
*Chapter 2*

*Networking Technologies and Multimedia*

- Wired Networking Technologies
- LANs, MANs and WANs
- Open System Interconnection (OSI) model
- Traditional ("Legacy") LANs
  - Ethernet
  - Token Ring
- FDDI
- Switched Hubs
- Fast Ethernet (100 Mbps)
- Gigabit Ethernet (1 Gbps)
- Levels of Mobility
- Wireless Networking Revolution
  - Bluetooth
  - HomeRF
  - IEEE 802.11

**Outline**

## The Dream

- **Dream Networking**
  - One network - No configuration
  - Nomadic networking
  - Always-on networking
  - secure networks that scale
- **The Connected Home**
  - No Pain Networking
  - The Home as a platform
  - Redefining Entertainment
- **Weaving the User to User web**
  - Click to communicate
  - Multimedia Collaboration
  - Presence

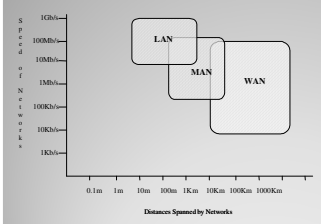
## Trends in Computing

- Moore's Law still going strong
  - Smaller, more computing devices every 18 months
- Miniaturization continues
  - 100Gb per square inch hard disk density
  - 128MB memory on a single chip
- Dramatic innovation towards longer battery time
  - Low power CPUs from Intel, AMD, etc…
  - Long Live Cell battery
- Smaller, lighter PC, PDA, phone designs enabling new networking scenarios
  - TVs on Cell phones (Vision), Wearable computers, digital cash, eBooks

## Trends in Applications

- SUN J2EE, W3C-XML, MS-.Net
  - revolution leading to web services
- "Presence" a paradigm shift in Real Time Communications and Collaboration
- Net attached Consumer Electronics and Gaming appliances emerging
- Applications assuming always on connectivity
- anytime, anywhere, anyhow accessibility
- Terminal, Personal & Session mobility

## Network Classification




- Networks are often classed according to how large they are. The classical classes are called LAN, MAN and WAN.
  - A *LAN* (Local Area Network) connects hosts in a single building or across a single campus.
  - A *MAN* (Metropolitan Area Network) connects hosts across a town or a city.
  - A *WAN* (Wide Area Network) connects hosts across a country or the world.

## Uses of LANs, MANs and WANs

- LANs tend to be used for small networks (up to 100 computers).
  - Their small size allows them to be fast because signals are less distorted over small distances.
- MANs are often used to connect LANs in offices across a town or a city.
  - They are also often used to connect LANs to Public Switched Data Networks (i.e. national networks provided by telephone companies for computer data).
- WANs are used to connect computers across a country or the world.
  - The Internet is the most obvious example of a WAN.

Networks can also be classed according to how they work

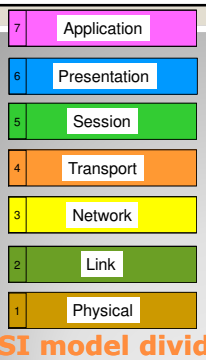
## Networking Technology for Multimedia

- Industrial communication networks can be modeled according to the Open System Interconnection (OSI) model:
  - The International Organization for Standardization (ISO) began developing the Open Systems Interconnection (OSI) model in 1977
  - It is now the most accepted standard for network modeling
  - The OSI model is not a protocol; it is a model for understanding and designing a network architecture that is flexible, robust and interoperable.

Defines rules that apply to the following issues

1. how network devices contact each other
2. how network devices communicate with each other
3. who has the right to transmit data
4. are transmissions received correctly and by the right node
5. how physical media are arranged and connected
6. ensure that network devices maintain a proper rate of data flow
7. how bits are represented on the network media

## Open System Interconnection (OSI) model




All services directly called by the end user (Mail, File Transfer,...) e.g. Telnet, SMTP
→ **everything else!**

Definition and conversion of the data formats (e.g. ASN 1)
→ **how to encode/decode msgs, security**

Management of connections (e.g. ISO 8326)
→ **how to manage connections**

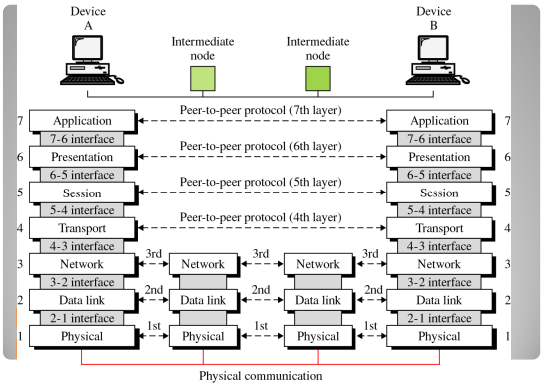
End-to-end flow control and error recovery (e.g. TP4, TCP)
→ **how to send packets reliably**

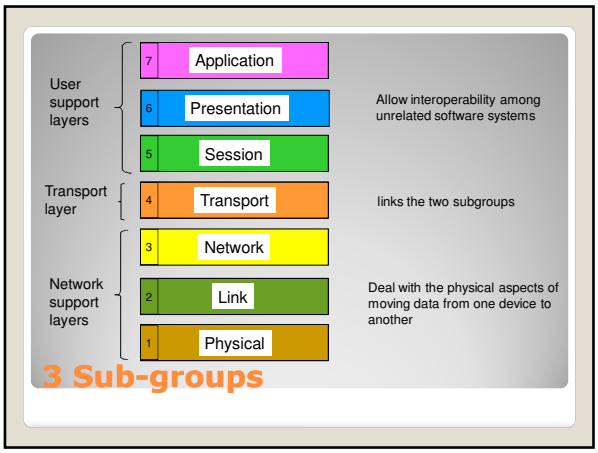
Routing, possibly segmenting (e.g. IP, X25)
→ **how to route packets**

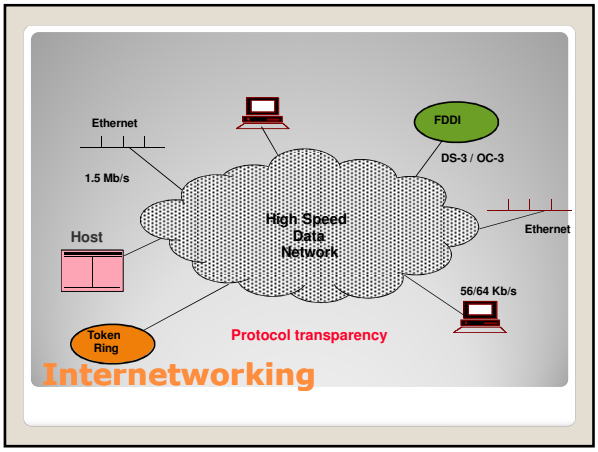
Error detection, Flow control and error recovery, medium access (e.g. HDLC)
→ **how to transmit frames**

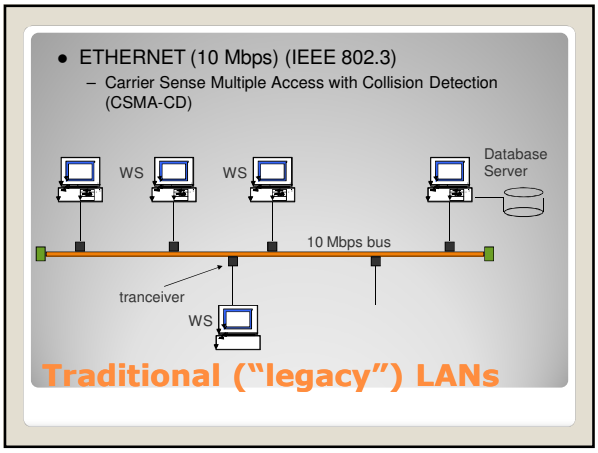
Coding, Modulation, Electrical and mechanical coupling (e.g. RS485)
→ **how to transmit bits**

## OSI model divides tasks into seven layers




User support layers
7 Application
6 Presentation
5 Session
Transport layer
4 Transport
3 Network
Network support layers
2 Link
1 Physical
Allow interoperability among unrelated software systems
links the two subgroups
Deal with the physical aspects of moving data from one device to another
3 Sub-groups


Ethernet
1.5 Mb/s
FDDI
DS-3 / OC-3
High Speed Data Network
Ethernet
Host
56/64 Kb/s
Token Ring
Protocol transparency
Internetworking


ETHERNET (10 Mbps) (IEEE 802.3)
Carrier Sense Multiple Access with Collision Detection (CSMA-CD)
WS
WS
Database Server
10 Mbps bus
tranceiver
WS
Traditional ("legacy") LANs

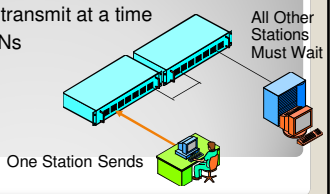
## Networking Devices

- *HUBs* (also called “repeaters”)
  - work at Physical Layer
  - every bit of incoming data will go out to everyone
- *Switches* (also called “bridges”)
  - work at Data Link Layer
  - incoming data is only sent to the named destination, not to all machines on the network
- *Routers*
  - work at Internet Layer
  - when data comes in, chooses best way to send it from possible alternatives (smart)

## Repeaters

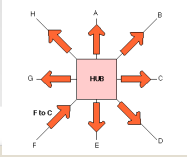
- Regenerate the signal
- Provide more flexibility in network design
- Extend the distance over which a signal may travel down a cable
- Example → Ethernet HUB

- Ethernet is a shared media LAN
  - Only one station can transmit at a time
  - Even in multi-hub LANs
  - Others must wait
  - This causes delay



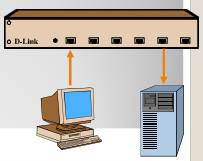

## HUB

- Hubs are a form of repeater which has multiple ports ("multi-port repeaters" or "active star networks")
- Whatever the type of connector, a single hub is only able to connect a group of equipment operating at the same speed (i.e. all equipment connected to a 10BT hub must operate at 10 Mbps)
- Each port (or interface) allows one piece of equipment to be connected to the hub.
- The hub is not able to recognize the addresses in the header of a frame, and therefore is unable to identify which port to send to. Therefore, every frame is sent to every output port.



## Switches

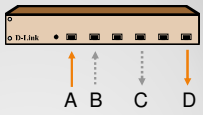
- A bridge stores the hardware addresses observed from frames received by each interface and uses this information to learn which frames need to be forwarded by the bridge.
- Signal comes in one port
- Signal only goes out one port - the receiver's
- No broadcasting
- No blocking of other ports



## Switches

- Multiple conversations can take place simultaneously
- No need to wait!
- unless the receiver's port is busy
- Switches reduce latency and congestion

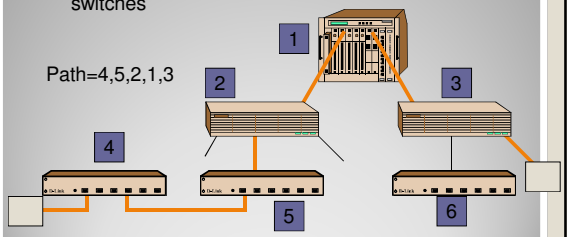
Simultaneous Conversations A-D and B-C



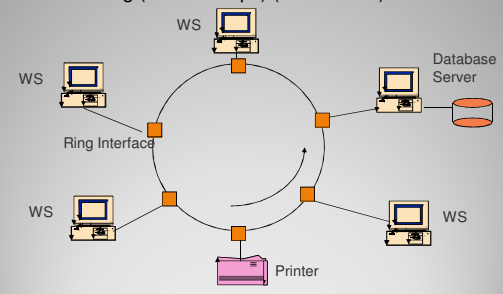

## Switched Ethernet

- Ethernet Switches must be Arranged in a Hierarchy (or daisy chain)
- Only one possible path between any two stations, switches

Path=4,5,2,1,3



- Token Ring (4 or 16 Mbps) (IEEE 802.5)



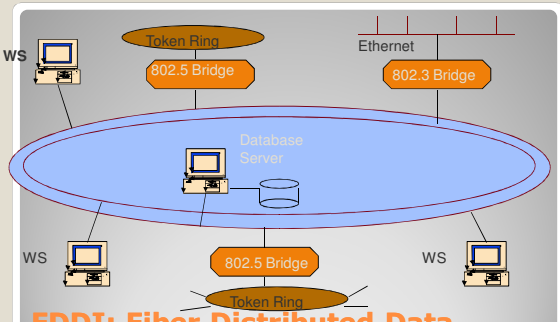

## Traditional ("legacy") LANs

- Physical Medium
  - twisted pairs, coaxial cables or fiber optics
- Operating Speed:
  - 4-16 Mbps

- Token
  - Special bit pattern circulating around the ring when all stations are idle.
  - When a station wants to transmit,
    - (1) it gets and remove the token,
    - (2) then sends and remove the data frame,
    - (3) finally regenerates the token

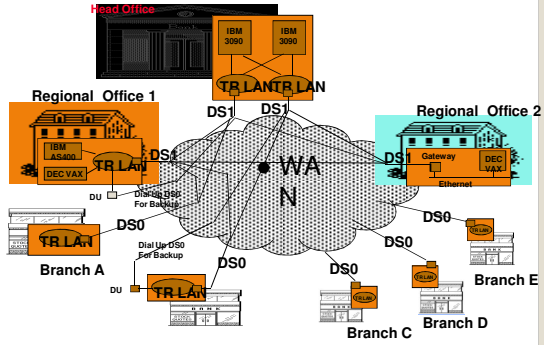
## Token Ring (IEEE 802.5)

100Mbps, distance up to 200km, 100 hosts mainly used as a backbone




## FDDI: Fiber Distributed Data Interface

## Corporate Networking Example




- Terminology
  - wireless communication, radio communications network
  - mobility / mobile communication
- Note
  - Wireless Communication ≠ mobile Communication

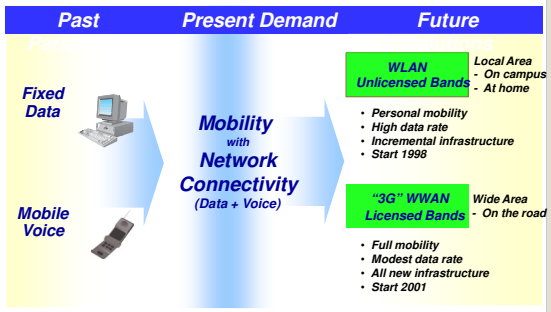
| Connection to net | Access Media | |
|---|---|---|
| | Wired | Wireless |
| Mobile | mobile IP<br>e.g. laptop in the hotel | mobile telephony<br>e.g. laptop in the car<br>PDA at customer site |

## Wireless & Mobile Communication

- Terminal mobility
  - end-device has a unique identifier
  - communication independent from location
  - realized by radio networks
  - mechanisms: handover, location management
  - enables the user to utilize services from both stationary end-devices or from mobile end-devices
- Individual mobility → Concept realized by UPT (Universal Personal Telecommunication)
  - participant has a number identifying him uniquely
  - communication independent from location and end-device
  - participant can use any end-device to receive and to issue calls
- Session mobility
  - participant can interrupt his session and later on continue at a different location

## Levels of Mobility

## Wireless Networking Revolution

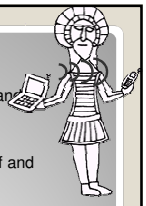



## Wireless Technology

- PAN
  - Bluetooth
  - infrared systems (IR-LAN)
  - Digital European Cordless Telecommunication (DECT)
- LAN
  - HomeRF
  - WiFi - wireless fidelity - (802.11b)
- WAN
  - GSM
  - GPRS
  - UMTS

## Bluetooth

Requirements:



- Goes where users go (global use, 2.4GHz ISM band, airline safe)
- Highly secure (business data)
- High capacity (High interference immunity to itself and others)
- Integrated feature in notebooks, cell-phones and handhelds (low cost, very small, low power)
- Replace the cables common to mobile devices (short range)
- The system must operate worldwide
- The system must support voice and data
- The transceivers must be small and operate at low power.

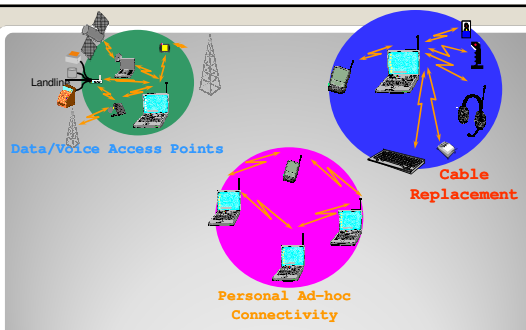
## Bluetooth Primer

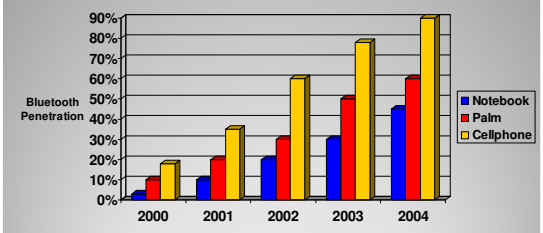
- Low-power, short-range “cable replacement”
  - 720 Kbps
  - 10 meters
  - voice and data support
- Perfect for mobile devices
  - small, low power, and low cost (Goal: $5 parts cost), but good performance
- Interconnecting a computer and peripherals
  - Clear the snake’s nest behind the desk!
- Interconnecting various handheld devices
  - Laptop computer, cell phone, palmtop
  - Preplanning of network is impractical

## A little bit of history

- The Bluetooth SIG (Special Interest Group) was formed in February 1998 by 5 promoter companies
  - Ericsson,IBM, Intel, Nokia, Toshiba
- The Bluetooth SIG went “public” in May 1998
- The Bluetooth SIG work (the spec: 1,600+ pages) became public on July 26, 1999 (ver. 1.0A)
  - ver. 1.0B was released on December 6, 1999
  - ver. 1.1 was released on March 1, 2001
- The promoter group increased in December 1999 to nine
  - added: 3Com, Lucent, Microsoft, Motorola
- There are 10,000 adopters (as of 9/25/2008)
  - adopters enjoy royalty free use of the Bluetooth technology

## What does Bluetooth do for you & me?






## Bluetooth Penetration by Device Type

- A short-range wireless technology: a couple of meters
- Low-cost, reasonable data rate: 4 MBit/s (IRDA 2.0)
- Pushed by Hewlett-Packard
- Most laptops adopted it
- Lots of cell phones and most palmtops have it
- But no software for general connectivity
- Even HP printers don't have IR ports!
- MORAL: a very nonlinear process
  - Value is low until most devices have it (cf. adoption of fax)
  - People won't bother with it until probability of benefit is high
- +cheap technology
- +no license required
- - low transmission range (a couple of meters)

- (large transmission range possible only with laser in point-to-point mode)

## Deja Vu: Remember Infra-Red?

| | | |
|---|---|---|
| **Topology** | Supports up to 7 simultaneous links | Each link requires another cable |
| **Flexibility** | Goes through walls, bodies, cloths... | Line of sight or modified environment |
| **Data rate** | 720 Kbps | Varies with use and cost |
| **Power** | 0.1 watts active power | 0.05 watts active power or higher |
| **Size/Weight** | 25 mm x 13 mm x 2 mm, several grams | Size is equal to range. Typically 1-2 meters. Weight varies with length (ounces to pounds) |
| **Cost** | Long-term $5 per endpoint | ~ $3-$100/meter (end user cost) |
| **Range** | 10 meters or less<br>Up to 100 meters with PA | Range equal to size. Typically 1-2 meters |
| **Universal** | Intended to work anywhere in the world | Cables vary with local customs |
| **Security** | Very, link layer security, SS radio | Secure (its a cable) |

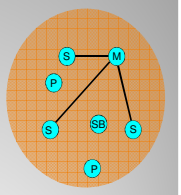
## Cable Replacement

## Technology Specifications

- **License Free band**
  - The 2.45 GHz ISM band
  - Ranges from 2.400 GHz to 2.4835 GHz
- **Frequency Hopping**
  - Considerable interferences (license free)
  - Apply spread spectrum techniques beyond 0 dBm power
  - Uses Frequency hopping spread spectrum (low cost and low power)
  - Slotted Bandwidth: 79 hop frequencies, 1 MHz each, 625µsec hop intervals (1600 hops/sec)
  - 10-meter range.
  - Up to 1 Mbps data rate.

## What is a Piconet?

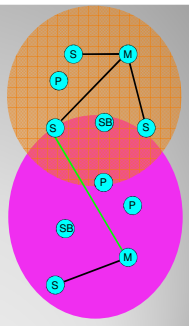
- A collection of devices connected in an ad hoc fashion.
- One unit will act as a master and the others as slaves for the duration of the piconet connection.
- Master sets the clock and hopping pattern.
- Each piconet has a unique hopping pattern/ID
- Each master can connect to 7 simultaneous or 200+ inactive (parked) slaves per piconet



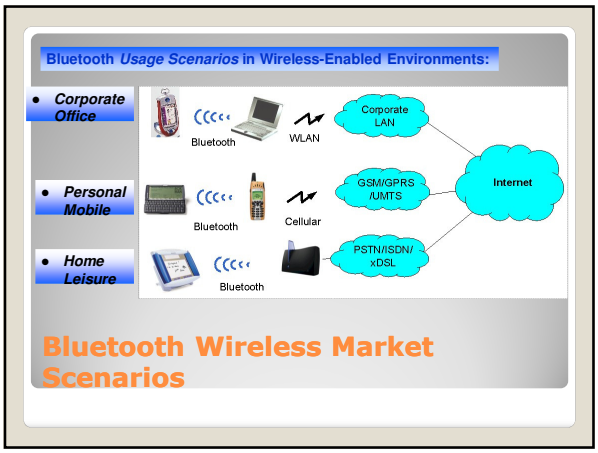

M=Master P=Parked
S=Slave SB=Standby

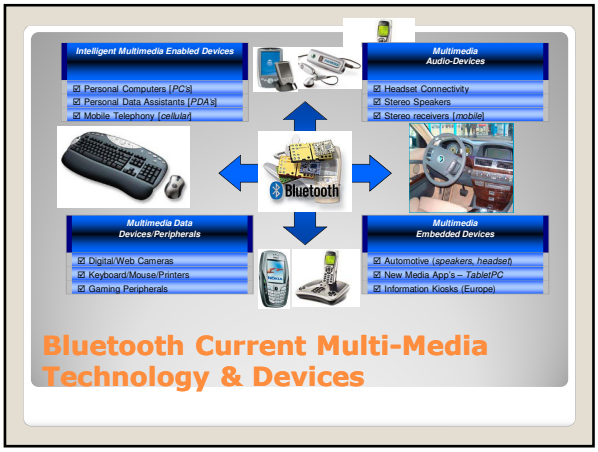
## What is a Scatternet?

- A Scatternet is the linking of multiple co-located piconets through the sharing of common master or slave devices.
- A device can be both a master and a slave
- Radios are symmetric (same radio can be master or slave)
- High capacity system, each piconet has maximum capacity (720 Kbps)

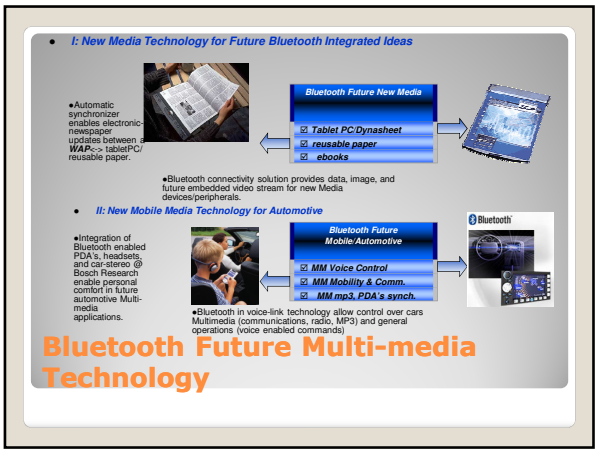


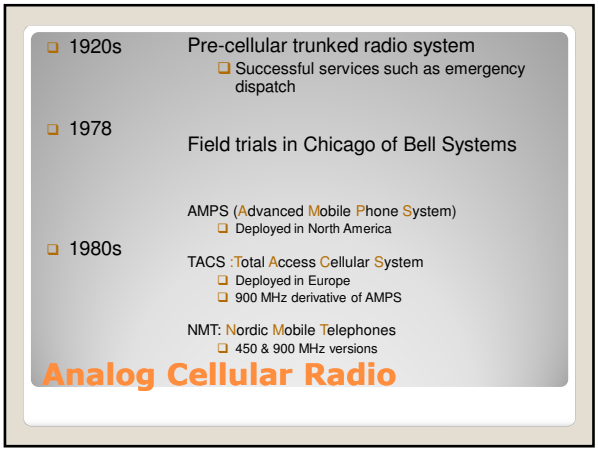

M=Master P=Parked
S=Slave SB=Standby

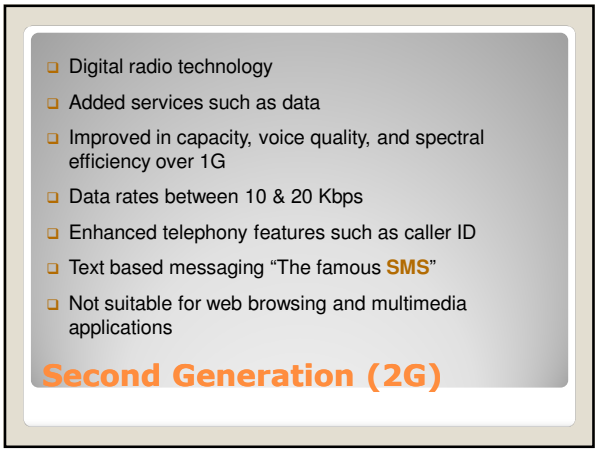

Bluetooth Usage Scenarios in Wireless-Enabled Environments:
Corporate Office
Personal Mobile
Home Leisure
Bluetooth
WLAN
Corporate LAN
Internet
GSM/GPRS /UMTS
Cellular
PSTN/ISDN/ xDSL
Bluetooth Wireless Market Scenarios


Intelligent Multimedia Enabled Devices
Personal Computers [PCs]
Personal Data Assistants [PDAs]
Mobile Telephony [cellular]
Multimedia Audio-Devices
Headset Connectivity
Stereo Speakers
Stereo receivers [mobile]
Bluetooth
Multimedia Data Devices/Peripherals
Digital/Web Cameras
Keyboard/Mouse/Printers
Gaming Peripherals
Multimedia Embedded Devices
Automotive (speakers, headset)
New Media App's – TabletPC
Information Kiosks (Europe)
Bluetooth Current Multi-Media Technology & Devices


Transfer of digital media to Bluetooth printers/scanners
Digital Camera Printing Kiosks and Printing
Transfer of digital media for commercial printing
MP3 player – Music applications - Video streams and Games
Automated Vending Machines Wireless Transfers
Transfer of MP3 and Streaming media between Bluetooth devices
Concept of mCommerce technology
Bluetooth Current Multi-Media Applications


I: New Media Technology for Future Bluetooth Integrated Ideas
•Automatic synchronizer enables electronic-newspaper updates between a WAP<-> tabletPC/ reusable paper.
Bluetooth Future New Media
Tablet PC/Dynasheet
reusable paper
ebooks
•Bluetooth connectivity solution provides data, image, and future embedded video stream for new Media devices/peripherals.
II: New Mobile Media Technology for Automotive
•Integration of Bluetooth enabled PDA's, headsets, and car-stereo @ Bosch Research enable personal comfort in future automotive Multi-media applications.
Bluetooth Future Mobile/Automotive
MM Voice Control
MM Mobility & Comm.
MM mp3, PDA's synch.
•Bluetooth in voice-link technology allow control over cars Multimedia (communications, radio, MP3) and general operations (voice enabled commands)
Bluetooth Future Multi-media Technology


1920s
Pre-cellular trunked radio system
Successful services such as emergency dispatch
1978
Field trials in Chicago of Bell Systems
1980s
AMPS (Advanced Mobile Phone System)
Deployed in North America
TACS :Total Access Cellular System
Deployed in Europe
900 MHz derivative of AMPS
NMT: Nordic Mobile Telephones
450 & 900 MHz versions
Analog Cellular Radio


Digital radio technology
Added services such as data
Improved in capacity, voice quality, and spectral efficiency over 1G
Data rates between 10 & 20 Kbps
Enhanced telephony features such as caller ID
Text based messaging "The famous SMS"
Not suitable for web browsing and multimedia applications
Second Generation (2G)

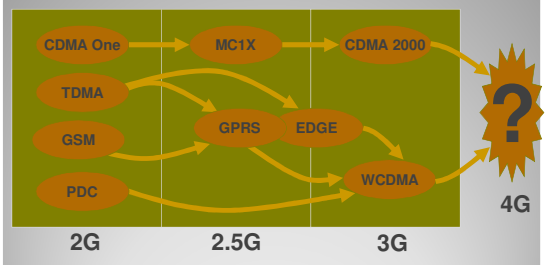
## 2G Technologies

- TDMA: Time Division Multiple Access
  - 30 KHz channels
  - used in North and South America
- CDMA: Code Division Multiple Access
  - 1.25 MHz bad
  - used allover the globe (started in USA)
- PDC: Personal Digital Cellular
  - Used only in Japan

## 2G Technologies (contd.)

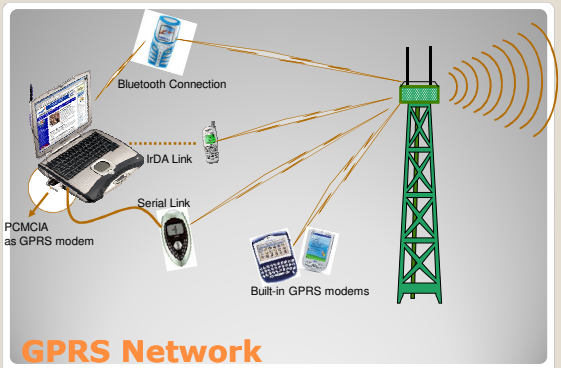
- GSM: Global System for Mobiles
  - Combination of FDMA and TDMA
  - Started in Europe
  - Uses 900, 1800, 1900 MHz bands
  - Bands divided into 200 KHz carrier frequencies
  - Each carrier frequency is divided into 8 time slots or channels
- 1995 5.5 million users in 60 countries
- 2000 270 million users in Europe alone!

## Wireless Communications Evolution

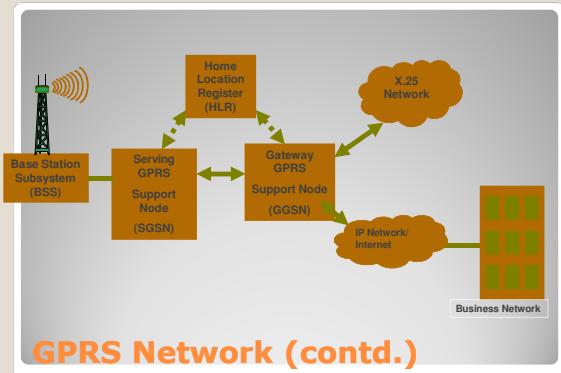


- An extension of GSM & TDMA toward 3G
- Packet-based data service
  - Supplement to circuit switched network
  - More spectrum efficient
- Improved quality of data service
  - Faster (max of 171.2 Kbps → real 56Kbps)
  - Robust
  - Security support
- Immediacy
  - Always-on connection
- Allow IP-based architecture

## GPRS: General packet radio service




## GPRS Network




## GPRS Network (contd.)

## GPRS Applications

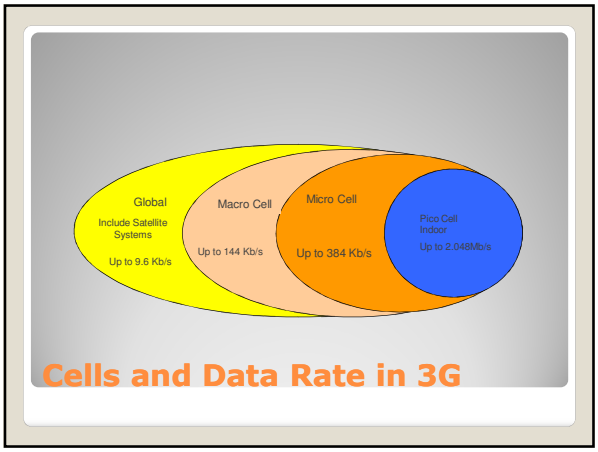
- Communications
  - Email
  - Fax
  - Internet Access
  - Unified messaging
- Advertising
- E-commerce
  - Retail
  - Packet purchasing
  - Banking
  - Financial trading
- Location-based Applications
  - Location finder
  - Airline/rail schedules
- Value Added Services (VAS)
  - Information services
  - Games
- Vertical Applications
  - Fleet management
  - Sales-force automation

## EDGE: Enhanced Data GSM Environment

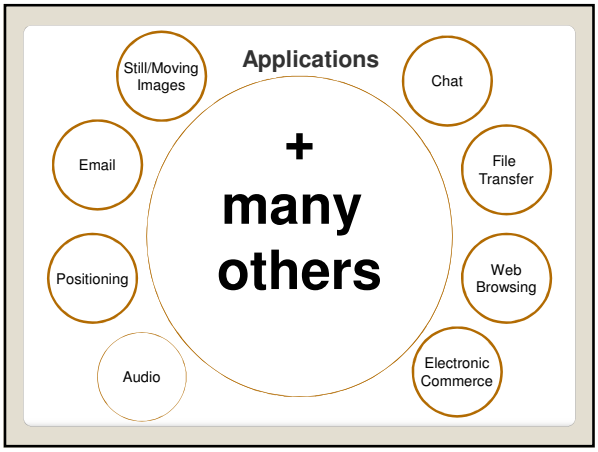
- It is an add-on to GPRS
- Method to increase data rates on GSM radio links (384 Kbps)
- Increase spectrum efficiency
- Facilitate new applications

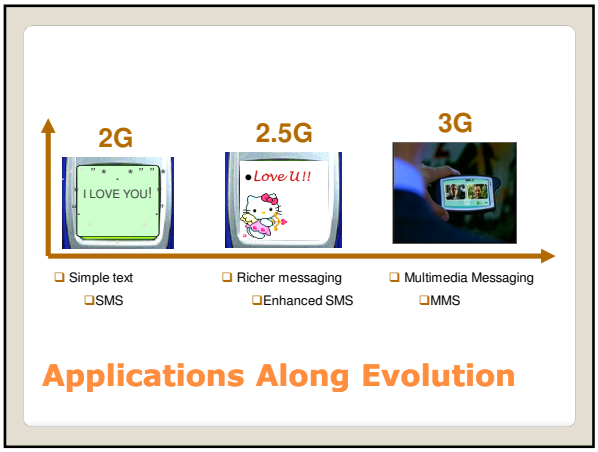
## CDMA: Code Division Multiple Access

- It allows frequency reuse
- Security
- Soft Handoff
- Multiple Access Capability
- Efficient power control




## Cells and Data Rate in 3G




## Applications Along Evolution

## 4G: What is 4G?

Is a **VISION** or **CONCEPT** to be discussed by governments, research organizations and wireless venders

No official definition…

4G means different things to different people

## Some Suggestions

- WLANs + 2.5G/3G?
  - Mobile on the move
    - Applications: Voice, SMS/E-mail, stock quotes, weather, time-tables, driving directions, bank accounts, yellow pages, delayed flights ...
    - High mobility, lower bandwidths
  - Semi-Mobile i.e. WLAN
    - Laptop or PDA download of e-mail and files
    - Low mobility, high bandwidths
- Some new radio interface (e.g. UWB) ?

## 4G Characteristics

- Use smaller cell size than 3G
- Will be far cheaper than 3G
- Convergence of cellular with IPv6, cable TV, PC, ATM, etc.
- Smooth transition from 3G
- Coexist with 3G and 2G