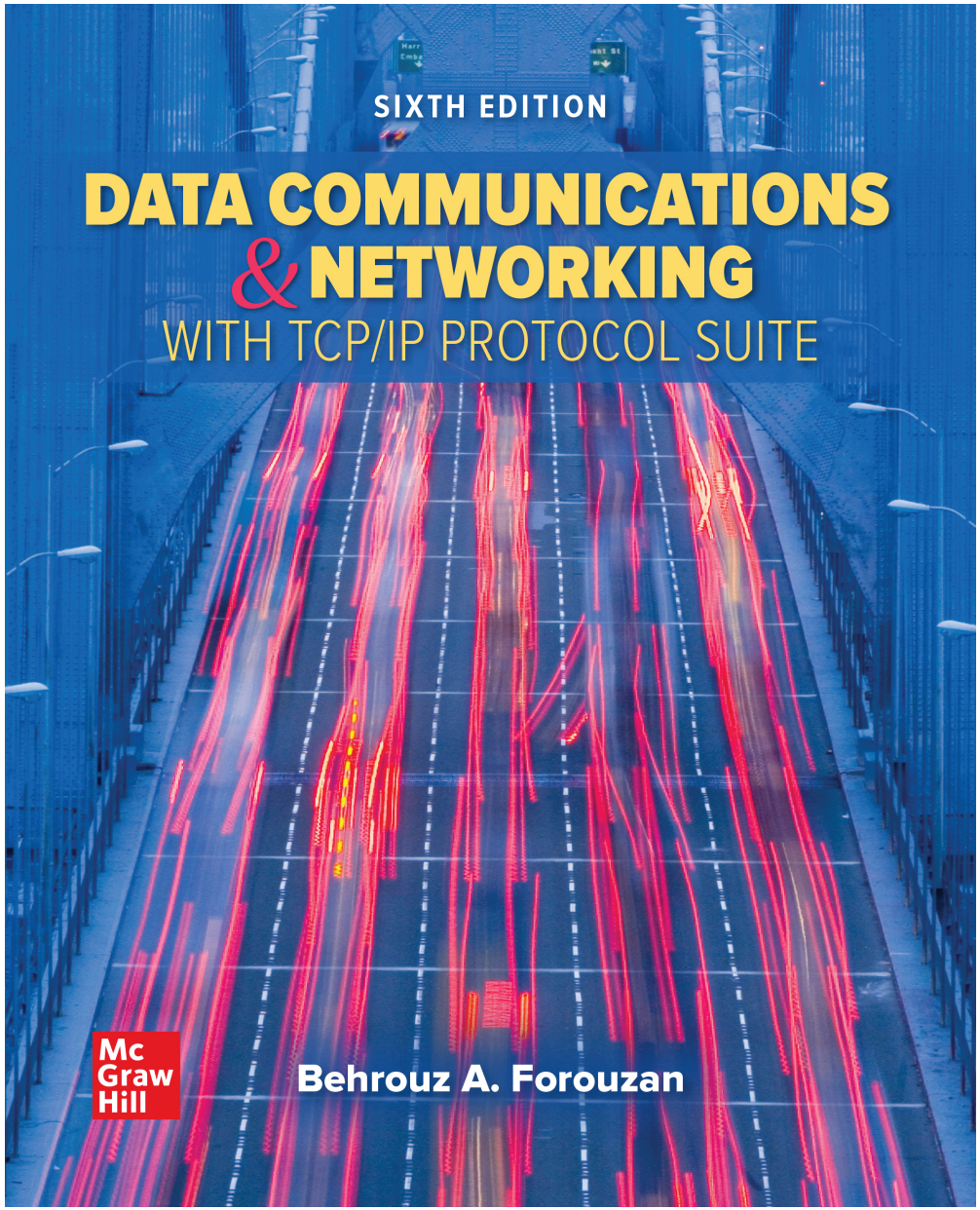
Chapter 01

Introduction

- Data Communications and Networking, With TCP/IP protocol suite Sixth Edition
- Behrouz A. Forouzan



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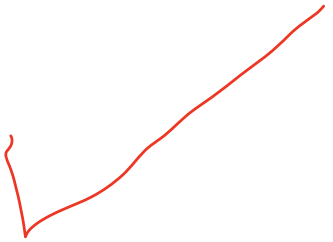
Chapter 1-Part 1: Outline

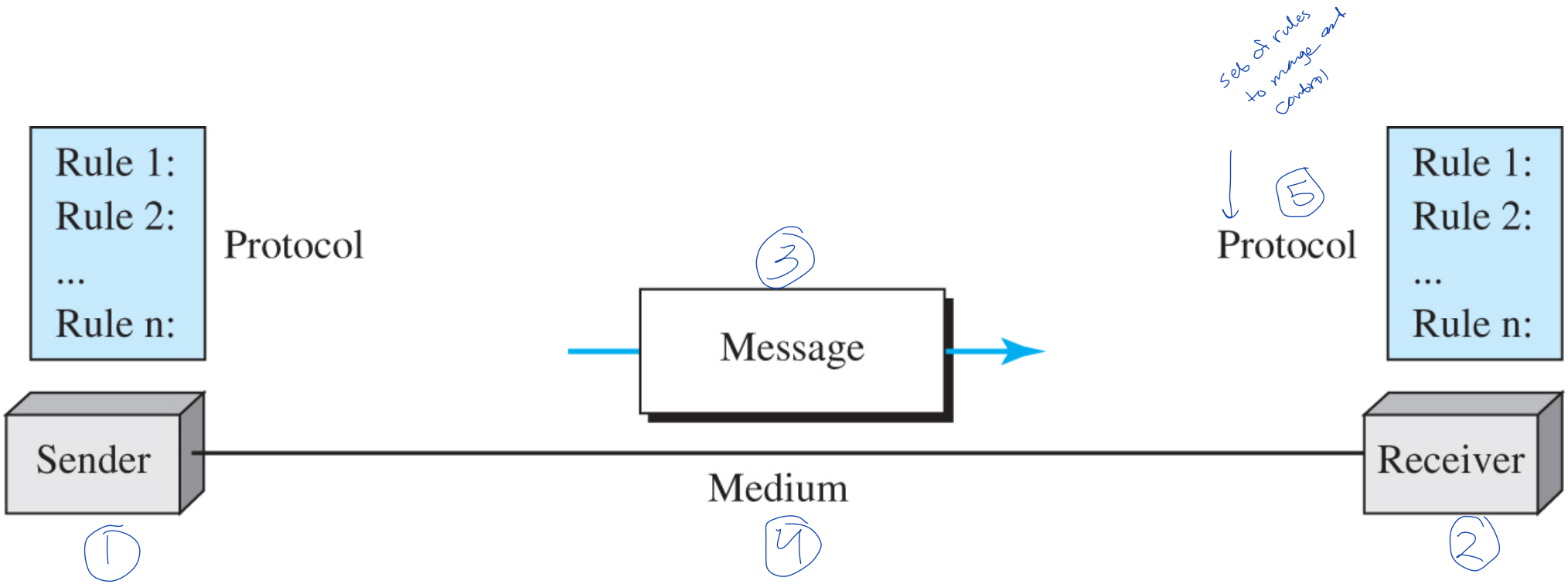
- 1.1 DATA COMMUNICATIONS
- 1.2 NETWORKS
- 1.3 NETWORK TYPES

Data Communications



- The exchange of Information between two devices through a transmission medium

Figure 1.1 Five components of data communication



1.1.2 Message

- Information today comes in different forms such as text, numbers, images, audio, and video.
  - Text is represented as a bit pattern using Unicode.
  - Numbers are represented in binary.
  - Images/videos/audio are represented as bit patterns

1.2 Networks

- A network is a set of devices (called nodes) connected by communication links.
  - Node can be host (a computer, printer, cell phone) or networking devices (routers, switches, modem, etc…)
  - Link is a communication pathway that transfer data from one device to another
  - Link can be wired or wireless
- Type of network connections
  - Point-to-Point: dedicated link between two devices
  - Multipoint : shared link between more than two devices

Figure 1.5 *Point-to-point connection*

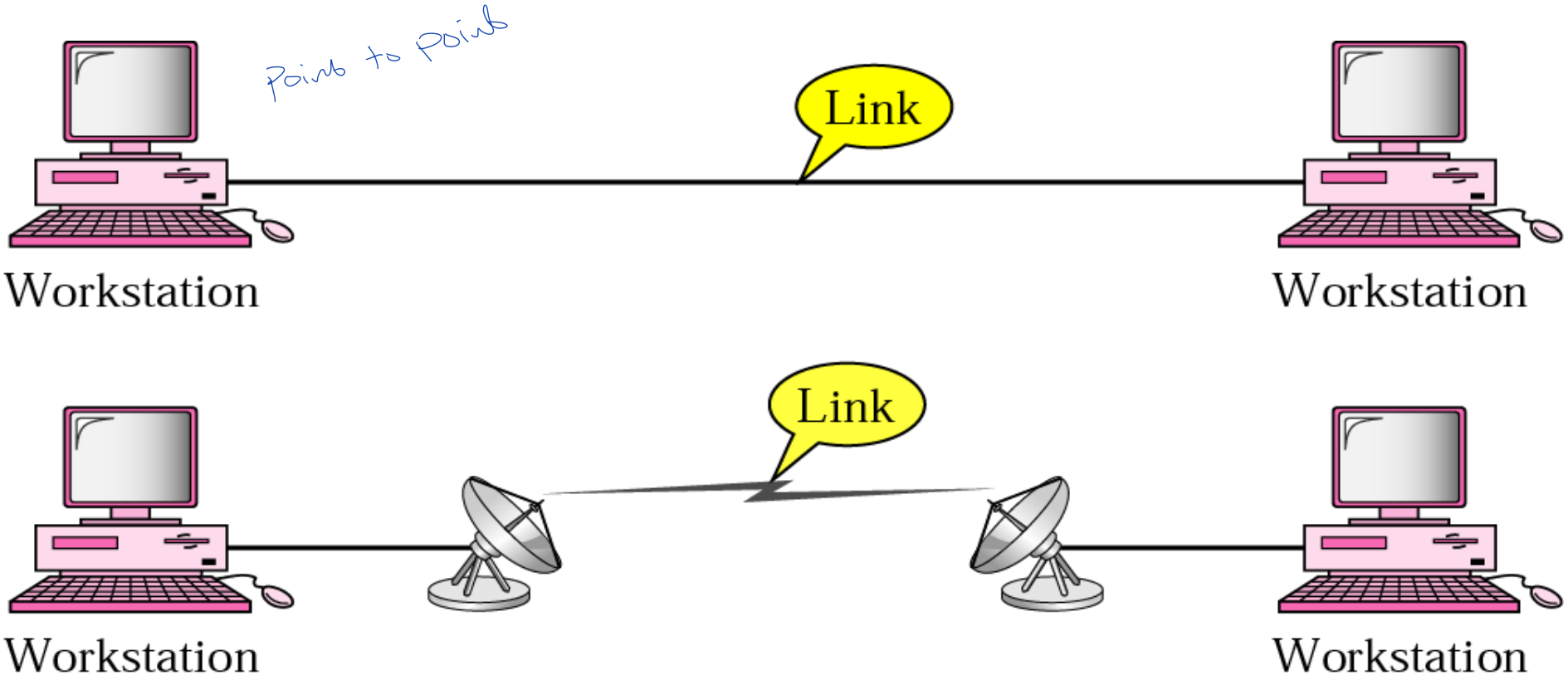
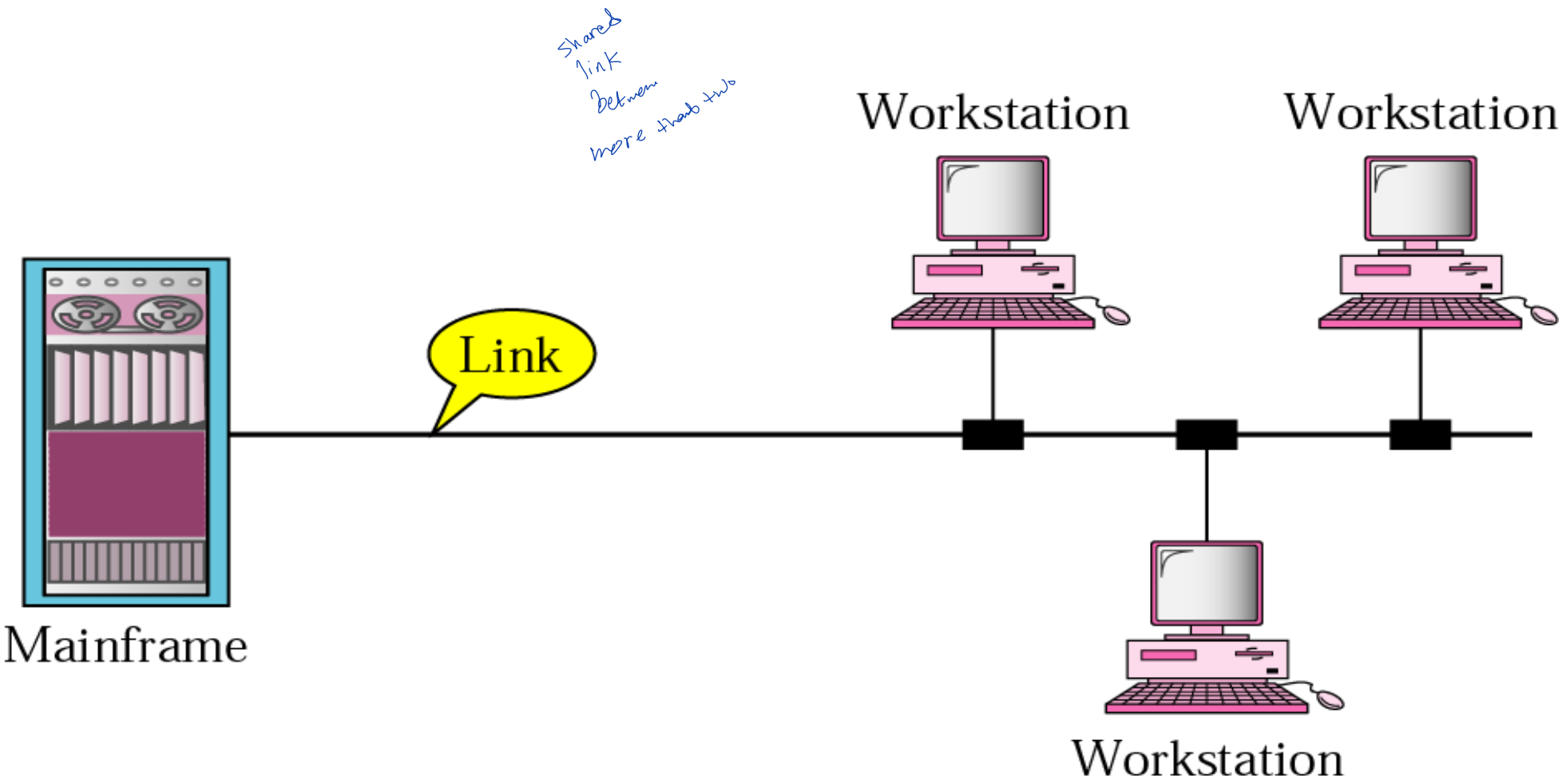


Figure 1.6 *Multipoint connection (shared)*



1.2 Networks

- A network must be able to meet a certain number of criteria. The most important of these are:
  - Performance
    - Depends on factors such as:
      - # of users, type of transmission medium, capabilities of Network hardware, Network software efficiency
    - Evaluated by:
      - Throughput (amount of data a user can send)
      - Delay (measured in transit time, and response time)
    - To have good performance, we need more throughput and less delay (contradict each other, because when throughput increases, it means more data arrive to the network, this will increase the delay
  - Reliability
    - Measured by:
      - Frequency of failure
      - Time it takes a link to recover from the failure
  - Security
    - Protecting data from unauthorized users, and damage, applying security policies for recovery from breaches and data losses

Figure 1.2: Data flow (direction of data flowing in the link)

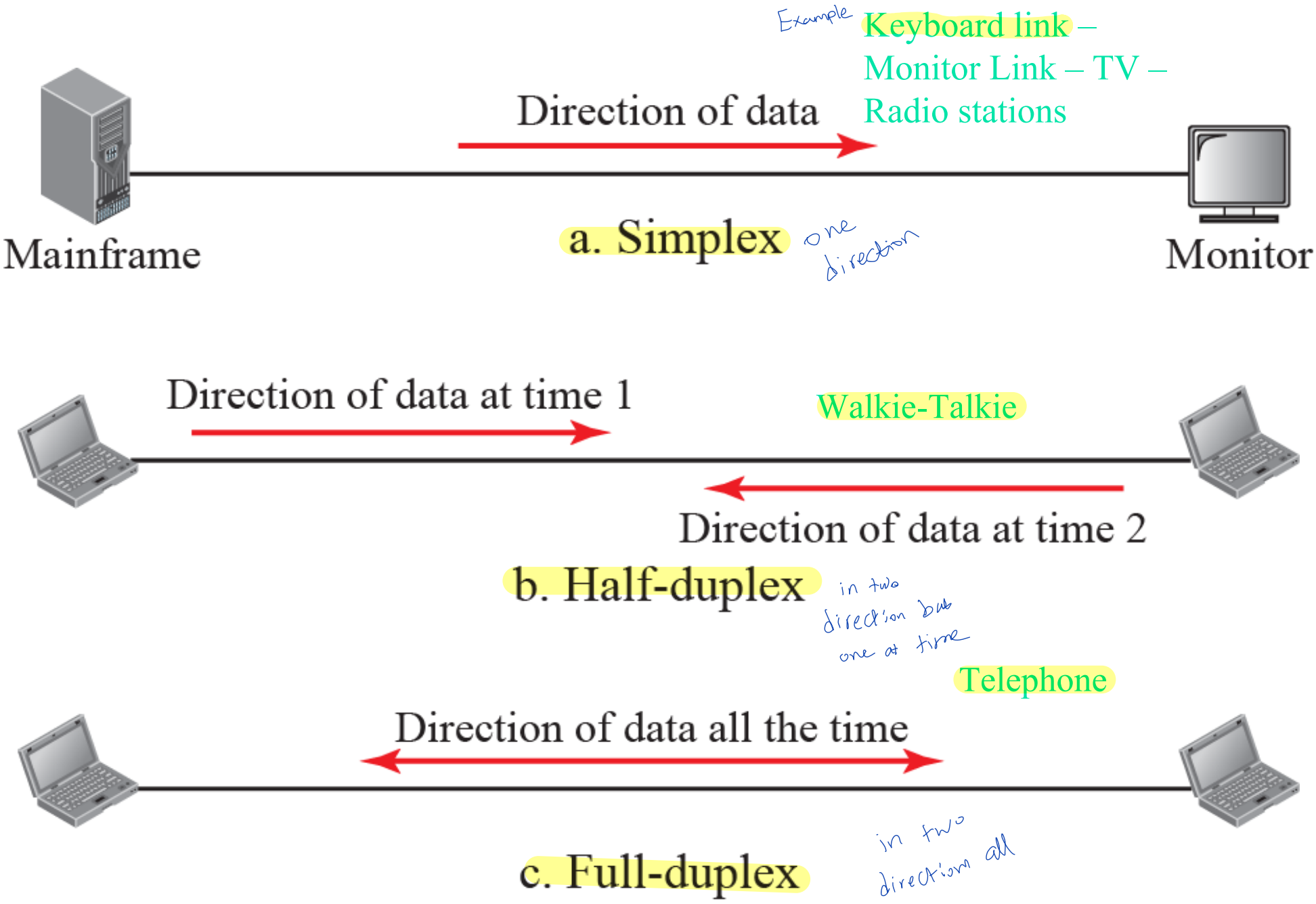
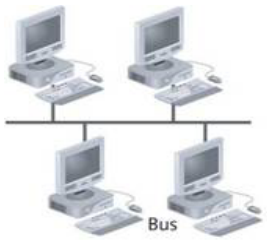
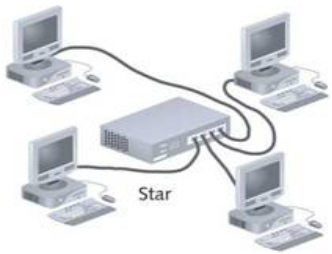


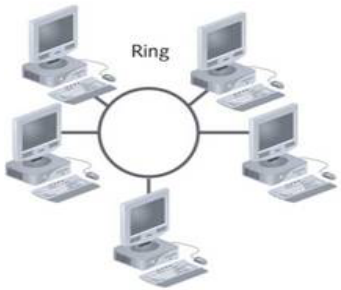
Figure 1.7 *Categories of topology*

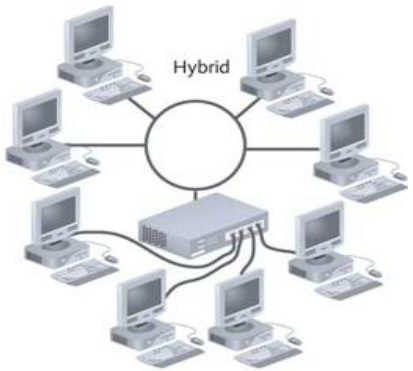
Topology: The way in which a network is physically built or

The way in which devices interconnect across the network









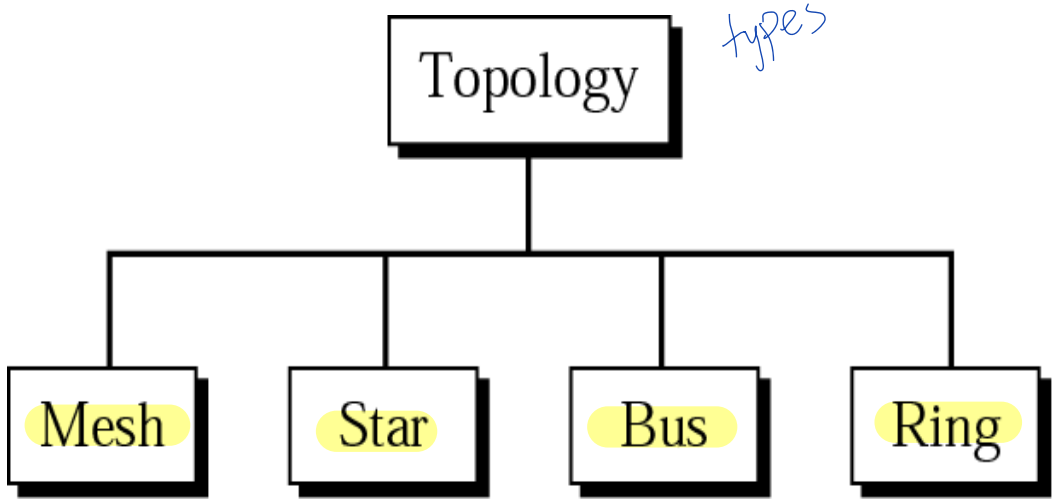


Figure 1.8 *Fully connected mesh topology (for five devices)*

- *Dedicated point-to-point link to every other node*
- Number of links = N(N-1)/2
- Advantages
  - Dedicated links secure, no traffic problems (no congestion)
  - Robust: if one link fails, the network will still work
  - Easy to discover faulty links
- Disadvantages?
  - Difficult to install & update (too much wiring)
  - Expensive (why?)
  - Number of Network interface cards (NIC) or Number of I/O ports = (N-1)per device
  - Number of cables = Number of links

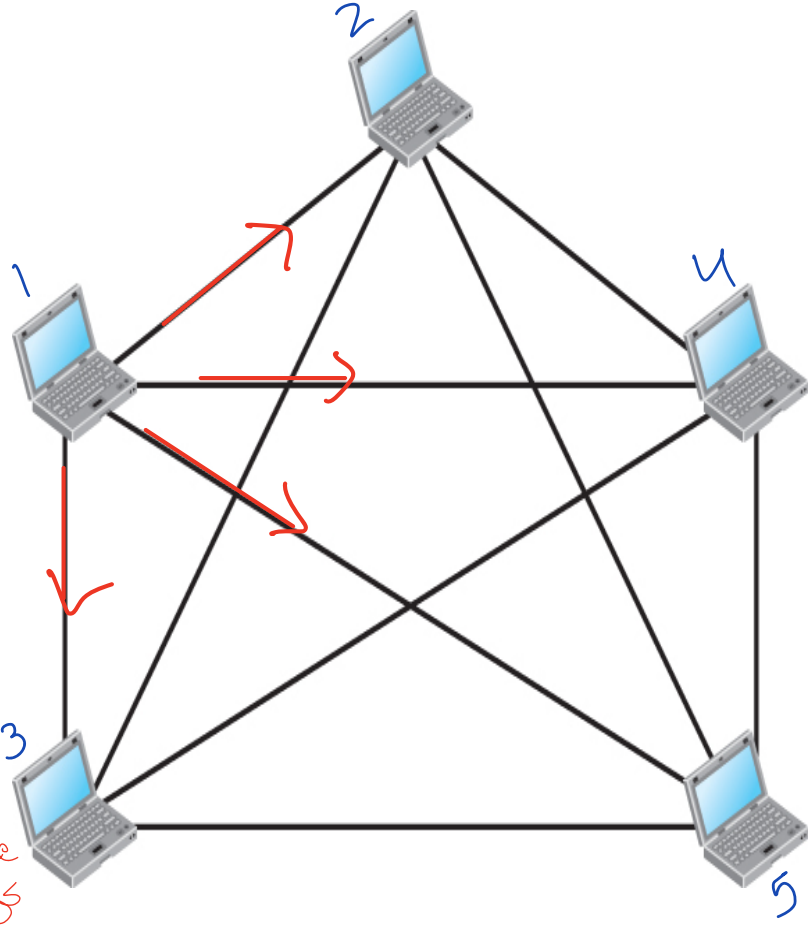


Figure 1.9 Star topology

Dedicated point-to-point link to a central controller only

- ***Number of links = N***
- **Advantages**
  - **Less expensive than mesh**
  - **Easy to install**
  - **Easy to add and remove devices**
  - **Robust (Reliable)**
  - **Easy to discover faulty links**
  - **Secure but less than mesh**
- **Disadvantages?**
  - **If the central device failed the whole network will not function**

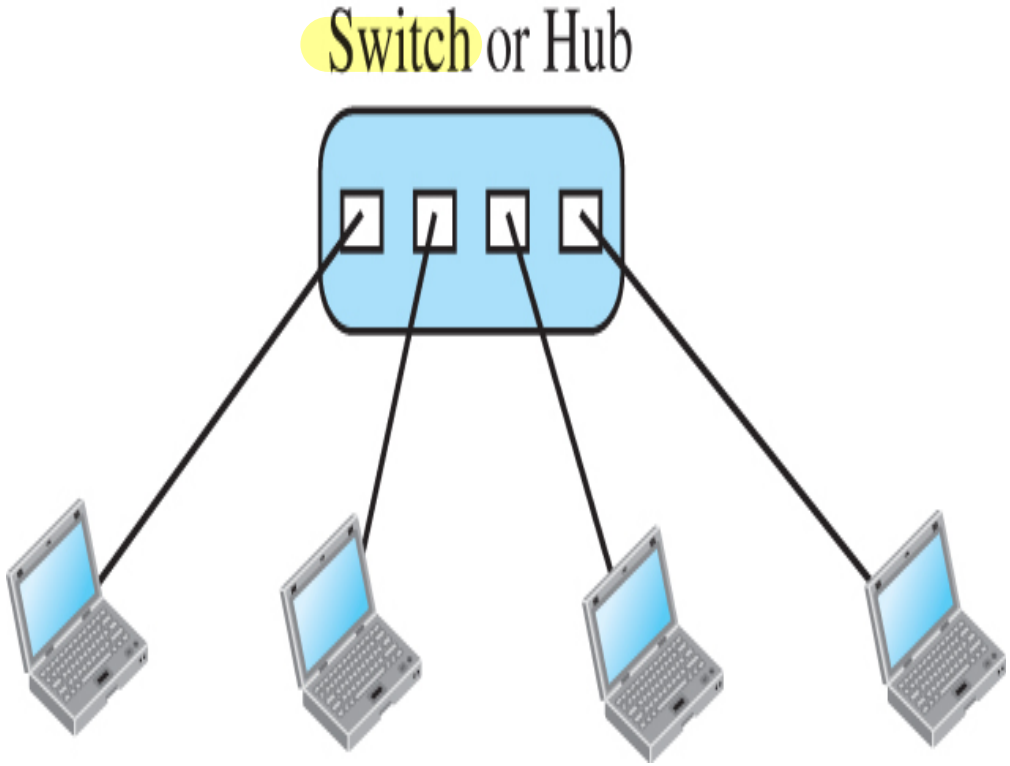
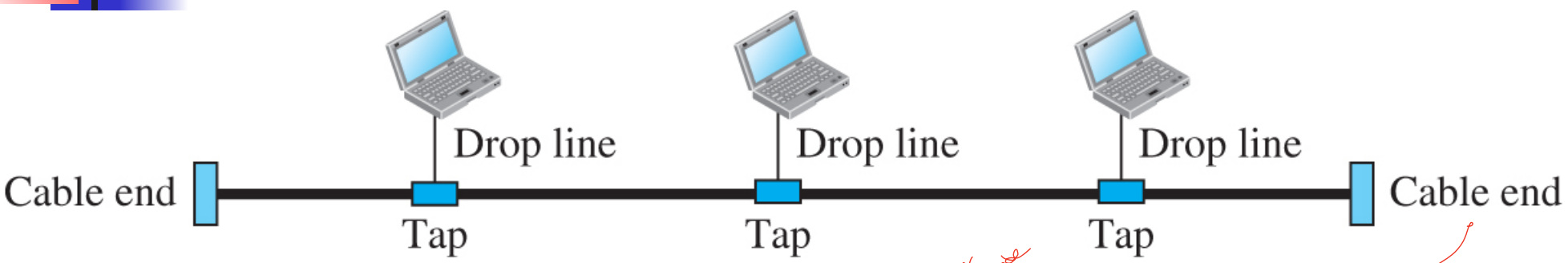


Figure 1.10 *Bus topology*



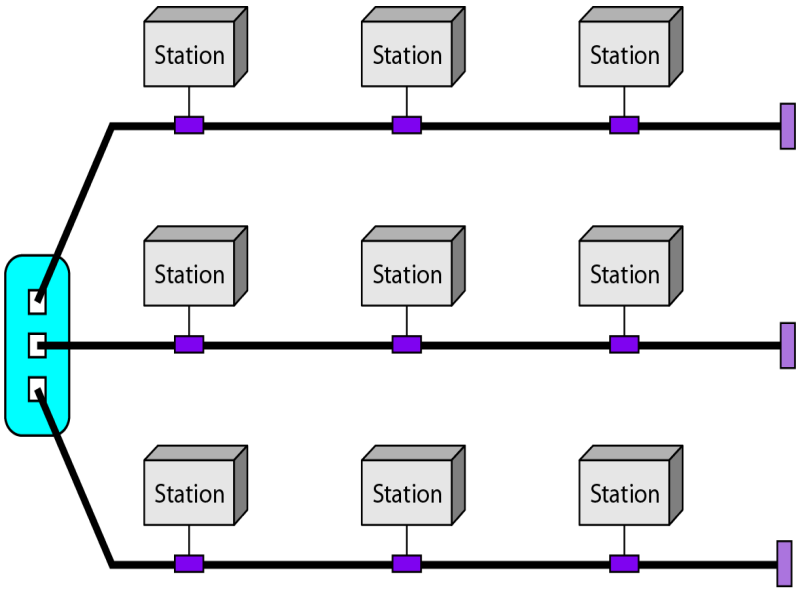
- ***Number of links = 1 Main + N droplines***

- **Advantages**
  - **Easy to install**
  - **less cabling than mesh and hub**
- **Disadvantages?**
  - **Difficult to isolate fault**
  - **Difficult to add new devices**
  - **A break in the bus cable stops all transmission**

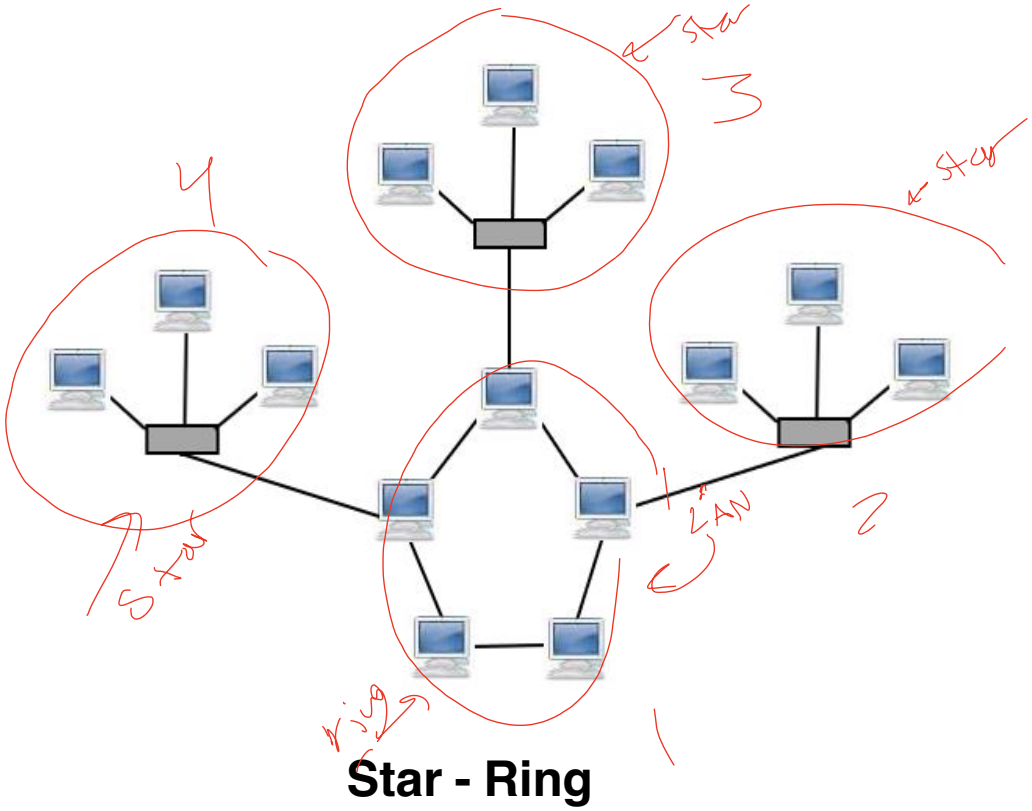
Figure 1.11 *Ring topology*

- Dedicated point-to-point link between a node and the two nodes on either side of it
- *Number of links = N*
- Advantages
  - Easy to install
  - less cable
- Disadvantage?
  - Not robust
  - Difficult to add or remove a device
  - Difficult to isolate fault

Figure 1.9 *A hybrid topology: a star backbone with three bus networks*

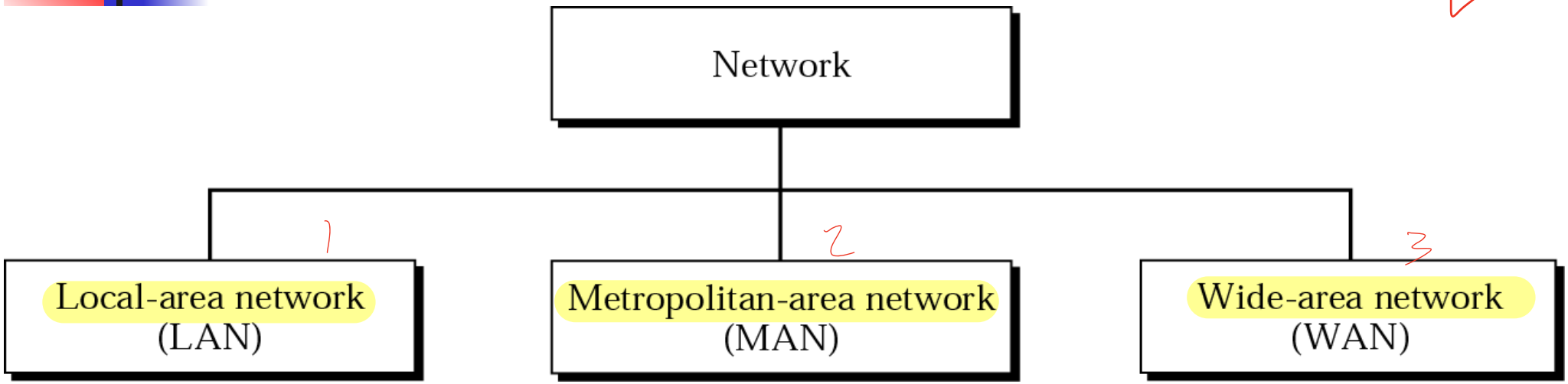


Star - Bus



Star - Ring

Figure 1.12 *Categories of networks*



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

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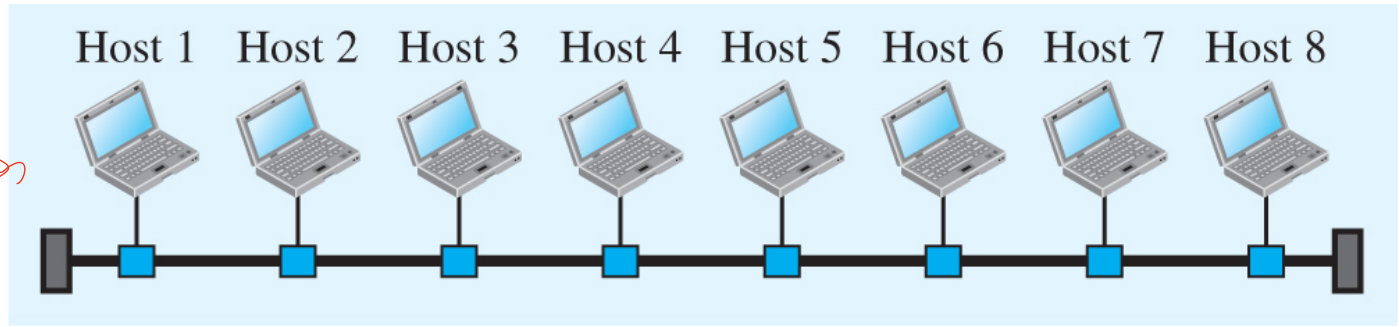
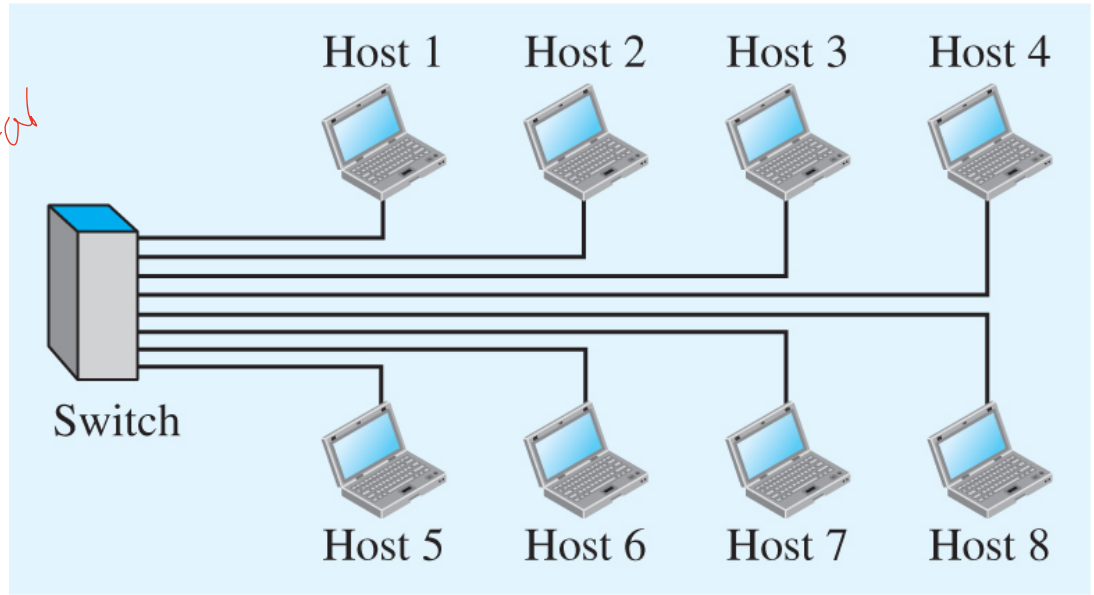
Figure 1.8 An isolated LAN in the past and today



a. LAN with a common cable (past)



b. LAN with a switch (today)

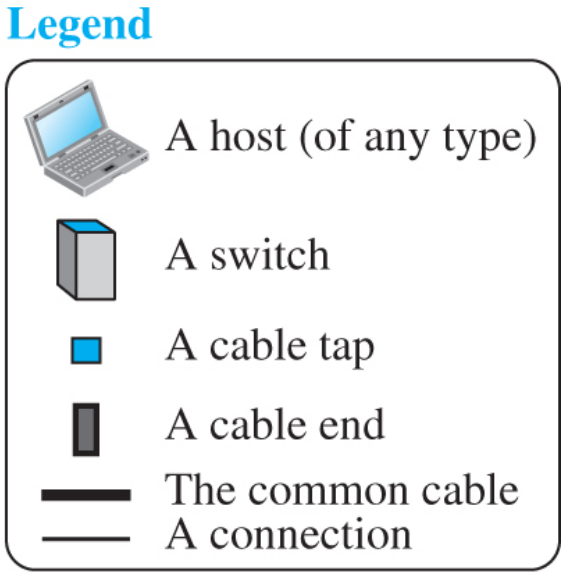


Figure 1.14 *MAN*

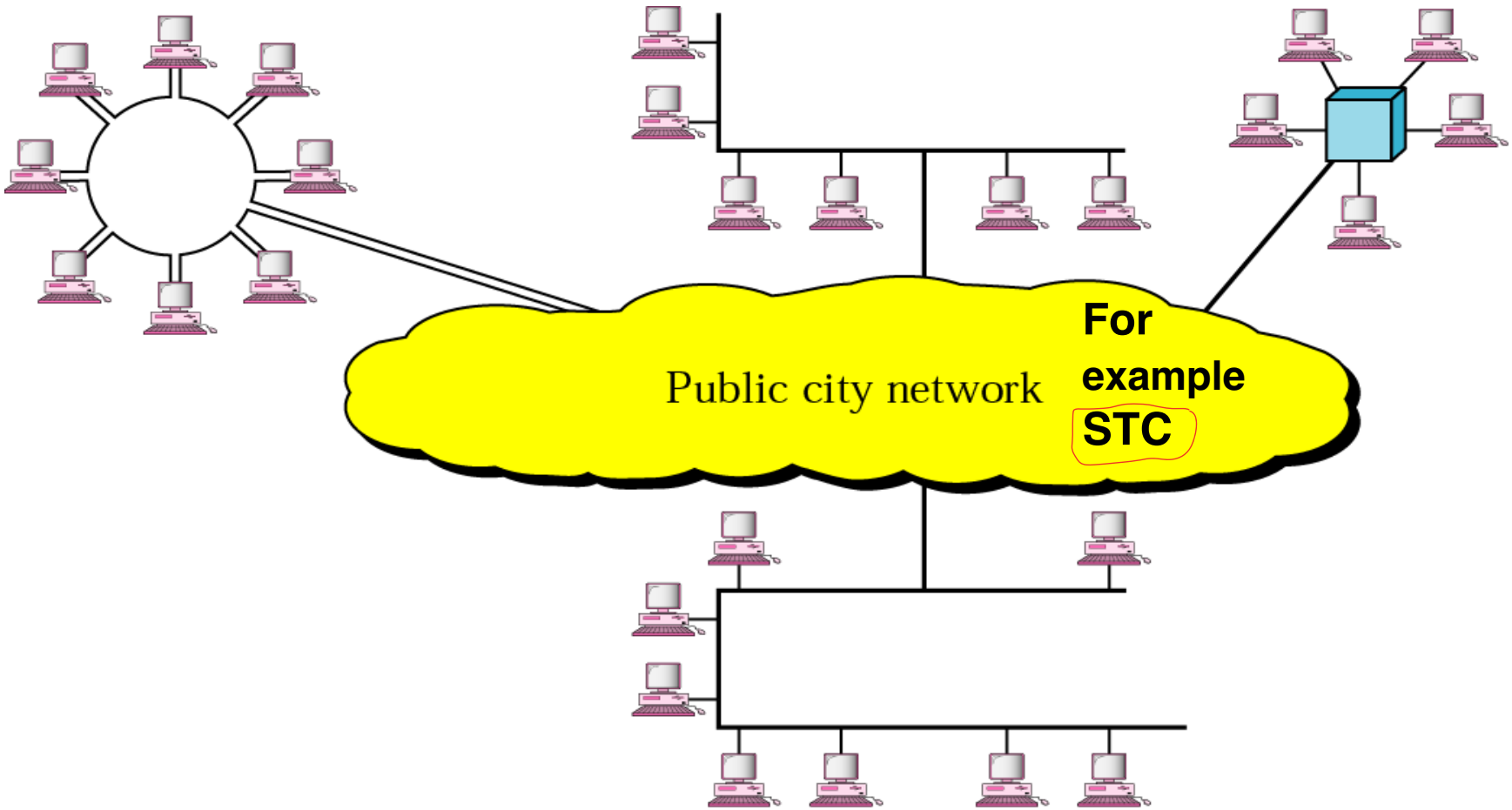


Figure 1.13 *LAN (two buildings)*

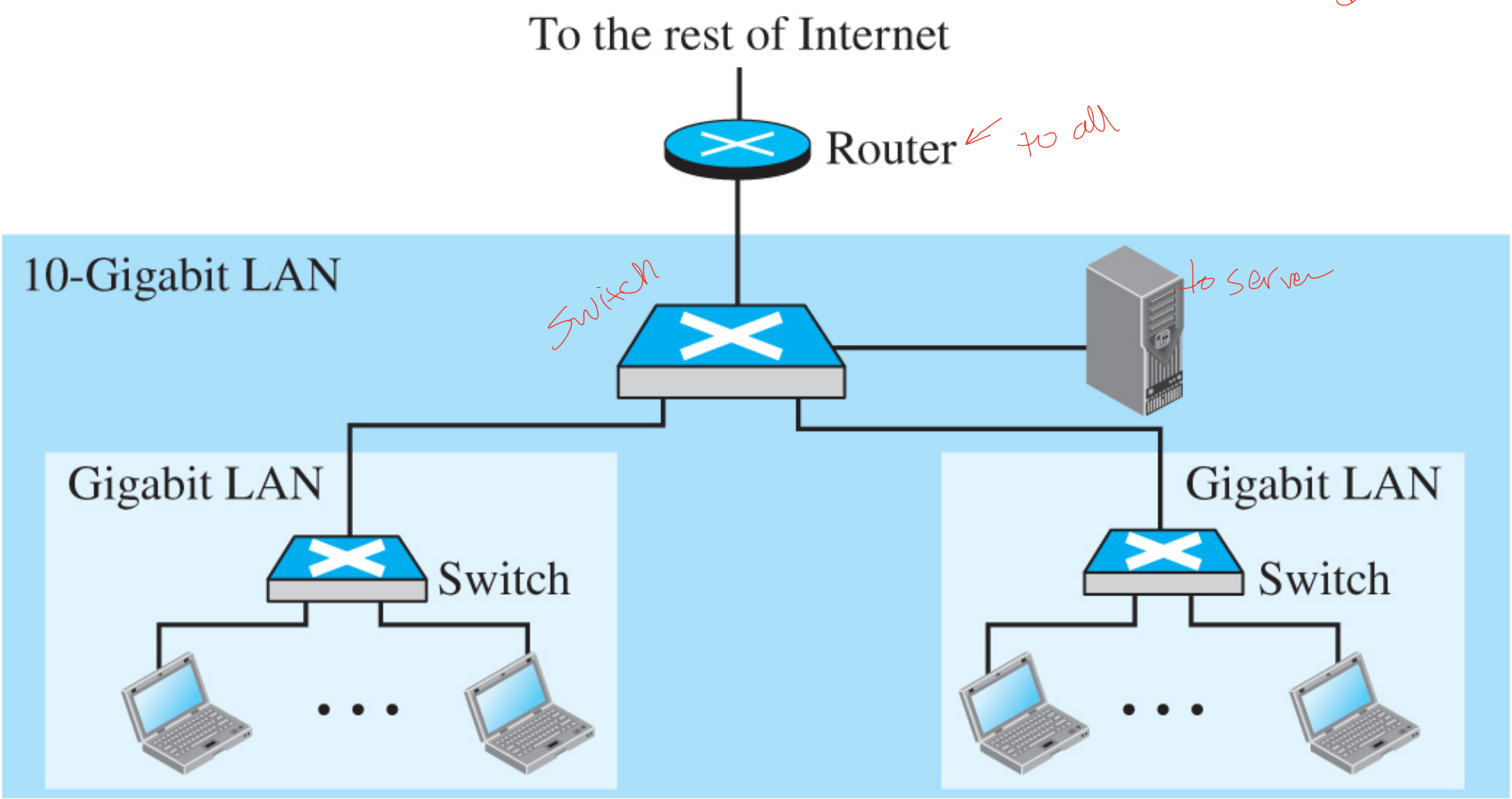


Figure 1.11 An internetwork made of two LANs and one WAN

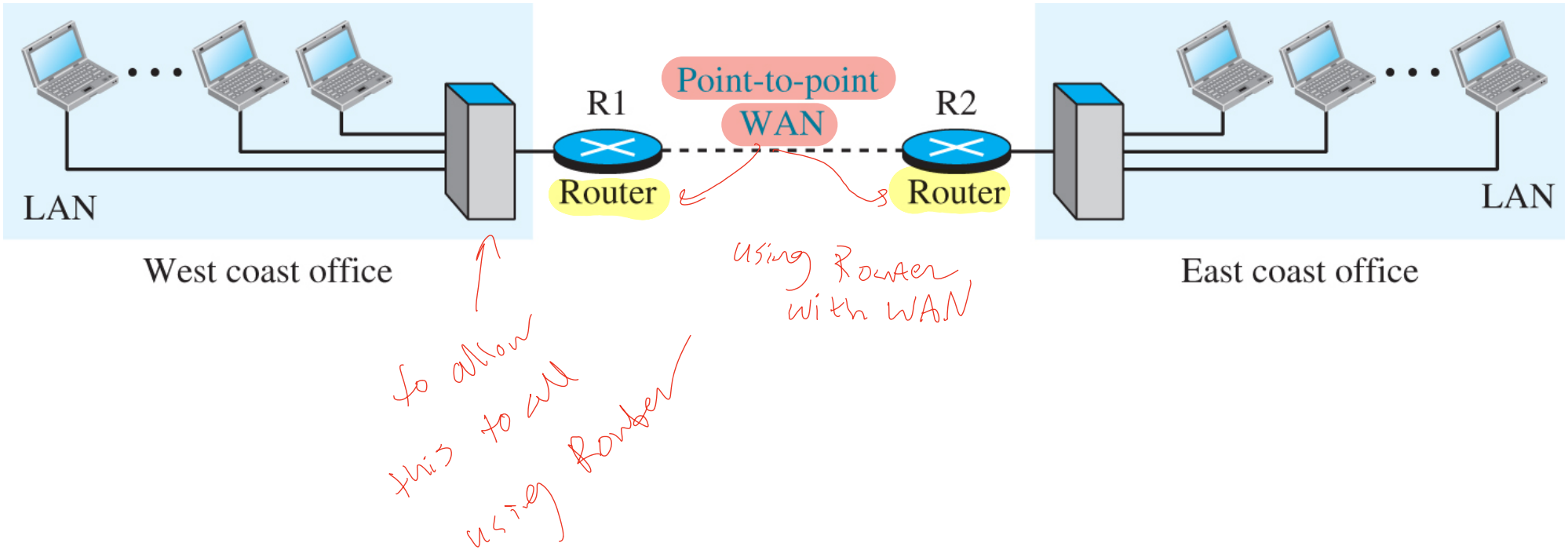


Figure 1.12 A heterogeneous network made of WANs and LANs

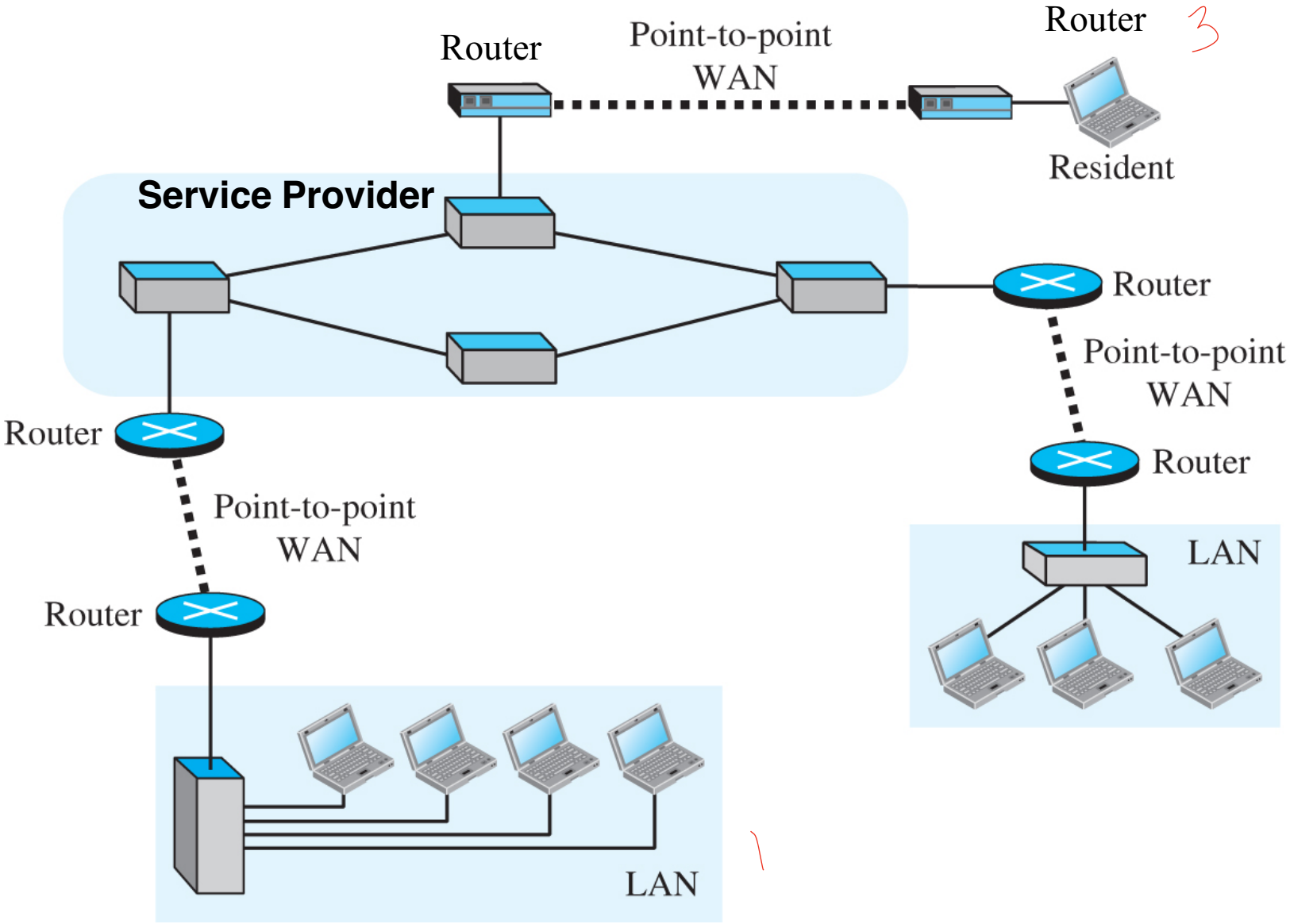
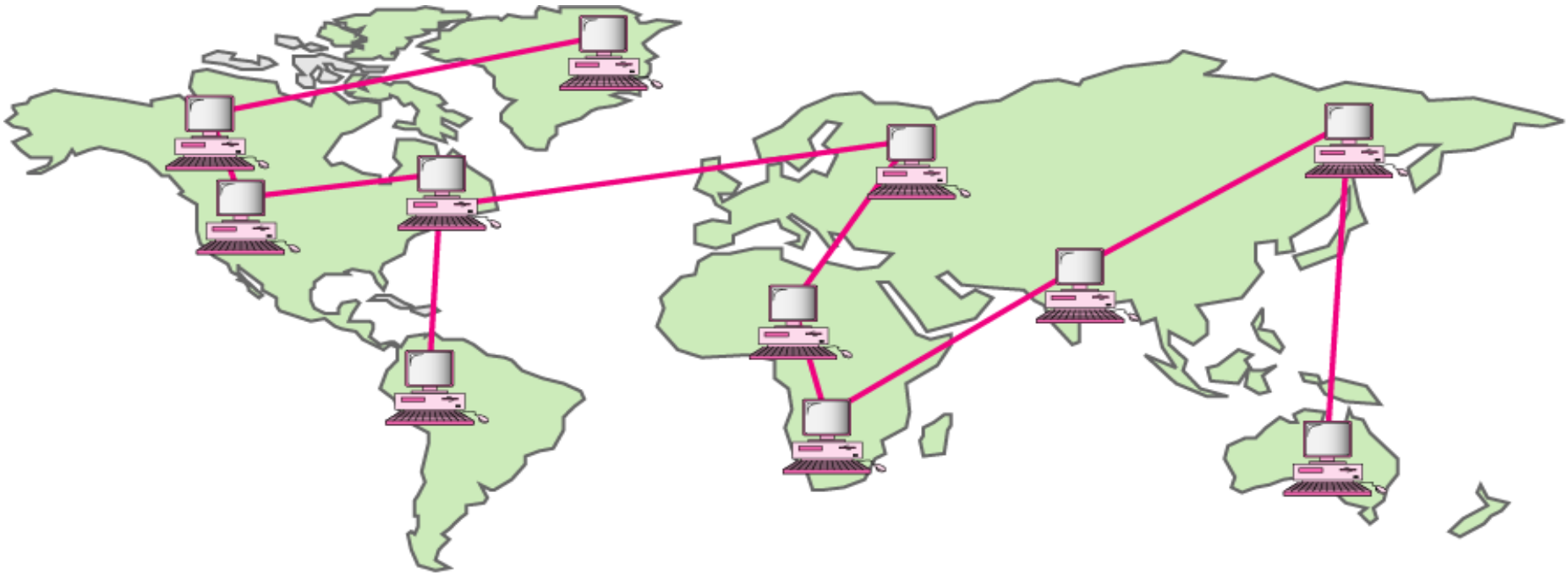


Figure 1.15 *WAN*

WAN: Provides long-distance transmission of data

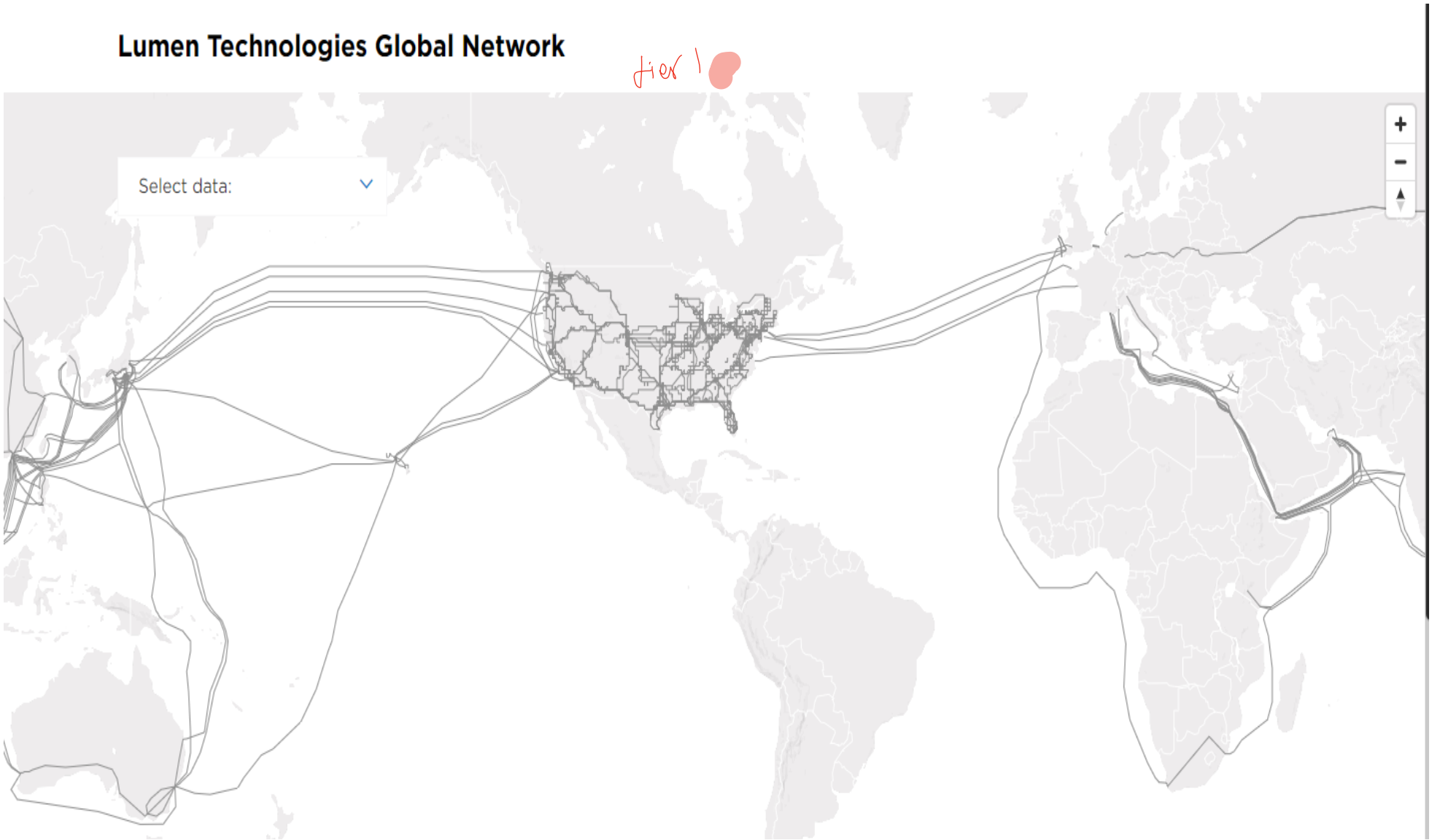


1.3 The Internet

- The Internet is a collection of different networks that run TCP/IP protocols suite
- It is made of many wide- and local area networks joined by connecting devices and switching stations
- In order to be considered on the Internet, your host machine should
  - run TCP/IP protocol
  - have Internet address
  - be able to send Internet Protocol (IP) packets to other machines on the Internet

Internet Service Providers (ISPs)

- **Backbones**: International Service providers (tier-1 ISPs)
  - International coverage
  - Called Internet backbone networks
  - Few number exists
  - Own links and routers to connect to other networks:
  - Connected directly to other tier-1 ISPs
  - Examples: Sprint, AT&T, LUMEN, etc.
- **Provider networks**: National or regional (tier-2 ISP)
  - Gateways to the international Internet
  - Connected to at least one tier-1 ISPs
  - has a regional or national coverage
  - Example: STC, ITC, Mobily
- **Local ISPs (Tier-3)**
  - Taking services from National Providers


Lumen Technologies Global Network
tier 1
Select data:

Internet structure: network of networks

- "Tier-3" ISPs and local ISPs
  - last hop ("access") network (closest to end systems)

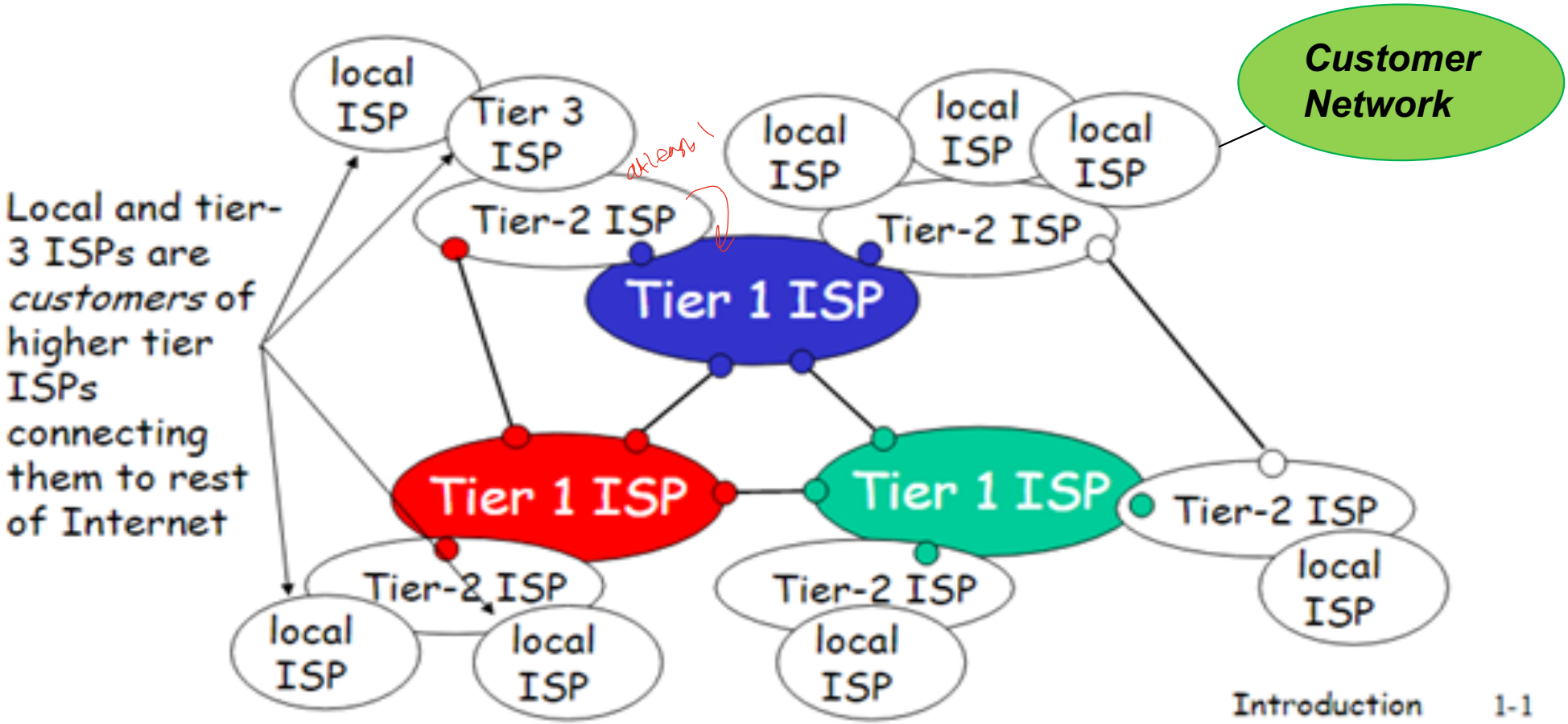
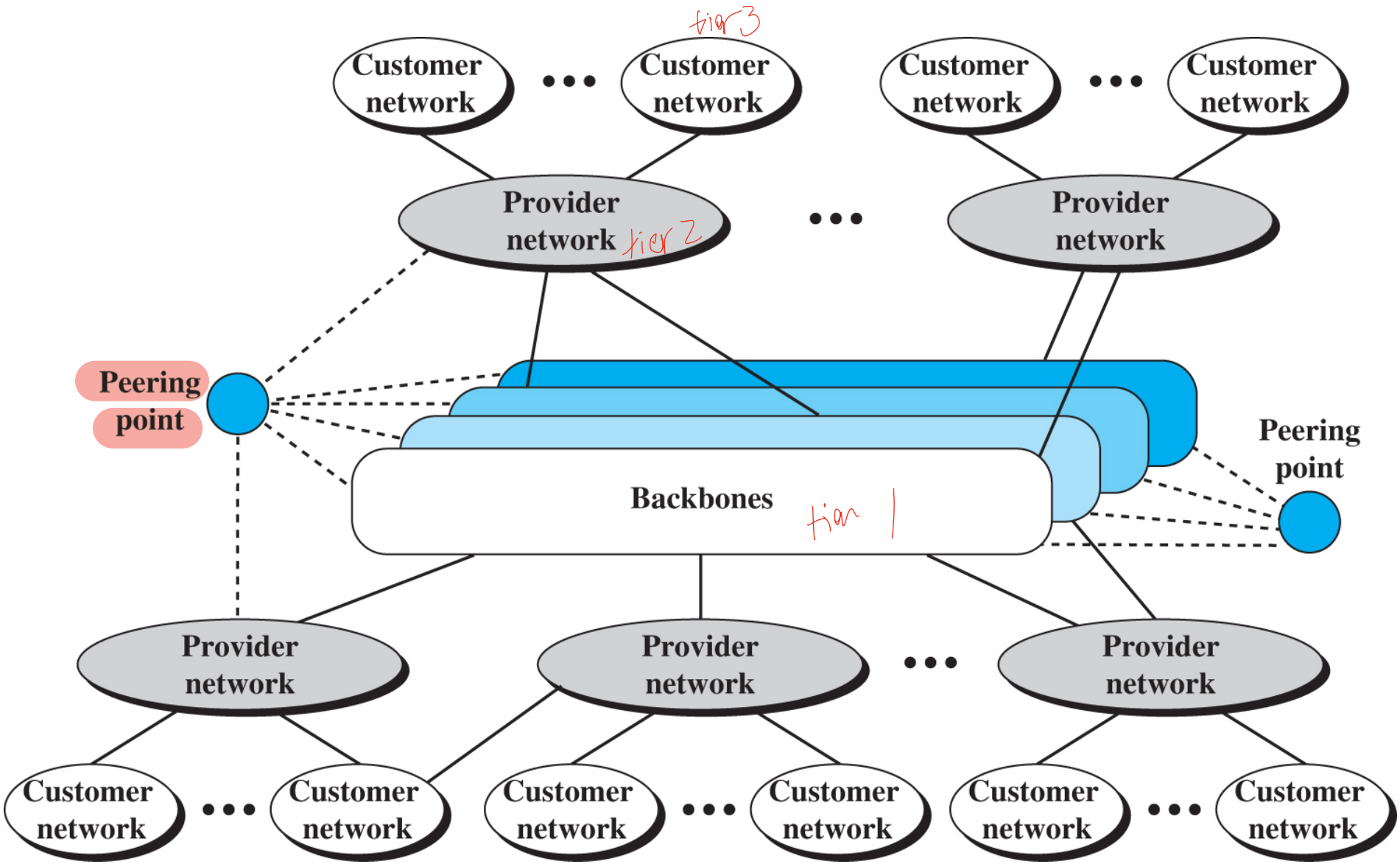


Figure 1.13 The Internet today



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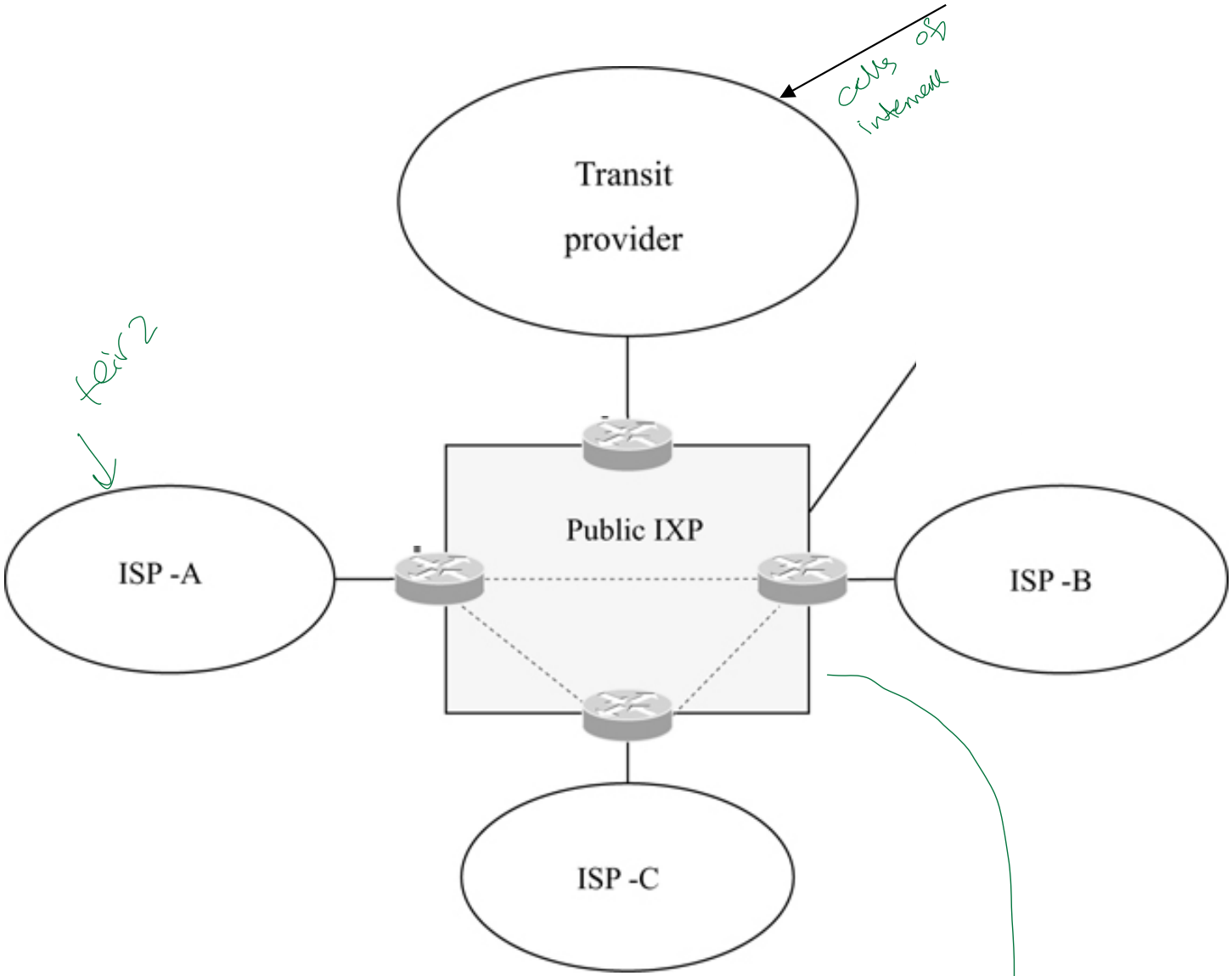
Methods of ISPs InterConnection

- **Peering is the interconnection of networks, allowing those networks to exchange traffic.**
- **Methods of ISP interconnection (peering):**
  - **Private Peering Points (Direct Connection)**
    - **Points at which one ISP is connected to the others and consist of a group of routers (devices that connects networks together)**
    - **Private Peering Points are owned and operated by ISPs not by a third party telecommunication company**
  - **Internet Exchange Points (IXP) (Public Peering)**
    - **is a physical infrastructure through which Internet service providers (ISPs) exchange Internet traffic between their networks**
    - **A public IXP is managed by a third party and enables any ISP to connect with any other ISP**
    - **IXP consists of Complex high speed switching networks**
    - **IXP exchange huge amounts of traffic**
  - **Current trend for connecting ISP:**
    - **International ISPs connect to each other at private peering points**
    - **National ISPs interconnect using IXP**

Internet Exchange Points (IXP)

ISP which provides access to other parts of the Internet



Customers from each ISP can communicate with each others through IXP network

Saudi Arabian Internet Exchange

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1.4 Internet Standards

- In early 1970s, IBM, Digital Equipment and other vendors developed networking architectures that allow only their own computers to operate in local computer networks
- Each company network can't communicate with other company equipments without using a major translation software.
- Question: How to allow these different networks communicate with each others easily?
  - Answer: Communicating devices *must agree* on a protocol or standards
- **Protocol**: set of rules controlling the exchange of data between two entities in a system.
  - Entities: application that is capable of sending and receiving information (ex: user applications, email,… etc).
  - Systems: computers, terminals, remote sensors

Internet Standards

- Standards and protocols specify hardware and software procedures through which computers can correctly and reliably talk to one another
- Required to allow for interoperability among equipments built by different vendors
- Advantages
  - Ensures a large market for equipment and software
  - Provide guidelines to manufacturers, vendors, government agencies.
  - Allows products from different vendors to communicate

Agreements must be at many levels ...

- How many volts pulse is a 0 and 1 ?
- How to determine the end of a message ?
- How to handle lost messages ?
- How many bits for different data types ? Integers/Strings, etc.; are ASCII chars ?
- How machines are identified in a network?
- How to find the way to reach a machine ?
- How applications speaks together through the network ?

Standards Organizations

Example

- International Organization for standardization (ISO)
- International Telecommunication Union (ITU-T) – UN Agency
- American National Standards Institute (ANSI)
- Institute of Electrical and Electronic Engineers (IEEE) – specializes in LAN/MAN standards
- World Wide Web Consortium (W3)