# I. What is a network?

A collection of devices (e.g. computers) that use a common communication scheme (protocol) to share resources with each other over a physical medium.

What are the minimum requirements to have a network?

Informally:

- more than one device, i.e. computers, printers, storage device
- physical medium (and a connection from the medium to the device)
- controlling software
- ability to communicate and understand

Formally:
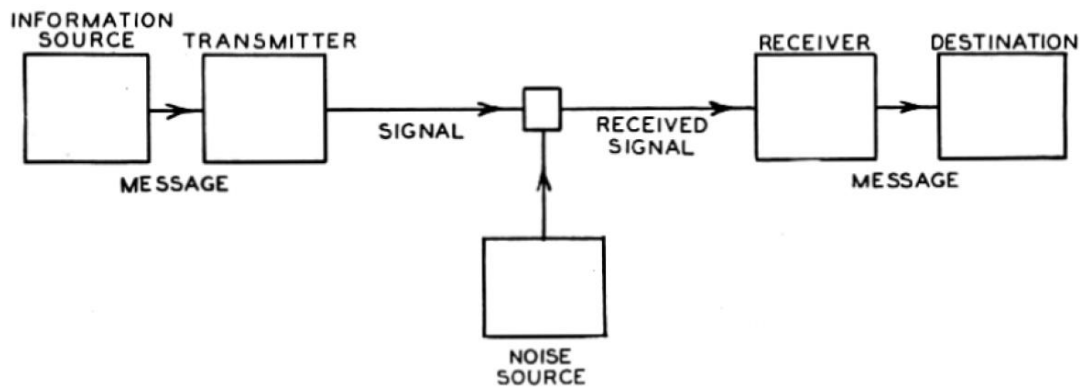
from Mathematical Theory of Communication, by Claude Shannon, 1949

- information source selects a desired message, from a set of possible messages
- transmitter changes the message into a signal which is then sent over a communication channel
- the receiver changes the signal back into a message
- the message is then passed along to the destination
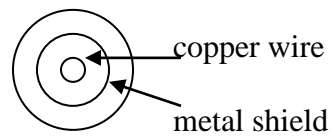
II. Transmission Media

1. Copper

    a) twisted pair

- twisting reduces electro-magnetic interference (EMI)
- also called unshielded twisted pair (UTP)
- standards currently: category 5/5e/6, pronounced cat 5

    b) coaxial

- uses shielding to reduce EMI

copper wire

metal shield

2. Fiber Optic

- uses glass or plastic
- no EMI, since uses light instead of electricity
- faster/longer distance, > data than copper, but > $$$$

3. Wireless

- uses Radio Frequency (RF), or Infrared (IR), or Microwave
- low bandwidth/slow(er)
- somewhat less secure

III. Protocols

allows establishment of a common language to communicate
typically defined in a **<u>layered</u>** hierarchy, referred to as a suite or a stack
allows interoperability between hardware vendors

examples:

- TCP/IP
- HTTP
- FTP
- IMAP
- POP
- SMTP

IV. Standards & Standards Organizations

1. Industry, Trade and Professional

   - EIA/TIA – Electronic/Telecommunications Industries Assoc.
   - IEEE – Institute for Electrical and Electronics Engineers
   - IETF – Internet Engineering Task Force (responsible for RFC management)

2. National

   - ANSI – American National Standards Institute

3. International

   - ISO - International Standards Organization
   - ITU - International Telecommunication Union (specifically ITU-T, formally CCITT)

4. Standards Management

   - standards documented and managed by RFC's (Requests for Comments)

V. Network Taxonomies (based upon geography)

1. **LAN** – Local Area Network

    typically located within a single building site
    typically controlled by a single organization (business)
    typically < 10 km in radius

2. **WAN** – Wide Area Network

    - larger area than a LAN, typically across buildings/organizations

3. **SAN** – Storage Area Network

4. **MAN** – Metropolitan Area Network

5. **PAN** - Personal Area Network - network around the home (also called HLAN)

6. **GAN** - Global Area Network

VI. Network Topologies

Physical topology defines the cable's actual physical configuration (star, bus, mesh, ring, cellular, hybrid)

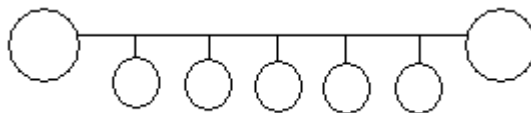**Logical topology** defines the network path that a signal follows (ring or bus)

a network's logical topology is not necessarily the same as its physical topology
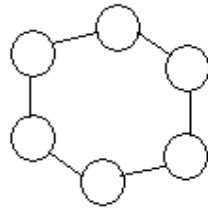
1. Point-to-Point

    - a point-to-point network consists of nodes that can only communicate with physically adjacent nodes/stations

2. Broadcast topologies
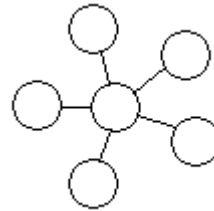
    a. bus

b. ring   c. star

With broadcast topologies,

- all broadcast networks share a single media channel
- data sent is received (seen) by **all** nodes on the channel

- how then does the destination node know the data is for them?

  addressing

Each node examines the <u>destination</u> address of the data…if the destination address is theirs, they process the data, otherwise, it is discarded (dropped)

- with multiple hosts sharing channel, this introduces the concept of **<u>contention</u>** – contend for use of the single channel at the same time.

Note: differing topologies and/or protocols will handle contention in differing manners

<u>Broadcast address types:</u>

1. unicast – single destination

2. multicast – multiple destinations (but not everyone)

3. broadcast – all nodes on (local) network

VII. Switched Networks

1. Circuit Switched

   - prior to any data transmission takes place, a dedicated physical circuit between source and destination nodes must be established

   - this circuit remains in place for the duration of the connection (even if no data transmission is taking place)

   - public telephone system works this way (POTS – plain old telephone service)

2. Packet Switched

   - concept pioneered by Paul Baran circa 1960

   - term "packet" created by Donald Davies

   - data is divided into smaller units/pieces called "packets"

   - data packets transmitted to destination node via intermediate "switches"

     a. <u>virtual circuit</u> packet switching – each data packet follows same "logical" (but non-dedicated) path

     b. <u>datagram</u> packet switching – each packet is transmitted independently of other packets

VIII. Reliability

   - Quality of Service (QoS)

   - data integrity: data received = data sent?

   - error detection
     - parity checking
     - CRC

   - error correction
     - retransmission ←———————— Note the cost of these
     - redundancy

IX. Protocol Reference Models

- provides a detailed set of standards for describing a network

- formally defines the concept of a <u>layered</u> network

- layered approach allows the functions & services of one layer to be completely independent from other layers, i.e. **transparent** & **encapsulated**

- new technologies from one layer can be added without affecting other layers

1. **<u>OSI</u>** (Open Systems Interconnection) Model by ISO

2. **<u>TCP/IP</u>**

   See pictures & handouts

   <u>Layer terminology</u>:

   Application: message
   Transport: message
   Network: packet or datagram
   Data Link: frame
   Physical: pure bits

   Layers provide different service types:

   1. Connection Oriented Service

      - connection established prior to data transfer
      - connection remains for length of session
      - pros: guarantees sequential delivery of data
      - cons: wastes bandwidth

   2. Connection-less Service

      - no connection established prior to data transfer
      - can be **reliable** (i.e. uses acknowledgements)
      - can be **un-reliable**