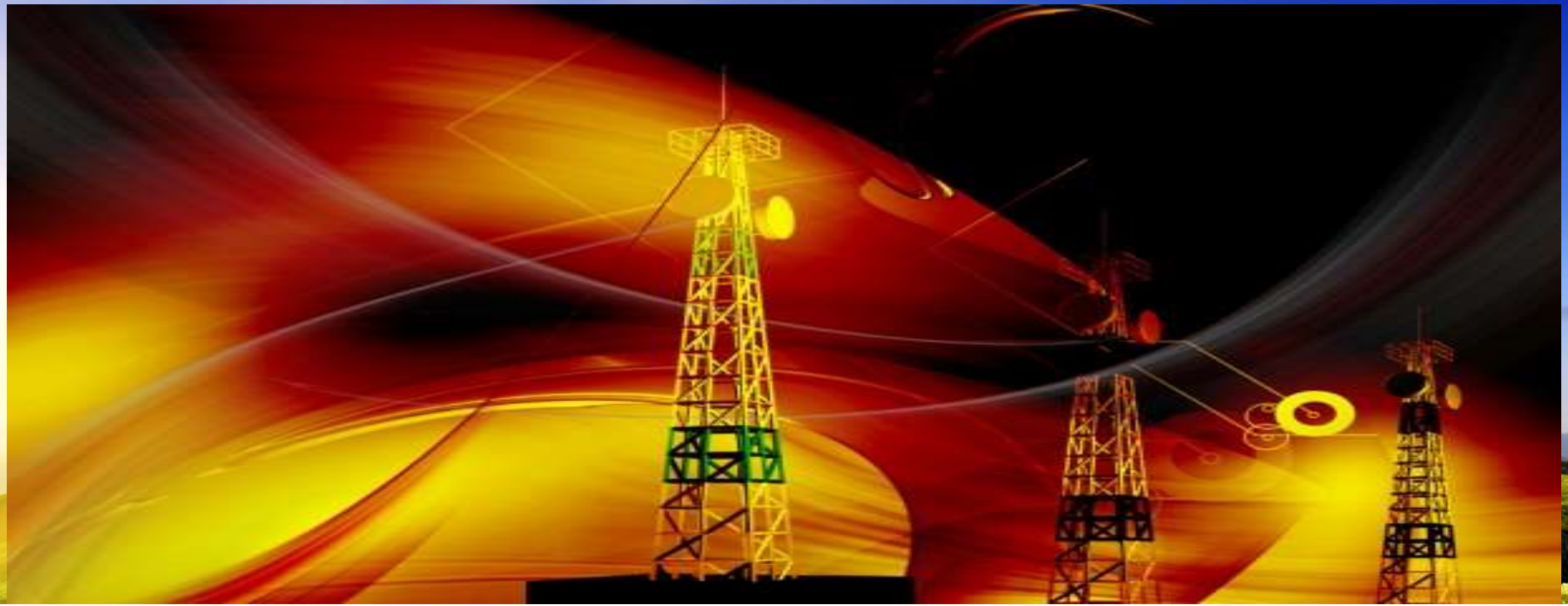

APPLICATIONS OF TELECOM

WIRELESS COMMUNICATION : Lecture 3

Ahmad Bilal
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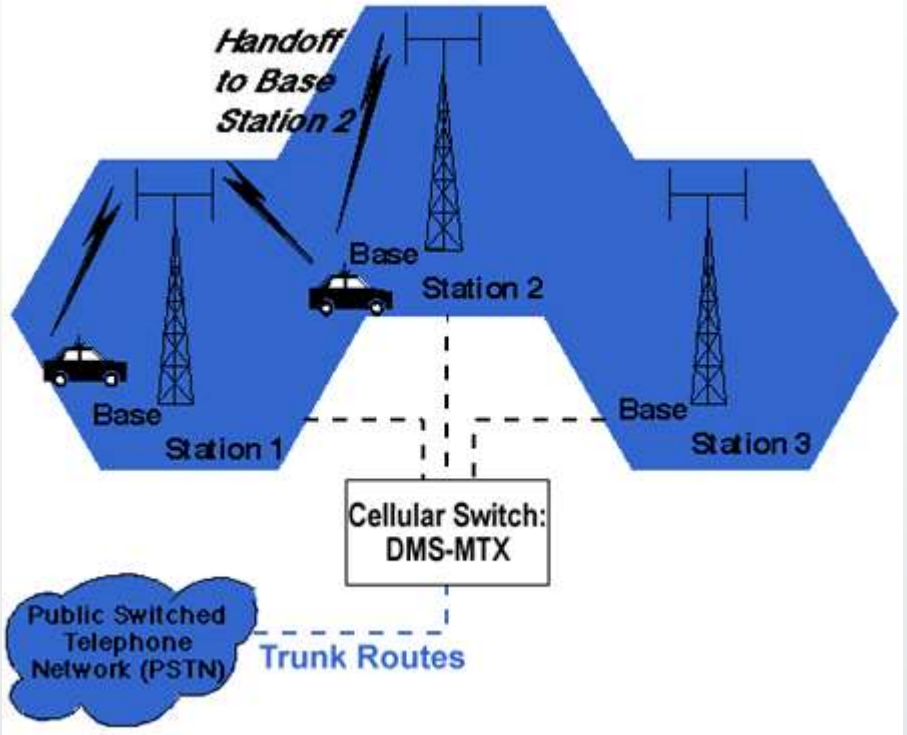
What is Mobility

- Initially Internet and Telephone Networks is designed assuming the user terminals are static
  - No change of location during a call/connection
  - A user terminals accesses the network always from a fixed location
- Mobility and portability
  - Portability means changing point of attachment to the network offline
  - Mobility means changing point of attachment to the network online

Degrees of Mobility : Challenge

- Walking Users
  - Low speed
  - Small roaming area
  - Usually uses high-bandwith/low-latency access
- Vehicles
  - High speeds
  - Large roaming area
  - Usually uses low-bandwidth/high-latency access
  - Uses sophisticated terminal equipment (cell phones)



What is PCS
Personal Communication Services

What is PCS

- Personal Communication Services
  - A wide variety of network services that includes wireless access and personal mobility services
  - Provided through a small terminal
  - Enables communication at any time, at any place, and in any form.
- The market for such services is tremendously big
  - Think of cell-phone market

Several PCS systems

- High-tier Systems
  - GSM: Global System for Mobile Communications
    - The mobile telephony system that we are using
  - IS-95 cdmaOne System
    - CDMA based multiple access

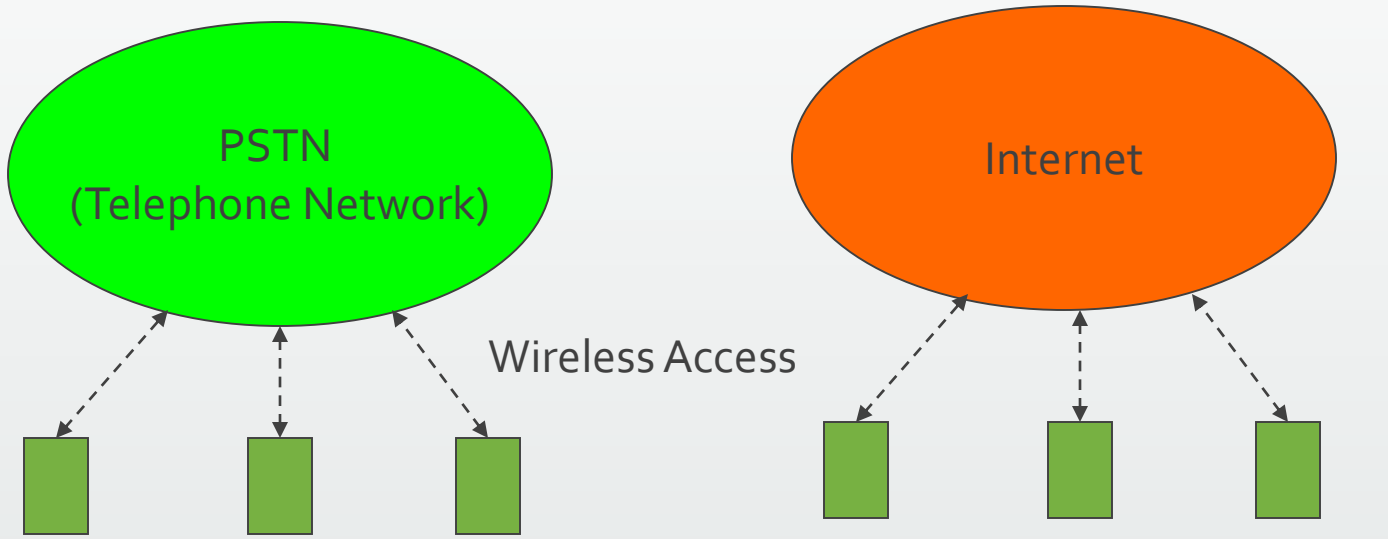
Several PCS systems

- Low-tier systems
  - Residential, business and public cordless access applications and systems
    - Cordless Telephone 2 (CT2)
    - Digital Enhanced Cordless Telephone (DECT)
    - Personal Access Communication Systems (PACS)

PCS Problems

- How to integrate mobile and wireless users to the Public Switched Telephone Network (PSTN) (Voice Network)
  - Cellular mobile telephony system
- How to integrate mobile and wireless users to the Internet (Data Network)
  - Mobile IP, DHCP, Cellular IP
- How to integrate all of them together and also add multimedia services (3G Systems)

Looking to PCS from different Angles



Mobile Users
-Cell phone users
-Cordless phone users

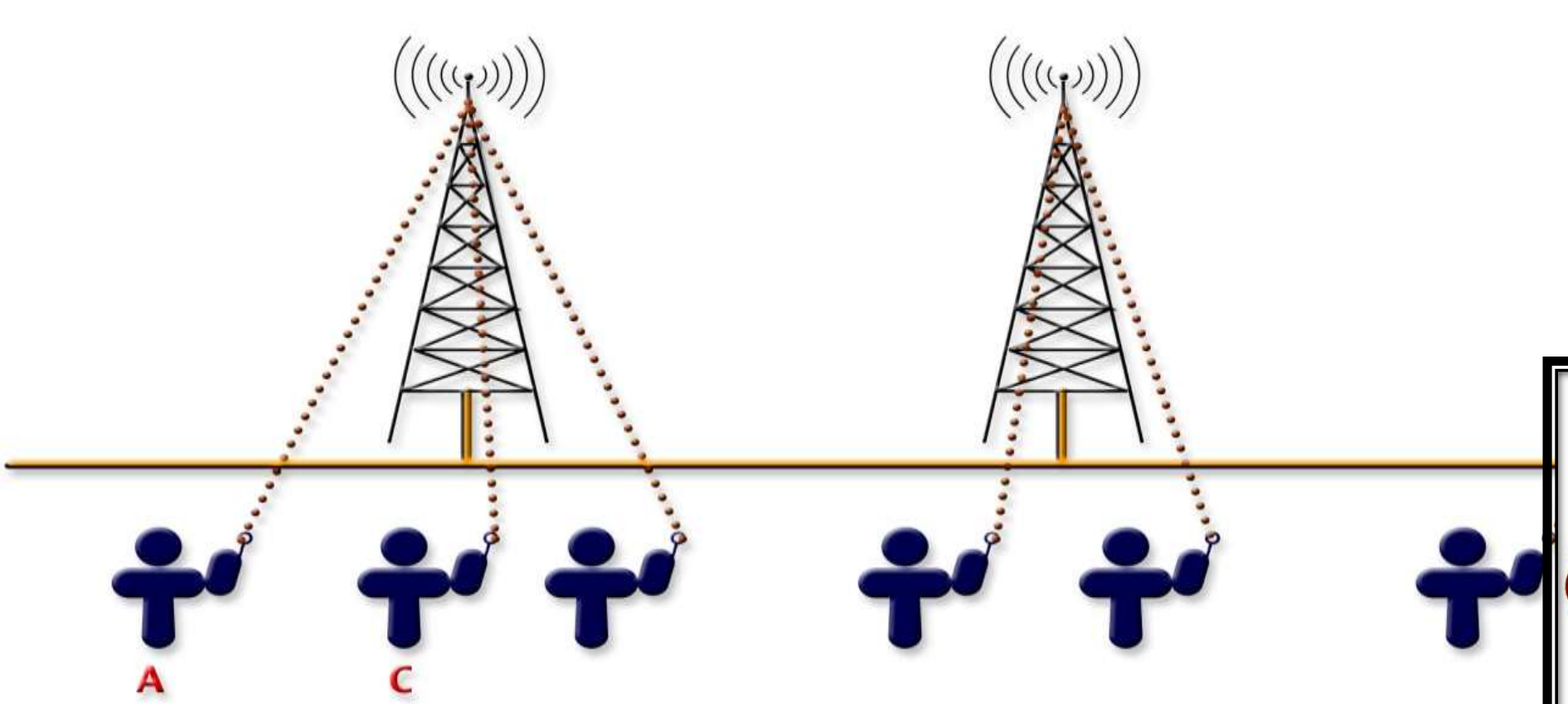
Telecom People View

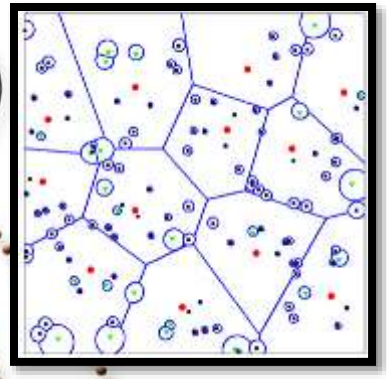
Mobile Users
-Laptop users
-Pocket PC users
-Mobile IP, DHCP enabled computers

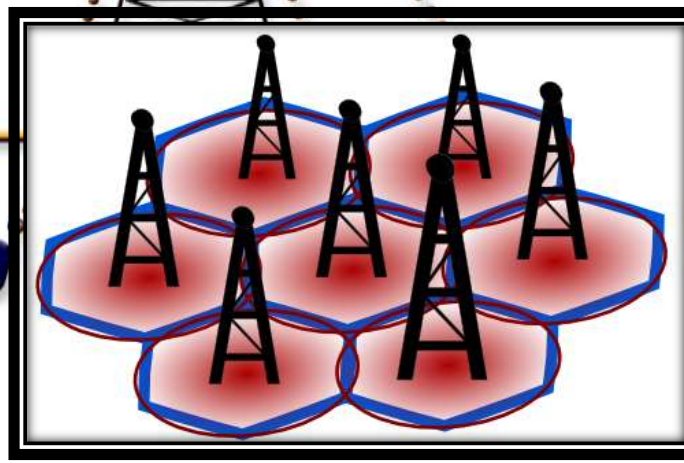
Data Networking People View

Major Mobile Radio Standards USA

Standard	Type	Year Intro	Multiple Access	Frequency Band (MHz)	Modulation	Channel BW (KHz)
AMPS	Cellular	1983	FDMA	824-894	FM	30
USDC	Cellular	1991	TDMA	824-894	DQPSK	30
CDPD	Cellular	1993	FH/Packet	824-894	GMSK	30
IS-95	Cellular/PCS	1993	CDMA	824-894 1800-2000	QPSK/BPSK	1250
FLEX	Paging	1993	Simplex	Several	4-FSK	15
DCS-1900 (GSM)	PCS	1994	TDMA	1850-1990	GMSK	200
PACS	Cordless/PCS	1994	TDMA/FDMA	1850-1990	DQPSK	300







Cellular System

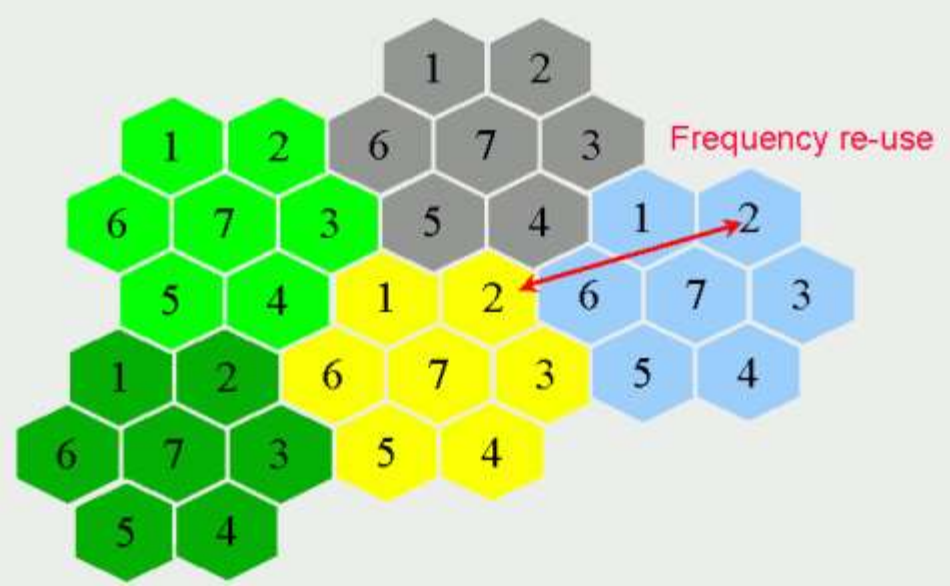
Introduction

Quick Answer

- Why it is called a cellular Service
- Is Wimax a cellular Service
- What are advantages of Cellular Services

Cellular Services

- Provide area Coverage to PSTN
- Limited Frequency Spectrum
- Geographical Region Divided in to cells
- Frequencies , Times, Codes reused to maximize Coverage



Cells should over Lap in real life ?

Features of Cellular Systems

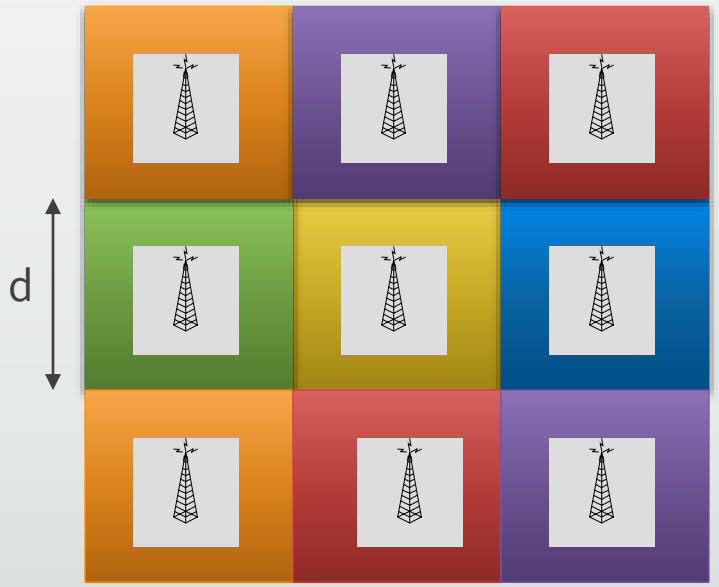
- High Capacity is achieved by limiting coverage of each Base station to a small geographical area called cell
- Hand off is a Important feature
- Cell - Cell Boundary
  - Users
  - Geo – Conditions
  - Link Budget
    - (Total Power Transmitted vs Total Power Recived)
  - (Cell boundaries are not fixed)- CDMA
  - Interference (Re using Phenomena)
    - Co Channel Interference (Worse at boundaries)

Features of Cellular Systems

System Capacity

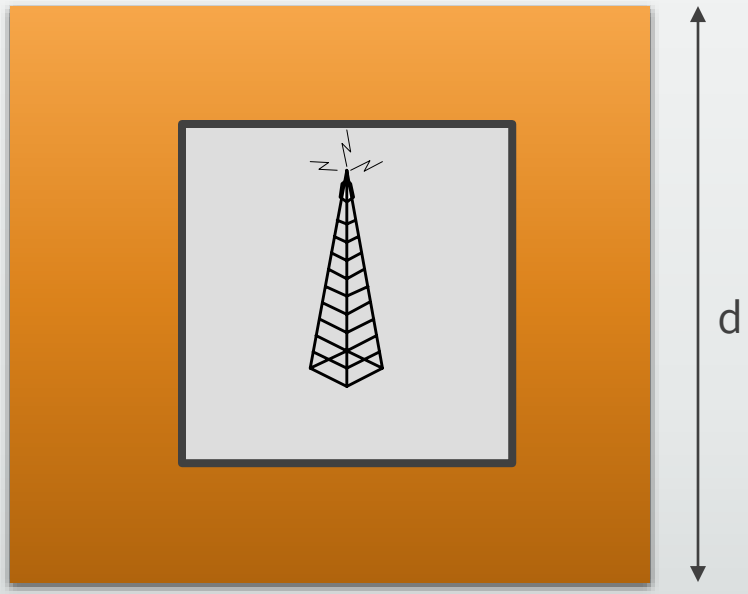
- System Capacity is the number all users that can communicate (use the system) at the same time
- A base station (cell) has a fixed number of channels available, hence at a given time a fixed number of users can talk simultaneously

System 1



Low cost base-stations covering a small area

System 2

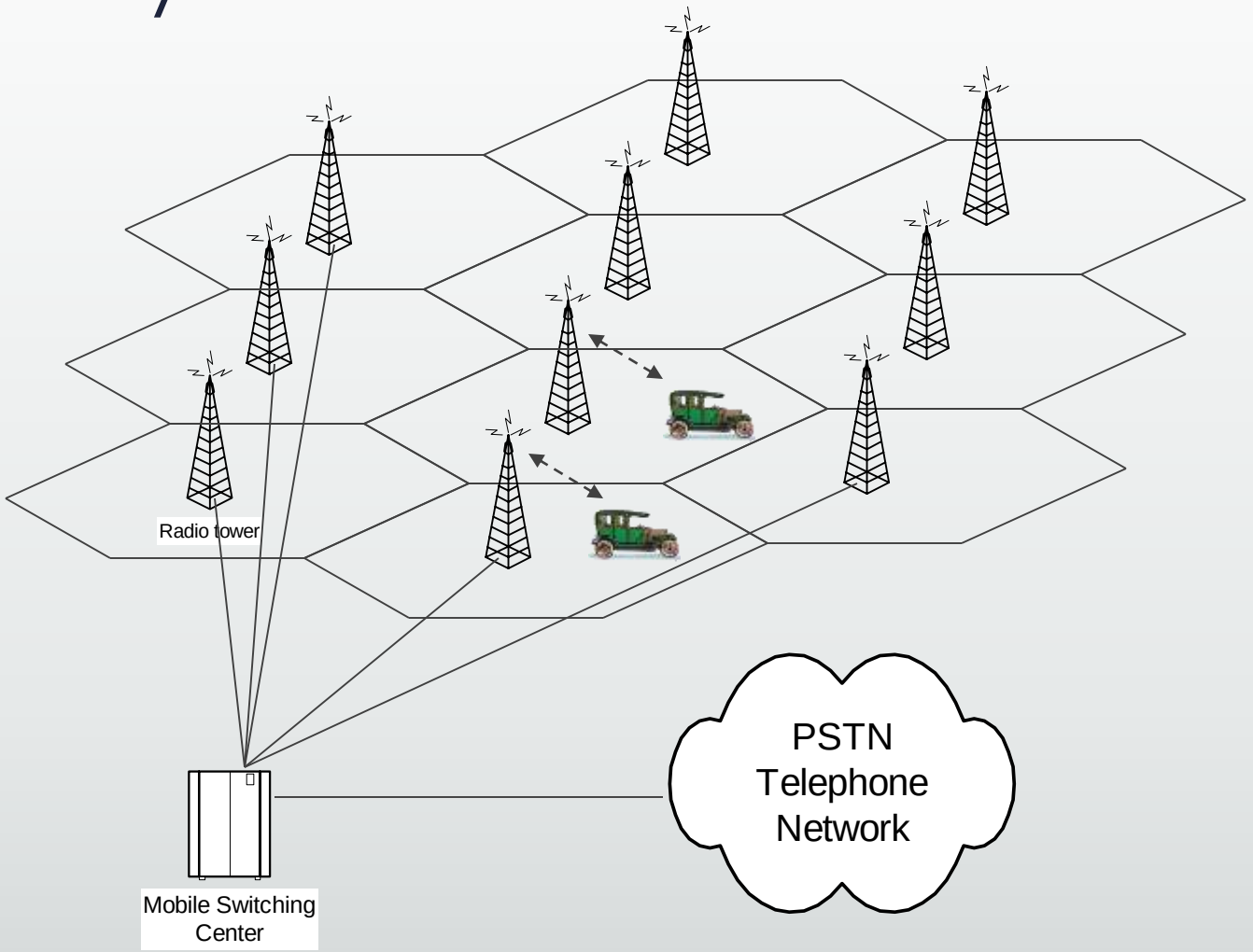


High cost base-stations covering a large area

Example : Cellular Telephony

- Characterized by
  - High mobility provision
  - Wide-range
  - Two-way voice communication
  - Handoff and roaming support
  - Integrated with sophisticated public switched telephone network (PSTN)
  - High transmit power requires at the handsets (~2W)

Cellular Telephony - Architecture



Wireless LANs (WLAN)

- Characterized by
  - Low mobility (not for vehicular use)
  - High speed data transmission
  - Confined regions – buildings and campuses
  - Coverage: 100m – 300m per base station
  - Nodes- Made by local Computer
  - Data is normally sent via Packet
  - Channel Access is Shared (Video)
  - Speed: 2-11Mbps, 20Mbps
  - Uses ISM bands
    - 902-928 MHz
    - 2400-2483.5 MHz
    - 5725-5850 MHz

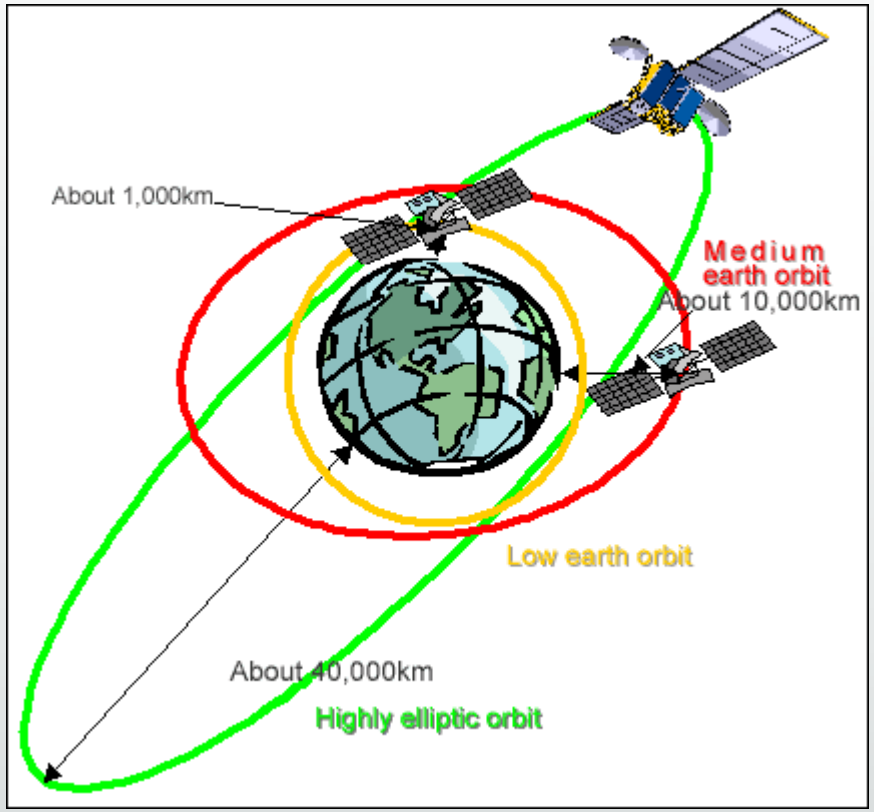
WLAN Standards

	Bitrate	Frequency Band	Range
IEEE 802.11b	5.5 – 11Mbps	2.4 GHz	~100m
IEEE 802.11a	54 Mbps	5 Ghz	~100m
HiperLAN (Europe)	20Mbps	5 GHz	~50m
HiperLAN/2	54 Mbps	5 GHz	~50m

Satellite Communication

Satellite Based Mobile Systems

- Categorized as
  - Two-way (or one-way) limited quality voice or data transmission
  - Very wide range and coverage
    - Large regions
    - Sometimes global coverage
    - Very useful in sparsely populated areas: rural areas, sea, mountains, etc.
  - Target: Vehicles and/or other stationary/mobile uses
  - Expensive base station (satellites) systems



Satellite based systems

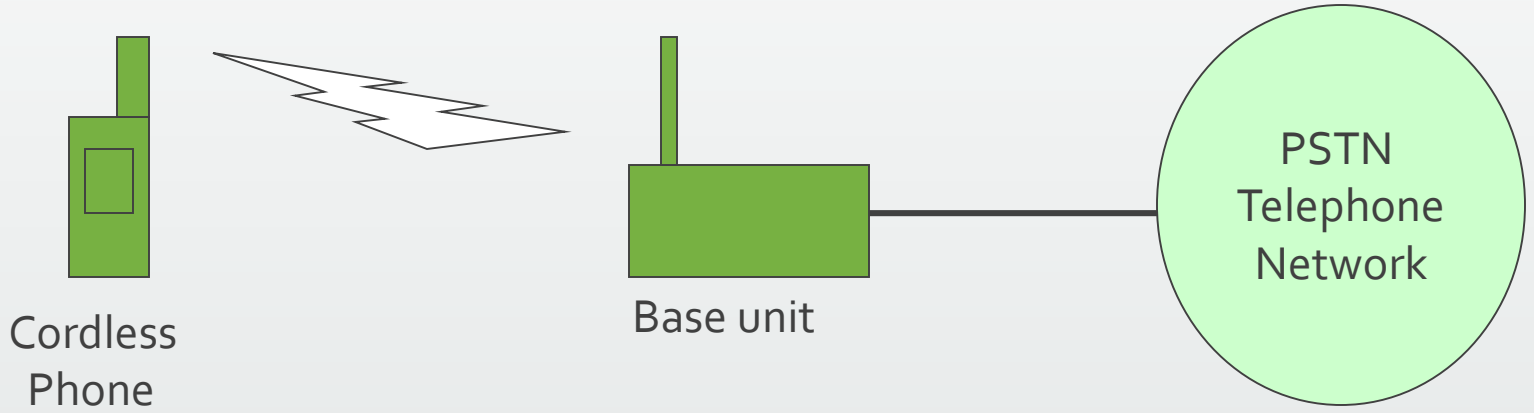
- Very large coverage
  - Low overall system capacity
- Expensive service
- Proposed Satellite Systems
  - LEOS: Low-earth orbit satellite systems
    - 10-100 satellites/system
    - High overall system capacity, low delay
    - Many but comparably less expensive satellites
  - MEOS: Medium-earth satellite systems
  - GEOS: Geostationary or Geosynchronous Orbit Systems
    - Fewer than 10 satellites/system
    - Low overall system capacity, high end-to-end delay (~0.5sec)
    - Very expensive satellites
- Iridium, Globalstar, Inmarsat are some example systems

Cordless System

Cordless Telephone

- Full Duplex
- Use radio Channel to Connect to BS
- BS is connected to PSTN via a telephone line
- May cover few meters

Cordless Telephones



Cordless Telephones

- Low power consumption
- Low cost equipment, small form factor and long talk-time
- No handoffs between base units

- Appeared as analog devices

Cordless Telephones

- Usage
  - At homes
  - At public places where cordless phone base units are available
- Design Choices
  - Few users per MHz
  - Few users per base unit
    - Many base units are connected to only one handset
  - Large number of base units per usage area
  - Short transmission range

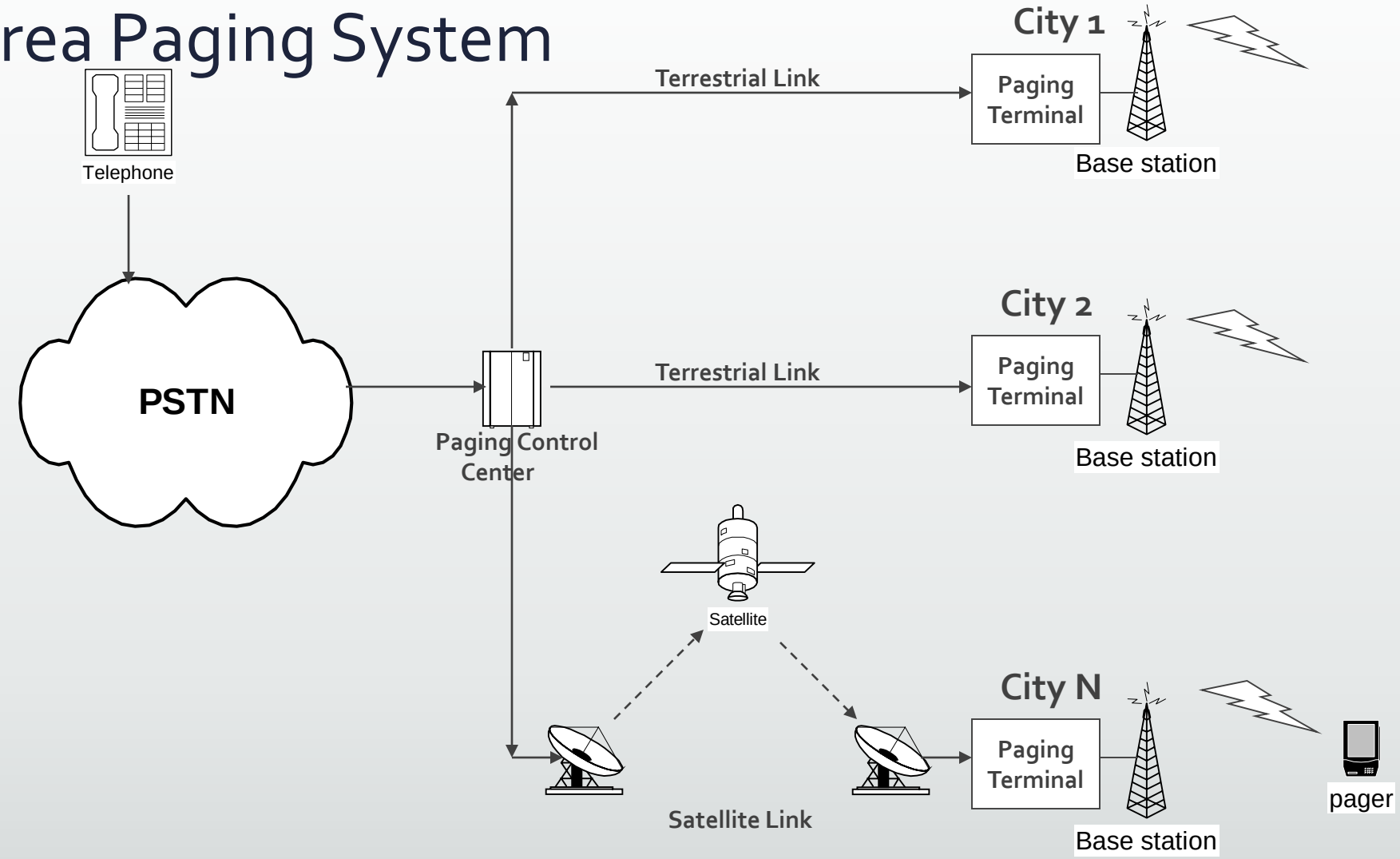
WIRELESS PAGING SYSTEM

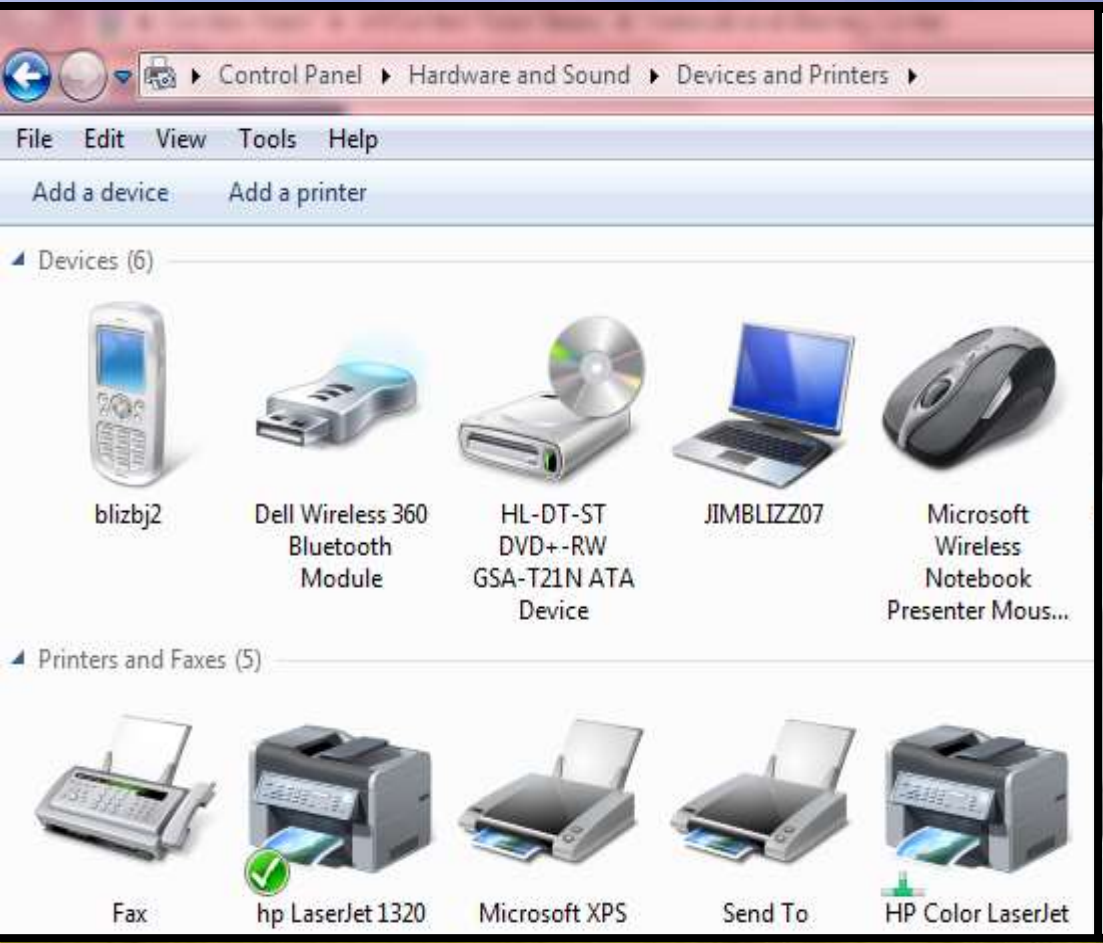
Paging System

Paging Systems

- Send brief message to subscriber. Message can be either numeric message, alpaha numeric message or voice message
- Categorized as
  - One-way messaging
  - Wide-area coverage (One cell may cover up to 2~5 KM)
  - Back bone may consist of satellites , Telephone lines
  - Low complexity, very low-power pager (receiver) devices
  - Being Replace by Mobile
  - Message(page) in Done in a Broad Cast Manner
  - Simple Terminals

Wide-Area Paging System




Control Panel ▸ Hardware and Sound ▸ Devices and Printers ▸
File Edit View Tools Help
Add a device Add a printer
Devices (6)
blizbj2
Dell Wireless 360 Bluetooth Module
HL-DT-ST DVD+-RW GSA-T21N ATA Device
JIMBLIZZ07
Microsoft Wireless Notebook Presenter Mous...
Printers and Faxes (5)
Fax
hp LaserJet 1320
Microsoft XPS
Send To
HP Color LaserJet

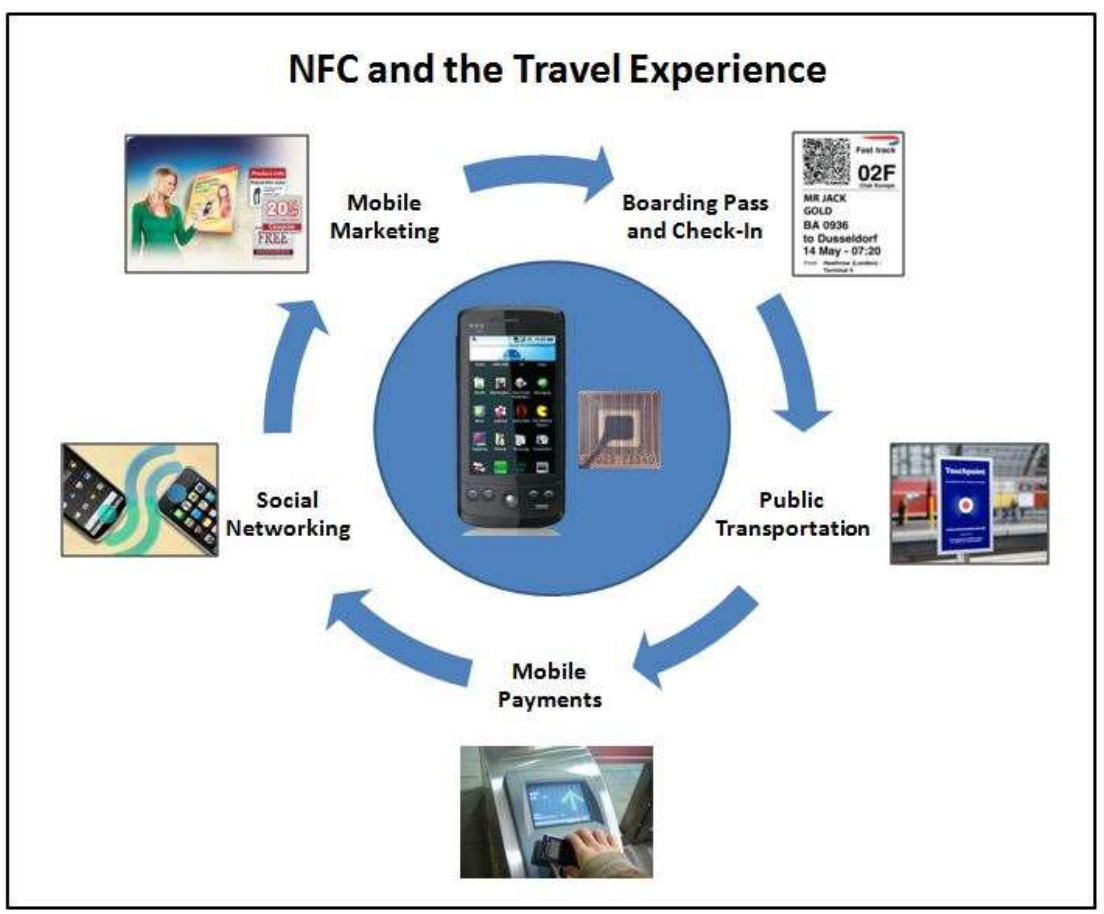

Transmission of data through short-range radio waves
Wireless enabled devices connect with limitations of
Techfuels.com

PAN

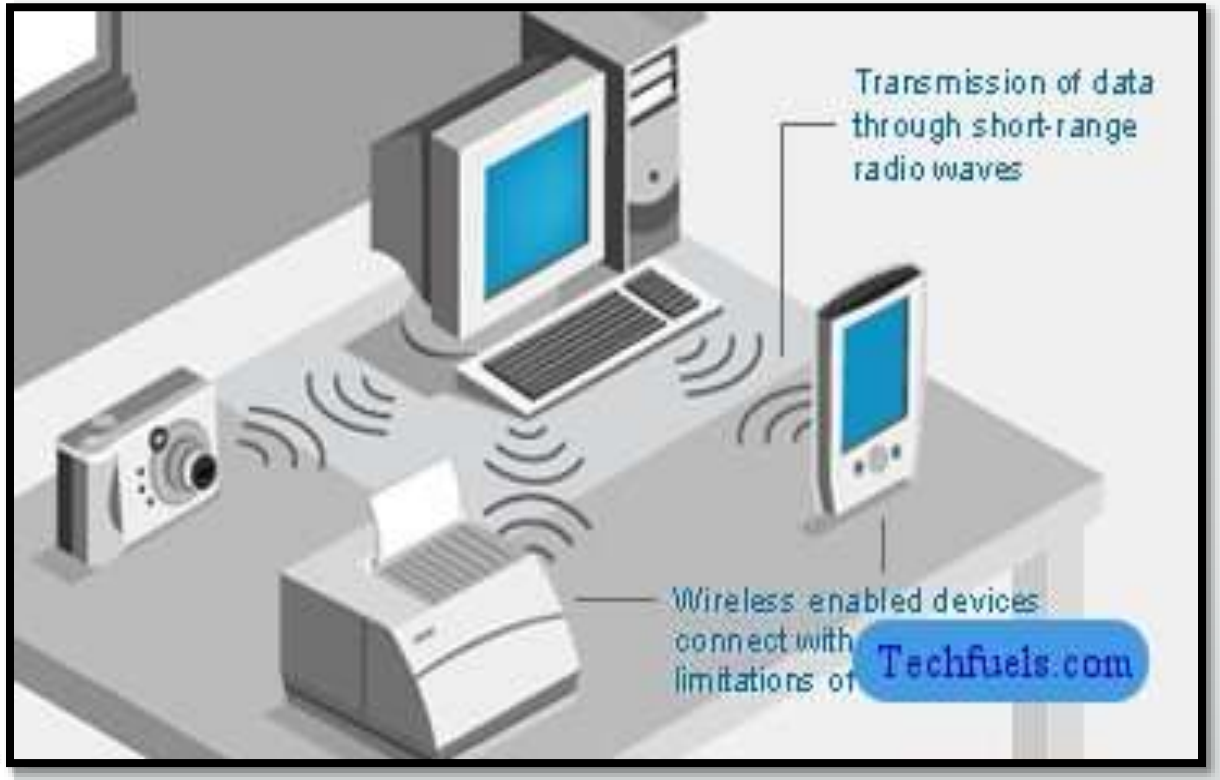
Personal Area Networks (PANs)

- Bluetooth
  - 2.5GHz ISM band
  - 10m range, 1mW transmit power
  - 100m range, requires increase in transmit power
  - 1 Mbps data rate shared between 7 devices
  - FHSS spread spectrum use
  - TDD duplex scheme
  - Retricted start topology
    - 1 master connects to 7 slaves

NFC



BLUETOOTH

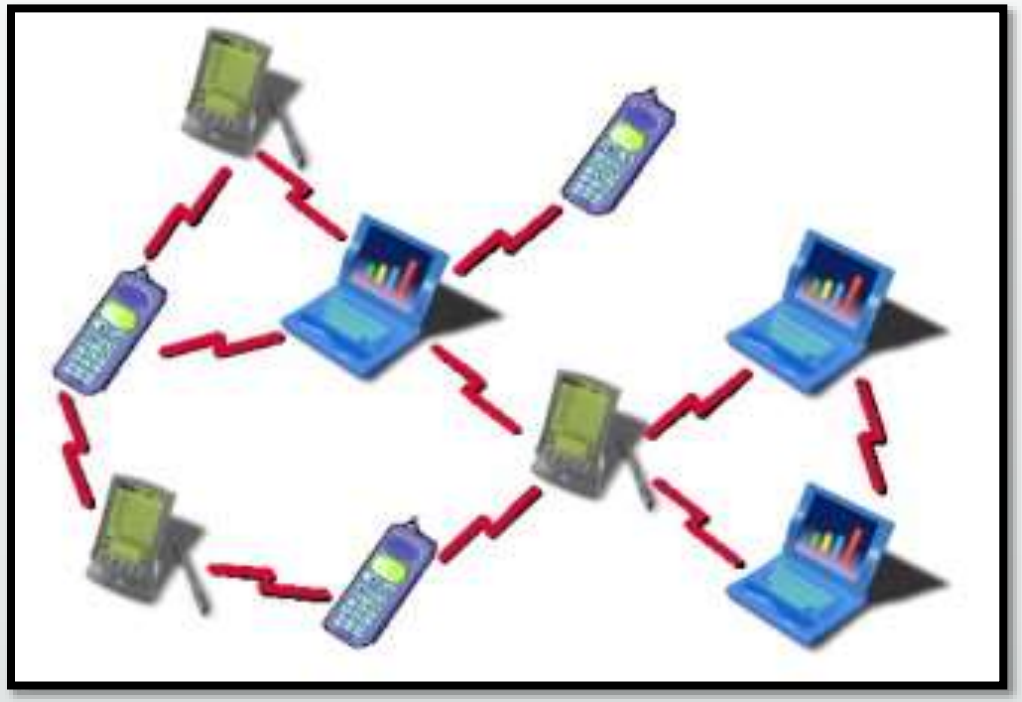


Emerging Wireless Technology

- Sensor Networks
- Ad- Hoc Networks
- Ultra Wideband

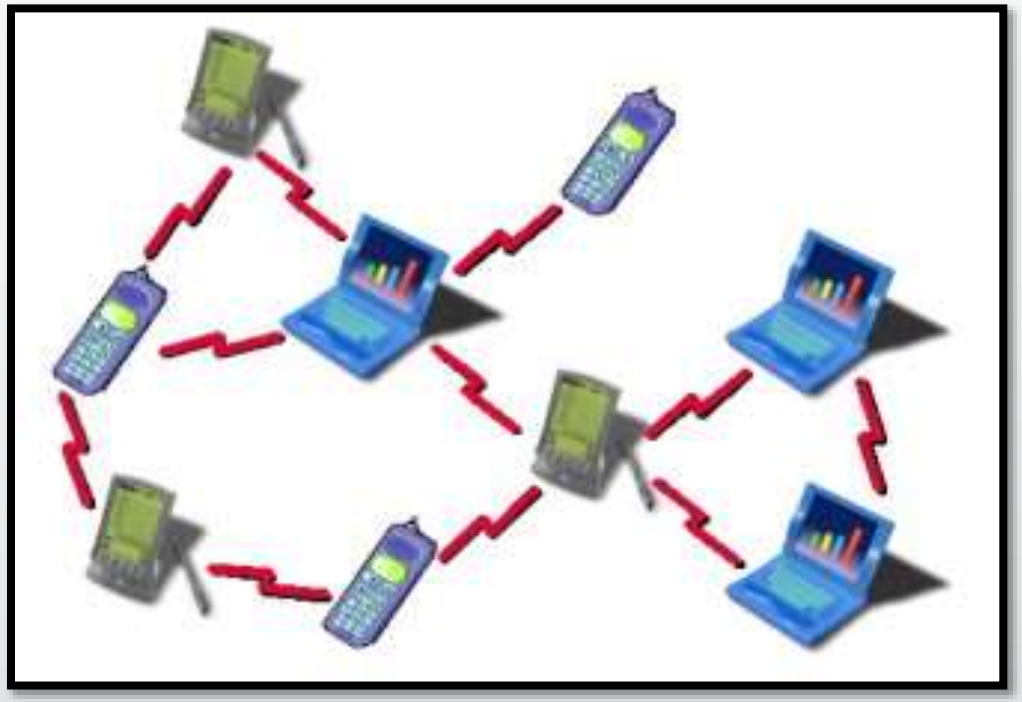
Ad-HOC NETWORK

- NO FIXED TECHNOLOGY – Dynamic Topology
- PEER TO PEER TECNOLOGY
- EVERY NODE ACTS A ROUTER
- RECONFIGUREABLE
- No Back Bone
- Multi Hope
- Fully Connected with Different SNR

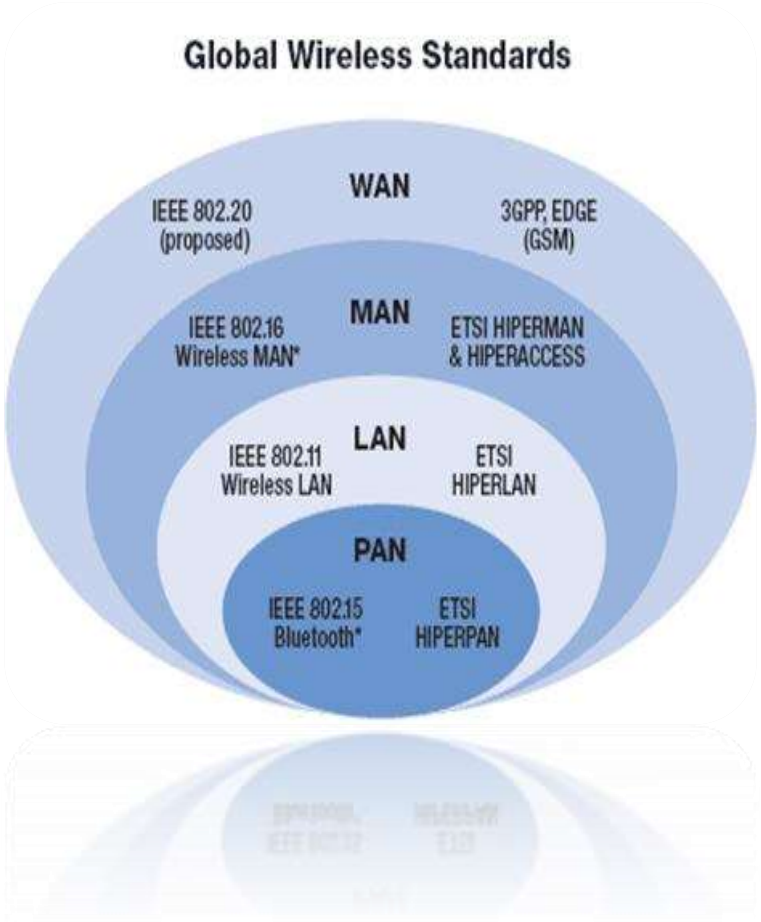


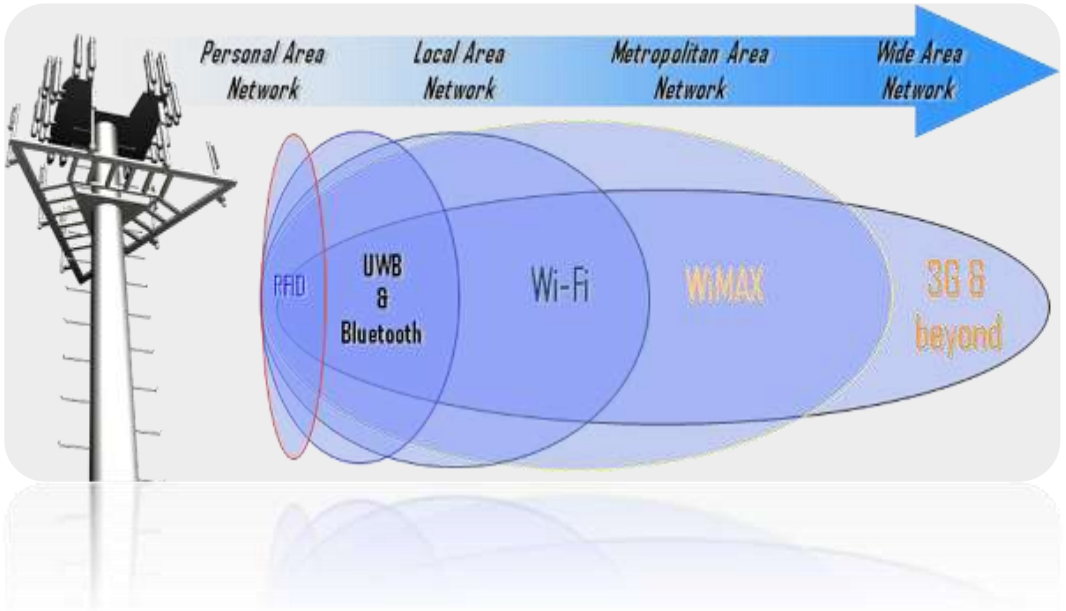
Ad-HOC NETWORK

- Capacity ~ Unknown
- Provides a Feasible Network
- Energy Constrains



A Small Comparison





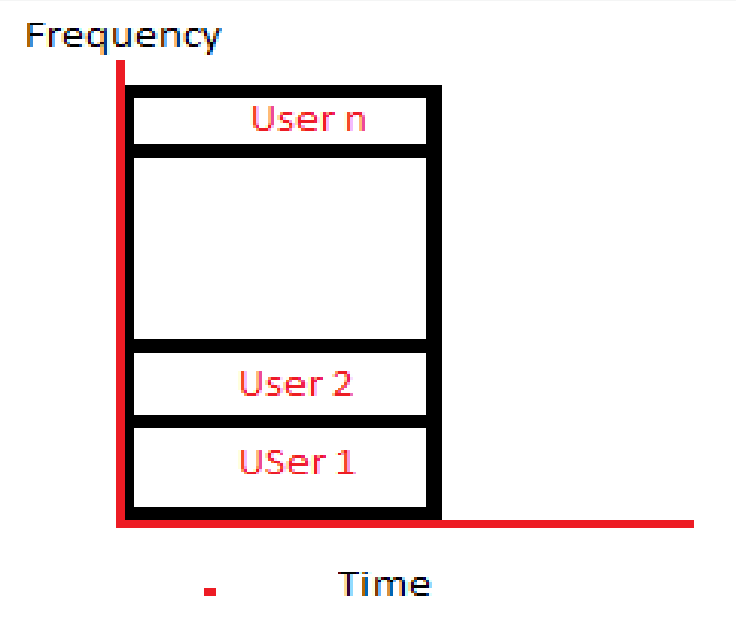
Basic Multiple Access Techniques

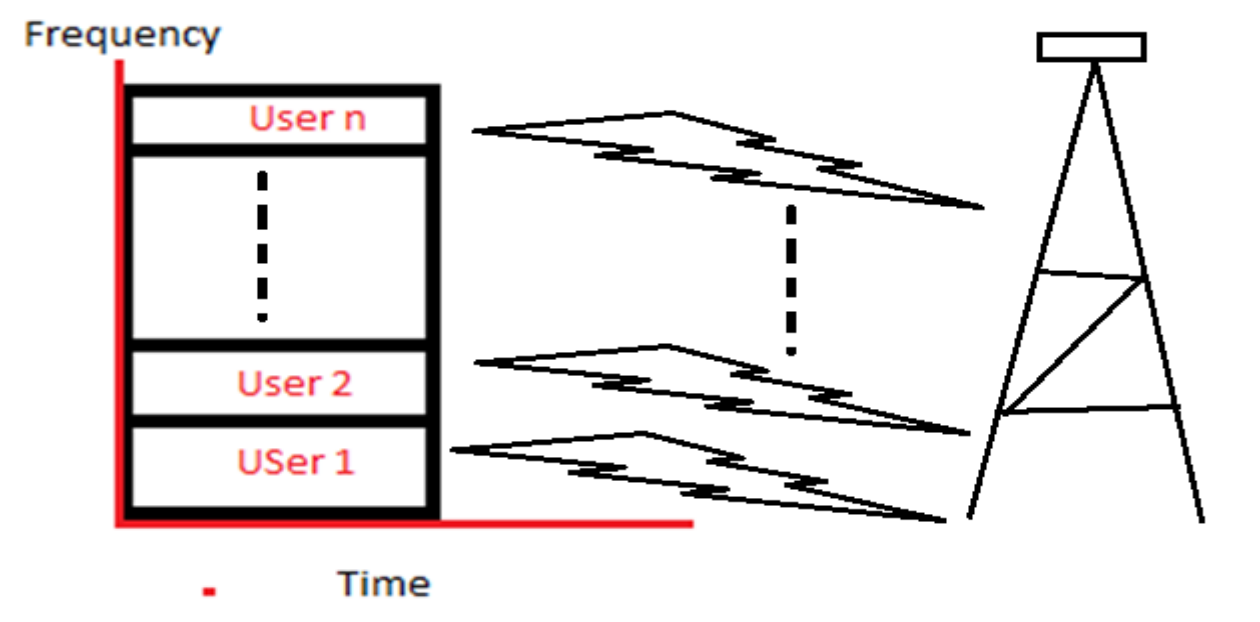
- We are not providing service to a particular user
- Allow many users to share spectrum
  - Finite Spectrum
  - Coast
- Advantages
  - High Capacity provided within the limited Spectrum
- Disadvantage
  - Performance Degradation
    - Every application we have QoS
    - For voice communication we have : **Maximum Delay , Call Duration; Packet Loss**
    - For voice Date Communication we have : BeR

Example 1 : FDMA

- Close Sub bands Means : Ideal

- Please note that during whole transmission , users are allowed to use their entire frequency band
- User pay for frequency band





- **Problem**
  - **Interference**
  - **Solution : Guard Band , Sharp Filters**

FDMA (2)

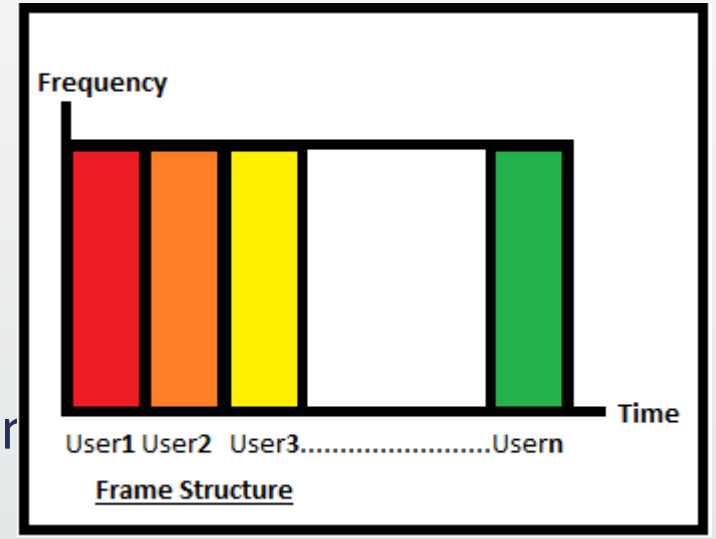
- Both BS and MS can transmit and receive at same time
- AT BS
  - Separate antennas for Transmitter and Receiver
- AT MS/Subscriber Unit
  - Single Antenna is used (Duplexer)
- IN FDD the transmitting and receiving frequency needs to be of different vlues

TDMA

- User uses time Slot
- Time Slot repeat

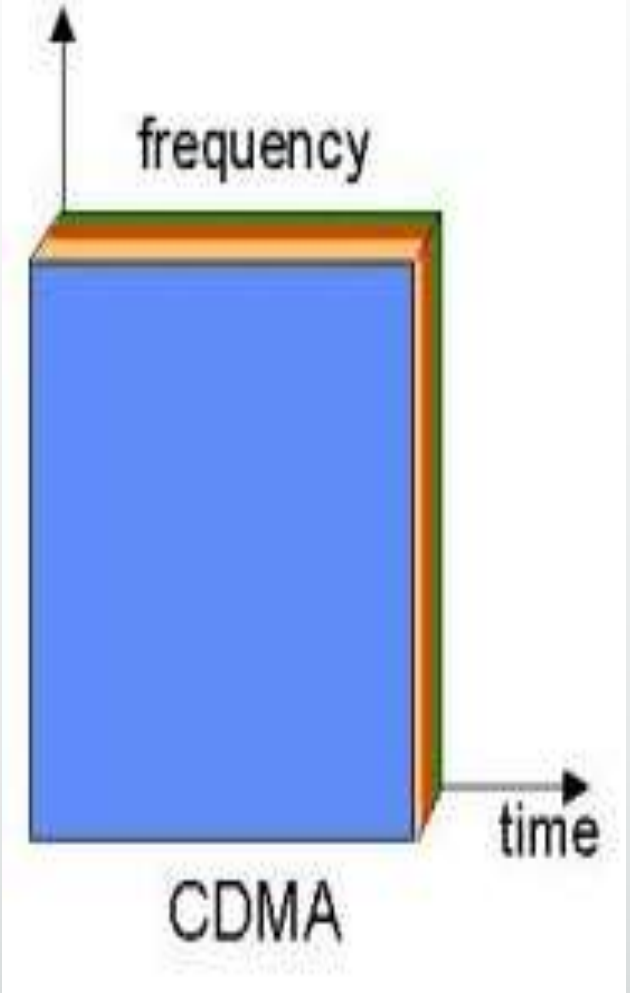
Q: Does it mean my voice will break while I am Talking

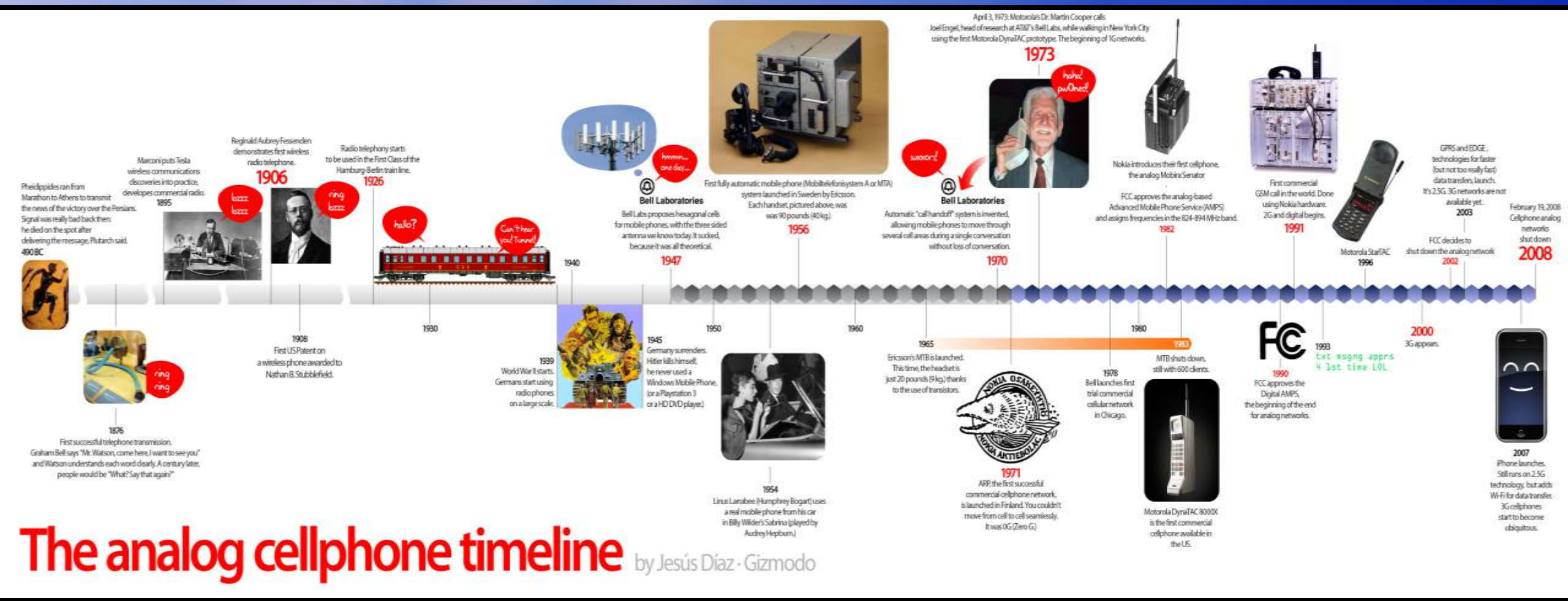
- No , The reason is Sampling
- First voice is sample w.r.t Nyquist Frequency
- Sample are transmitted at transmitter end
- Message is reconstructed via these samples at r end
- Problems
  - We Need Time Guard Band
  - Synchronization



CDMA

- Time and Frequency is Divided .
- Each user is provided with a Particular code
- Al users can talk at same time
- However as more and more users talk, interference increase
- Power CONTROL
- **How to choose Codes**
- Ideally Speaking the codes should be orthogonal
- Orthogonal codes are limited due to finite sequence .

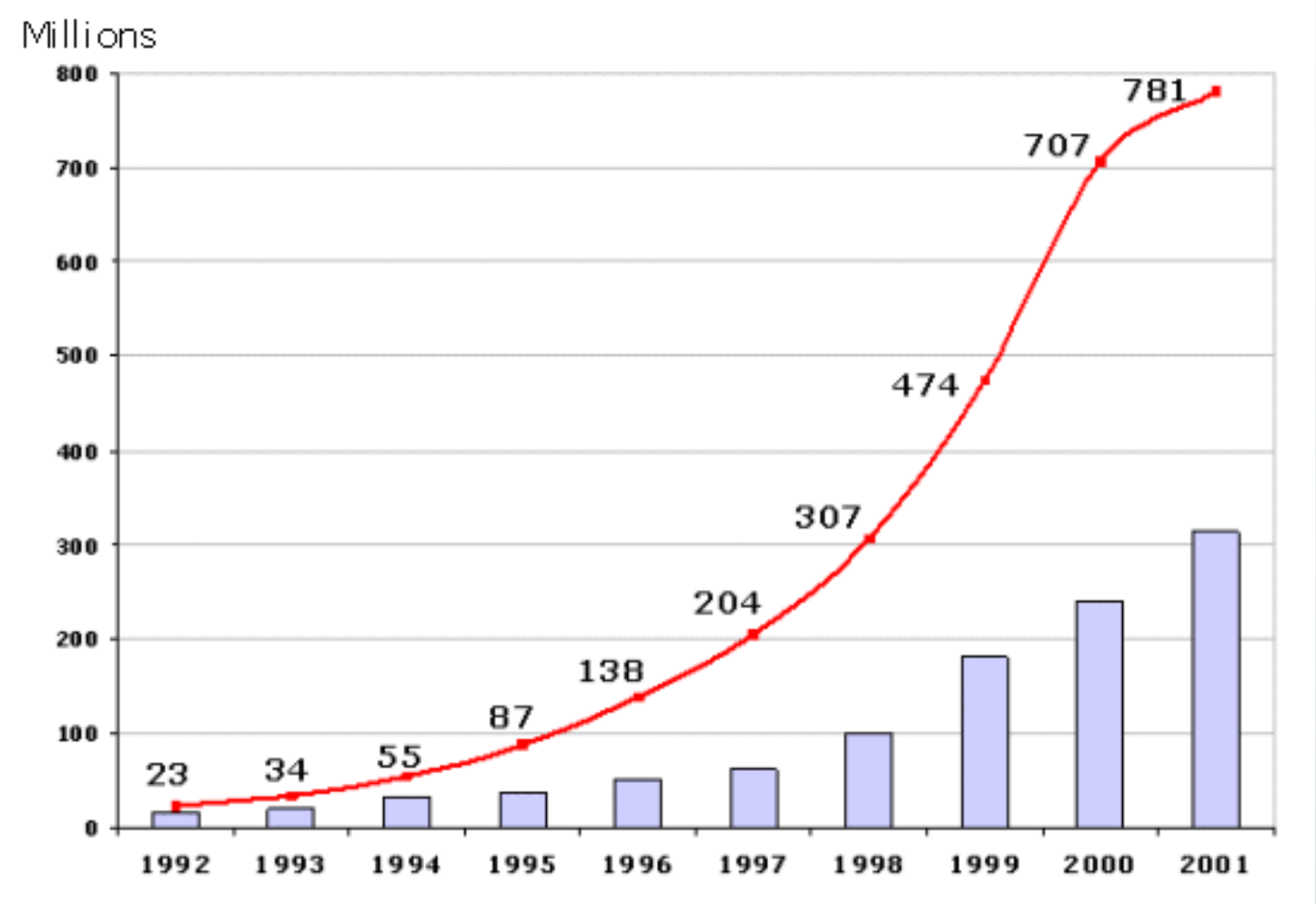




Modern Wireless Communication

History of Wireless and Mobile Communication

World Cellular Subscriber Growth



Cellular Networks

- First Generation
  - Analog Systems
  - Analog Modulation, mostly FM
  - AMPS
  - Voice Traffic
  - FDMA/FDD multiple access
- Second Generation (2G)
  - Digital Systems
  - Digital Modulation
  - Voice Traffic
  - TDMA/FDD and CDMA/FDD multiple access
- 2.5G
  - Digital Systems
  - Voice + Low-datarate Data
- Third Generation
  - Digital
  - Voice + High-datarate Data
  - Multimedia Transmission also

Cellular Networks ~ FIRST GENERATION

- Launched in Mid 1980s
- Purely analog
- Used Analog Modulation → FM
- Intended for Voice Trafiic
- FDMA
- AMPS ~ ADVANCED MOILE PHONE SERVICE

2G and Data

- 2G is developed for voice communications
- Used Digital Modulation ~ GSM
- For Multiple Access ~ Used TDMA/FDD , CDMA /FDD
- You can send data over 2G channels by using modem
- Provides a data rates in the order of ~9.6 Kbps
- Increased data rates are requires for internet application
- This requires evolution towards new systems: 2.5 G

2G Technologies

	cdmaOne (IS-95)	GSM, DCS-1900	IS-54/IS-136 PDC
Uplink Frequencies (MHz)	824-849 (Cellular) 1850-1910 (US PCS)	890-915 MHz (Eurpe) 1850-1910 (US PCS)	800 MHz, 1500 Mhz (Japan) 1850-1910 (US PCS)
Downlink Frequencies	869-894 MHz (US Cellular) 1930-1990 MHz (US PCS)	935-960 (Europa) 1930-1990 (US PCS)	869-894 MHz (Cellular) 1930-1990 (US PCS) 800 MHz, 1500 MHz (Japan)
Multiple Access	CDMA/FDD	TDMA/FDD	TDMA/FDD
Modulation	BPSK with Quadrature Spreading	GMSK	QPSK
Channel Data Rate	1.2288 Mchips/sec	270.833 Kbps	48.6 Kbps (IS-136) 42 Kbps (PDC)
Voice Channels per carrier	64	8	3

Limitation of 2 G

- Developed for voice Communication
- Low Data Rate
- Not Suitable for Internet (2G supported : Circuit Switch)

2.5 Technologies

- Voice + low Date Rate
- Internet Access was provided by
  - Step 1 : General Packet Radio Service
  - Step2 : Enhanced date rated for Global Evolution
- Evolution of TDMA Systems
  - GPRS for GSM and IS-136
    - Up to 171.2 Kbps data-rate
  - EDGE for 2.5G GSM and IS-136
    - Up to 384 Kbps data-rate
- Evolution of CDMA Systems
  - IS-95B
    - Up to 64 Kbps

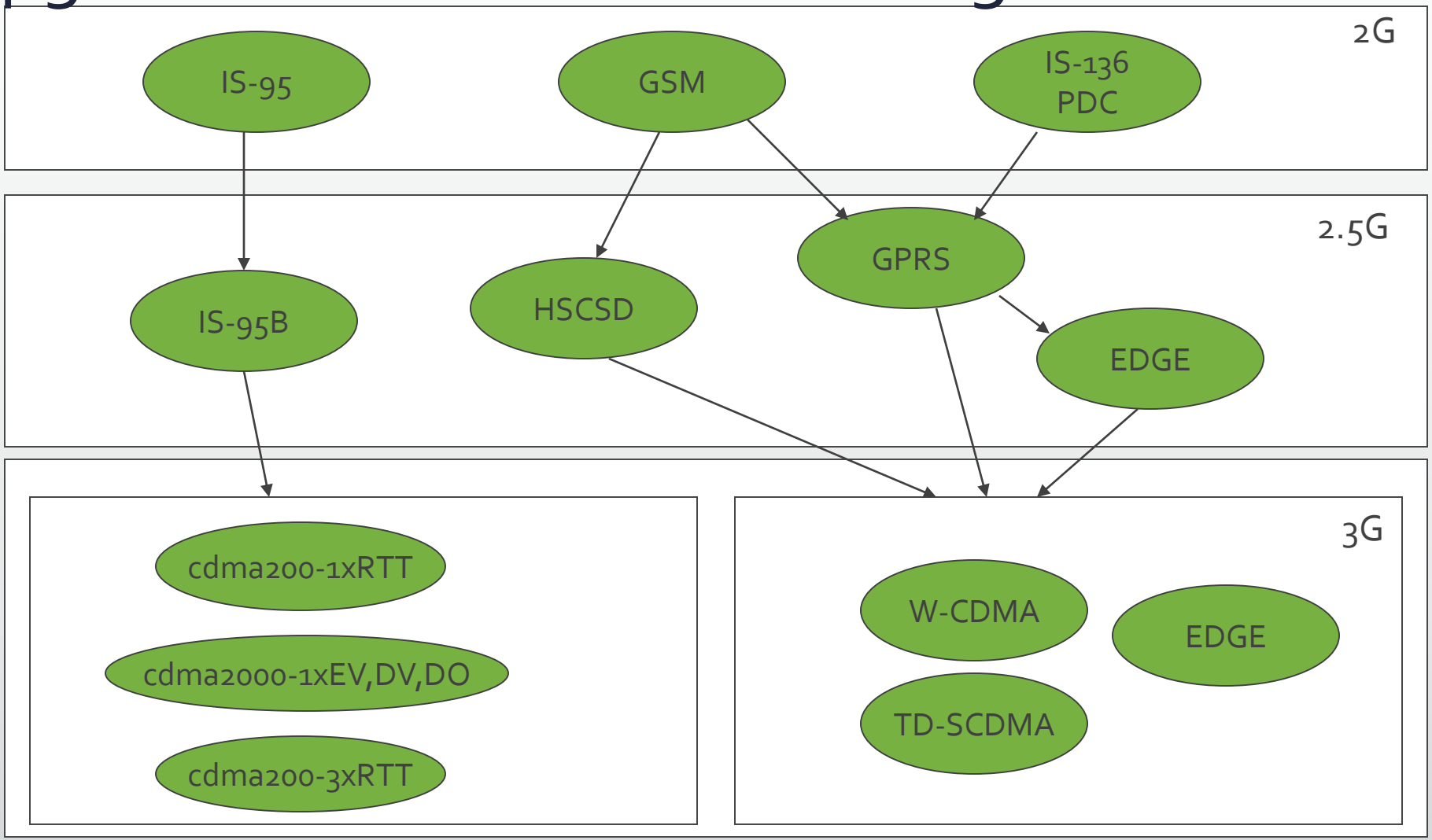
3G Systems

- Goals
  - Voice and Data Transmission
    - Simultanous voice and data access
  - Multi-megabit Internet access
    - Interactive web sessions
  - Voice-activated calls
  - Multimedia Content
    - Live music

3G Systems

- Evolution of Systems
  - CDMA sysystem evaolved to CDMA2000
    - CDMA2000-1xRTT: Upto 307 Kbps
    - CDMA2000-1xEV:
    - CDMA2000-1xEVDO: upto 2.4 Mbps
    - CDMA2000-1xEVDV: 144 Kbps datarate
  - GSM, IS-136 and PDC evolved to W-CDMA (Wideband CDMA) (also called UMTS)
    - Up to 2.048 Mbps data-rates
    - Future systems 8Mbps
    - Expected to be fully deployed by 2010-2015
  - New spectrum is allocated for these technologies

Upgrade Paths for 2G Technologies

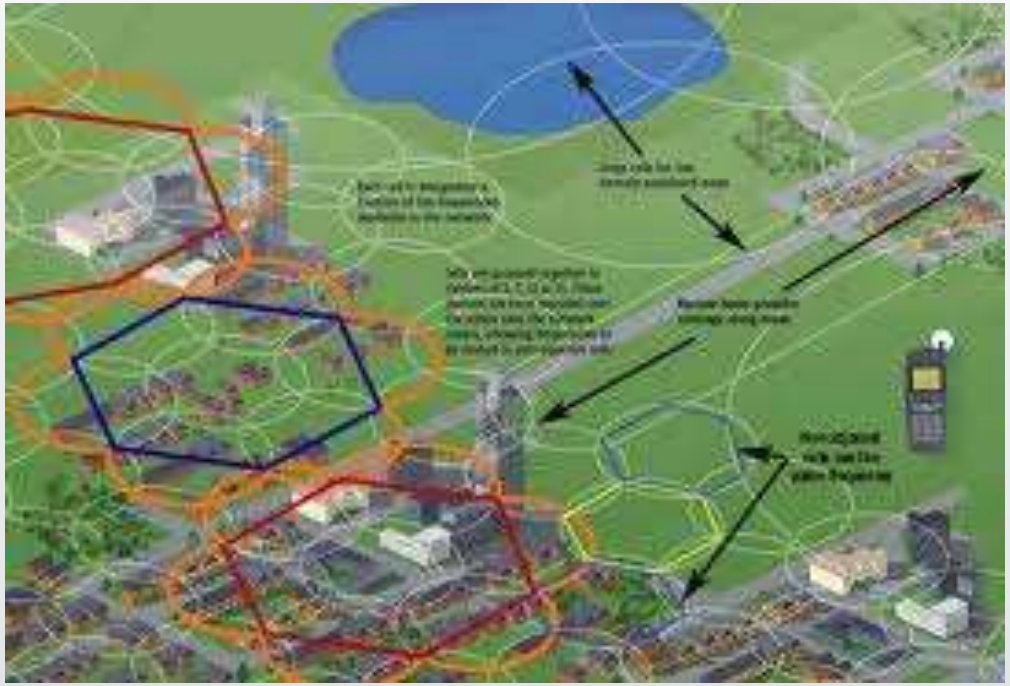


Control and Traffic Channel

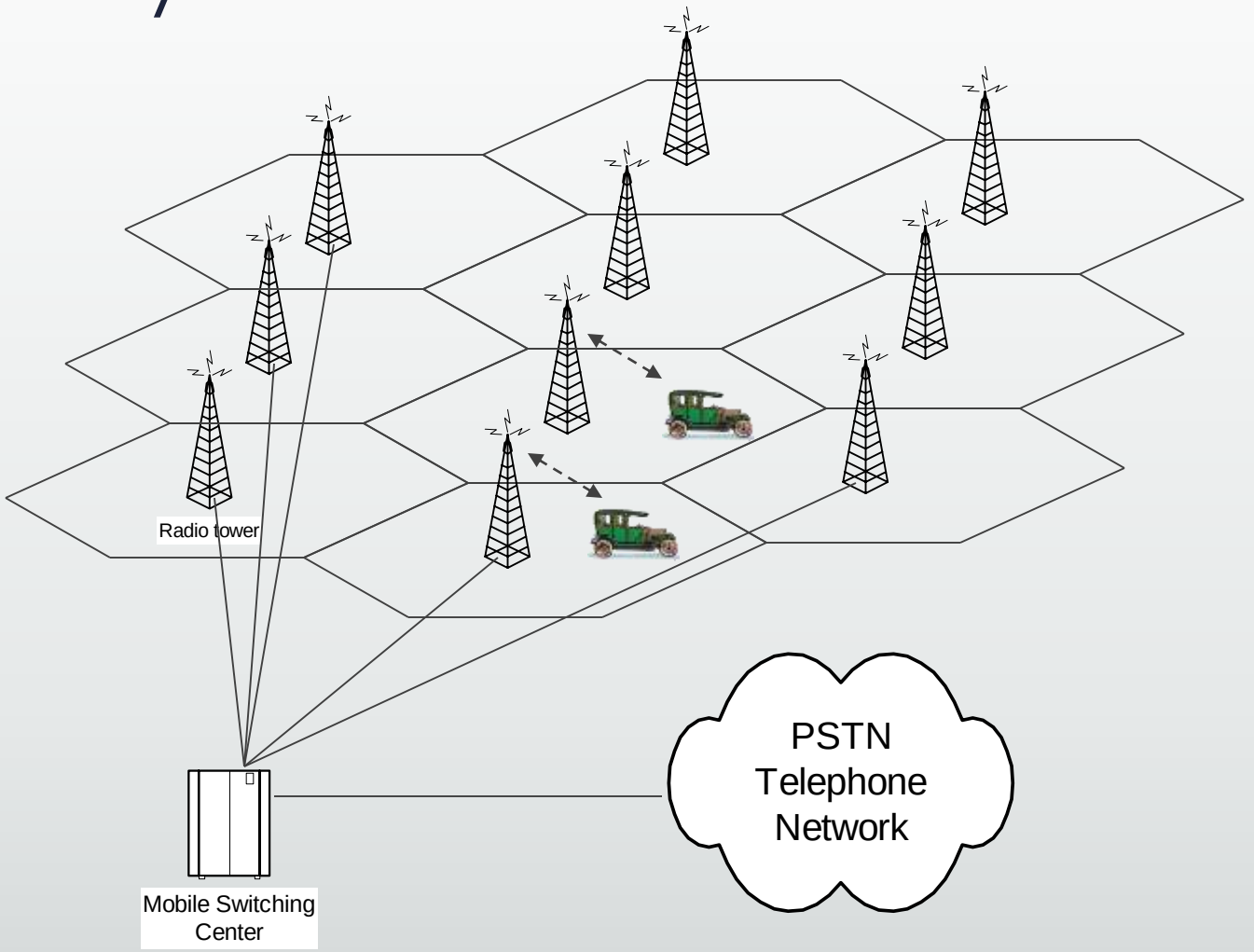
- Control Channel is used for setting up data
- Traffic channel is used for data communication

Cells

- We can provide more coverage by using frequency reuse factor and smaller cells
- Small cells can be created by decreasing power



Cellular Telephony - Architecture

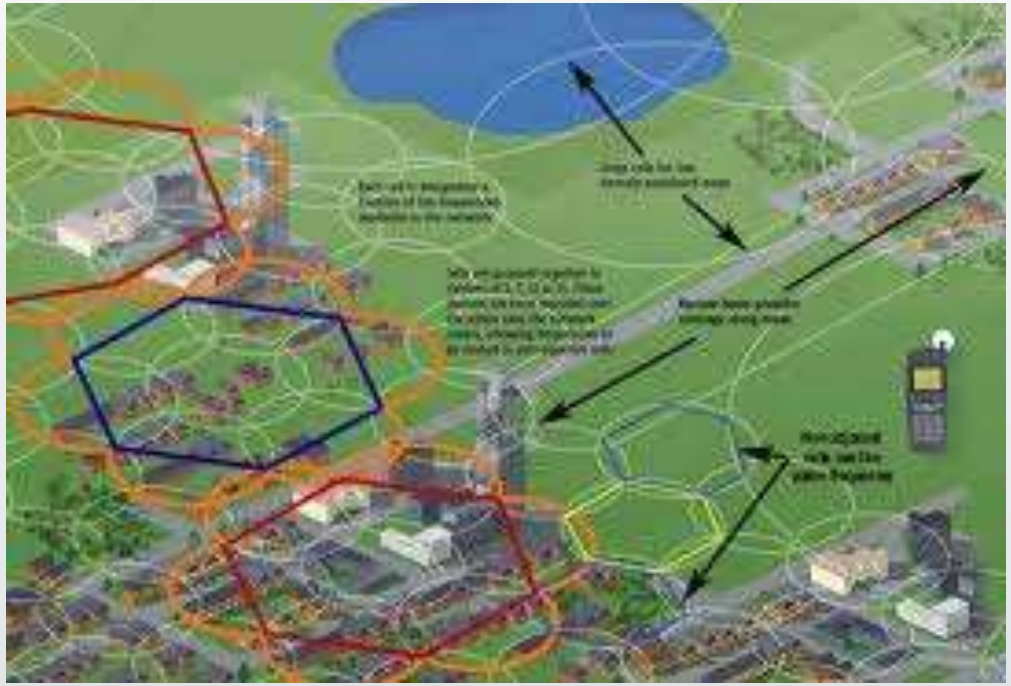


MAKING A MOBILE CALL

Channels

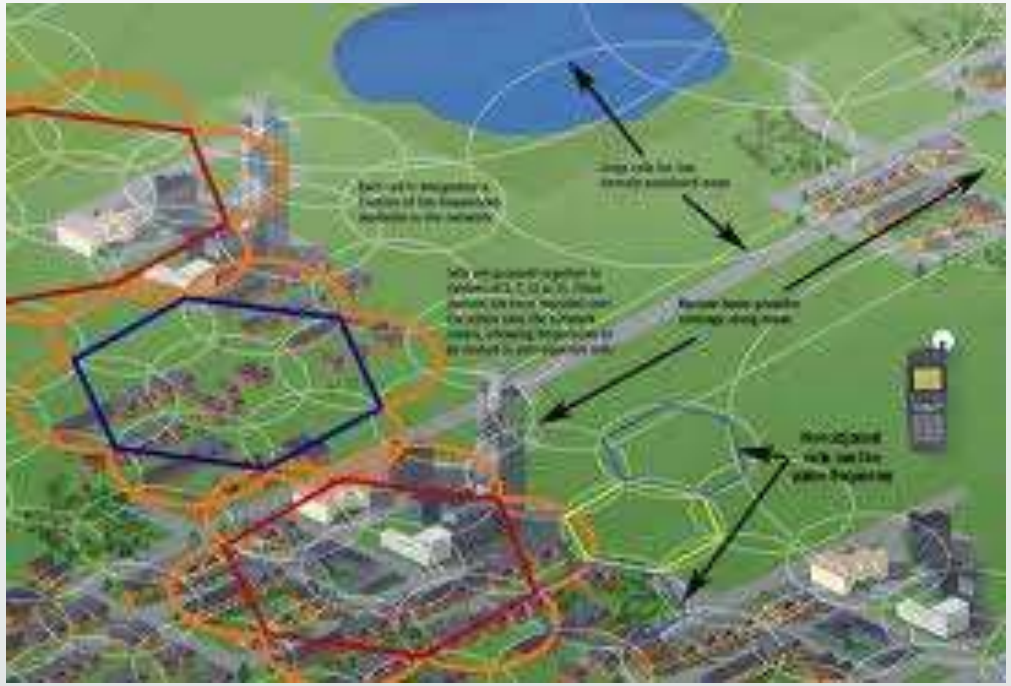
- Call is made via channel
- Forward Voice Channel ~ Used for voice transmission from BS to MS
- Reverse Voice Channel ~Used for voice transmission from MS to BS
- Forward Control Channel (FCC)
- Reverse Control Channel (RCC)
- FCC+RCC = Setup Channels (normally 5 % of bandwidth)

Pre Call Setup- Registering a Cell Phone



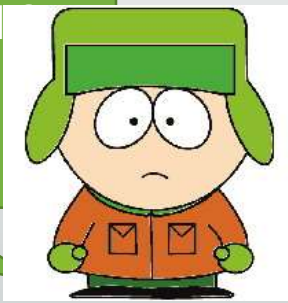
- Mobile phone is turned
- phone does not have an allocated channel,
- It is therefore necessary for there to be some methods or allocated means within the cellular telecommunications network, whereby a newly switched on mobile can communicate with the network and set up the standard communication.
- Even if a call is not to be made instantly, the network needs to be able to communicate with the mobile to know where it is

STEP 1 : Switch on The Phone



- Phone is turned on.
- Monitors Control Channel (Scan Channel).
- Scan the Strongest Forward channel
- It monitors that channel until it drops below a usable threshold
- Scans for Strongest BS

Remember : Control Channel makes up normally 5 % of total allocated frequency . Rest of frequency is used for data and voice

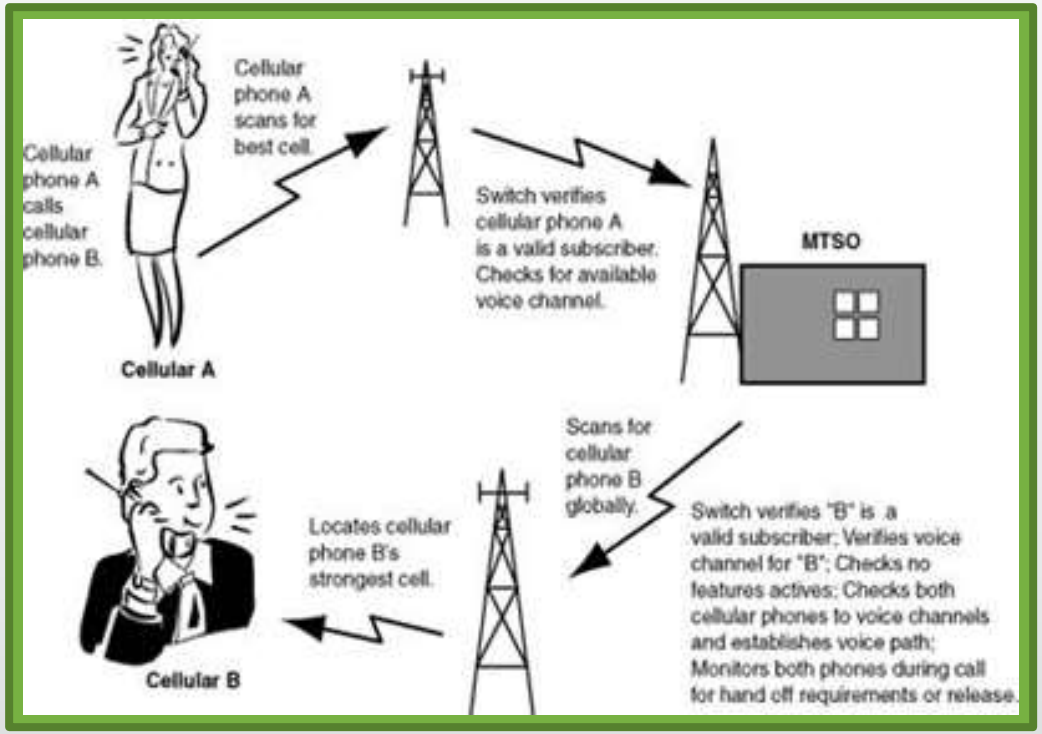


Calling a Mobile Phone

- MSC dispatches a Request to all BS in cellular System
- MIN (Mobile Identification Number) is broadcasted as a paging message on all FCH
- Mobile Identifies it self over reverse channel.
- BS→ MSC : Informs of handshake
- MSC instruct the BS to move the call to unused voice channel **(TYPICALLY 6)**
- BS→ Mobile : Change frequency
- Data message (Alert is transmitted) over FCH

Calling from Mobile Phone

- Call initiation request is sent
  - Transmits → (MIN, ESN, and Number to be called)
  - SCM –Station Class mark also Transmitted
- BS → Receives data and route it to MSC
- MSC validates request , initiate Billing
- Move call to PSTN/MSC
- MSC instruct the BS to move the call to unused voice channel **(TYPICALLY 6)**



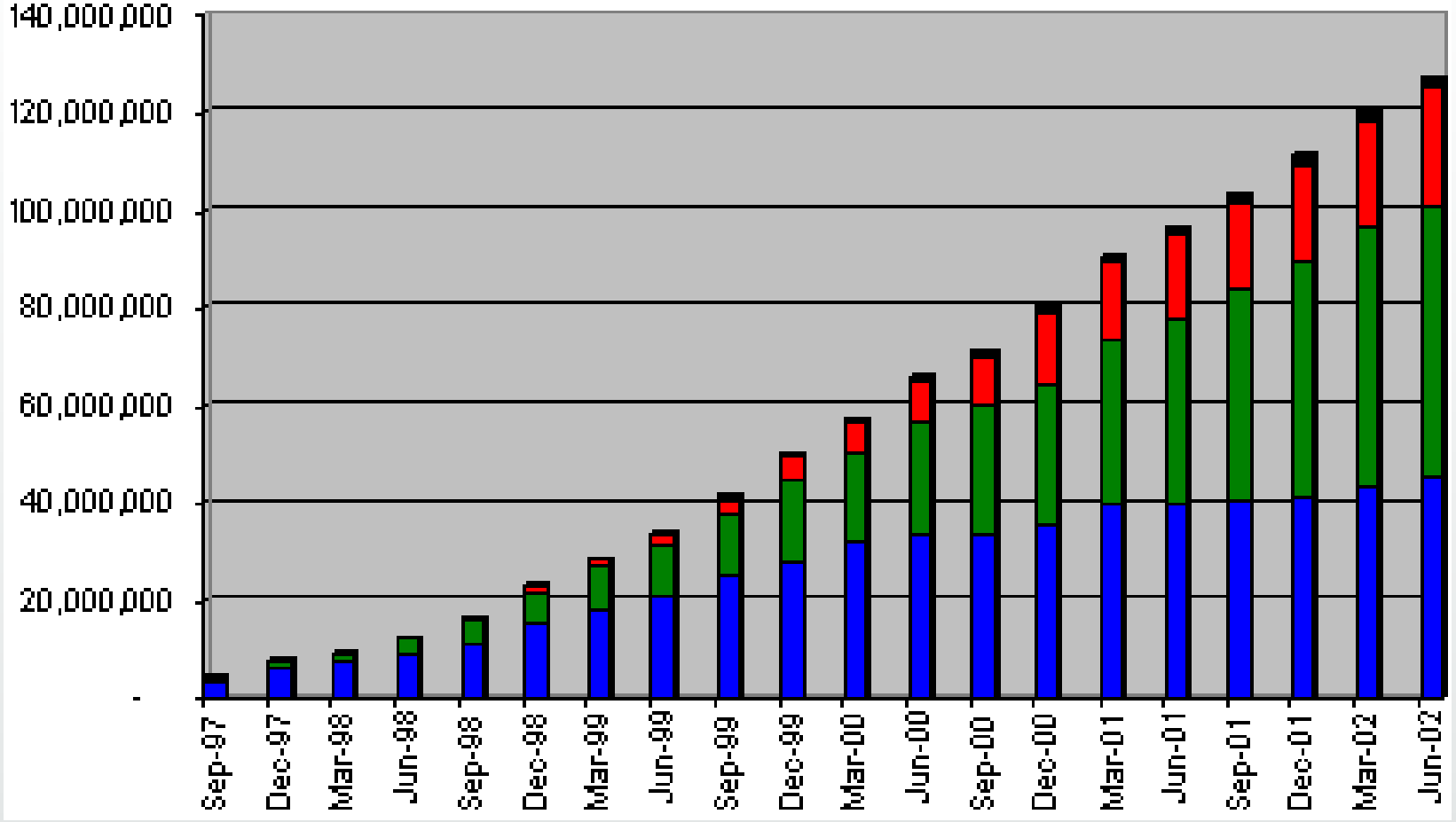
ROLE OF MSC during call

- MSC Adjust transmitted power of Mobile Unit and BS
- Handoff

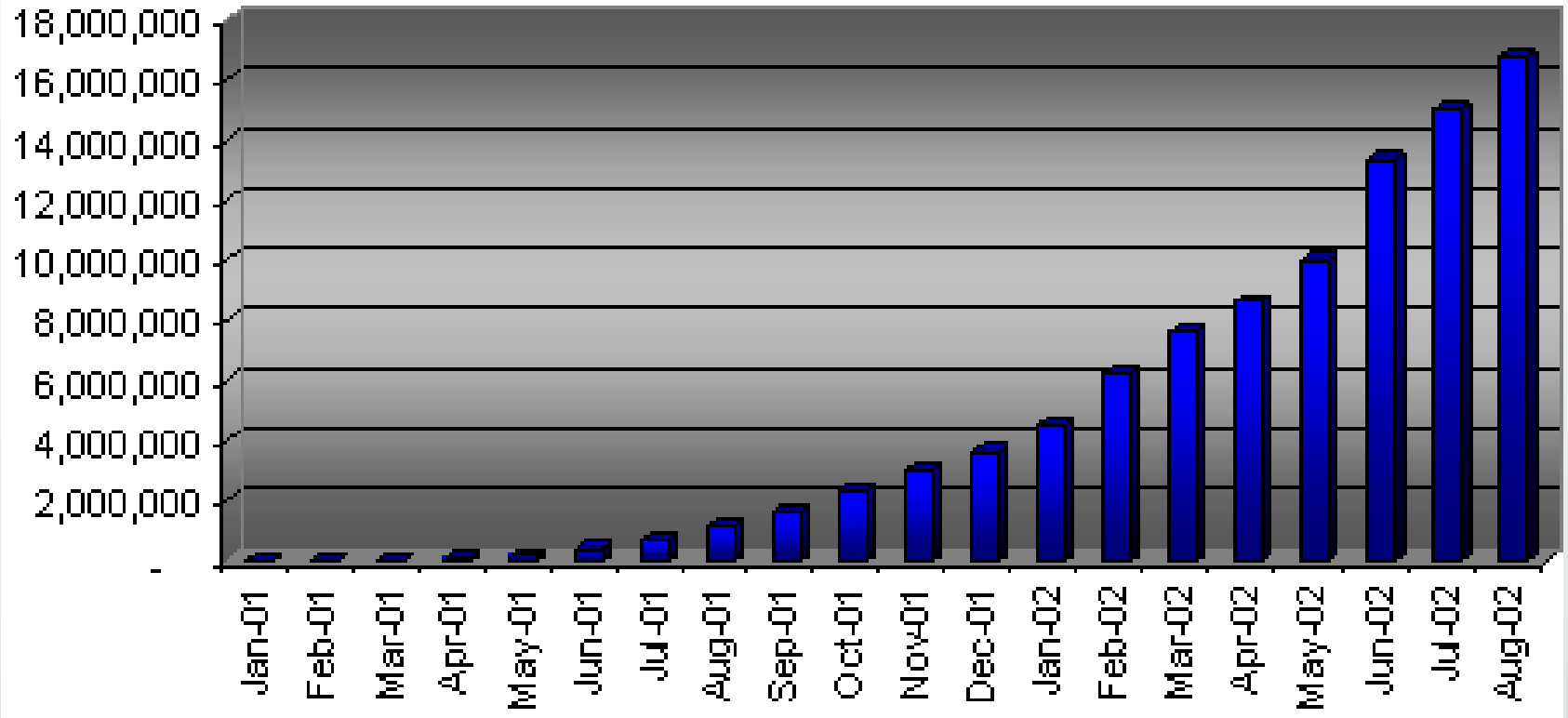
The Roaming

- In wireless telecommunications, **roaming** is a general term referring to the extension of connectivity service in a location that is different from the home location where the service was registered. Roaming ensures that the wireless device is kept connected to the network, without losing the connection.
- When a customer Enters a new geographical area , that is different From his HLR area, he is registered as a ROAMER
- This is Accomplished by
- MSC transmits (FCC)request to all unregistered mobiles to report the MIN and ESN over (RCC)
- Mobile Reports back
- Data is verified from HLR (billing Status)
- Allow Registration and Calling Facility

CDMA Subscriber Growth



CDMA2000 Subscriber Growth



GSM and CDMA Coverage Map Worldwide