Chapter 4 - Making It Work

Multiple Access
Radiowave Propagation
Signal Processing

The Network
The Network

1. Handset is connected to base station through mobile radio link

2. Base station is connected to mobile switching centre through fixed microwave link

3. Mobile switching centre is connected to
   - another mobile switching centre for a mobile to mobile call
   - the public switched telephone network for a mobile to distant fixed or mobile call

Mobile Location

Cellular network split up into location areas with identity number.

Base stations regularly transmit number.

When mobile changes location, it tells system which area it has moved to (registration).
Mobile Location

In Call Handoff

System continuously monitors signal strength and quality from mobiles.

When signal falls below threshold, system checks whether any other cell can receive better signal.

If so, channel is allocated and mobile commanded to switch frequency.
In GSM, Mobile Assisted Handoff (MAHO) is used. Mobile monitors signal strength from 6 neighbouring base stations and passes result to current base station. System evaluates which base station to handoff to for a signal improvement.

Services of GSM

GSM are classified as either tele-services or data services:

1) Telephone Services

2) Bearer Services and data services (up to 9.6 Kbps)

3) Supplementary ISDN services (call diversion, group calling, Caller identification and SMS.

The main features of GSM is the Subscriber Identity Modules and Privacy
Features of GSM

- **BTS** – base transceiver station
  - one in each cell
  - controls radio channels
  - does call frequency control, modulation, coding, etc

- **BSC** – base station controller
  - controls a group of BTS
  - controls handover, power control, etc

- **MSC** – mobile services switching centre
  - routes call from BSC to PSTN, ISDN,
  - public data networks, private networks
Features of GSM

MSC – mobile services switching centre
  manages calls –  
    call set-up, routing, control and termination 
  manages inter-MSC handover 
  manages call charge collection and 
    gathers accounting information 
  may be connected to other MSCs on 
    same network (eg Orange) 
  and to other networks 
  linked to important databases

HLR – home location register 
  - stores information on subscription levels, 
    supplementary services and network 
  and location most recently in use by “home” users

VLR – visitor location register 
  - stores same information as HLR, but for “visitors” 
  - may also know if phone is on or off
Features of GSM

- **AUC** – authentication centre
  - works closely with HLR
  - provides information to authenticate calls to prevent fraud

- **EIR** – equipment identity register
  - stores information about type of mobile in use
  - can bar call if mobile is stolen, not Type Approved or has a network threatening fault

- **Network management function**
  - monitors and controls major parts of infrastructure such as grade of service and traffic flow
  - used for maintenance and planning

GSM radio

- **GSM-900 uses**
  - 890–915 MHz to send information from the mobile station to the base station (uplink)
  - 935–960 MHz for the other direction (downlink),

- **It provides 124 RF channels** (channel numbers 1 to 124) spaced at 200 kHz. Duplex spacing of 45 MHz is used. Guard bands 100 kHz wide are placed at either end of the range of frequencies.
GSM radio

GSM-1800 uses:
• 1710–1785 MHz to send information from the mobile station to
• 1805–1880 MHz for the other direction, the base station (uplink, downlink),
• It provides 374 channels (channel numbers 512 to 885). Duplex spacing is 95 MHz.

Features of GSM
Channel Types

Traffic Channels
Speech
- full rate – 13kbps (TCH/FS)
- half rate – 6.5kbps (TCH/HS)
Data
- full rate – 9.6kbps (TCH/F9.6)

(TCH/F4.8)
(TCH/F2.4)

-half rate (TCH/F4.8)
(TCH/F2.4)
Features of GSM

Control Channels
- associated control channel – slow (SACCH)
  supervisory, power control, etc
- associated control channel – fast (FACCH)
  handover, etc
- stand alone dedicated control channel (SDCCH)
  registration, authentication, etc
- broadcast control channel (BCCH)
  base station sends out its ID, etc

Features of GSM

Control Channels (cont)
- synchronisation channel
  base station provides sync information
- frequency control channels
  base station provides carrier information
- common control channel
  paging (PCH) – bs calling ms
  random access (RACH) – ms calling bs
  access grant (AGCH) – response to RACH
  assigning dedicated control channel
Features of GSM
Frame Hierarchy

Hyperframe = 2048 Superframes = 2,715,648 TDMA frames

Superframe = 1325 TDMA frames (6.12sec)

Superframe could be…

0 1 2 ................................. 50 乙 traffic channel

Or it could be…

0 1 2 ................................. 25 乙 control channel

Features of GSM

Superframe could be…

0 1 2 ................................. 50 乙 traffic channel

0 1 2 ............10 11 SACCH 12 13 ........23 24 SACCH

1 multiframe = 26 TDMA frames (120ms)

0 1 2 ..........7 1 TDMA frame = 8 timeslots (4.615ms)

1 timeslot = 156 bits = 0.577ms
Features of GSM

1 timeslot = 156 bits = 0.577ms

... is made up of...

3 tailing bits | 58 encrypted bits | 26 training bits

58 encrypted bits | 3 tailing bits

8.25 bit duration guard space

Tailing bits allow transceiver to power up and down smoothly to reduce spurious adjacent channel emissions.
Training bits are used to reset the equaliser which helps to mitigate channel time dispersion.
Guard space allows for differences in average channel delay.

Encrypted data then assembled by
regular pulse excited speech encoder at 13kbps additional encoding
block of 456 bits partitioned into 8 x 57 sub-blocks sub-blocks are diagonally interleaved bits are encrypted

Features of GSM

For speech channel (TCH/FS)
Output from RPE = 13kbps
output from additional encoding = 22.8kbps

Timeslots are 114 bits in 4.615ms = 24.7kbps

difference of 1.9kbps allows SACCH channel to be carried simultaneously with speech
SACCH frame inserted as 13th and 25th frame in a multiframe as shown previously
Features of GSM

Control Channels

Mobiles scan all control channels at switch on
- dedicated control channels carry system data and paging channel numbers
- paging channel used to alert mobile of incoming call and to send data such as area identity, access channel numbers, etc.
- access channels used by mobiles to alert base stations of outgoing calls, location registration, etc.

Control Channel Signalling
- Data is digitally encoded and sent using FSK
  : deviation 6.4 kHz
  : data rate 8 kb/s
  : Manchester encoded to facilitate clock recovery to 16 kb/s
- Error correction etc.
  : BCH code generates parity word
  : parity word appended to block
  : frame consists of
    * bit and word synchronisation
    * block and parity word repeated several times
- Reception
  : majority voting on repeated bits and errors corrected
  : parity word used to correct one more error and tell if more than one error present
  : if errors remain message is rejected
Features of GSM

Call Origination

Key number into handset channels used by mobiles
to alert base stations of
outgoing calls, location registration, etc.
Press SEND
Mobile scans network access channels
Selects two strongest and reads access parameters
Mobile transmit and access request
Base station responds with available speech channel
Mobile sets up speech channel and
user hears call being set up

Features of GSM

Power Control

To improve spectral occupancy and
reduce interference mobiles have variable power
- minimum ERP = -22 dBW
- maximum ERP = 6 dBW
- in steps of 4 dB
- base station tells mobile to what level to use
using 3 bit code over a control channel