GSM Network Architecture

GSM Architecture

Numbering and Routing

GSM Services

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Introduction

- Global System for Mobile Communication (GSM)
  - Anybody – 500 million users (May 2001)
  - Anywhere – 168 countries (May 2001)
  - Any media – voice, messaging, data, multimedia

Source: Hillebrand, 1
GSM Architecture

BTS = Base Transceiver Station
AuC = Authentication Center
OMC = Operation and Maintenance Center
PSTN = Public Switched Telephone Network
ME = Mobile Equipment

Source: Stallings, 313
Source: Mehrotra, 27
### GSM Architecture

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Year Introduced</strong></td>
<td>1990</td>
</tr>
<tr>
<td><strong>Access method</strong></td>
<td>TDMA</td>
</tr>
<tr>
<td><strong>Channel Bandwidth</strong></td>
<td>200 kHz</td>
</tr>
<tr>
<td><strong>Number of duplex channels</strong></td>
<td>125</td>
</tr>
<tr>
<td><strong>Users per channel</strong></td>
<td>8</td>
</tr>
<tr>
<td><strong>Speech coding bit rate</strong></td>
<td>13 kbps</td>
</tr>
<tr>
<td><strong>Data coding bit rate</strong></td>
<td>12 kbps</td>
</tr>
<tr>
<td><strong>Frame size</strong></td>
<td>4.6 ms</td>
</tr>
</tbody>
</table>
SIM (Subscriber Identity Module)

Billions of Calls
Millions of Subscribers
Thousand of Different Types of Telephones
Hundreds of Countries
Dozens of Manufacturers….
And only one Card: The SIM

- Administrative data
- Security data
- Subscriber data
- Roaming data
- PLMN (Public Land Mobile Network)

Source: Hillebrand, 369
http://ucables.com/products/simcards/
Subscriber Identity Module (SIM)

- Contains
  - phone number (MSISDN)
  - international mobile subscriber identity (IMSI)
  - status of SIM
  - service code
  - authentication key
  - PIN (personal identification code)
  - PUK (personal unlock code)
SIM Cards

- SIM cards are embedded with a microprocessor
  - Stores customer identity information and is made to fit inside the cellular phone

- Memory capacity
  - 1K, 3K, 8K, 16K, 32K, 64K
Global GSM Mobility Card
*The Smart Card to use*

G S M

Mobile Station

SIM Card + Handset + Battery
SIM-Card and GSM Mobile Equipment

Subscriber knows
Called party number = MS-ISDN-PIN

Handset

Global GSM Mobility Card
The Smart Card to use
Contains:
- IMSI

G S M

SIM-Card

Calling line
0609225831
The SIM-Card Functions

μ SIM-Card

Credit Card Size

Permanent data:
- Unique mobile subscriber identity through IMSI number,
- Authentication parameter Ki,
- Authentication algorithm A3,
- Generating encryption key Kc algorithm A8.

Global GSM Mobility Card
The Smart Card to use

G S M

Microchip with stored user information

Removable data:
- Temporary Mobile Subscriber Number,
- Location Area Identification.
### Subscriber Identification

<table>
<thead>
<tr>
<th>Nature</th>
<th>IMSI</th>
<th>MS - ISDN</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>International Mobile Subscriber Identity</td>
<td>Mobile Station - Integrated Services Digital Network Nb</td>
</tr>
<tr>
<td></td>
<td>Conformity with E212</td>
<td>Similar to ISDN, Conformity with E164/E213</td>
</tr>
</tbody>
</table>

#### Format

<table>
<thead>
<tr>
<th>Nature</th>
<th>IMSI</th>
<th>MS - ISDN</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>MCC</td>
<td>CC</td>
</tr>
<tr>
<td></td>
<td>MNC</td>
<td>NDC</td>
</tr>
<tr>
<td></td>
<td>MSIN</td>
<td>SN</td>
</tr>
</tbody>
</table>

#### Meaning

<table>
<thead>
<tr>
<th>Nature</th>
<th>IMSI</th>
<th>MS - ISDN</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mobile Country Code</td>
<td>Country Code</td>
</tr>
<tr>
<td></td>
<td>Mobile Network Code</td>
<td>National Destination Code</td>
</tr>
<tr>
<td></td>
<td>Mobile Subscriber Ident. Nb</td>
<td>Mobile Subscriber (national definition)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>H1 H2</th>
<th>M1 M2</th>
</tr>
</thead>
<tbody>
<tr>
<td>x x x</td>
<td>x x x</td>
</tr>
</tbody>
</table>

#### Nb. digits

<table>
<thead>
<tr>
<th>Nature</th>
<th>IMSI</th>
<th>MS - ISDN</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>3</td>
<td>1 to 3</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>2 to 4</td>
</tr>
<tr>
<td></td>
<td>max 10</td>
<td>total max 15</td>
</tr>
</tbody>
</table>

*This code does not identify a geographical area but an operator*
### MS Classmark

<table>
<thead>
<tr>
<th>Classmark</th>
<th>Power classes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Revision level (Phase 1, 2, 2+)</strong></td>
<td><strong>GSM 900</strong></td>
</tr>
<tr>
<td><strong>RF power</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Encryption algorithm (A5/1,A5/2)</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Frequency (900/1800/1900)</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Short message</strong></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>1 W**</td>
</tr>
<tr>
<td>2</td>
<td>8 W*</td>
</tr>
<tr>
<td>3</td>
<td>5 W</td>
</tr>
<tr>
<td>4</td>
<td>2 W**</td>
</tr>
<tr>
<td>5</td>
<td>0.8 W</td>
</tr>
</tbody>
</table>

* Typical value for car mounted
** Typical value for handheld
MS (Mobile Station)

- Mobile Equipment (ME)
- Subscriber Identity Module (SIM)
MOBILE EQUIPMENT:

- Handportable Unit
- Portable Mobile Unit
- Vehicle Mounted

**RF POWER CAPABILITY**

<table>
<thead>
<tr>
<th>Power Class</th>
<th>Power Output</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20 Watts (delated)</td>
</tr>
<tr>
<td>1</td>
<td>8 Watts</td>
</tr>
<tr>
<td>3</td>
<td>5 Watts</td>
</tr>
<tr>
<td>4</td>
<td>2 Watts</td>
</tr>
<tr>
<td>5</td>
<td>0.8 Watts</td>
</tr>
</tbody>
</table>
ADVANTAGES OF GSM

Digital

Global

Noise Robust

Open Interfaces

Secure
NETWORK ARCHITECTURE

- **OMS**
  - Operations & Maintenance Subsystem

- **NSS**
  - Network Switching Subsystem

- **MS**
  - Mobile Station

- **BSS**
  - Base Station Subsystem
BSS Connectivity

BSS CONFIGURATIONS

-Star

-Loop
OPERATIONS AND MAINTENANCE SYSTEM (OMS):

Network Management Centre (NMC)
- global

Operations & Maintenance Centre (OMC)
- regional
The Network In Reality
GSM Network Elements

- **Handset**
- **BTS**: Base Transceiver Station
- **MSC**: Mobile Switching Center
- **BSC**: Base Station Controller
- **HLR/VLR**: Home Location Register/Visiting Location Register
- **SIM Card**: Subscriber Identity Module Card
- **Service Centers**: USSD, SMS, ...
Base Transceiver Station (BTS) / Base Station

- Responsible for communication to and from MHs via air interface
  - MS communicates with the mobile system using a radio channel to a BTS

- BTS comprises radio transmission and reception devices
  - Including the antennae and signaling processing specific to the radio interface

- BTS separates the speech and control signaling associated with a MS and sends them to the BSC on separate channels
Mobile services Switching Center (MSC)

- Responsible for all switching functions related to call processing
  - Coordinate the setting up of calls to and from GSM users
- MSC is the interface between GSM network & PSTN (Public Switched Telephone Network)
Gateway MSC (G-MSC)

- The MSC with an interface to other networks is called GMSC.
- Network operator may equip all there MSCs with gateway function or only few.
- MSC that don’t have gateway function has to route call from GMSC.
- GMSC has some additional tasks like call from outer network enters in GMSC which queries HLR then forwarded the call to MSC where the called party is located.
Base Station Controller (BSC)

- Monitor and Control several base stations
  - Frequency administration, control of BTSs, exchange functions
- Responsible for all the radio interface management
  - Channel allocation and release, handover management
- BSC is the interface between MSC and BTS
  - BSC is connected on one side to several BTSs and on the other side to the MSC
Home Location Register (HLR)

- A database in charge of the management of mobile subscribers
- Contains information of network subscribers
  - Information on teleservices and bearer services subscription, service restrictions, and supplementary services
  - The data stored in HLR is of a semi permanent nature and does not usually change from call to call
Visitor Location Register (VLR)

- Contains the relevant data of all MSs currently located in a serving MSC
  - The permanent data is the same as data in the HLR
  - The temporary data includes
    - Temporary Subscriber Identity (TMSI)
    - Location Area Identity (LAI) of an MS
  - VLR allocates mobile subscriber roaming numbers (MSRNs) for the incoming call setup
The relation between MSC and VLR

• Sum of MSC areas determine the geographical area of any PLMN.
• Each MSC has its own VLR so PLMN can also be described as the sum of all VLR areas.
• VLR can serve several MSC but one MSC always use only one VLR.
Equipment identity register (EIR)

• The separation of subscriber identity from the identifier of MS also bears a potential pitfall for GSM subscribers.
• It is possible to operate any GSM MS with any valid GSM SIM. An opportunity exists for black market and stolen equipment. • To combat this problem EIR is introduced to identify and track such equipment.
EIR (cont)

- Each GSM phone has a unique identifier IMEI which can not be altered.
- Like HLR and VLR, the EIR is also a data base which maintain three lists.
EIR (cont)

• The processes of mobile equipment fallen dramatically due to great success of GSM consequently the theft rate reduced. So several GSM operators have decided not to install the EIR.

• If the EIR is installed there is no specification when the EIR should be interrogated. The EIR may be interrogated any time during call setup or during location update.
Transcoding rate and adaptation unit. (TRAU)

- One of the most interesting features of GSM is TRAU. Its function is the compress and decompress the speech between TRAU and MS. Possible location are as below.
Geographical Network Structure

- **Location Units**
  - Cell
  - Location Area (LA)
  - MSC/VLR Service Area
  - PLMN (Public Land Mobile Network) Service Area
  - GSM Service Area

- **Cell Planning**
Location Information --
GSM Service Area Hierarchy

- The area in which a subscriber can access the network.
Numbering & Routing
Numbering

- **Mobile Subscriber ISDN Number (MSISDN)**
  - Mapping to Mobile Station Roaming Number (MSRN) by HLR

- **International Mobile Subscriber Identify (IMSI)**
  - Stored in SIM/HLR

- **Temporary Mobile Subscriber Identity (TMSI)**
  - Assigned by VLR, Stored in VLR

- **International Mobile Equipment Identity (IMEI)**
  - Unique ID to handset, used by air interface
ID-Numbers

**MSISDN = CC + NDC + SN**
- MSISDN: Mobile Station ISDN Number
- CC: Country Code
- NDC: National Destination Code
- SN: Subscriber Number

**IMSI = MCC + MNC + MSIN**
- IMSI: International Mobile Subscriber Identity
- MCC: Mobile Country Code
- MNC: Mobile Network Code
- MSIN: Mobile Station Identification Number
ID-Numbers (cont.)

**IMEI = TAC + FAC + SNR + spare**
- **IMEI**  Internal Mobile Equipment Identity
- **TAC**   Type Approval Code, determined by a central GSM/PCS body
- **FAC**   Final Assembly Code, identifies the manufacturer
- **SNR**   Serial Number, uniquely identifies all equipment within each TAC and FAC

**IMEISV = TAC + FAC + SNR + SVN**
- **IMEISV** International Mobile Equipment Identity and Software Version Number
- **SVN**   Software Version Number
ID-Numbers (cont.)

MSRN = CC + NDC + SN
- **MSRN** Mobile Station Roaming Number
- **CC** Country Code
- **NDC** National Destination Code
- **SN** Subscriber Number. In this case, the address to the serving MSC

LAI = MCC + MNC + LAC
- **MCC** Mobile Country Code
- **MNC** Mobile Network Code
- **LAC** Location Area Code
ID-Numbers (cont.)

- **CGI = MCC + MNC + LAC + CI**
  - CGI  Cell Global Identity
  - CI  Cell Identity

- **BSIC = NCC + BCC**
  - BSIC  Base Station Identity Code
  - NCC  Network Color Code (3bits)
  - BCC  Base Station Color Code (3bits)

- **LN = CC + NCD + LSP**
  - LN  Location Number
  - CC  Country Code
  - NCD  National Destination Code
  - LSP  Locally Significant Part
ID - Numbers (cont.)

- **LN = CC + NCD + LSP**
  - LN Location Number
  - CC Country Code
  - NCD National Destination Code
  - LSP Locally Significant Part

- **RSZI = CC + NDC + ZC**
  - RSZI Regional Subscription Zone Identity
  - CC Country Code
  - NDC National Destination Code
  - ZC length of the Zone code (2 octets)
Routing

- Information resident in MS & SIM
  - IMSI, TMSI, IMEI, and misc. information

- Routing Information used by Network
  - MSISDN, MSRN
GSM Services and Features

1. Tele Services

2. Bearer Services or Data Services

3. Supplementary Services
Teleservices

2 - Emergency Call

Global GSM Mobility Card
The Smart Card to use

Do not require a SIM-Card while "112" is invoked
Teleservices

3. Short Message Cell Broadcast

Information Provider A

Information Provider B

GSM Network
4 - Short Message Service
Teleservices

Alternate Speech and Fax:

5 - Fax

Automatic fax:
Teleservices

6 - User's Data Call Features

- Teleservices (voice)
- Embodied bearer treatments for radio transmission
- Cable that bears data
- Data / Fax kit adaptation
- Teleservices (Fax G3, SMS)
Teleservices

7 - Voice Messaging

Forward to voice mail box

GSM network

Voice mail box

Voice message server

Busy

Please leave a message after the tone

You have 3 voices messages...

Warming up...

Retrieving the voice messages

You have 3 voices messages...
Bearer Services

- Limited to 1, 2 and 3 OSI layer
- Packet Switched Protocols
- Data Rates from 300bps to 9.6kbps
Supplementary Services

1 - Line Identification

- Calling Line Identification
  - presentation (CLIP)
  - restriction (CLIR)

- Connected Line Identification
  - presentation (CoLP)
  - restriction (CoLR)

- Calling Name Presentation (CNAP)
Supplementary Services

2 - Call Transfer and Call Forwarding

- unconditional (CFU)
- on busy (CFB)
- on no reply (CFNRy)
- on not reachable (CFNRc)
Supplementary Services

3 - Waiting / Hold and Multi Party

Waiting / Hold:

Multi Party:

Max = 5 persons
Supplementary Services

4 - Call Barring

- Outgoing (BAOC)
- Outgoing international (BOIC)
- Outgoing international except home PLMN country (BOIC-exHC)
- Incoming (BAIC)
- Incoming when roaming outside (BIC-Roam)
Supplementary Services

5. Call Completion (CCBS)

- Unable to place a call.
- Reinitiate the call
- Call is established
- NEW!
- BUSY...
- Ring!
- SPEAKING
- This call in state
- Ring!
- Idle
- HELLO
- Speaking
- Speaking
Supplementary Services

Advice of Charge Information (AoCI)

6 - Advice of Charge

- Insert a SIM credit Card
- Completion of call need charging

Advice of Charge Charging (AoCC)

information on progress of the cost of the call
The aim of the CAMEL (Customized Application for Mobile network Enhanced Logic) is to provide GSM network operators with the ability to create specific services in their home network, and export these services to their subscribers when roaming outside the home network. CAMEL introduces the ability to provide location dependent IN type of services to mobiles subscribers.
IN Services: Prepaid Calling

- Multiple recharging options

- Multiple Tariff Plans
- Tariffs using fixed charge, CC, NC, distance, time & day, roaming charges...

- Possible language selection by subscriber

- Bulk account loading for easy provisioning

- Account status enquiry and notification

- Flexible features for easy service packaging
IN Services: Location Inquiry

The closest restaurants are:
- The Wind Jammer on 132 Flinton Street Sea food Phone 55 1968 press 1 to connect
- The Palace on 11 Bourke Street Chinese food Phone 55 0407 press 2 to connect
- The Anchor St Catherine Dock Phone 56 2548 Press 2 to connect

Possible customization of announcement directly by the advertiser

Cell dependent information
Direct connection to advertisers

Today’s special at The Anchor is Maine lobster soup
Be the first ten caller and get a free cocktail!