What is a Network?

A network consists of 2 or more computers connected together, and they can communicate and share resources (e.g. information)

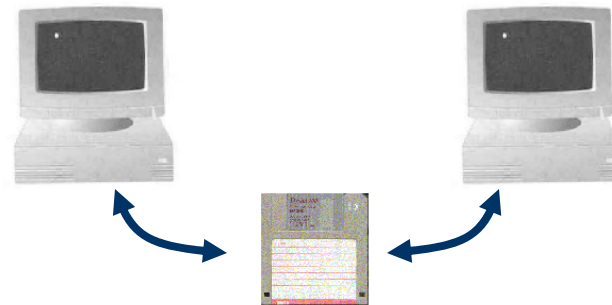# Why Networking?

- **Sharing information — i.e. data communication**
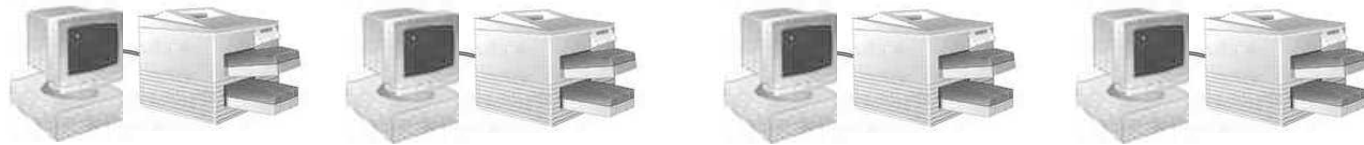
  - **Do you prefer these?**
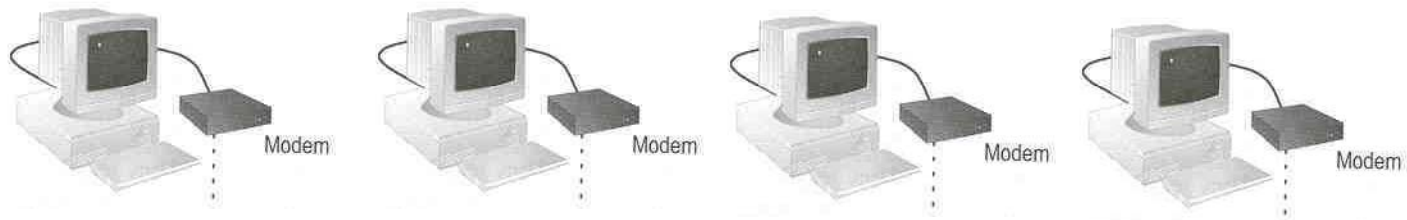
  - **Or this?**

- **Sharing hardware or software**

  - **E.g. print document**

- **Centralize administration and support**
  - **E.g. Internet-based, so everyone can access the same administrative or support application from their PCs**

How many kinds of Networks?

- **Depending on one's perspective, we can classify networks in different ways**

  - **Based on transmission media: Wired (UTP, coaxial cables, fiber-optic cables) and Wireless**

  - **Based on network size: LAN and WAN (and MAN)**

  - **Based on management method: Peer-to-peer and Client/Server**

  - **Based on topology (connectivity): Bus, Star, Ring …**

    ⋮

    ⋮

Transmission Media

- **Two main categories:**
  - **Guided** ― wires, cables
  - **Unguided** ― wireless transmission, e.g. radio, microwave, infrared, sound, sonar
- **We will concentrate on guided media here:**
  - **Twisted-Pair cables:**
    - ➢ **Unshielded Twisted-Pair (UTP) cables**
    - ➢ **Shielded Twisted-Pair (STP) cables**
  - **Coaxial cables**
 - **Fiber-optic cables**

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Twisted-Pair Cables

- **If the pair of wires are not twisted, electromagnetic noises from, e.g., motors, will affect the closer wire more than the further one, thereby causing errors**
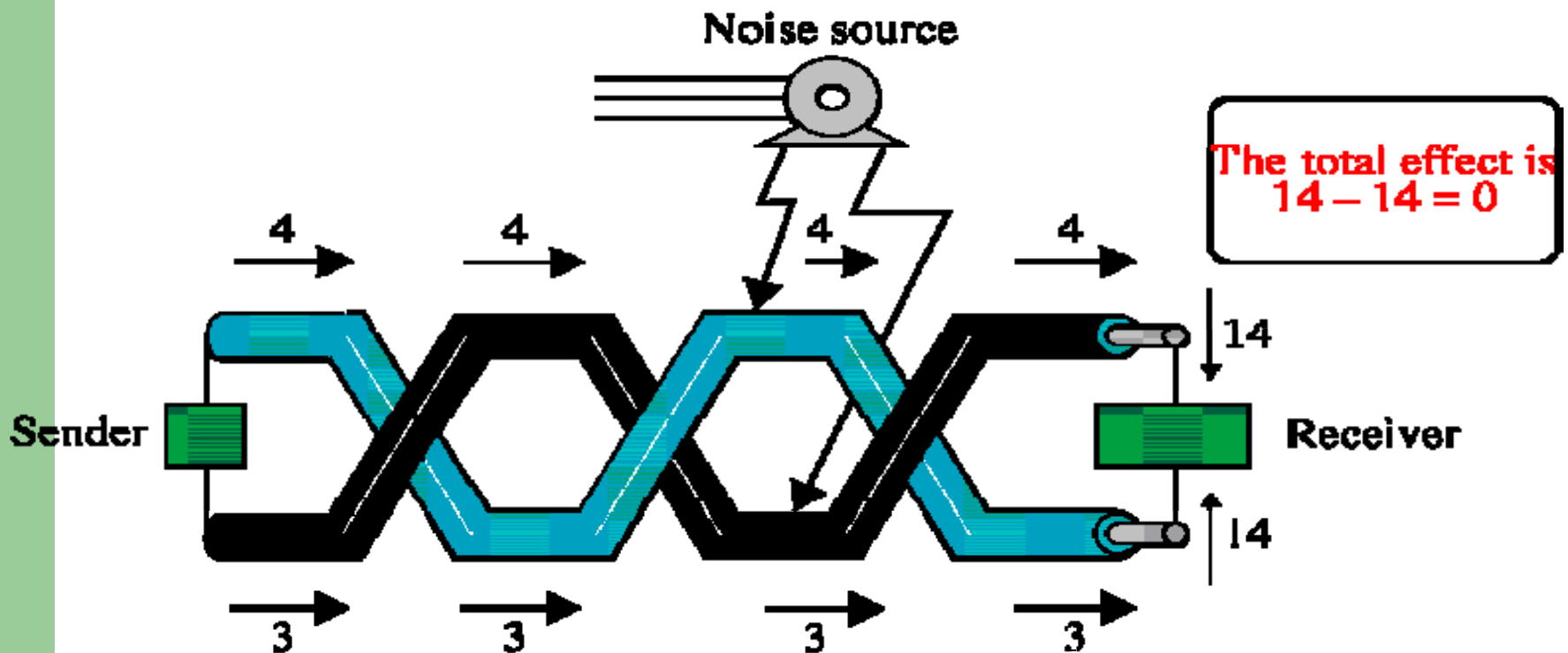
Unshielded Twisted-Pair (UTP)

- **Typically wrapped inside a plastic cover (for mechanical protection)**
- **A sample UTP cable with 5 unshielded twisted pairs of wires**

Plastic cover

Twisted pairs (5 pairs)
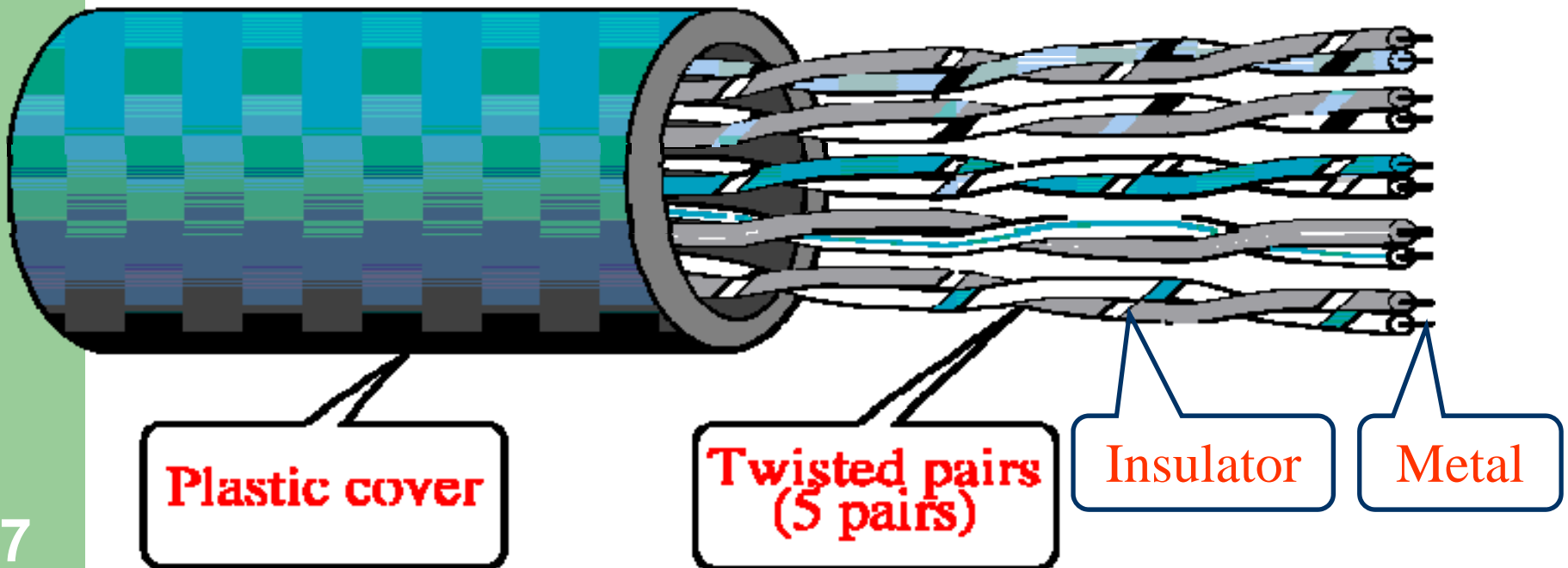
Insulator

Metal

Shielded Twisted-Pair (STP)

- **STP cables are similar to UTP cables, except there is a metal foil or braided-metal-mesh cover that encases each pair of insulated wires**

Plastic cover   Metal shield   Insulation   Copper
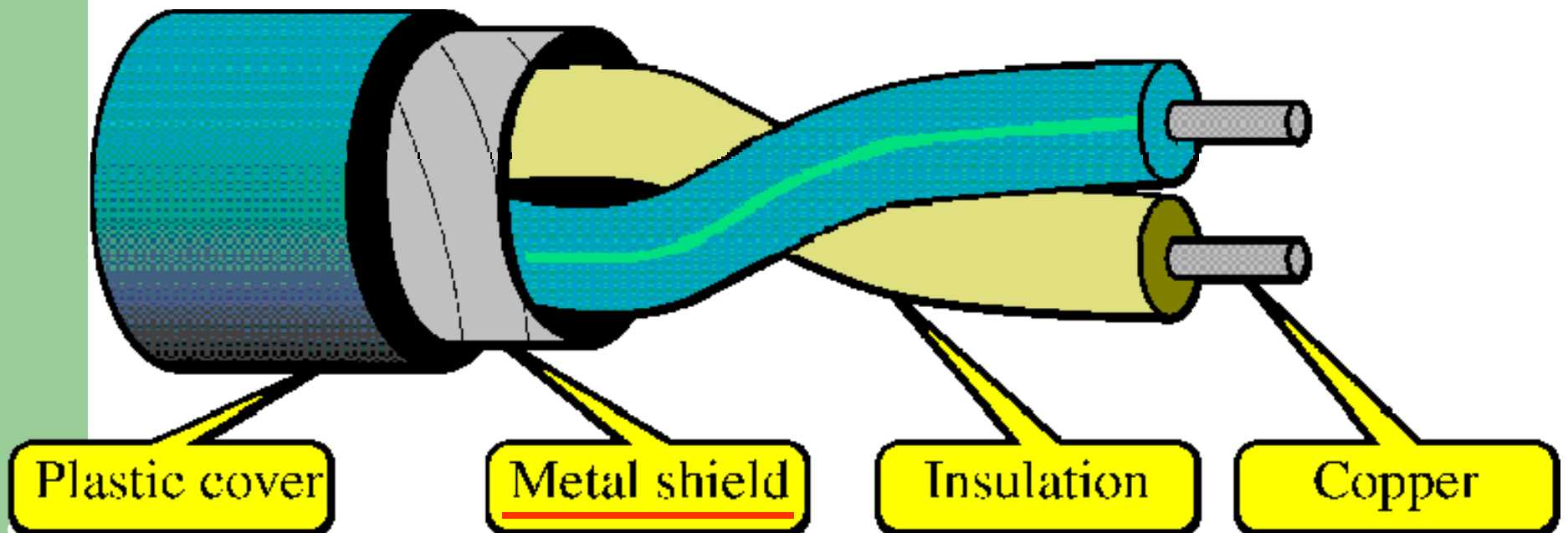
Categories of UTP Cables

EIA classifies UTP cables according to the quality:

- *Category 1* — the lowest quality, only good for voice, mainly found in very old buildings, not recommended now
- *Category 2* — good for voice and low data rates (up to 4Mbps for low-speed token ring networks)
- *Category 3* — at least 3 twists per foot, for up to 10 Mbps (common in phone networks in residential buildings)
- *Category 4* — up to 16 Mbps (mainly for token rings)
- *Category 5* (or *5e*) — up to 100 Mbps (common for networks targeted for high-speed data communications)
- *Category 6* — more twists than Cat 5, up to 1 Gbps

Coaxial Cables

- In general, <u>coaxial cables</u>, or <u>coax</u>, carry signals of higher freq (100KHz–500MHz) than UTP cables
- Outer metallic wrapping serves both as a shield against noise and as the second conductor that completes the circuit

Insulator

Plastic cover

Outer conductor (shield)

Inner conductor
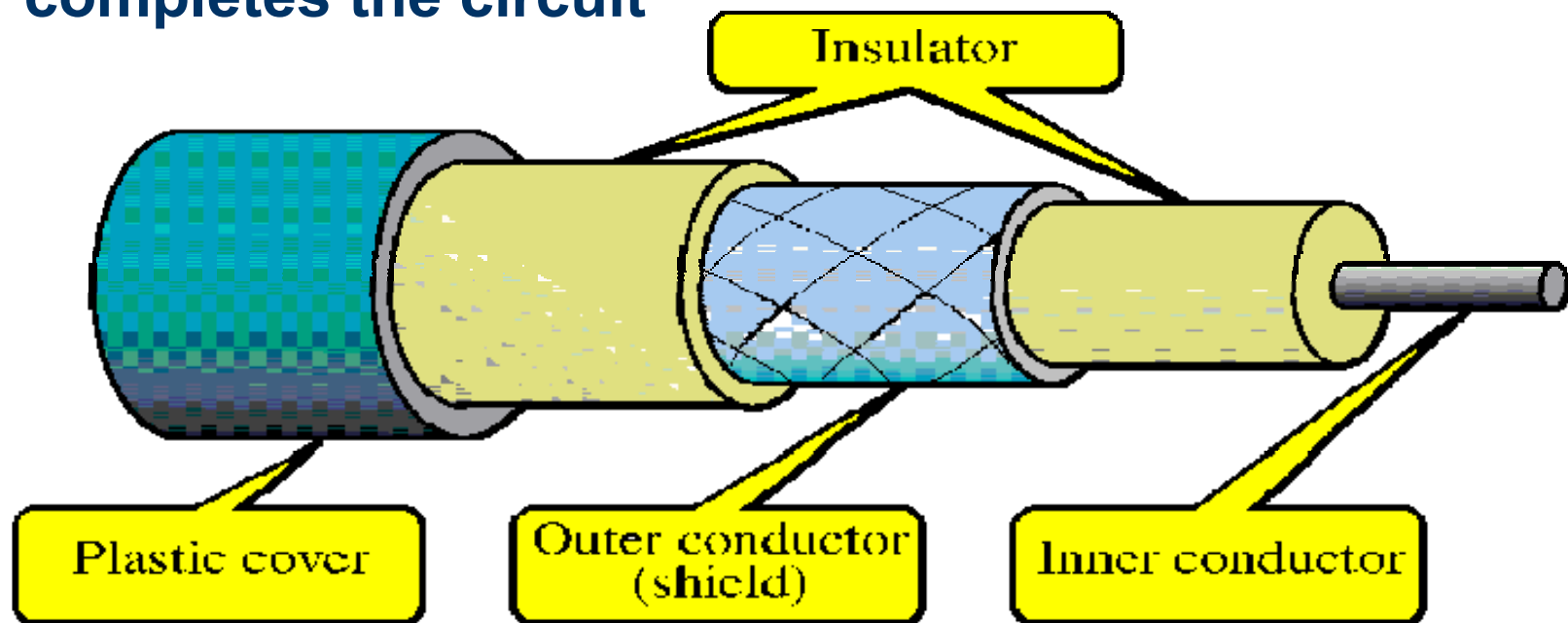
Fiber-Optic Cables

- **Light travels at $\underline{3\times10^8 \text{ ms}^{-1}}$ in free space and is the fastest possible speed in the Universe**

- **Light slows down in denser media, e.g. glass**

- **<u>Refraction</u> occurs at interface, with light bending away from the normal when it enters a less dense medium**
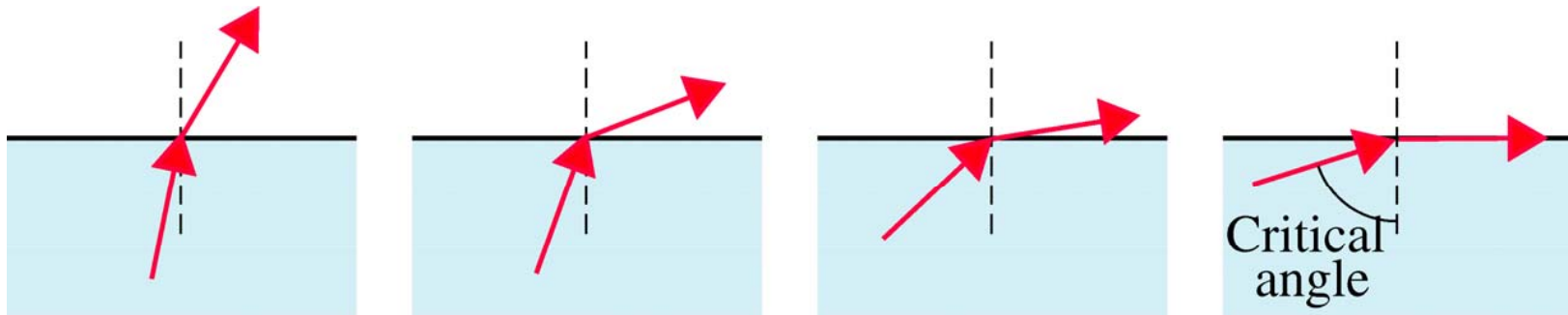
Critical angle

- **Beyond the _critical angle_ $\Rightarrow$ total internal reflection**

- An optical fiber consists of a __core__ (denser material) and a __cladding__ (less dense material)

- Simplest one is a **multimode step-index optical fiber**

- __Multimode__ = multiple paths, whereas __step-index__ = refractive index follows a step-function profile (i.e. an abrupt change of refractive index between the **core** and the **cladding**)

- Light bounces back and forth along the core

- Common light sources: LEDs and lasers

Core

Cladding
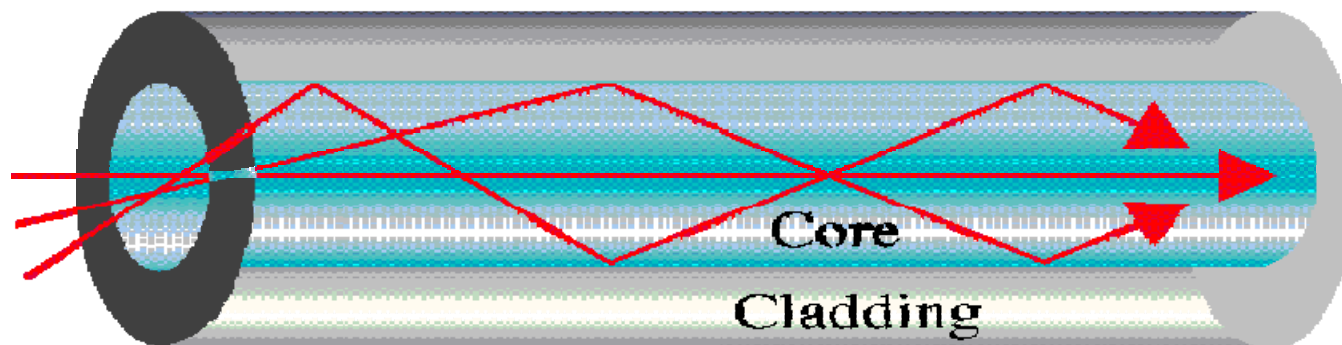
Advantages and Disadvantages

☺ Noise resistance — external light is blocked by outer jacket

☺ Less signal attenuation — a signal can run for miles without regeneration (currently, the lowest measured loss is about ~4% or 0.16dB per km)

☺ Higher bandwidth — currently, limits on data rates come from the signal generation/reception technology, not the fiber itself

☹ Cost — Optical fibers are expensive

☹ Installation/maintenance — any crack in the core will degrade the signal, and all connections must be perfectly aligned

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LAN and WAN

- **Local Area Network (LAN)**
  - **Small network, short distance**
    - **A room, a floor, a building**
    - **Limited by no. of computers and distance covered**
    - **Usually one kind of technology throughout the LAN**
    - **Serve a department within an organization**
  - **Examples:**
    - **Network inside the Student Computer Room**
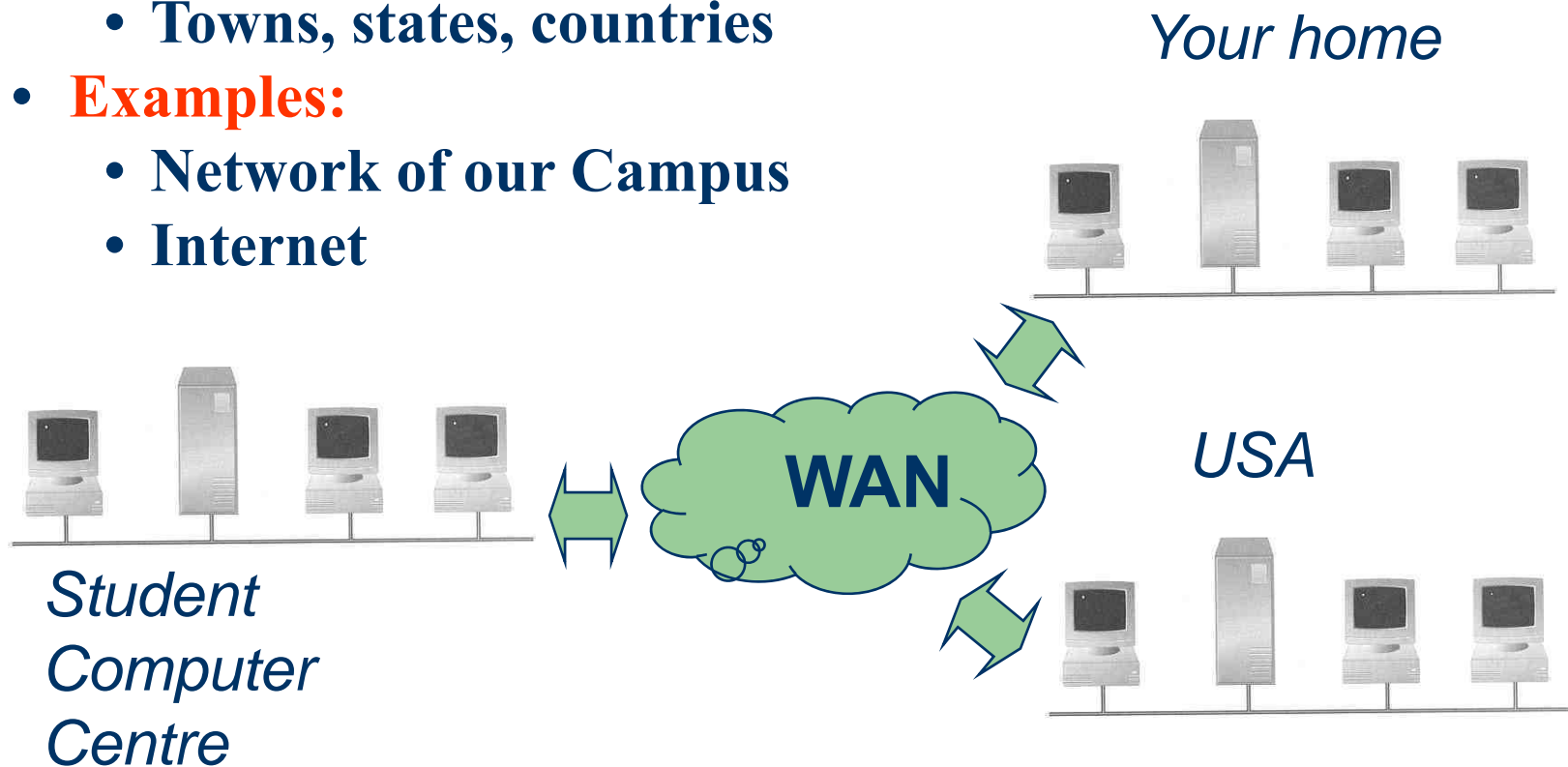   - **Network inside CF502**
    - **Network inside your home**

- **Wide Area Network (WAN)**
  - A network that uses long-range **telecommunication links** to connect 2 or more LANs/computers housed in different places far apart.
    - Towns, states, countries
  - **Examples:**
    - Network of our Campus
    - Internet

Your home

WAN
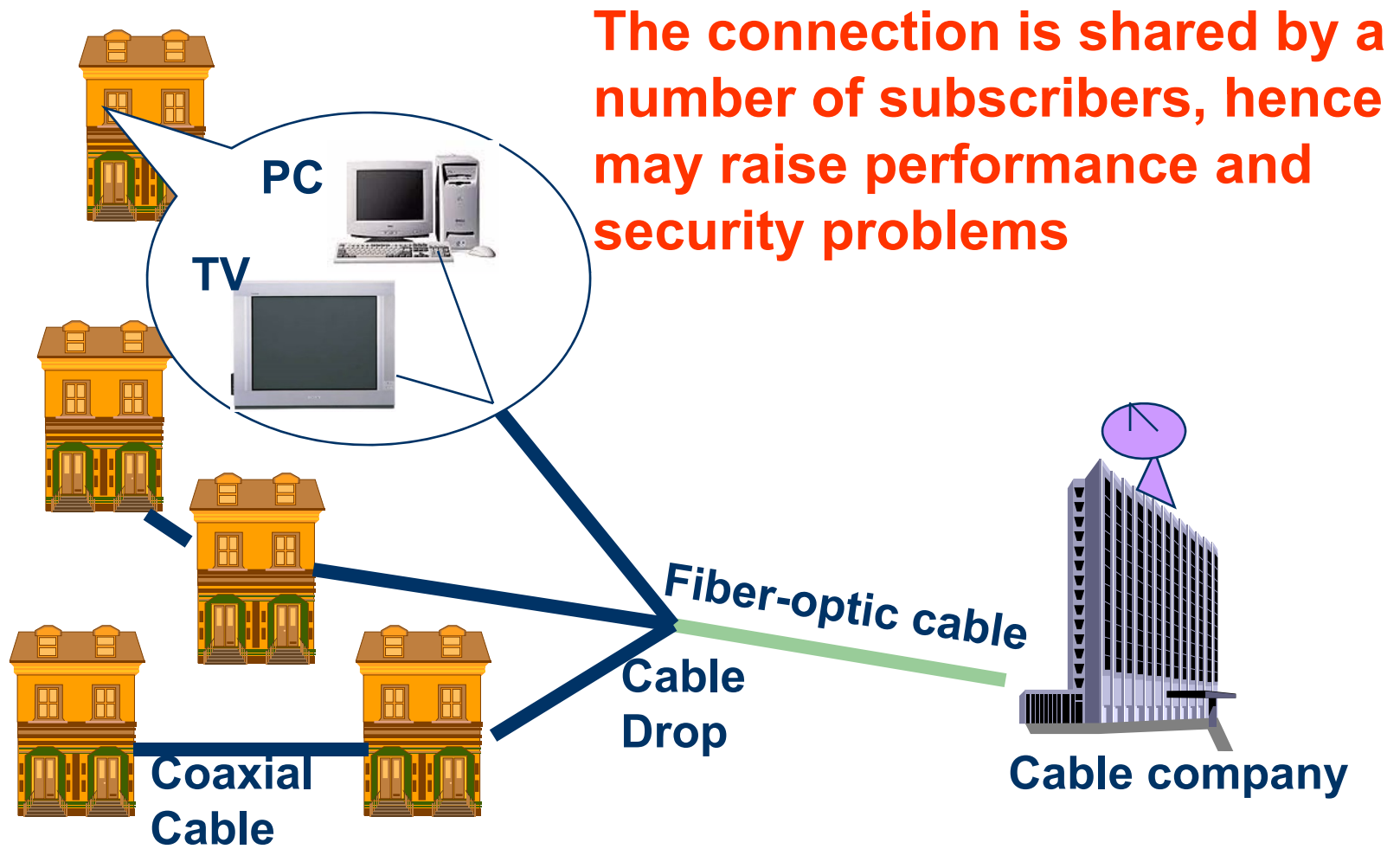
USA

Student Computer Centre

- **Example WAN technologies:**
  - **ISDN** – Integrated Service Digital Network
    - Basic rate: 192 Kbps   Primary rate: 1.544Mbps
  - **T-Carriers** — basically digital phone lines
    - T1: 1.544Mbps   T3: 28×T1
  - **Frame relay**
    - Each link offers 1.544Mbps or even higher
  - **ATM** – Asynchronous Transfer Mode
    - Support B-ISDN: 155Mbps or 622Mbps or higher
  - **SONET** – Synchronous Optical Network
    - Basic rate OC1: 51.84Mbps
    - Support OC12 and up to OC192 (9953.28Mbps) or even higher in the future

- **Example of WAN: Broadband Cable Network**

  - **Cable TV services have been extensively developed in most modern cities**

  - **Cable TV companies try to make use of their coaxial cable installed (that are supposed to carry TV signals) to deliver broadband data services**

  - **Many cable network wiring has been replaced with hybrid fiber-coax (HFC) — i.e. use of fiber-optic cable to connect to the subscribers' buildings, and then the original coaxial cable to connect to each household**

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The connection is shared by a number of subscribers, hence may raise performance and security problems

PC

TV

Fiber-optic cable

Cable Drop

Coaxial Cable

Cable company

- **Cable is an asymmetrical technology**
  - **Downstream: max 36 Mbps**
  - **Upstream: max 10 Mbps**

- **May be reduced to 3 – 10 Mbps downstream and 2 Mbps upstream, depending on no. of subscribers**

- **Need a special cable modem**

Ethernet link to PC

Teryon Cable Modem

Coaxial link from cable TV socket

Peer-to-Peer Networks

- **Peer-to-peer network is also called workgroup**
- **No hierarchy among computers $\Rightarrow$ all are equal**
- **No administrator responsible for the network**

Peer-to-peer

- **Advantages** of peer-to-peer networks:
  - Low cost
  - Simple to configure
  - User has full accessibility of the computer

- **Disadvantages** of peer-to-peer networks:
  - May have duplication in resources
  - Difficult to uphold security policy
  - Difficult to handle uneven loading

- **Where peer-to-peer network is appropriate:**
  - 10 or less users
  - No specialized services required
  - Security is not an issue
  - Only limited growth in the foreseeable future

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Clients and Servers

- **Network Clients (Workstation)**
  - Computers that request network resources or services
- **Network Servers**
  - Computers that manage and provide network resources and services to clients
    - Usually have more processing power, memory and hard disk space than clients
    - Run Network Operating System that can manage not only data, but also users, groups, security, and applications on the network
   - Servers often have a more stringent requirement on its performance and reliability

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- **Advantages of client/server networks**
  - **Facilitate resource sharing – centrally administrate and control**
  - **Facilitate system backup and improve fault tolerance**
  - **Enhance security – only administrator can have access to Server**
  - **Support more users – difficult to achieve with peer-to-peer networks**

- **Disadvantages of client/server networks**
  - **High cost for Servers**
  - **Need expert to configure the network**
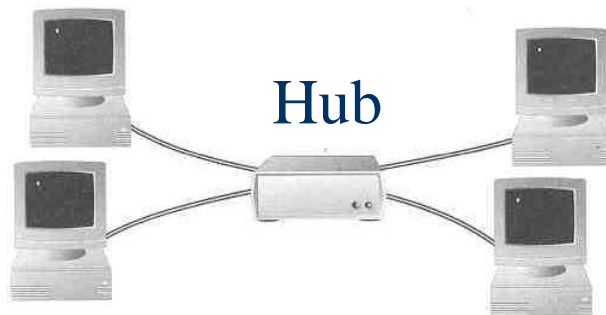 - **Introduce a single point of failure to the system**

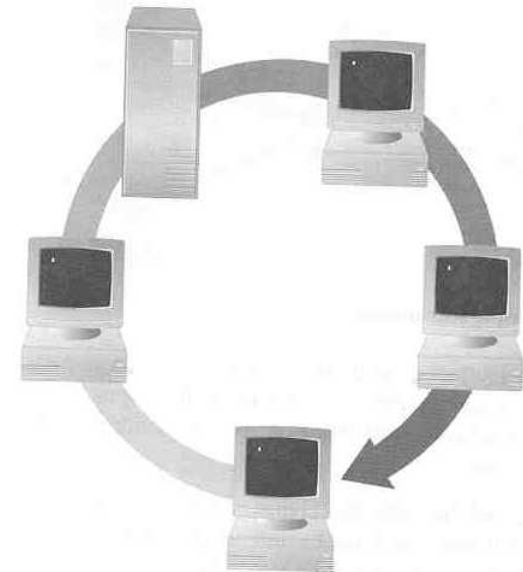# Topology — 3 basic types

- **How so many computers are connected together?**

Bus Topology

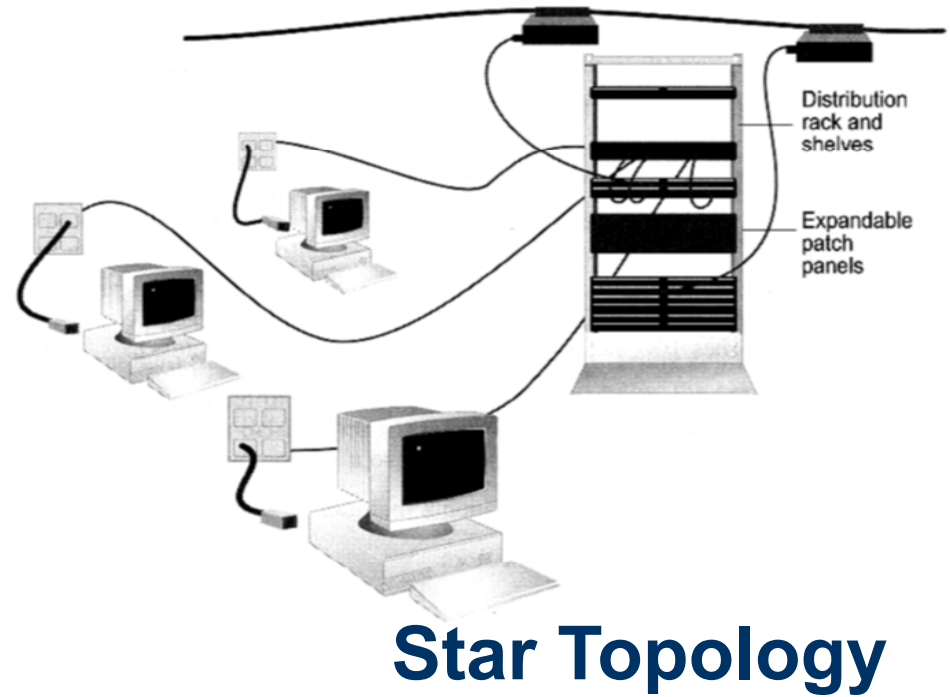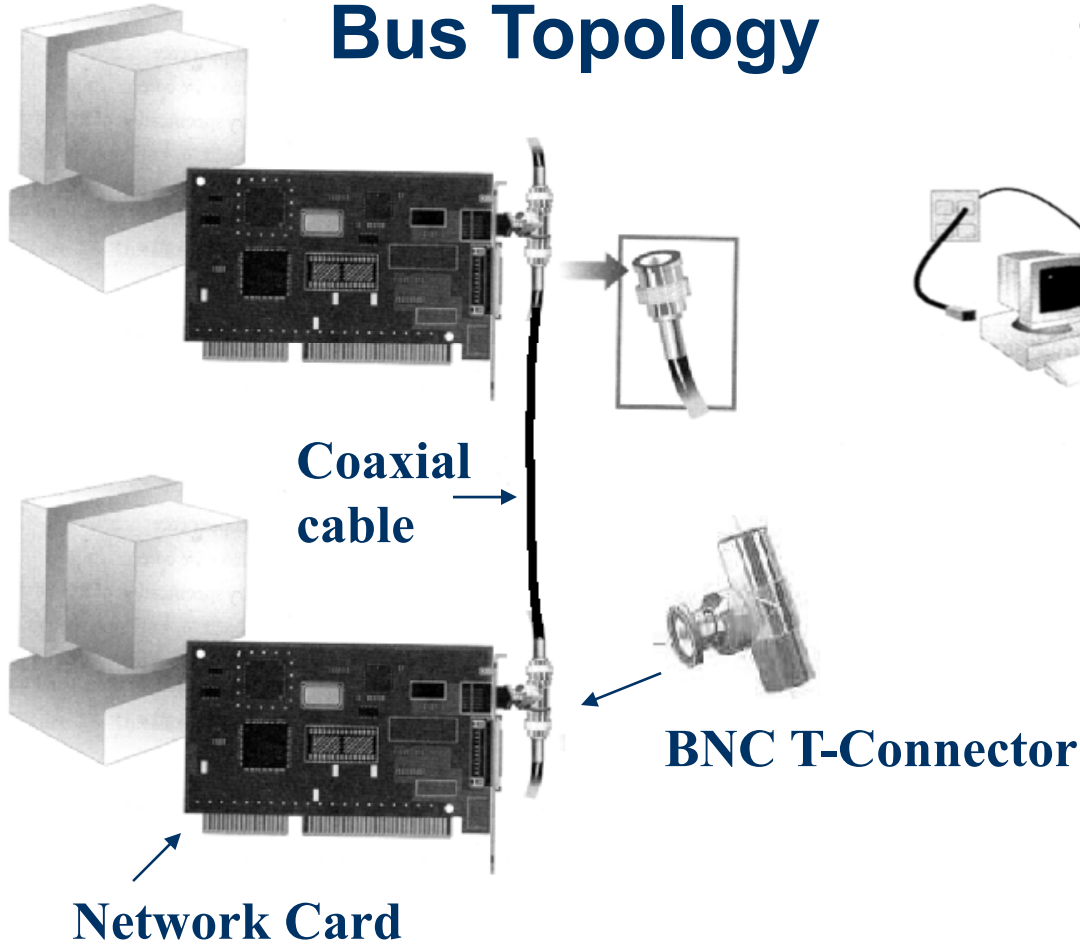### Ring Topology

Star Topology

Hub
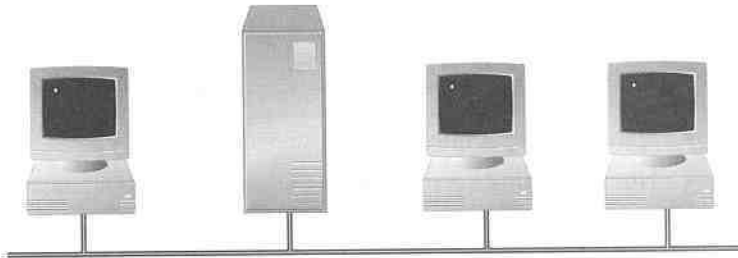
- **Bus Topology**
  - Simple and low-cost
  - A single cable called a **trunk** (**backbone**, **segment**)
  - Only one computer can send messages at a time
  - Passive topology - computer only listen for, not regenerate data

- **Star Topology**
  - Each computer has a cable connected to a single point
  - More cabling, hence **higher cost**
  - All signals transmission through the hub; **if down, entire network down**
  - Depending on the intelligence of hub, two or more computers may send message at the same time

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How to construct a network with Bus / Star Topology?

Bus Topology

Coaxial cable

BNC T-Connector

Network Card

Distribution rack and shelves

Expandable patch panels

Star Topology

- ## Ring Topology
  - **Every computer serves as a repeater to boost signals**
  - **Typical way to send data:**
    - **Token passing**
      - **only the computer who gets the token can send data**
  - **Disadvantages**
    - **Difficult to add computers**
    - **More expensive**
    - **If one computer fails, whole network fails**

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