

# Outline of this chapter

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## 1. GSM

### 1.1. Introduction

### 1.2. Architecture

### 1.3. Physical Layer

### 1.4. Data Link Layer

### 1.5. Network Layer

### 1.6. Recent Developments

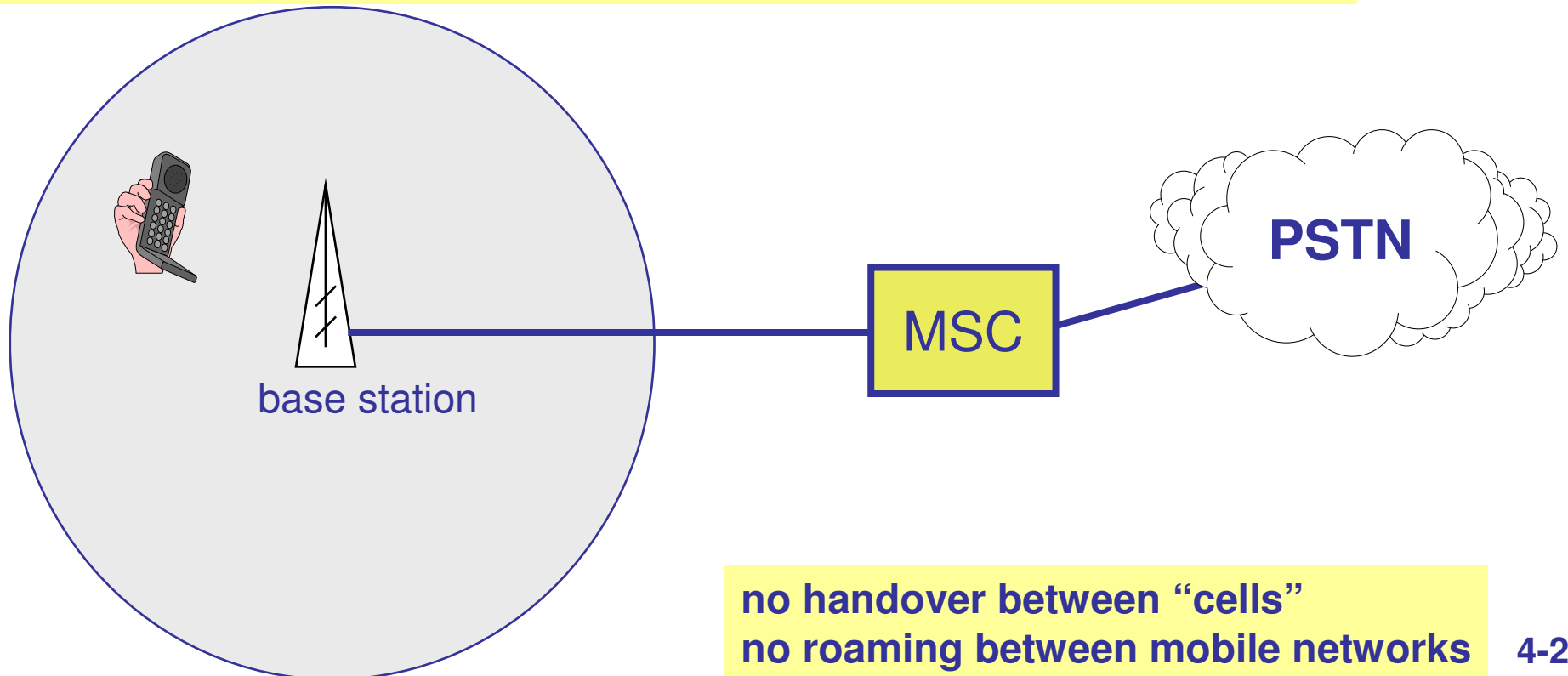
## 2. DECT

## 3. TETRA

## 4. UMTS

# Radio Telephone Service

popular since mid 1970's  
one antenna (base station)  
coverage 20 km radius  
number of users 4000  
interconnection to PSTN via Mobile Switching Center (MSC)  
MSC is similar to LEX in fixed PSTN network



no handover between "cells"  
no roaming between mobile networks 4-2

# Analog Cellular Networks: MOB-1 and MOB-2

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## MOB-1 :

- uplink : 150.4 - 151.4 MHz
- downlink : 155 - 156 MHz
- duplex distance : 4.6 MHz
- number of duplex channels : 40
- channel bandwidth : 25 kHz







Belgacom networks

FDMA/FDD  
systems

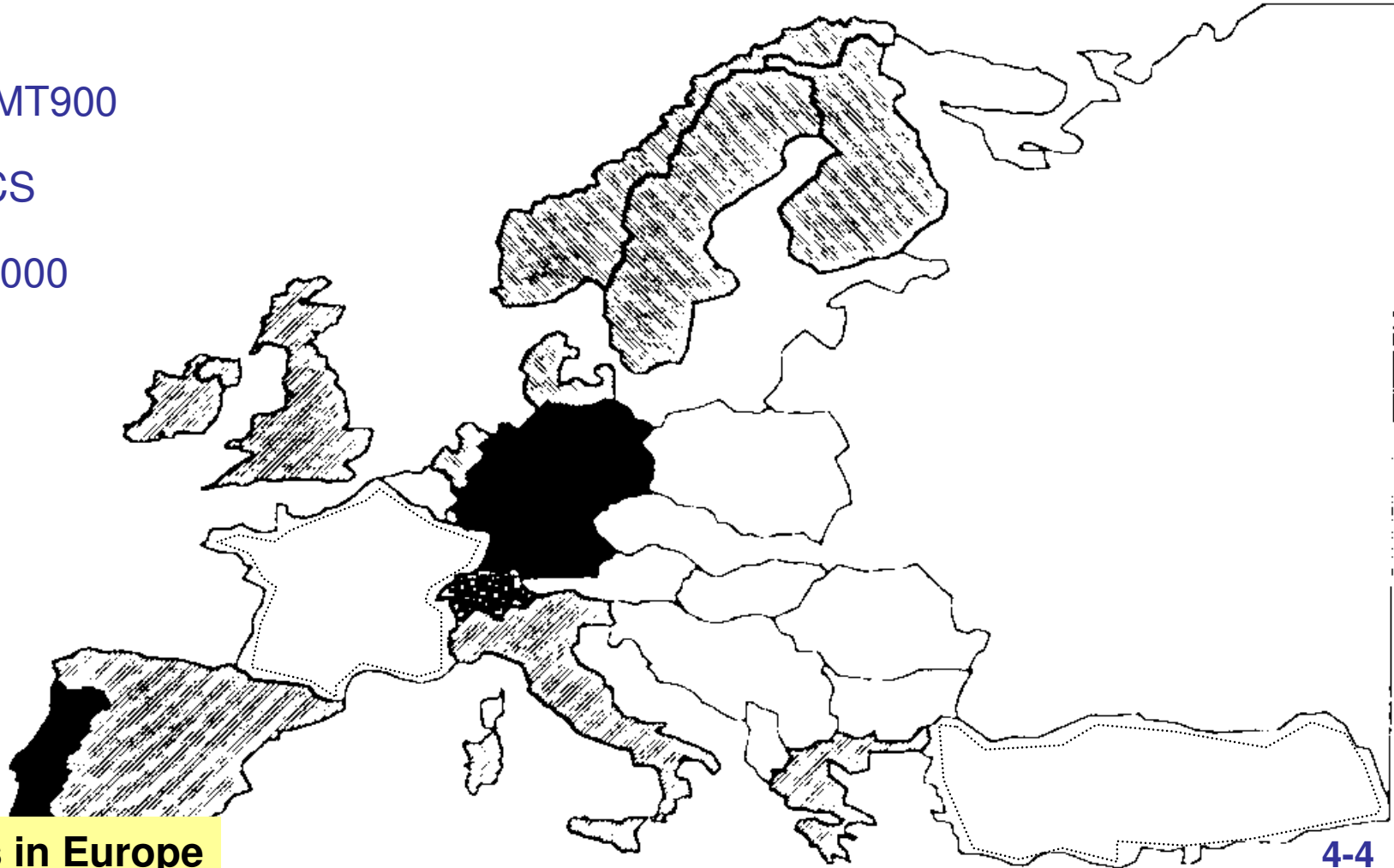
## MOB-2 (NMT-450)

- uplink : 451.3- 455.74 MHz
- downlink : 461.3 - 465.74 MHz
- duplex distance : 10 MHz
- number of duplex channels : 222
- channel bandwidth : 20 kHz

# Analog Cellular Networks : Europe

-  C450
-  NMT450
-  NMT900
-  NMT450/NMT900
-  TACS/ETACS
-  Radiocom 2000

AMPS : Advanced Mobile Phone Service (USA, 1977)  
NMT : Nordic Mobile Telephone Service (Nordic countries, 1981)  
TACS : Total Access Communication System (UK, 1985)



1993 : 6.5 M users in Europe

# Digital Cellular Network

- Communication
  - mobile, wireless communication; support for voice and data services
- Total mobility
  - international access, chip-card enables use of access points of different providers
- Worldwide connectivity
  - one number, the network handles localization
- High capacity
  - better frequency efficiency, smaller cells, more customers per cell
- High transmission quality
  - high audio quality and reliability for wireless, uninterrupted phone calls at higher speeds (e.g., from cars, trains)
- Security functions
  - access control, authentication via chip-card and PIN

**GSM : Global System for Mobile communications**

# Digital Cellular Network : GSM

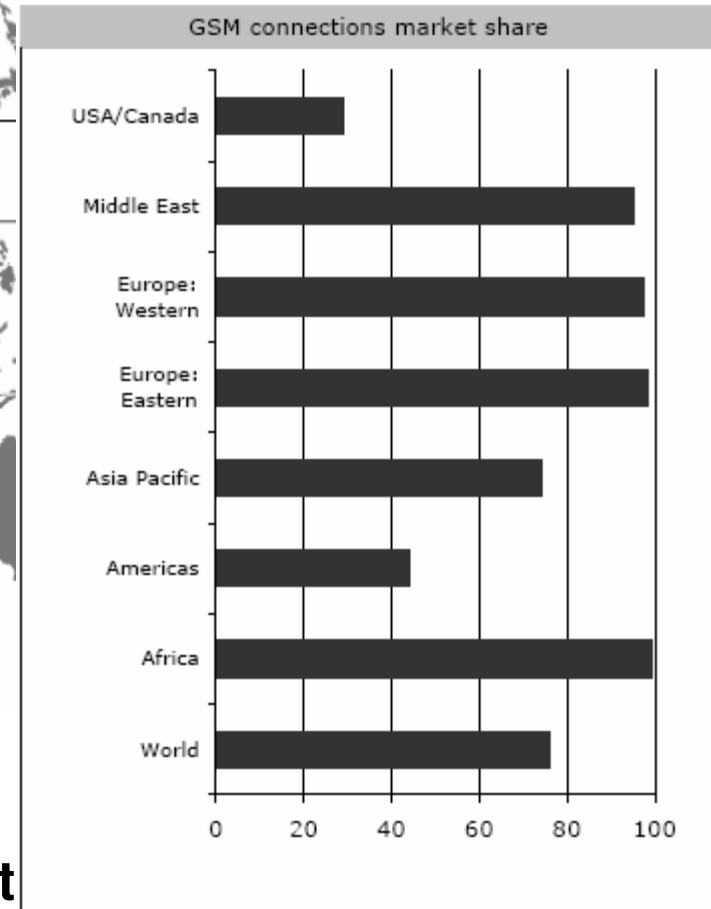
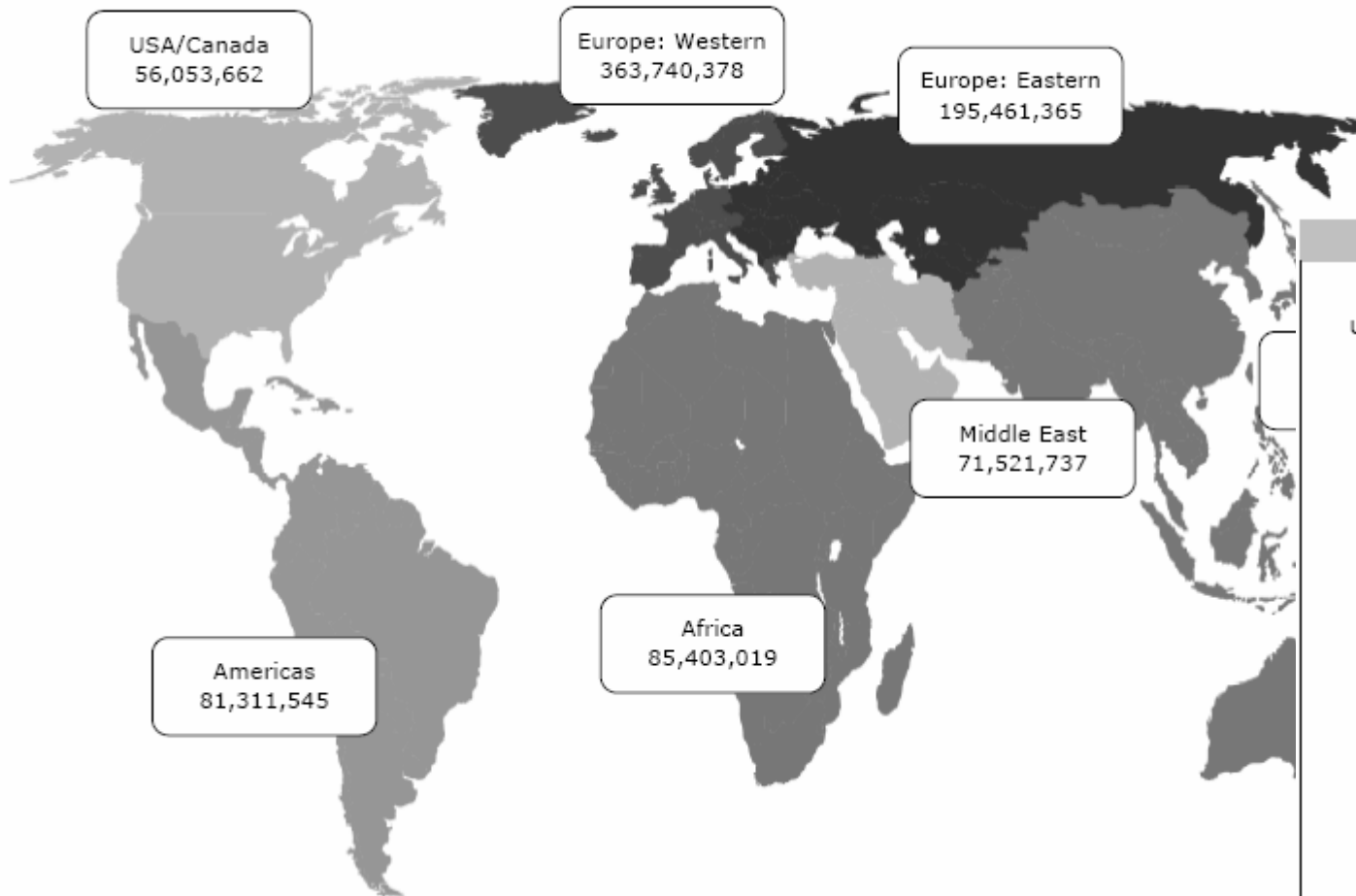
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- 1982 : CEPT : Groupe Special Mobile
- 1988 : ETSI : Global system for Mobile Communications
- 1991 : GSM phase 1 recommendations
- 1992 : first commercial service
- 1993 : 1 million users in Europe
- 1995 : GSM also used outside Europe
- 1998 (end) : over 100 million subscribers worldwide
- 1999 (end) : Belgium not far from 3 million subscribers

# Digital Cellular Network : GSM

## GSM regional statistics 2005 Q1



**March 2002 : # mobile > # fixed subscribers**

**2004 Q1 :  $10^{12}$  GSM users (total population  $6,5 \cdot 10^{12}$ )**

**2005 Q1 : GSM ( $1.4 \cdot 10^{12}$ ) 75% of digital mobile market**

# Digital Cellular Network : GSM

## general properties :

- multiple access : FDMA / TDMA / SDMA
- duplex : FDD
- uplink : 890 - 915 MHz
- downlink : 935 - 960 MHz
- duplex distance : 45 MHz
- channel spacing : 200 kHz
- number of frequencies : 124
- channel bitrate : 270.9 kbit/s
- frame duration : 4.615 msec
- number of time slots : 8 (=15/26 = 0.577 msec)
- speech bitrate : 13 kbit/s

# Special Case : GSM-R

## GSM-R : GSM-Rail used by railway companies

### Special Features :

- 19 exclusive channels (for speech and data)(876-880 and 921-925 MHz range exclusive for GSM-R, besides the standard channels for GSM)
  - emergency calls with acknowledgment
  - voice group call services (VCGS)
  - voice broadcast services (VBS)
  - calls with different priorities
  - very fast call set-up (emergency calls <2sec, group calls <5 sec)
  - calls to all users at certain location, to users with a specific function, to users within a number range, ...
  
  - control of trains, switches, level crossing, signaling, ...
- [ETCS : Electronic Train Control System]  
(note : trains<160 km/h : control possible from train)

# Digital Cellular Network : other technologies

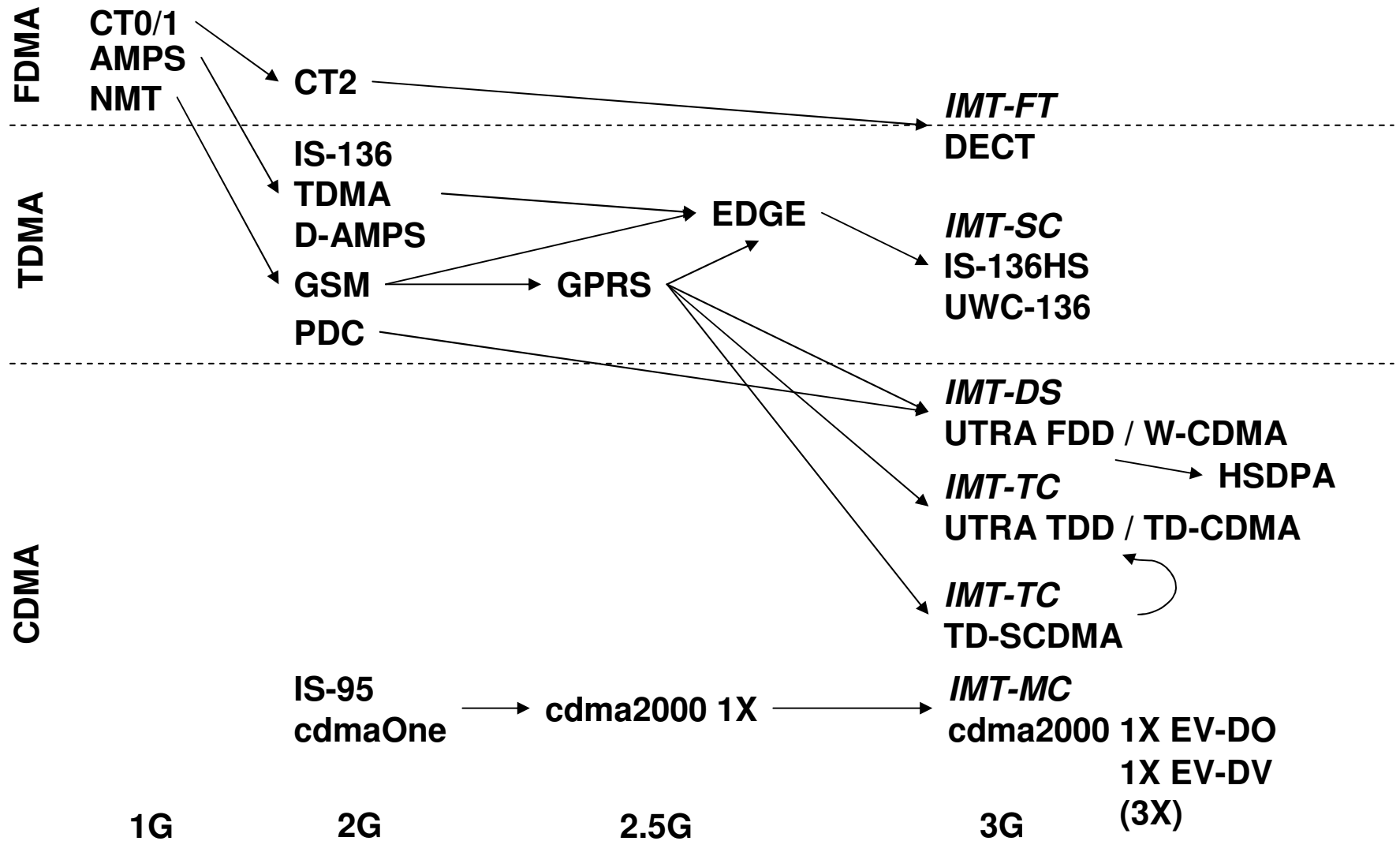
PARAMETER	GSM	DCS-1800	USDC (USA)	PDC (JAPAN)
Multiple Access	TDMA/ FDMA	TDMA/ FDMA	TDMA/ FDMA	TDMA/ FDMA
Duplex	FDD	FDD	FDD	FDD
Uplink	890-915 MHz	1710-1785 MHz	824-849 MHz	940-960 MHz
Downlink	935-960 MHz	1805-1855 MHz	869-894 MHz	810-830 MHz
Duplex distance	45 MHz	95 MHz	45 MHz	130 MHz
Channel spacing	200 kHz	200 kHz	30 kHz	25 kHz
Number of frequencies	124	374	832	800
Number of time slots	8	8	3	3
Speech bitrate	13 kbit/s	13 kbit/s	<13 kbit/s	<11 kbit/s
Data bitrate	9.6 kbit/s	9.6 kbit/s	4.8 kbit/s	4.8 kbit/s

**DCS-1800 : Digital Communication System at 1800 MHz (~GSM)**

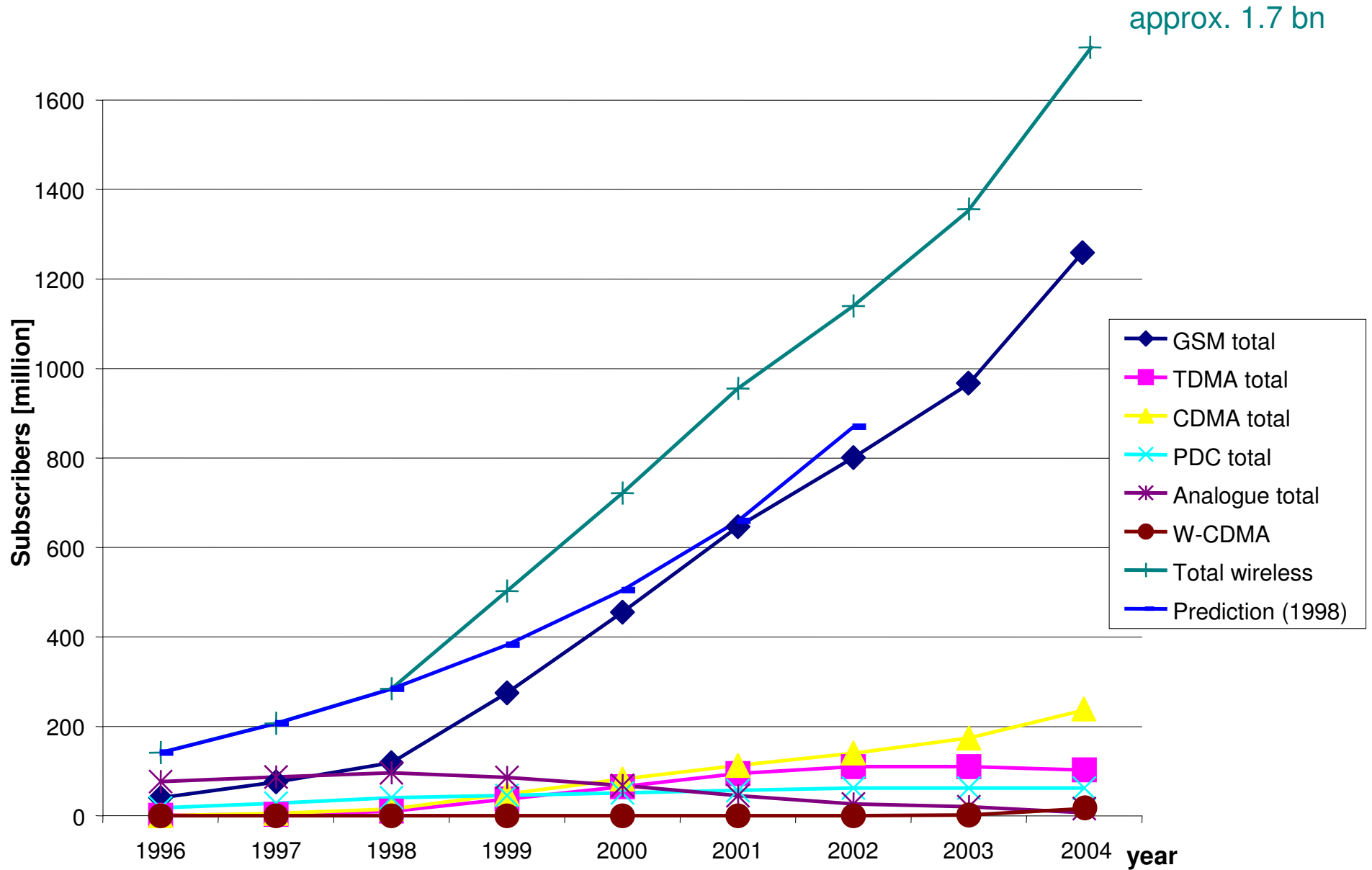
**USDC : US Digital Cellular system (USA)**

**PDC : Personal Digital Cellular system (Japan)**

# Mobile Networks : evolution

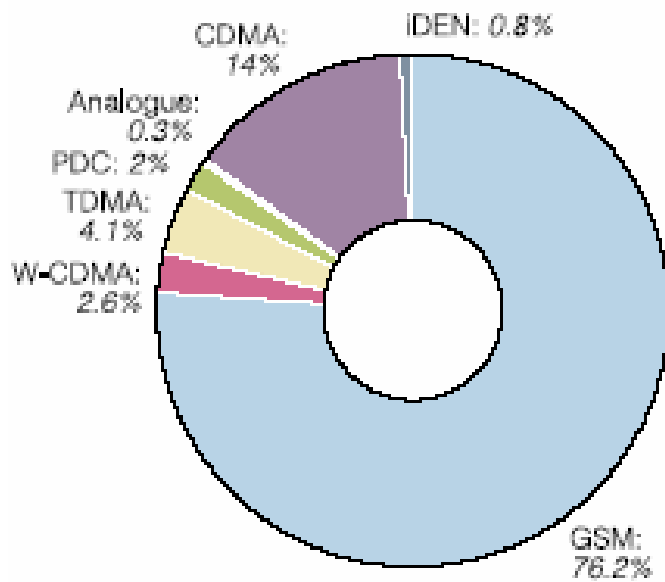


# Digital Cellular Networks

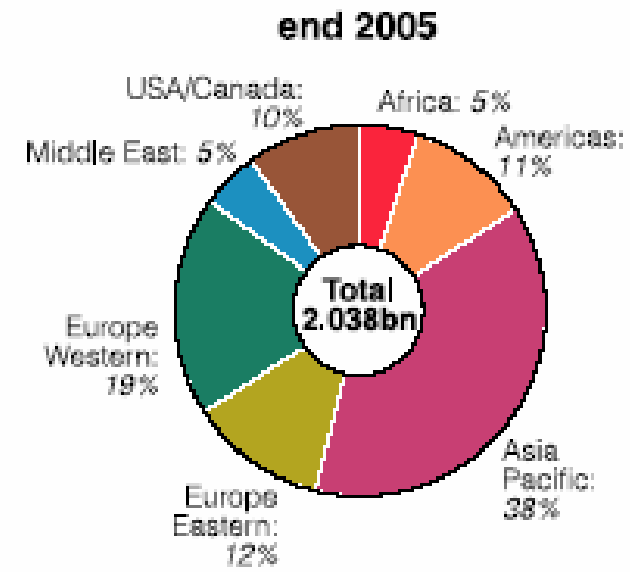
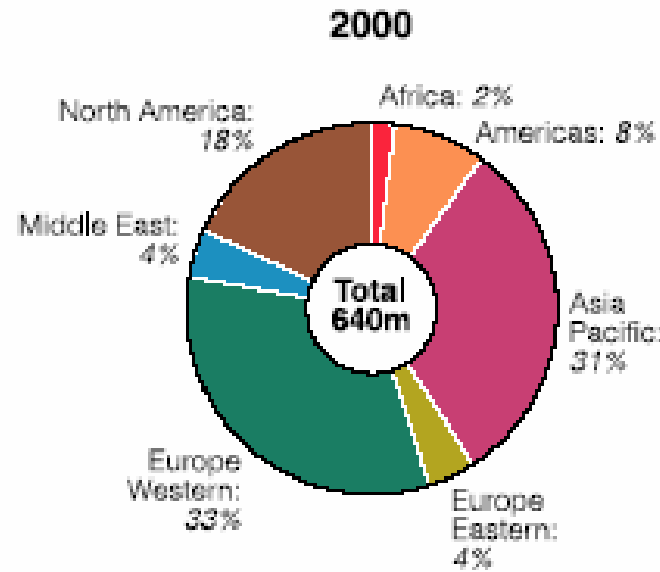


# Digital Cellular Networks

**Technology market shares**

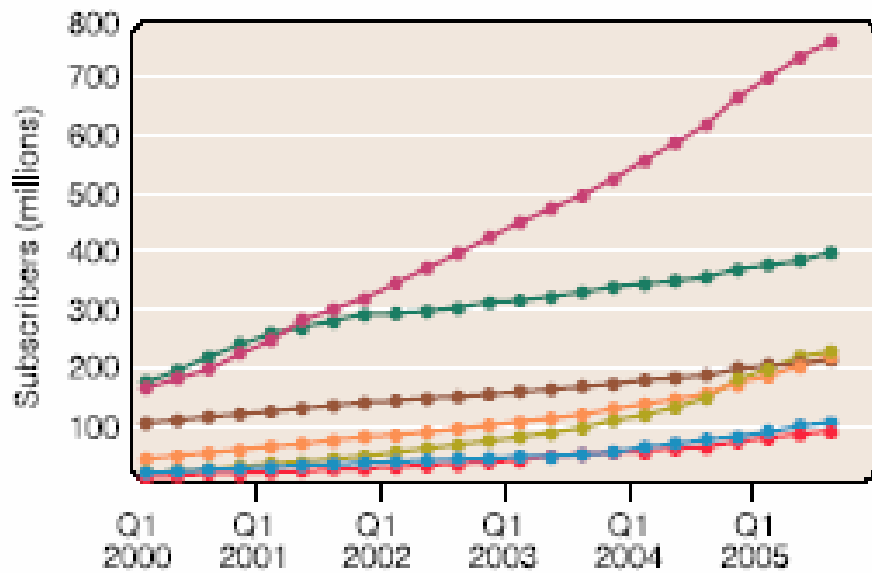


**Global cellular subscribers**

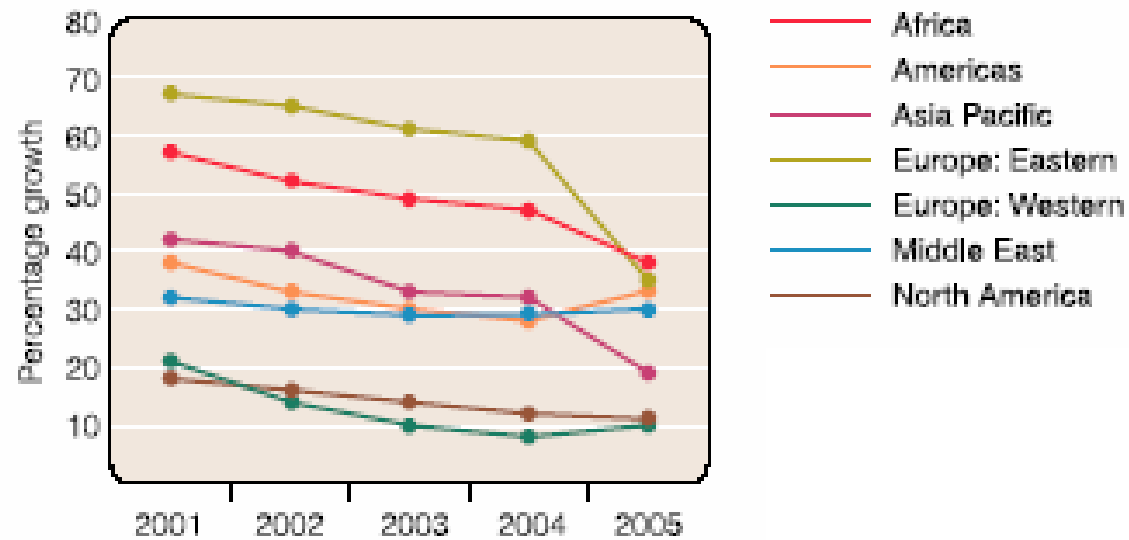


# Digital Cellular Networks

Global cellular subscribers by region



Global subscriber growth rates



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**1.2. Architecture**

1.3. Physical Layer

1.4. Data Link Layer

1.5. Network Layer

1.6. Recent Developments

1.2.1 mobile services

1.2.2 general architecture

1.2.3 functional grouping

1.2.4 protocol reference model

2. DECT

3. TETRA

4. UMTS

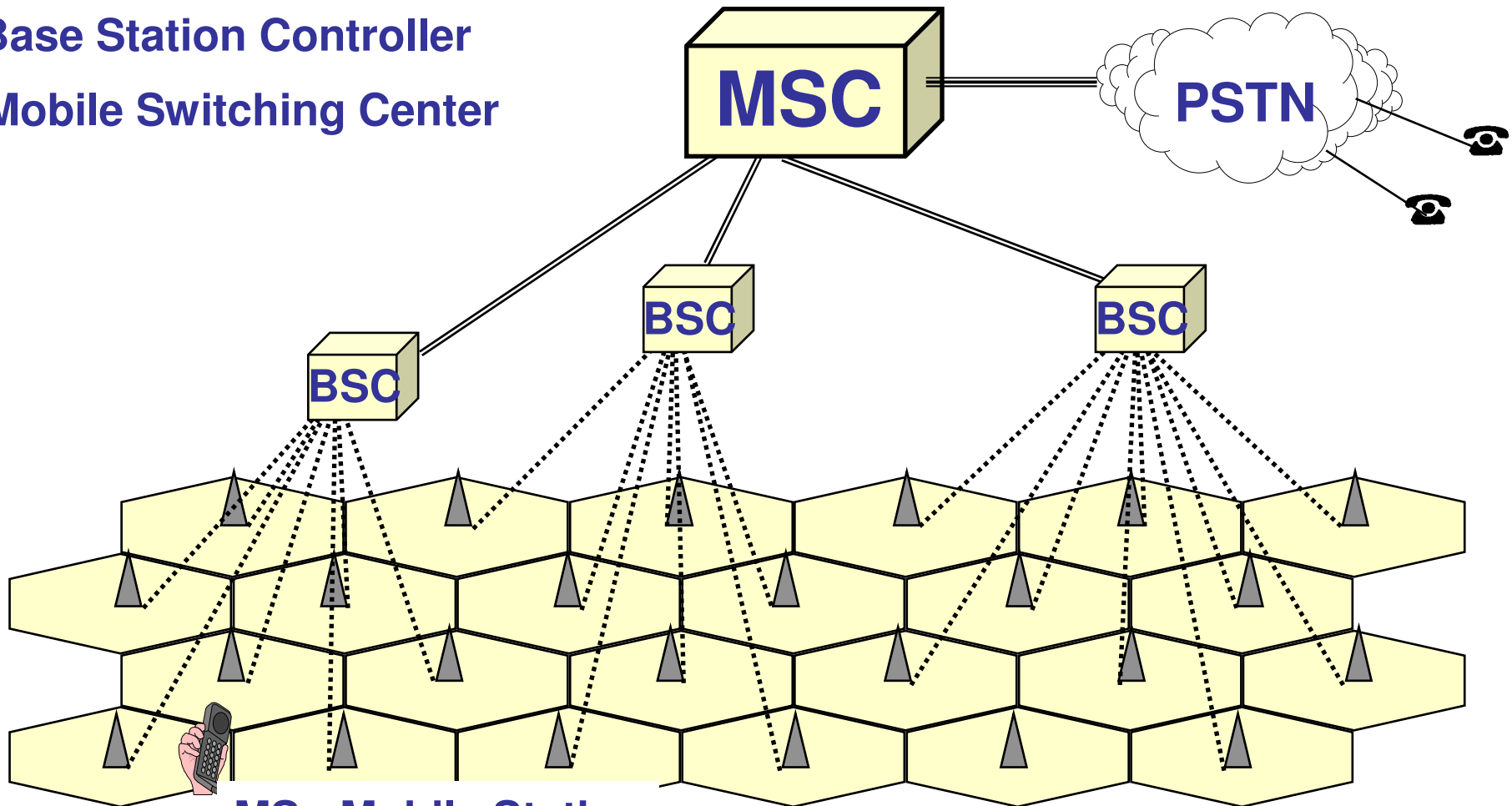
# Architecture

▲ **BTS : Base Tranceiver Station (antenna)**

⬡ **Cell**

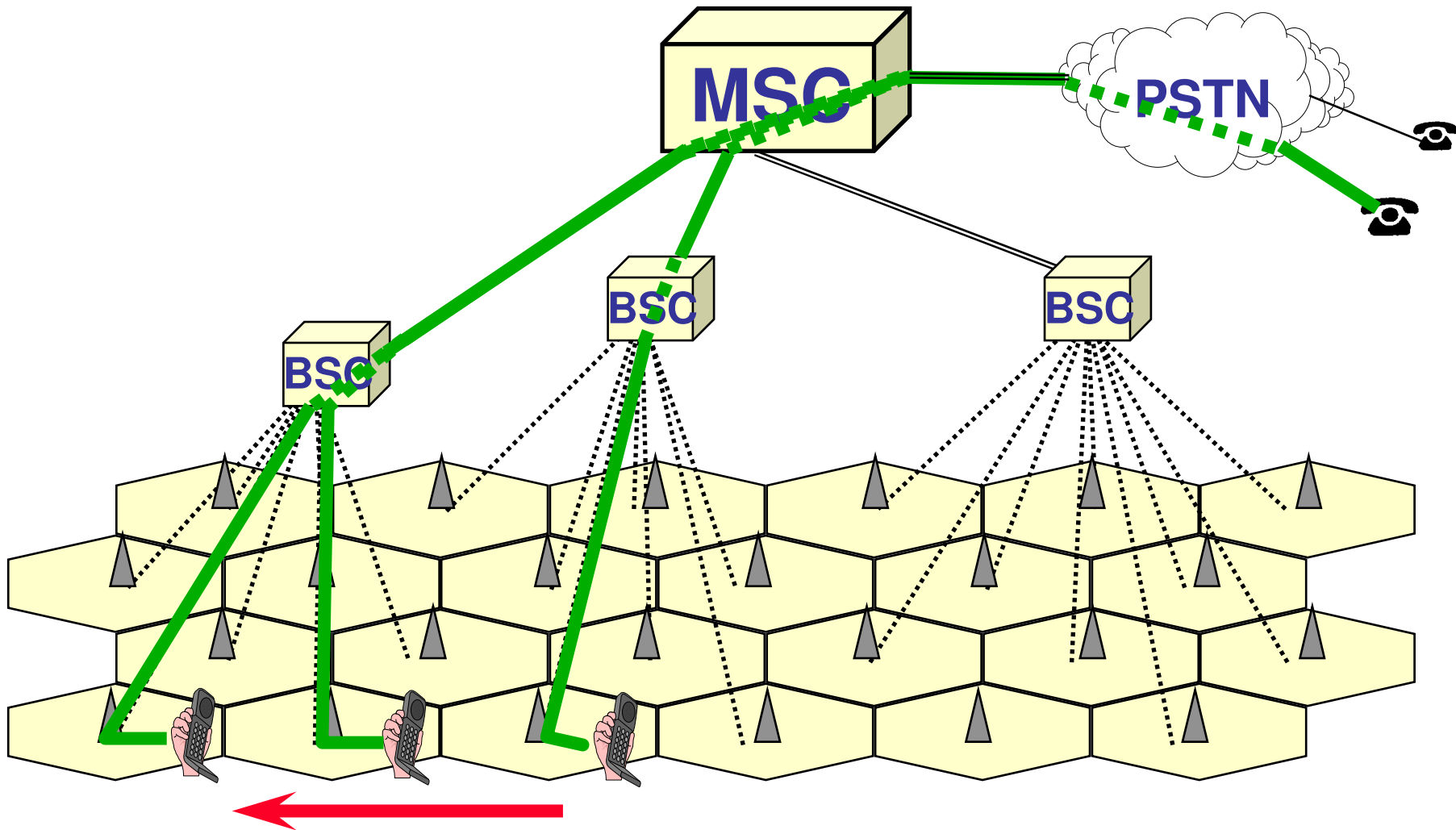
**BSC : Base Station Controller**

**MSC : Mobile Switching Center**



**MS : Mobile Station**

# Architecture : Example Handover



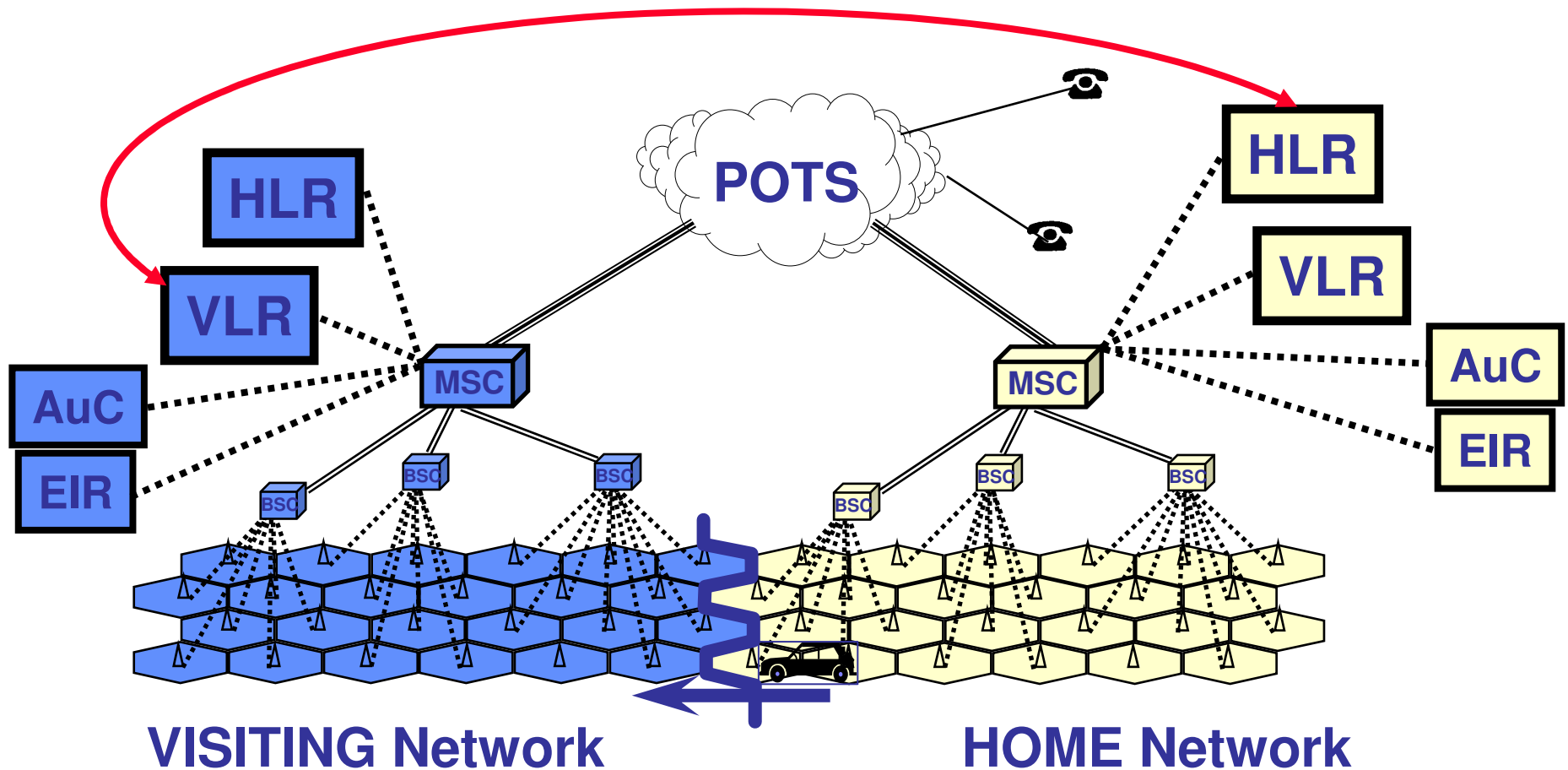
# Architecture : Example Roaming

**HLR : Home Location Register**

**AuC : Authentication Center**

**VLR : Visiting Location Register**

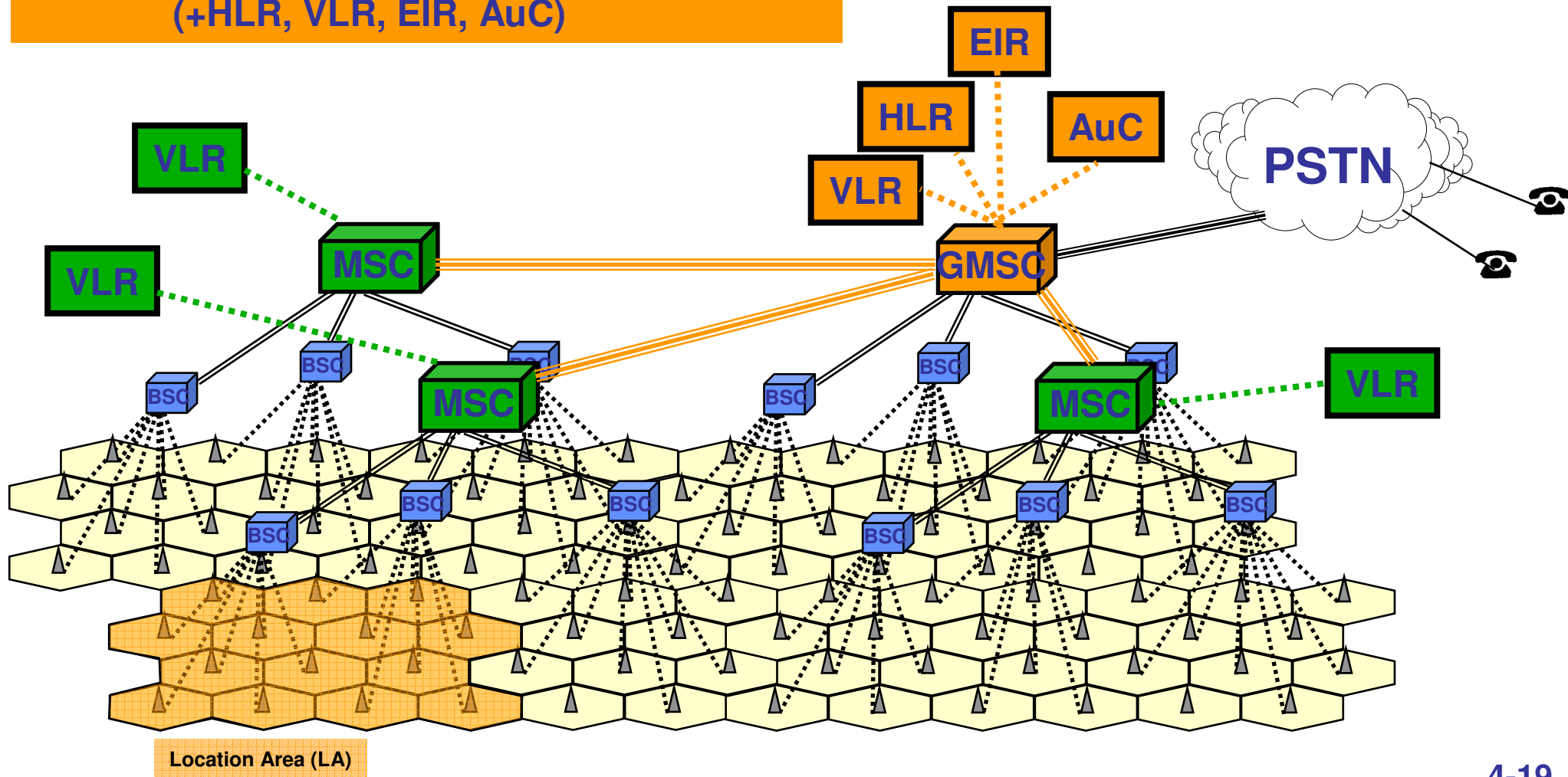
**EIR : Equipment Identity Register**



# Architecture : Overview

## PLMN : Public Land Mobile Network

**GMSC : Gateway MSC (connected to PSTN)**  
(+HLR, VLR, EIR, AuC)



# Functional Grouping / Reference Points

