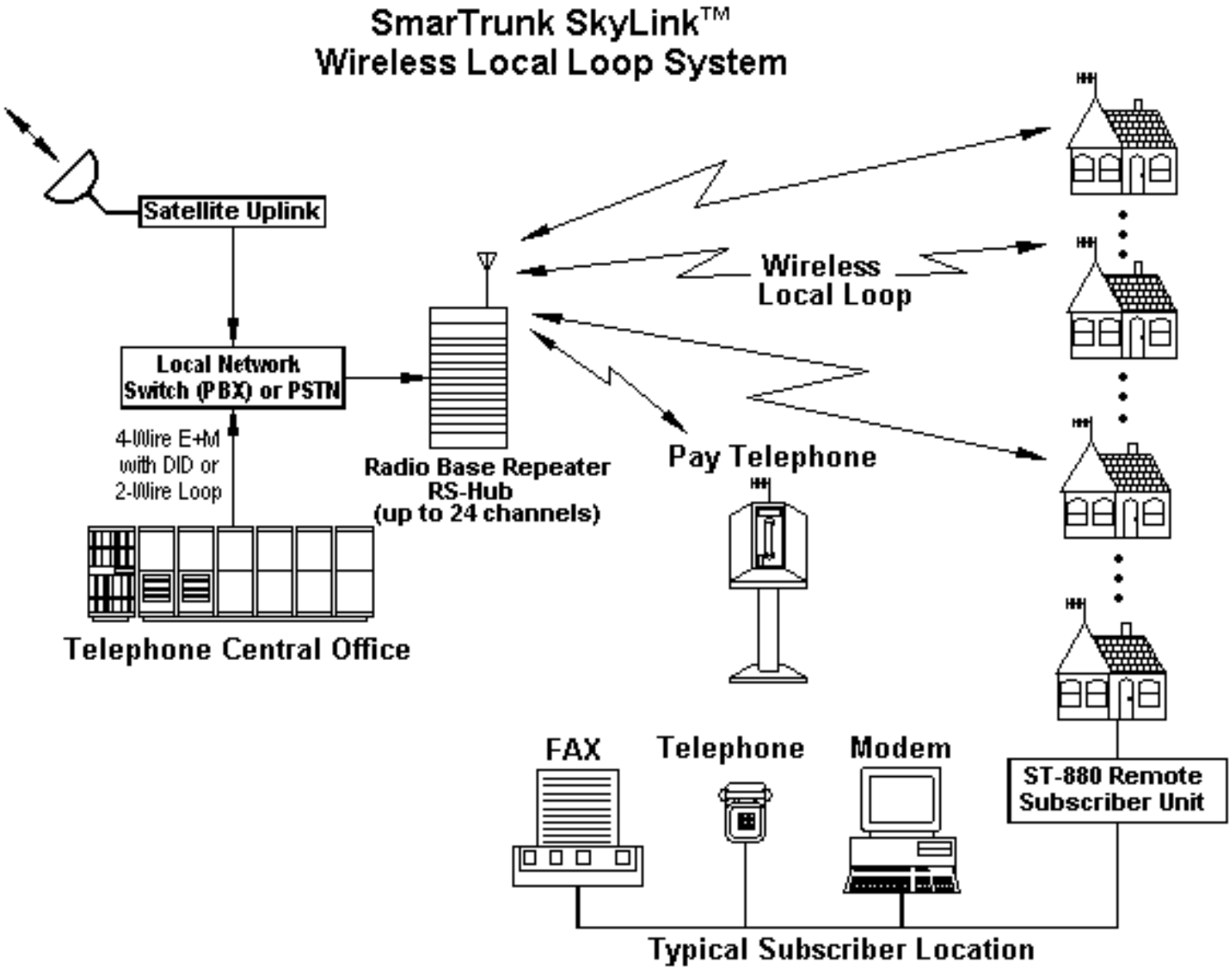
Wireless Local Loop

- What is WLL?

  - **WLL is a system that connects subscriber to the local telephone station wirelessly.**
- Systems WLL is based on:
  - Cellular
  - Satellite (specific and adjunct)
  - Microcellular
- Other names
  - Radio In The Loop (RITL)
  - Fixed-Radio Access (FRA).

A general WLL setup



WLL services

- Desirable:
  - Wireless feature should be transparent
  - Wireline Custom features
- Other:
  - Business related
    - Hunt groups,
    - Call transfers
    - Conference calling
  - Calling cards, coin phones
  - V.29 (9600bps)(MODEM)
  - ISDN (64kbps)(Integrated Services Digital Network)

WLL should provide…

- Toll-quality service
- Expand from a central office to about 8 kms
- Low license cost
- Subscriber costs equivalent or better than copper

Ideas for the market

- Supplement Copper Lines
  - Easier third telephone line
  - Data service
- Fixed Mobile Users
  - Take phone wherever you want / charged on 2 levels
  - “home” could mean neighborhood
  - Charged regular mobile rate if you’re on the road

Situations “made” for WLL

- Environments where 3rd line is degraded might be cheaper to go wireless
- Where it’s impossible to lay copper (3rd world, small islands)
- Business parks, industrial areas
- Speedy deployment, stop gap application till wireline is in
  - 90-120 days for activation

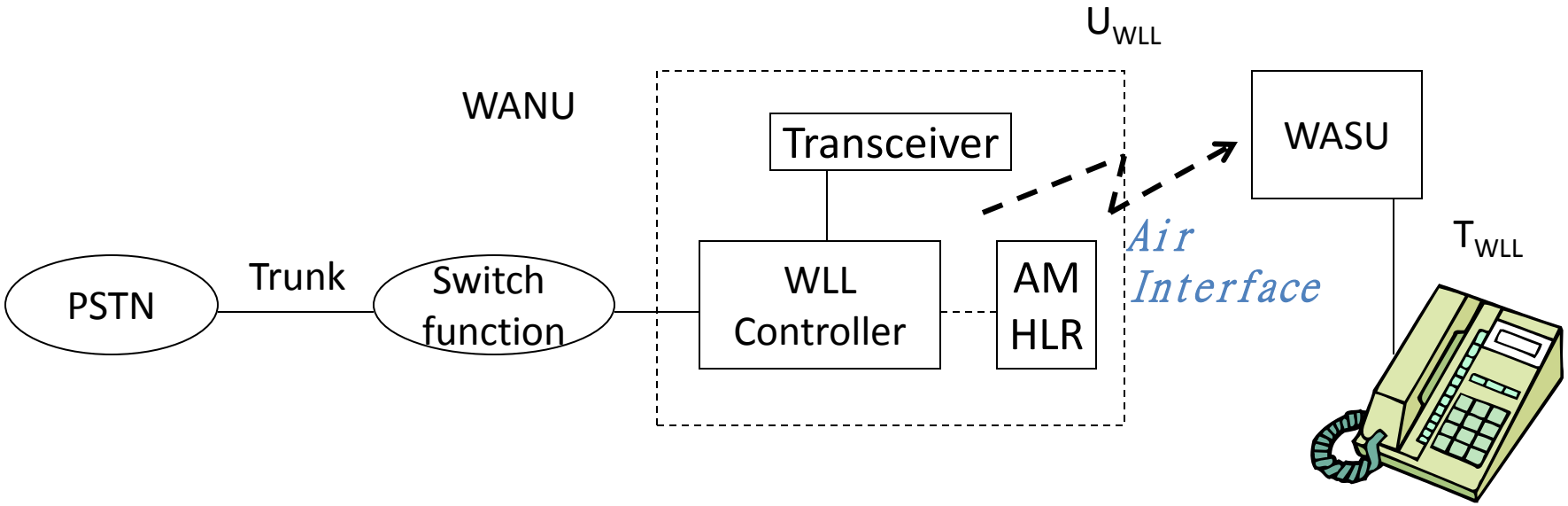
Developed vs. Developing

- Developed: Wireline service
  - Firmly established, cellular penetration is relatively high
  - Incumbent operator would use it to install 2nd, 3rd lines, coverage to rural areas
  - 2nd or 3rd competitive operator deploy it for fast & cost effective deployment
  - Quick way to establish market presence
  - cellular complement to their offerings

Developed vs. Developing

- Developing
  - Quick & easy to deploy in countries with little copper line service, so as to accommodate people on enormous waiting lists for basic service
  - Low maintenance costs
  - Allows more competition in provider market

Connection Setup



Wireless Access Network Unit(WANU)

- Interface between underlying telephone network and wireless link
- consists of
  - Base Station Transceivers (BTS)
  - Radio Controller(RPCU)
  - Access Manager(AM)
  - Home Location Register(HLR)

Wireless Access Subscriber Unit(WASU)

- **located at the subscriber**
- **translates wireless link into a traditional telephone connection**

Important Results of Fixed to Fixed Propagation in WLLs

- Signal channel is not a Rayleigh fading channel:
  - Power control algorithms are simpler and can be utilized more effectively
- Channel Randomness is lost:
  - Makes analysis difficult
- Pathloss exponent is considerably smaller (Why?):
  - 20dB/dec compared to 40dB/dec
  - Decreases cell capacity
  - Allows for larger coverage area

In-Cell Interference (CDMA)

- $I = (N_h - 1)\alpha S \approx N_h \alpha S$

  $\alpha =$ voice activity factor

  N_h = total # of houses

  S = power received at cell site from every house

Out-of-Cell Interference

- Pathloss: 20dB as opposed to 40dB/dec

  $\Rightarrow$ need to take in account more tiers
- Only from house whose antennas are directed at the center cell base station

Capacity comparison

for 5 MHz spectrum allocation

Detail	IS-95 CDMA		IS-136 TDMA		ETSI (GSM)	
	Mobile	WLL	Mobile	WLL	Mobile	WLL
Chan. BW (kHz)	1250	1250	30	30	200	200
# channels	4	4	167	167	25	25
E_b/N_0	7 dB	6dB	18dB	14dB	12dB	12dB
Freq. Reuse	1	1	7	4	3	3
Effective Chan. Per sect.	4	4	7.95	13.92	2.78	2.78
Erlangs per cell Per MHz	38.3	48.7	9.84	19.6	9.12	9.12

Comparison

WLL	Mobile Wireless	Wireline
Good LOS component	Mainly diffuse components	No diffuse components
Rician fading	Rayleigh fading	No fading
Narrowbeam directed antennas	Omnidirectional antennas	Expensive wires
High Channel reuse	Less Channel reuse	Reuse Limited by wiring
Simple design, constant channel	Expensive DSPs, power control	Expensive to build and maintain
Low in-premises mobility only, easy access	High mobility allowed, easy access	Low in-premises mobility, wiring of distant areas cumbersome
Weather conditions effects	Not very reliable	Very reliable

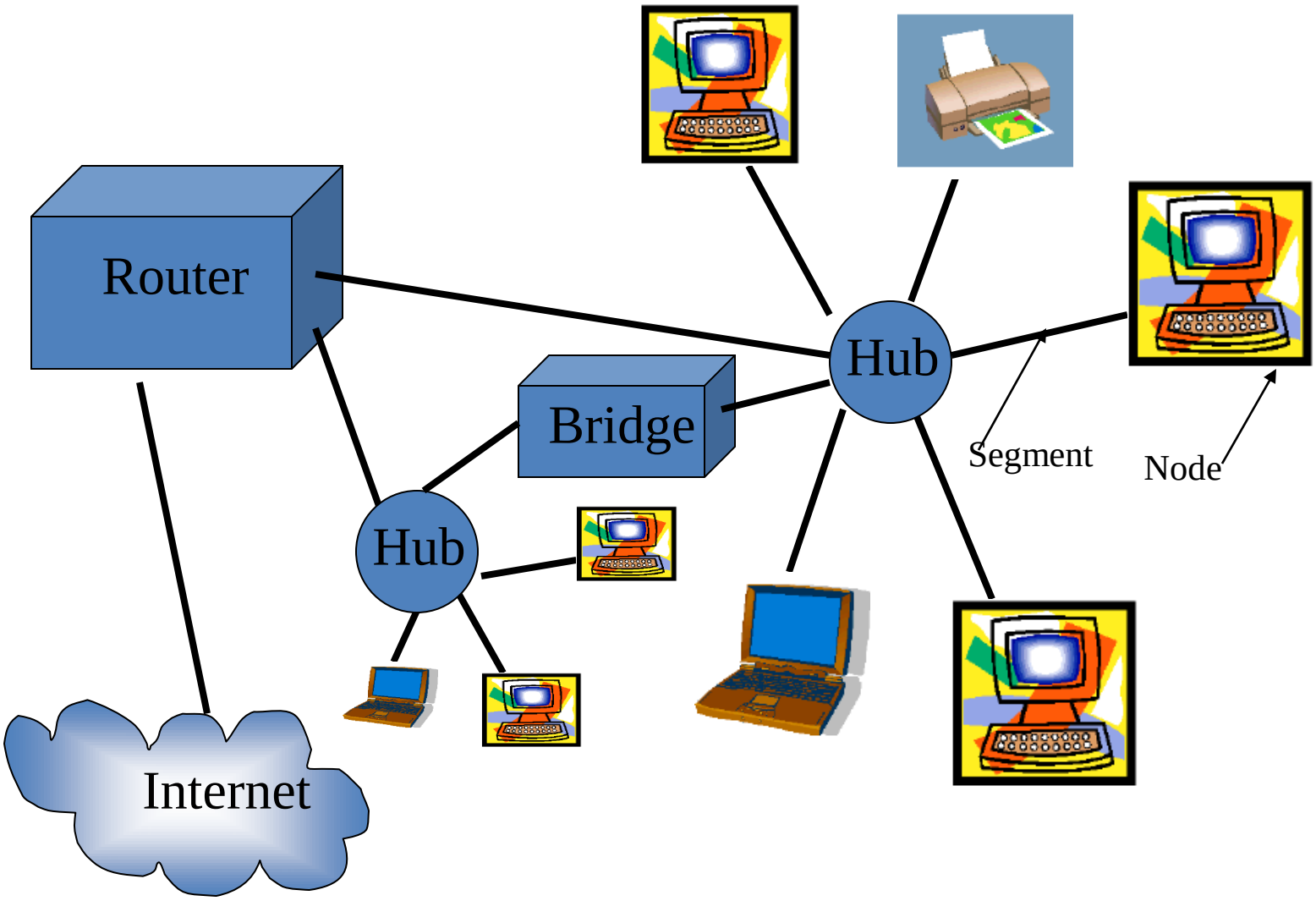
Examples of services provided

- **Marconi WipLL** (wireless IP local loop)
  - Based on Frequency hopping CDMA
  - Internet Protocol 64kbps to 2.4Mbps rates Committed Information Rate or best effort service
- **Lucent WSS** (wireless subscriber system)
  - 800 to 5000 subscribers per switch
  - Uses FDMA/FDD 12 Km to 40Km coverage
- **GoodWin** WLL
  - DECT standards
  - 9.6 kbps rate
  - Specified conditions -5°C...+55°C, 20...75% humidity

Computer Networks

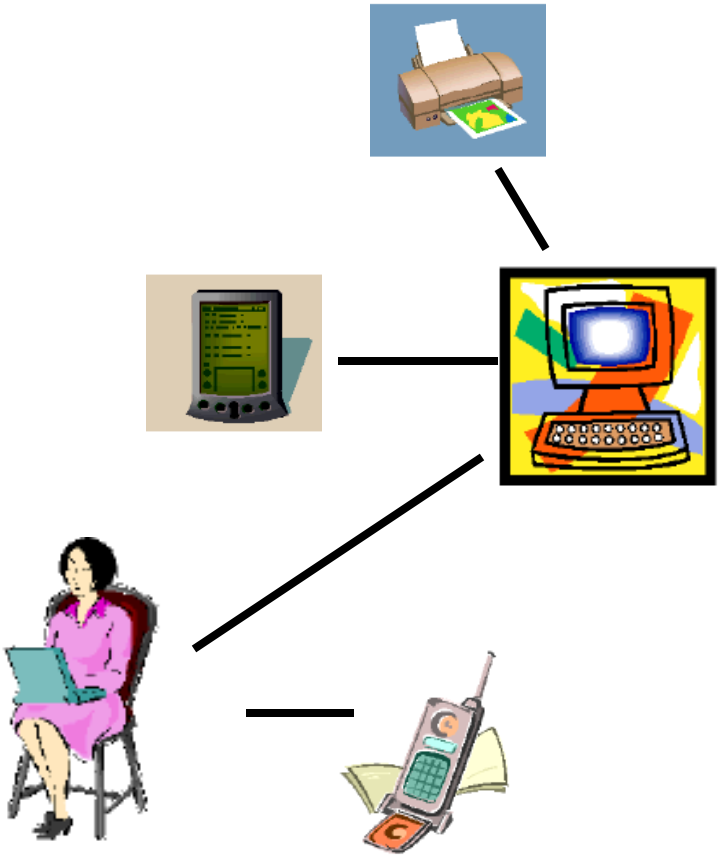
- *A computer network is a system for communicating between two or more computers and associated devices*
- A popular example of a computer network is the internet, which allows millions of users to share information
- Computer networks can be classified according to their size:
  - Personal area network (PAN)
  - Local area network (LAN)
  - Metropolitan area network (MAN)
  - Wide area network (WAN)

An example of a network



Personal Area Network

- *A PAN is a network that is used for communicating among computers and computer devices (including telephones) in close proximity of around a few meters within a room*
- It can be used for communicating between the devices themselves, or for connecting to a larger network such as the internet
- PAN's can be wired or wireless
  - PAN's can be wired with a computer bus such as a universal serial bus: *USB* (a serial bus standard for connecting devices to a computer-many devices can be connected concurrently)
  - PAN's can also be wireless through the use of *bluetooth* (a radio standard designed for low power consumption for interconnecting computers and devices such as telephones, printers or keyboards to the computer) or *IrDA* (infrared data association) technologies



Local Area Network

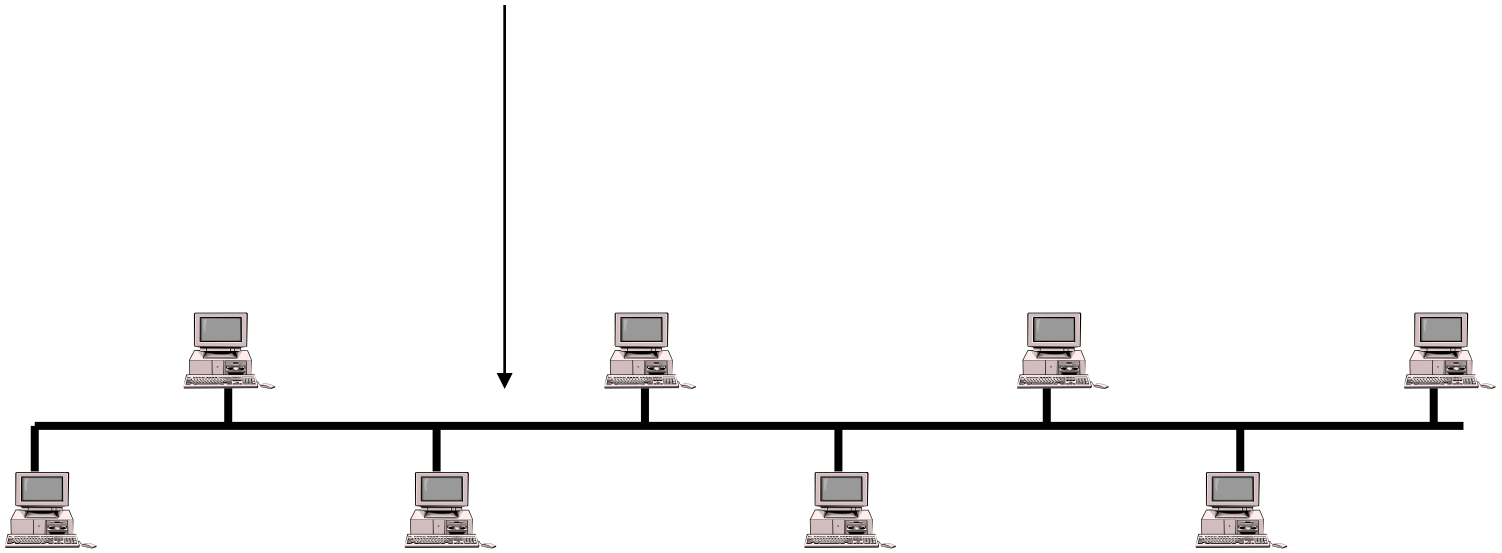
- *A LAN is a network that is used for communicating among computer devices, usually within an office building or home*
- LAN's enable the sharing of resources such as files or hardware devices that may be needed by multiple users
- Is limited in size, typically spanning a few hundred meters, and no more than a mile
- Is very fast, with speeds from 10 Mbps to 10 Gbps
- Requires very little wiring, typically a single cable connecting to each device
- Has lower cost compared to MAN's or WAN's

LAN basics

- LAN's can either be made wired or wireless. Twisted pair, coax or fiber optic cable can be used in wired LAN's
- Nodes in a LAN are linked together with a certain *topology*. These topologies include:
  - Bus
  - Ring
  - Star
  - Branching tree
- A *node* is defined to be any device connected to the network. This could be a computer, a printer etc.
- A *Hub* is a networking device that connects multiple segments of the network together
- A *Network Interface Card* (NIC) is the circuit board that is used to connect computers to the network. In most cases, this is an *Ethernet* card plugged in a computer's motherboard
- The *Network Operating System* (NOS) is the software that enables users to share files and hardware and communicate with other computers. Examples of NOS include: Windows XP, Windows NT, Sun Solaris, Linux, etc..
- Resource sharing in a LAN is accomplished with different *access methods*. These include:
  - Token based access
  - CSMA/CD

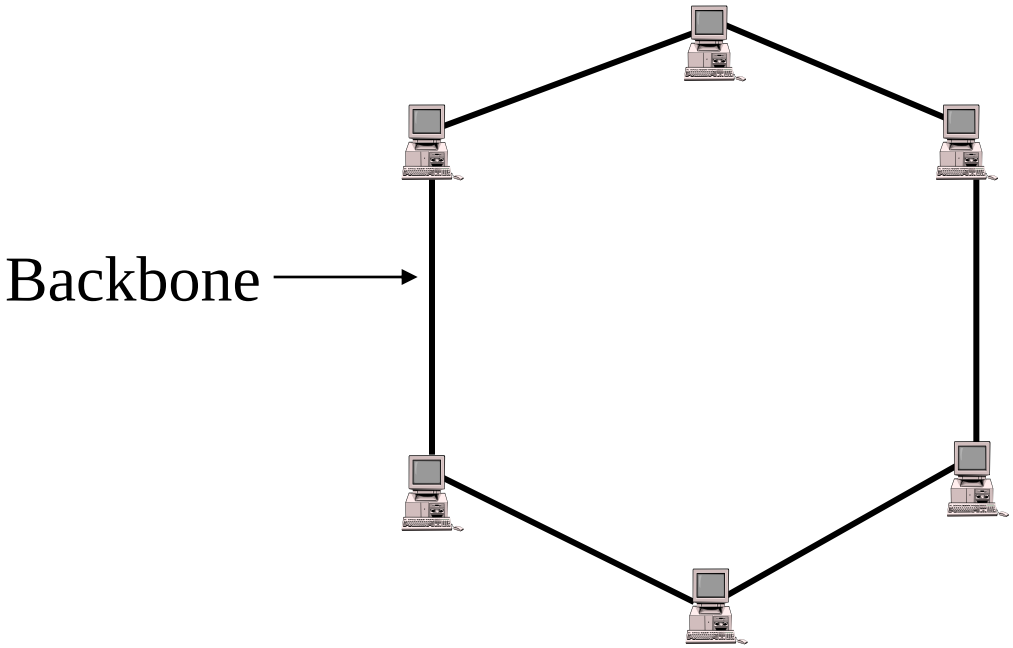
Network Topologies

- Bus Topology
  - Each node is connected one after the other (like christmas lights)
  - Nodes communicate with each other along the same path called the *backbone*

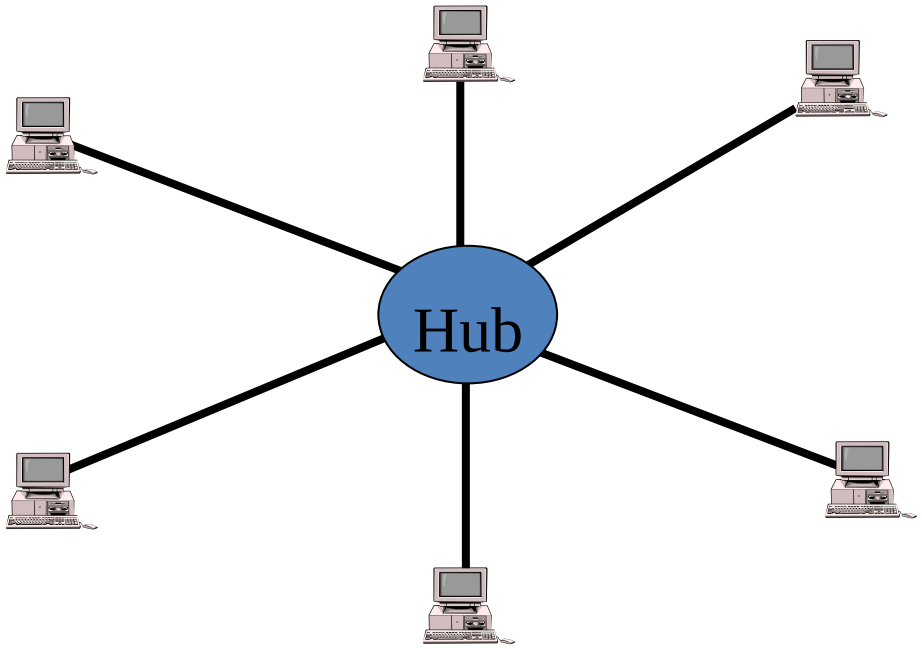


- Ring Topology

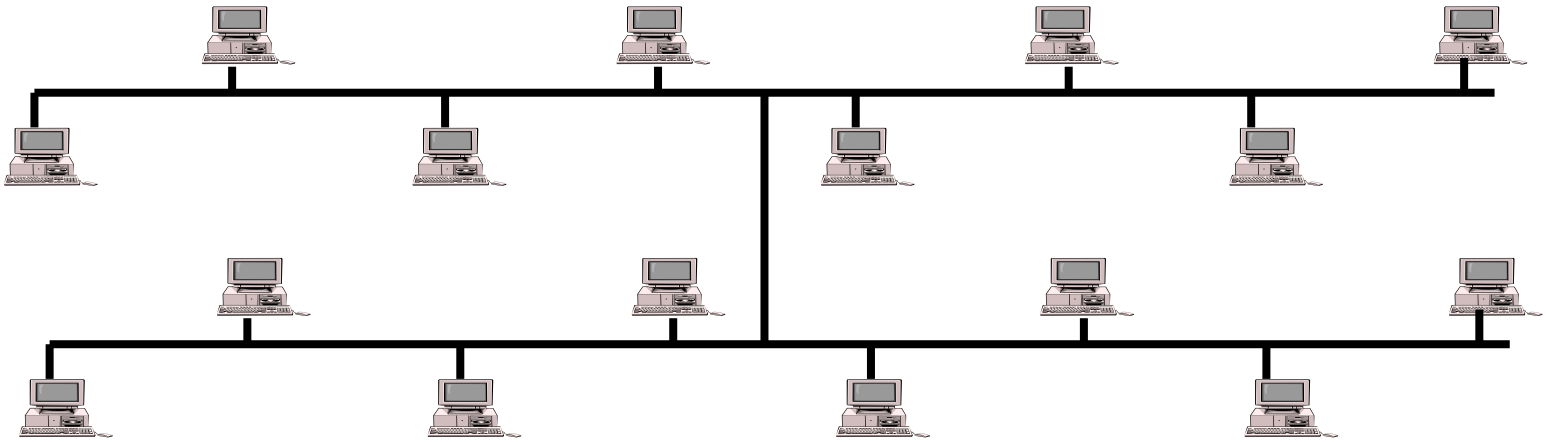
  - The ring network is like a bus network, but the “end” of the network is connected to the first node
  - Nodes in the network use tokens to communicate with each other



- Star Topology
  - Each node is connected to a device in the center of the network called a *hub*
  - The hub simply passes the signal arriving from any node to the other nodes in the network
  - The hub does not route the data



- Branching Tree Topology



Access Control Methods

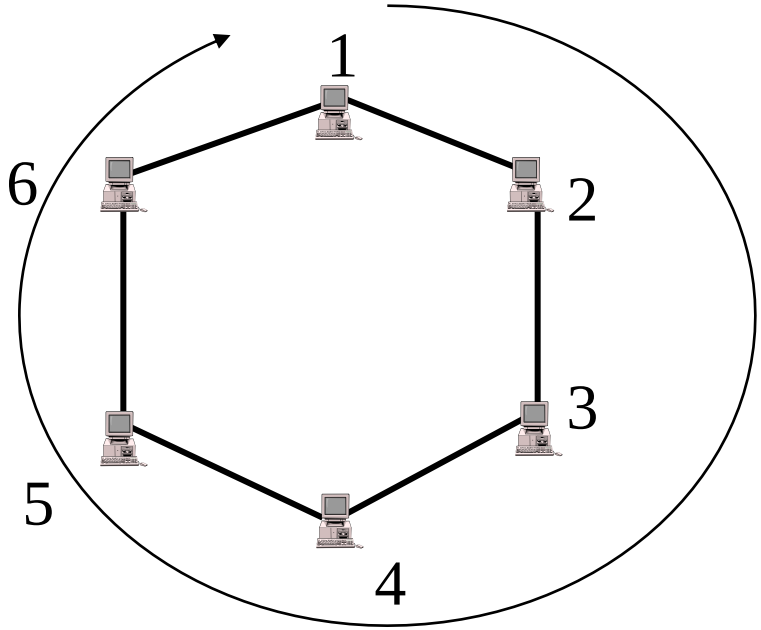
- Two primary access control methods exist for computers to communicate with each other over the network
  - Token based access
  - Carrier Sense Multiple Access with Collision Detection (CSMA/CD)

Token based access

- Used in bus and ring network topologies (token ring)
- Each computer in the network can only send its data if it has the *token.* This prevents collisions that occur when data is sent at the same time over the network
- The token is a special pattern of bits/bit in a frame that is directly detectible by each node in the network
- A computer may only transmit information if it is in possession of the token
- The message is sent to all other computers in the network

Operation of token ring

- As an example, suppose node # 1 wants to send information to node # 4 over the network
- Initially, an empty frame circulates in the network

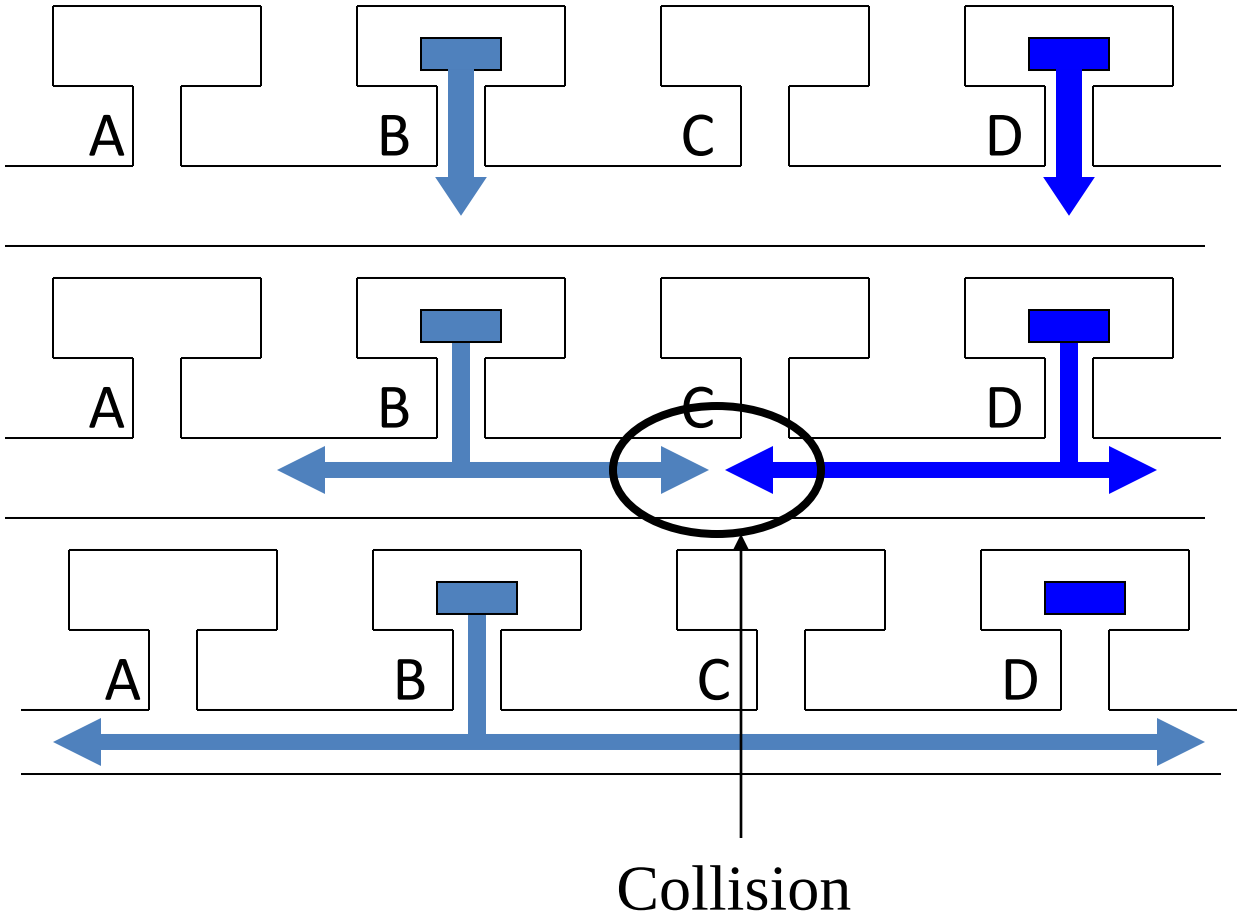


- When node # 1 receives the empty frame, it inserts a token in the token bit part of the frame. This operation may just be an insertion of a “1” bit
- The node then inserts the message it wants to send as well as the address of the receiving node in the frame
- The frame is then successively received and examined by each node in the network. First it is sent to node #2. Node #2 examines the frame and compares the address in the frame to its own address. Since addresses do not match, it passes the frame onto node #3, which does the same thing
- When the frame is received by node #4, the address of the node matches the destination address within the frame. The node copies the message and changes the token bit in the frame to “0”
- The frame is then sent over to node #5. This node also compares addresses and sends it to node #6 which does the same procedure
- When node #1 receives the frame, it examines the token bit and recognizes that it has been changed to “0”. Node #1 then concludes that the message has been received by the intended node: node #4. Node #1 then empties the frame and releases the empty frame back into the network for circulation

CSMA/CD

- Usually used in a bus topology
- Used in *Ethernet* LAN's
- Unlike the token ring, all nodes can send whenever they have data to transmit
- When a node wants to transmit information, it first "listens" to the network. If no one is transmitting over the network, the node begins transmission
- It is however possible for two nodes to transmit simultaneously thinking that the network is clear
- When two nodes transmit at the same time, a *collision* occurs
- The first station to detect the collision sends a jam signal into the network
- Both nodes back off, wait for a random period of time and then re-transmit

CSMA/CD



Types of LAN's

- The three most popular types of LAN's are:
  - Token ring
  - Ethernet
  - FDDI (Fiber Distributed Data Interface)

Ethernet

- First network to provide CSMA/CD
- Developed in 1976 by Xerox PARC (Palo Alto Research Center) in cooperation with DEC and Intel
- Is a fast and reliable network solution
- One of the most widely implemented LAN standards
- Can provide speeds in the range of 10Mbps- 10 Gbps
- Used with a bus or star topology

Types of Ethernet LANs

- 10Base-T
  - Operates at 10 Mbps
  - IEEE 802.3 standard
- Fast Ethernet (100Base-T)
  - Operates at 100 Mbps
- Gigabit Ethernet
  - Operates at 1 Gbps
  - Uses fiber optic cable
- 10 Gbps Ethernet
  - Latest development of ethernet
  - Uses fiber optic cable
  - Developed to meet the increasing bandwidth needs of the LAN market
- Wireless Ethernet
  - IEEE 802.11 standard
  - Operates at around 2.4 Gbps