Different Generations of Wireless Cellular Networks :-

The Different Generations of Wireless Cellular Networks are:-

- 1G
- 2G
- 2.5G
- 3G and
- 4G cellular systems

EVOLUTION OF 1G TO 5G TECHNOLOGY

1G Cellular Systems

- 1G refers to the first generation of wireless telephone technology
- Mobile telecommunications which was first introduced in 1980s and completed in early 1990s.
- It's Speed was up to 2.4kbps.
- 1G network use Analog Signal.
- Ex. For 1G – AMPS(Advanced Mobile Phone Service) - was first launched in USA

AMPS

Introduction:-

- All IG cellular systems used analog frequency modulation schemes.
- System employed is FDD
- ID are given to the cellular system and subscriber device
- Used to determine the mobile status.
- Channel spacing set by FCC

AMPS Characteristics

- AMPS began its operation in 800MHz frequency allotment.
- Downlink band – 824-849MHz
- Uplink band – 869 – 894MHz
- Channel spacing was set at 30KHz.
- Each base stations transmit and receive frequency was separated by 45MHz.
- FCC divided the allocated frequency spectrum band into A and B band.

AMPS Channels:-

- "A" Band- Reserved for companies solely in cellular business
- "B" Band Reserved for existing landline companies.
- A and B bands consists of 333 channels
- A band-333 AMPS channels are divided into 2 sets of channels
- Traffic channels(TCH)- 1-312 – Used for subscriber calls
- Control channels(CCH) -313-333 – used for system control functions
- B band – 334-354 – control channels
- 355 – 666 – traffic channels.
- Also additional 5MHz spectrum will be added later.
- So total 416 traffic and control channels per operator.

AMPS channel numbers and frequencies.

System Band	*Bandwidth in MHz*	*Number of Channels*	*Boundary Channel #s*	*Transmitter Center Frequency in MHz*	
				MS	*BTS*
A	10	333	1 to 333	825.030 to 834.990	870.030 to 879.990
B	10	333	334 to 666	835.020 to 844.980	880.020 to 889.980
A[1]	1.5	50	667 to 717	845.010 to 846.480	890.010 to 891.480
B[1]	2.5	83	717 to 799	846.510 to 848.970	889.510 to 883.970
A[1]	1	33	991 to 1023	824.040 to 845.000	869.040 to 870.00
Not Used	N/A	1	990	824.010	869.010

AMPS system components and layout

3 Components:-

- MS [Mobile Station]
- RBS / BTS [Radio Base Station / Base-Tranceiver Station]
- MTSO [Mobile Telephone Switching office]

and Communication links

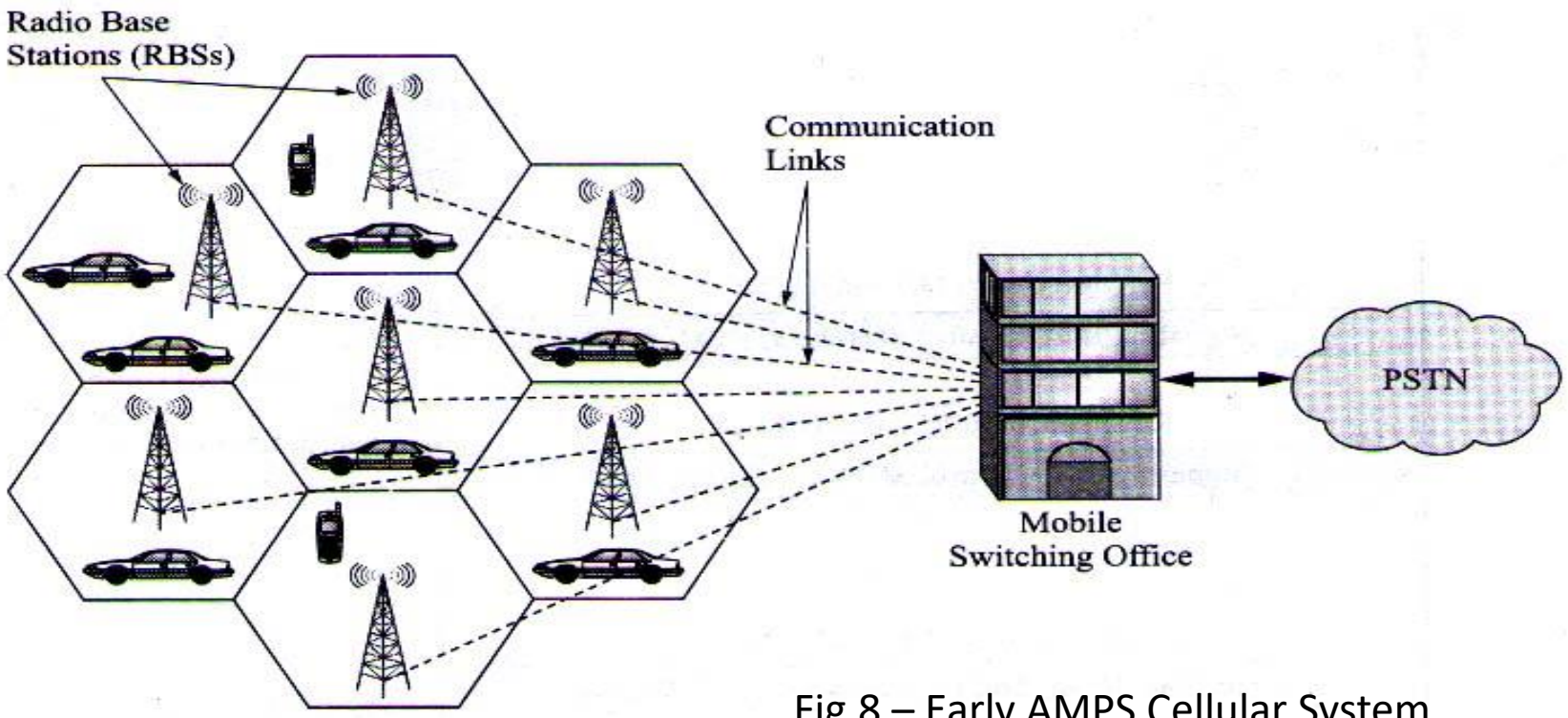


Fig.8 – Early AMPS Cellular System

Typical AMPS operations:-

2 sections of operations.

- Operations performed between the MS & BS
- Operations performed between the BS & MTSO

(1) Basic operations between MS & BS(BTS):-

- 2types of channels are used

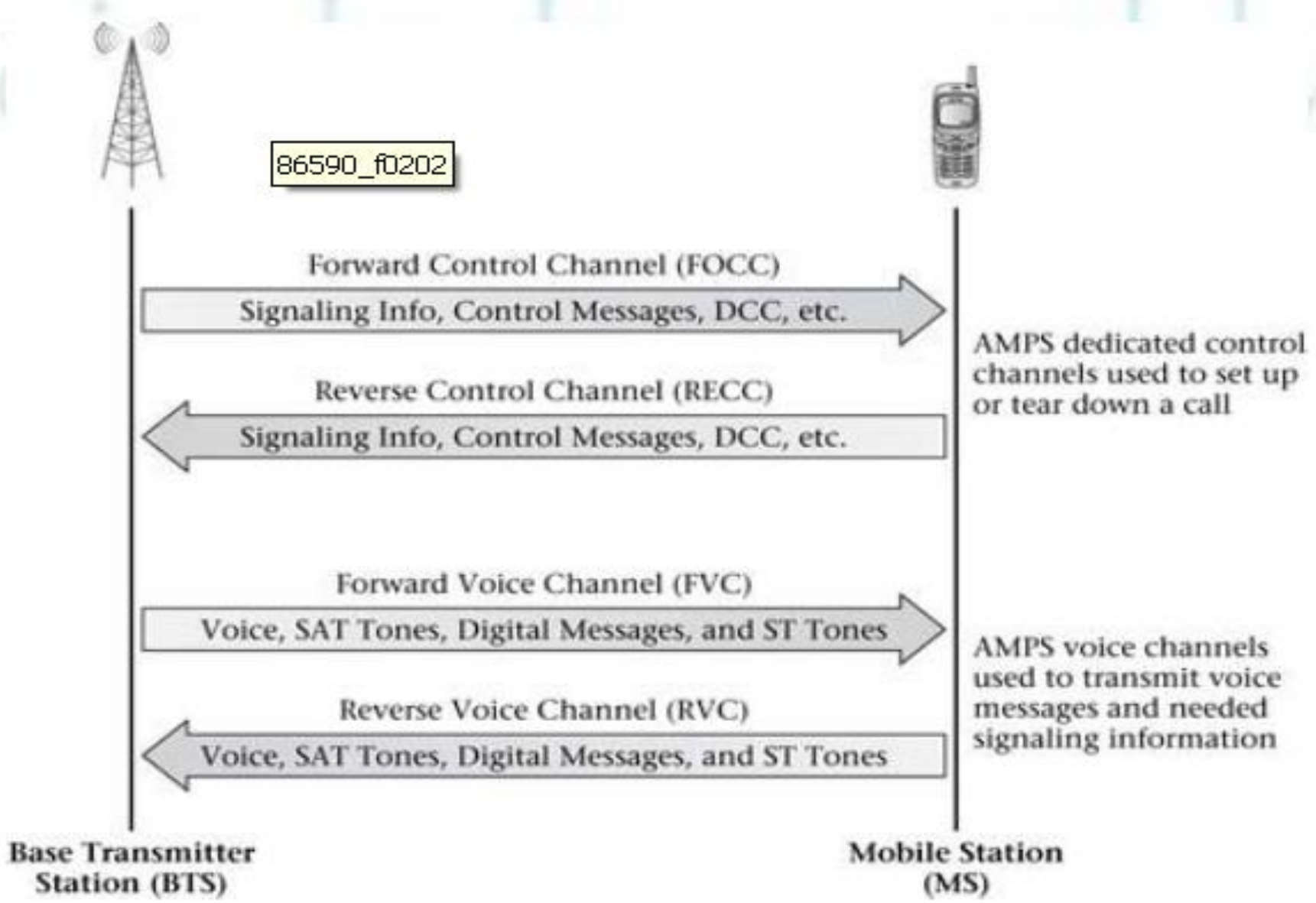
-Control channel – (i) FCC(Forward control channel)

(ii) RCC(Reverse control channel)

- Voice channels – FVC

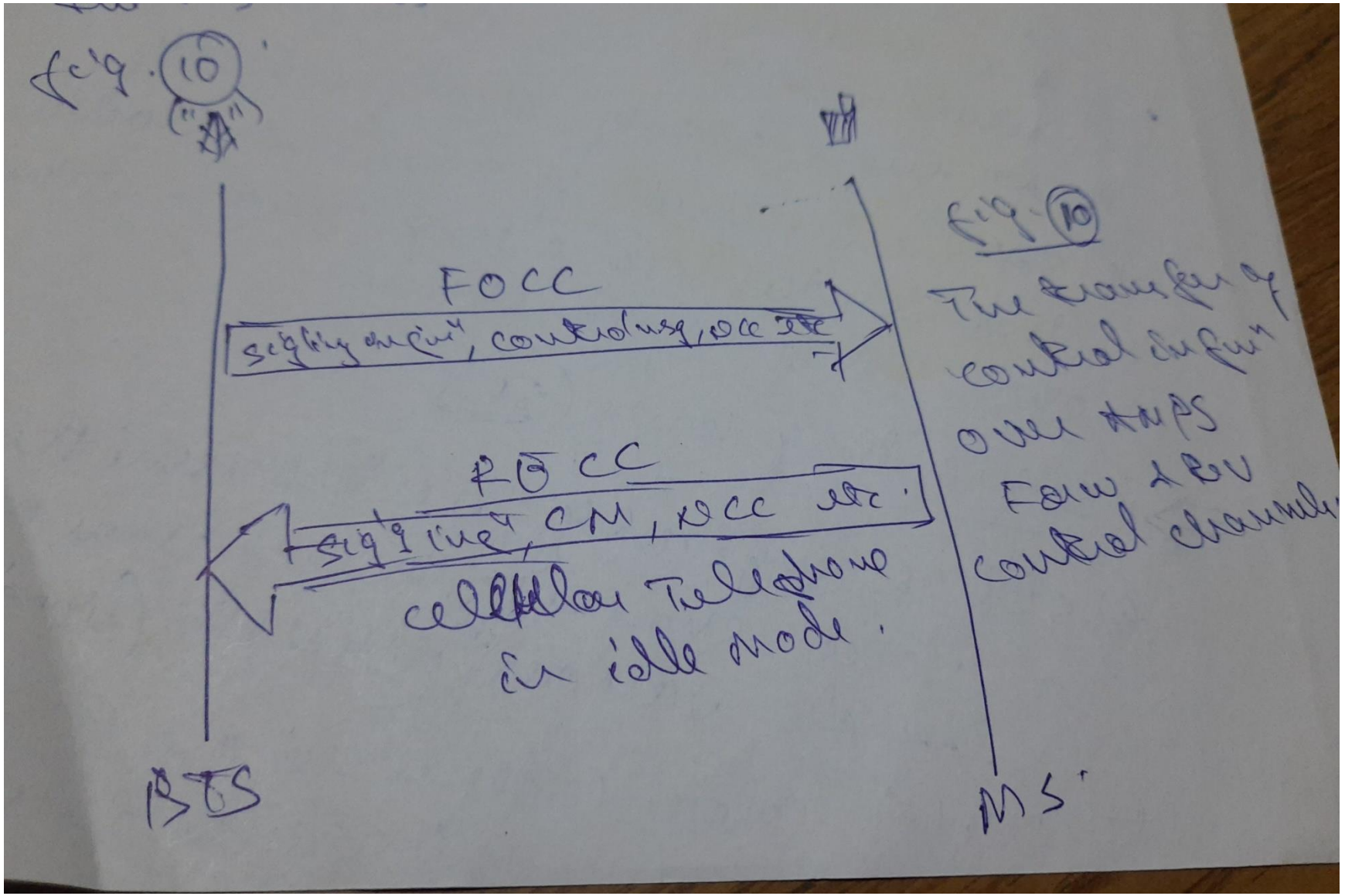
- RVC

Fig - AMPS Forward & Reverse , Control & Voice channels

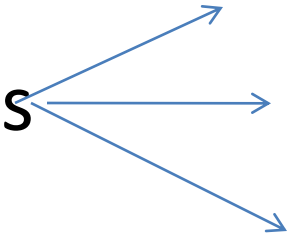


- SAT(Supervisory Audio Tones) or DCC(Digital color code) – 5970Hz,6000Hz and 6030Hz used to know radio link status.
- Base station adds SAT to Forward voice channel(FVC)
- Mobile station adds SAT to RVC.
- If both SAT mismatches, then mobile receiver will be muted.

More details on FOCC:-



- FOCC transmits three data streams in TDM format
- Data streams



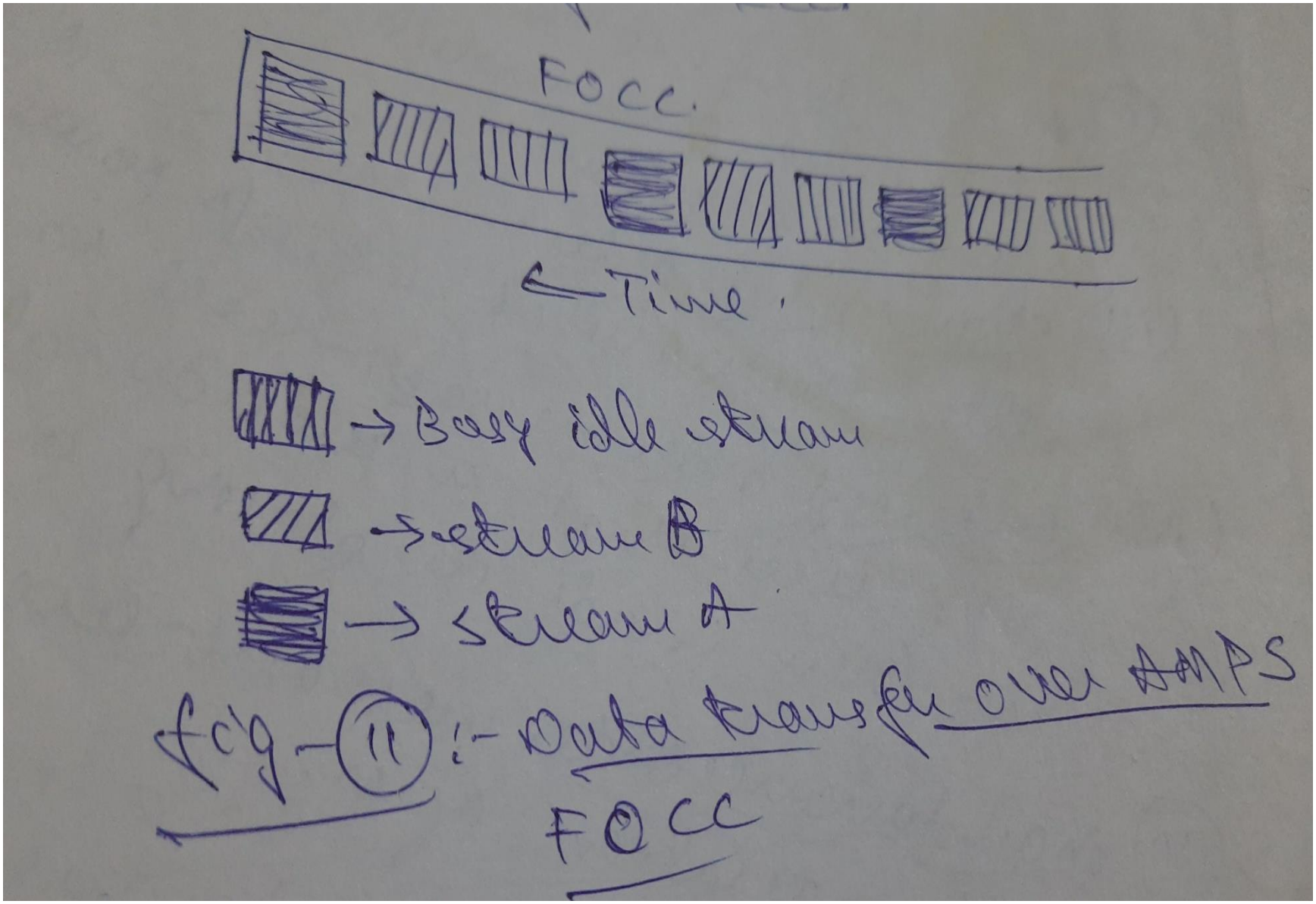
Stream A

stream B

busy idle stream

- LSB = 0 , MIN sent to stream A
- LSB = 1 , MIN sent to stream B
- Busy idle stream tells the status about Reverse control channel.

Fig - Data transfer over AMPS FOCC



FOCC message format:-

- Types of msgs on FOCC
  - over head
  - MS control msgs
  - control filler msgs
- Over head messages – initialization task, system access by mobile station and update by providing latest system parameters.
- MS control messages – order msgs to initiate particular operation
- Control filler messages – used when there is no other message to be sent

Different order messages

- Alert order messages – informs there is incoming mobile call
- Audit order messages – checks for mobile is busy or not
- Change power order message – changes mobile RF output power
- Intercept order message – any errors in placing a call
- Maintenance order message – checks operation of MS
- Release order message – to disconnect call
- Reorder order message – all facilities are in use
- Send called address order message - sends message to base station with dialed digit information
- Stop alert order message – stop alerting the user

AMPS security and identification

- ESN (Electronic serial number) – provided by mobile phone manufacturer.32 bit ID No.
- SID(system identification number) – 15 bit binary no. uniquely assigned, gives status of the mobile
- MIN(Mobile Identification Number) – 34 bit binary no. derived from MS's 10 digit telephone number. 24-bits- derived from 7 digit local number & 10 bits from area code.

10digit= 7 digit local no.(MIN1) + 3 digit area code(MIN2)

Summery of Basic AMPS operations:-

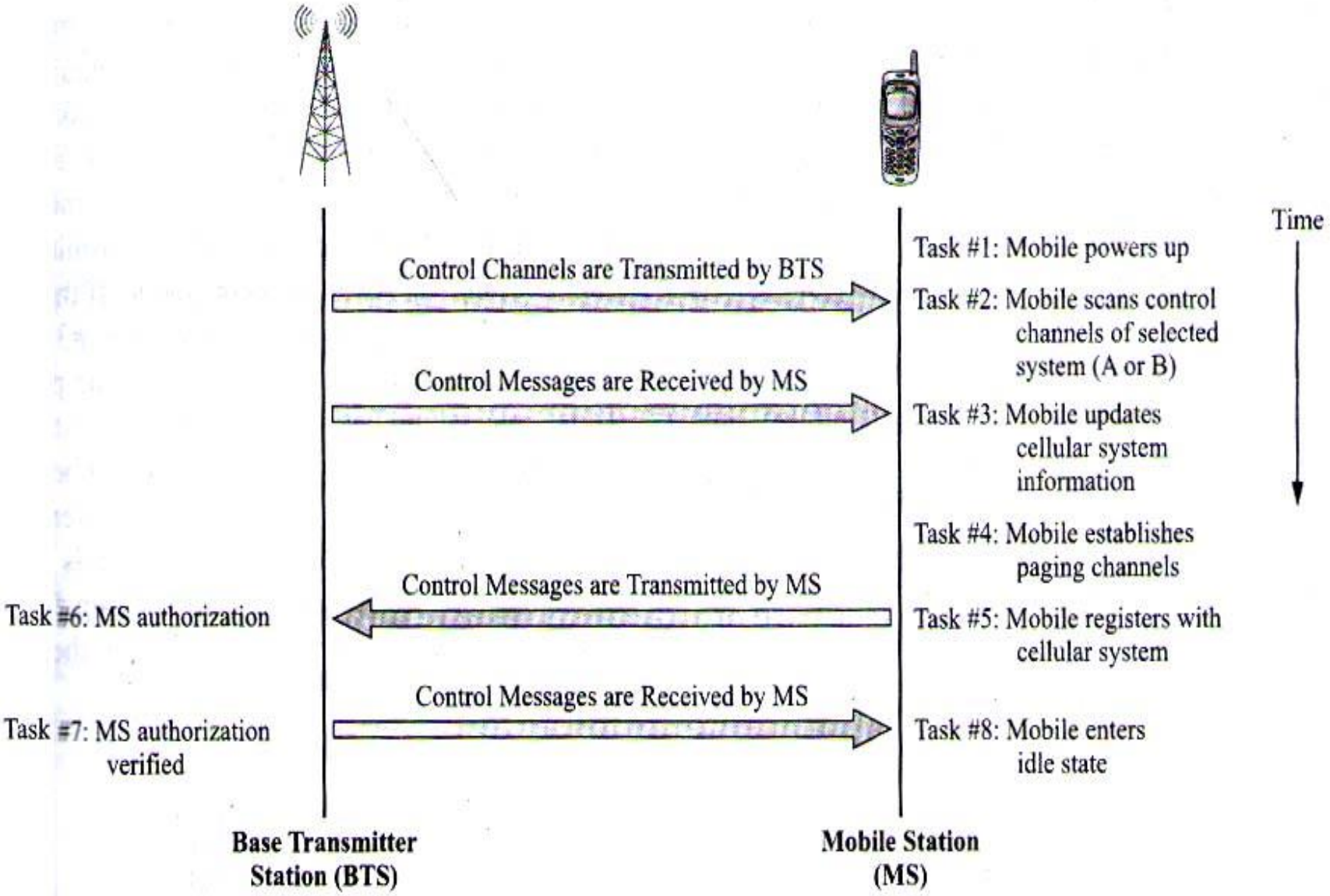
Operations include

- AMPS Mobile phone initialisation
- Mobile generated call
- Mobile terminated call
- AMPS network operations –

  - (i) AMPS network operations for a mobile originated call

  - (ii) AMPS Handoff operations

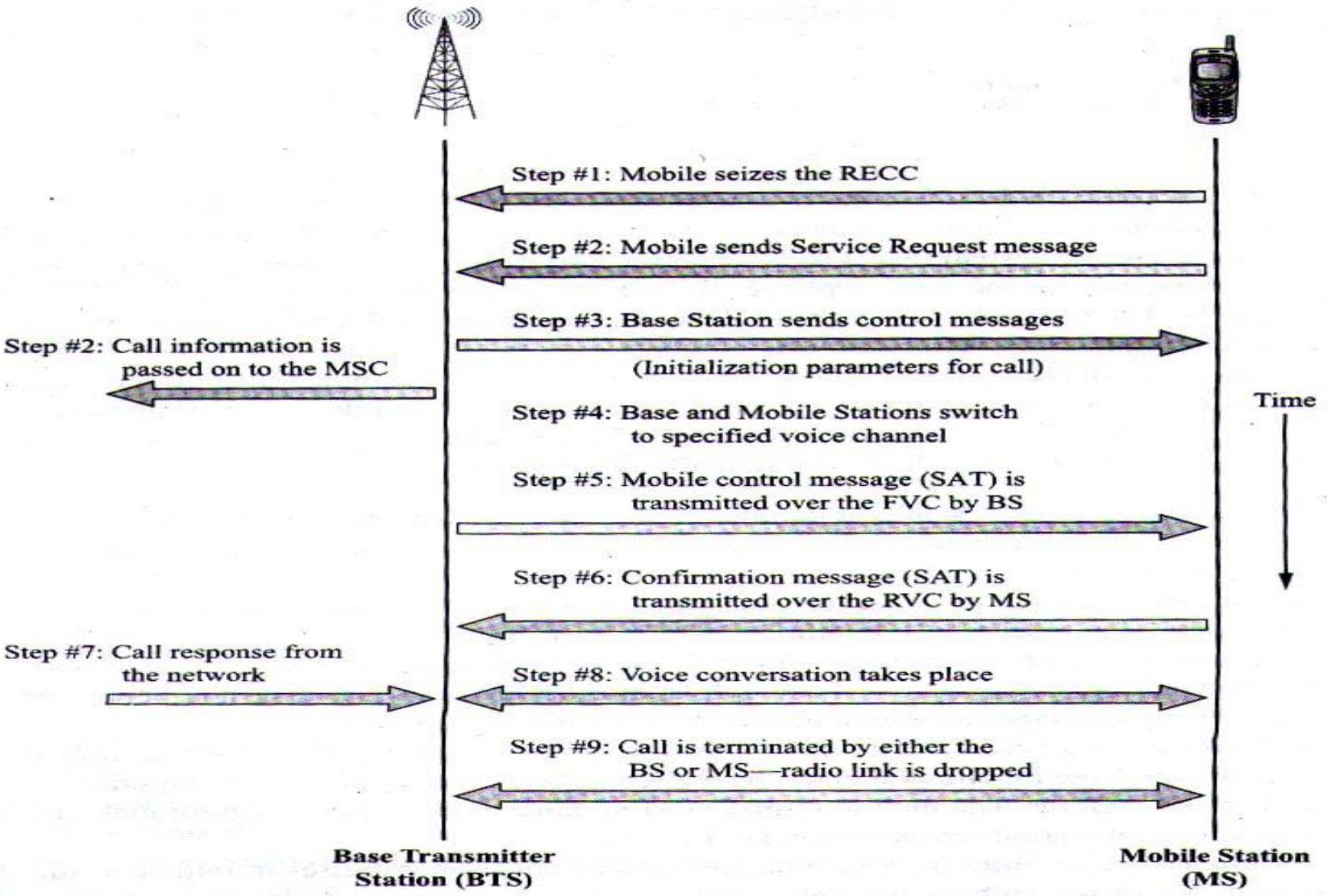
AMPS mobile phone initialization.



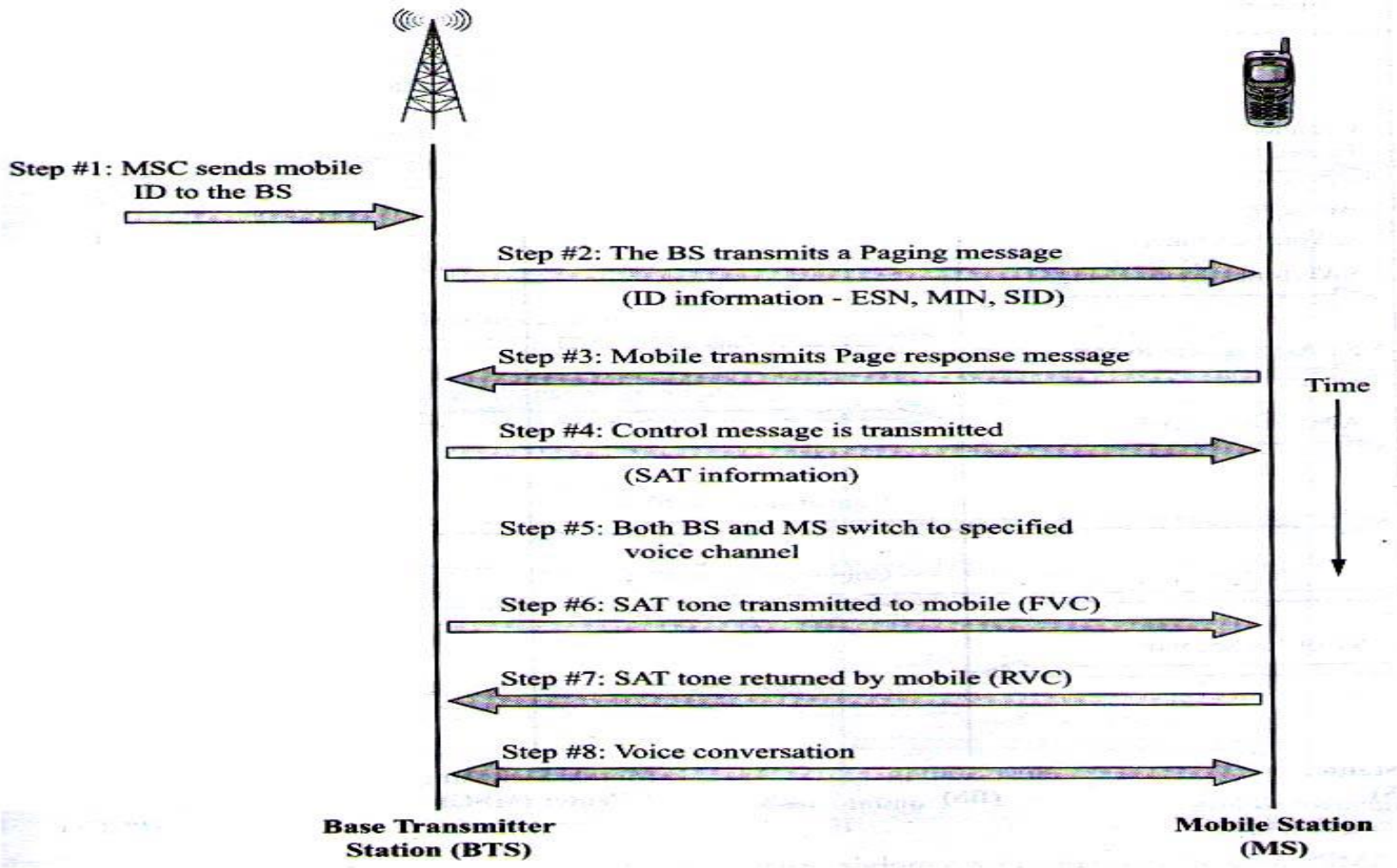
AMPS ongoing idle mode tasks

- Task #1: responds to overhead messages. Checks for present SID and last received SID
- Task #2:Page match:- monitors mobile station control messages
- Task #3:Order: responds to the order message received
- Task #4: Call initialization.

AMPS mobile-originated call (Mobile –to-Land calls)

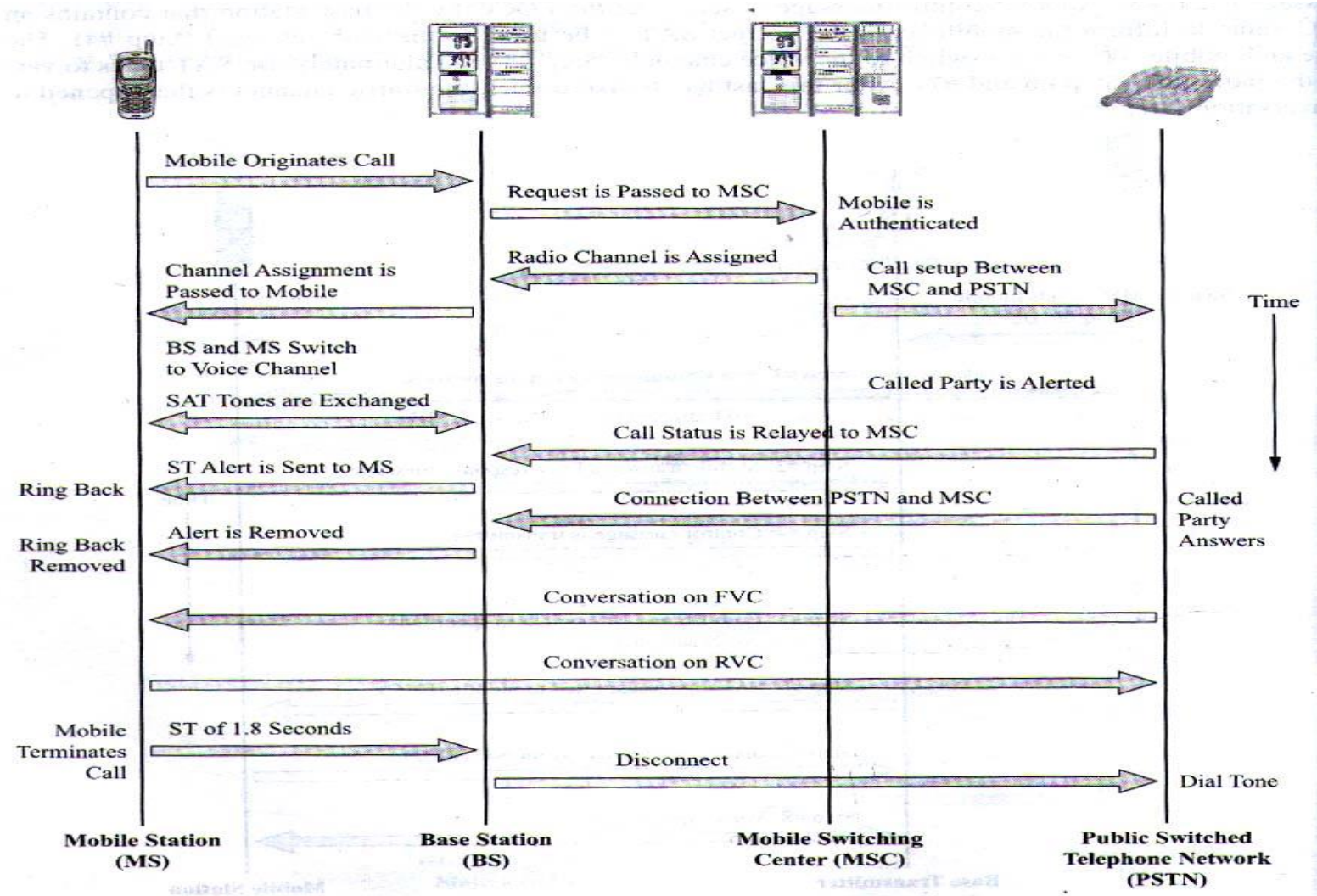


AMPS mobile-terminated call
(Land – to –Mobile and Mobile – to –Mobile call)

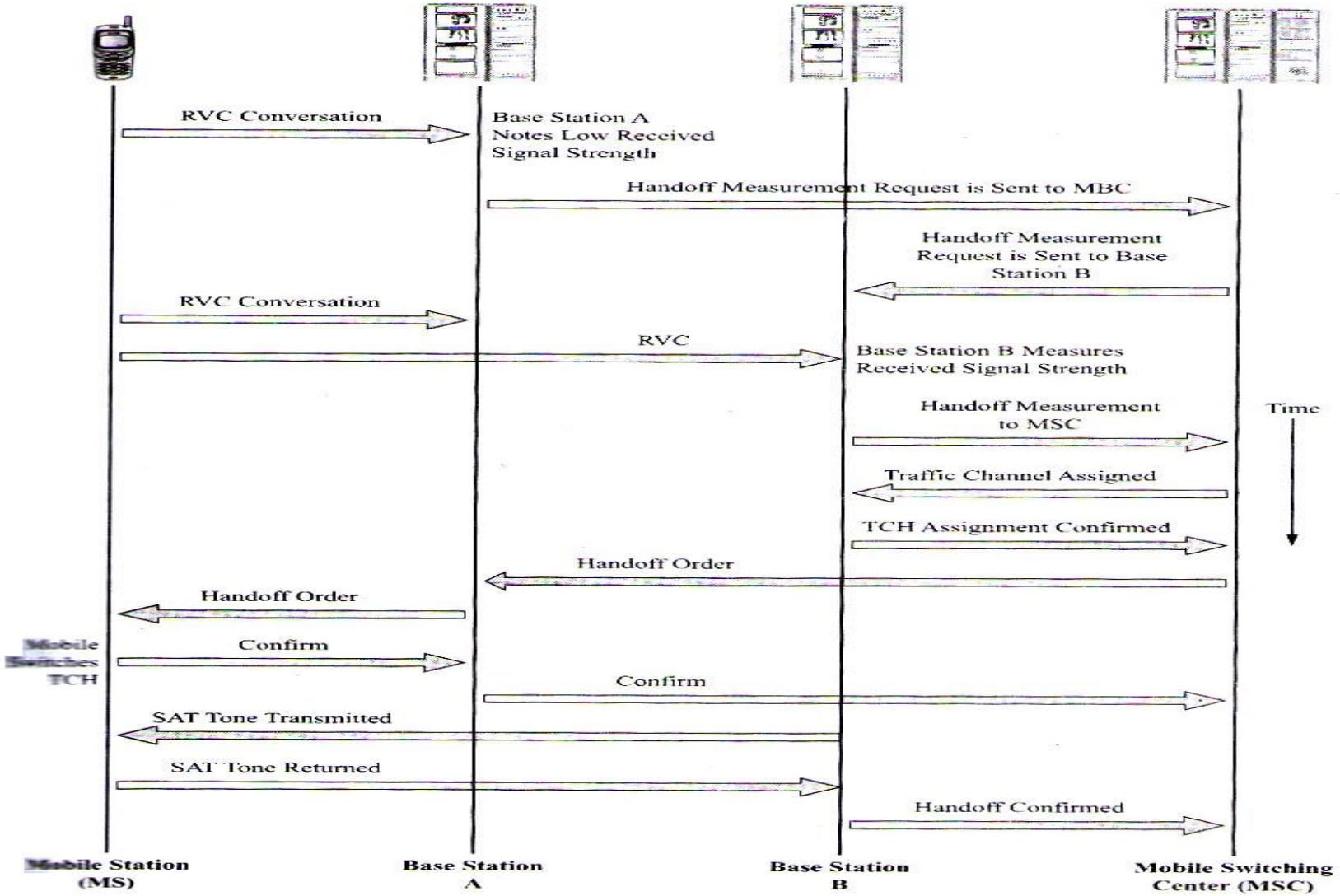


AMPS network operations

(i) AMPS network operations for a mobile-originated call.



(ii) AMPS handoff operation.



AMPS handoff operation.

Other AMPS Details:-

- One other type of information transmitted to BS from the MS in the AMPS system is –

  - SCM(Station Class Mark) – Contains information about the MS's maximum output power(its class) and additional details about MS's ability to support various operations concerning output power changes

Other 1G Systems

- TACS(Total Access Communication System)
- NMT(Nordic Mobile Telephone)cellular system
- NTT(Nippon Telegraph and telephone)cellular system.

TACS(Total Access Communication System)

i) Developed by motorola
ii) Operation began in 1985 in UK
iii) Operated in 800 & 900 MHz band.
iv) 1000 channels
v) Still in use in 25 countries world wide

NMT cellular

- Operated in 900MHz band with channel spacing 12.5KHz
- Across 50 countries world wide

NTT(Nippon telegraph & telephone) cellular

- Began operation at japan in 1979
- 400 & 800MHz band
- Channel spacing 25KHz

Other Analog Cellular Systems

Table 2–2 Worldwide 1G analog cellular systems.

Cellular Standard	*Downlink Frequency Band*	*Uplink Frequency Band*	*Channel Spacing*	*Region*
AMPS	824–849 MHz	869–894 MHz	30 kHz	United States
TACS	890–915 MHz	935–960 MHz	25 kHz	European Union
E-TACS	872–905 MHz	917–950 MHz	25 kHz	United Kingdom
NMT 450	453–457.5 MHz	463–467.5 MHz	25 kHz	European Union
NMT 900	890–915 MHz	935–960 MHz	12.5 kHz	European Union
C-450	450–455.74 MHz	460–465.74 MHz	10 kHz	Germany & Portugal
RMTS	450–455 MHz	460–465 MHz	25 kHz	Italy
Radiocom 2000	165.2–168.4 MHz 192.5–199.5 MHz 215.5–233.5 MHz 414.8–418 MHz	169.8–173 MHz 200.5–207.5 MHz 207.5–215.5 MHz 424.8–428 MHz	12.5 kHz	France
NTT	915–918.5 MHz 922–925 MHz 925–940 MHz	860–863.5 MHz 867–870 MHz 870–885 MHz	6.25 kHz 6.25 kHz 6.25/25 kHz	Japan
JTACS/NTACS	898–901 MHz 915–925 MHz 918.5–922 MHz	843–846 MHz 860–870 MHz 863.5–867 MHz	12.5/25 kHz 12.5/25 kHz 12.5 kHz	Japan

Digital AMPS

- It is an attempt to increase the capacity of the original AMPS cellular system.
- Introduced in North America in 1990’s
- Allows for the Continued use of AMPS bandwidth and many of the AMPS procedures.
- Used TDMA concept

2G Cellular systems

Characteristics of 2G systems

- More than one user per radio channel
- TDMA concept
- 2 major 2G technologies and standards are GSM and CDMA
- GSM used 8 time slots for 8 users per radio channel simultaneously.
- CDMA system used spread spectrum technique

1G V/S 2G

AM for transmission of voice	TDMA & CDMA
SAT & ST tones for system operations	No need of SAT & ST
NO secure	secure
Within a given area roaming was not a problem	Roaming was not problem all over the globe

GSM(Global system for mobile communication)

- Developed in 1991 & began its operation in 1992
- 1993 – 1 million signed up for the service
- 72% registered
- 500 GSM networks were in operation in 174 countries ,early 2004
- Channel spacing – 200KHz,8 simultaneous users per channel, used 900MHz band & later 1800MHz band
- Data rate – 9.6Kbps
- Versions of GSM are GSM 900,1800,850 & 450

CDMA

- Developed by qualcomm corporation
- In 1993, is-95 CDMA standard was adopted
- 1995-operation began
- 13% world wide use this technology

TDMA

- US developed for use of 800 & later for 1900 MHz band.
- Published as IS-136, today known as NA TDMA
- Presently 10% of world uses this technology

PDC(personal digital communication)

- By motorola in 1993, having common air interface
- 5% of worlds cellular subscribers use this technology

PCS(Personal communication services) system

- Used by mobile service providers for commercial purpose called FCC
- FCC allocated 153MHz of spectrum for PCS
- 453 frequency blocks available for basic trading areas
- CDMA, GSM 1900 and NA TDMA used to provide service in these areas

2.5G Cellular systems

- The main drawback in 2G was slow data transmission
- 2.5G uses protocol like EDGE(Enhanced Data over GSM Evolution)
- Used different technologies to increase data services over 2G n/ws

  - CPCD(Cellular Digital Packet Data)
  - HSCSD(High Speed Circuit Switched Data)
  -GPRS(General Packet Radio Service)
  - Packet data over CDMA and other technologies.

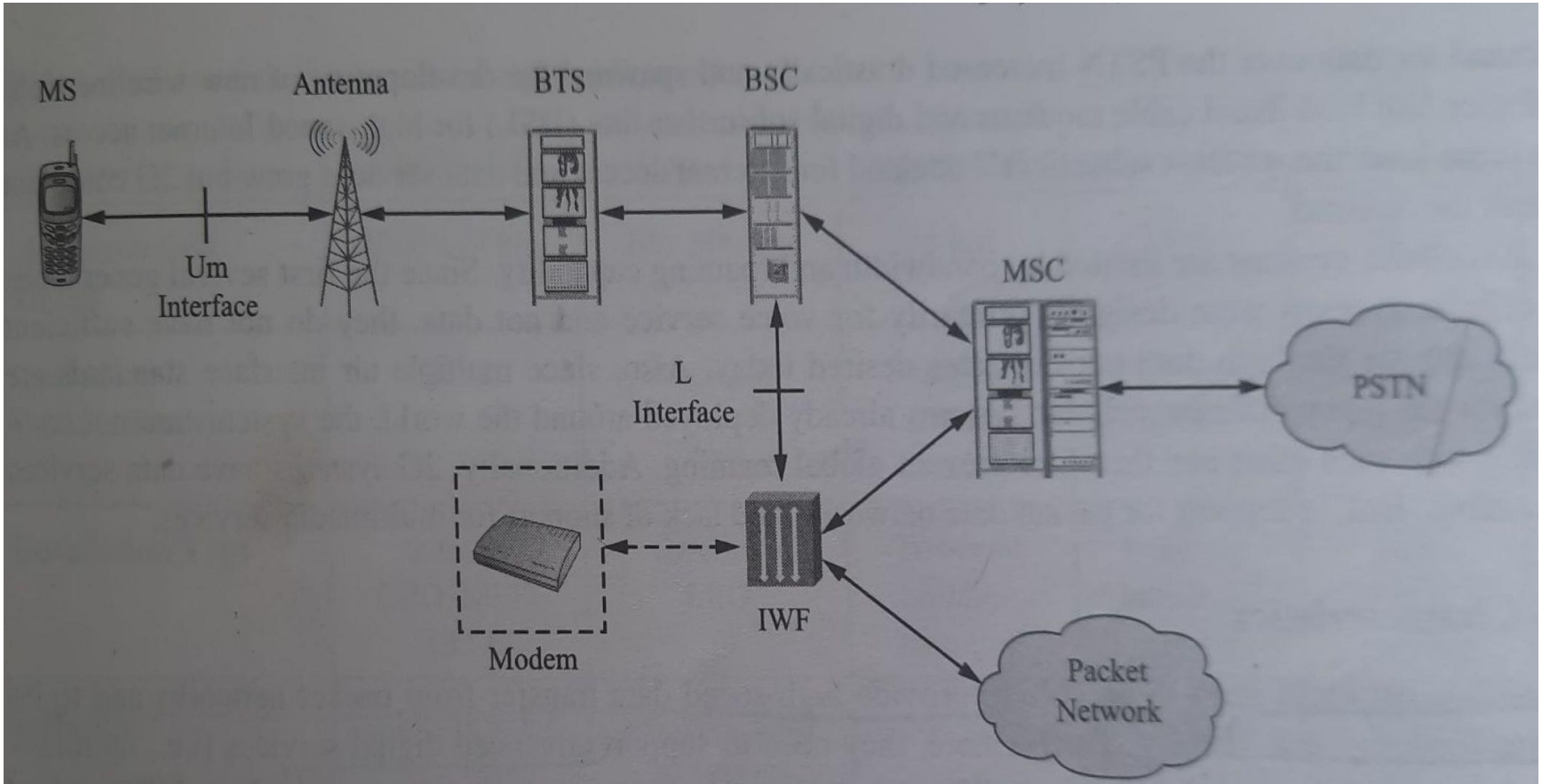


Figure 2–10 The CDMA interworking function node.

3G cellular systems

The “third generation mobile system” or 3G ,

- Used to represent a no. of cellular systems and their associated standards.
- These standards are being facilitated by the ITU(International Telecommunications Union) and other regional bodies as in fig.2.11
- In late 1990s,ITU formed IMT-2000 forum – to address mobile telecommunications needs.

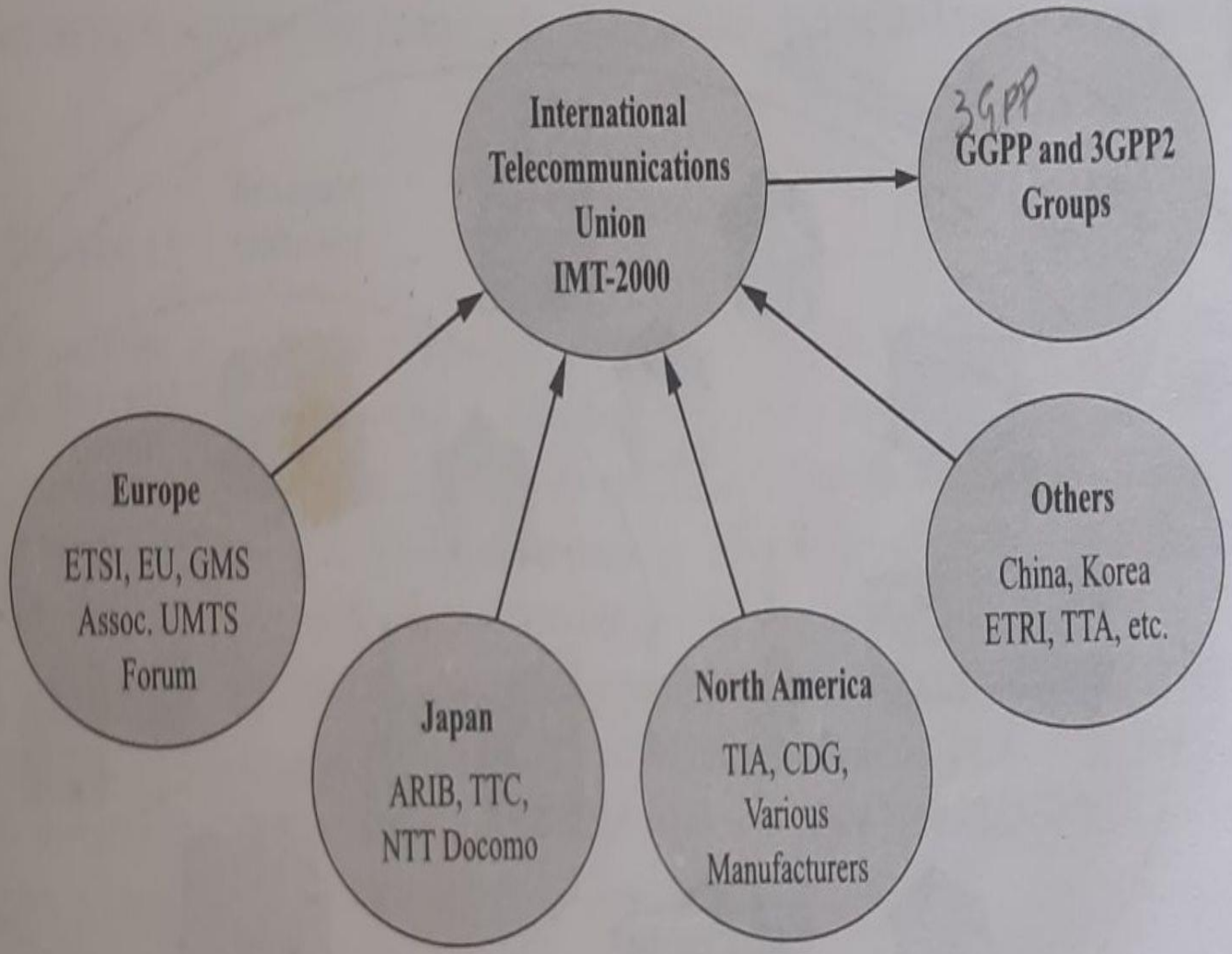
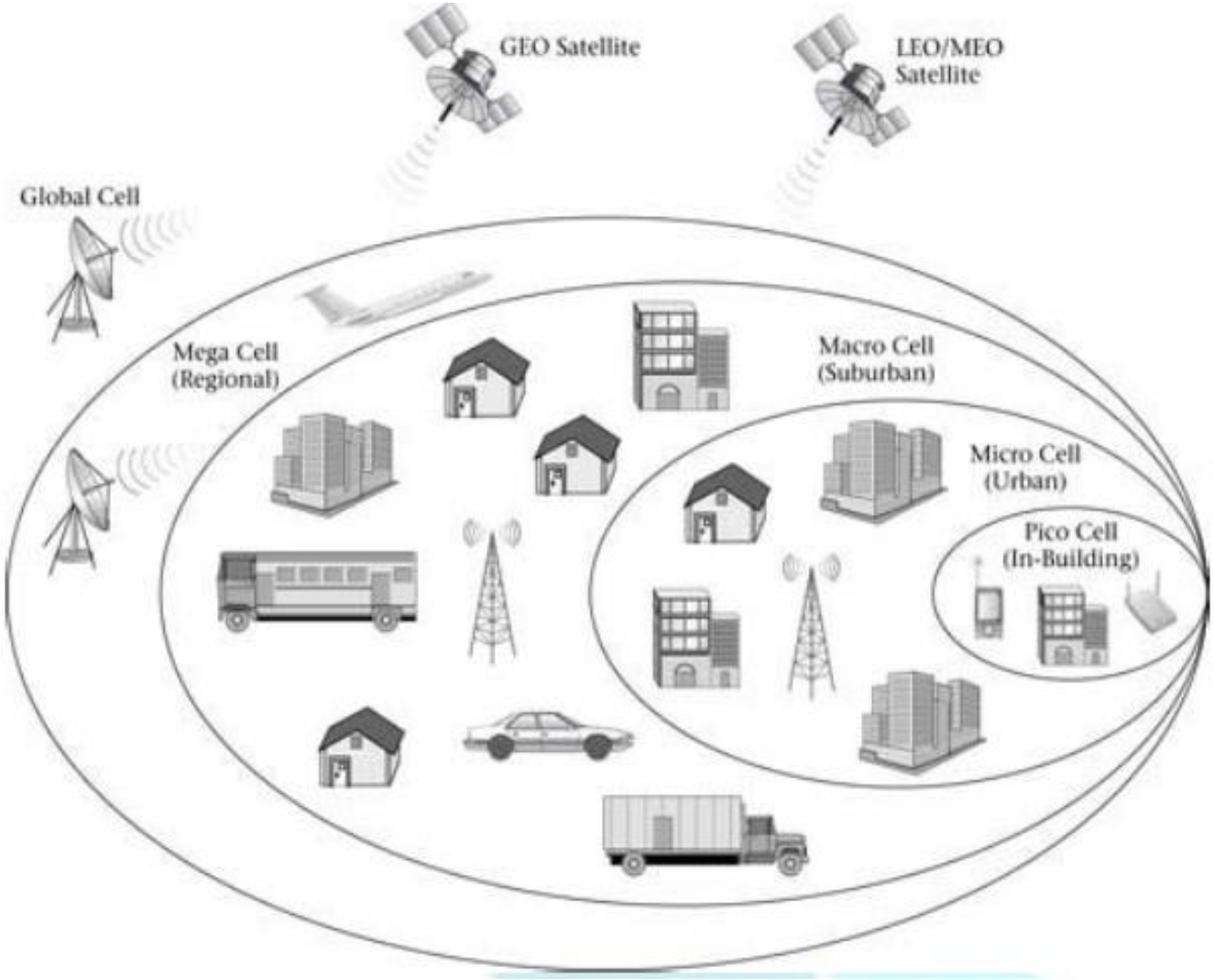


Figure 2–11 Organizations involved with the development of the 3G cellular standards.

3G Characteristics

- Permits high speed data transfer
- Global roaming
- Advanced digital services
- Able to work in different operating environments
- Providing bandwidth on demand
- Multiple simultaneous connection

3G operating Environment



3G Characteristics by cell size and mobile speed

3G characteristics by cell size & mobile speed

Cell Type	Global Cell	Mega Cell	Macro Cell	Micro Cell	Pico Cell
Maximum Cell Radius	1000's of km	100–500 km	35 km	1 km	50 m
Operating Environment	Global	Regional	Suburban (low user density)	Urban (high user density)	In-building
Installation Type	Satellite GEO, MEO, LEO	Satellites LEO	Tower or building mounted	Building facade or lamp-post	Inside of a building
Data Rate	100's of kbps to several mbps*	100's of kbps to several mbps*	144 kbps	384 kbps	2 mbps
Maximum Mobile Speed (Km/h)	N/A	N/A	500 km/h	100 km/h	10 km/h

T02-03

*Not part of the 3G standard

3G radio interfaces

- 2 major 3G cellular technology forwarded by ITU
- 1. CDMA 2000
- 2. UMTS/UTRA

UMTS(Universal Mobile Telecommunication System)

- Evolutionary pathway to 3G for GSM mobiles
- Uses 2GHz band
- Uses combination of wide band CDMA technology & TDD/FDD
- Supports symmetrical & asymmetrical services
- Time division synchronous CDMA is new technology proposed by china wireless telecommunication standards

CDMA 2000

- Supported by telecommunication industry association & by CDMA development group
- Supports data services upto 2Mbps,multimedia services & different radio link bandwidths

*CDMA 2000 → IXEV-DO(data only)

*CDMA 2000 → IXEV-DV(data & voice)

* Data rates of 2.4Mbps on downlink & 153kbps on uplink leading to MP3 & video conferencing possible

UWC-136/EDGE

- Developed by Wireless Communications Consortium for evolution of NA-TDMA cellular system

4G cellular systems & beyond

- Convergence of wireless mobile with wireless access communication technologies
- Leads to bandwidth efficiency
- Dynamic bandwidth allocation
- Quality of service
- Security
- Self organising networks
- Expected to reach over 20Mbps

Wireless standard organizations:-

There are several levels of standard organizations. Both GOVT & are sponsored at the implementation, national, regional & international or global level.

Implementation groups:-

Some of the groups presently active in wireless area are IEEE 802, CDMA development group, UMTS forum, - Committee TR-45 of TIA, - GSM association etc.

Regional organizations:-

Regional organizations developed stds. Govt agencies implementation groups. - have task of providing to stds. Some of well known regional organizations are:-

- European Telecom stds. Inst (ETSI)
- Telecom Tech. committee (TTC)
- Association of Radio Industries & Business (ARIB) - in Japan.
- Telecom Tech. Assoc (TTA) - Korea.
- Comm stds. Assoc (CCSA) - China

- committee T1 – Telecomⁿ (ANSI-T1) – US.
- EIA | TIA (Electronic industries Alliance | Telecomⁿ Industry Assoⁿ).

National organisations.

Most well known national stds organisation that exist in US is "The American National Stds Inst." or ANSI.

- The TIA & EIA develop North American wireless stds & forward them to ANSI for final approval as a natl std. etc.

Global organisations:-

Global std. organizations receive recommendations from regional orgns. These worldwide organisations give final approval for international stds.

There are 3 global std. orgns.

1. International telecomⁿ union (ITU)
2. " stds. orgⁿ (ISO)
3. " Electronical commission (IEC).

Wireless ATM

IEEE 802.20X

5G

THANK YOU