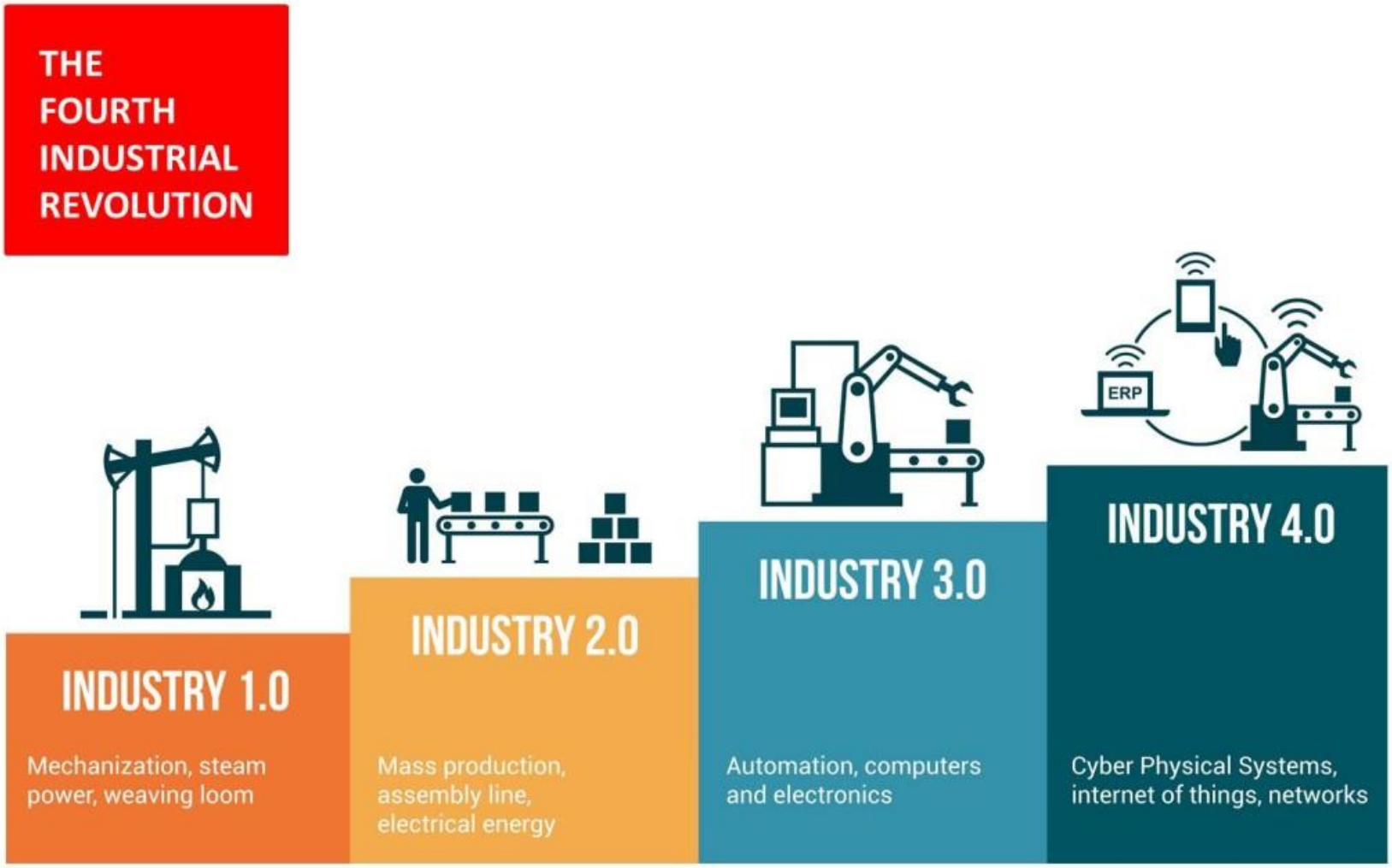
PART I :
INTRODUCTION TO DATA COMMUNICATION AND COMPUTER NETWORK

Data Communication and Computer Network

VER 2025

Introduction

Introduction

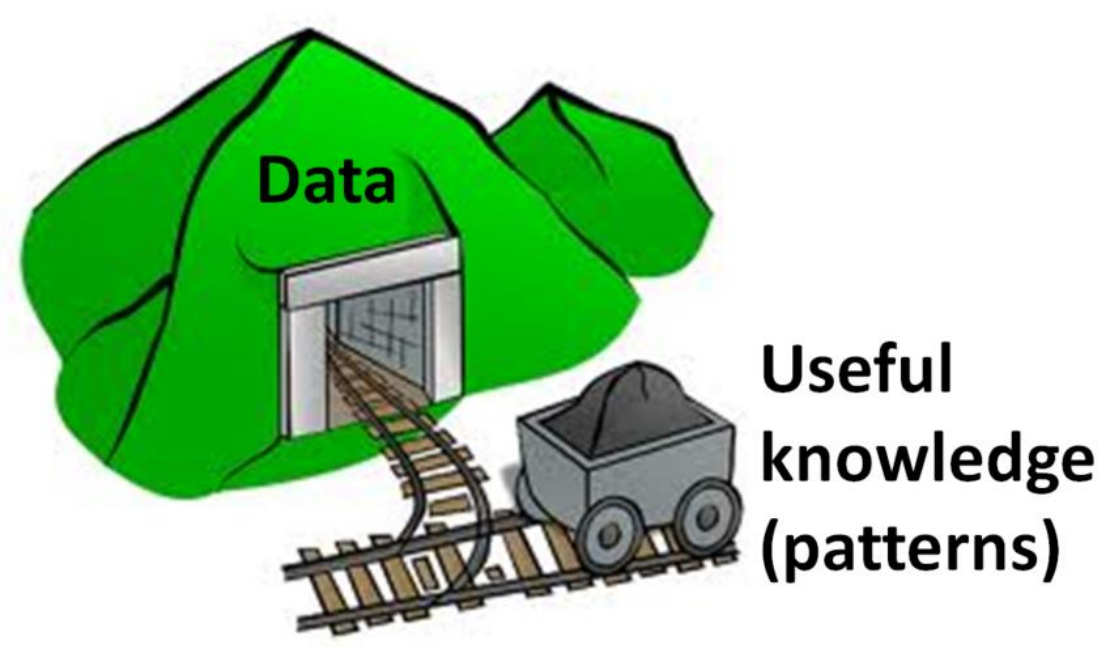


Industry 4.0

- The fourth industrial revolution will take what was started in the third with the adoption of computers and automation and enhance it with smart and autonomous systems fuelled by data and machine learning (forbes.com).

Industry 4.0's Application

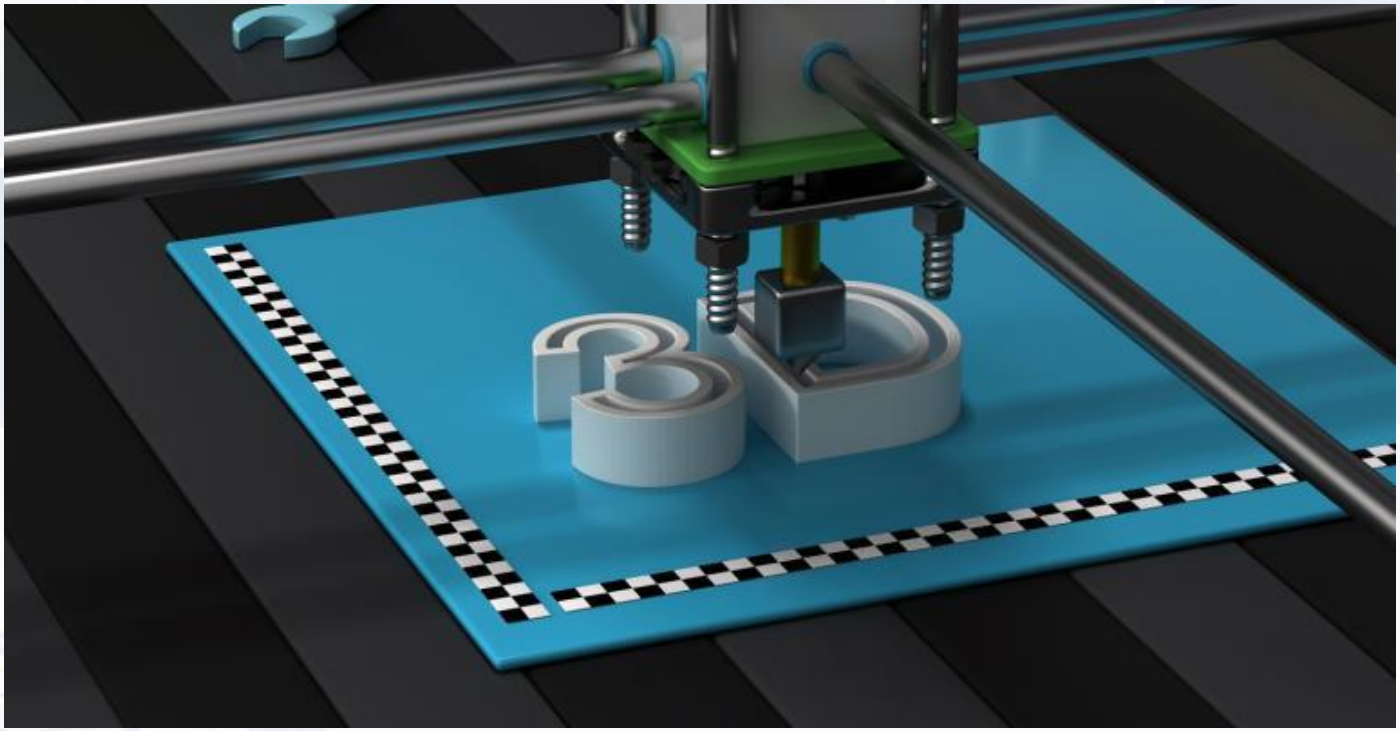
- Data Mining
- Data is new gold.



Industry 4.0's Application

- Identify opportunities
- Connected machines collect a tremendous volume of data that can :
  - inform maintenance, performance and other issues, analyze that data to identify patterns and insights that would be impossible for a human to do in a reasonable timeframe.
  - Industry 4.0 offers the opportunity for manufacturers to optimize their operations quickly and efficiently by knowing what needs attention.
  - By using the data from sensors in its equipment, an African gold mine identified a problem with the oxygen levels during leaching. Once fixed, they were able to increase their yield by 3.7%, which saved them $ 20 million annually.

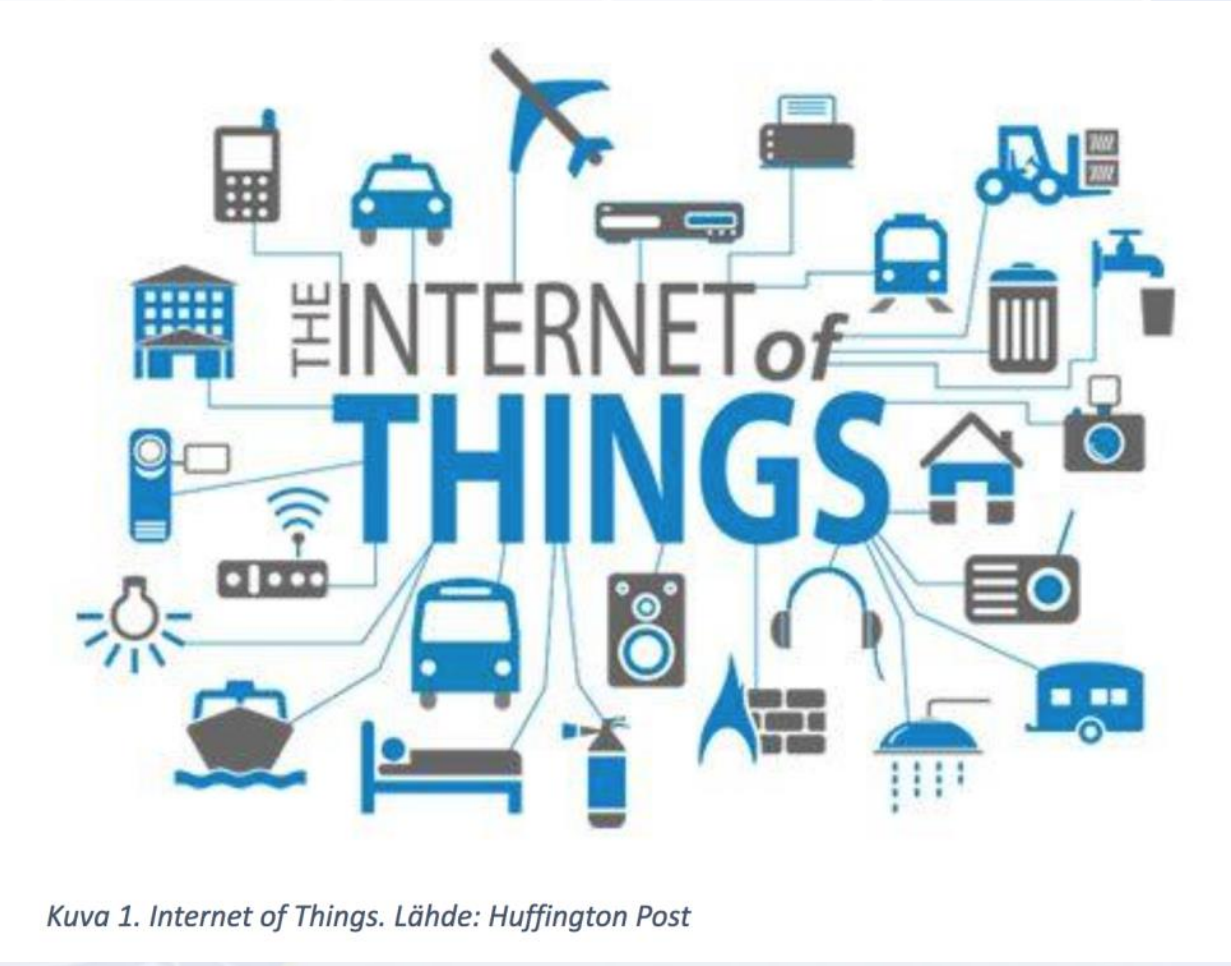
Industry 4.0's Application



Industry 4.0's Application

- Additive manufacturing (3D printing):
  - This technology has improved tremendously in the last decade and has progressed from primarily being used for prototyping to actual production.
    - Advances in the use of metal additive manufacturing have opened up a lot of possibilities for production.

Industry 4.0's Application



Kuva 1. Internet of Things. Lähde: Huffington Post

Industry 4.0's Application

- Internet of Things and the cloud:
  - A key component of Industry 4.0 is the Internet of Things that is characterized by connected devices.
    - Not only does this help internal operations, but through the use of the cloud environment where data is stored, equipment and operations can be optimized by leveraging the insights of others using the same equipment or to allow smaller enterprises access to technology they wouldn't be able to on their own.

Data Communication

- Communication : sharing information.
- Data : information presented in whatever form is agreed upon by the parties creating and using the data.
- Data communications are the exchange of data between two devices via some form of transmission medium such as a wire cable.

Characteristic (part 1)

The effectiveness of a data communications system depends on four fundamental characteristics:

- **Delivery**
  - The system must deliver data to the correct destination. Data must be received by the intended device or user and only by that device or user
- **Accuracy**
  - The system must deliver the data accurately. Data that have been altered in transmission and left uncorrected are unusable.

Characteristic (part 2)

- **Timeliness**
  - The system must deliver data in a timely manner. Data delivered late are useless. In the case of video and audio, timely delivery means delivering data as they are produced, in the same order that they are produced, and without significant delay. This kind of delivery is called *real-time transmission*
- **Jitter**
  - Jitter refers to the variation in the packet arrival time. It is the uneven delay in the delivery of audio or video packets.

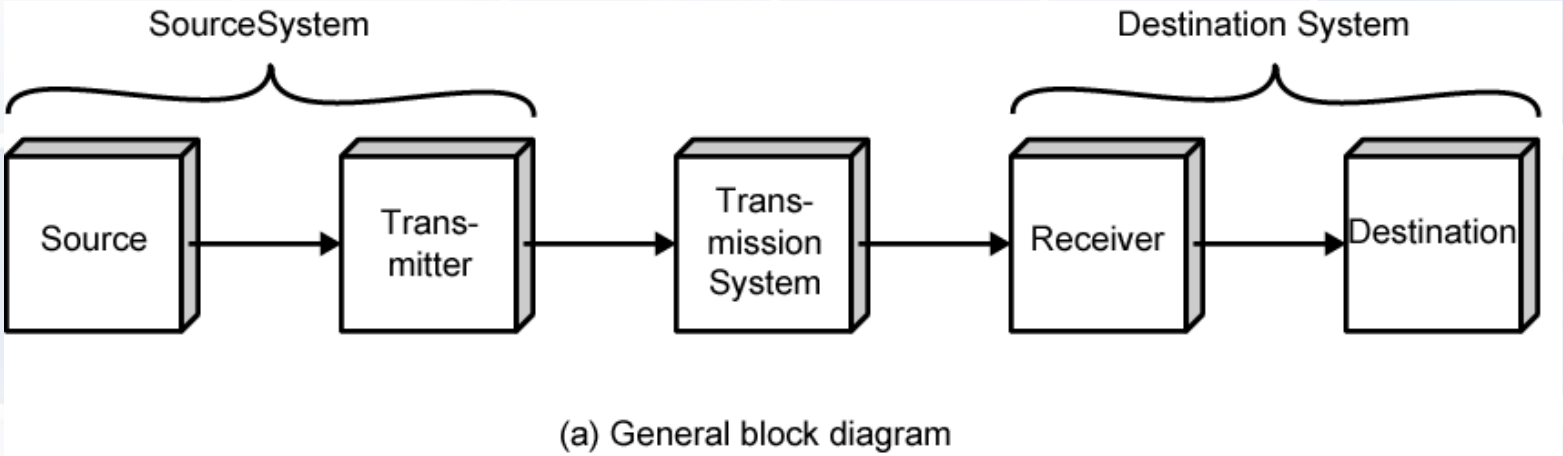
Component (part 1)

- **Message**
  - The message is the information (data) to be communicated.
  - Popular forms of information include text, numbers, pictures, audio, and video.
- **Sender**
  - The sender is the device that sends the data message. It can be a computer, workstation, telephone handset, video camera, and so on.
- **Receiver**
  - The receiver is the device that receives the message. It can be a computer, workstation, telephone handset, television, and so on.

Component (part 2)

- **Transmission medium**
  - The transmission medium is the physical path by which a message travels from sender to receiver. Some examples of transmission media include twisted-pair wire, coaxial cable, fiber-optic cable, and radio waves.
- **Protocol**
  - A protocol is a set of rules that govern data communications. It represents an agreement between the communicating devices. Without a protocol, two devices may be connected but not communicating, just as a person speaking French cannot be understood by a person who speaks only Japanese.

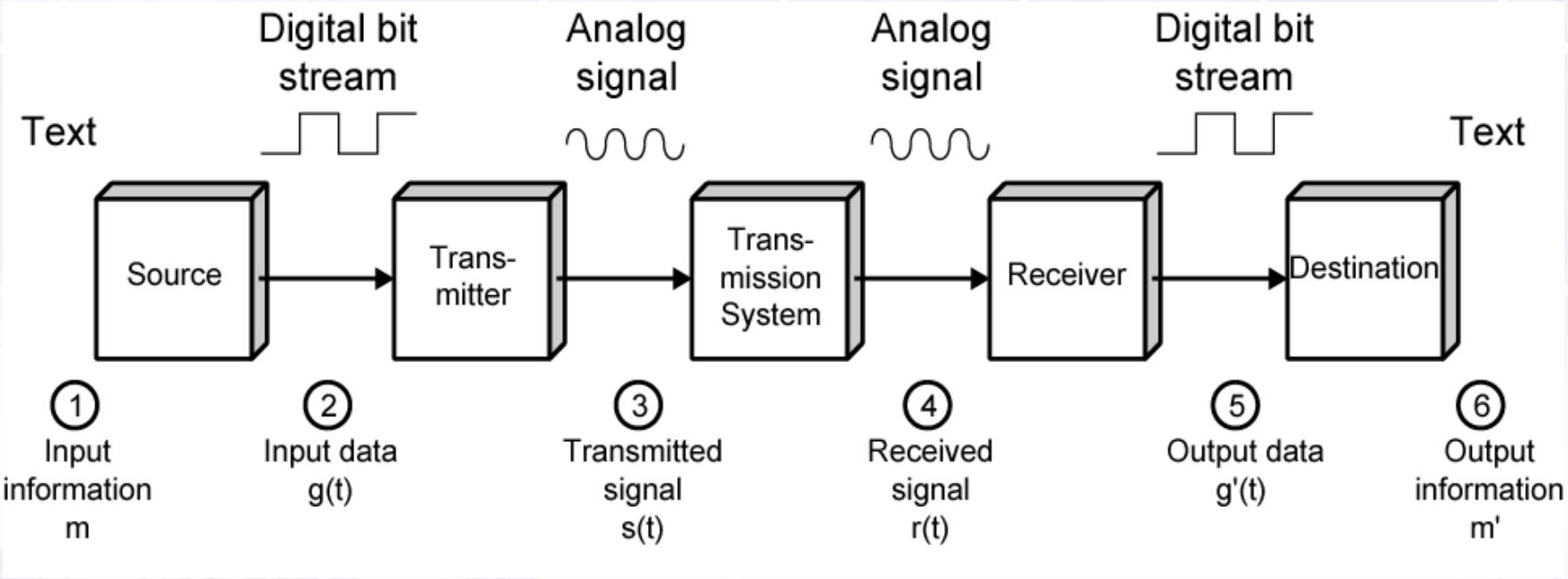
Block Diagram



(a) General block diagram

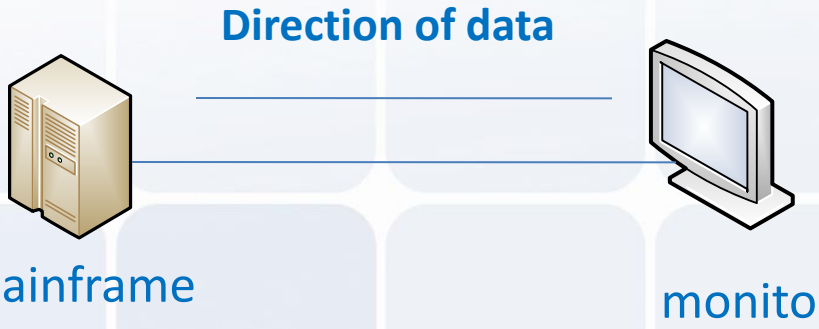
(b) Example

Block Diagram

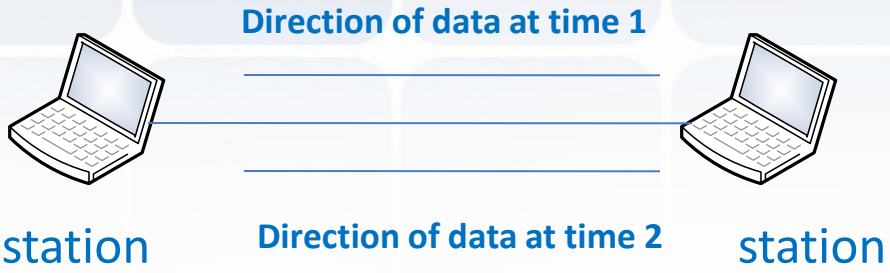


Data Flow

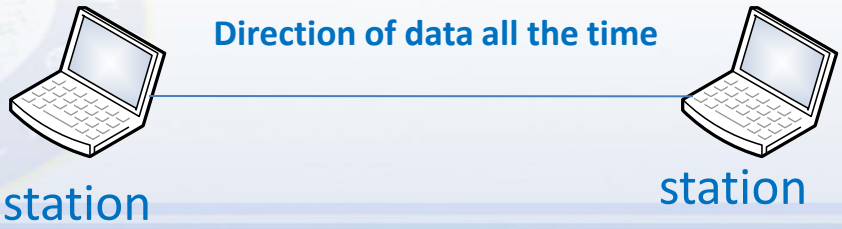
Simplex



Half - duplex



Full - duplex



Networks

- **A network** is a set of devices (often referred to as *nodes) connected by communication* links.
  - **A node can be a computer, printer, or any other device capable of sending and/or receiving data generated by other nodes on the network.**

- **Distributed Processing**

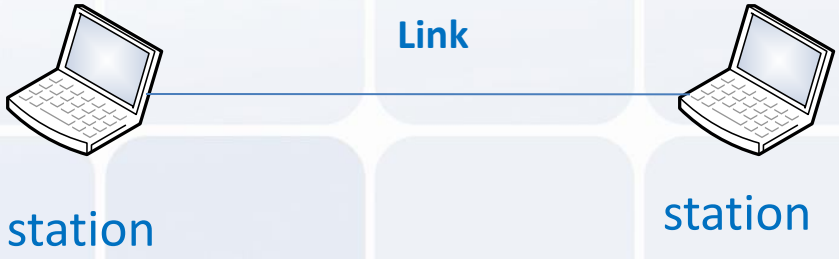
  Most networks use distributed processing, in which a task is divided among multiple computers. Instead of one single large machine being responsible for all aspects of a process, separate computers (usually a personal computer or workstation) handle a subset.

Network

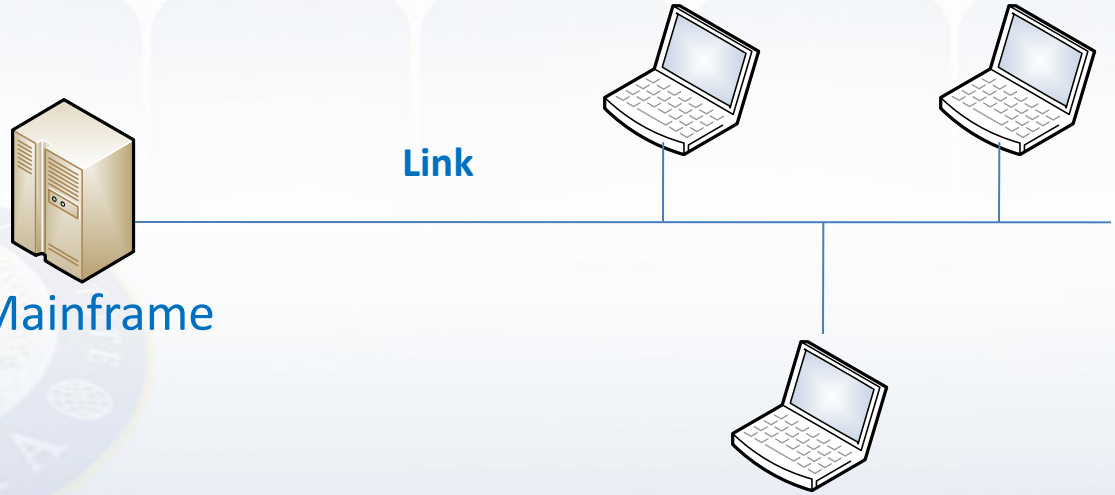
- **Network Criteria**
  - ***Performance,*** Performance can be measured in many ways, including transit time and response time.
  - ***Reliability,*** network reliability is measured by the frequency of failure, the time it takes a link to recover from a failure, and the network's robustness in a catastrophe.
  - ***Security.*** Network security issues include protecting data from unauthorized access, protecting data from damage and development, and implementing policies and procedures for recovery from breaches and data losses.

Type of Connections

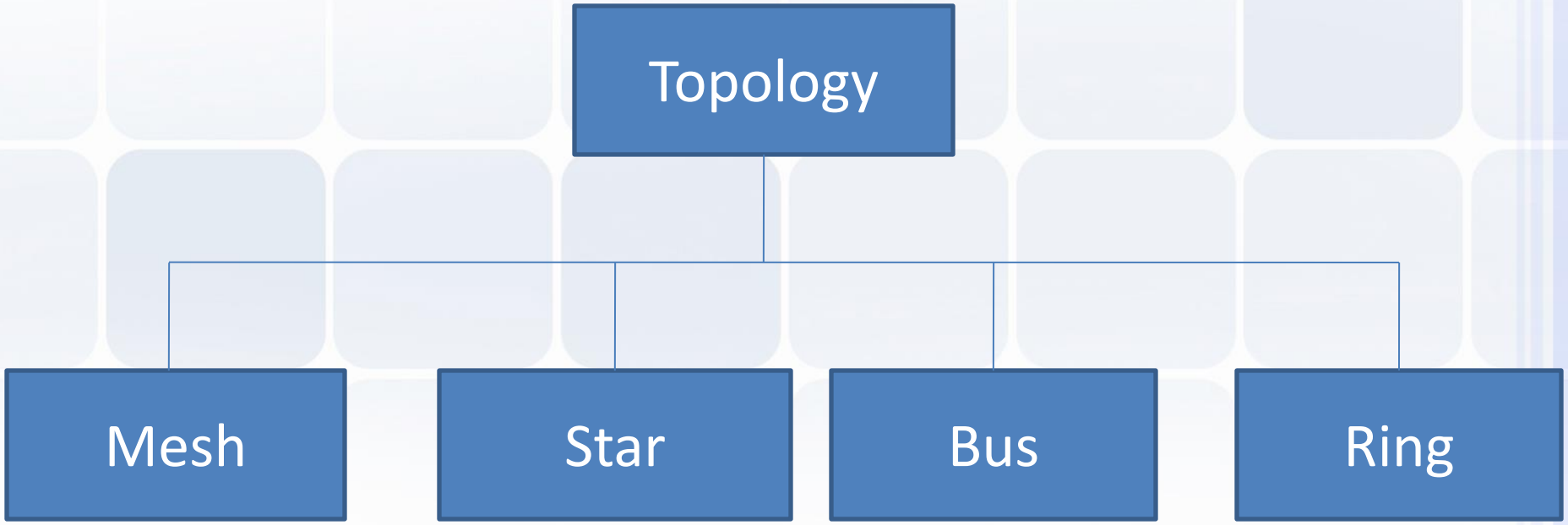
Point – to - point



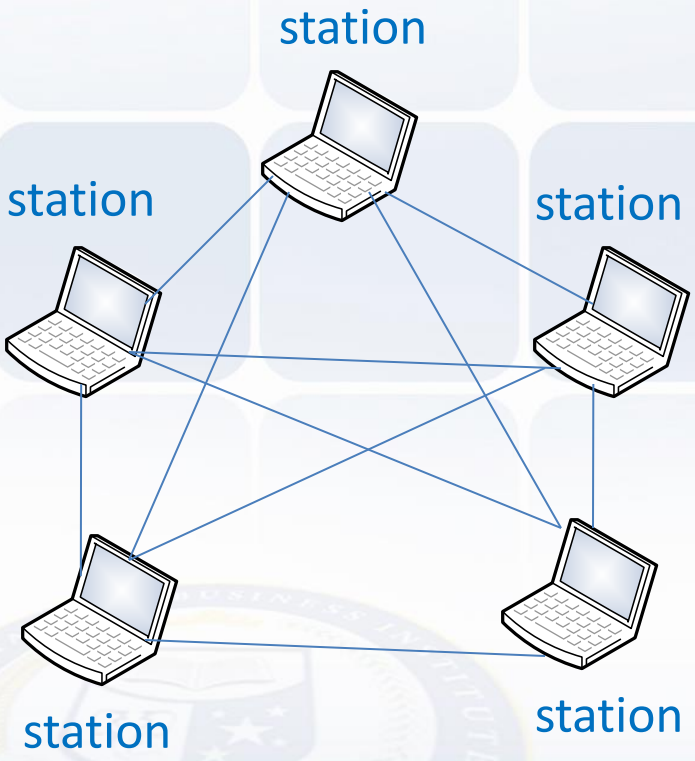
Multipoint



Physical Topology

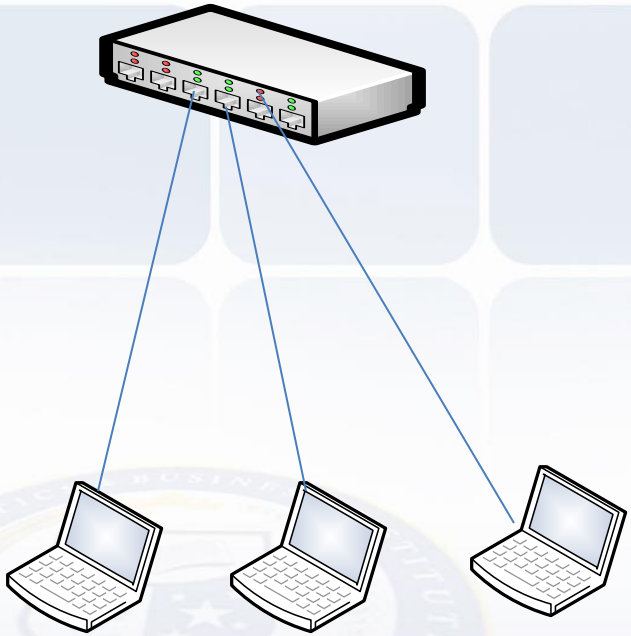


Mesh



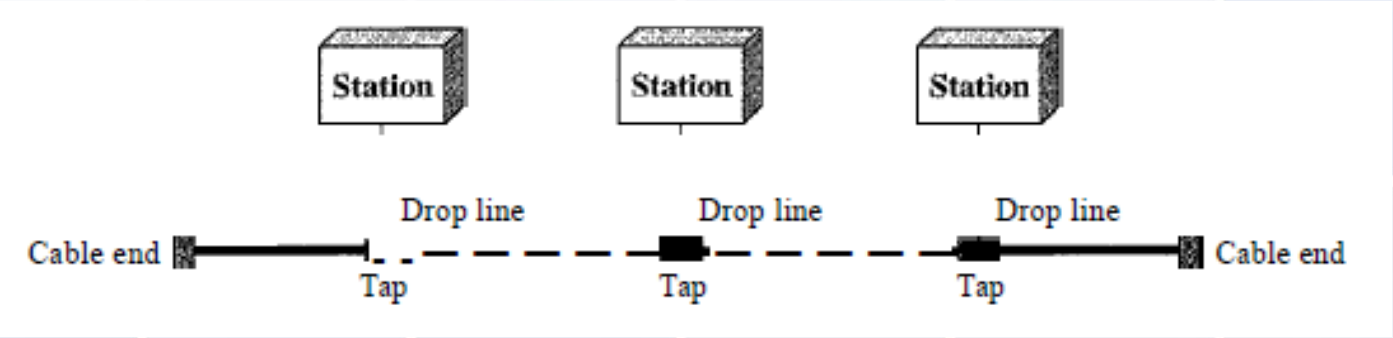
- In a mesh topology, every device has a dedicated point-to-point link to every other device.

Star



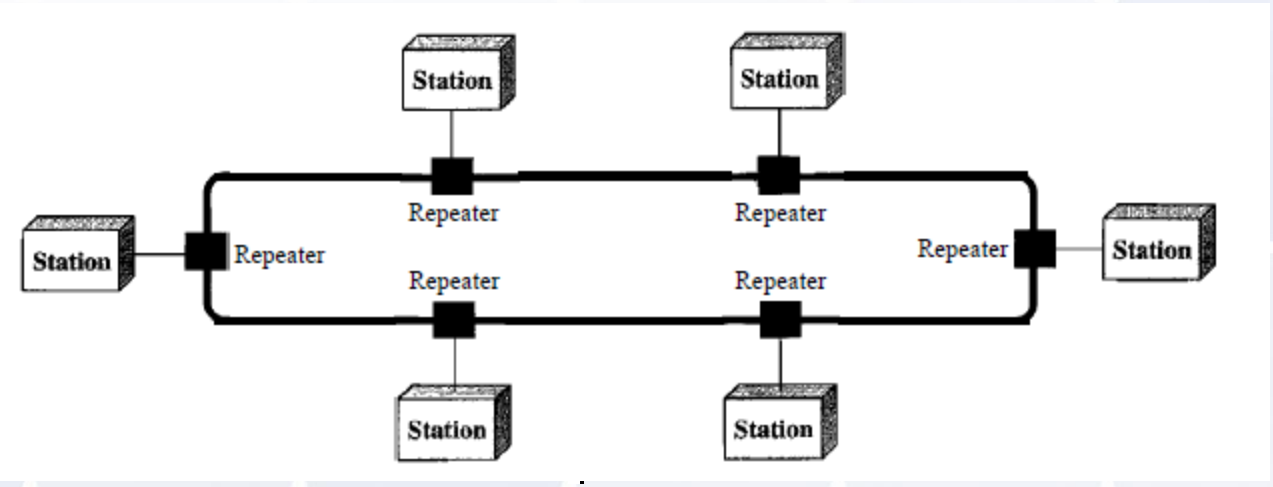
- In a star topology, each device has a dedicated point-to-point link only to a central controller, usually called a hub. The devices are not directly linked to one another.

Bus



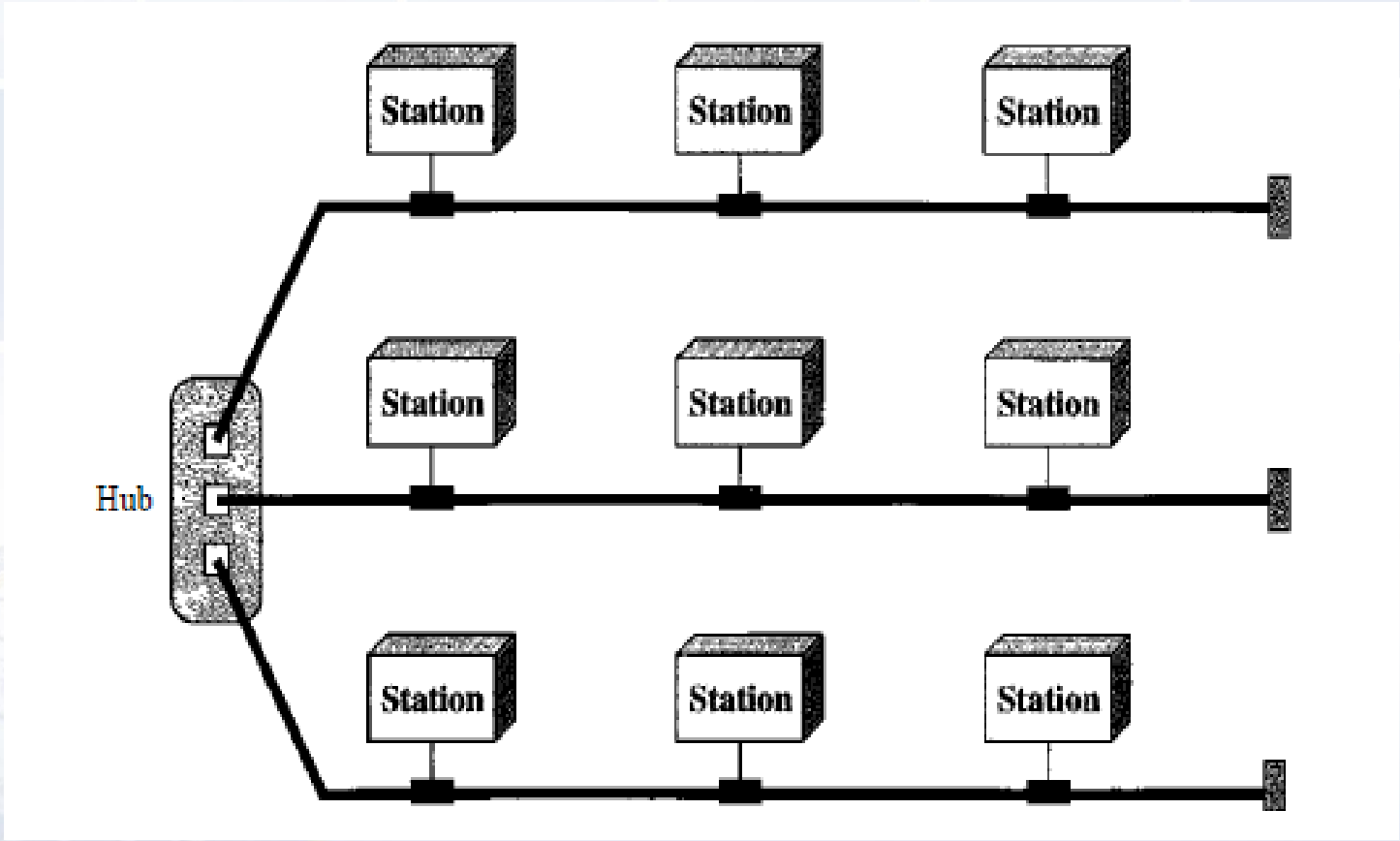
- In this topology, One long cable acts as a **backbone to link all** the devices in a network.
- Nodes are connected to the bus cable by drop lines and taps.
- A drop line is a connection running between the device and the main cable.
- A tap is a connector that either splices into the main cable or punctures the sheathing of a cable to create a contact with the metallic core.
- As a signal travels along the backbone, some of its energy is transformed into heat. Therefore, it becomes weaker and weaker as it travels farther and farther. For this reason there is a limit on the number of taps a bus can support and on the distance between those taps.

Ring



- In a ring topology, each device has a dedicated point-to-point connection with only the two devices on either side of it.
- A signal is passed along the ring in one direction, from device to device, until it reaches its destination.
- Each device in the ring incorporates a repeater. When a device receives a signal intended for another device, its repeater regenerates the bits and passes them along.

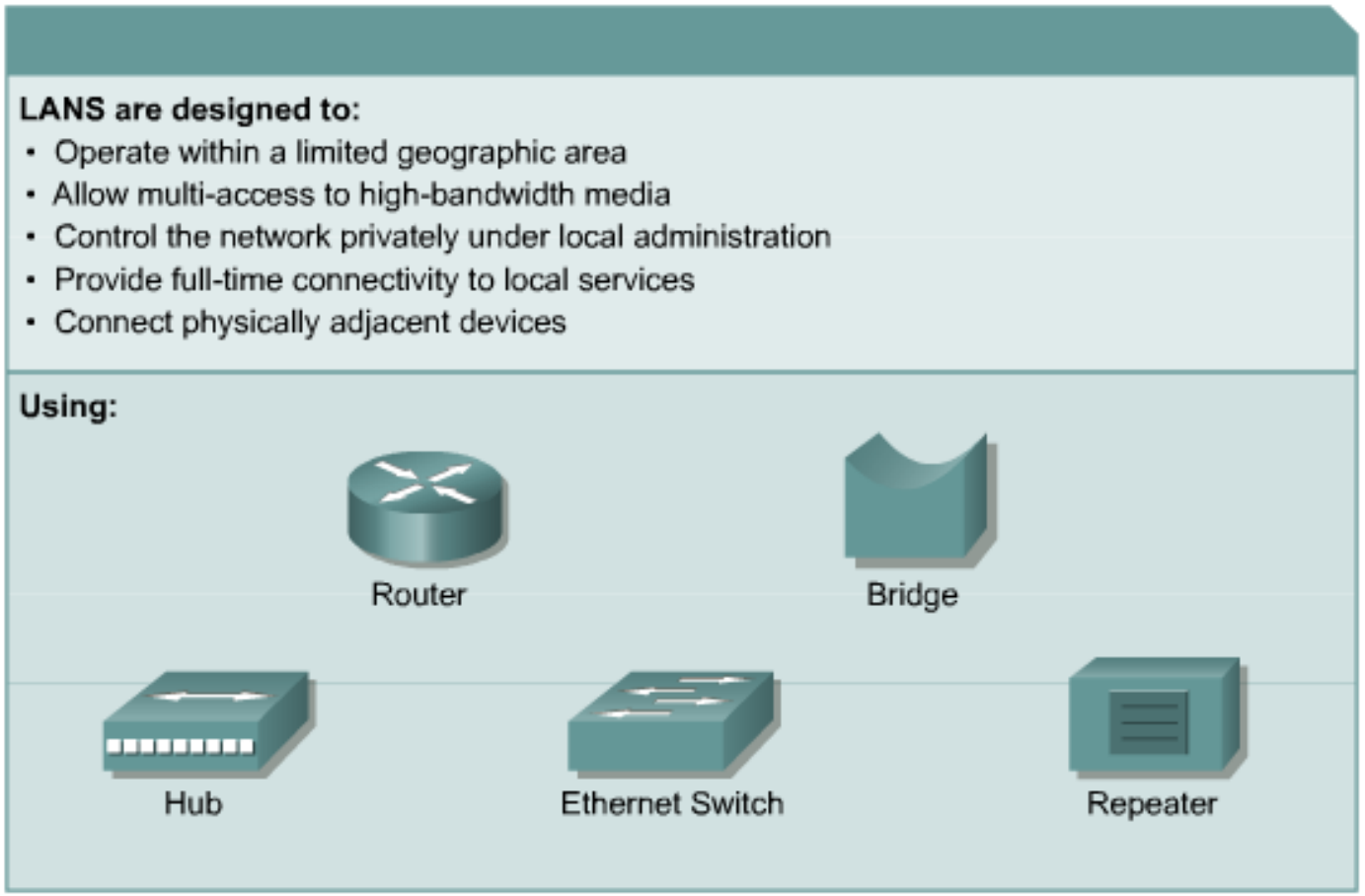
Hybrid Network



Categories of Network

- Local Area Network
- Wide Area Network
- Metropolitan Area Network

Local Area Network



Picture : copyright CISCO

Wide Area Network

WANS are designed to:

- Operate over a large geographical area
- Allow access over serial interfaces operating at lower speeds
- Provide full-time and part-time connectivity
- Connect devices separated over wide, even global areas

Using:

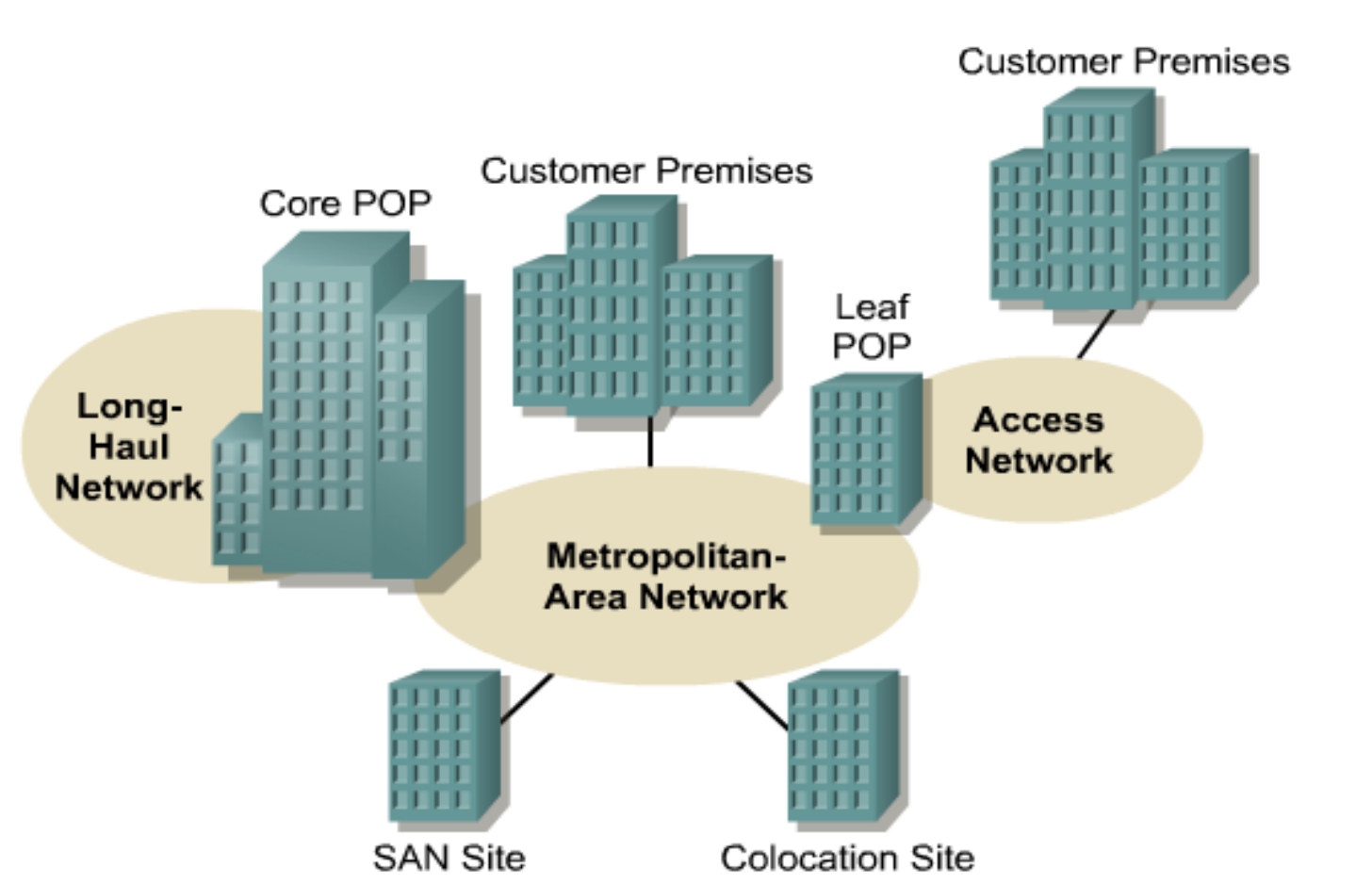
Router

Communication Server

Modem CSU/DSU TA/NT1

Picture : copyright CISCO

Metropolitan Area Network



Picture : copyright CISCO

Communication Network

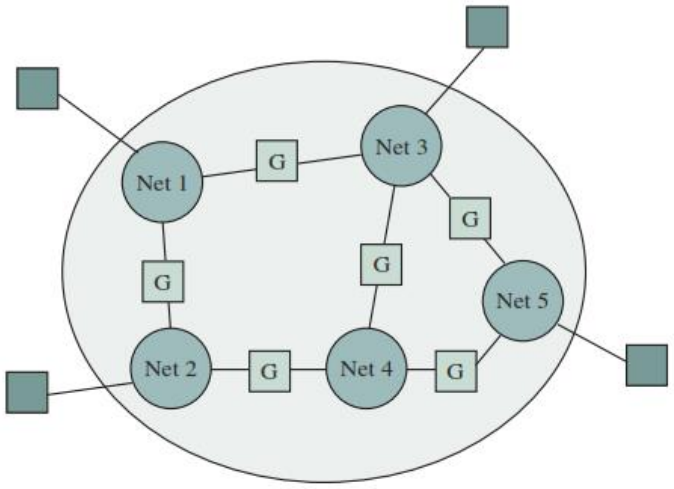
- A Communication network, in its simple form, a set of equipment and facilities that provides a service : the transfer information between users located at various geographical points.

The Internet

- In the mid-1970s after the ARPANET packet switching has been established, ARPA began exploring data communications using satellite and mobile packet radio network.
- The need to develop protocols to provide packet communications across multiple, possibly dissimilar, networks soon became apparent.
- An internetwork or internet involves the interconnection of multiple networks into a single large network.
- The component networks may differ in terms of their underlying technology and operation.
  - For example, these networks could consist of various types of LANs, ATM networks, or even a single point to point link.

The Internet

- The power of the internet concept is that allows different networks to coexist and interwork effectively.



G = gateway

FIGURE 1.18 An internetwork

Protocol and Standard

- **Protocol is a set of rules that govern data communications.**
- **A protocol defines what is communicated, how it is communicated, and when it is communicated.**

– **Syntax**

- The term *syntax refers to the structure or format of the data, meaning the* order in which they are presented. For example, a simple protocol might expect the first 8 bits of data to be the address of the sender, the second 8 bits to be the address of the receiver, and the rest of the stream to be the message itself.

– **Semantics**

- The word *semantics refers to the meaning of each section of bits.* How is a particular pattern to be interpreted, and what action is to be taken based on that interpretation? For example, does an address identify the route to be taken or the final destination of the message?

– **Timing**

- The term *timing refers to two characteristics: when data should be sent* and how fast they can be sent. For example, if a sender produces data at 100 Mbps but the receiver can process data at only 1 Mbps, the transmission will overload the receiver and some data will be lost.

Standard

- International Organization for Standardization (ISO).
- International Telecommunication Union-Telecommunication Standards Sector (ITU-T).
- American National Standards Institute (ANSI).
- Institute of Electrical and Electronics Engineers (IEEE).

End