

ICT course:

Mobile Wireless Communications

Lecturers:

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Course Schedule

- Lectures:

1. Introduction
2. Characteristics of mobile radio environment:
 - Propagation
 - Fading and mitigations
3. Cellular concept
4. Channel assignment (optional)
5. Modulation techniques
6. Multiple Access techniques
7. Coding for error detection and correction
8. Applications – Mobile network Generations:
 - GSM
 - 3G/LTE-4G
 - 5G and future of mobile networks (discussion)

- Exercises

- References:

- [1]. Mischa Schwartz: Mobile Wireless Communication, CAMBRIDGE UNIVERSITY PRESS, 1st Edition (2005)
- [2]. Wireless Communications: Principles and Practice (2nd Edition) by Theodore S. Rappaport
- [3]. Widjaja, Indra, and Alberto Leon-Garcia. "Communication Networks Fundamental Concepts and Key Architectures." *Mc GrawHill: USA* (2004).

Lecture 7: GSM system overview

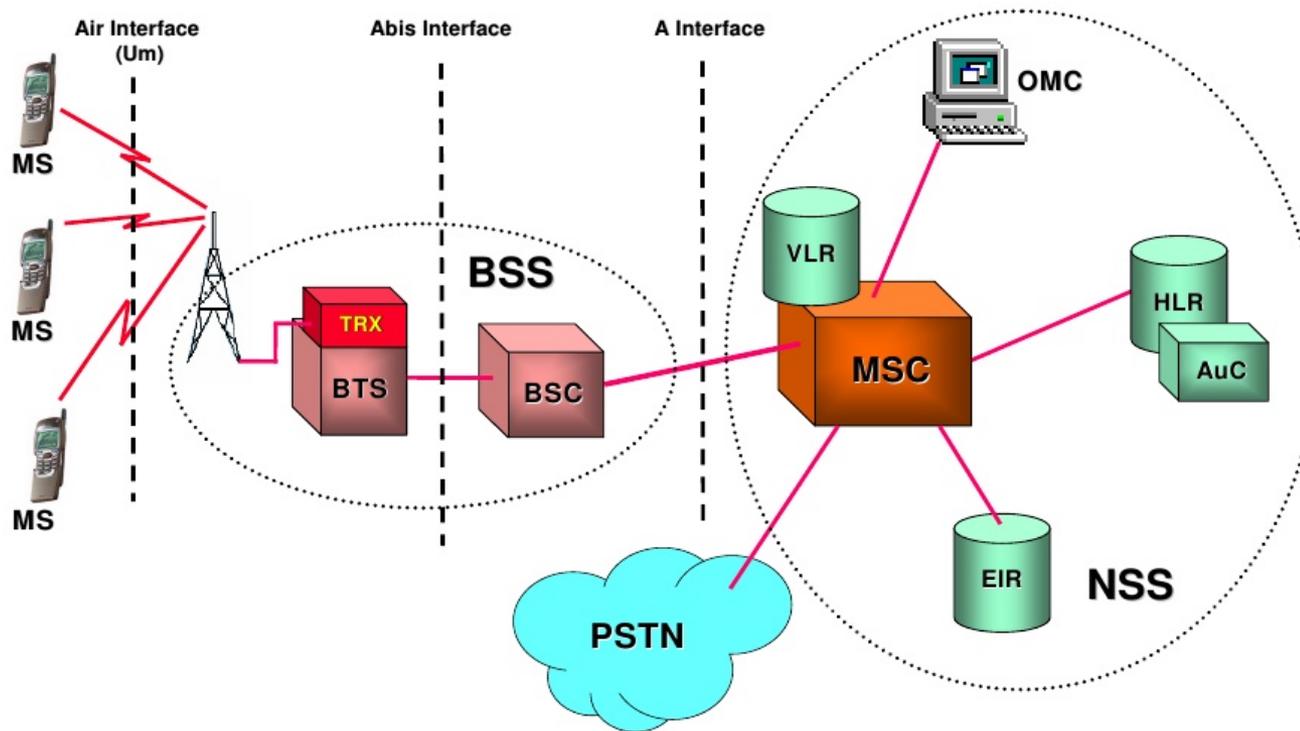
- Introduction
- Architecture overview
- Services
- Air interface
- Protocols
- Speech and channel coding
- ...

Introduction

- GSM (Global System for Mobile communications): a standard developed by the European Telecommunications Standards Institute (ETSI)
- GSM Cellular structure:
 - Re-use of frequencies
 - Planning this re-use is the key in designing

Architecture overview

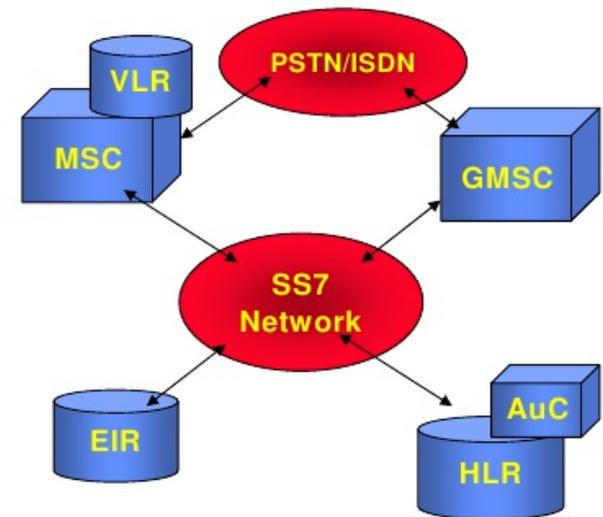
GSM Architecture Overview



- Mobile station (MS)
 - Mobile equipment
 - Subscriber identity module (SIM)

- Base station subsystem (BSS)
 - Base Transceiver Station (BTS)
 - Provides radio access to MS
 - Manage the radio access
 - Base station controller (BSC)
 - Allocates channel for a call
 - Maintains the call
 - BSS network topologies: chain, ring, star

- Network and Switching Sub-system (NSS):
 - Mobile switching center (MSC)
 - Visitor Location Register
 - Home Location Register (HLR)
 - Equipment Identity Register (EIR)
 - Gateway MSC (GMSC)
 - SS7 network



- MSC:
 - Switching, controlling and logging calls
 - Interface with PSTN, ISDN, PSPDN
 - Mobility management
 - Handovers between BSCs
 - Billing information
- VLR:
 - Each MSC has a VLR
 - Stores data (mobile served by the MSC):
 - IMSI
 - Mobile station ISDN number
 - Mobile Station roaming number
 - Temporary Roaming number
 - Local MS identity
 - Location area where MS registered
 - Supplementary service parameters

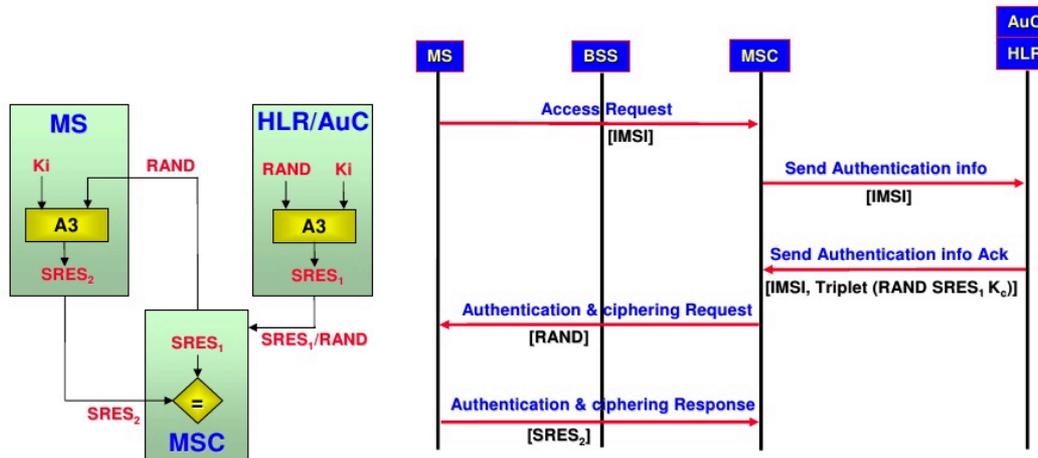
HLR:

Functions:

- Stores details of subscribers in the network
- Checks the validity and service profile of subscribers (together with AuC)

Authentication process:

General Authentication Procedure



- EIR:
 - A database: international IMEI number
 - Control access to the network
 - Response to IMEI query: status of a mobile
 - White-listed
 - Grey-listed
 - Black-listed
- GMSC:
 - Routes traffic entering a mobile network
 - Accesses the HLR to find location of the required subscriber

Services and operation

- Services:
 - Subscriber services:
 - Teleservices
 - Bearer services
 - Supplementary services:
 - Call forwarding
 - Bar incoming/outcoming calls
 - Call waiting
 - ...

- Operations:
 - Mobility management:
 - Switching mobile on (attach)
 - Switching mobile off (detach)
 - Location updates
 - Calls:
 - Mobile originated: Making a call
 - Mobile terminated: Receiving a call
 - Cell measurements and handover

- **Mobility management:**
 - **Switching on:**
 - MS sends IMSI to MSC via best serving BTS
 - MSC/VLR is updated in HLR
 - Subscriber data including current location area is added to local VLR
 - MSC and HLR do authentication check
 - EIR checks status of mobile
 - **Switching off:**
 - MS informs MSC
 - HLR stores last location area for MS
 - VLR records
 - Mobile powers off

- Calls

- Making a call:

- MS requests

- BSS:

- determines the nature of the call
 - Allocates radio resource

- NSS determines the destination:

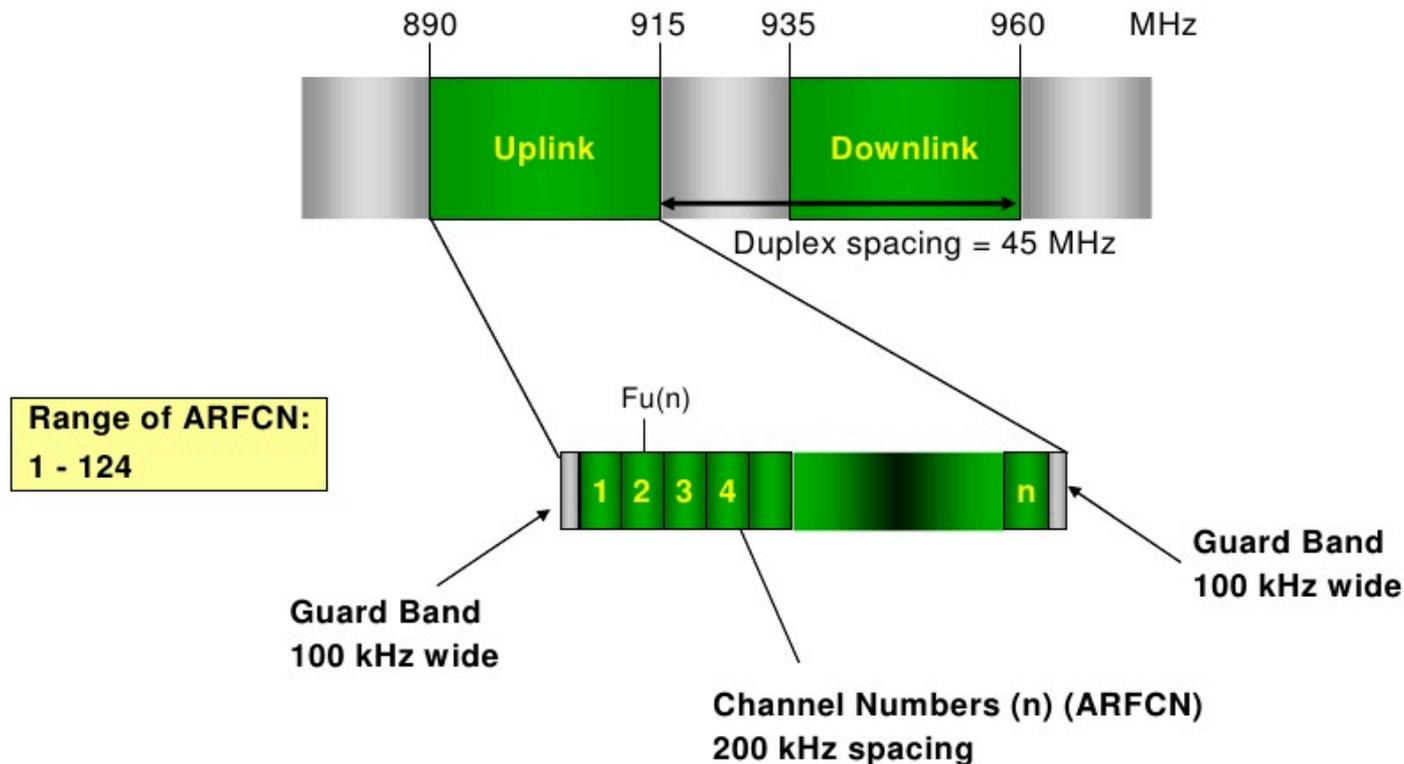
- Mobile to mobile, same PLMN
 - Mobile to mobile, another PLMN
 - Mobile to fixed network

- MSC/GMSC routes the call and handles signalling

- Receiving a call:
 - External caller
 - ISDN routes call to GMSC
 - VLR is found in HLR
 - Mobile subscriber roaming number sent to GMSC
 - GMSC routes call to correct MSC/VLR
 - Internal caller: HLR supplies current MSC/VLR
 - VLR supplies current location area
 - BSS pages mobile
 - Mobile responds and radio resources are allocated

GSM Spectrum Allocation

P-GSM Spectrum (Primary GSM)



GSM Spectrum Allocation

- E-GSM Spectrum (Extended GSM)
- DCS – 1800 spectrum
- PCS - 1900 spectrum
- 1800 MHz utilization in UK

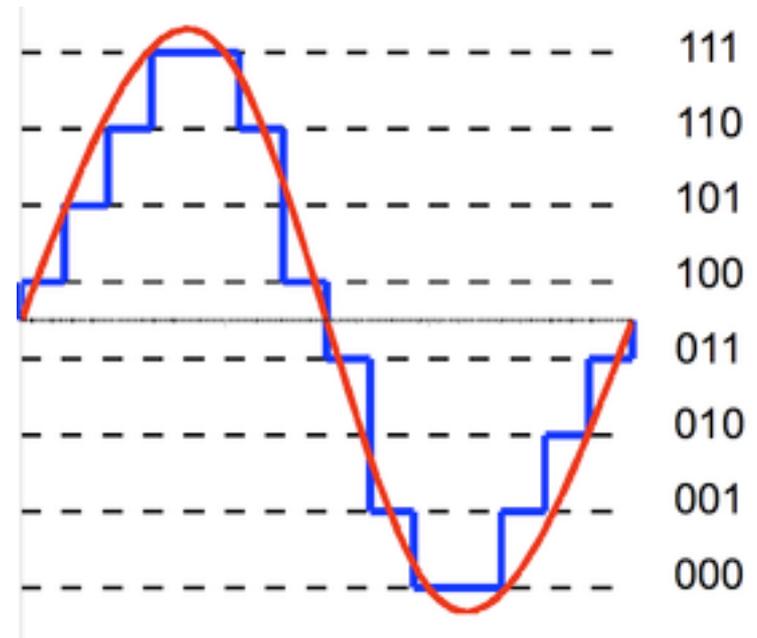
The Air Interface

- The air interface: how communication is achieved between mobile handset and base station.
- Modulation techniques
- Multiple access techniques
- Logical channels and physical channels

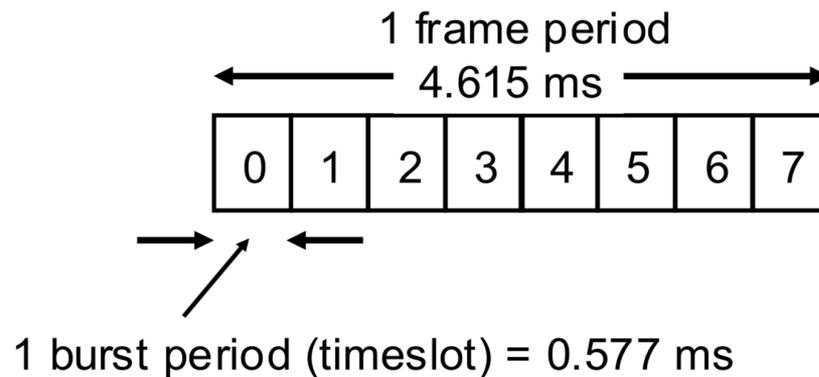
- Modulation techniques
 - 1st generation: analog modulation AM and FM
 - Digital modulation:
 - Voice → digital pulse: PCM
 - Digital modulation techniques: PSK, FSK, GMSK
- Multiple Access:
 - FDMA
 - TDMA
 - CDMA

Pulse code modulation (PCM)

- Used on all fixed telephone
- Analog speech signal is
 - Sampled
 - Quantized to discrete levels
 - Sampled levels: a sequence of binary data
 - Binary data: a train of digital pulses

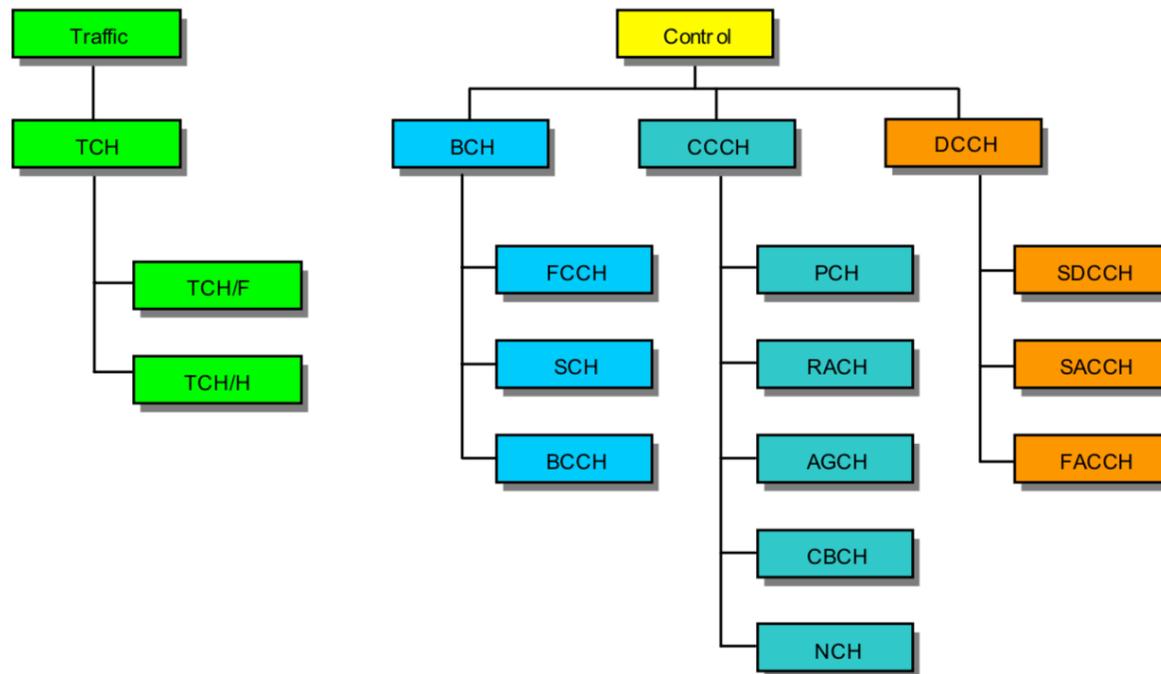


- GSM channels:
 - Physical channels: physical resource available for use
 - Using FDMA/TDMA: 1 carrier, 8 time slots
 - One burst of data: 1 physical channel



Logical channels:

- one physical channel may support many logical channels
- Classification:

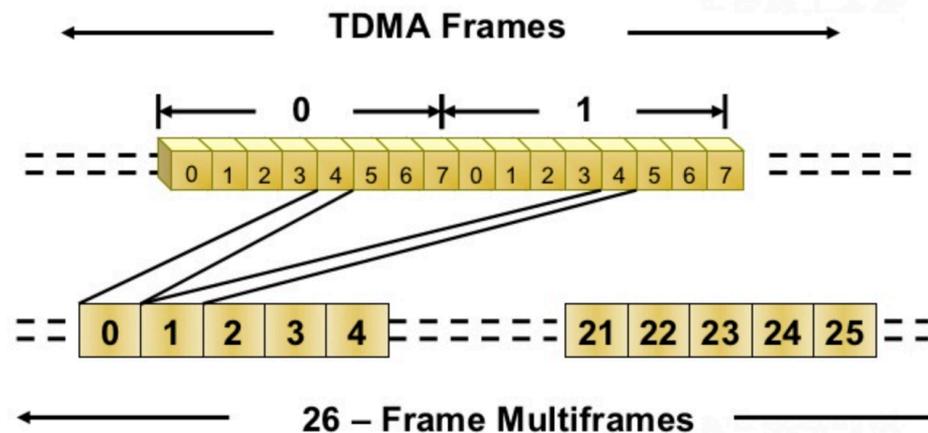


TCH	Traffic Channels
TCH/F	Traffic Channel (full rate) (U/D)
TCH/H	Traffic Channel (half rate) (U/D)
BCH	Broadcast Channels
FCCH	Frequency Correction Channel (D)
SCH	Synchronisation Channel (D)
BCCH	Broadcast Control Channel (D)
CCCH	Common Control Channels
PCH	Paging Channel (D)
RACH	Random Access Channel (U)
AGCH	Access Grant Channel (D)
CBCH	Cell Broadcast Channel (D)
NCH	Notification Channel (D)
DCCH	Dedicated Control Channels
SDCCH	Stand alone Dedicated Control Channel (U/D)
SACCH	Slow Associated Control Channel (U/D)
FACCH	Fast Associated Control Channel (U/D)

U = Uplink D = Downlink

▫ Multiframes:

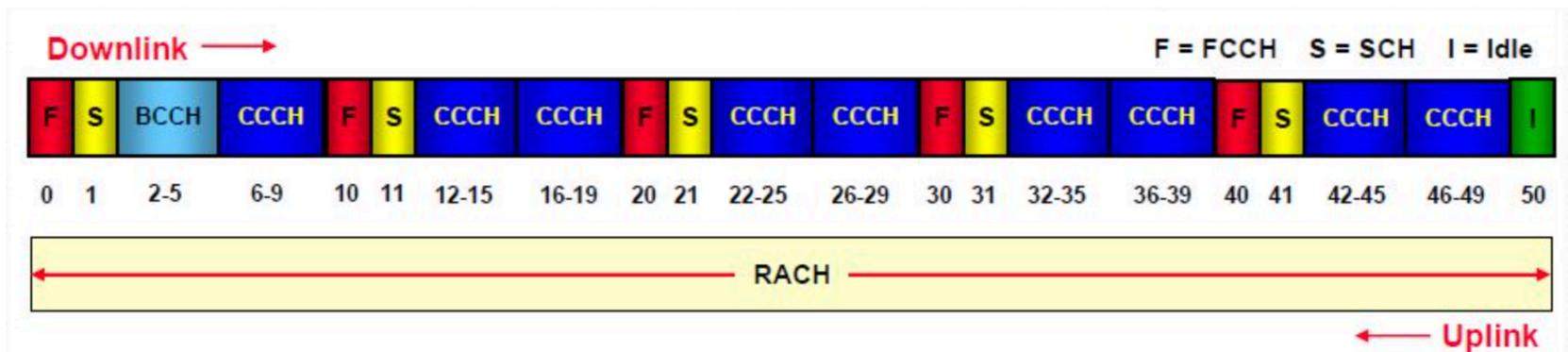
- Mapping logical channels to physical channels
- A multiframe is a series of a consecutive instances of particular timeslot
- GSM multiframe of 26 and 51 timeslots



- Traffic channel multiframe: TCH, SACCH, FACCH



- Control channel multiframe:



- **Frame hierarchy:**
 - **Multiframe: 26 or 51 timeslots (120ms or 235 ms)**
 - **Superframe: 26 or 51 multiframe (6.12ms)**
 - **Hyperframe: 2048 superframes**