

Data Communication & Networks

Chapter 1: Introduction

Course Basic Information

No.	Course Learning Outcome (CLO) Statements	Assessment Tools	Taxonomy Levels	PLO
1	Describe Internet architecture and network performance parameters.	Q1, M1	C2	1
2	Explain network applications and the model of transport layer	A1, M1, M2	C2	1
3	Demonstrate the application of network layer protocols.	A2, Q2, M2, F	C3	2
4	Analyze the design principles involved in data link layer	A3, F	C4	2
5	Explain physical layer concepts in data communication including data rates, line coding schemes, and Shannon's capacity limits.	A4, Q3, F	C2	1

Course Basic Information

Week	Course Contents/Topics	Chapter*	CLO*
01	Introduction to computer networks and reference models/network architectures	1 (1)	1
02	Data encapsulation and network performance parameters	1 (1)	1
03	Network applications and application layer protocols	7 (2)	2
04	The Transport Service	6 (3)	2
05	UDP, TCP	6 (3)	2
06	Network Layer	5 (4)	3
07	Internetworking; network layer in the Internet (IP)	5 (4)	3
08	Routing Algorithms	5 (4)	3
09	Introduction to the data link layer	3 (5)	4
10	Error detection and correction	3 (5)	4
11	ARQ Protocols	3 (5)	4
12	Multiple Access Protocols	4 (5)	4
13	Ethernet	4 (5)	4
14	Wireless LAN/Broadband Wireless	4 (6)	4
15	Physical Layer; fundamental concepts and theoretical basis for data transmission; guided/wireless transmission	2	5
16	Multiplexing; PSTN and GSM	2	5

***Reference book chapters are given in brackets**

Motivation

- **High Global Demand & Lucrative Jobs**
Network Engineer roles are among the most sought-after in the tech industry.
- In the **U.S.**, network engineers earn between **\$77K – \$100K annually**, with total compensation (including bonuses and equity) reaching **\$118K**
- In **Google**, network engineers make between **\$108K – \$195K per year**
- <https://www.coursera.org/articles/network-engineer>

Chapter 1: Introduction

Chapter 1 : Introduction

Introduction

What You Will Learn

- Lots of terminology
- Basics of communications
- Internetworking
- Network hardware
- Protocols and Layering
- Network Addressing
- Routing, Flow, Error and Congestion Control



Basics

Introduction

What You Will *NOT* Learn!

- Network operating systems
- How to configure/operate equipment in a vendor-specific way
- How to design and implement network software

You will not learn working with networks!
You will learn how to learn working with them

Introduction

➤ What is Computer Networks?

A **computer network** is a system in which two or more computers (or devices) are connected together to share resources, exchange data, and communicate with each other. These connections can be established through **wired** (like Ethernet cables) or **wireless** (like Wi-Fi, Bluetooth) methods.

Introduction

- A collection of transmission hardware and facilities, terminal equipment, and protocols
- Provides communication that is
 - Reliable
 - Fair
 - Efficient
 - From one application to another
- Automatically detects and corrects
 - Data corruption
 - Data loss
 - Duplication
 - Out-of-order delivery
- Automatically finds optimal path from source to destination

Introduction

Uses of Computer Networks

- Business Applications
 - online buying
- Home Applications
 - mail, chat
- Mobile Users
 - wireless: laptops, PDA, mobile, in plane
- Social Issues

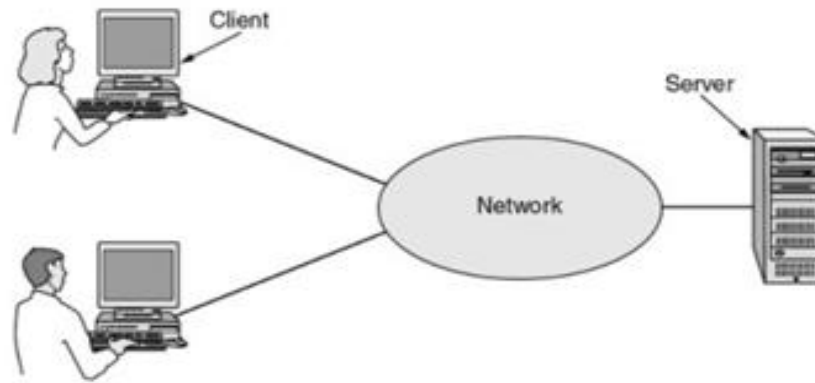
Introduction

- Client-Server Model

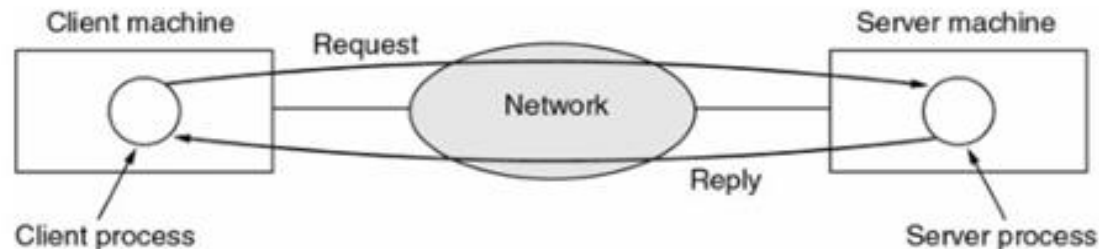
Business Applications of Networks

- A network with two clients and one server.

- ☐ Check bank account
- ☐ Pay bills
- ☐ Reserve ticket



- The client-server model involves requests and replies.



Introduction

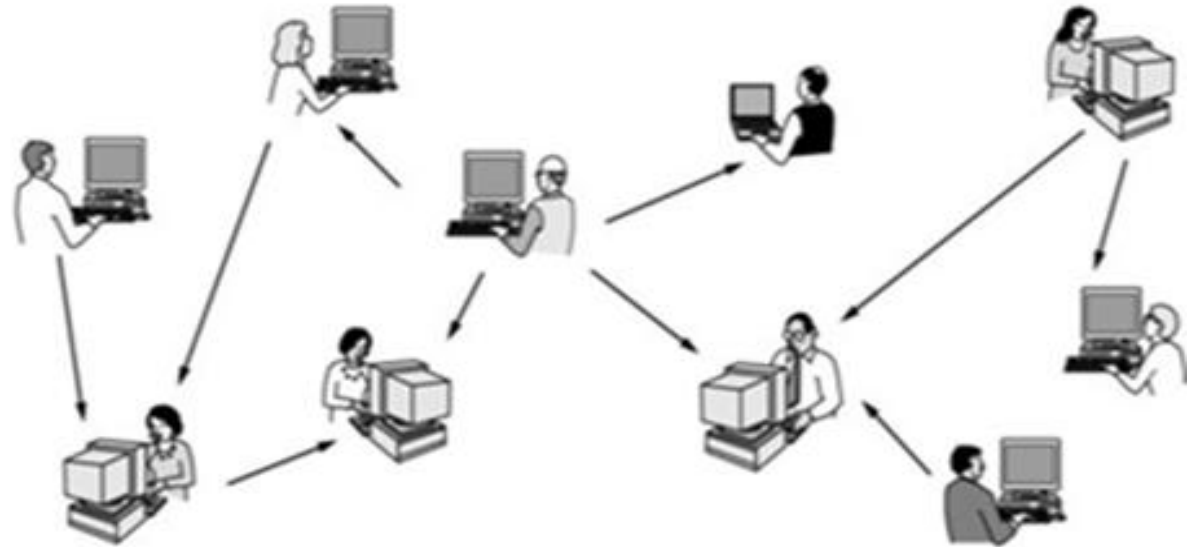
Home Network Applications

- Access to remote information
 - Learning online, downloading
- Person-to-person communication
 - chat, phone
- Interactive entertainment
 - games, movies, ...
- Electronic commerce

Introduction

Home Network Applications (2)

- Peer-to-peer (P2P)
 - Kazaa, Emule,



➤ Peer-to-Peer (P2P) Communication

- Peer-to-peer communication is a **network model** where two or more computers (called **peers**) communicate **directly with each other** without needing a central server.
- Each peer in this system is both a **client** (requesting resources) and a **server** (providing resources).

Introduction: Home Network Applications

- E-commerce

Full name	Example
Business-to-consumer	Ordering books on-line
Business-to-business	Car manufacturer ordering tires from supplier
Government-to-consumer	Government distributing tax forms electronically
Consumer-to-consumer	Auctioning second-hand products on-line
Peer-to-peer	File sharing

Introduction

Mobile Network Users

- Combinations of **wireless** networks and mobile computing.

Wireless	Mobile	Applications
No	No	Desktop computers in offices
No	Yes	A notebook computer used in a hotel room
Yes	No	Networks in older, unwired buildings
Yes	Yes	Portable office; PDA for store inventory

Introduction

Social Issues

- Discussions about
 - politics,
 - religion,
 - ...
- Hack and robbery

Introduction



What A Network Includes

- Transmission hardware
- Special-purpose hardware devices
 - interconnect transmission media
 - control transmission
 - run protocol software
- Protocol software
 - encodes and formats data
 - detects and corrects problems

Introduction

Network Hardware

- Transmission technology (2 types)
 - Broadcast links
 - Point-to-point links
- Scale
 - Local Area Networks (LAN)
 - Metropolitan Area Networks (MAN)
 - Wide Area Networks (WAN)
 - Wireless Networks
 - Home Networks
 - Internetworks
- Media
 - Wire line
 - Wireless

Introduction

Broadcast Networks



- There are **A single communication link** for all systems in network = **Broadcasting**
 - **TV programs**: **IRIB** (Islamic Republic of Iran **Broadcast**), ...
- Messages (**Packets**) contain destination address
- **Multicasting**: A subset of systems can get the message
- Usually used in small networks like LANs

Introduction

➤ **Point-to-Point Communication**

- Point-to-Point (P2P) is a type of **network connection** where data travels directly between **two specific devices** (or nodes) over a dedicated link.
- It is like having a **private line** between two devices, with no intermediaries.

➤ **Examples**

- **Telephone call** between two people (traditional landline).
- **Serial cable connection** between a computer and a printer.
- **Direct Wi-Fi link** (ad-hoc mode) between two laptops.

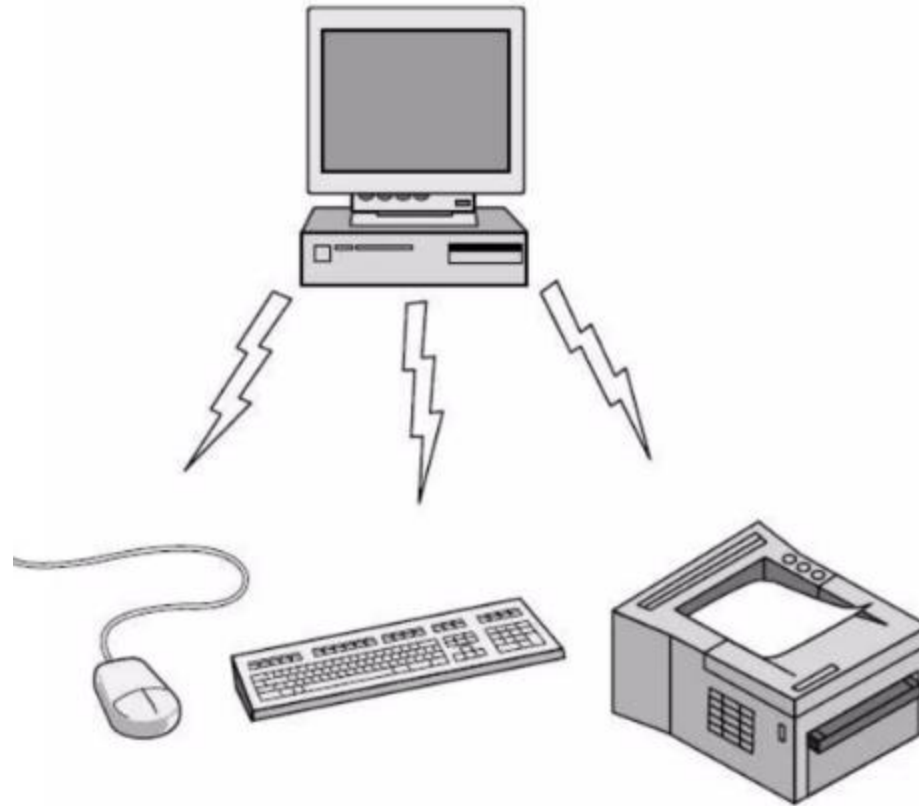
Introduction

Classification by scale

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

Introduction

Personal Area Network

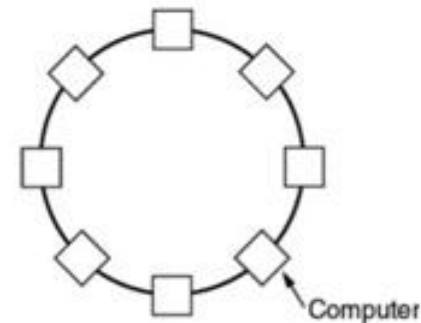
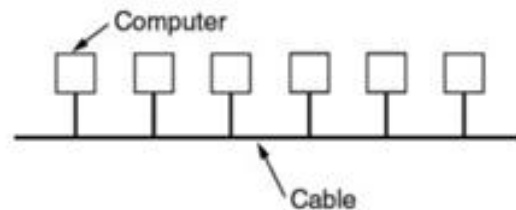


Bluetooth PAN configuration

Introduction

Local Area Networks (1)

- Privately owned. Can be up to several kilometers long;
Ex. in a building
- Separated by their:
 - **Size:** Restricted so worst case transmission time can be contained.
 - **Transmission technology:** Single channel with multiple machines connected to it. Run at speeds of 10, 100, or more Mbps.
 - **Topology:** two popular broadcast networks:
 - Bus
 - Ring



Introduction

➤ Must read Bus and Ring topology from the following link

- <https://www.geeksforgeeks.org/computer-networks/difference-between-ring-topology-and-bus-topology-in-computer-networks/>

Introduction

Local Area Networks (2)

- Topology ...

- Bus

- Ethernet (IEEE 802.3):

- Bus based broadcast network with decentralized control at 10 or 100 Mbps.

- Ring

- Token Ring (IEEE 802.5):

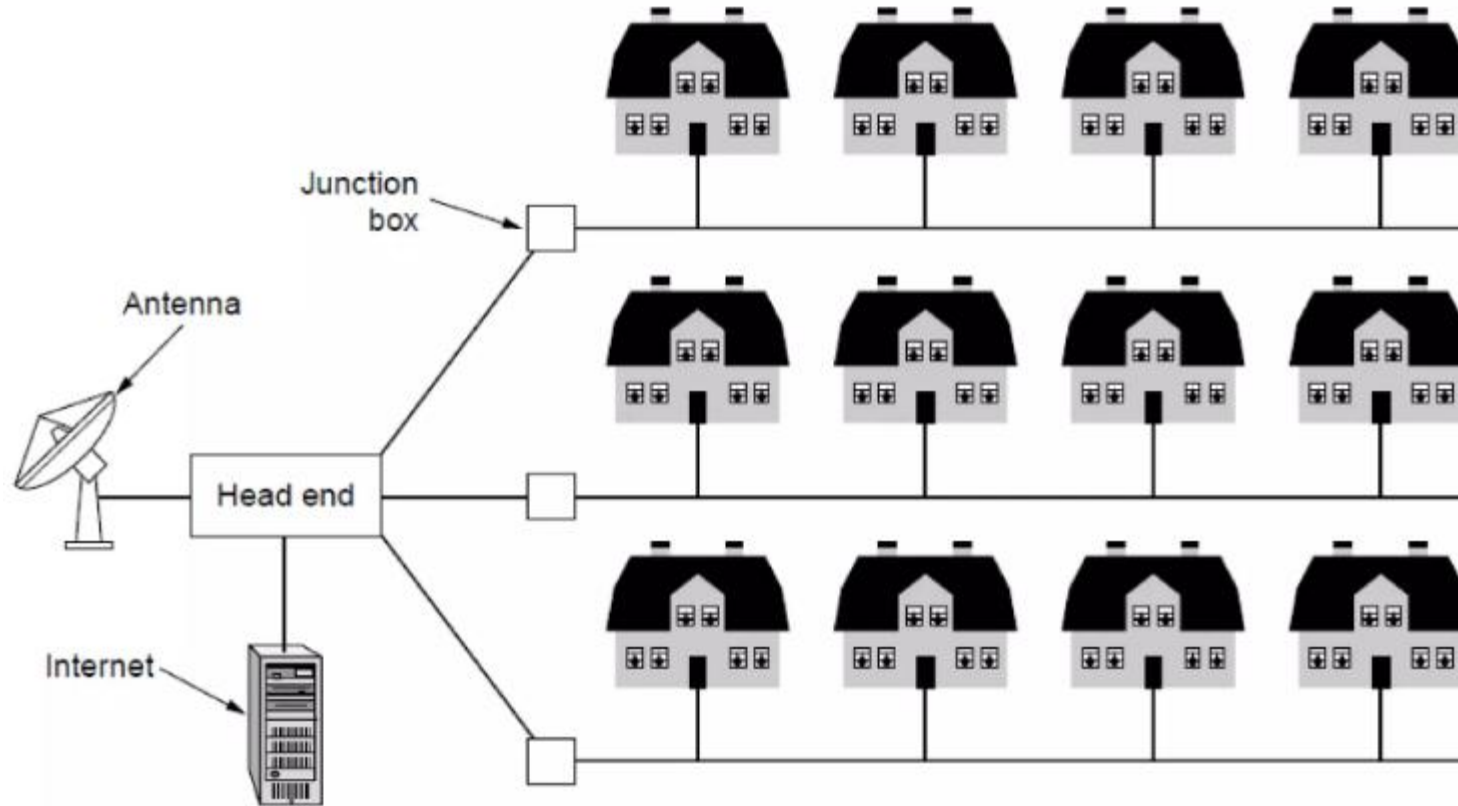
- Ring based broadcast network with token arbitration at 4 or 16 Mbps.

- ☒ Low delay. High reliability.

- ☐ Requires collision arbitration

Introduction

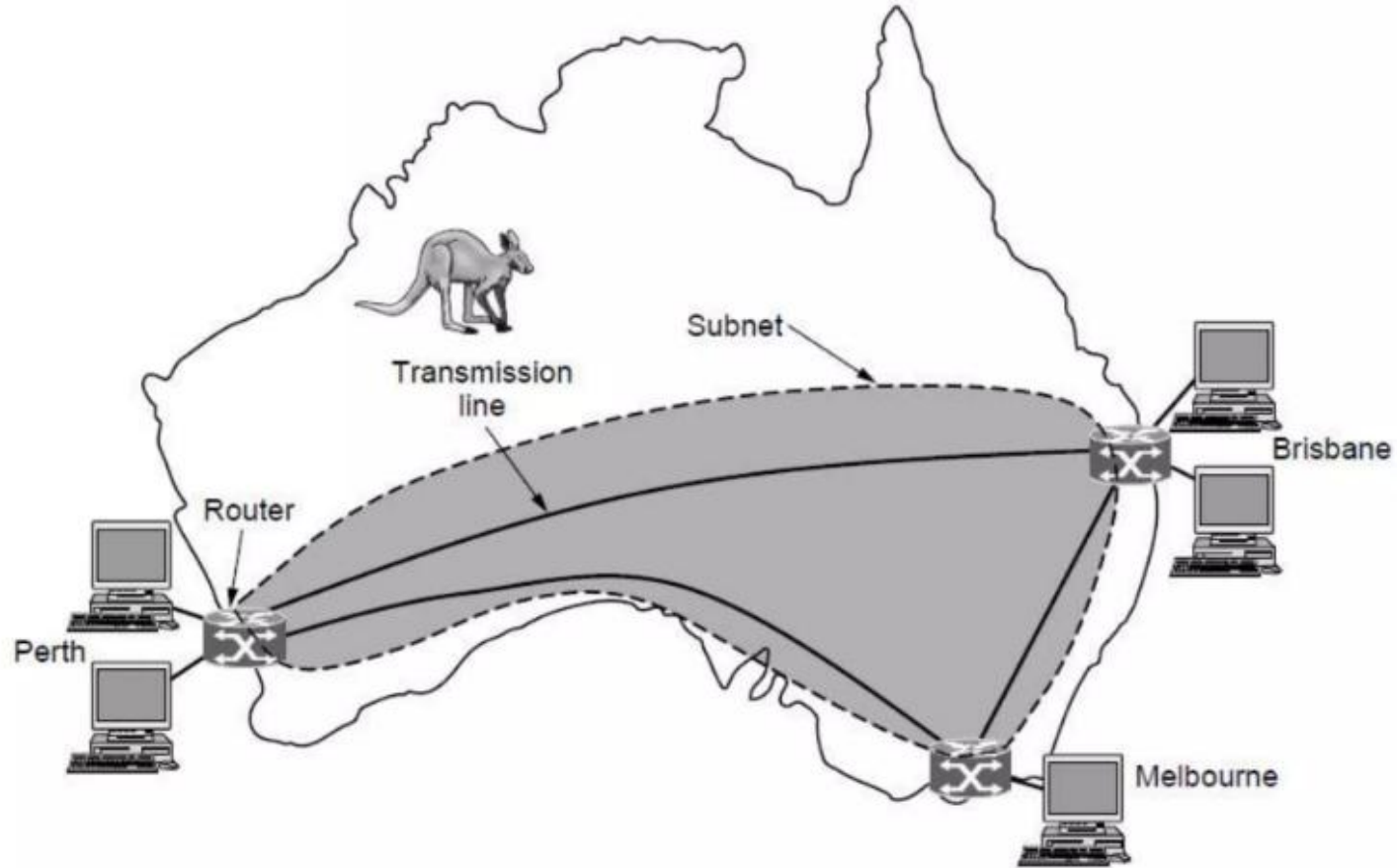
Metropolitan Area Networks



- Application: Modern day Cable TV System

Introduction

Wide Area Networks (1)



WAN that connects three branch offices in Australia

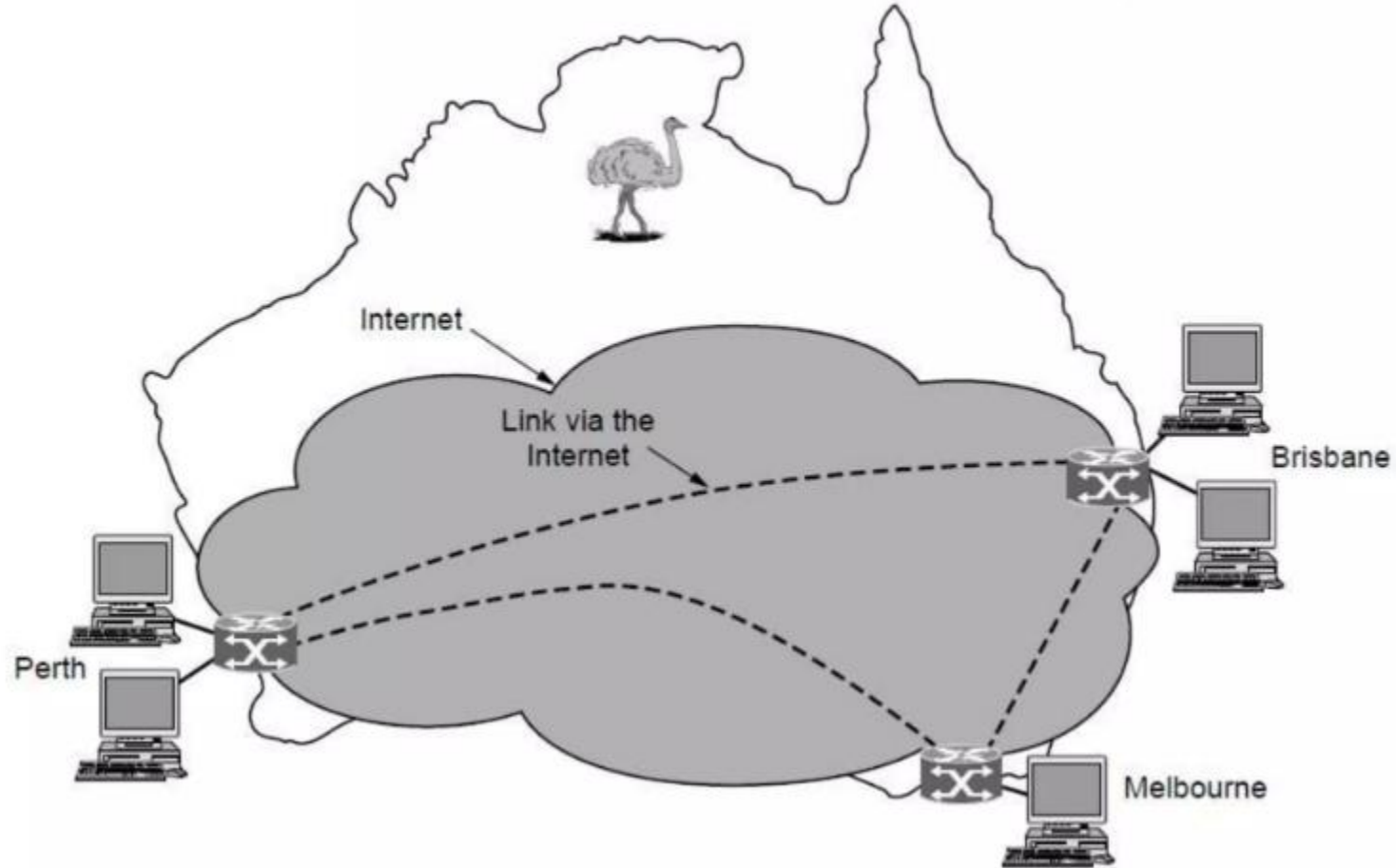
- End devices/Machines are called Hosts.

Introduction

- End devices/Machines are called Hosts
- Communication Subnet: The rest of the network that connects these hosts
- Subnet consists of Switches/Routers and transmission lines

Introduction

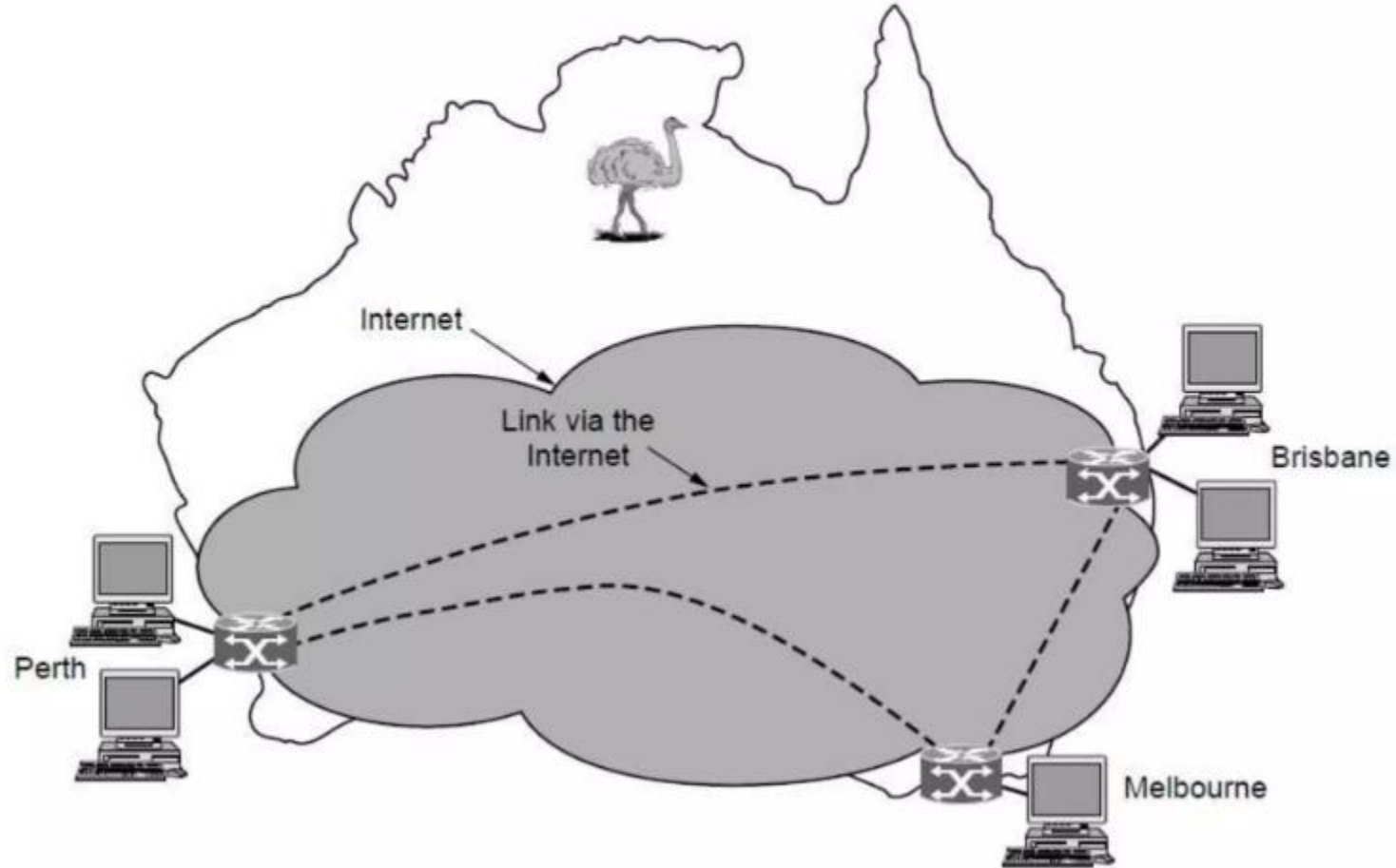
Wide Area Networks (2)



- Virtual Private Networks.

Introduction

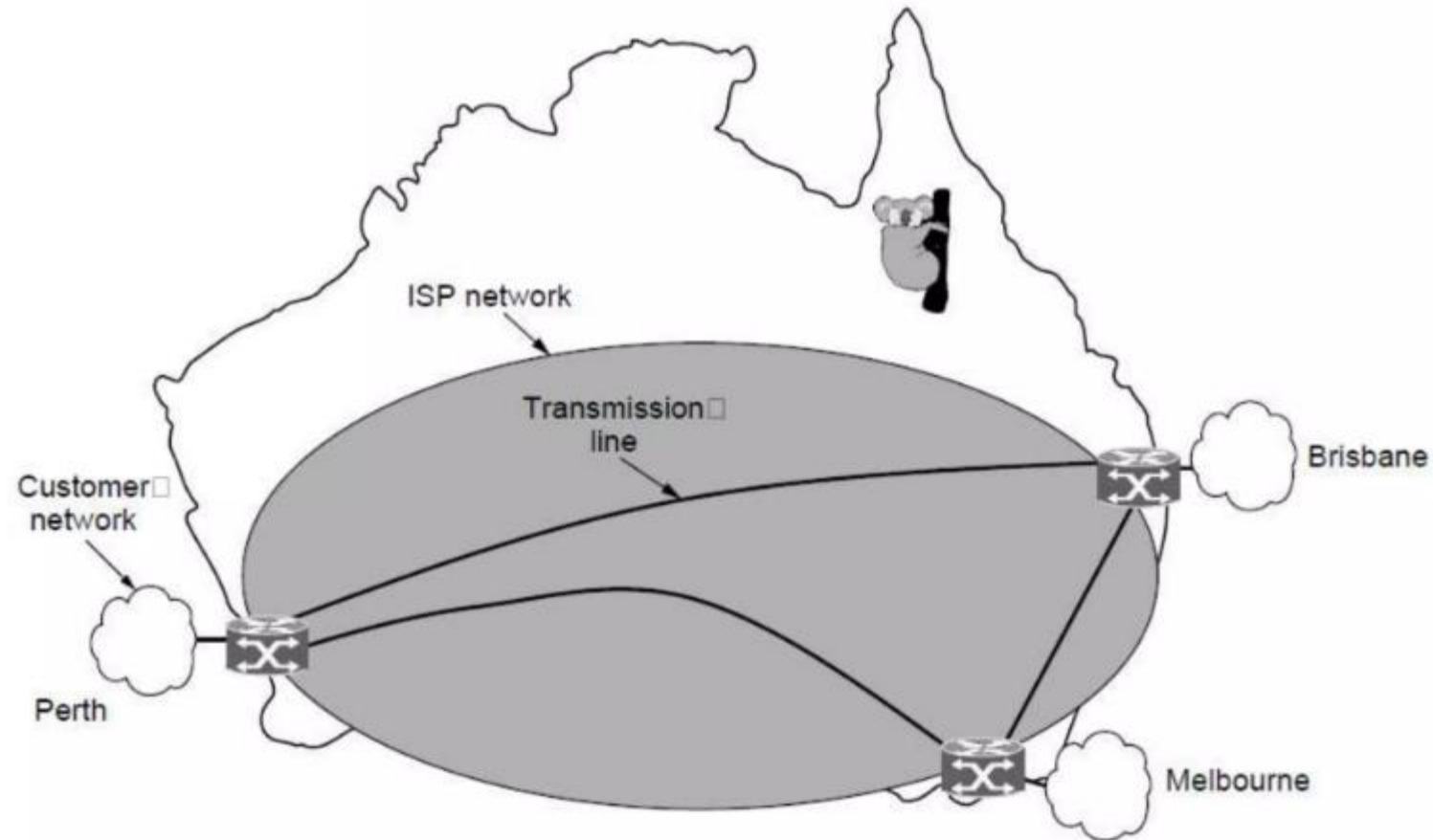
Wide Area Networks (2)



- Virtual Private Networks.

Introduction

Wide Area Networks (3)

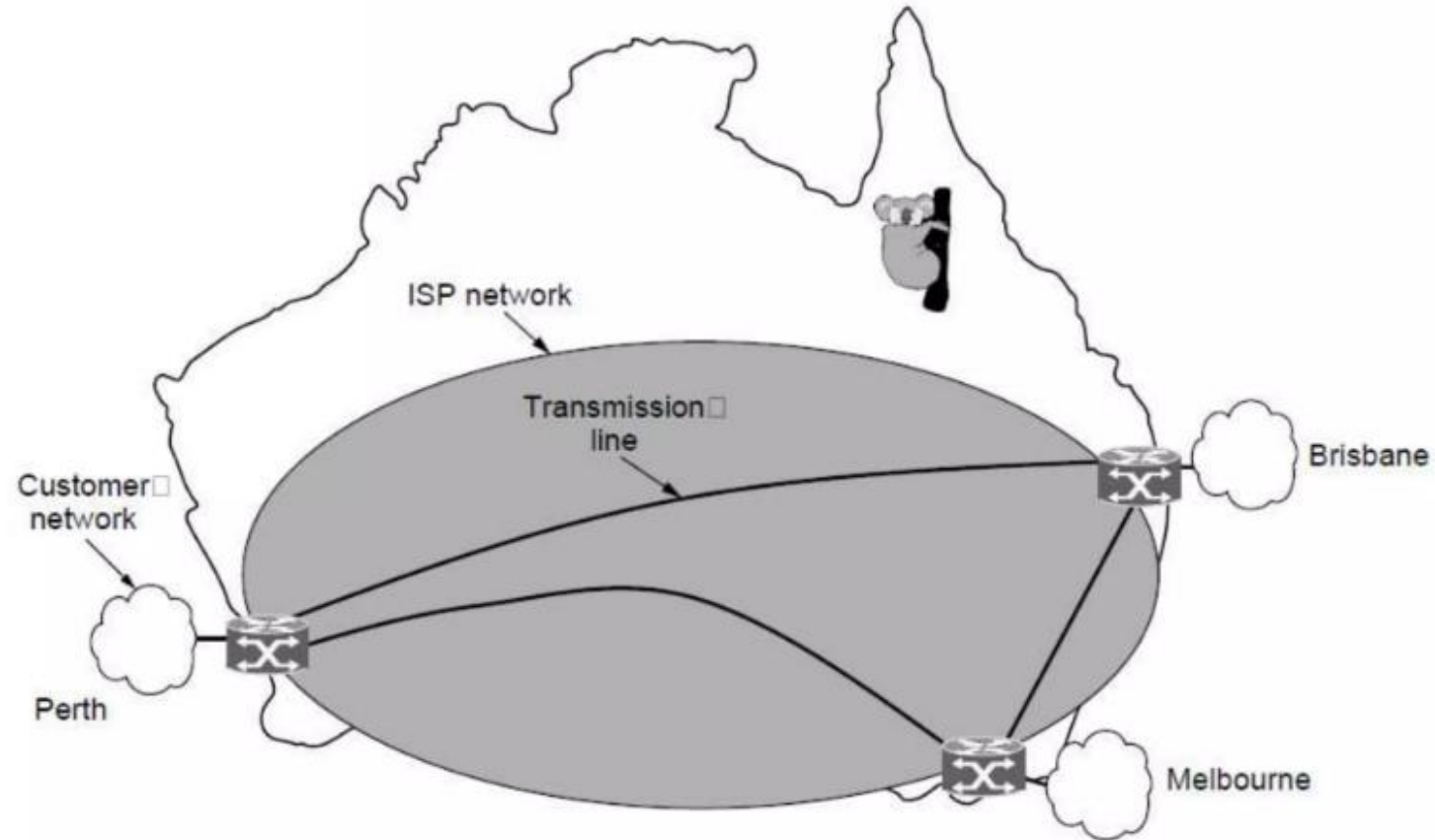


WAN using an ISP network.

- Interconnected Networks: ISP(Internet Services Provider)

Introduction

Wide Area Networks (3)

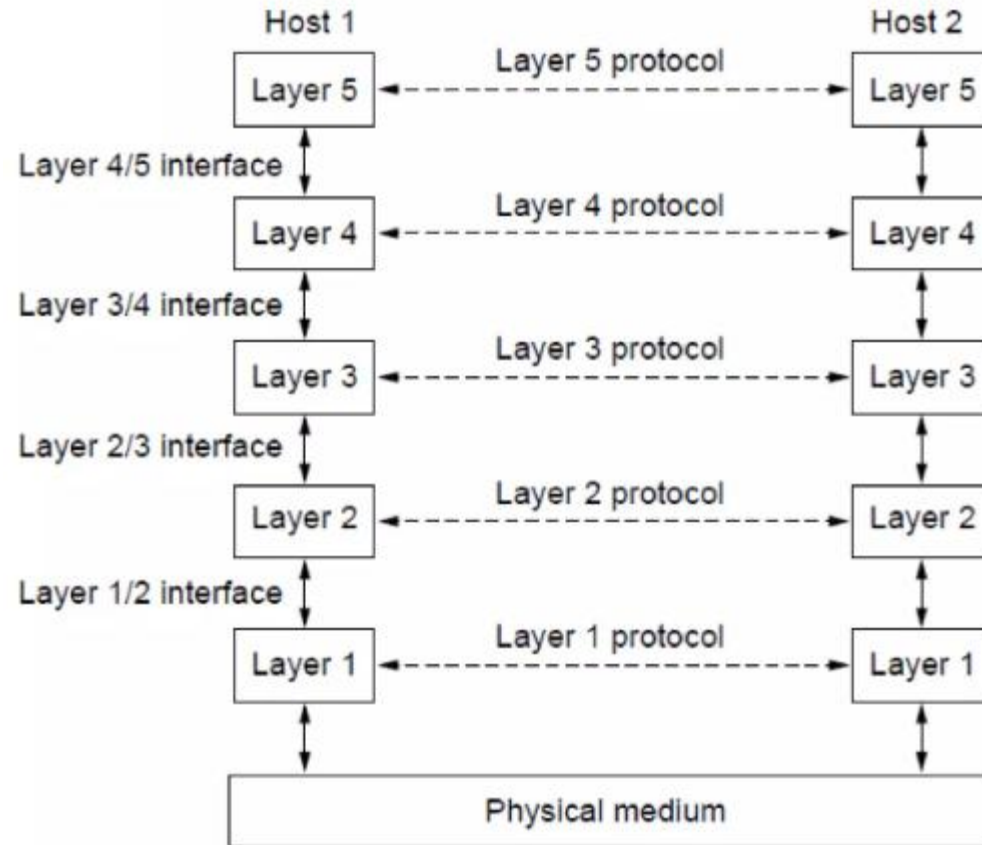


WAN using an ISP network.

- Interconnected Networks: ISP(Internet Services Provider)
- Internetworks are the combination of Interconnected networks

Introduction

Protocol Hierarchies (1)



Layers, protocols, and interfaces.

- Protocols: Agreement between two communicating parties

Introduction

Reference Models

- OSI reference model
- TCP/IP reference model
- Model used for this text
- Comparison of OSI and TCP/IP
- Critique of OSI model and protocols
- Critique of TCP/IP model

Introduction

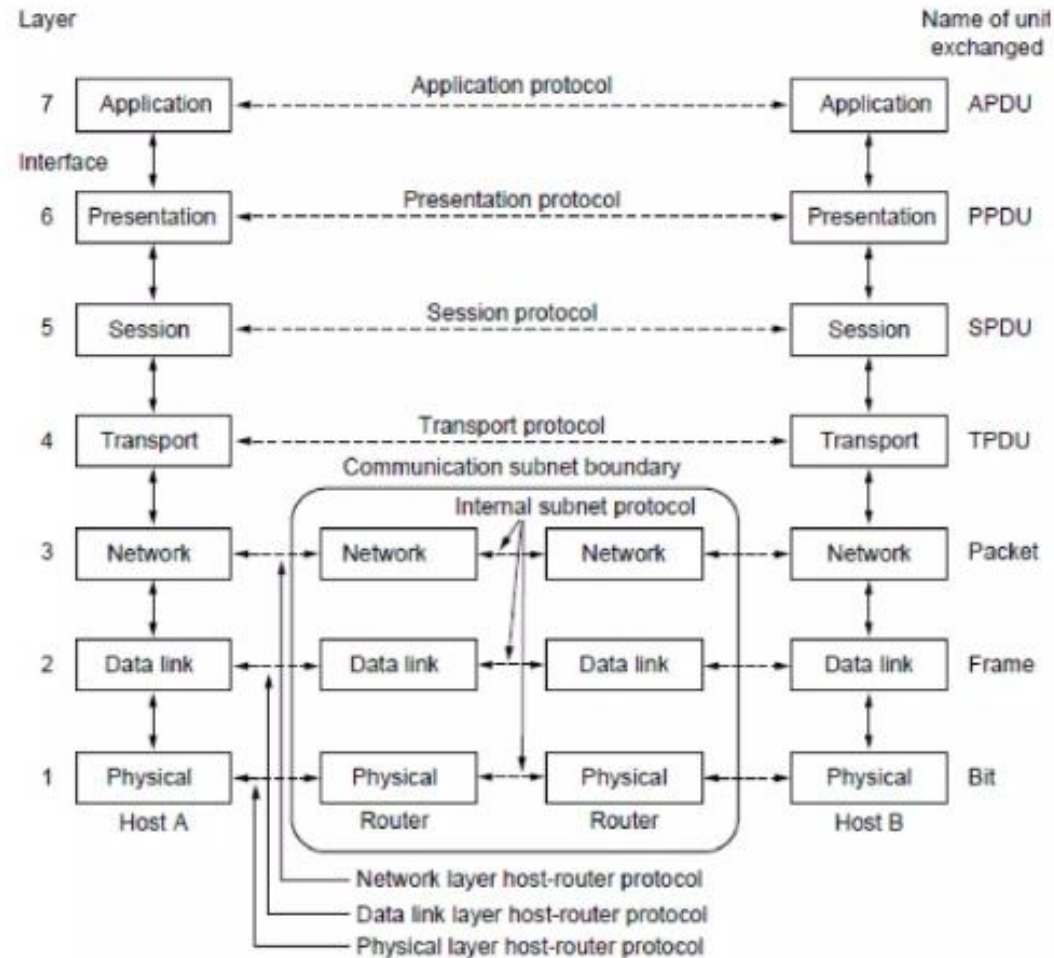
The OSI Reference Model

Principles for the seven layers

- Layers created for different abstractions
- Each layer performs well-defined function
- Function of layer chosen with definition of international standard protocols in mind
- Minimize information flow across interfaces between boundaries
- Number of layers optimum

Introduction

The OSI Reference Model



The OSI reference model

Introduction

OSI Reference Model Layers

- Physical layer
- Data link layer
- Network layer
- Transport layer
- Session layer
- Presentation layer
- Application layer

Introduction: Physical Layer

- Physical Layer: Responsible for transmitting data over the communication medium/channel.
- Data transfer in form of bytes (0 or 1)
- Data transfer from one network to other network

Introduction: Data Link Layer

- Data Link Layer: Break down the data into data frames (a division of few hundred or thousand bytes)
- Detect and remove errors in Bytes (Transmission error)
- Medium access control layer.

Introduction: Network Layer

- Network Layer: Delivery of individual packets from the source host to the destination host of other network.
- Same network transmission skip Network Layer
- Add Logical Addressing schemes.

Introduction: Transport Layer

- Transport Layer: Delivery of a complete message from one process to another process.
- Message from Session layer to Network Layer and Network Layer to Session layer
- Error control and Flow control.

Introduction: Session Layer

- Transport Layer: Establishes, maintains, and synchronizes the interaction (connection) among communicating systems.
- Dialog Control: Half-duplex mode or Full-duplex mode.
- Synchronization: Add checkpoints to check received and acknowledged messages.

Introduction: Presentation Layer

- Presentation Layer: syntax and semantics of the information exchanged between two networks
- Translation: Machine language (Bits).
- Compression: Reduces number of bits for transmission.
- Encryption/ Decryption: Messages into secure form.

Case Study as an Example

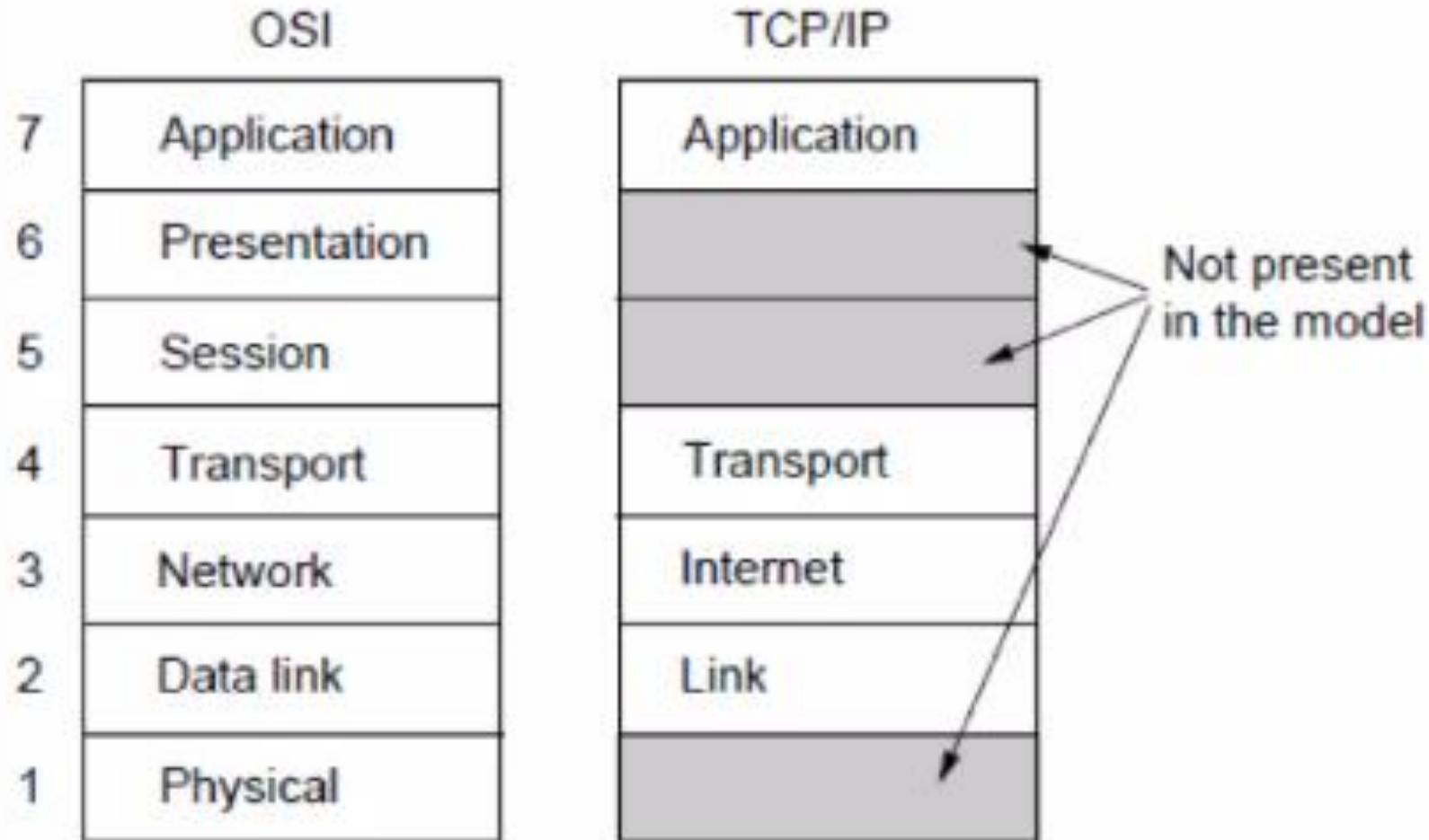
Focus on White Board and Lecture

Introduction: TCP/IP Reference Model

The TCP/IP Reference Model Layers

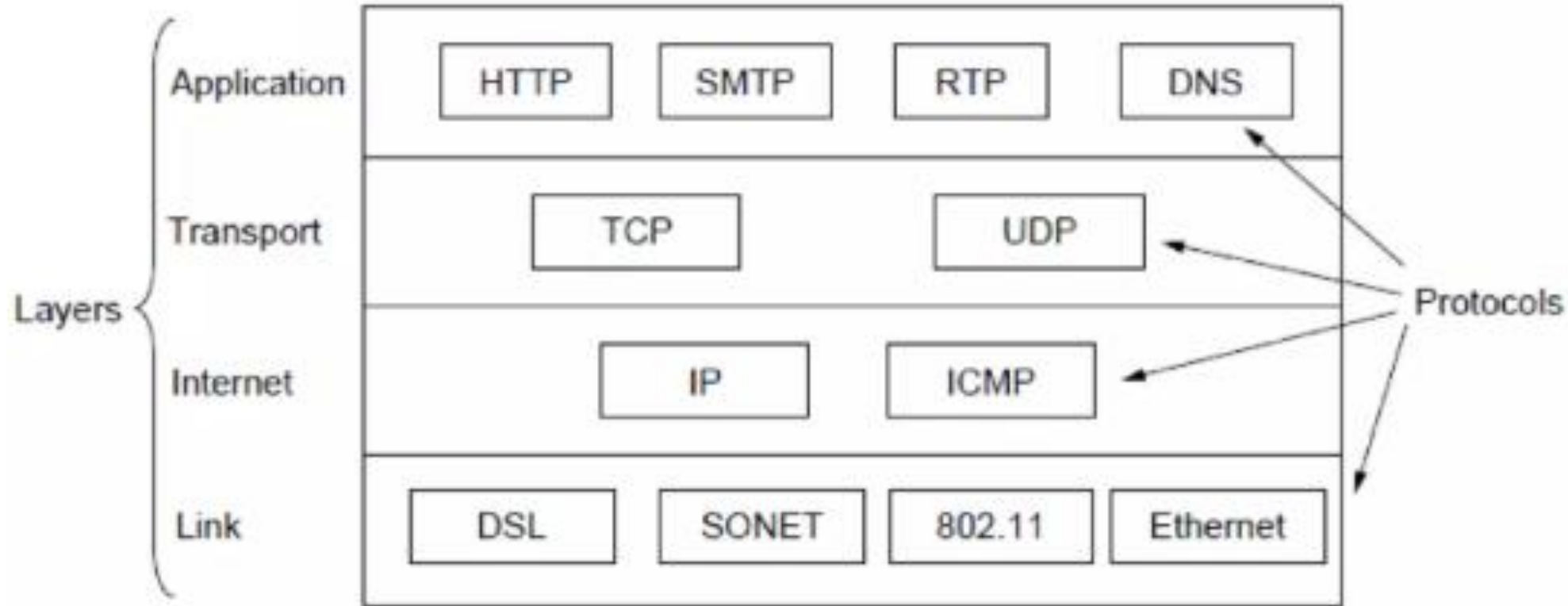
- Link layer
- Internet layer
- Transport layer
- Application layer

Introduction: TCP/IP Reference Model



The TCP/IP reference model

Introduction: TCP/IP Reference Model



The TCP/IP reference model with some protocols we will study

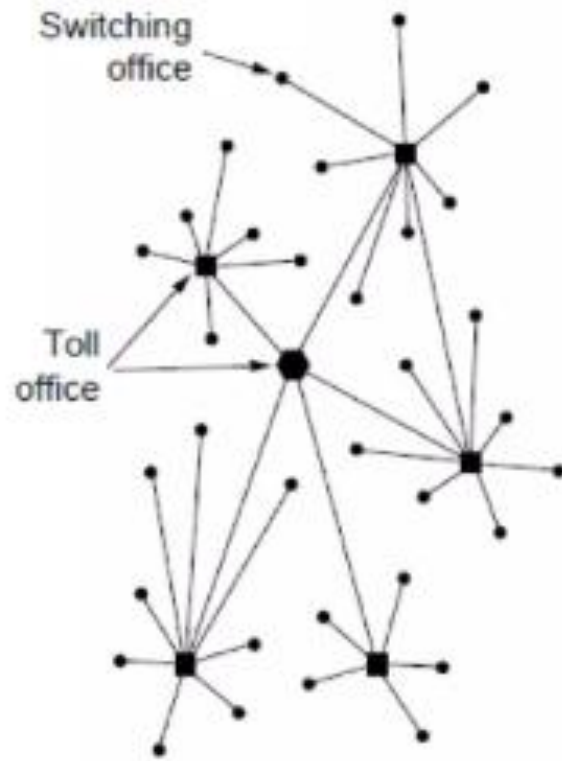
Introduction: Types of Computer Networks

Example Networks

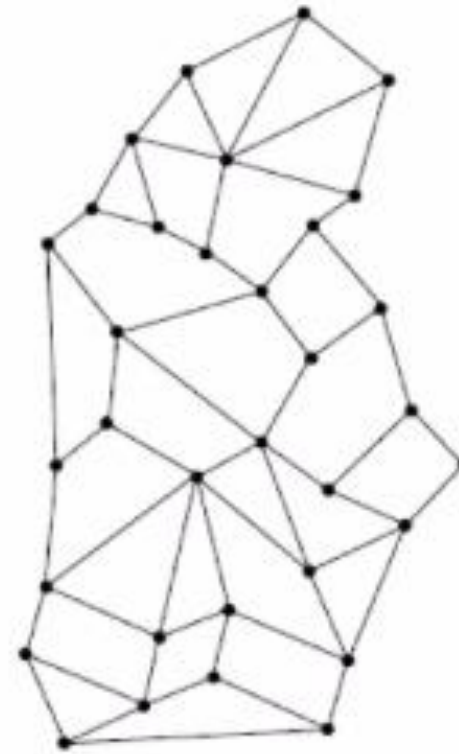
- Internet
- ARPANET
- NSFNET
- Third-generation mobile phone networks
- Wireless LANs: 802.11
- RFID and sensor networks

Introduction: Types of Computer Networks

The ARPANET (1)



(a)

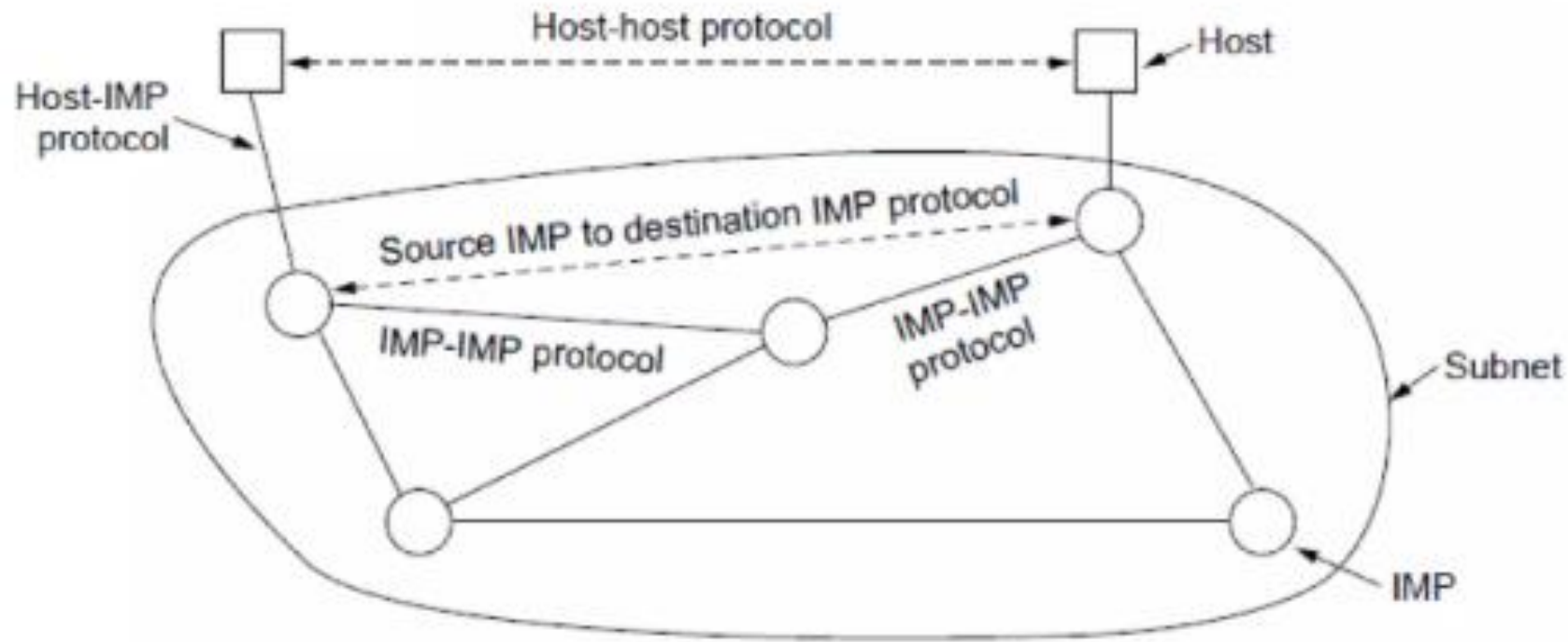


(b)

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

Introduction: TCP/IP Reference Model

The ARPANET (2)



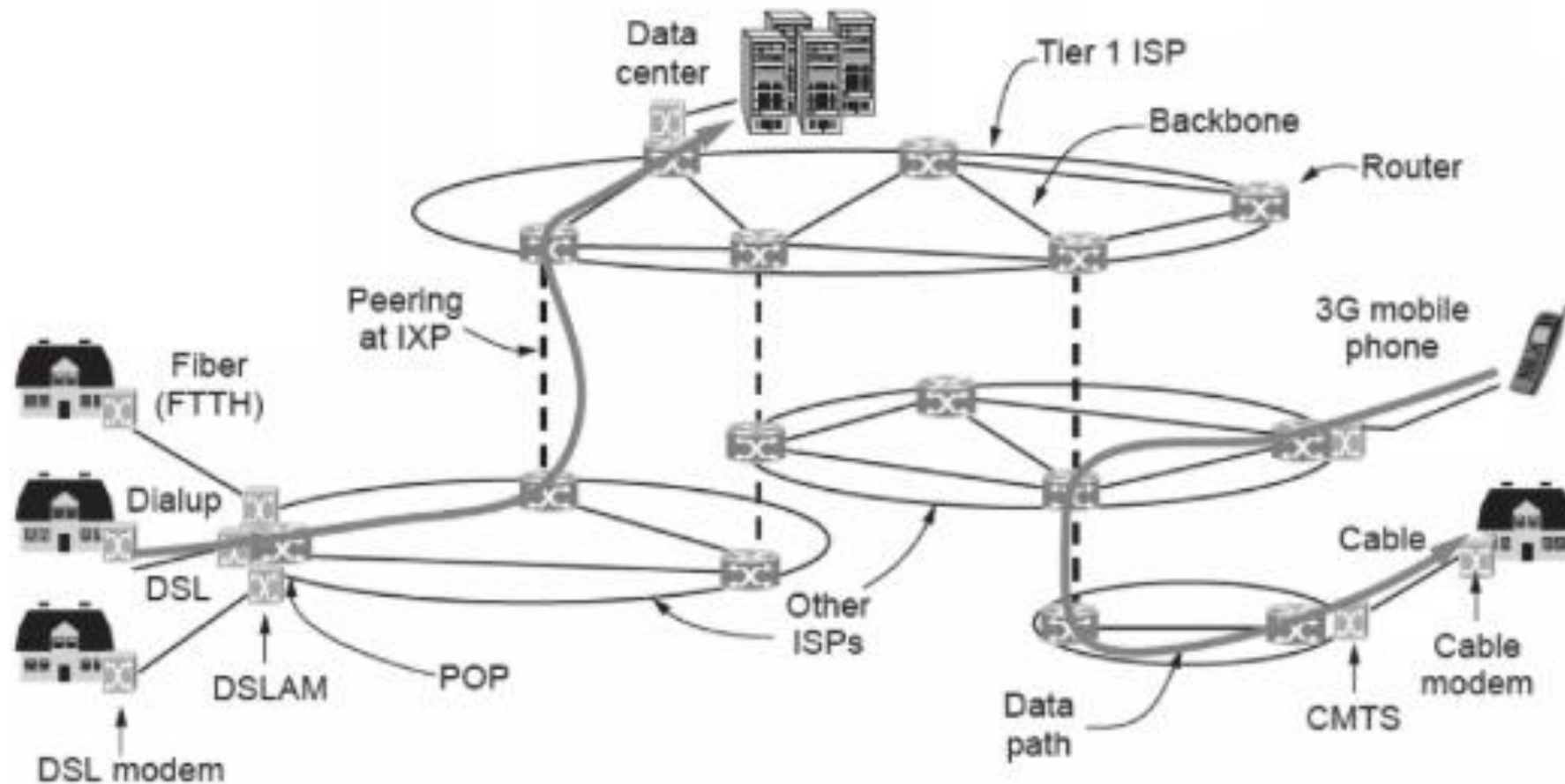
Introduction: TCP/IP Reference Model

◆ IMP = Interface Message Processor

- It was basically the **first-generation packet switch** (like today's router).
- Each host (computer) on ARPANET was connected to an **IMP**, and the IMPs were connected to each other over dedicated lines.
- The IMP handled **packet switching**, error checking, retransmission, and routing — leaving the host free to just send/receive messages.
- Developed by **BBN Technologies** in 1969 under contract from ARPA.
- The software on IMPs implemented the early **NCP protocol** (Network Control Protocol), the predecessor of TCP/IP.

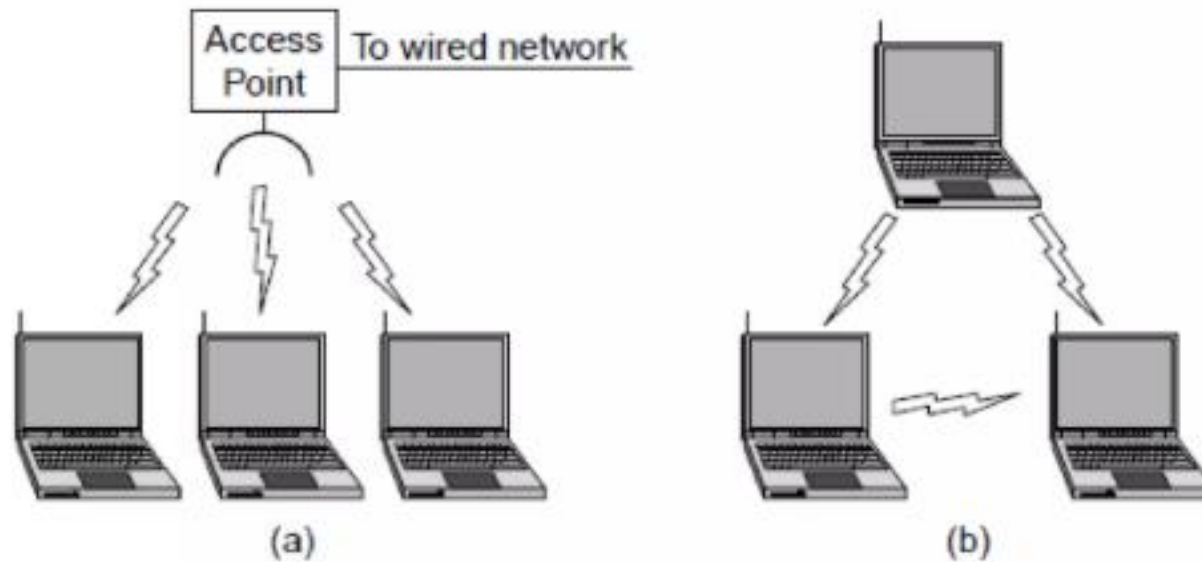
Introduction: Types of Computer Networks

Architecture of the Internet



Introduction: Types of Computer Networks

Wireless LANs: 802.11 (1)



- (a) Wireless network with an access point.
- (b) Ad hoc network.