

## Evolution from 2G To 4G Mobile Telecommunication systems



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# Wireless versus wireline

Advantages :

- Mobility
  - High efficiency in use of common Resources
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# Wireless versus wireline

Limitations :

- Multipath channel
  - Doppler effect
  - Complex technology
  - Reliability
-

# Mobile cellular generations

- **First generation**

freq. Band                    400/800 MHz

mod.                            FM

Ch. Bw.                        30 k

Access                         FDMA

service                        voice

handoff                        yes

no. of Sub.                    > 40 mil

exm.                            **TACS in EU, AMPS in  
USA and**

**JTACS in Japan**

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- **Second generation**

Freq. Band	900/1800/1900
mod.	Digital( psk/msk)
Ch. Bw.	200(gsm),30(DAMPS)
Access	T/FDMA
Service	voice and data
No. of Sub.	> 500 mil only for gsm
exm.	gsm in EU, DAMPS in USA and PDS in Japan

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- **second generation ( cordless sys.)**

<b>Freq. Band</b>	<b>1800</b>
<b>mod.</b>	<b>Digital</b>
<b>duplex</b>	<b>TDD</b>
<b>Access</b>	<b>T/FDMA</b>
<b>service</b>	<b>voice and data</b>
<b>Handoff</b>	<b>usu. no</b>
<b>Speech codec</b>	<b>ADPCM(32k)</b>
<b>cell radius</b>	<b>&lt; 500 m</b>
<b>exm.</b>	<b>CT2&amp;DECT in EU PHS in Japan</b>

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- **Second generation ( IS-95)**

Freq. Band	900 M
Access	CDMA
Ch. Bw.	1250 k
Mod	BPSK/QPSK
chip rate	1.2288 M
Duplex	FDD

# CDMA Technology

- تعریف: فناوری ارتباطات بیسیم مبتنی بر مخابرات باند پهن
- هدف: افزایش امنیت ارتباط، افزایش پهنای باند، افزایش برد
- سیستم CDMA: سیگنال پیام با باند باریک در سیگنال گسترده طیف با سرعتی بسیار بالا تر ضرب می شود
- CDMA بعنوان مالتی اکسس:
  - ۱- از رشته کدهای مجزا جهت تمایز مشترکین استفاده میکند
  - ۲- همه مشترکین از یک فرکانس حامل استفاده می کنند

# CDMA History

- Military
  - 1940 : cdma is proposed for mobile comm. due to more ability to enhance the capacity and use high degree of freq. reuse
  - 1991 : first field trials (IS-95)
  - 1995 : first commercial cdma service in Hong Kong
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# CDMA characteristics

- Near-far problem  
cdma needs power control mechanism
  - Soft Handoff
  - No freq. Plan
  - Reduced burst power → increase human health
-

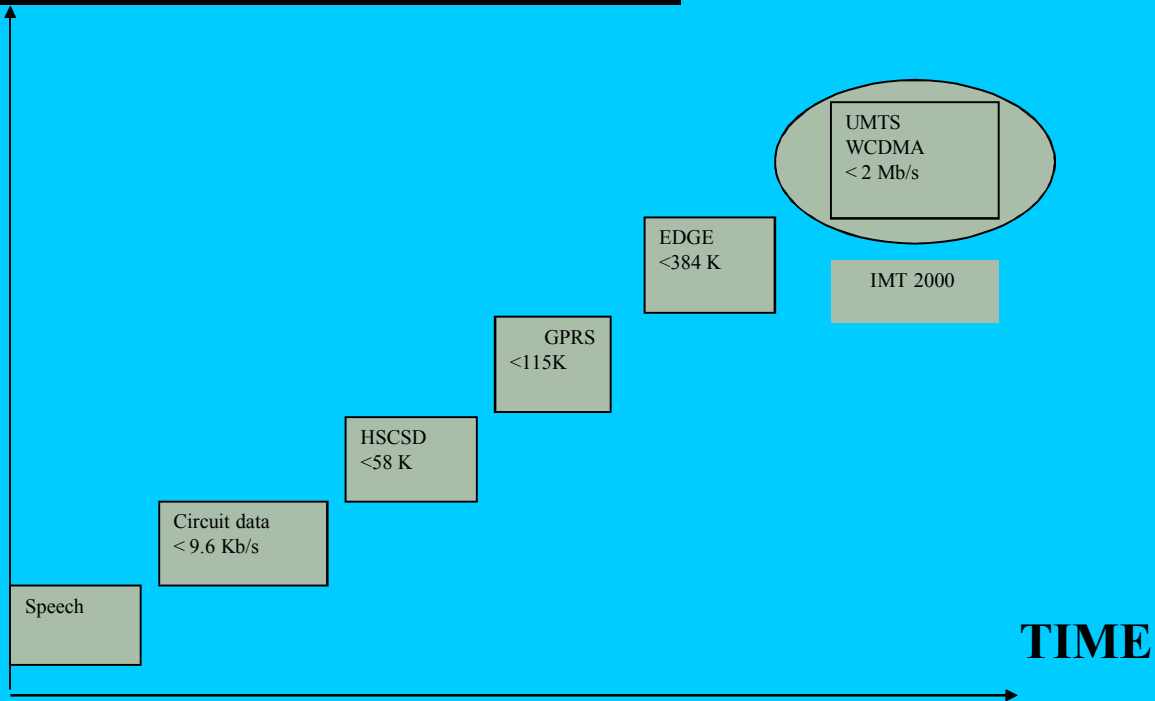
# UTRA's modes

- FDD mode ( using WCDMA)  
data rates up to 384 kbps
  - TDD mode (using T/CDMA)  
data rates up to 2 Mbps, asymmetric traffic
-

## Third generation requirement

- more capacity & flexibility
  - global roaming
  - unity standard
  - IMT 2000  
806-960MHZ,1710-1785MHZ,2110-2170MHZ  
,1920-1980MHZ,2500-2690MHZ
-

# systems development



# Internet - Future

Million  
Subscribers

800

600

400

200

2000

2001

2002

2003

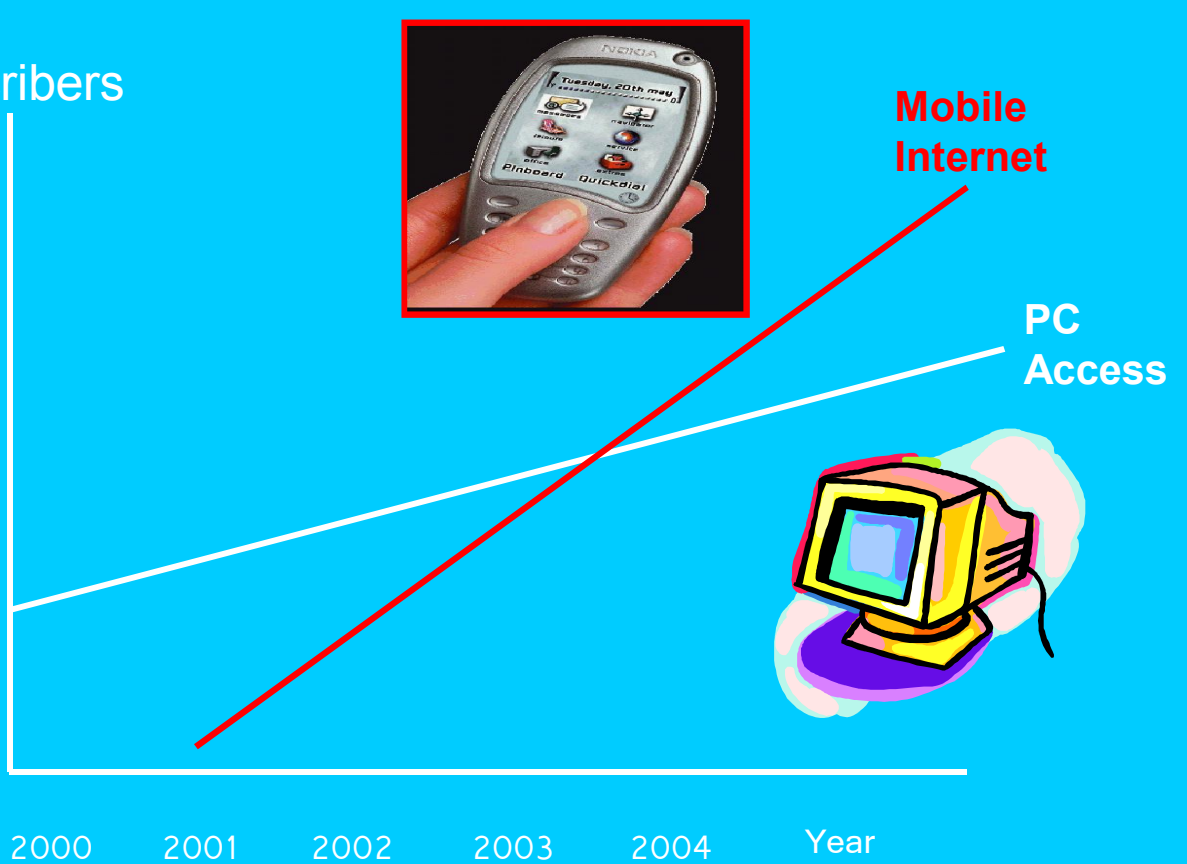
2004

Year

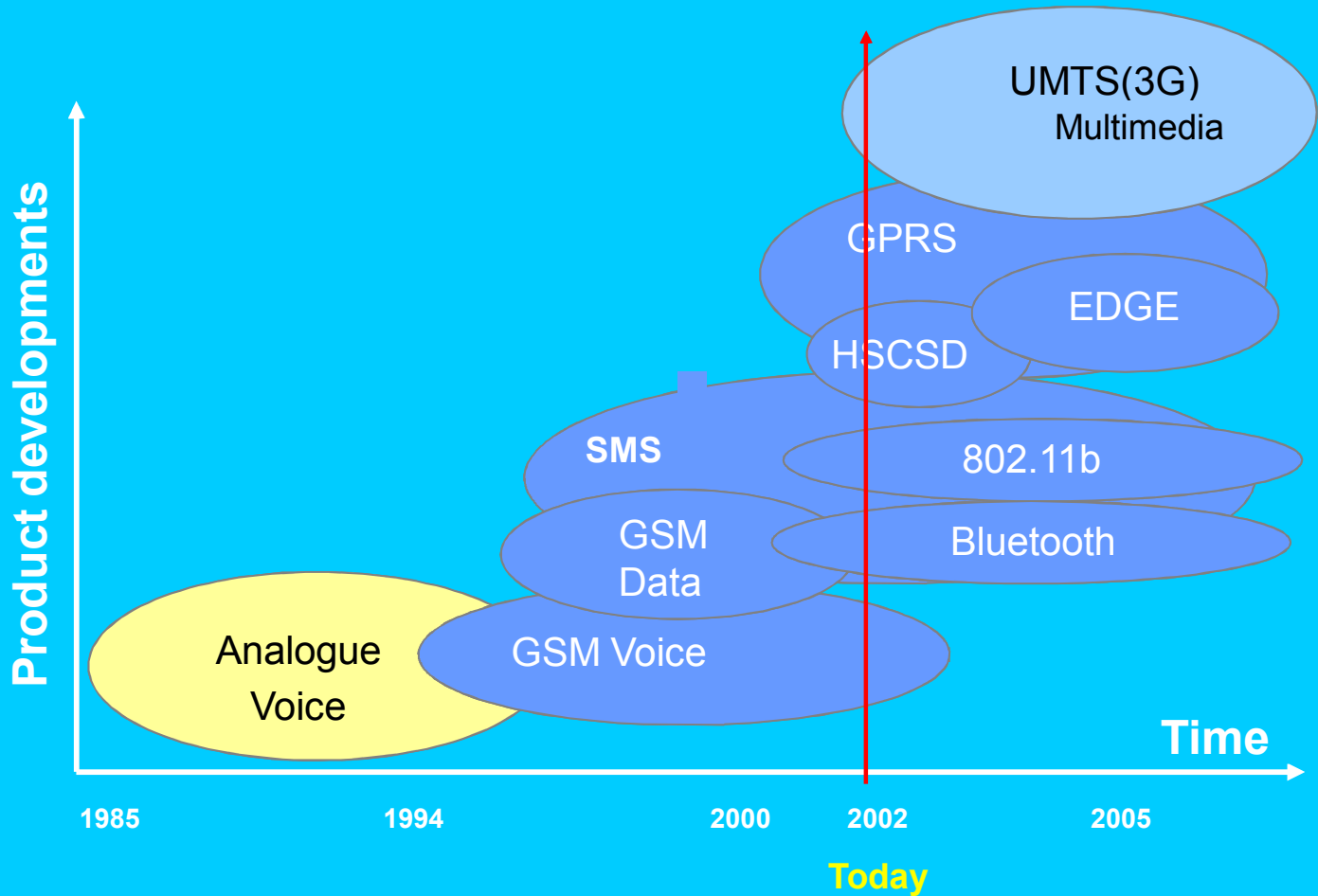


**Mobile  
Internet**

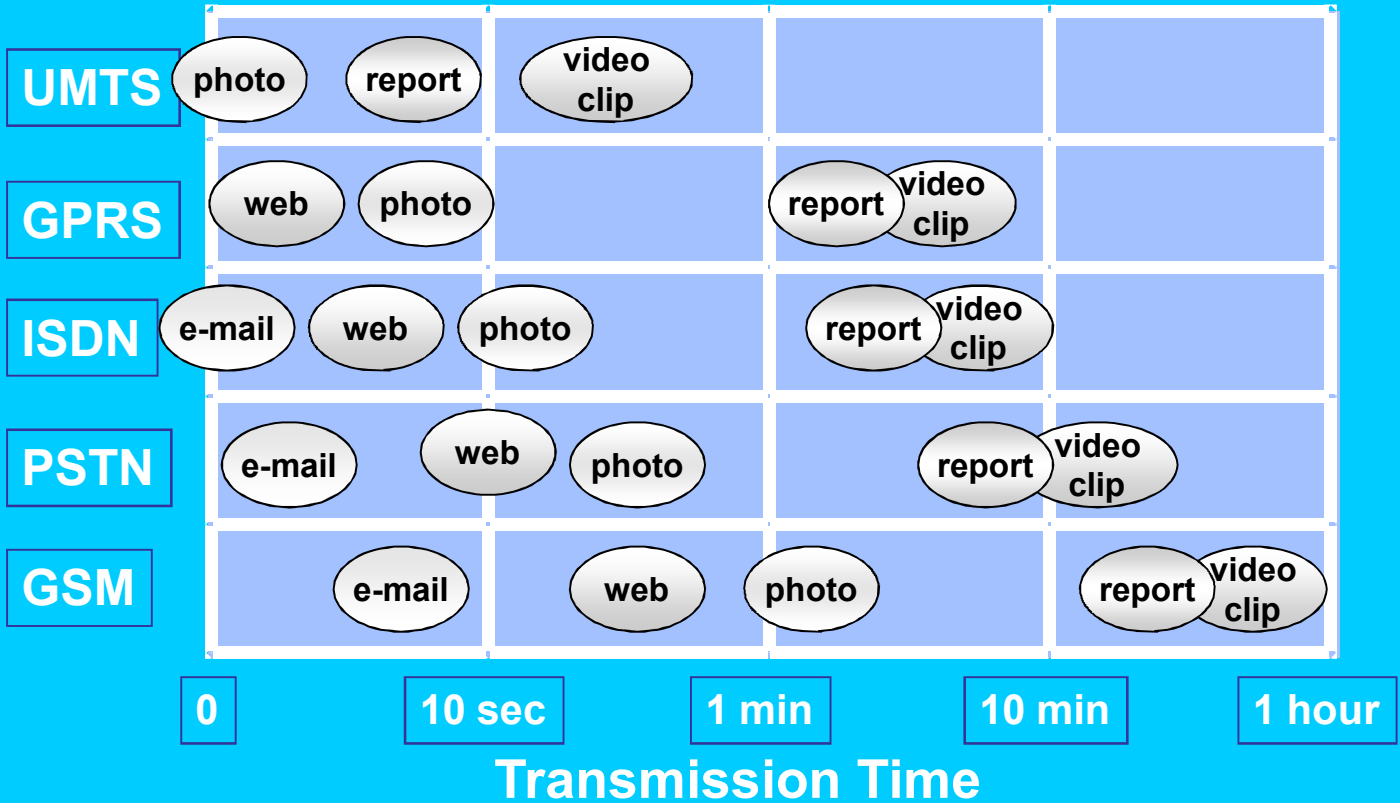
**PC  
Access**



# Communication Technologies

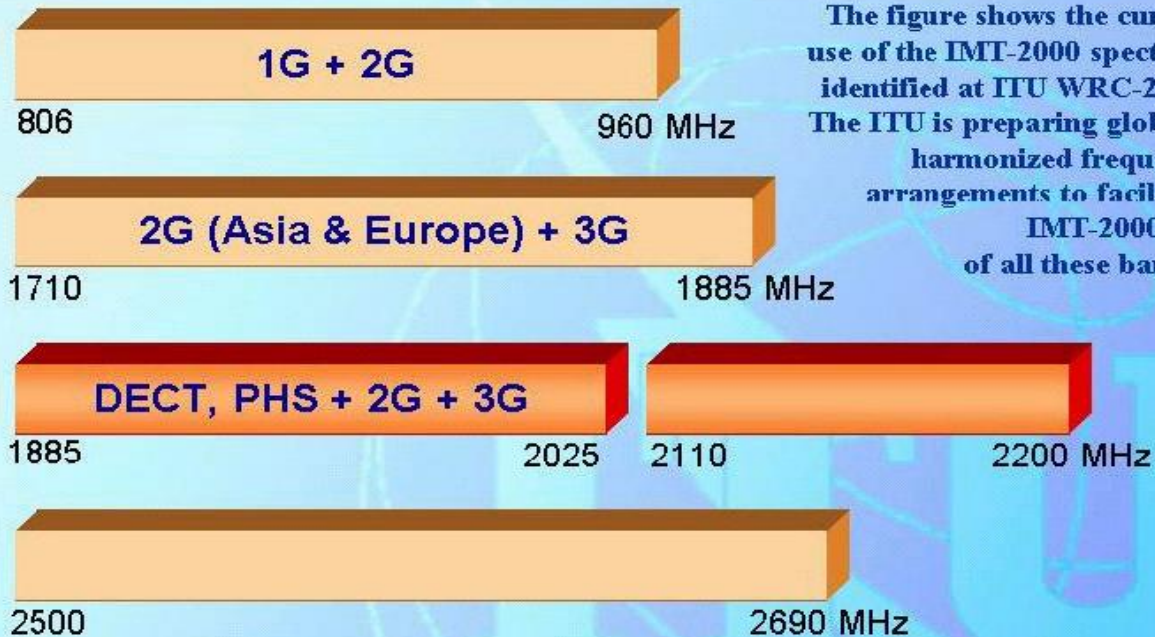


# Increasing Data Rates

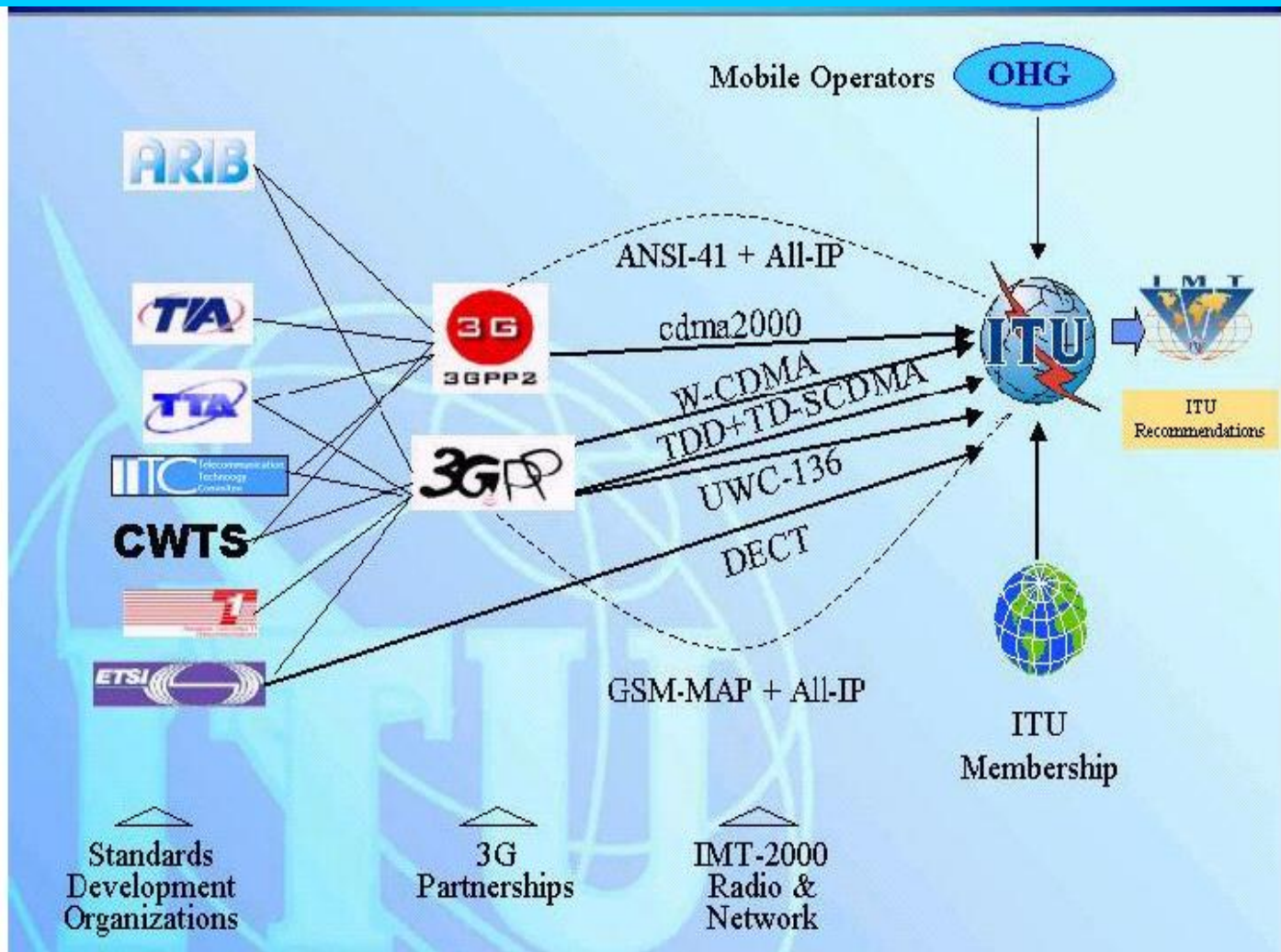




# IMT-2000 Frequency Bands



The figure shows the current use of the IMT-2000 spectrum identified at ITU WRC-2000. The ITU is preparing globally harmonized frequency arrangements to facilitate IMT-2000 use of all these bands.



# Third Generation, How?

- **Revolution**

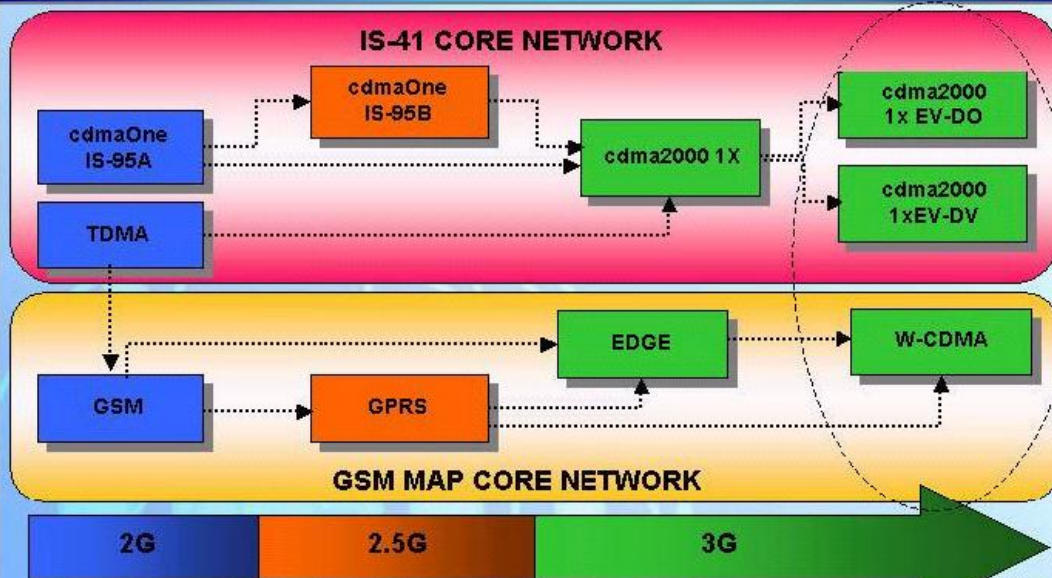
use of the systems based on the 3rd Gen. Standards.

- **Evolution**

upgrading the existing systems to support the new services.

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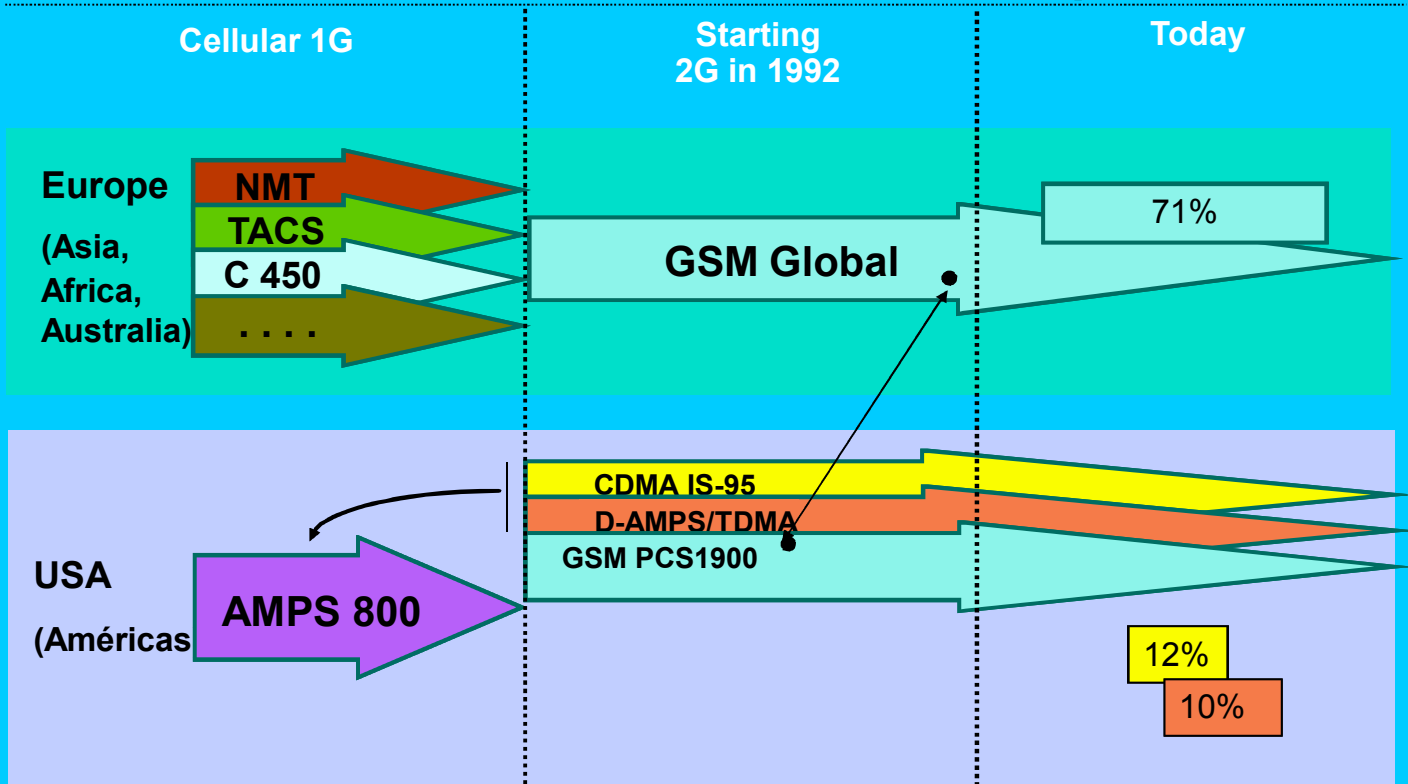
# Evolution Paths



It is the ITU goal that in IMT-2000 all radio access options should work with all network options, e.g., including cdma2000 on GSM MAP and W-CDMA on IS-41.

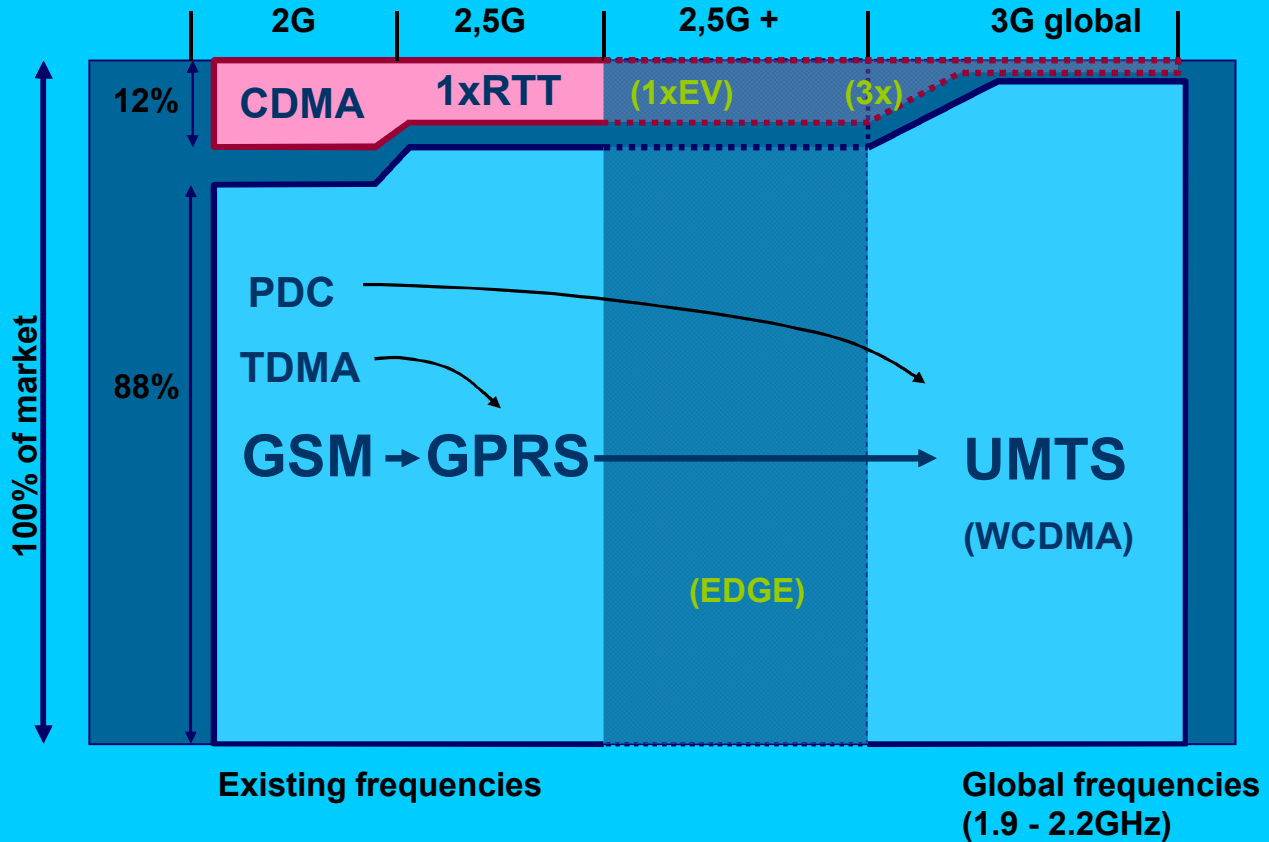


# UMTS, based on lessons from the past, ...

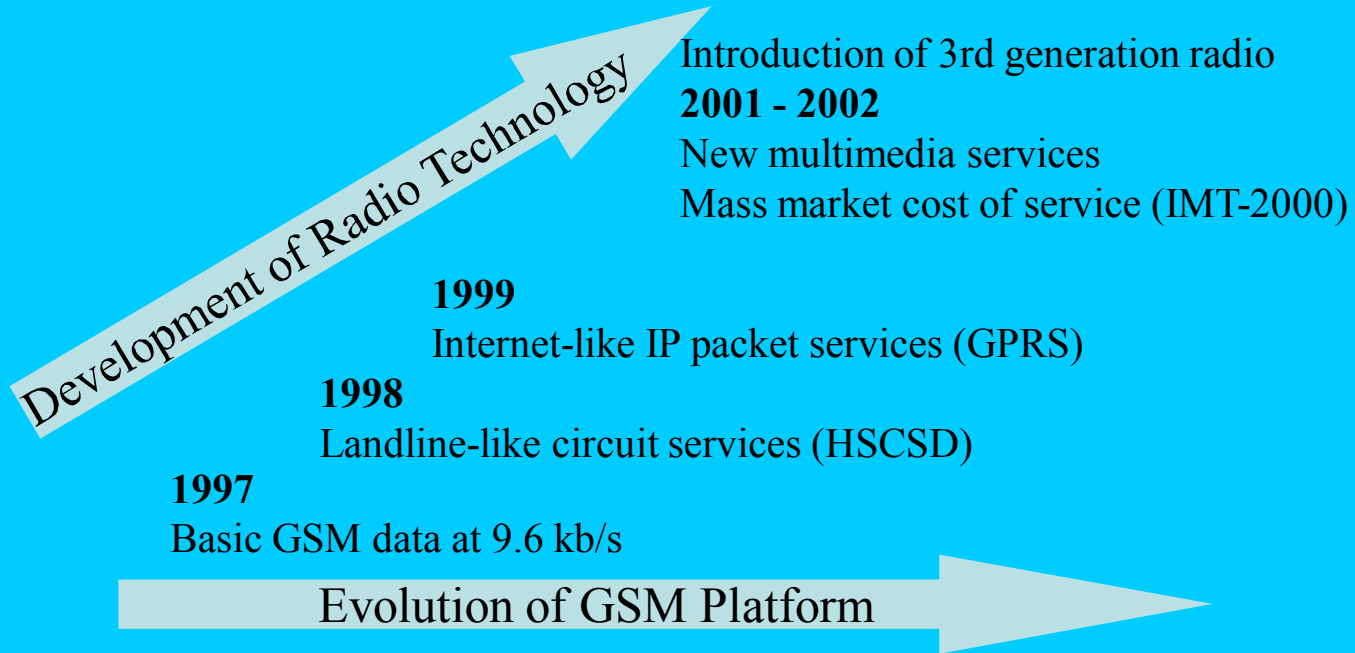


# ... UMTS is reaching early

## success



# GSM Radio Steps to 3rd Generation



# GSM

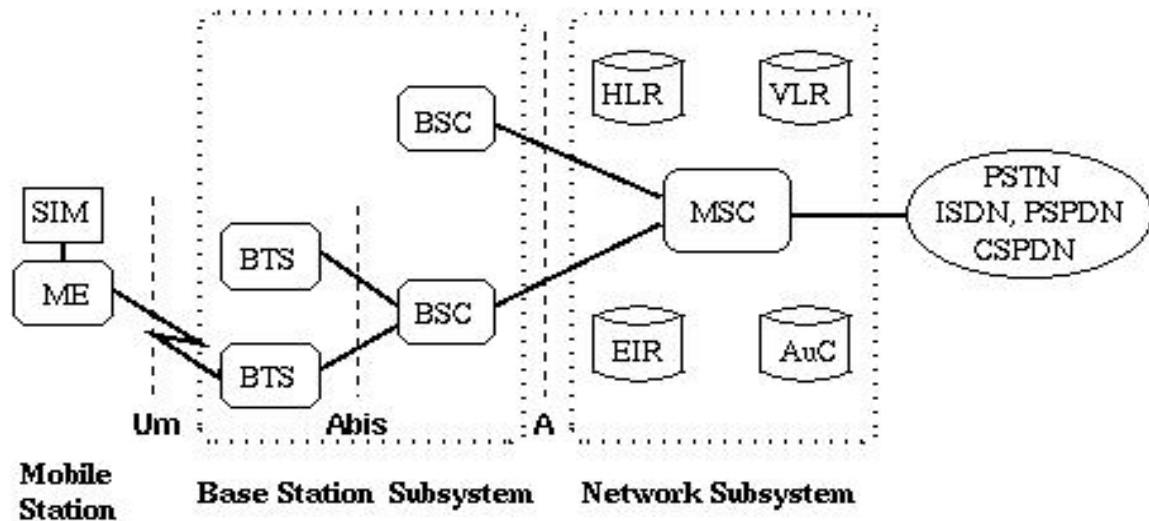
(Global system for mobile communications)

# Dual Band Network : GSM 900 & DCS 1800 Air Interface

	GSM 900	DCS 1800
Uplink Band	890-915 MHz	1710-1785 MHz
Downlink Band	935-960 MHz	1805-1880 MHz
Channel Spacing	200 kHz	200 kHz
Total Number of Channels	124	374
Duplex Spacing	45 MHz	95 MHz
Number of Timeslots per Channel	8	8

# What is GSM??

(Global System for Mobile Communications)



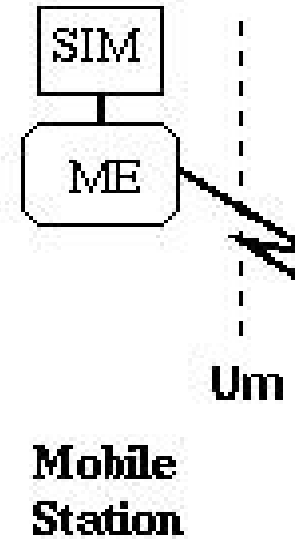
SIM	Subscriber Identity Module	BSC	Base Station Controller	MSC	Mobile services Switching Center
ME	Mobile Equipment	HLR	Home Location Register	EIR	Equipment Identity Register
BTS	Base Transceiver Station	VLR	Visitor Location Register	AuC	Authentication Center

# GSM Architecture

- Three broad parts
  - Mobile Station (MS): carried by the subscriber
  - Base Station Subsystem: control radio link with MS
  - Network Subsystem: its main part is MSC
- Interfaces:
  - Um Interface : known as air interface or radio link.
  - Abis Interface: between BTS and BSC
  - A Interface: between BSC and MSC

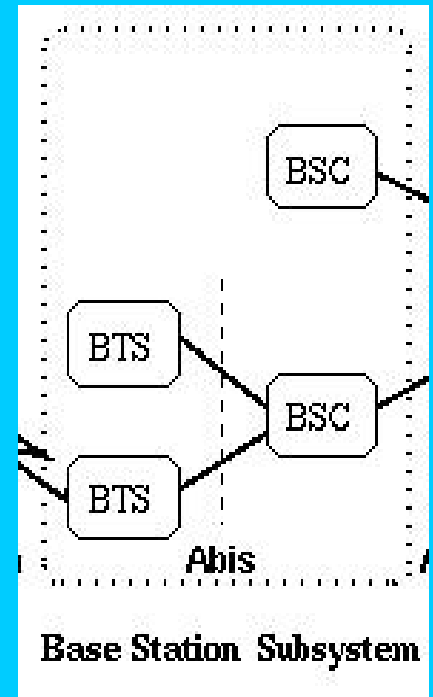
# Mobile Station

- ME(mobile equipment)
  - the terminal
- SIM (Subscriber identity Module)
  - Can insert the SIM card into another GSM terminal and use



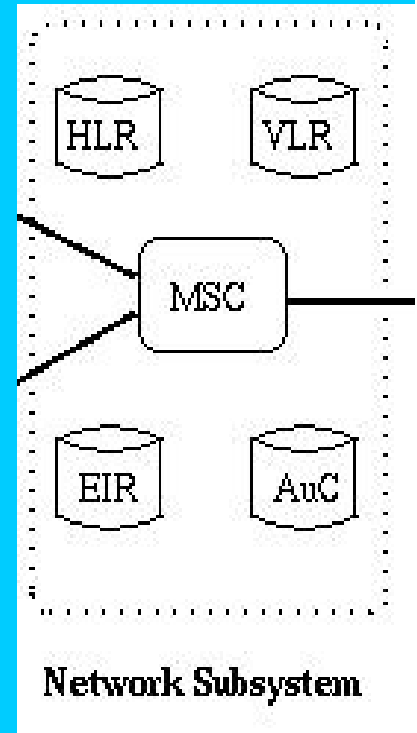
# Base Station Subsystem

- BTS (Base Transceiver Station)
  - handle the radio link protocols with the Mobile Station
- BSC (Base Station Controller)
  - manages the radio resources for one or more BTSs
  - handles such as: frequency hopping and handovers.
  - connection between MS and MSC



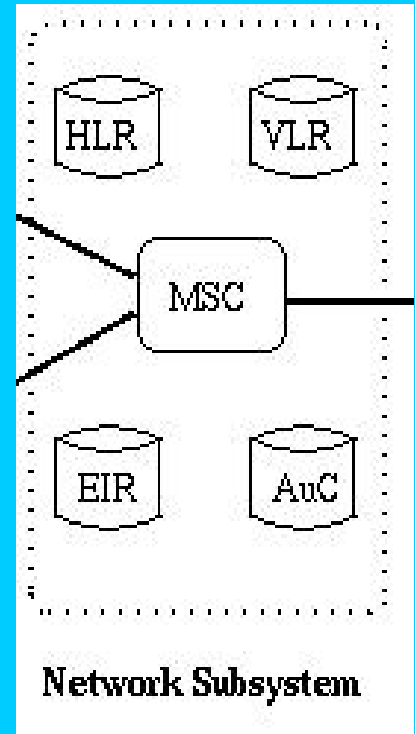
# Network Subsystem

- MSC (Mobile Services Switching Center)
  - acts like a normal switching node of the PSTN or ISDN
  - provides the connection to the fixed networks (such as the PSTN or ISDN).
- HLR (Home Location Register )
  - contains information of each subscriber registered in the corresponding GSM network, along with the current location of the mobile.
  - logically one HLR per GSM network

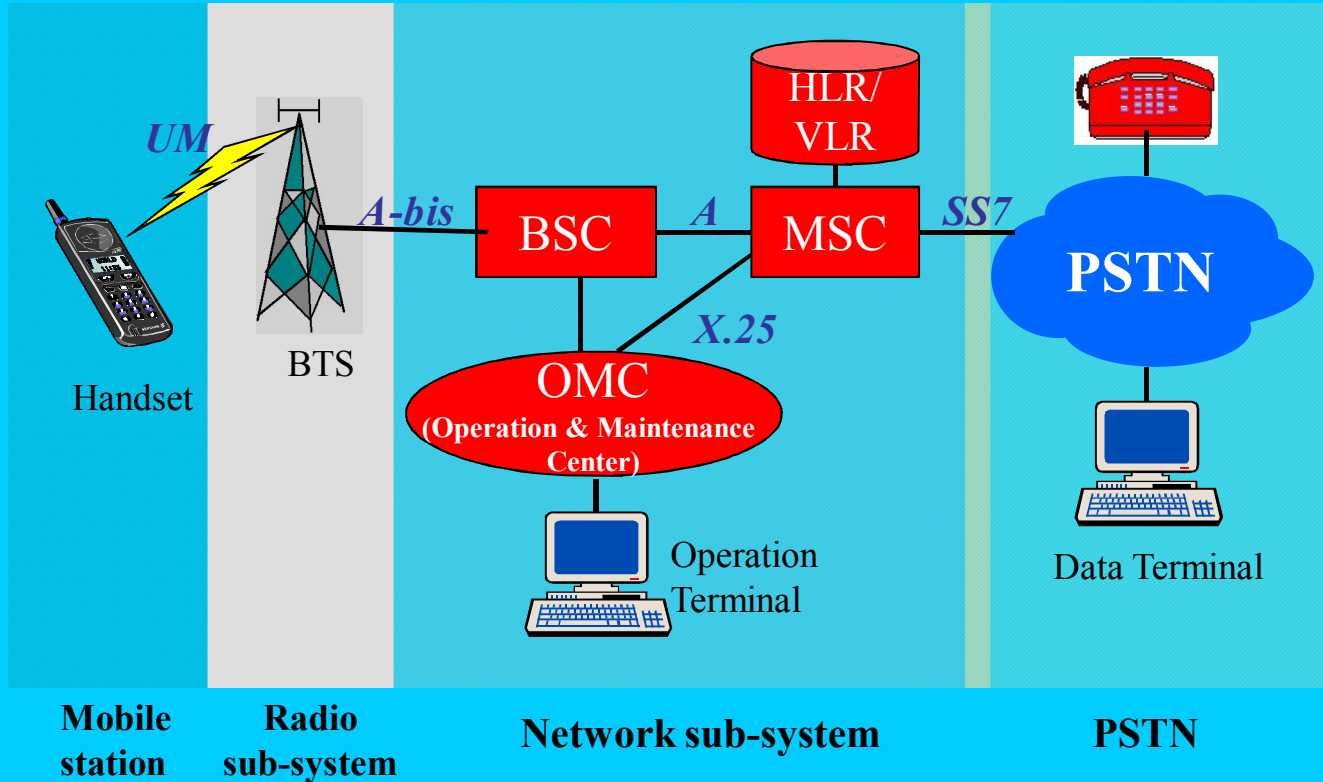


# Network Subsystem continue

- VLR (Visitor Location Register)
  - contains selected information from the HLR, necessary for call control and provision of the subscribed services,
  - each mobile currently located in the geographical area controlled by the VLR.
- EIR (The Equipment Identity Register)
  - a database that contains a list of all valid mobile equipment on the network,
- AuC (The Authentication Center)
  - is a protected database:secret key of SIM



# GSM System Architecture



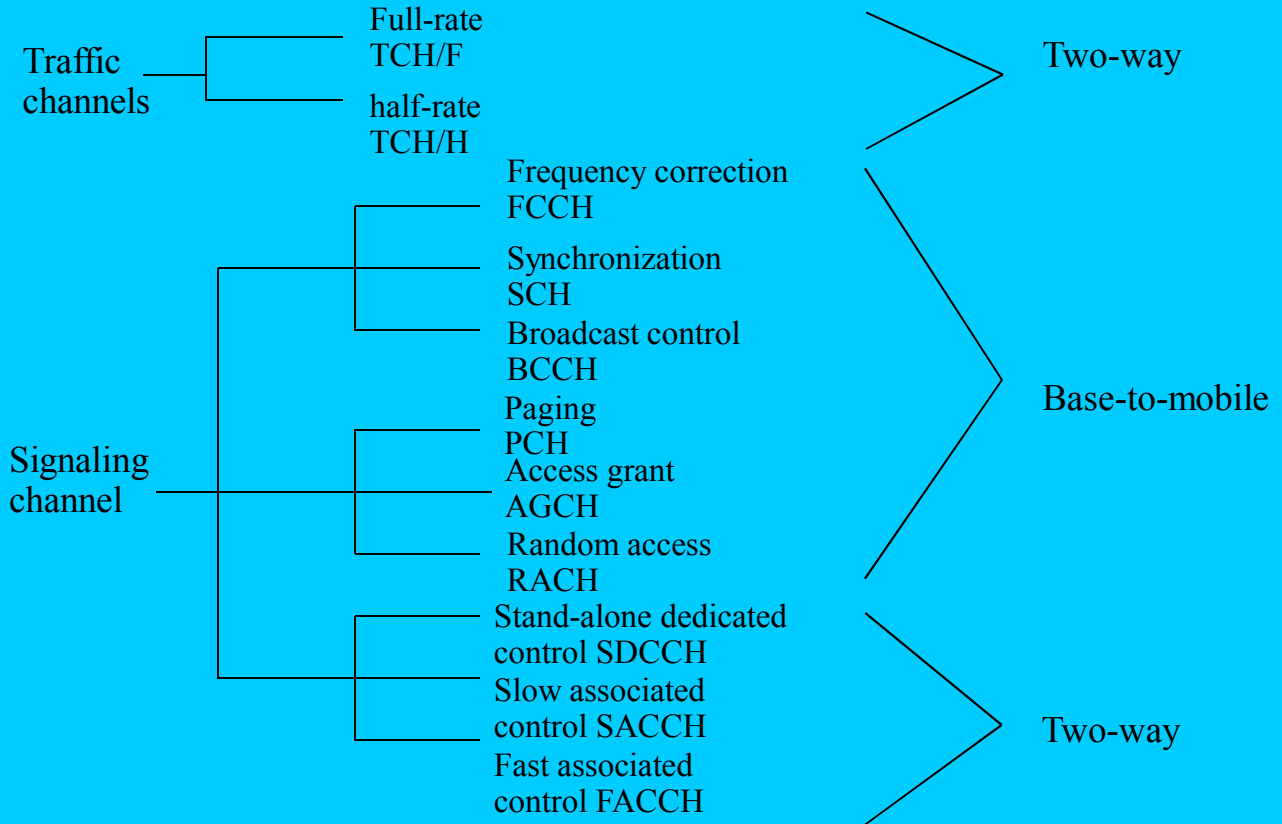
# Air Interface Protocols

- SS7
  - Between PSTN and PLMN ( Public Land Mobile Network)
- X.25
  - BSC and Operation centers
- A
  - Between BSC and MSC
- A-bis
  - Between BTS and BSC
- Um
  - Radio interface between BTS and Handset

# Air Interface Messages

- RR: Radio Resource Management Messages
- MM: Mobility Management Messages
- CM: Call Management Messages

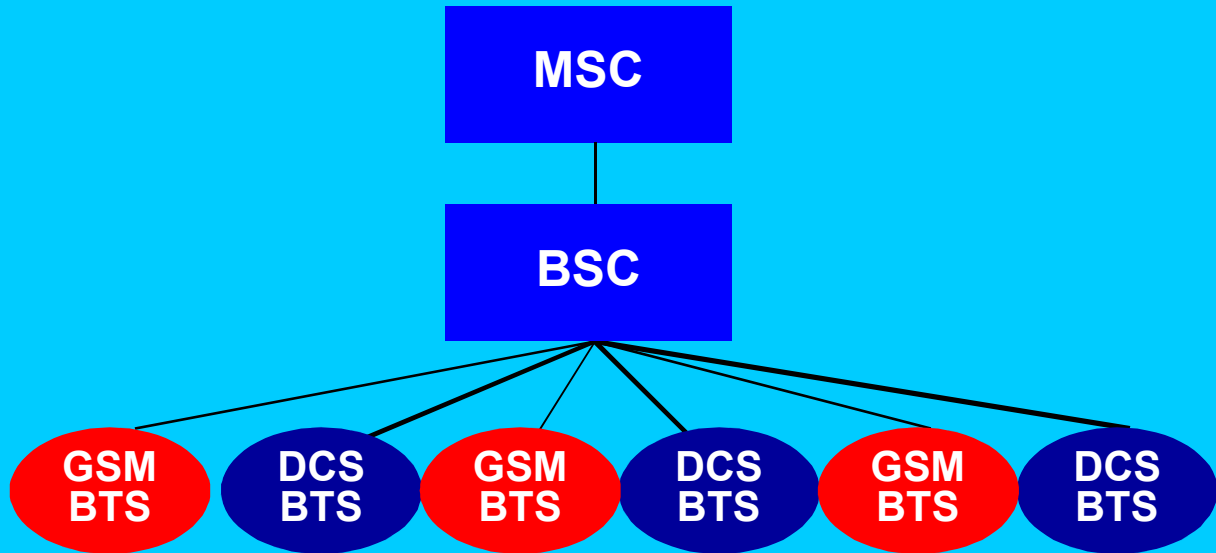
# Air Interface--Channels



# Integrate GSM and DCS Networks

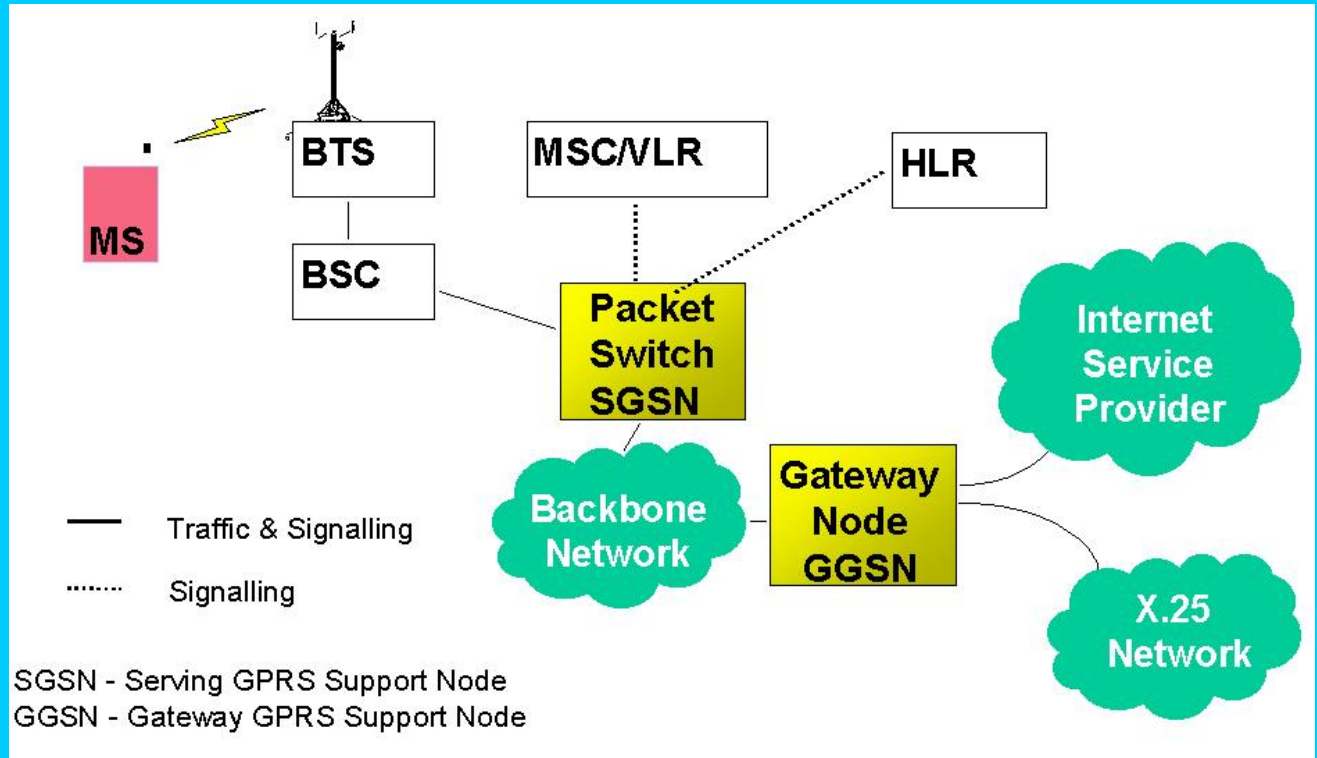
- Integrating 900 and 1800 networks by linking 900/1800 cells to same BSC: An Integrated dual band network
  - Sharing BSC, MSC, and HLR
- Benefits
  - Reuse existing resources
  - Simplify the handoff between networks
  - Flexible and changeable infrastructure

# Integrated Dual Band Network



# GPRS System

(General Packet Radio Service)



# What is GPRS

- GPRS is a new service in GSM networks which uses PS. technique and enhance data rate to 171 kbps.
  - charging is based on the volume of tr. data.
  - GPRS supports QoS ( in 4 level)
  - Ch allocation is dynamic
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# GPRS Standards

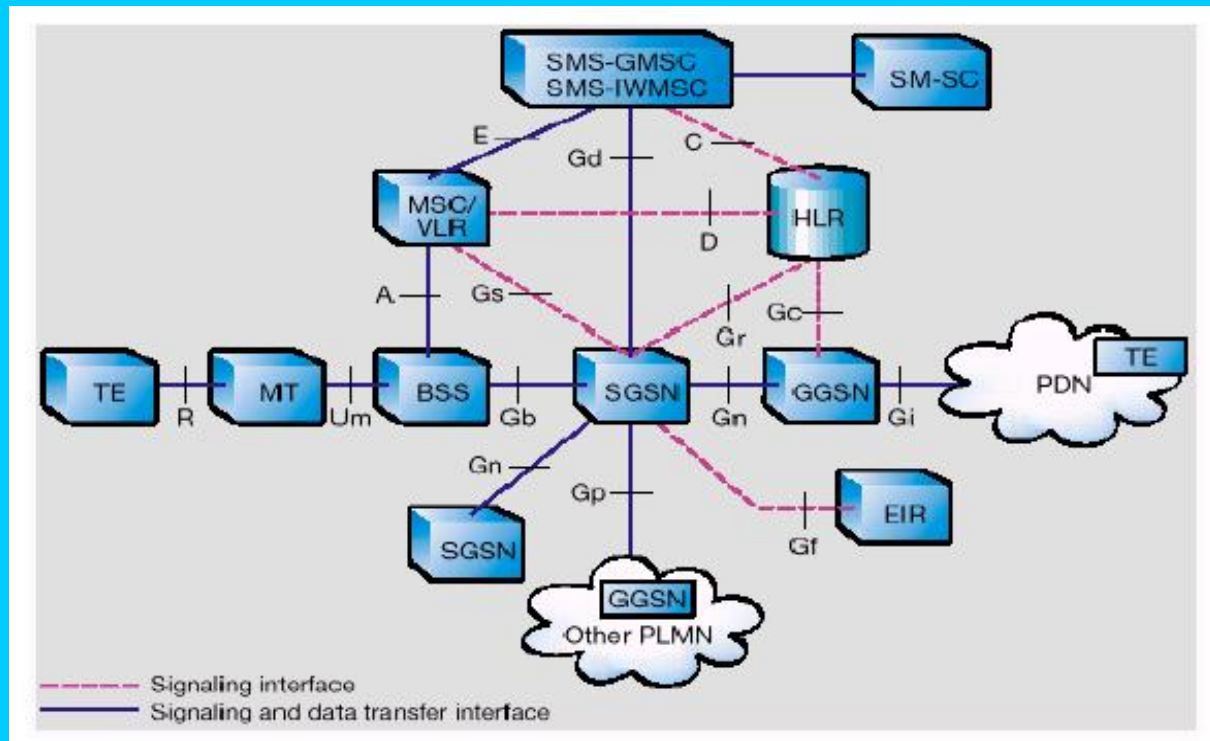
- GPRS standards are developed by ETSI in two phases :
  - 1.phase: supports PtP connection and the codes CS1 and 2
  - 2.phase : supports PtMP connection and the codes CS3 and 4
-

# GPRS - Applications

- GPRS bearer service will enable applications in the following segment areas:
  - Telemetry
  - Messaging
  - e-mail
  - Access to the World Wide Web
  - Job Scheduling and Despatch
  - Vehicle Location Services
  - Information services
  - E-commerce



# GPRS reference model



# GPRS MS

## classes

- Class A : GPRS and GSM services simultaneously
- Class B : GPRS and GSM services but not simultaneously
- Class C : only GPRS services are supported

# GPRS elements

- **SGSN**

packet routing and transfer to service area,

ciphering, authentication, MM and charging

- **GGSN**

Interface to ext. IP nets, access & routing func., Gateway func., Sub. address publish and charging data collection

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# IP address allocation

- **Static Address**

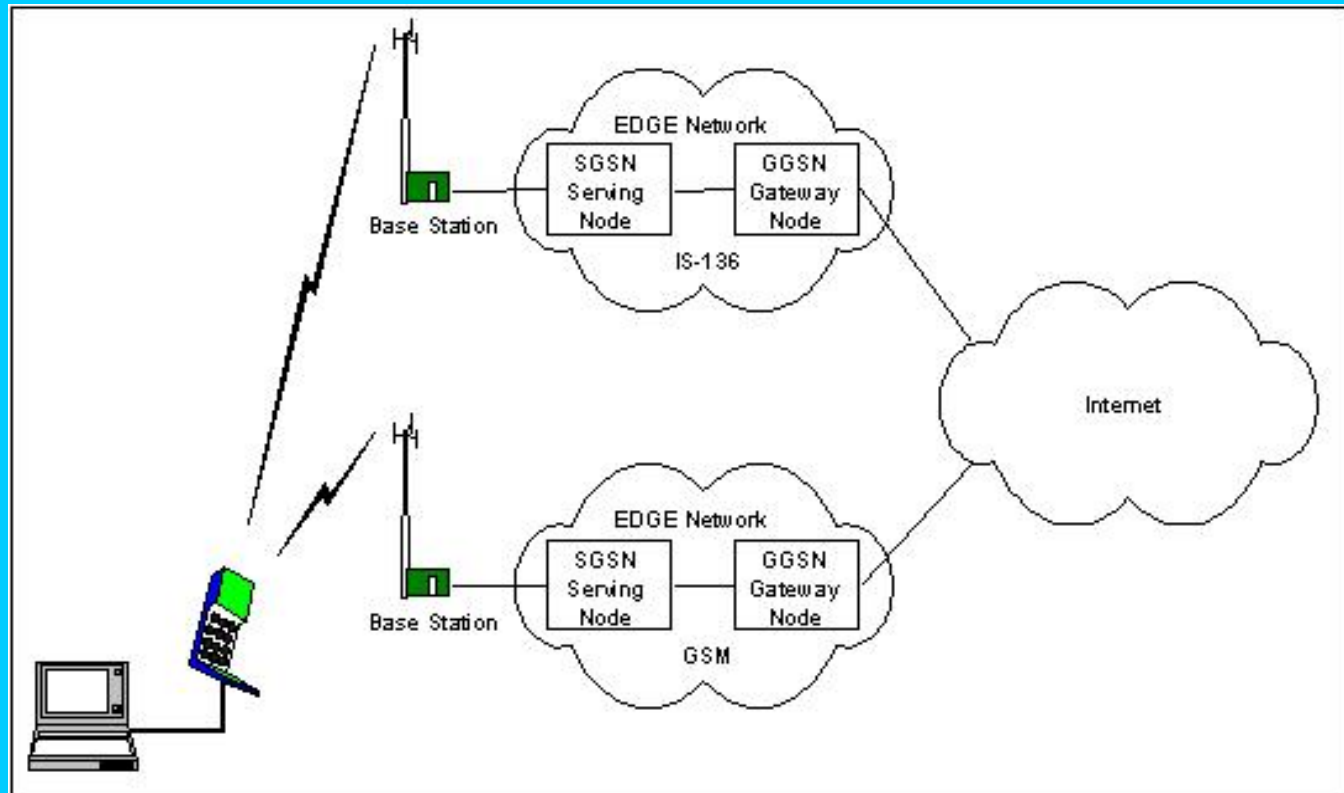
- the MS has a permanent address

## **Dynamic Address**

- operator use and reuses IP address
  - reduces the total no. of required IP address
  - it is a recommended technique of allocation
-

# EDGE

(Enhanced Data Rates for GSM Evolution)



# EDGE Features

- Introduce new methods at the physical layer
  - new form of modulation: 8PSK(phase Shift Keying)
    - introduced as a complement to GMSK (Gaussian Filter Minimum Shift Keying)
    - 8PSK: use 8 phases to carry signals
  - High radio interface data rates (up to 384kbps)

# EDGE Features cont.

- Provides an evolutionary migration path from GPRS to UMTS
  - Only one EDGE transceiver unit need to be added to each cell.
  - Software upgrades to BSC and Base Stations can be carried out remotely.
  - Higher layer protocols (GGSN, SGSN) stay the same
  - Can be introduced smoothly in GPRS(doesn't require any new elements)

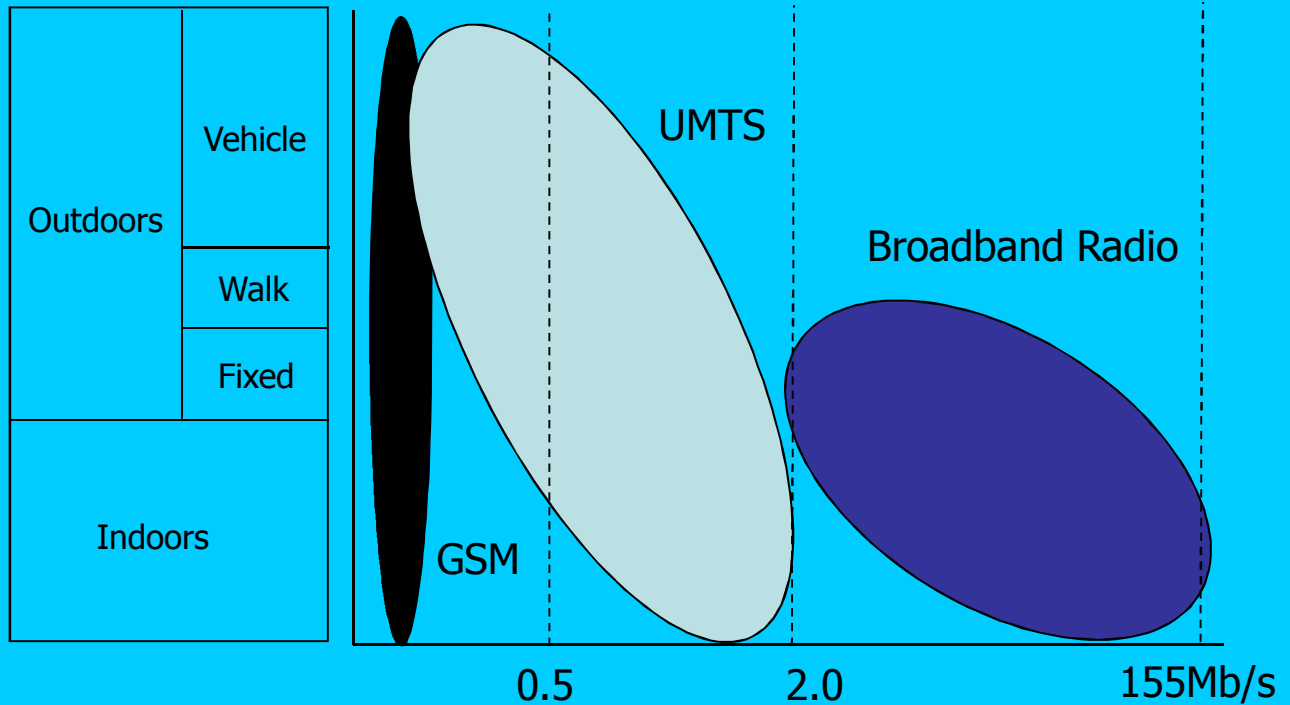
# What are 3G Technologies?

- **UMTS** (Universal Mobile Telecommunications Service)
  - EDGE can co-exist with UMTS
- **Cdma 2000**
  - based on the cdma One standard, two air modes:
    - one based on the parallel use of 3 contiguous cdmaOne carriers (multi-carrier approach),
    - the other one on the use of the corresponding 3 carriers width spreading (direct spread approach)

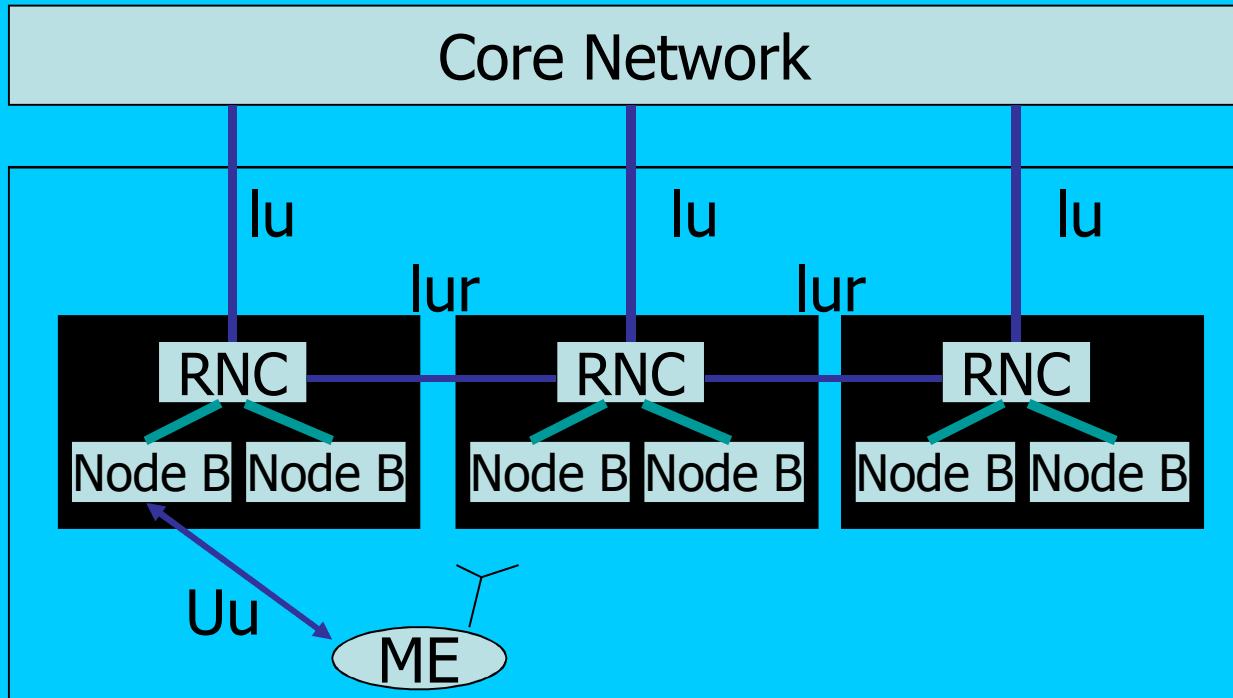
# What does UMTS provide?

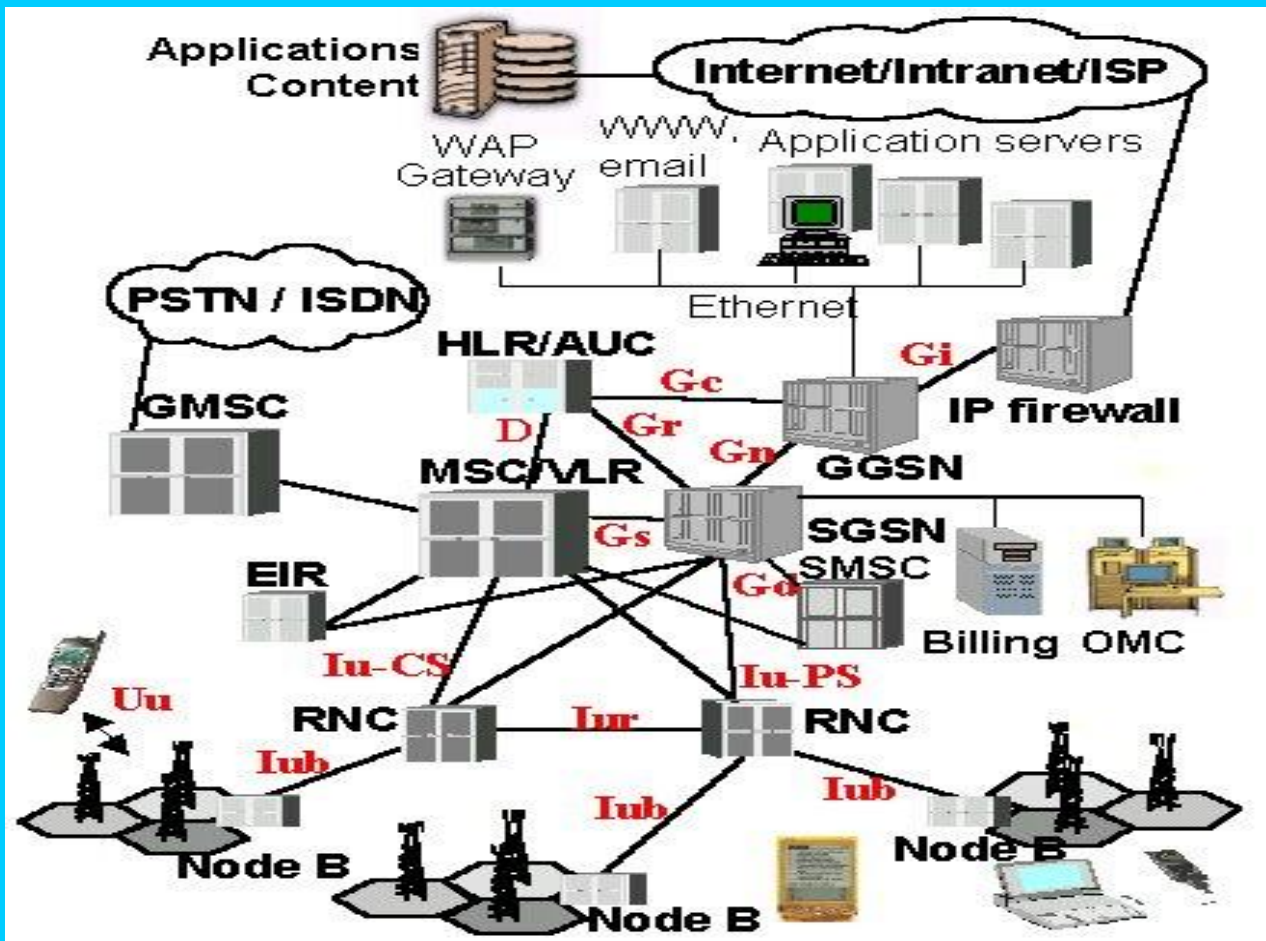
- Circuit- and Packet-Oriented Services
- Seamless Global Roaming
- Capacity and Capability to serve more than 50% population
- A Wide Range of Services
  - Voice, low-rate data and high-rate data
  - 144kb/s, 384kb/s , 2Mb/s

# UMTS coverage vs. bit rate



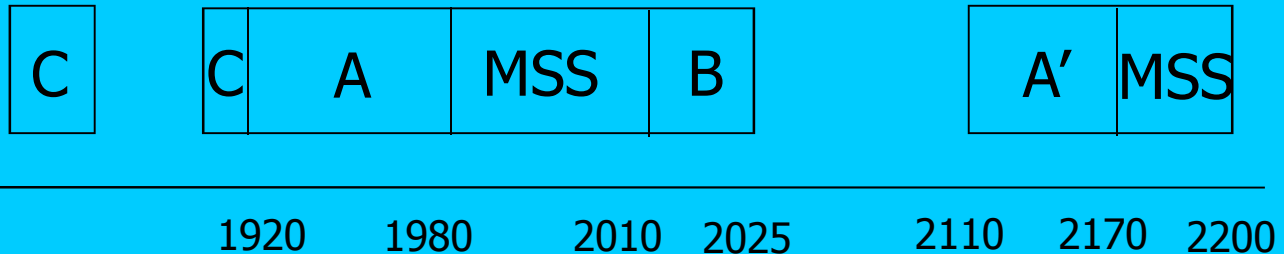
# UTRAN-UMTS Terrestrial Radio Access Network





# Frequency Allocation

- 1920-1980 MHz paired with 2110-2170 MHz



# WCDMA Radio Parameters

- Group 200KHz bands into 4.2-5.0 MHz carriers
- Chip Rate is 3.84 Mchips/sec

# Power Control In WCDMA

- Near-Far Problem in CDMA
  - Different Performance for Subscriber Links
  - A Few Subscribers closest to the BTS may contribute too much multiple Access Interference.

# Power Control In WCDMA

- How to do power control
  - Force all users to transmit the minimum amount of power
  - Reduce the power transmitted by users closest to the BTS; increase the power transmitted by users farthest to the BTS

# Power Control In WCDMA

- Open Loop vs. Close Loop
  - Open Loop Power Control
    - Subscriber measures the DL power and adjusts its transmission power
  - Close Loop Power Control
    - BS measures the UL power. MS measures the DL power and reports to the BS. BS instructs the user to raise or lower its transmission power

# Future GSM

