Wireless Communications

(Unit 4)

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

- TACS (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

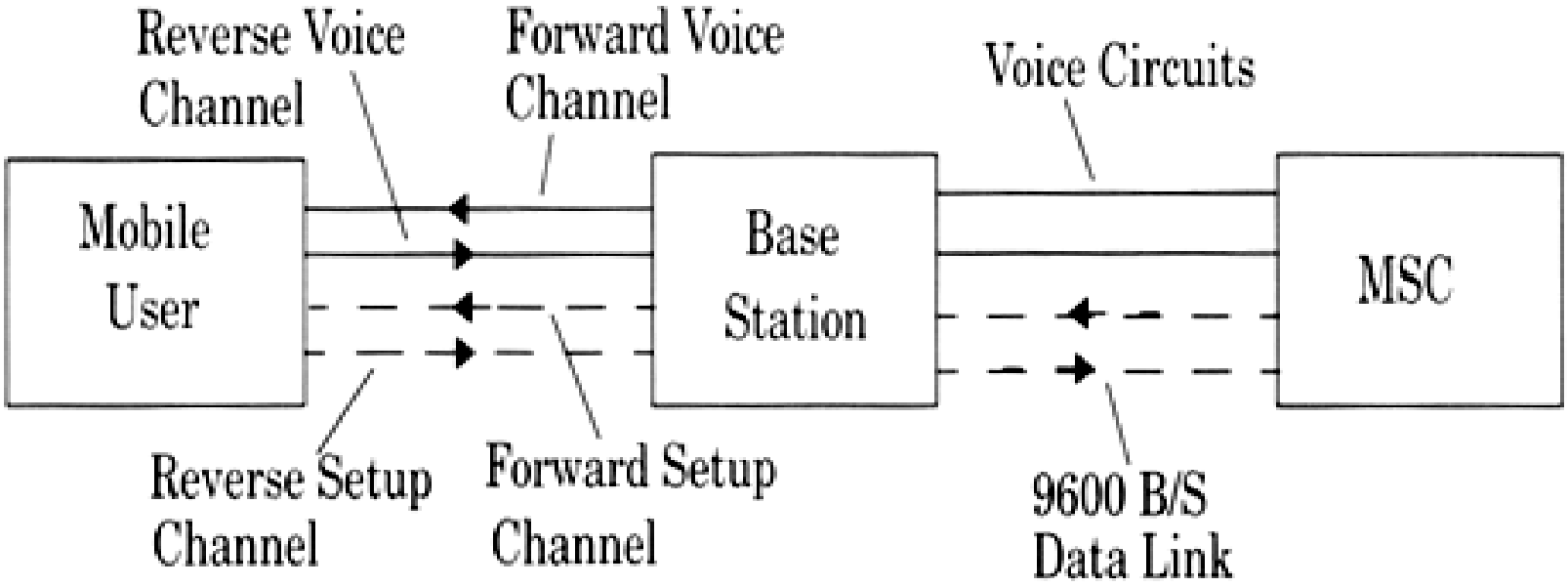


Figure 10.4 Communication signaling between mobile, base station, and MSC in first generation wireless networks.

Limitations of AMPS

LOW CALLING CAPACITY.

LIMITED SPECTRUM.

NO ROOM FOR SPECTRUM GROWTH.

POOR DATA COMMUNICATIONS.

SECOND GENERATION (2G)

- Early 1980s saw many competing analog technologies.
- Because of the shortcomings and incompatibility issues associated with analog systems, a completely new digital solution was instituted.
- The first **GSM** system was launched in late 1991 (almost a decade prior to launch of first 3G network).

SECOND GENERATION (2G)

- GSM is based on combination of FDMA and TDMA
- While most of 2G networks were based on FDMA and TDMA, **QUALCOMM** designed a CDMA scheme known as **IS-95**.
- IS-95 uses separate codes to distinguish between data transmitted by different uses on the same frequency.
- IS-95 is popular in SOUTH KOREA and UNITED STATES and offered tough competition to GSM technology.
- While majority of country opted GSM, **PDC** gained immense popularity in JAPAN.
- Another 2G system popular in NORTH AMERICA is US-TDMA (D-AMPS) which digital version of 1G AMPS technology.

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

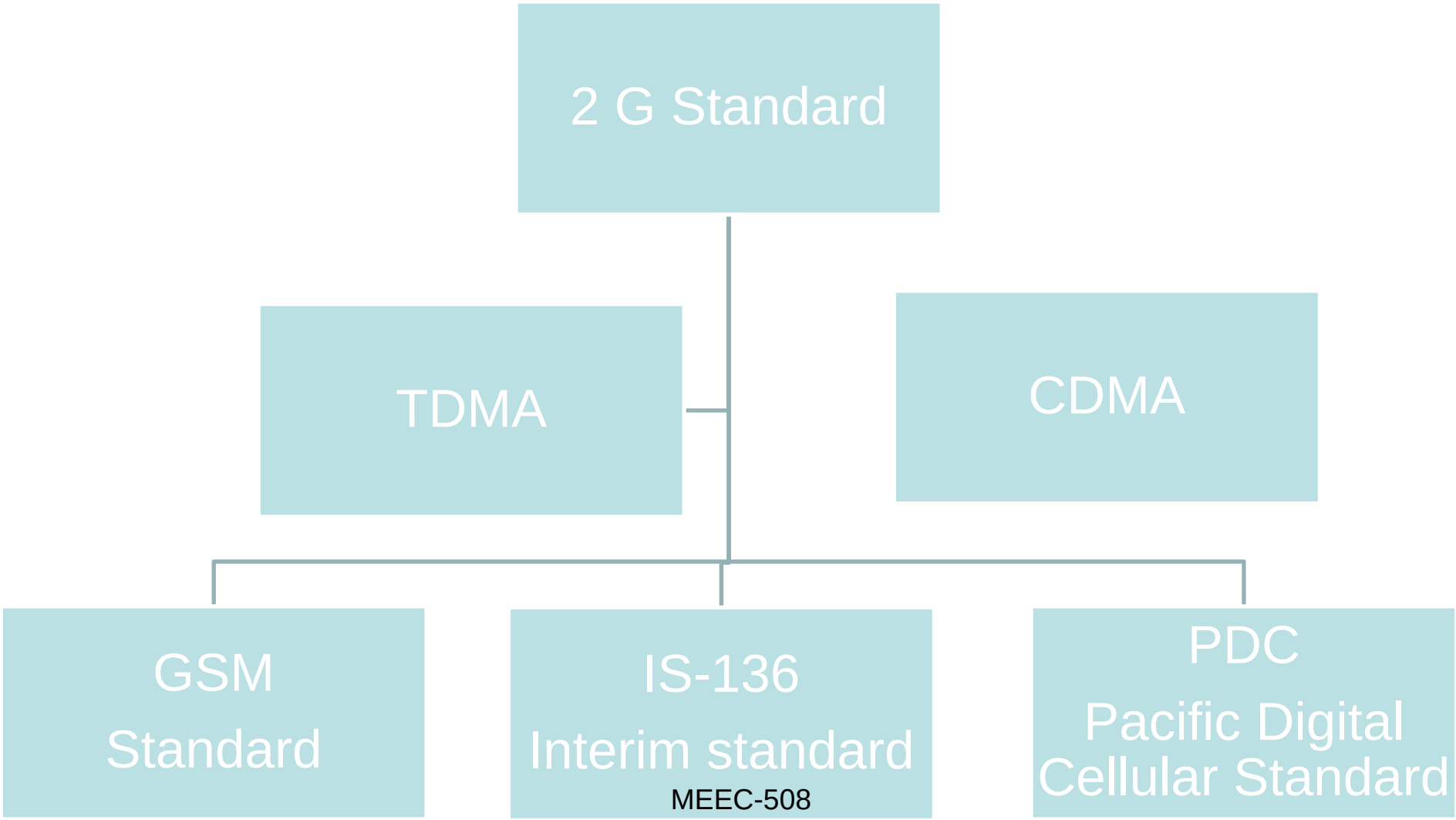
GSM FEATURES

- 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.

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.
- 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 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.

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
- Beyond voice, paging, data service such as fax, high data rate
- More flexibility in channel allocation scheme

Chronology of 2G wireless system

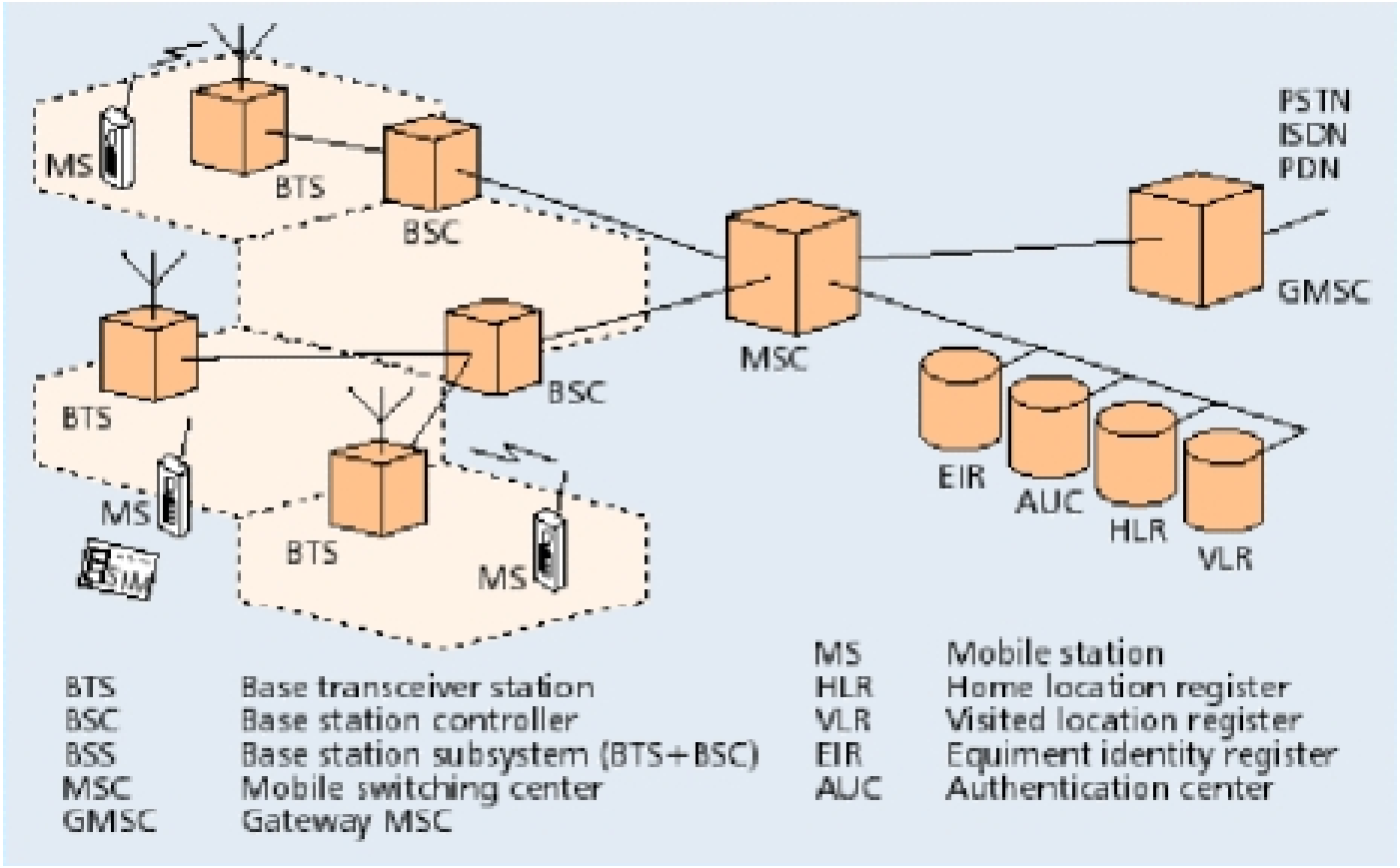
- 1982:CEPT established GSM to define future Pan-European Cellular Radio.
- 1990: IS-54(USDC) adopted by TIA.
- 1990: IS-19B (NAMPS)adopted by TIA
- 1991:Japanese PDC system standardized by the MPT.
- 1992: Phase I GSM system is operational.
- 1993: IS-95 (CDMA) adopted by TIA.
- 1994: IS-136 adopted 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

GSM ARCHITECTURE



GSM Network Components

- Mobile Station
  - SIM
  - Mobile Equipment
- Access Network
  - Base Transceiver Station (BTS)
  - BSC (Base Station Controller)
  - TRAU (Transcoding and Rate Adaptation)
- Core Network
  - Home Location Register (HLR)
  - Authentication Center (AuC)
  - Equipment Identity Register (EIR)
  - Short Message – Service Center (SM-SC)
  - Mobile Switching Center (MSC)/Visitor Location Register (VLR)
  - Gateway Mobile Switching Center (GMSC)

Base Transceiver Station (BTS)

- Interfaces with BSC on Abis interface and with MS on Um Interface
- Takes care of air interface signaling, speech processing and ciphering etc to ensure error free connection between MS and BTS
- It consists of radio transmitter & receiver, antennas and signal processing specific to radio interface

BTS Functions

- Modulation/De-modulation
- Channel Coding/Decoding
- Interleaving
- Encryption/Ciphering
- Frequency Hopping
- TRAU Frame Formatting
- BCCH management
- Signal Strength Measurement for active connections
- Idle Channel Measurements on free channels

Base Station Controller (BSC)

- Controls the radio network
- Main responsibilities are
  - Controls all BTS under its purview. This includes:
    - O&M (Configuration, alarm handling, etc.)
    - Resource Management
  - Connection establishment between MS and NSS
  - Mobility Management
  - Receiving Measurement reports from BTS and performing handover related decisions
  - Air and A interface signaling support

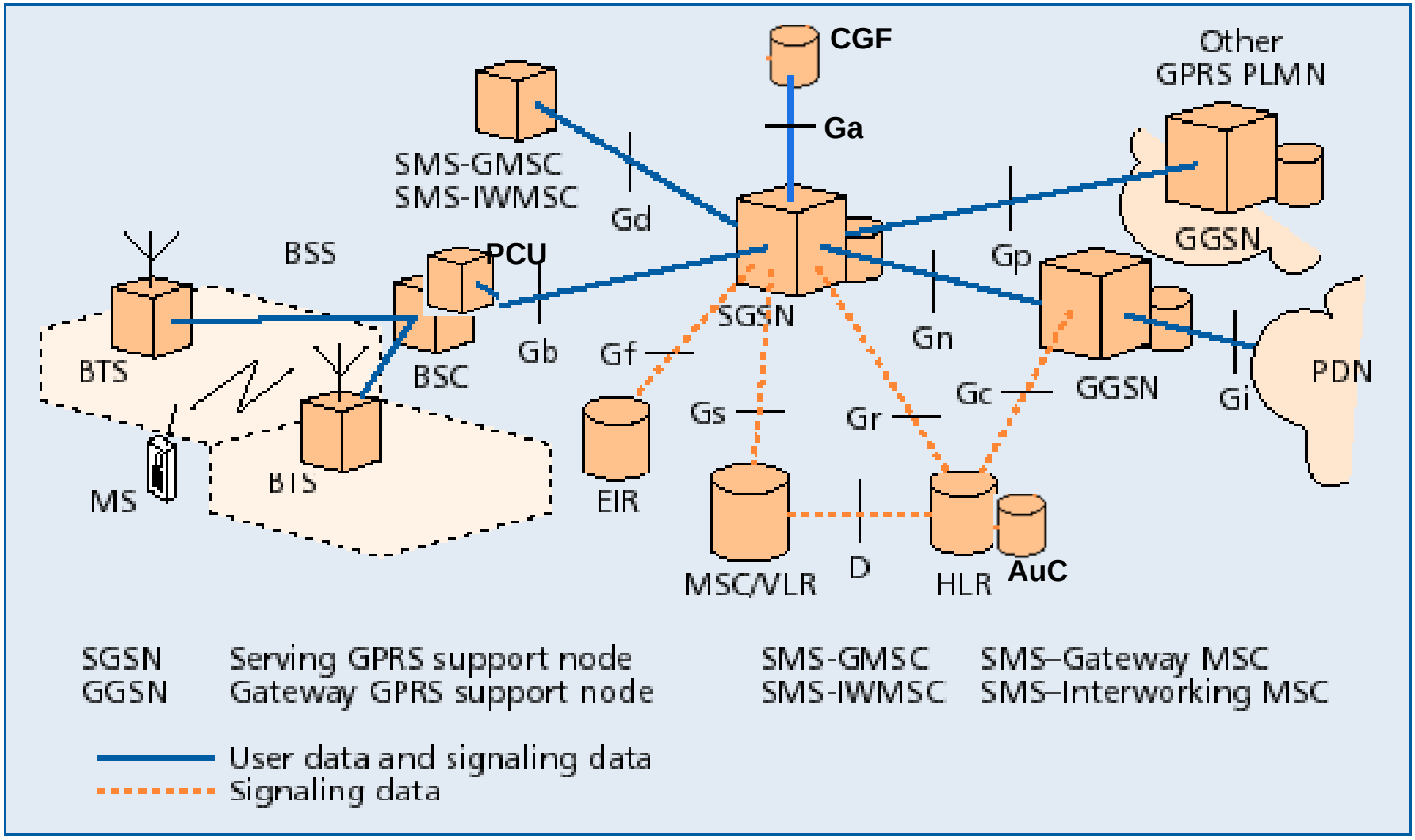
Mobile Switching Center (MSC)

- The MSC interfaces between the access and core network.
- MSC performs all functions necessary to handle the circuit switched services to and from the MS.
- An MSC can interface with multiple access networks.

Gateway Mobile Switching Center

- Similar to MSC
- Switches voice cells.
- Provides external interface with PSTN and other mobile networks

GPRS Network Architecture



Mobile Station

- Comprises of two separate units, viz. SIM and ME.
- The Structure provides terminal mobility.
- Subscriber Identity Module (SIM): Belongs to the operator (e.g. Bharti, Hutch).
  - Contains the permanent data of subscriber (e.g. IMSI).
- Mobile Equipment is developed by equipment manufacturers (e.g. Nokia, Alcatel).
  - Contains Mobile Termination and User Interface functions.
  - Communicates with SIM
- A totally new subscriber terminal is required to access GPRS services. These new terminals will be backward compatible with GSM for voice calls.

Base Transceiver Station

- Interfaces with BSC on Abis interface and with MS on Um Interface
- Takes care of air interface signaling to ensure error free data transfer between MS and BTS
- It consists of radio transmitter & receiver, antennas and signal processing specific to radio interface
- Main Functions:
  - Modulation/De-modulation
  - Channel coding and decoding
  - RF transmit and receive circuits (Power control, Frequency Hopping, Antenna Diversity)

Base Station Controller (BSC)

- Interfaces with SGSN through Gb interface
- Interfaces with BTS through Abis interface
- Main responsibilities are
  - Connection establishment between MS and NSS
  - Manages radio resources for one or more BTS
  - Allocation and release of radio channels
  - Frequency hopping
  - Power control algorithm
  - Handover management

Packet Control Unit

- PCU provides a physical and logical interface for packet data traffic.
- PCU can be located at
  - BTS or
  - BSC or
  - SGSN
- PCU located at BSC or SGSN site is called **Remote PCU**
- PCU communicates with the Channel Codec Unit (CCU) at BTS.

Serving GPRS Support Node

- Interfaces with BSS (Gb) and with GGSN through (Gn/Gp)
- Responsible for the delivery of data packets from and to the mobile stations within its service area.
- Communicates to HLR for getting GPRS subscriber data
- Functions of SGSN include
  - Packet routing and transfer,
  - Mobility management (attach/detach and location management),
  - Logical Link management,
  - Authentication
  - Charging functions
- The database of the SGSN stores Location information (e.g., current cell, current VLR), Registered GPRS subscriber profiles (e.g., IMSI, PDP address(es), etc.).

Gateway GPRS Support Node

- GGSN is an interface between the GPRS backbone network and the external packet data networks.
- GGSN forwards outgoing packets to the external PDN
  - Converts the GPRS packets coming from the SGSN into the appropriate packet data protocol (PDP) format (e.g., IP or X.25)
- GGSN forwards incoming packet from external PDN to SGSN of the addressed MS
  - PDP addresses of incoming data packets are used to determine the destination.
  - The packets are then tunneled to the responsible SGSN.
- GGSN stores the current SGSN address of the user and subscriber profile in its location register.
- GGSN also performs charging functions.

MSC

- Mobile Switching Center (MSC)
  - A Mobile Switching Centre is a telecommunication switch or exchange within a cellular network architecture
  - Capable of inter-working with location databases.
  - No direct involvement to GPRS network
  - Forwards CS paging for a GPRS attached MS (Gs interface)

WHY 3G

- Limitation from older systems.
  - No or minimum standardization.
  - Restricted Mobility.
  - Poor support for packet-based data services.
  - Networks built mainly to offer Voice-based services.
  - Very low data rates.
- Need for multimedia services.
- QoS Reasons.

3G Technologies

- 3G evolution of GSM, IS-136, PDC leads to Universal Mobile Telecommunication System(UMTS) under 3GPP

- 3G evolution for CDMA leads to CDMA2000 (3GPP 2)

a) CDMA2000-1xRTT

b) CDMA2000-1xEV, DV, DO

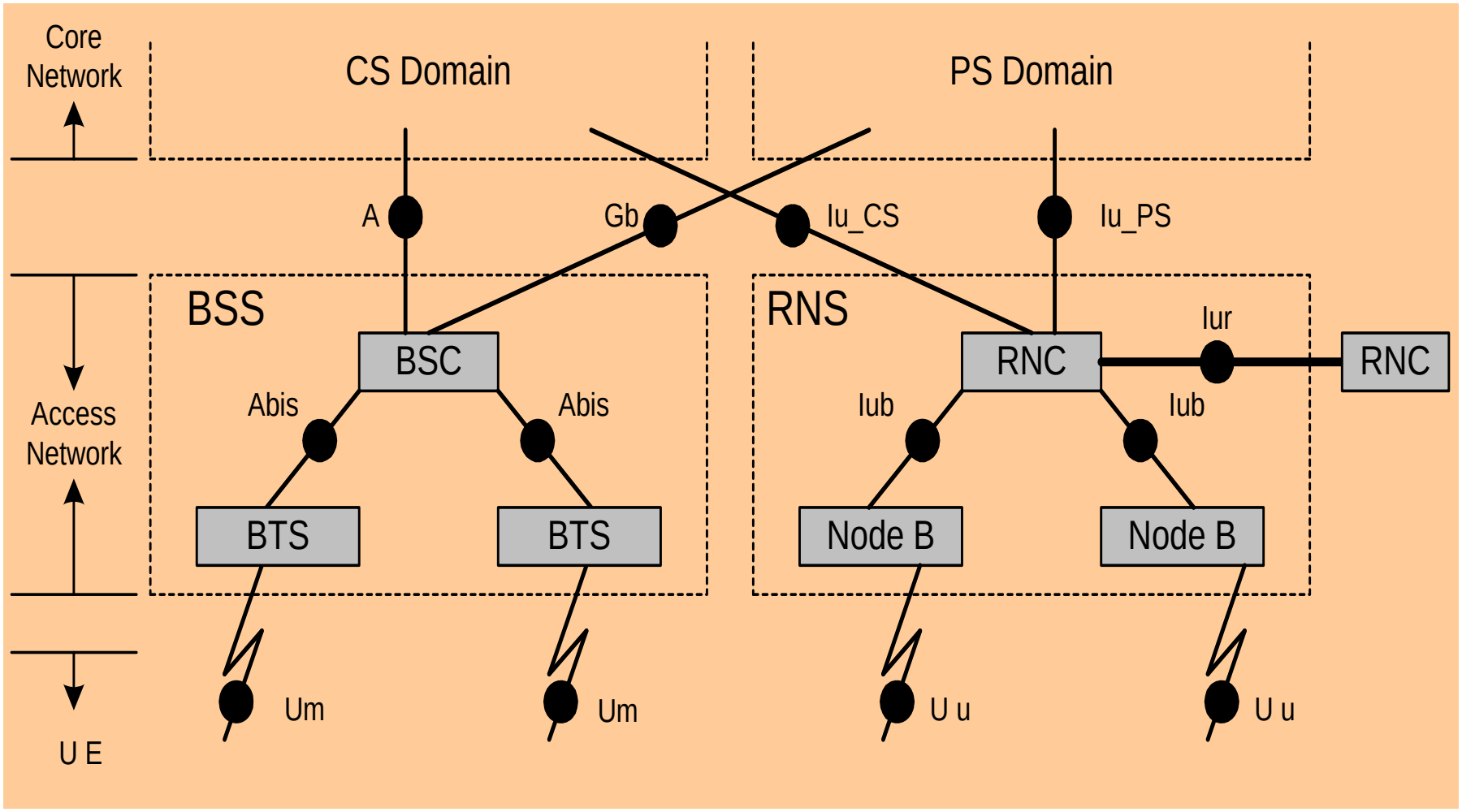
c) CDMA2000-3xRTT

EV: Evolutionary advancement of CDMA2000

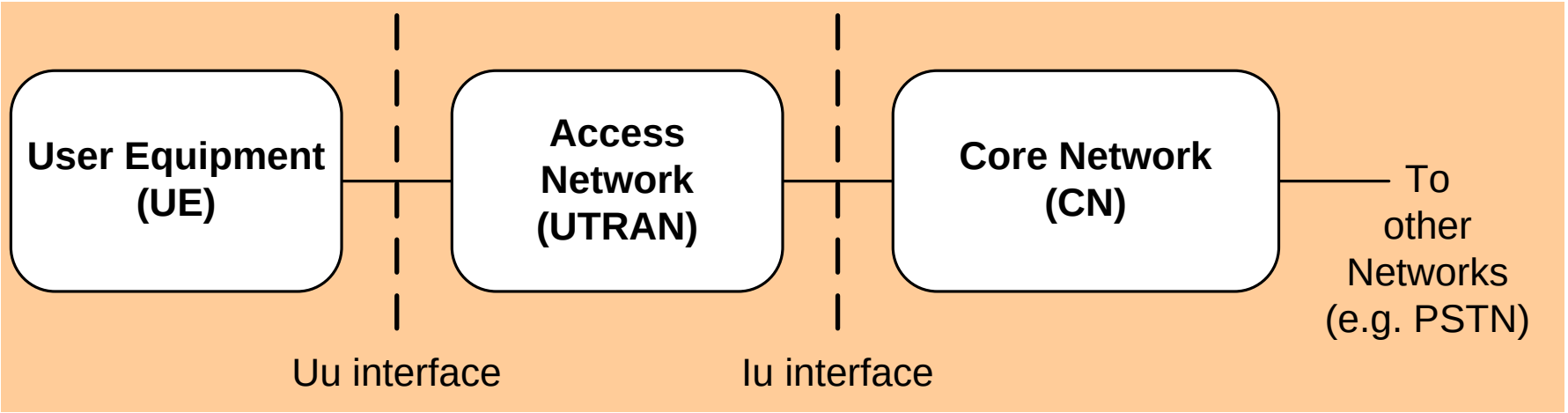
DV: data & Voice

DO: Data Only

UMTS (3G) Architecture



UMTS Network Architecture

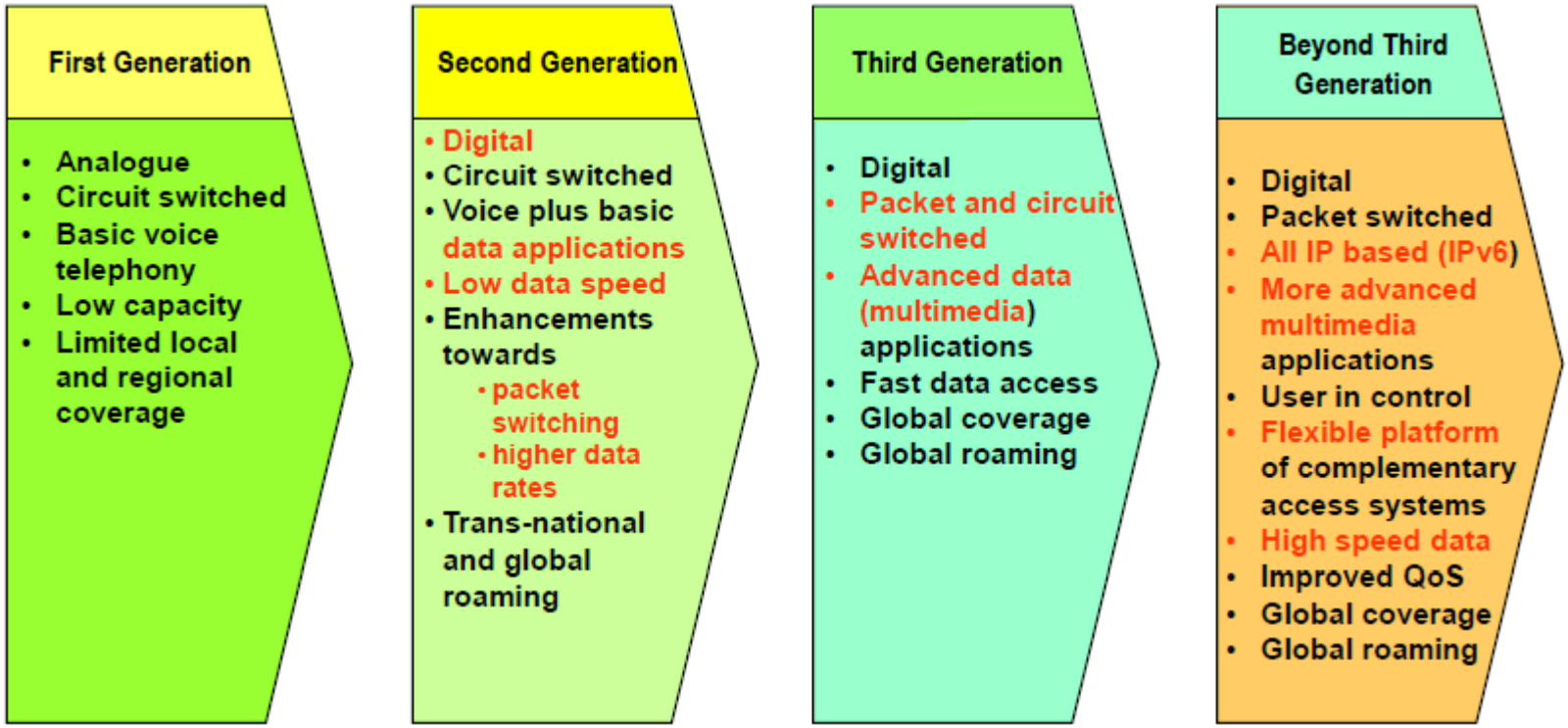


- A typical UMTS network can be modeled as comprising of three basic parts:
  - User Equipment (UE)
  - Access Network (UTRAN)
  - Core Network (CN)

Radio Network Subsystem

- Radio Network Controller (RNC): Controls one or more Node B. The important functions performed by RNC include:
  - Radio Resource Management,
  - Control of Node B,
  - Encryption/Decryption,
  - Admission control and
  - Downlink power control and uplink outer loop power control.
- Node B: Node B provides services in a cell. The important functions performed by Node B include
  - Channel Coding,
  - Rate Matching
  - Spreading/Despreading
  - Inner-loop power control

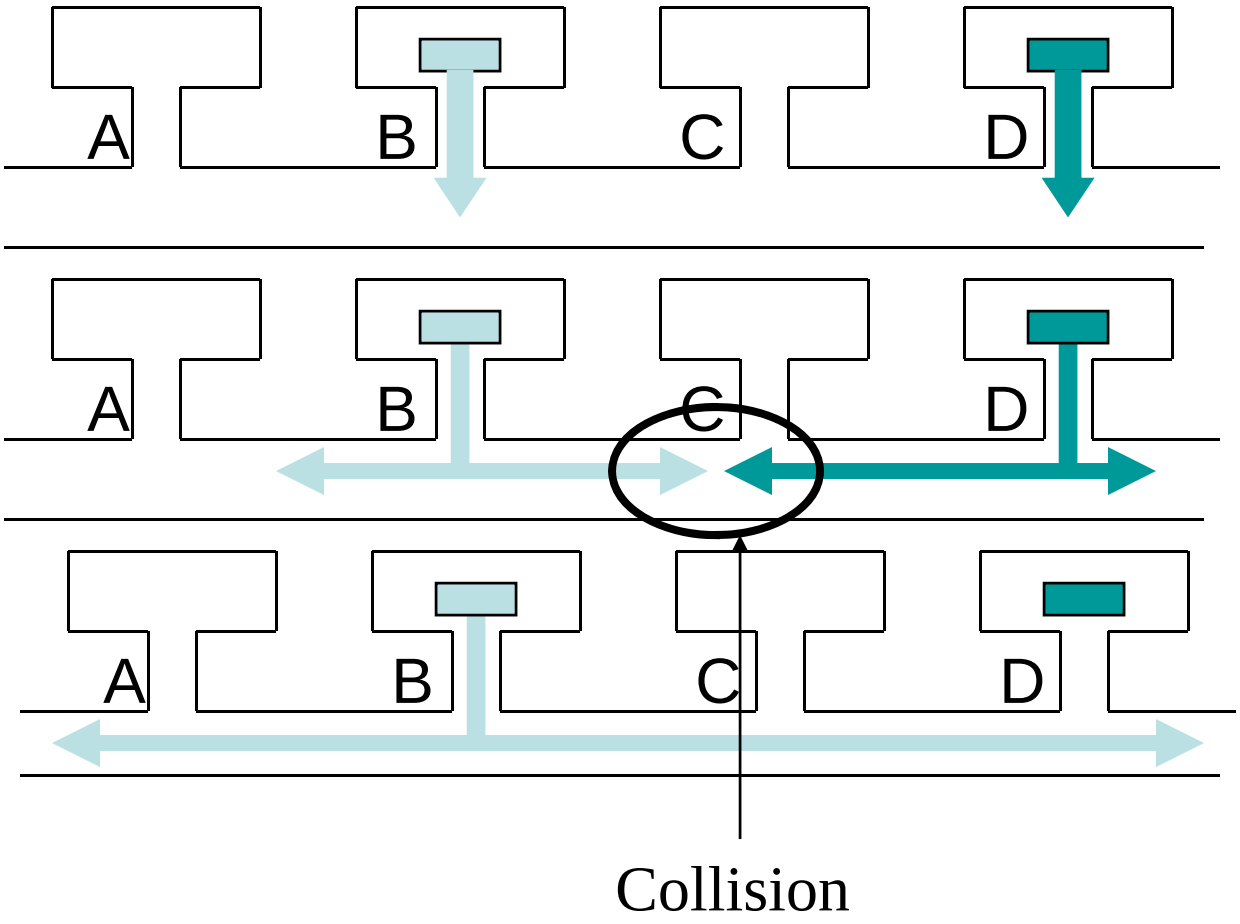
Paradigm From 1G to Beyond 3G



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



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

Thank You