

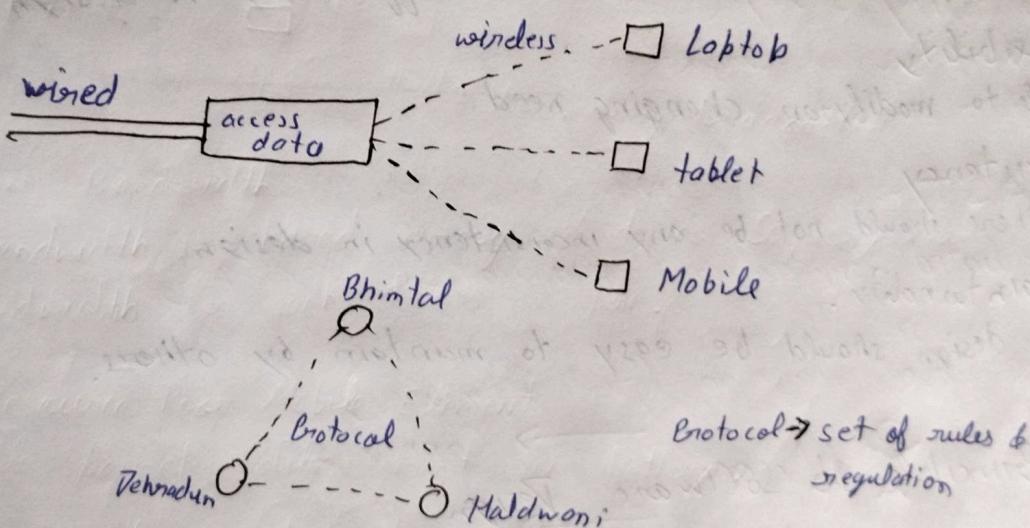
# Mobile Computing

↓  
movable

↓  
Processing + transformation +  
Storage

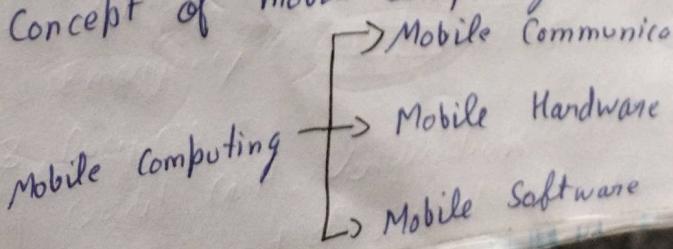
Mobile Computing is the technology that uses computing devices (tablets, mobile phone, ~~iPad~~, laptop, etc) and allows transmission of data (audio, video, text, picture) wirelessly any time, anywhere.

Communication is spread over both wired & wireless medium.



Set of distributed computing system participate connect & synchronise through mobile communication protocols.

Concept of mobile computing divided into three parts :-



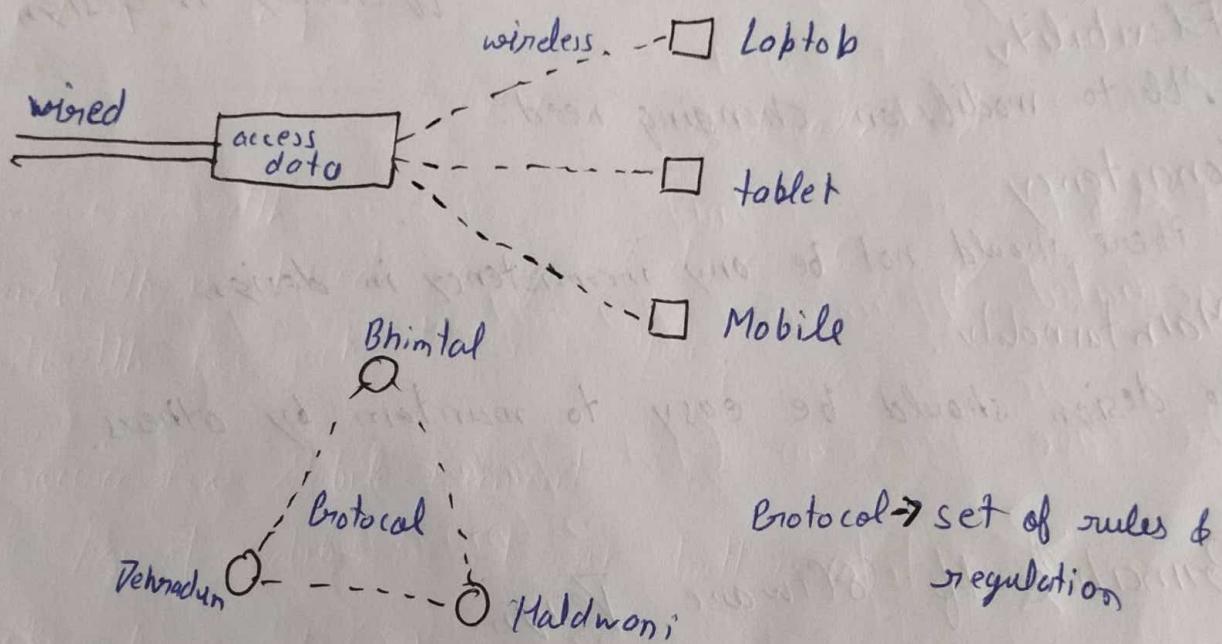
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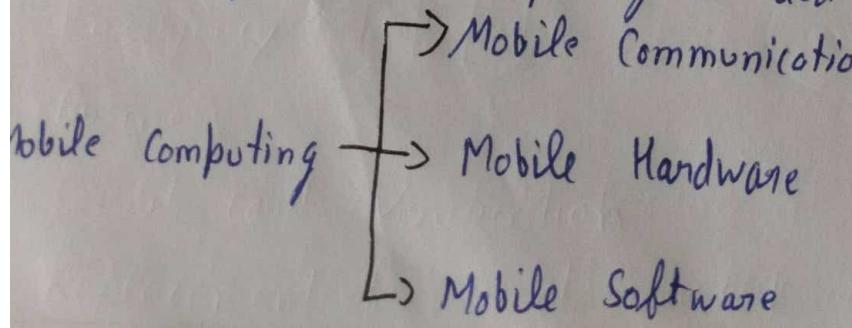
Mobile Computing is the technology that uses computing devices (tablets, mobile phone, ~~etc~~ I Pod, laptop, etc) and allows transmission of data (audio, video, text, picture) wirelessly any time, anywhere & everywhere.

Communication is spread over both wired & wireless medium.



Set of distributed computing system participate connect & synchronise through mobile communication protocol.

Concept of mobile computing divided into three parts :-



## • Mobile Communication

Services that deals with the method of communicating data.

### • Mobile Hardware

Devices/Components that can excess these services. These devices can send/receive data at the same time.

### • Mobile Software

Deals with software/operating system used inside these devices like window, linux etc.

## ★ Characteristic of Mobile Computing

### 1. Ubiquity

Provide the ability to user to perform computation from anywhere any time.

### 2 Location Awareness

Tracking current/present location of the hand held devices.

Example: GPS, etc

### 3 Adoption

Adjusting bandwidth fluctuation without user inconvene.

### 4 Broadcast

Signal is broadcasted by tower to get efficient delivery of data/information to many devices simultaneously.

### 5 Personalisation

As per user profile mobile services are customized.

## ★ Challenges In Mobile Computing

### 1 Disconnection

Frequent failure of network or disconnection of network due to mobile computing design.





## Advantage / Characteristic of Mobile Computing

- 1 ~~Large~~ Larger number of User.
- 2 Large geographical area.

3

- Reuse the radio frequency by the concept of cell.

- 4 Reduce interference from other signal.

~~QUESTION~~

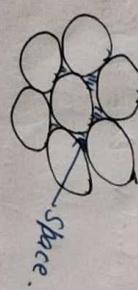
- ★ Why we use Hexagonal Structure for cell?

- We know that, each cell has a particular bandwidth.

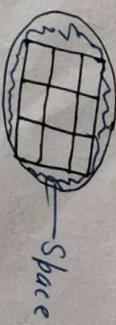
- Co-channel has same set of frequencies but cannot interfere each other because of sufficient distance.

- In these cell we use low power & short height tower so that the total cell area can be cover.

- Antenna radiate in omni-direction (circle), we don't use it because it leave some space.



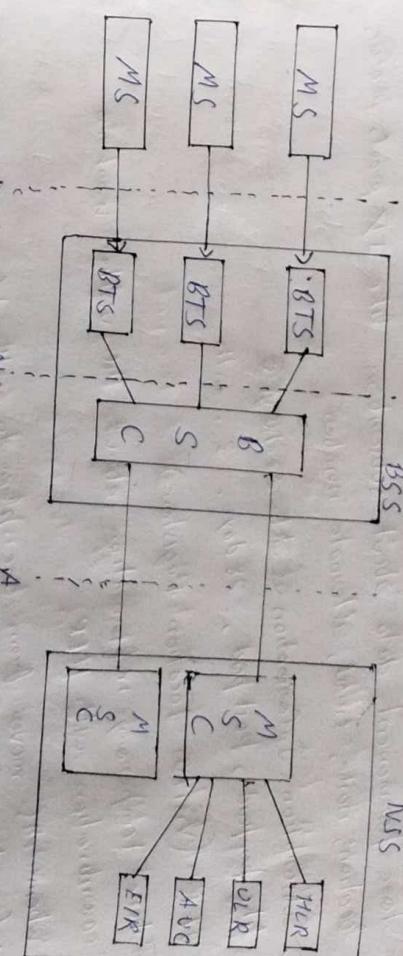
- We don't use square also because it leave space in outer part of geographical area.



- We don't use octagonal because it create complexity.
- Hexagonal structure is best approach available.

Note:- It is theoretical approach for calculation of area.

## Cellular Network Architecture



- Mobile Equipment
- Subscriber Identity Module (SIM)
- Base Transceiver Station (BTS)
- It send & receives signal from mobile station.
- BTS facilitate wireless communication between user equipment & network.
- BSC (Base Station Controller)
  - If control BTS.
  - When BTS is overloaded, it handles the traffic & direct to another BTS.
  - Mobile Switching Center (MSC)
  - If it is associated with communication switching function such as call.

Setup, release & routing.

- HLR (Home Location Register)

- Store permanent data about subscribers like ID proof, profile, location, name, email, alternate number.

- Subscription Information ~~Information~~  
like prepaid, post paid, 28 days, 3 month.

- VLR (Visitor Location Register)

- Store temporary information about the visitor working in coordination with HLR.

- When MS moves from one place to another place VLR ask about information from HLR.

- AUC (Authentication Center)

- Protect from different type of frauds, stores a copy of secret key.

- Used for authentication of MS.

- EIR (Equipment Identity Register)

- EIR IMEI → used to identify each MS.

EIR is database that contains record of all of the mobile subscribers that are allowed or banned in the network.

- Base Station Sub-System (BSS)

- Handle traffic & signals between a mobile phone & the network switching sub-system.

- Network Switching Sub-System (NSS)

- It carries out call & mobility ~~management~~ management function for mobile phone present in network.

## ★ Bluetooth Technology

- It is a low power wireless technology that uses a short range radio, that provides a way to connect nearby devices to each other based on mobile computing.
- Used in PAN (Personal Area Network).
- Open wireless technology standard used to send & receive data to connected devices.
- Known as IEEE 802.15 standard.
- Frequency bands <sup>is from</sup> 2.4 GHz to 2.485 GHz.
- Range upto 10 meters.
- Speed about 1 Mbps.
- Help to interconnect a set of devices with ambient computer that individual person might require.
- The developing unit of this technology is a group of five companies called special interest group which was formed in 1998.

## → Application of Bluetooth

Bluetooth Speakers

Bluetooth Headphone & Earphones

Bluetooth Headset

Wireless mouse & keyboard.

In personal vehicles.

## → Advantage of Bluetooth

- Wireless technology
- Cheap technology
- Low Energy Consumption.
- Free to use if the device is installed with bluetooth.
- Very simple to form a Piconet.

- Can pass through wall also.

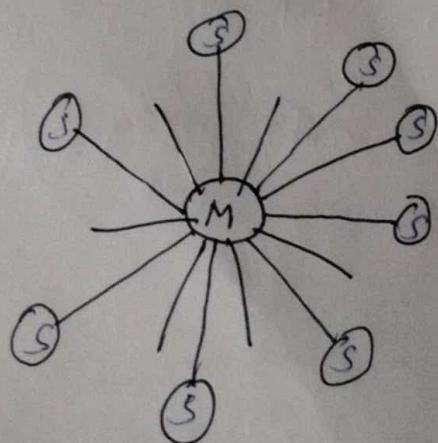
→ Disadvantage of Bluetooth

- Low in Bandwidth.
- Range is Less.

→ Pico Net

An architecture of Bluetooth is called Piconet.

- Piconet offers the technology with the help of which data transmission occurs based on its nodes.
- i) Master Node → from which data is being send.
- ii) Slave Node → nodes in which data is received.
- In Piconet, one primary node & seven active secondary nodes, So maximum number of nodes in Piconet is 8.
- Maximum number of devices that can be paired is equal to  $2^8 - 1$  or 255.
- Piconet is a combination of ~~code~~ division multiple access (CDMA) & frequency hopping spread spectrum (FHSS).

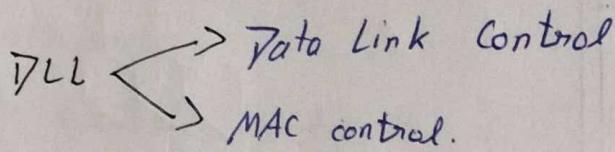


<sup>active slave</sup>  
only 7 node can connect at a time  
for data transfer.  
but total number of node which can  
be connected as both active & waiting  
is 255.

Combination of piconet is scatter network

## ★ Wireless Multiple Access Control (wMAC)

- Used to allow many mobile users to share simultaneously a finite amount of radio spectrum in the efficient manner.
- In a OSI model, function of DLL (Data-Link Layer) are divided into two parts.

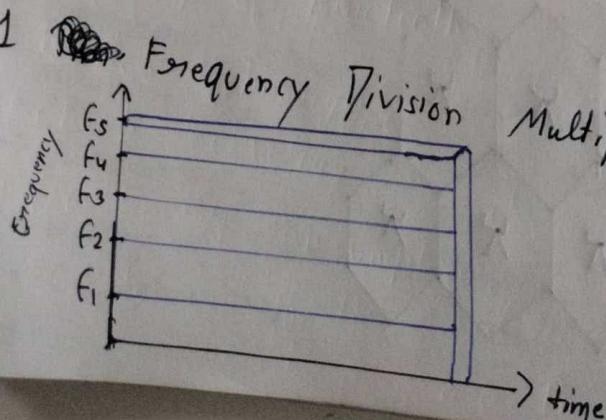


### Data Link Control :-

It is responsible for reliable transmission of messages over transmission channel by using techniques like, framing, error control & flow control

### MAC control :-

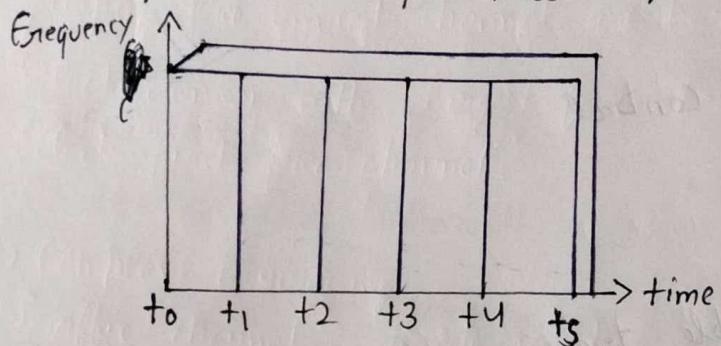
- In wireless ~~radio~~ communication, system subscribers is allowed to send information simultaneously to the base station, while receiving information from the base station.
- We know that, the main aim of cellular system design is to able to increase the capacity of channel that is to handle as many calls possible in a given bandwidth with a sufficient level of quality of service.
- TDMA, FDMA, CDMA are the three major multiple access techniques used to share available bandwidth in a wireless communication system.



Multiple Access (FDMA)

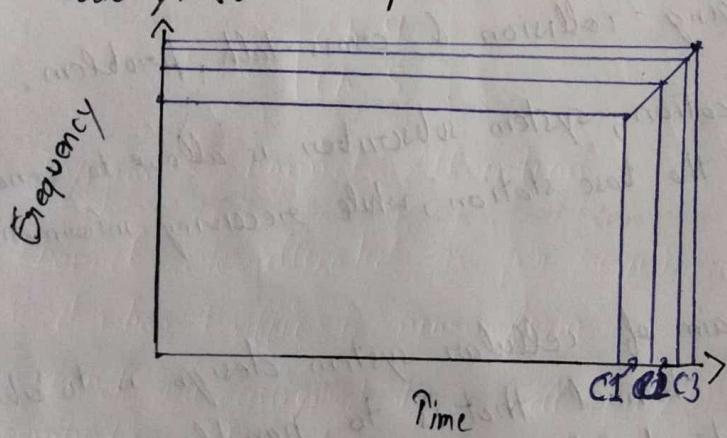
The available bandwidth is divided into frequency bands, each station/user is allocated a band/frequency to send data.

## 2. Time Division Multiple Access (TDMA)



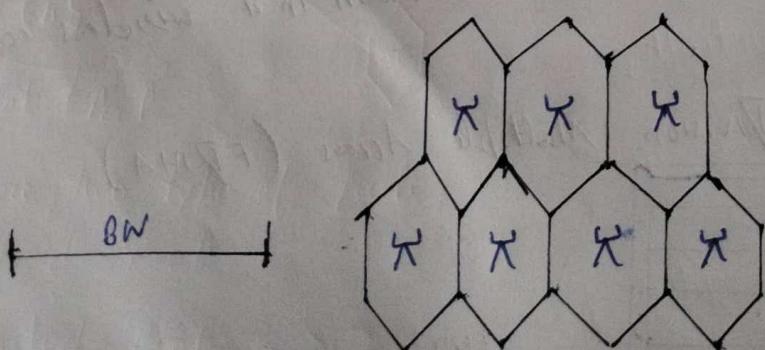
The available bandwidth is divided into time bands, each station/user is allocated a band to send data.

## 3. Code Division Multiple Access



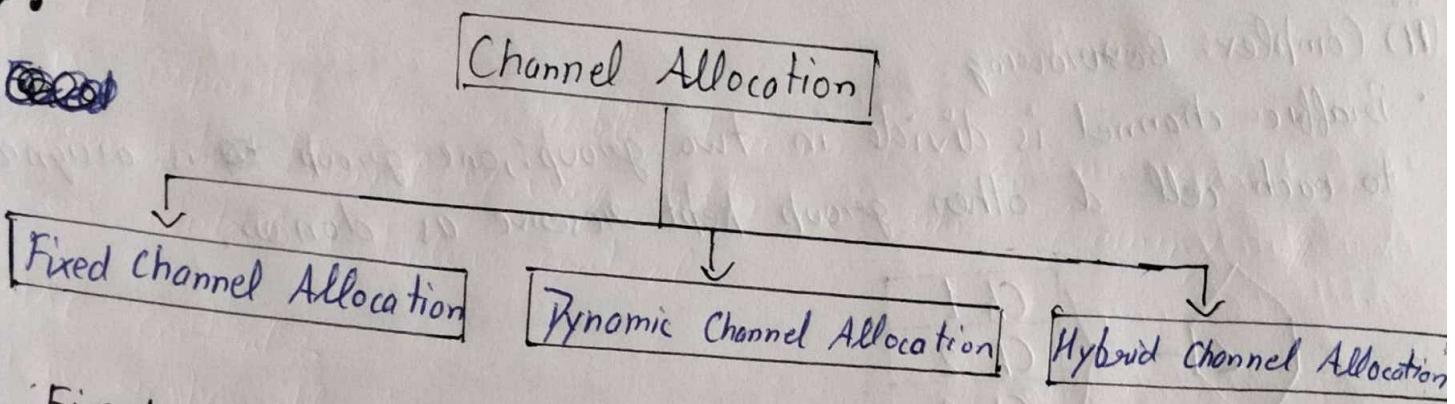
The available bandwidth is divided into code and each station/user is allocated a code to send data.

### ★ Channel Allocation in cellular network.



Allocation is a process of allocating a channel to a cell in a network.

- For each cell a channel has to be allocated.
- Channel Allocation means focusing on ~~on~~ selecting a channel frequency to each cell in other to avoid interference.
- The available bandwidth is divided into channel.



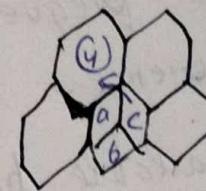
### 1. Fixed Channel Allocation

- Also called static channel allocation/assignment.
- Fixed number of channel are allocated to each cell.
- Static hence can't be changed.
- Frequency reused is maximized.
- We have to find out the number of channel required to serve a coverage area this formulae:  
$$N = \frac{D}{d\sqrt{R}}$$
      
$$\left. \begin{array}{l} N \rightarrow \text{Number of cells/channel,} \\ D \rightarrow \text{Frequency reused distance} \end{array} \right\}$$
- Permanently channels are allocated to a particular cell.
- Borrowing scheme is introduced in fixed channel allocation to minimize the blocking of cell.  
→ Disadvantage.
  - Wastage of channel bandwidth.
  - Conjunction may occur if traffic is not uniform.

→ Borrowing  
 When cells are allocated with fixed channel & traffic channel ~~out~~  
 increases then free channel are borrowed from neighbouring cell.

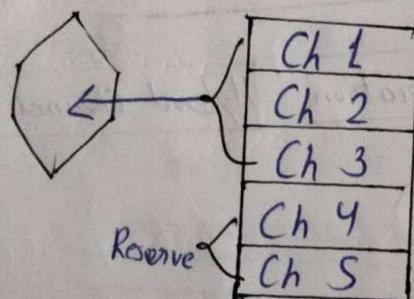
### (i) Simple Borrowing -

- Simply free unused channel are borrowed.
- Select donor with largest free channel.
- Select first free channel.



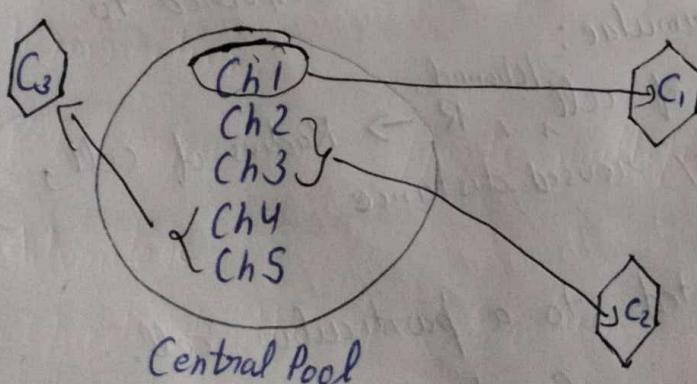
### (ii) Complex Borrowing

- Braffic channel is divide in two group; one group ~~is~~ is assigned to each cell & other group kept reserve as donor.



## 2 Dynamic Channel Allocation

- Channel are allocated as per requirement.
- Used when traffic is non-uniform
- Channel are assigned to a cell only when required & after the completion, channels are back to pool.



- There are two type of pools

(i) Centralised Pool

(ii) Distributed Pool → ○ ○ ○

## Unit → 2

### ★ Data Management Issues

#### ★ Mobile Database

- Allows application for hand held devices to access data stores given by on the move.
- Makes data from database application available all the time to all the mobile users.
- Data Management is a practice of collecting, organising, protecting and storing network data, so it can be analysed for processing & taking decision.

#### ★ Features in Mobile Database

- Mobile Transition should be robust towards unexpected discussion due to mobility.
- Transmission Processing system also need to cope with restricted resources like low battery life, slower processor speed, limited memory.
- Mobile Application should react fast forward with frequent environment changes like location & narrow bandwidth.

→ There are various issues occurs in data management

- 1 ~~Mobile~~ Mobile Database Design
- 2 Security
- 3 Data distribution & replication
- 4 Mobility Management
- 5 Wireless medium
- 6 Portability

#### ★ Mobility

- It is the ability of a node to change its point of attachment while maintaining an existing communication using same IP address

- The location of mobile unit is an important parameter in locating a mobile station that may hold the require data & when selecting information specially location dependent information.
- Mobile unit has a home base station that keeps track of its location by receiving notification of its movement.

## ★ Data Replication & Its type

- Sharing of information to ensure data consistency between software & hardware resources connected via a internet to improve :-
- Reliability
- Availability
- Fault Tolerance
- Accessibility of Data.
- It is a process in which the data is copied at multiple location to improve the availability of data.
- A mobile host needs to have its own complete or partial copy of the relevant data from main database so it can process data locally.
- In mobile computing environment data replication is essential as it would allow user to contribute operating during temporary disconnection.
- Data replication supports multiple users & give high performance.

### → Advantage

- Speed up the query resolution.
- Efficient way to ensure data availability, integrity & fault tolerance
- Minimize the communication cost.

### → Disadvantage

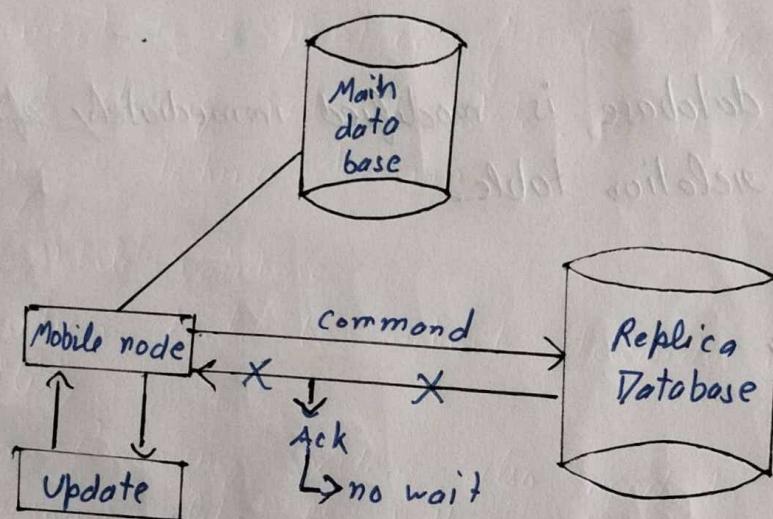
- More storage space is needed as storing the replicas of some data at different sites or location.

- Expensive
- Increase complexity of data update.
- High maintenance.

→ ~~Types~~<sup>Methods</sup> of Replication

- 1 Asynchronous
- 2 Synchronous

## 1 Asynchronous Replication



- Mobile node send commands to replicate data on remote/rePLICATE database & doesn't wait for acknowledgement.
- The replica will be modified after ~~commit~~ commit action is fired on the database.

→ Advantage

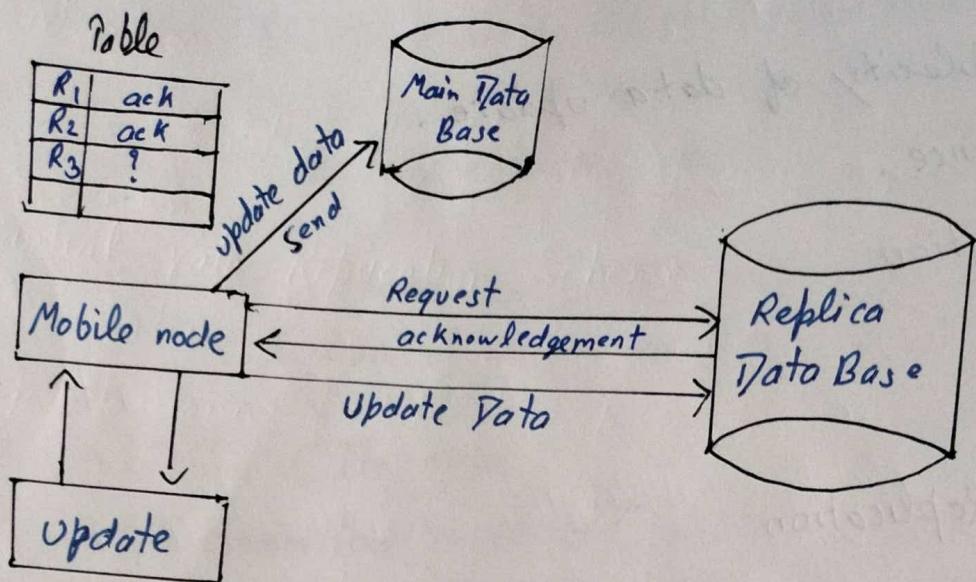
- Fast
- Work as O-S label
- High Consistency

→ Disadvantage

- High Risk of Data Loss

## 2 Synchronous Replication.

- Mobile node send update requests & wait for an acknowledgement from database being replicated.



- The **replica** of database is modified immediately after changes are made in the relation table.

→ Advantage

- Security of Data
- 
- 

→ Disadvantage

- Slow
- 
- 

### ★ ~~Replication~~ Schemes

There are mainly three types of <sup>replication</sup> schemes :-

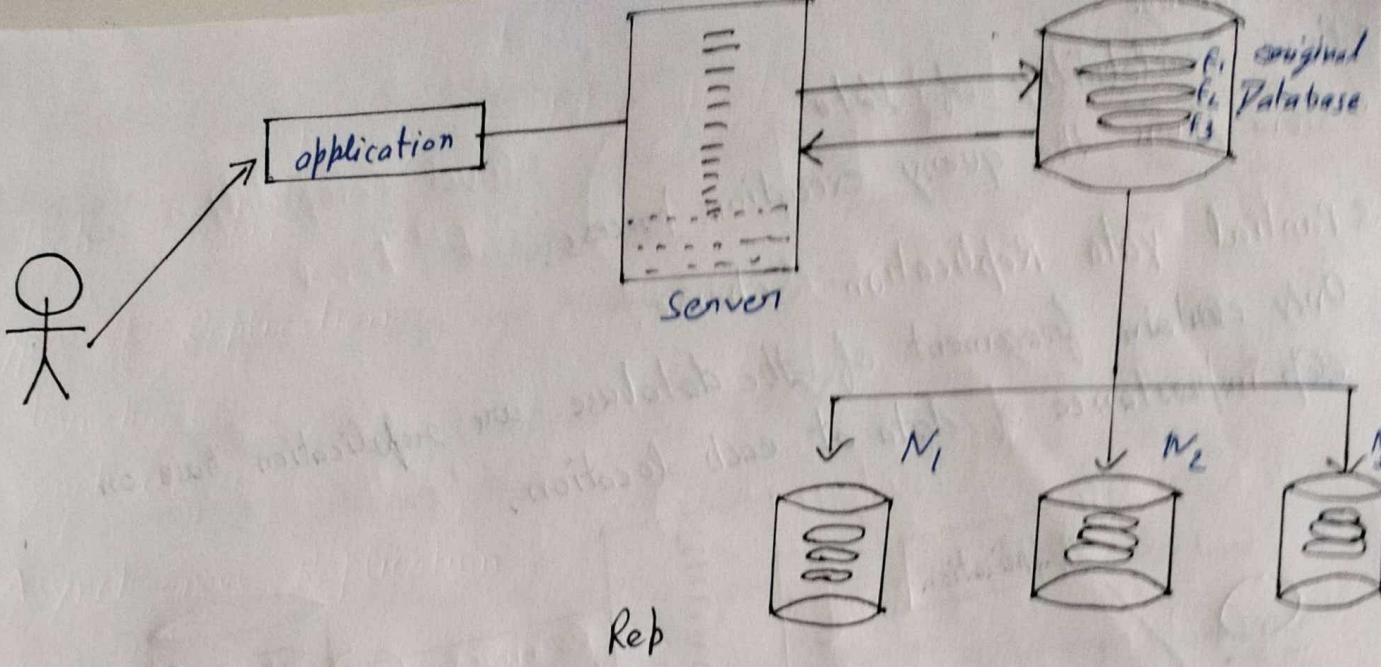
1 Full Replication Scheme

2 ~~Low~~ Replication Scheme

3 Partial Replication Scheme

### 1 Full Replication Scheme

- The database is available for almost every location or user in communication network.
- It contributes faster execution of global queries as the result can be obtained from any local server.



### Advantage

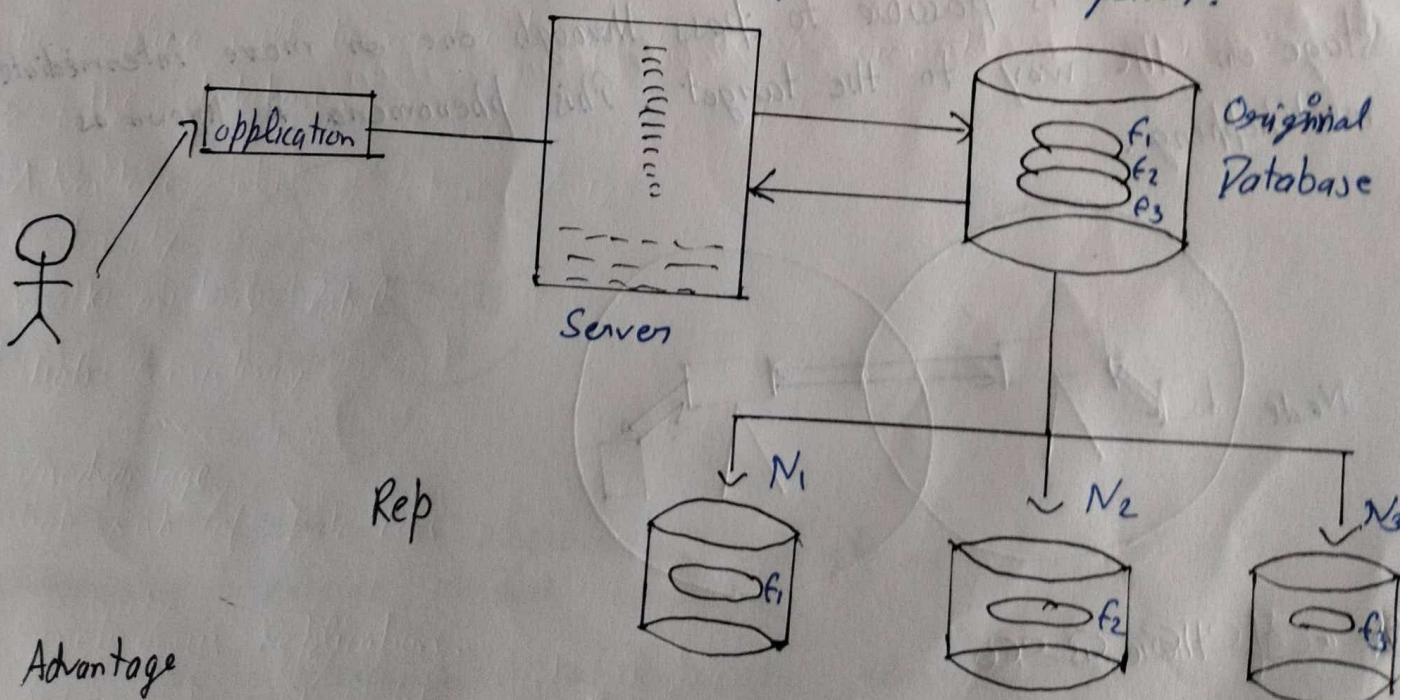
- High Availability of Data
- Faster Execution of queries

### Disadvantage

- Control is difficult
- Update process is slower

## 2 Replications

- Only one fragment exist on each side of distribution system.



### Advantage

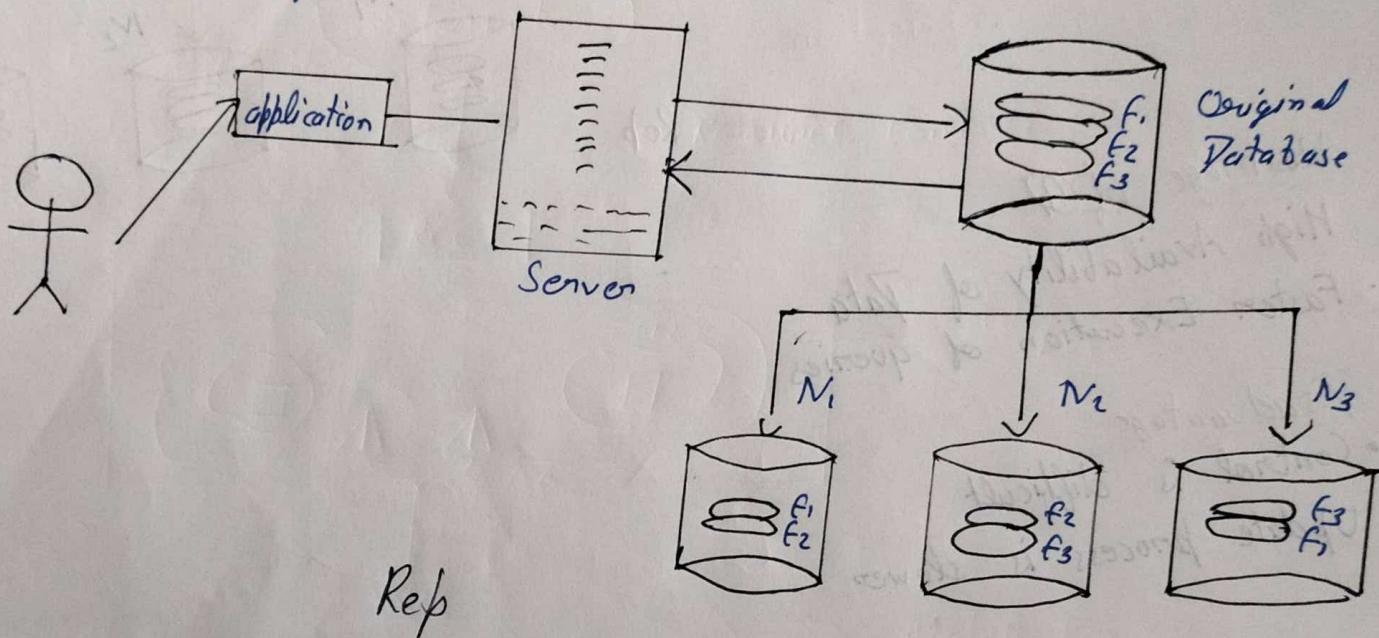
- Easy Recovery of Data
- Concurrency can be minimize.

## Disadvantage

- Poor availability of Data
- Slow Down the query execution process.

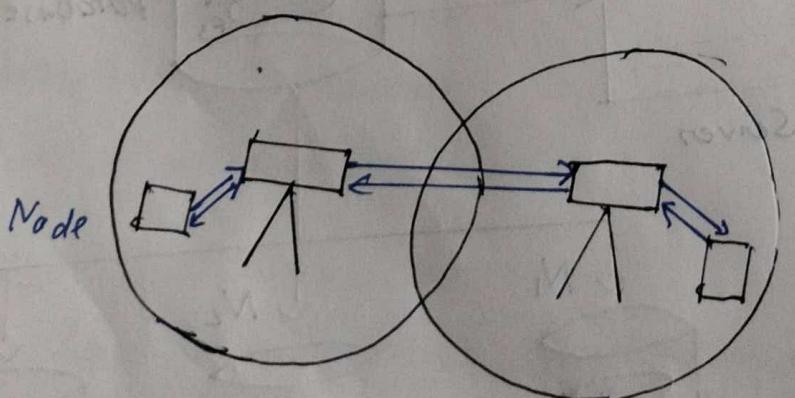
## 3. Partial Data Replication Scheme.

Only certain fragment of the database are replicated base on the importance of data at each location.



## ★ Multihopping

If there is no direct communication link between the source & destination it is possible to pass through one or more intermediate stage on the way to the target. This phenomena is known as multihopping.



• If there is no

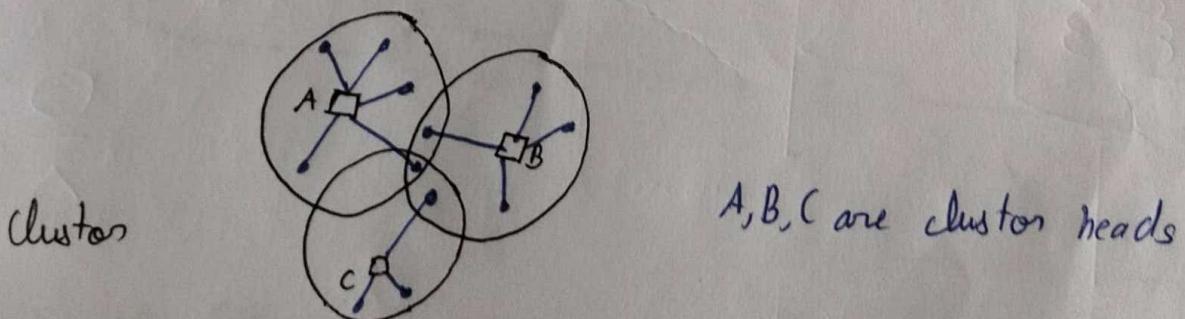
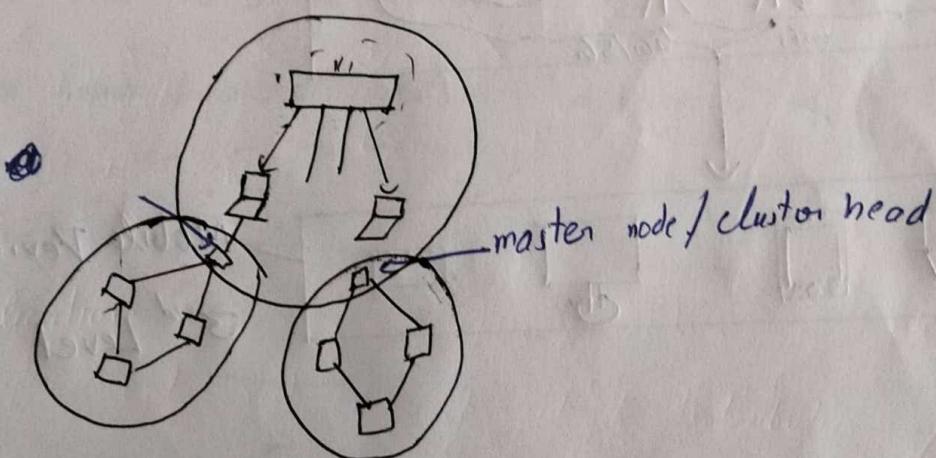
## ★ Multi-Cluster Architecture

**Clustering** → A cluster consists of a collection of interconnected stand alone computers or nodes working together as a single computing resource.

A Cluster is a subset of node which can communicate with a cluster head & positively with each other.

Entire population of nodes are grouped into clusters.

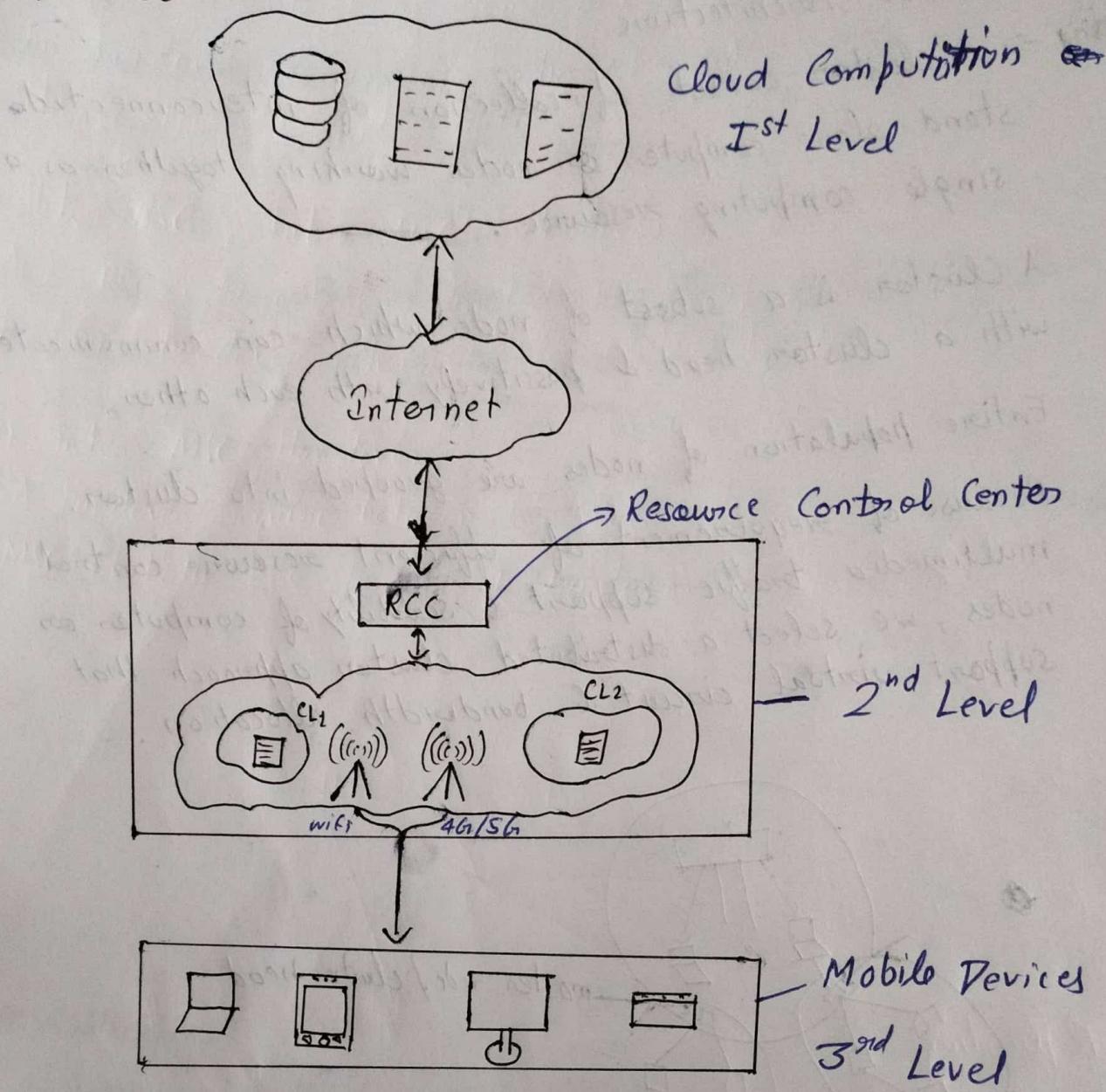
Because of requirement of efficient resource control multimedia traffic support & scalability of computer or nodes, we select a distributed cluster approach that support virtual circuit & bandwidth allocation.



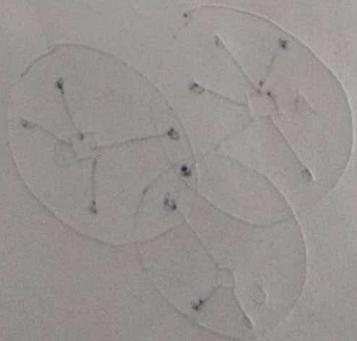
Each of them serve as a regional broadcast not as a local coordinator to enhance channel throughput

To find a visible interconnected set of cluster, covering the entire node population, clustering algorithm is used for example, lowest ID algorithm & highest ~~connectedness~~ connectivity algorithm.

# Architecture



★ Frequency Spectrum for Mobile Communication.



## ★ Handover

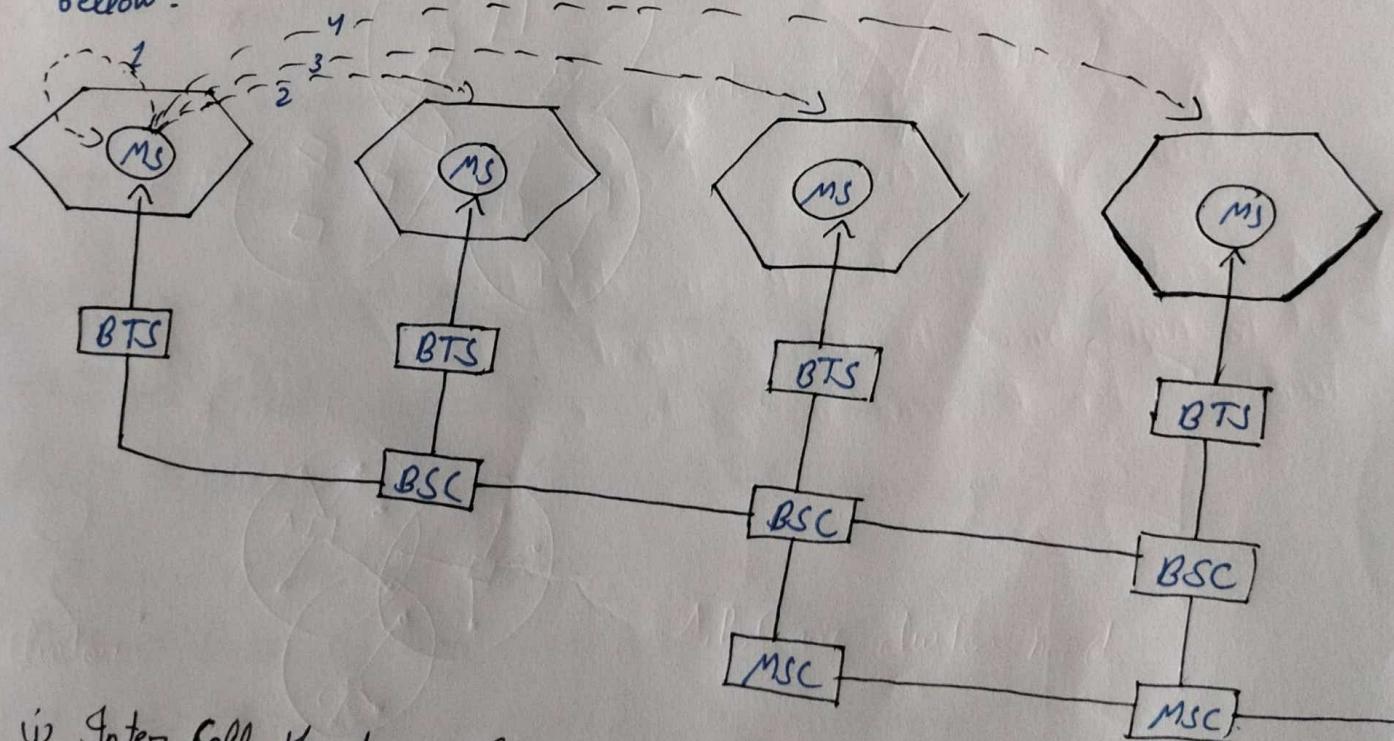
- A cellular system requires a handover procedure as single cell do not cover the whole service area.
- A handover should not cause cut off or call drop.
- GSM aims to maximum handover duration 50 ms
- There are basically two reasons of handover:
  - (i) MS moves out of the range of the BTS if decrease signal strength & increase error rate. Hence, decrease quality of Radio link.

MS → ↓ Sign S → ↑ error rate → ↓ Quality of Radio link

(ii) Due to the load balancing.

when MS/BTS decide the traffic is too high in one cell & shift some MS to other cells with a lower load.

- There are four possible handover scenarios of GSM are as below:



(i) Inter Cell Handover (I)

~~Inter cell~~ Within a cell narrow band interference could make transmission at a certain frequency impossible. The BSC could then decide to change the carrier bandwidth.

(ii) Inter ~~cell~~ Intra BSC Handover

The mobile station moves from one cell to another but stays in

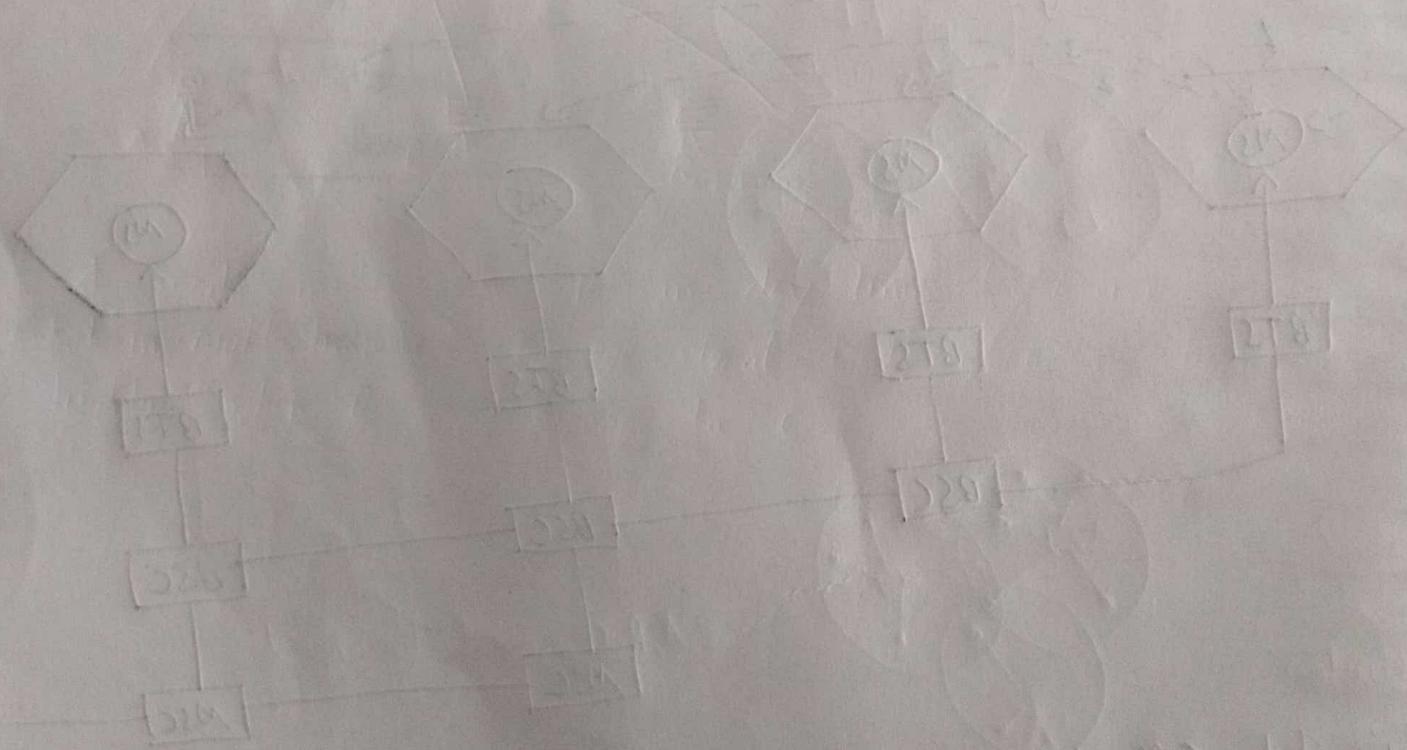
within the control of some BSC. The BSC then performs the handover a signal or radio channel in the new cell & release the old one.

iii) Inter BSC ; Intra MSC Handover

As a BSC only control a limited number of cells, GSM also has to perform handover between cells controlled by the MSC.

iv) Inter MSC Handover

A handover could be required between two cells belonging to different MSC & both MSC performed handover together.



## Full Form

- ISP → Internet Service Provider
- FDMA → Frequency Division Multiple Access
- TDMA → Time Division Multiple Access
- SIM → Subscription Identity Module
- MS → Mobile station
- BSC → Base Station Controller
- BTS → Base Trans-Receiver station
- MSC → Mobile Switching Control
- VLR → Visitor Location Register
- HLR → Home Location Register
- AUC → Authentication Center
- EIR → Equipment Identity Register
- MT → Mobile Terminal
- MAC → Multiple Access Control
- MSI → Mobile Subscription Identification
- GSM → Global System for Mobile Communication
- RA → Registration Area
- BSS → Base System Sub-System
- NSS → Network Switching Sub-System

## ★ Location Management

### Mobility Issues

- Radio Resource Management
- Location Information Management
- Security
- Temporary loss of connectivity during movement.
- Resources, small device, low battery power, small CPU, less memory, light weight.
- React to sudden change due to bandwidth & other resource changed.

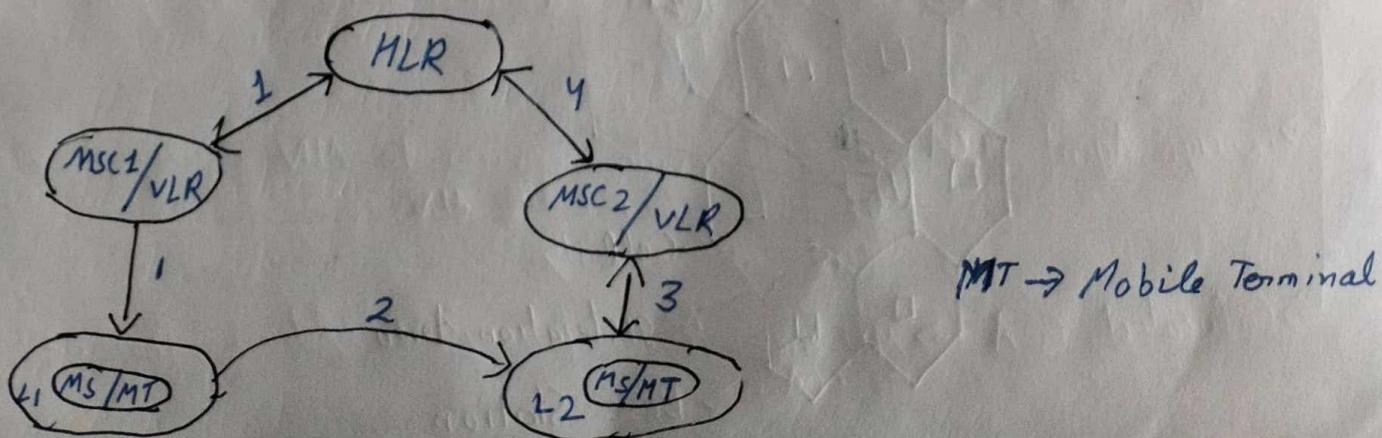
## ★ Location Management

How to keep track on an active mobile within a cellular network.

### → How to Manage & Update Location

- Based on search & update ~~location~~ operation.
- Tradition mobile communication application has voice, text, email or remote file downloaded. But now new video streaming, telemedicine, surveillance, etc are included, hence location management is very essential.

Search & Update operation.



- The Location  $L_1$  of a mobile node is maintained by MSC1 (where it last registered) permanently.
- For each mobile node, the HLR maintains a mobility table / binding, now if  $L_2$  is the latest cell of MS known to HLR.
- $(MS, L)$  in HLR is updated as follows:

a) Location Management Scheme

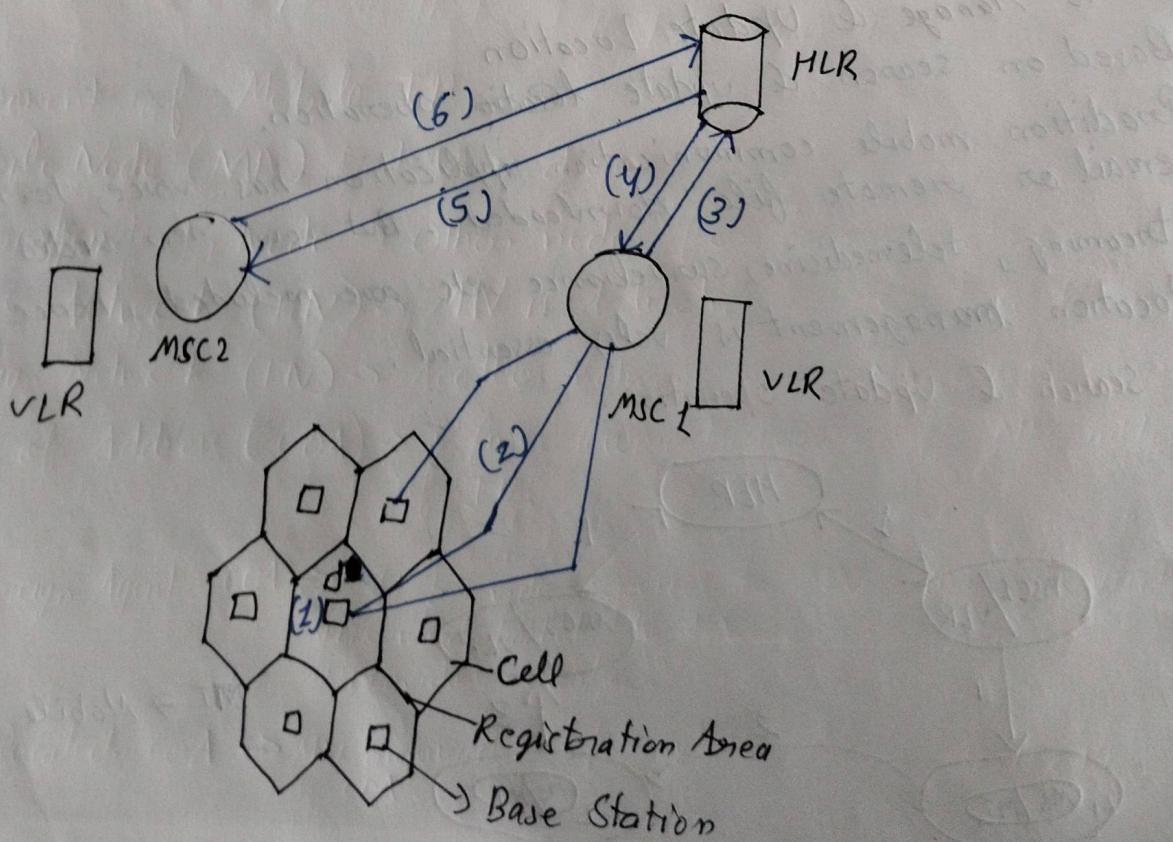
This scheme is based on two level hierarchy :-

- Location Update / registration
- Paging

b) Location Registration

Network coverage area is partitioned into registration areas. All base stations belonging to the same registration area belongs to the same MSC.

When a MS / MT moves to a new registration area.

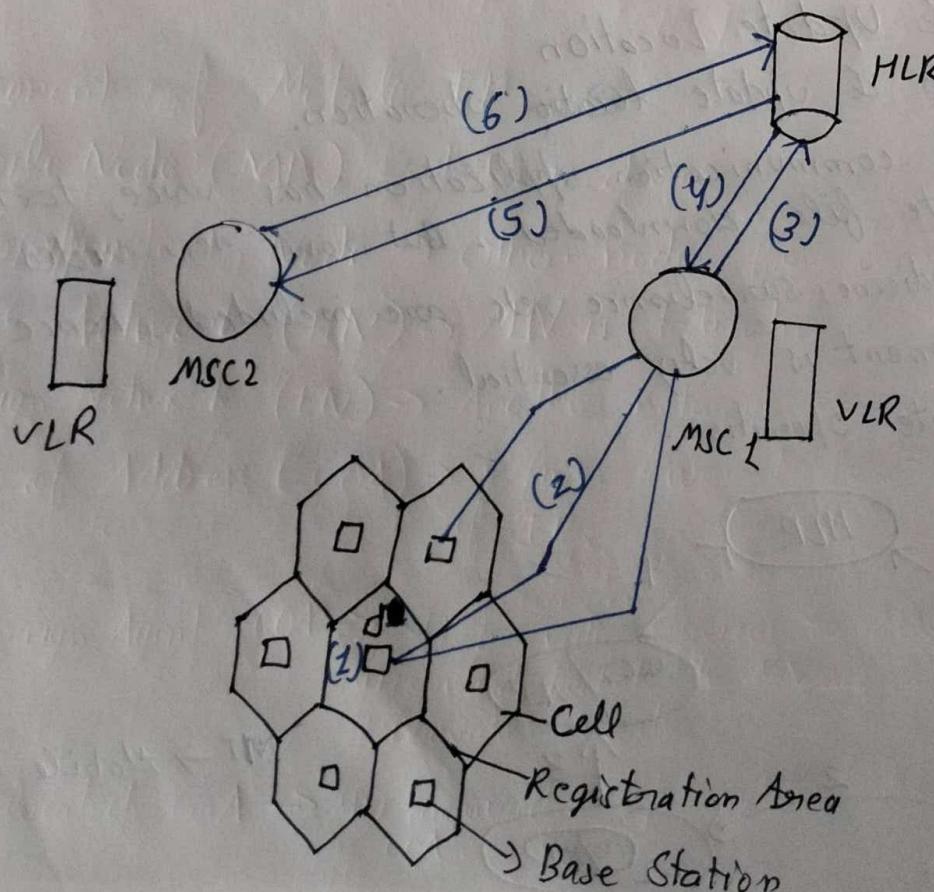


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This scheme is based on two level hierarchy :-
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### ④ Location Registration

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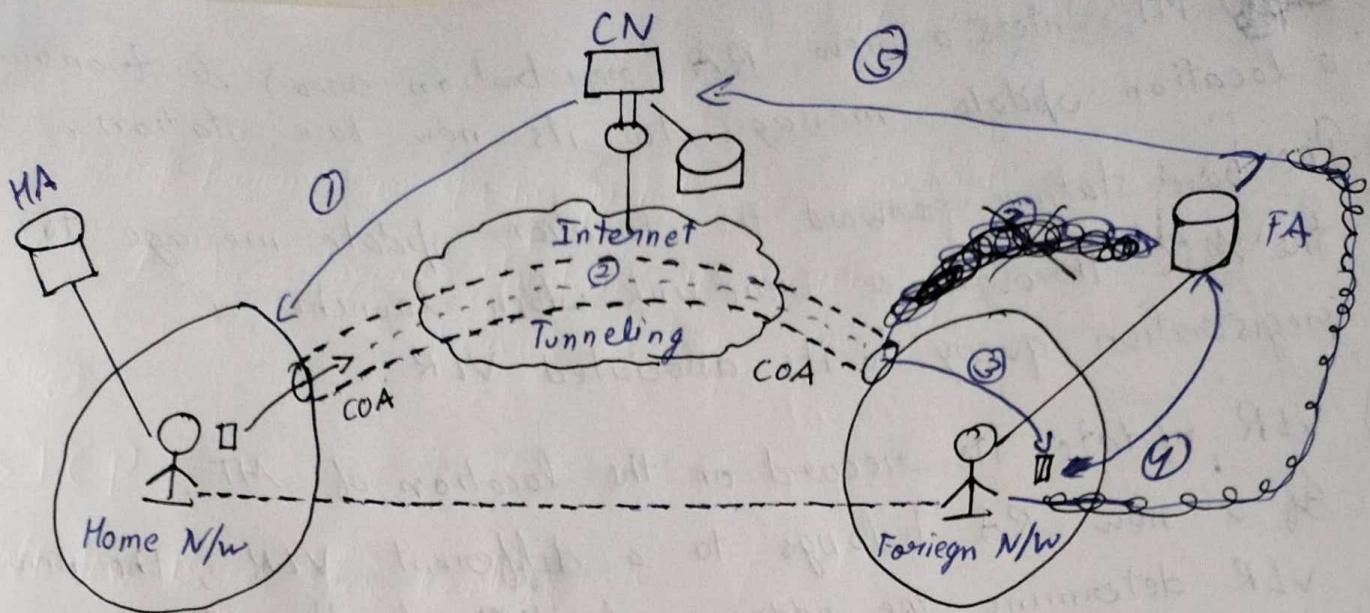
When a MS / MT moves to a new registration area.



- (1) MT enters a new RA (registration area) & transmit a location update messages to its new base station.
- (2) The base station forward the location update message to the MSC through a wire link which launches a registration query to its associated VLR.
- (3) VLR update its record on the location of MT.  
If a new RA belongs to a different VLR, the new VLR determine the addresses of HLR of the MT to a lookup table & sends a location registration message in HLR.
- (4) The HLR records the ID of new serving VLR of the MT & sends a registration acknowledgement to the new VLR.
- (5) The HLR then sends a registration cancellation message to the old VLR.
- (6) The old VLR removes the record of the MT & return as acknowledgement to the HLR.

### ★ Mobile IP

- Mobile IP is an IETF (Internet Engineering Task Force) Standard communication protocol that is design to allow mobile device user to move from one network to another network without changing the IP address.
- Every device is provided an IP address - within a home network a device can used normal IP routing but as soon as it moves to visitor network it can't use a normal IP routing and due to this active session can be terminated.  
∴ Solution is Mobile IP.
- The concept of COA (Care of Address) will help to register home agent to foreign network agent.



## Main Components of Mobile IP

(i) Home Agent

(ii) Foreign Agent

(iii) Correspondent Node  $\rightarrow$  It belongs to some third network who wants to send data to mobile node who is now in foreign network.

(iv) COA (Care of Network)

Tunneling :-

Encapsulation  $\rightarrow$  Start point

Decapsulation  $\rightarrow$  End point

## Components of Mobile IP

- Mobile Node (MN) End User devices
- Correspondent Node  $\rightarrow$  Other node for communication.
- Home Network (HN)  $\rightarrow$  MN is dedicated & registered to the network.
- Foreign Network (FN)  $\rightarrow$  Another network where MN moves.
- Care of Address (COA)  $\rightarrow$  Defines current location of MN in terms of IP.

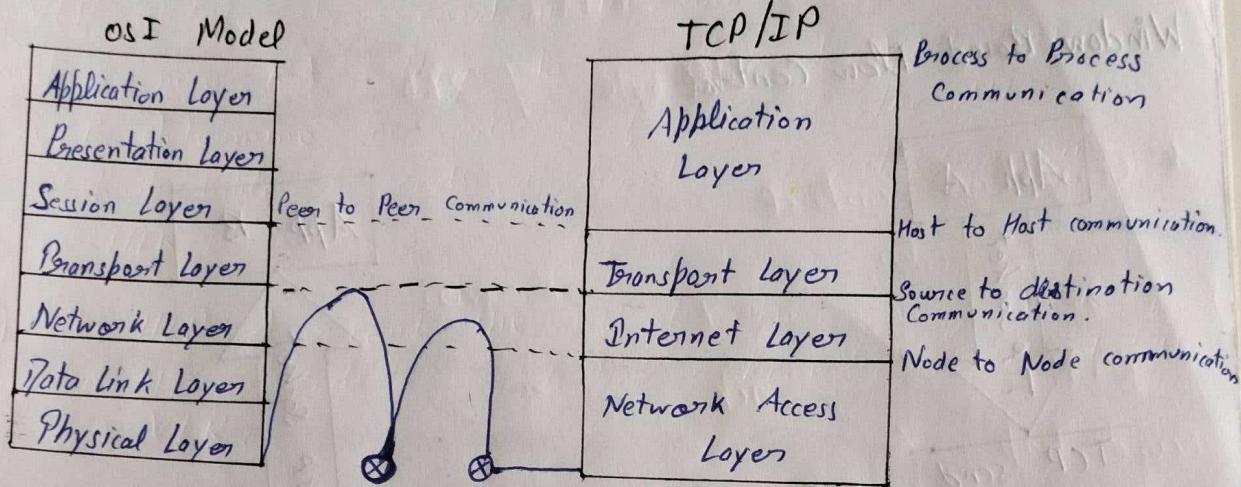
$\rightarrow$  Foreign Agent COA  $\rightarrow$  It provides services to MN during its visit.

- (i) Forward packet to MN
- (ii) Provide security.

$\rightarrow$  Collocated COA  $\rightarrow$  MN acquired temporary IP address. That address act as COA.

- Home Agent (HA)  $\rightarrow$  Located in a home network
  - (i) Tunnel for packet,
  - (ii) Forward towards MN, start at HA.
  - (iii) Has location registry.

## ★ TCP Over Wireless / TCP & Mobility



TCP  $\rightarrow$  Transmission Control Protocol.

This model governs how data b/w two different devices are transmitted over a communication channel.

### Responsibility of Layer

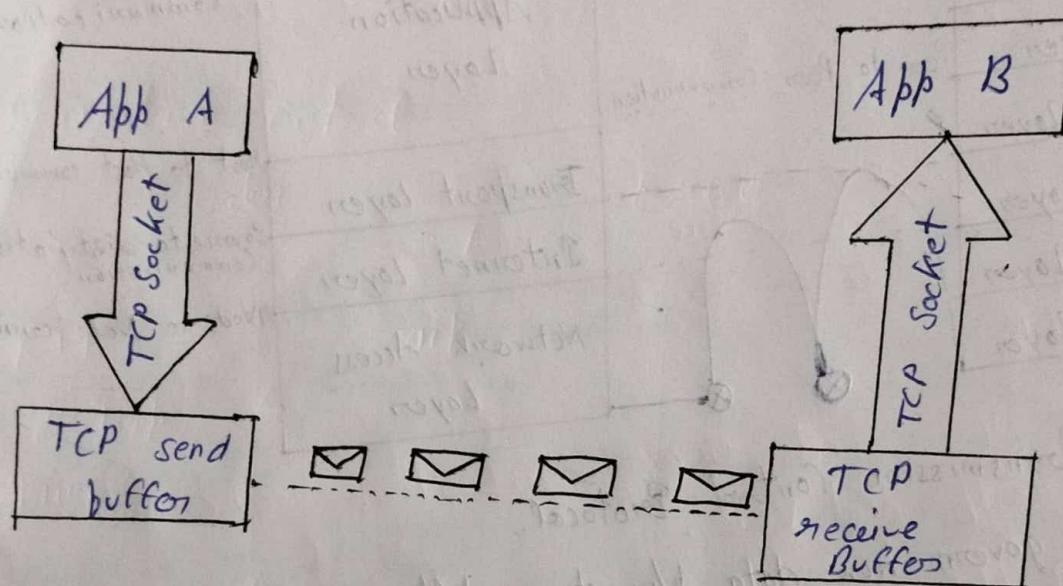
- Application Layer  $\rightarrow$  Responsible for maintaining the protocols essential for interaction between user & application.
- Transport Layer  $\rightarrow$  Responsible for maintaining data flow between sender & receiver
  - (i) Reliable ordered delivery.
    - $\rightarrow$  Uses sequence number, acknowledgement, timeout & retransmission.
    - $\rightarrow$  End to end semantic acknowledgement after data received.
  - (ii) Provide Flow & congestion control
    - $\rightarrow$  Using sliding window based buffers & feedback from receiver or network

to adjust bandwidth

- Internet Layer → For sharing packets from sender to receiver
- Network Access Layer → Maintain the various task related to sending receiving data in raw bits.

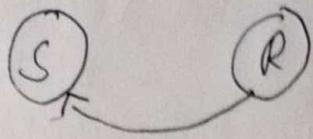
→ TCP

### Window Based Flow Control



- TCP flow control means that, TCP will help to ensure that the sender is not overloaded the receiver by sending more packets than it can handle.
- TCP implements flow control by increasing / decreasing window size as required.
- Buffer is the capacity of receiving data at a time by a receiver.
- When buffer / receiver become overflow , there is a delay in data transmission a control mechanism needs to overcome this problem. ~~control~~ window
- Window is a mechanism in which the receiver tells the sender about the capacity of receiving data.
- Windowing System is used for reliable delivery .
- Receiver advertise its window size.

→



Received buffer size = 100 bytes  
 Last byte Received = 150 bytes  
 Last Read byte = 120 byte  
 bytes sends by sender = 180  
 Outstanding bytes = 110

I Maximum receiver buffer should be less than/equal to last byte Received  $\leq$  last byte Read. of MSB  $\leftarrow LBR - LBRead \}$

II Advertise buffer/window sized = Maximum Received Buffer - (Last byte received - last byte read)

III Last Byte Send - Last Byte Acknowledge  $\leq$  Advertising Window.

$$I \quad \text{MSB} \leq 150 - 120 \Rightarrow 100 \leq 30$$

$$II \quad AWS = 100 - (150 - 120) = 100 - 30 = 70$$

$$III \quad 180 - 150 \leq 70 \Rightarrow 30 \leq 70$$

IV Effect window (sender side window)

Effect window = Advertising window - (Last byte send - last byte acknowledge)

$$= 70 - (180 - 150)$$

$$= 70 - 30$$

$$= 40$$

V Maximum Window = Minimum of  $\begin{cases} \text{Advertise window} \\ \text{congestion window} \end{cases}$   
 initiated by receiver      initiated by network.

VI ~~Effect window remains same as advertised~~

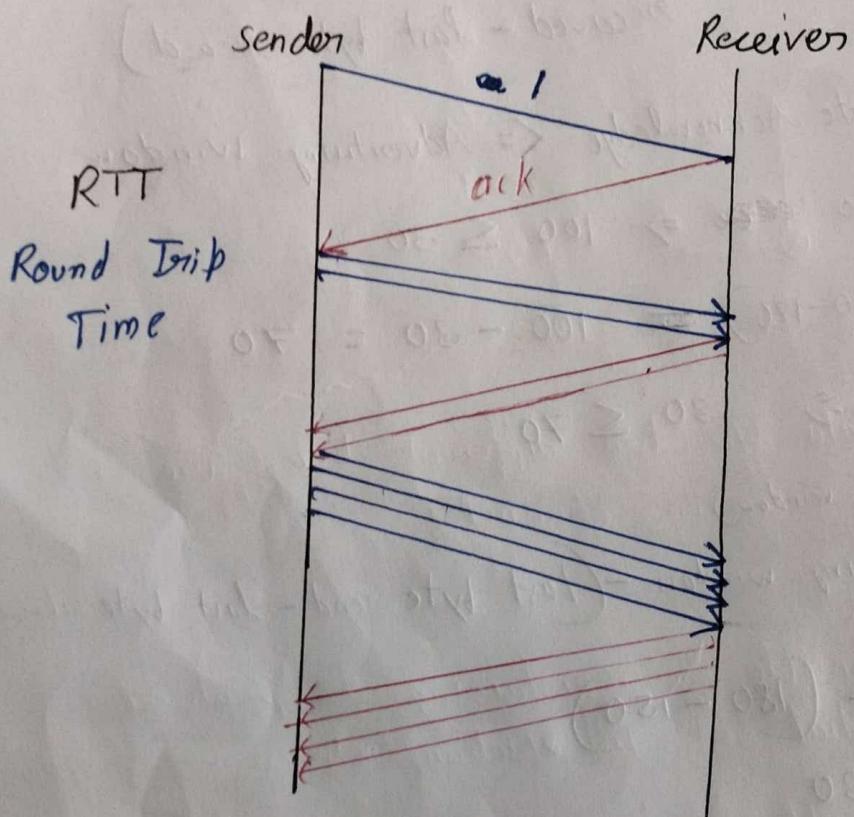
Q. On a TCP connection current congestion window size is 4 Kb, the window size advertise by the ~~sent~~ receiver is 6 Kb. The last byte send by sender is 10240 & Last byte Acknowledged

by the receiver is 8192. What is the current window size at the sender.

Sol ~~effective~~ max window =  $\min(4\text{kb}, 6\text{kb})$

$$\begin{aligned}\text{Effective window} &= 4\text{kb} - (10240 - 8192) \\ &= 4\text{kb} - 2048 \text{ b} \\ &= 4096 \text{ b} - 2048 \text{ b} \\ &= 2048 \text{ byte} / 2\text{kb}\end{aligned}$$

## ★ Congestion Control



It is slow start

It goes in a  $2^0, 2^1, 2^2, 2^3$

Window size = Threshold Window

2

Example

Let we have to send 50 packets. Packet size is 1kb.  
Last Packet are 10, 25, 34 & 45.

