

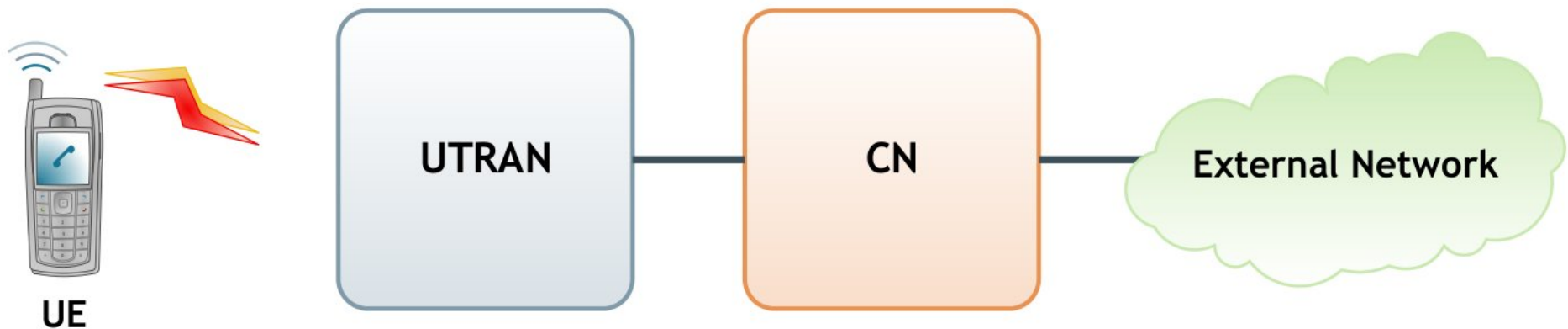
# Voice services in 3/4G networks

Ján Kučerák

ČVUT FEL, Katedra telekomunikační techniky  
kucerj17@fel.cvut.cz

# UMTS architecture

- UTM Release 99
  - New air interface and access network UTRAN
    - WCDMA (Wideband Code Division Multiple Access)
    - FDD ( symmetric channel)
    - TDD ( asymeric channel)
    - Radio Channel 5 MHz
  - Core network based on the GSM/GPRS NSS



UE	User Equipment
UTRAN	UMTS Terrestrial Radio Access Network, (or RAN)
CN	Core Network

# New Entities in UMTS R99

PLMN

Databases

PDN

PS

CS

PSTN

UTRAN



UE



Node B



RNC

# Node B functionality

- Spreading and Modulation
  - code generation
  - supports FDD, TDD or both, and CDMA
- Fast power control ("Inner Loop")
  - Node B measures strengths of received signals and informs UE if it needs to adjust
- measures connection quality and strength
- handover

# RNC functionality

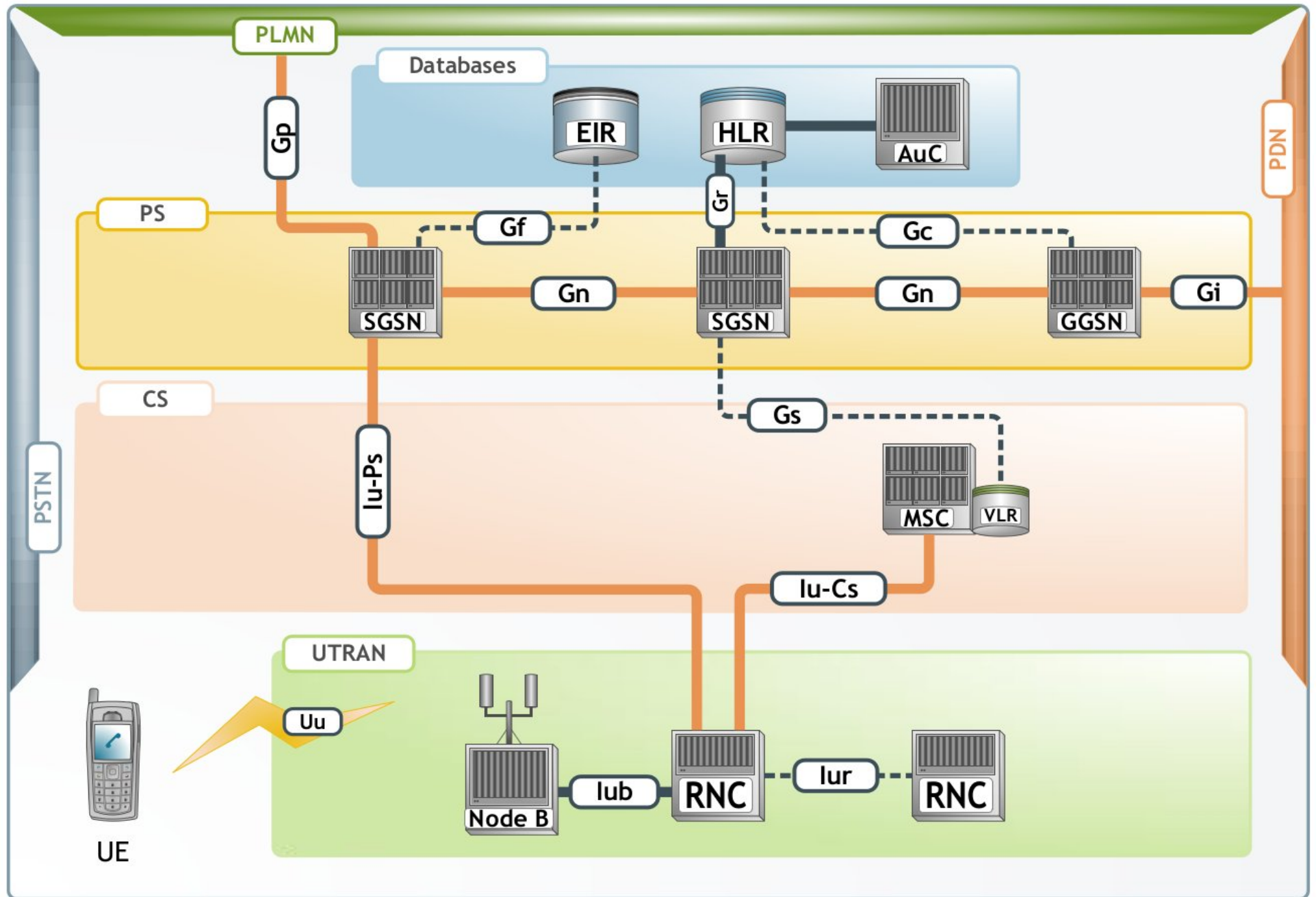
## Radio Resource Management

- guarantees stability and QoS of radio connection (radio bearer)
  - Power control ("outer loop")
  - Handover control
    - decide based on measurements by UE and Node B
  - Admission control and packet scheduling
    - can a new session be established on the UTRA without compromising the quality of existing sessions?
    - Plan channel use, calculate interference and utilisation levels
    - Configure radio resources accordingly
  - Code management
  - Macrodiversity management

## Reallocation

- For each UE, one RNC is responsible - Serving RNC (SRNC)
- If the UE moves to a cell controlled by a different RNC, this becomes the Drift RNC (DRNC) but control stays with SRNC

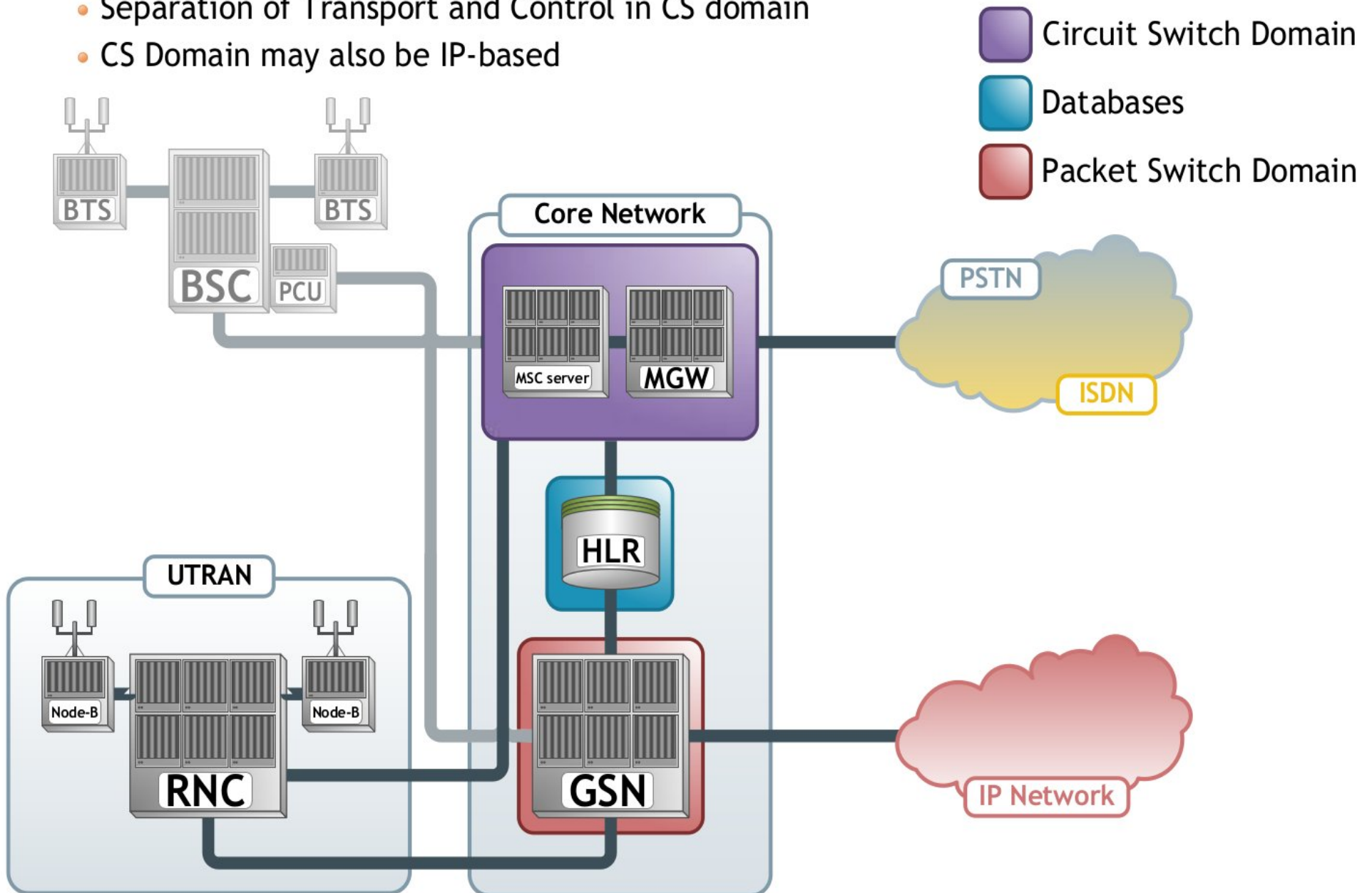
# UMTS Interfaces R99



# UMTS Architecture

- UMTS Release 4

- Separation of Transport and Control in CS domain
- CS Domain may also be IP-based



# UMTS Architecture

- UTRAN Evolution

- IP transport in UTRAN (...instead of ATM)

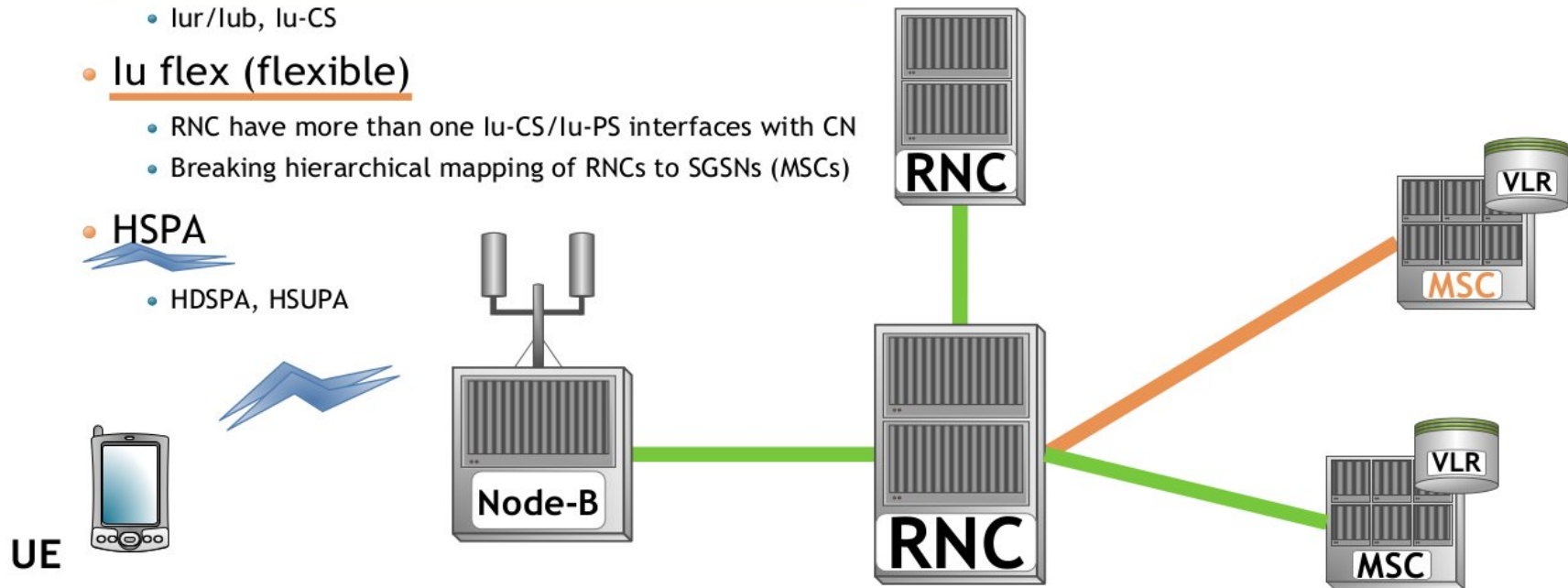
- Iur/Iub, Iu-CS

- Iu flex (flexible)

- RNC have more than one Iu-CS/Iu-PS interfaces with CN
  - Breaking hierarchical mapping of RNCs to SGSNs (MSCs)

- HSPA

- HSDPA, HSUPA





# UMTS Architecture

- UMTS Release 5

## Core

- New core entities known as IP Multimedia Subsystem platform

## IMS

- is a global service control architecture that enables various types of multimedia services to end user using common Internet-based protocols
- multimedia services are e.g. Video, voice, possibly simultaneously with data etc.
- the PS domain just provides QoS, it does not provide multimedia services (app. layer)
- the PS domain serves as access system to the IMS
- the IMS in principle is access-system independent

# Main Entities in IMS

## CSCF (Call Session Control Function)

- Processes SIP signaling in the IMS

## P-CSCF

- First point of contact between the IMS terminal and network
- Security
- Compression of signaling messages

## I-CSCF

- Assigning S-CSCF - upon reception of registration request from UE
- Routing incoming requests further to an assigned S-CSCF

## S-CSCF

- Central node of the IMS signaling plane
- Registration of user, Authentication
- Routing decisions

## HSS

- Instead of HLR (mobility management, security, identification, etc.)

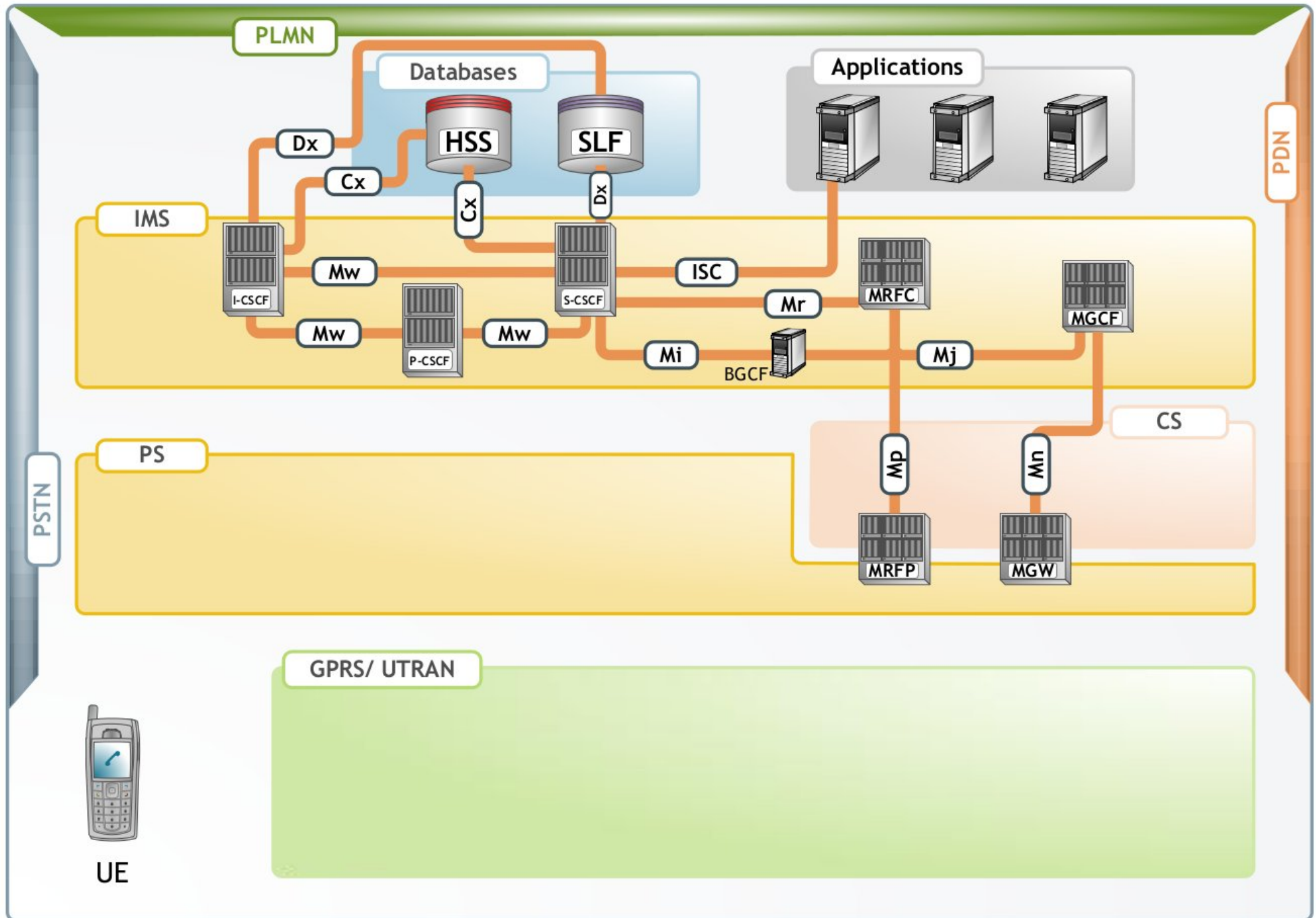
## MGCF

- Handling of protocol conversion between ISUP and IMS call control protocols
- Exchange of signalling related to IP services between UMTS and CS networks

## MRF

- Setting up multimedia connections

# UMTS Interface R5



# Evolution of network architecture

Public circuit-switched network

Public or private IP network

PSTN

PSTN

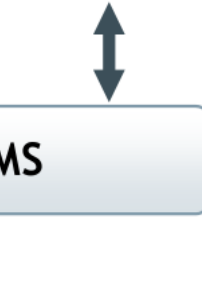
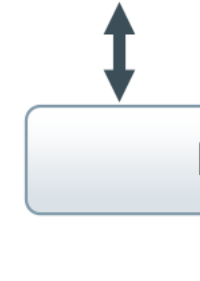
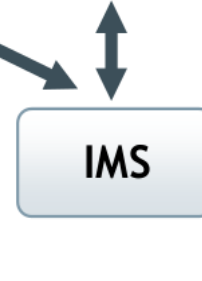
IP

PSTN

IP

PSTN

IP



Cs

Cs

Ps

Cs

Ps

IMS

Packet Core

Access

Access

Access

Access

2G initial architecture (GSM)

2G packet evolution (GPRS/EDGE)

3G IMS evolution

EPS architecture

(1991)

(2000)

(2004)

(2008/200?)

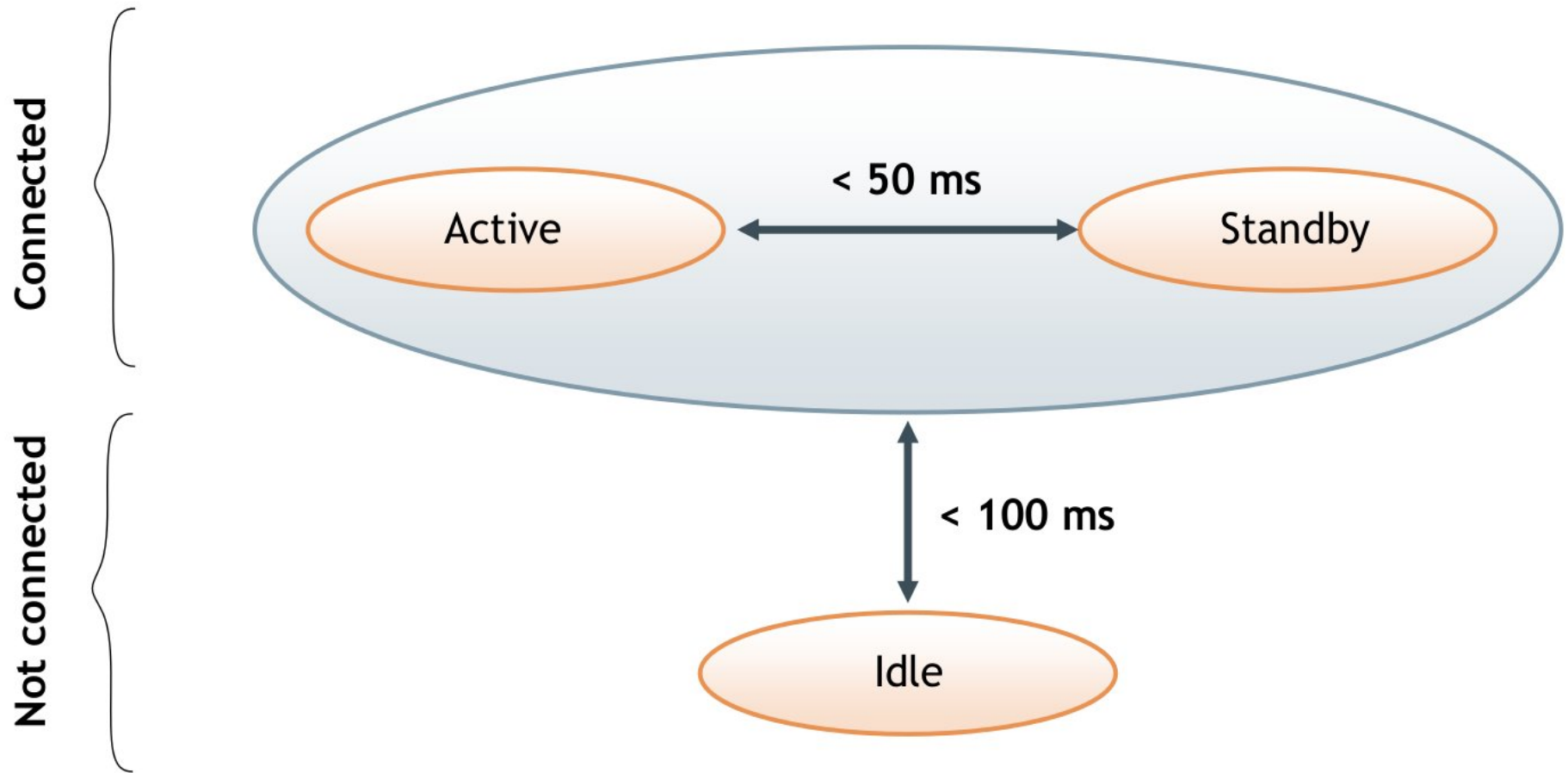
# The Access Network Requirements

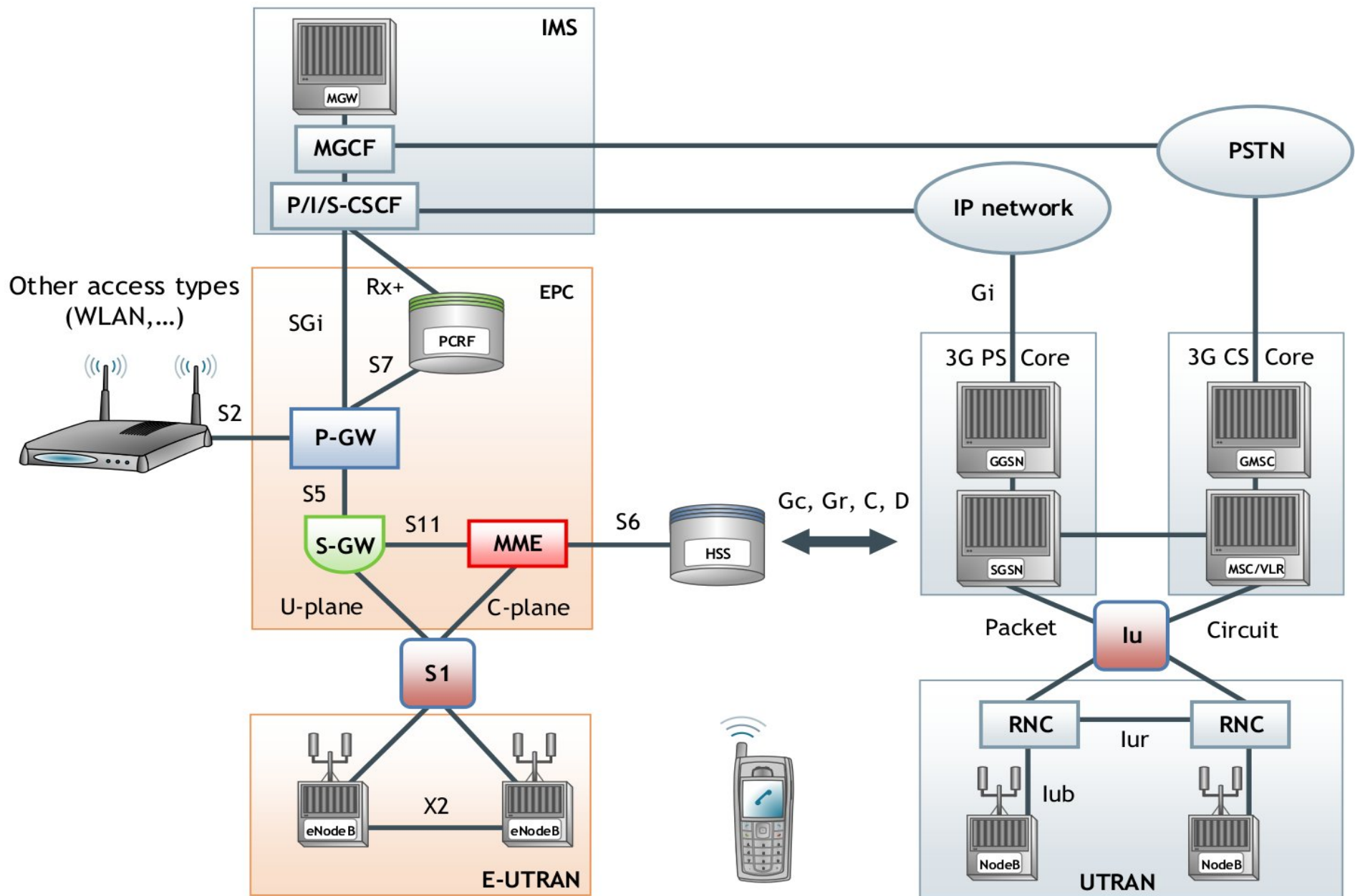
- Radio interface throughput
- Data transmission latency
- Terminal state transition requirements
- Mobility requirements
- Flexibility in spectrum usage
- Mobility requirements between systems

# Radio Interface Throughput

- instantaneous downlink (from network to terminal)  
peak data rate of 100 Mb/s within a 20 MHz downlink spectrum
- an instantaneous uplink (from terminal to network)  
peak data rate of 50 Mb/s within a 20 MHz
- corresponds to a spectrumefficiency:
  - 5 bits/s/Hz for the downlink,
  - 2.5 bits/s/Hz for the uplink
- (compare to max 2.9 bits/s/Hz for downlink for UMTS)

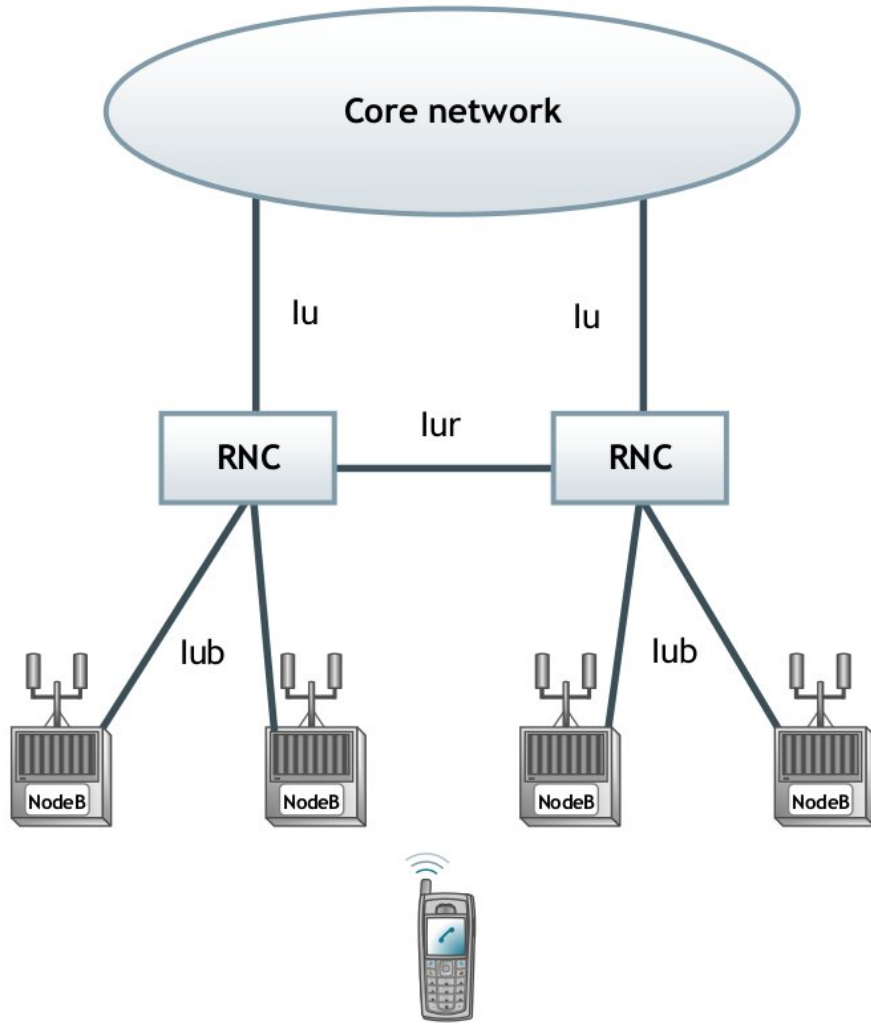
# Terminal State Transition



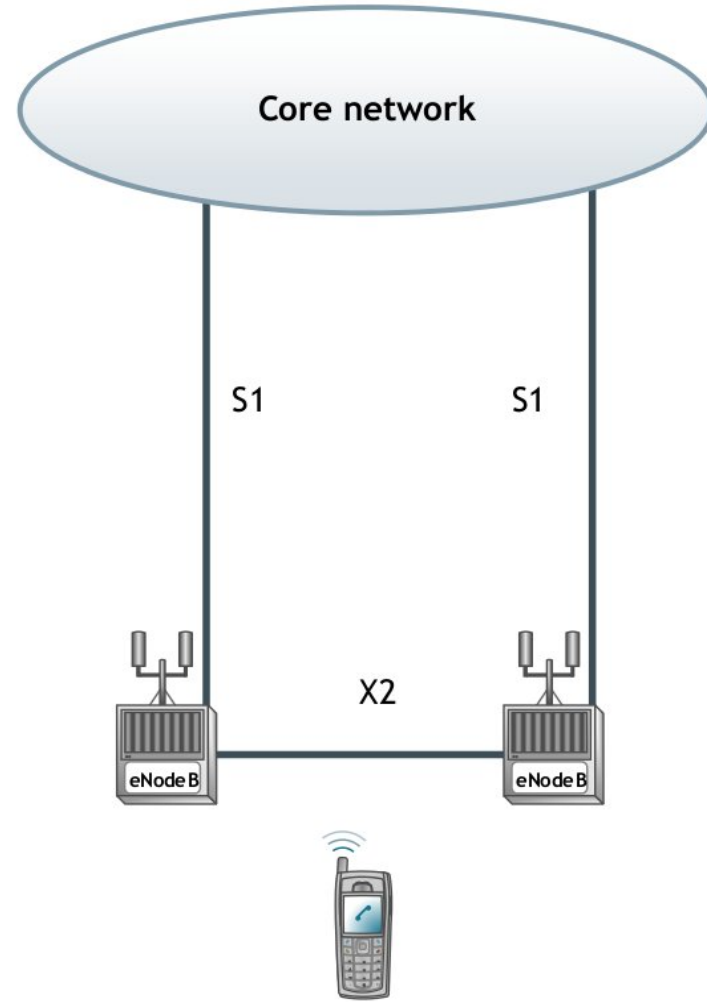




# UTRAN vs E-UTRAN

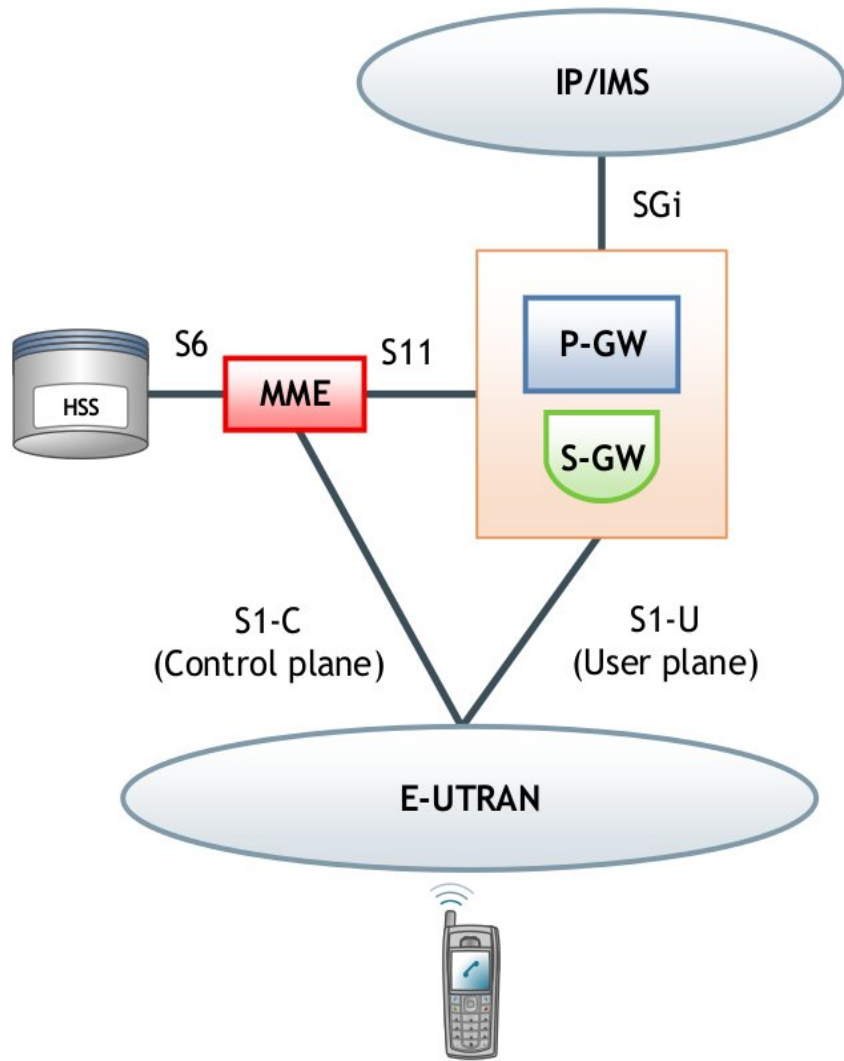


UTRAN architecture

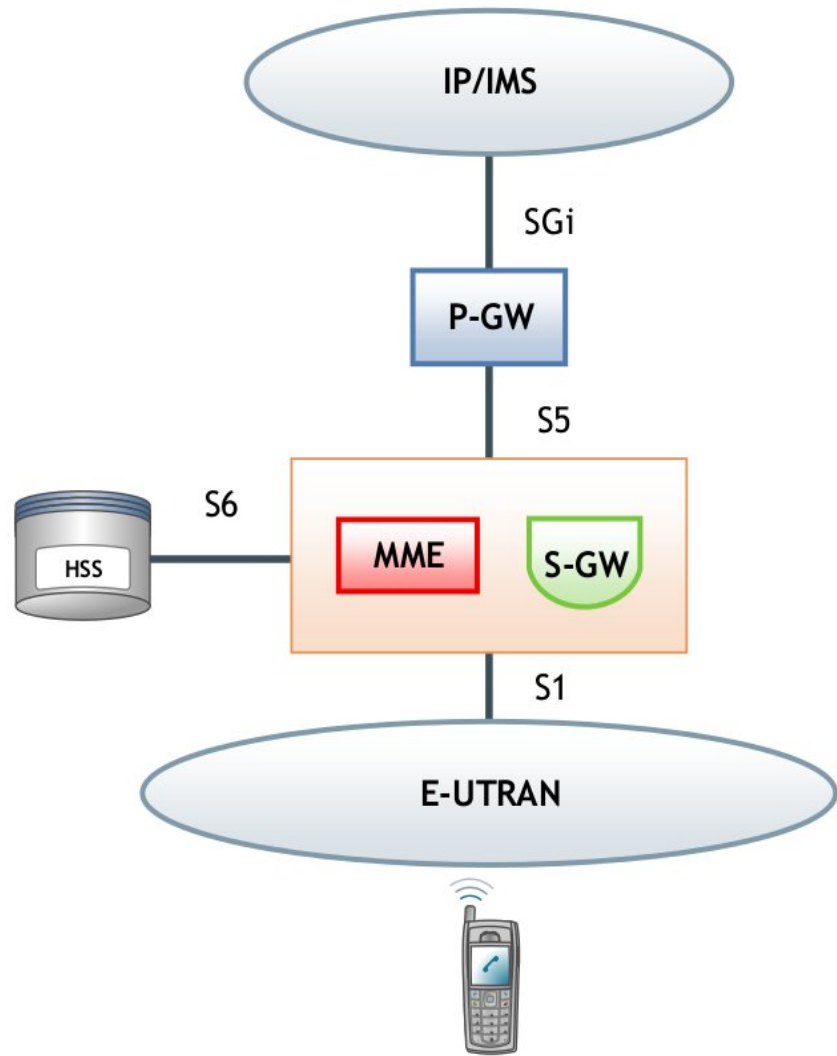


E-UTRAN architecture

# Physical nodes & functions merging



Merging the two gateways



Merging S1 Control and User planes

# Network entities

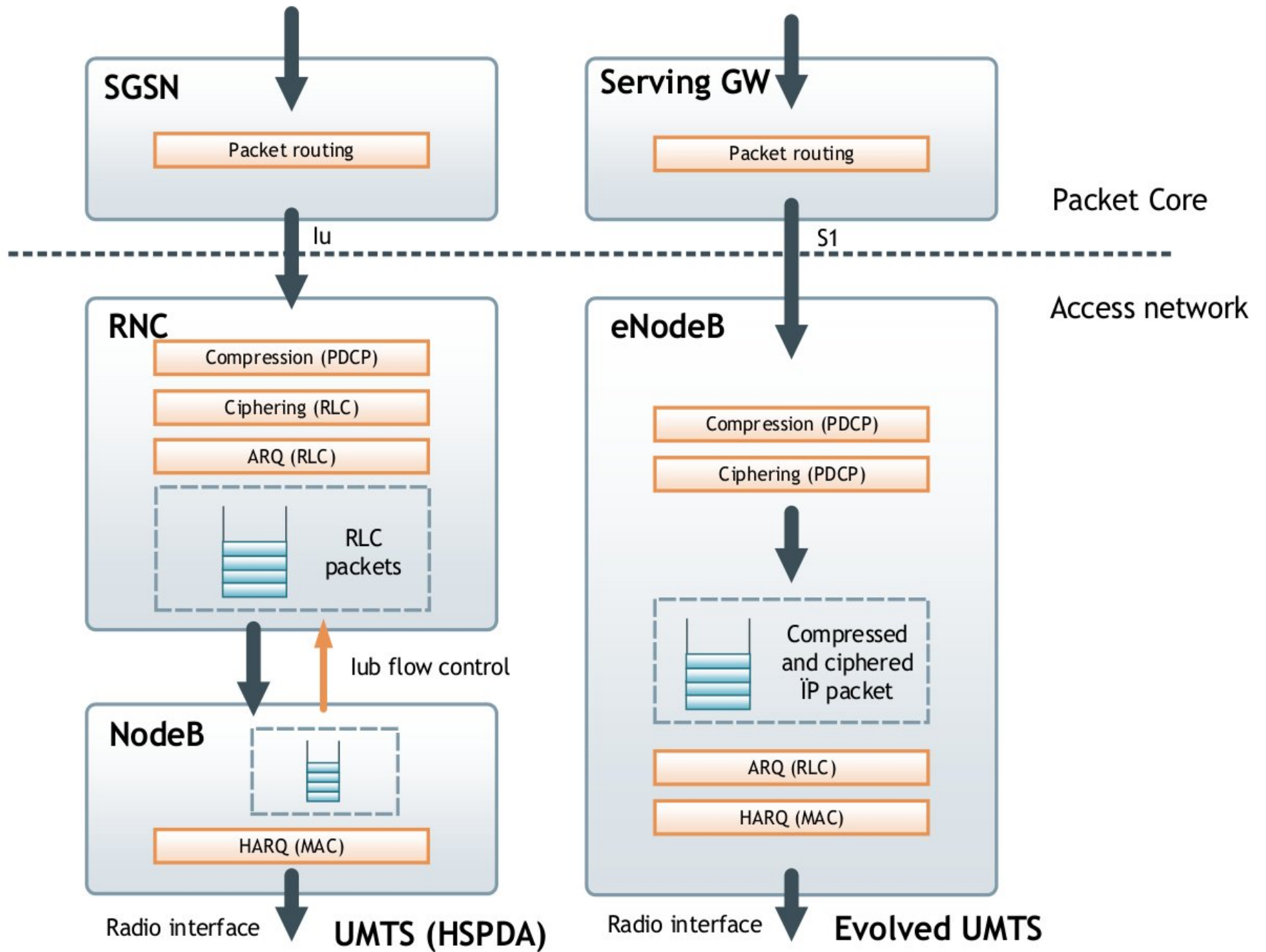
- eNodeB,
- Mobility Management Entity (MME)
- Serving GW (S-GW)
- PDN GW(P-GW)
- PCRF

# eNodeB

- in charge of radio interface
  - radio resource management
  - radio bearer control
  - radio admission control
  - scheduling of uplink and downlink
- provides IP header compression and encryption of the user-plane data

## eNodeB 3G equivalent

- 3G equivalent would be NodeB of course, but eNB is much smarter than NB
- since there is no RNC any more eNB takes care of all the functions RNC was responsible for in UTRAN



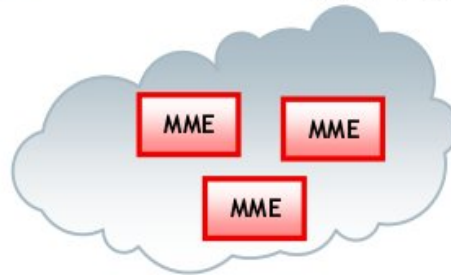
# MME

**Control Plane only**

**Implementation**

- separate box
- as part of SGSN
- or integrated with S-GW

**S1Flex:** MME-Pool

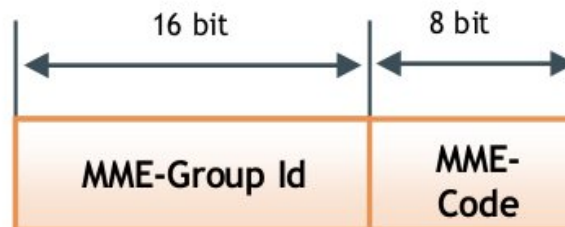


Pol Area



**Identification**

- Through MEI:



# Mobility Management Entity MME

- main node for control of the LTE access network
- selects the Serving GW for a UE
  - during the initial attachment
  - during handover
- responsible for
  - tracking and paging procedures during UE Idle mode
  - activation and deactivation of bearers on behalf of a UE
    - EPS session management
  - end-user authentication, communicates with HSS(also in roaming case, S6a int. )
  - control-plane functionality for legacy networks mobility ( LTE and 2G/3G access networks, the S3 int. to SGSN)



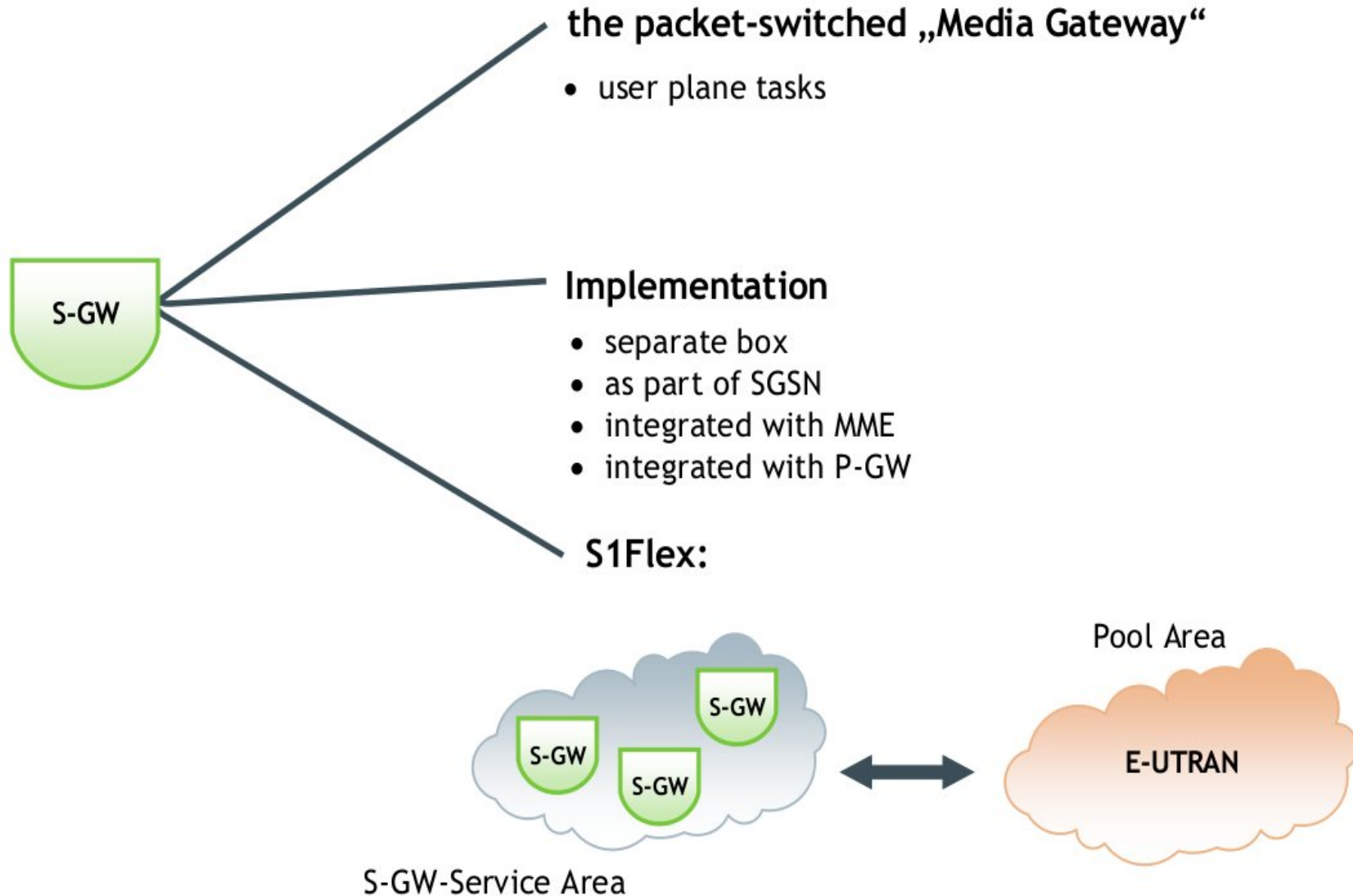
# MME

- MME is fully responsible for Non-Access Stratum (NAS) signaling with UE
- acts as the termination point in the network for the security of NAS signaling
  - handling the ciphering protection
  - management of security keys
- handles lawful intercept related to signaling

# MME 3G equivalent

- 3G equivalent is a control plane part of SGSN

# S-GW



# Serving GW (S-GW) 1/3

- terminates the interface towards E-UTRAN
- every UE that attaches to an EPS is associated with a single Serving GW
- selected for the UE based on network topology and UE location just like MME
  - The Domain Name Service (DNS) may be used to resolve a DNS string of possible Serving GW addresses that serve the UE's location

## S-GW 2/3

- handles the forwarding of end-user data packets
- acts as a local anchor point for inter-eNodeB handover
- terminates the S4 interface
  - provides a connection for the transfer of user traffic from 2G/3G network systems and the P-GW

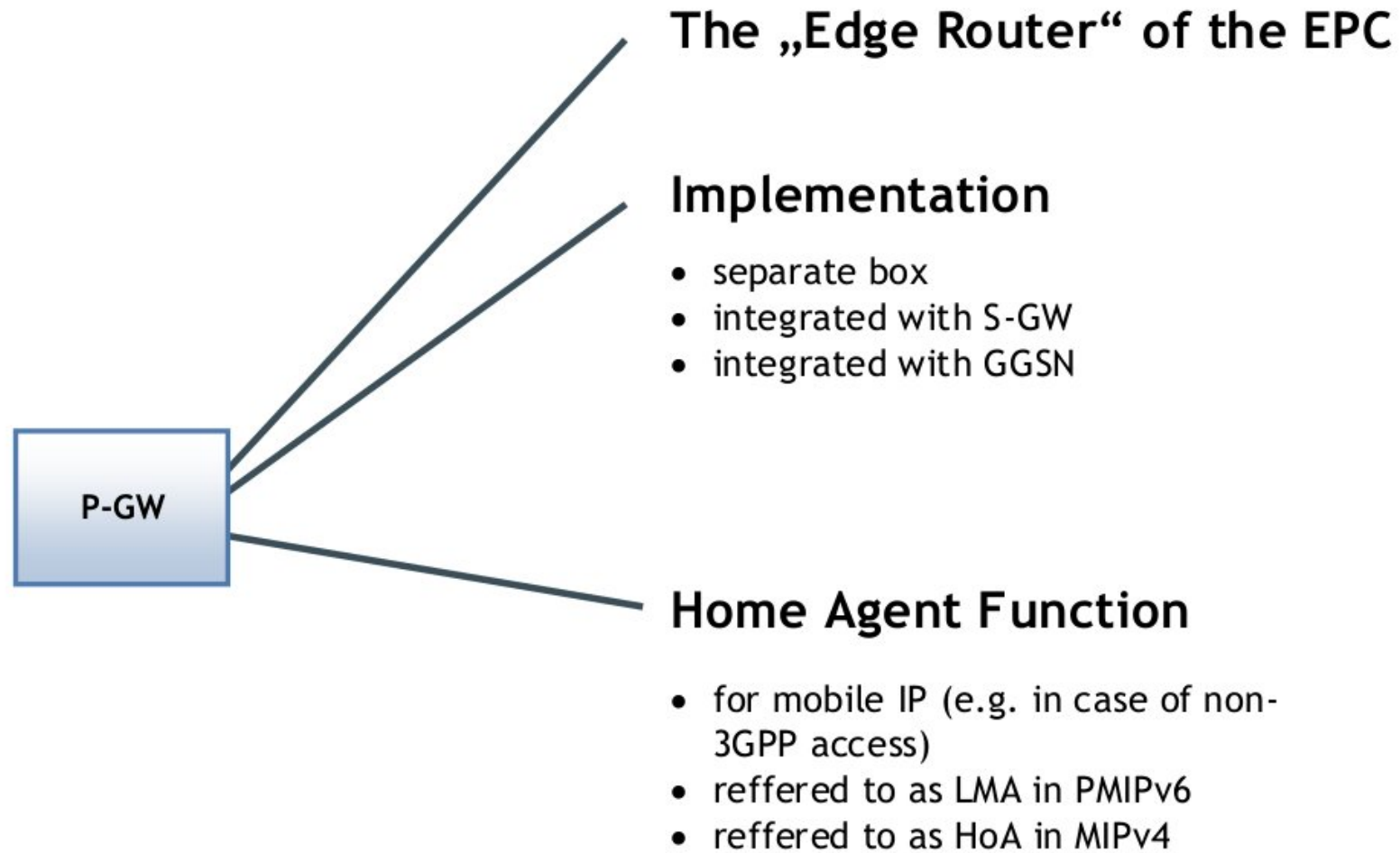
## S-GW 3/3

- terminates the downlink (DL) path for data during UE idle state
  - If new packets arrive, triggers paging
- responsible for the reproduction of user traffic for lawful interception purposes

# S-GW 3G equivalent

- user plane part of SGSN

# P-GW





# PDN GW (P-GW) Packet data network gateway

- provides connectivity to external PDNs for UE
- entry and exit point for the UE data traffic
- allocates an IP address to the UE
- may perform deep packet inspection or packet filtering on a per-user basis
- performs service-level gating control
- rate enforcement through rate policing and shaping.
- From a QoS perspective, marks the uplink and downlink packets with, for example, the DiffServ Code Point.

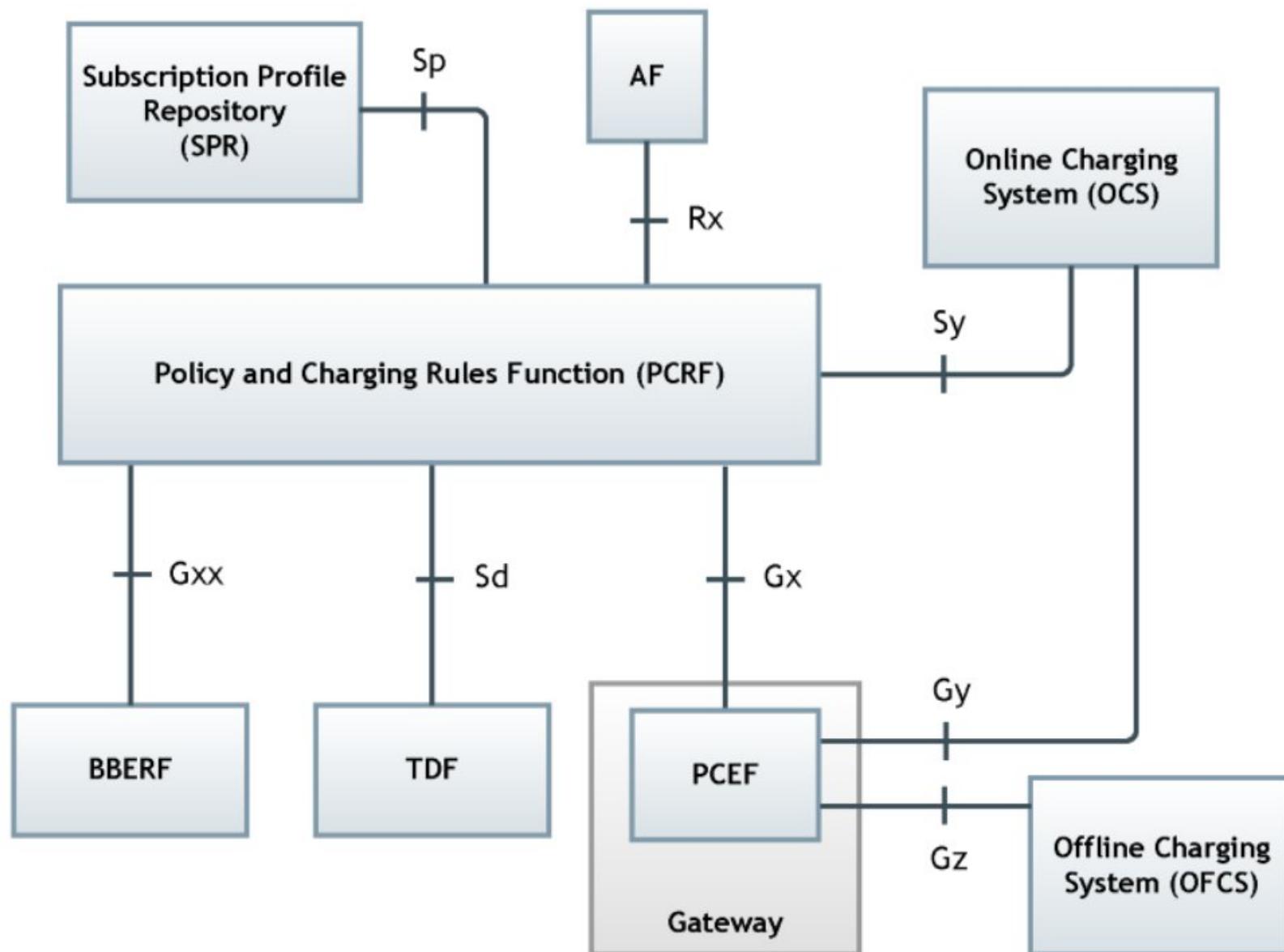
# P-GW 3G equivalent

- GGSN for sure

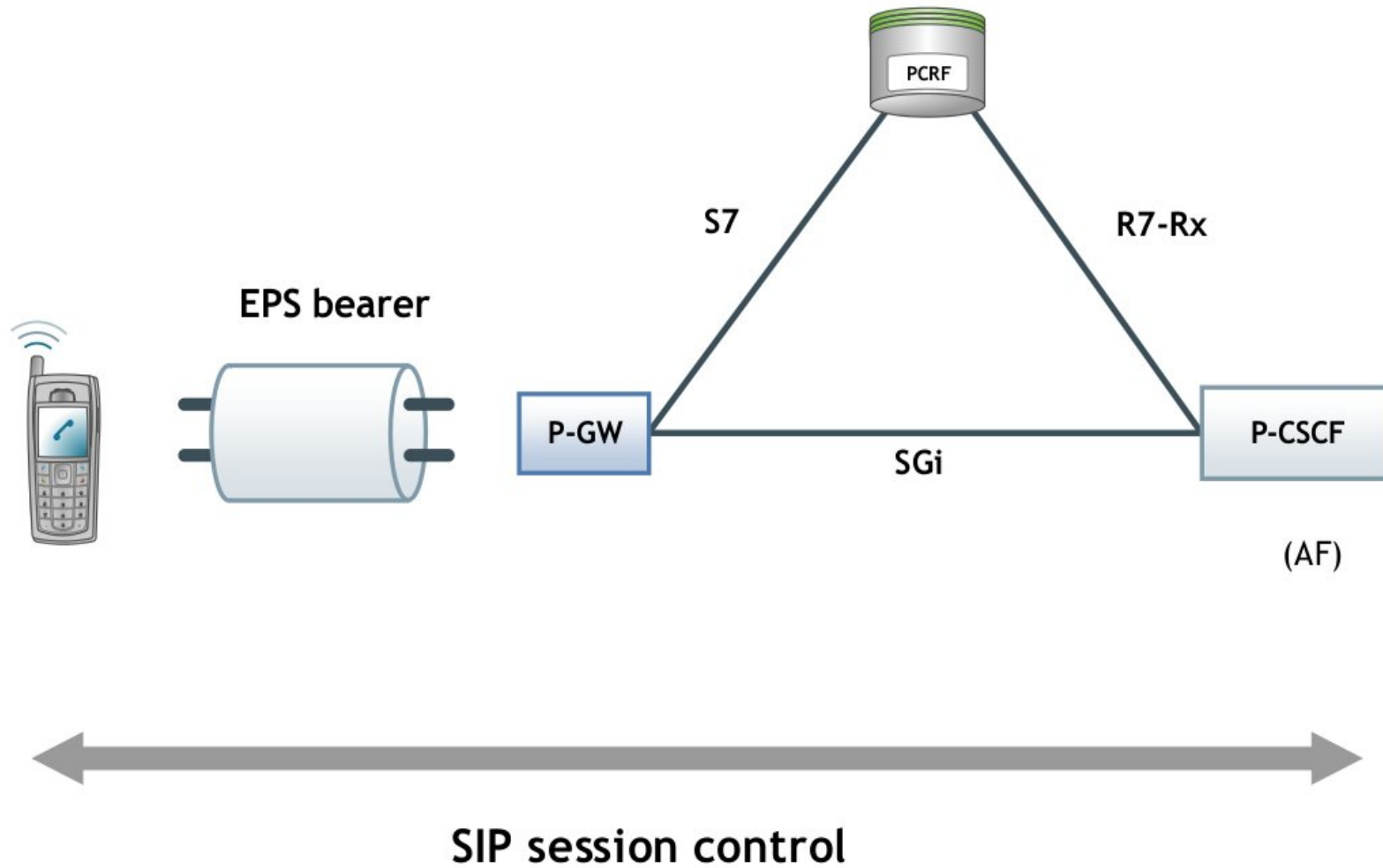
# Policy and Charging Rules Function PCRF

- policy and charging control element of the SAE architecture
- provides network-based control related to:
  - service data flow detection
  - gating
  - QoS, and flow-based charging
- the control is provided towards the Policy and Charging Enforcement Function (PCEF).
- not responsible for credit management

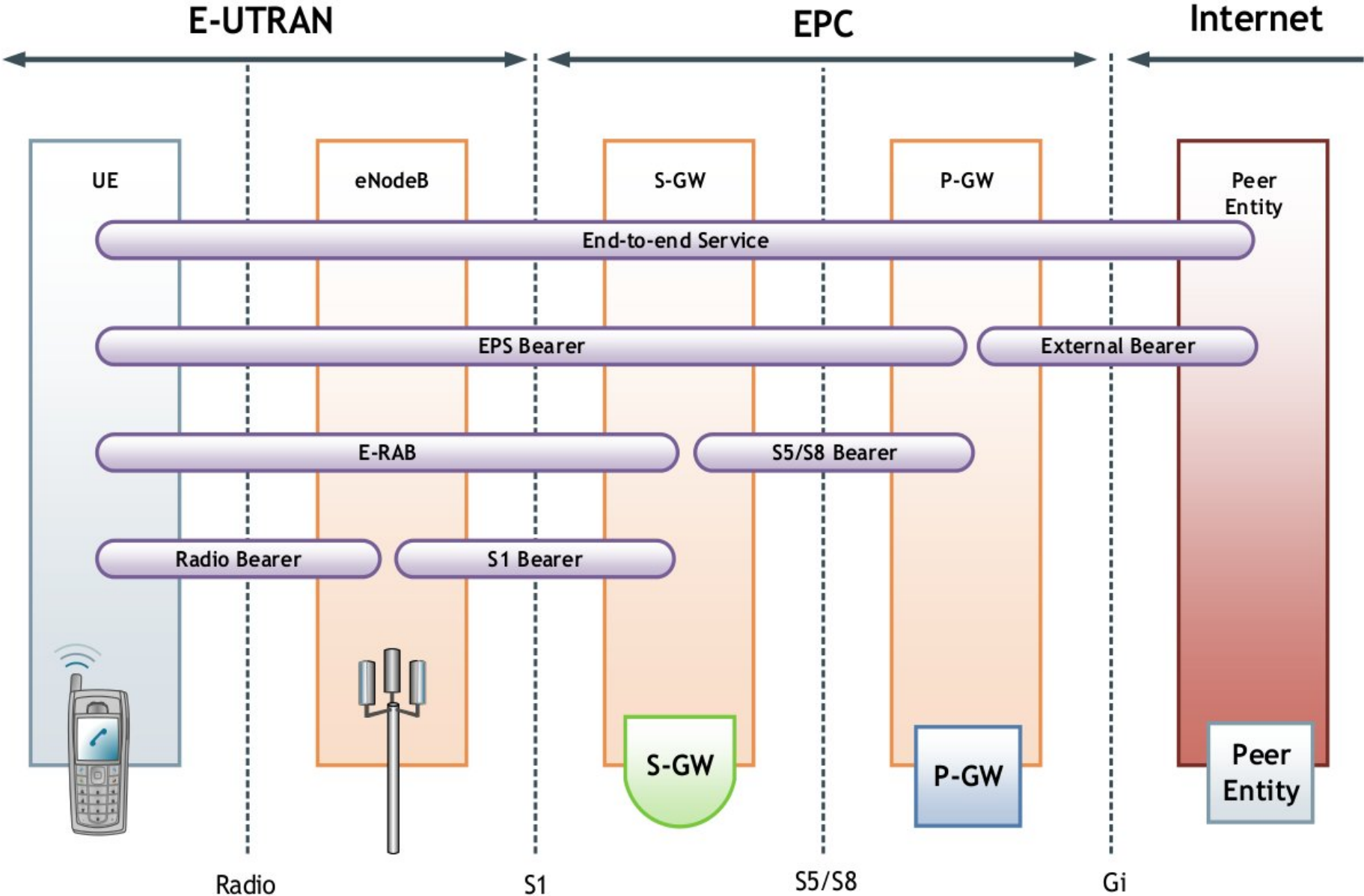
# Overall PCC architecture (non-roaming)



# EPC & PCC



# EPS bearer



Voice ??

SV-LTE

CSFB?

IMS...

VoLGA ?

**Lte**™

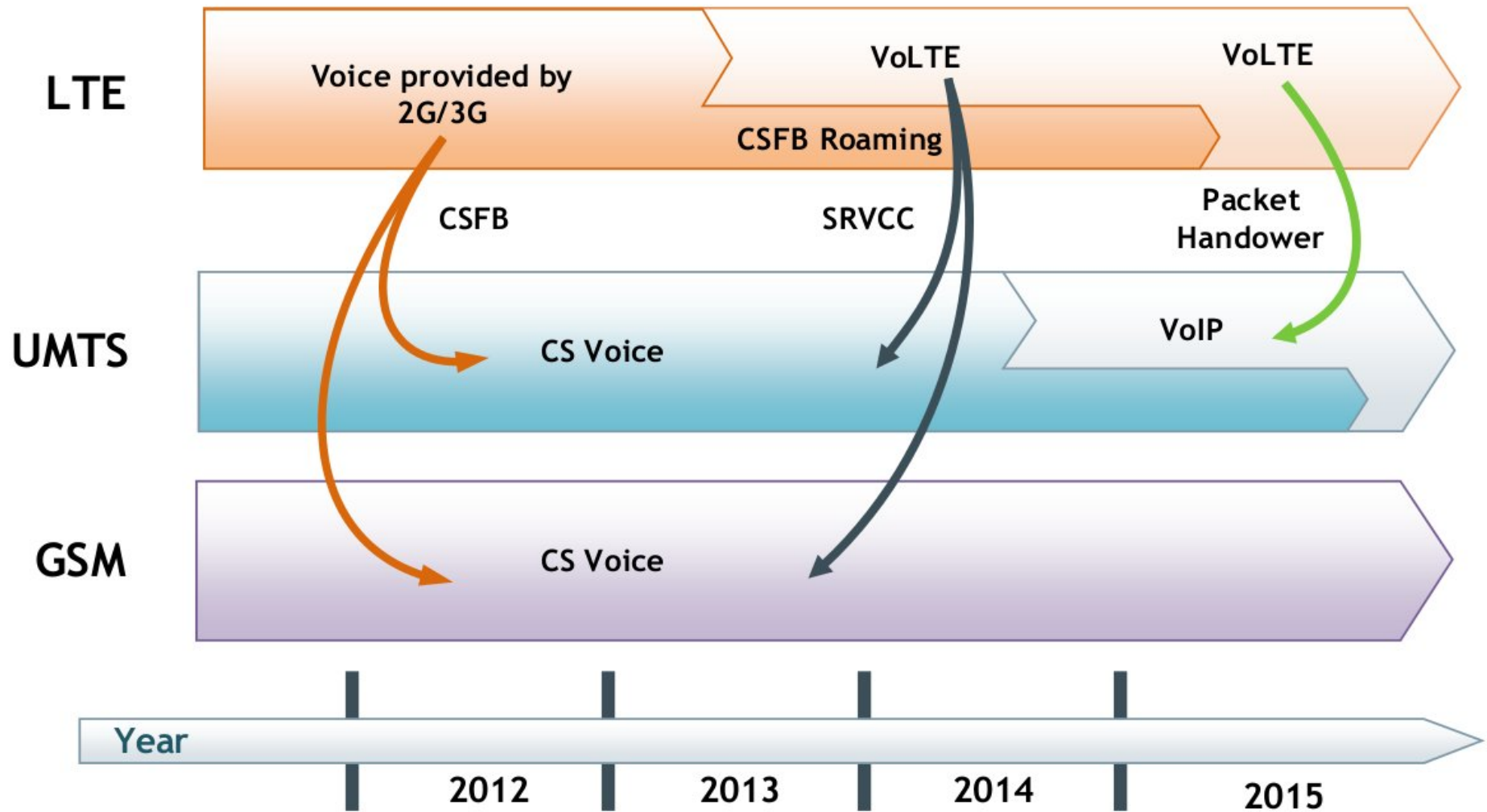


# Voice in LTE alternatives

- CSFB
- VoLGA
- SVLTE
- OTT
- VoLTE
- SRVCC



# Voice evolution



CSFB: Circuit Switched Fallback

SRVCC: Single radio Voice Call Continuity (if LTE coverage ends)