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Mobile Computing

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Information & technology

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DIGITAL LEARNING CONTENT

UNIT-3

Global system for mobile communication

GSM: Overview

- **GSM (**Now: Global System for Mobile Communication)
  - GSM 900(890–915 MHz for uplinks and 935–960 MHz for downlinks)
  - GSM at 1800 MHz (1710–1785 MHz uplink, 1805–1880 MHz downlink) – Digital Cellular system
  - 1900 MHz (1850–1910 MHz uplink, 1930–1990 MHz downlink) – Personal communication services
- **Performance characteristics of GSM**

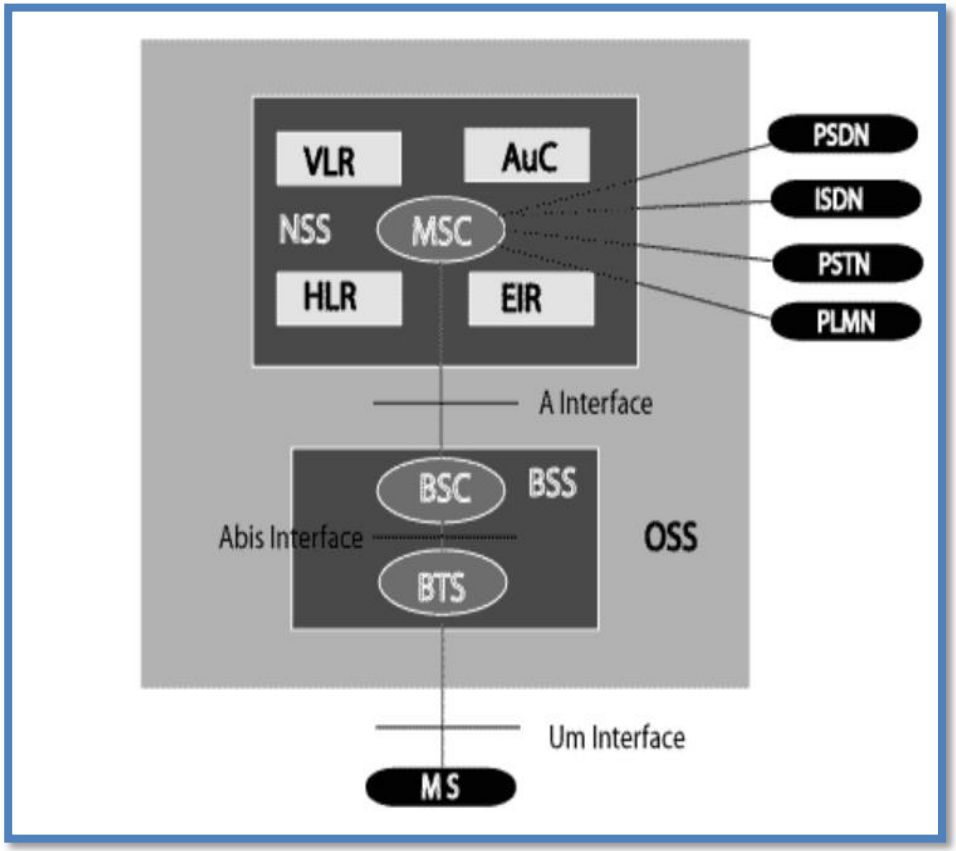
  Communication
  Total mobility
  Worldwide connectivity
  High capacity
  High transmission quality
  Security functions

Architecture of the GSM system

GSM is a PLMN (Public Land Mobile Network)

- Several providers setup mobile networks following the GSM standard within each country
- Components
  - MS (mobile station)
  - BS (base station)
  - MSC (mobile switching center)
  - LR (location register)
- Subsystems
  - RSS (radio subsystem): covers all radio aspects
  - NSS (network and switching subsystem): call forwarding, handover, switching
  - OSS (operation subsystem): management of the network

GSM: Architecture



- **Components**
  - MSC (Mobile Services Switching Center):
  - IWF (Interworking Functions)
  - ISDN (Integrated Services Digital Network
  - PSTN (Public Switched Telephone Network)
  - PSPDN (Packet Switched Public Data Network)
- **Databases**
  - HLR (Home Location Register)
  - VLR (Visitor Location Register)

(Image Source: https://www.tutorialspoint.com/gsm/gsm_architecture.htm

Contd...

- **Base transceiver station (BTS)**
  A BTS comprises all radio equipment, i.e., antennas, signal processing, amplifiers necessary for radio transmission.
- **Base station controller (BSC)**-(The BSC basically manages the BTSs)

- It reserves radio frequencies, handles the handover from one BTS to another within the BSS, and performs paging of the MS.

- **Mobile station (MS)**

- The MS comprises all user equipment and software needed for communication with a GSM network.
- Subscriber identity module (SIM) - which stores all user-specific data that is relevant to GSM
- MS can be identified via the international mobile equipment identity (IMEI)

Contd…

- **MSCs are high-performance digital ISDN switches**.
- They set up connections to other MSCs and to the BSCs via the A interface, and form the fixed backbone network of a GSM system.
- A gateway MSC (GMSC) has additional connections to other fixed networks, such as PSTN and ISDN.
- **Home location register (HLR)**
- Stores all user-relevant information.
- comprises static information, such as:
  - The **mobile subscriber ISDN number (MSISDN)**
  - Subscribed services (e.g., call forwarding, roaming restrictions, GPRS)
  - The **international mobile subscriber identity (IMSI)**.
- Dynamic information , such as:
  - The current **location area (LA)** of the MS,
  - The **mobile subscriber roaming number (MSRN)**,
  - the current VLR and MSC

Contd…

➢ **Visitor location register (VLR)**

- Dynamic database which stores all important information needed for the MS users currently in the LA that is associated to the MSC (e.g., IMSI, MSISDN, HLR address).
- If a new MS comes into an LA the VLR is responsible for, it copies all relevant information for this user from the HLR.
- This hierarchy of VLR and HLR avoids frequent HLR updates and long-distance signalling of user information.

System architecture: Operation subsystem…

1. AUTHENTICATION CENTER(AuC)

AuC has been defined to protect:

User identity

Data transmission

2. Operation and Maintenance Center (OMC)

Typical OMC management functions are traffic monitoring, status reports of network entities, subscriber and security management, or accounting and billing.

3. Equipment identity register (EIR)

- It stores all device identifications registered for this network.
- The EIR has a blacklist of stolen (or locked) devices.
- In theory an MS is useless as soon as the owner has reported a theft..
- The EIR also contains a list of valid IMEIs (white list), and a list of malfunctioning devices (gray list)

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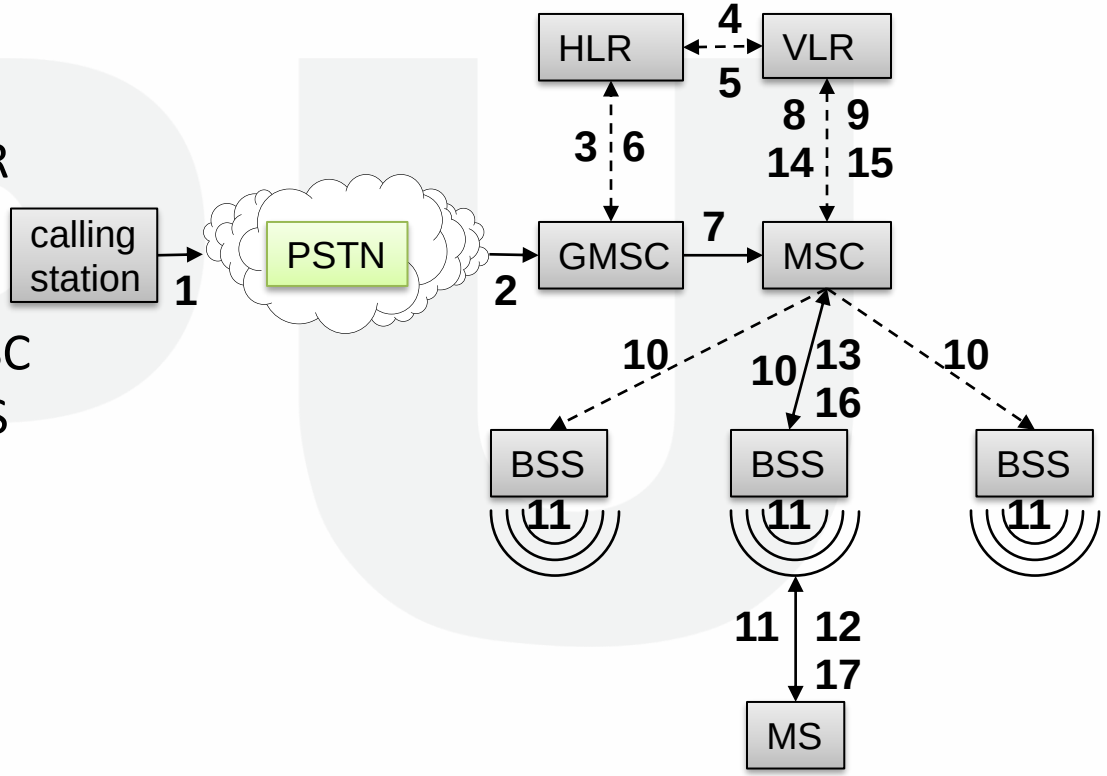
Call routing in GSM

1: calling a GSM subscriber
2: forwarding call to GMSC
3: signal call setup to HLR
4, 5: request MSRN from VLR
6: forward responsible MSC to GMSC
7: forward call to current MSC
8, 9: get current status of MS
10, 11: paging of MS
12, 13: MS answers
14, 15: security checks
16, 17: set up connection



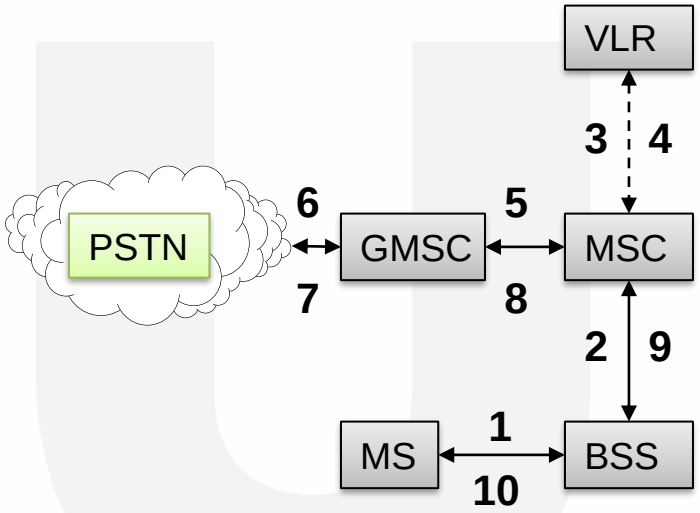
Mobile Originated Call

1, 2: connection request

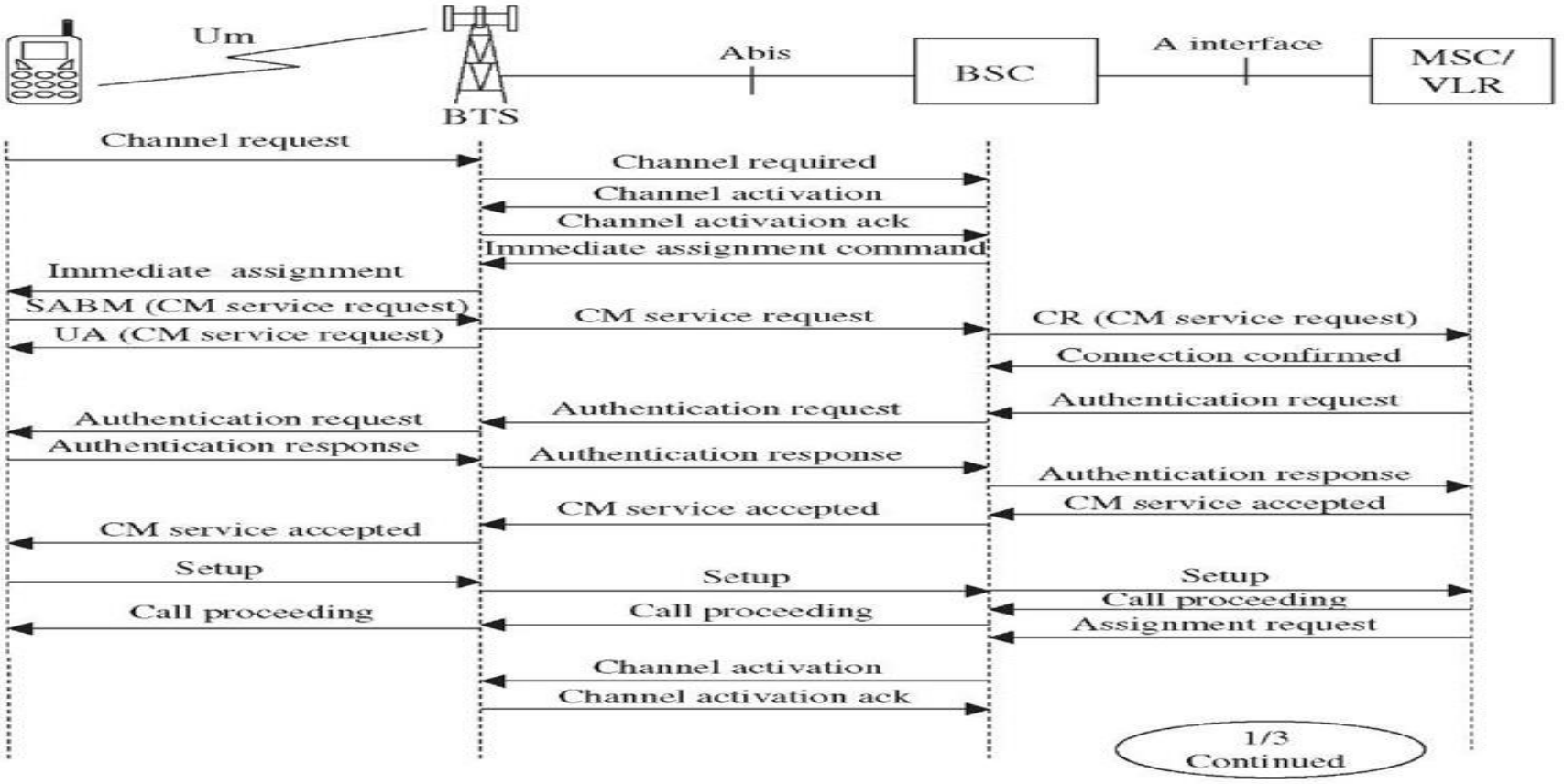
3, 4: security check

5-8: check resources (free circuit)

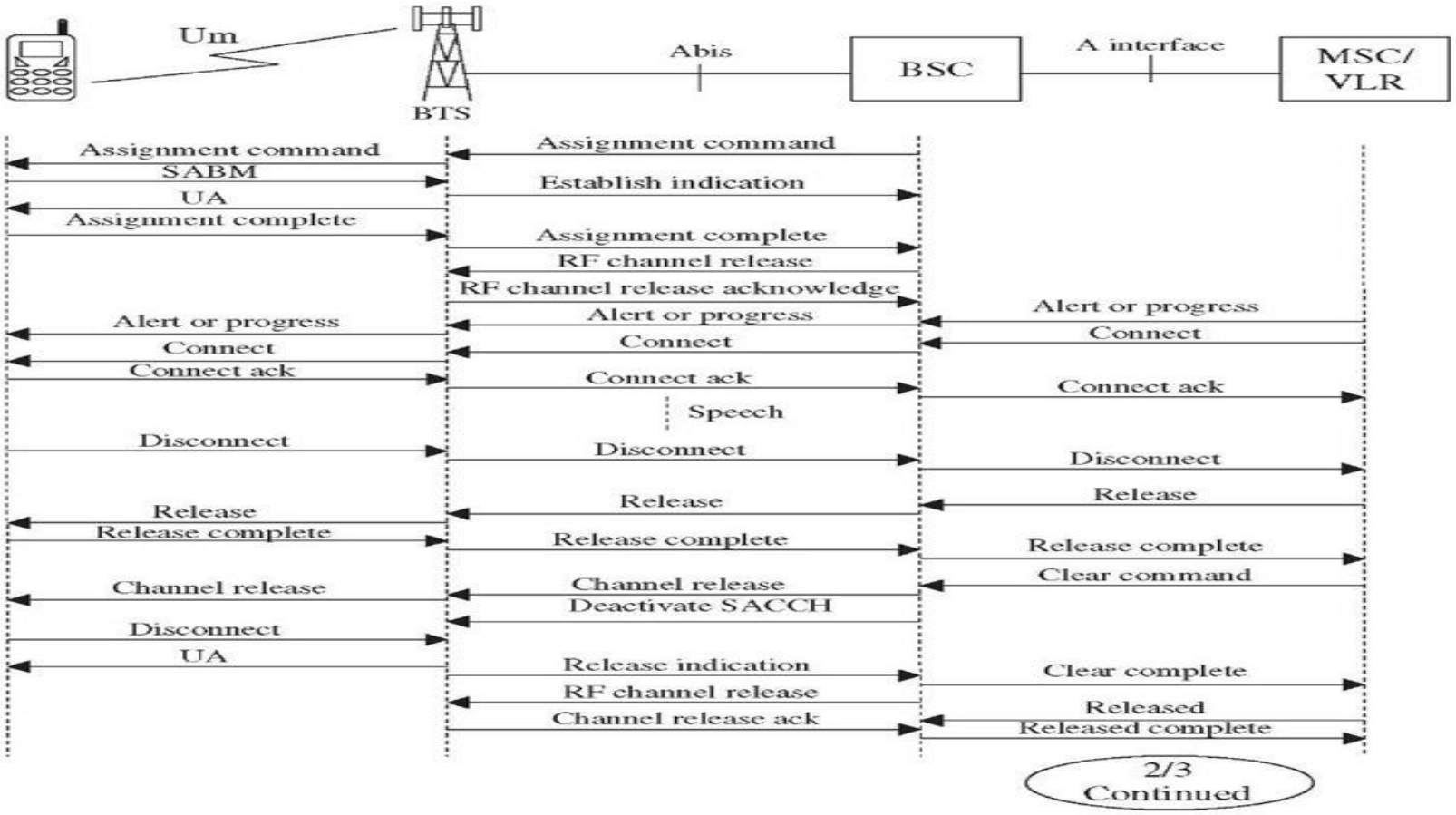
9-10: set up call



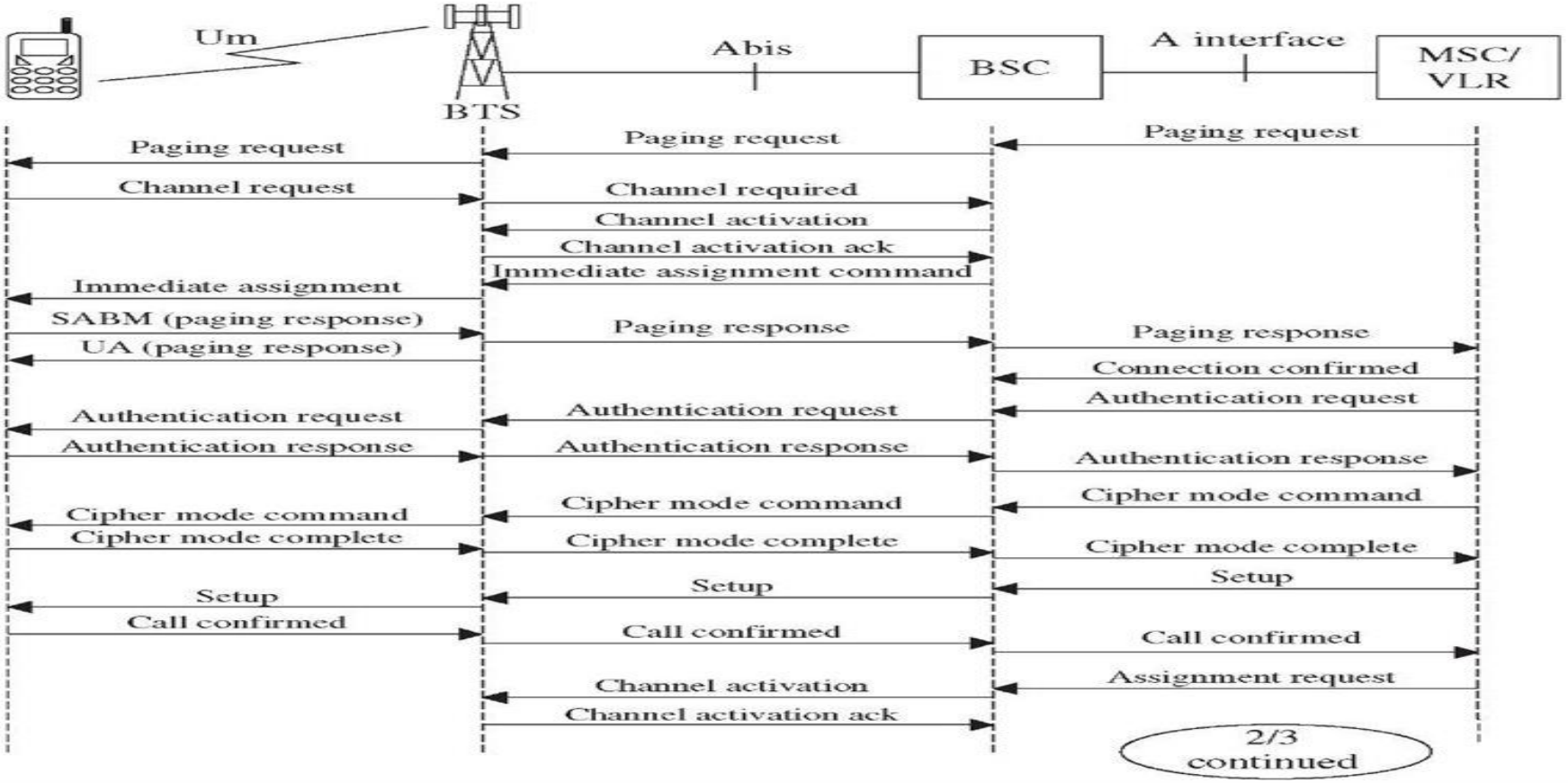
MOC


Um
BTS
Abis
BSC
A interface
MSC/
VLR
Channel request
Channel required
Channel activation
Channel activation ack
Immediate assignment command
Immediate assignment
SABM (CM service request)
UA (CM service request)
CM service request
CR (CM service request)
Connection confirmed
Authentication request
Authentication request
Authentication response
Authentication request
Authentication response
Authentication response
CM service accepted
CM service accepted
CM service accepted
Setup
Setup
Setup
Call proceeding
Call proceeding
Call proceeding
Assignment request
Channel activation
Channel activation ack
1/3
Continued

MOC


Um
BTS
Abis
BSC
A interface
MSC/
VLR
Assignment command
SABM
UA
Assignment complete
Assignment command
Establish indication
Assignment complete
RF channel release
RF channel release acknowledge
Alert or progress
Connect
Connect ack
Alert or progress
Connect
Connect ack
Speech
Disconnect
Release
Release complete
Channel release
Disconnect
UA
Disconnect
Release
Release complete
Channel release
Deactivate SACCH
Release indication
RF channel release
Channel release ack
Alert or progress
Connect
Connect ack
Disconnect
Release
Release complete
Clear command
Clear complete
Released
Released complete
2/3
Continued

MTC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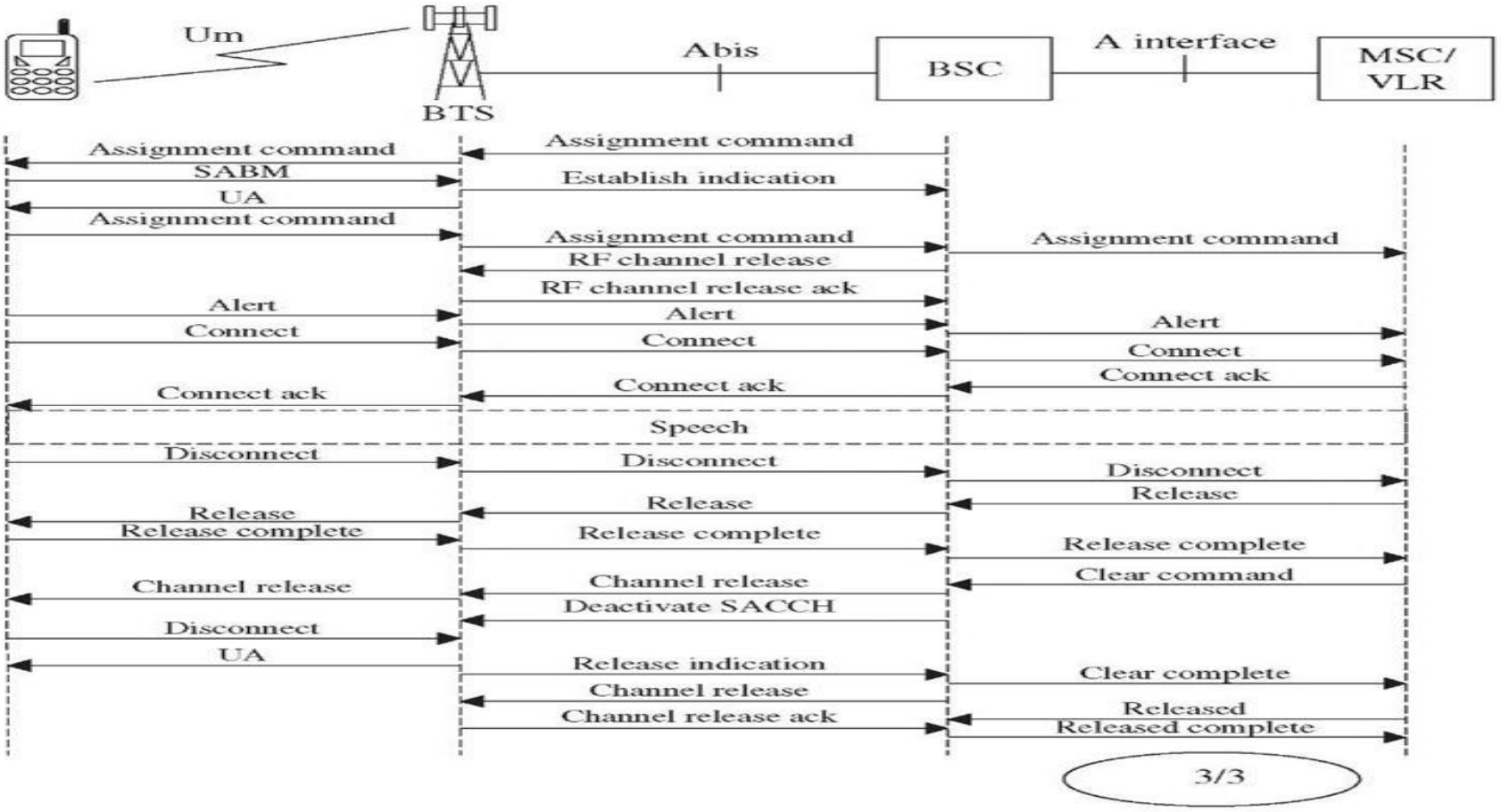
Paging request
Paging request
Channel request
Channel required
Channel activation
Channel activation ack
Immediate assignment command
Immediate assignment
SABM (paging response)
UA (paging response)
Paging response
Paging response
Connection confirmed
Authentication request
Authentication request
Authentication request
Authentication response
Authentication response
Authentication response
Cipher mode command
Cipher mode command
Cipher mode command
Cipher mode complete
Cipher mode complete
Cipher mode complete
Setup
Setup
Call confirmed
Call confirmed
Call confirmed
Channel activation
Assignment request
Channel activation ack
2/3
continued

MTC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Assignment command
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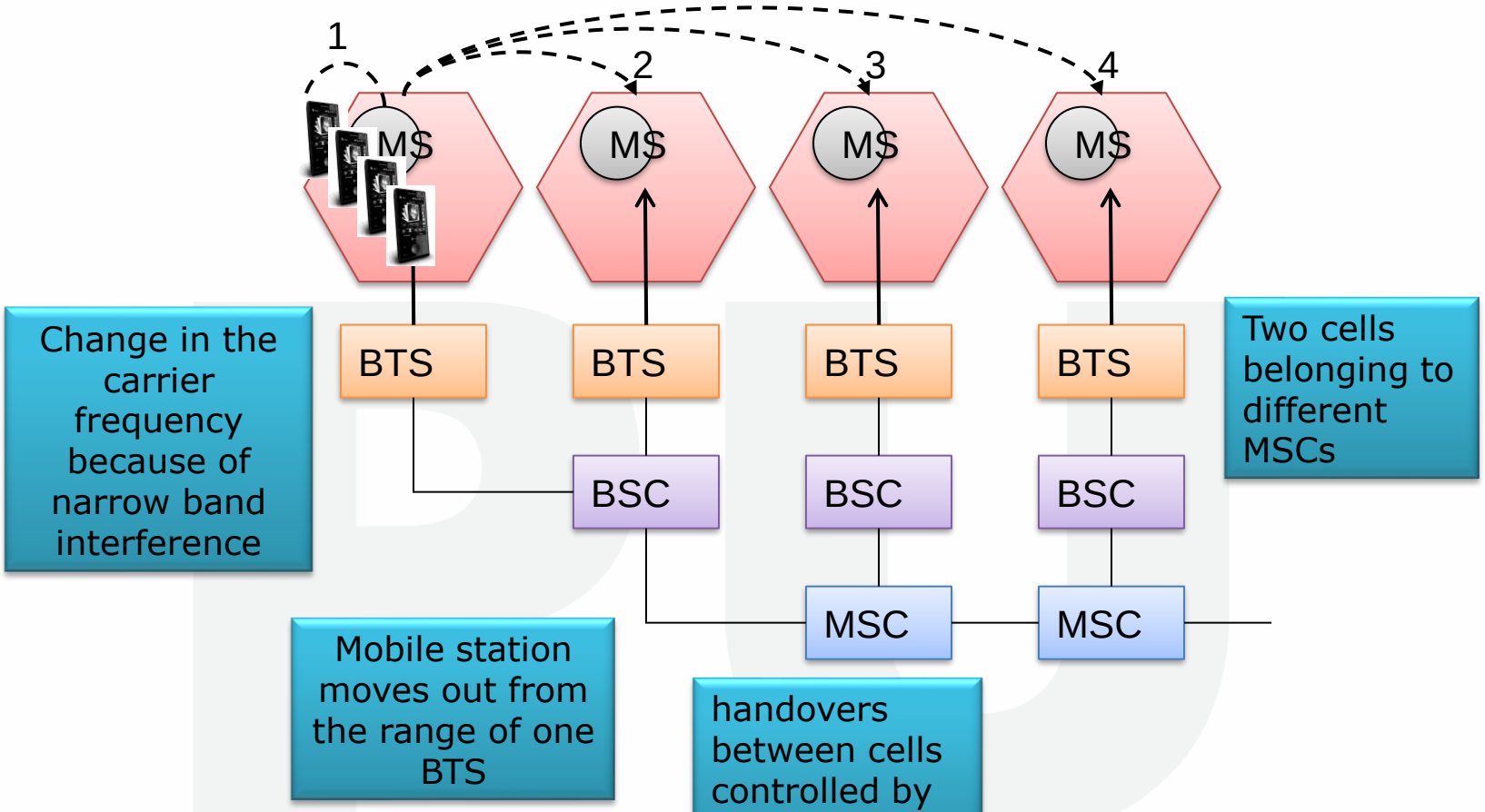
Assignment command
RF channel release
RF channel release ack
Assignment command
Alert
Connect
Connect ack
Alert
Connect
Connect ack
Speech
Disconnect
Release
Release complete
Channel release
Disconnect
UA
Disconnect
Release
Release complete
Deactivate SACCH
Release indication
Channel release
Channel release ack
Disconnect
Release
Release complete
Clear command
Clear complete
Released
Released complete
3/3

Handover

- Cellular systems require handover procedures, as single cells do not cover the whole service area, but, e.g., only up to 35 km around each antenna on the open areas and some hundred meters in cities
- The smaller the cell size and the faster the movement of a mobile station through the cells, the more handovers of ongoing calls are required.
- A handover should not cause a cut-off, also called call drop.
- There are two basic reasons for a handover:
  - Quality of the radio link
  - Load balancing

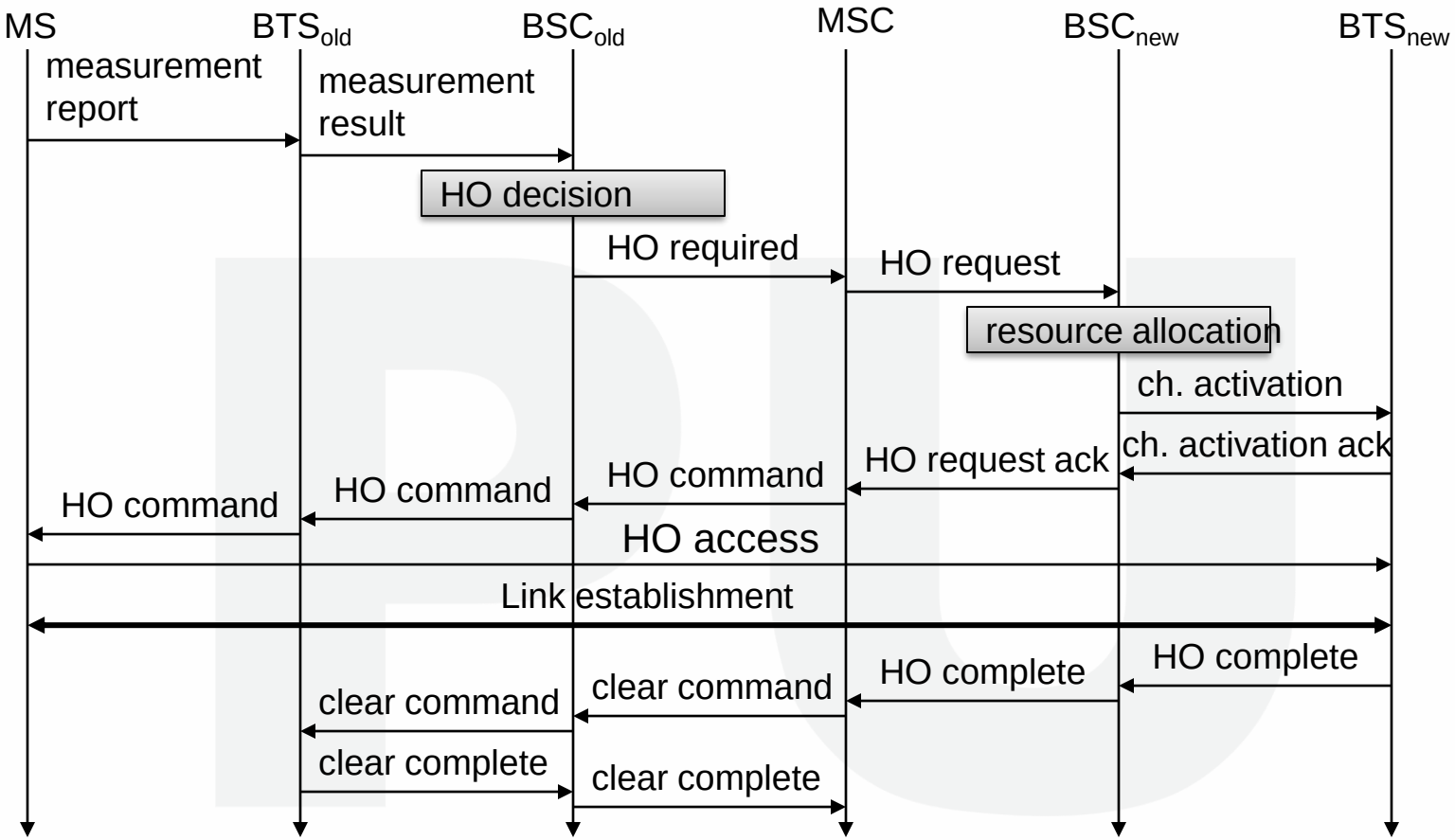
Types of handover



Handover decision

- To provide all the necessary information for a handover due to a weak link, MS and BTS both perform periodic measurements of the downlink and uplink quality respectively.
- Measurement reports are sent by the MS about every half-second and contain the quality of the current link used for transmission as well as the quality of certain channels in neighboring cells.
- When MS moves away from one BTS (BTS old) closer to another one (BTS new), the handover decision does not depend on the actual value of the received signal level, but on the average value.
- Therefore, the BSC collects all values (bit error rate and signal levels from uplink and downlink) from BTS and MS and calculates average values.
- These values are then compared to thresholds, i.e., the handover margin (HO_MARGIN)

Handover procedure



GSM addresses and identifiers

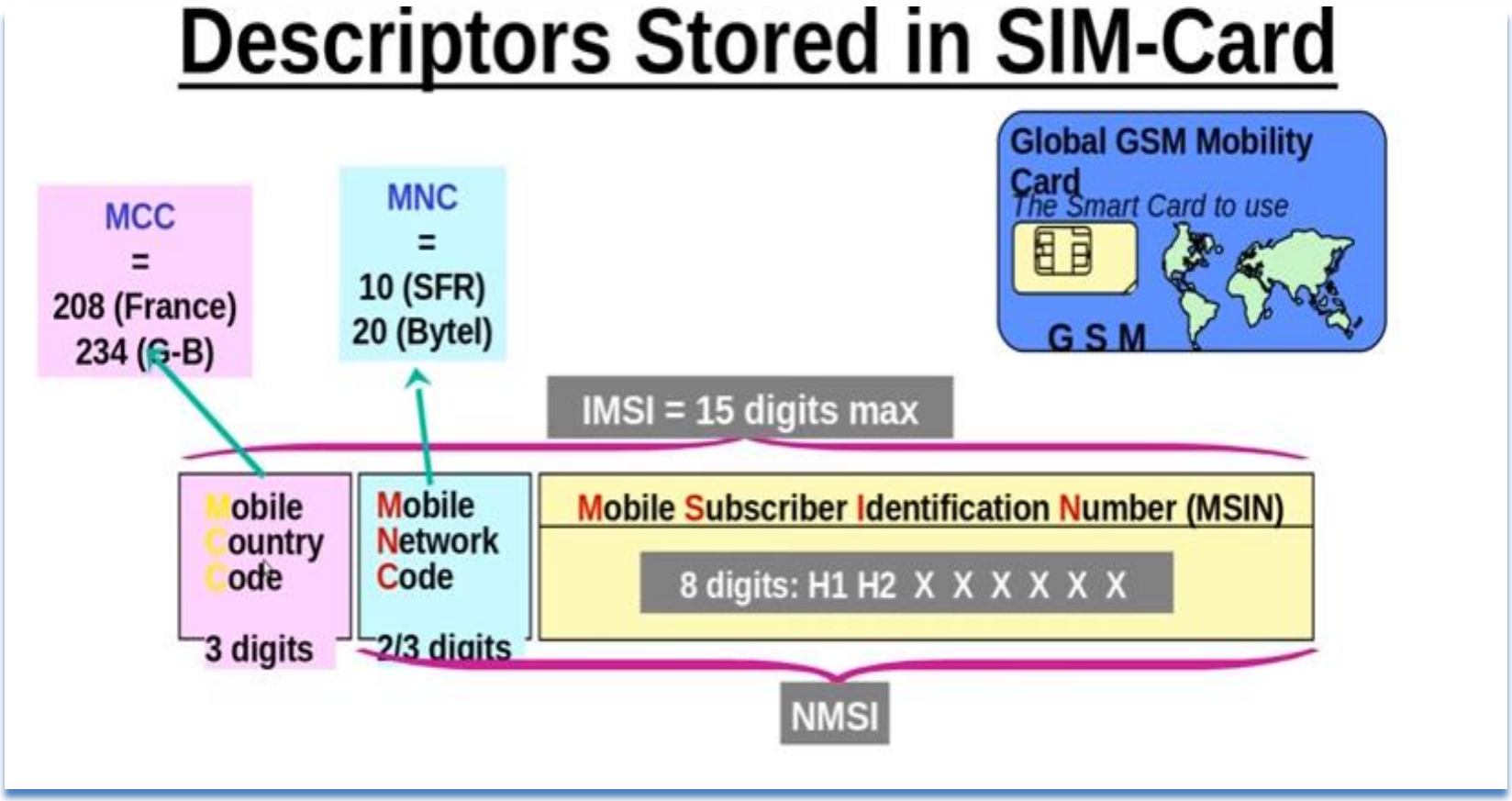
1. Mobile station international ISDN number (MSISDN):

- The only important number for a user of GSM is the phone number.
  - Consists of the country code (CC)(e.g., +49 179 1234567 with 49 for Germany)
  - The national destination code (NDC)(i.e., the address of the network provider, e.g., 179)
  - The subscriber number (SN)

2. International mobile subscriber identity (IMSI):

- GSM uses the IMSI for internal unique identification of a subscriber.
- IMSI consists of
  - A mobile country code (MCC)(e.g., 240 for Sweden, 208 for France)
  - The mobile network code (MNC)(i.e., the code of the network provider),
  - The mobile subscriber identification number (MSIN).

International mobile subscriber identity (IMSI):



(Image Source: https://www.google.com)

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3. Temporary mobile subscriber identity (TMSI):

- To hide the IMSI, GSM uses the 4 byte TMSI for local subscriber identification.
- TMSI is selected by the current VLR and is only valid temporarily and within the location area of the VLR .
- Additionally, a VLR may change the TMSI periodically.

4. Mobile station roaming number (MSRN):

- Another temporary address that hides the identity and location of a subscriber is MSRN.
- The VLR generates this address on request from the MSC, and the address is also stored in the HLR.
- The MSRN helps the HLR to find a subscriber for an incoming call.
- MSRN contains :- The current visitor country code (VCC),
  - The visitor national destination code (VNDC),

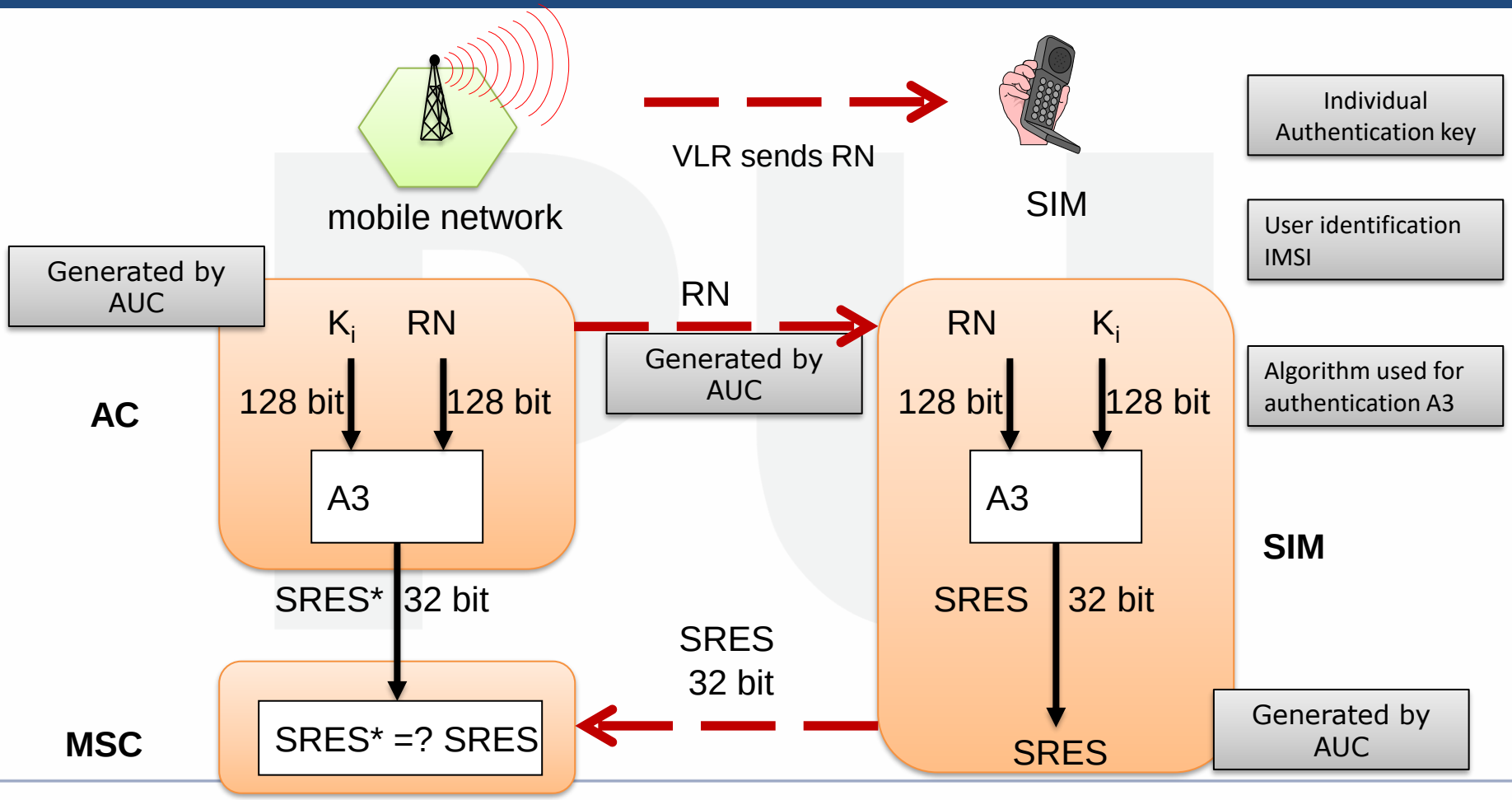
Authentication and security

Security services are provided using Confidential information in AUC & SIM.
SIM stores personal, secret data and it is protected with PIN against unauthorized use.
Ex: Secret key Ki – used in authentication and encryption procedures.

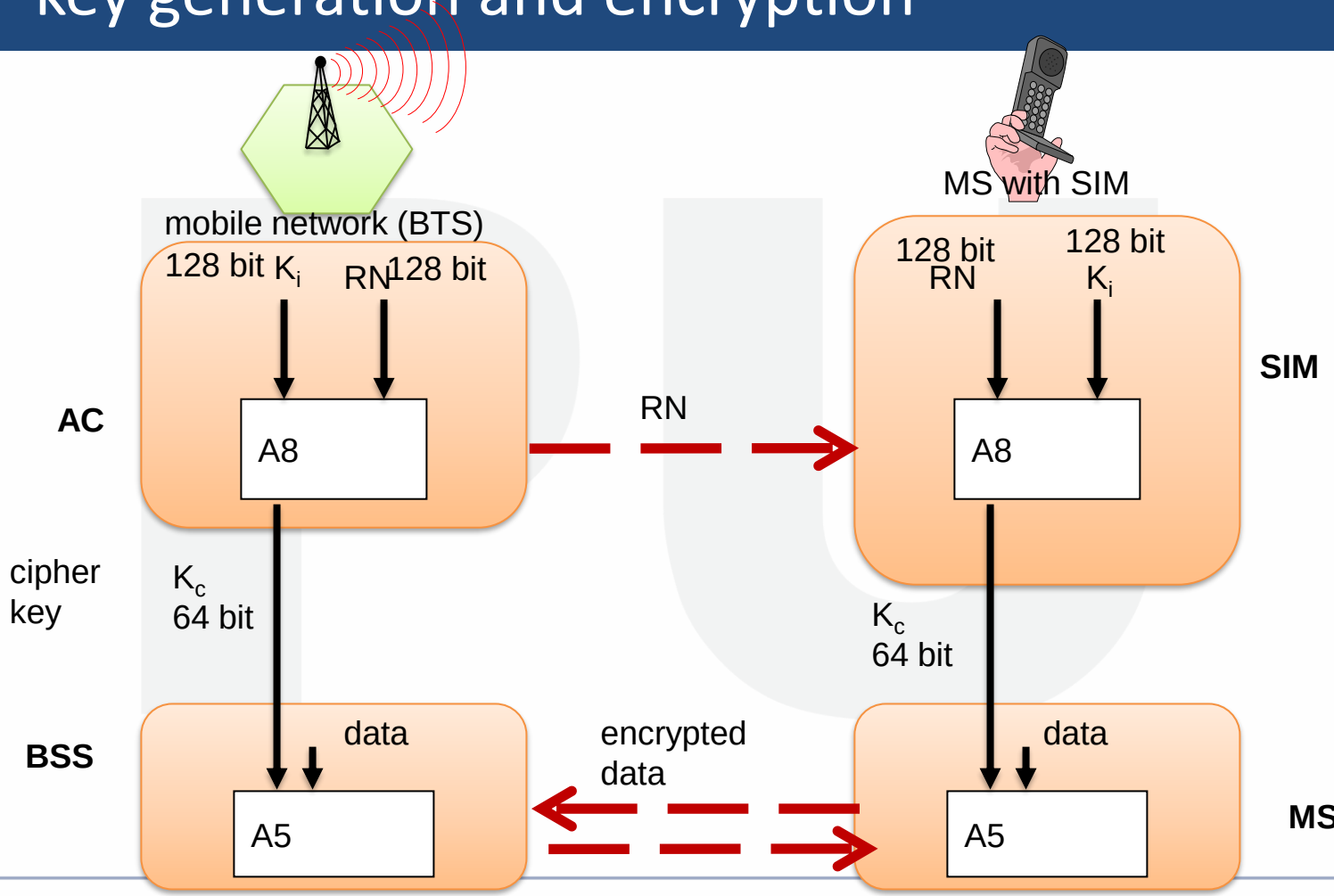
- Three basic services:
  1. Access control/authentication
  2. Confidentiality
  3. Anonymity

- 3 algorithms specified in GSM
  1. A3 for authentication (“secret”, open interface)
  2. A5 for encryption (standardized)
  3. A8 for key generation (“secret”, open interface)

GSM – authentication (Challenge Response)



GSM - key generation and encryption



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General packet radio service(GPRS)

General packet radio service(GPRS)

- General Packet Radio Service (GPRS) is a new bearer service for GSM that greatly improves and simplifies wireless access to packet data networks
- GPRS applies packet radio principal to transfer user data packets in an efficient way b/w MS & external packet data network

➢ Benefits of GPRS

- New Data Services
- High Speed (Data Rate 14.4 – 115 kbps)
- Efficient use of radio bandwith (Statistical Multiplexing) Circuit switching & Packet Switching can be used in parallel
- Constant connectivity

GPRS and packet data network.

- Packet mode transfer for applications that exhibit traffic patterns such as
  - Frequent transmission of small volumes (e.g., typical web requests)
  - Infrequent transmissions of small or medium volumes (e.g., typical web responses) according to the requirement specification.
  - It should provide a selection of QoS parameters for the service requesters.
  - GPRS should also allow for broadcast, multicast, and unicast service.
  - Network providers typically support this model by charging on volume and not on connection time as is usual for traditional GSM data services .

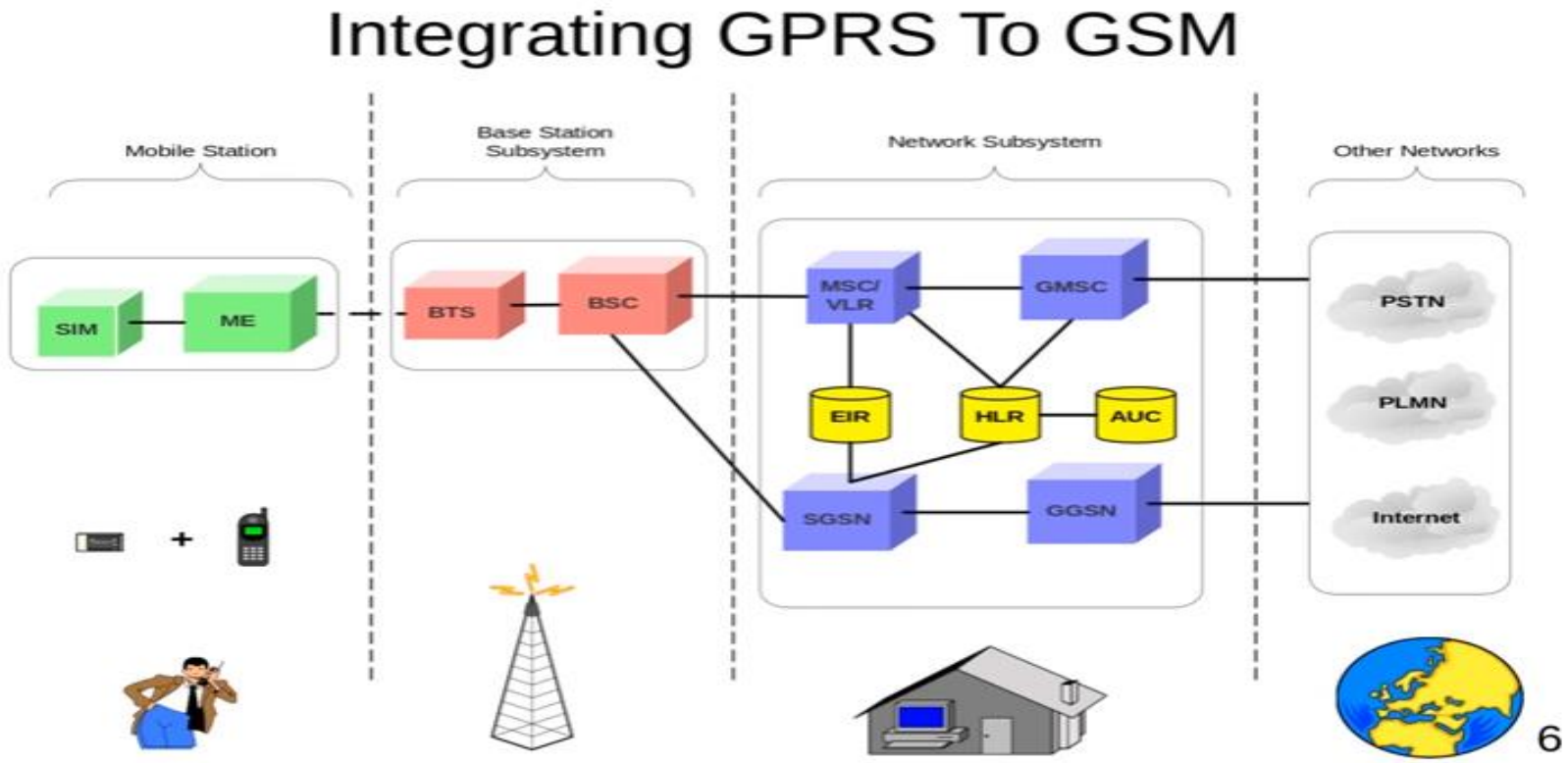
GPRS quality of service

GPRS allows defining QoS profiles using the following parameters.

Service Precedence : The preference given to a service when compared to another service is known as **Service Precedence**.

- **Reliability** : The reliability classes are defined which guarantee certain maximum values for the probability of loss, duplication, mis-sequencing, and corruption of packets
- **Delay** : The delay is defined as the end-to-end transfer time between two communicating mobile stations or between a mobile station and the GI interface to an external packet data network.
- **Throughput** : The throughput specifies the maximum/peak bit rate and the mean bit rate.

GPRS architecture and interfaces



(Image Source: https://www.google.com)

GGSN

- The **GPRS architecture** introduces two new network elements:
- GPRS support nodes (GSN) – routers
- Gateway GPRS support node (GGSN) – interworking unit between the GPRS network and external packet data networks (PDN).
- This node contains routing information for GPRS users, performs address conversion, and tunnels data to a user via encapsulation.
- The other new element is the **serving GPRS support node (SGSN)** which supports the MS via the Gb interface.

SGSN

The SGSN:

requests user addresses from the **GPRS register (GR)**,
keeps track of the individual MSs' location,
responsible for collecting billing information (e.g., counting bytes), and
performs several security functions such as access control.
Packet data is transmitted from a PDN, via the GGSN and SGSN directly to the BSS and finally to the MS.
The MSC, which is responsible for data transport in the traditional circuit-switched GSM, is only used for signaling in the GPRS scenario.

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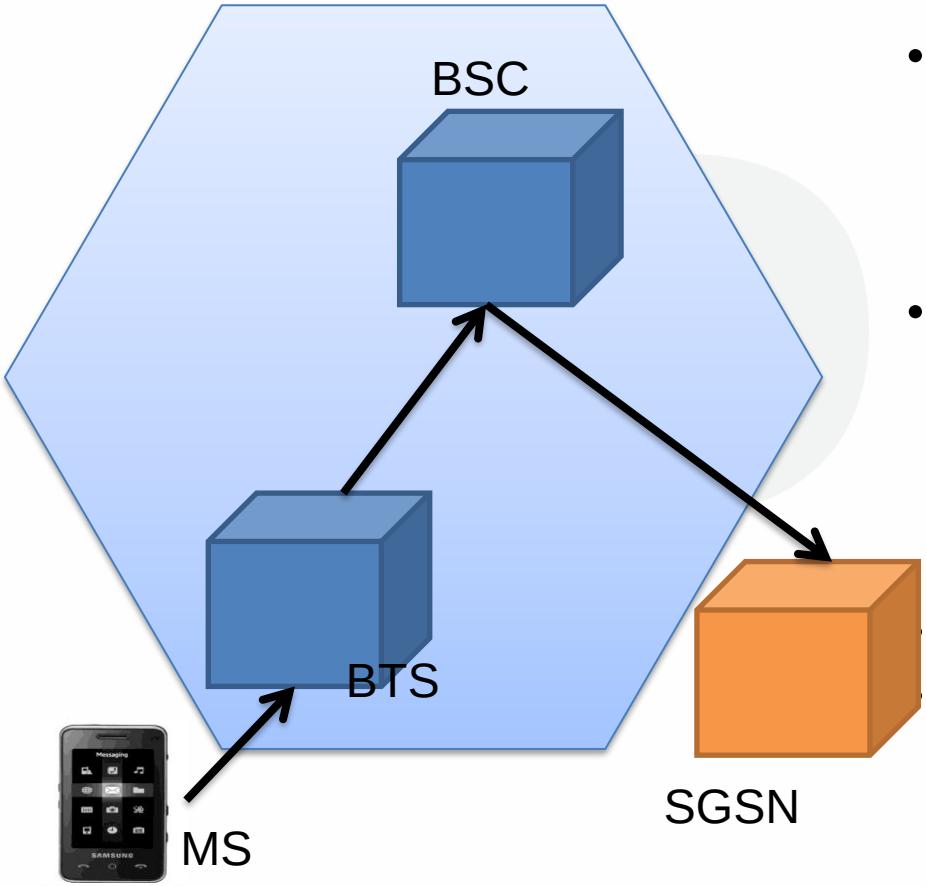
GPRS Network Operations

1. GPRS Attachment and Detachment Procedure
2. Mobility Management
3. Routing
4. Communication with the IP networks.

GPRS Attachment and Detachment Procedure



- Before the mobile station can use the GPRS Service, first the mobile station must register with the SGSN of the GPRS Network.
- The network checks for authorization of the user, copies the user profile from HLR database to the SGSN and assign the packet temporary mobile subscriber identity (P-TMSI) to the user.

This procedure is called GPRS attach.

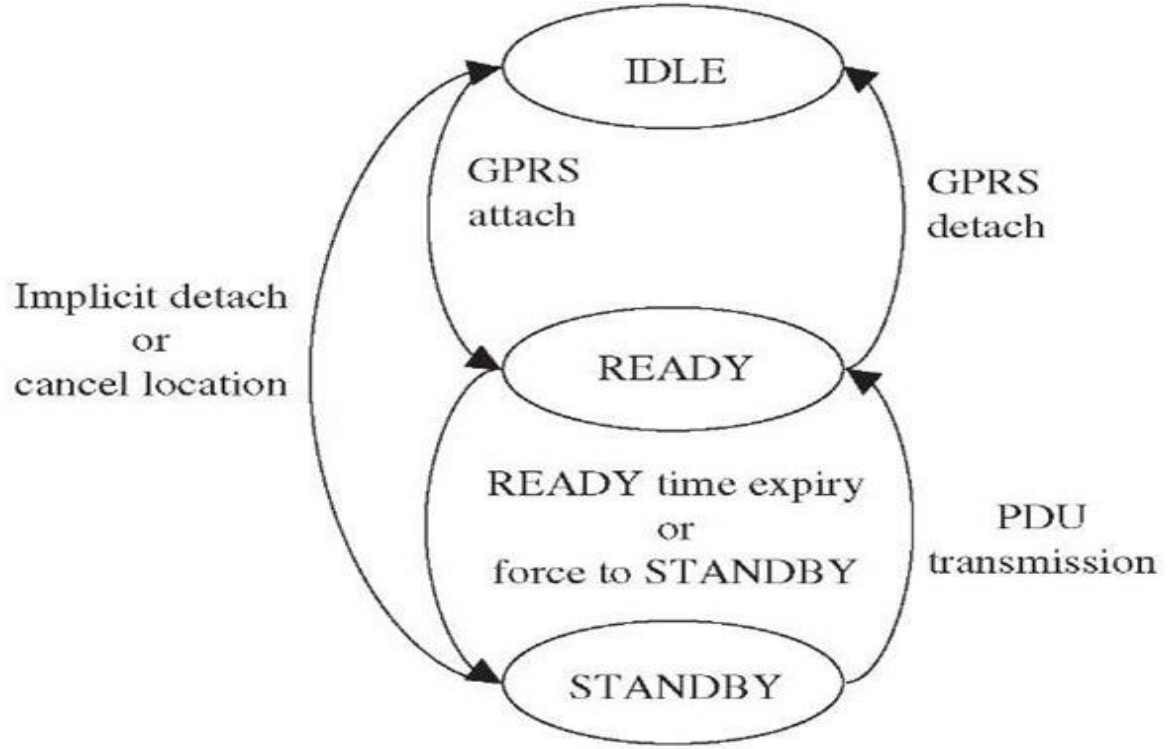
The disconnection from the GPRS network is called GPRS detach.

Mobility Management

- The main task of the mobility management is to keep track of the user's current location.
- The MS sends the location update message to the SGSN so that the network can be always aware of the current location of the MS.
- There are three states exist in the GPRS mobility management and the different location information is available in each state.
- As a result, the different mobility management strategies are applied in the different states.

Three States of MS in GPRS Network

- An MS(Mobile Station) has three states in GPRS Network.
  - Idle/Initialisation
  - Ready
  - Standby



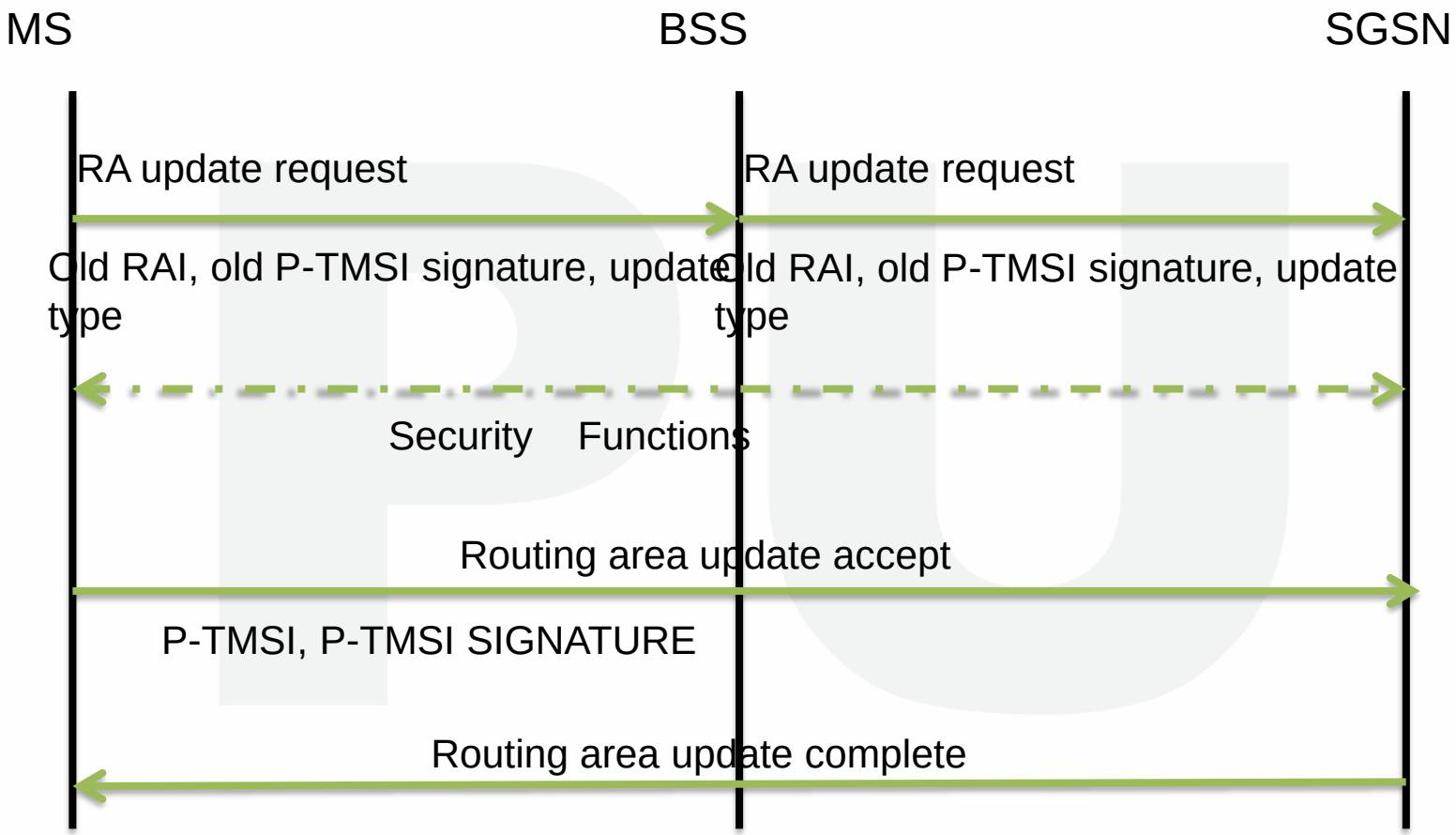
Location Update

- The State Model of GPRS Mobile Station deploys an appropriate location update strategy in order to maintain the optimum network capacity as well as the MS battery drain.
- When MS crosses LA border, a location update and RA update shall be done. In case MS moves within the same LA but crosses different RA, the RA update is needed.
- When the MS moves within the same LA and RA, cell update may be needed. It depends on the current state of the MS.
- This strategy ensures that the accurate location of the MS is always known and packet data can be delivered faster as no paging procedure is necessary.
- In this strategy, when data packet is sent to the MS, paging is required in order to find out the current location of the MS.
- Thus, uplink capacity will be wasted for paging response and every downlink packet requires paging of the mobile delay.

RA update

- Whenever the MS moves to a new RA, it sends a routing area update request including the routing area identity (RAI) of the old RA to its assigned SGSN.
- When the message arrives at the base station subsystem (BSS), the BSS adds the cell identifier (CI) of the new cell.
- Based on the RAI and CI data, the SGSN can derived the new RAI.
- The SGSN knows already all necessary user profile, and can assign a new packet temporary mobile subscriber identity (P-TMSI) to the user without the need to inform other network elements.

Routing


MS
BSS
SGSN
RA update request
RA update request
Old RAI, old P-TMSI signature, update type
Old RAI, old P-TMSI signature, update type
Security Functions
Routing area update accept
P-TMSI, P-TMSI SIGNATURE
Routing area update complete

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Inter –SGSN Routing

- Inter-SGSN routing area update:
- The MS has moved to an RA, assigned to a different SGSN.
- The new SGSN does not have the user profile of the MS.
- The SGSN contacts the old SGSN and requests the PDP context of the user.
- After receiving the PDP context of the user, the new SGSN informs the involved network elements, such as the GGSN about the new PDP context of the user, and the HLR about the user's new SGSN, etc.

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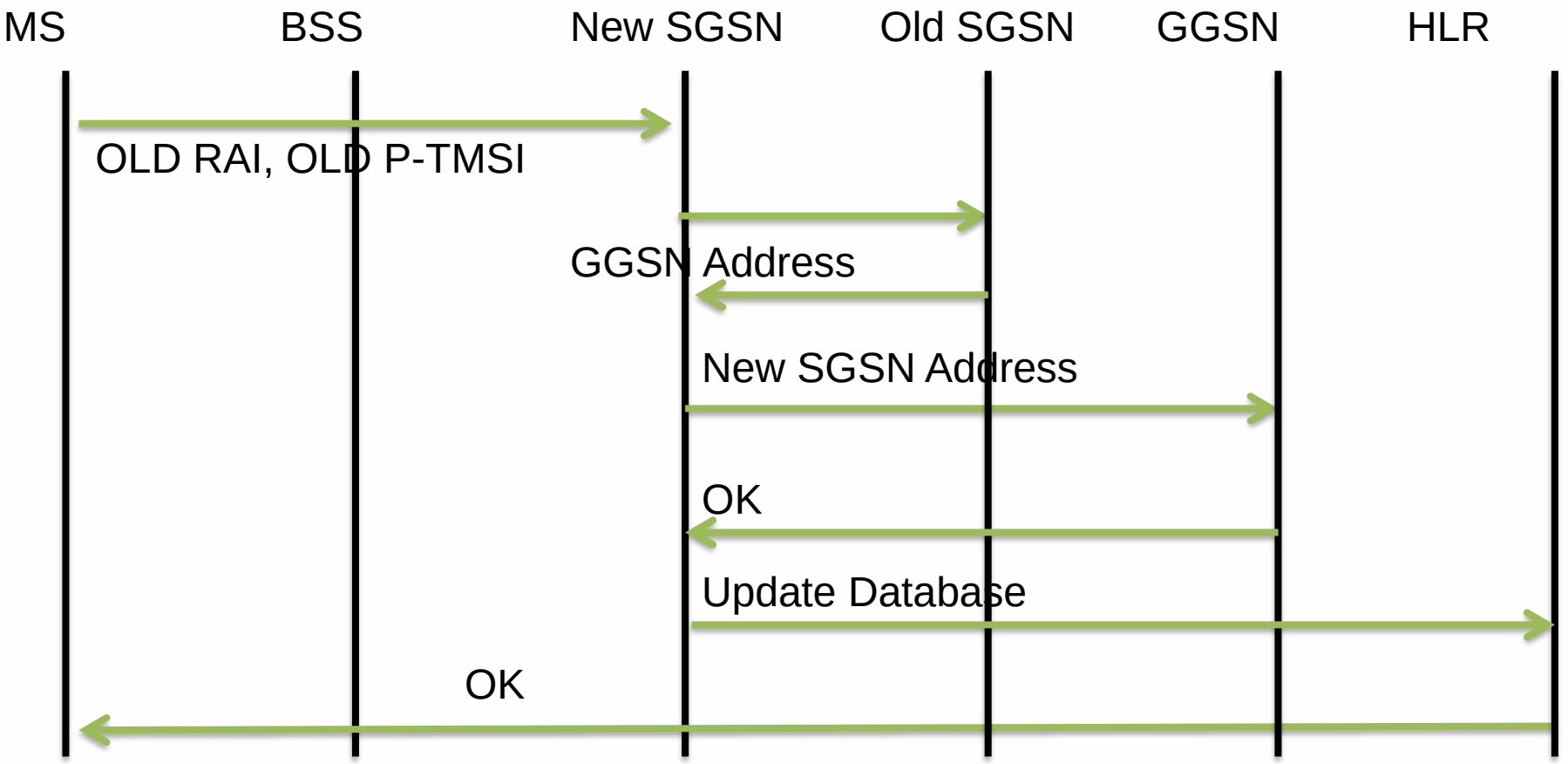
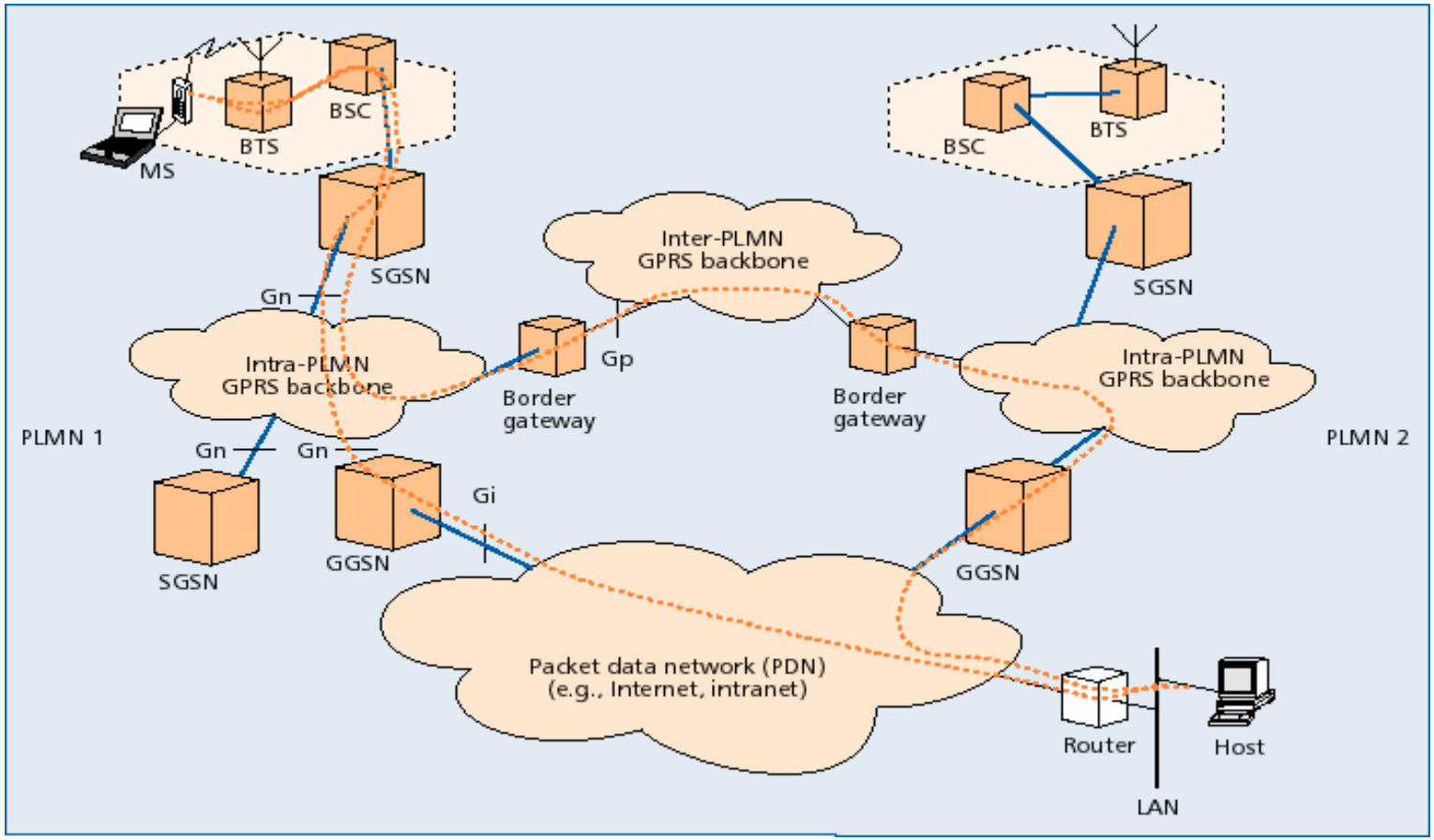

MS
BSS
New SGSN
Old SGSN
GGSN
HLR
OLD RAI, OLD P-TMSI
GGSN Address
New SGSN Address
OK
Update Database
OK

Routing



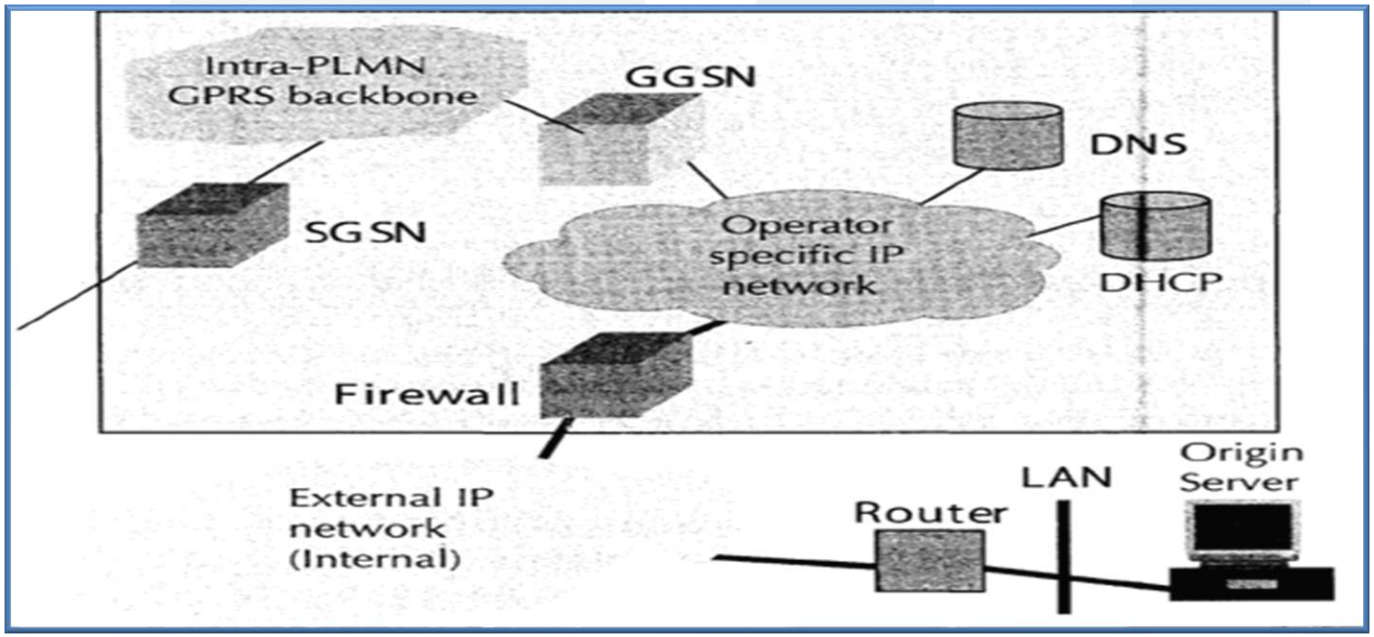
(Image Source: https://www.google.com)

Continued..

- The example assumes two intra-PLMN backbone networks of different PLMNs.
- Intra PLMN backbone networks connect GSNs of the same PLMN or the same network operator.
- Ex : Airtel GSNs in Ahmedabad connecting Airtel GSNs in Delhi through a private data network.
- Intra PLMN backbone are connected with inter PLMN backbone which connects GSNs of different PLMNs and operators.
- Ex : Airtel GSNs in Ahmedabad connecting Vodafone GSNs in Delhi through a private data network.
- The gateways between PLMNs and the external inter-PLMN backbone are called border Gateways.

Communication with the IP networks.

- GPRS interconnected with internet or corporate network.
- GPRS like any other IP network and GGSN as a router.
- DHCP and DNS server
- Firewall install between GPRS and external IP network



(Image Source: https://www.google.com)

Applications of GPRS

- Web browsing
- Corporate & Internet Email
- Vehicle Positioning
- Remote LAN Access
- Home Automation
- Document Sharing/Collaborative working

Billing and charging in GPRS

- The GGSN and SGSN register all feasible aspects of a GPRS user's behavior and generate billing information respectively. This billing information is collected in so-called Charging Data Records (CDR) which is further provided to a billing gateway.
- **Volume** - Volume is the amount of bytes being transferred, i.e., how much of data is being downloaded and uploaded.
- **Duration** - The long duration of a PDP context session.
- **Time** - Date, time of day, and day of the week (enabling lower tariffs at off peak hours).
- **Final destination** - A customer can be charged for an access to the specific network, such as through a proxy server.
- **Location** - Location describes the current location of the subscriber.

Billing and charging in GPRS

- **Quality of Service** - Customer can be charged more for higher network priority.
- **SMS** - The SGSN will produce specific CDRs for SMS.
- **Served IMSI/subscriber** - Several subscriber classes (various tariffs for frequent users, businesses, or private users).
- **Reverse charging** - The receiving customer might not be charged for the received data; instead, the sending party is charged.
- **Free of charge** - Sme of the specified data to be free of charge.
- **Flat rate** - A fixed monthly fee.

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Wireless System Operations and standards

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DIGITAL LEARNING CONTENT

Wireless System Operations and standards

1. Cordless Systems,
2. Wireless Local Loop,
3. WiMAX and IEEE 802.16 Broadband Wireless Access Standards
4. Mobile IP and Wireless Application. Protocol

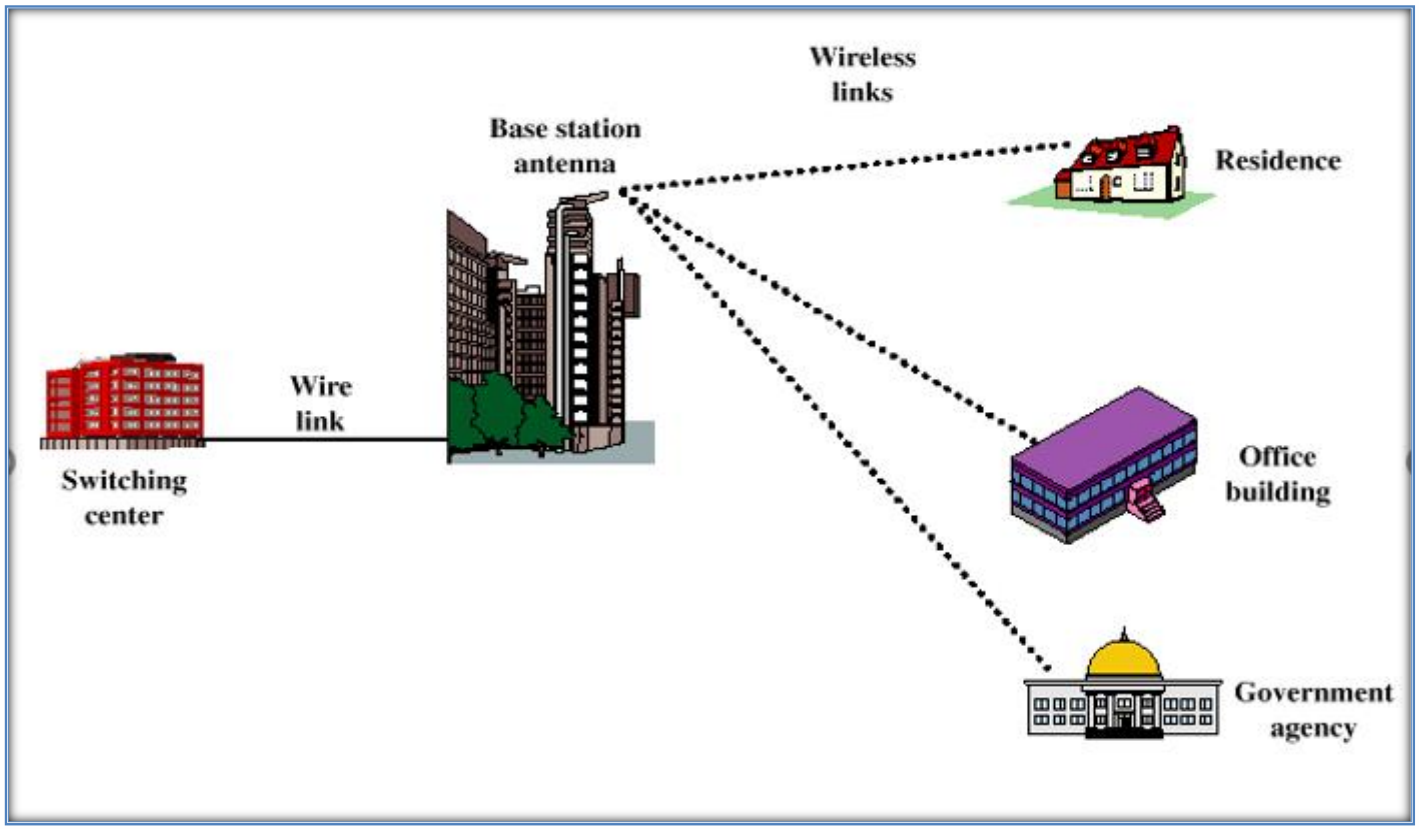
Cordless Systems

- Residential – a single base station can provide in-house voice and data support
- Office
  - A single base station can support a small office
  - Multiple base stations in a cellular configuration can support a larger office
- Telepoint – a base station set up in a public place, such as an airport
- Modest range of handset from base station, so low-power designs are used
- Inexpensive handset and base station, dictating simple technical approaches
- Frequency flexibility is limited, so the system needs to be able to seek a low-interference channel whenever used

Wireless Local Loop

- **Wireless local loop** (**WLL**), is the use of a **wireless** communications link as the "last mile / first mile" connection for delivering plain old telephone service (POTS) or Internet access (marketed under the term "broadband") to telecommunications customers. Various types of **WLL** systems and technologies exist.
- Wired technologies responding to need for reliable, high-speed access by residential, business, and government subscribers
  - ISDN, cable modems
- Increasing interest shown in competing wireless technologies for subscriber access
- Wireless local loop (WLL)
  - Narrowband – replacement for existing telephony services
  - Broadband – high-speed two-way voice and data service

Wireless Local Loop Configuration



(Image Source: https://www.google.com)

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Advantages of WLL over Wired Approach

- Cost – wireless systems are less expensive due to cost of cable installation that's avoided
- Installation time – WLL systems can be installed in a small fraction of the time required for a new wired system
- Selective installation – radio units installed for subscribers who want service at a given time
- With a wired system, cable is laid out in anticipation of serving every subscriber in a given area

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802.16/WiMAX

- 802.16 family of standards is officially called Wireless MAN in IEEE
- It has been commercialized under the name "WiMAX" (from "Worldwide Interoperability for Microwave Access") by the WiMAX Forum industry alliance.
- The Forum promotes and certifies compatibility and interoperability of products based on the IEEE 802.16 standards
- Formed in June 2001 to promote conformance and interoperability of the 802.16 standard
- Develops “system profiles” that define mandatory and optional features of standard

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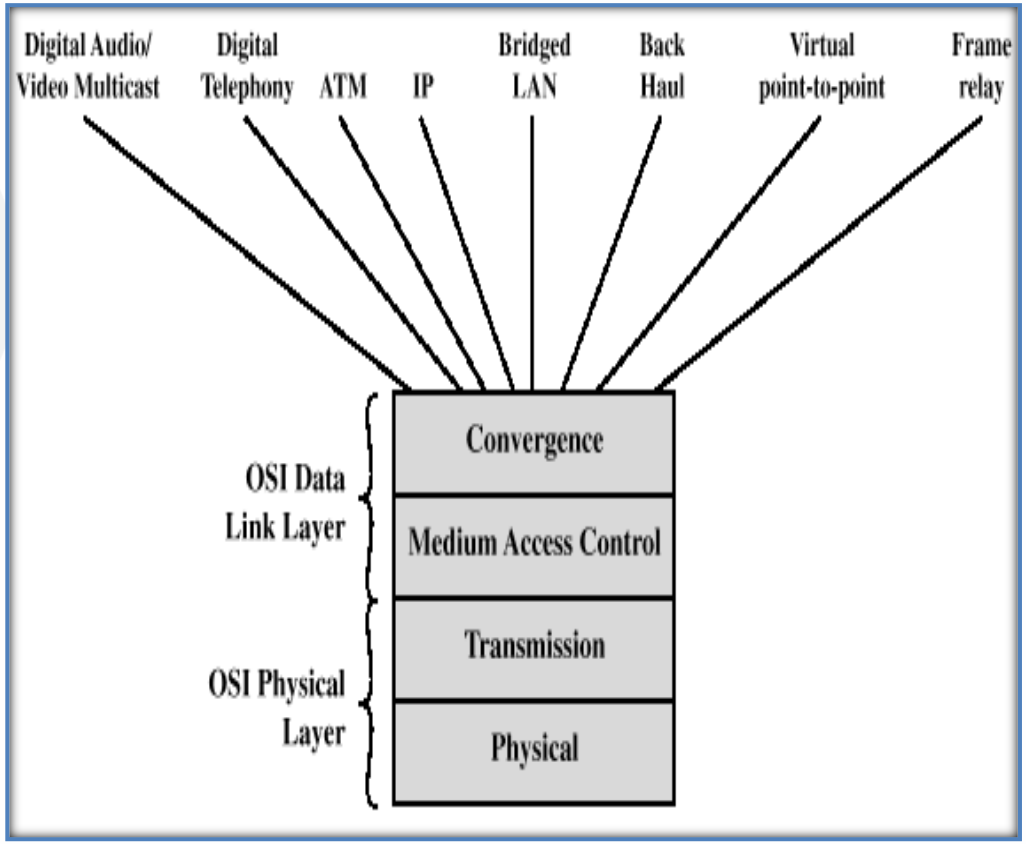
802.16 Standards Development

- Use wireless links with microwave or millimeter wave radios
- Use licensed spectrum
- Are metropolitan in scale
- Provide public network service to fee-paying customers
- Use point-to-multipoint architecture with stationary rooftop or tower-mounted antennas



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IEEE 802.16 Protocol Architecture

- Physical and transmission layer functions:
  - Encoding/decoding of signals
  - Preamble generation/removal
  - Bit transmission/reception
- Medium access control layer functions:
  - On transmission, assemble data into a frame with address and error detection fields
  - On reception, disassemble frame, and perform address recognition and error detection
  - Govern access to the wireless transmission medium
- Convergence layer functions:
  - Encapsulate PDU framing of upper layers into native 802.16 MAC/PHY frames
  - Map upper layer's addresses into 802.16 addresses
  - Translate upper layer QoS parameters into native 802.16 MAC format

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IEEE 802.16 Services

- Digital audio/video multicast
- Digital telephony
- Internet protocol
- Bridged LAN
- Frame relay
- Voice transport
- Data transport

Mobile IP

- **Developed as a means for transparently dealing with problems of mobile users**
- Enables hosts to stay connected to the Internet regardless of their location and without changing IP addresses
- Requires no changes to software of non-mobile hosts/routers
- **Requires addition of some infrastructure**
- Has no geographical limitations
- Requires no modifications to IP addresses
- Supports security

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Requirements of Mobile IP

Compatibility:	Mobile IP should be compatible or should be integrated with the existing operating systems applications, network protocols, existing router software, lower layers of standard IP and the mobile nodes using mobile IP should be able to communicate with fixed systems without mobile IP.
Non-Transparency from higher layers:	The mobile node should be non-transparent to the higher layers so that the change in point of attachment to the mobile node does not affect working of higher layers.
Quick reestablishment:	The mobile node after entering the foreign network suffers from a negligible disconnection for the time it acquires and registers the COA with the home agent. The reestablishment from this disruption should be fast because TCP connection is able to survive small disconnections not longer ones.
Scalability	It should be scalable over the entire devices worldwide.
Efficiency	It should not adversely affect the efficiency of the whole network.
Security	The mobility of the mobile node should not be transparent to the other nodes so address should be encapsulated or hidden. It should be ensure the packets intended for a mobile node practicing mobile IP should reach it only and fake IP addresses should be avoided by proper authentication methods.

Mobile IP Entities

- **Mobile Node (MN)**
  - The entity that moves from network to network
  - Assigned a permanent IP called its *home address* to which other hosts send packets regardless of MN's location.
  - MN are not necessarily small device but a router on aircraft is also strong mobile node.
- **Home Agent (HA)**
  - Router with additional functionality
  - Located on home network of MN
  - Mobility binding of MN's IP with its *Care of Address* (COA)
  - Forwards packets to appropriate network when MN is away – uses encapsulation

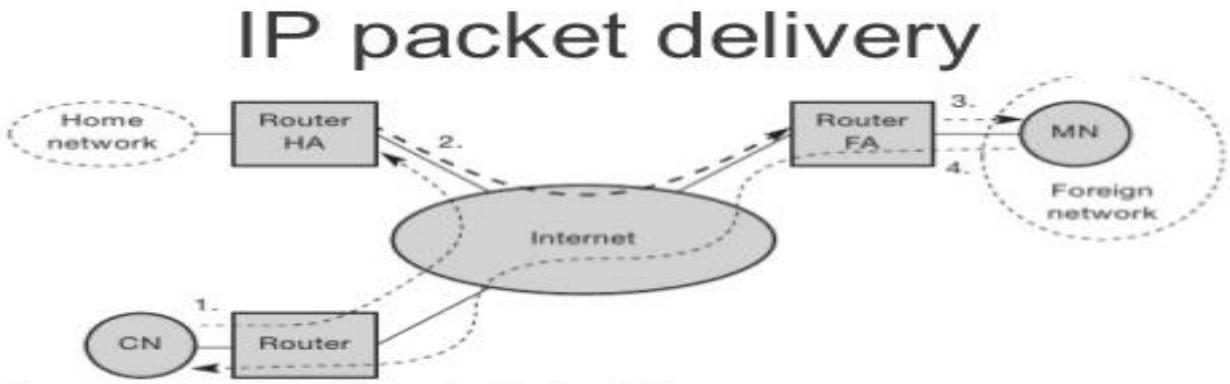
Mobile IP Entities

- **Foreign Agent (FA)**
  - Another router with enhanced functionality
  - Used to send/receive data between MN and HA
  - Advertises itself periodically
  - Provide service to MN while it is in FN
- **Care-of-address (COA)**
  - Address which identifies MN's current location
  - Sent by FA to HA when MN attaches
  - Usually the IP address of the FA
- **Correspondent Node (CN)**
  - End host to which MN is corresponding (eg. a web server)

Mobile IP Support Services

- **Agent Discovery**
  - HA's and FA's broadcast their presence on each network to which they are attached
  - MN's listen for advertisement and then initiate registration
- **Registration**
  - When MN is away, it registers its COA with its HA, via FA
  - Registration control messages sent via UDP to well known port
- **Encapsulation/de capsulation** – just like standard IP only with COA

Mobile IP packet delivery

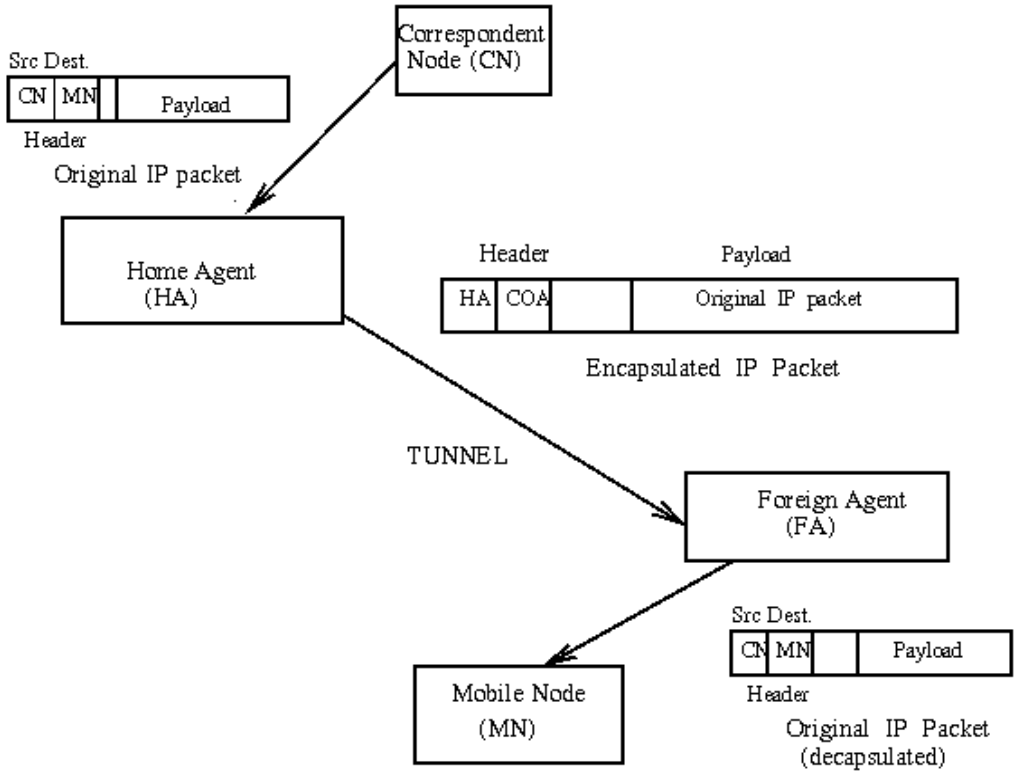


- CN wants to send an IP packet to the MN.
- Internet , not having info on the current location of MN, ***routes the packet to the router(Home Agent)*** responsible for the home network of MN.
- ***HA now intercept*** the packet(to find current location)
- Not found in home n/w then encapsulated and tunnelled to the COA.
- A ***new header put in front of the old header*** showing the (FA) COA as the new destination.
- ***FA now decapsulates*** the packets (remove additional header)
- Last, ***MN sends*** the packets as usual with its own ***fixed IP address as source*** and ***CN's address as the destination***.

(Image Source: https://www.google.com)

Mobile IP Tunneling

- HA encapsulates all packets addressed to MN and forwards them to FA
  - IP tunneling
- FA de-capsulates all packets addressed to MN and forwards them via hardware address.



(Image Source: https://www.google.com)

Security in Mobile IP

- Authentication can be performed by all parties
  - Only authentication between MN and HA is required
- Replay protection
  - Timestamps are mandatory
  - Random numbers on request reply packets are optional
- HA and FA do not have to share any security information.

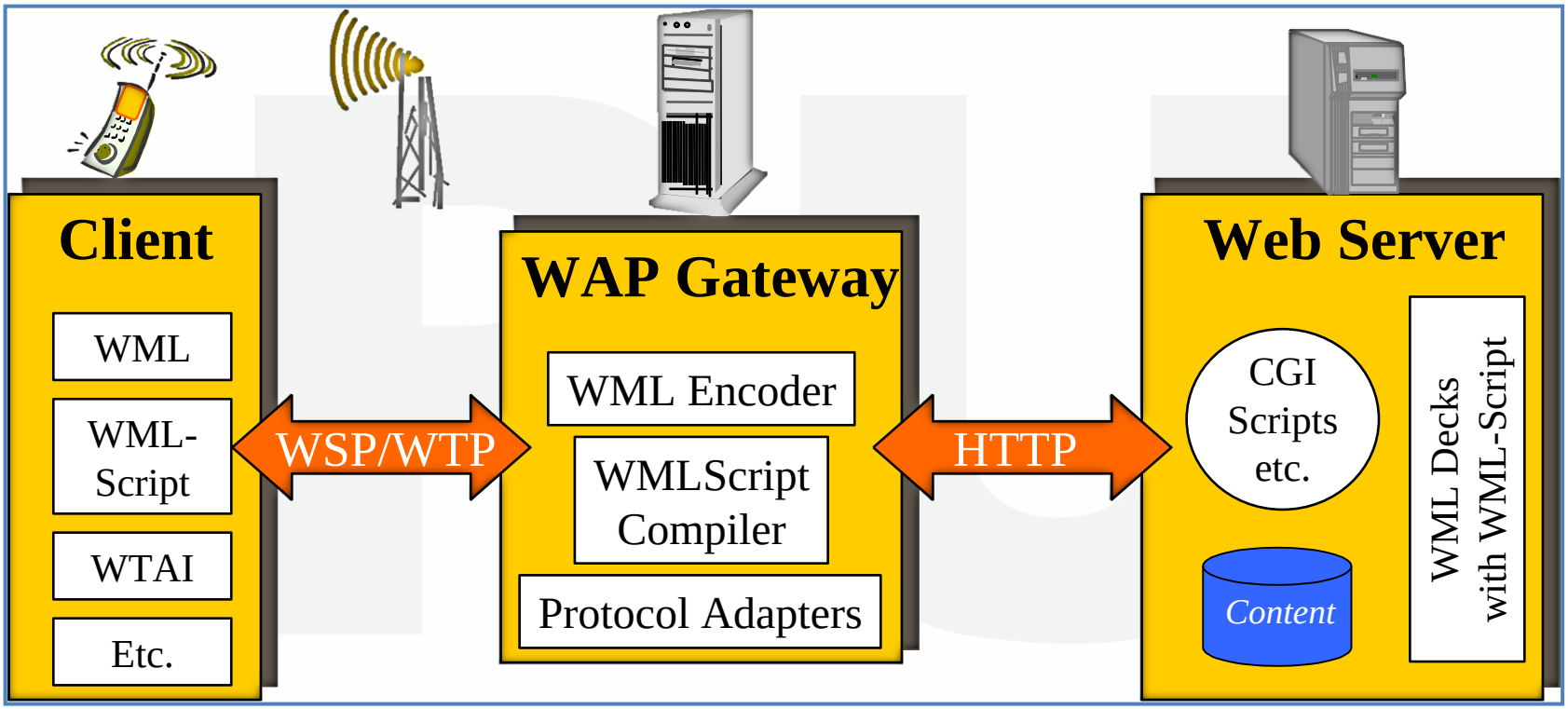
(Image Source: https://www.google.com)

Wireless Application Protocol (WAP)

- A universal, open standard developed by WAP forum to provide services:
  - wireless phone, pager, personal digital assistants, Internet, web, etc.
- It is designed to work with all wireless network technologies
- It is based on Internet standards:
  - IP, XML, HTML and http

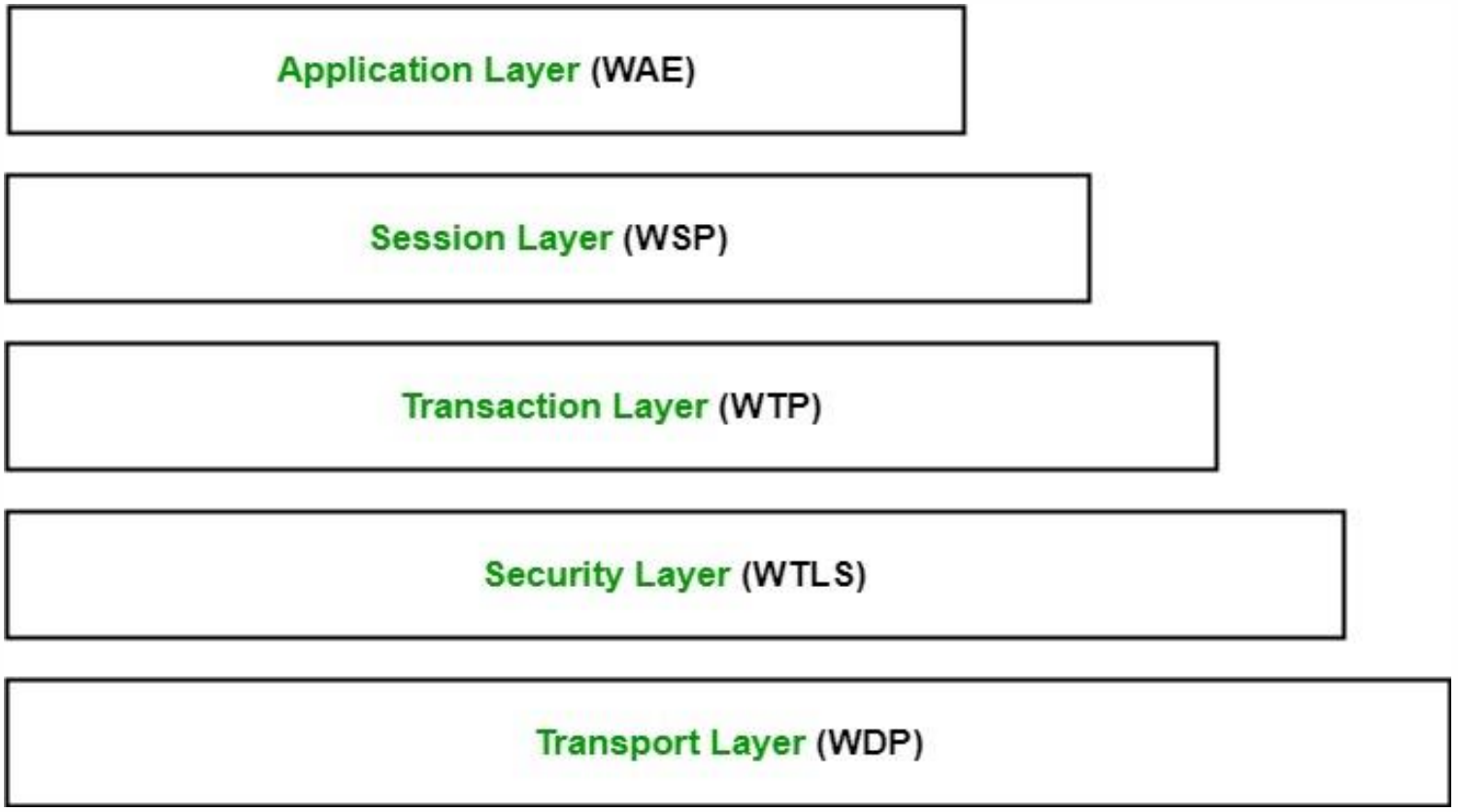
➢ WAP Specification
  - A programming model based on the WWW Programming Model
  - A markup language, the Wireless Markup Language, adhering to XML
  - A specification of a small browser suitable for a mobile, wireless terminal
  - A lightweight communications protocol stack
  - A framework for wireless telephony applications (WTAs)

Wireless Application Protocol (WAP) model



(Image Source: https://www.google.com)

WAP Protocol Stack



(Image Source: https://www.google.com)

WAP Advantages

- WAP is a very fast-paced technology.
- It is an open-source technology and completely free of cost.
- It can be implemented on multiple platforms.
- It is independent of network standards.
- It provides higher controlling options.
- It is implemented near to Internet model.
- By using WAP, you can send/receive real-time data.
- Nowadays, most modern mobile phones and devices support WAP.

(Image Source: https://www.google.com)

WAP Disadvantages

- The connection speed in WAP is slow, and there is limited availability also.
- In some areas, the ability to connect to the Internet is very sparse, and in some other areas, Internet access is entirely unavailable.
- It is less secured.
- WAP provides a small User interface (UI).

(Image Source: https://www.google.com)

WAP Applications

- WAP facilitates you to access the Internet from your mobile devices.
- You can play games on mobile devices over wireless devices.
- It facilitates you to access E-mails over the mobile Internet.
- Online mobile banking is very popular nowadays.
- It can also be used in multiple Internet-based services such as geographical location, Weather forecasting, Flight information, Movie & cinema information, Traffic updates etc. All are possible due to WAP technology.

(Image Source: https://www.google.com)

WML Wireless Markup Language

- Tag-based browsing language:
  - Screen management (text, images)
  - Data input (text, selection lists, etc.)
  - Hyperlinks & navigation support
- XML-based language
- Inherits technology from HTML
- Card metaphor
  - User interactions are split into cards
  - Navigation occurs between cards
- Explicit inter-card navigation model
  - Hyperlinks
  - UI Event handling
  - History

WML Example

```
<WML>
    <CARD NAME="card2">
        Services
        <SELECT KEY="type">
            <OPTION VALUE="em">Email</OPTION>
            <OPTION VALUE="ph">Phone</OPTION>
            <OPTION VALUE="fx">Fax</OPTION>
        </SELECT>
    </CARD>
</WML>
```

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