DATA PACKET EVOLUTION

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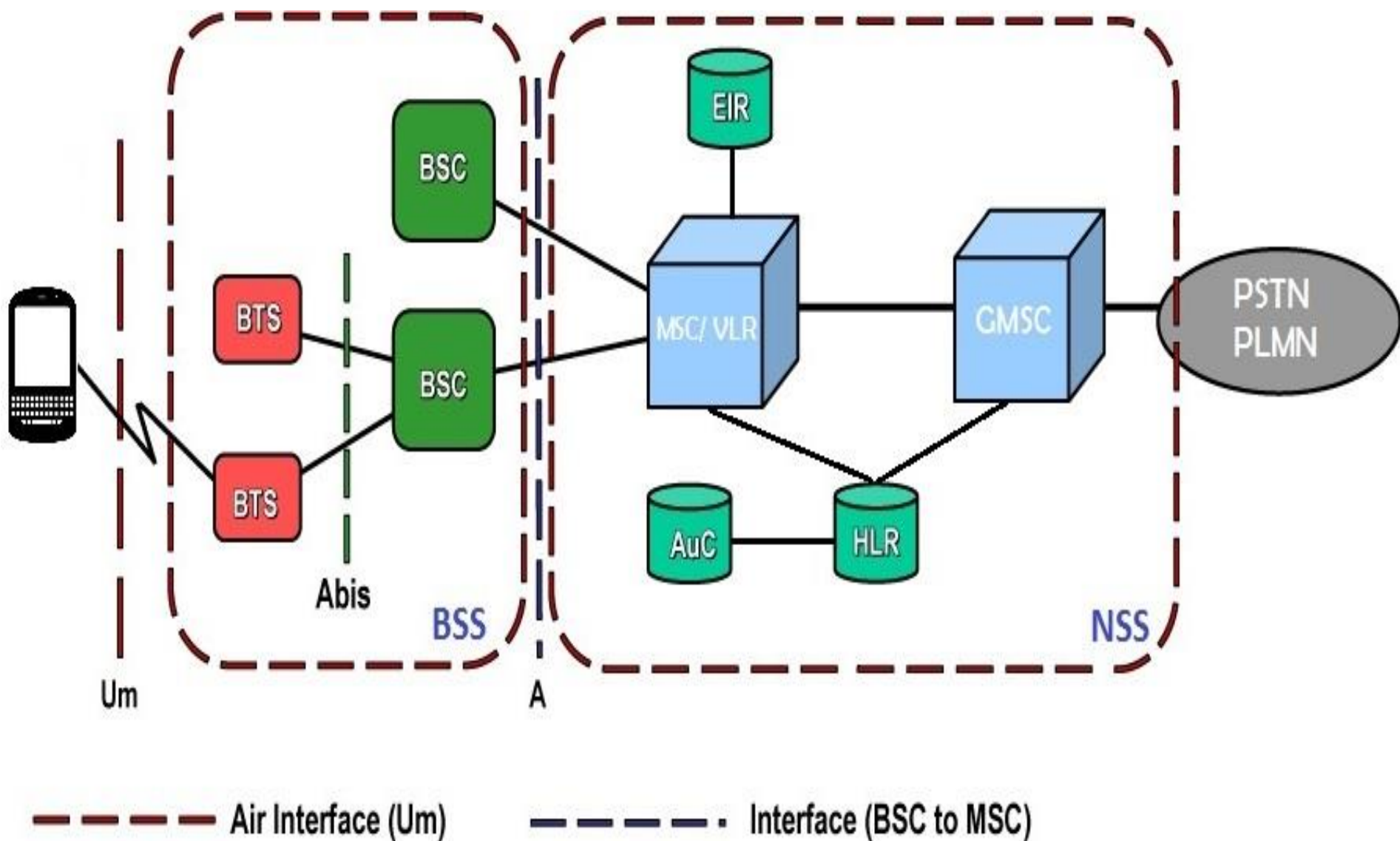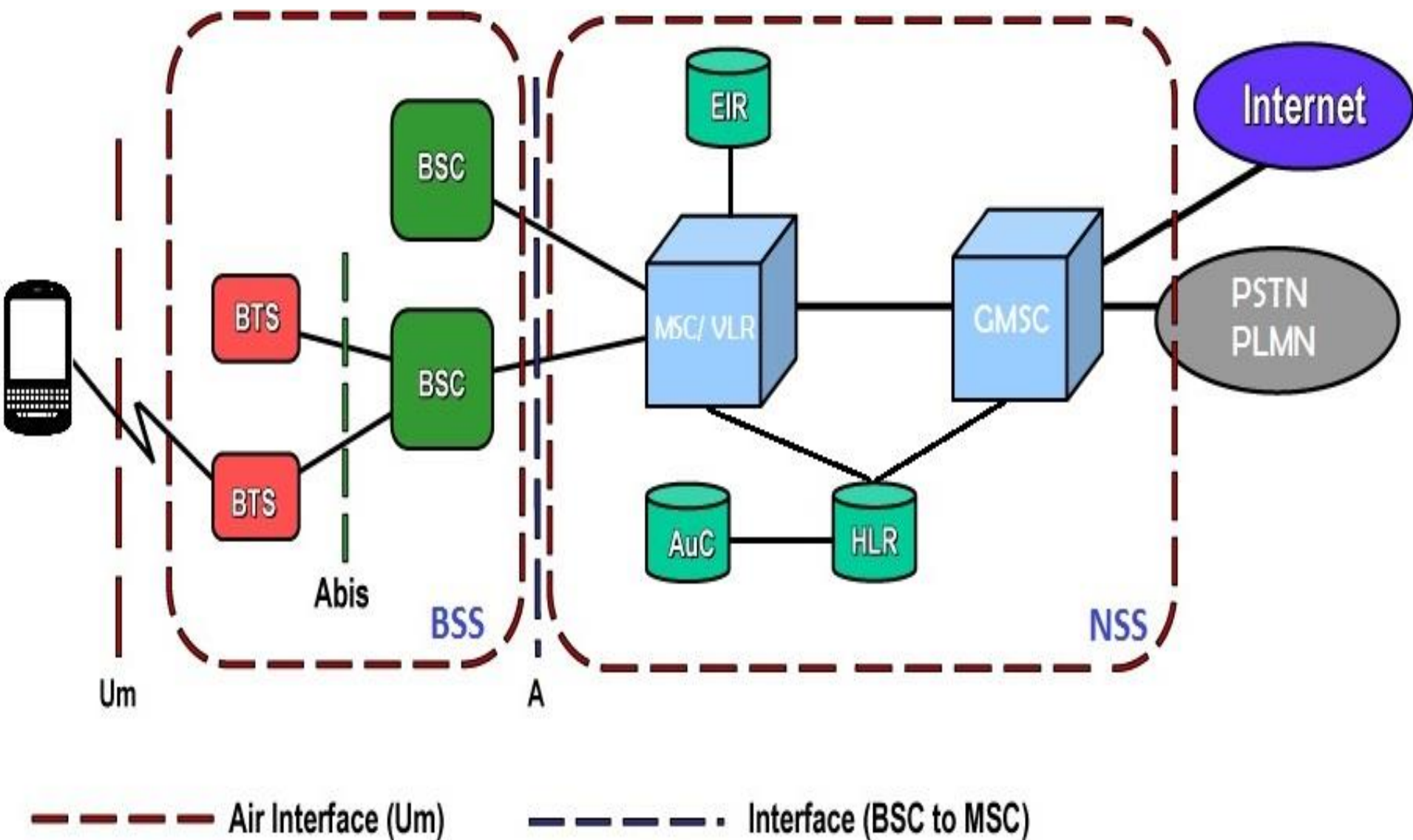
Agenda

mobinil

What is GSM ?

- Global System for Mobile communications.

- First and most successful digital cellular system (2G).

- Services:
  - Voice.
  - SMS.
  - Circuit switched data.

GSM network architecture

GSM network architecture

GSM Data services shortcomings

- Low data rates: 9.6 kbps ceiling.

- Circuit switched services are expensive for bursty applications.

- Inefficient use of radio resources.

- Displeased customers.

Introduction of Packet switched

| Circuit switched	Packet switched
End-to-end connection (call) establishment needed	**No connection** needed
Dedicated resources for one user are reserved during call establishment	**Resources are shared** between different user sessions, Not dedicated
Only 30-40% of resources are efficiently used for speech transfer	Resources are requested **on demand**, more efficient use
Speech is transferred in **real time**	Packets are not sent in real time
Speech **doesn't accept delays**	Packets accept buffering and delays
Errors in transmission are not so critical for speech	**Error correction** and detection possible
Charging is usually based on **time**	Charging is usually based on **volume** (number of packets)

Introduction of GPRS [2.5G]

- Technology which permits mobile data communication using packet switching techniques.

- GPRS designed as an extension to digital cellular networks.

- Connectionless packet switched (PS) data services.

- Radio resources shared between CS & PS data.

- New terminals are required.
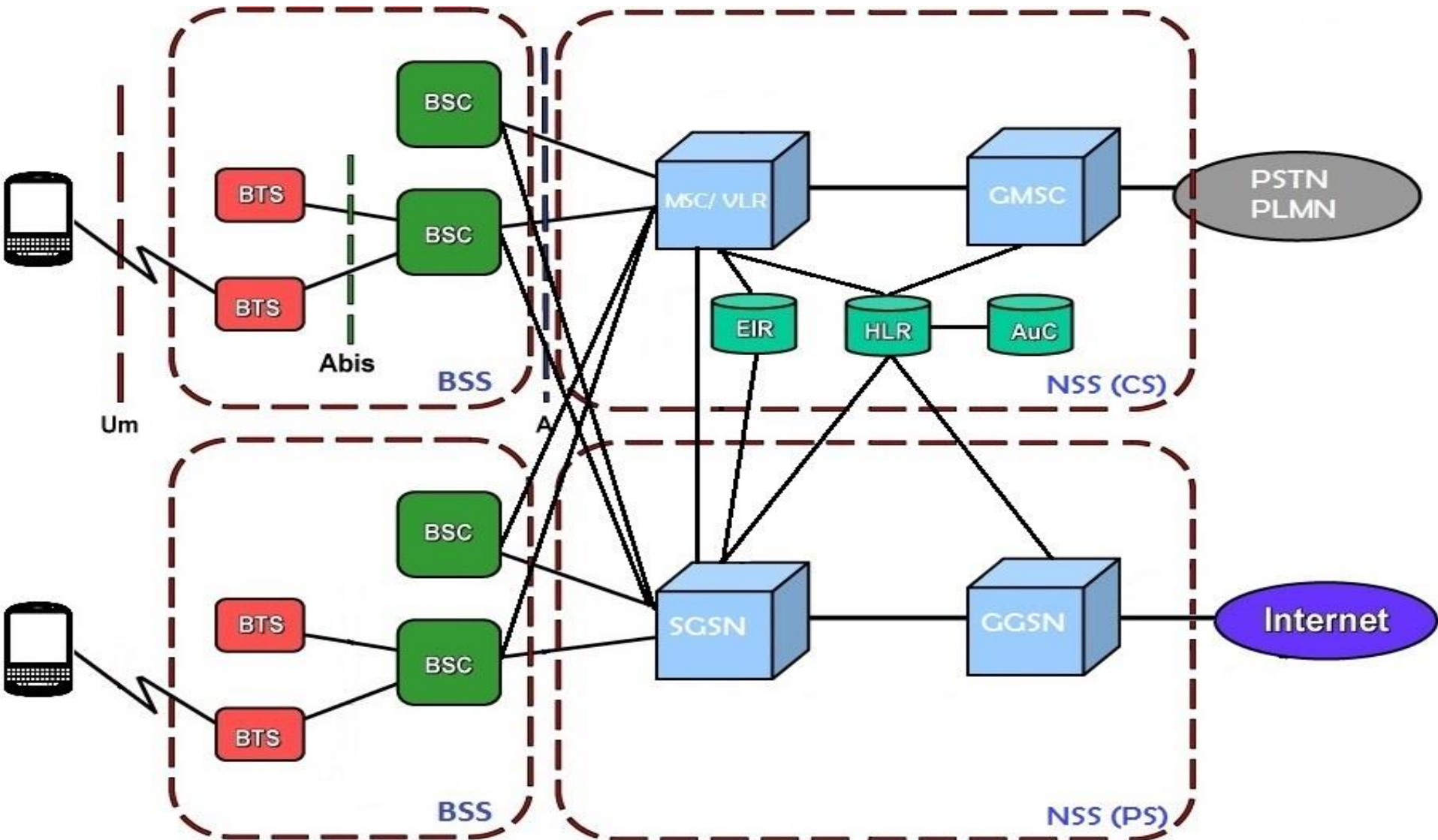
- Data rates: 181 kbps.

GPRS Advantages

- For users:
  - Charging based on amount of data transferred (volume).
  - Higher transmission speeds.

- For Operators:
  - Fast network roll-out with minimum investments.
  - Excess voice capacity used for GPRS data.
  - Smooth path to 3G services.

GPRS Architecture
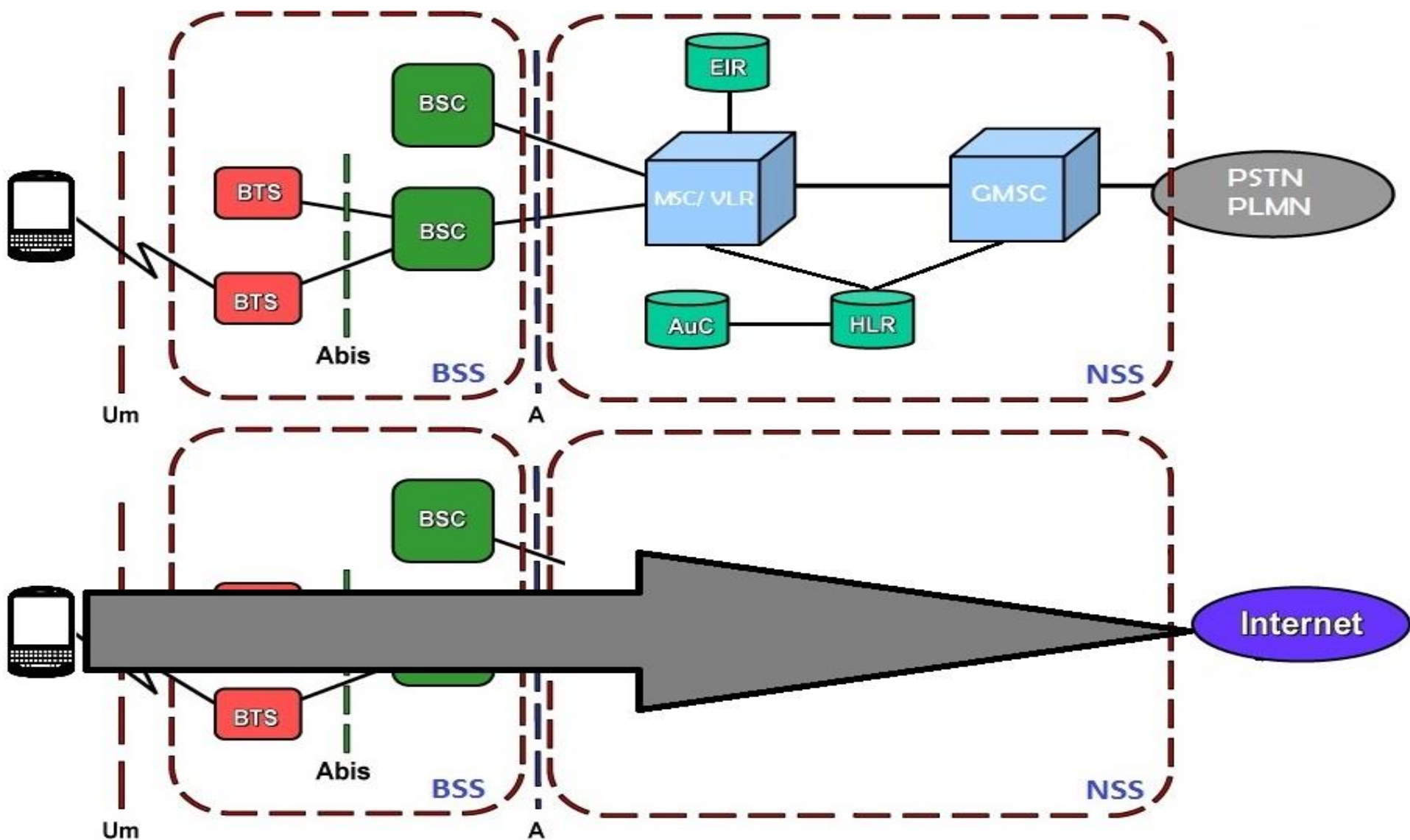
GPRS Architecture

SGSN & GGSN functions

- SGSN functions:
  - Signaling evaluation (IP header).
  - Packet Routing: delivery of data packets from & to MS.
  - GPRS Mobility Management (attach, de-attach, authentication & authorization).
  - Location register (current cell, current VLR, user profile IMSI).
  - Session Management (PDP context management).

- GGSN functions:
  - Interrogation with HLR.
  - Interfaces external networks.
  - Allocates dynamic or static IP addresses to mobile either by itself or the help of DHCP.

PDP context

- A data structure present on both the SGSN & the GGSN which contains the subscriber's session information when the subscriber has an active session. When a mobile wants to use GPRS, it must first attach and then activate a PDP context.

- The data recorded includes
  - Subscriber's IP address.
  - Subscriber's IMSI.
  - Subscriber's Tunnel Endpoint ID (TEID) at the GGSN.
  - Subscriber's Tunnel Endpoint ID (TEID) at the SGSN.

- PDP context activation.

GPRS Tunneling Protocol (GTP)

- Defining IP-based protocol of the GPRS core network.

- Allows end users to move from place to place while continuing to connect to the Internet as if from one location at the GGSN.

- It does this by carrying the subscriber's data from the subscriber's current SGSN to the GGSN which is handling the subscriber's session

GTP types

- GTP-U
  - For transfer of user data in separated tunnels for each Packet Data Protocol (PDP) context.

- GTP-C
  - Setup and deletion of PDP contexts.
  - Verification of GSN reachability.
  - Updates (as subscribers move from one SGSN to another).

- GTP Prime (GTP')
  - For transfer of charging data from GSNs to the CG.

GPRS Architecture
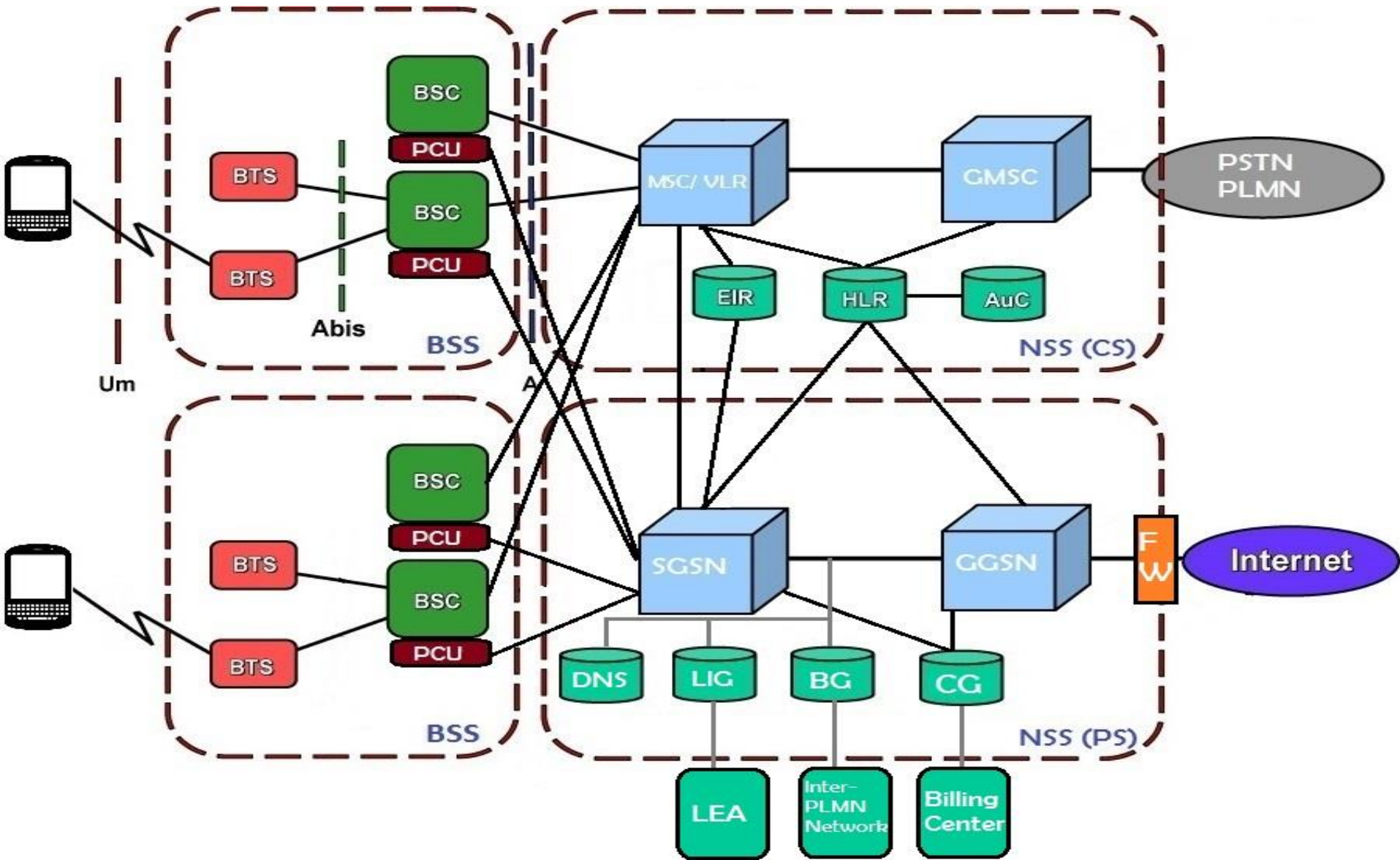
GPRS components

- PCU: (Packet Control Unit)
  - Decides dynamically which resources are allocated to CS & PS.
  - Based on priority & operator set rules.

- CG: (Charging Gateway)
  - Collects GPRS CDRs data together, processes it & passes it to billing system.

- BG: (Boarder Gateway)
  - Interconnects the operator's GPRS backbone networks via secure connection.
  - Supports roaming.

GPRS components

- EIR: (Equipment Identity Register)
  - Centralized database for IMEI.
  - Contains 3 lists:
    - White list: for valid MS equipments.
    - Black list: for stolen or denied MS.
   - Gray list: for mal-performance MS (faulty software).

GPRS components

- LIG: (Lawful Interception Gateway)
  - Obtaining communications network data pursuant to lawful authority for the purpose of analysis or evidence.

- LEA: (Law Enforcement Agency)

- DNS: (Domain Name Service)
  - Converts IP names to IP addresses.

- FW: (Fire Wall)
  - Protects IP network against external attacks.
  - Can be configured to reject all packets that are not part of GPRS subscriber initiated connection.
  - Can also include NAT & NAPT.

Charging Data Records (CDRs)

- GGSN CDR: (G-CDR)
  - Start collection: PDP context activation.
  - Stop collection: PDP context de-activation.
  - Collected info:
    - Traffic volumes (uplink / downlink).
    - QoS negotiation.
    - Duration.
    - SGSN & GGSN address.
    - Access Point Name.

- SGSN CDR: (SCDR)

- Mobility Management: CDR (M-CDR)
  - Collected data: Location changes.

GPRS Interfaces
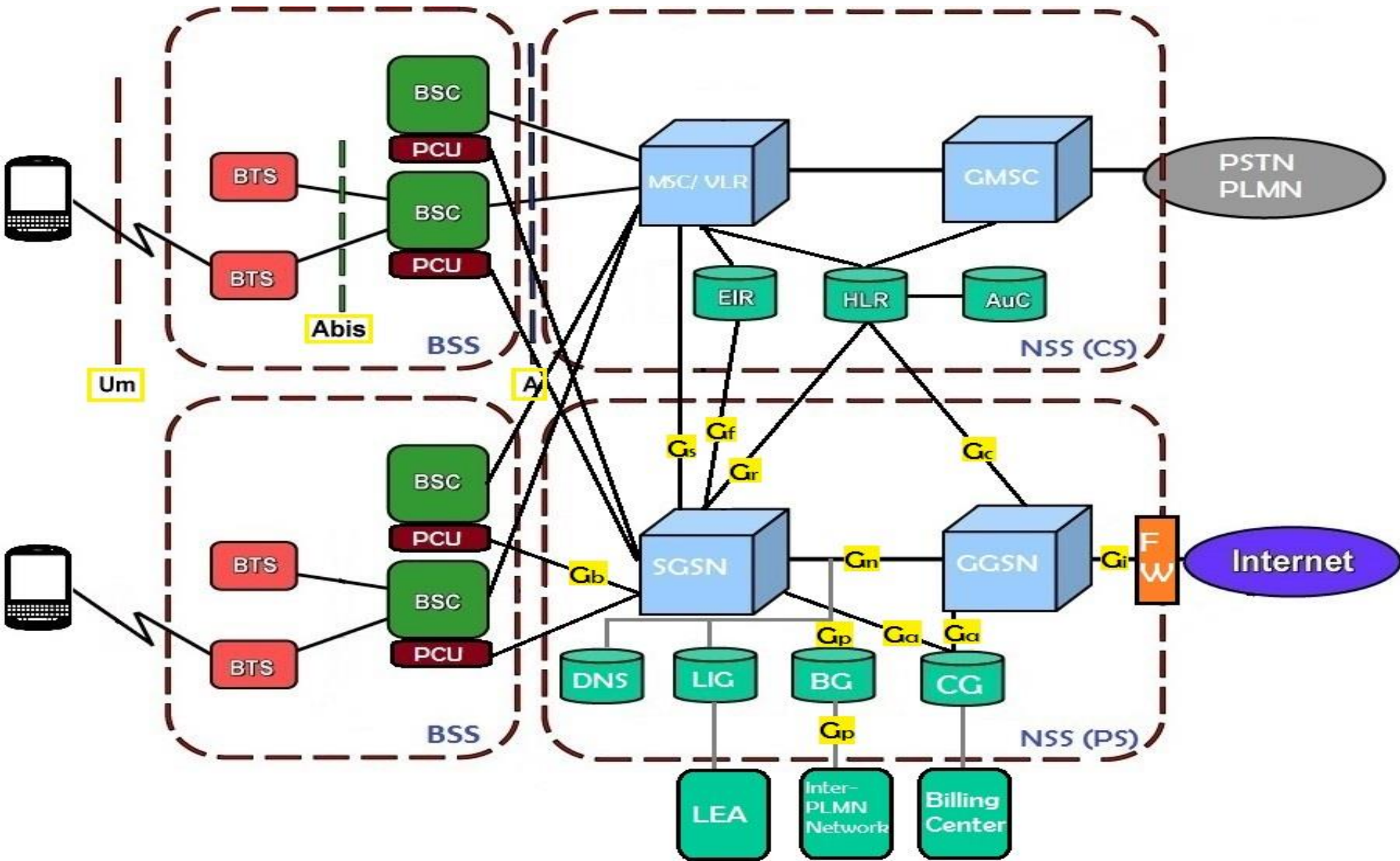
GPRS Interfaces

- Gb – SGSN to BSS.
- Gn – between GSNs (GTP).
- Gr – between SGSN & HLR.
- Gs – SGSN to MSC.
- Gi – GGSN to external network.
- Gf – between SGSN & EIR.

GPRS Identities

- Where:
  - CGI (Cell Global Identity).
  - RAI (Routing Area Identity). [Stored in SGSN]
  - SGSN number in HLR.

- Who:
  - IMSI (International Mobile Subscriber Identity).
  - P-TMSI (Packet Temporary Mobile Subscriber Identity).

- What:
  - APN (Access Point Name).
  - QoS (Quality of Service).
  - PDP (Packet Data Protocol).

GPRS attach / de-attach scenario

- Attach procedure:
  - MS sends an attachment request to SGSN.
  - MS & SGSN perform the security functions.
  - SGSN update the location in HLR.
  - HLR insert the subscriber's data in SGSN.
  - SGSN sends to MS that the GPRS attach Is accepted.

- De-attach procedure:
  - MS sends a de-attach request to SGSN.
  - The SGSN sends a delete PDP context request to GGSN.
  - The GGSN delete the PDP context.
  - SGSN send to MS that the de-attach is accepted.

Roaming

- Roaming has 2 scenarios.
  - Outbound roaming.
  - Inbound roaming.

- Roaming icon examples.

DHCP function in GGSN
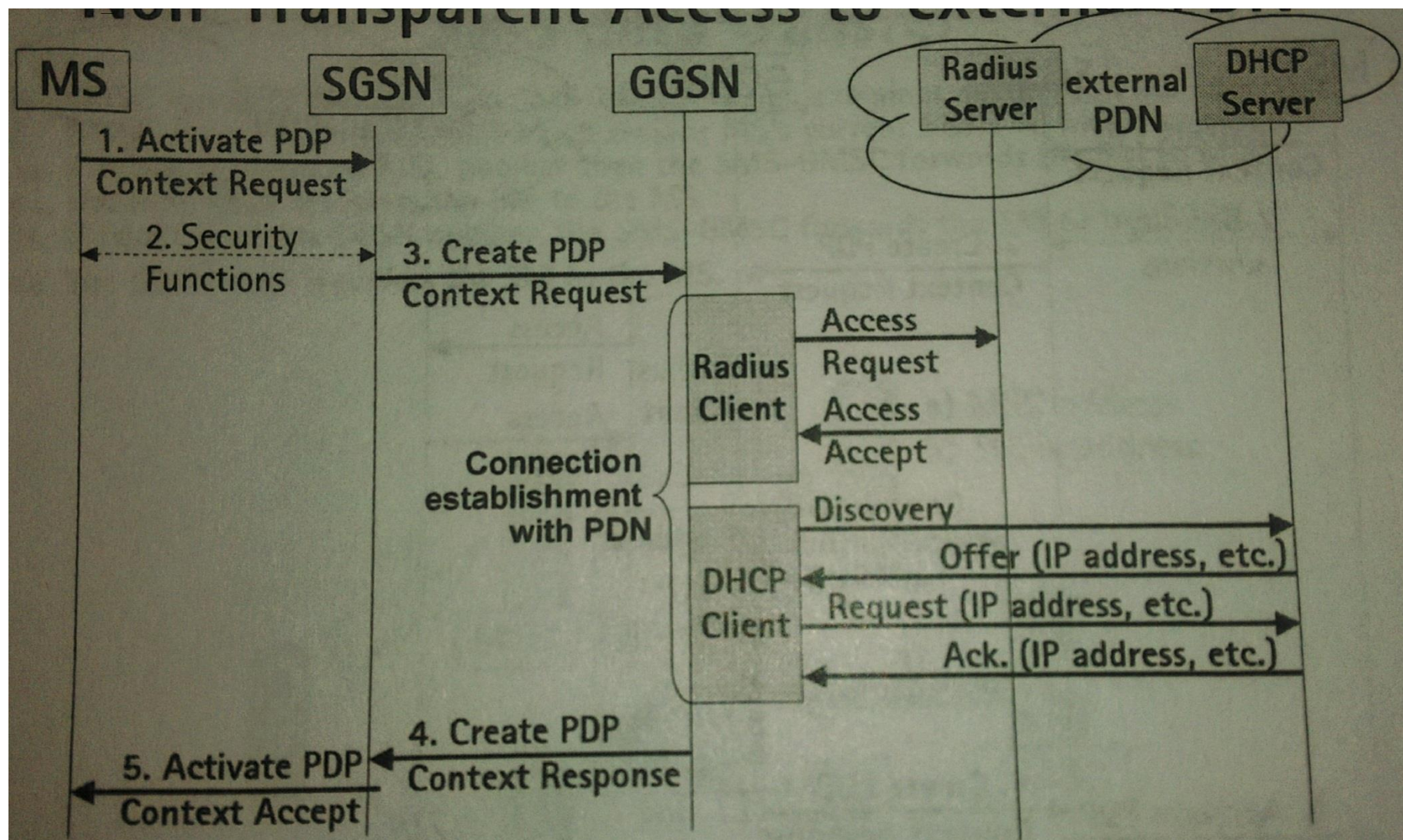
EDGE [2.75 G]

- Bandwidth efficient.

- Higher data rates: 384 kbps.

- Can be used with GPRS
  - EGPRS (Enhanced GPRS) = EDGE + GPRS

UMTS [3 G]

- Universal Mobile Telecommunications System.

- Data rates: 2 Mbps.

- Uses WCDMA (Wide Code Division Multiple Access).

- While not an evolutionary upgrade on the airside, it uses the same core network as the 2G GSM networks deployed worldwide, allowing dual mode mobile operation along with GSM/EDGE.

- Applications:
  - Global Positioning System (GPS).
  - Mobile TV.
  - Video Call.

UMTS architecture
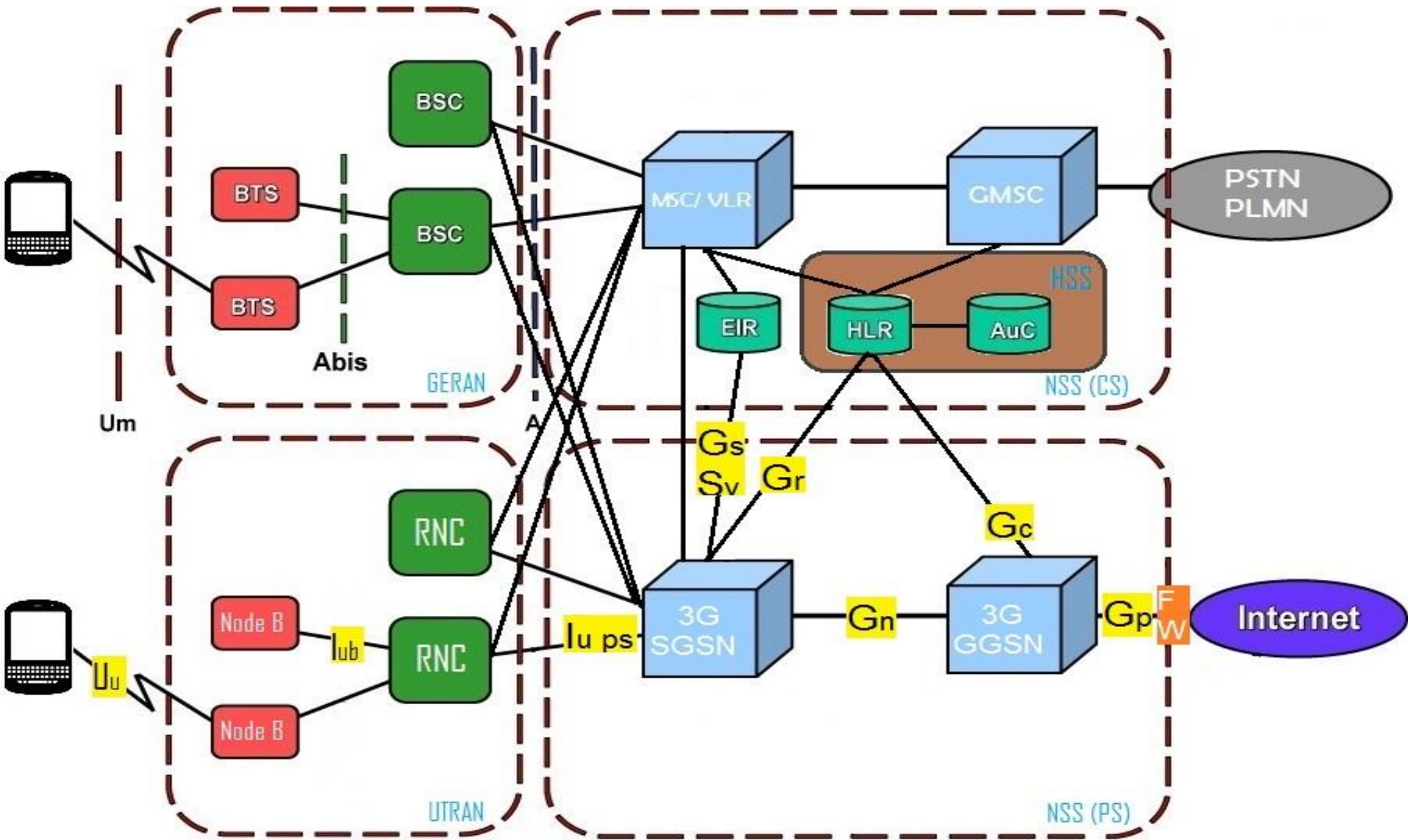
UMTS components

- Node B:
  - The same function as BTS in GSM.
  - Uses WCDMA as air transport technology (Freq: 2100 MHz).
  - Contains radio frequency transmitters & receivers.

- RNC: (Radio Network Controllers)
  - Control of the Node B's.
  - Radio resources management.
  - Mobility Management.
  - Encryption.

- GERAN (GSM EDGE Radio Access Network).

- UTRAN (UMTS Terrestrial Radio Access Network).

UMTS components

- The major advantages of 3G-SGSN over 2G-SGSN are:
    - More powerful processor.
    - Routing for high speed & real time services.
    - Mobility Management (MM) is handled by SGSN & RAN.
    - Compression & Ciphering handled by RAN.
    - Support for multimedia traffic.
    - Support for VoIP traffic through the mobile packet core network.

HSPA [3.5 G] / HSPA+ [3.75 G]

- HSPA
  - 14.4 Mbit/s down.
  - 5.76 Mbit/s up.
  - Is backward-compatible with and uses the same frequencies as W-CDMA.

- HSPA+
  - Further revision and upgrade of HSPA.
  - 168 Mbit/s in the downlink (Theoretical peak data rates).
  - 22 Mbit/s in the uplink.
  - MIMO.

UMTS attach / de-attach scenario

- Attach procedure:
  - UE send an attach request to the new SGSN.
  - The new SGSN identifies the subscriber from old SGSN.
  - Security functions are performed by UE, new SGSN & HLR.
  - The new SGSN update the location area at HLR.
  - The new SGSN send to UE that the attach is accepted.

- De-attach procedure:
  - MS sends to SGSN a detach request.
  - SGSN request the GGSN to delete PDP context.
  - SGSN indicate the MSC with IMSI & GPRS detachment.
  - SGSN send to MS that detach is accepted.

4G

- Provides mobile broadband Internet access.

- All IP packet switched network (IPV6).

- Applications:
  - IP telephony.
  - Gaming services.
  - High-Definition mobile TV.
  - Video conferencing.
  - Cloud computing.

- Uses OFDMA.

- The peak bit rate is further improved by smart antenna arrays for MIMO communications.

- Actual Data rates of 300 Mbit/s (Release 8)

Long Term Evolution (LTE)

- The LTE standard supports only packet switching with its all-IP network. Voice calls in GSM, UMTS are circuit switched, so with the adoption of LTE, carriers will have to re-engineer their voice call network.

  - Voice over LTE (VoLTE).
  - Circuit-Switched FallBack (CSFB).
 - Simultaneous Voice and LTE (SVLTE).

System Architecture Evolution (SAE)

- SAE is the core network architecture of 3GPP's LTE wireless communication standard.

- SAE is the evolution of the GPRS Core Network, with some differences:
  - Simplified architecture.
  - All-IP Network (AIPN).
  - Support for higher throughput and lower latency radio access networks (RANs).
  - Support for, and mobility between, multiple heterogeneous access networks, including E-UTRA (LTE and LTE Advanced air interface), 3GPP legacy systems (for example GERAN or UTRAN, air interfaces of GPRS and UMTS respectively), but also non-3GPP systems.
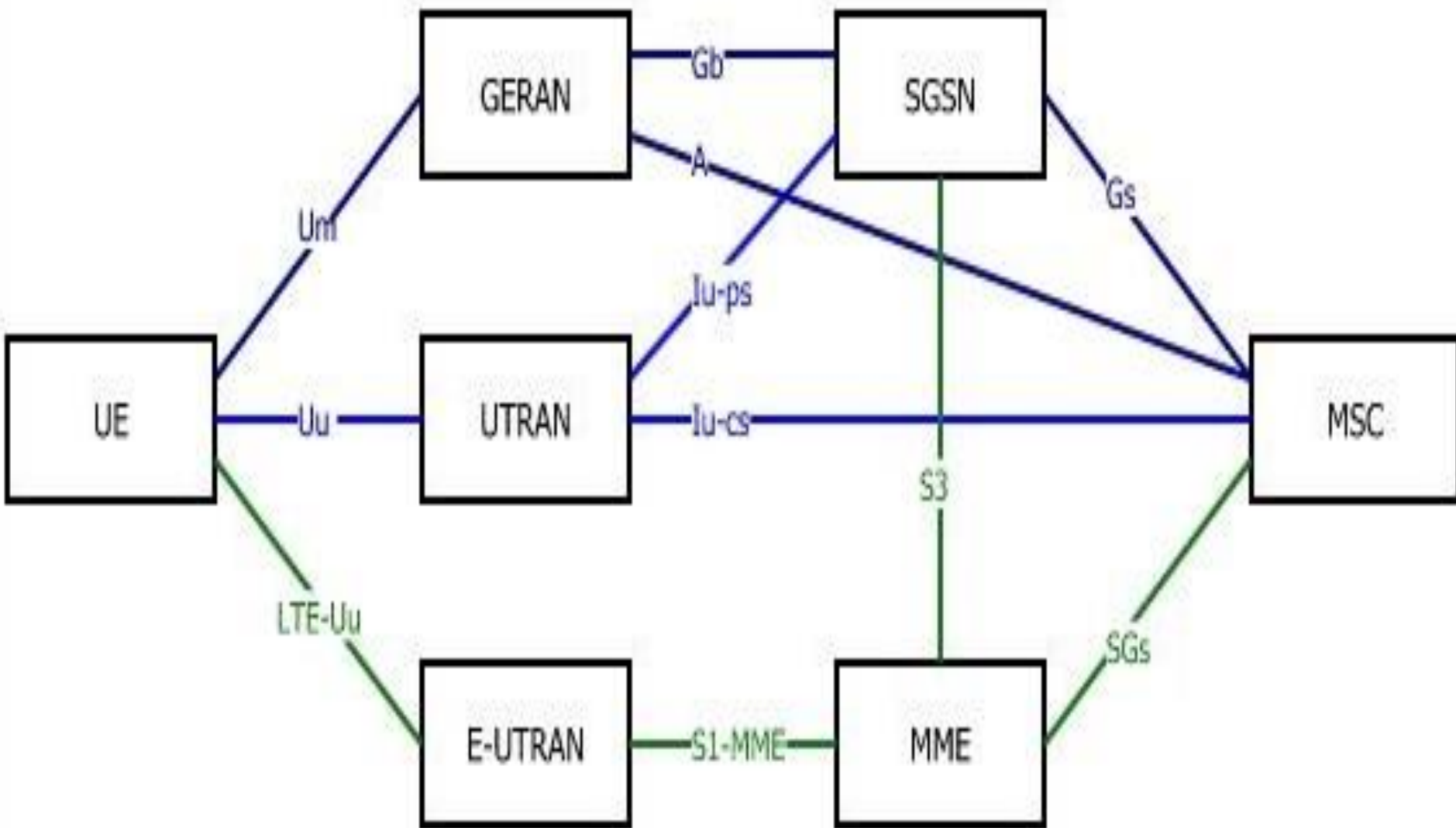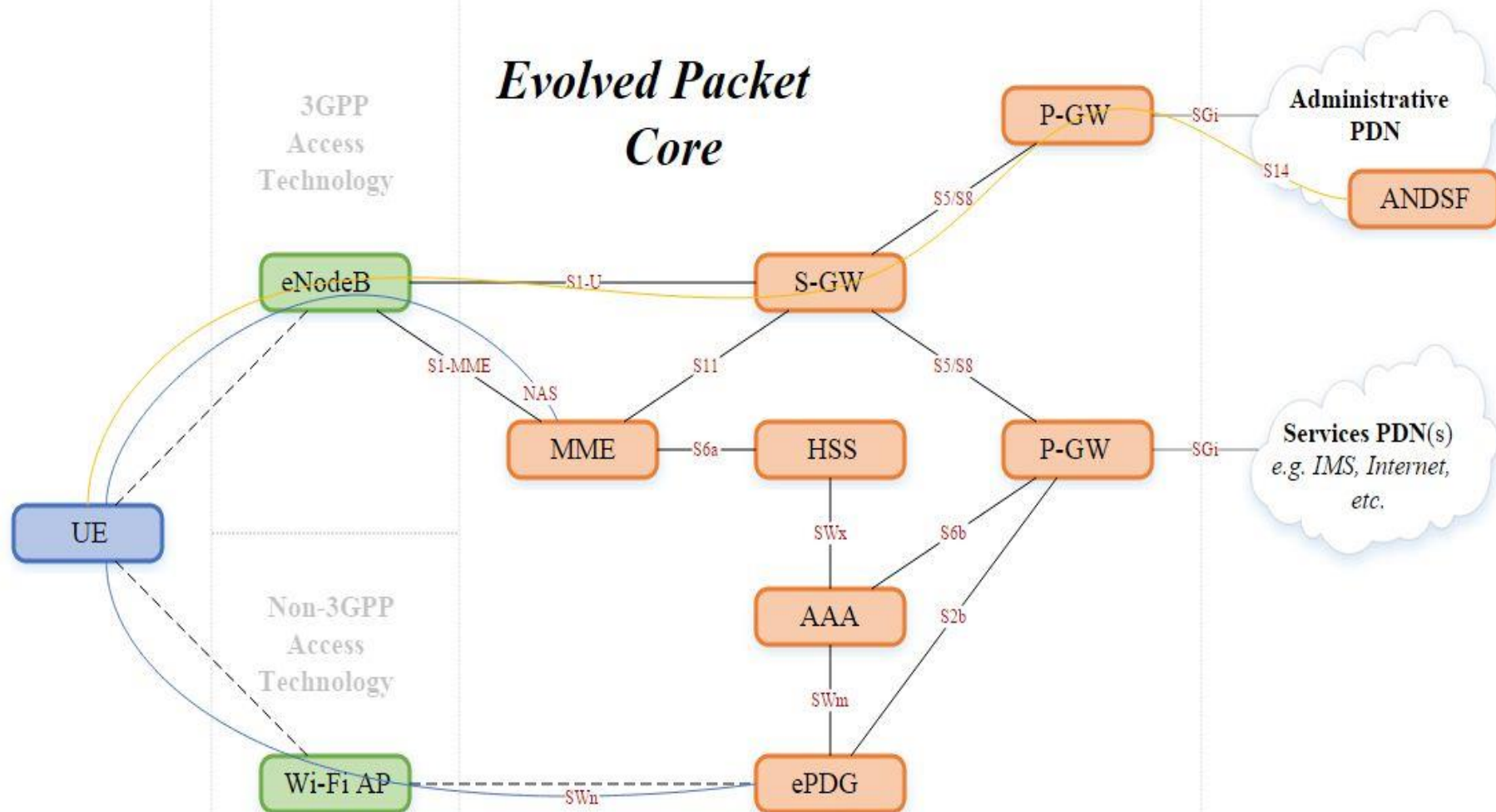
SAE Architecture
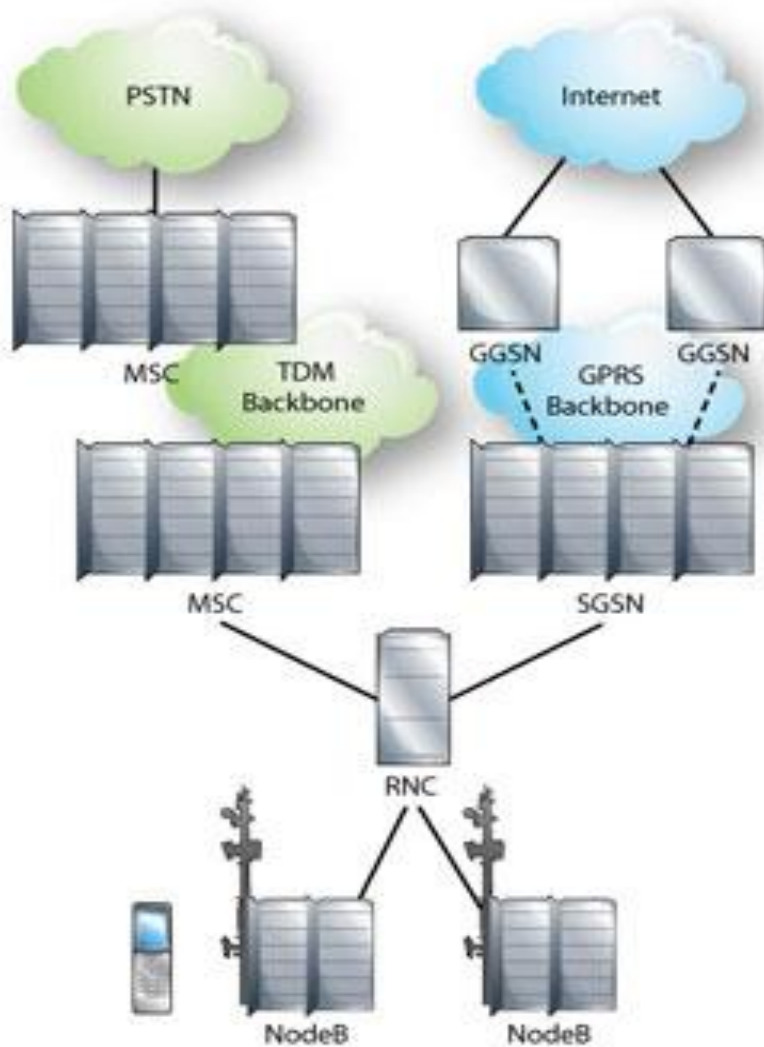
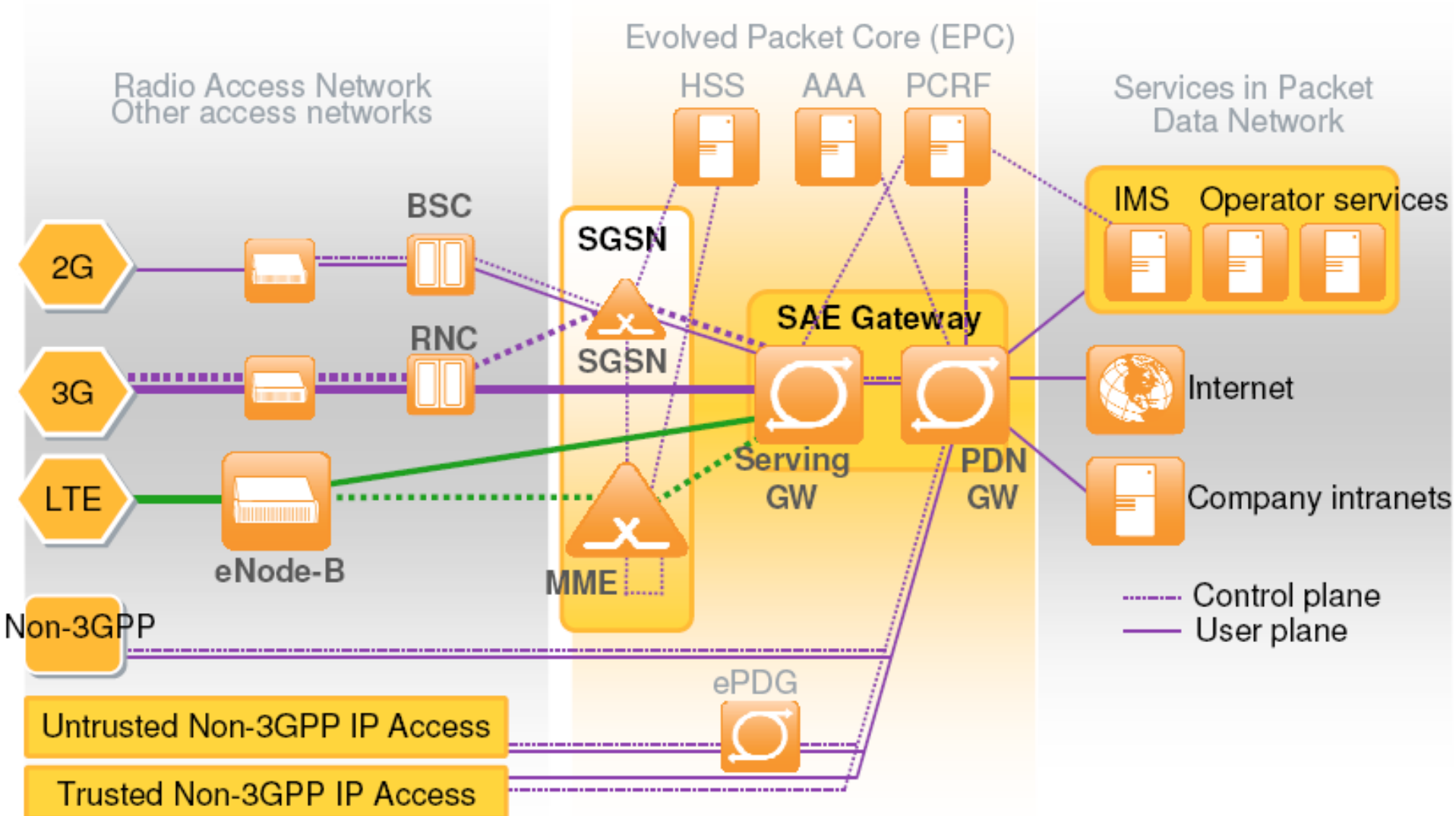

A 3GPP R99 Network
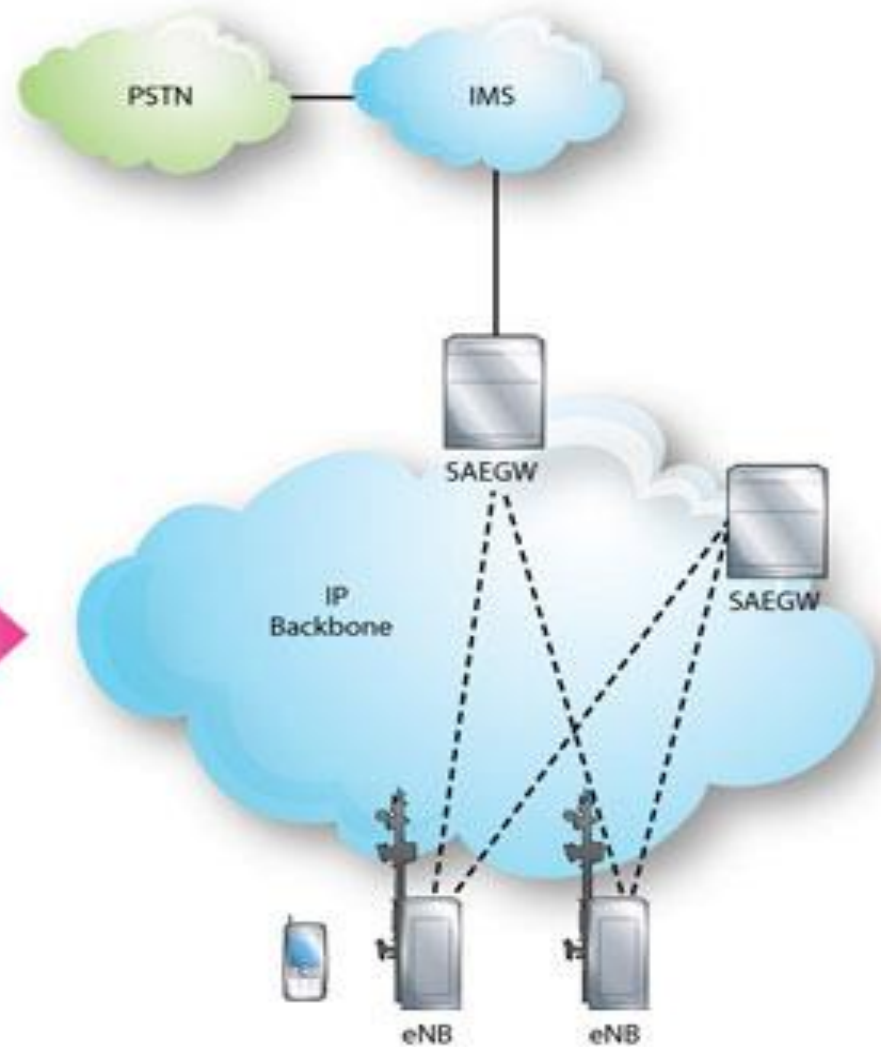
An LTE/SAE Network

SAE Intefaces

SAE Architecture

SAE Architecture

SAE components

- E-UTRAN:
  - No RNC is provided anymore.
  - The evolved Node Bs take over all radio management functionality.

- IP transport layer:
  - EUTRAN exclusively uses IP as transport layer.

SAE components

- MME (Mobility Management Entity):
  - Responsable for idle mode UE paging and tagging procedure including retransmissions.
  - Bearer activation/deactivation process.
  - Responsible for choosing the SGW for a UE at the initial attach.
  - Responsible for authenticating the user (by interacting with the HSS).
  - Checks the authorization of the UE to camp on the service provider's PLMN & enforces UE roaming restrictions.
  - Supports Lawful interception of signaling.

- SGW (Serving Gateway):
  - Routes and forwards user data packets.
  - Terminates the downlink data path and triggers paging when downlink data arrives for the UE.
  - Manages and stores UE contexts.

SAE components

- PGW (PDN Gateway):
  - Provides connectivity from the UE to external packet data networks.
  - A UE may have simultaneous connectivity with more than one PGW for accessing multiple PDNs.
  - Performs policy enforcement, packet filtering for each user, charging support, lawful interception and packet screening.

- HSS (Home Subscriber Server):
  - Central database that contains user-related and subscription-related information.
  - Mobility management, call and session establishment support, user authentication and access authorization.

SAE components

- ANDSF (Access Network Discovery and Selection Function):
  - Provides information to the UE about connectivity to 3GPP and non-3GPP access networks (such as Wi-Fi).
  - Assist the UE to discover the access networks in their vicinity and to provide rules (policies) to prioritize and manage connections to these networks.

- ePDG (Evolved Packet Data Gateway):
  - Secure the data transmission with a UE connected to the EPC over an untrusted non-3GPP access.
  - For this purpose, the ePDG acts as a termination node of IPsec tunnels established with the UE.

SAE Multiple Access Networks

- The UE can connect to the EPC using several access technologies.

- 3GPP accesses:
  - GPRS, UMTS, EDGE, HSPA, LTE and LTE Advanced.

- non-3GPP accesses:
  - Trusted accesses: can accesses interface directly with the network.
    - (CDMA 2000)
  - Untrusted accesses: connected to the network via an ePDG, which provide additional security mechanisms (IPsec tunneling).
    - WIFI.