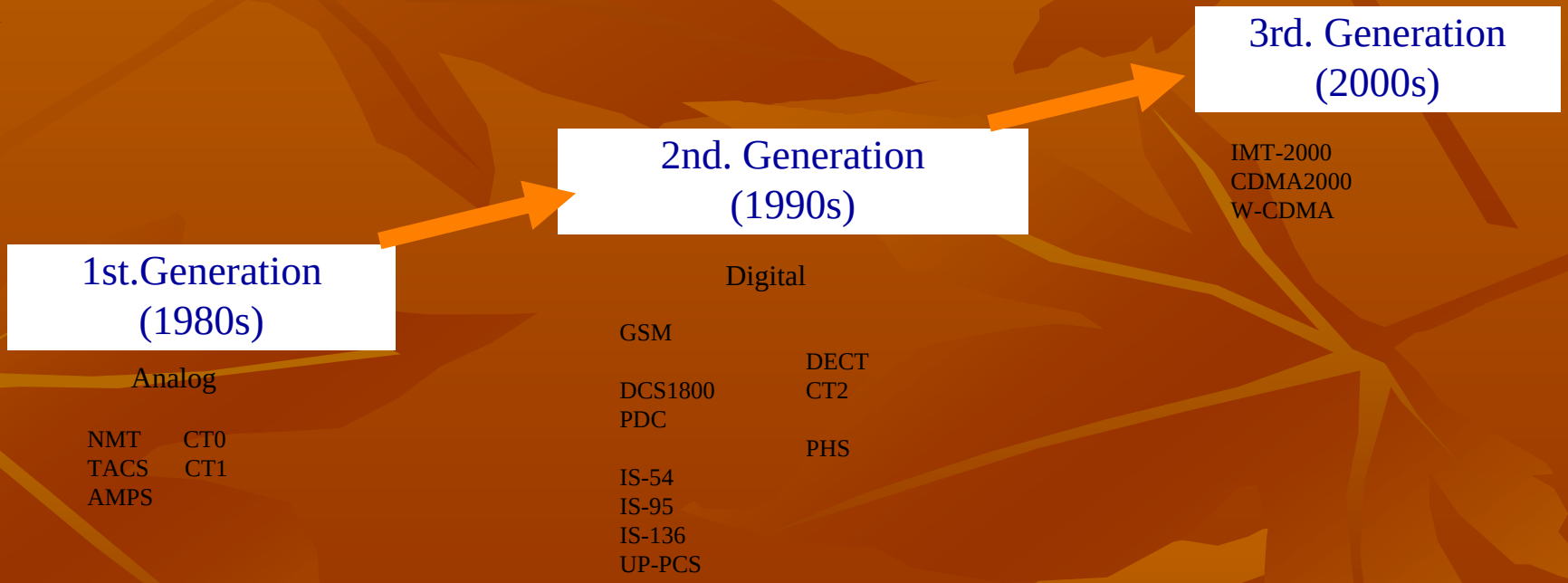
MOBILE COMMUNICATION THROUGH CDMA TECHNOLOGY

MOBILE COMMUICATION HISTORY



Analog Systems (1st Generation)

- **AMPS:** Advanced Mobile Phone Service (US, 800 MHz Band)
- **TACS:** Total Access Communication System (UK , 900 MHz Band)
- **NMT450:** Nordic Mobile Telephone Service (Scandinavian, 450 MHz & 900 MHz Band)

Digital Systems
(2nd Generation) 1990's

- **DAMPS:** Digital AMPS
  (US, 800 MHz Band, IS-54
  IS-136)

- **CDMA:** Code Division Multiple Access System
  (US, 900 MHz Band, 1S-95)

- **GSM:** Global System For Mobile Communication.
  (Europe, 900 / 1800 MHz Band)

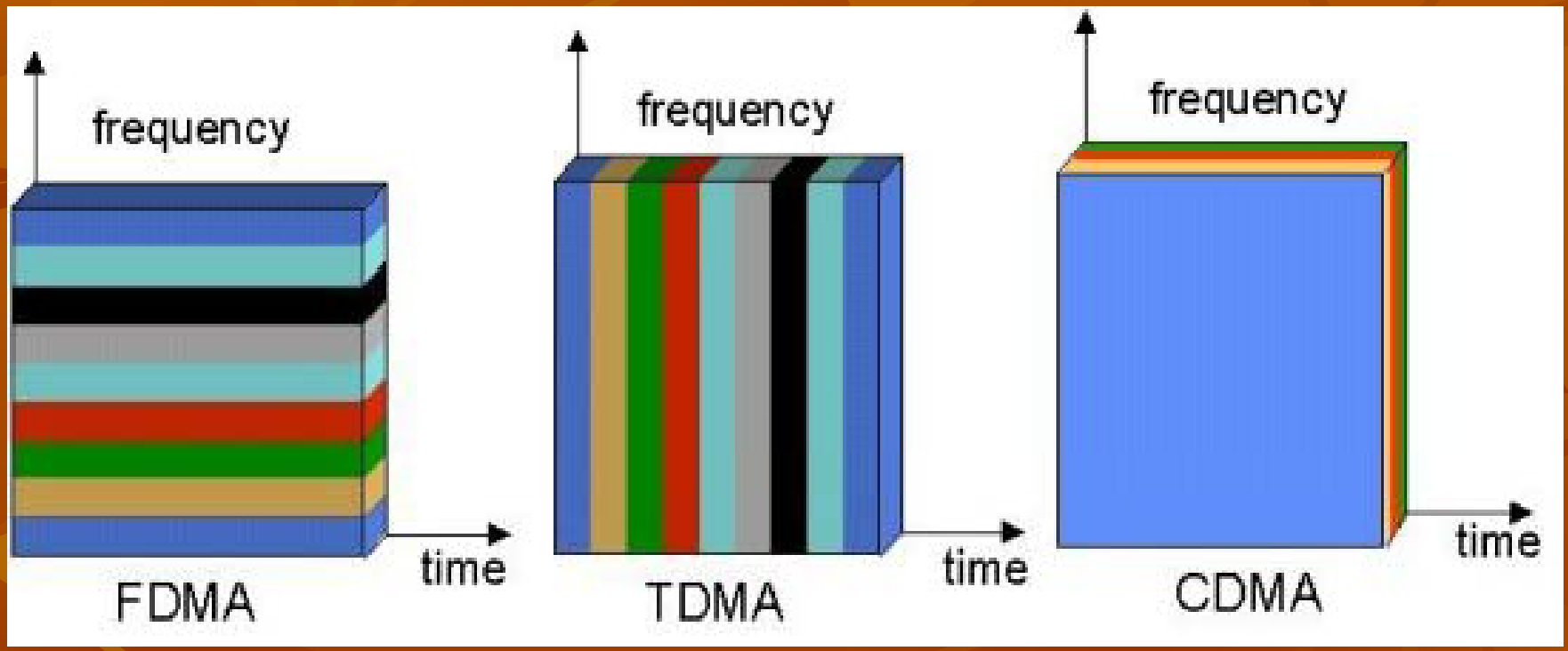
Requirements for 3rd generation Mobile Systems

- High Capacity
- Tolerance for interference
- Privacy
- Tolerance for fading
- Ability to various data rate transmission
- Flexible Quality of Service (QoS)

CDMA

Code Division Multiple Access

- Each user has specified frequency for all time
- Each user has been given a unique code pattern
- From these codes connections are identified.
- This unique code is buried within a shared signal, mingled with other user's code patterns.
- If a user's code pattern is known, the presence or absence of their signal can be detected, thus conveying information.
- Numbers of users are very large


frequency
time
FDMA
frequency
time
TDMA
frequency
time
CDMA

In Technology CDMA Has Plus Point Over GSM, Why?

Because

- CDMA is faster
- CDMA is more secure
- Connection on a CDMA network will never get dropped when moving from cell to cell
- CDMA base stations cover a large area

1 Billion GSM Subscriber's To CDMA's 270 Million

- GSM replaced archaic analogue system
- Late appearance of CDMA
- Adopting CDMA means paying royalty to QUALCOM
- World standard for mobile communication
- Availability of international roaming

FUTURE'S TECHNOLOGY

- GSM & CDMA both are moving towards improved technology based on CDMA technique
- These techniques are Wideband-CDMA & CDMA 2000.

R F OVERVIEW

- What is cell?

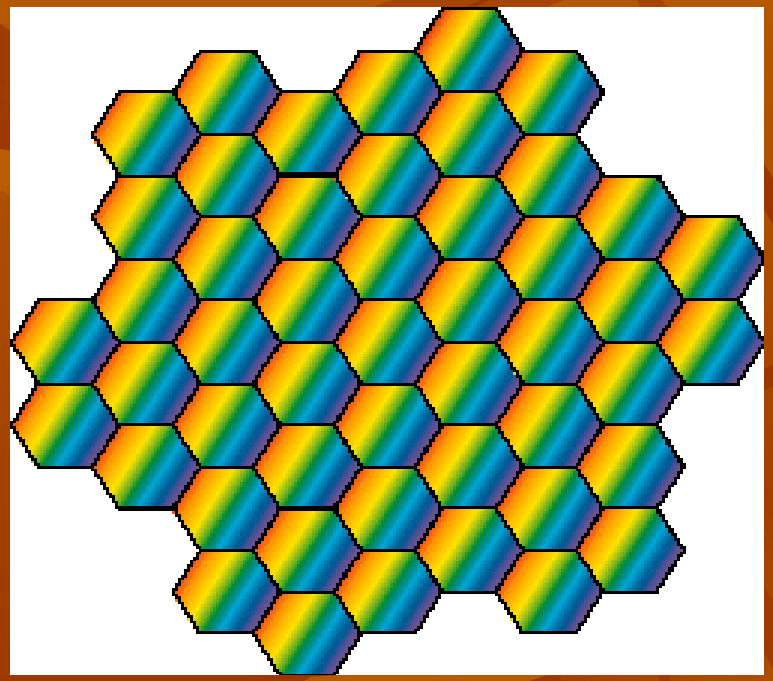
  A cell is a small area of service within a city, serviced by its own antenna.

- Frequency Reuse In CDMA-

  All users use same frequency

  Universal frequency reuse applies to the users in the same cell as well as to those in others

  Complicated reuse pattern is not necessary



Band of CDMA

- The 850MHz CDMA band is most popularly used all over the world
- This band works between

  824-849MHz used for the Reverse link communication

  869-894MHz used for the Forward link communication each of 25MHz.

The total band of 25MHz is divided into small channels of 30KHzeach.An actual CDMA carrier will be using a multiple of the 30KHz channels.

This means for an actually utilized bw of 1.23MH will need 41*30KHz channels.

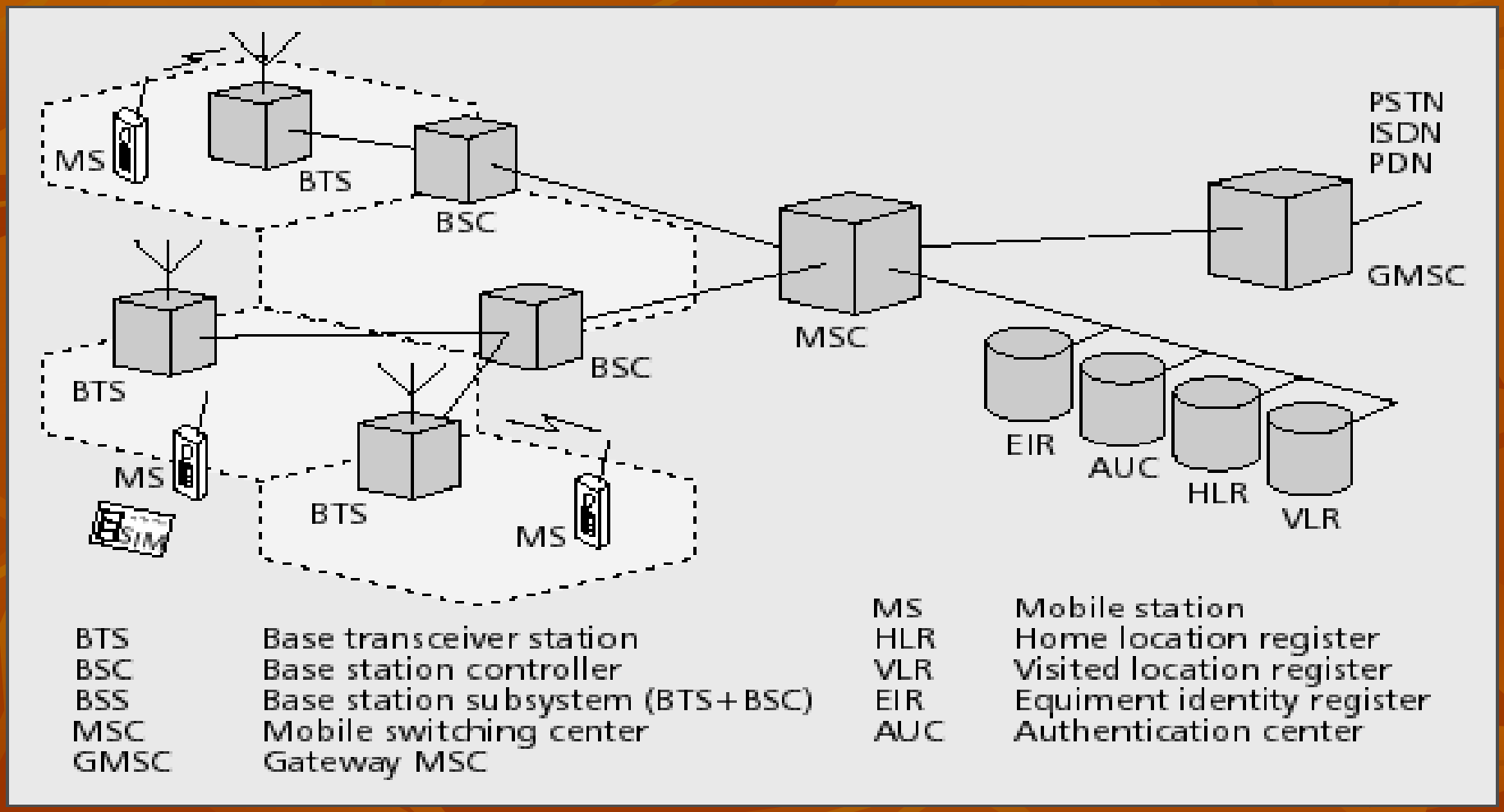
Relationship between the channel numbers and actual freq.

Reverse link frequency =(825+N0.03)MHz

Forward link frequency=(870+N0.03)MHz

N=CDMA Channel Number

CDMA Switch Overview



CDMA Network Architecture

MS(Mobile Switch)

- **This consists of the mobile telephone, fax machine etc. This is the part of the network that the subscriber will see.**
- **The MS consists of two parts, the Mobile Equipment (ME) and an electronic 'smart card' called a Universal Identity module (UIM).**
- **The ME(Mobile Equipment) is the hardware used by the subscriber to access the network. The hardware has an identity number associated with this identity number is called the International Mobile Equipment Identity (IMEI).**
- **The UIM is a card which plugs into the ME or programmed into it. This identifies the MS subscriber. The subscriber is identified by an identity number called the International Mobile Subscriber Identity (IMSI).**
- **Mobile Equipment may be purchased from any store but the UIM must be obtained from the CDMA network provider. Without the it, the ME will only be able to make emergency calls.**

BTS(Base Tranciever Station)

- This is a part of the CDMA network which communicates with MS .
- The BTS contains the RF components that provide the air interface for a particular cell.The antenna is included as part of the BTS.
- The BTS comprises the radio equipment such as transreceivers and antennas which are needed to serve each cell in the network .
- A group of BTSs are controlled by a BSC.
  - BTS in Trans-direction does:
    - Channel Coding
    - Interleaving
    - Frame Building
    - Modulation Up-Conversion
    - Amplification.

Continued...

- **BTS in <u>Receive-direction</u> does:**
  - **Down-Conversion**
  - **Demodulation**
  - **De-Scrambling**
  - **Decoding**
  - **Digital to Analog (D/A) conversion.**
- BTS is usually located in the center of the cell.
- BTS has 1 to 16 RF channels. These channels are to be different from those of the adjacent cells
- It **acts as mobile interface** to the cellular network.

BSC(Base Station Controler)

- The BSC manages all the radio-related functions of a CDMA network.
- It is a high capacity switch that provides functions such as MS handover,radio channel assignment and the collection of cell configuration data.A number of BSCs may be controlled by each MSC.
  - Performs radio resource management
    - Assigns and releases frequencies and time slots for all the MS's in its area
    - Reallocation of frequencies among cells
    - Hand over protocol is executed here.
    - Time and Frequency Synchronization signals to BTS's.
    - Time Delay Measurement and notification of an MS to BTS
    - Power Management of BTS and MS.

HANDOVER

Handover occurs when a call has to be passed from one cell to another as the user moves between cells. In a traditional "hard" handover, the connection to the current cell is broken, and then the connection to the new cell is made. This is known as a "break-before-make" handover. Since all cells in CDMA use the same frequency, it is possible to make the connection to the new cell before leaving the current cell. This is known as a "make-before-break" or "soft" handover. Soft handovers require less power, which reduces interference and increases capacity.

MSC(Mobile ServicesSwitching Centers)

- **The MSC is included in the CDMA system for call-switching. Its overall purpose is the same as that of any telephone exchange.**
- **Each MSC provides service to MSs located within a defined geographic coverage area.**
- **One MSC is capable of supporting a regional capital with approximately one million inhabitants. An MSC of this size will be contained in about half a dozen racks.**

GMSC(Gateway Mobile Services Switches Centers)

- Connects mobile network to a fixed network.
- Entry point to a **PLMN.**
- Usually one per **PLMN.**
- Request **routing information** from the HLR and routes the connection to the local MSC

MSC(Mobile ServicesSwitching Centers)

- The functions carried out by the MSC are listed below:
  a. Call Processing
  b. Operations and Maintenance Support
  c. Billing
- Signaling protocol with BSC.
- Paging and Short Message Services.
- Routing of traffic and signaling.
- It undertakes Radio Resource Management.
- Verifying IMSI, Authentication, Interrogation of HLR.

HLR(Home Location Register)

- n/w database that stores and manages all mobile subscriptions belonging to a specific operator.
- The information stores includes:

  . Subscriber identity.

  . Subscriber supplementary services.

  . Subscriber location information.

  . Subscriber authentication information.
- The HLR is a centralized

VLR(Visitor Location Register)

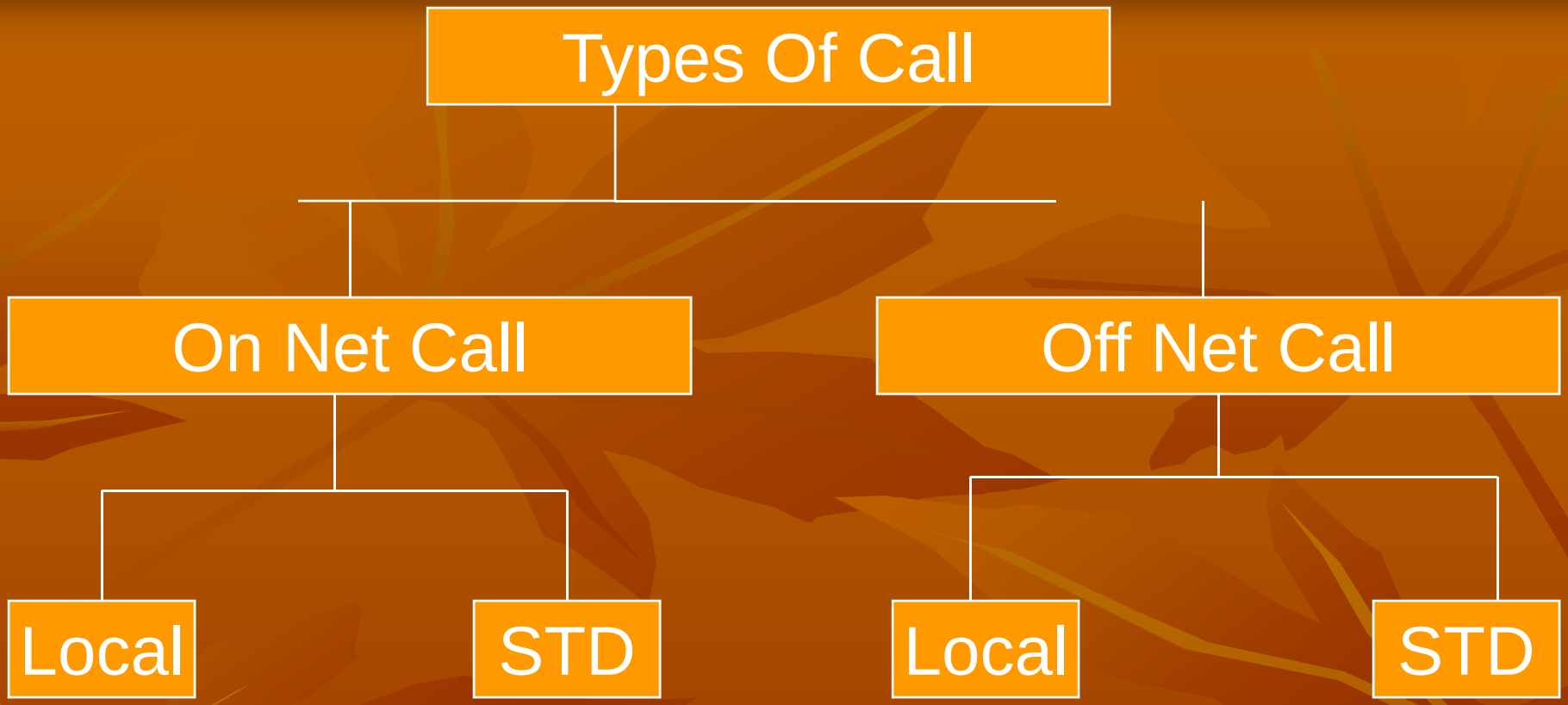
- **The VLR database contains information's about all mobile subscribers currently located in an MSC service area.**
- **There is one VLR for each MSC in a network.**
- **When a subscriber roams into new MSC service area, the VLR connected to that MSC requests information about the subscriber from the subscriber's HLR.**
- **The HLR sends the copy of the information to the VLR and updates its own location information.**
- **When subscriber makes a call,the VLR will already have the information required for call set up.**

EIR & AuC

- **Equipment Identity Register (EIR):**
  - Contains three lists for IMEI check:
  - White list – contains mobile equipment approved without restriction.
  - Grey list – contains the equipment to be observed.
  - Black list – contains the unapproved equipment.
  - EIR checks whether the IMEI fits into one of these lists and passes result to MSC. For example, if mobile fits into the black list, it cannot participate in the call setup.
- **Authentication Center (AuC):**
  - Security related functions.
  - Verifies individual parameters assigned to each mobile subscriber.

CALL FLOW

- **Mobile Subscriber ISDN (MSISDN):**
  - **Country Code (CC)** (Up-to 3 decimal places)
    National Destination Code (NDC) (2 to 3 digits).
    Subscriber Number (SN) (Max up-to 10 digits).
  - A subscriber can hold several ISDN's for selection of different services.
- **International Mobile Subscriber Identity (IMSI):**
  - **Mobile Country Code (MCC)**
  - **Mobile Network Code (MNC)**
  - **Mobile Subscriber Identification No. (MSIN)**
  - IMSI is stored in the SIM. Mobile Station can be operated if SIM with the valid IMSI is inserted in the equipment.
  - The Equipment should have valid IMEI.



- On Net Call-call in same network
- Off Net Call-call in other network

Call Initiation, Setup and Termination

- The mobile user when decides to make a call, enters the desired phone number. This initiates an access probe. The mobile uses the access channel and attempts to contact the serving base station.

- Since no traffic channel has been established, the mobile uses open loop power control. Multiple tries are allowed at random times to avoid collisions that can occur on the access channel. Each successive attempt is made at a higher power level. After each attempt, the mobile listens to the paging channel for a response from the base stations.

Call Initiation, Setup and Termination

Once the access request has been received by the base station, the base station responds with an assignment to a traffic channel (Walsh code). The base station initiates the land link, and conversation takes place.

Call termination can be initiated either from the mobile or the land side. In either case the transmissions are stopped, the Walsh code is freed, and the land line connection is broken. The mobile unit resumes monitoring the page channel of the current serving cell.

Outgoing Call

- The mobile user dials the desired digits, and presses SEND.
- Mobile transmits an Origination Message on the access channel.
- The system acknowledges receiving the origination by sending a base station acknowledgement on the paging channel.
- The system arranges the resources for the call and starts transmitting on the traffic channel.
- The system notifies the mobile in a Channel Assignment Message on the paging channel.
- The mobile arrives on the traffic channel.
- The mobile and the base station notice each other's traffic channel signals and confirm their presence by exchanging acknowledgment messages.
- The base station and the mobile negotiate what type of call this will be -- I.e., 13k voice, etc.
- The audio circuit is completed and the mobile caller hears ringing.

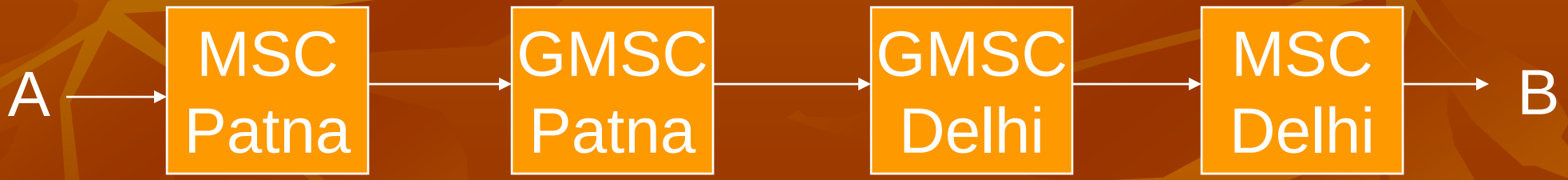
Receiving Incoming Call

- All idle mobiles monitor the paging channel to receive incoming calls.
- When an incoming call appears, the paging channel notifies the mobile in a General Page Message.
- A mobile which has been paged sends a Page Response Message on the access channel.
- The system sets up a traffic channel for the call, then notifies the mobile to use it with a Channel Assignment Message.
- The mobile and the base station notice each other's traffic channel signals and confirm their presence by exchanging acknowledgment messages.
- The base station and the mobile negotiate what type of call this will be -- I.e., 13k voice, etc.
- The mobile is told to ring and given a "calling line ID" to display.
- When the human user presses the send button, the audio path is completed and the call proceeds.

CALL FLOW SCENARIO FOR 93……MOBILE NO.S..

- **Call from 9334….to local 9334….**

- **Call from 9334….to STD Delhi No.093.**



93 Local to B.S.N.L Local

93 Local to B.S.N.L. STD

Ending Call

- A normal call continues until one of the parties hangs up. That action sends a Release Order, “normal release”.
- The other side of the call sends a Release Order, “no reason given”.
  - *If a normal release is visible, the call ended normally*.
- At the conclusion of the call, the mobile reacquires the system.
  - Searches for the best pilot on the present CDMA frequency
  - Reads the Sync Channel Message
  - Monitors the Paging Channel steadily
- Several different conditions can cause a call to end abnormally:
  - the forward link is lost at the mobile, and a fade timer acts
  - the reverse link is lost at the base station, and a fade timer acts
  - a number of forward link messages aren’t acknowledged, and the base station acts to tear down the link
  - a number of reverse link messages aren’t acknowledged, and the mobile station acts to tear down the link

ADVANTAGES

1. It has high capacity.
2. It has the capability of using signals that arrive in the receivers with different time delays.
3. It is interference limited multiple access system.
4. It uses unique spreading codes due to which it has low noise level.
5. High capacity increases as well as extended battery life for handsets.
6. Increased cellular communications security.
7. Simultaneous conversations.
8. Increased efficiency, meaning that the carrier can serve more subscriber.
9. Smaller phones.
10. Low power requirements and little cell-to-cell coordination needed by operators.

DISADVANTAGES

1. It causes ‘near-far’ problem i.e. a transmitter ”near” the receiver sending a different code than the receiver’s desired code produces in the receiver a signal comparable wit that of a ”far” transmitter sending the desired code.
2. Synchronization of the receiver and the transmitter is complex.
3. Due to its proprietary nature,all of CDMA’s flaws are not known to the engg. Community.
4. CDMA is relatively new,and the network is not as mature as GSM.
5. CDMA cannot offer international roaming,a large GSM advantage.

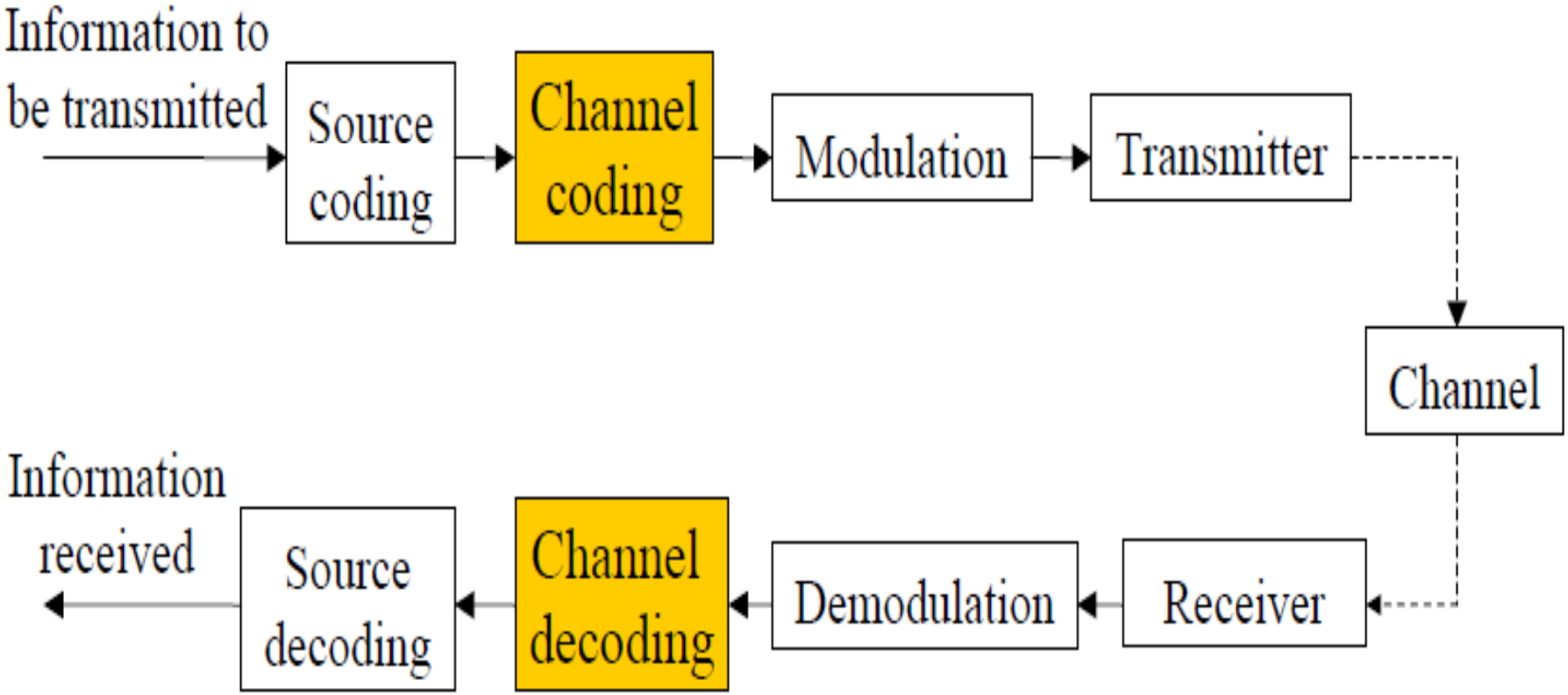
Third Generation CDMA Systems (CDMA 2000)

- CDMA 2000 is third Generation Mobile Technology.
- Supports data rates up to 2 Mbps.
- Support traditional voice & voice over IP (VoIP).
- Intended for indoor/outdoor environment pedestrian or vehicular applications.

Coding/Spreading Trade Off

- Channel coding protects digital data from errors by selectively introducing redundancies in transmitted data.
- Channel codes that are used to detect errors are called error detection codes.
- Codes that can detect and correct errors are called error correcting codes.
- Basic purpose of channel coding is to introduce redundancies in data to improve wireless link performance.
- Channel coding increases bandwidth requirement for a fixed source data.

Source Coding & Channel Coding



Coding/Spreading Trade Off

Fixed bandwidth should be allocated between coding & spreading.

For CDMA signals bandwidth expansion factor is >> 1 for each user.

Each coding scenario has different probability distribution of achieving certain peak signal to noise ratio (PSNR) for decoding image.

$$PSNR = 10 \log (\text{peak image energy} / \text{noise image energy})$$

Where noise image = received image –original image.

Trade off among the parameters allow us to tune the system performance to a particular set of requirement.

Coding/Spreading Trade Off

Allocating more bandwidth to source coding allows us to achieve a higher maximum image quality but probability of achieving this quality is smaller.

On the other hand allocating more bandwidth to spreading decreases the number of source information bits transmitted and limits best achievable quality but probability of achieving this quality is higher.