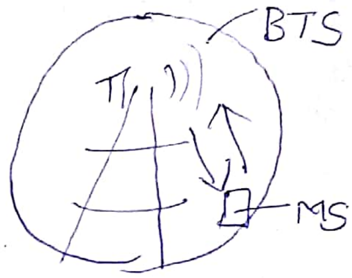
16/03/2021.

→ Different Gen. of w/l Cellular s/y :

I. 1G (Advanced mobile Phones - AMPs)

- analog freq. mod. schemes - ASK
- 2 separate freq. band. - Frequency division duplex (FDD)
  - Uplink (Reverse link) : MS to BPS - 869 to 894 MHz
  - downlink (forward link) : BPS to MS - 824 to 849 MHz
- FDM → ↑ s/y capacity



- 800 MHz : FCC & ITU

A band → each service provide → 333 channel

B band → service pro. → 333 channel

666 ⇒ 416 - traffic channel → voice

250 - control " → set up/clear a call

→ for n/w opⁿ - call hand off

→ Idle BTS

→ o/p power adjustment

- ID :
  - MS
    - ESN → electronic serial no. → from mobile manufactures
    - MIN → mobile identificatⁿ no. → 34 bit → 10 digit dialable no.
  - BTS - 15 bit → SID - service Provider ID no.

- MS → RBS → MTSO (MSC) → PSTN/Landline

MS - user mobility

RBS - coverage area

MTSO - mobile telephone switching office
- Switch call to correct cell
- allocate freq. band to RBS
- checks channels
- control RBS

- channel spacing : 30 kHz
- each BTS T_x^t & R_x^e freq. : 45 MHz → to ↓ adj. channel interference.

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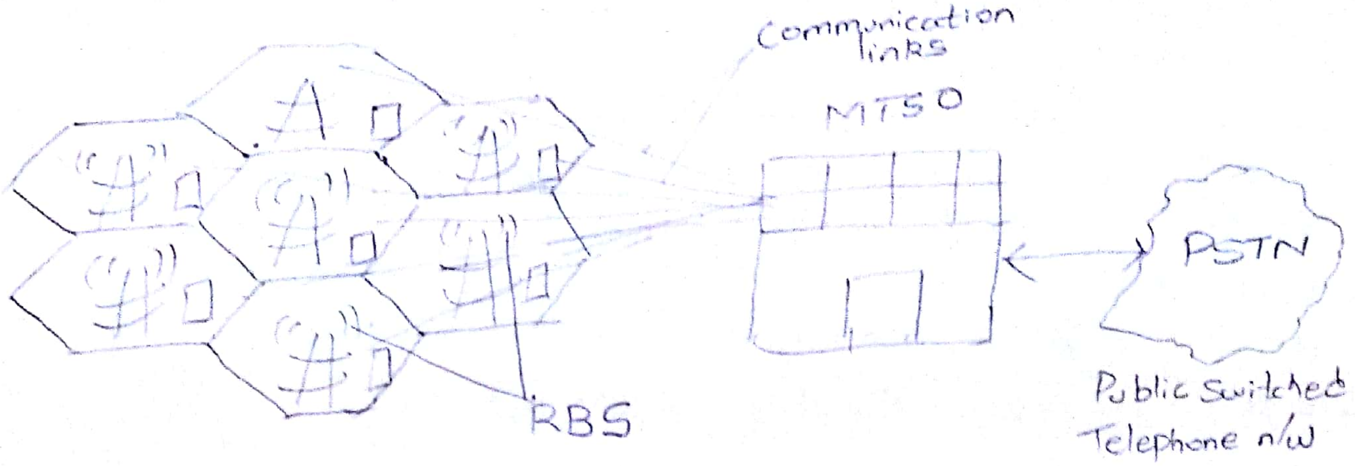
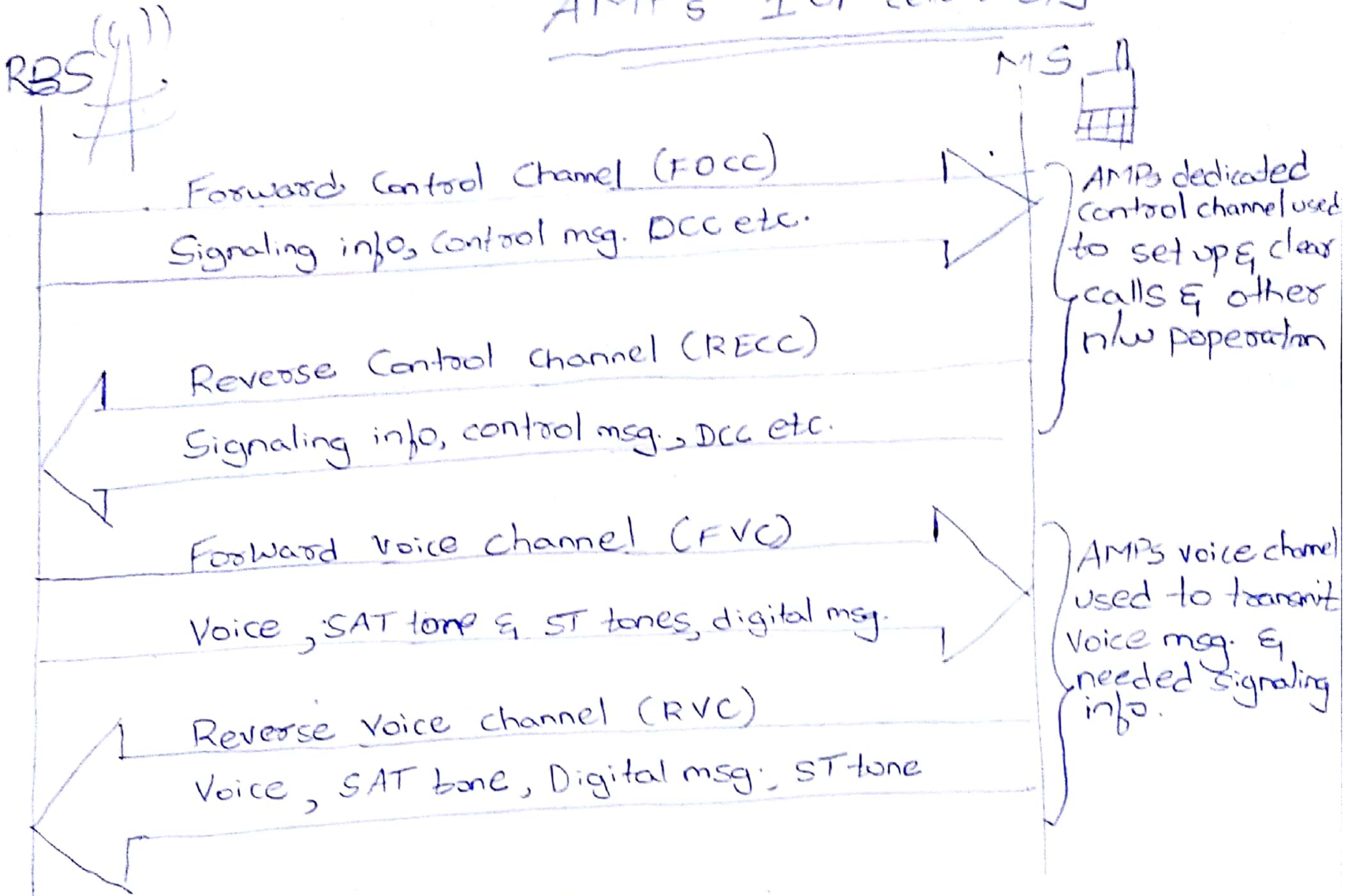


AMP's 1G cellular s/y



DCC – Digital colour code
SAT - Superwisory audio tone - 5970, 6000 & 6030 Hz
ST - signaling tone - 10 kHz · to send order msg. to RBS.

AMPs Forward & Reverse Control & Traffic Channels

- 1-312 → traffic } A   334 → 666 } B
  21 → control
- 7 cells ⇒ N = 7 : 59 + traffic   3 - control.
- SAT : checks signal strength (Radio link Status)

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Basic AMPs operation :

i. Mobile phone initialisatⁿ
ii. Mobile originated call (MS↔MS) → outgoing (MS↔PSTN)
iii. Mobile terminated call (incoming call)
iv. Call handoff (BS I ↔ BS II)

- Voice call
- analog mod.
- 30 kHz
- 800 MHz

- SAT : checks Radio link status
- ST : Sends order msg. BTS ↔ MS

→ i. alert order msg : alerts mobile of incoming call
ii. audit -"- -"- : how many MS are working
iii. change power -"- -"- : dis. calⁿ ⇒ changes Power accordingly
iv. Intercept -"- -"- : any wrong while placing call
v. Maintainance -"- -"- : Database
vi. Release -"- -"- : disconnectⁿ of call
vii. Stop alert -"- -"- : stop ring tone if not received
viii. Address -"- -"- : enter 10 digit no.

- Typically the BS in AMPs system, controls the mobile phone by sending order msg. to mobile.
- 10 kHz signaling tone can be Txd over a voice channel to confirm orders & various signal request.

→ i. Alerts mobile of incoming call.
ii. Sent by BS to determine the mobile is still active in system
iii. Used to change mobile RF o/p power
iv. Used to inform the user that a procedural error has been made in placing a call
v. Used to check the operatⁿ of mobile.
vi. Used to disconnet a call
vii. Stop alerting/ringing
viii. Base statⁿ requires a diled digit info

- Mobile Phone Initialisation

BTS MS

Control channels are Tx^d by BTS

Control msg. are Rx^d by MS

Control msg. are Tx^d by MS

Control msg. are Rx^d by MS

- Task 1 : Mobile powers up
- Task 2 : Mobile scans control channels of selected s/y (A or B)
- Task 3 : Mobile updates cellular s/y info.
- Task 4 : Mobile establishes paging channels
- Task 5 : Mobile registers with cellular s/y (ESN, SID & MIN)
- Task 6 : MS authentication
- Task 7 : MS authentication verified
- Task 8 : Mobile enters idle state

20/03/2021 AMPs n/w operat^n for ~~mobile~~ ~~to~~ Landline call

MS BTS MSC Landline PSTN

MS originates call

Request is passed to MSC

Mobile is authenticated

Radio channel is assigned

Radio link channel assignment is passed to MS

Call setup b/w MSC & PSTN

SAT tone are exchanged

Call status is relayed to BSC

Call party answers

Ring back tone is sent to MS

Connection b/w PSTN & BSC

Alert is removed

Conversat^n of FVC

Conversat^n on RVC

Disconnect

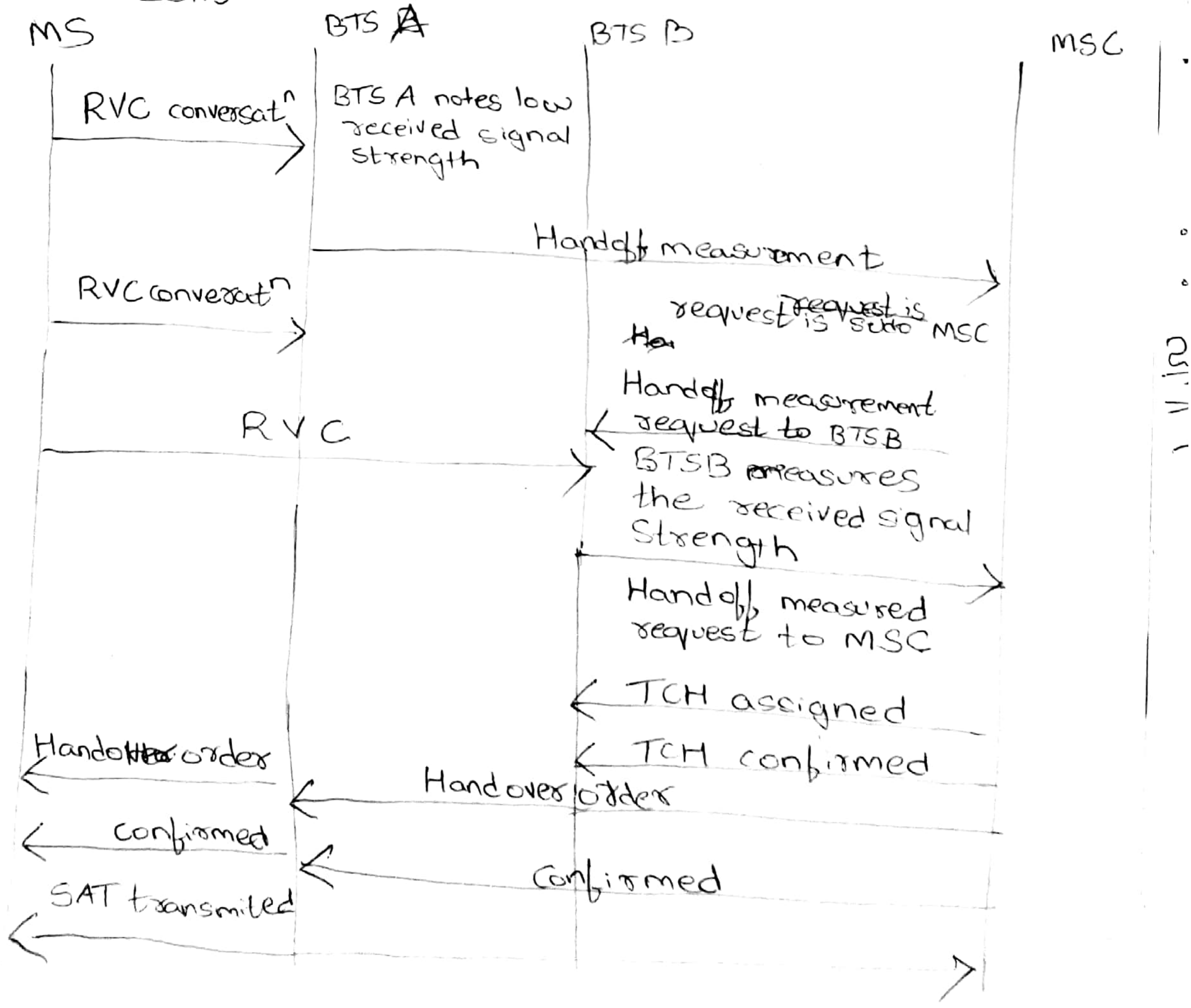
Mobile terminates

ST of 1.85

• The mobile subs. wants to make a call, several handshaking msg. must be exchanged b/w BS & MS & b/w MSC & PSTN.
• The inter sys. std. ~~TIA/TIA~~ TIA-EIA-634B is used b/w MSC & BS.
• After the radio link b/w MS & BS is confirmed, the telephone call is connected to called up party over PSTN
• The calledup party answers, alert ringback signal is removed. & a conversatⁿ ensures on f/b & r/v voice channels.
• Either the called up party or MS may terminate the call.

— Handoff Operations

• An HoO occurs in a cellular sly when a MS moves to another cells



- The signal depicts the handshaking operatⁿ that take place for handoff to occur.
- In this case a MSC connected to 2 or more BS within a geographic area.
- Consider that BS A is handing an active call from a MS within its area of coverage
- However MS is in transit & is moving away from BS A & towards BS B's coverage area
- BS A constantly moniters the received signal power from MS.
- When signal from MS goes below a pre determine threshold level, BS A sends handoff measurment request to MSC.
- The MSC req. that all the BS that are able to Rx Tx^n from specified MS, moniter it's power level
- It is determined that BS B is Rx^g strongest signal from mobile.
- MSC assigns a traffic channel (TCH) to BS ~~A~~B.
- BS B responds & handover order is sent from MSC to BS A
- BS-A sends handoff control signal to MS with necessary new channel info. & then the mobile switches to new voice channel with ~~this~~ its newly prescribed o/p power.
- As before mobile Rx^s BS-B's SAT & returns it
- If everything goes well handoff is confirmed.

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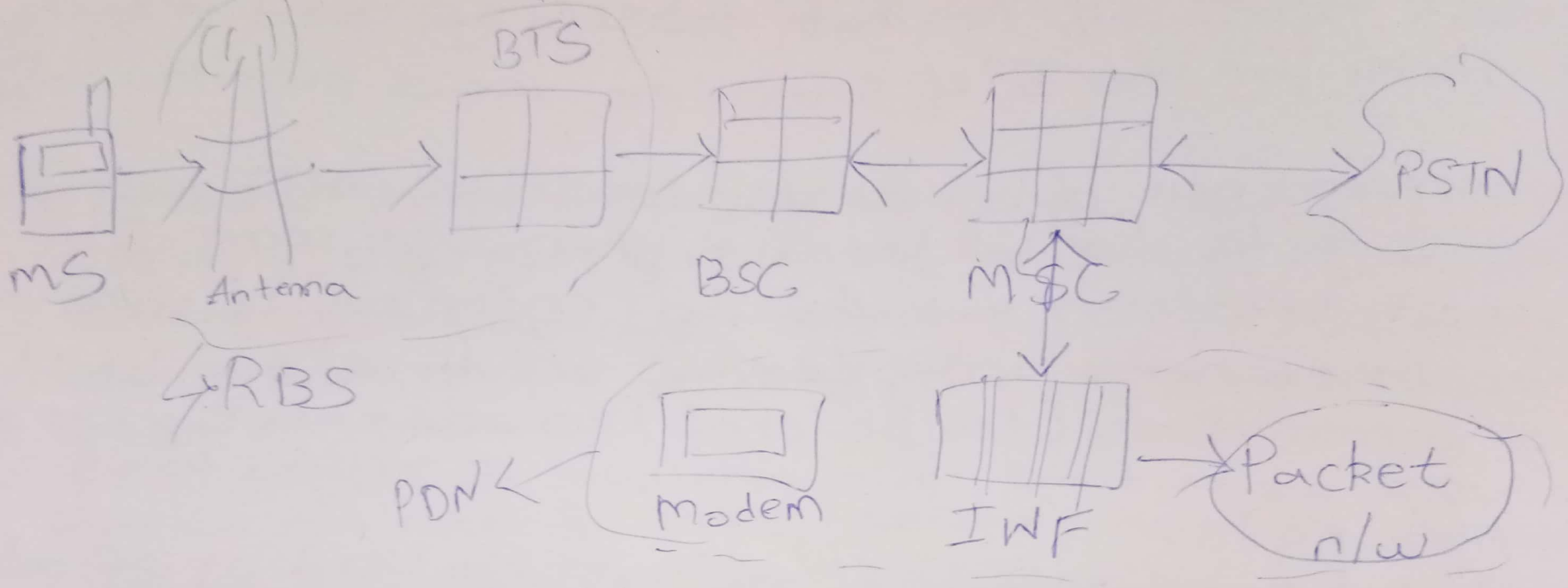
III). 2 G

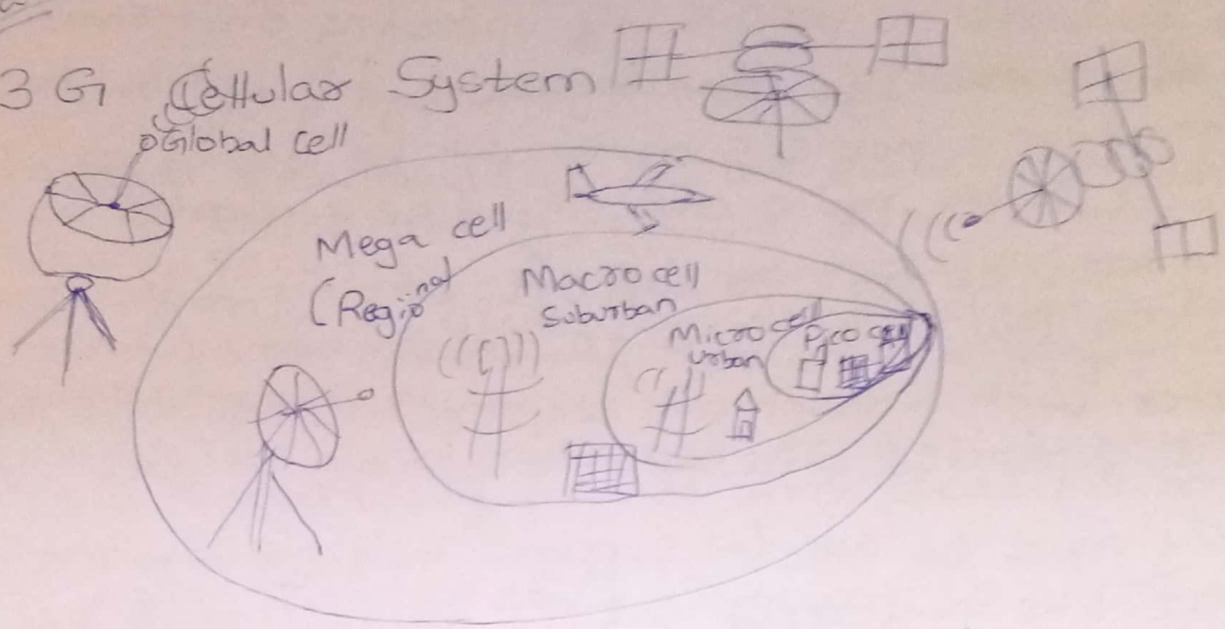
- The most basic diff. is that the 1G sys. used analog mod. tech. for the Tx^n of subscribers voice over the traffic chnl.
- on subsequent gen. of cellular sys., convert a users voice ~~fro~~ analog sig. to digital form & then use some form of dig. mod to transmit the dig. encoding of voice msg.
- This conversion to a dig. format result in the ability ~~of~~ of a comm. link (traffic chnl.) to accomodate more than one user at a time This attribute is reffered to as multiplexing.
- The 2 most popular form of multiplexing used by 2G cellular sys are TDMA & CDMA.
- The control signals for 1G s/y used SAT & ST sig. that have no need for 2G s/y
- By using dig. encoding for user traffic, digital encryption may be employed to proved security & privacy for mobile users n/w. This was not possible in 1G sellular s/y
- Dig. encoding & mod. allows for use of error detect & correct^n control cosy. The use of which to some extent combats the ~~power~~ type of fading & noise effect to radio chnl.
- The ability of 2G cellular s/y to suppler more than one user per radio channel is through the use of adv. dig. muxing tech.
- TDMA s/y (GSM) use time slots to allocate a fixed periodic time, subs. has excl. use of pertinalar chnl.
- The GSM s/y (TDMA) uses a Tx^n format with 8 time slots & hence the s/y can support 8 users per channel. simultaneously
- CDMA cellar s/y uses a dig. mod. tech known as spread spectrum.
- In this s/y at Tx^r, each user's dig. encoded sig. nal is further encoded by a special code that converts each bit of the original msg. into many bits.
- At the Rx^r same special code is used to recover the original bit streams.
- The special code used to perform this encoding/decoding fn. has unique prop. that each Rx^d sig looks like noise to a Rx^r that does not share the same code as the Tx^r of sig.
- Hence in synch. s/y, many radio sig. can be simul. Tx^d in same radio chnl. w/o interfering with each other.



CDMA interworking functional nodes

6/03/2021

I. 3G Cellular System



3G operating environment.

Cell type →	Global cell	Mega cell	Macro cell	Micro cell	Pico cell
Max. cell radius	1000km	100-500km	35km	1km	50m
operating environment	Global	Regional	Suburban (low user density)	Urban (high user density)	in-building
Installation Type	Satellite: GEO, MEO LEO	Satellite: LEO/MEO	Tower or Building mounted	Tower (Small)	Inside a building
Data Rate	100s of kbps to Mbps	100s of kbps to Mbps	144 kbps	384 kbps	200bps
Max. mobile speed	N/A	N/A	500km/h	100 km/h	10 km/h

3G char. by cell size & Data

- The term 3G mobile s/y is used to represent a no. of cellular s/y & their associated stds, that have the ability to support high data rate services, adv. multimedia services (voice, data & video) & global roaming.
- These stds. are being fecilitated by ITU & other regional bodies aroud the world.
- 3G mobile n/w need to be abled to provide high speed data transfer from packet n/w & to be able to permit global roaming.

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· They also need to support adv. digital services & to be able to work in various diff. operating environments (low th high mobility, urban to suburban & to global locatn etc. i.e. anywhere a mobile subs. might be located except for the most sevior radio envi. should be supported by 3G.

· 3G s/y must be able to support varying data rates by providing BW on demand to subscriber.

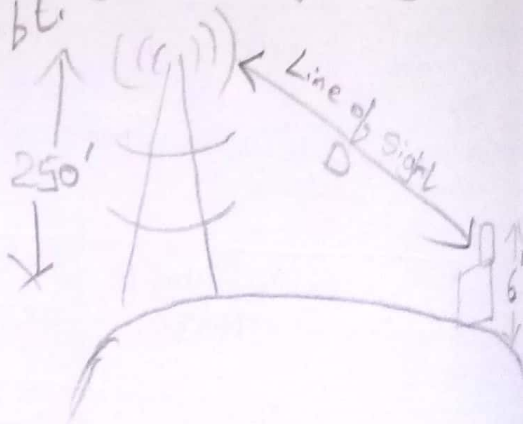
· 3G char. with hirarchical cell str. in corr. size, mobility rate & supported data rate is shown in table.

· 3G s/y must be able to support multiple simultaneous connectn like conference call, IP addressing & be backward compatible with 2G n/w

1. Assume that Tx^g ant. for 1st mobile radio telephone s/y was located on a tower at a height of 250 ft. Det. the range of s/y., assuming line of sight Tx^n & a Rx^g ant. of height 6 ft.

$$D = \sqrt{2R_e}\left(\sqrt{h_t} + \sqrt{h_r}\right) \; ; \; R_e = 6{,}350\,km$$

$$1ft = 0.3048\,m$$



2. Which 2 components of AMPs provide air interface
BTS, MS

3. Explain the purpose of AMPs supervisory audio tones

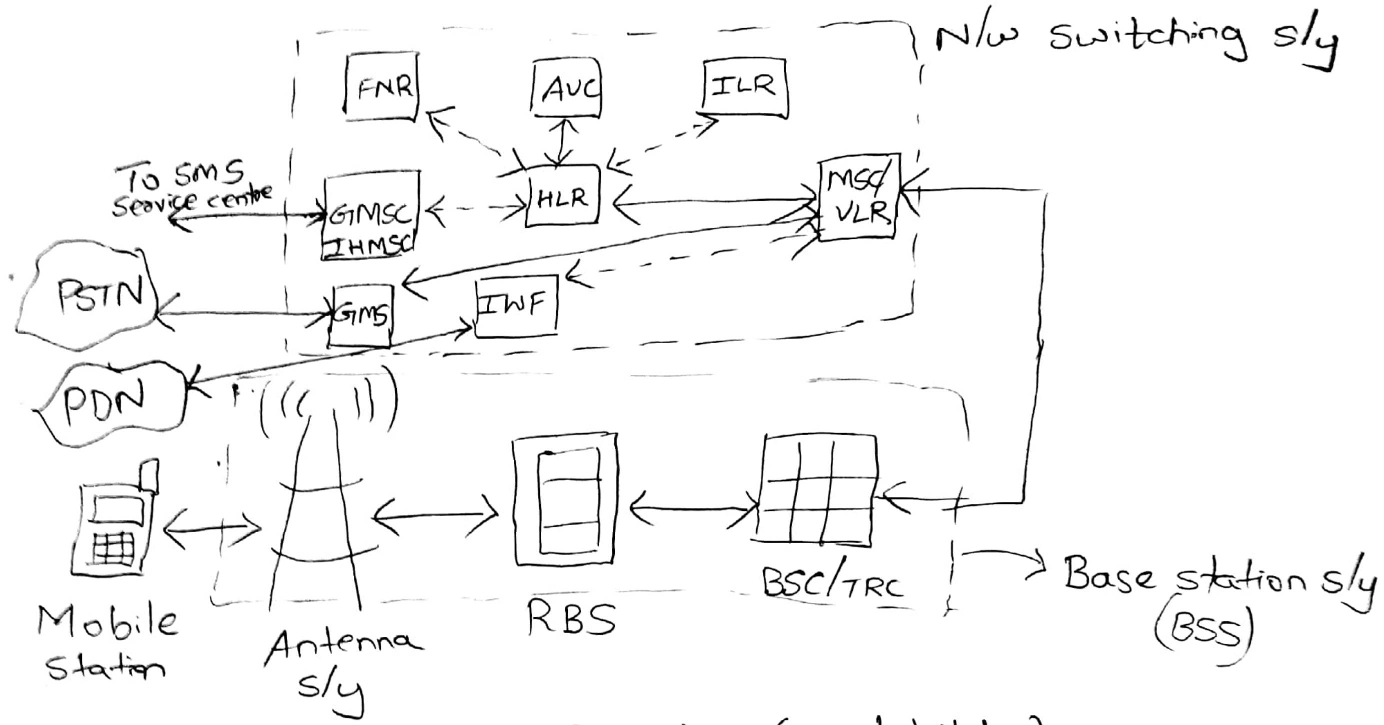
27/03/2021

4. Describe the seq. of events when AMPs s/y is first turned
5. What is the purpose of SID no.
6. What is the diff. b/w mobile originated & mobile terminated c
7. What event triggers AMPs hand off operatn.
8. What is the fundamental diff b/w 1G & 2G s/y
9. How do 2G cellular s/y support more than 1 user per chan
10. Adv. of digi. encoding for higher gen. cellular s/y
11. Basic char. of 4G cellular s/y

IV. 4G Cellular System

- Role of 4G is the convergence of w/l mobile with w/l access comm? tech.
- A converged broadband w/l s/y will evolve in response to the issues in BW efficiency, dynamic BW allocation, quality of service, security, digital transreceiver tech., self organising n/w, future concerns related to all iP archetecture & connectivity for anyone anywhere at any time mobile n/wing.
- 4G mobile n/w data rates are expected to reach over 20 Mbps & eventually provide ATM speed w/l connectivity

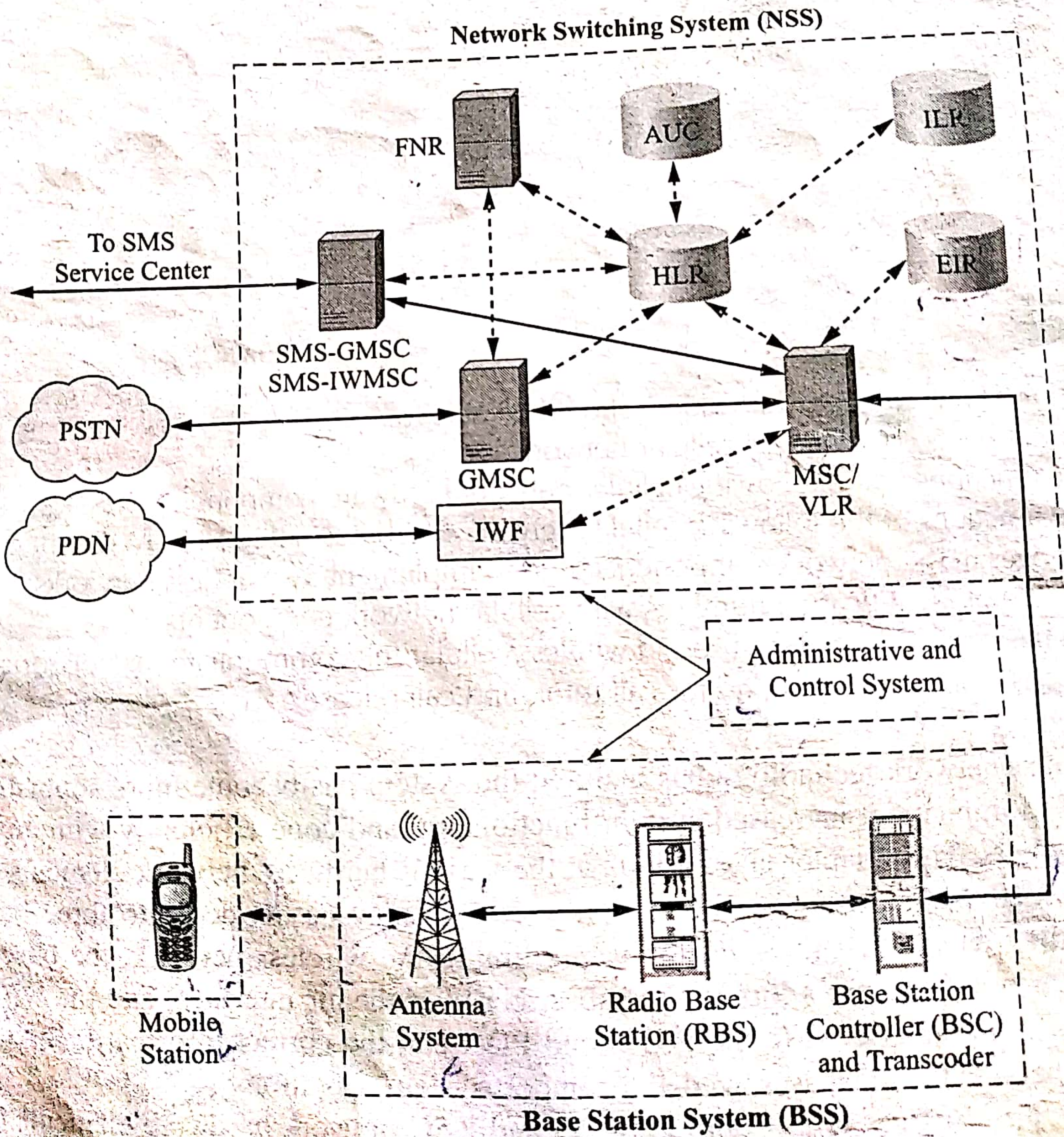
→ Common Cellular S/y Components



- FNR - Flexible Number Register (portability)
- AUC - Authentication centre (Authorisatn)
- ILR - Inter working location register (Roaming)
- EIR - Equipment Identity Register (Auditing of MS)
- HLR - Home Location Register (Data base)
- IWF - Inter working Functional Node (PDN)
- MSC/VLR - Mobile Switching ckt /
- PDN - Public Data N/w
- BSC - Base Station Control
- TRC - Transcoder Controlere (vocoding/rate)
- GMSC - Gatway MSC

1 COMMON CELLULAR NETWORK COMPONENTS

e typical post–first generation (1G) wireless cellular telecommunications system as shown in Figur nsists of several subsystems or network elements designed to perform certain operations in support tire system. For 2G and 2.5G cellular networks, the air interface functions are typically performe ed radio base station (RBS) and a mobile station (MS) or subscriber device (SD) that provide user . The radio base station is usually controlled by a base station controller (BSC) and this portion llular system is usually referred to as the base station system (BSS).



igure 3–1 Typical wireless cellular system components.

The base station ...

Figure 3–1 Typical wireless cellular system components.

The base station system is connected to a fixed switching system (SS) that handles the routing of b voice calls and data services to and from the mobile station or subscriber device. This switching syst usually consists of a mobile switching center (MSC) and various databases and functional nodes used support the mobility management and security operations of the system. The switching system is usua connected to the PSTN, the PDN, other public land mobile networks (PLMNs), and various data messagi networks through gateway switches (GMSCs). Other typical connections to the switching system are to n work management systems and other accounting or administrative data entry systems.

The various network elements that make up the wireless system are interconnected by communicatio links that transport system messages between network elements to facilitate network operations and deliv the actual voice call or data services information. The rest of this section is devoted to descriptions of thes network elements and brief overviews of their basic functions. It should be pointed out again that all cellular wireless systems are standards based and therefore both the names of the system subunits and the communication interfaces between them are defined by the standard for the particular type of technology used by the system (GSM, NA-TDMA, CDMA, etc.).

In this chapter, the subject matter will be dealt with in as generic a way as possible using common terms and definitions. Later chapters devoted to particular systems will present the names of the system components and interfaces using the correct nomenclature for them as specified by the appropriate system standard.

Subscriber Devices

The first generation of wireless cellular systems provided connectivity to the PSTN for voice service. The initial term used in several standards for the mobile transceiver supplied to the cellular system users was mobile station. As cellular systems have matured and added ever faster data service delivery to the traditional teleservices available to the user, the term *subscriber device* (SD) has come to be used to describe the mobile transceiver for these newer systems. As the wireless network evolves toward an all-IP network, the expression used for the mobile transceiver is expected to morph one more time with the eventual adoption of the term **end terminal** (ET). This name change will be in keeping with the mobile station's ability to connect to an all-IP network and thus provide the functionality of an end terminal device.

The **subscriber device** is the link between the customer and the wireless network. The SD must be able to provide a means for the subscriber to control and input information to the phone and display its operational status. Additionally, the SD must be able to sample, digitize, and process audio and other multimedia (e.g., video) signals; transmit and receive RF signals, process system control messages; and provide the power needed to operate the complex electronics subsystems that provide the functionalities mentioned earlier. Therefore, as shown in Figure 3–2, the basic sections of the SD are as follows: some form of a man-machine interface, an RF transceiver section, a signal processing section, a system control processor, and a power supply/management section.

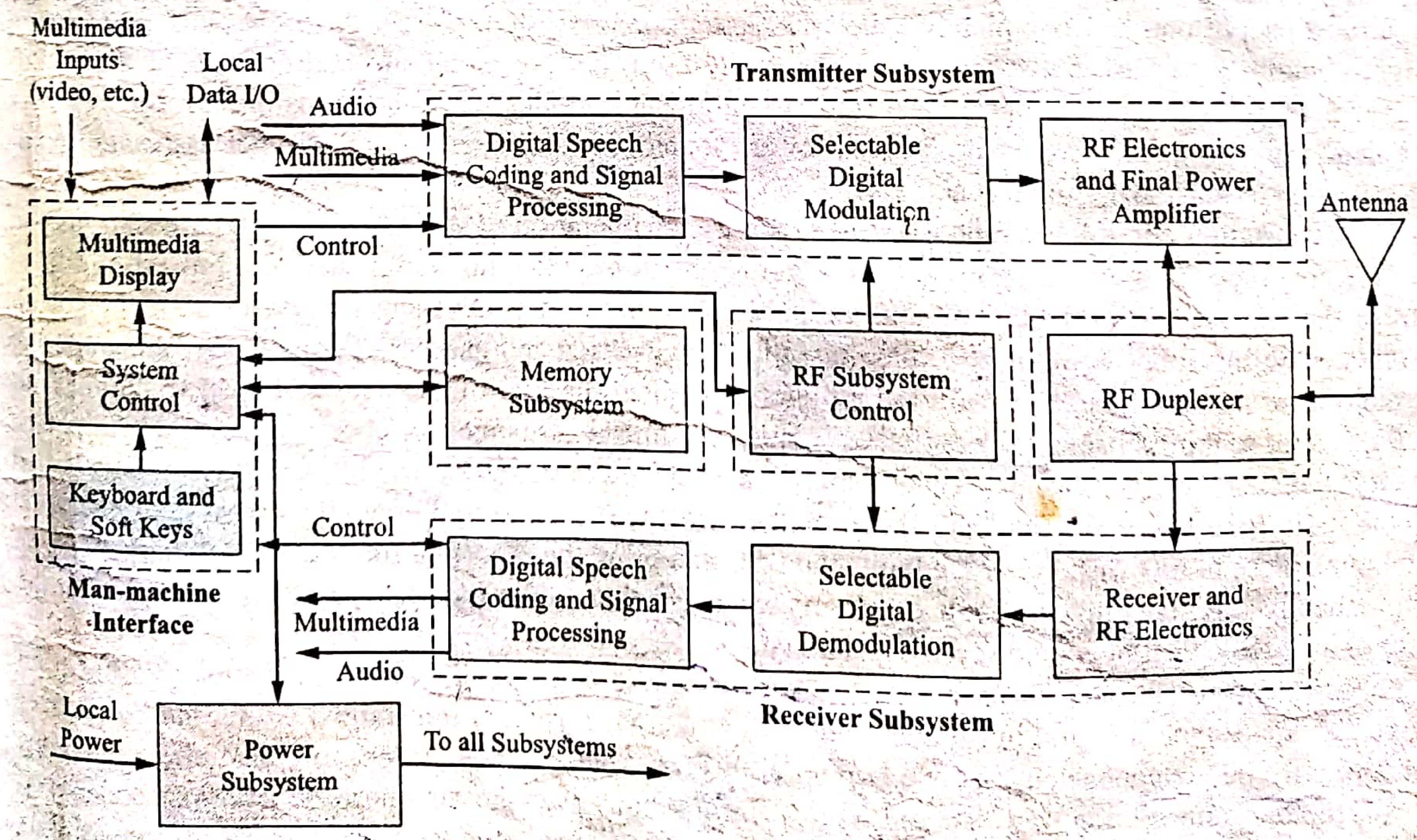


Figure 3–2 Typical subscriber device block diagram.

The man-machine interface can be as simple as a standard telephone keypad, an alphanumeric text display, and a microphone/speaker combination. Or, it may be more sophisticated with soft-key keypad functions and multimedia capability with a high-resolution color display and video camera or cameras for the transmission and display of video messages. Additional accessory interfaces usually also exist to provide the option of hands-free operation, battery charging, and a service port or a data port for connection to a PC.

The RF transceiver section contains the high-frequency RF electronics needed to provide the proper digital modulation and demodulation of the air interface RF signals and the ability to transmit and receive these RF signals. This section must also permit both variable power output and frequency agility under system software control.

The signal processing section of a subscriber device is usually based on digital signal processor (DSP) technology. Some of the functions performed by this section are speech sampling and coding, channel coding, and audio and video processing.

The system control processor provides overall subscriber device management. It implements the required interface with the other wireless network elements to provide radio resource, connection management, and mobility management functions through software control of the various functions and operations it must perform to set up and maintain the air interface radio link.

Finally, the power supply section provides the power to energize the entire system. Usually, the SD is battery operated with sophisticated algorithms built into the system to save and minimize power usage as much as possible in an effort to extend the battery life. When the battery becomes discharged, it may be recharged through a home accessory battery charger or through the accessory connector of one's car.

Base Station System Components

The **base station system** handles all radio interface-related functions for the wireless network. The BS typically consists of several to many radio base stations (RBSs), a base station controller (BSC), and transcoder controller (TRC). It should be noted that these last two network elements did not exist in the fir analog cellular systems. In 1G systems the RBSs were connected directly to the MSC. The radio equipme required to serve one cell is typically called a base transceiver system (BTS). A single radio base stati might contain three base transceiver systems that are used to serve a cell site that consists of three 12 degree sectors or cells. The radio base station equipment includes antennas, transmission lines, pow couplers, radio frequency power amplifiers, tower-mounted preamplifiers, and any other associated har ware needed to make the system functional.

The base station controller's function is to supervise the operation of a number of radio base stations th provide coverage for a contiguous area (see Figure 3–3). It provides the communication links to the fix part of the wireless network (PSTN) and the public data network (PDN) and supervises a number of interface mobility functions. Some of these tasks include location and handoff operations and the gatheri of radio measurement data from both the mobile device and the radio base station. The base station co troller is used to initially set up the radio base station parameters (channels of operation, logical cell name handoff threshold values, etc.) or change them as needed. The BSC is also used to supervise alarms issu by the radio base stations to indicate faults or the existence of abnormal conditions in system operatio (including those of its own). For some faults the BSC can bring the reporting subsystem back into operatio automatically (i.e., clearing the fault or alarm) whereas other faults require operator intervention in th form of an on-site visit by a field service technician.

The transcoder controller performs what is known as rate adaptation. Voice information that has bee converted to a standard digital pulse code modulation (PCM) format is transmitted within the PSTN ov standard T1/E1/J1 telephone circuits at 64 kbps. Both TDMA and CDMA systems use data rates of 16 kb or less for the transmission of voice and control information over the air interface. The transcoder co troller's function is to convert the PCM data stream to a format suitable for the air interface. **Vocoding**

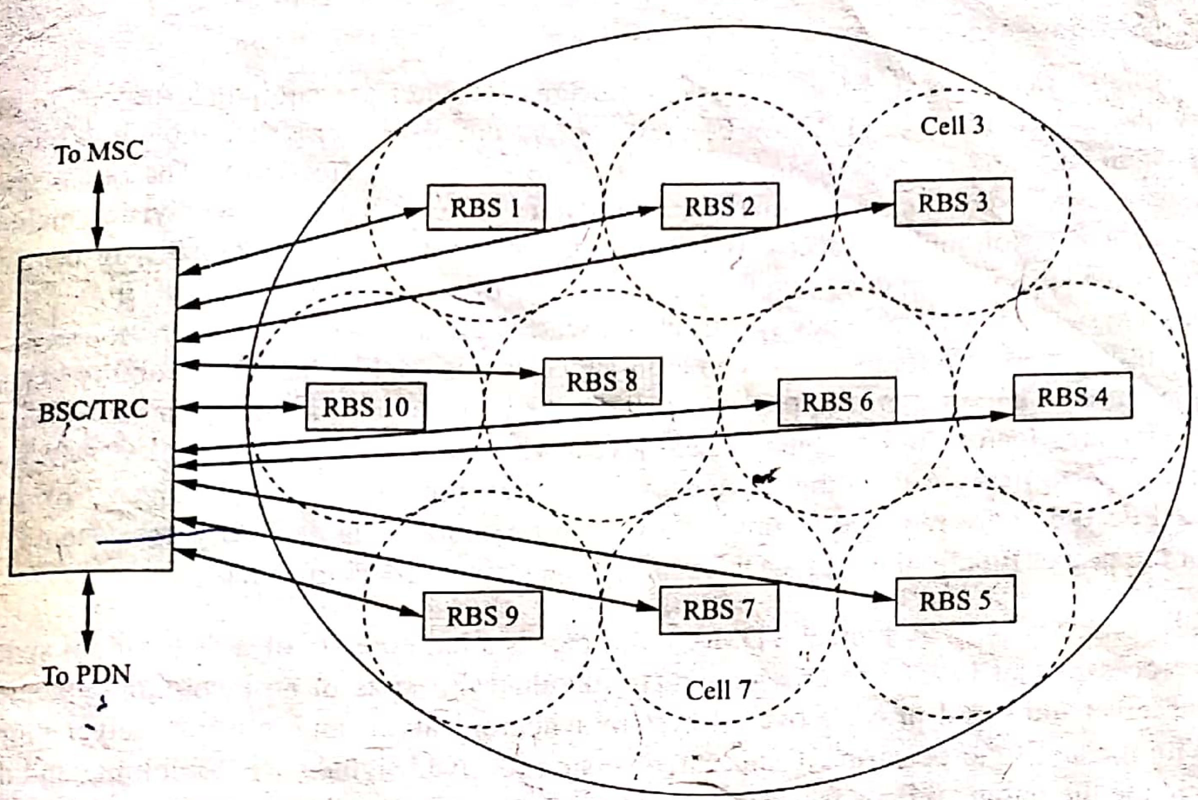


Figure 3–3 The base station controller's function.

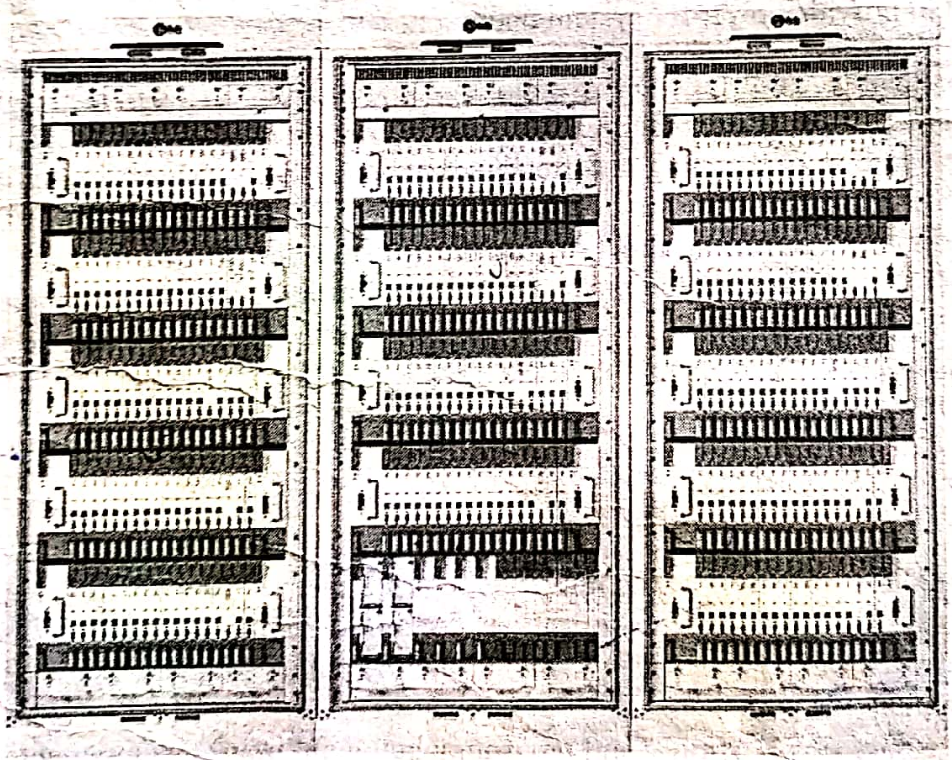


Figure 3–4 Typical cellular wireless equipment (BSC, TRC, and RBS) (Courtesy of LG Electronics Corp.).

another common term used for the process of converting audio to a digital format suitable for cellular transmission.

Physically, these units (BSC, TRC, and RBSs) are contained in standard radio relay rack enclosures. Figure 3–4 shows what a typical system looks like. Within the rack enclosure are subsystems devoted to functions such as power supply and control, environmental conditioning, switching, communications, processing, and so on. Additional hardware details about cellular base station systems will be presented in Chapters 5 through 8.

Radio Base Station

The **radio base station** consists of all radio and transmission interface equipment needed to establish radio link with the MS. The typical RBS is composed of several subsystems that allow it to transmit to the MS on one frequency and to receive signals from the MS on another frequency. The two major wireless cellular systems used today for the air interface function are a form of either time division multiple access (TDMA) or code division multiple access (CDMA). The architecture and functionality of the air interface components of the RBS will depend upon the particular type of access system it is used in.

For TDMA systems, since frequency spectrum is a scarce resource, the primary function of the BSS is to optimize the use of available frequencies. The RBS supports this goal by having the ability to perform frequency hopping and support dynamic power regulation and the use of discontinuous transmission modes. All of these features tend to reduce interference levels within a TDMA system. For CDMA systems, all transmission is performed on the same frequency. However, precise timing, power control, and CDMA encoding and decoding are required to optimize system operation. The necessary subsystem components required for the proper functioning of a CDMA radio base station reflect this fact.

TDMA Radio Base Stations A typical TDMA radio base station consists of a distribution switch and an associated processor that is used to cross-connect individual timeslots of an incoming data stream to the correct transceiver units and provide overall system synchronization, multiple transceiver units (one per timeslot) with the ability to perform RF measurements on received signals, RF combining and distribution units to combine the output signals from the transceiver units and also distribute received signals to all the transceivers, an energy control unit to supervise and control the system power equipment and also to regulate the environmental conditions of the RBS, and power supply components (both rectified AC and battery-supplied DC) to provide power for system operation.

CDMA Radio Base Stations A typical CDMA radio base station consists of many of the same switching function, RF transceiver, power supply, and environmental conditioning components as the TDMA radio base station with the addition of a timing and frequency module that receives timing information from **Global Positioning System** (GPS) receiver colocated with the RBS and channel cards that are responsible for the CDMA encoding and decoding functions on the forward and reverse links to and from the subscriber devices. For CDMA radio base stations, a typical design might consist of a main and a remote unit. The main unit provides all the functions except for RF power amplification. The two units are linked by fiber-optic communications cables and power supply cables. These cables supply all the signals needed by the high-power RF amplifier and the remote electronics that are typically mounted on a tower near the system antenna.

Base Station Controller

The **base station controller** functions as the interface between the mobile switching center and the **packet core network** (PCN) and all of the radio base stations controlled by the BSC. The PCN is a term used for the interface node (network element) between the BSC and the public data network. Figure 3–5 shows how the systems are interconnected.

Aside from the necessary power supply and environmental conditioning components, the BSC typically consist of several subsystems all colocated in a main cabinet or possibly several cabinets. The system organization tends to divide up these subsystems into those that are used to provide a connection or link between the MSC and the radio base stations and those subsystems that control the operation of these aforementioned units. The typical connection from BSC to the MSC or TRC (if it is not integrated into the BSC) is over standard T1/E1/J1 PCM links as is the connection from BSC to RBSs. A standard switching fabric is used within the BSC to direct incoming voice calls from the MSC to the correct RBS. Another switching fabric that can deal with subrate transmissions (less than 64 kbps) is usually also available within the BSC adding increased functionality to the system. If the TRC is colocated with the BSC, transcoding functions are also performed within the combined BSC/TRC unit.

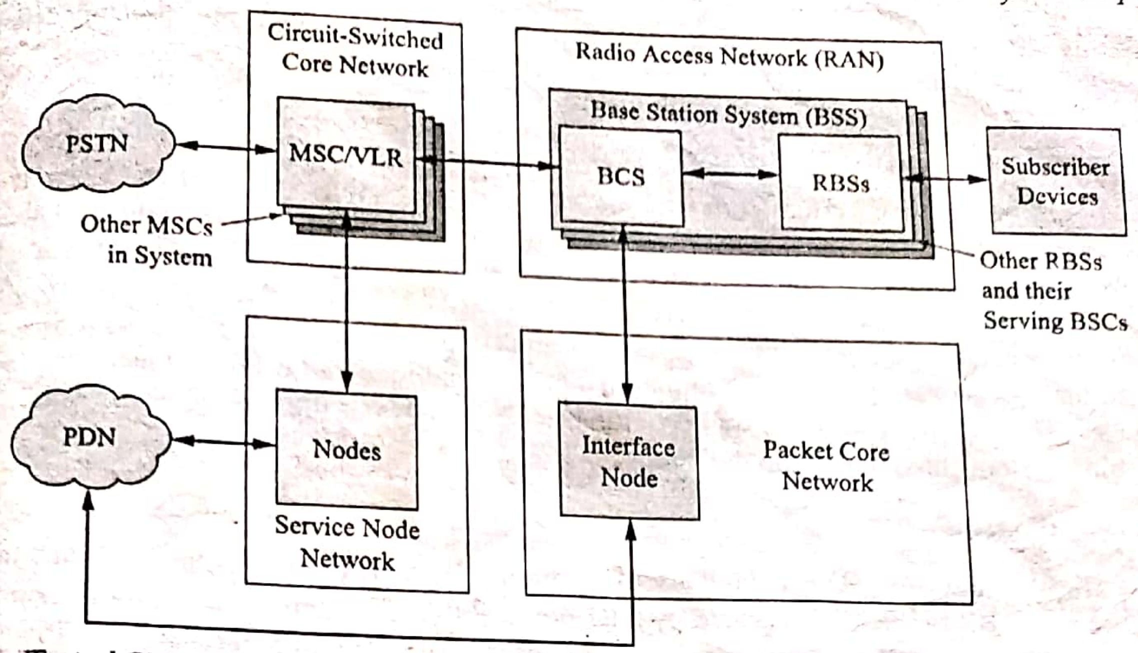


Figure 3–5 Typical CDMA wireless system (Courtesy of Ericsson).

The operation of each of these subsystems is controlled by processors under stored program control. Furthermore, the BSC system provides timing signals and connectivity to every subsystem within it and computer interfaces to the entire system for either network or element (subsystem) management functions.

Additionally, the BSC will supply signaling toward the MSC using message transfer part (MTP) protocol to transfer the messages over a PCM link connected to SS7 signaling terminals located within the MSC and the BSC. Signaling between the BSC and the RBSs is done over a PCM link using link access protocol on D-channel modified for mobile (LAPDm) signaling functions.

Connections to the PDN through an interface unit (PCN) connected to the BSC will be discussed in greater length and detail in Chapter 7.

Transcoder Controller

The **Transcoder Controller** (TRC) consists of subsystems that perform transcoding and rate adaptation. The TRC can be either a stand-alone unit or, more commonly, combined with the BSC to yield an integrated BSC/TRC. The TRC also can support the power saving option of discontinuous transmission. If pauses in speech are detected, the mobile station will discontinue transmission and the TRC will generate "comfort noise" back toward the MSC/VLR. An integrated BSC/TRC can typically handle many 100s of RBS transceivers.

Both TDMA and CDMA systems transmit speech over the air interface using digital encoding techniques that yield data rates of less than 16 kbps. The PSTN uses a PCM encoding scheme that yields a data rate for voice of 64 kbps. Therefore, voice messages coming from the PSTN must be transcoded to a rate suitable for the cellular system and, similarly, voice messages originating from a mobile station must be transcoded into a format suitable for the PSTN. This operation takes place in the TRC. The incoming PCM signal from the PSTN is converted back to an analog signal. At this point, 20-ms segments of the analog signal are converted to a digital code by a device known as a **vocoder.** The vocoder compares the 20-ms speech segment against a table of values. The entry in the table that is closest to the actual value is used to produce a code word that is much shorter than the corresponding PCM codes for the same 20-ms period. This compressed code word is what gets transmitted by the system. At the MS, the process is reversed to obtain an analog voice signal. For voice signals going in the opposite direction the steps are duplicated but in the reverse order. The obvious advantage to the use of vocoding is the reduced data rate needed for speech transmission. Additional enhancements to this process have led to half-rate speech coders that c encode speech signals in only 8 kbps, and other variations on this theme.

Swiching System Components

As stated earlier, the switching system performs several necessary cellular network functions. It provid the interface (MSC) both to the radio network portion of the system (BSS) and to the PSTN and oth PLMNs. It also provides an interface to the PDN and other network support nodes and gateways. Includ in the switching system are functional databases (HLR, VLR, AUC/EIR, etc.) that contain informatio about the system's subscribers, their network privileges and supplementary services, present SDs locatio and other information necessary to locate, authenticate, and maintain radio link connections to the su scriber's devices. The following sections will provide brief overviews of the functions and operation of t various switching system subsystems and databases.

Visitor Location Register

The **visitor location register** (VLR) is a database that temporarily stores information about any mobile st tion that attaches to a RBS in the area serviced by a particular MSC. This temporary subscriber informatio is required by the MSC to provide service to a visiting subscriber. When an MS registers with a new MS service area, the new VLR will request subscriber information from the MS's home location registe (HLR). The HLR sends the subscriber information to the VLR and now if the MS either sends or receives call the VLR already has the information needed for call setup. In a typical wireless network the VLR i integrated with the MSC to form an MSC/VLR thus reducing the amount of SS7 network signaling nece sary to perform wireless network operations.

Mobile Switching Center

The **mobile switching center** (MSC) is at the center of the cellular switching system. It is responsible for the setting up, routing, and supervision of voice calls to and from the mobile station to the PSTN. These functions are equivalent to those performed by the traditional telephony circuit switch (e.g., 5ESS, DMS-100/200, and AXE 810) used in a central office by the wireline PSTN. The traditional equipment manufacturers of this type of switching system all sell a cellular version of their standard wireline switch. Most of these systems also combine VLR functionality, in addition to the telephony switching functions, yielding an integrated MSC/VLR system.

The basic functions performed by the MSC/VLR are as follows: the setting up and control of voice calls including subscriber supplementary services, providing voice path continuity through the use of the handoff process, call routing to a roaming subscriber, subscriber registration and location updating, subscriber data updating, authentication of MSs, delivery of short messages, signaling to other network elements (BSC, HLR, etc.) or networks (PSTN, PLMNs, etc.), and the performing of charging/accounting, statistical, and administrative input/output processing functions.

As shown in Figure 3–6, the typical MSC consists of the following components or subsystems devoted to network operations: a central processor and associate processors, group switch, traffic interfaces, timing and synchronization modules, and software to provide operations and maintenance (O&M) functions. The next several sections will provide some additional detail about the operation of a typical MSC.

MSC Interface and Switching Functions Today's "trunk" connections (i.e., high-capacity facilities) between local central office (CO) exchanges and gateways to long-distance provider facilities make available the transport of high bit-rate digital signals. These local and long-distance interoffice connections are most often supplied by fiber-optic cables that are carrying SONET-based optical signals at bit rates in the 100s of mbps range or higher (the STS-3 signal carried as OC-3 is 155.520 mbps). SONET is capable of transporting multiple T1/E1/J1 carriers and asynchronous transfer mode (ATM) traffic. The standard voice call is

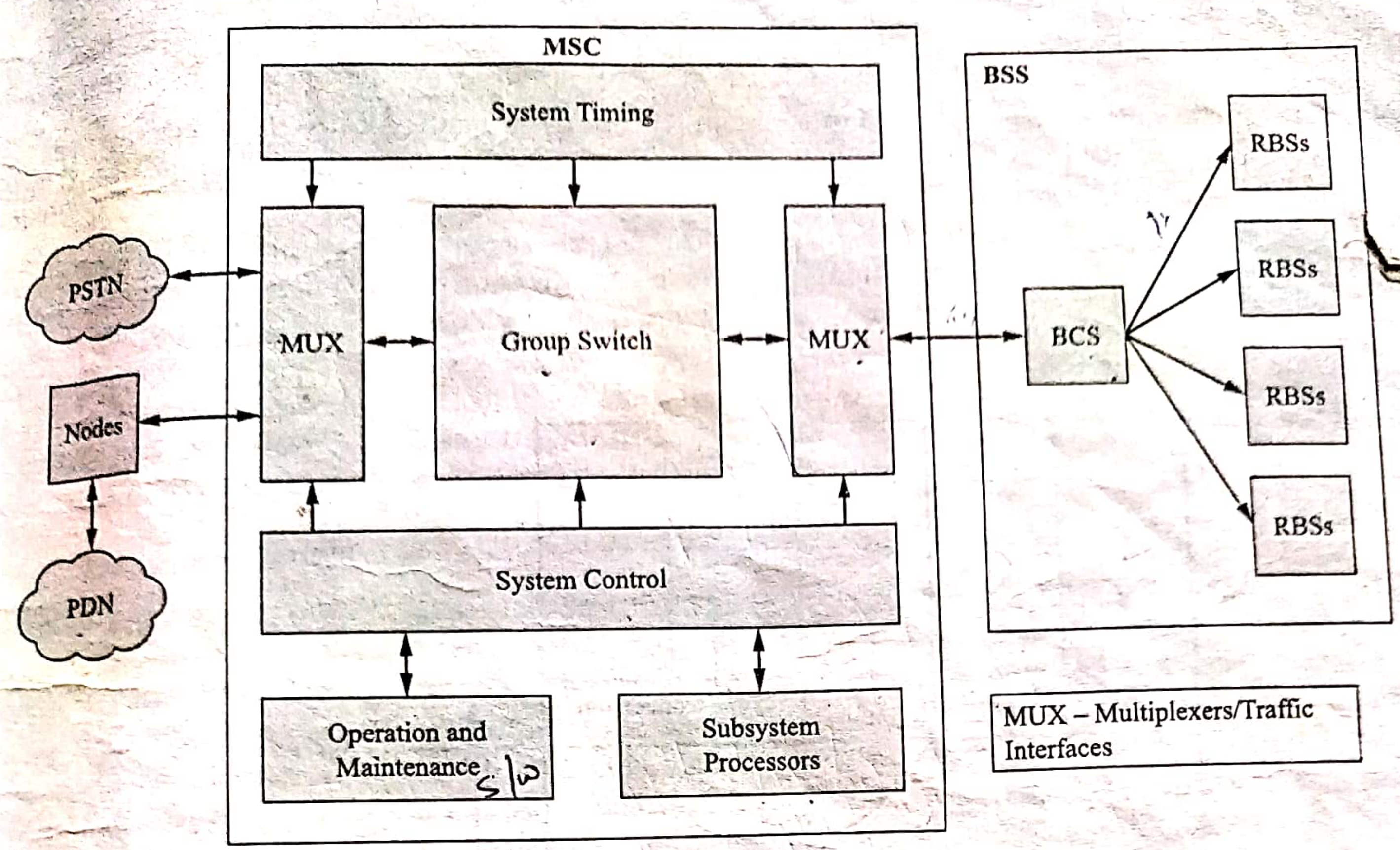


Figure 3–6 Typical MSC subsystems.

carried over these facilities as a DS0 signal that has a bit rate of 64 kbps. A T1/J1 carrier can transport twenty-four digitized voice calls and the E1 carrier has a capacity of thirty calls. The MSC can be thought of as just another central office exchange in that it has its own local exchange routing number(s) (i.e., N1/0N-NNX-XXXX where N1/0N is the three-digit area code and NNX is the exchange number). Therefore, the connection from the MSC to the PSTN or other PLMNs is usually provided in the same manner as other interoffice connections, over fiber trunk facilities or through traditional Tn/En/Jn carrier facilities depending upon the needed capacity.

Therefore, the MSC needs to provide the ability to multiplex and demultiplex signals to and from the PSTN. This functionality is built into the traffic interface subsystems (refer back to Figure 3–6). These interface units will bring the high bit-rate data streams down to the base T1/E1/J1 carrier signal after demultiplexing of the signals from the PSTN. Or conversely, they can be used to multiplex together many T1/E1/J1 signals to form a high bit-rate signal to be transmitted over a high-speed transmission facility back toward the PSTN (this operation is typically referred to as **backhaul**) or other networks as needed. The connection between the MSC and the base station controllers it services is also implemented with the same standard transmission T1/E1/J1 facilities or larger-capacity fiber facilities. Recently, cellular providers have been providing their own high-speed fixed point-to-point digital microwave backhaul networks with T1/E1/J1 or higher capacity from remote RBSs to BSCs and then from BSCs to the MSC location when traditional facilities are either not available or prove to be too costly to install and lease.

The **group switch** provides the same functionality in the MSC as it does in the PSTN local exchange. In both cases, the incoming voice calls on a particular T1/E1/J1 carrier arrive assigned to a particular timeslot. In order that the voice call can be directed to the correct BSC a combination space and timeslot interchange (TSI) switch must be used to redirect the voice call to both the correct output line and also to a free timeslot within the T1/E1/J1 carrier signal. The following example will describe the operation of a typical group switch in an MSC/VLR.

Example 3–1

A certain mobile subscriber is registered to a certain RBS in a cell that is located in an area that uses six BSCs to control the RBSs in that area. Show how the MSC directs an incoming call to the mobile subscriber if the MS's RBS is controlled by BSC #4.

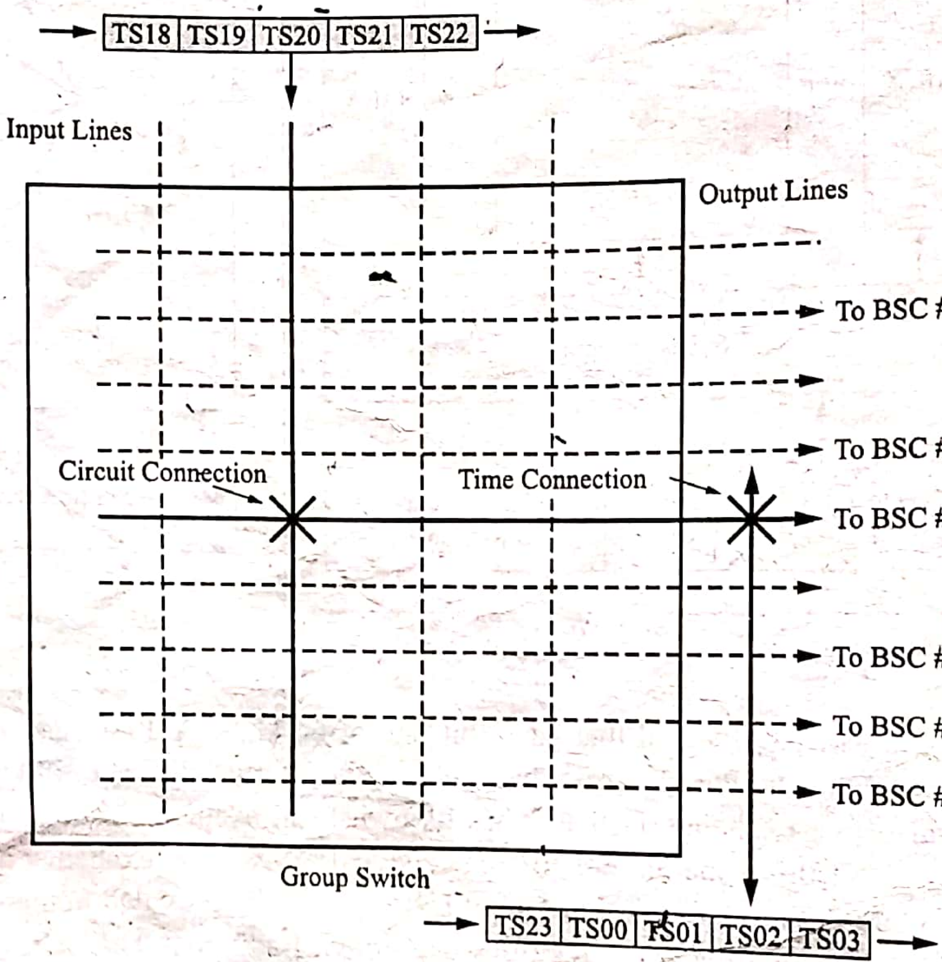


Figure 3–7 Operation of the group switch for Example 3–1.

Solution: Referring to Figure 3–7, assume that the incoming voice call occupies Timeslot #21 (any value from 0 to 23 could be used here) on a T1 carrier signal connected to a local exchange in the PSTN. After any necessary demultiplexing, the signal is applied to the group switch. The group switch processor implements a path that allows the signal to be redirected to available Timeslot #2 on the line connected to BCS #4 (this latter information is provided by the MSC). The switch performs this function as indicated by Figure 3–7 and the voice call is correctly routed toward BSC #4. The MSC and the BSC have been in contact by sending messages to one another over SS7 so that the BSC is aware of the new incoming voice call on Timeslot #2. Note that a functionally identical call path must also be established in the reverse direction to provide for duplex operation. There are duplicate subsystems available within the MSC to accomplish this task.

Home Location Register

The **home location register** (HLR) is a database that stores information about every user that has a cellular service contract with a specific wireless service provider. This database stores permanent data about the network's subscribers, information about the subscriber's contracted teleservices or supplementary services, and dynamic data about the subscriber's present location. The type of permanent data stored includes mobile station identification numbers that identify both the mobile equipment and the PSTN plan that it is associated with. This information would include a mobile station ID number that consists of a **country code,** either a national destination code or a number planning area code, and a subscriber number. Other ID numbers as defined and required by the particular wireless network are also stored by the HLR.

The HLR also plays a major role in the process of handling calls terminating at the MS. In this case, the HLR analyzes the information about the incoming call and controls the routing of the call. This function is usually supported by the transfer of information from the HLR to the VLR within the MSC where the subscriber's mobile is registered.

HLR Implementation and Operation An HLR can be implemented as a stand-alone network element or it can be integrated into an MSC/VLR to create an MSC/VLR/HLR system. The HLR itself consists of the following subsystems: storage, central processors, I/O system, and statistics and traffic measurement data collection. Additionally, SS7 signaling links are maintained between a network HLR and the MSC/VLRs and GMSC that compose a cellular network. Usually, a wireless service provider will have more than one HLR within a **public land mobile network** (PLMN) to provide the necessary redundancy to support disaster recovery. The information about subscriber subscriptions is usually entered into the HLR database through a service order gateway (SOG) or an operations support system (OSS) interface.

The HLR has two basic functions. It maintains databases of subscriber-related information. This information may consist of both permanent data such as subscriber-associated MS numbers and dynamic data such as location data. The HLR is able to support typical database operations like the printing and modification of subscriber data and the addition or deletion of subscribers. More complex operations like the handling of authentication and encryption information and the administration of MS roaming characteristics are also performed. The HLR also performs call handling functions such as the routing of mobile terminating calls, the handling of location updating, and procedures necessary for delivery of subscriber supplementary services.

HLR Subscription Profile A basic function of the HLR is to store a subscriber's profile. This profile defines a group of services that the subscriber has signed up for when first contracting for mobile service. The types of services available are typically referred to as **teleservices** (telephony, short message service, fax, etc.) and **bearer services** (i.e., data services). These services are typically grouped into basic service groups that are packaged for sales and promotion purposes. A user's profile stored by the HLR may be updated or modified at any time with vendor-specific computer commands or more easily by clicking on graphical user interface (GUI) icons in a Windows-based application program.

Supplementary services are system functions like call waiting and call holding, multiparty service, calling line and connected line identification, call forwarding, call barring, and so on. Within each of these categories, there are many options that may be selected. These supplementary services may be programmed into a user's profile fairly easily as mentioned earlier. As well as the normal services that may be specified by a particular system standard, systems will typically offer vendor-specific supplementary services that are used in an attempt to provide some form of marketplace differentiation.

HLR/AUC Interconnection The authentication center (AUC) provides authentication and encryption information for the MSs being used in the cellular network. For GSM systems, so-called triplets are provided for the authentication of a mobile. Upon a request from a VLR, the HLR will be delivered a **triplet** (i.e., a ciphering key, a random number, and a signed response) for a particular mobile subscriber. The HLR receives the triplet information in response to a request to the AUC for verification of a subscriber. The HLR forwards the random number to the MSC/VLR where it is passed on to the mobile. The mobile performs a calculation using the random number and returns it to the MSC/VLR and from there to the HLR. If the results are the same as the signed response, the mobile is **authenticated** and it is now able to access the radio resources of the network. The AUC contains a processor, a database for the storage of key information for each subscriber, maintenance functions for subscriber information, and an interface for communications with the HLR. CDMA systems use a similar system for authentication.

Interworking Location Register

Interworking location registers (ILRs) are used to provide for intersystem roaming. The ILR allows a subscriber to roam in several different systems. For instance, in a wireless cellular system using an appropriate ILR, a subscriber could roam between an AMPS system and a PCS system. In this case, the ILR would consist of an AMPS HLR and parts of a PCS VLR.

Authentication Center and Equipment Identity Register

The authentication center (AUC) is a database that is connected to the HLR. The authentication center provides the HLR with authentication parameters and ciphering keys for GSM systems. Using the cipher keys, signaling, speech, and data are all encrypted before transmission over the air interface. The use of encryption provides over-the-air security for the system.

The equipment identity register (EIR) database is used to validate the status of mobile equipment. In GSM systems, the MSC/VLR can request the EIR to check the current status of an MS through the global database maintained by the GSM Association. This global database is updated daily to reflect the current status of an MS. The MS can be "black listed" indicating that it has been reported stolen or missing and thus not approved for network operation. Or, the MS might be "white listed" and therefore registered and approved for normal operation. The hardware necessary to perform AUC/EIR functions might be colocated within a wireless network.

within a wireless network.

Gateway MSC

The **gateway MSC** (GMSC) is an MSC that interfaces the wireless mobile network to other telecommunications networks. Although a cellular network might have numerous MSCs to facilitate coverage of a large geographical area, not all of these switching centers need to be connected to other wireline networks or other PLMNs. Usually this connection is made at one particular MSC and this MSC is now known as a gateway MSC or GMSC. To support its function as a gateway, the GMSC will contain an interrogation function for obtaining location information from the HLR of a subscriber. The GMSC will also have the ability to reroute a call to an MS using the information provided by the HLR. Charging and accounting functions are typically implemented in the GMSC.

Interworking Units

Interworking units (IWUs) are required to provide an interface to various data networks. These nodes are used to connect the base station controller and hence the radio base stations to various data services networks. This is necessitated by the fact that the MSC is a circuit-switched device and inappropriate for the transmission of data packets. Presently, for both TDMA and CDMA systems, these interworking units have evolved into specific functional nodes such as gateway GPRS support nodes (GGSNs) and **packet core network** (PNC) nodes, respectively. These IWUs will be discussed in greater detail in Chapter 7.

Data Transmission Interworking Unit An early interworking unit, the data transmission IWU (DTI), was used to allow the subscriber to alternate between speech and data during the same call. The main functions performed by the DTI were protocol conversion and the rate adaptation necessary for fax and data calls through a modem.

SMS Gateways and Interworking Units To provide **short message service** (SMS) (i.e., the sending of a text message consisting of up to 160 alphanumeric characters either to or from a mobile), two network elements are required in GSM networks: the short message service gateway MSC (SMS-GMSC) and the short message service interworking MSC (SMS-IWMSC). This first device is capable of receiving a short message from an SMS center (SC), interrogating an HLR to obtain routing information and message waiting data, and finally delivering the short message to the MSC of the receiving mobile. The second device is capable of receiving a mobile-originated short message from the MSC or an alert message from the HLR and delivering these messages to the subscriber's SMS center. Multimedia message service or MMS uses a different means of providing data transmission through the wireless network than SMS does. Again, more detail about SMS and MMS operations will be forthcoming in Chapter 7.

Network Management System

All modern telecommunication networks have some form of network management built into the system. This overarching management tool provides for overall network surveillance and support to the operation and maintenance of the entire network. A wireless service provider will usually have a **network operations center** (NOC) devoted to the use of this network management system (NMS) to provide 24/7 coverage of the system. Different equipment manufacturers have different names for these management systems; however, they all tend to have the same functionality. They provide fault management in the form of network surveillance, performance management, trouble management, configuration management, and security management.

Usually, the NMS has subnetwork management platforms that provide management of the circuit, packet, and radio networks. These subnetwork management platforms also provide configuration, fault, performance, and security management of their respective subsystems.

Other Nodes

Other nodes that may be connected to the switching system but are not really part of the telecommunications network itself are the SMS or service center (SC), the billing gateway (BGW), and the service order gateway (SOG). The service center acts like a store and forward center for short messages, the billing gateway collects billing information, and the service order gateway provides subscription management functions.

Service Center

The service center is used to facilitate the operation of short message service. It performs two functions: a mobile-originated short message is transferred from the cellular network to the SC for storage until the message can be transferred to its MS destination, or the SC stores a mobile-terminated short message from some other short message entity (SME) that might or might not be a MS until it can be accepted by the intended MS.

Billing Gateway

The billing gateway (BGW) collects billing information from various wireless network elements (principally, the MSC and GMSC). The common term used for the information collected by the BGW is call data records (CDRs). As these call records are collected from the network elements they become files used by a customer administrative system to generate billing information for the system's subscribers. Information about monthly access fees, home usage and roaming usage charges, data and special services usage charges, and so on, are all used to generate a monthly bill for each subscriber.

Service Order Gateway

The **service order gateway** (SOG) is used to connect a customer administrative system to the switching system. This system is used to input new subscriber data to the HLR or to update current subscriber data already contained in the HLR. The SOG also allows access to the AUC and the EIR for equipment administration. When a customer initially signs a service contract with a cellular service provider, the information about the contract is entered into the customer administrative system. The administrative system sends customer service orders to the SOG. The SOG interprets the service orders and delivers the appropriate information to the correct network elements in the form of network service orders.

3.2 HARDWARE AND SOFTWARE VIEWS OF THE CELLULAR NETWORK

At this point in our discussion of the various hardware elements that are used to realize a cellular system will be instructive to examine a possible implementation of a typical 2G/2.5G/2.5G+/3G wireless syst How the components are actually physically laid out and connected to provide coverage to a particular will be discussed. How the network elements are viewed by system software is slightly different howe This view will also be presented and contrasted with the hardware point of view. See Figure 3–8 for illustration of a possible hardware layout used to cover a specific geographic area.

Figure 3–8 depicts a fairly large geographic area with a potential subscriber base of approxima 100,000 that is served by a cellular network consisting of two mobile switching centers and a total of base station controllers. The reader is urged to try and relate the demographic and geographic features his or her own hometown location to this example. For the sake of clarity, all the radio base stations (ce for only one BSC are shown. All the details of the individual cells are not included at this time.

Hardware View of a Cellular Network

The area on the left side of the diagram is served by MSC-1 and thus will be known as the service area MSC-1. The right side of the diagram is served by MSC-2 and is thus labeled as the service area of MSC MSC-1 interfaces with three BSCs (BSC-1A, BSC-1B, and BSC-1C) that are used to cover the three ar that the MSC-1 service area has been subdivided into. Each of these BSCs has several to many RBSs s viced by it depending upon the population density and nature of the various areas (urban, suburb business district, industrial, etc.). In some of the areas there may be both microcells and macrocells wher other locations will just have macrocells. In the service area of MSC-2, there are three more BSCs (BSC 2A, BSC-2B, and BSC-2C).

The RBSs might be named to reflect their connection to a particular BSC (i.e., RBS-2A1, RBS-2A2, an so on for RBSs connected to BSC-2A). In this diagram, the GMSC provides the gateway connection to th PSTN for MSC-1 and MSC-2, and MSC-1 has the switching system databases colocated with it. PCM link

Scanned with CamScanner

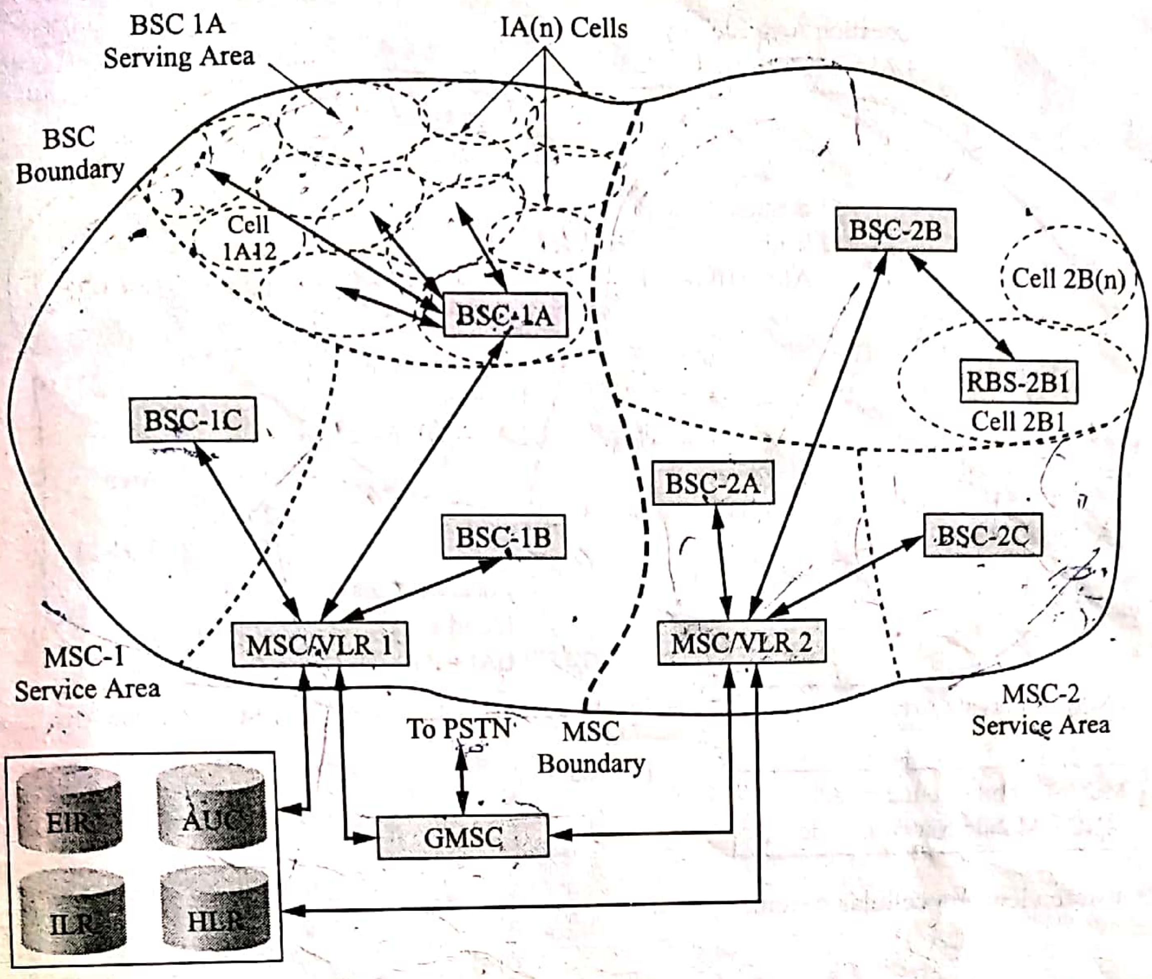


Figure 3–8 Hardware view of a cellular system.

exist between each RBS and its BSC, between each BSC and its MSC/VLR, and between the MSC/VLRs. These PCM links might be leased from the local telephone company or they may be implemented using microwave digital radio links installed by the service provider or a combination of both facilities. The gateway MSC is most likely linked to the PSTN by some form of high-capacity T-carrier or fiber span. Actual statistics about cell site locations and antenna statistics of cellular and PCS systems are available from the FCC's Web site. This information is contained in the universal licensing system database that may be found at http://wireless.fcc.gov/uls/.

Software View of a Cellular Network

The operations performed within the cellular network to complete calls, keep track of a mobile's location, and maintain radio links through handoff, but to name a few, are all directed by the network elements under program or software control. The cellular network therefore takes on a slightly different appearance to the system software. Physical objects and areas take on logical names to distinguish them from each other and to allow the software the ability to perform the required operations. Figure 3–9 shows the same geographic area as Figure 3–8; however, this time the cellular network is shown from a software viewpoint.

As shown in Figure 3–9, the network is defined by location area identity (LAI) numbers and cell global identity (CGI) numbers. The CGI numbers locate a particular cell whereas the LAI numbers define an area for paging. Because a mobile may have moved since its last location updating message (that would include the LAI number), an incoming call to the mobile will result in a page to every cell within the location area. If a mobile moves into another location area, it is required to automatically update its location with the VLR for the new location area.

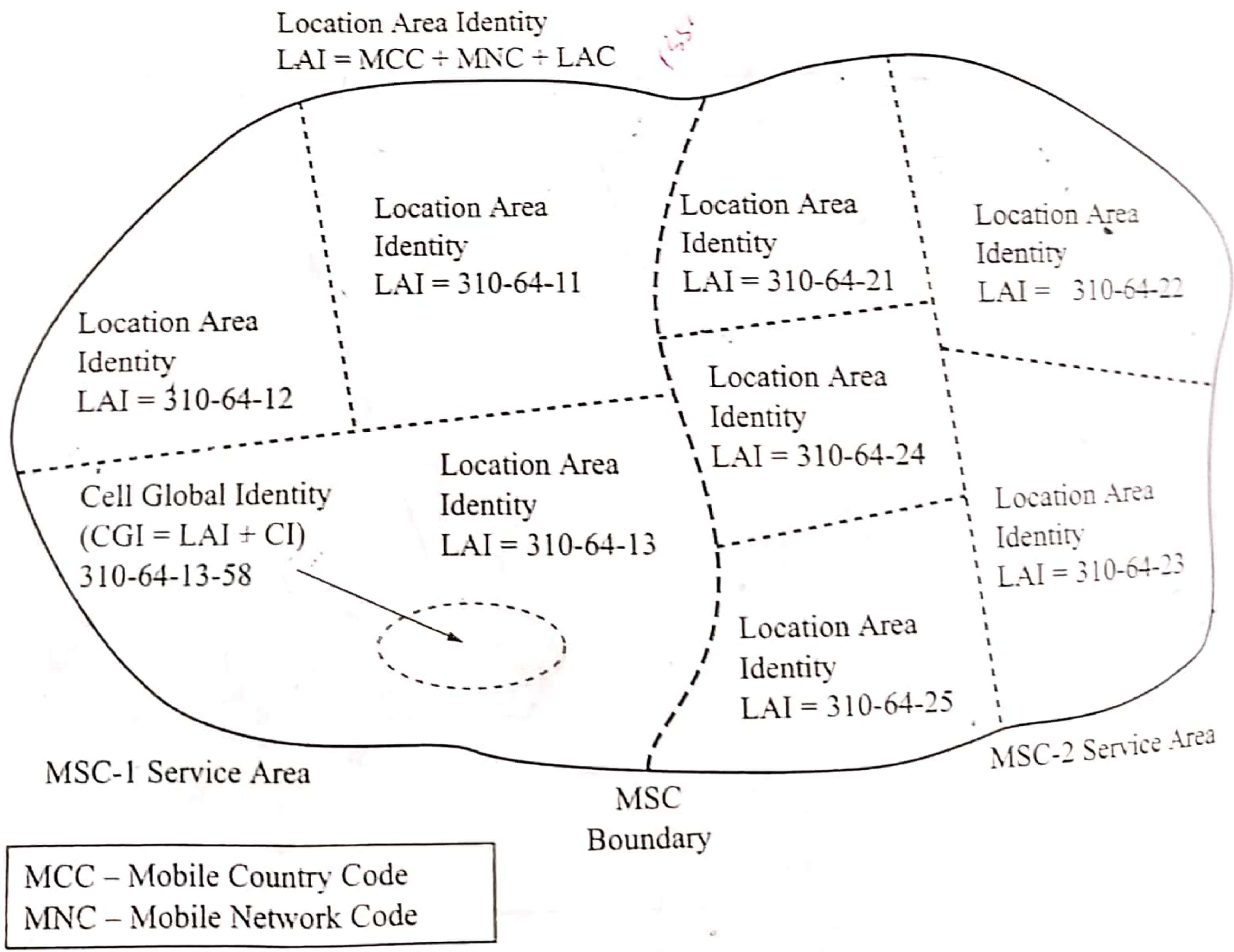


Figure 3–9 Software view of a cellular system.

3.4 CELLULAR COMPONENT IDENTIFICATION

To switch a voice call from the PSTN to a mobile subscriber the correct cellular network elements must b involved in the operation. It is therefore necessary to address these elements correctly or the operation w not be completed properly. The International Telecommunications Union (ITU), acting in its capacity as global standards organization, has adopted several standards and recommendations to deal with these issues. Recommendation E.164 is known as the international public telecommunication numbering plan This recommendation, adopted in 1997, details the numbers to be used for assigning PSTN telephone numbers on a global basis. This same recommendation is followed when assigning numbers to cellular tele-phones and provides a dialable number with which one can connect with the mobile through a wireless network. Furthermore, Recommendation E.212 deals with the numbering schemes for mobile terminals on a global basis. As stated before, the transmission of messages between cellular network elements used to facilitate cellular switching and control operations is accomplished through the use of SS7, in the same fashion as the PSTN. Therefore, network switching elements or processing nodes are associated with addresses assigned to SS7 signaling points. These signaling point addresses are generated by the translation of E.164 and E.212 information into mobile global titles (Recommendation E.214) during the processing of operations by the cellular system elements.

This section will examine some of the basic numbering schemes used in wireless mobile networks for the different network elements that make up the system. Further details about specific systems will be offered in upcoming chapters.

Subscriber Device Identification

The mobile subscriber device (SD) can have several different system identification numbers associated with it. The identification information used depends upon the type of cellular technology (TDMA, GSM, or CDMA) employed by the network it is being used in and the scope of the network (e.g., national or international). The next few sections will expand upon this topic.

Mobile station International subscriber Directory Number

Mobile Station ISDN Identification Number

The mobile-station ISDN (MSISDN) number is a dialable number that is used to reach a mobile telephone. There are slight variations in the MSISDN number depending upon whether one is in North America or in other parts of the world. Figure 3–11 provides a graphic of how these MSISDN numbers are formed.

As shown, in North America an MSISDN number consists of the following:

$$MSISDN = CC + NPA + SN$$

(country or geographical area

Where, CC = Country Code, NPA = Number Planning Area, and SN = Subscriber Number

Subscriber no

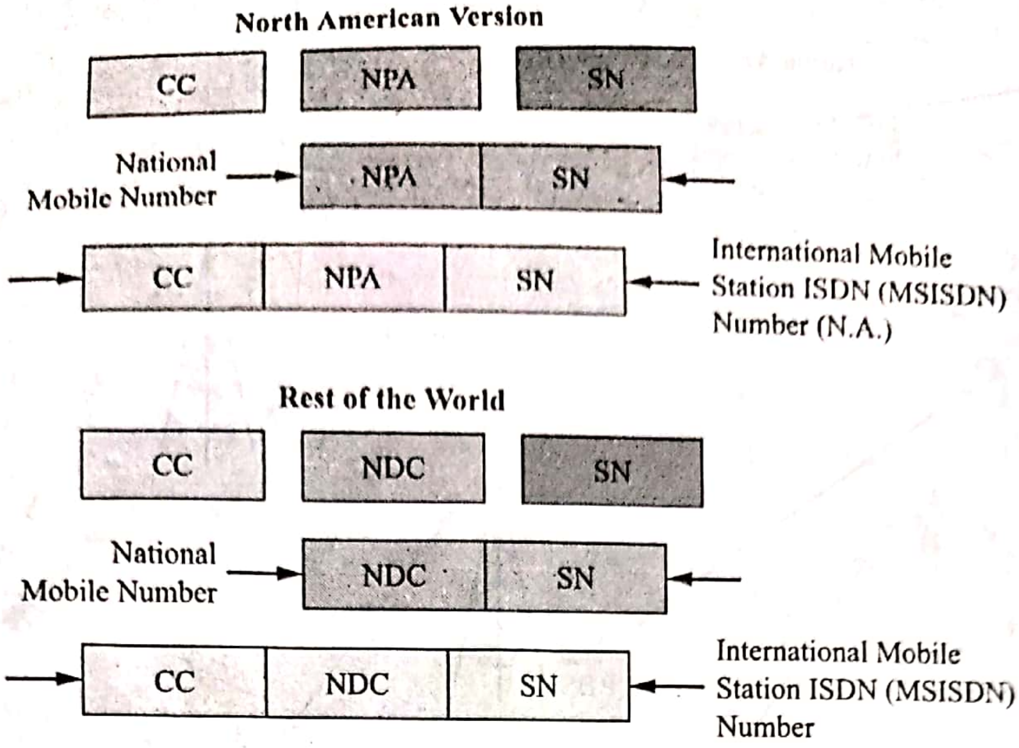


Figure 3–11 Formation of the MSISDN number.

Example 3–2

A cellular telephone subscriber signs up for service in Springfield, MA, USA. What is the su
MSISDN?

Solution: Since the country code for the USA is +1 and the area code for Western Massachusetts i
MSISDN will take the form

MSISDN = +1-413-732-XXXX

areacode SN

contry code - areacode - National Destination
NU planning
+SN

Contrycode - National Destination +

In the rest of the world an MSISDN number consists of the following:

MSISDN = CC + NDC + SN → station subscribe numb ISDN number

0821 Mysore
+91 MCC
SN

Where, NDC = National Destination Code. The NDC is similar to the NPA but can also identify th
network (fixed, wireless, etc.) being called.

International Mobile Subscriber Identity

For international public land mobile networks an international mobile subscriber identity (IMSI) is
to each subscriber. Figure 3–12 indicates how the IMSI is formed.

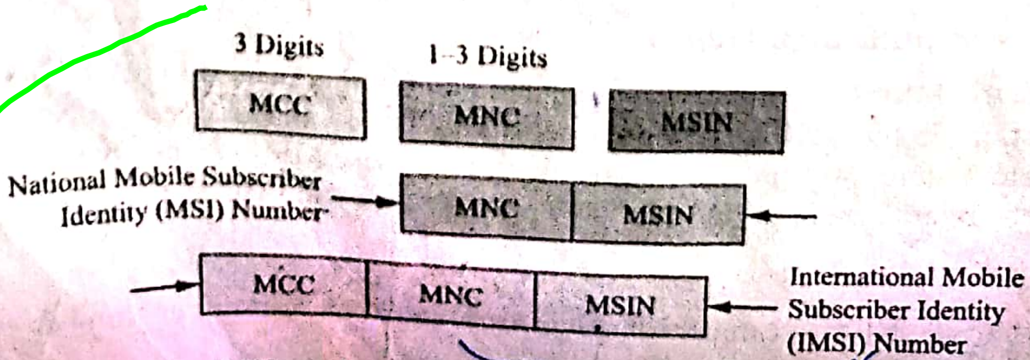


Figure 3–12 Formation of the IMSI number.

NMSI 15 digits

Reliance 71 - China 86 - Hong Kong 79 - Indonesia

As shown, the IMSI number consists of the following:

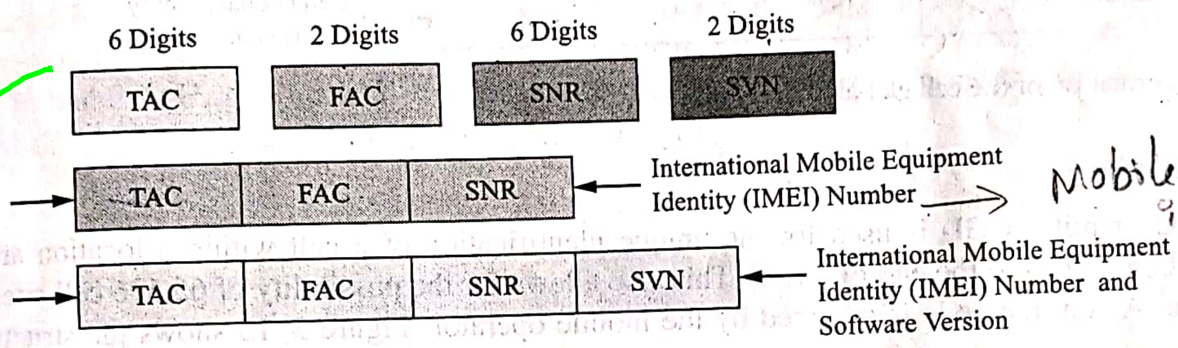
IMSI = MCC + MNC + MSIN

Where, MCC = Mobile Country Code (see Recommendation E.212), MNC = Mobile Network Code, and MSIN = Mobile Subscriber Identification Number. For a GSM network the IMSI number is stored in the SIM (subscriber identity module) card that is inserted into the mobile telephone and provided to the subscriber by the service provider.

There is also a temporary mobile subscriber identity (TMSI) number that may be used instead of the IMSI. This TMSI number is used to provide security over the air interface and therefore only has local significance within an MSC/VLR area.

International Mobile Equipment Identity

For international mobile networks, an international mobile equipment identity (IMEI) number is defined and is used to uniquely identify a MS as a piece of equipment to be used within the network. Figure 3–13 indicates the structure of the IMEI number.



Mobile identity num
it is in the Phone back of batt

Figure 3–13 Formation of the IMEI number.

The IMEI can be modified to include information about the software version of the subscriber device operating system or application software within the identity number.

Cellular System Component Addressing

The rest of the cellular network hardware components that make up the switching system or the base station system have either signaling point (SP) addresses or some type of logical name assigned to them to distinguish them from similar components within the network. Some of the addresses are predetermined by the ITU Recommendations E.164 and E.212 and some are translated into new addresses that conform to Recommendation E.214. The logical names of devices are assigned by the system operator.

Additionally, physical areas of network coverage are also defined and given logical identification names and numbers to provide for the mobility management functions of the system or to define billing areas for regional or national service plans.

Location Area Identity

The location area identity (LAI) is used for paging an MS during an incoming (mobile terminating) call and for location updating of mobile subscribers. Figure 3–14 shows the structure of an LAI number.

As shown, the LAI consists of the following:

LAI = MCC + MNC + LAC

Where, again, MCC = Mobile Country Code, MNC = Mobile Network Code, and LAC = Location Area Code, which is 16 bits in length and therefore allows the network operator 65,536 different possible areas or codes within a network. The code is assigned by the mobile operator.

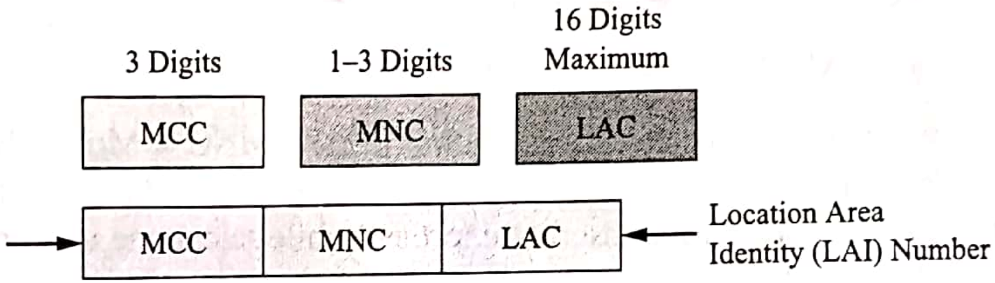


Figure 3–14 Formation of the location area identity number.

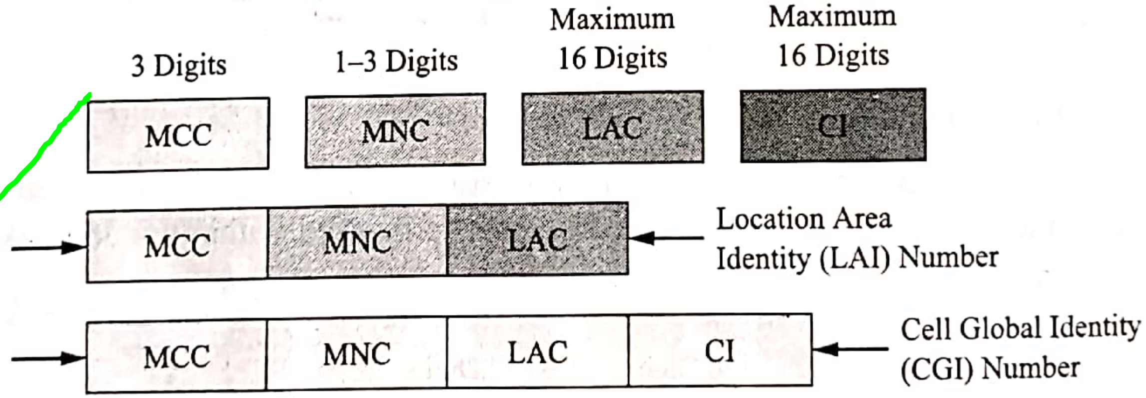


Figure 3–15 Formation of the cell global identity number.

Cell Global Identity

The cell global identity (CGI) is used for the unique identification of a cell within a location area. I formed by adding 16 bits to the end of a LAI. This also allows for the possibility of 65,536 cell sites w a location area. Again, the code is assigned by the mobile operator. Figure 3–15 shows the structure CGI number.

Radio Base Station Identity Code

A radio base station identity code (BSIC) is used by the mobile operator to identify RBSs within the less network. This code allows an MS to distinguish between different neighboring base stations. The usually consists of a 3-bit network color code and a 3-bit base station color code.

3.5 CALL ESTABLISHMENT

The topic of **call establishment** was first introduced in Chapter 2 during an overview of the first-generation analog AMPS system. At that time, the reader was introduced to the many handshaking functions that were performed between the MS and the BS and between the BS and the MSC to complete call setup and hand-off functions. Now that more detail about the network elements and databases of digital wireless cellular systems has been introduced, it would again be instructive to take a look at some of the basic wireless

Mobile-Terminated Call

The mobile-terminated call consists of the steps shown in Figure 3–17. Step #1: Any incoming call t mobile system from the PSTN is first routed to the network's gateway mobile switching center (GMS Step #2: When the wireless mobile system detects an incoming call at the GMSC, the mobile system m first determine where the mobile is located at that particular moment in time. To determine the mobil location, the GMSC will examine the mobile station's MDISDN to find out which home location reg (HLR) the mobile subscriber is registered in. Using SS7 (SCCP), the MSISDN is forwarded to the H with a request for routing information to facilitate the setup of the call. Step #3: The HLR looks up wh MSC/VLR is presently serving the MS and the HLR sends a message to the appropriate MSC/V requesting an MS roaming number (MSRN), so that the call may be routed. This operation is required b this information is not stored by the HLR; therefore, a temporary MSRN must be obtained from the app priate MSC/VLR. Step #4: An idle MSRN is allocated by the MSC/VLR and the MSISDN numbe linked to it. The MSRN is sent back to the HLR. Step #5: The MSRN is sent to the GMSC by the H Step #6: Using the MSRN, the GMSC routes the call to the MSC/VLR. Step #7: When the ser MSC/VLR receives the call, it uses the MSRN number to retrieve the mobile's MSISDN. At this poin

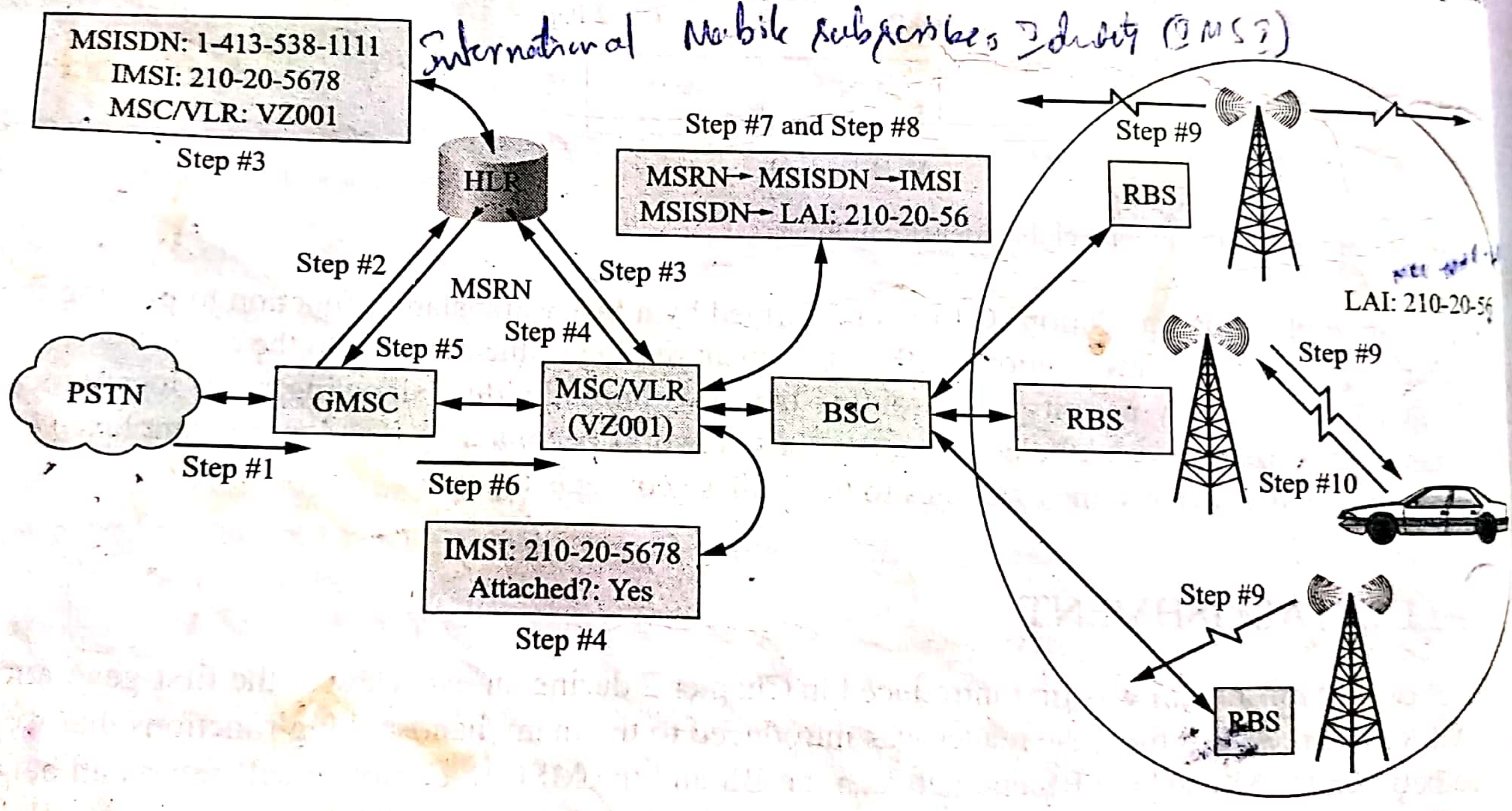


Figure 3–17 Mobile-terminated call operations.

temporary MSRN number is released. Step #8: Using the mobile's MSISDN, the MSC/VLR determines th location area where the mobile is located. Step #9: The MS is paged in all the cells that make up this loca tion area. Step #10: When the MS responds to the paging message, authentication is performed anc encryption enabled. If the authentication and encryption functions are confirmed, the call is connected from the MSC to the BSC to the RBS where a traffic channel has been selected for the air interface.

Mobile-Originated Call

A mobile-originated call consists of the steps shown in Figure 3–18. Step #1: The originating mobile subscriber call starts with a request by the mobile for a signaling channel using a common control channel. If possible, the system assigns a signaling channel to the mobile. Step #2: Using its assigned signaling channel, the MS indicates that it wants service from the system. The VLR sets the status of the mobile to "busy." Step #3: Authentication and encryption are performed. Step #4: The mobile specifies what type of service it wants (assume a voice call) and the number of the party to be called. The MSC/VLR acknowledges the request with a response. Step #5: A link is set up between the MSC and the BSC and a traffic channel is seized. The acquisition of the traffic channel requires several steps: the MSC requests the BSC to assign a traffic channel, the BSC checks to see if there is an idle channel available, if a channel is idle the BSC sends a message to the RBS to activate the channel, the RBS sends a message back to the BSC indicating that the channel has been activated, the MS responds on the assigned traffic channel, the BSC sends a message back to the MSC to indicate that the channel is ready, and finally the MSC/VLR sets up the connection to the PSTN. Step #6: An alerting message is sent to the mobile to indicate that the called party is being sent a ringing tone. The ringing tone generated in the PSTN exchange that is serving the called party is transmitted through the MSC back to the mobile. When the called party answers, the network sends a Connect message to the mobile to indicate that the call has been accepted. The mobile returns a Connect Accepted message that completes the call setup process.

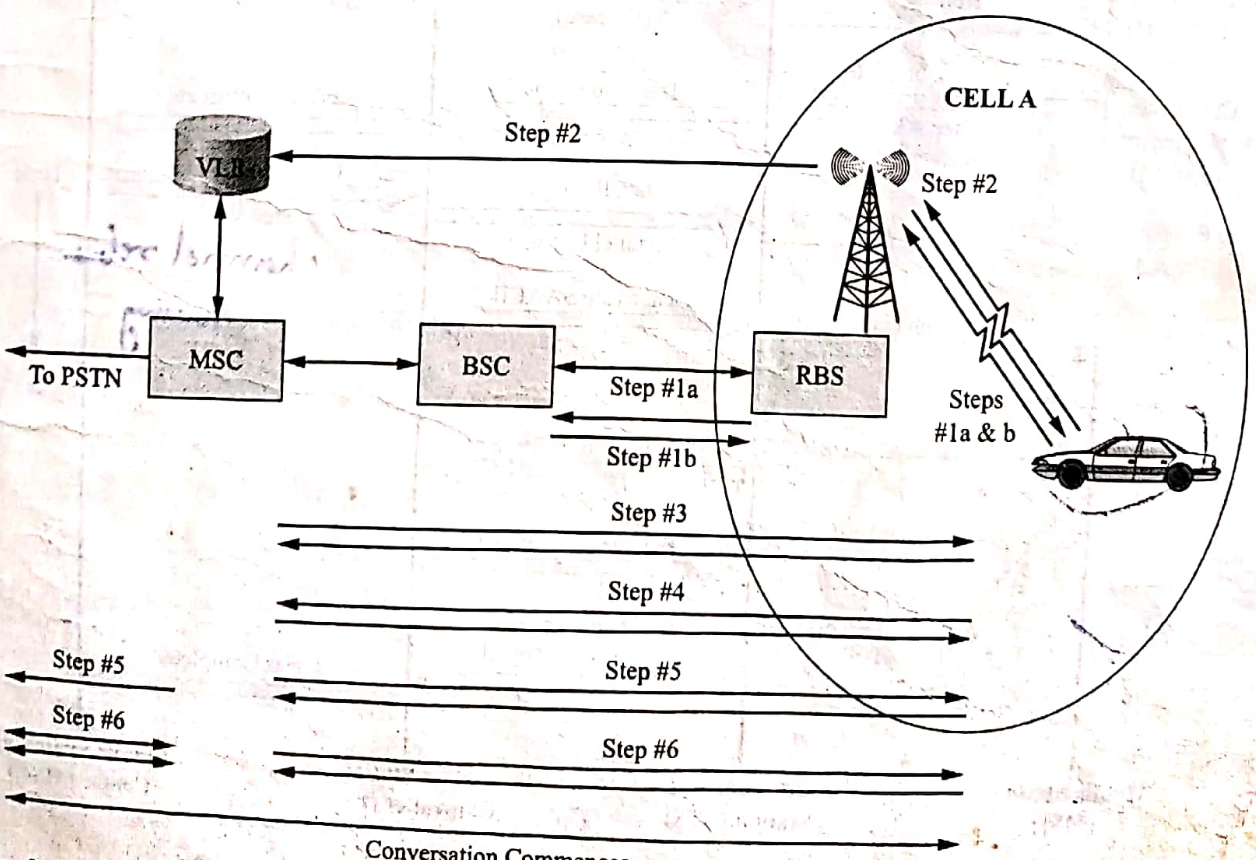
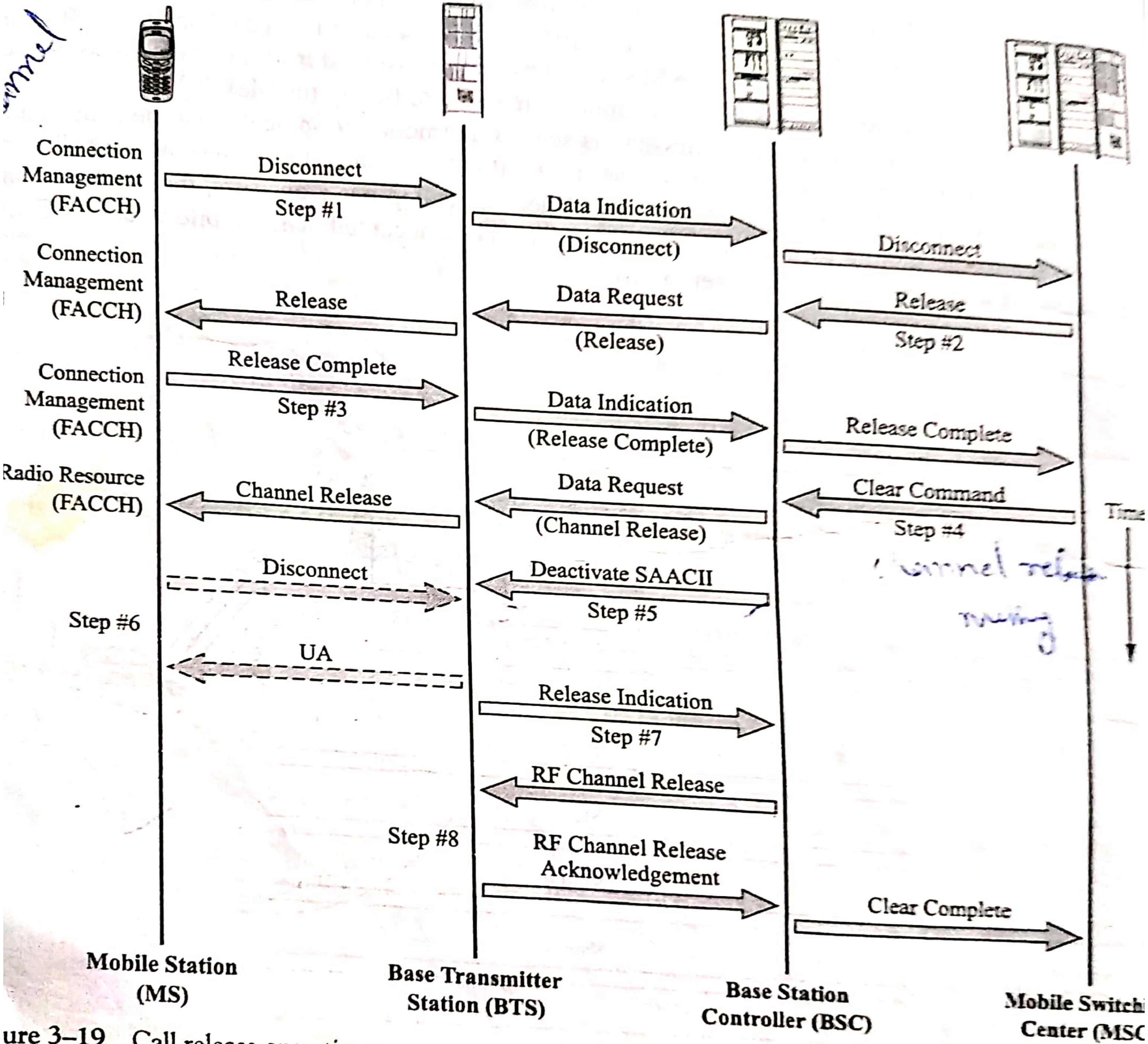


Figure 3–18 Mobile-originated call operations.

Call Release

Call release initiated by the mobile consists of the steps shown in Figure 3–19. Step #1: The mobile sends a Disconnect message to the RBS, the message is passed on to the BSC where it is sent through a signaling link to the MSC. Step #2: The MSC sends a Release message to the MS. Step #3: The MS sends a Release Complete message back to the MSC as an acknowledgement that the operation is complete. Step #4: The network initiates a channel release by sending a Clear Command message from the MSC to the BSC. The BSC sends the Channel Release message to the mobile through the RBS. Step #5: At this point, the BSC sends a Deactivate message to the RBS telling it to stop sending periodic messages to the mobile on a control channel. Step #6: When the mobile gets the Channel Release message, it disconnects the traffic channel and sends the LAPDm disconnect frame. The RBS sends an LAPDm acknowledgement frame back to the mobile. Step #7: A Release Indication message is sent from the RBS to the BSC. Step #8: The BSC sends an *RF* Channel Release message to the RBS that is acknowledged as shown, as soon as the RBS stops transmitting on the traffic channel. After a short period (regulated by a BSC system timer) a Clear Complete message is sent to the MSC from the BSC.



ure 3–19 Call release operations.

wireless mobile network and the overall system-level functions that occur.

QUESTIONS AND PROBLEMS

1. Which two elements of a wireless cellular system perform the "air interface" function?
2. What is the function of the transcoder controller?
3. What is the function of the visitor location register?
4. What is the function of the home location register?
5. What is the function of the mobile switching center?
6. What wireless cellular network element or elements provide security functions for the system?
7. What does a cell global identity number correspond to?
8. The LAI is used for what purpose?
9. What is the function of a radio network controller?
10. Name the two core networks associated with 3G cellular networks.
11. What is the difference between an MSISDN number and an IMSI number?
12. What is the purpose of a global title?
13. What is a mobile global title?
14. What is global title translation?
15. Using the Internet, determine the mobile country code for Mexico.
16. Explain the function of a mobile station roaming number.
17. During a mobile-originated call, when is authentication and encryption performed?
18. What is the first step performed by the mobile during a call release operation?
19. What is the last step performed during a call release operation?
20. What wireless cellular network elements are involved in a mobile-originated call?