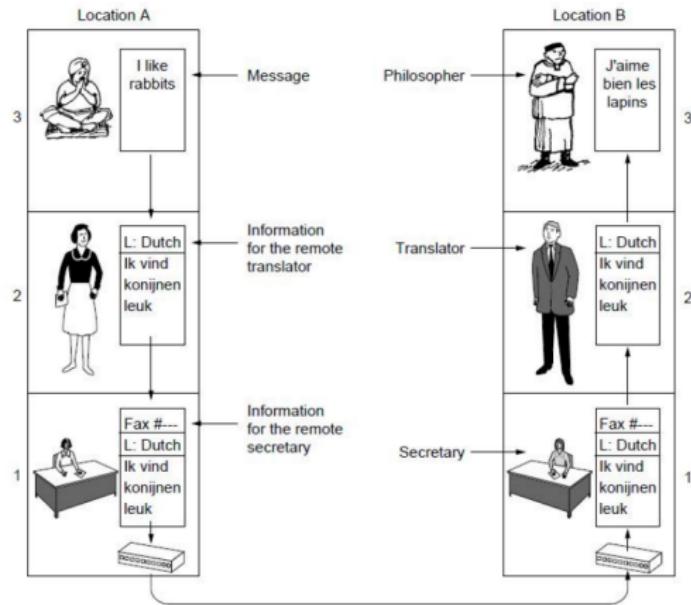
Network Software Layered Architecture

Topics in Layered Architecture

- ① Protocol hierarchies
- ② Design issues for the layers
- ③ Connection-oriented versus connection-less service
- ④ Service primitives
- ⑤ Relationship of services to protocols

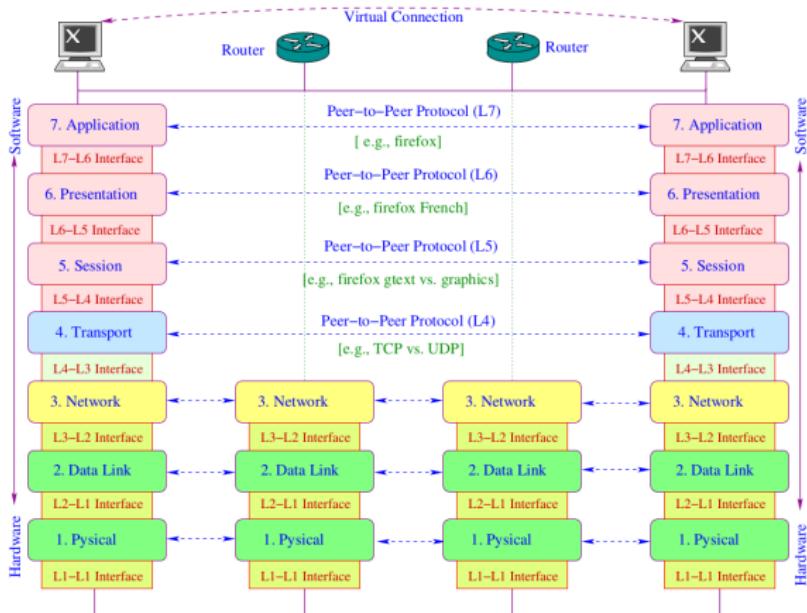
Network Software Layered Architecture

Example 1.1 (The philosopher-translator-secretary architecture)



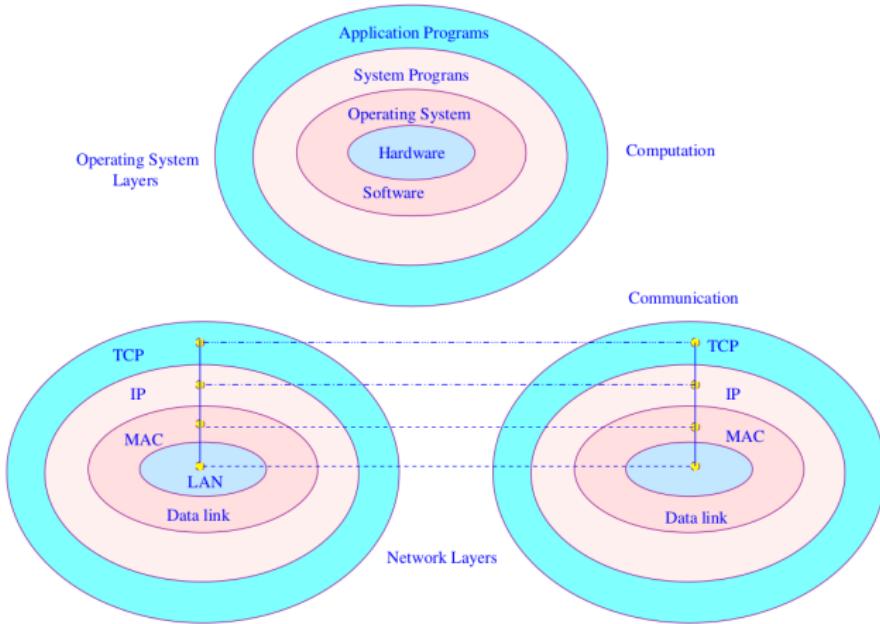
Network Layers

Hardware and Software



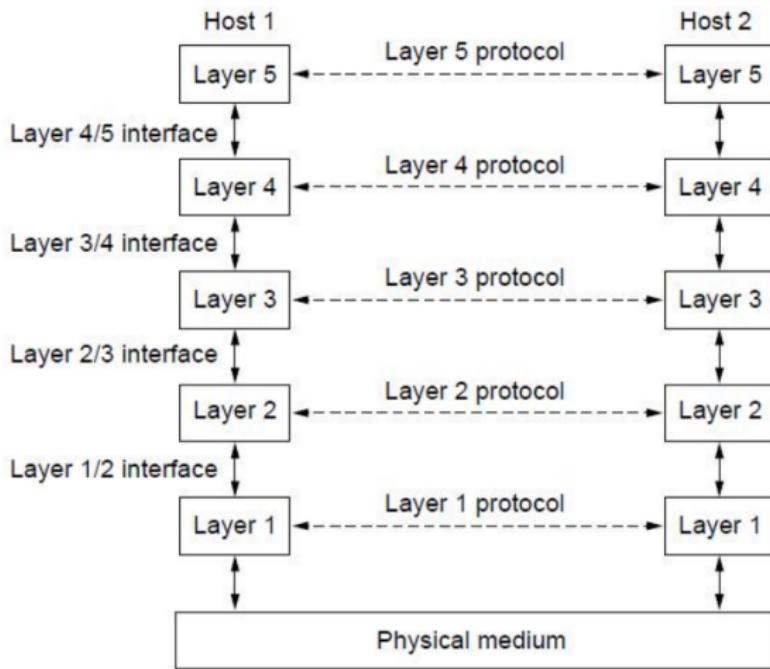
Network Layers

Layers, OS vs. Networks



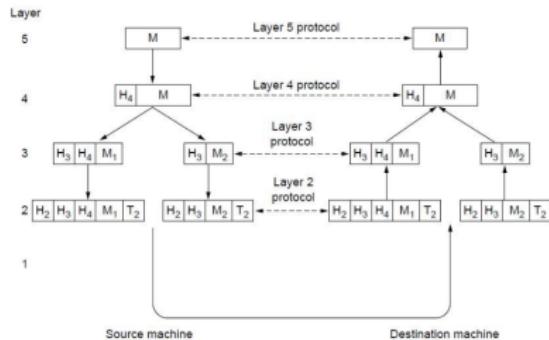
Network Layers

Layers, Protocols, and Interfaces



Network Layers

Information flow supporting virtual communication in layer 5
5



- The more layers, the more overhead ↓
- The more layers, the easier to design, manage, update ↑

Design Issues for the Layers

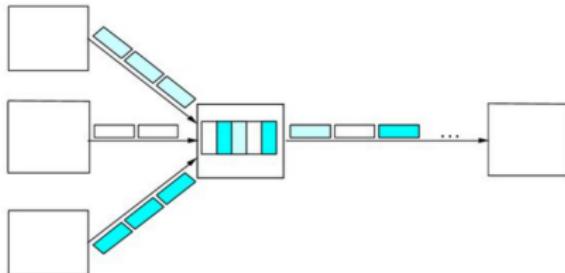
Reliability Issues

- Error Detection and Correction
- Routing
 - ① Addressing OR Naming
- Internetworking
- Scalability
- QoS
- Confidentiality and Authentication

Design Issues for the Layers

Statistical Multiplexing

- On-demand time-division (rather than in specific time slot)
- Schedule link on a per-packet basis
- Packets from different sources interleaved on link
- Buffer packets that are contending for the link
- Buffer (queue) overflow is called *Congestion*



Connection-oriented vs. Connection-less Service

Type of Services

		Services		Examples
Connection–Oriented	Reliable	Message stream	Sequence of pages	
	Unreliable	Byte stream	Remote login	
Connection-less–Oriented	Reliable	Datagram /Pulse	Digitized voice	
	Unreliable	Acked datagram	Sequence of pages	
	Reliable	Request–Reply	Registered mail	
	Unreliable	Datagram	Database query	

→ *Six different types of service*

→ *Each can be implemented on each layer*

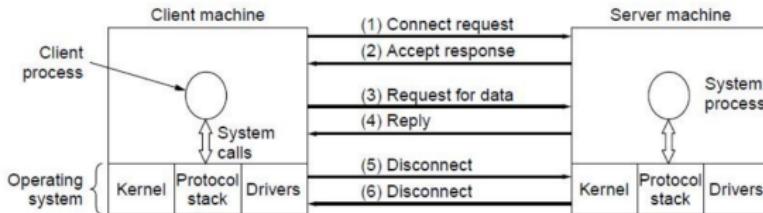
Service Primitives

Connection-Oriented

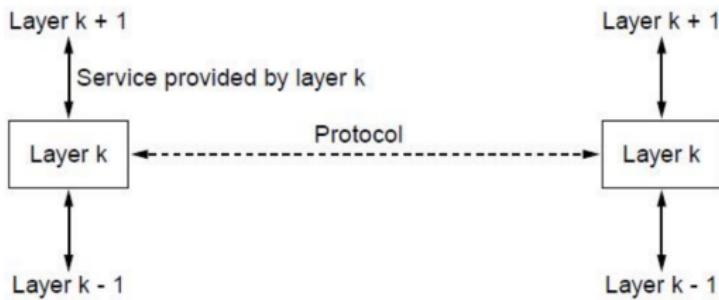
- Six service primitives that provide a simple connection-oriented service

Primitive	Meaning
LISTEN	Block waiting for an incoming connection
CONNECT	Establish a connection with a waiting peer
ACCEPT	Accept an incoming connection from a peer
RECEIVE	Block waiting for an incoming message
SEND	Send a message to the peer
DISCONNECT	Terminate a connection

- A simple client-server interaction using acknowledged datagrams



The Relationship of Services to Protocols



→ *The relationship between a service and a protocol*

- Layer ⇒ Black Box
- Service Provider ⇒ Input/Output ⇒ Depend on the Direction ⇒ Send/Receive Service

Reference Models

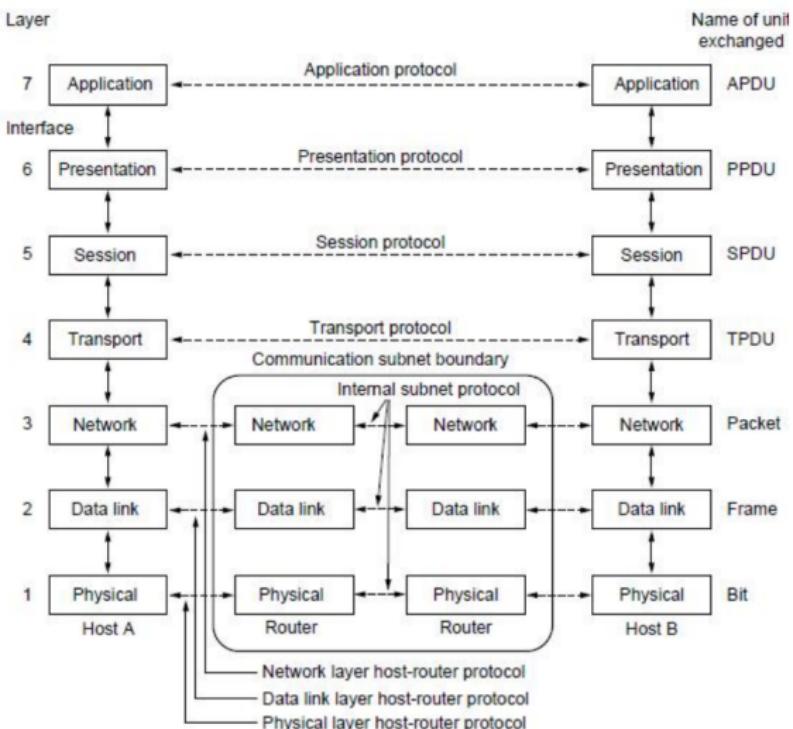
Towards Standardization

- ① Open Systems Interconnection (OSI) reference model
- ② Transport Control Protocol (TCP)/IP reference model
 - Models used in the text
 - Comparison of OSI and TCP/IP
 - Critique of OSI model and protocols
 - Unrealistic
 - Too many layers ⇒ overheads
 - Critique of TCP/IP model
 - TCP/IP model doesn't care about LAN

The OSI Reference Model

- ① Layers are created for different abstractions
- ② Each layer performs well-defined function(s)
- ③ The function of a layer is chosen with the definition of international standard protocols in mind
- ④ Minimize information flow across interfaces between boundaries
- ⑤ Optimal number of layers

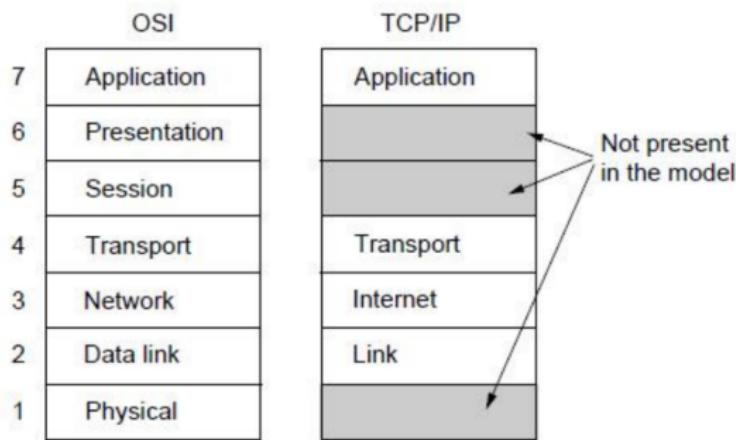
The OSI Reference Model



TCP/IP Reference Model

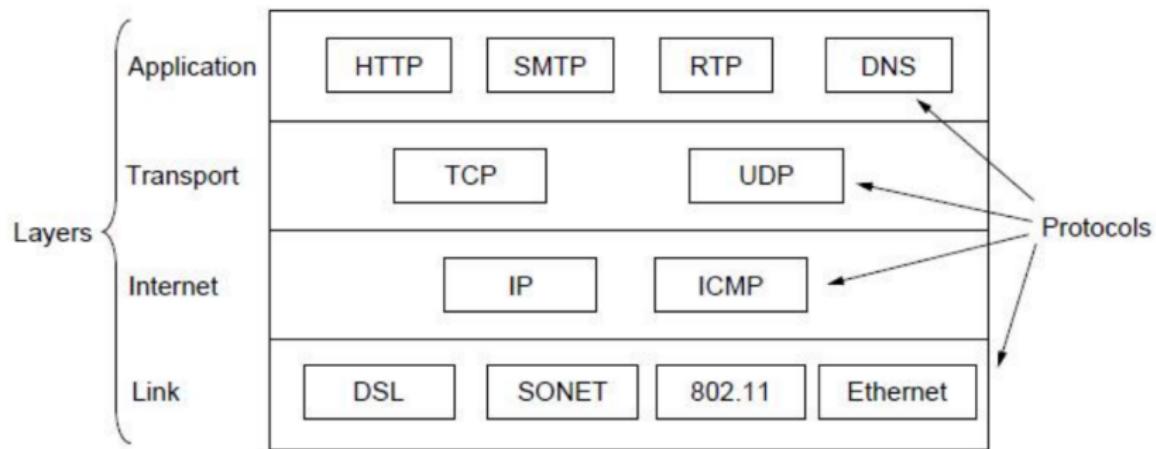
4 Layers

- ① Link Layer
- ② Internet Layer
- ③ Transport Layer
- ④ Application Layer



TCP/IP Reference Model

4 Layers



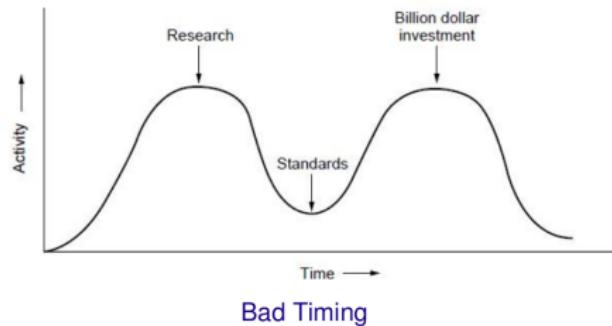
4 Layers

① Concepts central to OSI model

- Services
- Interfaces
- Protocols

② Critique of the OSI Model and Protocols

- Bad Timing
- Bad Technology
- Bad Implementation
- Bad Politics



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Network Examples

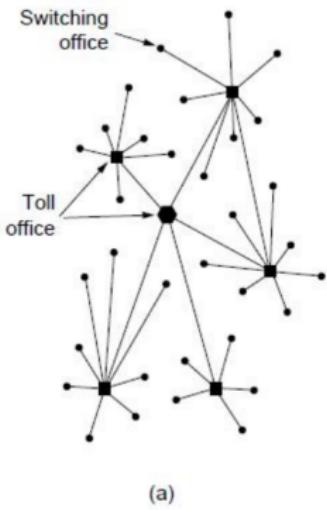
- ARPNET
- NSFNET
- Internet
- Third-generation mobile phone networks
- Wireless LANs: 802.11 (WiFi), 802.16 (WiMax), 802.15 (Bluetooth)
- Radio Frequency Identification (RFID) and Sensor Networks

Network Examples

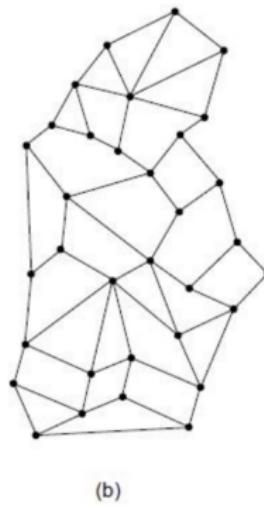
Name	Description	Status
IEEE 802.1	Higher Layer LAN Protocols Working Group	Active
IEEE 802.2	LLC	Disbanded
IEEE 802.3	Ethernet	Active
IEEE 802.4	Token bus	Disbanded
IEEE 802.5	Token Ring MAC layer	Disbanded
IEEE 802.6	MANs (QDB)	Disbanded
IEEE 802.7	Broadband LAN using Coaxial Cable	Disbanded
IEEE 802.8	Fiber Optic TAG	Disbanded
IEEE 802.9	Integrated Services LAN (ISLAN or isoEthernet)	Disbanded
IEEE 802.10	Interoperable LAN Security	Disbanded
IEEE 802.11	Wireless LAN (WLAN) & Mesh (Wi-Fi certification)	Active
IEEE 802.12	100BaseVG	Disbanded
IEEE 802.13	Unused ^[2]	Reserved for Fast Ethernet development ^[3]
IEEE 802.14	Cable modems	Disbanded
IEEE 802.15	Wireless PAN	Active
IEEE 802.15.1	Bluetooth certification	Disbanded
IEEE 802.15.2	IEEE 802.15 and IEEE 802.11 coexistence	Hibernating ^[4]
IEEE 802.15.3	High-Rate wireless PAN (e.g., UWB, etc.)	?
IEEE 802.15.4	Low-Rate wireless PAN (e.g., ZigBee, WirelessHART, MiWi, etc.)	Active
IEEE 802.15.5	Mesh networking for WPAN	?
IEEE 802.15.6	Body area network	Active
IEEE 802.15.7	Visible light communications	?
IEEE 802.16	Broadband Wireless Access (WiMAX certification)	Hibernating
IEEE 802.16.1	Local Multipoint Distribution Service	Hibernating
IEEE 802.16.2	Coexistence wireless access	Hibernating
IEEE 802.17	Resilient packet ring	Disbanded
IEEE 802.18	Radio Regulatory TAG	Active
IEEE 802.19	Wireless Coexistence Working Group	?
IEEE 802.20	Mobile Broadband Wireless Access	Disbanded
IEEE 802.21	Media Independent Handoff	Hibernating
IEEE 802.22	Wireless Regional Area Network	Hibernating
IEEE 802.23	Emergency Services Working Group	Disbanded
IEEE 802.24	Vertical Applications TAG	?

ARPNET

Difference Between ARPANET and Telephone Network



(a)

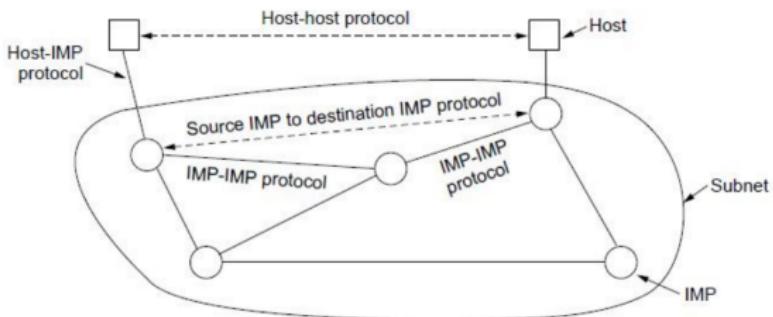


(b)

- (a) Structure of the telephone system
- (b) Baran's proposed distributed switching system

The original ARPANET Design

Role of Routers

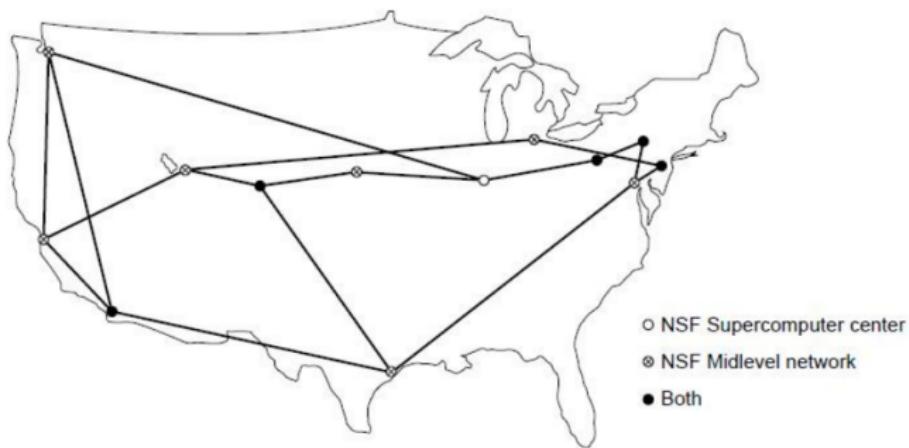


- Interface Message Processor (IMP) = Router
- Routers are programmable switched (layer 3)
- Switches are layer 2 devices

See Internet's first router

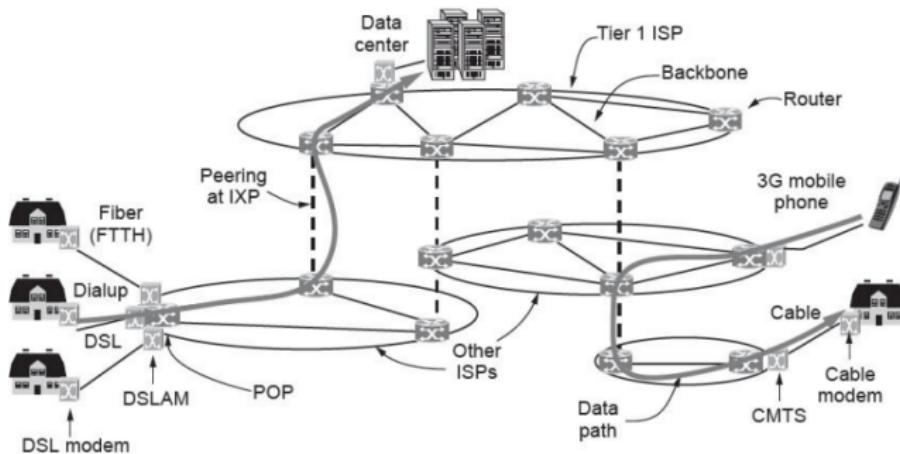
NSFNET

Towards Academic and Public Use



- The NSFNET backbone in 1988

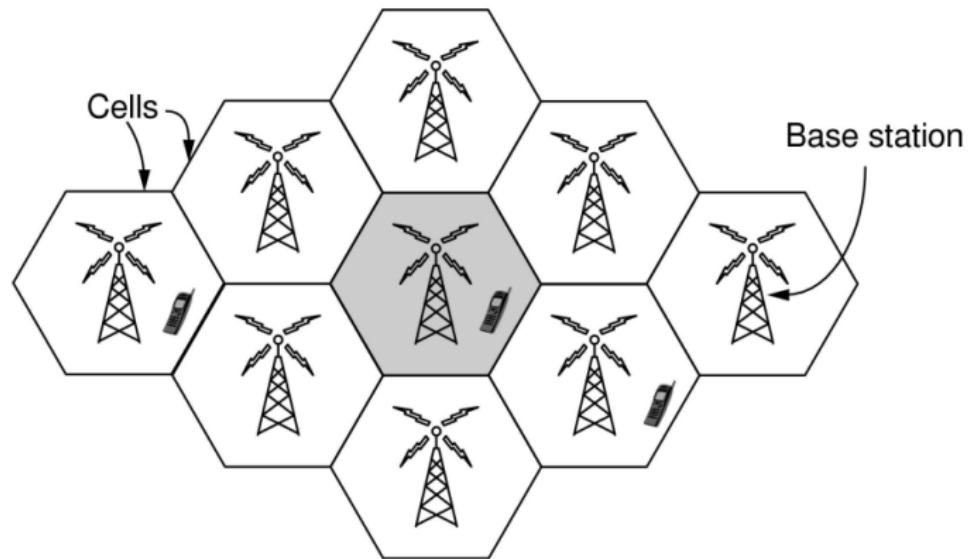
Architecture of the Internet



- Overview of the Internet architecture
 - DSLAM: Digital Subscriber Line Access Multiplexer
 - POP: Point of Presence
 - FTTH: Fiber to the Home
 - IXP: Internet eXchange Point
 - CMTS: Cable Modem Termination System

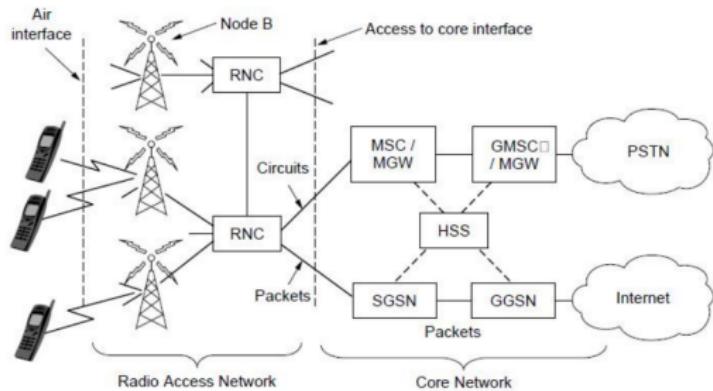
Third-Generation Mobile Phone Networks

Digital + Cellular + Texting



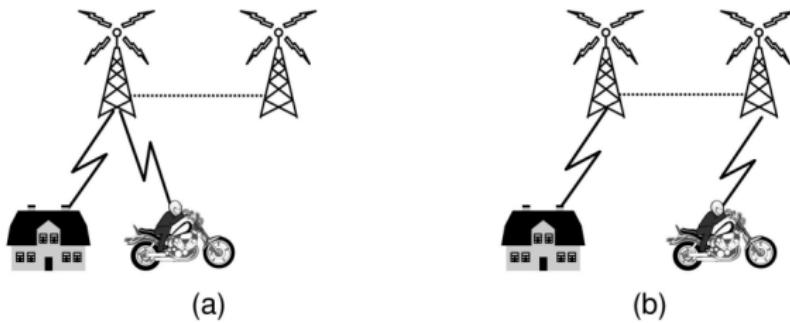
Third-Generation Mobile Phone Networks

Digital + Cellular + Texting



- UMTS: Universal Mobile Telecommunication System
- RNC: Radio Network Controller
- GPRS: General Packet Radio Service
- GGSN: Gateway GPRS Support Node
- SGSN: Service GPRS Support Node
- MGW: Media Gateway
- GMSC: Gateway Mobile Switching Center
- HSS: Home Subscriber Server

Third-Generation Mobile Phone Networks



- Mobile phone handover (hand-off) (a) before, (b) after
- 4th & 5th generations tried to improve
 - Transmission range
 - Better bit-rate (bandwidth)
 - Quality of Service (QoS)
 - Better security

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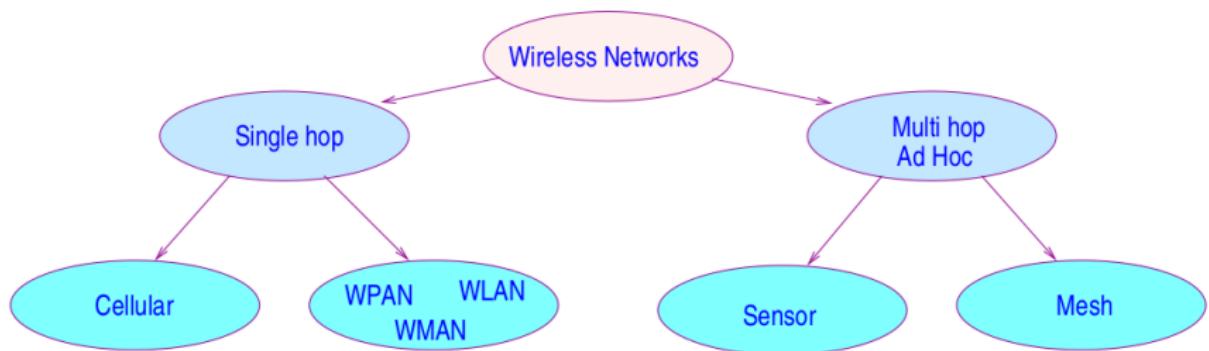
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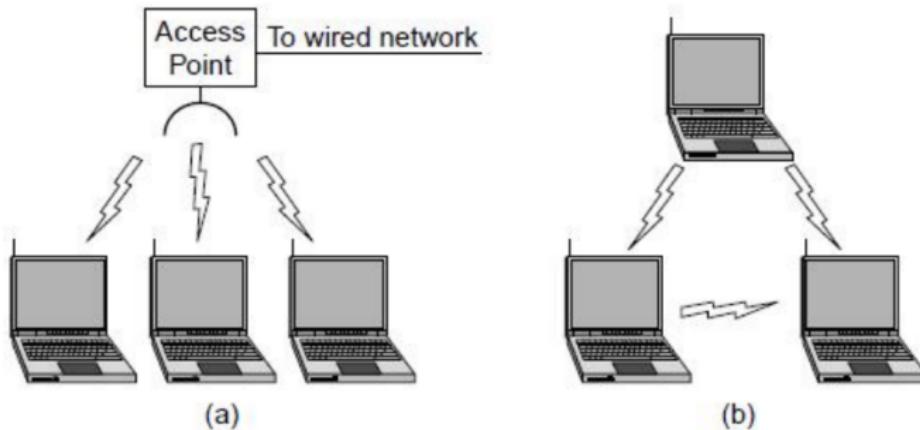
Wireless Networks

Classification



Wireless Networks

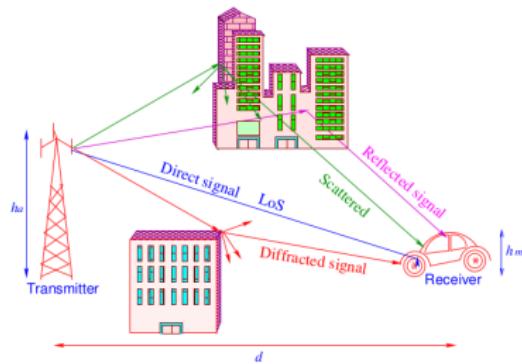
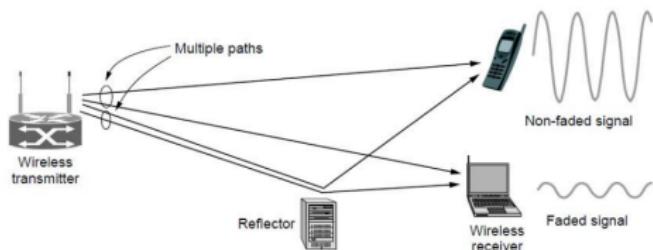
IEEE 802.11



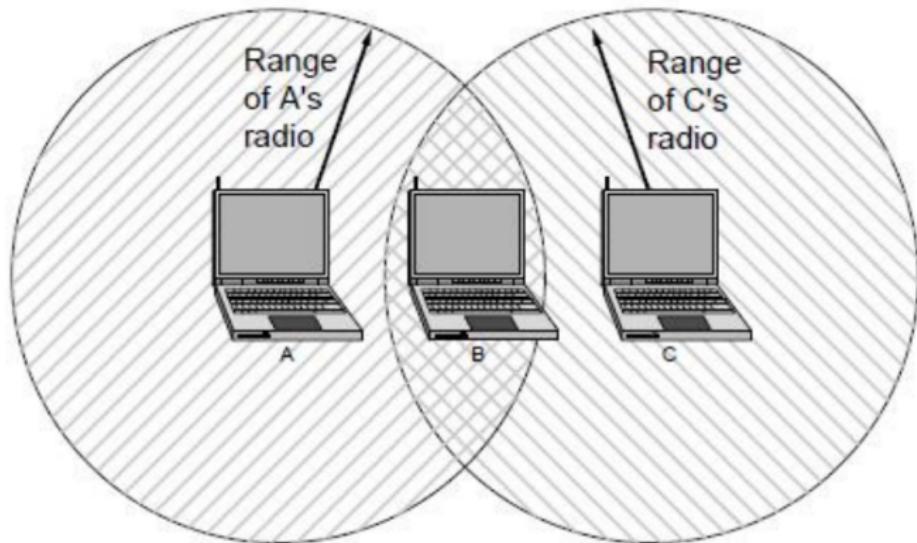
- ① Wireless network with an access point
- ② Ad-hoc network

Wireless LANs: IEEE 802.11

Multi-path Fading



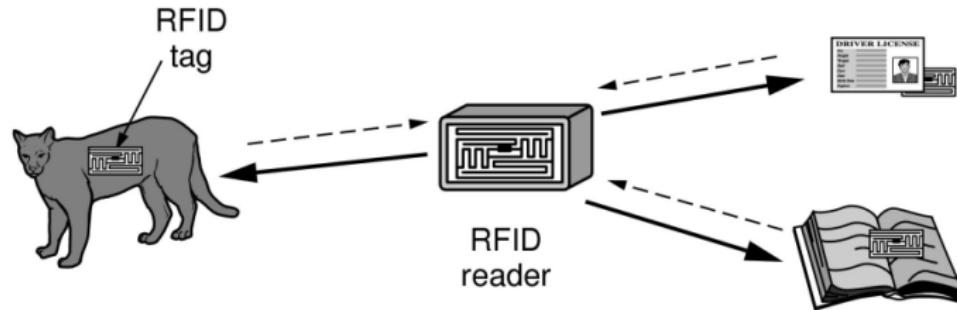
Wireless LANs: IEEE 802.11



- 1 The range of a single radio may not cover the entire system

RFID and Sensor Networks

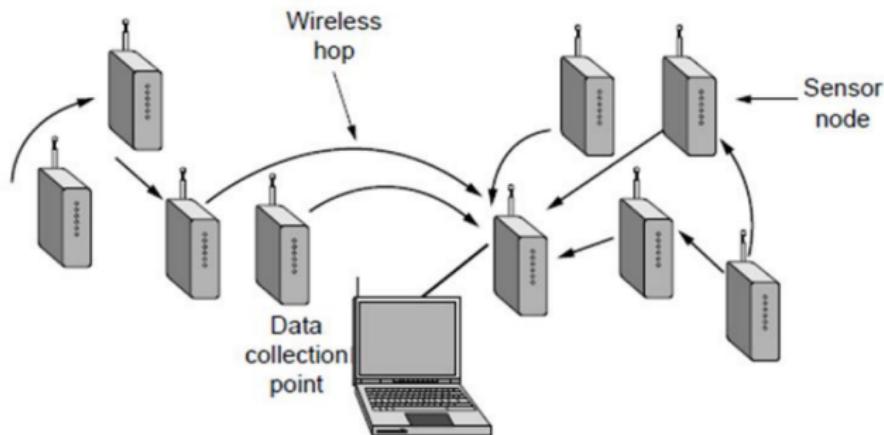
RFID



- RFID used to network everyday objects

RFID and Sensor Networks

Sensor Networks



- Multihop topology of a sensor network

Network Standardization

- ① International Standards Organization (ISO)
 - makes standards for many different activities
- ② American National Standards Institute (ANSI)
 - US representative to ISO
- ③ CCITT
 - One part of the UN agency International Telecommunications Union
 - Concerned with telephone and data communication services
 - US representative is the State Department
- ④ National Institute of Standards and Technology (NIST)
 - Standards body for US government purchases
- ⑤ Institute of Electrical and Electronics Engineers (IEEE)
 - Key standards for LANs
- ⑥ Internet Engineering Task Force (IETF)

802 Working Group

802.x

Number	Topic
802.1	Overview and architecture of LANs
802.2 ↓	Logical link control
802.3 *	Ethernet
802.4 ↓	Token bus (was briefly used in manufacturing plants)
802.5	Token ring (IBM's entry into the LAN world)
802.6 ↓	Dual queue dual bus (early metropolitan area network)
802.7 ↓	Technical advisory group on broadband technologies
802.8 †	Technical advisory group on fiber optic technologies
802.9 ↓	Isochronous LANs (for real-time applications)
802.10 ↓	Virtual LANs and security
802.11 *	Wireless LANs (WiFi)
802.12 ↓	Demand priority (Hewlett-Packard's AnyLAN)

- The important ones are marked with *
- The ones marked with ↓ are hibernating
- The one marked with † gave up and disbanded itself

802 Working Group

802.11

Amendment	Description
802.11a	Physical Layer 5 GHz band
802.11b	Physical Layer 2.4 GHz band
802.11c	Bridging operations with roaming (802.11d)
802.11d	Roaming operations
802.11e	QoS to the MAC layer
802.11g	Physical Layer 2.4 GHz band
802.11h	Spectrum management
802.11i	Enhancing security
802.11j	4.9-5.0 GHz operation in Japan
802.11k	Radio resource measurements
802.11m	Maintenance of the standard
802.11n	MIMO antenna
802.11p	High mobility
802.11r	Fast roaming
802.11s	Mesh
802.11t	Testing WLAN Equipment
802.11u	Internet working with other networks
802.11v	Network management
802.11w	Extension 802.11i; Enhancing security further
802.11y	3.65-3.7 GHz in the US

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What's Next?

Road Map

- Device-to-Device Communication
 - Chapter 2
- Point-to-Point (P2P) Communication (one hop communication)
 - Chapters 3 & 4
- End-to-End (E2E) Communication (multi-hop communication)
 - Chapters 5 & 6

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[Tanenbaum and Wetherall, 2011] Tanenbaum, A. S. and Wetherall, D. J. (2011). Computer Networks: 5th Edition. Prentice Hall PTR.