MASTERING THE PRINCIPLE OF RADIO NETWORK PLANNING AND OPTIMIZATION(GSM,WCDMA,LTE)

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INTRODUCTION TO TELECOMMUNICATIONs

INTRODUCTION TO TELECOMMUNICATION

What is Telecommunication?

Telecommunication is the transmission of signals over a distance for the purpose of communication. Signals are transmitted in form of electromagnetic waves.

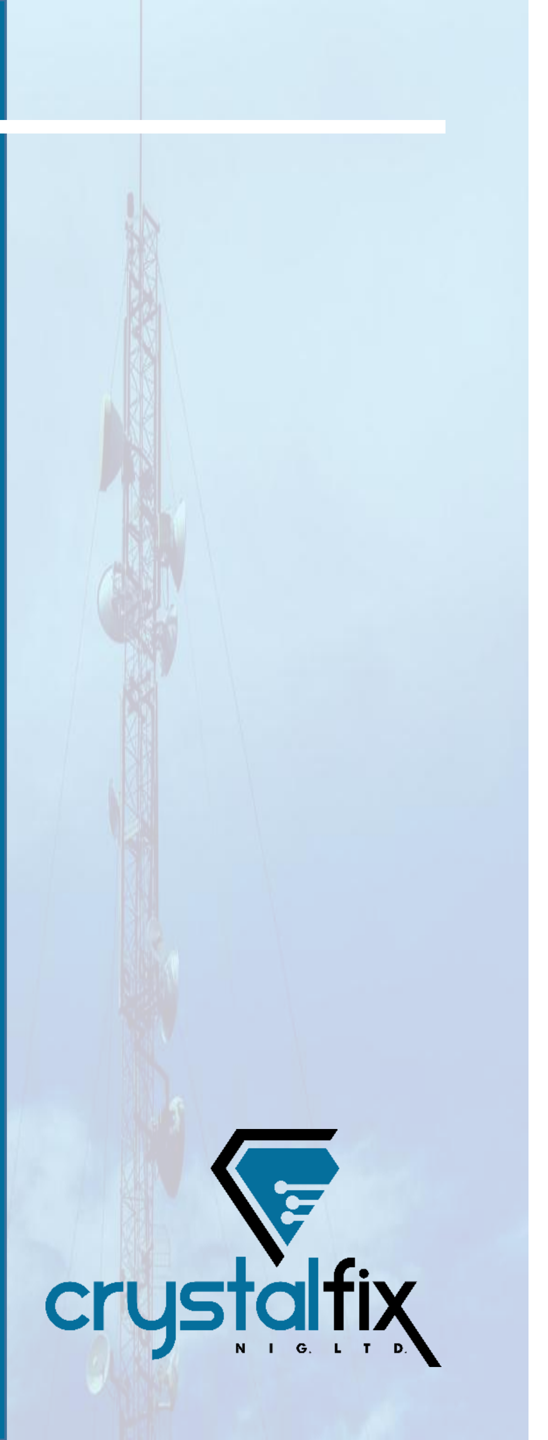
The Evolution of Mobile Telephone System

- Advance Mobile Phone System (AMPS) first deploy in North Americas in 1978.
- In 1990 D- AMPS took over.
- GSM and CDMA became the 'second generation' mobile phone systems in 1990s.
- GSM widely deployed in Europe while CDMA deployed in US and Asia market.

Technology Improvement in Mid 1990 with Small phone and Advanced Batteries System.
1992 UK lunch SMS message on their GSM network followed in 1993 by the first person- to-person SMS sent in Finland.

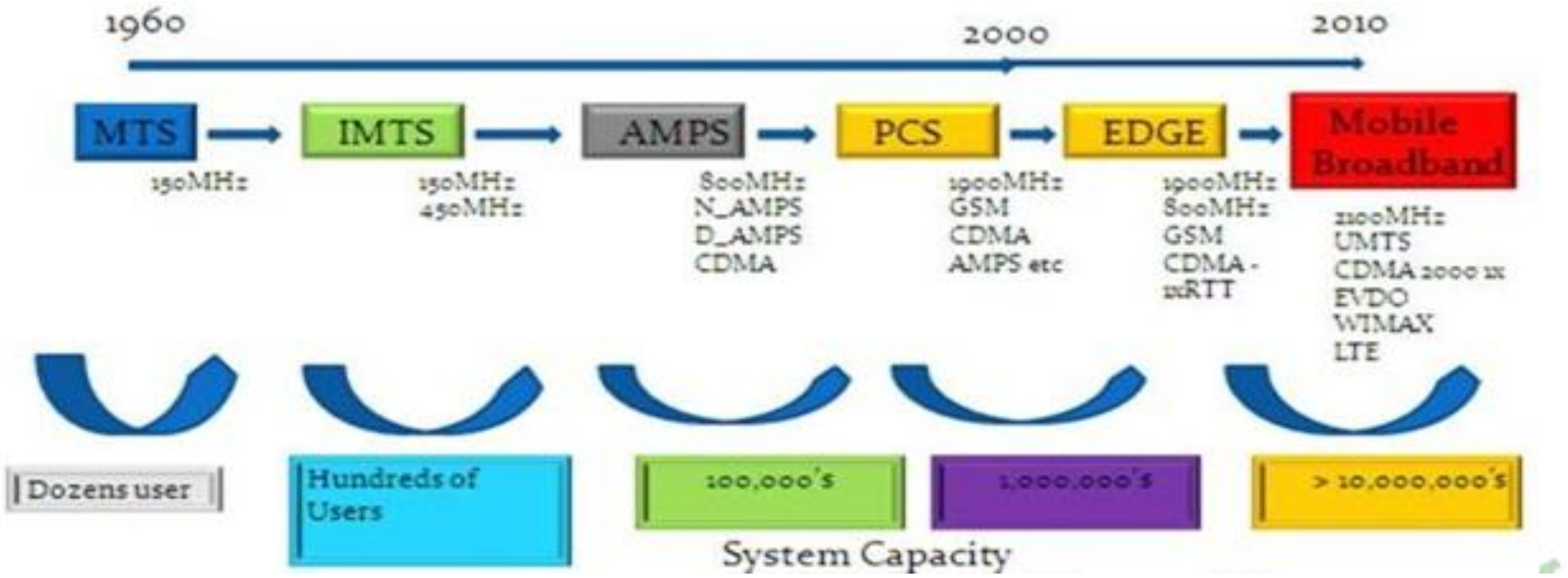
In 1998 Supplementary services such as ring tone, access media, and advertisement were implemented on the GSM platform.
By 1999 exponential growth of mobile device.
GSM took the largest share of the mobile market.
The first pre-commercial trial network with 3G was launched by NTT DoCoMo in Tokyo Japan in 2001. Which began 3G (WCDMA) revolution.

It was followed by CDMA2000 1xEV-DO.
During the development of 3G systems, 2.5G systems such as CDMA2000 1x and GPRS were developed as extensions to existing 2G networks.
In June of 2008, the Next Generation Mobile Networks Alliance (NGMN) selected LTE. This began the 4G revolution which has been deployed in America, Asia and Europe.
Some Countries in Africa (Nigeria, S. Africa, Egypt) and Mideast are currently in deployment state .



SYSTEM EVOLUTION CAPACITY

System capacity has exponentially grown. The evolution of mobile broadband will bring in new data services and high data usage:



1982- GSM (Groupe Speciale Mobile) is formed by Confederation of European Posts Telecommunications (CEPT) to design a pan European mobile technology.

1985 – European Commission endorse GSM Project

1986- 900MHz spectrum band was reserve for GSM by the EC Telecommunication council. France, Germany, Italy and UK on standard and MOU was signed by 15 members from 13 European countries.

1989- Groupe Speciale Mobile was defined the GSM standard as the internationally accepted digital cellular telephony standard.

1990- GSM adaptation work started for DCS1800 band.

1991- The first GSM call was made in Finland.

1992 to 1995- GSM with SMS feature was deployed and roaming agreement between some European telecom companies. DCS1800 GSM network was opened in UK.

1995- GSM global subscriber exceed 10 million and first North America PCS 1900 was opened in US.

1996 to 1999 – GSM network has spread to over 100 countries. GSM subscriber has surpassed 100 million and WAP trial begin in France and Italy to launch GPRS.

2000 to present- GSM evolve to GPRS/EDGE due to increase in data usage.

By 2001 WCDMA network goes live in France.

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TECHNOLOGY PATHWAY FROM 1G TO 5G

1G-NMT
TACS
Analogue
Voice

2G-Voice,SMS
2.5G –GPRS
Data rate at
115kbps
2.75G –EDGE
Data rate at
474kbps

3G-Voice,SMS,Video call and R99 Data rate at 384Kbps
3.5G –HSPA Data rate at 14.4Mbps/5.76Mbps
3.75G –HSPA+ data rate 42Mbps/11.5Mbps
3.9G –Dual UL/HSDPA MIMO up to 84Mbps on DL

4G/LTE
DL up to 300Mbps
UL up to 150Mbps
VoLTE
CSFB

5G
10Gbps on Download
1Gbps on Upload

LIMITATIONS OF ANALOG SYSTEMS

Limitations of analog systems

- Incompatibility – NMT Mobile equipment could not call or communicate with AMPS Mobile equipment.
- Insufficient capacity – the number of subscribers exceeded the network.
- Limited equipment market

Advantages of Digital Communication

- Digital circuits are more reliable, easy to design and cheaper than analog circuits.
- The occurrence of cross-talk is very rare in digital communication.
- Signal processing functions such as encryption and compression are employed in digital circuits to maintain the secrecy of the information.
- The probability of error occurrence is reduced by employing error detecting and error correcting codes. Spread spectrum technique is used to avoid signal jamming.
- Combining digital signals using Time Division Multiplexing TDM is easier than combining analog signals using Frequency Division Multiplexing FDMFDM.
- The configuring process of digital signals is easier than analog signals.
- Digital signals can be saved and retrieved more conveniently than analog signals.
- The capacity of the channel is effectively utilized by digital signals.

NMT - Nordic Mobile telephony

- TACS – Total Access Communication System
- AMPS - Advanced Mobile Phone Systems
- GSM - Global System for Mobile Communication
- GPRS - General Packet Radio System
- EDGE - Enhanced Data Rate for GSM Evolution
- TDMA - Time Division Multiple Access
- CDMA - Code Division Multiple Access
- WCDMA - Wideband Code Division Multiple Access
- TD-SCDMA - Time Division Synchronous Code Division Multiple Access
- HSPA - High Speed Packet Access
- HSUPA – High Speed Uplink Packet Access
- HSDPA - High Speed Downlink Packet Access
- LTE - Long term Evolution

MODES OF COMMUNICATION

Simplex Mode – signal travels in one direction alone. It is a point to multipoint mode of communication. E.g. radio and TV stations

Half Duplex – signal is propagated to and fro along one frequency. E.g. Walkie talkie

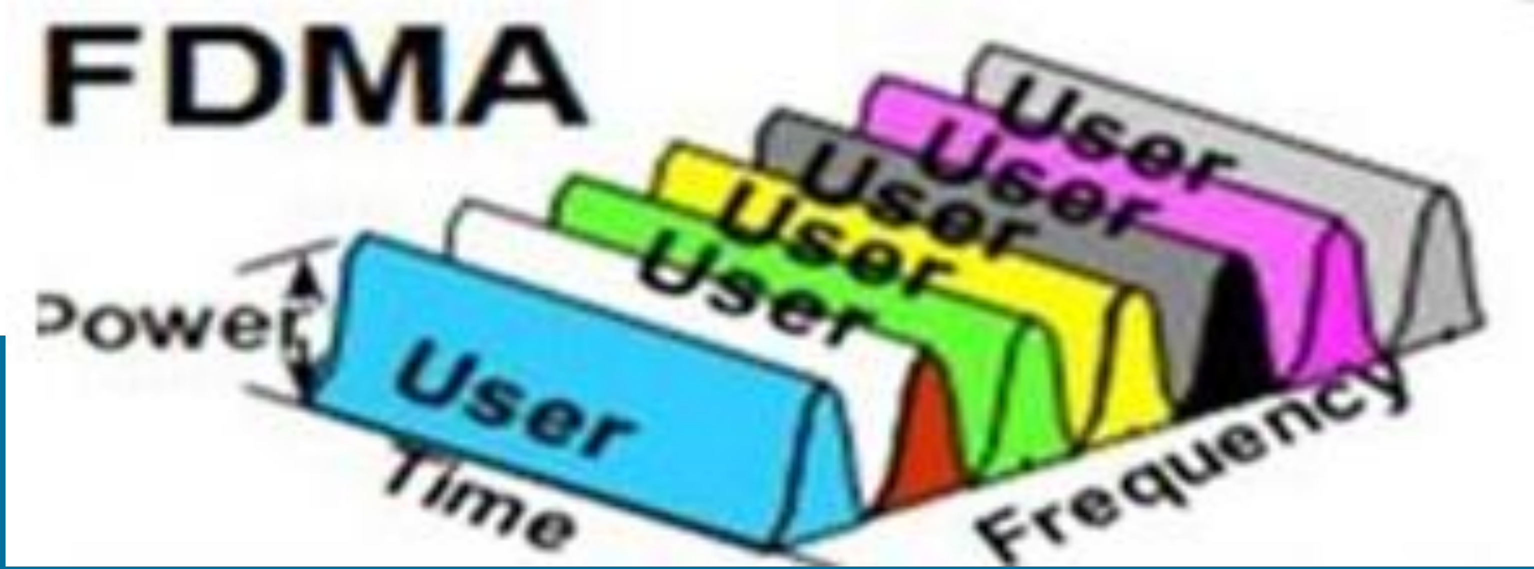
Full Duplex – signals are propagated to and fro but along

RADIO ACCESS TECHNIQUE (RAT)

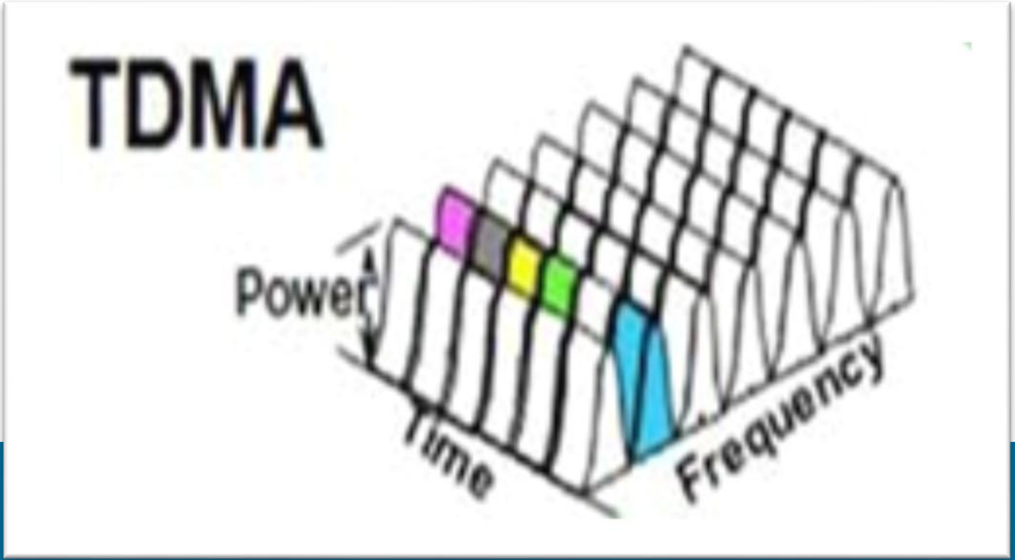
The Multiple Access Technique allows many subscribers to use the same communication medium.

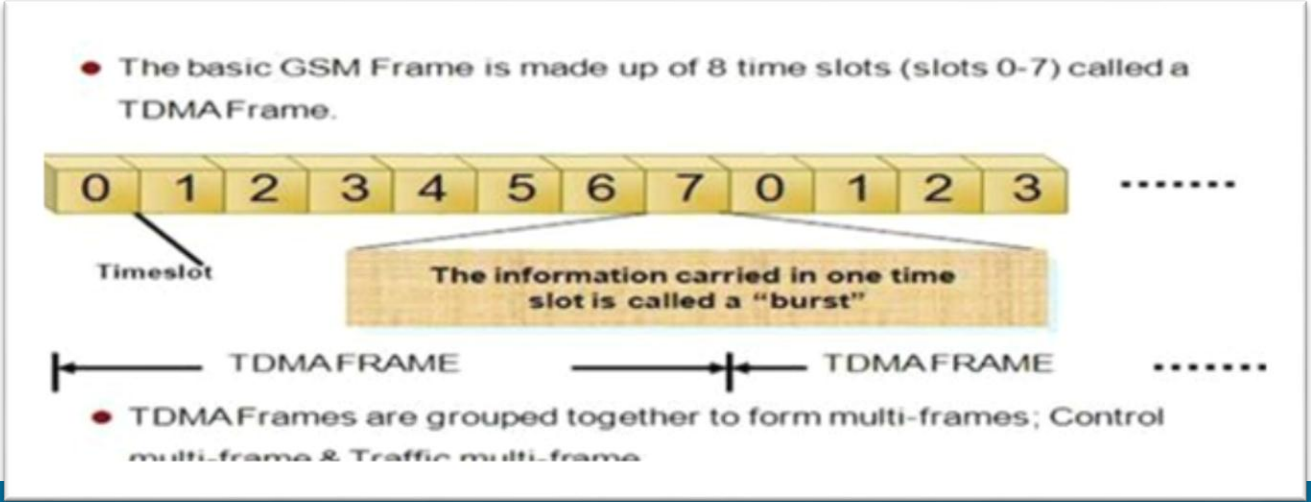
Types of MAT

Frequency Division Multiple Acess (FDMA) sometimes called channelization, means dividing the whole available spectrum into many single radio channels (transmit/receive carrier pair). The whole frequency spectrum available is divided into many individual channels (for transmitting and receiving), every channel can support the traffic for one subscriber or some control information. Each frequency channel used for transmission and reception of signals is 0.2MHz away from the next adjacent channel.

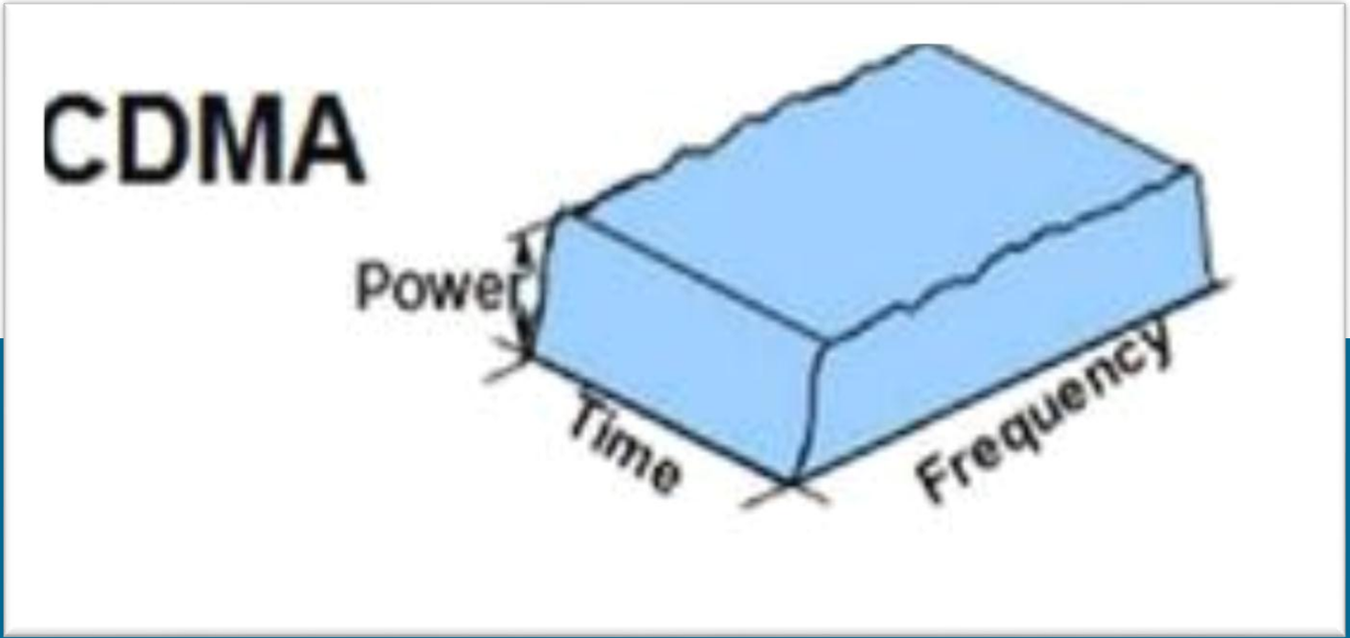


Time Division Multiple Access(TDMA) means that the wireless carrier of one bandwidth is divided into multiple time division channels in terms of time (or called timeslot). Each user occupies a timeslot and receives/transmits signals within this specified timeslot





Code Division Multiple access(CDMA) accomplishes the communication in different code sequence.
Special coding is adopted before transmission, then different information will lose nothing after being mixed and transmitted together on the same frequency and at the same time.
CDMA can transmit the information of multiple users on a channel at the same time. Mutual interference between users **is permitted**.



THE GSM FREQUENCY SPECTRUM

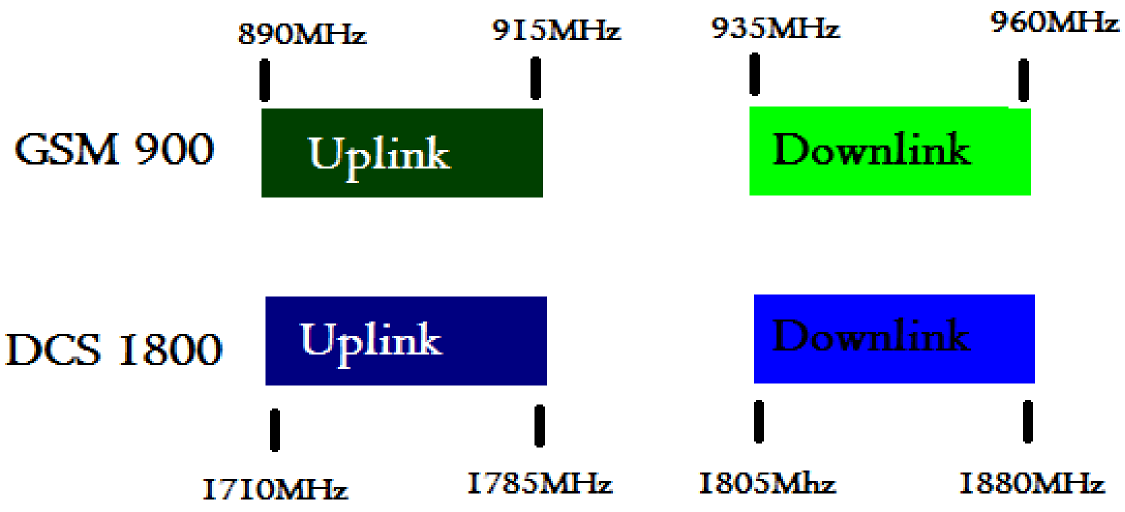
GSM 900 Duplex Separation: 45MHz
Channel Bandwidth: 200 KHz
ARFCN: F (n) = 890 + 0.2n
DCS 1800 Duplex Separation: 95MHz
ARFCN: F (n) = 1710.2 +0.2 (n - 512)

Uplink - Frequency that propagates signals from the MS to the BTS

Downlink-Frequency that propagates signals from the BTS to the MS

Duplex Separation - the distance between the uplink frequency and the corresponding downlink frequency.

Channel bandwidth - the distance between adjacent carrier frequencies in the UL & DL frequencies. It is needed to reduce interference.



ARFCN – Absolute Radio Frequency Channel Number: No. assigned to an already existing frequency channel

UARFCN–UMTS Absolute Radio Frequency Channel Number: No. assigned to an already existing frequency channel on WCDMA Networks.

EARFCN–E-ULTRAN Absolute Radio Frequency Channel Number: No. assigned to an already existing frequency channel on LTE Networks

Guard Band- This is a spared(unused frequency)for an operator and can be either the start or the end frequency)

Refer to NCC website for Spectrum allocation in Nigeria for different technologies and operators.

NETWORK IDENTITY & ARCHITECTURE

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NETWORK IDENTITIES

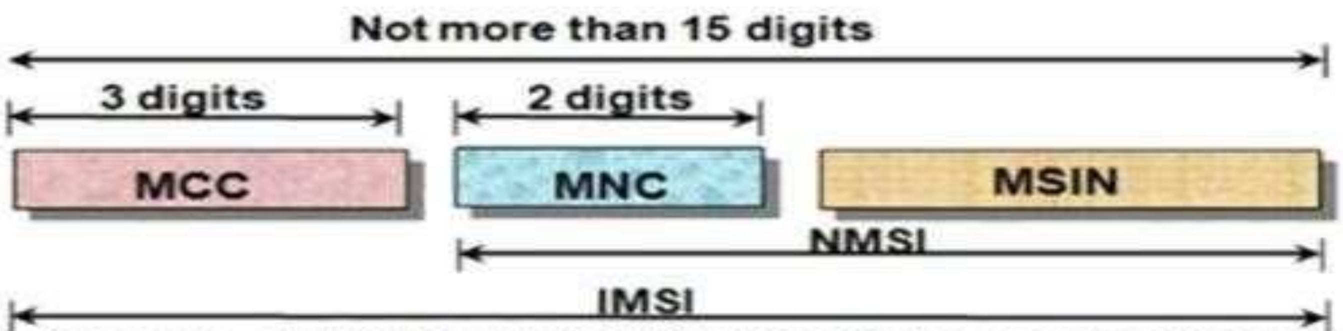
MOBILE STATION MS = ME + SIM

ME = Mobile Equipment **SIM** = Subscriber Identity Module

<u>ME Related Identities</u>

SIM Related Identities

IMSI



This is a non- dial able number for identifying a subscriber in the GSM network.

MCC: Mobile Country Code. It consists of 3 digits
For example: The MCC of Nigeria is "621"

MNC: Mobile Network Code. It consists of 2 digits
For example: The MNC of MTN Nigeria is "30"

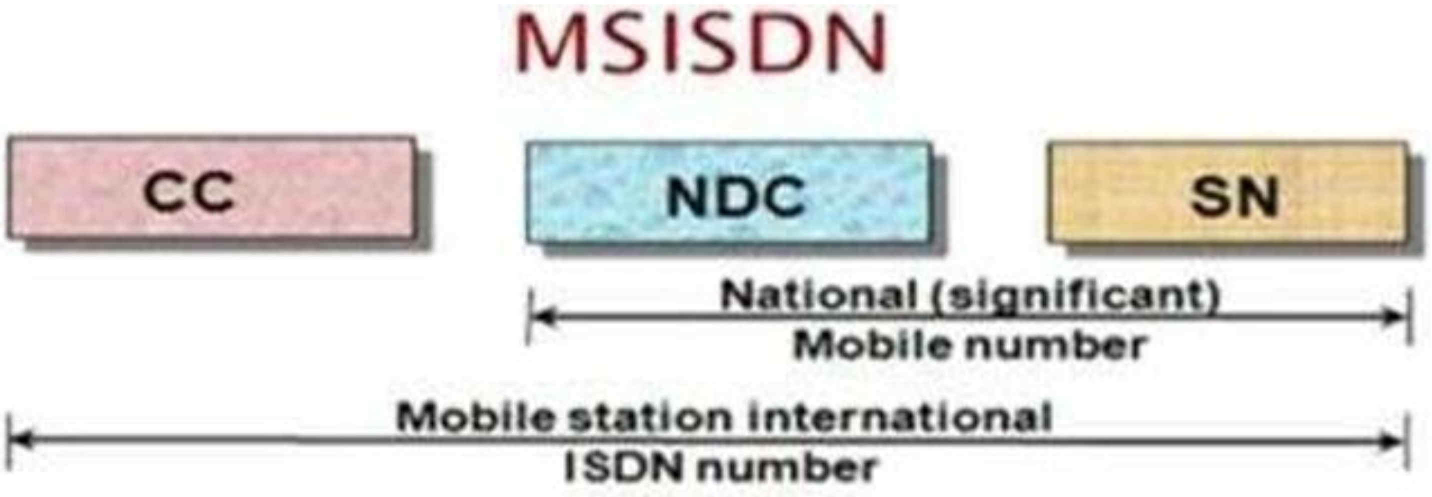
MSIN: Mobile Subscriber Identification Number H1H2H3 S ABCDEF
For example: 803-321418

NMSI: National Mobile Subscriber Identification. MNC and MSIN form it together.

TMSI

TMSI: Temporary Mobile Subscriber Identification)

- The TMSI is assigned only after successful subscriber authentication.
- The VLR controls the allocation of new TMSI numbers and notifies them to the HLR.
- TMSI is used to ensure that the identity of the mobile subscriber on the air interface is kept secret.
- The TMSI consists of 4 bytes(8 HEX numbers) and determined by the operator.



Mobile Station International Subscriber Directory Number **(MSISDN)** is a number used to identify a mobile phone number internationally

CC is country code …Nigeria is 234

NDC is Network Destination code like 803 for MTN,805 for Glo

SN Is the serial number of the subscriber on that network.

Just Like 8304568

IS can be 234|803|8304568

LAI

The LAI is the international code for a location area. It determines the need for location updating and it is the area within which a MS is paged.

MCC: Mobile Country Code. It consists of 3 digits .
For example: The MCC of Nigeria is "621"

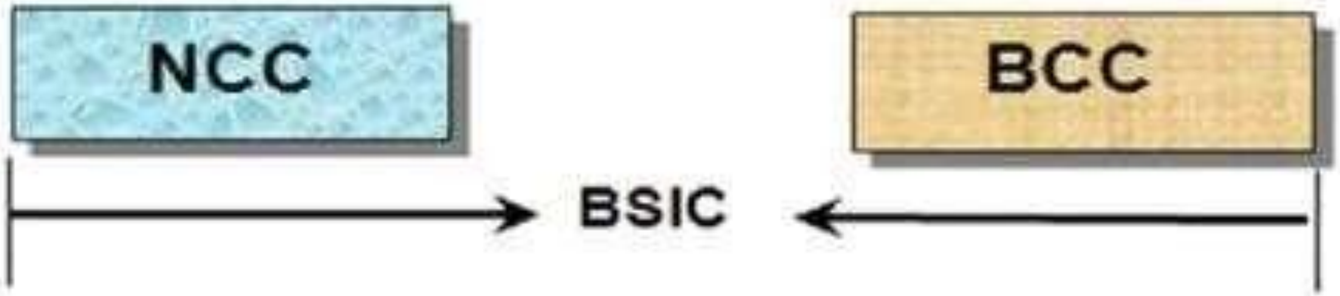
MNC: Mobile Network Code. It consists of 2 digits .
For example: The MNC of MTN Nigeria is "30"

LAC: Location Area Code. It is a two bytes hex code
The value 0000 and FFFF is invalid

For example: 621-30-0011

BSIC

BSIC（Base Station Identity Code)



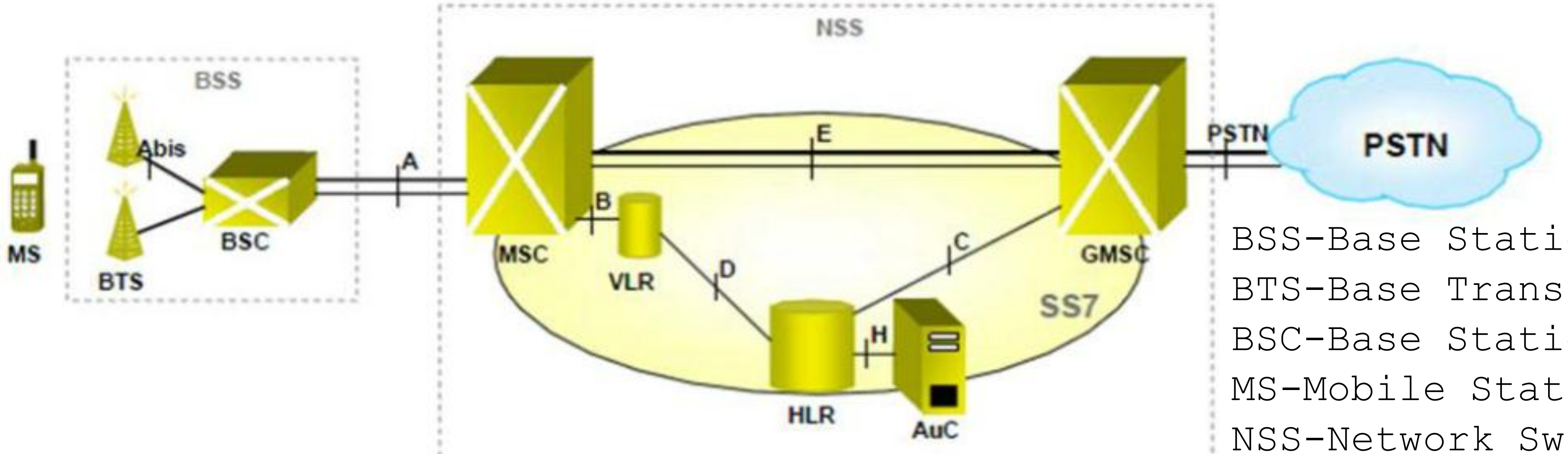
Allows a MS to distinguish between two cells using the same frequency.
NCC: PLMN network color code. It comprises 3 bit. It allows various neighboring PLMNs to be distinguished.
BCC: BTS color code. It comprises 3 bit, used to distinguish different cells assigned the same frequency.

CGI

CGI: Cell Global Identification

The CGI is a unique international identification for a cell
The format is LAI+CI
LAI: Location Area Identification
CI: Cell Identity. This code uses two bytes hex code to identify the cells within an LAI.

NETWORK ARCHITECTURE



BSS-Base Station Systems
BTS-Base Transciever station
BSC-Base Station controller
MS-Mobile Stations
NSS-Network Switching Sub Systems
MSC-Mobile Service Switching Center
VLR-Visitors Location Register
HLR-Home Location Register
AuC-Authentication Center

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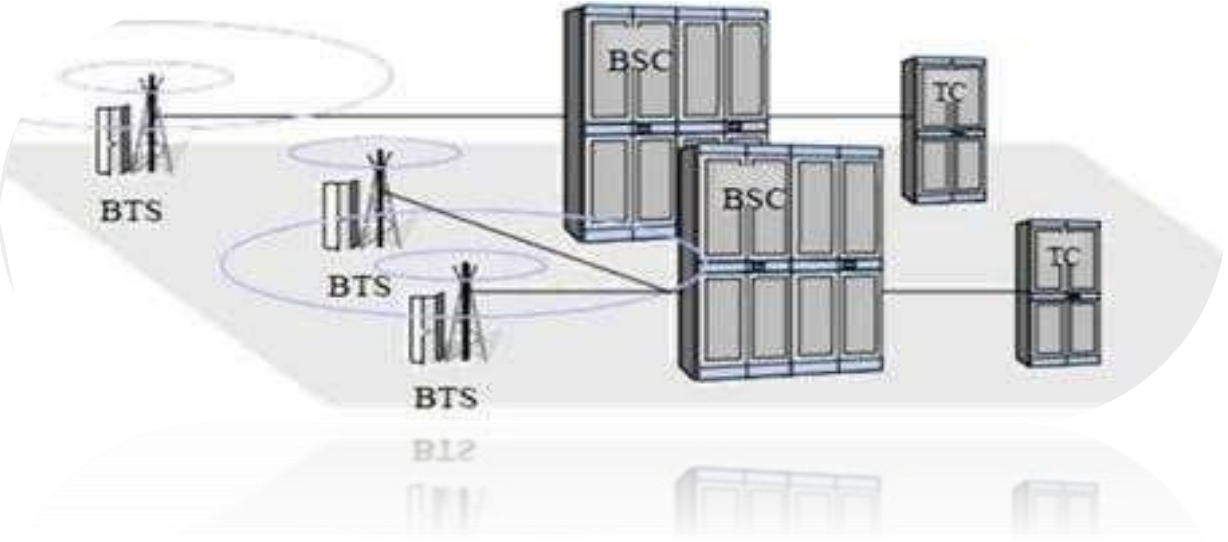
2G ARCHITECTURE SUBSYSTEMS IN THE GSM NETWORK

NETWORK ARCHITECTURE

FUNCTIONS OF THE BSS

- Carries out signaling between the MS and NSS
- Handles traffic Carries out transcoding of speech signal
- Allocates radio channels to MS



FUNCTIONS OF THE BTS

- Minimizing transmission problems
- Ciphering
- Speech processing
- Maintaining the air interface

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NETWORK ARCHITECTURE

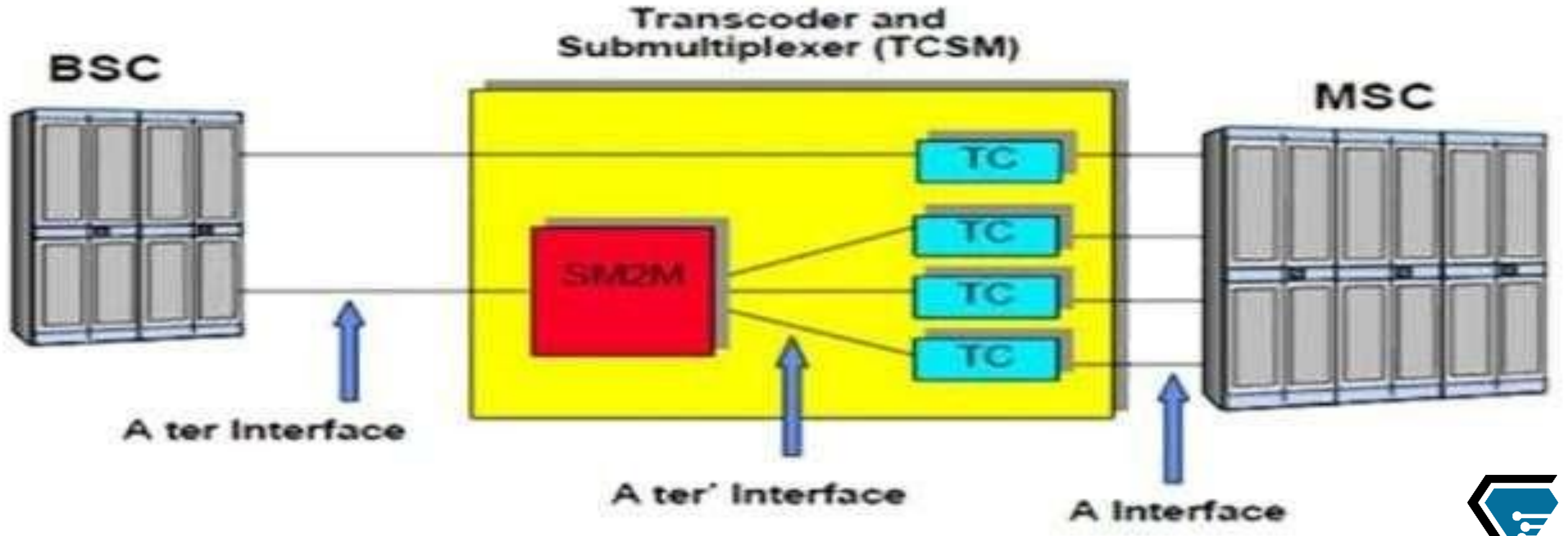
FUNCTIONS OF THE BSC

- Carries out signaling between the MS and NSS
- Handles traffic Carries out transcoding of speech signal
- Allocates radio channels to MS

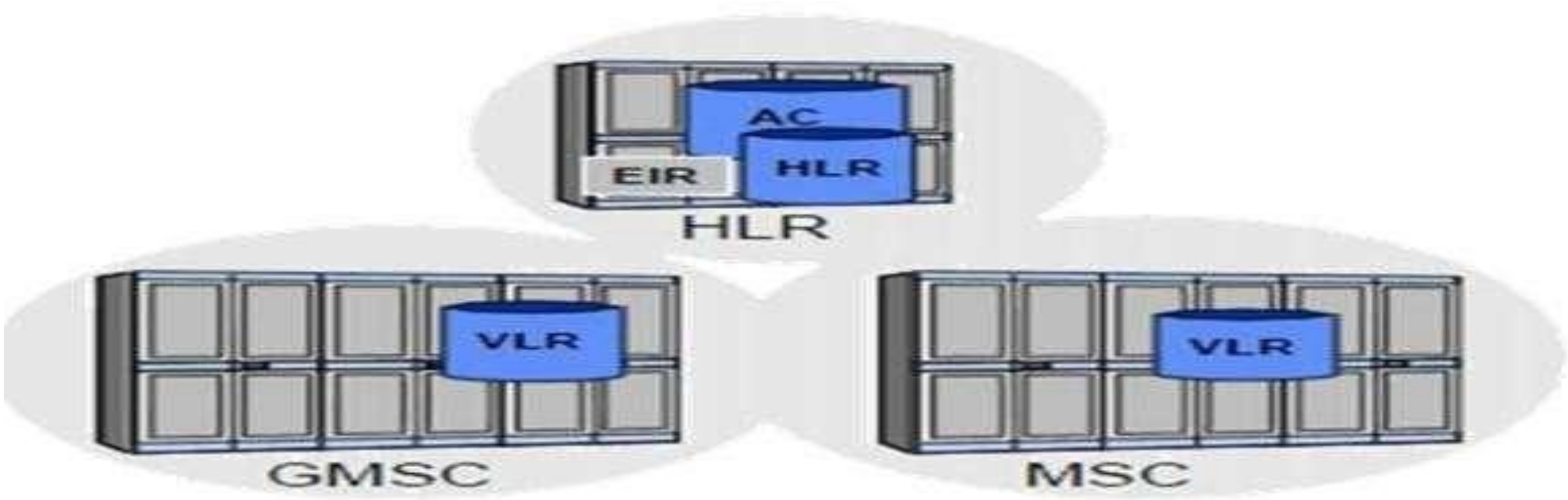
FUNCTIONS OF THE TC

- For efficient transmission of speech over the air interface, the digital speech must be compressed. For transmission over the air interface, the speech signal is compressed by the MS to 13kbps (Full rate or enhanced full rate), or 5.6kbps (Half rate)
- The standard bit rate for speech is PSTN is 64kbps.
- Call Control -Call setup and routing of the calls Allocation of access resources
- Mobility Management -Location registration Initiation of paging
- Reallocation of frequencies to BTSs in its area
- Charging -Billing for all subscribers based in its area

TRANSCODER POSITIONING



NETWORK ARCHITECTURE



NETWORK ARCHITECTURE

FUNCTIONS OF THE VLR

- Database that stores information about subscribers currently being in the service area of the MSC.
- Information stored includes;
- Mobile Status (IMSI attached / detached / busy / idle etc.)
- Location Area Identity(LAI)
- Temporary Mobile Subscriber Identity(TMSI)
- Allocating the Roaming Number

FUNCTIONS OF THE HLR

- Database that stores all the data of all subscribers available to a specific operator Information stored include;
- Current subscriber VLR (current location)
- Subscriber ID (IMSI and MSISDN)
- Supplementary service information
- Subscriber status (registered/deregistered)
- Authentication key and AuC functionality

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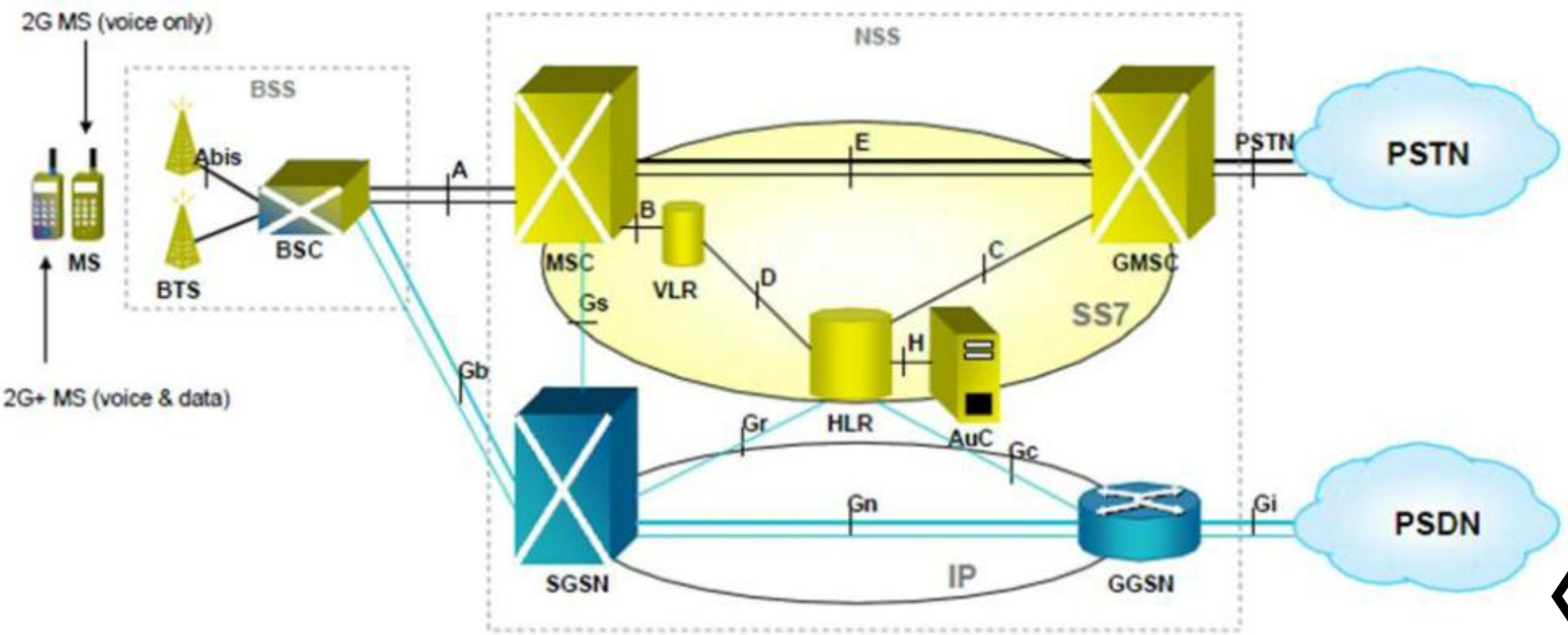
NETWORK ARCHITECTURE

FUNCTIONS OF THE EIR

- **White List** -contains list of IMEIs known to have been assigned to valid MSs.
- **Black List** -contains IMEIs that have been reported stolen/it is not allowed to operate within the network
- **Grey List** – contains IMEIs of MEs with faults not important enough for barring.

2.5G ARCHITECTURE



SGSN-Serving GPRS Support Node
GGSN-Gateway GPRS Support Node
GPRS-General Packet Radio Services

ARCHITECTURE

- Gb -Between the PCUSN Relay.
- Gr -Between SGSN and Application Part (MAP).
- Gn -Between SGSN and GGSN, the GTP (tunneling) protocol.
- Gi -Between GGSN and PDNs (X.25 and Internet Protocol [IP]).
- Gs -Between SGSN and MSC/VLR, for some simultaneous GPRS and GSM operations
- Gd -Delivers SMS messages via GPRS (same as MAP from GSM).
- Gc -Between GGSN and HLR.
- NB; To understand GPRS system architecture it is helpful to first understand architecture of GSM system. . GPRS is an enhancement over the GSM and adds some nodes in the network to provide the packet switched services. These network GSNs (GPRS Support Nodes) and are responsible for the routing and delivery of the data packets to and from the MS and external packet data networks (PDN).

Network Addition of two network elements;

Serving GPRS Support Node (SGSN) Function:

- Ciphering of GPRS data between the MS and SGSN
- Authentication of GPRS users
- Mobility Management
- Routing of data to the relevant GGSN when a connection to an external network is made Interaction with the NSS
- Collection of charging data

Gateway GPRS Support Node (GGSN) Function:

- Routing Mobile designated packets coming from external network to the relevant SGSN
- Deals with security issues, interfaces to external IP Networks Collects data and traffic statistics

GPRS BSS

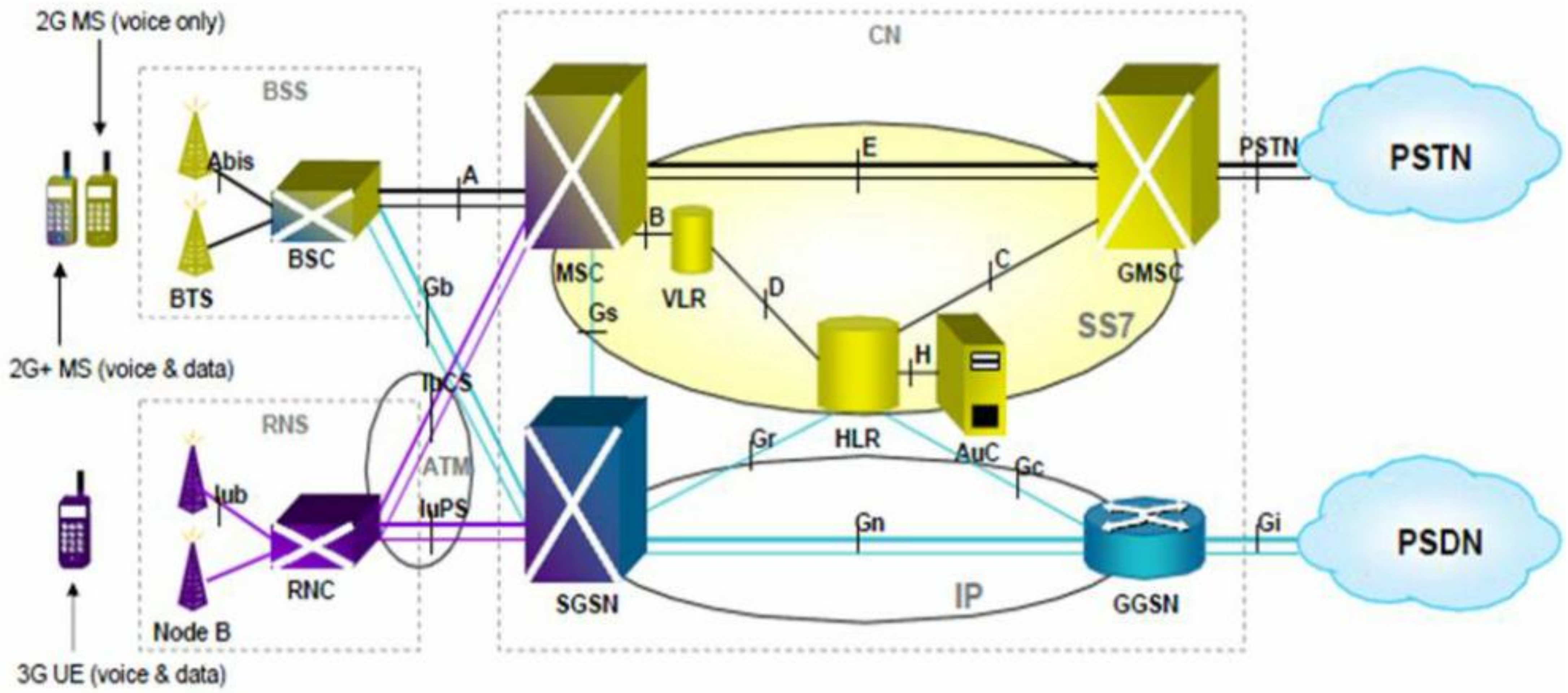
A software upgrade is required at the Base Transceiver Station(BTS).

The Base Station Controller (BSC) also requires a software upgrade, and the installation of a new piece of hardware called a packet control unit (PCU).

The PCU directs the data traffic to the GPRS can be a separate hardware element associated with BSC.

The PCU provides a physical and logical data interface out of BSS for packet data traffic

3G ARCHITECTURE



NOTE the difference between 2G and 3G Interfaces.

GSM INTERFACE

GSM NETWORK GEOGRAPHIC AREA AND NUMBER

- **Cell:** A cell is the smallest area within a GSM network served by a BCCH.

- **Location area:** Location areas are comprised of one or several radio cells. Each location area is given an unique number within the network, the

Location Area Code (LAC); This code is used as a unique reference for the location of a mobile subscriber. This code is necessary to address the subscriber in the case of an incoming call. The LAC forms part of the Location Area Identifier (LAI) and is broadcasted on the Broadcast Control Channel(BCCH).

- **MSC Service Area:** It consists of many Location area differentiated by a unique LAC.

- **PLMN Service Area:** This is an area within a cellular network that consists of one or more operators. Its uses a unique identifier, MNC to differentiate b

REMEMBER ;

GSM CHARACTERISTICS

Specifications for different Personal Communication Services (PCS) systems vary among the different PCS networks. The GSM specification is listed below with important characteristics.

- **Modulation** is a form of change process where we change the input information into a suitable format for the transmission medium. We also changed the information by demodulating the signal at the receiving end. The GSM uses Gaussian Minimum Shift Keying (GMSK) modulation method.
- **Access Methods:** Because radio spectrum is a limited resource shared by all users, a method must be devised to divide up the bandwidth among as many users as possible. GSM chose a combination of TDMA/FDMA as its method. The FDMA part involves the division by frequency of the total 25 MHz bandwidth into 124 carrier frequencies of 200kHz bandwidth.

GSM CHARACTERISTICS

One or more carrier frequencies are then assigned to each BS. Each of these carrier frequencies is then divided in time, using a TDMA scheme, into eight time slots. One time slot is used for transmission by the mobile and one for reception. They are separated in time so that the mobile unit does not receive and transmit at the same time.

- **Transmission Rate:** The total symbol rate for GSM at 1 bit per symbol in GMSK produces 270.833 K symbols/second. The gross transmission rate of the time slot is 22.8 Kbps.
- GSM is a **digital syste**m with an over-the-air **bit rate of 270 kbps.**
- Frame duration: 4.615 mS
- **Duplex Technique:** Frequency Division Duplexing and Time Division Multiple access (FDD/TDMA).
- **Speech Coding:** GSM uses linear predictive coding (LPC). The purpose of LPC is to reduce the bit rate. The LPC provides parameters for a filter that mimics the vocal tract. The signal passes through this filter, leaving behind a residual signal. Speech is encoded at 13 kbps.

GSM INTERFACES

- The **Air interface** is the wireless medium for carrying the user voice & data from MS to BTS, hence it has to be an open interface to be able to support MS produced by various manufacturers.
- The **Abis interface** is generally a wireless (microwave) or a wired (Copper/fiber optic) medium between BTS to BSC, the type of medium to be used depends on the capacity (Mbps) the link has to carry and also considering future expansion of the network. It is a proprietary interface i.e. the BTS & BSC should be from the same manufacturer to be able to understand the signalling as well as traffic that is to be routed.
- The next is the **Ater interface** between BSC to TCSM which is again proprietary as the BSC & the Transcoder should be compatible to each other to be able to understand each other.

GSM INTERFACES

- Generally the medium is a **high capacity Fiber optic** link or Microwave link using SDH Technology.
- The **A interface** is between TCSM & MSC which again is an open interface, as the individual user info is to be converted to PSTN compatible 64Kbps rate. As for a large number of users there would be a large number of cables required between TCSM & MSC hence to minimize the cabling cost the TCSM is kept at the MSC.

GSM PHYSICAL/LOGICAL CHANNELS

GSM PHYSICAL & LOGICAL CHANNEL

Physical Channels: It is a medium over which the information is carried at 200KHz and 0.577ms burst time (a burst is an information carried on one time slot). Time Division multiple access(TDMA) divides one KHz radio frequency channel into consecutive periods of time, each one called a “TDMA frame". Each TDMA frame contains eight shorter periods of time called “timeslots”. These timeslots are called “Physical channels” since they are used to physically move information from one place to another.

Logical Channels: It consists of the information carried on the physical channel. The contents of the physical channels are called the logical channels. They consist of the information carried on the physical channels.

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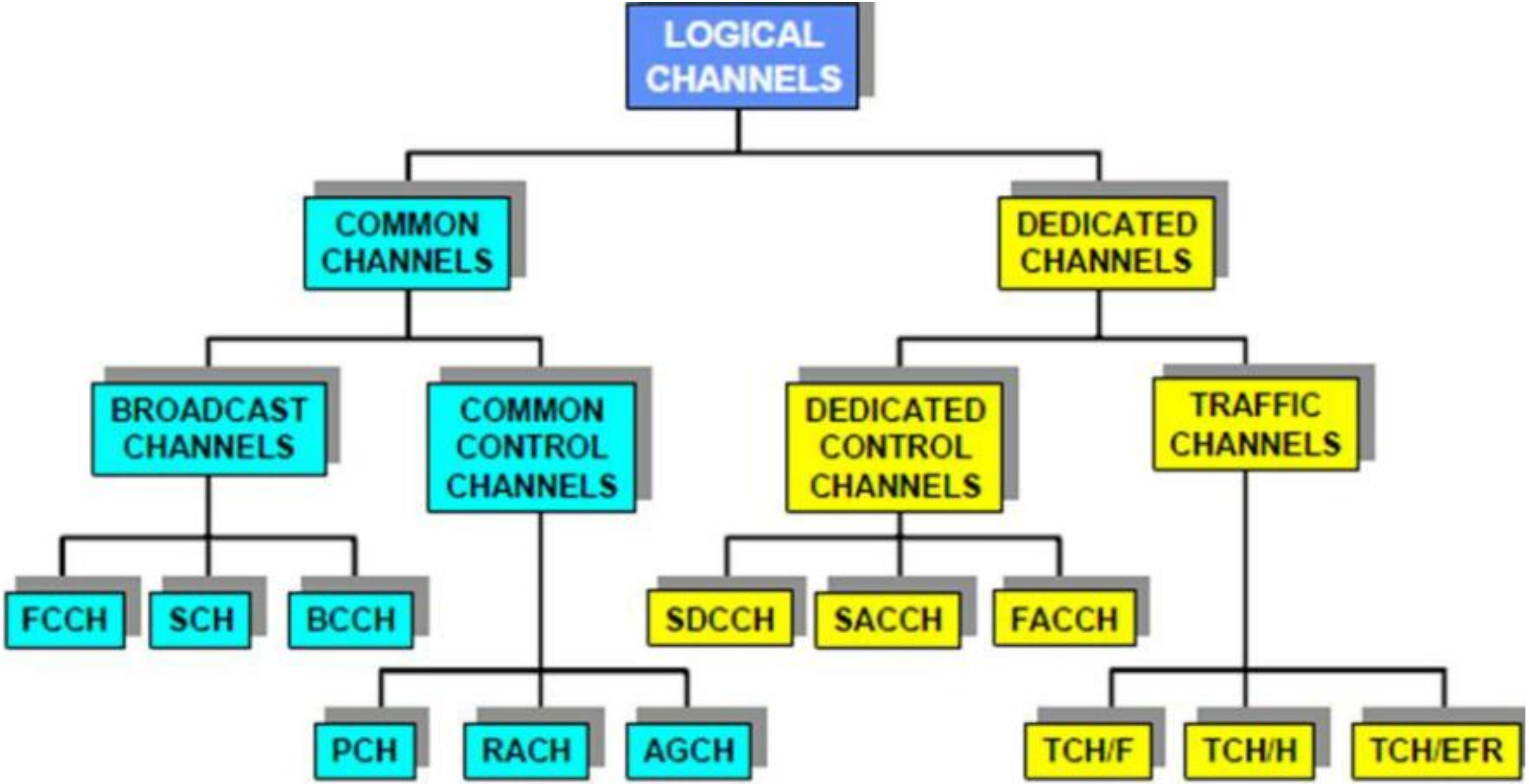
LOGICAL CHANNELS



BROADCAST CONTROL CHANNEL(BCCH)

Information on surrounding cells -a MS has to know what the cells surrounding the serving cell are and the frequencies they broadcast since it has to constantly measure the signal strength and quality of the surrounding cells.

Frequency correction channel (FCCH) – the MS scans for this signal after it has been switched on since it has no information as to which frequency to use.

Synchronization Channel (SCH) contains the BSIC. The BSIC is needed to identify that the frequency strength being measured by the MS is coming from a particular BS. It allows the MS to synchronize with the TDMA frame and for BTS identification.

Common Control channel (CCCH)

The CCCH is responsible for transferring control information between all mobiles and the network. They are used to setup a point to point connection. There are three types of CCCH

1. **Paging Channel (PCH)** – a downlink channel that is broadcast by all BTS of a LA in the case of a mobile terminated call.
2. **Random Access channel (RACH**) – an uplink channel used by the MS to request for network resources e.g. Voice call, packet services.

Access Grant Channel(AGCH) – a downlink channel used by the network to answer a RACH application.

Dedicated Control Channel

DCCH is assigned to MS to enable it to conduct point-to-point signaling transmission with BTS. There are three types of DCCH

1. **Stand Alone Dedicated Control Channel (SDCCH)** – for call set up, authentication, location update, assignment of traffic channel and transmission of short messages.
2. **Slow Associated Control channel(SACCH)** – transmits measurement reports and is used for power control.
3. **Fast Associated Control Channel(FACCH)** – is used when a handover is required. It is mapped unto a TCH. Also makes multiple calls possible

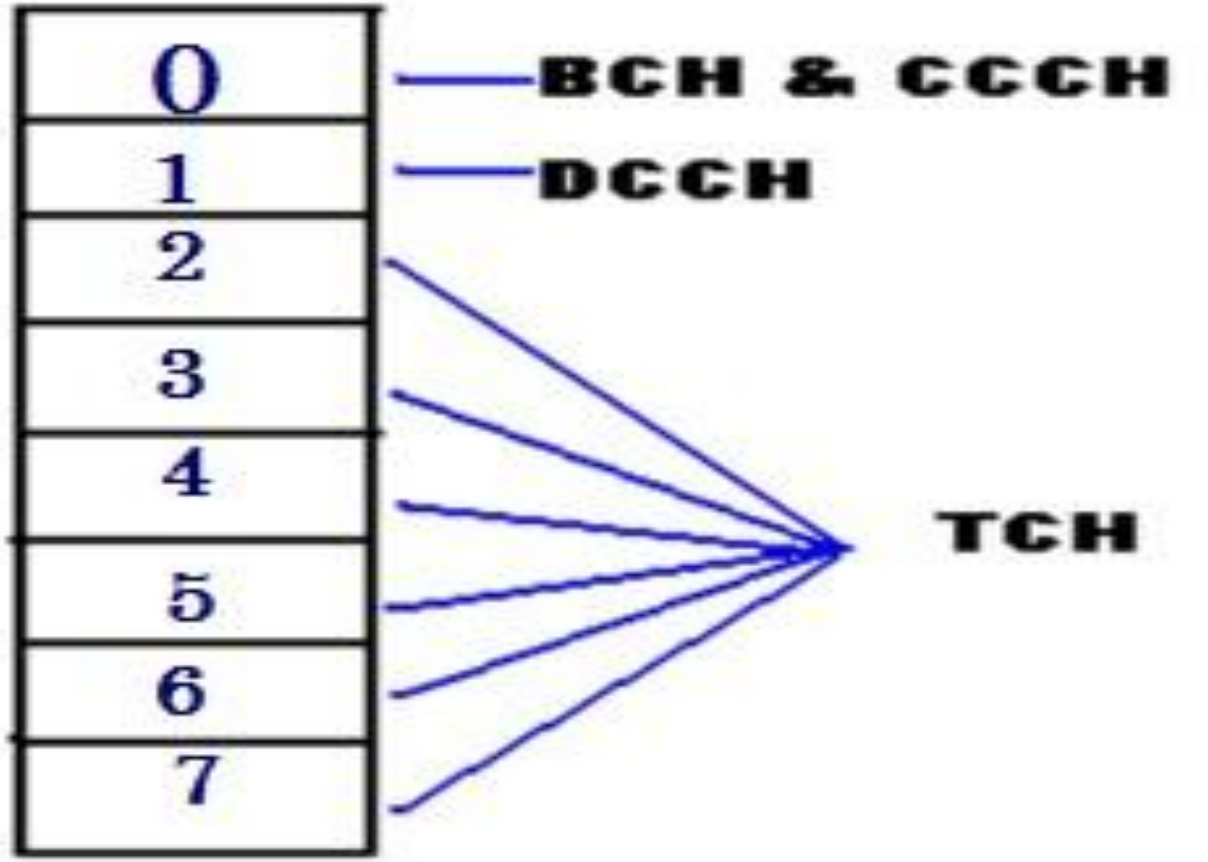
MODES OF MS

The MS can exist in three modes

1. **Attached Mode/Idle mode** – MS is powered on but not in use (the MS is not assigned any DCCH)
2. **Active/Dedicated mode** – MS is in use. It is assigned a DCCH
3. **Detached Mode** – MS is switched or powered off

MAPPING OF LOGICAL CHANNELS

Basically, GSM logical channels are mapped as below, several changes can be made in form of addition when the need for Data and capacity expansion arise.



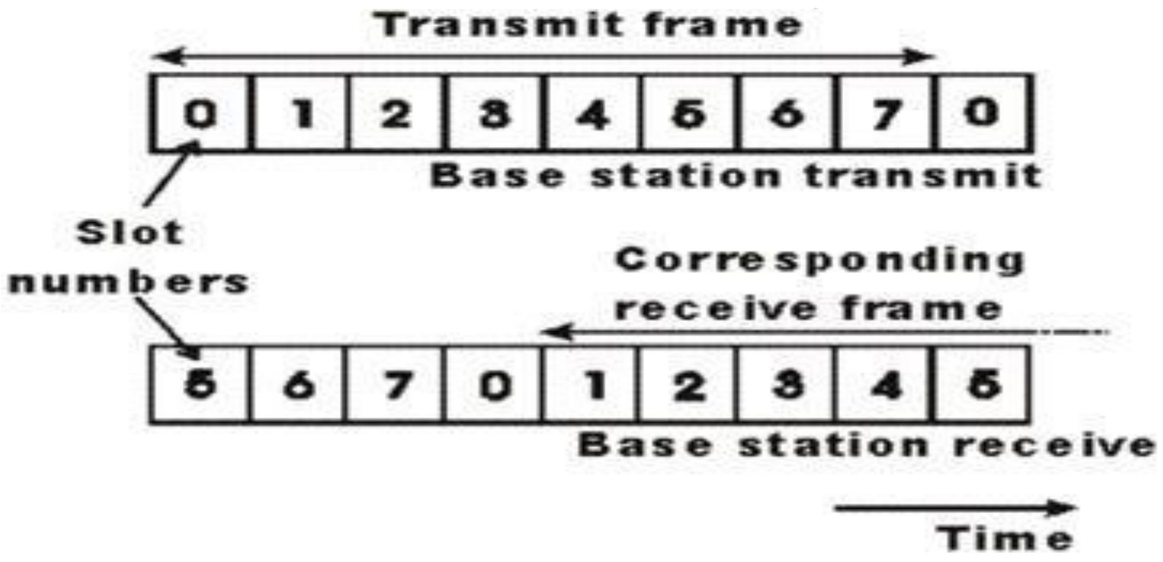
DATA FRAME NUMBERING

GSM frame structure uses slots, frames, multiframes, superframes and hyperframes to give the required structure and timing to the data transmitted.

The GSM system has a defined GSM frame structure to enable the orderly passage of information. The GSM frame structure establishes schedules for the predetermined use of timeslots. By establishing these schedules by the use of a frame structure, both the mobile and the base station are able to communicate not only the voice data, but also signaling information without the various types of data becoming intermixed and both ends of the transmission knowing exactly what types of information are being transmitted. The GSM frame structure provides the basis for the various physical channels used within GSM, and accordingly it is at the heart of the overall system.

BASIC GSM FRAME STRUCTURE

The basic element in the GSM frame structure is the frame itself. This comprises the eight slots, each used for different users within the TDMA system. As mentioned in another page of the tutorial, the slots for transmission and reception for a given mobile are offset in time so that the mobile does not transmit and receive at the same time.



GSM frame consisting of eight slots

The basic GSM frame defines the structure upon which all the timing and structure of the GSM messaging and signaling is based. The fundamental unit of time is called a burst period and it lasts for approximately 0.577 ms (15/26 ms). Eight of these burst periods are grouped into what is known as a TDMA frame. This lasts for approximately 4.615 ms (i.e.120/26 ms) and it forms the basic unit for the definition of logical channels. One physical channel is one burst period allocated in each TDMA frame.

In simplified terms the base station transmits two types of channel, namely traffic and control. Accordingly the channel structure is organized into two different types of frame, one for the traffic on the main traffic carrier frequency, and the other for the control on the beacon frequency.

Multiframes; The GSM frames are grouped together to form multiframes and in this way it is possible to establish a time schedule for their operation and the network can be synchronized.
There are several GSM multiframe structures:
Traffic multiframe: The Traffic Channel frames are organized into multiframes consisting of 26 bursts and taking 120 ms. In a traffic multiframe, 24 bursts are used for traffic. These are numbered 0 to 11 and 13 to 24. One of the remaining bursts is then used to accommodate the SACCH, the remaining frame remaining free. The actual position used alternates between position 12 and 25.

Control multiframe: The Control Channel multiframe that comprises 51 bursts and occupies 235.4ms. This always occurs on the beacon frequency in time slot zero and it may also occur within slots 2, 4 and 6 of the beacon frequency as well. This multiframe is subdivided into logical channels which are time-scheduled. These logical channels and functions include the following:Frequency correction burst, Synchronization burst, Broadcast channel (BCH), Paging and Access Grant Channel (PACCH) ,Stand Alone Dedicated Control Channel (SDCCH)

GSM Superframe: Multiframes are then constructed into superframes taking 6.12 seconds.
These consist of 51 traffic multiframes or 26 control multiframes. As the traffic multiframes are 26 bursts long and the control multiframes are 51 bursts long, the different number of traffic and control multiframes within the superframe, brings them back into line again taking exactly the same interval.

GSM Hyperframe:
Above this 2048 superframes (i.e. 2 to the power 11) are grouped to form one hyperframe which repeats every 3 hours 28 minutes 53.76 seconds. It is the largest time interval within the GSM frame structure.
Within the GSM hyperframe there is a counter and every time slot has a unique sequential number comprising the frame number and time slot number. This is used to maintain synchronization of the different scheduled operations with the GSM frame structure. These include functions such as:

Frequency hopping:
Frequency hopping is a feature that is optional within the GSM system. It can help reduce interference and fading issues, but for it to work, the transmitter and receiver must be synchronized so they hop to the same frequencies at the same time.

Encryption:
The encryption process is synchronised over the GSM hyperframe period where a counter is used and the encryption process will repeat with each hyperframe. However, it is unlikely that the cellphone conversation will be over 3 hours and accordingly it is unlikely that security will be compromised as a result.

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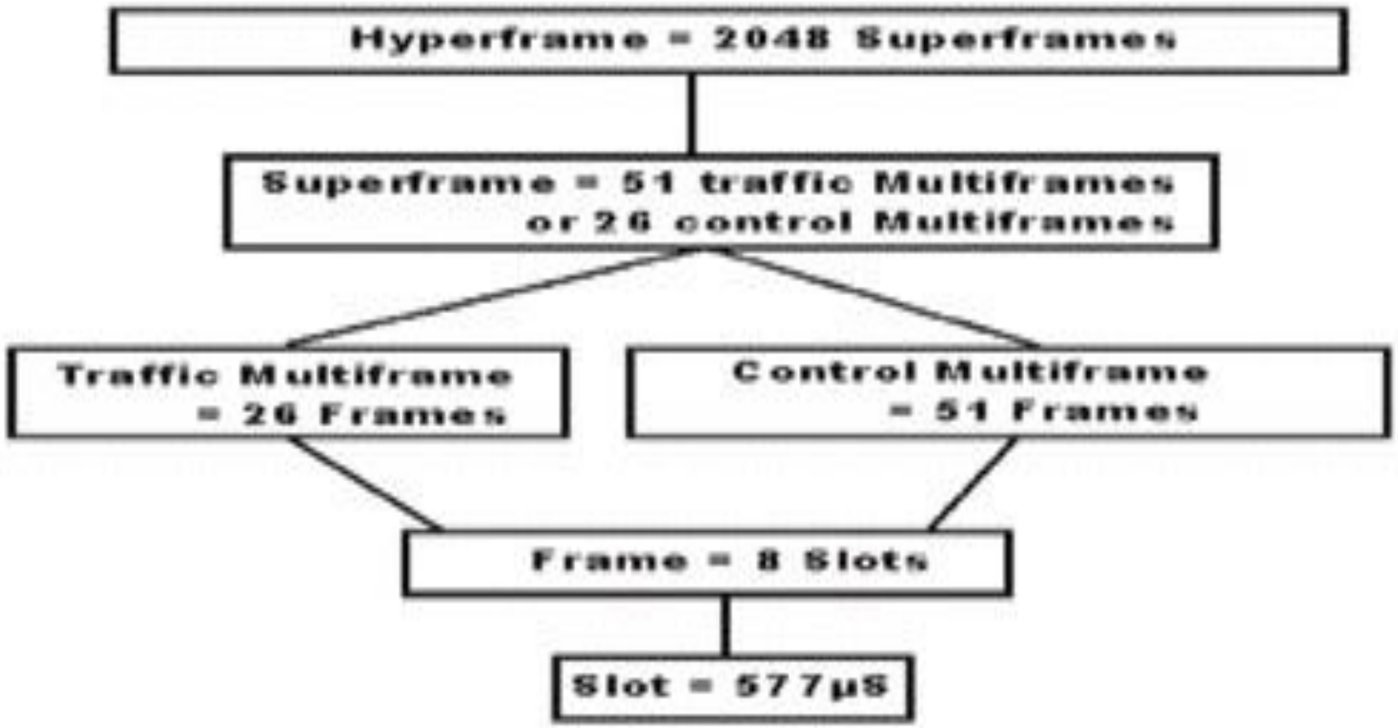

GSM Frame Structure Summary

The frame structure might be depicted as follows:

1 Frame =1250bits GMSK symbol= 2 bits

Total symbols= 625 Symbols

625 symbols occupies = 4.615 ms long. Consist of 8 time slots (0-7)

1 slot =156.25bits

GSM Mobility Management

TRAFFIC CASES are:IMSI Detach,IMSI Attach,Location Update, Implicit Detach,Paging,Handover and Cell reselection.

IMSI Attach

When an MS is switch on, the IMSI attach procedure is executed. This involves the following steps:

- The MS sends an IMSI attach message to the network indicating that it has change state to idle.
- The VLR determines whether there is a record for the subscriber already present. If not the VLR contacts the subscribers HLR for a copy of subscription information.
- The VLR updates the MS status to idle.
- Acknowledgement is sent to the MS.

If the MS has change LA while powered off, the IMSI attach procedure may lead to an update to the location of MS. During IMSI attach, the VLR may determine that the current LAI of the MS is different from the LAI stored in the MSs subscription information. If so, the VLR updates the LAI of the MS.

IMSI Detach

IMSI detach enables the MS to indicate to the network that it is switch off.

At power off, the MS sends an IMSI detach message to the network.

On reception, the VLR marks the corresponding IMSI as detached. The HLR is not informed. No acknowledgement is sent to the MS.

If the radio link quality is poor, the system might not be able to decode the information.

Because no acknowledgement is sent to the MS, no further attempt is made.

In this case, the system still regards the MS as attached. If the periodic registration is in use the system will eventually determine that the MS is detached. The VLR then performs an implicit detach, marking the MS as detached.

- A GSM mobile is in idle mode when the MS is switched ON

and there is no dedicated connection. Idle mode management is necessary for mobile to camp on the best suitable cell just;

- For MS to receive system info from the NW on DL For MS to be able to initiate a call whenever needed
- For the NW to be able to locate the MS when there is a MT call/SMS
- Idle Mode Tasks includes; PLMN selection, Cell selection and reselection Location update

RADIO POWER MEASUREMENT

dBm definition;dBm or *decibel-milliwatt* is an electrical power unit in decibels(dB), referenced to 1 milliwatt (mW).

The power in decibel-milliwatts (*P*(dBm)) is equal to the base 10 logarithm of the power in milliwatts (*P*(mW)):

dBs are brilliant and fun and make radio and signal level calculations a lot easier. Read here for an explanation plus a handy calculator which will convert dB values into watts and vice versa.

In radio communications you have many items (amplifiers, attenuators, signal splitters and combiners, loses cables etc) that either increase or decrease the signal level. To work out the end result for a signal going through a chain of such devices you use the dB gain or dB attenuation of each device and simply add all the dB values together.

MS Class	Full Rate	
	Power mW	dBm
GSM class 2	960	39 (8W)
GSM class 3	600	37 (5W)
GSM class 4	240	33 (2W)
GSM class 5	96	29 (0.8W)
DCS class 1	120	30 (1W)
DCS class 2	30	24 (.25W)
DCS class 3	480	36 (4W)

Power in Watt	Power in dBm
10W	40
20W	43
40W	46
80W	49

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ANTENNA BASIC PRINCIPLE

ANTENNA BASIC PRINCIPLES

What is an Antenna?

By definition, an antenna is simply a reciprocating device which converts high frequency currents to radio waves. It’s also a device designed to transmit or receive electromagnetic energy, matching these sources of energy and the space. The original information (high frequency current) is changed, for example through some kind of modulation and treatment, and still conveyed or guided by a cable to the antenna. The antenna then radiates this information(Electromagnetic wave)by the medium(air) until it reaches the other antenna, which in this case will make receiving the signal, making it still the way the cable to the device that

CLASSIFICATIONS OF ANTENNA

Classify by working band: UHF, VHF, microwave,etc.

Classify by radiate pattern:

- Omnidirectional: Radiates equally in all direction
- Directional: Unidirectional/Sectoral antenna and Bi-directional antenna which radiates in two direction.

directional Antenna

omni direction

ANTENNA PROPAGATION

A useful abstraction in the study of antennas is the isotropic radiator, which is an ideal antenna that radiates (or receives) equally in all directions, with a spherical pattern. The isotropic radiator is also sometimes called an omni-directional antenna, but this term is usually reserved for an antenna that radiates equally in all directions in one plane, such as a whip antenna, which radiates equally over azimuth angles but varies with elevation. The power density, S, due to an isotropic radiator is a function only of the distance, d, from the antenna and can be expressed as the total power

$$G = \eta \cdot \frac{\text{Power density at } d \text{ in max direction}}{P_T / 4\pi d^2}$$

Where, P_T is the power applied to the antenna terminals

$4\pi d^2$ is the surface area of a sphere with radius d

η is the total antenna efficiency, which accounts for all losses in the antenna, including resistive and taper* losses ($\eta = \eta_t \eta_R$)

That is, the power is uniformly distributed over the sphere. Thus for an isotropic radiator, the power density at a given range is constant over all angles and is equal to the average power density at that range.

For a real antenna, there will be certain angles of radiation, which provide greater power density than others (when measured at the same range). The directivity of an antenna is defined as the ratio of the radiated power density at distance, d, in the direction of maximum intensity to the average power density over all angles at distance, d. This is equivalent to the ratio

Antenna Gain: This can be measured in terms of dipole and isotropic. Dipole radiates in 2 directions while isotropic radiates in all direction. Antenna **gain: dBi=dBd + 2.15dB**

NB; Isotropic gain is 2.15 more than dipole gain

Note:

>16dBi High gain

14dBi – 16dBi, Medium gain

<13dBi Low gain

Gain

The radiation ability of certain antenna overlap dipole or isotropic

Indicates the antenna feauture of electromagnetic radiation in a specific direction.

Antenna Polarization

Polarization is defined as the orientation of the plane that contains the electric field component of the radiated waveform. In many cases, the polarization of an antenna can be determined by inspection. For instance, a vertical whip antenna generates and receives vertical polarization. Similarly, if the antenna element is horizontal, the wave polarization will be horizontal. Vertical and horizontal polarizations are both considered linear polarizations. Another type of polarization is circular or elliptical polarization. Circular polarization is similar to linear polarization, except that the polarization vector rotates either clockwise or counterclockwise, producing right-hand circular or left-hand circular polarization. Circular polarization is a special case of elliptical polarization, where the vertical and horizontal components of the

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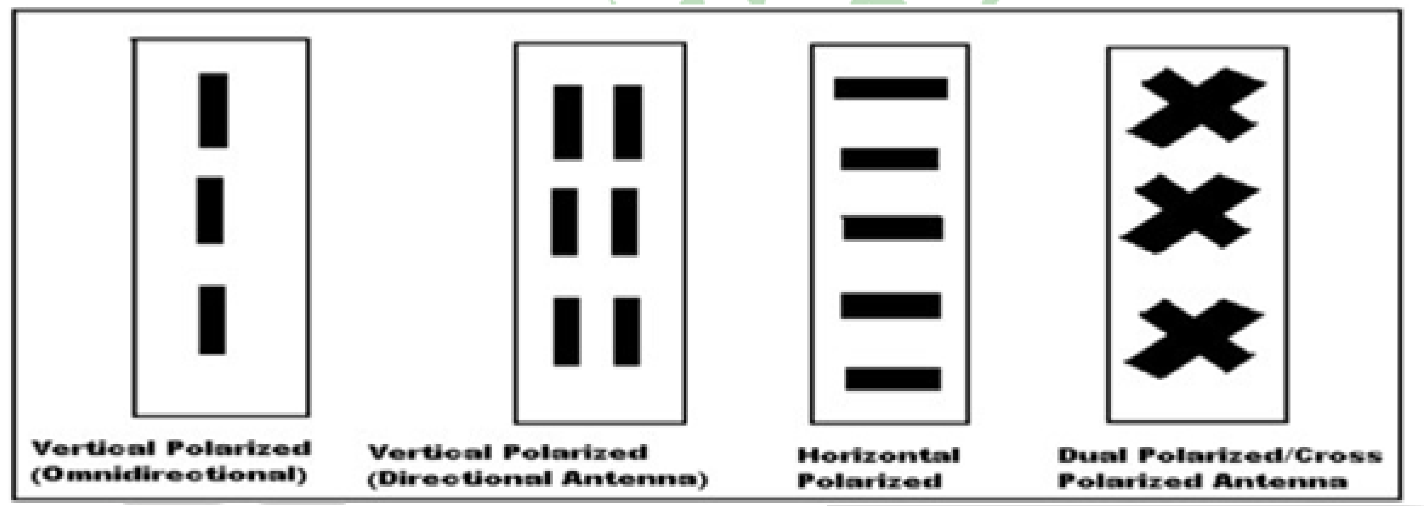

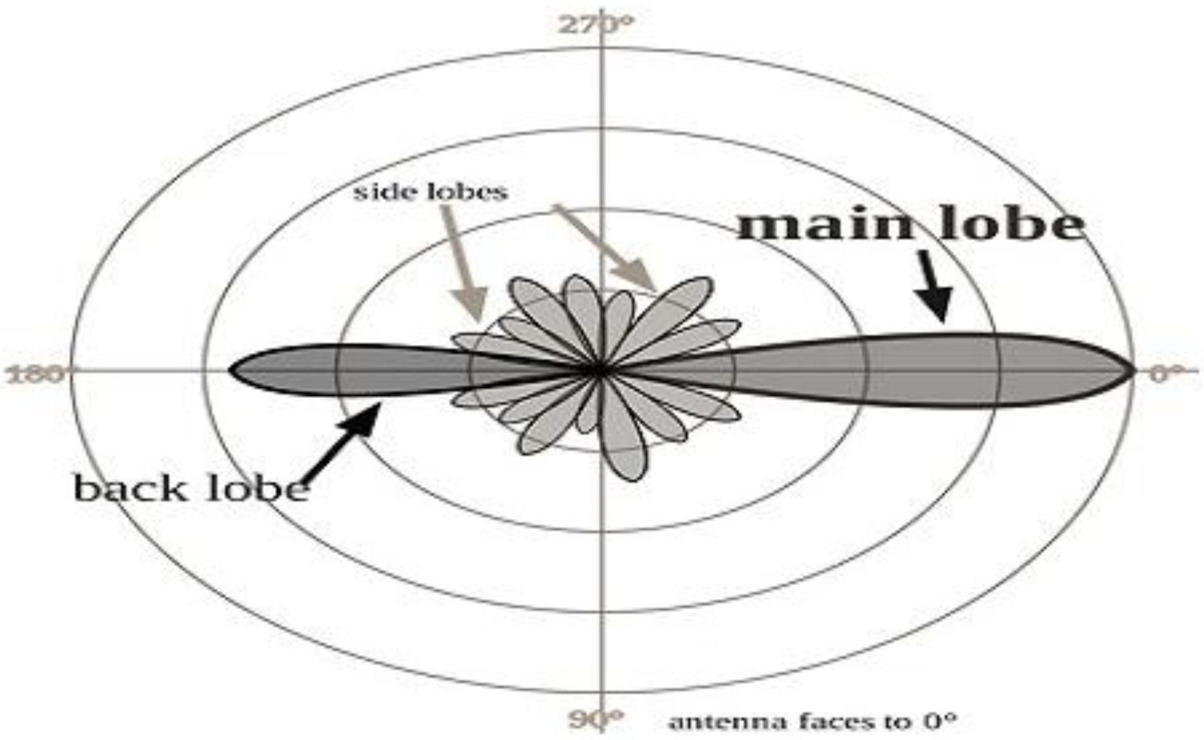

antenna-directivity

Radiation Pattern

Vertical and Horizontal pattern of an antenna is as below in directivity diagram.

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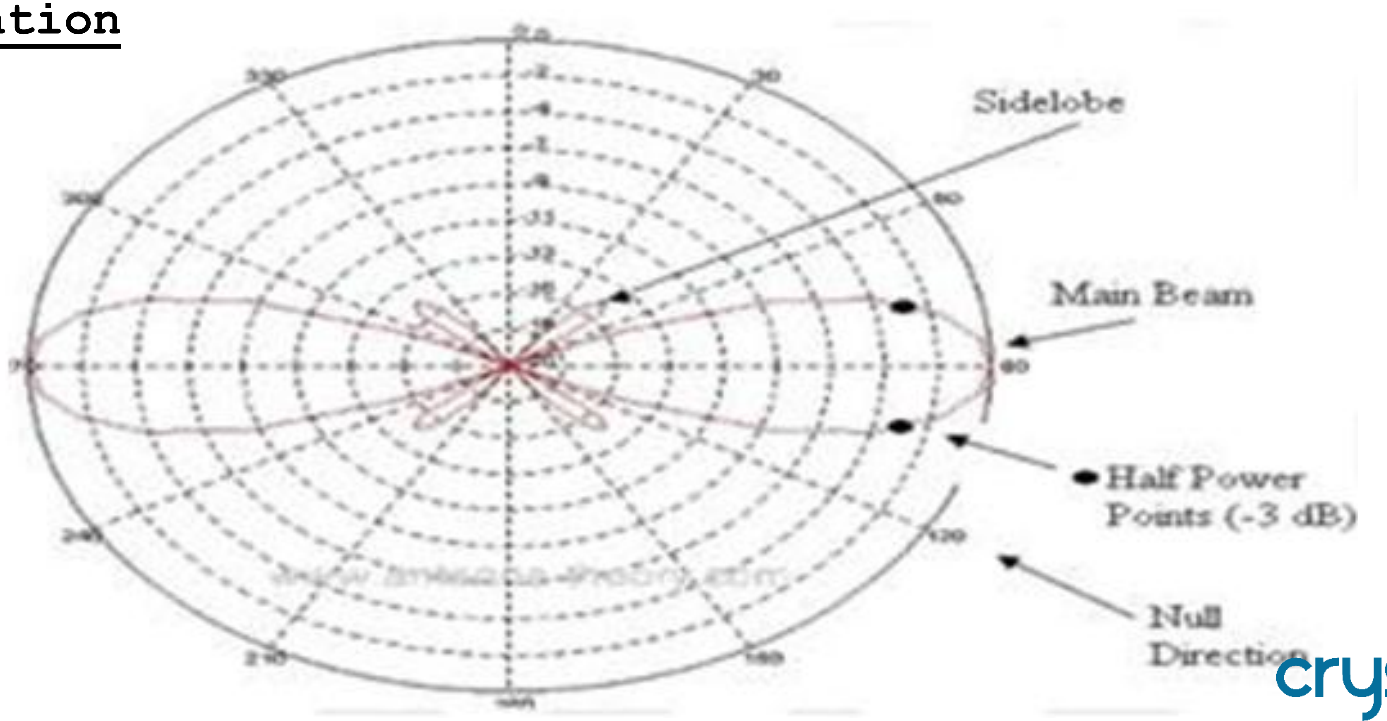
Front to Back ratio: Front to back ratio of an isotropic antenna is 1.If FB ratio of a directional antenna is high that means the front lobe has much value than the Back. This kind of antenna are normally used in urban/suburban areas in order to avoid interference(with back lobe)

i.e It shall apply null field technology when zero depth is less than main beam for 26dB.

Non Zero field(Null Field): Its used to control under tower effect.High gain antenna especially adopt Null field technology to effectively improve nearby coverage.

Beam width: See the polar radiation picture(PRP).



The main beam is the region around the direction of maximum radiation (usually the region that is within 3 dB of the peak of the main beam). The main beam in PRP is centered at 90 degrees. The sidelobes are smaller beams that are away from the main beam. These sidelobes are usually radiation in undesired directions which can never be completely eliminated. The sidelobes occur at roughly 45 and 135 degrees.

The **Half Power Beamwidth (HPBW)** is the angular separation in which the magnitude of the radiation pattern decrease by 50% (or -3 dB) from the peak of the main beam. From PRP, the pattern decreases to -3 dB at 77.7 and 102.3 degrees. Hence the HPBW is 102.3-77.7 = 24.6 degrees.

Another commonly quoted beamwidth is the Null to Null Beamwidth. This is the angular separation from which the magnitude of the radiation pattern decreases

Antenna Feeder Line system

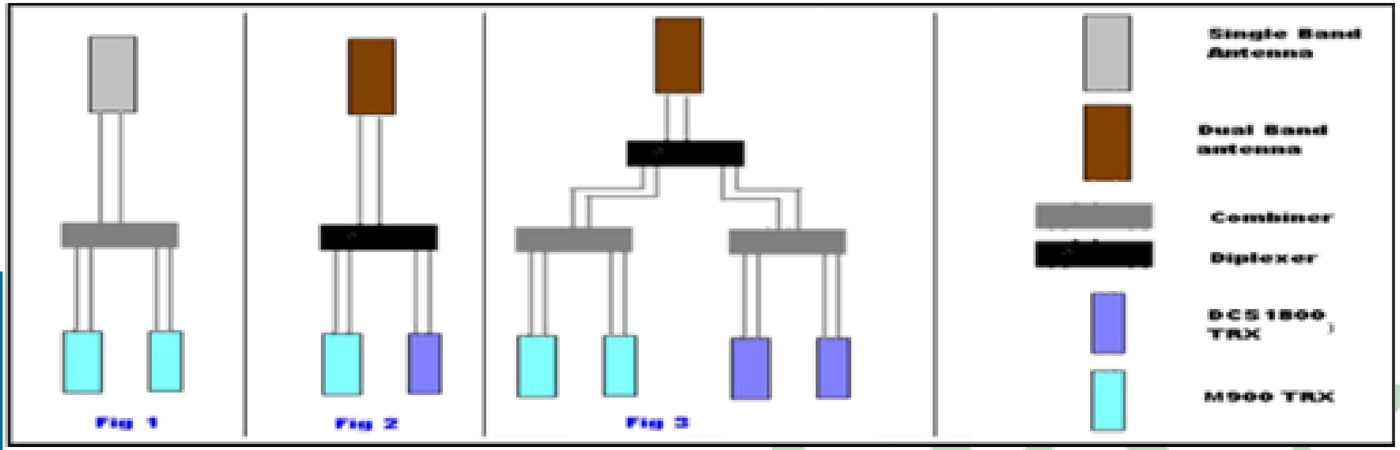
Cables and Types of Connectors

Jumper cable is flexible or can be bent connected TMA to antenna

Feeder cables are also connected to jumper cable using a connector or directly to an antenna (depending on the site configuration).

Duplexers /Diplexer /Combiner

Combiner combines cables from multiple TRX into 1(Tx, Rx) outfeed to the antenna. Diplexer/Duplexer combines cables from 2 different frequency into 1,fed into an antenna.



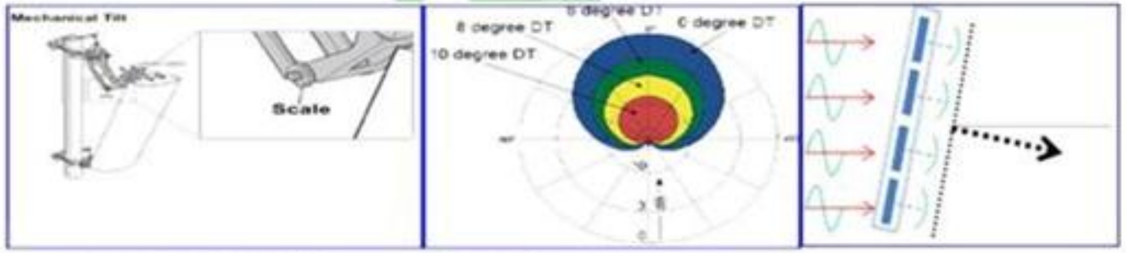
Tower Mount/Top Amplifier(TMA/TTA) : It is used to

- √ Amplify weak uplink signals
- √ Balance Uplink/Downlink signals
- √ Compensate loss on feeder/cables/connectors

Antenna Tilt

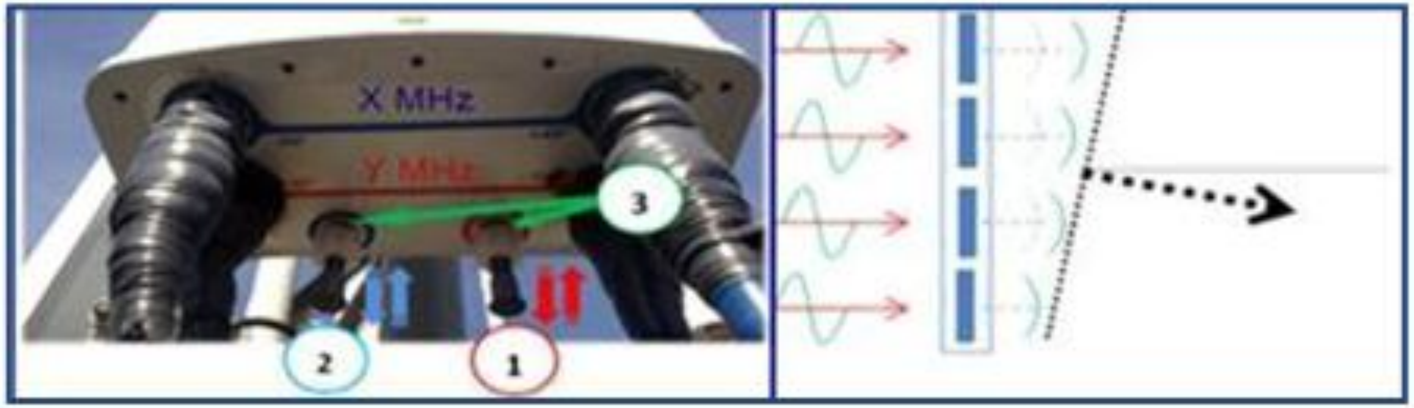
Antenna Tilt; It is the inclination or angle of the antenna to its axis. We apply tilt to change the antenna radiation pattern. There are two possible types of Tilt (which can be applied singly/together):

Mechanical tilt: tilting the antenna, through specific accessories on its bracket, without changing the phase of the input signal, the diagram (and cor



rections) is modified.

Electrical tilt: the modification of the diagram is obtained by changing the characteristics of signal phase of each element of the antenna, as seen below



Remote Electrical tilt: the modification of the diagram is obtained by changing the characteristics of signal phase of each element of the antenna remotely(From Backoffice OSS), as seen below.

PHYSICAL SITE OPTIMIZATION

Antenna Azimuth Adjustment:

Antenna azimuth/Direction means concentrating the beam from an antenna to a specific/designed direction for better coverage(Traffic concentrated area not bush or river)

Antenna E/M Tilt adjustment procedures:

The efficiency of a cellular network depends of its correct configuration and adjustment of radiant systems: their transmit and receive antennas. And one of the more important system optimizations task is based on correct adjusting tilts, or the inclination of the antenna in relation to an axis. With the tilt, we direct irradiation further down (or higher), concentrating the energy in the new desired direction.

When the antenna is tilted down, we call it 'downtilt', which is the most common use. If the inclination

is up (very rare and extreme cases), we call 'uptilt'.

NB: for this reason, when we refer to tilt in this tutorial this means we're talking

ANTENNA TILT SAMPLE PATTERN:

With the mechanical tilt, the coverage area is reduced in central direction, but the coverage area in side directions are increased.

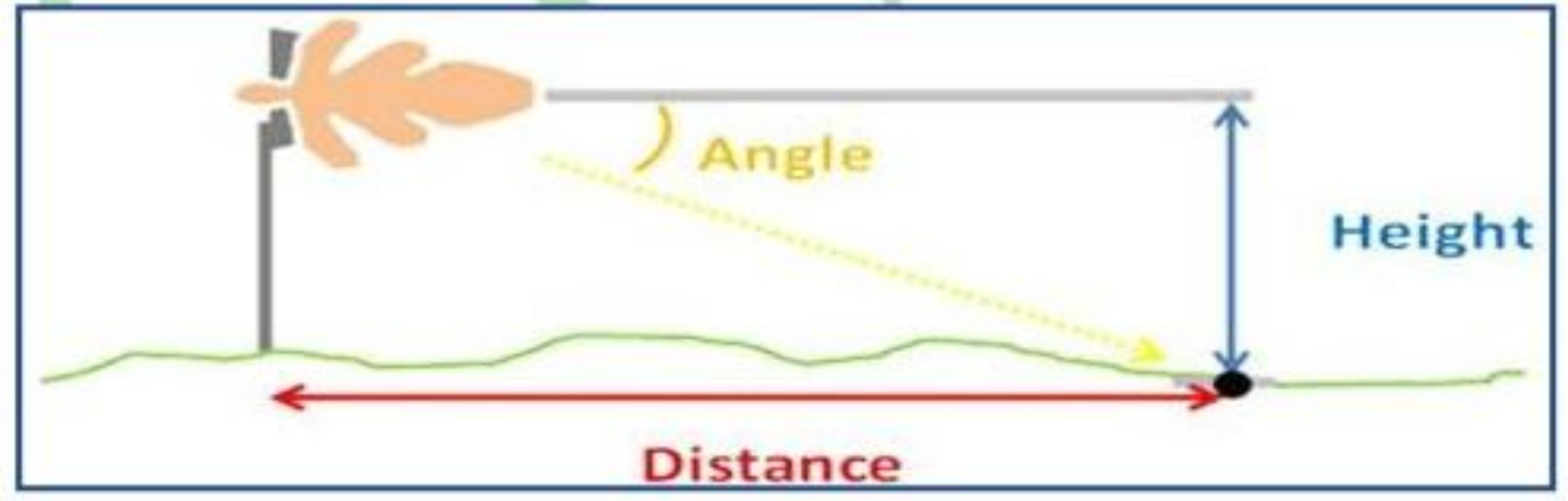
With the electrical tilt, the coverage area suffers a uniform reduction in the direction of the antenna

Conclusion:

The advantages of one tilt type to another tilt type are very based on its application – when one of the above two result is desired/required . But in General, the basic concept of tilt is that when we apply the tilt to an antenna, we improve the signal in areas close to the site, and reduced the coverage in more remote locations. In other words, when we're adjusting the tilt we seek a signal as strong as possible in areas of interest (where the traffic must be), and similarly, a signal the weakest as possible beyond the borders of the cell. Of course everything depends on the 'variables' involved as tilt angle, height and type of antenna and also of topography and existing obstacles . Roughly, but that can be used in practice, the tilt angles can be estimated through simple calculation of the vertical angle between the antenna and the area of interest.

In other words, we chose a tilt angle in such a way that the desired coverage areas are in the direction of vertical diagram. It is important to compare: the antenna angle toward the area of interest ; the antenna

As basic formula, we have: *Angle = ArcTAN (Height / Distan*



So, calculations (and measurements) must be made to predict (and check) the results, and if that means coverage loss, we should re-evaluate the tilt.

It is a good practice to define some 'same' typical values (default) of tilt to be applied on the network cells, varying only based on region, cell size, and antennas heights and types.

It is recommended not to use too aggressive values: it is better to start with a small tilt in all cells, and then go making any adjustments as needed to improve coverage/interference.

When using mechanical tilt, remember that the horizontal beamwidth is wider to the antenna sides, which can represent a problem in C/I ratio in the coverage of neighboring cells.
Always make a local verification, after changing any tilt, by less than it has been. This means assessing the coverage and quality in the area of the changed cell, and also in the affected region. Always remember that a problem may have been solved ... but another may have arisen!

Antenna Tilt; It is the inclination or angle of the antenna to its axis. We apply tilt to change the antenna radiation pattern.
There are two possible types of Tilt (which can be applied singly/together):
Mechanical tilt: tilting the antenna, through specific accessories on its bracket, without changing the phase of the input signal, the diagram (and consequently the signal propagation directions) is modified.
Electrical tilt: tilting the antenna, through specific knob on the antenna.

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Recommendations

The main recommendation to be followed when applying tilts, is to use it with caution.

Although the tilt can reduce interference, it can also reduce coverage, especially in indoor locations.

So, calculations (and measurements) must be made to predict (and check) the results, and if that means coverage loss, we should re-evaluate the tilt.

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RF PROPAGATION FUNDAMENTALS

RF PROPAGATION FUNDAMENTALS(RF TERMS)

Network Problems; Most radio network problems occurs when the radio signal is interrupted by

physical object or other signal or when the distance between the BTS and MS becomes too much.

1. **Pathloss** ; Occurs when the MS moves far away from the BTS. The signal becomes weak and if there is

no handover to other cell ,the call will drop.

2. **Interference** ; This happens when there is distortion in signal resulting to bad quality.

Sources; Improper frequency planning(frequency reuse pattern)

External frequency(Interferer)

Multipath (Long Echo)

Types of interference is majorly co-channel (Same BCCH frequency) and

b) Suitable site location

c) Discontinous Transmission; It takes advantage of the fact that a person speaks less than 40% of the time in a normal conversation, thereby turning off the transmitter during silent periods. This also conserves power. **Voice activity detection(VAD)** is a component of DTX that distinguishes between voice and noise input. If a voice signal is misinterpreted as noise, the transmitter is turned off and a very annoying effect called 'clipping' is heard at the receiving end.

d) Adaptive Channel allocation

e) Antenna optimization

f) Using Adaptive Antenna.

3. **Fading:** It is the loss of signal strength or attenuation due to obstacles or obstructions. The wireless channel may experience fading in time or frequency. The two types of fading are;

i. **Lognormal or slow fading;** Occurs when there is obstacle between the BTS and MS. It's called shadowing. It's a problem in the uplink direction because a BTS transmit information at a much higher power compared to the MS.

Solution to Lognormal Fading are

a) Adaptive power control; Based on the quality of the received signal, the BTS informs the MS to increase or decrease its output power. The information is sent on SACCH.

b) Power control; Both UL and DL power settings can be adjusted independently to reduce fading and interference

ii.Rayleigh/Fast fading; Occurs when radio signal is reflected by obstacles within or near its environment, this causes frequency dips resulting in poor speech quality.

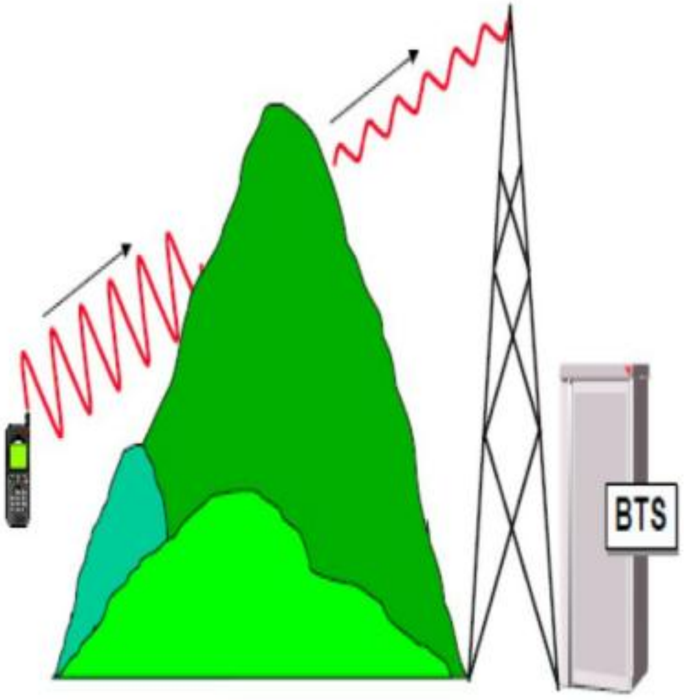
Solution:

a. Time diversity ;It involves channel coding and interleaving.

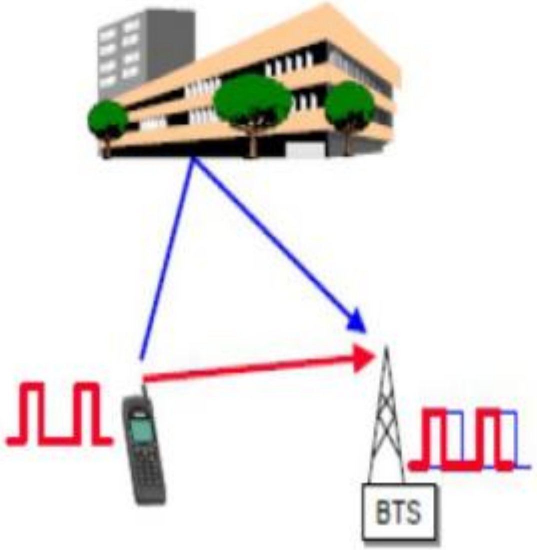
In Channel coding(user data is coded using standard algorithms for error detection and correction purposes, It requires extra information to be added to the user data.

b. Interleaving; Spreading of the coded speech into many bursts to be able to recover the data even if one

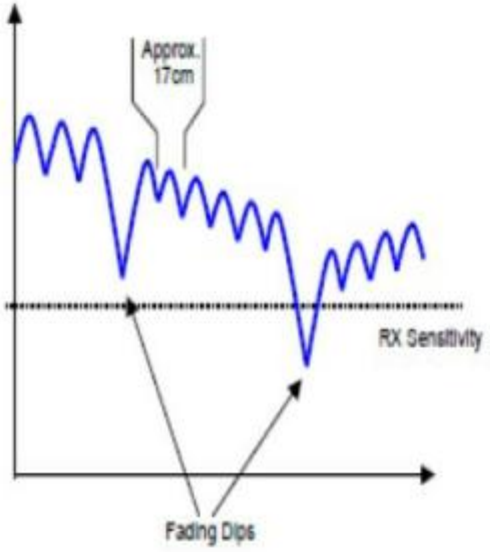
burst on techniques. Antenna diversity e.t.c



SHADOWING



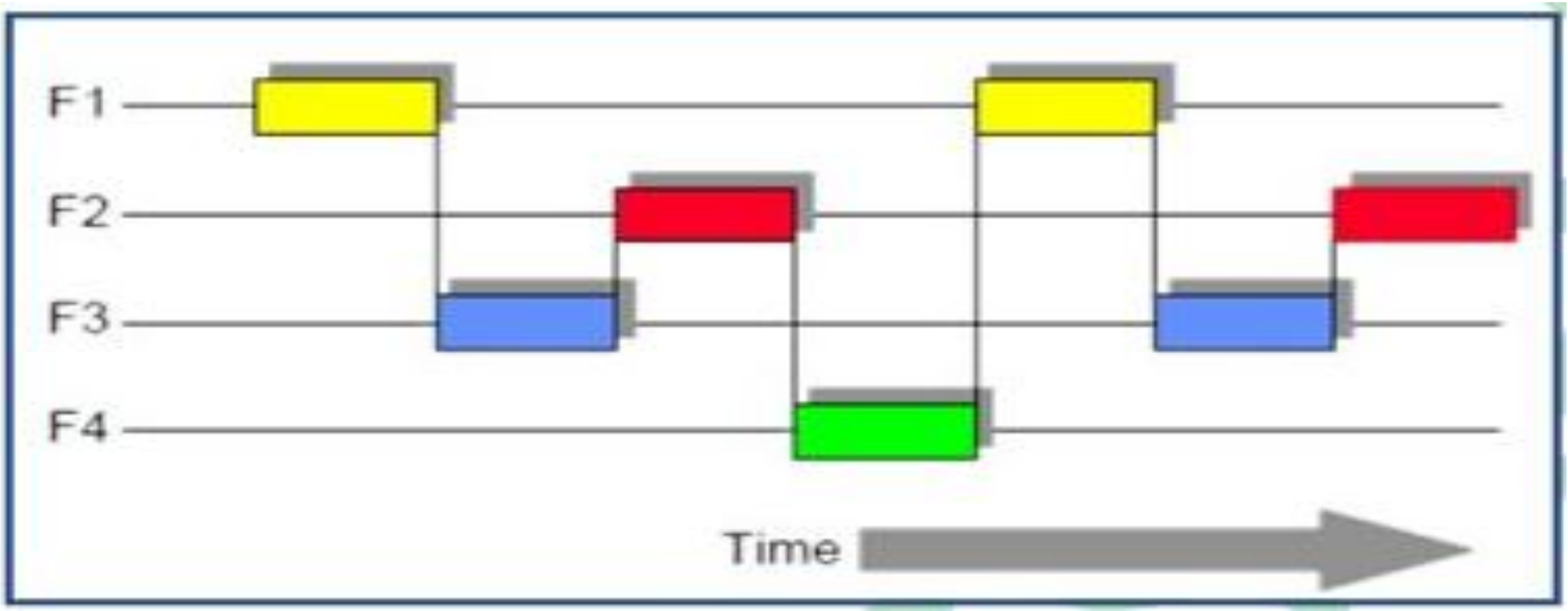
Inter Symbol Interference



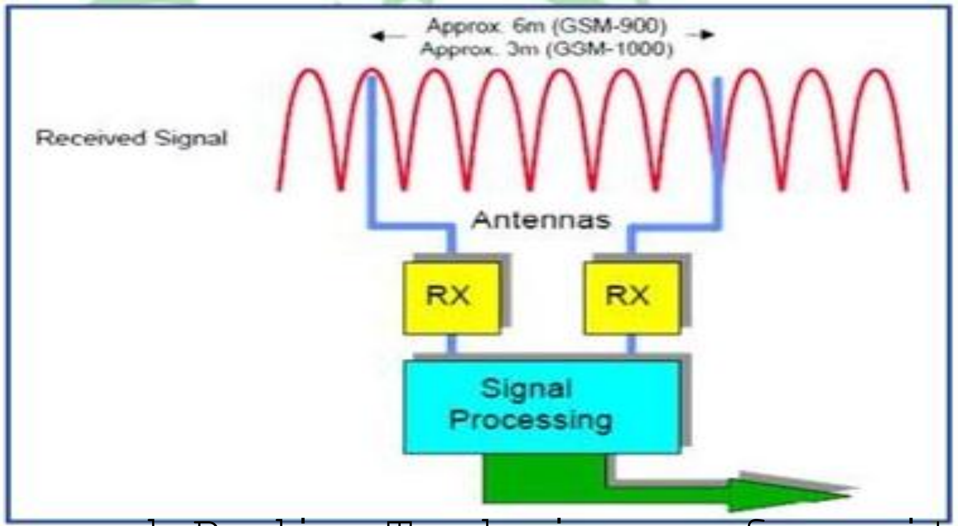
Fading dips caused by multipath propagation

c. Frequency Hopping; The frequency on which information is transmitted is changed for every burst however if there are less than four frequencies in the cell it may not improve the performance

s



d. Antenna/Space Diversity; Incorporate two separate receiving antenna that are physically seperated. Each antenna receives the same radio signal independently and both do not interfere at the same time. The system chooses the



Other Network problems and Radio Techniques for mitigation;

Time dispersion; This is caused by signal reflection of far-away objects such as hills, mountains e.t.c The reflected delayed bits interferes with the direct bits causing inter symbol interference. The bits interfere with each other making it difficult to detect which is the direct bit.

Solution;

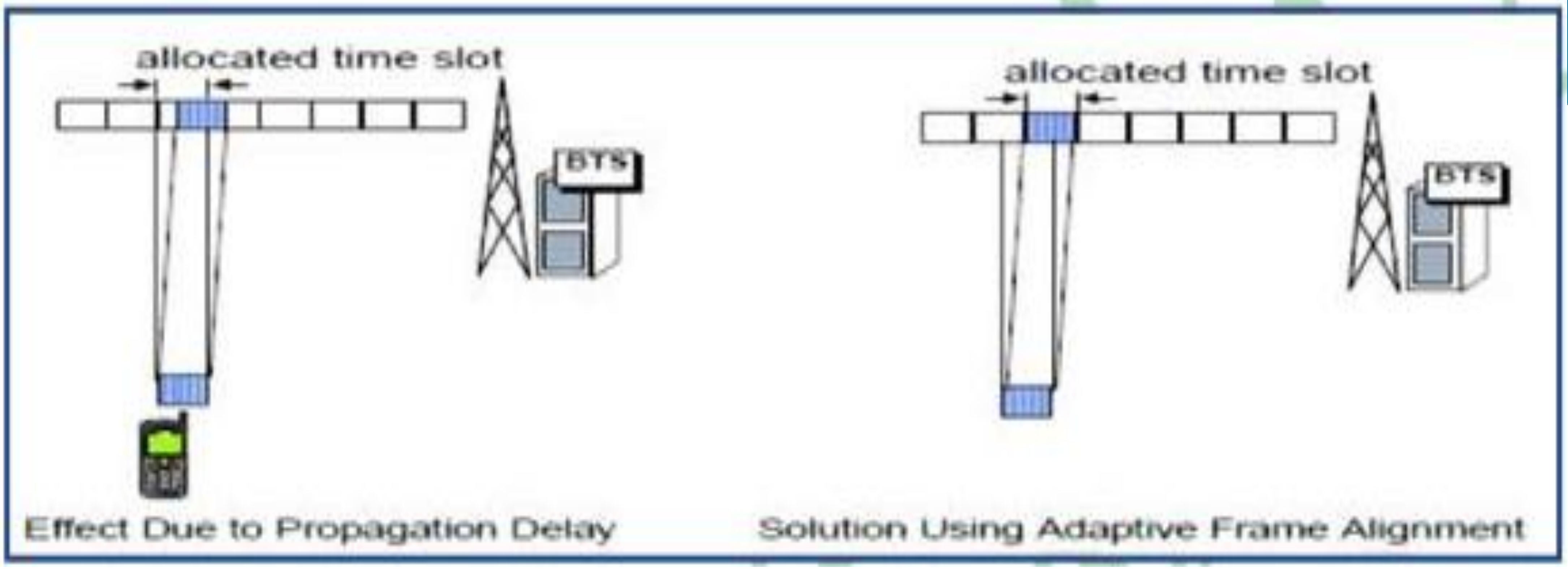
Viterbi equalization; The information is sent in burst from the MS to the BTS and transmitted on the time slot. Part of the information in a burst is called a training sequence which is used by the equalizer to determine to determine what was to be received versus what was actually received

Time Alignment;This occurs when the MS moves further away from the BTS and the radio signal takes a longer time to arrive. This cause the transmission to slide in to the neighbour slot.

Solution;

Timing Advance; When a MS is moving away from the BTS, the timing parameter t [illegible] slot

s [illegible]



RADIO NETWORK PLANNING

RADIO NETWORK PLANNING

Radio Network Planning Flow

A. Preplanning Stage

Decides the layout of the future network ,It entails;

i. Traffic and Coverage Analysis - the cell planning process starts with this. The analysis produces information about the geographical area and the expected need for capacity.

Information collected includes:

- Costs of building the network Capacity of the network
- Coverage and location of network elements
- Grade of service (max. congestion allowed)
- Quality of calls
- Further development of the network
- Population distribution
- Income distribution in the area
- Telephone subscription
- Car usage distribution
- Subscription charges, call charges

ii. Simulation/Nominal Cell Plan – planning of subscriber distribution with the aid of planning software. E.g. ASSET, HuaweiUNET, Ascom TCP, Forsk Atoll e.t.c

At this stage, coverage and interference predictions are started.Coverage predictions are made to predict the coverage of the Network to be constructed according to the location and to see if it can meet the subscriber demands.

Difficulties encountered in preplanning:

- Complex emission environs/ severely fluctuating signals
- Severe Interference
- Limited frequency resources

B.Planning stage

Site surveys – assess the real environment to determine whether the proposed site is a suitable location.

- Principles of site selection
- Population distribution
- Traffic distribution
- Subscriber flow direction
- Surrounding environment
- Accessibility to site
- Power supply
- Signal propagation model

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1) Coverage planning – from the coverage predictions made, if the results do not meet the requirements, adjustments need to be made.

- When there are subscribers outside the cell coverage area where it is not economical to set up a BTS, broadcast stations should be used.
- when the signal in the coverage area is weak or if there is a blind area, the micro cell technique is considered to solve this problem.

Micro cells are used in city areas to cover close by areas or distances.

- If the cell coverage area does not overlap one another enough, consider increasing the antenna height or the number of BS according to the cell splitting technique.

Cell Splitting - Involves splitting of a large omni-directional cell/BS into smaller cells and splitting of smaller sector cell into smaller cells.

Coverage planning includes selecting the design parameters:

Antenna height (Above ground) ,Antenna azimuth angle ,Antenna gain, tilt ,BS height above sea level ,BS type,Propagation models(Cost 231 HATA model,Okumura HATA model,Cost 231 Wallish Ikegami models e.t.c) and Transmitter output power

2) Capacity Planning – capacity analysis helps to make reasonable investment decisions.

Consider: income, telephone subscription, economic development of the area, population distribution.

Traffic of each subscriber is considered. Traffic is the usage of channels and it is measured in Erlangs.

The traffic a cell can carry depends on the number of traffic channels available and the acceptable probability that the system is congested (GoS) – no. of unsuccessful calls.

To calculate the number of subscriber=Traffic that 1 cell can offer (Acell) / Traffic per subscriber(A sub) or otherwise explained as below;

1 Subscriber is assumed to require 1 Traffic Channel for his voice call.

From Erlang table1 Subscriber will use 0.02 Erlang on that 1 TCH.

With this, it's easier to know numbers of traffic channels X subscriber will require by first calculating the amount of erlangs X subscribers will generate.

ERLANG B TABLE

Chs	1%	2%	3%	5%	Chs	1%	2%	3%	5%
1	0.01	0.02	0.03	0.05	21	12.80	14.00	14.90	16.20
2	0.15	0.22	0.28	0.38	22	13.70	14.90	15.80	17.10
3	0.46	0.60	0.72	0.90	23	14.50	15.80	16.70	18.10
4	0.87	1.09	1.26	1.52	24	15.30	16.60	17.60	19.00
5	1.36	1.66	1.88	2.22	25	16.10	17.50	18.50	20.00
6	1.91	2.28	2.54	2.96	26	17.00	18.40	19.40	20.90
7	2.50	2.94	3.25	3.75	27	17.80	19.30	20.30	21.90
8	3.13	3.63	3.99	4.54	28	18.60	20.20	21.20	22.90
9	3.78	4.34	4.75	5.37	29	19.50	21.00	22.10	23.80
10	4.46	5.08	5.53	6.22	30	20.30	21.90	23.10	24.80
11	5.16	5.84	6.33	7.08	31	21.20	22.80	24.00	25.80
12	5.88	6.61	7.14	7.95	32	22.00	23.70	24.90	26.70
13	6.61	7.40	7.97	8.83	33	22.90	24.60	25.80	27.70
14	7.35	8.20	8.80	9.73	34	23.80	25.50	26.80	28.70
15	8.11	9.01	9.65	10.60	35	24.60	26.40	27.70	29.70
16	8.88	9.83	10.50	11.50	36	25.50	27.30	28.60	30.70
17	9.65	10.70	11.40	12.50	37	26.40	28.30	29.60	31.60
18	10.40	11.50	12.20	13.40	38	27.30	29.20	30.50	32.60
19	11.20	12.30	13.10	14.30	39	28.10	30.10	31.50	33.60
20	12.00	13.20	14.00	15.20	40	29.00	31.00	32.40	34.60

- NB: We are using Erlang B table here .

Example;to know the nos of Traffic Channels required for 1500 Subscribers.

We assumed 1 Subscriber uses 1 Channel which is 0.02 Erlang on the table.

1500 subscriber will use how many erlangs? X erl = 1500*0.02 = 30 erlangs.

Note:No 30 erlangs on that table but we have 30.10 erlangs with equivalent of 39 Traffic channels as shown on the table.

Therefore ,We need 39 Traffic channels for 1500 subscribers.

3) Frequency Planning - using radio channels of the same frequency in the cells of different coverage areas ,Towns and villages rich in capacity/ subscribers use 4/12 reuse pattern Big and middle sized cities – 3/9 reuse pattern

4) LAC Planning – the planner presents the allocation and resource application of the LAC based on network structure and scale.

5) Radio Parameter Planning ;It involves Handover/cell reselection parameters, Idle mode parameters, MAIO/HSN parameters, cell attribute parameters e.t.c

6) Cell Data Making – Configure the relevant data for each BS cell

Cell attribute parameter, Cell handover band selection Channel allocation algorithm selection. If to use frequency hopping, power control or DTX

C. Cutover/Launch - system installation and commissioning and testing are performed following the planning stage.

D.Network Monitoring and Optimization – the system is continually evaluated to determine how well it meets the demand.

Frequent optimization and adjustment is needed as subscribers increase.

LINK BUDGET

It’s used to balance uplink and downlink.

PBTS= PMS + Ga -Kb

PBTS= BTS Power

PMS = MS Power

Ga = Antenna Gain

Kb = Losses

A link budget is the accounting of all of the gains and losses from the transmitter, through the medium (free space, cable, waveguide, fiber, etc.) to the receiver in a telecommunication system. It accounts for the attenuation of the transmitted signal due to propagation, as well as the antenna gains , feeder/cable loss and miscellaneous losses. Randomly varying channel gains such as fading are taken into account by adding some margin depending on the anticipated severity of its effects. The amount of margin required can be reduced by the use of mitigating techniques such as antenna diversity and frequency hopping.

A simple link budget equation looks like this:

Received Power (dBm) = Transmitted Power (dBm) + Gains (dB) − Losses (dB) VSWR (Voltage Standing Wave Ratio)

VSWR=input/ output. VSWR tolerable value=1.15

Tool for Test/correction: Site Master

It helps detect DTF(Distance to fault) on feeder lines

SITE SURVEY ENGINEERING

It involves the process to assess the real environment to determine whether the proposed site is in a suitable location(After nominal cell planning). A nominal coordinate is given for an Engineer to carry out his survey.

We have 2 types of survey namely;

Preliminary survey and Detailed survey.

In preliminary survey; It is done randomly for a given area. Its the first stage of survey and the survey must have at least two candidates for any point given.

Detailed survey; comes after deciding on the sites to use, after ITP getting list from customers, Site Types(Indoor or Outdoor),Site ID, Site Name, Types of antenna and network capacity/site configuration.

Types of sites

- New tower(Green field or new location)
- Roof top(especially in urban areas)
- Collocation(An existing tower of an operator).
- Visiting Target areas(Schools, mosques, hospitals, market e.t.c)

Azimuth taken based on target areas,(Antenna type, Antenna height, Structure support, Antenna model,Antenna quantity, Antenna height on structure with altitude, Antenna tilt, Terrain, population and comprehensive analysis of every other observations).

Also Coordinates of search area is needed.

panoramic view pictures in all direction and Pictures of each candidate.

Task;

Download or use GPS APP on your phone to take coordinates of many hotspots and note the Longitude and Latitude.

TOOLS REQUIRED;

Software includes: Digital Maps,MapInfo and Google earth

Hardware includes;

- Digital Camera for taking pictures
- Survey GPS for tracing and marking location (It helps in taking coordinates, your reference point on earth surface.)
- Compass for getting directions (Antenna orientation/azimuth).
- Altimeter can give an accurate measurement of altitude.
- Tape rule for measuring distance
- Binoculars for viewing environment and microwave link and other far distance objects.
- Laser meter is used to measure height of buildings, trees and towers.
- Laptop for easy storage and transfer of information on camera and also battery and charger is a necessity.

SITE CONFIGURATION

Site configuration is determined by the type of service we want to render to a particular area.

Capacity of a site will determine the nos of TRx to be used on a site(per cell basis).

For example;S111/222 configuration means the site has 1 TRx each on 900 band of sector A,B and C, and also 2 TRx each on 1800 band of sector A,B and C.

Practical exercise can be considered in the class on site configurations and Picking points (The Use of Compass, GPS and Digital Camera).

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RADIO BASE STATION OR BASE TRANSCIEVER STATION

BTS Components ; it consists of BTS indoor and Outdoor Units Indoor Unit
BTS –Base Transceiver Station.
The Base transciever station, or BTS, contains the equipment for transmitting and receiving radio
signals (Transcivers),Antennas, and equipment for encrypting and decrypting communications with the Base station controller (BSC). Typically a BTS has several transceivers (TRXs) which allow it to serve several different
frequencies and different sectors of the cell

Components of indoor units
Transceiver (TRX) Quite widely referred to as the driver receiver (DRX). DRX are either in the form of
single (sTRU), double (dTRU) or a composite Double Radio Unit (DRU). It basically does transmission
and reception of signals. Also does sending and reception of signals to/from higher network entities (like the Base station controller in mobile telephony)

RADIO BASE STATION OR BASE TRANSCIEVER STATION

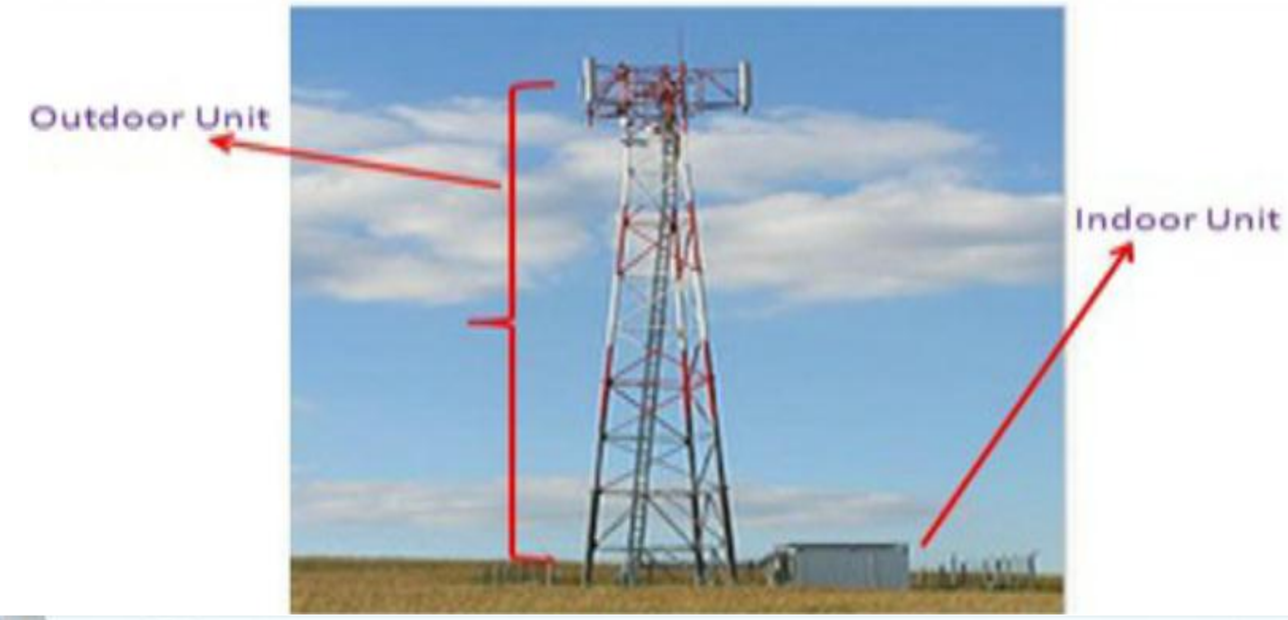
Power amplifier (PA) amplifies the signal from DRX for transmission through antenna; may be integrated with DRX a single antenna. Allows for a reduction in the number of antenna used.

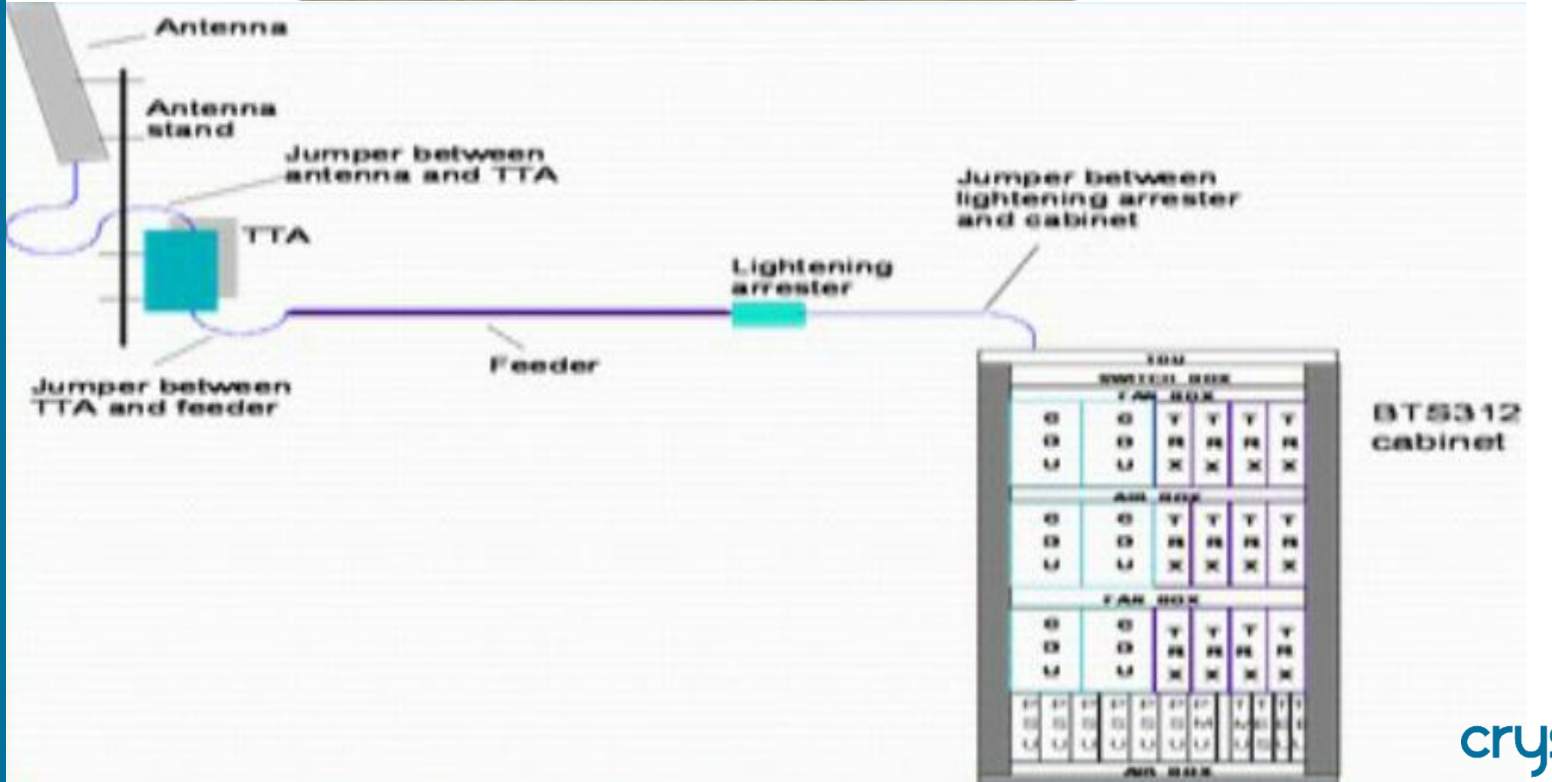
Duplexer; For separating sending and receiving signals to/from antenna. Does sending and receiving signals through the same antenna ports (cables to antenna).

Baseband receiver unit or RMU(Radio Main unit): This is the unit that performs processing of traffic received.

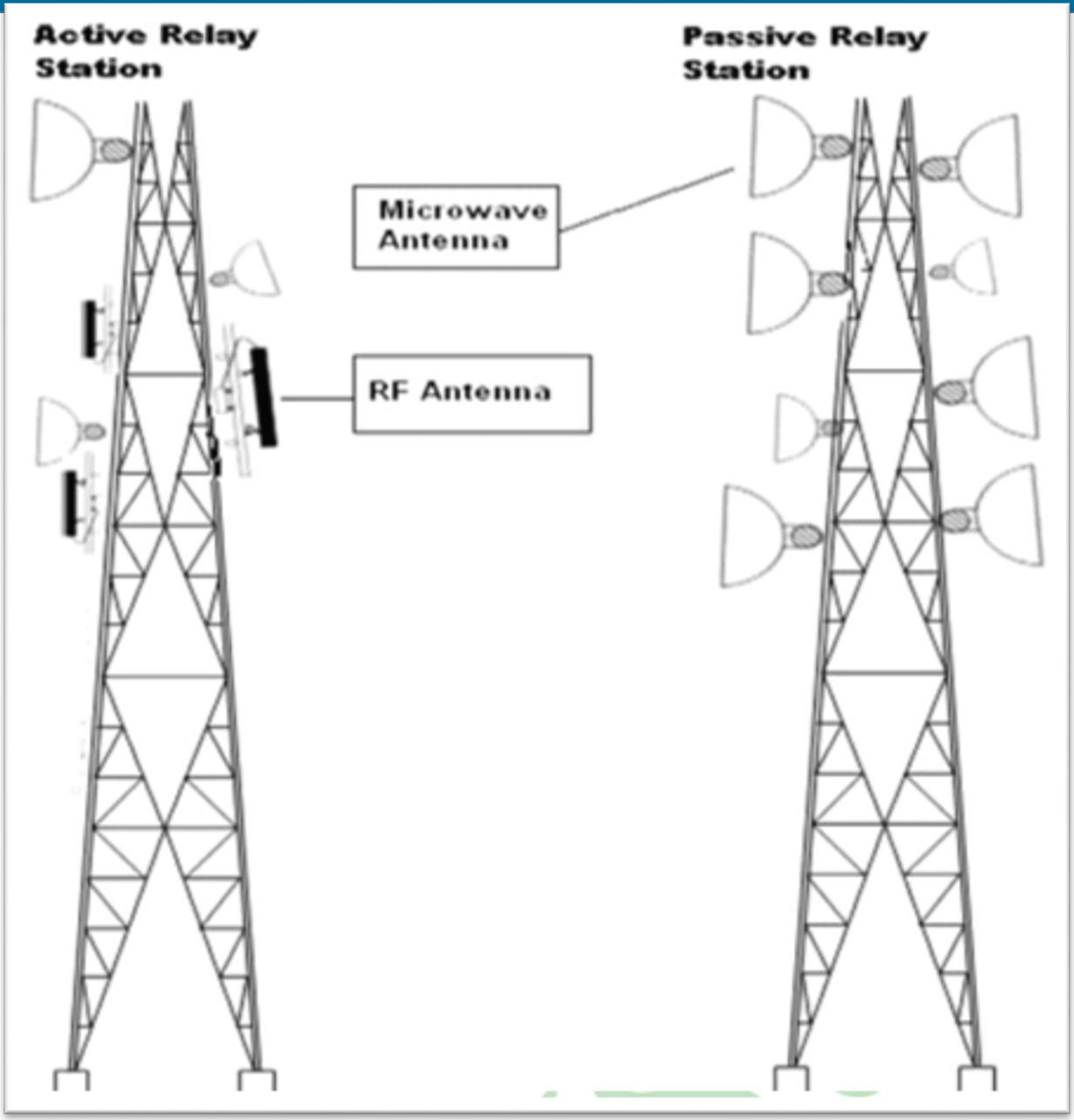
Outdoor Units

- Antenna
- Feeder Cable
- Jumper cable
- TTA/TMA/RRU(3G)
- Tower
- Aviation light
- Lightning arrester e.t.c



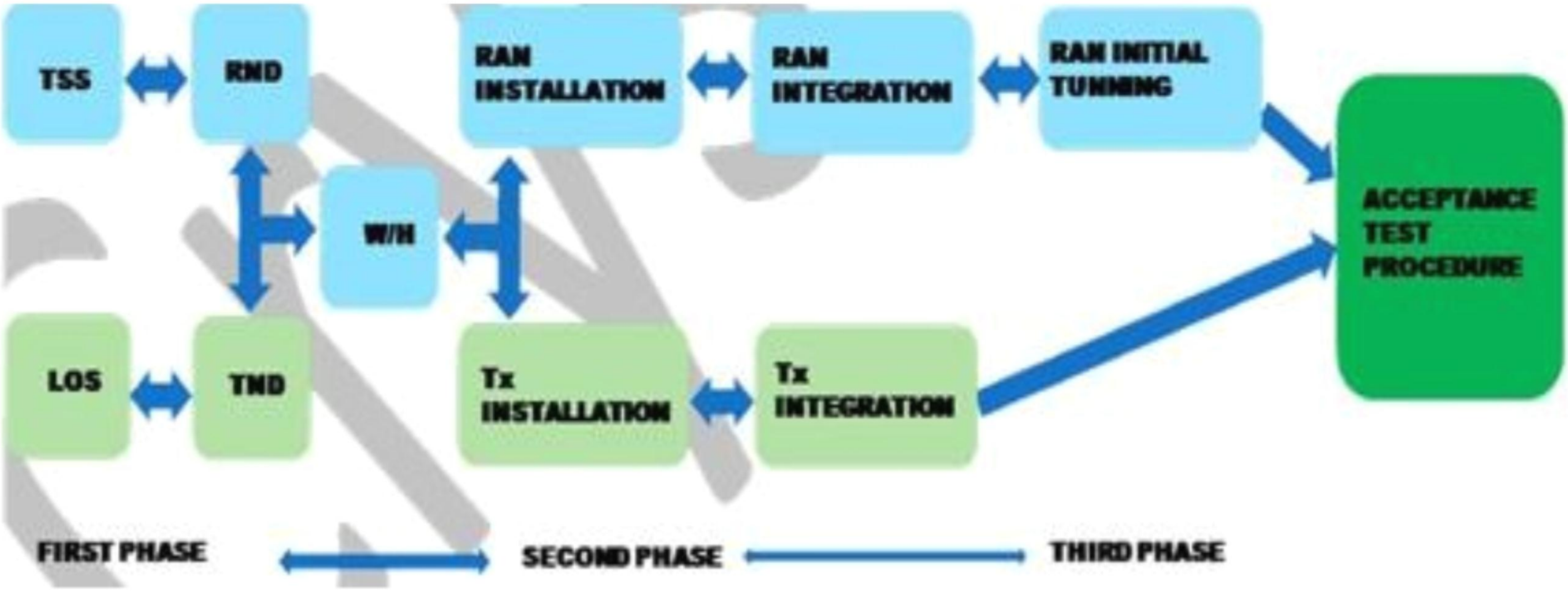


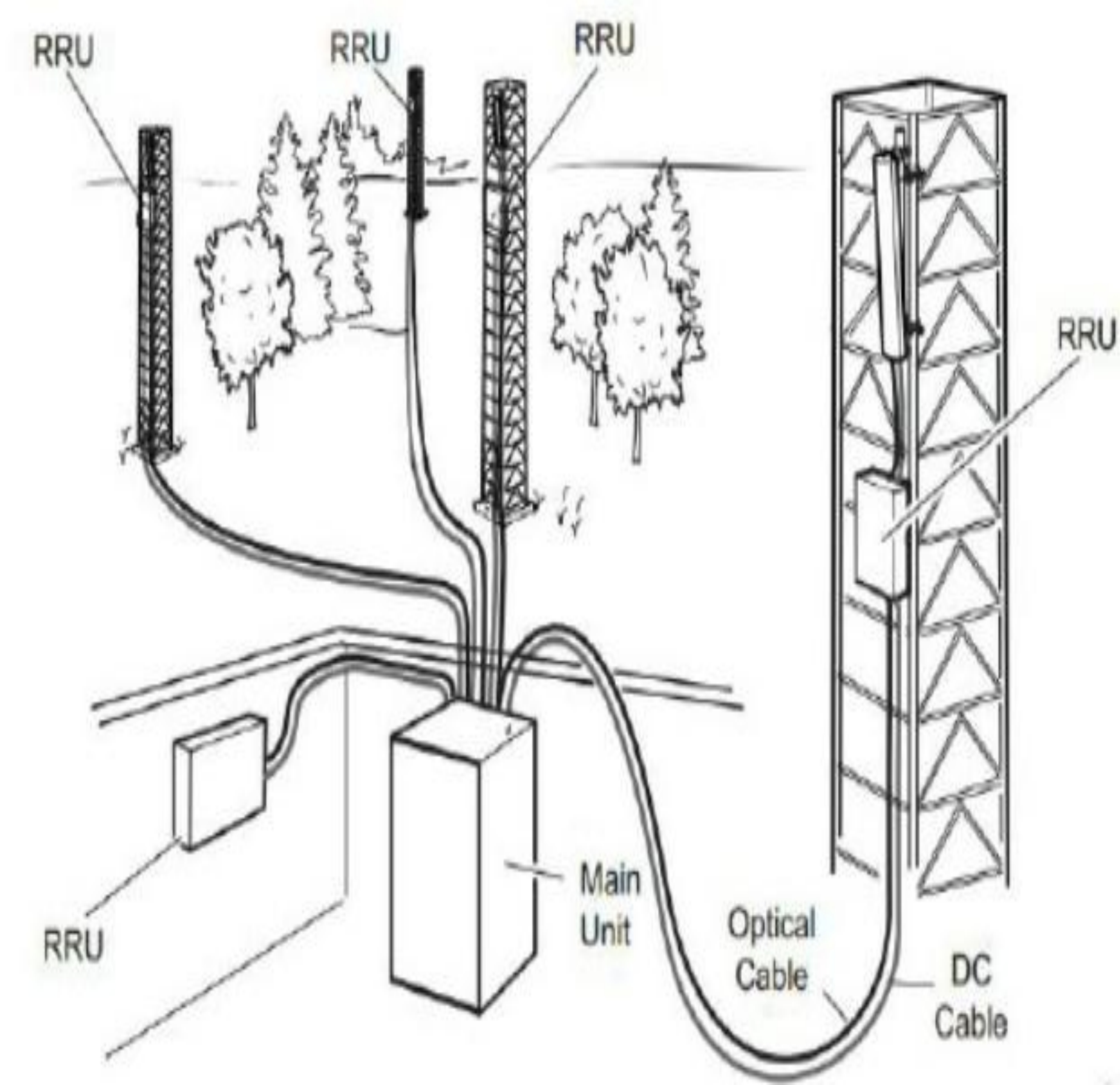
RELAY STATIONS



SITE INSTALLATION

SITE INSTALLATION WORKFLOW





TSS means Technical site survey(RF Survey for Green field site or existing one)

LOS means Line of site survey for Microwave Transmission

RND means Radio Network Design

TND Means Transmission Network Design

Tx Means transmission

RAN Means Radio Access Network

SITE INSTALLATION PROCEDURES(ERICSSON RBS 6301)

Site Installation Procedures(Process): The purpose of the work flow is to enable every Project member recognize the stage of the project , how critical it is and also the party involved in the execution. From the above workflow, We will go into the procedures involved in RAN Installation(Ericsson BTS 6301) for the purpose of this class.

The installation steps as to be carried out ON-Site is as listed below;

- Antenna/RRU Installation
- Hoistling of Antennae
- Main Unit(eNode B) Installation
- SPD/Power Cabling
- Cleaning and Installation
- Checklist Validation(Site Completion checklist)
- RRU/Antenna jumper connector

Antenna/RRU Installation

The installation steps as to be carried on Antenna/RRU installation are as listed below;

- Dismantling the equipment carton
- Coupling antenna clamp
- Attaching the male connector/Antenna jumper
- Assembling antenna support
- Fixing antenna to pole
- Fixing Bracket to RR
- Fixing RRU to Pole
- RRU/Antenna jumper connector

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Antenna Hoisting

The installation steps as to be carried out is as listed below;

- Mounting Antenna on the tower
- Running cables and Clamping to tower
- Cleaning up tower terminations

RMU (Node B) Installation

- RMU Slab positioning and Hole drilling
- Use Plum to check cabinet is leveled
- Cable termination to RRU/Optical cable termination
- SPD cabling/Terminating Power cable

After **RAN Installation,** adequate check must be ensure to enable the installation meets required quality as in the Quality Checklist

SAMPLE SITE IMPLEMENTATION QUALITY CHECKS

Adequate check must be ensure to enable the installation meets required quality;

- Check Antenna azimuth, coordinate, tilt, supports.
- Retrace cable to ensure firm support, good termination
- Check antenna supports/Boltings
- Check Optical cable termination
- Check SPD cabling/Terminating Power cable
- Cabinet installed according to speqifications, leveled & grouting done using insulation washer & tube and OK.
- Top Cover, Door and locks are properly installed & working OK.
- Cable entry kits and sealing installed correctly, Cabinet gaskets not damaged. Air filter installed correctly (and cleaned according to requirements)
- Internal Plug-in unit / Modules installed correctly as per configuration requirements. Dummy panels & Doors ground straps installed correctly
- OD Cabinet grouted by using specified size nuts bolts & washers, usage of SS/Galvanized nuts bolts only. Cabinet is isolated from floor. Check for vertical & horizontal level using sprit level.

- eNodeB Cabinet grounded with specified cables and terminated to site main grounding bus bar.
- Door Fan sensor installed and working OK ,All nuts bolts properly tightened,All SFP and CPRI cables properly connected,All internal cables properly routed
- All Cables are labeled

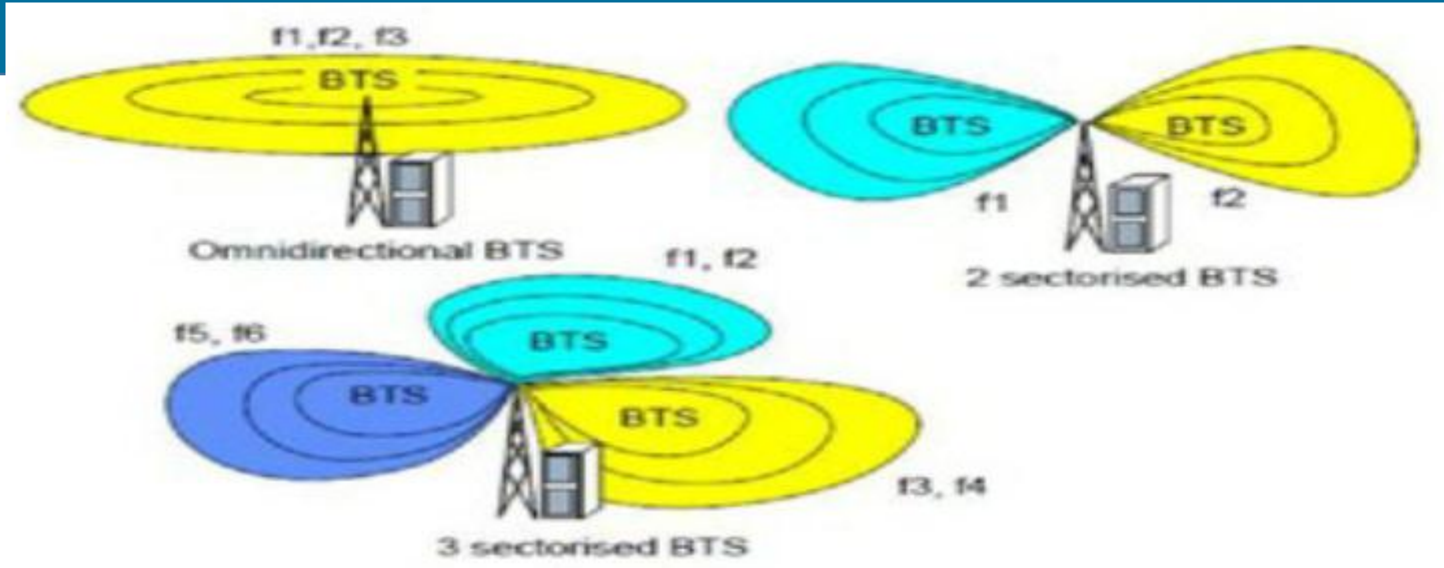
Refer to Quality Checklist Document for others

CELL TYPES

- **OMNI DIRECTIONAL CELL** – is a cell that contains an omnidirectional antenna installed and broadcasts the same frequency signals in all directions
- **DIRECTIONAL /120 DEGREE CELL** – is a cell that has sectoral antennas installed and broadcasts different frequencies. It transmits in only one direction.

FREQUENCY REUSE: Frequency reuse consists in using the same frequency channel on areas that are separated enough to avoid interference.

- It is the use of the same frequency pattern in more than one location.
- The reason is because the frequency resource of mobile system is very limited



GSM FREQUENCY REUSE PATTERNS

1(site) x3(sector) = 1/3
2(site) x3(sector) = 2/6
3(site) x3(sector) = 3/9
4(site) x3(sector) = 4/12
7(site) x1(sector) = 7/7
7(site) x3(sector) = 7/21
4/12 Reuse Pattern is the Commonly Used Pattern In GSM

Cluster - region in which all the frequencies available to a network are totally utilized.

Site	Sectors					
	A	B	C	AI	BI	CI
I	I	5	9	I3	I7	2I
2	2	6	I0	I4	I8	22
3	3	7	II	I5	I9	23
4	4	8	I2	I6	20	24

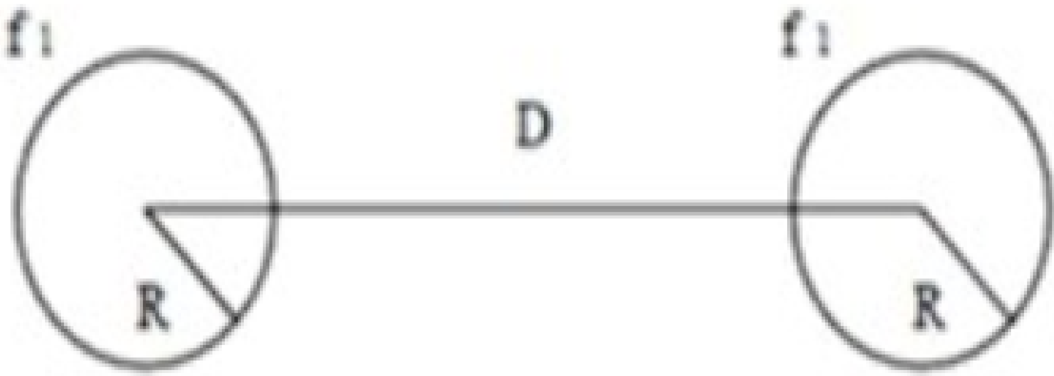
Distance of reuse between cells

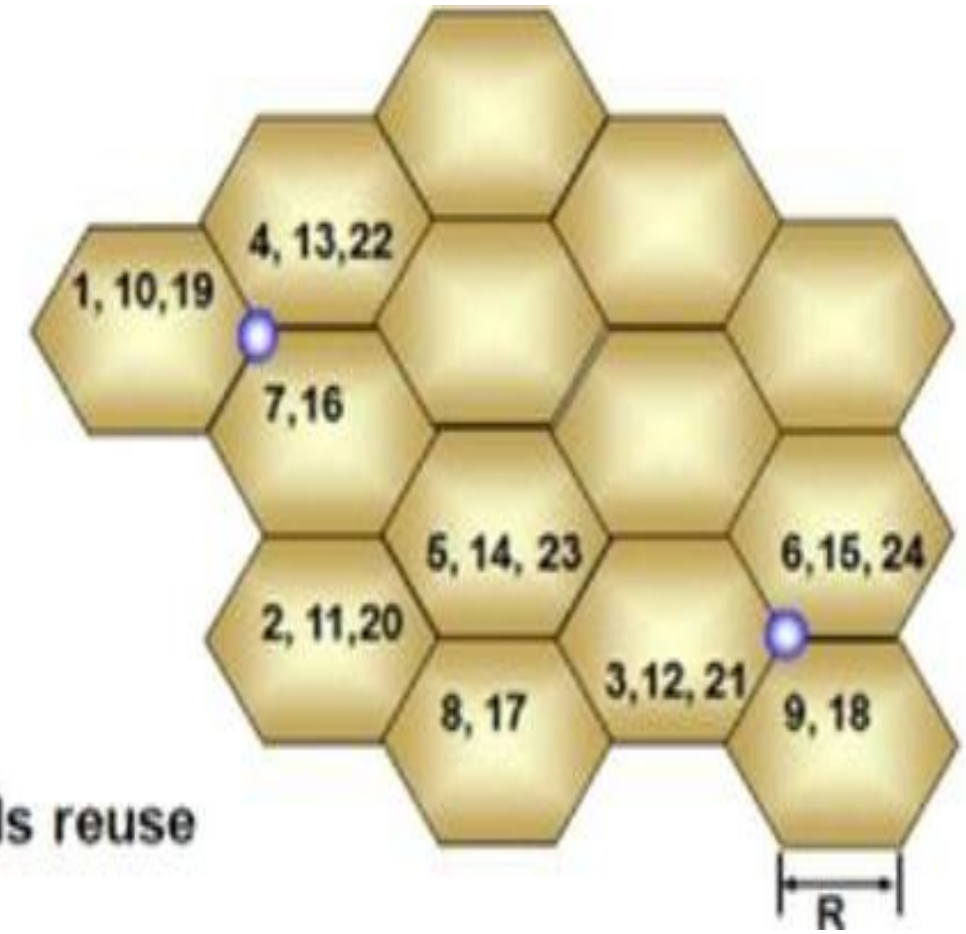
Lower required C/I means shorter distance and higher capacity C/I >= 9dB

Reuse separation distance ranges from 4 to 6 times the cell radius

R= Cell Radius D= Frequency reuse distance

3/12 Reuse pattern





3 site X 3 cells reuse

Site	Sectors								
	A	B	C	A1	B1	C1	A2	BA	C2
1	1	4	7	10	13	16	19	22	
2	2	5	8	11	14	17	20	23	
3	3	6	9	12	15	18	21	24	

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WCDMA FUNDAMENTALS

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WCDMA FUNDAMENTALS

Technology Overview

Universal mobile telecommunication system (UMTS) networks based on wideband code division multiple access (WCDMA) have been deployed worldwide as 3rd generation mobile communications systems. UMTS provides a clear evolutionary path to high-speed packet access (HSPA). HSPA refers to the combination of high-speed downlink packet access (HSDPA) and high-speed uplink packet access (HSUPA). HSDPA allows data rates up to 14.4 Mbit/s in the downlink. HSUPA makes uplink data rates of 5.76 Mbit/s possible. HSPA also boosts capacity in UMTS networks and provides significant latency reductions.

In order to exploit the full potential of WCDMA 5 MHz operation, the performance of HSPA- based radio networks has been further enhanced in terms of spectrum efficiency, peak data rate and latency. HSPA+ as specified in 3GPP Release 7 includes downlink MIMO operation, higher-order modulation (downlink 64QAM, uplink 16QAM) and protocol improvements that specifically allow a high number of “always on” users to be supported in the network. Peak data rates reach 28 Mbit/s in the downlink and 11.5 Mbit/s in the uplink with round-trip times below 50 ms.

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3GPP Release 8 specifies further improvements for HSPA+ such as downlink dual carrier operation and the combination of MIMO and 64QAM modulation. Both features enable a maximum data rate of 42.2 Mbit/s in the downlink.

Furthermore, circuit-switched voice over HSPA provides optimized support of voice services in an HSPA packet-switched radio access network. In addition, latency is further improved by allocating common E-DCH resources in the CELL_FACH state and applying Layer 2 enhancements in the uplink.

3GPP Release 9 continues to improve primarily data rate capabilities. The dual cell HSUPA feature supports two carrier frequencies in the uplink direction leading to uplink data rates of 23 Mbit/s.
Additionally, in downlink direction dual carrier operation can be combined with the MIMO feature
reaching data rates up to 84.4 Mbit/s. Spectrum flexibility has also been increased because the dual band dual cell HSDPA feature makes it possible to allocate resources on two carrier frequencies in different frequency bands. The latest 3GPP Release 10 specification includes four carrier HSDPA, which enables to pool four carrier frequencies for a single end user device and thus span 20 MHz bandwidth.
UMTS WCDMA/HSPA/HSPA+ is being specified in the 3rd Generation Partnership Project (3GPP).
3GPP Release 99 contains the first WCDMA specifications. HSDPA and HSUPA were introduced in 3GPP Release 5 and 3GPP Release 6, respectively. HSPA+ forms part of 3GPP Releases 7, 8, 9 and 10.

WCDMA PLANNING PRINCIPLE

- 3G networks are commercially available all over the world
- Network designs are based on propagations models and simulations (coverage verification)
- 3G technology (WCDMA) is different from 2G
- Tools and methods for 3G Networks though little similarities in the architecture but the components of Node B and principles are different from 2G.
- In General,

➢ The Technology is more complicated (Overlapping cells, soft hand over, power control, cell breathing etc)

➢ High performance requirements on products (UE & Network nodes)

➢ Co-located GSM/3G sites

➢ Shared Antenna System

➢ Interworking with other technologies like GSM and LTE

- WCDMA is a wideband direct-sequence code division multiple access system.
- User information is spread over a wide bandwidth by multiplying it with quasi-random bits known as CDMA spreading codes.
- Has a chip rate of 3.84Mcps which enables it to support high data rate and increased multipath diversity.
- Support highly variable user data rates which could be understood in the context of “Bandwidth on Demand” BoD.
- Supports soft handoff and Hard handover.
- Has unique fast power control at the 15OOHz.

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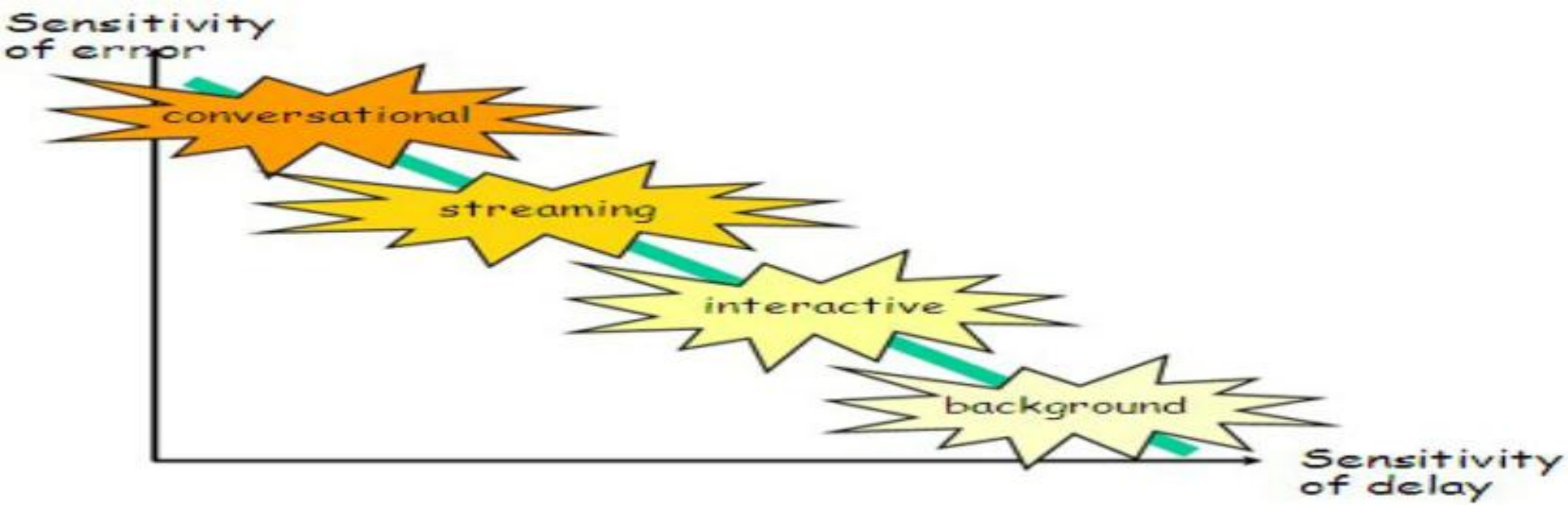
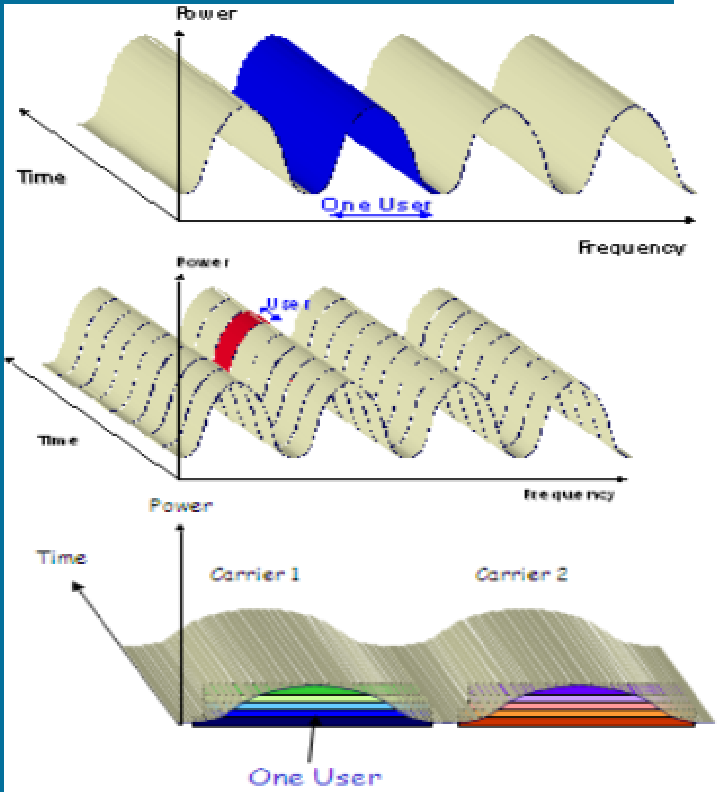
WCDMA BEARER SERVICES

NB: 3G main resources are;
- Code
- Power
- Channel Element
- IuB resource.





FDMA Frequency Division Multiple Access

- uses band pass for carrier signal which are non-overlapping in the frequency domain

TDMA Time Division Multiple Access

- carrier signals are non overlapping in the time domain

CDMA Code Division Multiple Access

- spreads the signal over the entire available bandwidth by using codes with good correlation properties

CODE RESOURCE ALLOCATION

In WCDMA, code resources are mainly divided into channelization codes and scrambling codes.

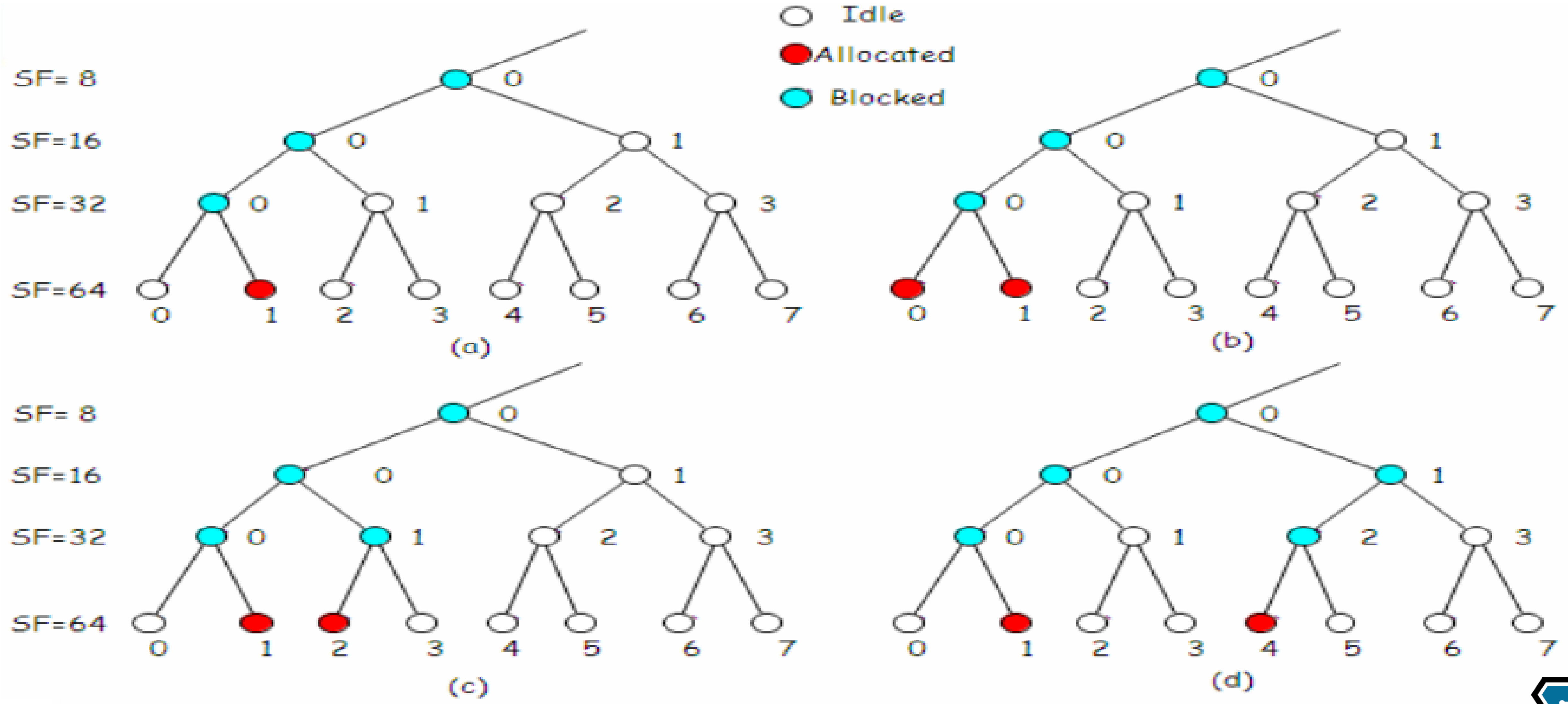
Channelization code: Channelization codes are based on the orthogonal variable spreading factor (OVSF) technology. Transmission from a single source are separated by channelization codes.

Scrambling code: Scrambling codes are used after spreading, which will not change the signal bandwidth. They are only used to differentiate different UEs or Node Bs.

Premise of code allocation: ensure not occupied for the code in the root direction and downwards subtree

Result of code allocation: block all low rate SC in subtree and high rate in upwards root direction

CODE RESOURCE ALLOCATION



In addition to spreading, part of the process in the transmitter is the scrambling operation. This is needed to separate terminals or base stations from each other. Scrambling is used on top of spreading, so it does not change the signal bandwidth but only makes the signals from different sources separable from each other.

Spreading code = Scrambling code + Channelization code

Scrambling codes (Repeat period 10 ms=38400 chips)

- Separates different mobiles (in uplink)
- Separates different cells (in downlink)

Channelization codes

- Separates different channels that are transmitted on the same scrambling code
- Orthogonal Variable Spreading Factor (OVSF) codes
- Period depends on data rate
- User information bits are spread into a number of chips by multiplying them with a spreading code
- The chip rate for the system is 3.84 Mchip/s and the signal is spread in 5 MHz

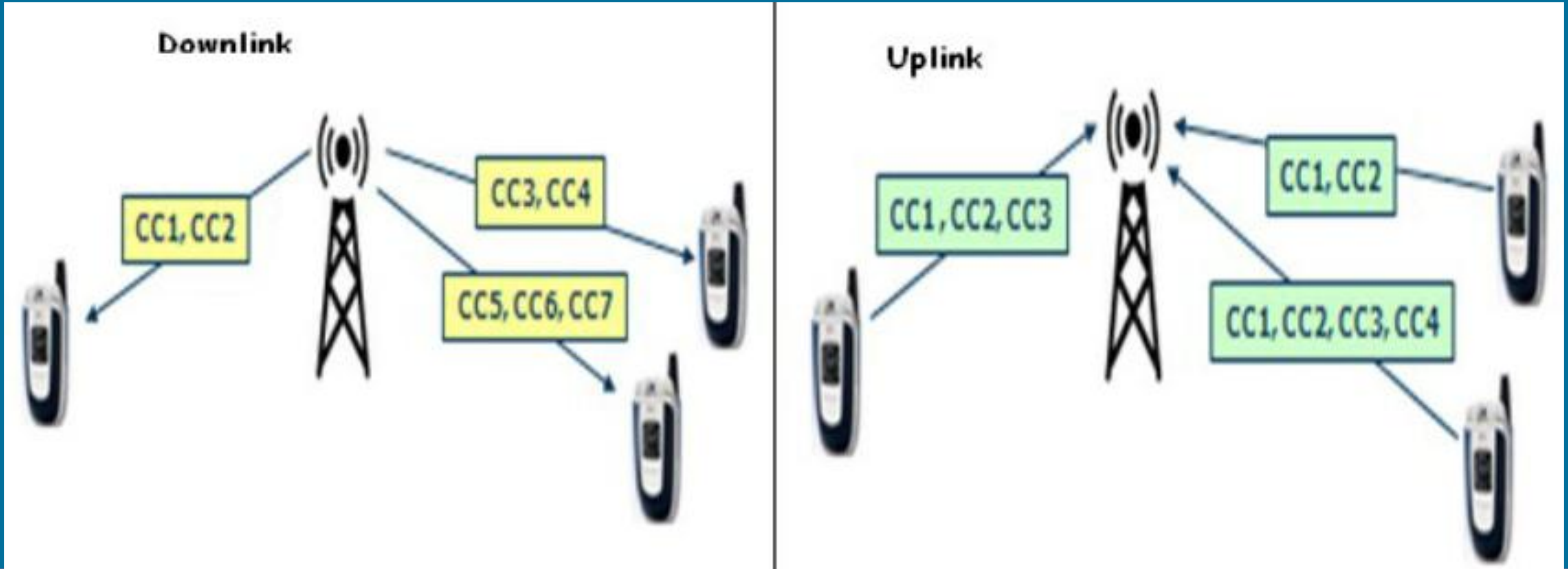
- The Spreading Factor (SF) is the ratio between the chip rate and the symbol
- The same code is used for de/spreading the information after it is sent over the air interface

Channelization Codes

Channelization Codes have different length depending on;

In the Downlink, Channelization Codes are used to distinguish between data (and control) channels coming from the same RBS on the bit rate.

In the Uplink, Channelization Codes are used to distinguish between data (and control) channels from the same UE



SCRAMBLING CODES

After the Channelization Codes, the data stream is multiplied by a special code to distinguish between different transmitters.

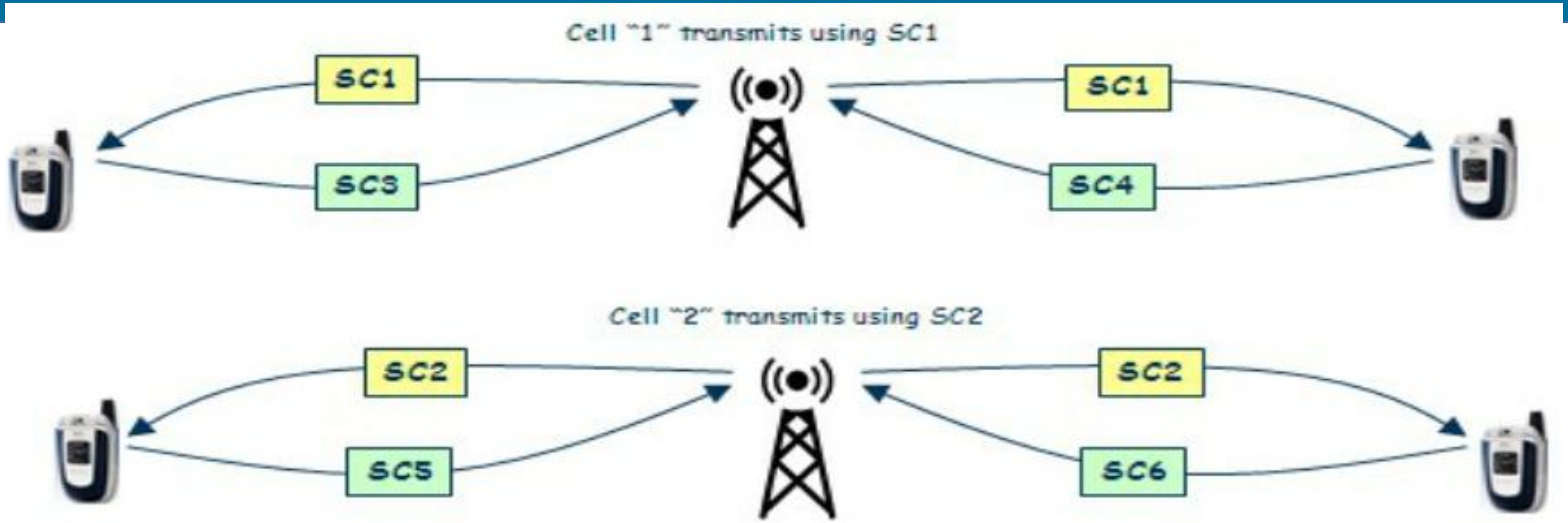
Scrambling codes are not orthogonal so they do not need to be synchronized

The separation of scrambling codes is proportional to the code length – longer codes, better separation (but not 100%)

Scrambling codes are 38400 chips long

In the Downlink, the Scrambling Codes are used to distinguish each cell (assigned by operator – SC planning)

In the Uplink, the Scrambling Codes are used to distinguish each UE (assigned by network

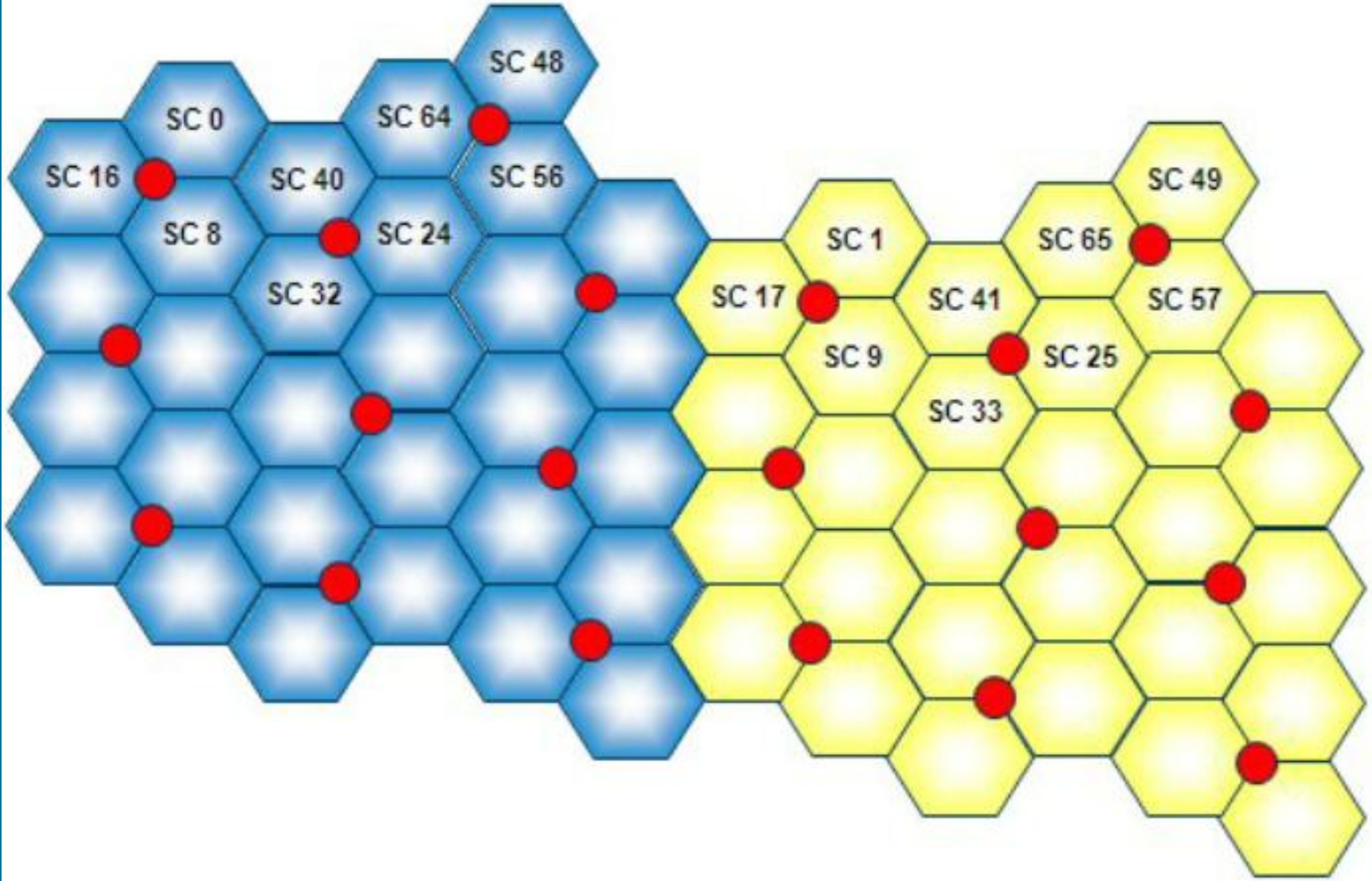


SCRAMBLING CODE PLANNING

SC are organized in Code Groups. The first SC in each Code Group differs from the first SC in the subsequent Code Group by a multiple of 8

64 Code Groups

0	8	16	...	...	504
1	9	17	...	...	505
2	10	18	...	...	506
3	11	19	...	...	507
4	12	20	...	500	508
5	13	21	...	501	509
6	14	22	...	502	510
7	15	23	...	503	511



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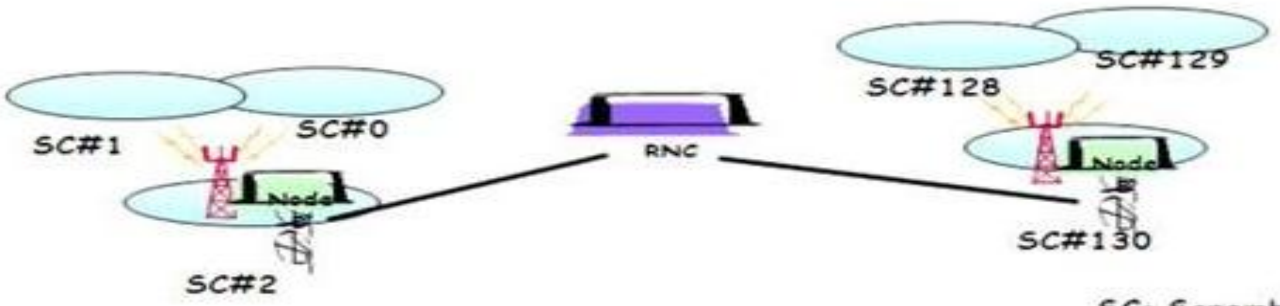
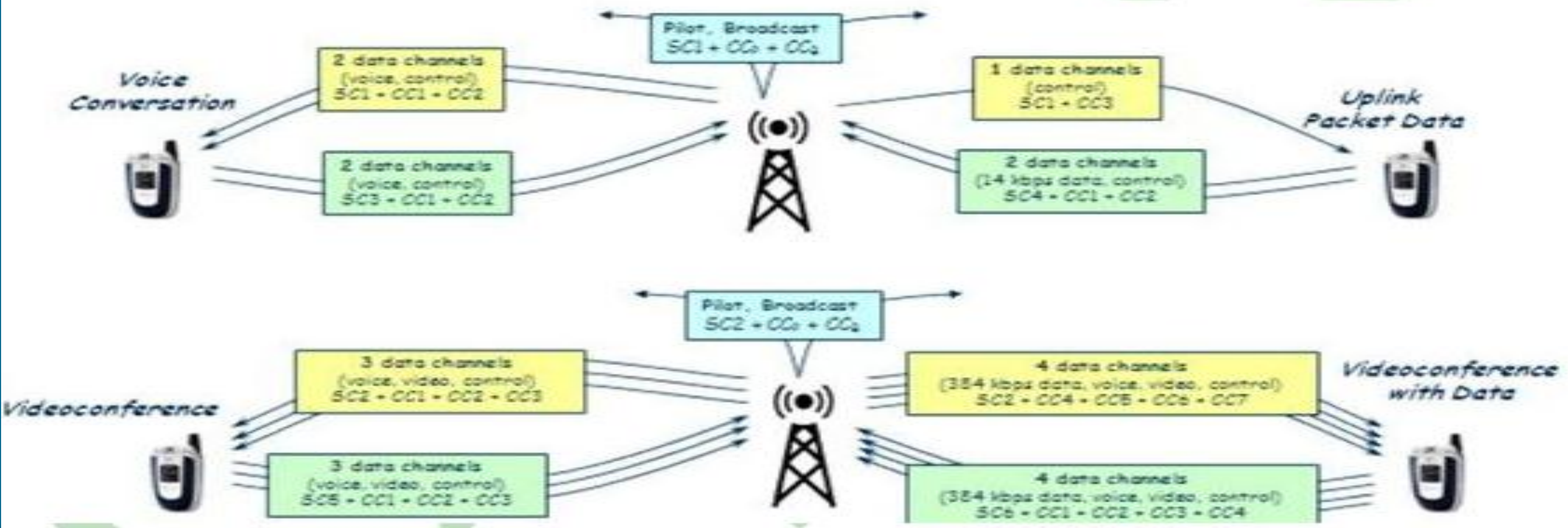
Downlink Scrambling Code

Downlink scrambling code

- One code per cell (sector/carrier) : Configurable by operator
- 512 sets of 16 codes each (1 primary and 15 secondary)
- Only the primary scrambling code is used for all Common Channels

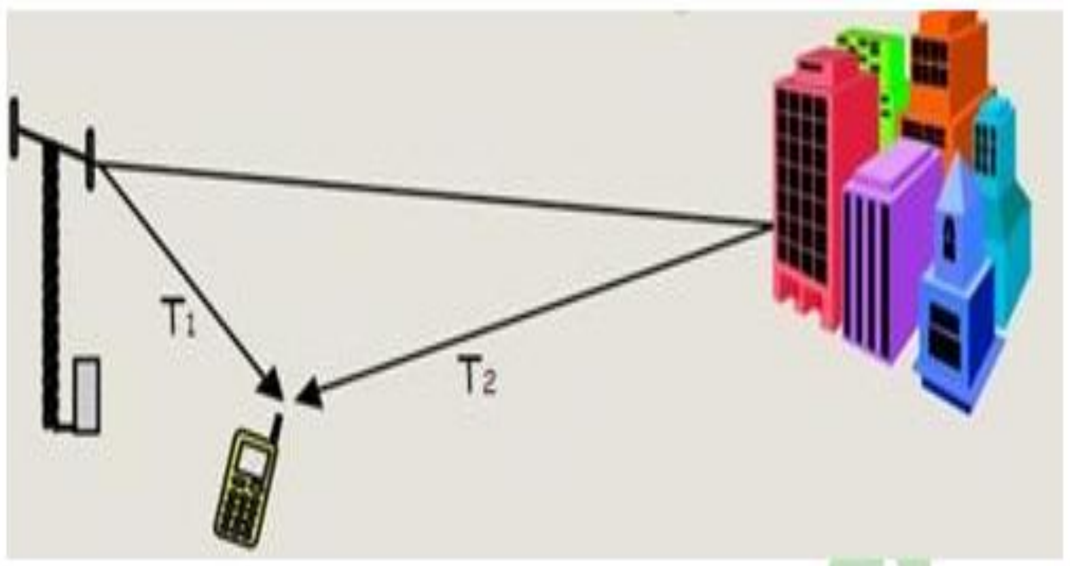


SC: Scrambling Code



Multi-path Diversity - the RAKE Receiver

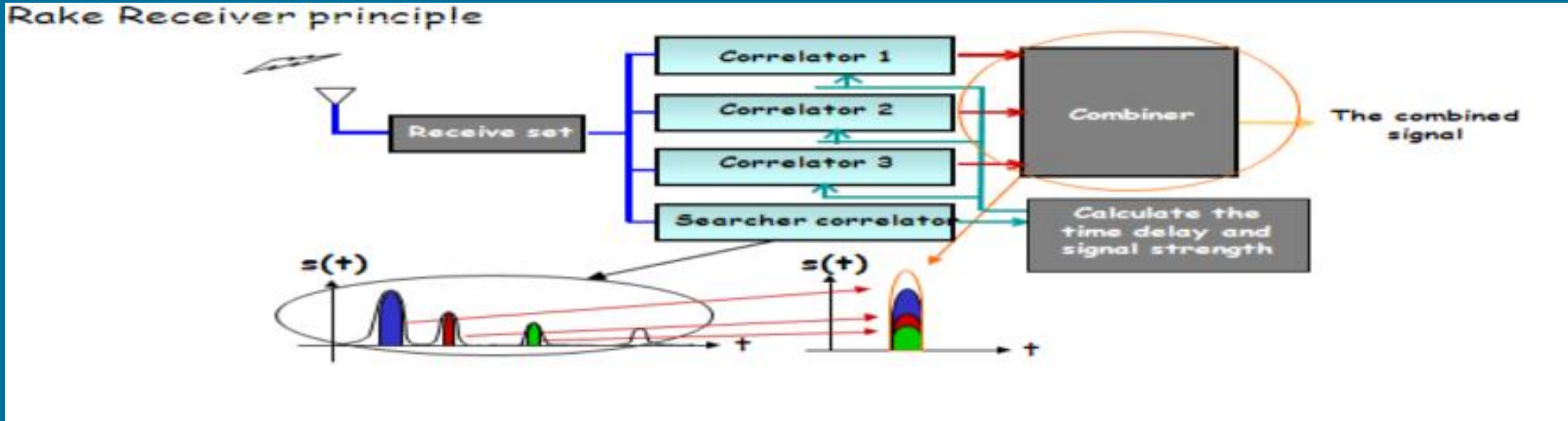
can combine multipath components, which are time-delayed versions of the original signal transmission. This combining is done in order to improve the signal to noise ratio (SNR) at the receiver. RAKE receiver attempts to collect the time shifted versions of the original signal by providing a separate correlation receiver for each of the multipath signals. This can be done due to multipath components are practically uncorrelated from another when their relative propagation delay exceeds a chip period. Due to reflections from obstacles a radio channel can consist of many copies of originally transmitted signals having different amplitudes, phases, and delays. If the signal components arrive more than duration of one chip apart from each other, a RAKE receiver can be used to resolve and combine them.



The RAKE receiver uses a multipath diversity principle. It is like a rake that rakes the energy from the multipath propagated signal components.

$\Delta T = T2 - T1 > Tchip \Rightarrow$ Multi-path diversity
RAKE receiver combines multi-path diversity components
4 Mcps $\Rightarrow$ Tchip = 250 ns, corresponding to 75 m distance difference

A RAKE receiver utilizes multiple correlators to separately detect M strongest multipath components. The outputs of each correlator are weighted to provide better estimate of the transmitted signal than is provided by a single component. Demodulation and bit decisions are then based on the weighted outputs of the M correlators.



RAKE antennas help to overcome on the multi-path fading and enhance the receive performance of the system

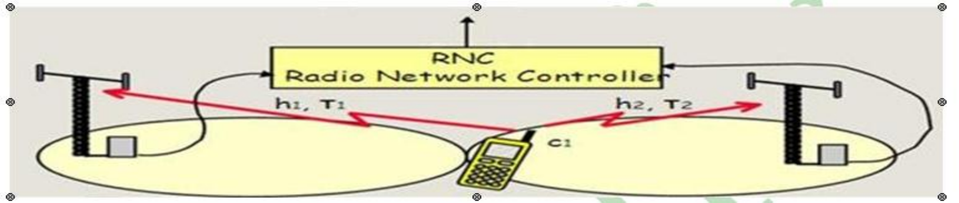
HANDOVER

A handover is a process in telecommunications and mobile communications in which a connected cellular call or a data session is transferred from one cell site (base station) to another without disconnecting the session.
There are two types of handovers:

Hard Handover: An instantaneous handover in which the existing connection is terminated and the connection to the destination channel is made. It is also known as a **break-before-make** handover. The process is so instantaneous that the user does not hear any noticeable interruption.

Soft Handover: A substantial handover where the connection to the new channel is **made before** the connection from the source channel is disconnected. It is performed through the parallel use of source and destination channels over a period of time. Soft handovers allow parallel connection between three or more channels to provide better service.
This type of handover is very effective in poor coverage areas.

- Soft handover: A mobile station communicates with two base stations simultaneously.
- Soft handover possible because of one-cell reuse • Soft handover necessary because of one-cell reuse .
- Two or more base stations receive the mobile signal, which is then combined in the network



NB: Soft Handoff is present between intra frequency cells in 3G

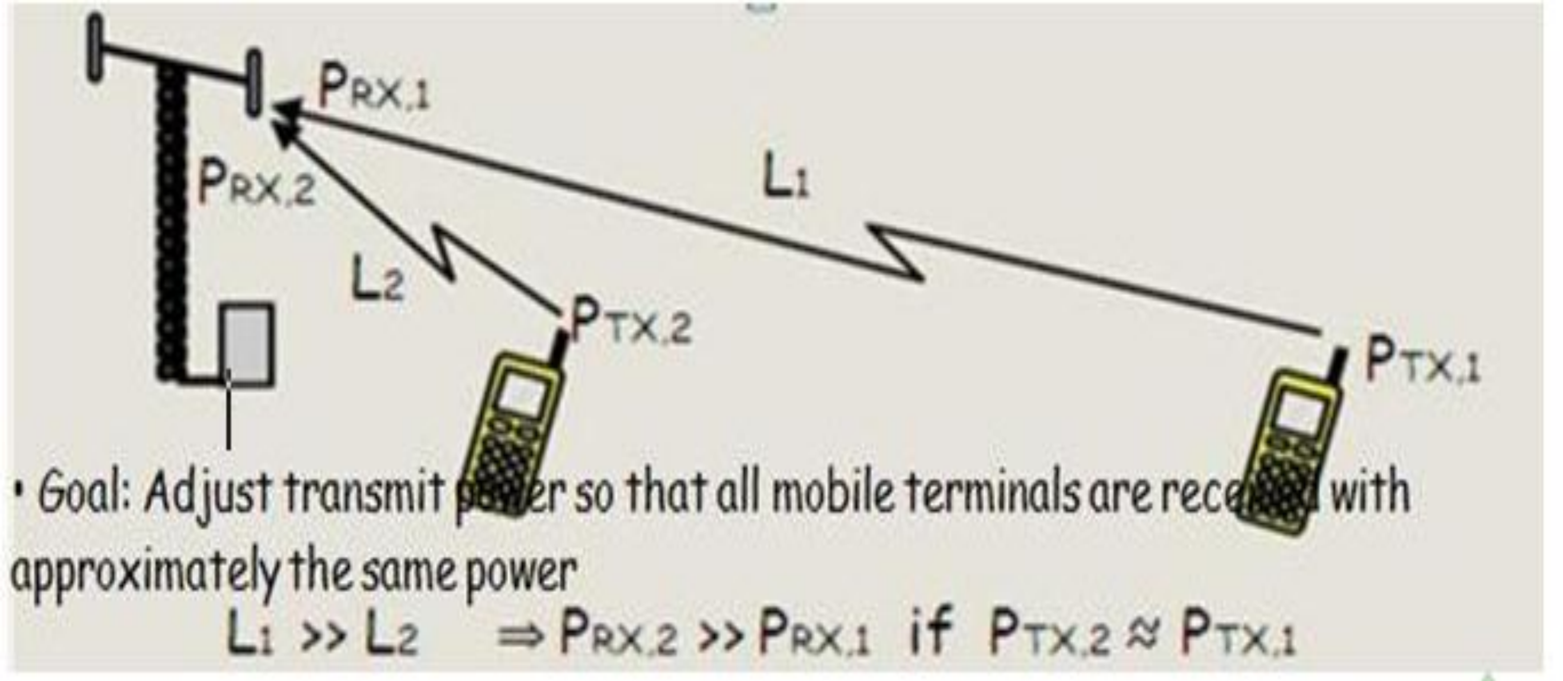
- Cells on same NodeB Calles Softer Handover
- Cells on different NodeB called Soft Handover
- Cells on Different RNC

Hard handoff takes place between inter frequency and Inter-system cells an example of this is Inter Radio Access Technology **(IRAT)** Handover

Power Control in 3G

Several mobile terminals transmit on the same frequency

- Same transmit power ⇒ large variations in received power
- Mobiles with low path loss will cause large interference



Set PTX,1 and PTX,2 so that PRX,1 ≈ PRX,2

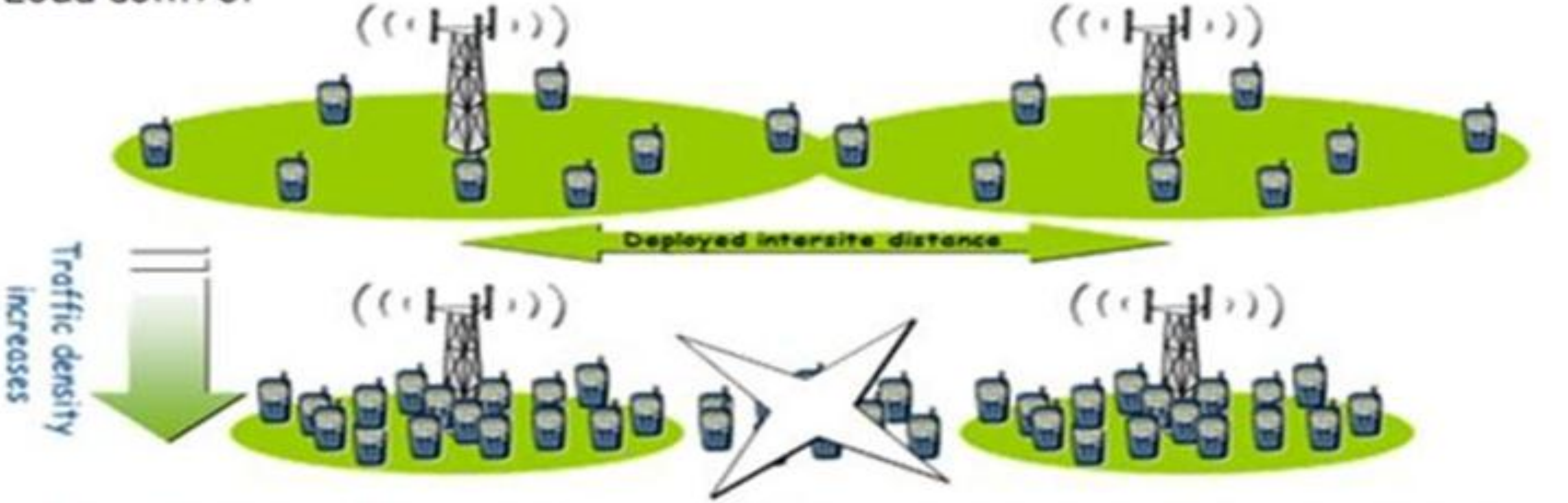
Open-loop and closed-loop power control

Cell breathing

Considering the limitation of maximal transmit power, the increase of required received power due to high traffic will lead to decrease the cell range

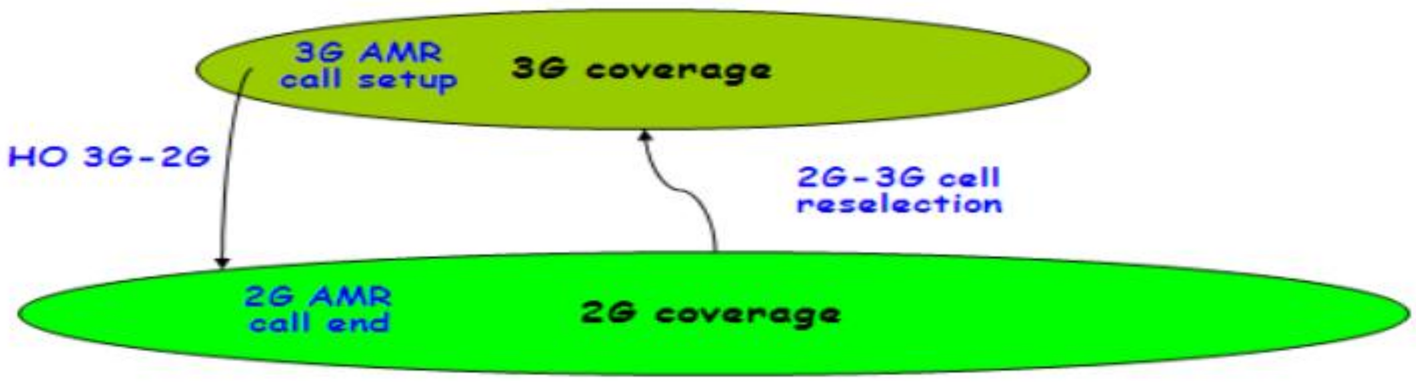
The cell service coverage decreases when the traffic increases : so-called "cell breathing" phenomenon

Load control



In order to avoid power control instability and coverage holes due to high traffic level, the level of interference received by a base station should be controlled by means of admission and load control algorithms

IRAT HO GLOBAL STRATEGY IN 3G



GLOBAL STRATEGY

- Keeping UE as long as possible on the 3G Network
- Trigger reselection to 2G only when 3G coverage/Quality is not good enough
- Once on 2G network,triggers reselection to 3G as soon as when 3G coverage/Quality is good enough

COMMON RF TERMS

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COMMON RF TERMS

RSCP(Received Signal Code Power); It's the measurement of Pilot signal level/strength in WCDMA(Unit-dBm)

EcNo or EcIo or Ec/Io or Ec/No(Energy per Chip per Noise spectral density or Energy per Chip per Interference); It's the measurement of Signal Quality in WCDMA(Unit-dB)

UeTx Power ; It's the transmit power of the User Equipment ,Its measured in dB(Decibel)

CQI(Channel Quality indicator);Its gives measurement about the quality of HSPA channels during data session.

Cell I.D – This is the identity or name given to a particular **Node B** and its cell by the operator.

UARFCN – It is the frequency band allotted to the operator. One spectrum bandwidth is of 5MHz in WCDMA or 3G.This window shows us the center frequency of the bandwidth allotted to the operator.

Cell Name – It is the name given to particular Node B's by the operator generally along the lines of the name of the area the **Node B** is located in.

Scrambling Code – Scrambling code is a code assigned to a particular cell. There are 512 such codes
for the network to differentiate among different Node B"s and these codes can be repetitive. They are of two types primary and secondary.
AS – This stands for Active Set. Active Set is the set of Scrambling Code which the U.E is currently latched on and there can be a maximum of 6 Scrambling codes in Active Set.
MN – MN Stands for monitored neighbor i.e the neighbor cell that is detected by the U.E as a neighbor and is also defined as a neighbor in the network. U.E will initiate a Handover onto the monitored neighbor in case the monitored neighbor has a stronger Rx level than the AS.
DN - DN stands for Detected Neighbor and as the name suggests it is the neighbor detected by the UE but, is not defined in our network . Hence, the U.E does not handover to the detected neighbor. It can be because of Overshooting of a site, incomplete neighbor list or in case of a new site. It is very important to optimize and have no DNs as they are one of the major reasons of Call drops in 3G.
C/I (Carrier to Interference ratio); It must not be less than 12 practically.

ARFCN ; Absolute Radio Frequency Channel number, It's the frequency carrier number in GSM.
It depends on M900 or DCS 1800 Technology.

UARFCN ; UMTS Absolute Radio Frequency Channel number, It's the frequency carrier in
WCDMA. It depends on how many carrier an operator is using.

BCCH(Broadcast Control Channel); It's the Frequency channel that carries system information and measurement between MS and BTS. MS Camps on this in Idle Mode.

Cell ;It's the coverage area of one BCCH

Location Area; It's an area where an MS is allowed to roam without Location update.

TCH (Traffic Channel); It's a channel used when a mobile is in active or dedicated mode, i.e in conversation.

PSC(Primary scrambling Code) ;Its used by UE to differentiate between serving cells in WCDMA

HSDPA(High Speed Downlink Packet Access) ; Download session, Its throughput is greater than 384Kbps

HSUPA(High Speed Uplink Packet Access) ; Upload session Its throughput is greater than 384 Kbps

R99 (Release 99); A technology of WCDMA before HSPA. Its throughput is

Azimuth/Antenna Orientation; Degree of the direction faced by an antenna.

Coordinate; Geographical Location of a site

Swapped sector/Cross cabling ;Mismatch of Cable A into B or vise-versa

Overshooting; Cell serving outside its server distance

Poor Coverage ;Its means poor signal strength Poor

Quality/Interference ;It means poor quality

No service mode; Emergency calls, no service at all

Call set up failure/Blocked call ; A user is unable to make call Dropped Calls; A user call drops during conversation.

Handover failure ; A cell attempt to handover to the target cell fails

IRAT Handover ; Inter Radio Access Technology Handover(3G to 2G)

BSC/RNC ; Base station Controller /Radio Network Controller-Controls BTS or Node Bs

BTS/NodeB ;Base Transceiver station or Node Bs carries the physical RF equipment like antennas, cables and the transceivers

MS/UE ;Mobile Station/ User Equipment

Cell ID/Sector ID ;Name of a particular cell **Site ID/Site Name** ;Name of a site

Road Map ; A vector of the routes in an area.

Cell ref/Cell file ; Database of cells or sites-All information enclosed

RxLevel; Level of Received signal strength. In dBm or step.

If the value inform of step substract 110 to the value to get dBm value.Rx Level

is received power level at MS (maximum Rx Level measured by MS is (±)-60dBm)

RxQual; Received signal quality level,measured base on BER (bit error rate).The value is between 0-7,the lower the better.

SQI;The parameter used by TEMS to measure Speech Quality.

SQI has been designed to cover all factors that Rx Qual lack to measure. SQI computation considers the factors: the bit error rate(BER),the frame erasure rate(FER),data on handover events,statistics on the distribution of these parameter.

FER – Frame erasure rate; See on"Radio Parameter" windows

Hopping ;Indicating if SFH implemented. See on "Current Channel" windows, on hopping channel,
hopping frequencies, MAIO,HSN"

C/I Interference (carrier-over-interference ratio); is The Ratio between the signal strength of the
current ,Serving cell and the signal strength of undesired(interfering) signal components. The C/I
measurement function built into TEMS Investigation enables the identification of frequencies that are
exposed to particularly high levels of interference, something which comes in useful in the verification and optimization of frequency plans.

TA (Timing Advance.): This is valid only in dedicated mode, To measure *the distance* of MS from serving cell.. See on "Radio Parameter" windows.

Radio Link Time out; Radio Link Timeout (T100 in the MS) is sent in the Cell Options information element. The mobile uses this value to determine whether there is still good radio contact with the base station. The S counter in the mobile is loaded with this value, fixed at 8 SACCH frames, and the value is decremented by 1 if an SACCH message could not be decoded, or incremented by 2 if an SACCH message was properly received. If the value drops to 0, the mobile communicates that it has lost the base station.

DRIVE TEST OPTIMIZATION

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DRIVE TEST OPTIMIZATION

Drivetest is the process of data collection from the network in order to know or have an idea of the subscribers_ perception of the network from the view of a single subscriber. It is carried out to check the network performance by means of coverage evaluation, system availability, network capacity, network retainability and call quality. This is accomplished by checking for the status of the KPI(Key Performance Indicator) such Rx Level (Receive Level), Rx Quality (Receive Quality), SQI (Speech Quality Index), etc in order to make appropriate recommendations where necessary for effective optimization.

DRIVE TEST EQUIPMENT

- Laptop
- Dongle
- TEMS software/Nemo/Xcal/RCU Dongili
- Inverter -Power supply needed, usually using inverter in the car from laptop, GPS and MS
- GPS (Global Positioning System)
- MS -TEMS phones/Xcal phones like Samsung,Nokia,Sony Ericsson
- USB Hub
- Scanner, AQM Module for MOS e.t.c

TYPES OF DRIVE TEST

- Pre-Launch Drive Test or Single Site Verification (SSV) which involves Trx test, Coverage test, Ftp test, PS attach & Detach and Handover test.
- Cluster Drive Test
- Preswap and post swap Drive test
- Troubleshooting Drive Test
- Benchmarking Drivetest as it may be categorized.

MODES OF DRIVE TEST

Long Call Mode ; Making continuous call along drive test activity. Before starting
the route, call the Mobile Terminating Call(MTC) number, ex. 385 for a network. Create call for 9999999999 Secs and idle for 10 s.
And only stop the call when the route (drive test) is finished. This is carried out to see the quality and coverage of the network and to check the network retainability or sustainability e.g Call Drop Rate, Handover Success Rate, etc

Short Call Mode; Creating the sequence of call along the drive test activity Before starting the route create call sequence, for example:
Create call for 45s and idle for 10 s.
NB; Short call is used to check the network accessibility e.g Call Set-up Success Rate

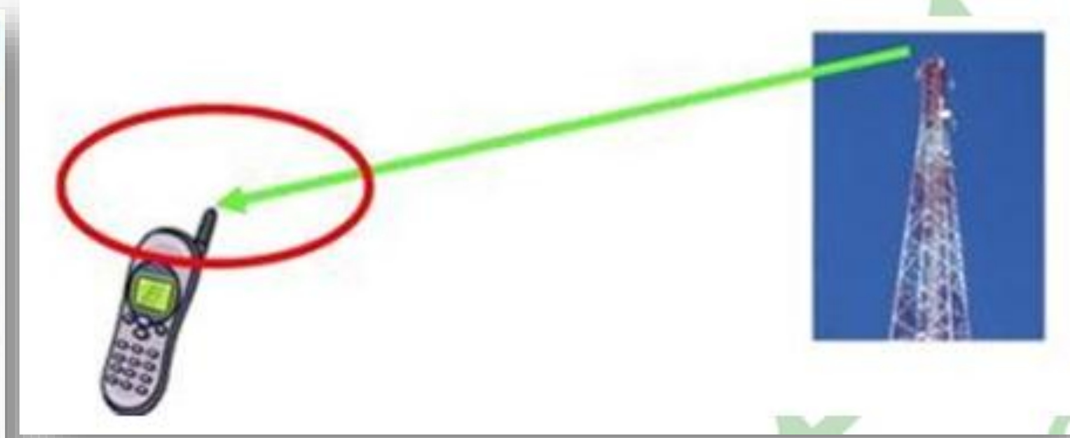
IDLE MODE; Along the drive test activity, the MS is "ON" but no call occur

DRIVETEST PARAMETERS

- **RxLevel** ;Level of Received signal strength. In dBm or step. If the value in form of step substract 110 to the value to get dBm value. RxLevel is received power level at MS (maximum RxLevel measured by MS is (±)– 60 dBm

- **RxQual**; Received signal quality level, measured base on BER (bit error rate). The value is between 0-7, the lower the better.

Parameters	Range	Remark
Rx Level (dBm)	Above -60	Good
	-60 to -85	Fair
	-85 downward	bad
Rx Quality	3 downward	Good
	3 to 5	Fair
	5 and above	Bad
SQI	18 and above	Good
	12 to 18	Fair
	12 downward	bad



- **SQI;** The parameter used by TEMS to measure Speech Quality.

SQI has been designed to cover all factors that RxQual lack to measure.
SQI computation considers the factors: the bit error rate (BER),the frame erasure rate (FER) and data on handover events statistics on the distribution of these parameters

- Others

FER -**Frame erasure rate; See on "Radio Parameter" windows**
ARFCN BCCH-BSIC • Absolute Radio Frequency Channel Number of Broadcast Control Channel

SQI values	Perceived speech quality
20 ≤ SQI ≤ 21 / 30	Very good for FR / EFR
1 ≤ SQI ≤ 19	good
SQI ≤ 0	bad

Base Station Identity Code Important data of a site Hopping,Indicating if SFH was implemented.
See on “Current Channel” windows,
on hopping channel, hopping frequencies, MAIO, HSN_
C/I Interference; The carrier-over-interference ratio is the ratio between the signal strength of the
current serving cell and the signal strength of undesired (interfering) signal components. The C/I measurement function built into TEMS Investigation enables the identification of frequencies that are exposed to particularly high levels of interference, something which comes in useful in the verification and optimization of frequency plans.
TA Timing Advance;This is valid only in dedicated mode. ; To measure the distance of MS
from serving cell.. See on “Radio Parameter” windows.
C1 criteria used for cell selection and cell reselection
C2 criteria used for cell reselection

During the course on Drivetest, We shall be learning the following:

- How to setup workspace for 2G/3G/LTE
- How to load cell ref
- How to load road Map
- How to set important Information Elements
- How to set command sequence
- How to connect tools and also set up on Laptop

- The principles guiding each test and scenerios
- How to check good and bad parameters
- How to Use the Tems Post processing tools
- How to use Mapinfo
- How to generate TEMS report
- How to conduct Drivetest
- How to Navigate and many more in Manual 2.

During Tuning,We assumed no traffic in the network, No subscribers Network tuned only based on drive test data. Its labour intensive with repeated drive test, All is about Pre-launch activities

During Optimization,Commercial traffic, subscribers using the network Statistics used widely to monitor network performance

Drive testing just in case

All is about Post-launch activities Things to look out for in Drive Test

Voice /Video/PS calls

- Long calls
- short calls

Identify problem areas

- Blocked calls
- Dropped calls
- Delay/Throughput
- Call set-up failure and drops during short calls can be mainly
- used to analyse Accessibility failure due to:

- UE Failure
- Unsuitable Parameters Setting
- Coverage Problem
- Interference
- Drops during long call can be used to identify:
- Missing Neighbor Relation
- Coverage Problem
- UE Problems
- Network Characteristics
- Best Parameter Setting
- Others

KEY PERFORMANCE INDICATORS

- Accessability (Call set-up success rate)
- Retainability (Dropped calls)
- Mobility (Handover success rate)
- Integrity (BLER and throughput)

LTE FUNDAMENTALS

LTE uses Orthogonal Frequency Division Multiple Access (OFDMA) on the downlink, which is
well suited to achieve high peak data rates in high spectrum bandwidth. WCDMA radio technology is essentially, as efficient as Orthogonal Frequency Division Multiplexing (OFDMA) for delivering peak data rates of about 60 Mbps in 5 MHz of bandwidth. Achieving peak rates in the 300 Mbps range with wider radio channels.
The OFDMA approach is also highly flexible in channelization, and LTE will operate in various radio channel sizes ranging from 1.4 to 20 MHz. LTE also boosts spectral efficiency.
On the uplink, however, a pure OFDMA approach results in high Peak to Average Ratio (PAR) of the signal, which compromises power efficiency and, ultimately, battery life. Hence, LTE uses an approach for the uplink called Single Carrier FDMA (SC-FDMA), which is somewhat similar to OFDMA, but has a 2 to 6 dB PAR advantage over the OFDMA method used by other technologies such as WiMAX IEEE 802.16e.

INTRODUCTION TO LTE

LTE capabilities include:

- Downlink peak data rates up to 326 Mbps with 20 MHz bandwidth Uplink peak data rates up to 86.4 Mbps with 20 MHz bandwidth Operation in both TDD and FDD modes
- Scalable bandwidth up to 20 MHz, covering 1.4 MHz, 3 MHz, 5 MHz, 10 MHz, 15 MHz, and 20 MHz in the study phase Increased spectral efficiency over Release 6 HSPA by two to four times
- Reduced latency of up to 10 milliseconds(ms) round-trip times between user equipment and the base station, and to less than 100ms transition times from inactive to active.

LTE DRIVE TEST PARAMETERS

RSRP :- Reference signal receive power. RSRP (dBm) = RSSI (dBm) -10*log (12*N)

where RSSI = Received Signal Strength Indicator

N: number of RBs across the RSSI is measured and depends on the BW

Significance :

RSRP is the most basic of the UE physical layer measurements and is the linear average power (in watts) of the downlink reference signals (RS) across the channel bandwidth for the Resource elements that carry cell specific Reference Signals.

Knowledge of absolute RSRP provides the UE with essential information about the strength of cells from which path loss can be calculated and used in the algorithms for determining the optimum power settings for operating the network. Reference signal receive power is used both in idle and connected states

Range :- -44 to -140 dBm

RSRP term is used for coverage same as RSCP in 3G RSRQ :

Reference signal receive quality RSRQ = RSRP / (RSSI / N)

N is the number of resource blocks over which the RSSI is measured

RSSI is wide band power, including intra cell power, interference and noise.

Significance :-

It provides the Indication of Signal Quality .

Measuring RSRQ becomes particularly important near the cell edge when decisions need to be made, regardless of absolute RSRP, to perform a handover to the next cell. Reference signal receive quality is used only during connected states

Range :- -3 to -19.5 dB

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RSRQ term is used for Quality same as Ec/No in 3G.

SINR :- Signal to Noise Ratio.
SINR = S / I + N
S -- Average Received Signal Power
I -- Average Interference power
N -Noise Power

Significance : Is a way to measure the Quality of LTE Wireless Connections. As the energy of signal fades with distance i.e Path Loss due to environmental parameters (e.g. background noise , interfering strength of other simultaneous transmission)

RSSI :- Received Signal Strength Indicator.
RSSI = wideband power = noise + serving cell power + interference power
RSSI=12*N*RSRP
RSSI per resource block is measured over 12 resource elements.
N: number of RBs across the RSSI is measured and depends on the BW
Based on the above:

RSRP (dBm) = RSSI (dBm) -10*log (12*N)

Significance :-
Is the parameter represents the entire received power including the wanted power from the serving cell as well as all the co channel power & other sources of noise

CQI :- Channel Quality Indicator Range :- 1 to 15

Significance:
CQI is a measurement of the communication quality of wireless channels i.e. it indicates the downlink mobile radio channel quality as experienced by the UE .CQI can be a value representing
a measure of channel quality for a given channel. Typically, a high value CQI is indicative of a channel with high quality and vice versa. CQI is measured in the Dedicated mode only. CQI depends on the RF conditions.
Better the CQI better the throughput will get and vice versa.

PCI :- Physical Cell Id Range :- 0 to 503

Significance - PCI used to identify the cell & is used to transmit the data

PCI = PSS + 3*SSS

SSS is Secondary Synchronization Signal (identifies Cell Id group). SSS value can be 0 to 167.

BLER :- Block Error Rate

Block Error Ratio is defined as the ratio of the number of erroneous blocks received to the total number of blocks transmitted

Significance -

A simple method by which a UE can choose an appropriate CQI value could be based on a set of Block Error Rate (BLER) thresholds . The UE would report the CQI value corresponding to the Modulation Coding Schemes that ensures BLER ≤ 10% based on the measured received signal quality

BLER is Calculated using Cyclic Redundancy error Checking method High BLER leads to loss of Peak rates & efficiency

BLER threshold should be low i.e. ≤ 10%

DOWNLINK THROUGHPUT

In E-UTRAN may use a maximum of 2 Tx antennas at the ENodeB and 2 Rx antennas at the UE (MIMO).

Significance - Target for averaged user throughput per MHz, 3 to 4 times Release 6 HSDPA i.e Higher user throughput as compared to 3G (Over 300 Mbps downlink as compared to 14 Mbps in UMTS)

The supported user throughput should scale with the spectrum bandwidth.

UPLINK THROUGHPUT

- I n E-UTRAN uses a maximum of a single Tx antenna at the UE and 2 Rx antennas at the E Node B.
- Greater user throughput should be achievable using multiple Tx antennas at the UE (MIMO

Significance-

Target for averaged user throughput per MHz, 2 to 3 times Release 6 Enhanced Uplink i.e Higher user throughput as compared to 3G (Over 50 Mbps Uplink as compared to 5.76 Mbps in UMTS).The user throughput should scale with the spectrum bandwidth provided that the maximum transmit power is also scaled.

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DRIVETEST OPTIMIZATION PRATICALS

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THANK YOU!

LEAD INSTRUCTOR

ENGR.ADEOLA OGUNDELE(MNSE,COREN)

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