MOTOROLA

Chapter 2

Features of GSM

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Section Objectives

On completion of this section the student will be able to:

- Understand the advantages of a digital air interface.
- Realise the implications of using standard open interfaces.
- Recognise the enhanced range of services that may be offered by a GSM network.
- Understand the part played by the mobile station in the handover process.
- Appreciate how software is used to provide flexibility.

Features of GSM

Cellular telephone systems provide the MS subscriber and network provider with many advantages over a standard telephone network, but there are still many drawbacks.

Compatibility

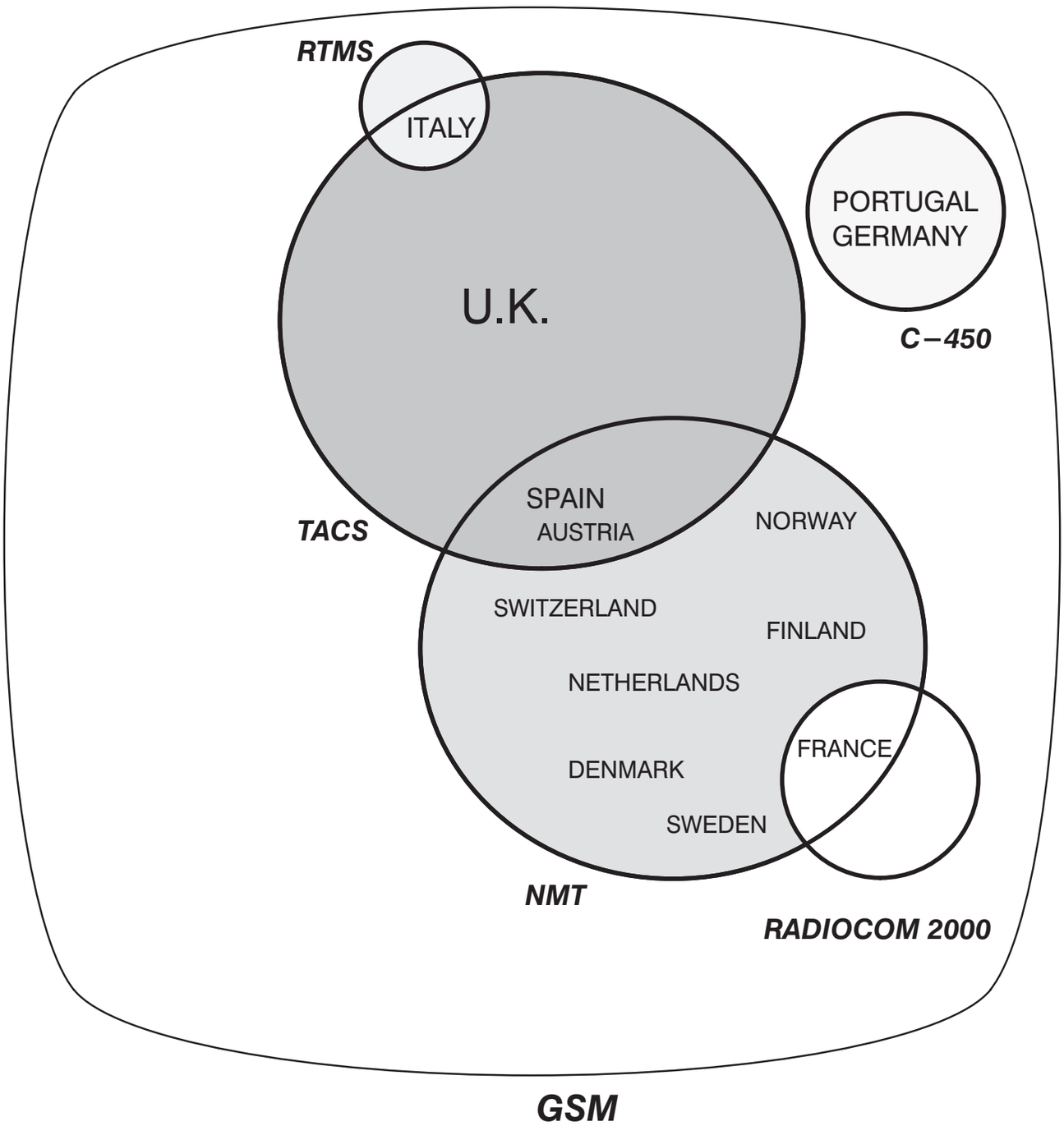
The rapid development of analogue cellular networks during the 1980s resulted in many different cellular systems which were incompatible with one another.

The need for a common standard for mobile telecommunications was therefore obvious, and so an executive body was set up to co-ordinate the complicated task of specifying the new standardized network.

GSM has been specified and developed by many European countries working in co-operation with each other. The result is a cellular system which has been implemented throughout Europe and many parts of the world.

An additional advantage resulting from this is that there is a large market for GSM equipment. This means that manufacturers can produce equipment in higher quantities and of better quality, and also, due to the number of manufacturers, a competitive and aggressive pricing structure exists. This results in lower costs for the MS subscriber and the network operators.

Compatibility



Noise Robust

In cellular telephone systems, such as AMPs, TACs or NMT the MS communicates with the cell site by means of analogue radio signals. Although this technique can provide an excellent audio quality (it is widely used for stereo radio broadcasting, for example), it is vulnerable to noise, as anyone who has tried to receive broadcast stereo with a poor aerial will testify!

The noise which interferes with the current system may be produced by any of the following sources:

- A powerful or nearby external source (a vehicle ignition system or a lightning bolt, perhaps);
- Another transmission on the same frequency (co-channel interference);
- Another transmission “breaking through” from a nearby frequency (adjacent channel interference);
- Background radio noise intruding because the required signal is too weak to exclude it.

In order to combat the problems caused by noise, GSM uses digital technology instead of analogue.

By using digital signals, we can manipulate the data and include sophisticated error protection, detection and correction software. The overall result is that the signals passed across the GSM air interface withstand more errors (that is, we can locate and correct more errors than current analogue systems). Due to this feature, the GSM air interface in harsh RF environments can produce a usable signal, where analogue systems would be unable to. This leads to better frequency re-use patterns and more capacity.

Sources of Noise

- **Vehicle ignition systems**
- **Lightning**
- **Co-channel interference**
- **Adjacent channel interference**
- **Background spurious noise**

GSM Answers

- **Digital interface**
- **Interleaving**
- **Error detection**
- **Error correction**

Flexibility and Increased Capacity

With an analogue air interface, every connection between an MS and a cell site requires a separate RF carrier, which in turn requires a separate set of RF hardware. In order to expand the capacity of a cell site by a given number of channels, an equivalent quantity of hardware must be added. This makes system expansion time consuming, expensive and labour intensive.

Re-configuration of an analogue site suffers similar problems since much of the equipment requires manual re-tuning and this makes the system inflexible.

GSM equipment is fully controlled by its software. Network re-configurations can be made quickly and easily with a minimum of manual intervention required. Also, since one carrier can support eight users, expansion can be made with less equipment.

An enhancement soon to be realised is the half rate speech channel, where mobiles will use new speech algorithms requiring half as much data to be sent over the air interface. By implementing half rate, one carrier will be able to support 16 users, effectively doubling the capacity of the network. However, this is the optimum since the mobile, as well as the BTS, will need to be modified to support half rate.

GSM networks also offer the flexibility of international roaming. This allows the mobile user to travel to foreign countries and still use their mobiles on the foreign network. If necessary, the user may leave their mobile equipment at home and carry only the SIM card, making use of a hired mobile or any available equipment.

GSMs use of a digital air interface makes it more resilient to interference from users on the same or nearby frequencies and so cells can be packed closer together, which means more carriers in a given area to give better frequency re-use.

Multi-band networks and mobiles are available where a user can make use of both the 900 MHz network and the 1800/1900 networks. The mobile must be capable of operation in dual frequency bands, however, to the user it will be transparent. This enables network operators to add in capacity and reduce network interference by using cells operating in different frequency bands. The operator will be required to show that they have made efficient use of their existing frequencies before they will be granted access to frequencies in another band. This means using techniques like sectorisation, microcells and frequency hopping.

GSM is highly software dependent and, although this makes it very complex, it also provides for a high degree of flexibility.

Flexibility/Increased Capacity

- **Easily (RF) configured (software driven)**
- **Half rate**
- **International roaming**
- **Better frequency re-use**
- **Multi-band operation**

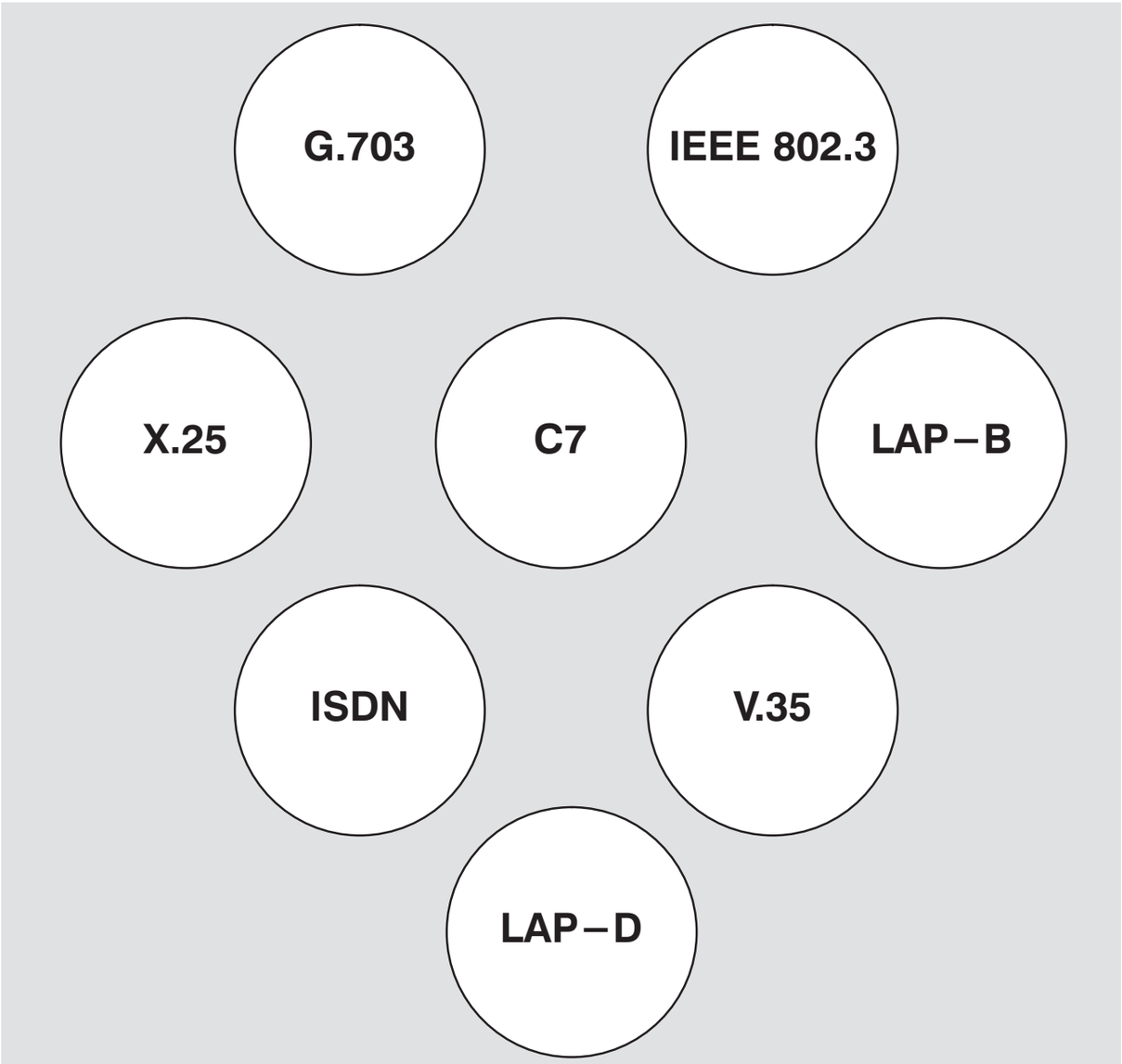
Use of Standardised Open Interfaces

The equipment in each of the analogue cellular networks tends to be produced by one manufacturer. This is because the equipment is only designed to communicate with other equipment made by that manufacturer. This situation is very profitable for the manufacturers as they have a great deal of influence over the pricing of their product. Unfortunately for the MS user and the network provider, this means high prices.

The situation is very different with GSM, where standard interfaces such as **C7** and **X.25** are used throughout the network**.** This means that network planners can select different manufacturers for different pieces of hardware. Competition between manufacturers is therefore intense in the GSM market and manufacturers must ensure they support the latest developments at a competitive price.

In addition, network planners have a great deal of flexibility in where the network components are situated. This means that they can make the most efficient use of the terrestrial links which they operate.

Use of Standardized Open Interfaces



Improved Security and Confidentiality

Security figures high on the list of problems encountered by some operators of analogue systems. In some systems, it is virtually non-existent and the unscrupulous were quick to recognize this. With some of the “first generation” systems, it has been estimated that up to 20% of cellular phone calls are stolen.

Extensive measures have been taken, when specifying the GSM system, to substantially increase security with regard to both call theft and equipment theft.

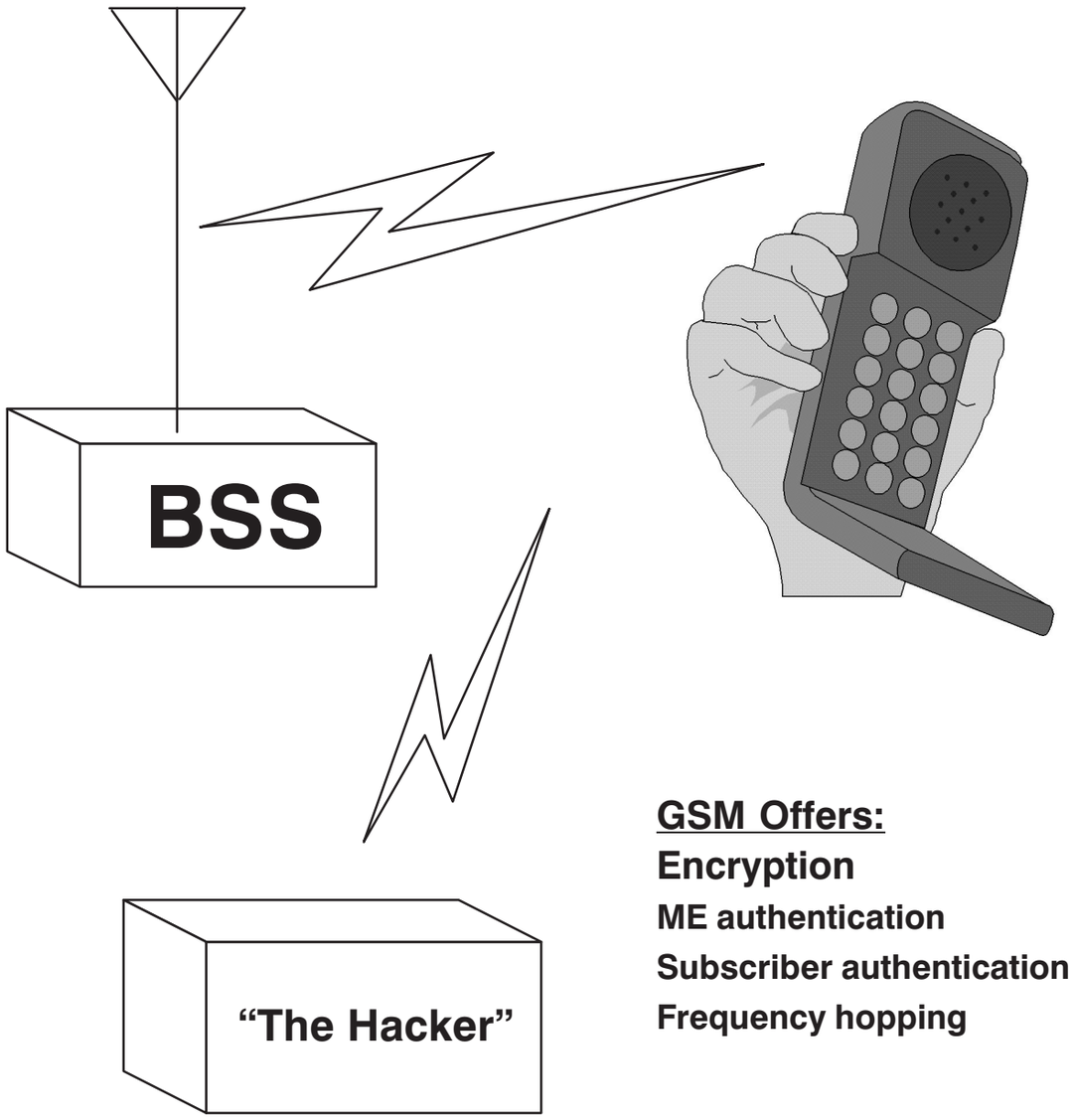
With GSM, both the Mobile Equipment (ME) and Mobile Subscriber are identified. The ME has a unique number coded into it when it is manufactured. This can be checked against a database every time the mobile makes a call to validate the actual equipment. The subscriber is authenticated by use of a smart card known as a Subscriber Identity Module (SIM), again this allows the network to check a MS subscriber against a database for authentication.

GSM also offers the capability to encrypt all signalling over the air interface. Different levels of encryption are available to meet different subscriber/country requirements.

With the authentication processes for both the ME and subscriber, together with the encryption and the digital encoding of the air interface signals, it makes it very difficult for the casual “hacker” to listen-in to personal calls.

In addition to this, the GSM air interface supports frequency hopping; this entails each “burst” of information being transmitted to/from the MS/base site on a different frequency, again making it very difficult for an observer (hacker) to follow/listen to a specific call. Although it should be noted that frequency hopping is employed to optimize network performance by overcoming interference problems in busy areas, to increase call quality and capacity.

Improved Security and Confidentiality



GSM Offers:

Encryption

ME authentication

Subscriber authentication (SIM)

Frequency hopping

Flexible Handover Processes

Handovers take place as the MS moves between cells, gradually losing the RF signal of one and gaining that of the other.

The MS switches from channel to channel and cell to cell as it moves to maintain call continuity. With analogue systems, handovers are frequently a problem area and the subscriber is often aware that a handover has occurred!

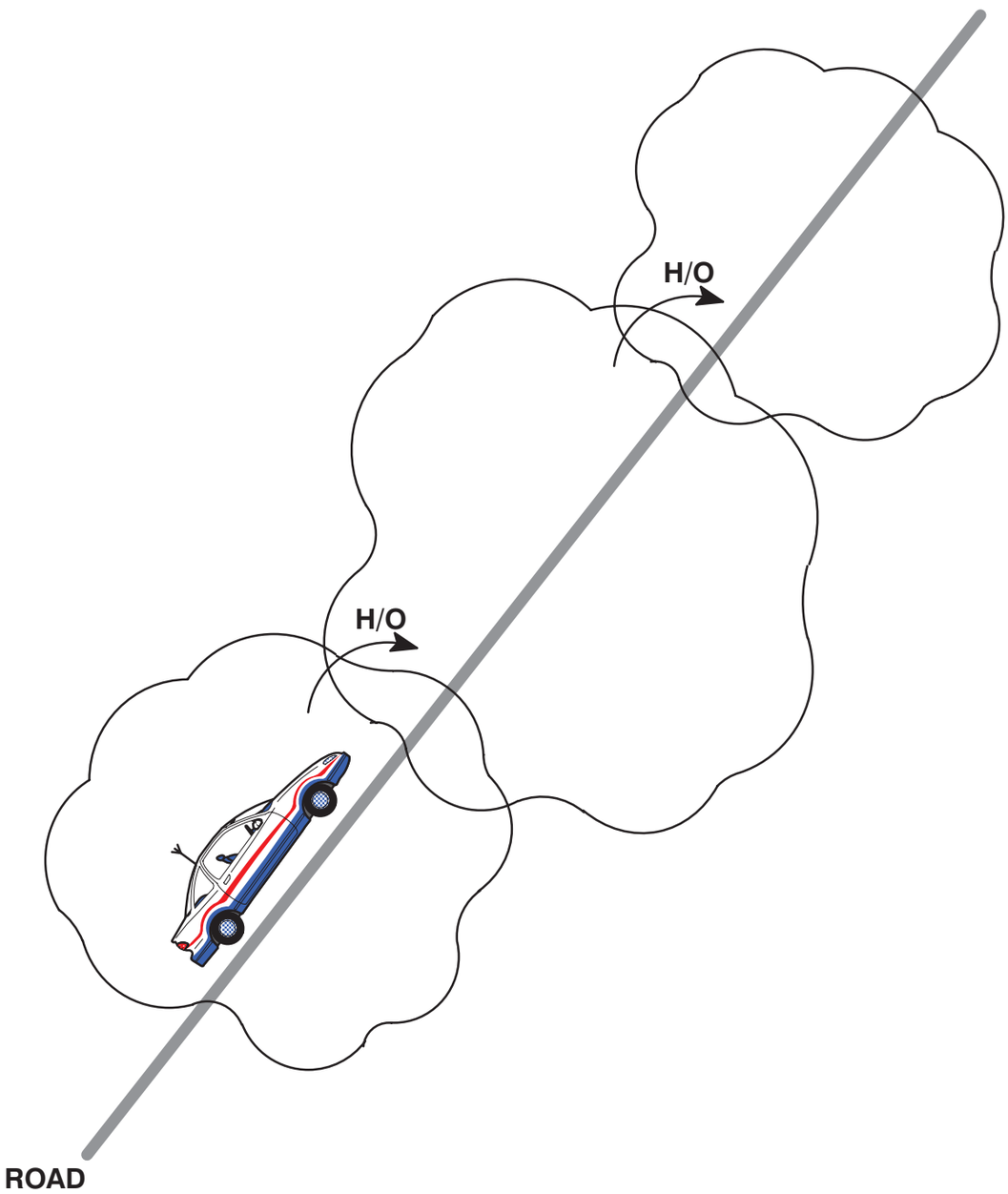
When GSM was specified a great deal of thought went into the design and implementation of handovers. Although the GSM system is more complicated than analogue in this area, the flexibility of the GSM handover processes offer significant improvements which provide a much better quality of service to the subscriber.

GSM provides handover processes for the following:

- Quality (uplink/downlink).
- Interference (uplink/downlink).
- RF level (uplink/downlink).
- MS distance.
- Power budget.

More handover algorithms have been developed for specific applications, such as microcellular, and are currently being implemented.

Flexible Handover Processes



ISDN Compatibility

Integrated Services Digital Network (ISDN) is a standard that most developed countries are committed to implement. This is a new and advanced telecommunications network designed to carry voice and user data over standard telephone lines.

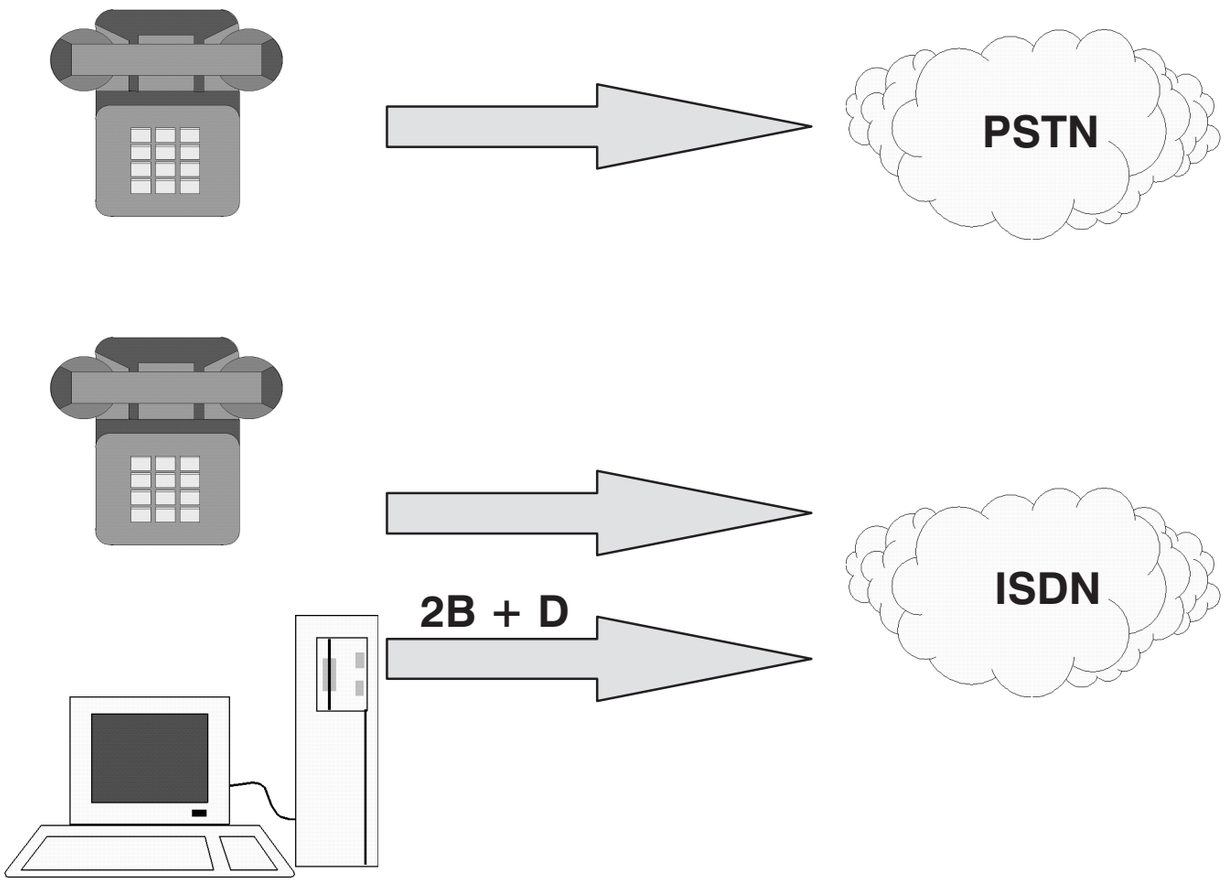
Major telephone companies in Europe, North America, Hong Kong, Australia and Japan are committed to commercial enterprises using ISDN.

The GSM network has been designed to operate with the ISDN system and provides features which are compatible with it. GSM can provide a maximum data rate of 9.6 kbit/s while ISDN provides much higher data rates than this (standard rate 64 kbit/s, primary rate 2.048 Mbit/s).

2B+D

This refers to the signals and information which may be carried on an ISDN line. There are effectively three connections, one for signalling (‘D’) and the other two for data or speech (‘2B’).

ISDN Compatibility



Note:

1. B= 64 kbit/s

2. D= 16 kbit/s

∴ 2B+D = 144 kbit/s

Enhanced Range Of Services

GSM has the potential to offer a greatly enhanced range of services compared to existing analogue cellular systems. As well as a full range of data transmission options and fax, there will be a wide range of supplementary services.

The basic call services which are already provided within analogue systems such as Call Forwarding, Voice Message Services etc, are already available in some operational systems. Whether these services and others are provided as part of the basic service or at additional cost to the subscriber will depend on the network provider.

When services were specified on GSM, the current land PSTN and ISDN system had to be taken into consideration; after all it is these systems we are most likely to be communicating with.

The services available to a subscriber will be determined by three factors:

- The level of service provided by the network provider.
- The level of service purchased by the subscriber.
- The capabilities of the subscriber's mobile equipment.

Enhanced Range of Services

- **Offered by network provider**
- **Purchased by subscriber**
- **Capabilities of mobile equipment**

Speech Services

The following services listed involve the transmission of speech information and would make up the basic service offered by a network provider:

Telephony

Provides for normal MS originated/terminated voice calls.

Emergency Calls (with/without SIM Card inserted in MS)

The number “112” has been agreed as the international emergency call number. This should place you in contact with the emergency services (Police, Fire, Ambulance) whichever country you are in.

Short Message Service Point To Point

Provides the transmission of an acknowledged short message (128 bytes maximum) from a service centre to a MS. It is also intended that the MS should be able to send short messages to land-based equipment. This will obviously depend upon the equipment owned by the land-based user.

Short Message Cell Broadcast

Provides the transmission of an unacknowledged short message (75 bytes maximum) from a service centre in the fixed network to all MSs within one cell. This may carry information from the network provider, for example traffic information or advertising.

Advanced Message Handling Service

Provides message submission and delivery from the storage from a public Message Handling System (MHS) for example, electronic mail.

Dual Personal and Business Numbers

Permits the allocation of dual telephone numbers to a single subscriber. This will allow calls to be made and be billed either to “business” or “personal” numbers.

Speech Services

- **Telephony**
- **Emergency calls**
- **Short message services**
- **Dual personal and business numbers**

Data Services

Data can be sent over the air using some of the present systems, but this requires specially designed “add ons” to protect the data content in the harsh environment of the air interface.

Special provision is made in the GSM technical specifications for data transmission. Therefore, like ISDN, GSM is “specially designed” for data transmission. GSM can be considered as an extension of ISDN into the wireless environment.

Text files, images, messages and fax may all be sent over the GSM network. The data rates available are 2.4 kbit/s, 4.8 kbit/s and 9.6 kbit/s.

In addition to supporting data transmission, GSM also provides for Group 3 Fax transmission.

Data Services

- **Raw Data:**
  - **9.6 kbit/s**
  - **4.8 kbit/s**
  - **2.4 kbit/s**
- **Fax**

Supplementary Services

A supplementary service is a modification of, or a supplement to, a basic telecommunication service. The network provider will probably charge extra for these services or use them as an incentive to join their network.

Here is a list of some of the optional supplementary subscriber services that could be offered to GSM subscribers:

Number Identification

- Receiving party requests calling number to be shown.
- Calling party requests calling number not to be shown.

Call Barring

- Bar all incoming or all outgoing calls.
- Bar specific incoming or outgoing calls.

Call Forwarding

- Forward all calls.
- Forward calls when subscriber is busy.
- Forward calls if subscriber does not answer.
- Forward calls if subscriber cannot be located.

Call Completion

- Enable incoming call to wait until subscriber completes current call.
- Enable subscriber to place incoming calls on hold.

Charging

- Display current cost of call.

Multi-party

- Three party service.
- Conference calling.

Supplementary Services

- **Number identification**
- **Call barring**
- **Call forwarding**
- **Call completion**
- **Charging**
- **Multi-party**