FUNDAMENTALS OF MOBILE COMPUTING
(CSE 305)

MODULE I – 20%

- PCS Architecture
- Mobility Management
- Networks signalling
- Global System for Mobile Communication (GSM) system overview :-
- GSM Architecture, Mobility Management, Networks Signalling.

MODULE II – 25%

- GPRS Architecture
- GPRS Network Nodes
- Mobile Data Communication : WLANs (wireless LANs) IEEE 802.11 standard, Mobile IP.
- Wireless Application Protocol (WAP) : The mobile internet standard, WAP Gateway and Protocols, WML.

MODULE III – 25%

- Introduction to International Mobile Telecommunications 2000 (IMT 2000) vision
- W-CDMA and CDMA 2000
- Quality of services in 3G.
- Wireless Local Loop : Introduction to WLL, Architecture, Wireless local loop Technologies.

MODULE IV – 10 %

- Global Mobile Satellite systems : Case studies of the IRIDIUM and Globalstar system, GPS satellite navigation.

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TUESDAY

MOBILE COMPUTING

* BOOK

Jochen Schiller — Mobile Communication

* MODULE - I GSM ARCHITECTURE

GSM System Hierarchy

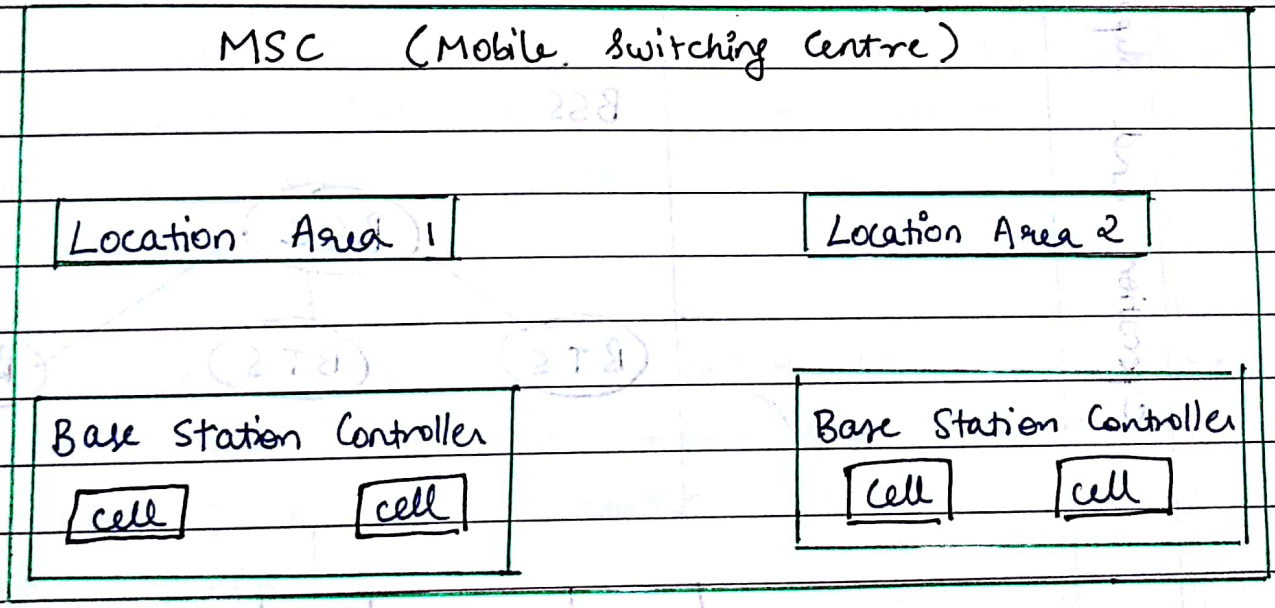
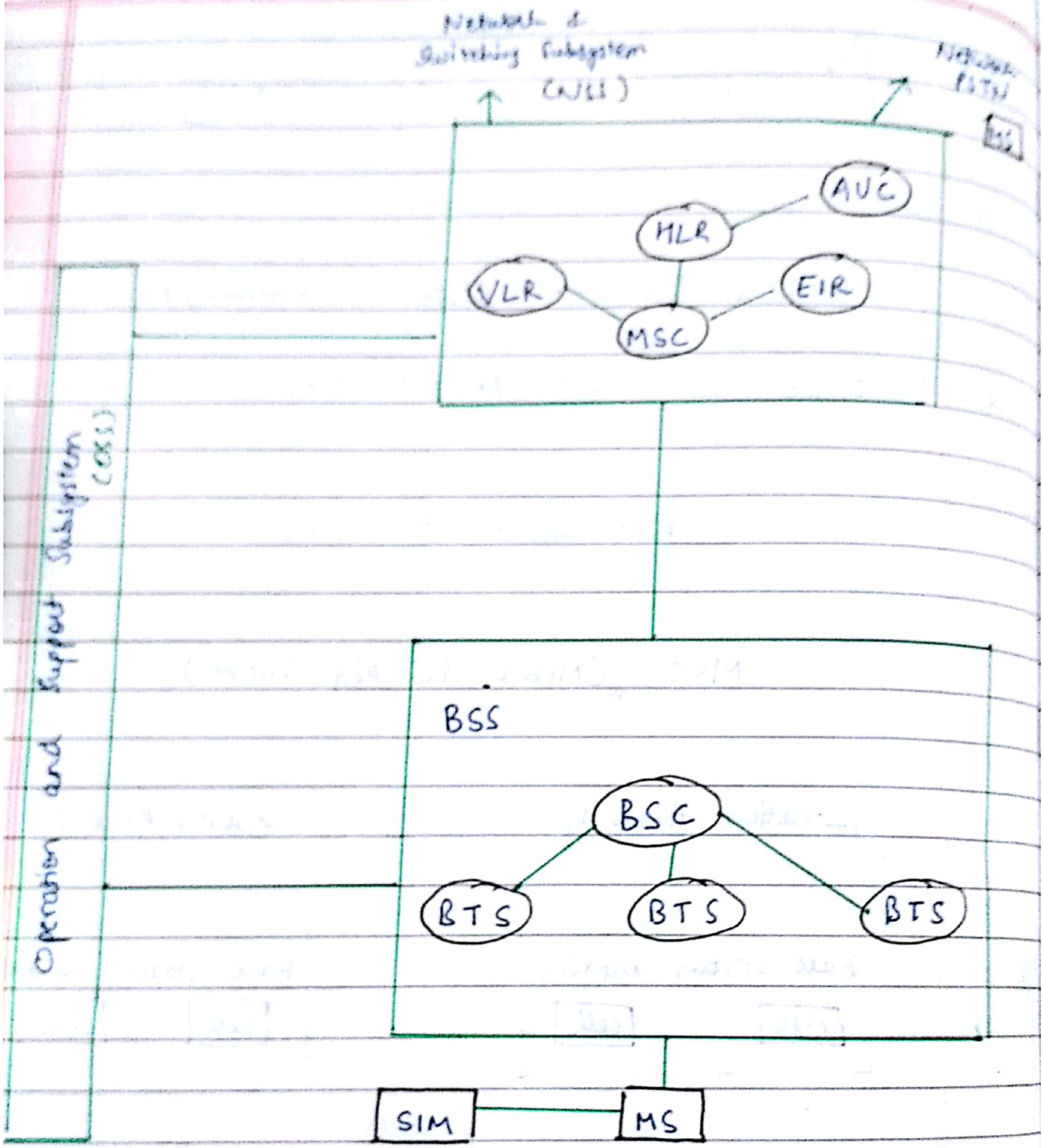


Fig 1.1



Simplified GSM Network Architecture

Fig 1.2

* Global System for Mobile Communication

INTRODUCTION

GSM is based on a set of standards formulated in the early 1980's. The proposed GSM system had to meet certain business objectives. These are -

a) Support for international roaming.
b) Good speech quality.
c) Ability to support handheld Terminals. Low Terminal and service cost, etc.

* GSM Architecture

The GSM network architecture consists of different elements that all interact together to form the overall GSM system. These include elements/systems like -
BSC, MSC, HLR, VLR etc.

1) MS [MOBILE STATION].

Mobile station, mobile equipment or as they are most widely known - cell or mobile phones are the section of a GSM network that the user sees and operates.

The SIM [Subscriber Identity Module] contains the information that provides the Identity of the user to the Network.

It contains variety of information, including a number known as IMSI [International Mobile Subscriber Identity]

2) BSS [Base station subsystem]

The BSS section of GSM network Architecture that is fundamentally associated with communicating with the mobiles on the network. It consist of two element -

(i) BTS [Base Transceiver station]

The BTS used in a GSM network comprises the radio transmitter, receiver and their associated antennas that transmit and receive to directly communicate with the device.

The BTS is the defining element for each cell.

(ii) BSC [Base Station Controller]

It controls a group of BTS and is often colocated with one of the BTS in its group. It manages the radio resources and controls items such as hand-over within the group of BTS, allocates channels.

3) NSS [Network Switching Subsystem]

The GSM architecture contains a variety of different elements and is termed the core network. It provides the main control and interfacing for the whole mobile network. The major elements within the core network includes -

(i) MSC [Mobile Switching Centre / Mobile Services Switching Centre] -

The main element within the core network area of the overall GSM network

architecture is the MSC. The functions of MSC includes - registration, authentication, call location, inter MSC handovers and call routing to a mobile subscriber.

(ii) HLR [Home Location Register]
This database contains all the administrative information about each subscriber along with their last known location. In this way, the GSM network is able to route calls to the relevant base station for the Mobile station (MS).

When the user switches on their phone, the phone registers for the network and from this it is possible to determine which BTS it communicates with so that incoming calls can be routed appropriately.

(iii) VLR [Visitor Location Register]
This contains selected information from the HLR that enables the selected services for the subscriber to be provided. It is an integral part of MSC.

(iv) EIR [Equipment Identity Register]
The EIR is the entity that decides whether a given mobile equipment may be allowed onto the network. Each mobile equipment has a number known as the IMEI [International Mobile Equipment Identity]. This number is installed in the equipment and is checked by the network during registeration.

(v) AUC [Authentication Centre]
The AUC is a protected database that contains the secret key also contained in the User's SIM card.

4) OSS [Operation & support System]
The OSS is an element within the overall GSM network architecture that is connected to the components of the NSS and BSS. It is used to control, & monitor and performing maintainance tasks for the overall GSM network.

GMSC [Gateway Mobile Switching Centre]
The GMSC is the point to which a MS terminating call is initially routed, without any knowledge of MS location.
The GMSC is incharge of obtaining the MSRN [Mobile Station Roaming Number] from the HLR and routing the call to the correct visited MSC

* GSM Mobility Management

- Handover / Handoff -
There are 4 types of handovers in the GSM System, which involve transferring a call between -

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1) Channels in the same cell
2) Cells (BTS) under the control of the same BSC.
3) Cells under the control of different BSCs belonging to the same MSC
4) Cells under the control of different MSCs.

The first two types of handovers are called internal handovers, involve only one BSC.

The last two types of handovers are called external handovers, are handled by the MSC.

There are two types of handoffs / handovers -

1) Hard Handover
This handoff is one where an existing connection must be broken before the new connection is established.
While this is the most common form of handoff where frequencies are changed

2) Soft Handover
It is defined as a handover where a new connection is established before the old one is released.

Handover Procedure

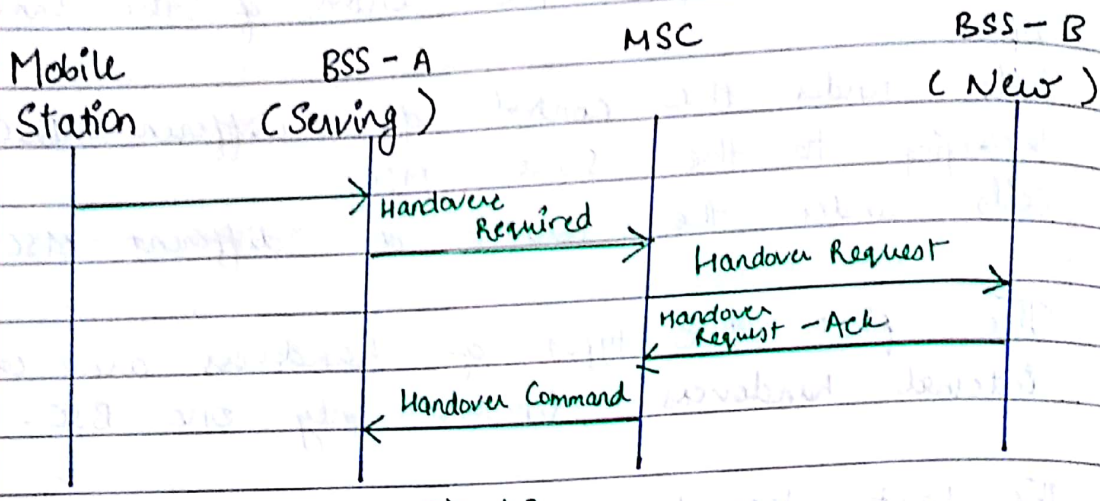

Fig 1.3

* Roaming

Handover relates to moving from one point of attachment to another point of attachment within the same network operator. When this movement happen b/w two different networks it is called roaming.

Roaming is of two types :-

1) Horizontal Roaming
It is b/w two networks from same family. For eg. GSM to GSM domain.

2) Vertical Roaming
It is b/w two networks from different families. For eg. GSM to CDMA roaming.

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Working of roaming facility:-

When a mobile station is powered off, it performs an IMSI detached procedure in order to tell the network that it is no longer connected. When a mobile station is switched on or a new network, the subscriber must register with the new network to indicate its current location.

The first location update procedure is called the IMSI attach procedure where the mobile station indicates its IMSI to the new network. Normally a location update message is sent to the new MSC/VLR, which records the location area information and then sends the location area information to the subscriber's HLR.

If the mobile station is authenticated and authorized in the new MSC/VLR, the subscriber's HLR cancels the registration of the mobile station with the old MSC/VLR.

Allocation update is also performed periodically. If after updating time period, the mobile station has not registered it is then de-registered.

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new Q. Why uplink frequency is low & downlink is high.

new Q. 1G (Analog signal) - < 2.4 kbps

2G < 64 kbps [2.5G - GPRS 64-144 kbps
2.75G - EDGE

3G - 144 kbps - 2 Mbps

4G - 100 Mbps - 1 Gbps

5G

Ans 1. The attenuation faced by a high frequency wave is more than that faced by a lower frequency wave. Since the resources on a satellite are precious the satellite is allowed to transmit in low frequencies (downlink)

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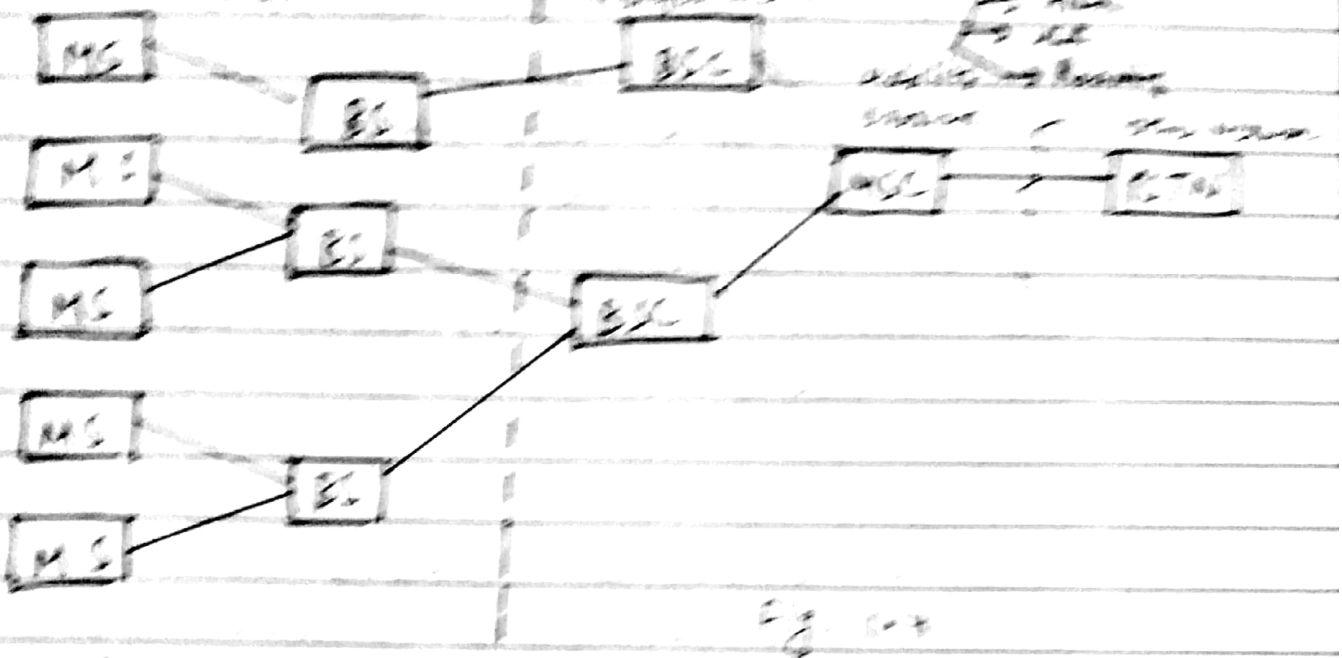
* PCS Architecture

PCS technology is commonly divided in two areas -

1) Cellular Telephony (High-Tier) → AMPS, GSM, IS-95, IS-136 (TDMA standard)
2) Cordless and low-tier PCS Telephony
   - PHS (Personal handyphone system)
   - PACS (personal access communication system)

PCS Architecture

- Radio Network
- Wireline Transport Network



MS - Mobile station
BS - Base station
BSC - Base station controller
MSC - mobile switching center
PSTN - Public switched telephone network

Mobile Station (MS)

MS is referred as mobile phone, terminal, subscriber unit, portable device or cell phone. For users the one entire piece he is carrying.

Base station (BS)

Base station is Base Transceiver System (BTS)
It has all the signalling equipment such as antenna, signal processing devices etc.
The radio coverage by a BTS is called a cell.

- Base Station Controller (BSC)
  BSC is responsible for the switching functions and it connects MS to MSC. The BSC supports radio channel allocation / release and Handoff management.
  A BSC may connect to the several Base stations and maintain cell configuration data of there Base stations.

- Mobile Switching Centre
  MSC communicates with mobility databases to track the location of mobile stations. MSC is connected to the PSTN to provide suvies between the PCS users and the wireline users.

* Mobility Management (in PCS)

There are two aspects of Mobility in a PCS Network -

1) Handoff
2) Roaming

Handoff

When a mobile user is engaged in a conversation the MS is connected to a BS through a radio link if the mobile user moves to the coverage area of another BS the radio link to the parent BS is eventually disconnected and a radio link to the new BS should be

established to continue the conversation; this process is called Handoff or Handover or Automatic Link Transfer.

Three strategies have been proposed to detect the need for Handoff

1) Mobile controlled Handoff (MCHO)
The MS continuously monitors the signals of the surrounding BS and initiates the Handoff process when some handoff criteria are met. It is used in DECT and PACS.

2) Network Controlled Handoff (NCHO)
The surrounding BS measures the signal from the MS and the network initiates the handoff process when some handoff criteria are met. It is used in AMPS

3) Mobile Assisted Handoff (MAHO)
The network asks the MS to measure the signal from the surrounding BS. The Network makes the handoff decision based on reports from the MS. MAHO is used in GSM and IS 95 CDMA.

Roaming Management

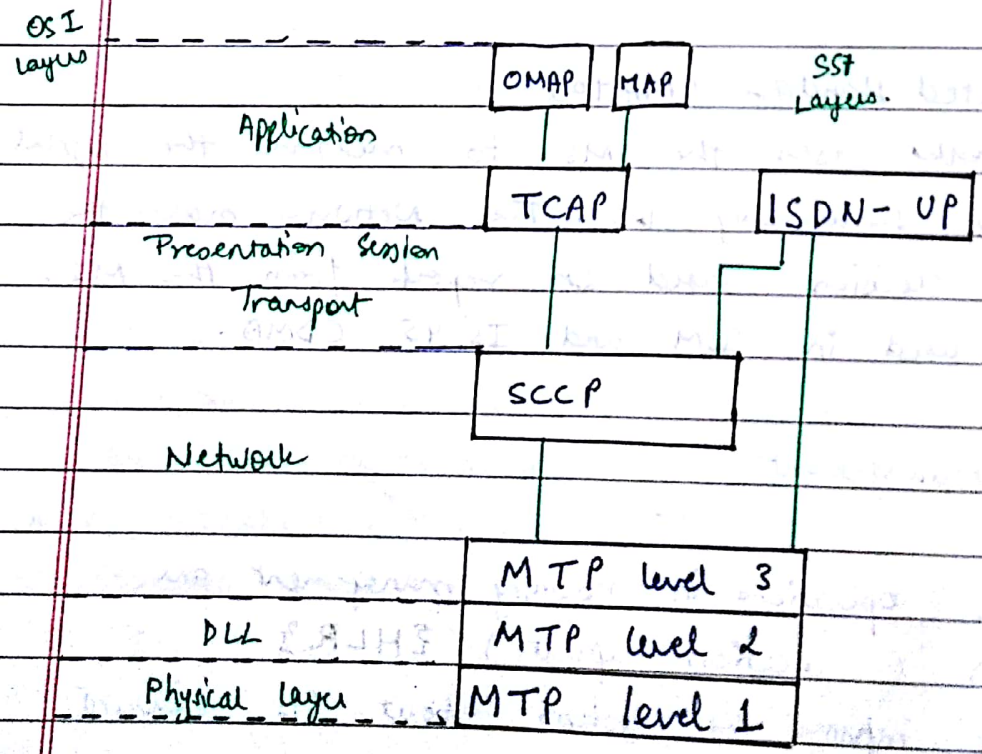
Two basic operations in roaming management are
1) Registration (location update) {HLR}
i.e MS informs the system about its current location.

2. Location tracking [VLR]
The process during which the system locates the MS. Location tracking is required when the network attempts to deliver a call to the mobile user

17/1/18 Network signalling for PCS

* SS7 - Signalling System 7
SS7 - i.e signalling system 7 is the PSTN signalling protocol (interconnection between PCN and PSTN. The SS7 protocol layers can be related with OSI layers

Fig. 1.5 SS7 Signalling System



- Message Transfer Part (MTP)

The MTP level 1 defines the physical, electrical and functional characteristics of the signalling links connecting SS7 components.

MTP level 2 is responsible for reliable transfer of signalling message between two directly connected signalling points.

MTP level 3 provides the functions and procedures related to message routing and network management

- Signalling Connection Control Part (SCCP)

The SCCP provides additional functions such as global title translation (GTT) to the MTP. The MTP utilize GTT to transfer non circuit related signalling information such as PCS registration and cancellation.

Global Title is an address used in SCCP protocol for routing signalling messages on telecom networks. Its a unique address which refers to only one destination

- TCAP - Transaction Capabilities Application Part

It provides the capability to exchange information b/w applications using non-circuit related signalling

- ISDN-UP / ISUP - Integrated Service Digital Network User Part

It establishes circuit switched network connections (call setup).

- Operation Maintenance and Administration part (OMAP)

- Mobile Application Part (MAP)

* GSM Network Signalling

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MODULE II

GPRS Architecture
GPRS Network Nodes
WLAN 802.11
Mobile IP
WAP Mobile Infomation
WAP Gateway & protocol
WML

* General Packet Radio Servie (GPRS)

In early 2000 only limited subscribers of GSM used data services because existing GSM does not support easy acces, high data rate and attractive prices. Solution of these issues is GPRS which provides end-to-end packet switched services by reusing existing gsm infrastructure

GPRS products were decided in 1999 and servie deployment began.

Features of GPRS -

1) GPRS is a servie not a system.
2) Resource allocation only when data is to be sent or received.
3) Flexible channel allocation
   (a) one-eight (1-8) can timeslots can be allocated to the user.

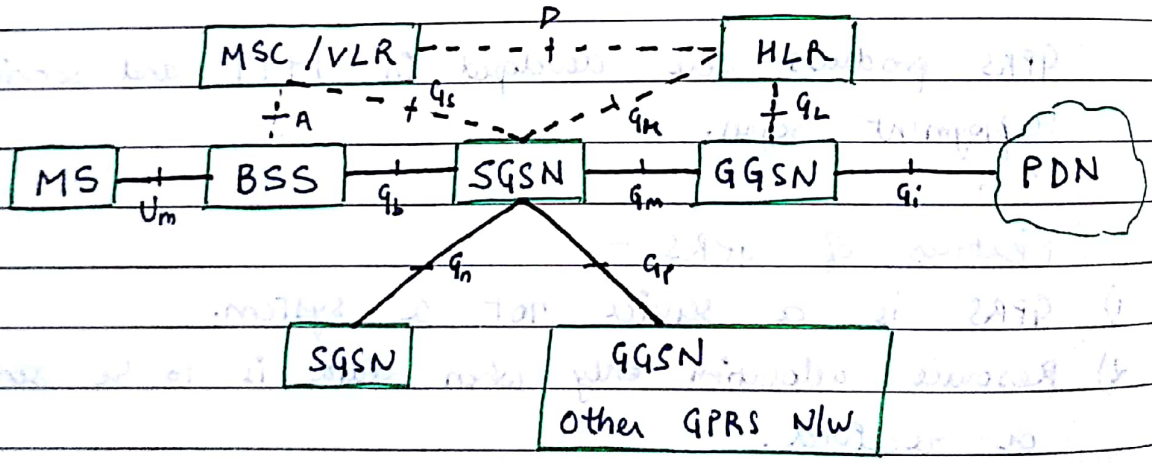
(b) Available resources can shared by active users.
(c) Uplink and downlink channels reserved separately.
(d) Several active users can share a single timeslot.
(e) Radio resources can be shared dynamically between speech and data services as a function of traffic load and operator preferences.

4) Various channel coding schemes are specified to permit bitrates from 9 Kbps to 150 Kbps per user

5) GPRS fast reservation is designed to start packet transmission within 0.5 – 1 second.

GPRS is designed for quick and efficient delivery of information with lowest expenditure as compared to SMS and circuit switched data.

* GPRS Architecture



Signaling Transfer

Signaling & Data Transfer Interface

Fig 9.1 GPRS Architecture

PDN - Packet Data N/w
SGSN - Serving GPRS Support Node
GGSN - Gateway GPRS Support Node

→ In this architecture, MS, BSS, MSC, VLR, HLR in existing GSM network are modified.
For eg. HLR is enhanced with GPRS subscriber information.
Two new network nodes are introduced in GPRS i.e SGSN which is equivalent to MSC in GPRS and second is GGSN which provides inter-networking with external packet switched network and is connected with SGSN via an IP based GPRS backbone network.

The BSS and SGSN are connected by "Gb" interface using frame relay.

Interfaces A, G_s, G_n, G_c and D are used for signalling without involving user data transmission in GPRS.
Interfaces Um, G_b, G_n, G_p, G_i are used for both signalling and transmission in GPRS.

* GPRS NETWORK NODES

A GPRS mobile station consists MT (Mobile Terminal) & MTE (Mobile Terminal Equipment).
MT communicates with BSS over the air.
The MT is equipped with software for GPRS functions in order to establish links to the SGSN.

A TE can be a terminal attached to the MT. GPRS MS utilize automatic retransmission (ARQ) at DLL to re-transmit the error frames.
With multiple time-slots, GPRS may provide high transmission rate.

- BSS -
To accomodate GPRS, BTS and BSC in BSS are modified.
A new component, the packet control unit is introduced.
BTS is modified to support new GPRS channel coding schemes.
The BSC forwards circuit switched calls to the MSC & and packet switched data via PCU to the SGSN

A BSC can connect to only one SGSN.
The G_b interface is implemented to accomodate functions such as paging and mobility management for GPRS

The PCU can be viewed as equivalent to transcoder and rate adapter unit (TRAU) for the packet data services.

* GPRS Support node

There are 2 kinds of GSN i.e
1) SGSN - Serving GSN
2) GGSN - Gateway GSN

SGSN

The role of SGSN is equivalent to the MSC/VLR in the current GSM Network. SGSN connects BSS to GGSN which provides ciphering, mobility management and charging.

GGSN

It supports traditional gateway functionality such as publishing subscriber address, mapping address, routing packets, securing messages and counting packets. A GGSN may contain DNS functions to map routing area identifiers with serving GSN and DHCP functions to allocate dynamic IP Address to MS.

HLR & VLR :-

To accomodate GPRS (subscription and routing info) new fields in the MS records are introduced in HLR They are accessed by SGSN and GGSN by using IMSI as the index key.

MODULE II

MOBILE DATA COMMUNICATION

- WLAN Standards IEEE 802.11
- Mobile IP

* Mobile IP -
It is an open standard defined by the internet enginering task force, RFC in 2002. It allows users to keep the same IP Address stay connected and maintain ongoing applications while roaming between IP Networks.

X Mobile IP is based on IP - any media that can support IP. X

The No. of wireless devices for voice or data can transfer through mobile IP.

* Mobile IP Overview
In IP Networks routing is based on stationary IP addresses. The problem occurs when a device is away from its home network and is no longer reachable using normal IP routing. This results in the active sessions of the device be terminated. So, Mobile IP was created to enable users to keep the same IP while

travelling to a different network. i.e ensuring that a roaming individual could continue communication without connections being dropped.

Mobility functions of mobile IP are performed at the network layer rather than the physical layer. The mobile device can span different types of wireless and wireline networks while maintaining connections and ongoing applications.

* COMPONENTS OF MOBILE-IP NETWORK

Mobile IP has three components –

1. Mobile Node
2. Home Agent
3. Foreign Agent

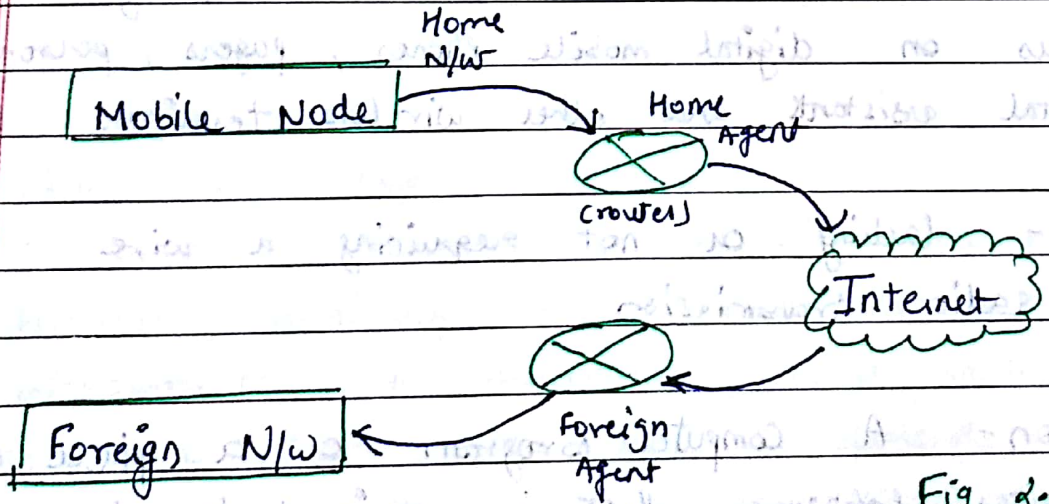


Fig 2.2 Components

Mobile Node - It is a device such as a cellphone, a personal digital assistance or laptop whose software enables network roaming capabilities.

- Home Agent - It is a router on the home network. It tunnels packets from a device on the internet (called a correspondent node) to the roaming mobile node.

- Foreign Agent - It is a router that may function as the point of attachment for the mobile node when it roams to a foreign networks i.e delivering packets from the home agent to mobile node.

* Wireless Application Protocol (WAP)

It is a world wide standard for providing internet communications and advanced telephony services on digital mobile phones, pagers, personal digital assistants and other wireless terminals.

Wireless - lacking or not requiring a wire for radio transmission

Application - A computer program or a piece of computer software that is designed to do a specific task.

Protocol - A set of technical rules about how information should be transmitted and received using computers.

WAP is the set of rules governing the transmission and reception of data by computer applications via wireless devices like mobile phones.

Web allows wireless devices to view specifically designed pages from the internet using only plain text. It is optimized for low display capability, low memory and low bandwidth devices. with the appearance of WAP we have the massive information communication and data resources of the internet becoming more easily available to anyone with a mobile phone or communication device.

WAP being an open and secure is well suited for many different applications. WAP application requires only few modification to existing web applications.

* WAP Micro browser

To browse a standard internet site you need a web browser, Similarly WAP enabled website requires microbrowser. A microbrowser is a small piece of software that makes minimal demands on hardware memory and CPU. It can display information written in a restricted mark up language called WML.

* WAP Model

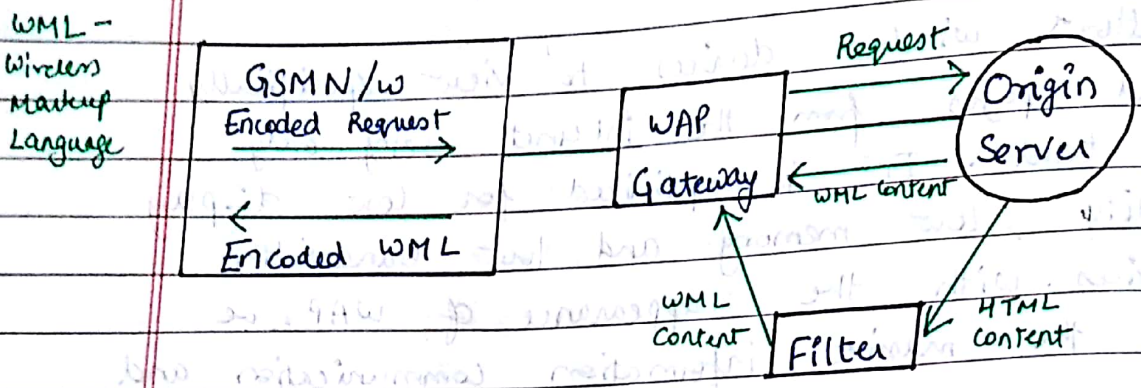


Fig 2.3 WAP Model

As shown in fig 2.3 a WAP handset (mobile) communicates with the Origin Server through the mobile network. The Origin Server is a standard HTTP web server ~~and~~

The contents received by the WAP handset (mobile) are encoded in the compact binary format of wireless markup language so that they can be efficiently delivered in the bandwidth limited mobile network.

The WAP gateway is located b/w the internet and the mobile Network. It receives the WAP request from the handset and decodes the request from binary format into text format and forwards to the origin server. The origin server receives the WAP request and finds out what to retrieve

It can be possible that origin server only provide HTML content and thus cannot understand WML, in this case HTTP response of the origin Server is first sent to the HTML filter which translates HTML text into WML format.

The WAP Gateway verifies HTTP header and the WML content sent from the Origin Server and encodes them into WML bytecodes then the result is sent from the WAP handset (mobile)

* WML - Wireless Markup Language

The wireless markup language is based on the standard HTML known from the WWW and HDML.

1) WML brings internet to cellular users.
2) Reuse fundamental internet concepts (TCP/IP, HTTP, HTML, Javascript etc) but adapted to lower bandwidth small screen, limited i/p facilities and limited computational resources.
3) WML is a page description language that describes the WAP content present in the WAP handset.
4) The i/p option available in the handset and the response of the user agent. User agent is a device or software that shows content which also acts on behalf of the user with the applications.

5) The agent can be a voice browser, a search engine, a textual browser etc

WML documents are divided into set of cards each representing one unit of interaction between the user and user agent.

A WML document is made up of multiple cards and the cards can be grouped together into a deck.

A WML deck is similar to an HTML page.

A user navigates with the WML browser through a series of WML cards

The user agent on a handheld device has to describe how to best present all elements of a card. This presentation depends much on the capabilities of device.

* WML Basic Features

- Text and Images

- Text and images can be presented to a user. The exact presentation of data to a user is up to the user agent running on the portable device

- WML only provides set of markup elements.

— User Interaction

- WML supports different elements for user input For eg. Text entry controls for text or password entry.
- The user agent is free to choose how these inputs are implemented

— Navigation

- WML offers a history mechanism with navigation with the browsing history, hyperlinks and other inter card navigation elements.

— Content Management

- WML allows for saving the state between different decks without server interaction i.e State can be shared accross different decks.

* WAP Gateway

A WAP gateway utilizes WAP proxy technology to provide efficient wireless Access to the internet. A proxy plays the roles of both server and client, making request on behalf of the client. A WAP handset cannot directly communicate with the Origin server.

The WAP Gateway serves as a proxy to handle the request from the WAP handset and passes

the request to the origin servers.

WAP Gateway translate request from the WAP protocol stack to the internet protocol stack.

The WAP Gateway supports DNS service to resolve the Domain names used in URLs.

It also provides quick response to the WAP handset by aggregating data from different origin servers and by caching frequently used information.

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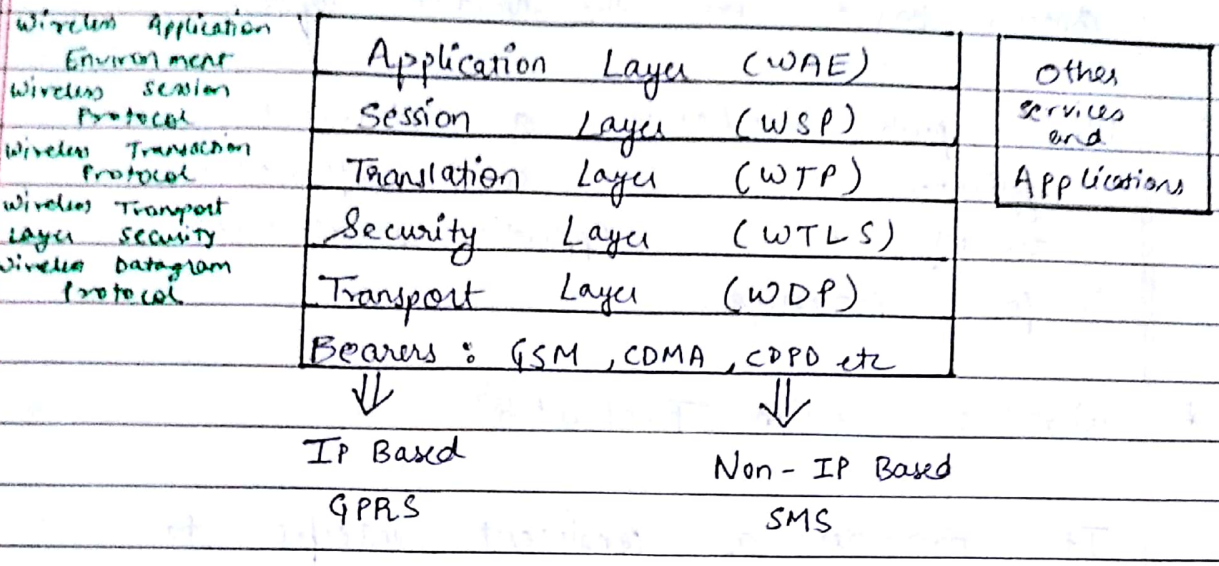
WAP Architecture suggests that appropriate charging info can be collected in the WAP Gateway

WAP Gateway may use the distillation technique to perform ON-demand transformation which effectively reduces the wireless traffic.
It is a kind of compression Technique.

* WAP Protocols.

WAP specification defines a set of lightweight protocols designed to operate over a variety of wireless services.



WAP has 6 layers and similar approach to OSI

* WAP Application Environment (WAE)

WAE defines the WAP Application Layer which provides an environment for mobile operators and content providers to efficiently build applications on top of different wireless platforms.

WAE defines a set of content formats including images phonebook records and calendar information It also defines a microbrowser for WML and wireless telephony applications

WAE also supports user agent profile and push technologies. With User Agent profile (UAProf) a WAP handset can describe its capability to Application Servers so that servers can generate

Contents based on the handset capability.

With push mechanism a trusted application server can send information directly to the Application environment for processing.

* Wireless Session Protocol

It provides a consistent interface to WAE for two types of session services :-

1) Connection Oriented
2) Connection-less

i.e create and release a connection between the client and server.

Exchange data b/w the client and server using a coding scheme that is much more compact than tradition HTML.

* Wireless Transaction Protocol

It provides transaction services to WAP. It handles acknowledgements if a transaction succeeded. It provides retransmission of transactions in case they are not successfully received. It removes duplicate transactions. WTP manages different classes of transactions for WAP devices i.e unreliable oneway requests, reliable one-way request & reliable two-way req

* Wireless Transport Layer Security
It provides services to protect data including
- data integrity
- privacy (encryption)
- Authentication
- Denial of Service protection

* Wireless Datagram Protocol
It provides a consistent interface to higher layers of the WAP Architecture and provides Data Error correction.

* Wireless Communication Networks / Bearer services
WAP designed to run on a variety of networks including SMS, circuit switched connections and packet switched networks.
Each types of network has pros and cons in terms of performance, delay and errors.

* WLAN 802.11
The networking is such that all units in the set can address and communicate with each other. WLAN means a wireless LAN which is based on communication protocol IEEE 80

* WLAN LAN CONFIGURATIONS
A WLAN configuration is a peer to peer independent network. It connects a set of computing systems each with wireless interfaces. Two or more wireless interfaces must be within the

range of each other at any instance. The network forms on demand. and Generally requires no administration or pre configuration.

There is another configuration which is based on infrastructure network. There can be multiple access points connected wirelessly with mobile computing systems and linked by wired network to the internet or other protocols.

It allows a users to share network resources.

WLAN generally follows two communication techniques.

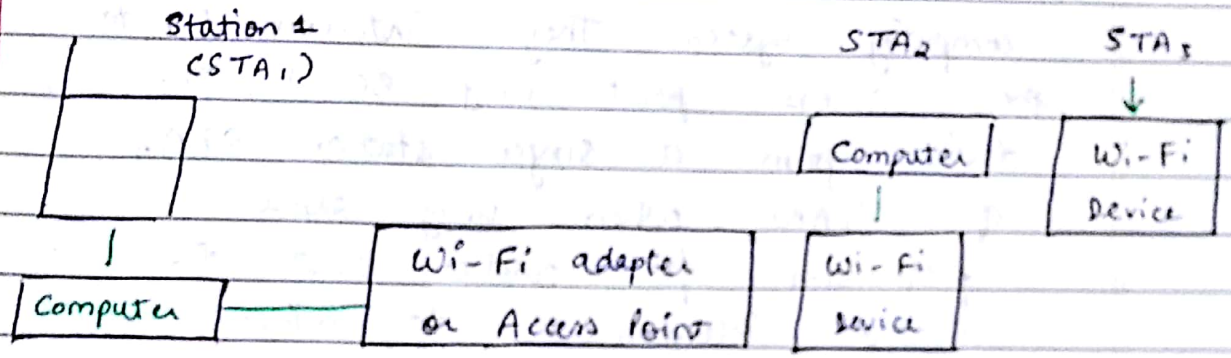
- Spread Spectrum
- Infrared WLAN's

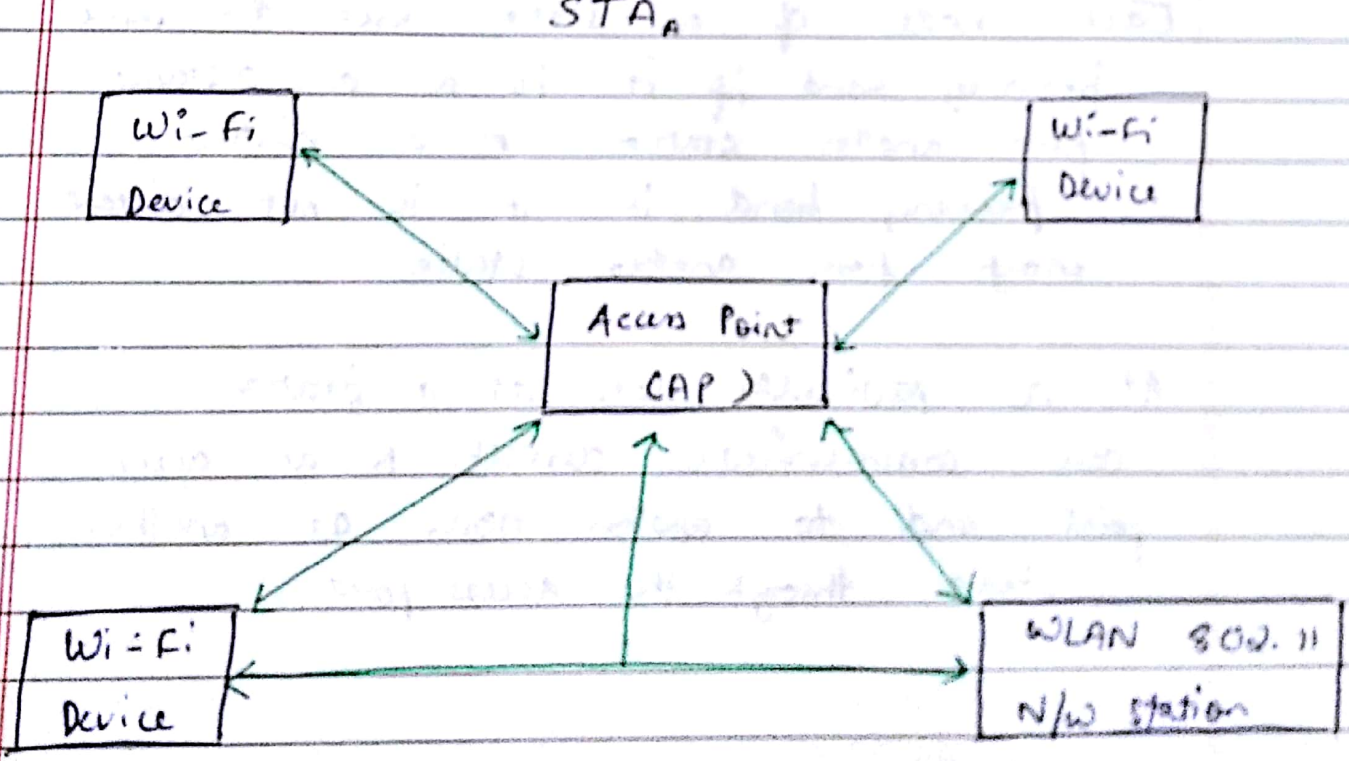
The following considerations are important while configuring WLAN -

(i) Range / Coverage
(ii) Throughput
(iii) Interference and Coexistence
(iv) Scalability
(v) Ad-hoc Network
(vi) Security, Reliability & Integrity.
(vii) Cost

* Advantages of WLAN Config
1. Installation of WLAN is ~~fast~~ fast.
2. WLAN hardware is simple to installed.
3. WLAN can be installed anywhere.
4. Reduced cost of ownership.

* WLAN Architecture





BSS

STATION (STA)

An addressable unit in WLAN is called a station.

Basic Service Set (BSS)

Figure shows a BSS in the WLAN architecture. SET A consists of 1 station. (STA_A) SET BSSA can have a number of devices or computing systems. They interconnect to the access point using 802.11. The devices form a single station STA_A of WLAN when using same frequencies for radio and the station interconnects to other stations only through access points

Each node of a station uses the same frequency band if it is at a distance from another station or a distinct frequency band if it is not distant enough from another station.

At a particular node at a station can communicate directly to an access point and to another node at another station through the access point