ANALOG VS DIGITAL CELLULAR SYSTEMS

FEATURE	ANALOG	DIGITAL
TRAFFIC CH	VOICE USE FM	VOICE ENCODED IN DIGITAL FORMAT
PROCESSING	MORE DIFFICULT	EASIER BY USING MODEM
ENCRYPTION	NO SECURITY	PROVIDES THIS CAPABILITY
NOISE	MORE NOISY	INHERENTLY LESS NOISY

ANALOG VS DIGITAL CELLULAR SYSTEMS (contd)

FEATURE	ANALOG	DIGITAL
ERROR DETECTION AND CORRECTION	NO SUCH FACILITY.SO VOICE WAS NOT CLEAR	SUCH CAPABILITY PROVIDED.SO VOICE IS CLEAR
CHANNEL ACCESS	ONE CH TO ONLY ONE USER.EACH CELL SUPPORTS A NO OF FIXED CH.	ONE CH SHARED BY NO OF USERS USING TDMA/CDMA
COMPATIBILITY	NOT COMPATIBLE WITH OTHER DEVICES	COMPATIBLE WITH COMPUTERS /COMPUTERS N/W WHICH USE DIGITAL FORMAT.

ANALOG CELLULAR SYSTEM

- 1 G / First Generation Cellular system.
- Evolved in early 80s.
- Called **AMPS – ADVANCED MOBILE PHONE SYSTEM**
- Released in 1983.
- Employed in North & South America, China, Australia etc.

General Specifications

• Base Stn Tx Band	869-894 M Hz
• M U Tx Band	824-849 M Hz
• Spacing between FCh & RCh	45 M Hz
• Channel Bandwidth	30 K Hz
• No of Full Duplex Ch	790
• No of Full Duplex Control Ch	42

Analog Cellular System (Contd)

- M U Max Power — 3 W
- Cell Size Radius — 2-20 Km
- Modulation Voice Channel — FM, 12 KHz Peak
- Modulation Control Channel — FSK 8 KHz
- Data Transmission Rate — 10 Kbps
- Each AMPS contains Numeric Assignment Module (NAM) in read only memory. This contains the Telephone No of the phone (MIN) which is assigned by the service provider & the serial no of the phone (ESN) which is assigned by the manufacturer. When the phone is switched on, it transmits its serial no and phone no to the MSC through BS. The MSC maintains the data base of the user for Billing Purpose or for blocking the Call.

1G Mobile Standards

- NMT (Nordic mobile Telephone)

  Used in Nordic countries , Switzerland, Netherland, eastern Europe and Russia.

- AMPS(Advance Mobile Phone system)

  Used in United State

- CDPD(total access communication system)

Used in United Kingdom.

Chronology of 1G wireless system

- 1970 : Developments of radio & computer technology for 800/900 MHZ mobile communication.
- 1976: WARC (world administrative Radio Conference) allocates spectrum for cellular radio.
- 1979: NTT (Nippon Telephone & Telegraph)introduces the first cellular system in Japan.
- 1981: NMT 900 system introduces by Ericsson Radio system AB & develop in scandinavia(region of Europe).
- 1984: AMPS introduces by AT&T in North America.

First Generation Wireless Networks

- AMPS: FM modulation

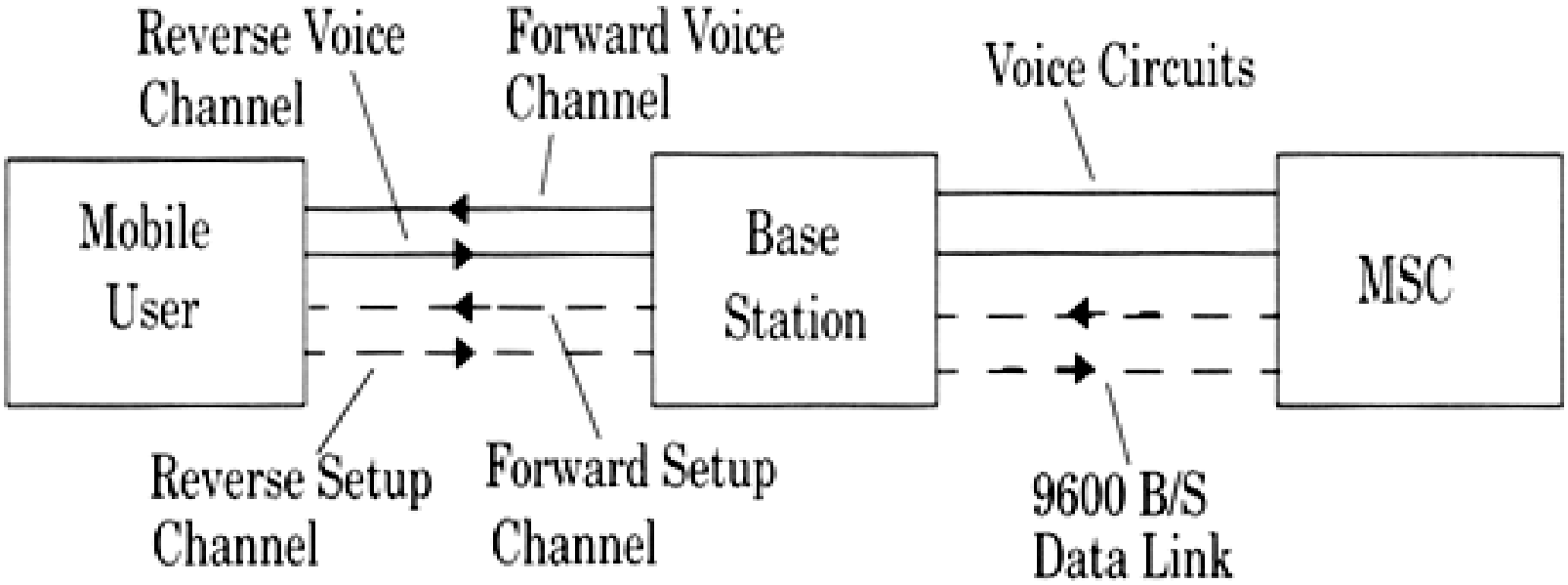


Figure 10.4 Communication signaling between mobile, base station, and MSC in first generation wireless networks.

Limitations of AMPS

LOW CALLING CAPACITY.

LIMITED SPECTRUM.

NO ROOM FOR SPECTRUM GROWTH.

POOR DATA COMMUNICATIONS.

MINIMAL PRIVACY.

INSUFFICIENT SCHEME PROTECTION.

DIGITAL CELLULAR SYSTEM –(GSM)

- GSM –GLOBAL SYSTEM FOR MOBILE COMMUNICATIONS.
- YEAR INTRODUCED 1990
- ACCESS METHOD TDMA
- BASE STN TX CH 935-960 M Hz
- M U TX CH 890-915 M Hz
- SPACING BETWEEN FWD AND REV CH 45 M Hz
- CH BANDWIDTH 200 K Hz
- NO OF DUPLEX CH 125
- MU MAX POWER 20 W
- USERS PER CH 8
- MODULATION GMSK
- CARRIER BIT RATE 270.8 Kbps
- SPEECH CODING BIT RATE 13 Kbps
- FRAME SIZE 4.6 ms

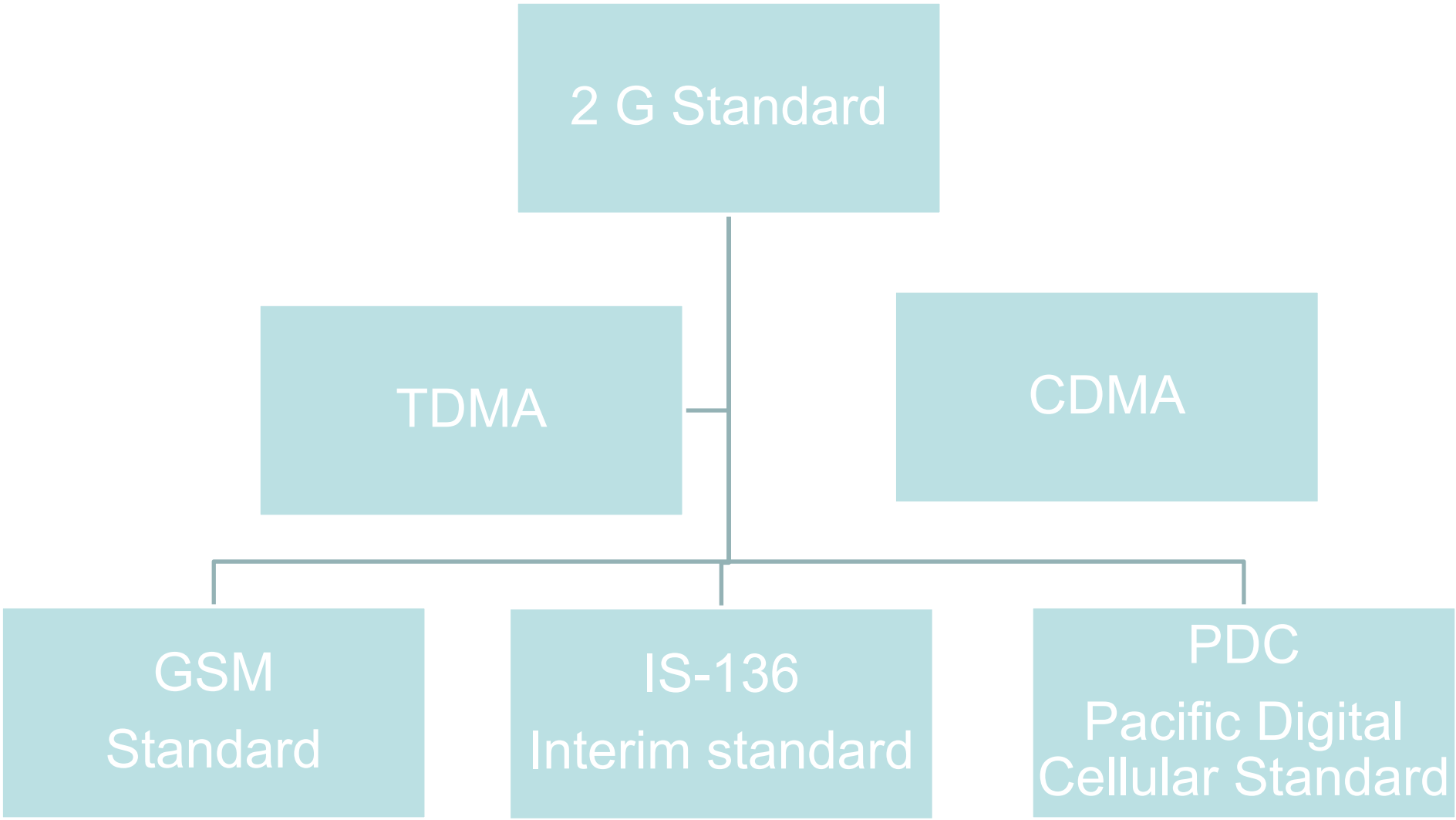
GSM FEATURES

- More capacity.
- Ensures rapid call set up.
- Handsets smaller & more robust.
- Talk to no of other parties simultaneously.
- Can place a call on hold while one accesses another call.
- Notifies you of another call at the same time as on a call.
- Encrypted conversation that can not be tapped.
- Short message service (sms) which allows one to send and receive 126 character text messages.
- Ability to use same phone in a no of n/w related countries.
- No static connections.

GSM FEATURES (CONTD)

- Allows data & fax transmission & reception across gsm n/w at speeds up to 9.6 mbps currently.
- Forwarding of calls to another no.
- Emergency calls – in majority of countries , the global 112 emergency no can be called free.
- Allows location/ cell-specific reception of text msgs.
- One can bar outgoing calls and incoming calls.
- Clip allows one to see the telephone no of the incoming caller on the LCD screen of the handset.
- Real time call costs on the handsets LCD screen.
- Closed user group – allows a set of phones to be classed as PBX (private branch exchange) extensions.

SECOND GENERATION CELLULAR NETWORKS



SECOND GENERATION CELLULAR NETWORKS

- 2 G Systems are based on digital technology.

  TWO TYPES – TDMA /CDMA

TDMA BASED STANDARDS :

(a) GSM - Used world wide

(b) IDEN – Integrated digital enhanced n/w. Developed by motorola used in usa & canada.

(c) IS -136 (Interim Standard 136)Also called Digital Mobile Phone System (D-MPS).used in North & South America.

(d) PDC – Personal Digital Cellular system. Used in Japan

CDMA BASED STANDARDS

- IS – 95 Developed by Qualcomm(American global telecommunication corporation). Also known as TIA- EIA -95 or CDMA - One

SECOND GENERATION CELLULAR NETWORKS (CONTD)

- **CODEC** 2 G make use of CODEC (compression & decompression algorithm) to compress and multiplex digital voice data.
- 2 G n/w can handle more calls per amount of bandwidth as compare to1 G n/ w.
- 2 G cellphones usually smaller.
- Emit less radio power
- Safer for consumers to use.
- Battery life of handsets lasts longer.
- Offers additional services as sms & e-mails.
- Error checking has improved sound quality.
- Reduction of noise level.
- Digital voice encoding has made calls less susceptible to unwanted eavesdropping(over listening) from third parties due to use of radio scanner.

Second Generation Wireless Networks

- Digital modulation and advanced call processing capability
- GSM, TDMA(IS136) and CDMA (IS95)
- Cordless phone: CT2 (US), PACS(UK), DECT (Europe)
- Base station controller, standardized of interface, reduce burden of MSC
- Signaling in air interface, between MSC, and between PSTN
- Beyond voice, paging, data service such as fax, high data rate
- More flexibility in channel allocation scheme
- System can be deployed in a less coordinated manner

Chronology of 2G wireless system

- 1982:CEPT established GSM to define future Pan-European Cellular Radio.
- 1990: IS-54(USDC) adopted by TIA.
- 1990: IS-19B (NAMPS)adopted by TIA
- 1991:Japanese PDC system standardized by the MPT.
- 1992: Phase I GSM system is operational.
- 1993: IS-95 (CDMA) adopted by TIA.
- 1994: IS-136 adopted by TIA.
- 1995: PCS Licenses issued in North America.
- 1996:Pase II GSM operational.
- 1997:North American PCS Deploys GSM ,IS-54,IS-95.
- 1999:

  IS-54 :North America

  IS-95:North America, Hong kong, Israle, Japan, China . etc

  GSM.: 110 countries

Third Generation Wireless Networks

- Goal: a single standard to meet a wide range of wireless applications and provide universal access
- Broadband integrated services digital network: B-ISDN
- Voice, data, and video; dense or sparsely populated; stationary users and vehicular users
- IP, packet radio
- Personal communication system (PCS) and personal communication network (PCN)
- IMT-2000 vs. UMTS(universal mobile telecommunication standard).

Features of new release

- Release 99

- Bearer services
- 64 kbit/s circuit switches.
- 64 kbit/s packet switches.
- Location services
- Call services:GSM-compatible. USIM-based.

Release 4

- EDGE radio
- Multimedia messaging.
- Improved location services

Release 5

- IP Multimedia subsystem
- IPv6 transport in UTRAN (UTMS Radio Access Network)

Features of new release

- Improved in GERAN(GSM,EDGE Radio Access Network)
- HSDPA

- Release 6

- WLAN integration
- Multimedia broadcast & multicast
- Improvement in IMS
- HSUPA

An Introduction to BLUETOOTH TECHNOLOGY

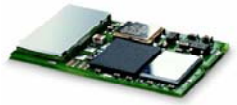
Example : The Networked Home

What is Bluetooth?

- “Bluetooth wireless technology is an open specification for a low-cost, low-power, short-range radio technology for ad-hoc wireless communication of voice and data anywhere in the world.”

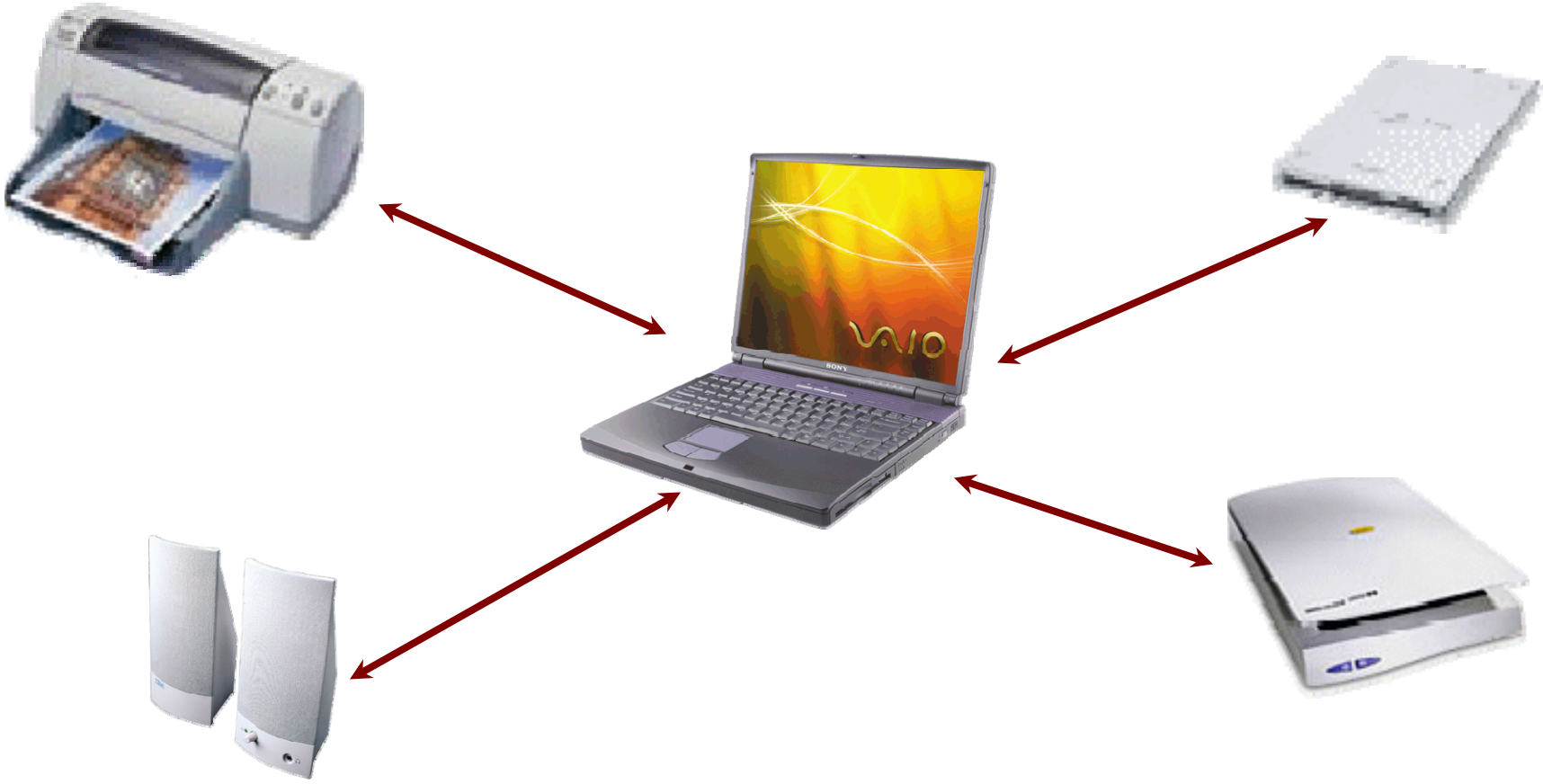
A recent module

One of the first modules (Ericsson)



Ultimate Headset

Cordless Computer



Bluetooth Goals & Vision

- Originally conceived as a cable replacement technology
- Short-Range Wireless Solutions
- Open Specification
- Voice and Data Capability
- Worldwide Usability
- Other usage models began to develop:
  - **Personal Area Network (PAN)**
  - **Ad-hoc networks**
  - **Data/voice access points**
  - **Wireless telematics**

Overview of Bluetooth History

- What is Bluetooth?
  - **Bluetooth is a short-range wireless communications technology.**

- When does it appear?
  - **1994 – Ericsson study on a wireless technology to link mobile phones & accessories.**
  - **5 companies joined to form the Bluetooth Special Interest Group (SIG) in 1998.**
  - **First specification released in July 1999.**

Timeline

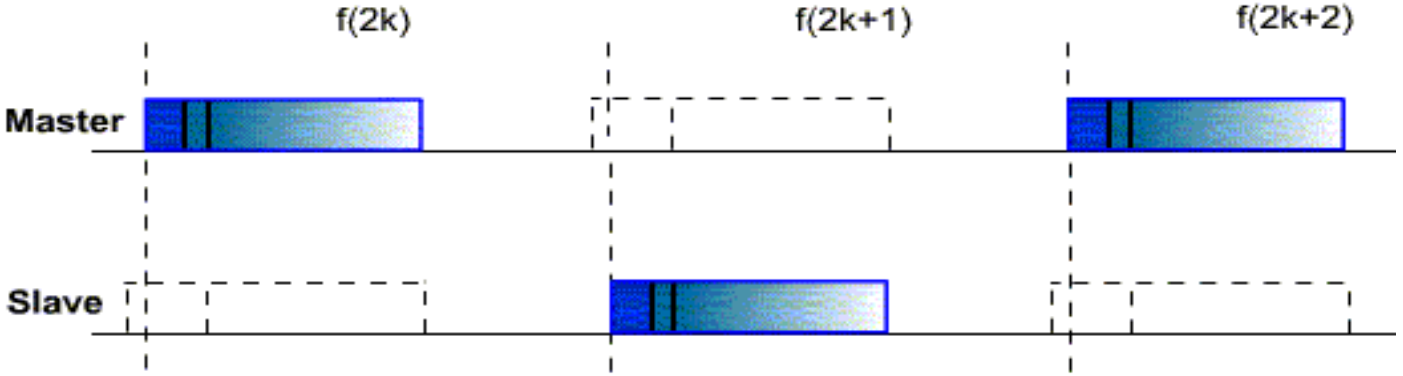
- 1994 : Ericsson study complete / vision
- 1995 : Engineering work begins
- 1997 : Intel agrees to collaborate
- 1998 : Bluetooth SIG formed: Ericsson, Intel, IBM, Nokia & Toshiba
- 1999 : Bluetooth Specification 1.0ASIG promoter group expanded: 3Com, Lucent, Microsoft & Motorola
- 2000 : Bluetooth Specification 1.0B, 2000+ adopters
- 2001 : First retail products released, Specification 1.1
- 2003 : Bluetooth Specification 1.2
- 2005 : Bluetooth Specification 2.0 (?)

Technical features

Connection Type	**Spread Spectrum (Frequency Hopping) & Time Division Duplex (1600 hops/sec)**
Spectrum	**2.4 GHz ISM Open Band (79 MHz of spectrum = 79 channels)**
Modulation	**Gaussian Frequency Shift Keying**
Transmission Power	**1 mw – 100 mw**
Data Rate	**1 Mbps**
Range	**30 ft**
Supported Stations	**8 devices**
Data Security –Authentication Key	**128 bit key**
Data Security –Encryption Key	**8-128 bits (configurable)**
Module size	**9 x 9 mm**

Time-Division Duplex Scheme

- Channel is divided into consecutive slots (each 625 μs)
- One packet can be transmitted per slot
- Subsequent slots are alternatively used for transmitting and receiving
  - Strict alternation of slots between the master and the slaves
  - Master can send packets to a slave only in EVEN slots
  - Slave can send packets to the master only in the ODD slots



Classification

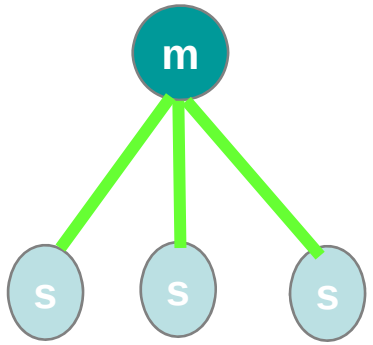
- **Classification of devices on the basis of Power dissipated & corresponding maximum Range.**

	POWER	RANGE
CLASS I	20 dBm	100 m
CLASS II	0-4 dBm	10 m
CLASS III	0 dBm	1 m

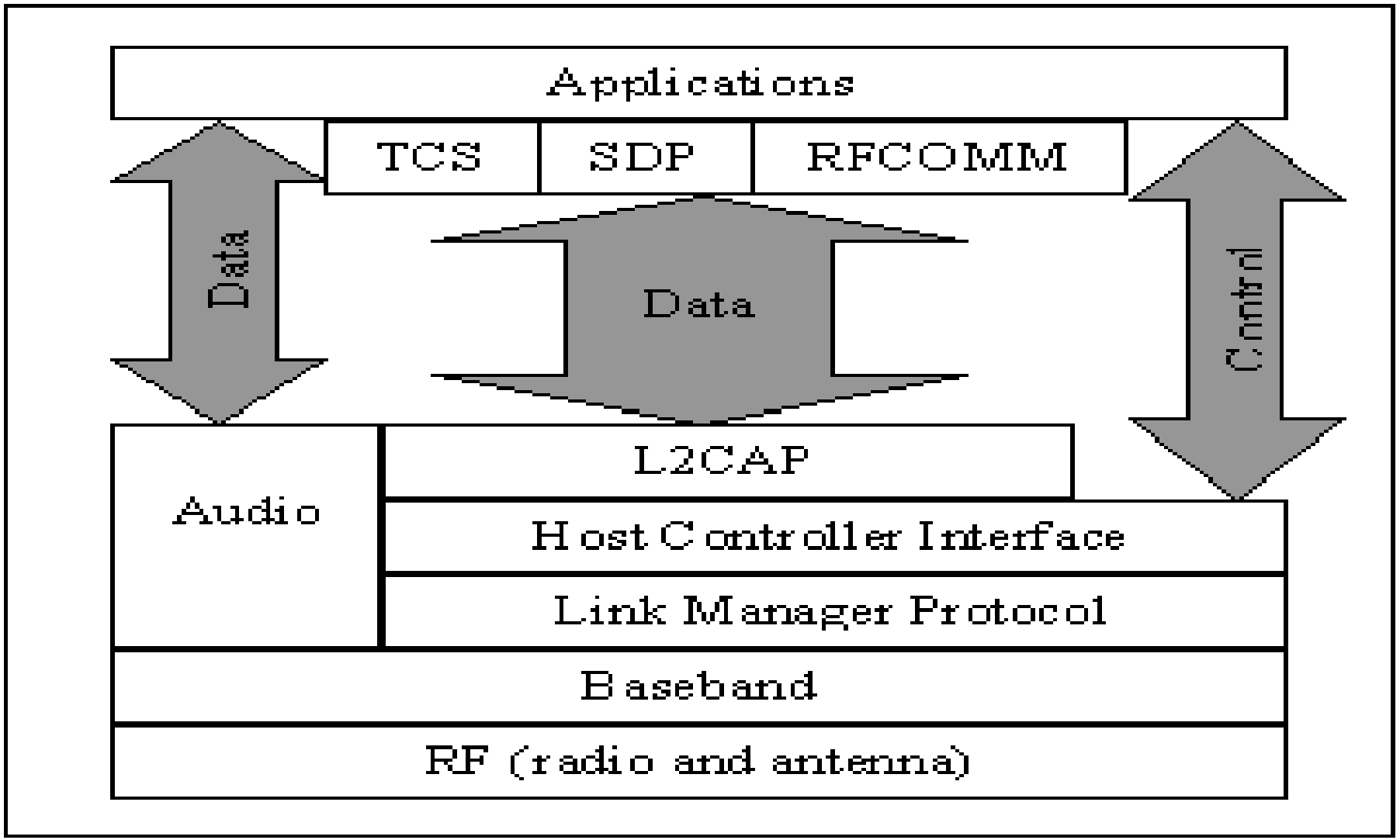
Typical Bluetooth Scenario

- Bluetooth will support wireless point-to-point and point-to-multipoint (broadcast) between devices in a piconet.
- Point to Point Link
  - **Master - slave relationship**
  - **Bluetooth devices can function as masters or slaves**
- Piconet

  - **It is the network formed by a Master and one or more slaves (max 7)**
  - **Each piconet is defined by a different hopping channel to which users synchronize to**
  - **Each piconet has max capacity (1 Mbps)**



Bluetooth Protocol Stack

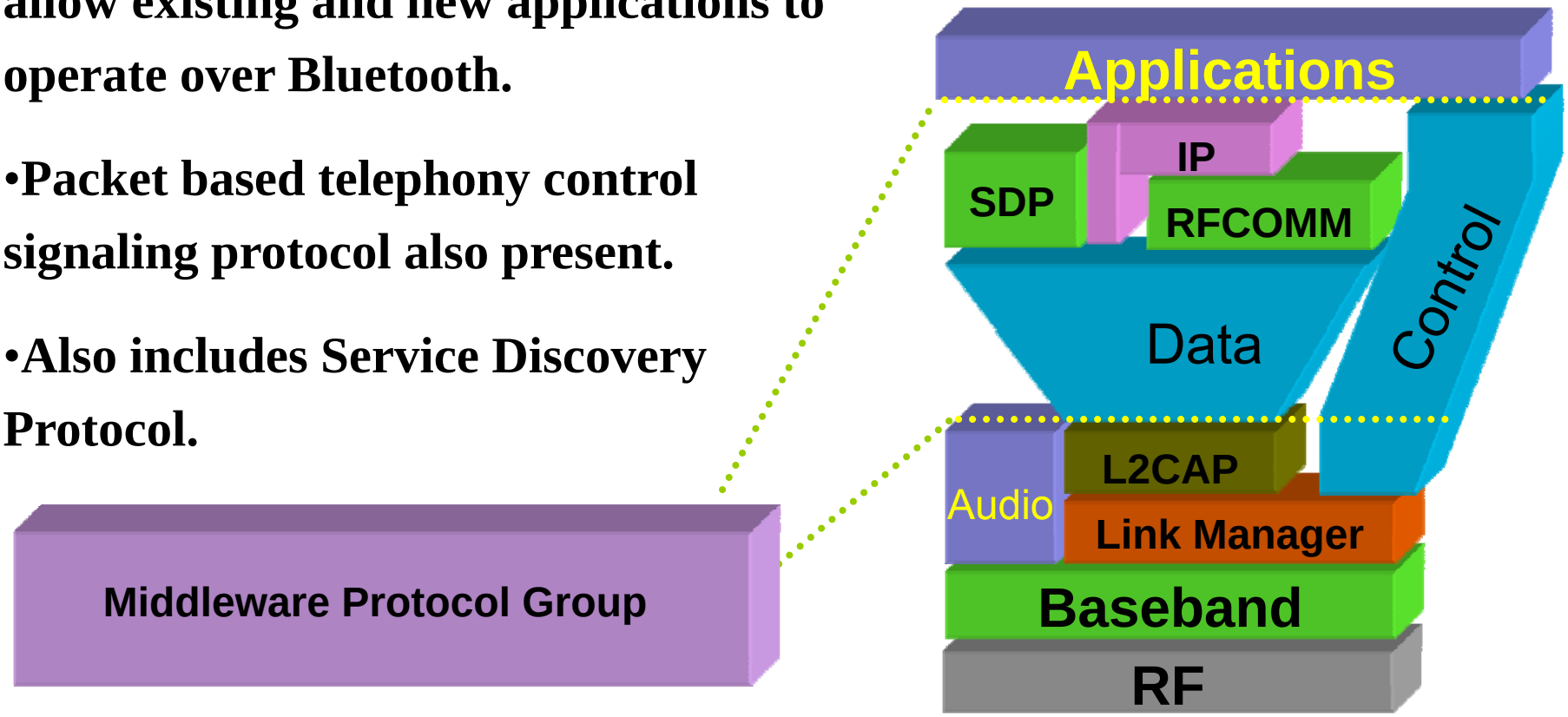


Bluetooth Protocol Stack

- **TCS**(Telephony Control Protocol specification): provides telephony services.
- **SDP**(Service Discovery Protocol):discover that what services other Bluetooth devices support.
- **RFCOMM**: provides as RS 232 link Serial interface.
- **L2CAP**:(logical link control & adaption) it multiplex the data from higher layers & converts the different packet sizes.
- **Link Manager:** It handles the communication between a separate host & bluetooth module.
- **Baseband:** it controls the physical link via the radio ,assembling packet & controlling frequency hoping
- **RADIO:** It modulates & demodulates data for transmission on air.

Middleware Protocol Group

- **Additional transport protocols to allow existing and new applications to operate over Bluetooth.**
- **Packet based telephony control signaling protocol also present.**
- **Also includes Service Discovery Protocol.**



Middleware Protocol Group (contd.)

- Service Discovery Protocol (SDP)
  - Means for applications to discover device info, services and its characteristics.
- TCP/IP
  - Network Protocols for packet data communication, routing.
- RFCOMM
  - Cable replacement protocol, emulation of serial ports over wireless network.

Link Manager Protocol

- The Link Manager carries out link setup, authentication & link configuration.
- Channel Control
  - **All the work related to the channel control is managed by the master**
    - The master uses *polling* process for this
  - **The master is the first device which starts the connection**
    - This roles can change (master-slave role switch)

L2CAP

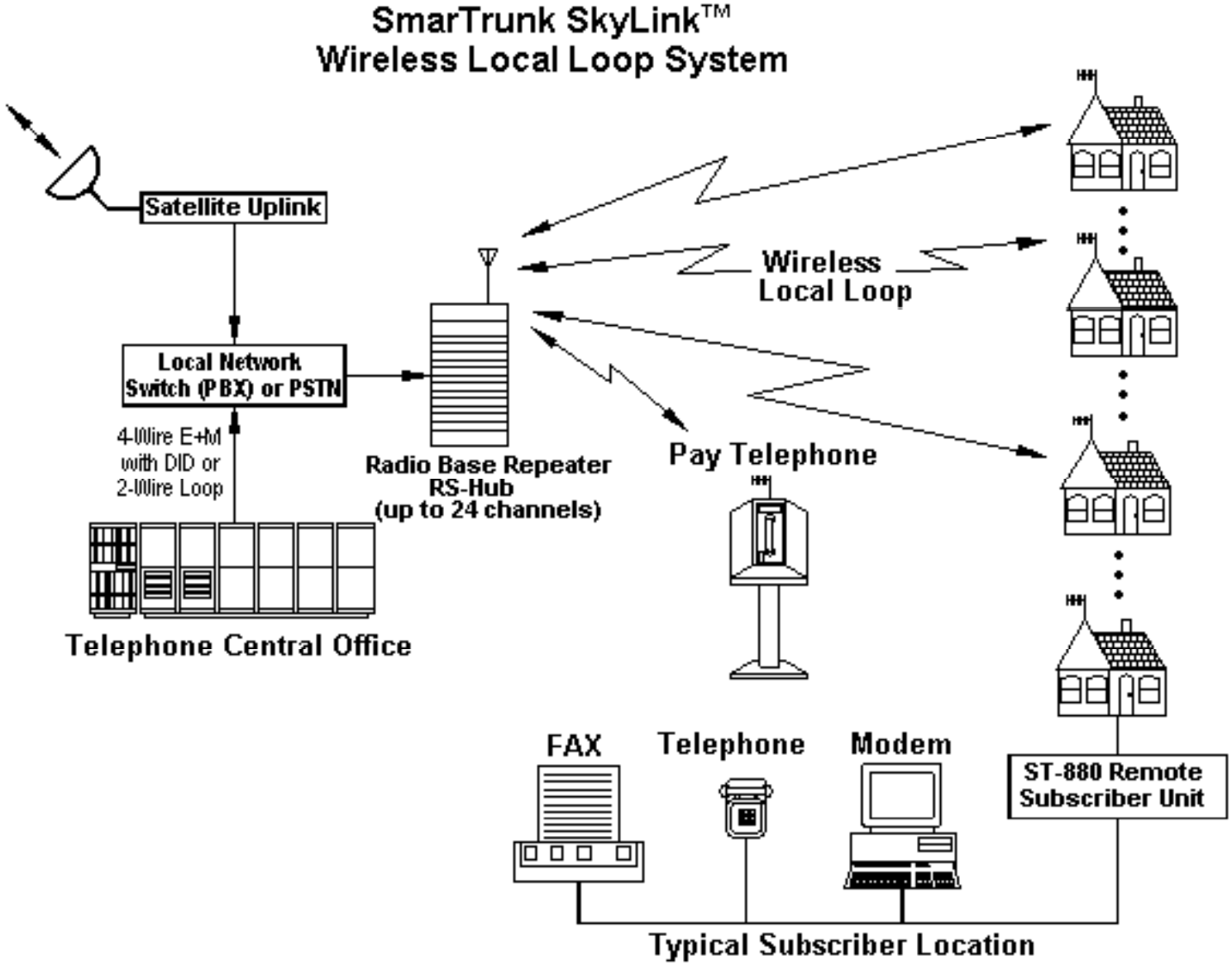
- Service provided to the higher layer:
  - **L2CAP provides connection-oriented and connectionless data services to upper layer protocols**
  - **Protocol multiplexing and de-multiplexing capabilities**
  - **Segmentation & reassembly of large packets**
  - **L2CAP permits higher level protocols and applications to transmit and receive L2CAP data packets up to 64 kilobytes in length.**

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

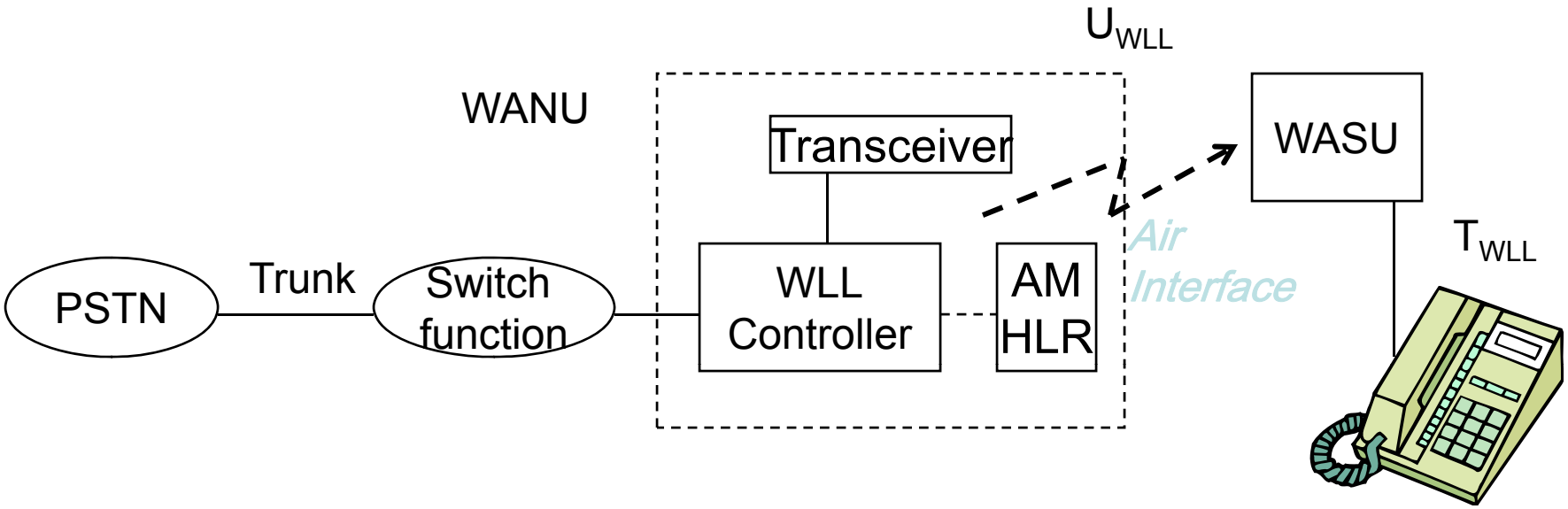
Developed vs. Developing

- 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

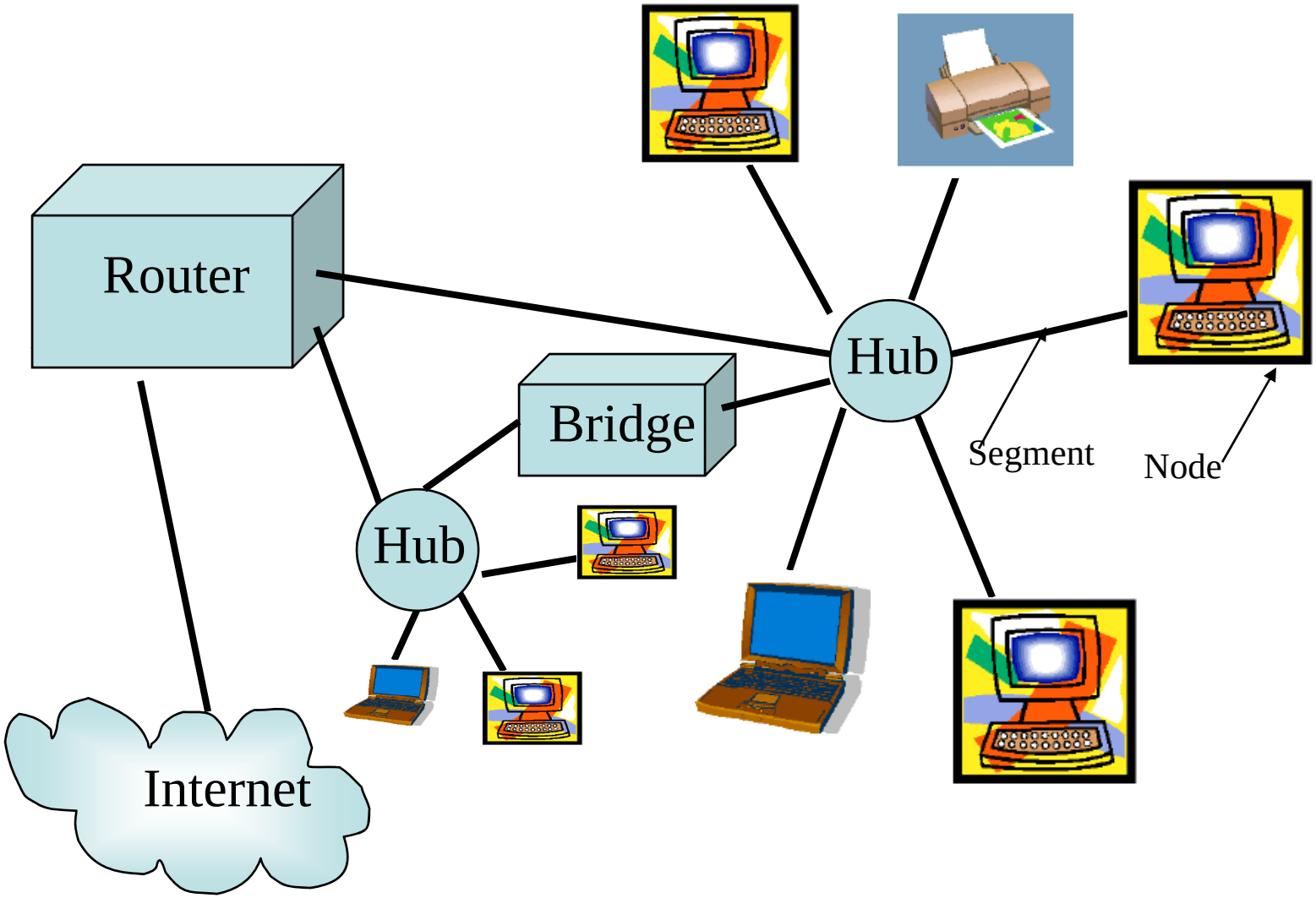
Examples of services provided

- **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

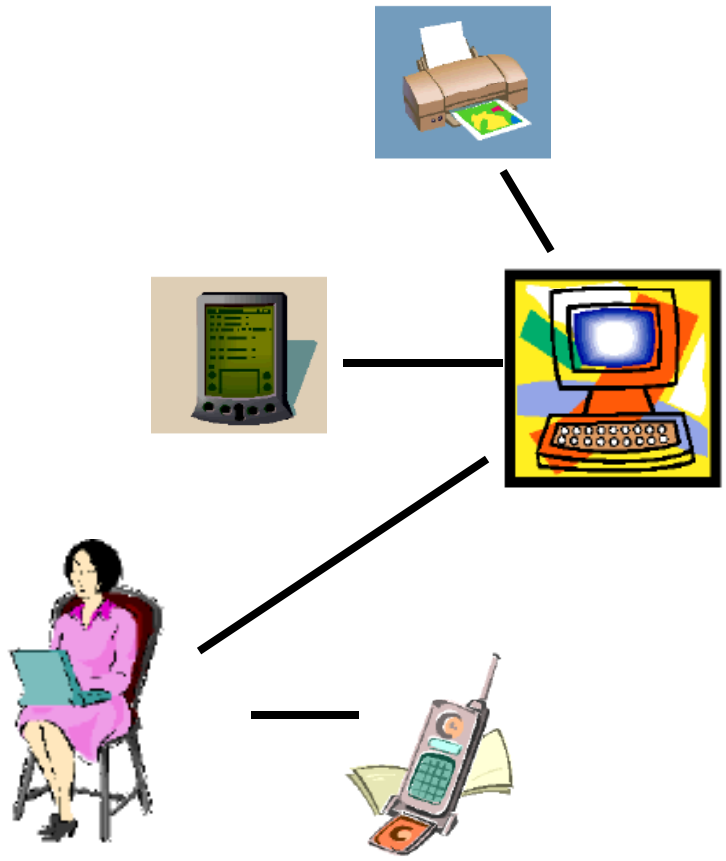
- *A computer network is a system for communicating between two or more computers and associated devices*
- A popular example of a computer network is the internet, which allows millions of users to share information
- Computer networks can be classified according to their size:
  - Personal area network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

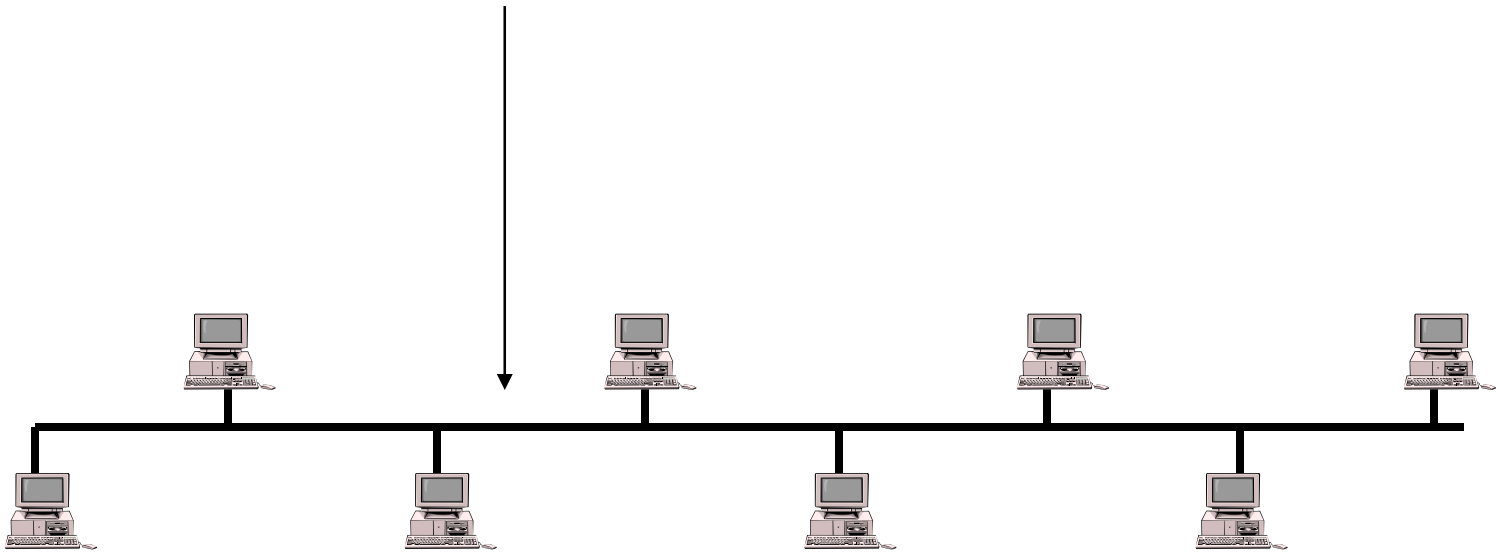
- *A LAN is a network that is used for communicating among computer devices, usually within an office building or home*
- LAN's enable the sharing of resources such as files or hardware devices that may be needed by multiple users
- Is limited in size, typically spanning a few hundred meters, and no 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

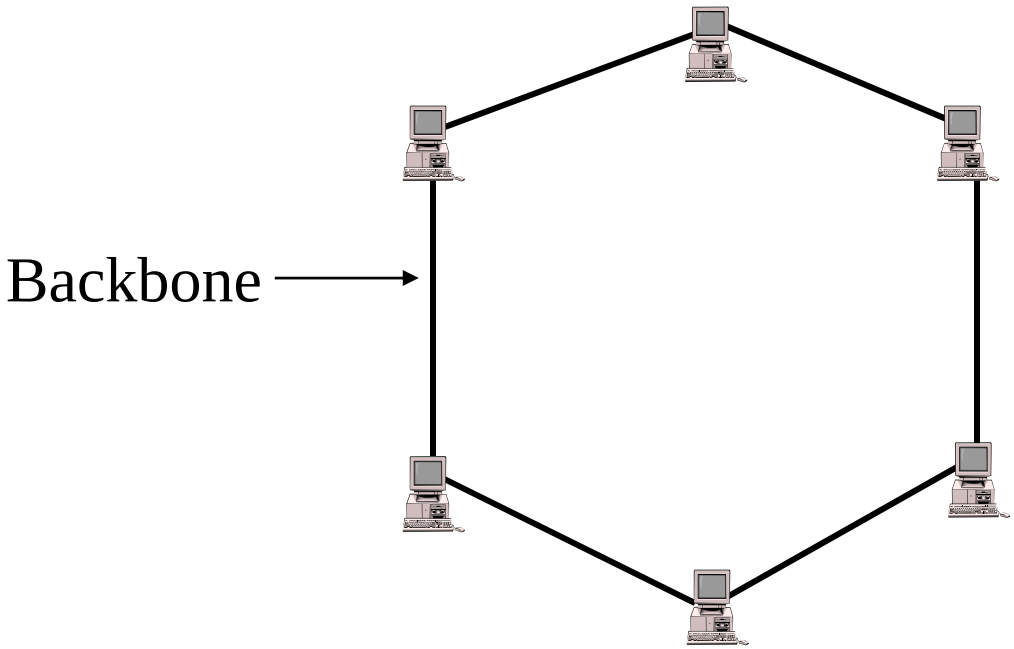
Network Topologies

- 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*

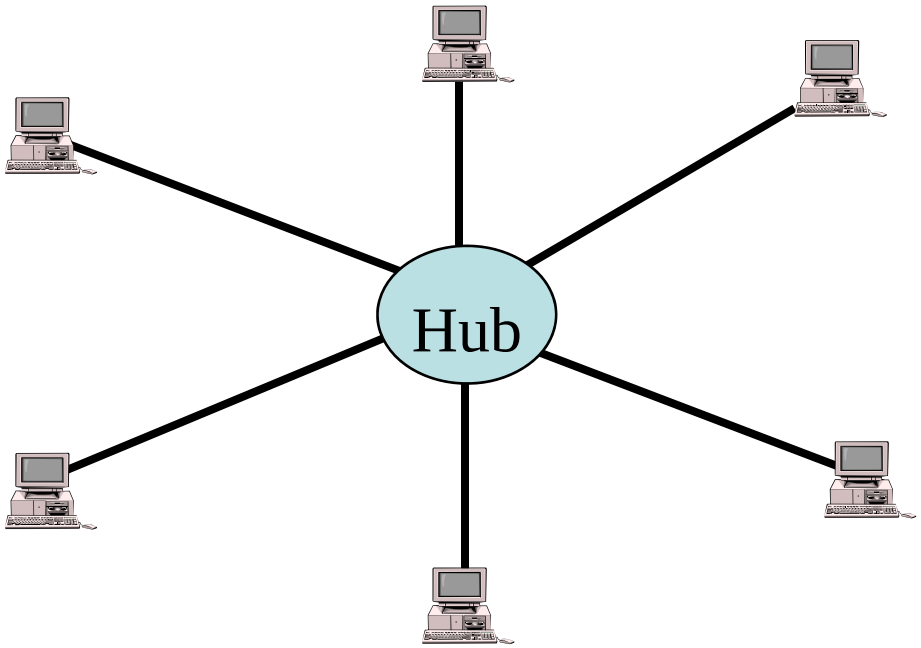


- Ring Topology

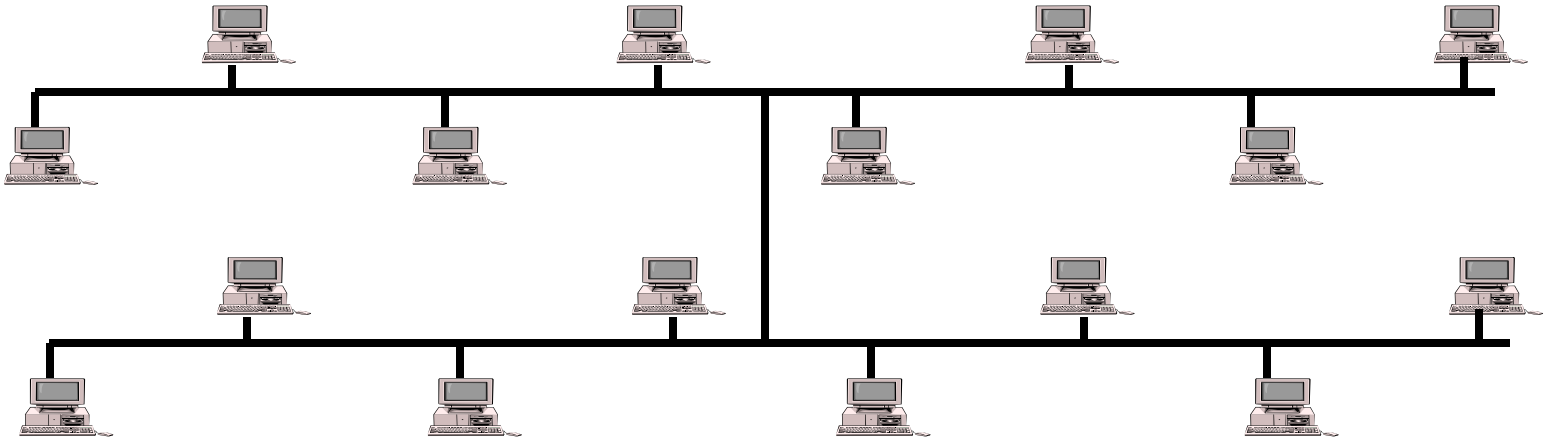
  - The ring network is like a bus network, but the “end” of the network is connected to the first node
  - Nodes in the network use tokens to communicate with each other



- 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

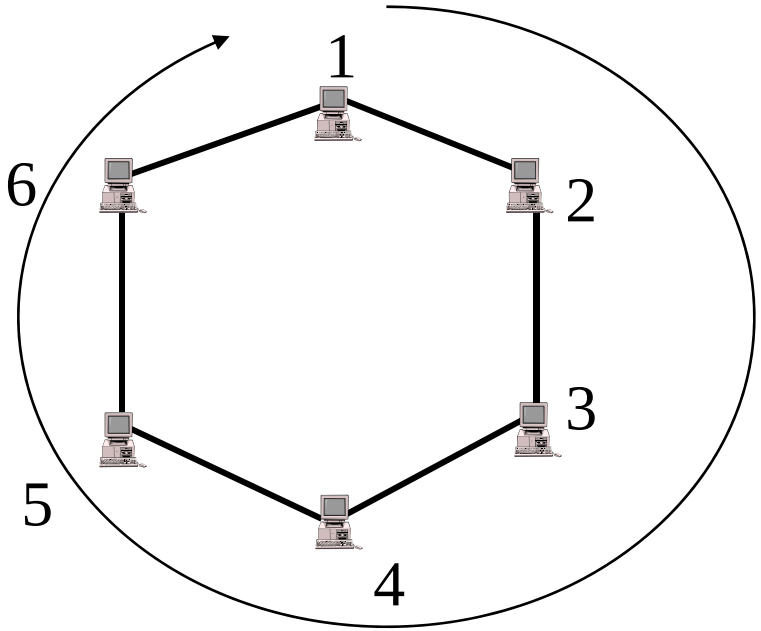
- Two primary access control methods exist for computers to communicate with each other over the network
  - Token based access
  - Carrier Sense Multiple Access with Collision Detection (CSMA/CD)

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

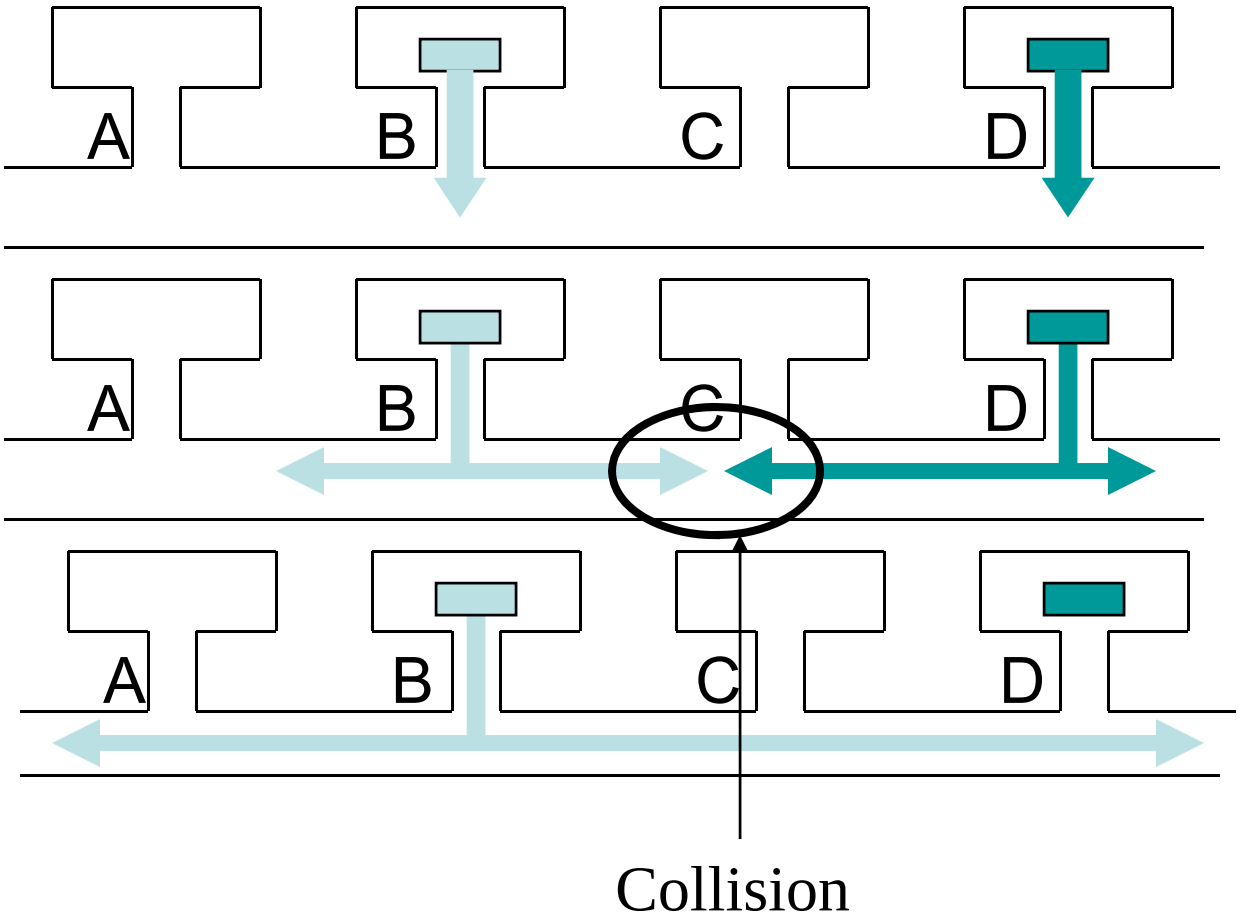


- When node # 1 receives the empty frame, it inserts a token in the token bit part of the frame. This operation may just be an insertion of a “1” bit
- The node then inserts the message it wants to send as well as the address of the receiving node in the frame
- The frame is then successively received 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