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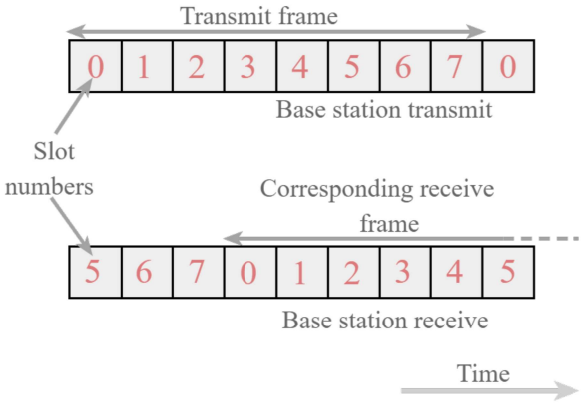
Sub:	Wireless and Cellular Communication					Sub Code: 18EC81
Date:		Duration:	90 Minutes	Max Marks:	50	Sem / Sec:

1 Describe the GSM Hyper frame structure with neat sketch. 10

GSM frame structure - the basics

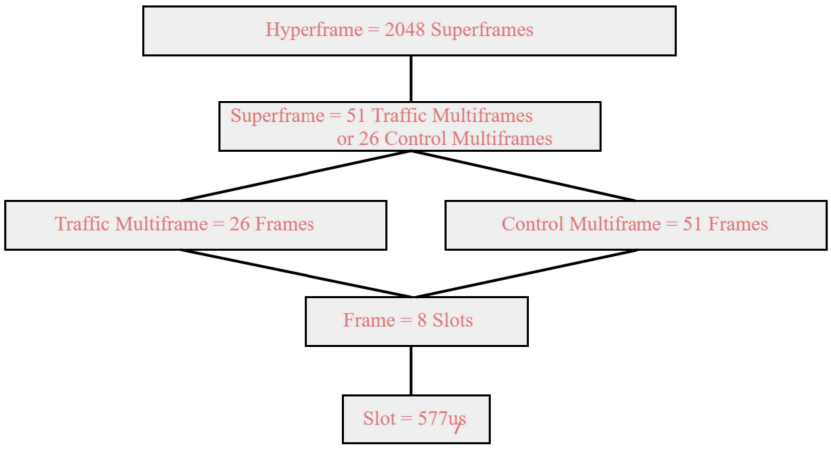
The basic element in the GSM frame structure is the frame itself. This comprises the eight slots, each used for different users within the TDMA system. As mentioned in another page of the tutorial, the slots for transmission and reception for a given mobile are offset in time so that the mobile does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



The basic GSM frame defines the structure upon which all the timing and structure of the GSM messaging and signalling 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.

GSM multiframe

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 synchronised.



GSM Superframe

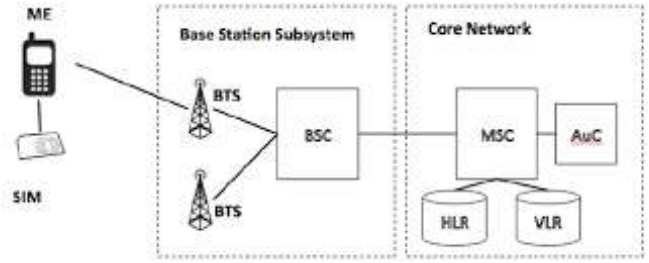
Multiframes are then constructed into superframes taking 6.12 seconds. These consist of 51 traffic multiframes or 26 control multiframes. As the traffic multiframes are 26 bursts long and the control multiframes are 51 bursts long, the different number of traffic and control multiframes within the superframe, 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 synchronisation of the different scheduled operations with the GSM frame structure.

2 Draw the block diagram explaining the network architecture of GSM involving four subsystems and Network switching system each in detail. 10



A GSM network comprises of many functional units. These functions and interfaces are explained in this chapter. The GSM network can be broadly divided into −

- The Mobile Station (MS)
- The Base Station Subsystem (BSS)
- The Network Switching Subsystem (NSS)
- The Operation Support Subsystem (OSS)

GSM - The Mobile Station

The MS consists of the physical equipment, such as the radio transceiver, display and digital signal processors, and the SIM card. It provides the air interface to the user in GSM networks. As such, other services are also provided, which include −

- Voice teleservices
- Data bearer services
- The features' supplementary services

The MS also provides the receptor for SMS messages, enabling the user to toggle between the voice and

data use. Moreover, the mobile facilitates access to voice messaging systems. The MS also provides access to the various data services available in a GSM network.

GSM - The Base Station Subsystem (BSS)

The BSS is composed of two parts −

- The Base Transceiver Station (BTS)
- The Base Station Controller (BSC)

The BTS and the BSC communicate across the specified Abis interface, enabling operations between components that are made by different suppliers. The radio components of a BSS may consist of four to seven or nine cells. A BSS may have one or more base stations. The BSS uses the Abis interface between the BTS and the BSC. A separate high-speed line (T1 or E1) is then connected from the BSS to the Mobile MSC.

The Base Transceiver Station (BTS)

The BTS houses the radio transceivers that define a cell and handles the radio link protocols with the MS. In a large urban area, a large number of BTSs may be deployed.

The BTS corresponds to the transceivers and antennas used in each cell of the network. A BTS is usually placed in the center of a cell. Its transmitting power defines the size of a cell. Each BTS has between 1 and 16 transceivers, depending on the density of users in the cell. Each BTS serves as a single cell. It also includes the following functions −

- Encoding, encrypting, multiplexing, modulating, and feeding the RF signals to the antenna
- Transcoding and rate adaptation
- Time and frequency synchronizing
- Voice through full- or half-rate services
- Decoding, decrypting, and equalizing received signals
- Random access detection
- Timing advances
- Uplink channel measurements

The Base Station Controller (BSC)

The BSC manages the radio resources for one or more BTSs. It handles radio channel setup, frequency hopping, and handovers. The BSC is the connection between the mobile and the MSC. The BSC also translates the 13 Kbps voice channel used over the radio link to the standard 64 Kbps channel used by the Public Switched Telephone Network (PSDN) or ISDN.

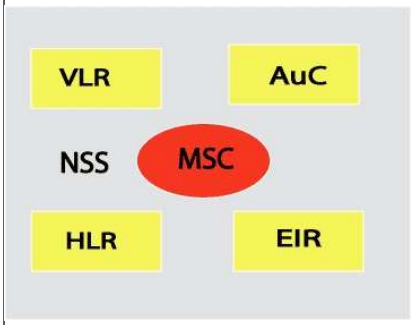
It assigns and releases frequencies and time slots for the MS. The BSC also handles intercell handover. It controls the power transmission of the BSS and MS in its area.

The additional functions include−

- •Control of frequency hopping
- •Performing traffic concentration to reduce the number of lines from the MSC
- •Providing an interface to the Operations and Maintenance Center for the BSS
- •Reallocation of frequencies among BTSs
- •Time and frequency synchronization
- •Power management
- •Time-delay measurements of received signals from the MS

GSM - The Network Switching Subsystem (NSS)

The Network switching system (NSS), the main part of which is the Mobile Switching Center (MSC), performs the switching of calls between the mobile and other fixed or mobile network users, as well as the management of mobile services such as authentication.



The switching system includes the following functional elements −

Home Location Register (HLR)

The HLR is a database used for storage and management of subscriptions. The HLR is considered the most important database, as it stores permanent data about subscribers, including a subscriber's service profile, location information, and activity status.

Mobile Services Switching Center (MSC)

The central component of the Network Subsystem is the MSC. The MSC performs the switching of calls between the mobile and other fixed or mobile network users, as well as the management of mobile services such as registration, authentication, location updating, handovers, and call routing to a roaming subscriber.

Visitor Location Register (VLR)

The VLR is a database that contains temporary information about subscribers that is needed by the MSC in order to service visiting subscribers. The VLR is always integrated with the MSC.

Authentication Center (AUC)

The Authentication Center is a protected database that stores a copy of the secret key stored in each subscriber's SIM card, which is used for authentication and ciphering of the radio channel.

Equipment Identity Register (EIR)

The Equipment Identity Register (EIR) is a database that contains a list of all valid mobile equipment on the network, where its International Mobile Equipment Identity (IMEI) identifies each MS. An IMEI is

	marked as invalid if it has been reported stolen or is not type approved. ## GSM - The Operation Support Subsystem (OSS) The operations and maintenance center (OMC) is connected to all equipment in the switching system and to the BSC. The implementation of OMC is called the operation and support system (OSS). Here are some of the OMC functions− •Administration and commercial operation (subscription, end terminals, charging, and statistics). •Security Management. •Network configuration, Operation, and Performance Management.
3	Explain GSM Identities 10 **GSM Identities** 

To switch a call to a mobile subscriber, the right identities need to be involved. It is therefore important to address them correctly. Followings are those identities;

Mobile Station ISDN Number (MSISDN)

The MSISDN is a number, which uniquely identifies a mobile telephone subscription in the public switched telephone network numbering plan. These are the digits dialed when calling a mobile subscriber.

The MSISDN is consisted with followings;

- Country Code (**CC**)
- National Destination Code (**NDC**)
- Subscriber Number (**SN**)

MSISDN = CC + NDC + SN

International Mobile Subscriber Identity (IMSI)

The IMSI is a unique identity allocated to each subscriber to allow correct identification over the radio path and through the network and is used for all signaling in the PLMN. All network-related subscriber information is connected to the IMSI. The IMSI is stored in the SIM, as well as in the HLR and in the serving VLR.

The IMSI is consisted with followings;

- Mobile Country Code (**MCC**)
- Mobile Network Code (**MNC**)
- Mobile Subscriber Identification Number (**MSIN**)

IMSI = MCC + MNC + MSIN

Temporary Mobile Subscriber Identity (TMSI)

The TMSI is a temporary number used instead of IMSI to identify an MS. The TMSI is used for the subscriber's confidentiality on the air interface. The TMSI has only local significance (that is, within the MSC/VLR area) and is changed at certain events or time intervals.

International Mobile Equipment Identity (IMEI)

The IMEI is used for equipment identification and uniquely identifies a MS as a piece or assembly of equipment.

The IMEI is consisted with followings;

- Type Approval Code (**TAC**), determined by a central GSM body
- Final Assembly Code (**FAC**), identifies the manufacture
- Serial Number (**SNR**), uniquely identifies all equipment within each TAC & FAC
- Spare, a spare bit for future use.

IMEI = TAC + FAC + SNR + Spare

Mobile Station Roaming Number (MSRN)

A MSRN is used during the call setup phase for mobile terminating calls. Each mobile terminating call enters the GMSC in the PLMN. The call is then re-routed by the GMSC, to the MSC where the called mobile subscriber is located. For this purpose MSRN is allocated by the MSC and provided to the

GMSC.

The MSRN is consisted with followings;

- Country Code (CC)
- National Destination Code (NDC)
- Subscriber Number (SN)

MSRN = CC + NDC + SN

Location Area Identity (LAI)

The LAI is used for paging, to indicate to the MSC in which Location Area (LA) the MS is currently situated and also for location updating of mobile subscribers.

The LAI is consisted with followings;

- Mobile Country Code (MCC)
- Mobile Network Code (MNC)
- Location Area Code (LAC)

LAI = MCC + MNC + LAC

Cell Global Identity (CGI)

Each cell is identified by cell identity (CI). A CI is unique within a location area (LA).

CGI is consisted with following;

- Mobile Country Code (MCC)
- Mobile Network Code (MNC)
- Location Area Code (LAC)
- Cell Identity (CI)

CGI = MCC + MNC + LAC + CI

Base Station Identification Code (BSIC)

In GSM, the mobile station uses BSIC to distinguish between neighboring base station.

The BSIC is consisted with

- Network Colour Code (NCC)
- Base Transceiver Colour Code (BCC).

BSIC = NCC + BCC

4. Explain the types of GSM location updating 10

GSM Location Update: The location update procedure allows a mobile device to inform the cellular network, whenever it moves from one location area to the next. Mobiles are responsible for detecting location area codes. When a mobile finds that the location area code is different from its last update, it performs another update by sending to the network, a location update request, together with its previous location, and it's Temporary Mobile Subscriber Identity (TMSI) In order to make a mobile terminated call, The GSM network should know the location of the MS (Mobile Station), despite of its movement. For this purpose the MS periodically reports its location to the network using the Location Update

procedure.

Location Area (LA): A GSM network is divided into cells. A group of cells is considered a location area. A mobile phone in motion keeps the network informed about changes in the location area. If the mobile moves from a cell in one location area to a cell in another location area, the mobile phone should perform a location area update to inform the network about the exact location of the mobile phone.

The Location Update procedure is performed:

- The MS moves from LA1 to LA2, where both LAs are connected to the same MSC

Step 1:

A location update request message is sent from the MS to the MSC through the BTS, include the address of the previously visited LA, MSC, and VLR. In this, the addresses of previous MSC & VLR are same as those for the new MSC & VLR. TMSI is used to avoid sending the IMSI on the radio path. TMSI is temporary mobile subscriber identity of the MS. This temporary identity is allocated to an MS by the VLR at inter VLR registration, and can be changed by VLR after every call setup

Step 2:

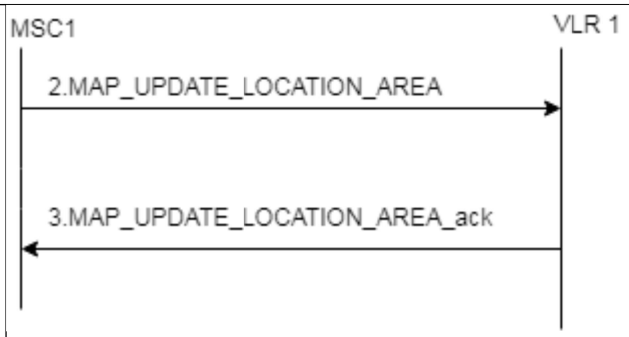
The MSC forwards the location update request to the VLR by a TCAP message, MAP_UPDATE_LOCATION_AREA

The message includes:

- Address of the MSC
- TMSI of the MS
- Previous location area identification (LAI)
- Target LAI

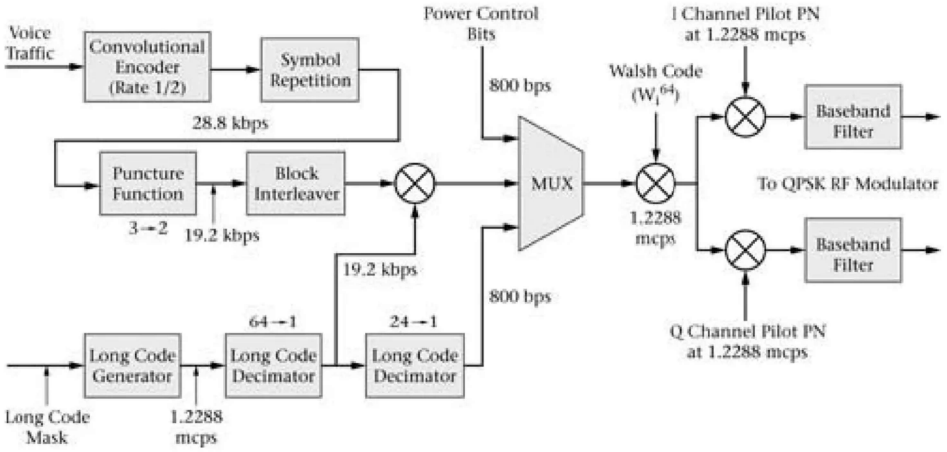
Step 3 and Step 4:

MSC updates the LAI field of the VLR record, and replies with an acknowledgment to the MS through the MSC.



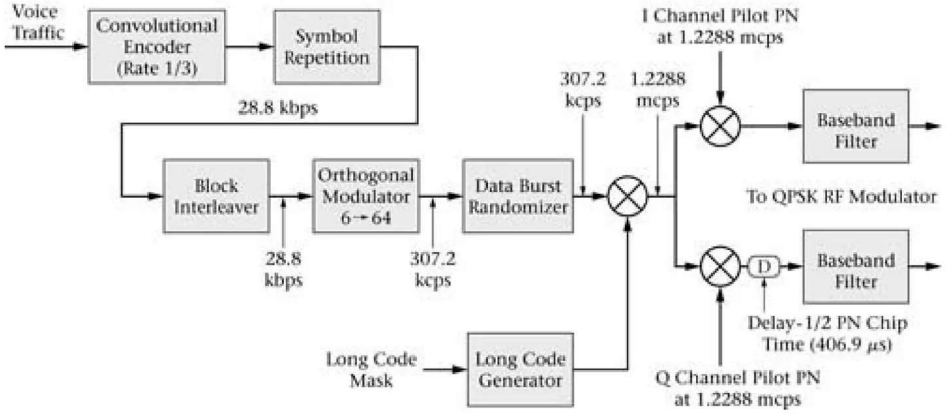
5 Explain with the block diagram the generation of CDMA forward traffic control wit power control for 14.4kbps traffic 10

Traffic / power control channels (14.4 kbps)



- Traffic channels carry actual informaton (Digitally encoded voice or data)
- Different rate sets – Rate set 1 – 9.6 kbps (max) to 4.8,2.4,1.2 kbps.
- RS2- 14.4, 7.2, 3.6 , 1.8 kbps.
- Symbol repetition block – Data rate is doubled.
- The " puncture" function block selects 4 out of 6 bits offered and reduces the data rates to 19.2 kbps (actually from repetition – 14.4 X 2= 28.8 kbps)
- Then block interleaver prevents errors spreading.
- Further scrambling with long and short PN sequences before transmission.
- Power control information is used to set the output power of the mobile on the reverse link and is multiplexed with the scrambled voice bits at a rate of 800 bps.

Traffic/power control channels

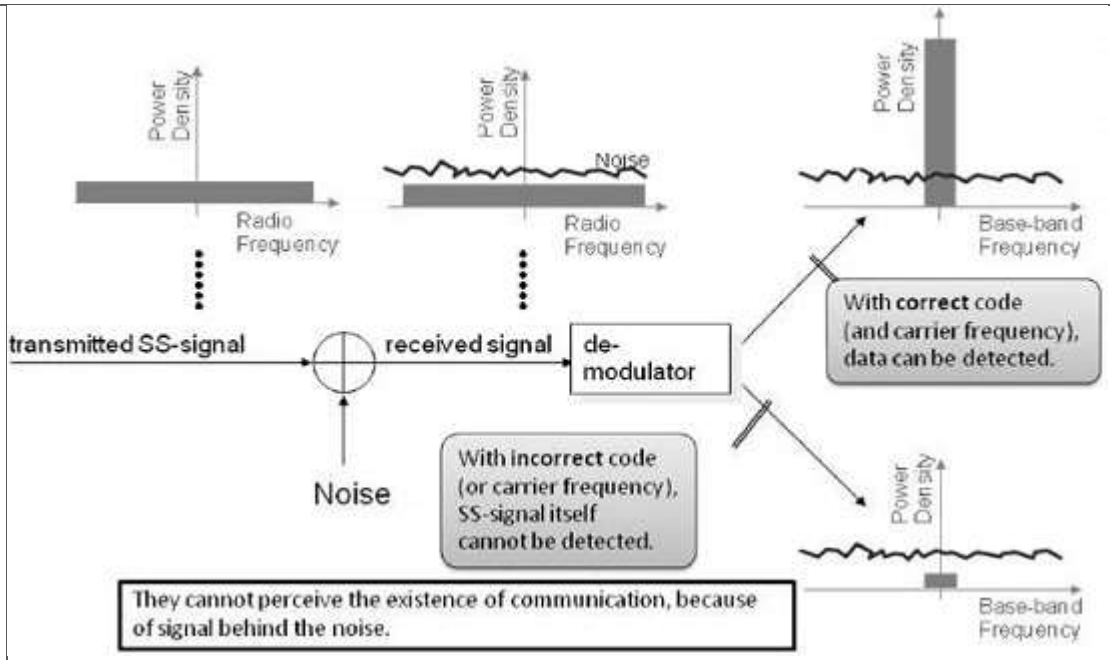


- Supports both voice and data at the two rate sets (RS1 and RS2)
- In both cases, the data rate at the input to the orthogonal modulator subsystem will be 28.8 kbps.
- output process rate will be 307.2 kcps.
- The signal is processed by data burst randomizer that in essence to eliminate redundant data.
- The signal is then spread by long PN sequence code and further scrambled by short PN sequence.

6 Explain the CDMA basic spectrum spreading operation with necessary sketches 10

Features of Spread Spectrum

As shown in the following figure, the power density of Spread Spectrum signals could be lower than the noise density. This is a wonderful feature that can keep the signals protected and maintain privacy.



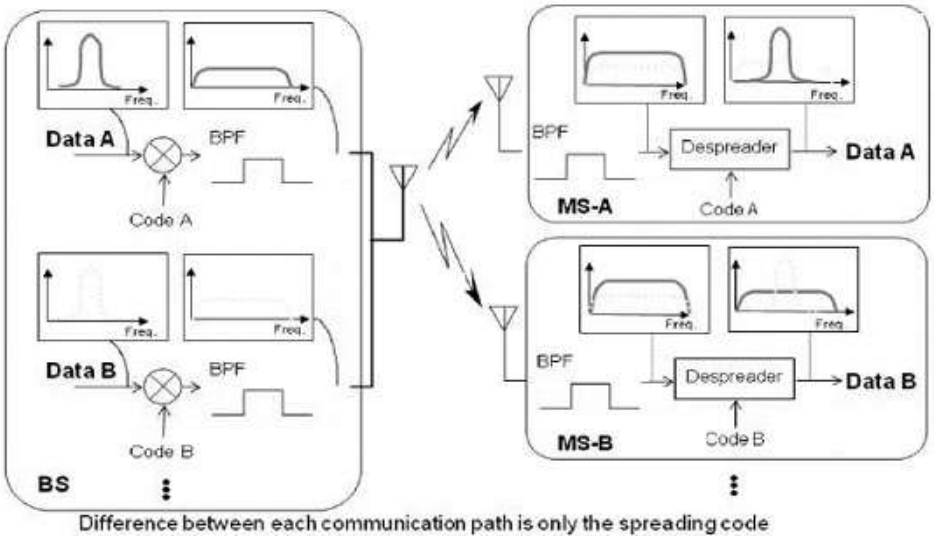
By spreading the spectrum of the transmitted signal, one can reduce its power density such that it becomes less than the power density of the noise. In this way, it is possible to hide the signal in the noise. It can be demodulated if you know the code that was used to send the signal. In case the code is not known, then the received signal will remain hidden in the noise even after the demodulation.

DS-CDMA

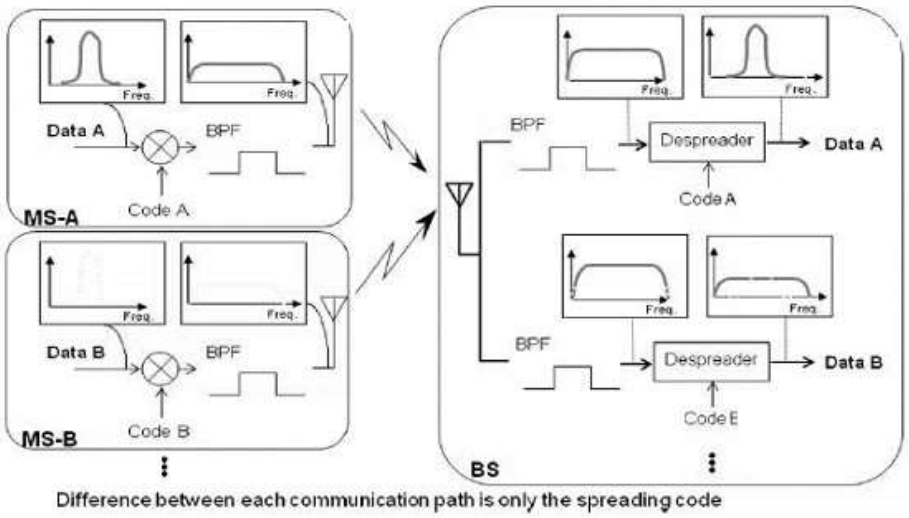
DS code is used in CDMA. So far, it has been explained basic part of the spread spectrum communication. From here, we will explain how Direct Sequence Code Division Multiple Access (DS-CDMA) works.

The signal which is spread spectrum, can be demodulated only by a code used for transmission. By using this, the transmission signal of each user can be identified by the separate code when it receives the signal. In the given example, the spread signal of the user A at the code A, and diffused signal of user B at code B. Each of the signal when it receives are mixed. However, by the inverse diffuser (Despreadder), it identifies the signal of each user.

DS-CDMA System - Forward Link



DS-CDMA System - Reverse Link



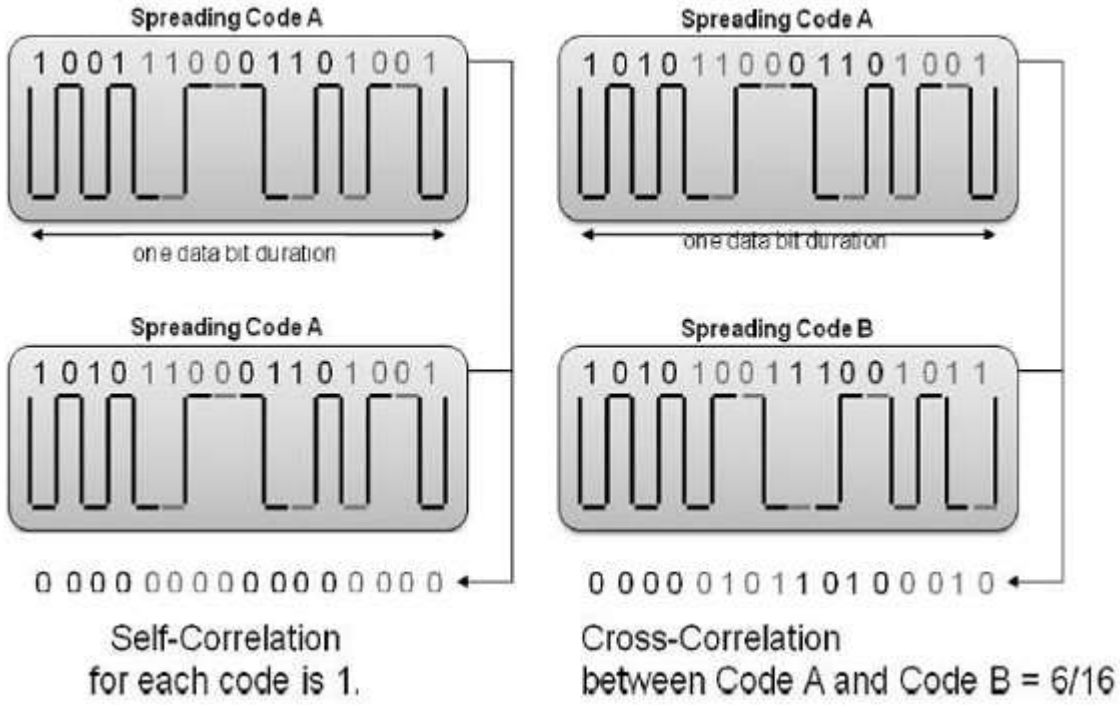
Difference between each communication path is only the spreading code

Spreading Code

Cross-Correlation

Correlation is a method of measurement of how precisely a given signal matches with a desired code. In CDMA technology, each user is assigned with a different code, the code which is being assigned or chosen by the user is very important to modulate the signal because it is related to the performance of the CDMA system. One will get best performance when there will be clear separation between the signal of desired users and signals of the other users. This separation is made by correlating the desired signal code which was locally generated and other received signals. If the signal matches with the code of the user, then the correlation function will be high and the system can extract that signal. If the user's desired code has nothing in common with the signal, the correlation should be as close to zero as possible (thus eliminating the signal); also known as cross correlation. So, there is a self-correlation (Self-Correlation) and cross-correlation (Cross-Correlation).

Properties of self-correlation and code are shown in the diagram given below where correlation between spreading code ‘A’ and spreading code ‘B’ is shown. In this example, the calculated correlation of spreading code ‘A (1010110001101001) and spreading code ‘B’ (1010100111001001) is given, while performing calculations in below example, the result has come to 6/16.



Preferable Codes

Preferable code is used in CDMA. There are different codes that can be used depending on the type of a system of CDMA. There are two types of system −

- •Synchronous (Synchronous) System and
- •Asynchronous (Asynchronous) System.

In a synchronous system, orthogonal codes (Orthogonal Code) can be used. In asynchronous system for this, such as pseudo-random code (Pseudo-random Noise) or Gold code is used.

In order to minimize mutual interference in DS-CDMA, the spreading codes with less cross-correlation should be chosen.

Synchronous DS-CDMA

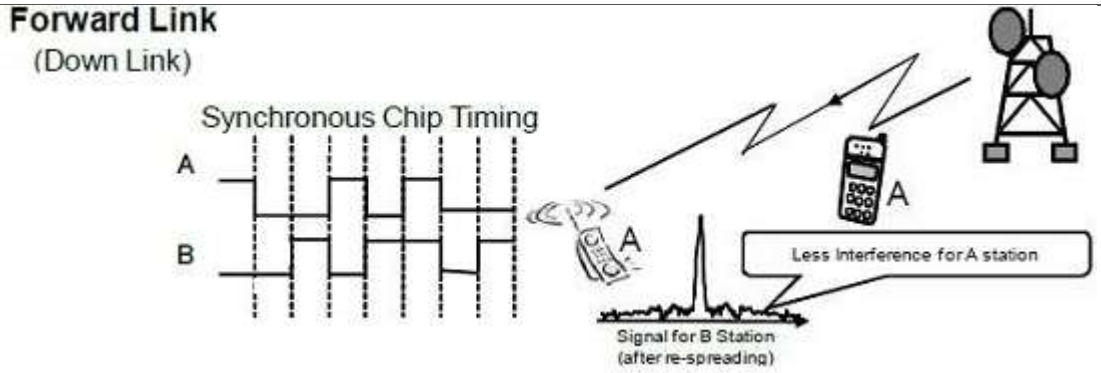
- •Orthogonal Codes are appropriate. (Walsh code etc.)

Asynchronous DS-CDMA

- •Pseudo-random Noise (PN) codes/Maximum sequence
- •Gold Codes

Synchronous DS-CDMA

Synchronous CDMA Systems are realized in Point to Multi-point Systems. For example, Forward Link (Base Station to Mobile Station) in Mobile Phone.

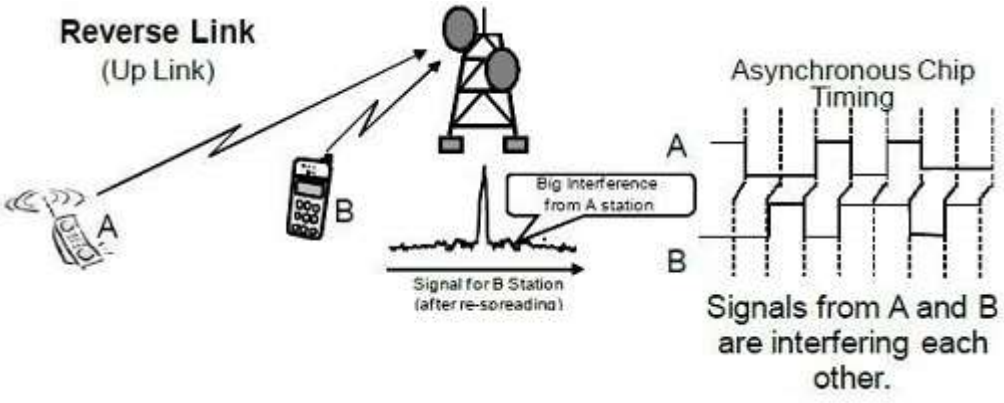


Synchronization system is used in one-to-many (Point to Multipoint) systems. For example, at a given time, in a mobile communication system, a single base station (BTS) can communicate with multiple cell phones (forward link/downlink).

In this system, a transmission signal for all the users can communicate in synchronization. Means, "Synchronization" on this point is a sense that can be sent to align the top of each user signal. In this system, it is possible to use orthogonal codes and it is also possible to reduce mutual interference. And orthogonal codes, it is the sign, such as cross-correlation i.e. 0.

Asynchronous DS-CDMA

In asynchronous CDMA system, orthogonal codes have bad cross-correlation.



Unlike the signal from the base station, the signal from the mobile station to the base station, becomes the asynchronous system.

In an asynchronous system, somewhat mutual interference increases, but it uses the other codes such as PN code or Gold code.

Advantages of Spread Spectrum

Since the signal is spread over a wide frequency band, the power spectral density becomes very low, so other communication systems do not suffer from this kind of communication. However, the Gaussian noise increases. Given below is a list of a few major advantages of Spread Spectrum −

- Multipath can be agreed with, as a large number of codes can be generated, allowing a large number of users.
- In spread spectrum, there is no limit of users whereas there is limitations of users in FDMA technology.
- Security − without knowing the spreading code, it is hardly possible to recover the transmitted

	data. •Descending rejection − as large bandwidth is used the system; it is less susceptible to deformation.