

# UNIK4230: Mobile Communications

**Abul Kaosher**

abul.kaosher@nsn.com

# Tentative lecture schedule

- 20. Jan. 2012 (14:00) Introduction (Kaosher)
- 26. Jan. 2012 (13:15) Network Architecture and Functionality (Kaosher)
- 02. Feb. 2012 (14:00) Propagation Characteristics of Wireless Channel-I (Kaosher)
- 09. Feb. 2012 (13:15) Propagation Characteristics of Wireless Channel-II (Kaosher)
- 16. Feb. 2012 (13:15) Combating the effect of Fading in Mobile Systems (Josef)
- 23. Feb. 2012 Winter Holiday
- 01. Mar. 2012 (?) Modulation/ or xx (Kaosher?)
- 08. Mar. 2012 (?) Cell and Cellular Traffic-I (Kaosher)
- 15. Mar. 2012 (?) Cell and Cellular Traffic-II (Kaosher)
- 22. Mar. 2012 (?) Multiple Access-I (?)
- 29. Mar. 2012 (?) Mobile Broadband-I (Market Trends, Evolution, LTE) (Kaosher)
- 12. April. 2012 (?) Mobile Broadband-II (LTE, SON, QoS, LTE-A) (Kaosher)
- 19. April. 2012 (?) Lecture from Students on selected topics (All)
- 26. April. 2012 (?) Refarming and the challenges of Mobile Communications, 700 MHz - 2.6 GHz as well as technology focus with LTE, 3G (HSPA) (?)
- 03. May 2012 (?) Femto Solution
- 10. May. 2012 (?) Examination

# Reference literature & examination

- Lecture slides (will be uploaded before lectures)
- Book
  - P. M. Shankar, *Introduction to Wireless Systems*, 2002, Wiley.
    - Syllabus: chapter 2, 3, 4, 5 & 6
    - Do you need a copy of the chapters?
- Articles
  - Will be provided during lectures (when necessary)
- Examination type:
  - Oral examination (based on lecture slides, chapters of the course book, articles provided during lectures); if book chapter discusses more, contents in the lecture slide will limit the syllabus; however, lecture slides may contain more topics than the book chapter. In that case, follow the extra topics only from the slides and the articles (if given).
- Assignments
  - Presentation on selected topics

# Introduction

# Importance of Telecommunication

## Telekom er viktigere enn strøm og vei

### Mobile Communication:

- Mobile Device is most personalized device
- Voice, SMS
- Data/Internet
- Emergency (police, ambulance, fire)
- Payment
- M2M communication
- Entertainment (music, gaming)
- Social Network and life

Jeg ble veldig overrasket da jeg forsto for første gang at telekommunikasjon er viktigere enn strøm og vei. Vi kan klare oss uten strøm og vei, men telekom kan vi ikke klare oss uten.

-**Torstein Olsen**, direktør i Post- og teletilsynet informerte

-Source: dn.no. Publisert: 13.01.2012 - 16:40 Oppdatert

# Agenda

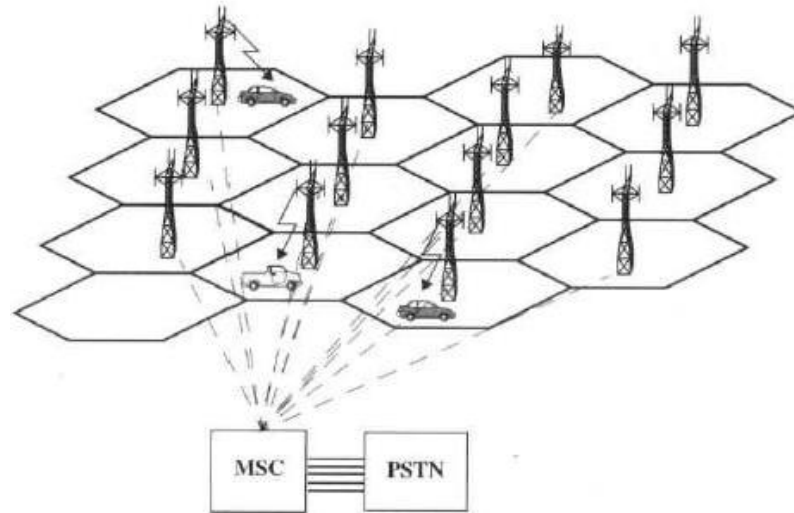
- What is mobile communication?
- History and trends
- Elements in mobile communication systems
- Basic functionality

# Agenda

- What is mobile communication?
- History and trends
- Elements in mobile communication systems
- Basic functionality

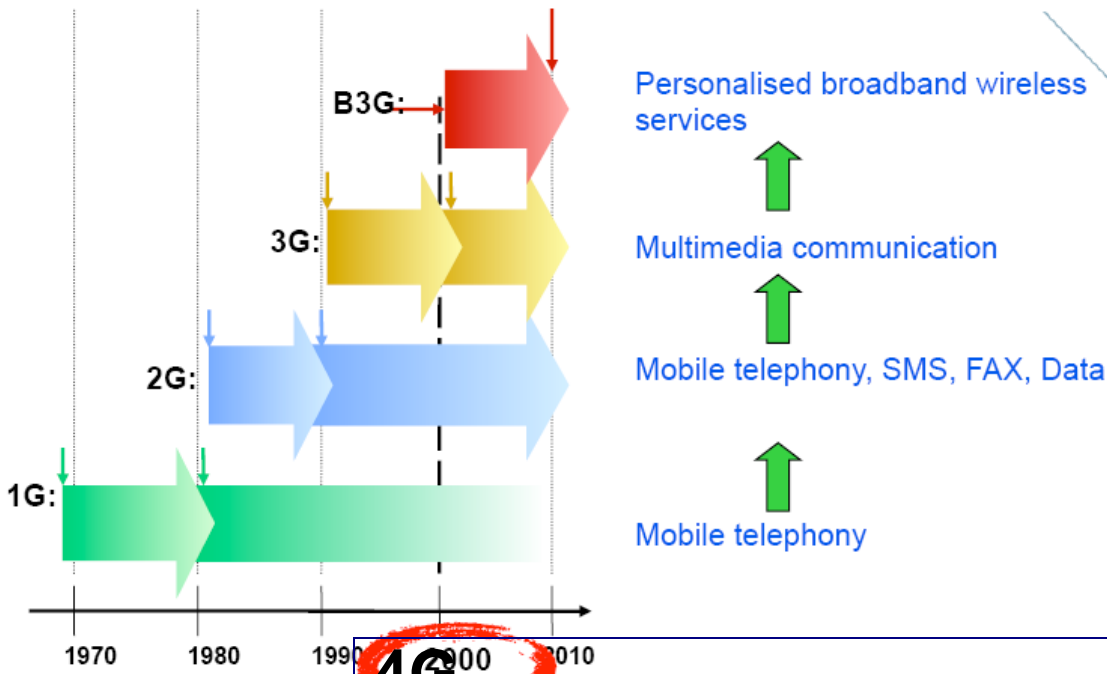
# What is mobile communication?

- Mobile communication system allows communication to and from handheld terminals during movement
- The system can handle a large number of users and provides almost a continuous coverage in a large geographical area
- Base station provides an area coverage
- The system has underlying infrastructure that provides communication to/from other type of communication networks





# Generations in Mobile communication



## 1G

Analog communication  
Only voice  
e.g NMT-450, AMPS

## 2G

Digital communication  
Mostly voice service, data service limited and low speed  
e.g. GSM

## 3G

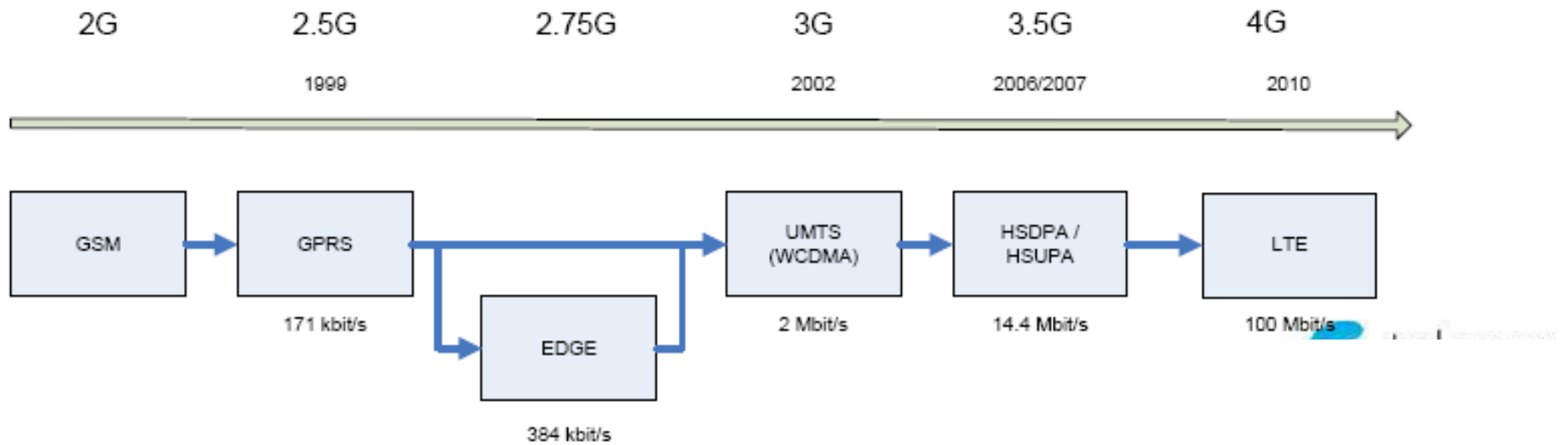
Simultaneous voice and data  
peak data rate at least 200 kbps (IMT-2000 specs.)  
Latest UMTS release HSPA+ (Evolved HSPS): upto 84Mbit/s (DL), upto 22 Mbit/s (UL) -> 3.75G?

## 4G

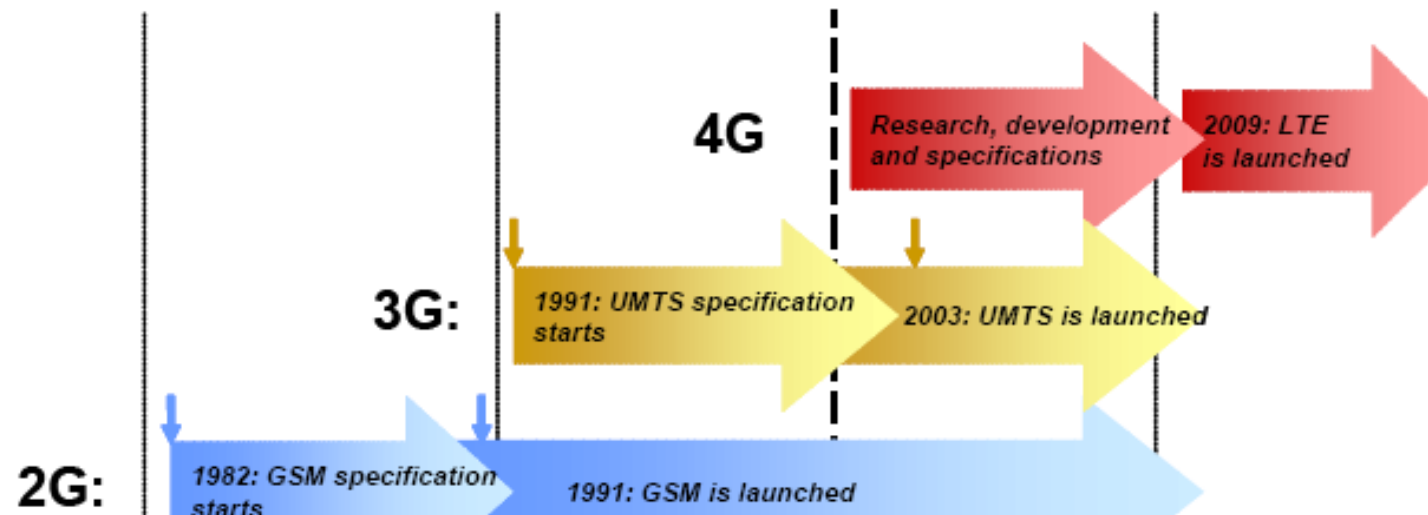
Original: B3G study, Jan 2001

100 Mbit/s for high mobility communication  
1 Gbit/s low mobility communication  
LTE wont fulfill ITU-R requirements  
Candidate: LTE-A  
Service e.g. Mobile broadband

# Generations in Mobile Communications



# Generations in Mobile Communications



# Frequency band, technologies & operators

|              | Frekvens-<br>bånd      | Total<br>mengde<br>tilgjengelig | Bruk i Norge<br>(forventet<br>bruk) | Aktører i<br>Norge                       |
|--------------|------------------------|---------------------------------|-------------------------------------|--|
| 450 MHz      | 453-457<br>463-467     | 2*4 MHz                         | CDMA                                | "ICE"                                    |
| DD (800 MHz) | 790-820<br>832-862     | 2*30 MHz                        | (LTE)                               | (frekvenser<br>ikke delt ut)             |
| 900 MHz      | 880-915<br>925-960     | 2*35 MHz                        | GSM                                 | Netcom/<br>Telenor                       |
| 1800 MHz     | 1710-1805<br>1805-1880 | 2*75 MHz                        | GSM                                 | Netcom/<br>Telenor/<br>Network<br>Norway |
| 2100 MHz     | 1920-1980<br>2110-2190 | 2*60 MHz                        | UMTS                                | Netcom/<br>Telenor                       |
| 2600 MHz     | 2500-2570<br>2620-2690 | 2*70 MHz                        | LTE                                 | Netcom                                   |

# Agenda

- What is mobile communication?
- **History and trends**
- Elements in mobile communication systems
- Basic functionality

# History

Bell lab was testing mobile radio telephone in 1924



# History- NMT

- NMT was first tested in Stockholm between 1975-1979
- In October 1981, Nordic countries (Norway, Sweden, Denmark, Finland, Iceland) opened NMT network with automatic roaming between countries
- In Norway 250-300 BTS were expected to provide land coverage
- Initially capacity was 35000 subscriber that could be increased to 140000
- The first mobile phone weighed about 17 kg and cost was 35000 kr!



# History- NMT

- In 1984 NMT started facing capacity problem
- In 1986 NMT-450 had 87000 subscription in Norway
- To increase capacity, NMT later rolled out NMT 900 MHz band
- In 1995, two years after the start of GSM NMT subscriber number peaked and there were 488 000 NMT subscribers in Norway
- Finally NMT were laid down in 2005, a month after 3G network was opened in Norway



# History- GSM

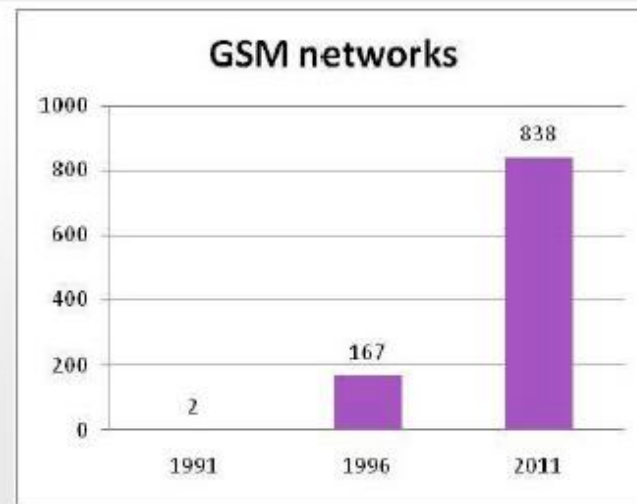
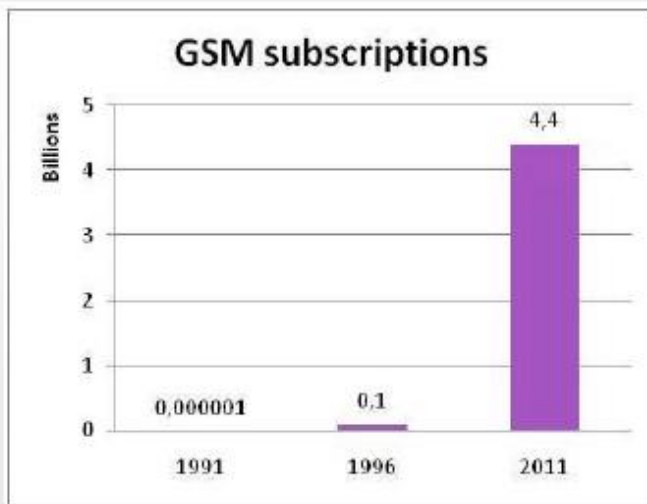
- In 1982, the Conference of European Posts and Telegraphs (CEPT) formed an Groupe Spécial Mobile (GSM) study group to develop a pan-European public land mobile system
- In 1987, 15 representatives from 13 European countries signed a memorandum of understanding to develop and deploy a common cellular telephone system
- In 1990, the Phase I of the GSM specifications for voice and Short Messaging Services (SMS) were published by ETSI
- In 1991, First commercial network launched by Radiolinja (Elisa Finland)



1991: Radiolinja (now Elisa) the first GSM Network in Finland. Mr. Harri Holkeri, then prime minister of Finland made the first GSM call.

# History- GSM

- 1993: Tele-Mobil (Telenor Mobil) and NetCom GSM opens their networks in Norway
- 1998: GSM 1800 starts operation to increase the network capacity in cities in Norway
- 2001: GPRS service started by Telenor Mobil
- 2004: EDGE Service started in Norway
- 2003: First 3G service in Europe

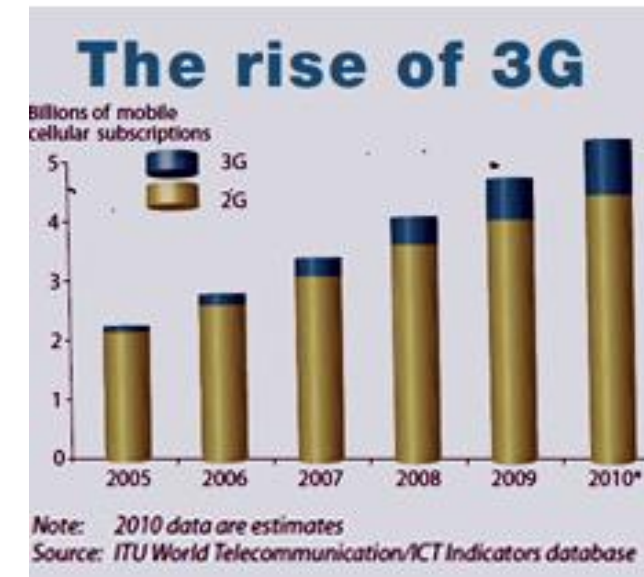
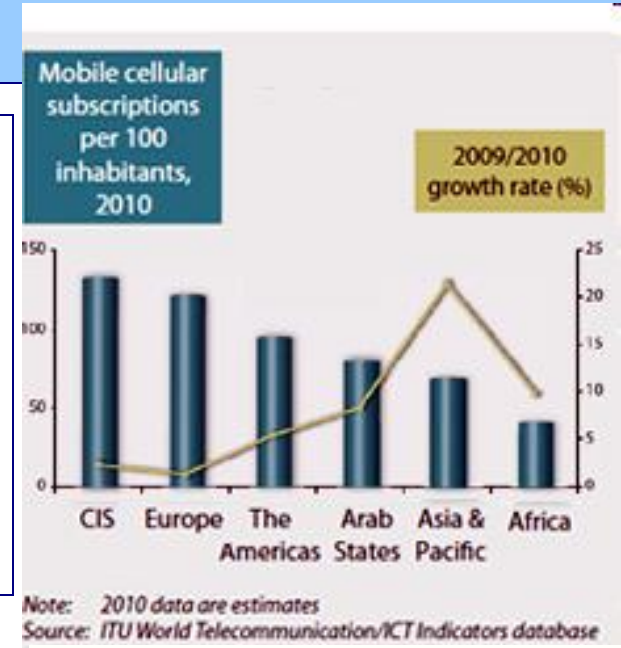


# Regulation & standardization

- National & International regulators decide to use different frequency band for different applications. The most important regulatory bodies are:
  - Post & Telecommunication Authority, regulatory authority in Norway
  - CEPT (Conference of European Post and Telecommunications Administrations)
  - ITU-R (International Telecommunication Union – Radio Communication), international regulatory authority arrange WRC (World Radio Communication Conference), next in 2012
- Standard organizations develop and adopt international standards for telecommunication systems, most important bodies are:
  - ETSI (European Telecommunication Standard Institute), developed GSM standards
  - ITU-T (International Telecommunication Union Standardization Sector), part of the ITU standardization
  - 3GPP (3rd Generation Partnership Project), cooperation between regional standardization body of Europe, North America and Asia; responsible for all standardization of 3G and GSM development

# Statistics

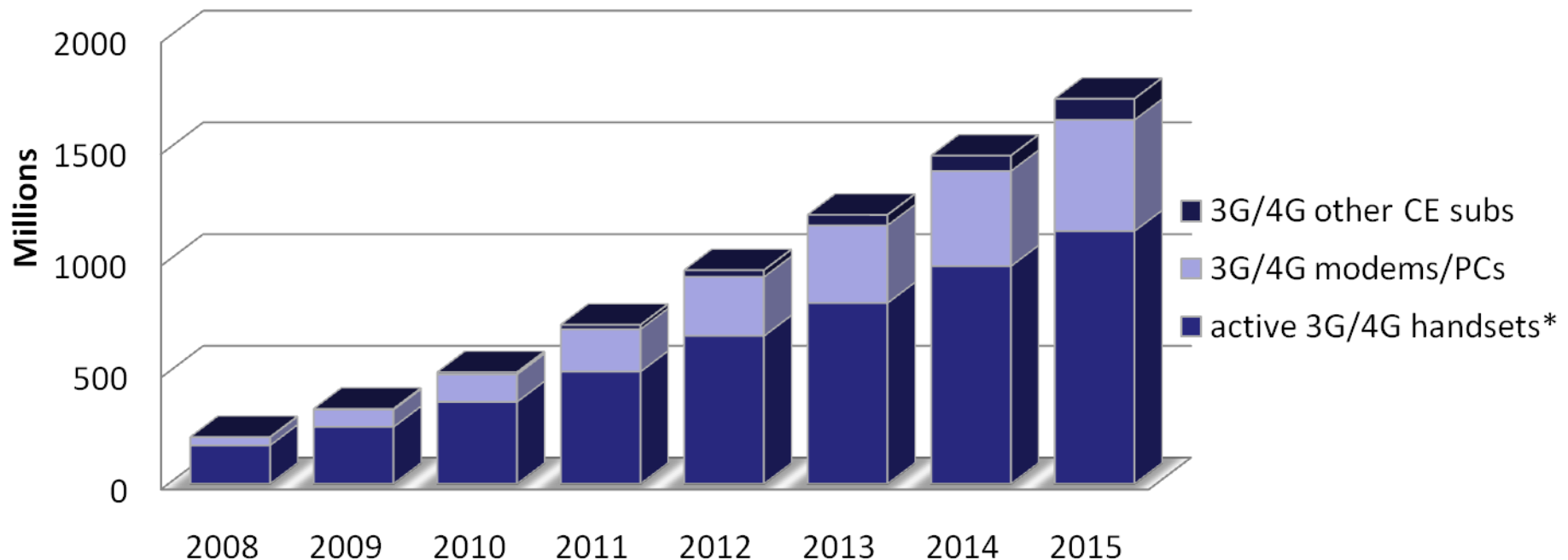
- By end of 2010, ~5.3 billion mobile phone subscriber worldwide led by China and India (ITU estimated)
- Nearly a billion of these are 3G subscriptions
- SMS is still the king mobile messaging (~6.1 trillion SMSs send in 2010)



# Trend: mobile broadband – 0.5B Active Users Today – 1.7B in 2015

- Smartphones and modems dominating mid-term MBB market
- 3G/4G device ecosystem opening up though handsets/computers will maintain early lead
- Active MBB connections to increase 2.5x by 2015

Active Mobile Broadband Connections



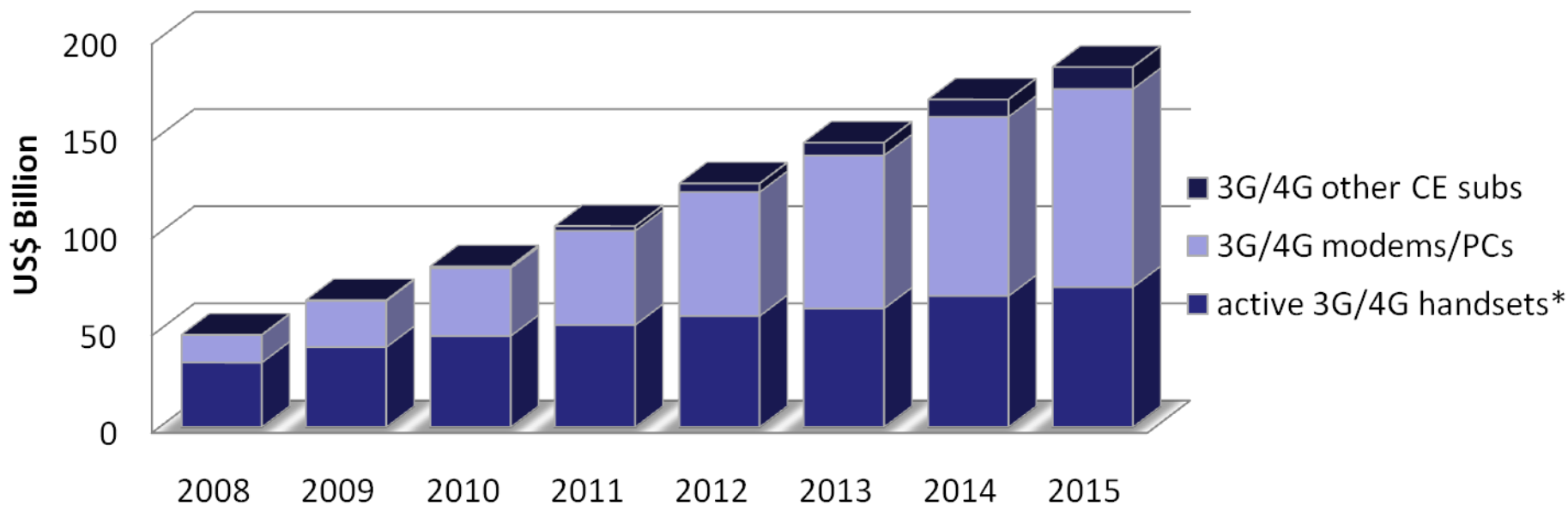
\* Active 3G/4G handsets = 3G/4G phones used with non-SMS data services

Source: Strategy Analytics Mobile Broadband Opportunities

# Trend: mobile broadband – 9% of Wireless Revenues in 2010, 18% in 2015

- Smartphones lifting handset access revenues
  - Strong ARPU uplift, though dilution will occur
  - Health share of incremental revenue flowing to subsidies
- PC connections accounting for over 40% of MBB market value

## Mobile Broadband Traffic/Access Revenues



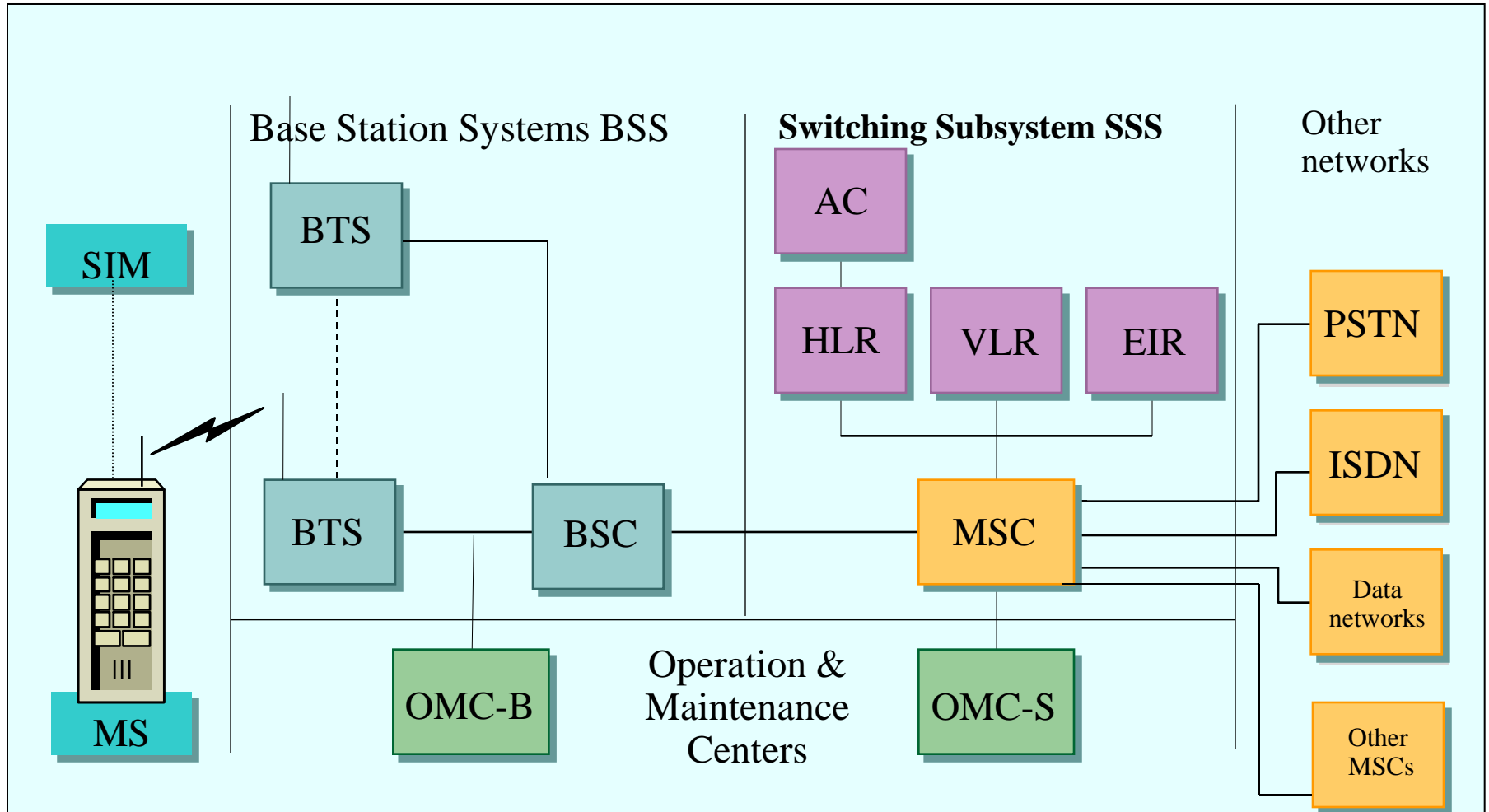
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# Architecture of GSM Network



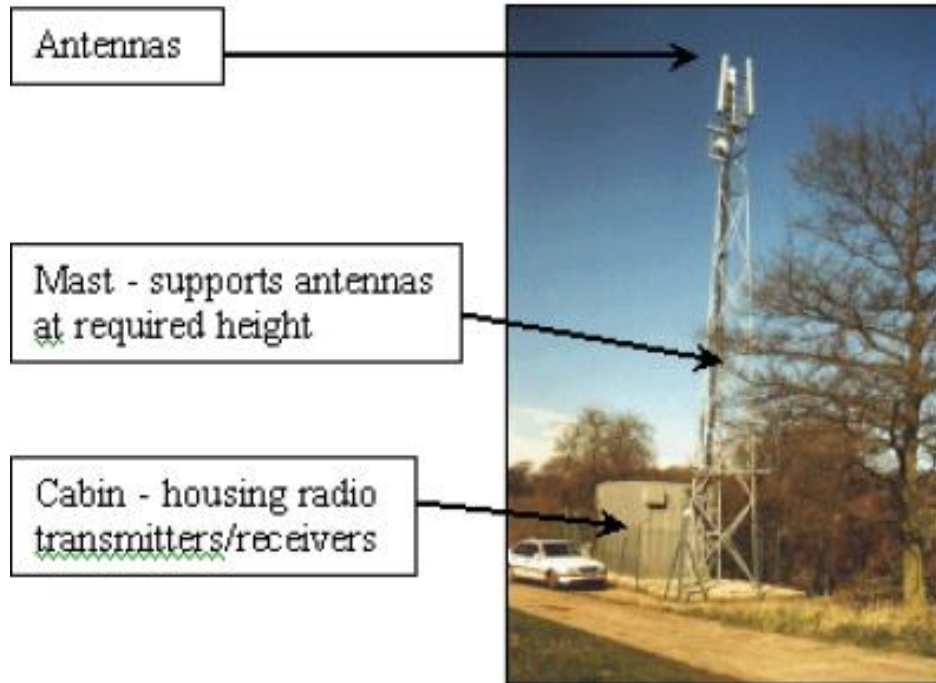


# Basic elements in mobile communication systems

- SIM – A smart card stores identification (IMSI) of a subscriber, holds Auth. Key that identifies SIM on the mobile network
- ME/MU/MS – the mobile device
- BTS – Facilitate wireless communication between UE/ME and the network
- BSC – Allocates radio channel to ME, several BTS under the control of one BSC
- MSC – carries out call switching (ME-ME, ME-phones of other network)
- VLR – linked to MSC, temporary DB of subscriber who roamed into a specific MSC
- HLR – a central DB of ME
- AuC – to authenticate each SIM
- EIR – keeps lists of ME which are to be banned or monitored



# Basic elements



Basestasjon-skap



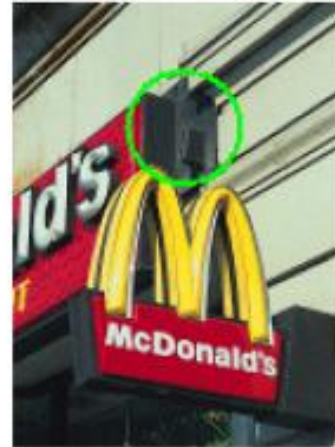
# Some concepts in mobile communications

- **Cell** – A limited geographic area covered by a BTS (e.g. max. Cell size of GSM cell 35km, typically several km)
- **Control channel** – Radio channel used for all control info. e.g. call request, call set up etc.
- **Information channel** – Radio channel used for user info. e.g. data or voice
- **Downlink (forward channel)** – communication from BTS till ME
- **Uplink (reverse channel)** – communication from ME till BTS
- **Handover (handoff)** – transferring an ongoing communication from one BTS to another BTS typically due to movement
- **Full duplex/half duplex/simplex** –  
Both direction simultaneously/ both direction but only one direction at a time/Only one way communication

# Basic elements



Typical macrocell



Typical microcell

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# Services Offered in GSM

## Tele-services

- Mobile telephony
- Emergency calling

## Bearer Services

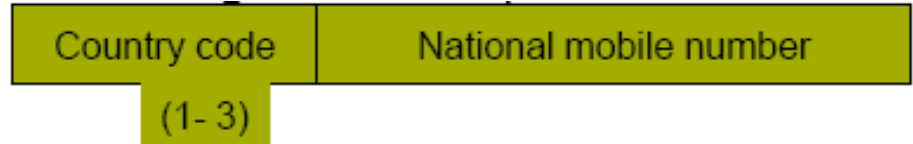
- Data services up to 9.6 Kbps
- Short Message Service (SMS)
- Fax
- Voice mailbox
- Electronic mail

## Supplementary services

- Call Waiting
- Call Hold
- Call Barring
- Call Forwarding
- Multi Party Call Conferencing
- CLIP
- CLIR
- CUG

# Identification of user and mobile phones

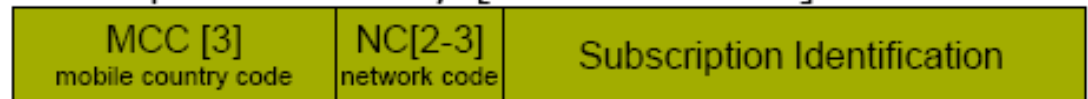
- A typical mobile number (MS-ISDN number) follows the numbering plan for telephony (max. 15 digits)



**MSISDN = CC + NDC + SN**

Where, CC = Country Code, NDC= National Destination Code, SN= Subscriber Number

- IMSI used to identify (uniquely) mobile subscription internationally (max. 15 digits)



**IMSI = MCC + MNC + MSIN**

- IMEI used to identify ME

Type `*#06#` to get IMEI

# Circuit switching and packet switching

- **Circuit Switching (CS):** In circuit-switched networks, a dedicated path is set up between the two parties. This path remains for the exclusive use of both parties for the duration of the call, and is therefore not available to any other users.

Inefficient mode

E.g. GSM used CS

- **Packet switching (PS):** Packet switching involves dividing the data into packets (or cells or frames) prior to transmission. The length of the packets varies enormously, depending on the technology employed.

Added to each packet is the destination address, together with other control information. The packets are then transmitted across the network. This addressing means there is no requirement to set up a pre-established link. To some extent, each individual packet can be viewed as being able to find its own way to its destination.

In a packet-switched network, the resources are shared between many users.

Efficient but of course takes more data field

E.g. from 2.5 G uses PS



# Message services

- **SMS**

A text communication service of mobile communication system using standard communication protocols that allow short text messages (typically 160 characters) between mobile devices or between fixed lines and mobile devices.

SMS service is the most successful mobile service commercially

- **MMS**

MMS is a standard way to send multimedia content (e.g. text, audio, video) to and from Phone

Both SMS and MMS are 'store and forward' service

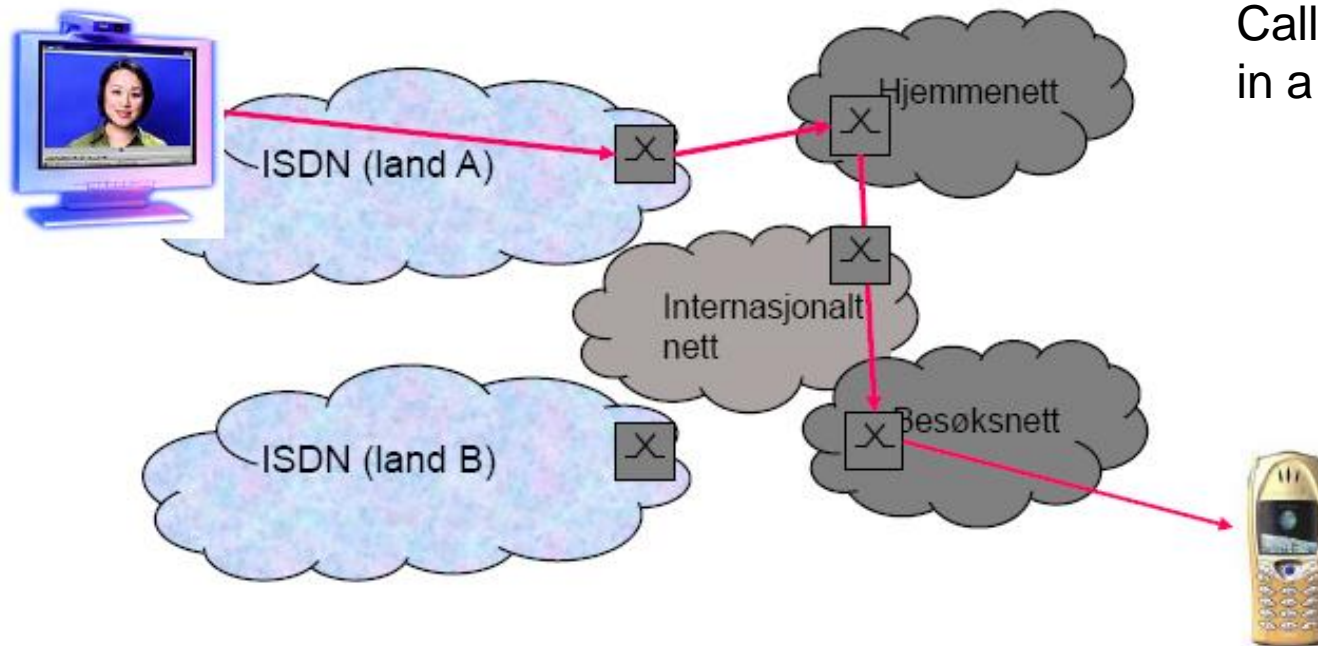
# Security functionality

- The purpose of security features is to protect users and the network against abuse:
  - Verification that the user has a valid subscription
  - Verification of the network that the user communicates with a 'real' network entity
  - Protection of user's identity against tracking
  - Protection against eavesdropping by radio link
- Mutual authentication crucial (e.g. In 3G, not in 2G)
- User's identity information is stored both in SIM card and in the network
- Advanced encryption method is used on radio channel to protect information
- Security mechanisms are also used in core network (not only in access network where information is transmitted over the radio)
- BUT there is no appropriate location privacy in today's mobile network

# Roaming

- The continuity of communication services in a location that is different from the home location where the service was registered.

## Roaming



Call to a phone that is in a visit

# Roaming

Mobile to mobile call in a visited network

## Roaming (2)

