Mobile Communication

08/03/21

UNIT-1: Introduction to wireless telecomm^n systems & n/w's History & evolution of different generations of wireless cellular n/w 1G, 2G, 3G & 4G N/W's. Common cellular n/w components, common cellular n/w components, H/W & S/W views of cellular n/w's. 3G cellular system components, call establishment, cell release operations.

UNIT-2: Wireless N/W architecture & operations, cellular concept & cell fundamentals, capacity expansion techniques, cellular backbone backbone n/w, mobility management, Radio Resources & power management wireless n/w security. GSM & TDMA technique, GSM system overviews, GSM n/w & system architecture, GSN channel concepts, GSM identifiers.

UNIT-3: GSM system operation, Traffic cases call hand off, Roaming, GSM protocol architecture, TDMA & CDMA technology CDMA overview, CDMA channel concept & CDMA operations.

UNIT-4: Wireless modulation techniques & H/W, characteristics of air interface, pathloss models, wireless coding techniques OFDM, UWB radio frequencies, Diversity techniques, Rate reciever, Typical GSM H/W.

UNIT-5: Introduction to wireless LAN 802.11x technologies, Evolution of WLAN, Introduction to 802.15x technologies in PAN applications & Bluetooth architecture, Introduction to Broadband wireless MAN, 802.16x technologies.

References: 1. Mullet: Wireless Telecom systems & N/W, Thomson learning - 2009.
2. Lee W.C.Y mobile cellular Telecomm^n, M&H, 2002
3. D.P Agarwal: Wireless Comm^n, 2nd ed^n TL - 2007

→ Practical electrical communication began in US over 150 yrs ago with the invention of telegraph by Morse. In 1876 invention of telephone by Bell Laboratory is manually switched wireline N/W.
(Both are wired comm^{n})

★ Radio & wireless was invented at the turn of 20th century. For many yrs, wireless comm^n primarily provided entertainment & news through radio broadcasting services. Wireless mobility took the form with syntax operation.

★ 2 way mobile wireless comm^n for limited use by various public service departments, military, govt. agencies, etc.

★ As technology decreased the size of mobile unit becomes a handheld device known as Walkie Talkie. Further advances in IC technology, there were cordless telephones in 1970's

★ In 1985, cellular telephone sys, thus wireless system provide mobile access to the public switch telephone n/w [PSTN] i.e Mobile to landline & vice versa.

★ Today's cellular n/w provide access to the public telephone n/w from almost anywhere & provide access to the public data n/w [PDN or Internet]

1st generation cellular system:

1G cellular sys used analog frequency modulation scheme (ASK), for transmission of voice messages with 2 separate bands for down link (Base station to mobile) & uplink (mobile to Base station) transmission. This type of system is known as frequency division duplex (FDD). Also within these 2 separate bands frequency div. multiplexing (FDM) is used to increase the system capacity. The AMP's (Advanced mobile phones) began operation in 800 MHz band. The down

link / forward band is (824-849) MHz & uplink / reverse band was (869-894) MHz. The channel spacing was set at 30 KHz. Each base station transmit & reciever frequency was separated by 45 MHz. Federal communication commission (FCC) dividing the alloted freq spectrum into A & B bands. A band was allocated to 1 service provider & B band was allocated to another service provider within specific serving area. Initially A & B bands both consist of 333 channels. channels 1-312 in the A band were traffic channels used for subscriber calls & channels 313-333 (around 21) channels in the A band was used for system control functions. These 21 control channels are used by mobile & base station to setup & clear calls & also some other n/w operations such as hand off operations

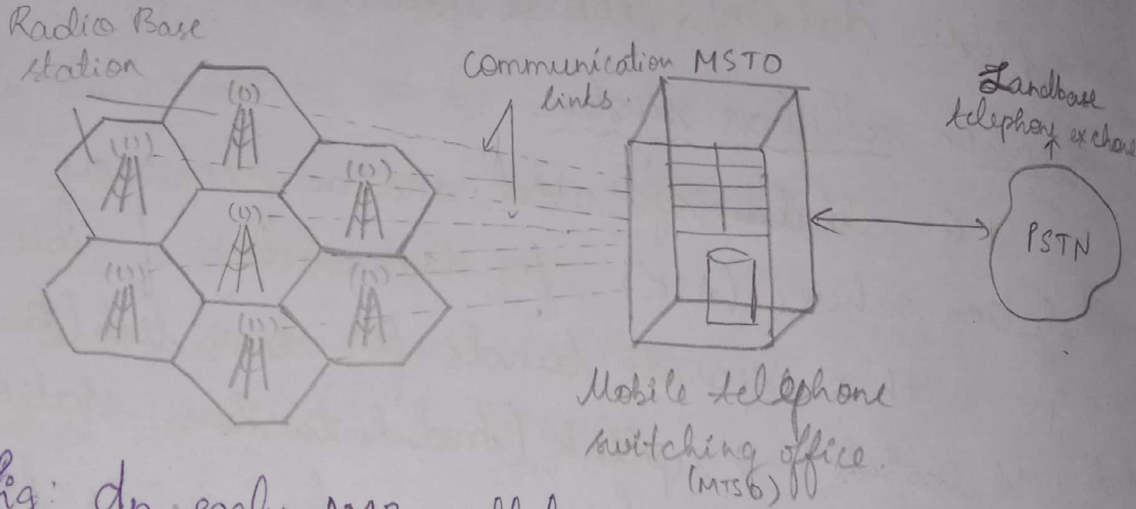


fig: An early AMPs cellular systems.

The typical early AMP cellular sys contain following components;

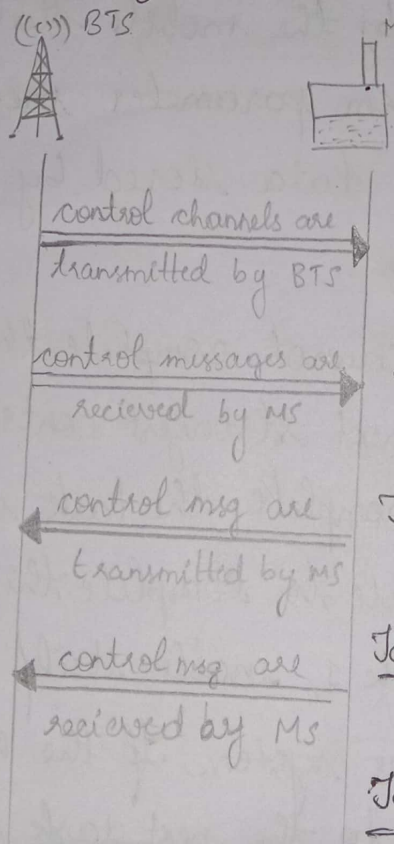
a) cell base station
b) Many mobile stations
c) MTSO

* Now MTSO is replaced by MSC (Mobile switching center). The base station refer to as base transreciever stations form cells that provide coverage to mobile subscribers over a particular geographic area. The Base stations are connected to the MTSO then connected to the Public switch Telephone n/w (PSTN). Together Base station & mobile station provide the air interface. that permits the subscriber mobility while connected to the PSTN.

* MSC/MTSO performs system control by switching the call to the correct cells, interfacing with PSTN, monitoring system traffic for billing, performing various diagnostic services & managing the operation of entire n/w.

* The mobile unit has ability to change its operating frequencies to those designated by MSC & its o/p power level if so instructed

Mobile phone initialization:



Task 1: Mobile powers up.

Task 2: Mobile scans for control channels of selected system (A or B)

Task 3: Mobile updates cellular system information.

Task 4: Mobile establishes paging channel.

Task 5: Mobile registers with

cellular system.

Task 6: MS authorization.

Task 7: MS authorization is verified.

Task 8: Mobile enters Idle state.

* The process of AMP's mobile phone initialization as shown in the fig. When the mobile phone is 1st powerd up, goes through initialization process, This process allows cellular phone to set itself to use either cellular provider A or B

* 2nd step in the process is scanning of all dedicated control channels of the selected service provider system by the mobile phone. At the completion of task 2, the mobile station selects the strongest control channel to lock onto.

* This control channel will have all probability associated with the cell in which the mobile is located.

* 3rd step in the process will be updating of overhead information by the mobile station. The base station transmits system parameter messages that are used to update the data stored by mobile station about cellular system.

* If the M.S cannot complete this task within 3 sec it will go to next strongest control channel signal + attempt to complete the task within 3 sec time interval. If unable to complete this task, the mobile will now return to task 1, enable itself to use the other service provider system. If the M.S can complete task 1, 2, 3 it moves to the next task. 4 requires the

M.S to scan the paging channels of the system & then logon to the strongest paging channel.

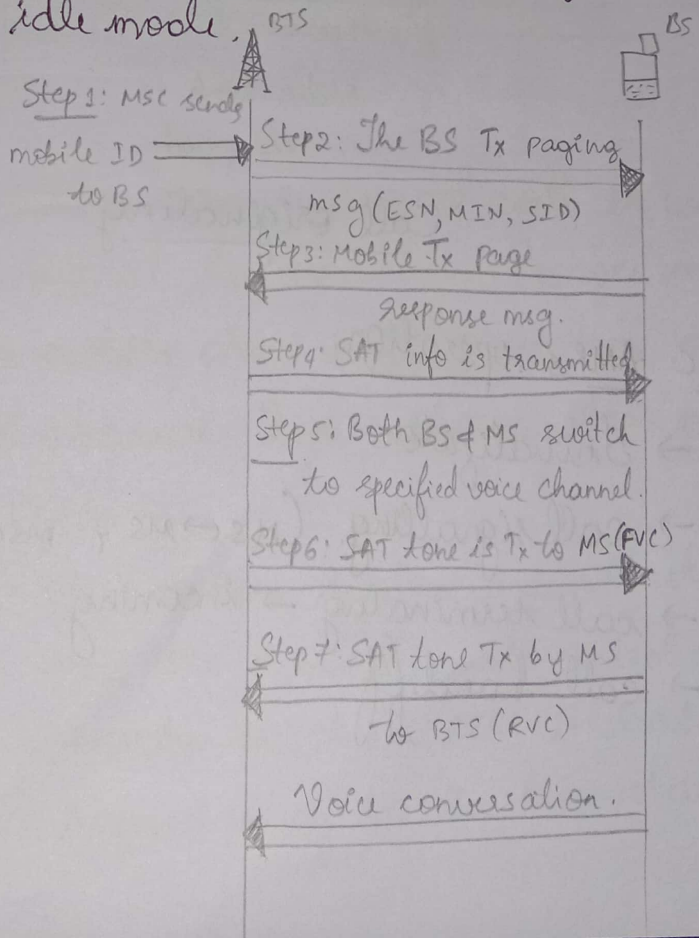
* During this task, the mobile will compare its home system ID to that of the system ID delivered to it in the overhead message. If the 2 system ID's are not the same, M.S knows that it is in roaming status & sets parameter to allow roaming operations ~~sha~~ to take place s/w itself & system that is attached to.

* Task 1-4 is completed successfully, the mobile will identify or register itself with n/w by sending its ESN, SID & MIN numbers over the RECC. These ID numbers are compared against database at MSC to validate the mobile status.

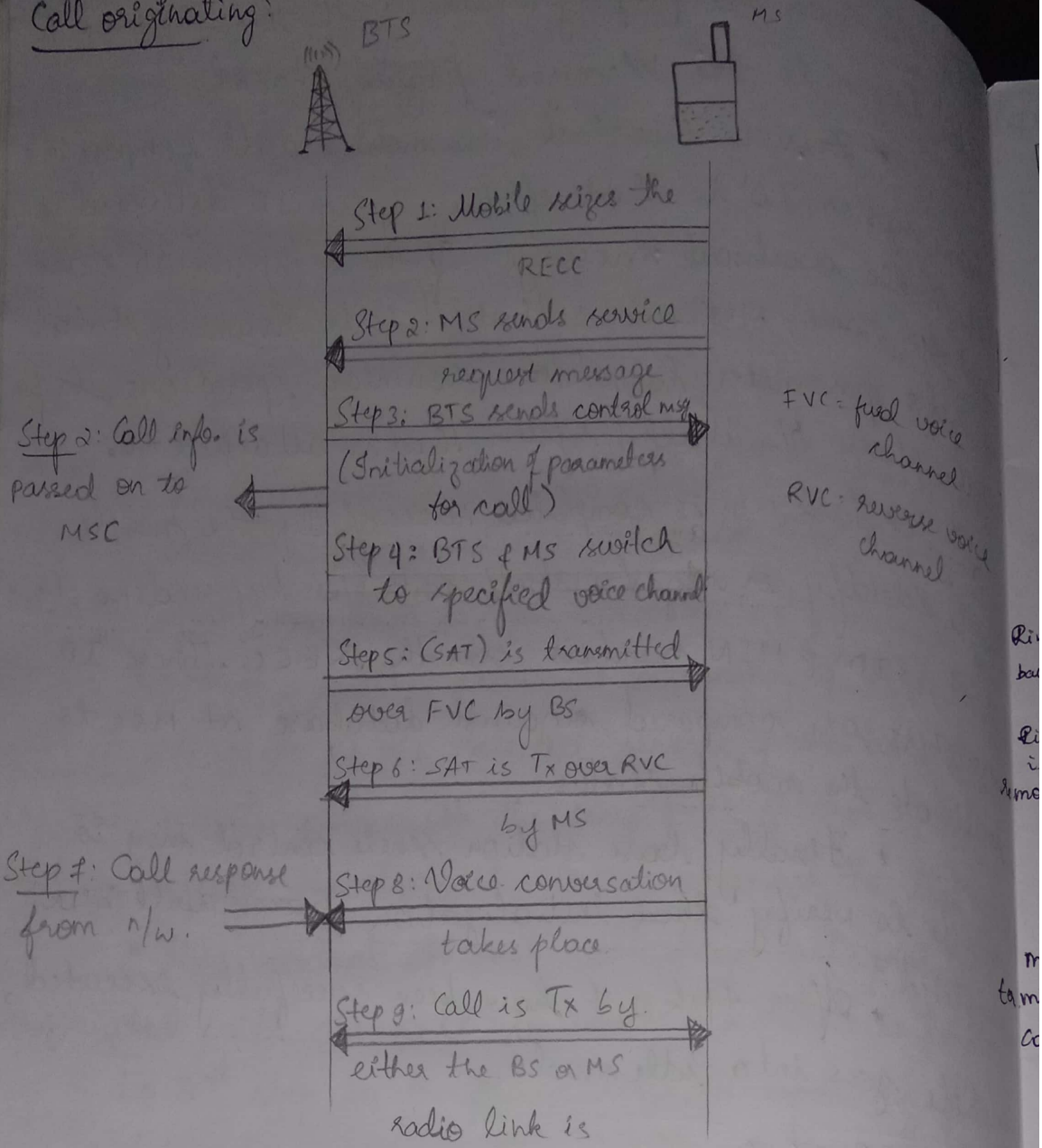
* Finally base station sends control msg to mobile to verify that initialization process will be completed.

* After task 1-7 have been succefully executed, mobile goes into idle mode.

Call originating: Mobile terminated call:



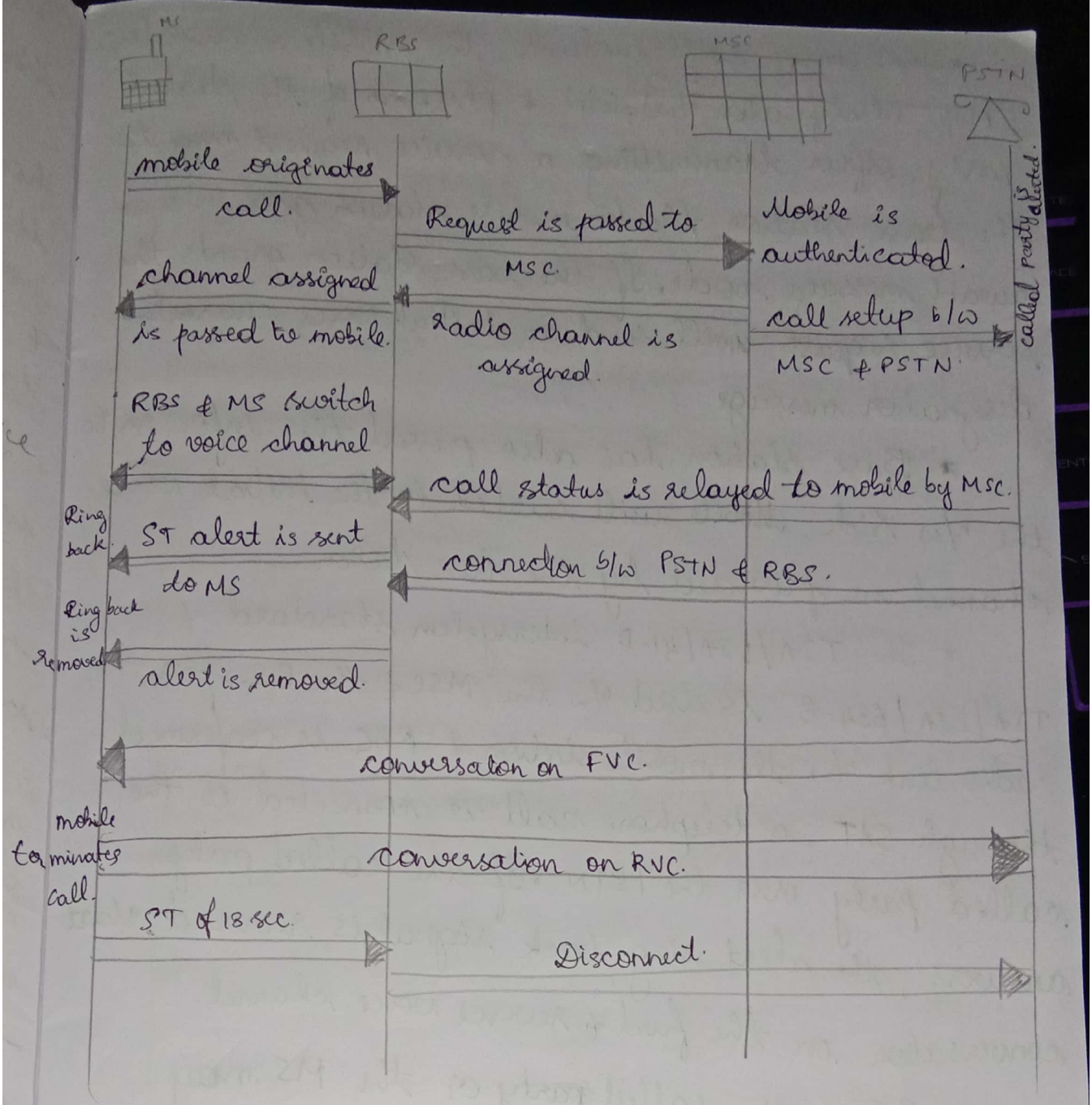
Call originating:



'Call originating'

Basic AMPS operation:

- → Initialization
- → call signalling. (MS↔MS & MS↔PSTN)
- → call terminating → incoming
- → call handoff



* The mobile station can recieve a call or wants to make a call several handshaking messages must be exchanged b/w mobile phone & base station over the various control channels. Figure shows steps needed to complete this task

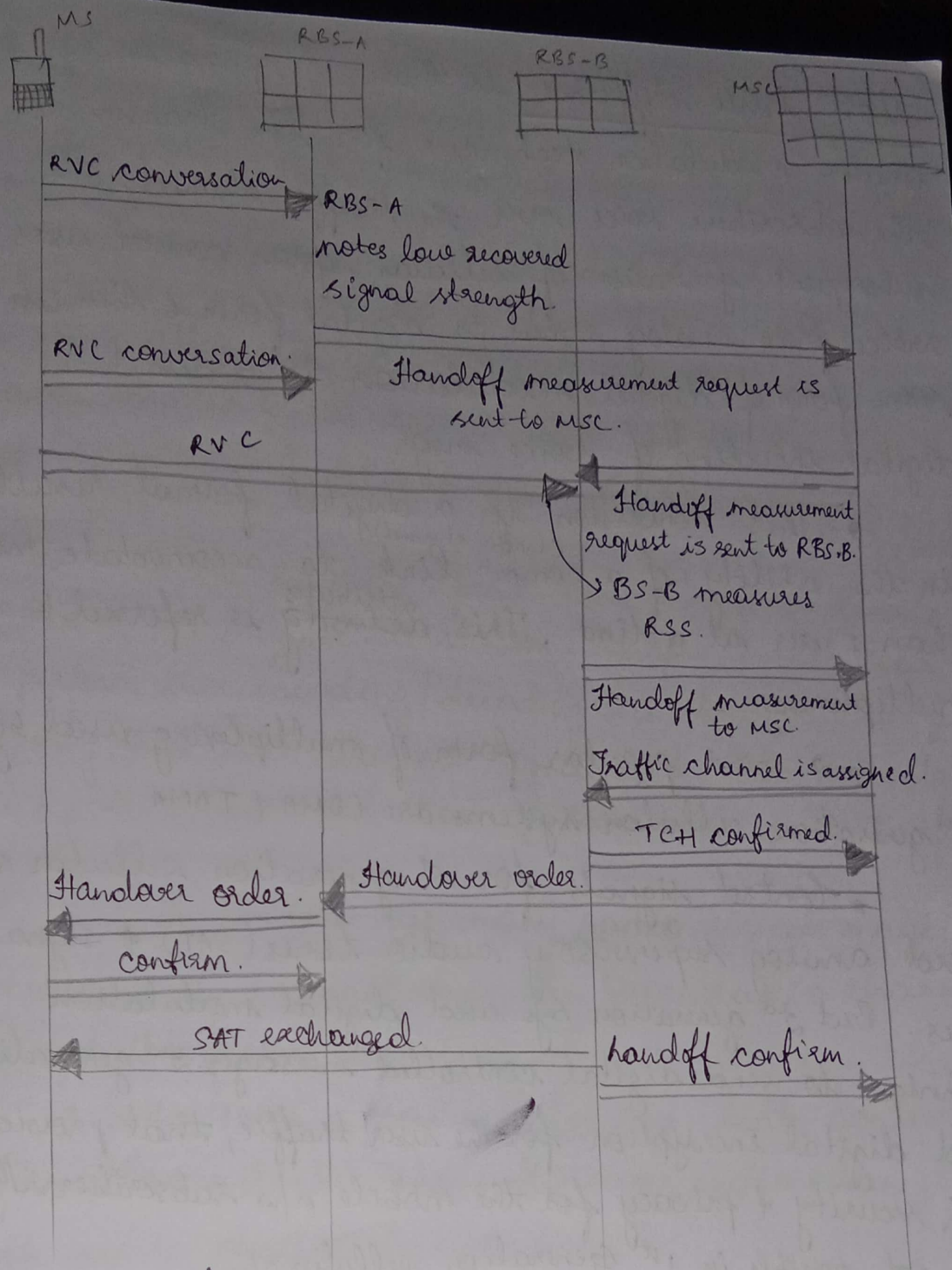
* The mobile station enters system access task mode & then attempts to seize the RECC (Reverse control channel) Once the mobile has ~~reacho~~ seized the RECC it starts to transmit a service request msg to the base station over the RECC.

• This msg will include the mobile stations (MIN) [Mob. identification n/w], ESN & phone no. of the dialed party. After transmitting a service request msg to the base station, the ~~to~~ mobile station goes into an await message mode. If the base station grants the service request will send an initial voice channel designation message.

* Base station has also passed this info. on to the n/w side. Mobile will switch to the initial voice channel no. provided by the base station.

* The TIA/EIA/41-D intersystem standard & TIA/EIA/634-B is used b/w the MSC & the BS. After the radio link b/w the mobile station & RBS is confirmed through SAT, a telephone call is connected to the called party over the PSTN. If the called party answers, the alert ring back signal is removed, start conversation on the fwd & reverse voice channel.

* Either the called party or the MS may terminate the call.



AMPS operations:

- → Mobile phone Initialization.
- → Mobile signating call (MS→MS, MS↔PSTN)
- → Mobile terminating call.
- → call handoff.

Most basic difference is that 1st generation sys used analog modulation technique for the transmission of the subscribers voice over the traffic channel. All subsequent generation of cellular system convert users voice from analog signal to digital form & then use some form of digital modulation to transmit the digital encoding of voice msg.

* This conversion to a digital format results in the ability of a comm^{n} link (traffic channel) to accomodate more than 1 user at a time. This activity attributes. is referred to as multiplexing.

* 2 most popular form of multiplexing used by 2nd generation cellular systems are CDMA & TDMA

* Control signals for 1st generation cellular sys. used analog supervisory audio tones (SAT) & signalling tones. But 2nd generation sys used digital modulation technique to send digital controlled messages. 2nd generation used digital encryption for the user traffic, that provides both security & privacy for the mobile n/w subscriber. This was not possible in 1st Generation cellular n/w.

* Digital encoding & modulation are used for the use of error detection & correction codes to combat the type of fadings & noise effects to the radio channel. to some extent.

* The ability of these cellular sys to support more than 1 user per radio channel is to the use of advanced digital multiplexing techniques.

* TDMA systems (GSM) all use time slots to allocate a fixed periodic time when subscriber

has exclusive use of particular channel.

* GSM sys. uses transmission format with 8 time slots & therefore sys. can support 8 users simultaneously at a time per radio channel.

* CDMA cellular system use a digital modulation technique known as spread spectrum. In this system, at the transmitter each user's digitally encoded signal is further encoded by a special code. ~~At the Rx at the Tx~~ that converts each bit of original digital msg into many bits.

* At the Rx same special code is used to decode or recover the original bit stream. The special code used to perform this encoding/decoding fun' have the unique property that each recieved signal looks like noise to the Rx that does not share the same code as the Tx of the signal.

* ∴ In a CDMA sys. many radio signals maybe simultaneously transmitted in the same radio channel without interfering with each other.

* Either TDMA or CDMA cellular sys. both control information & traffic share the same radio channel. Both are in digital format.

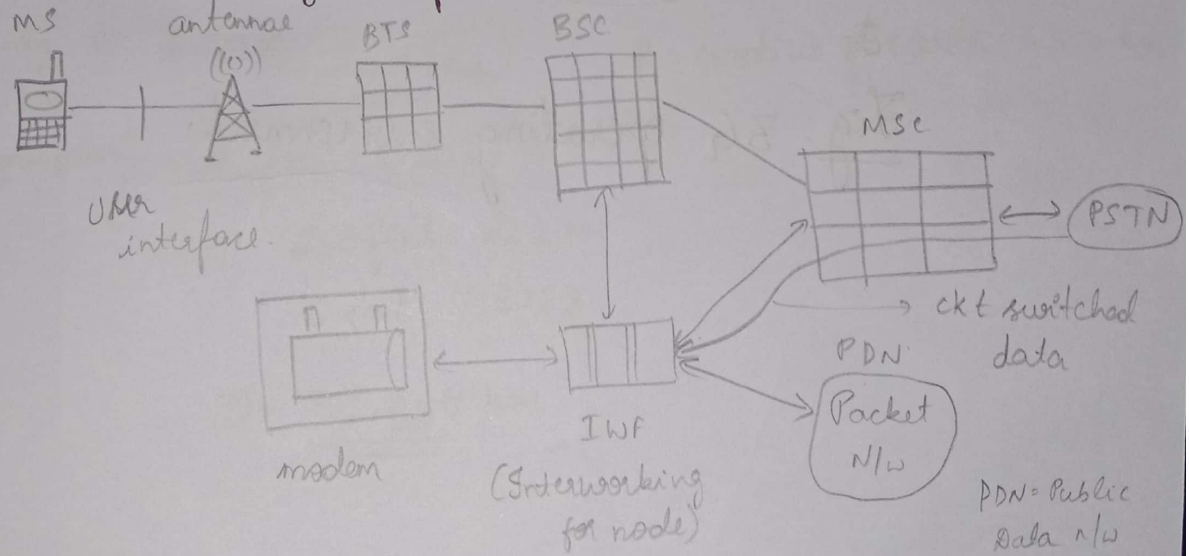


Fig: The CDMA Interworking function node.

* The CDMA system used interworking function node (IWF) component i.e necessary for both ckt & packet data. For ckt switched data, IWF supplies a modem connection to the PSTN & the modem func' is built into the mobile subscriber's CDMA telephone.

* IWF provides interface b/w wireless sys. & the external packet n/w with a max. data rate of 14.4 kbps

3G characteristics:

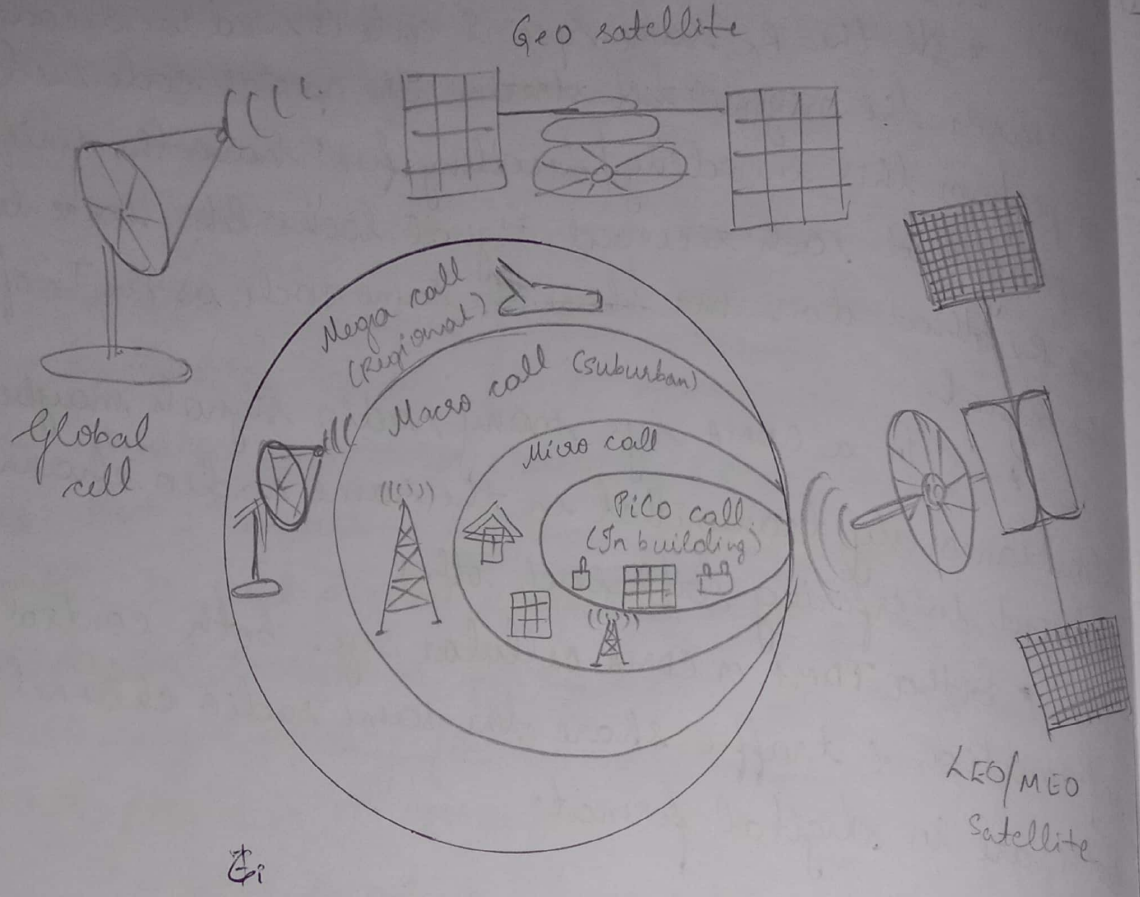


Fig: 3G operating environment.

3G characteristics by cell type, size & data rate.

cell type	Global cell	Mega cell	Macro cell	Micro cell	Pico cell
Maximum cell radius	1000's of km	100-500 km	35km	1Km	50m.
Operating environment	Global	Regional	Suburban (low user density)	urban (High user density)	In buildings
Installation type	Satellite LEO/MEO/ GEO	Satellite LEO/MEO	Tower	Towers	In buildings
Data rate	several Mbps	—"—	144 kbps	384 kbps	2 Mbps.
Max mobile speed (km/h)	N/A	N/A	500	100	10.

(1) Assume that transmitting antennae for the 1st mobile radio telephone sys. was located on a tower at a height of 250 feet. Determine the range of this system assuming line of sight Tx^n, a recieving antennae height of 6 feet.

Given: $h_t = 250$ feet $h_r = 6$ feet

(only for LOS propagation) $D = \sqrt{2R}\left(\sqrt{h_t} + \sqrt{h_r}\right)$ R = radius of earth = 6350 km.

1 foot = 0.3048 m.

250 feet = 76.2 m.

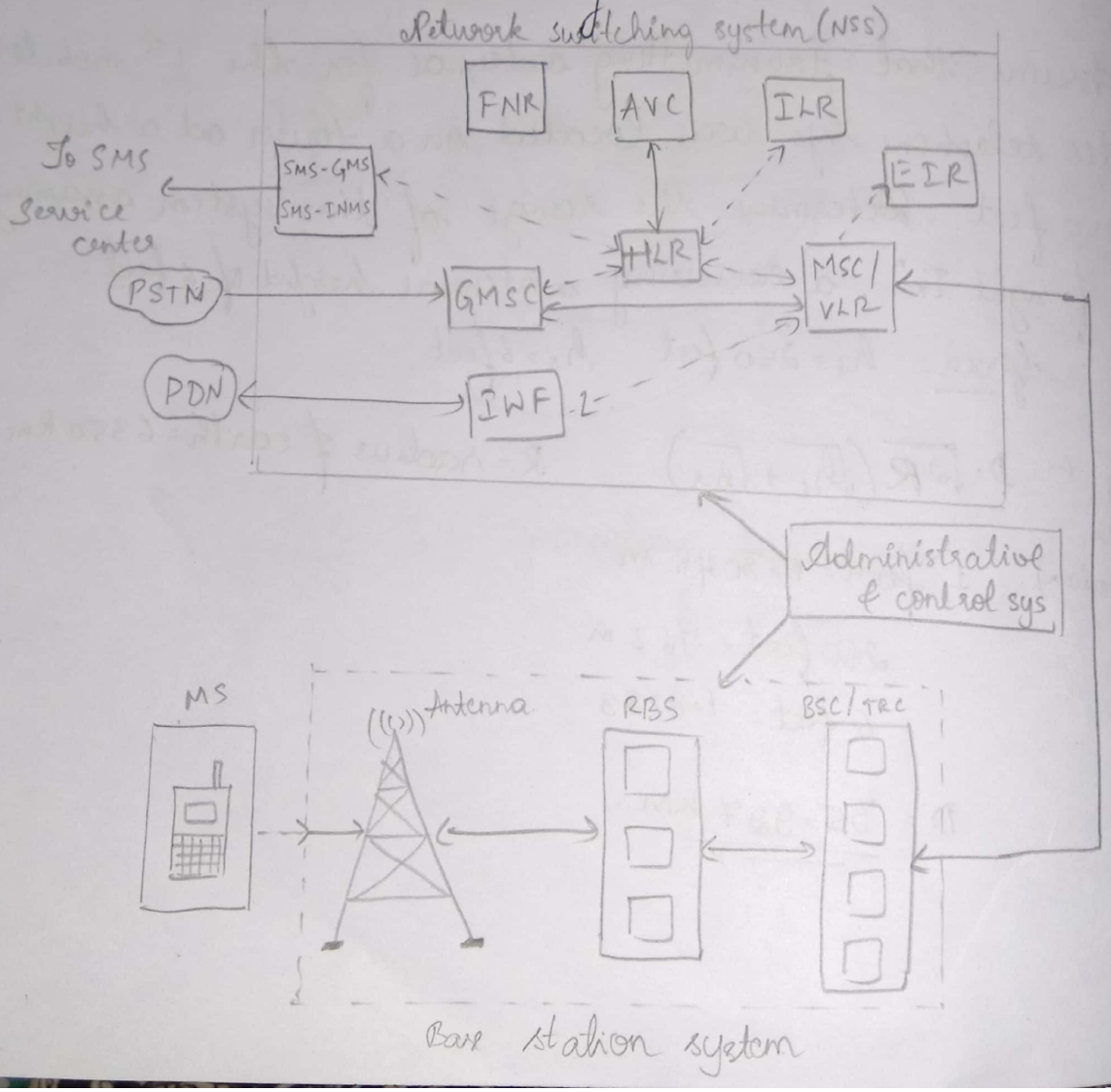
6 feet = 1.8288

$D = 35.927$ km.

Basic characteristics of 4G cellular telephone system:

* 4G mobile communication involves a mix of few new concepts & technology. Goal of 4G is convergence of wireless mobile with wireless access communication technology. This converged system will evolve in response to the issue of bandwidth efficiency, dynamic bandwidth allocation, quality of service, security, next generation digital transreciever technologies, self organising networks.

* 4G mobile networking will require an all IP architecture & connectivity for anyone, anywhere at any time. 4G mobile n/w datarates are expected to reach several Mbps (20M to 100Mbps) & eventually provide ATM speed wireless connectivity



MS → SD : Subscriber Device
RBS → Radio Base station
BSC → Base station control
TRC → Transcoder controller
MSC → Mobile switching center
VLR → Visitor location register
HLR → Home "
EIR → Equipment identity system
ILR → Interworking location register
AUC → Authentication center
FNR → Flexible numbering register
IWF → Interworking function node.
SMS → short msg service
GMSC → Gate message switching center
PSTN → Public switching telephone n/w
PDN → Public Data n/w.

* The common cellular telecommunication sys as shown in fig consist of several subsystem or n/w elements to perform certain operation in support of the entire system. These n/w elements maybe divided into 3 basic groups. a) Mobile / Subscriber device provides the user link to the wireless n/w.

b) Base station system provides wireless system link to subscriber over the air interface.

c) n/w switching system provides the interfaces to the PSTN & PDN with ort info" & connections to locate the subscriber. Provides the databases (VLR, EIR, HLR) & functional nodes used to support the (AUC, FMR, IWF, ILR) mobility management & security opr of the sys.

Switching sys is usually connected to PSTN, PDN

& various data messaging n/w sys to gateway switches. Other typical connections to the switching sys are n/w management sys & other accounting & data entry system.