

5. Introduction to Networking



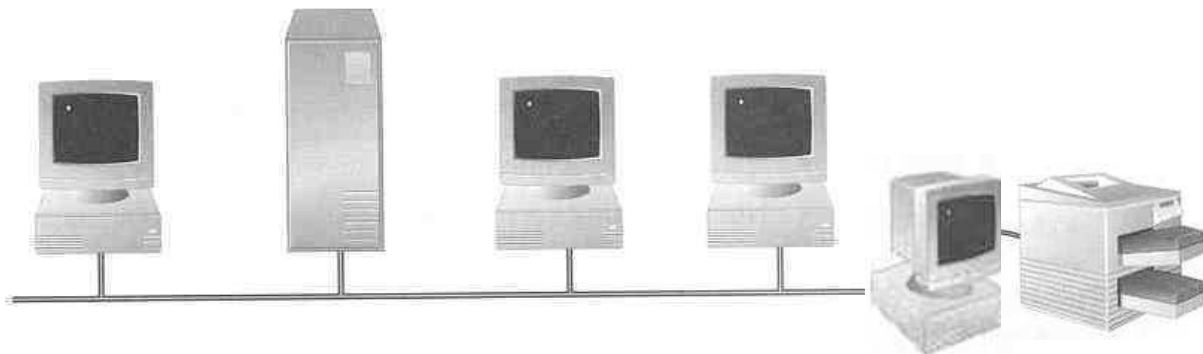
References

- Held G., “*Internetworking LANs and WANs – Concepts, Techniques and Methods*”, Wiley, 2nd Ed., 1998
 - **Comment: Good at concepts**
- Stallings W., “*Data and Computer Communications*”, Prentice Hall, 7th Ed., 2004
 - **Comment: Good at concepts and very up-to-date**
- Forouzan B. A, “*Data Communications and Networking*”, McGraw-Hill, 2nd Ed., 2000
 - **Comment: Many good revision questions at ends of chapters**
- Redmond W., “*MCSE Training Kit: Networking Essentials Plus*”, Microsoft Press, 2000
 - **Comment: Practical oriented**



What is a Network?

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





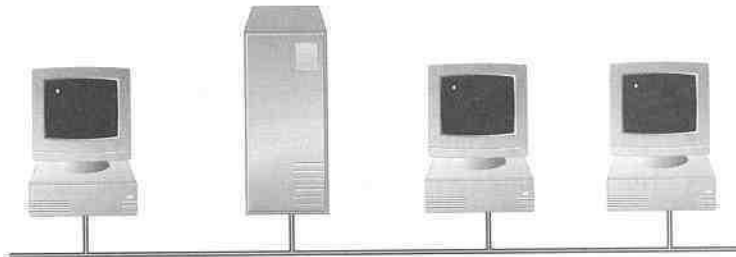
Why Networking?

- Sharing information — i.e. data communication

- Do you prefer these?



- Or this?





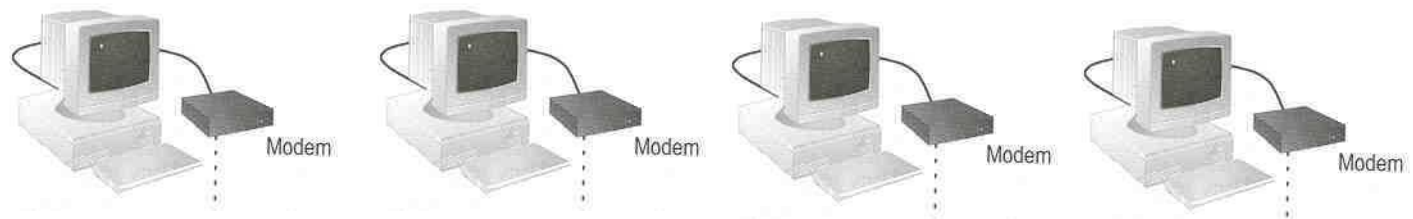
- **Sharing hardware or software**

- **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 ...
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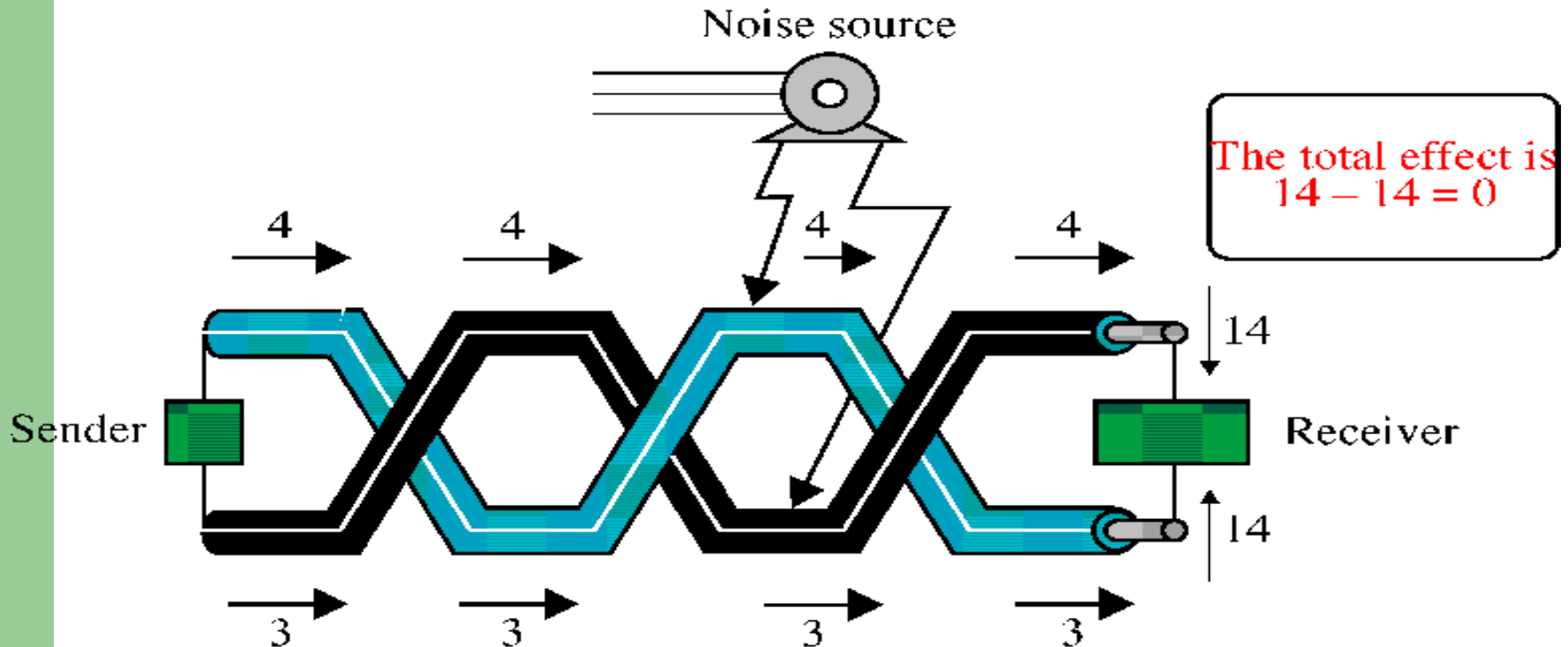
Transmission Media

- **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**



Twisted-Pair Cables

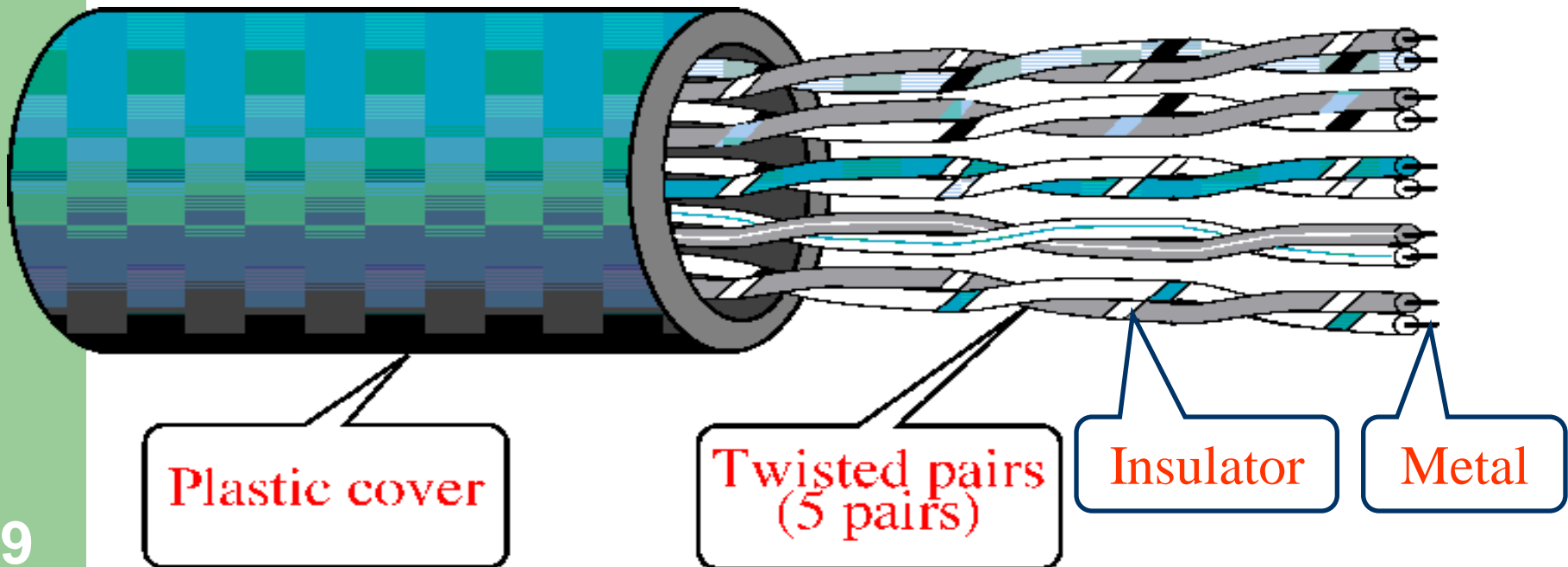
- If the pair of wires are not twisted, electromagnetic noises from, e.g., motors, will affect the closer wire more than the further one, thereby causing errors





Unshielded Twisted-Pair (UTP)

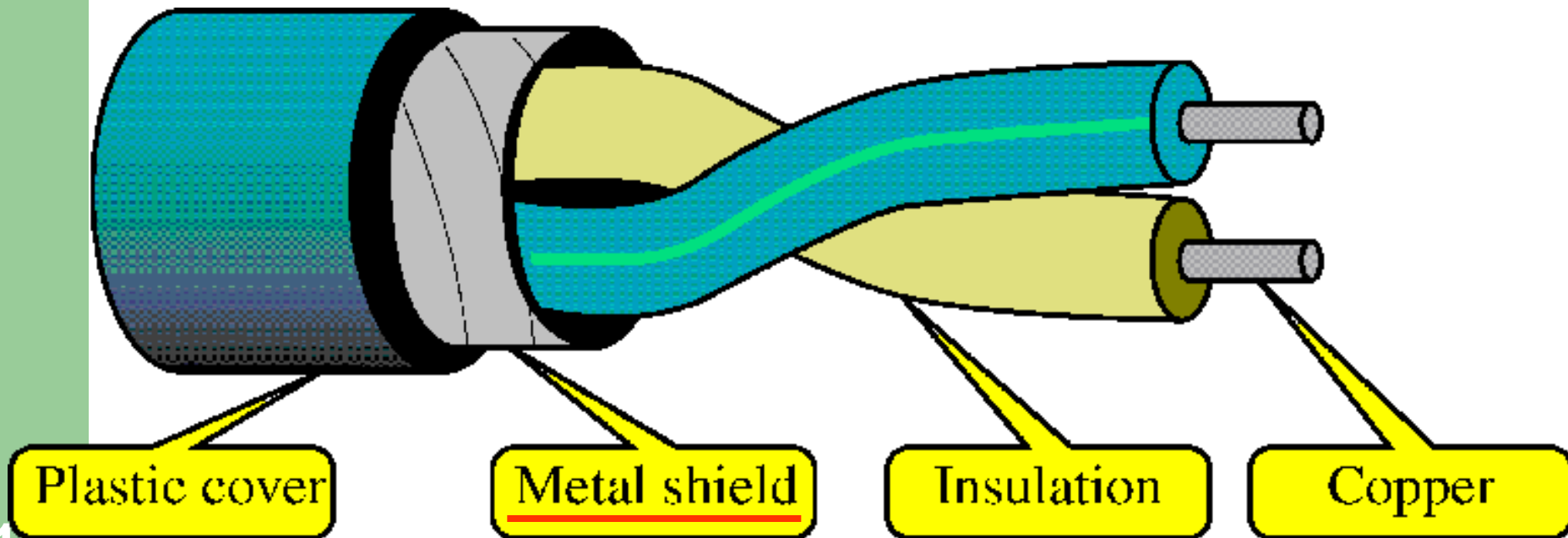
- Typically wrapped inside a plastic cover (for mechanical protection)
- A sample UTP cable with 5 unshielded twisted pairs of wires





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





Categories of UTP Cables

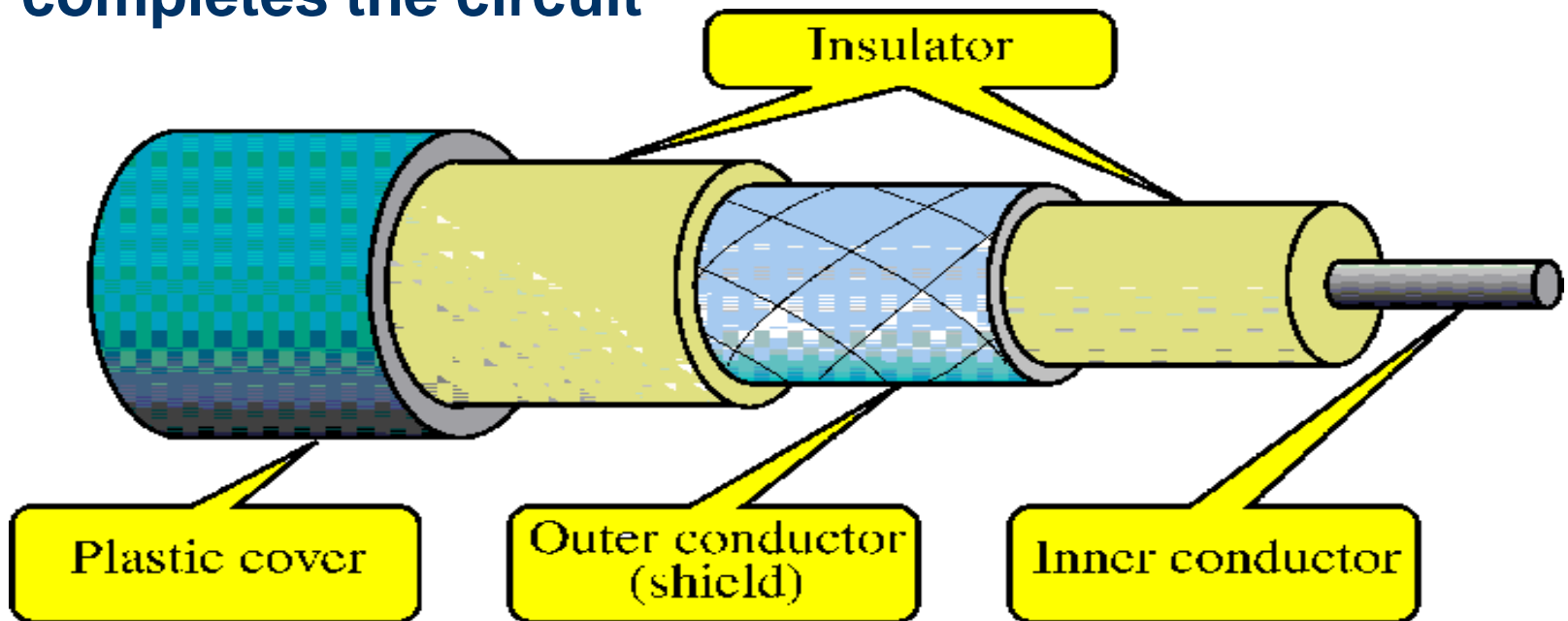
EIA classifies UTP cables according to the quality:

- *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

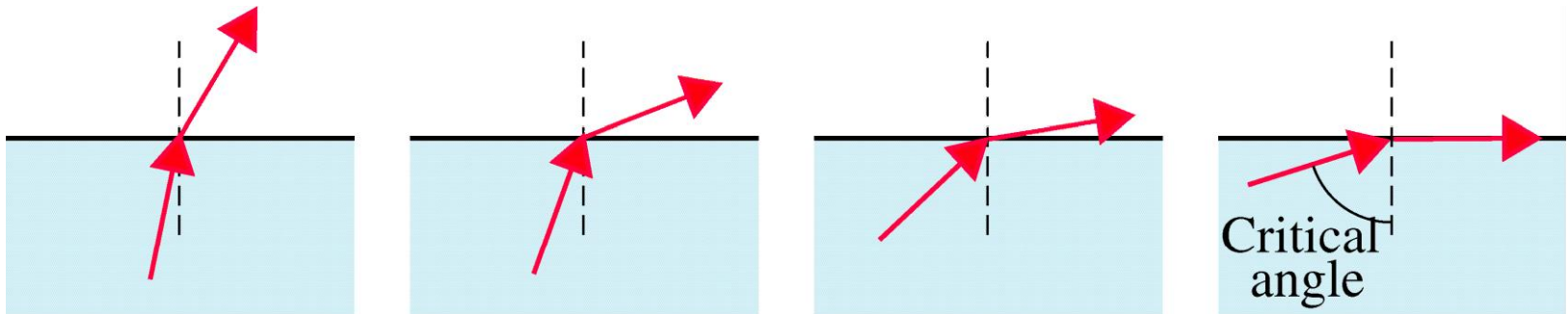
- In general, coaxial cables, or coax, carry signals of higher freq (100KHz–500MHz) than UTP cables
- Outer metallic wrapping serves both as a shield against noise and as the second conductor that completes the circuit





Fiber-Optic Cables

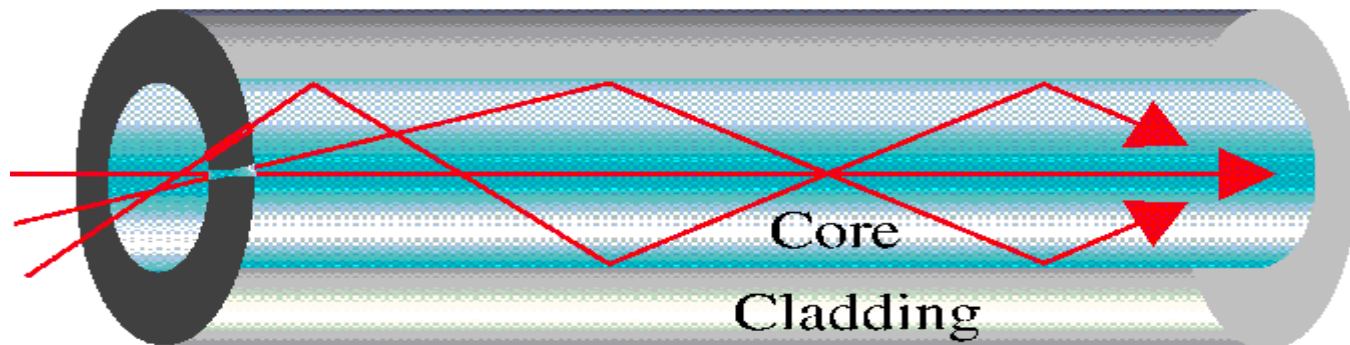
- Light travels at $3 \times 10^8 \text{ ms}^{-1}$ in free space and is the fastest possible speed in the Universe
- Light slows down in denser media, e.g. glass
- Refraction occurs at interface, with light bending away from the normal when it enters a less dense medium



- 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





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



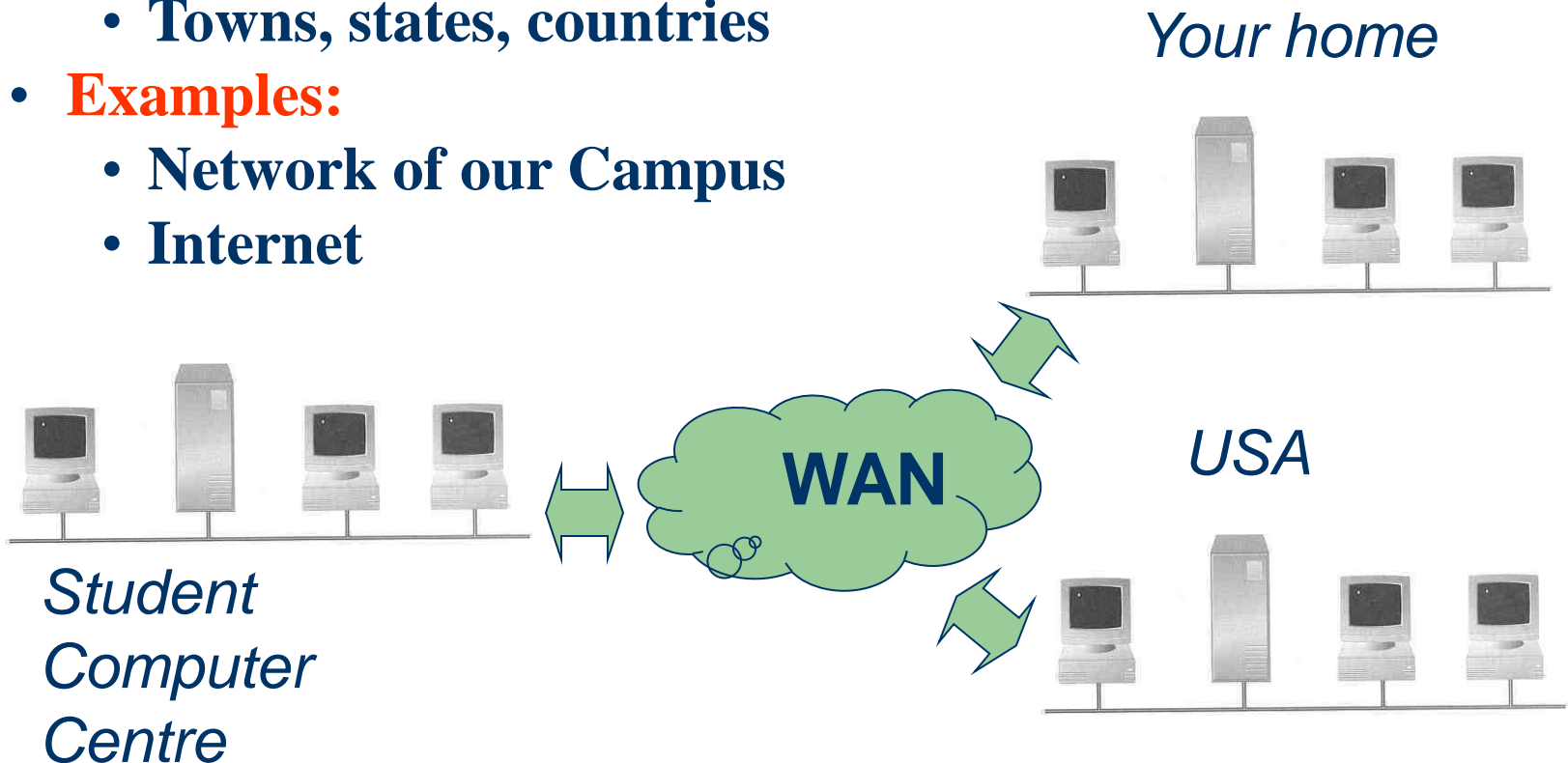
LAN and WAN

- **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





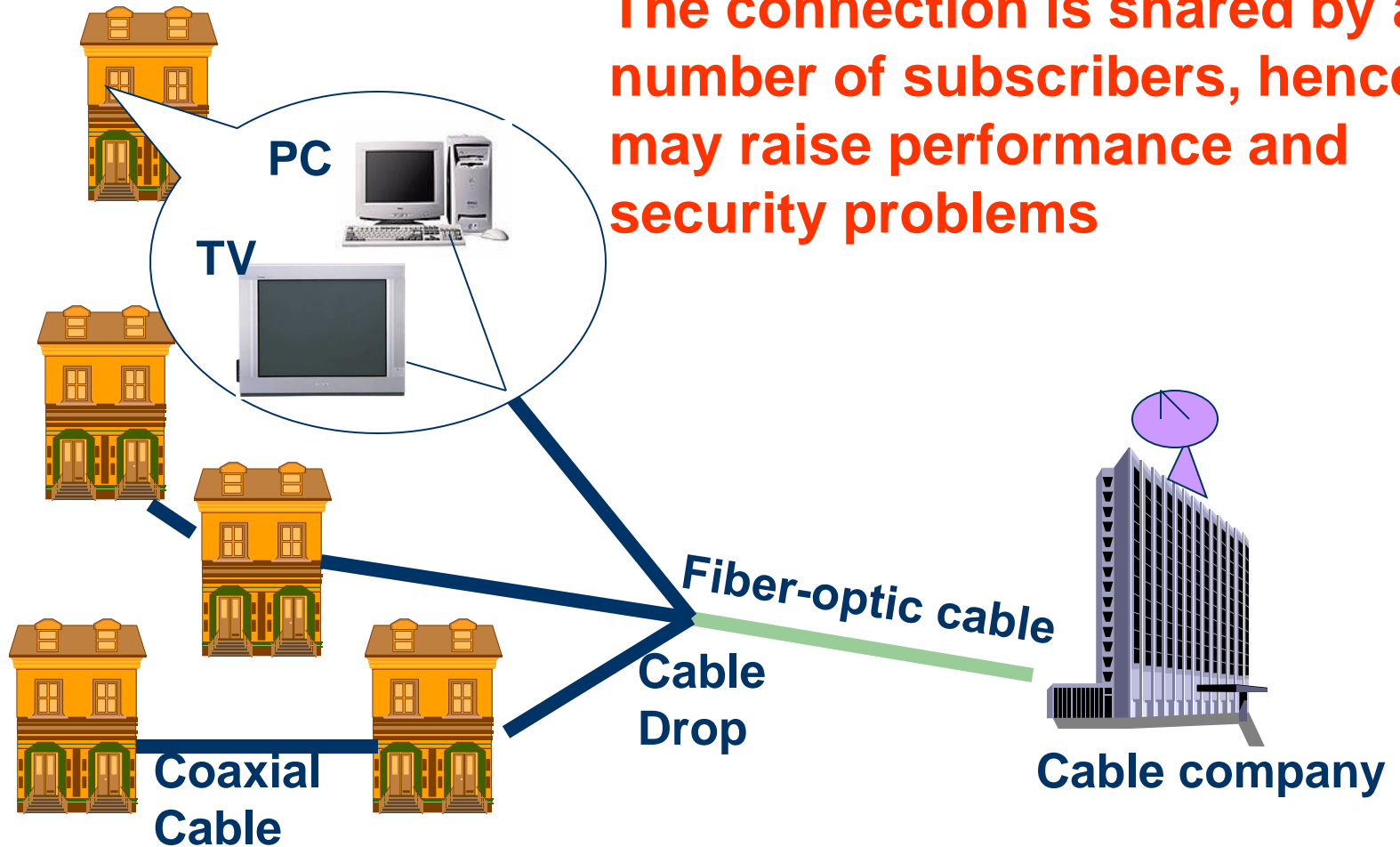
- **Example WAN technologies:**
 - **ISDN** – Integrated Service Digital Network
 - Basic rate: 192 Kbps Primary rate: 1.544Mbps
 - **T-Carriers** — basically digital phone lines
 - T1: 1.544Mbps T3: 28×T1
 - **Frame relay**
 - Each link offers 1.544Mbps or even higher
 - **ATM** – Asynchronous Transfer 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



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





5. Introduction to Networking

- 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**



Terayon Cable Modem



Ethernet link to PC

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





- **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



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**



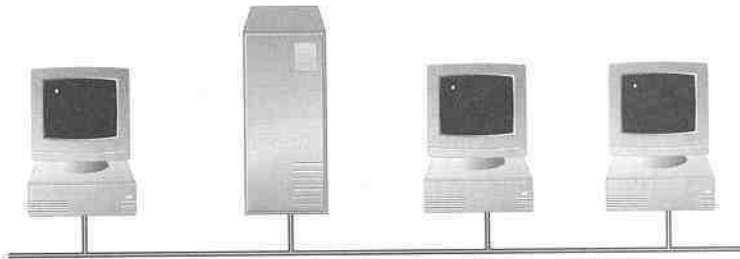
- **Advantages of client/server networks**
 - Facilitate resource sharing – centrally administrate and control
 - Facilitate system backup and improve fault tolerance
 - Enhance security – only administrator can have access to Server
 - Support more users – difficult to achieve with peer-to-peer networks
- **Disadvantages of client/server networks**
 - High cost for Servers
 - Need expert to configure the network
 - Introduce a single point of failure to the system



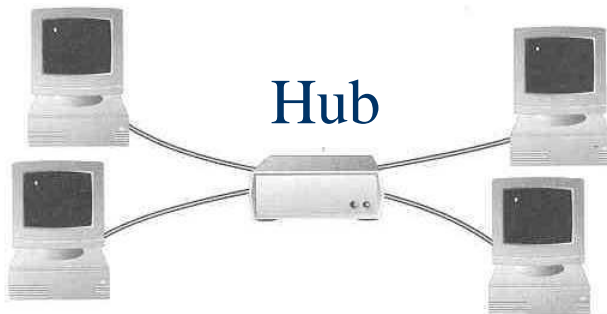
Topology — 3 basic types

- How so many computers are connected together?

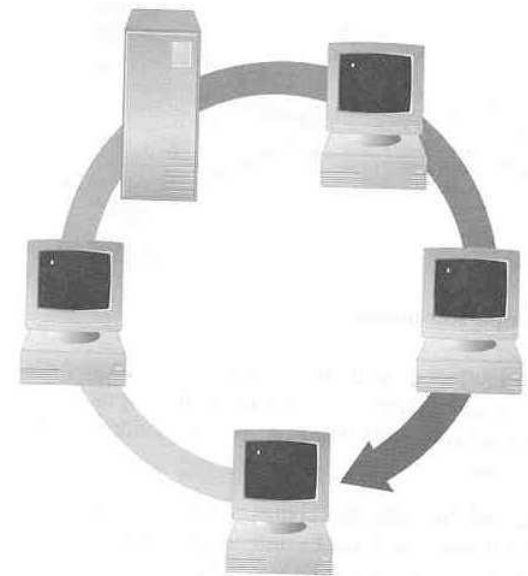
Bus Topology



Star Topology



Ring Topology



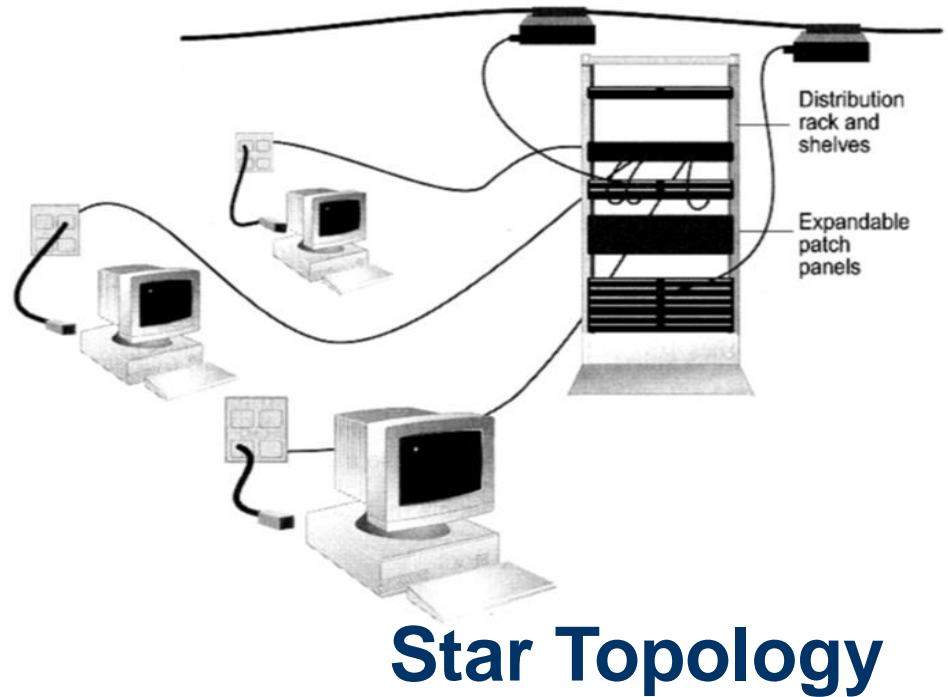
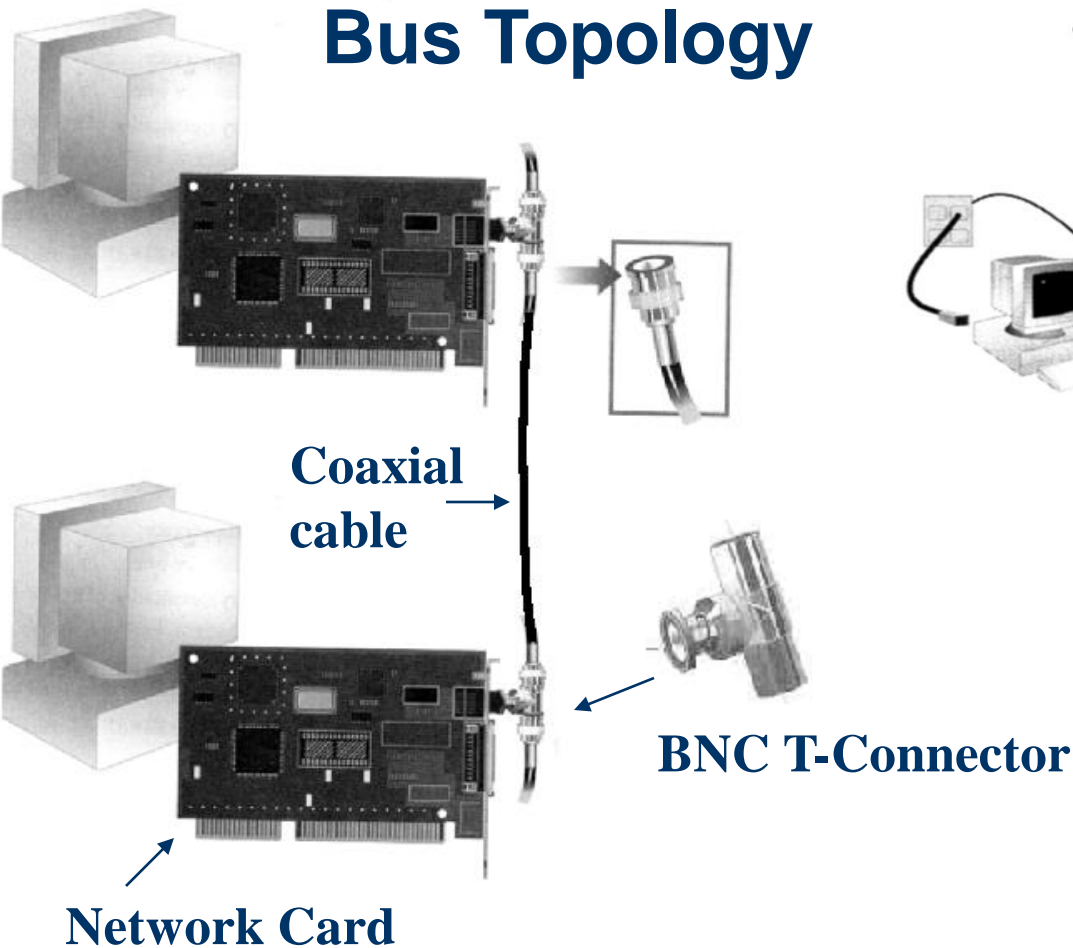


- **Bus Topology**
 - Simple and low-cost
 - A single cable called a **trunk (backbone, segment)**
 - Only one computer can send messages at a time
 - Passive topology - computer only listen for, not regenerate data
- **Star Topology**
 - Each computer has a cable connected to a single point
 - More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



How to construct a network with Bus / Star Topology?

Bus 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

