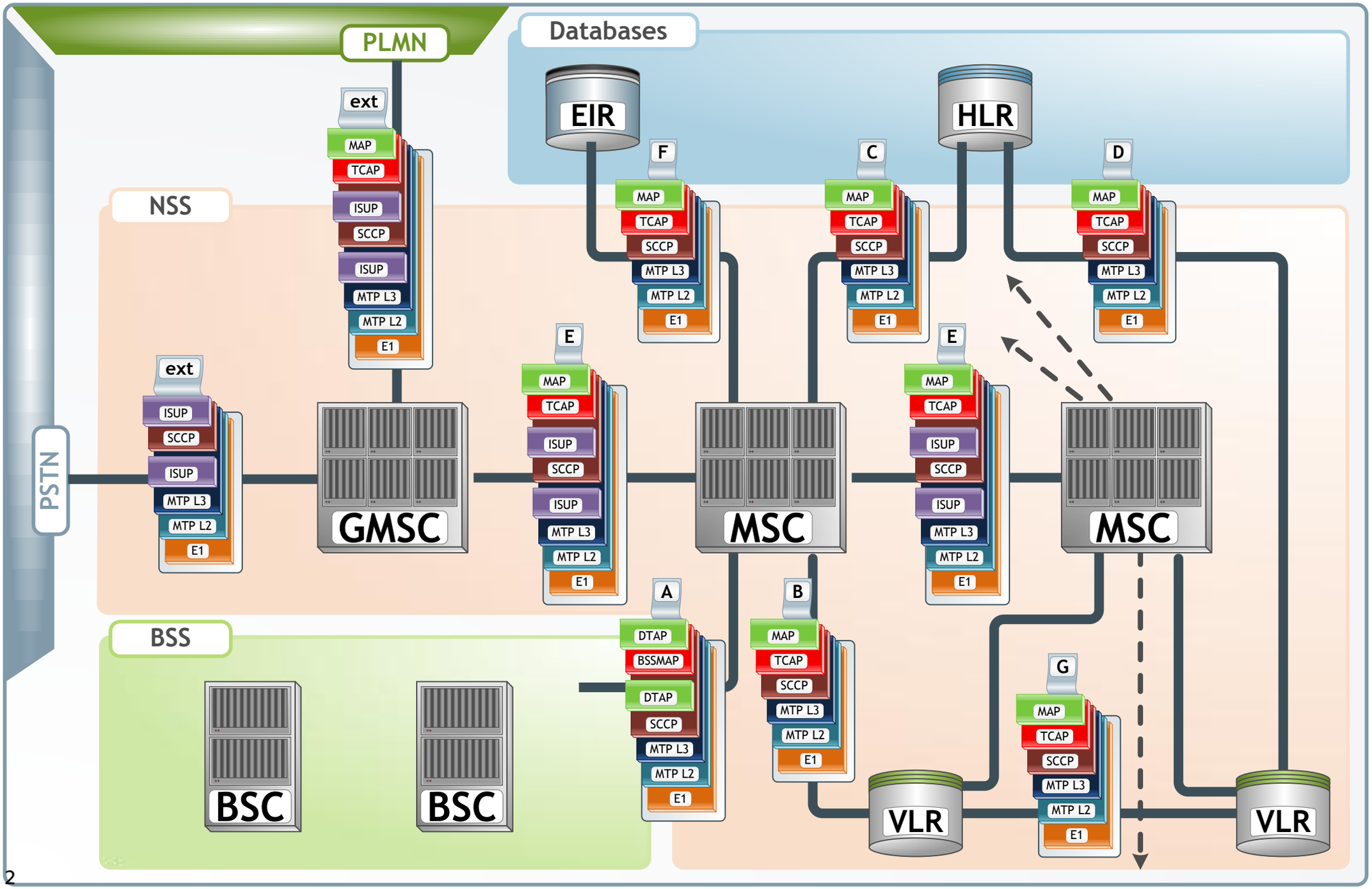
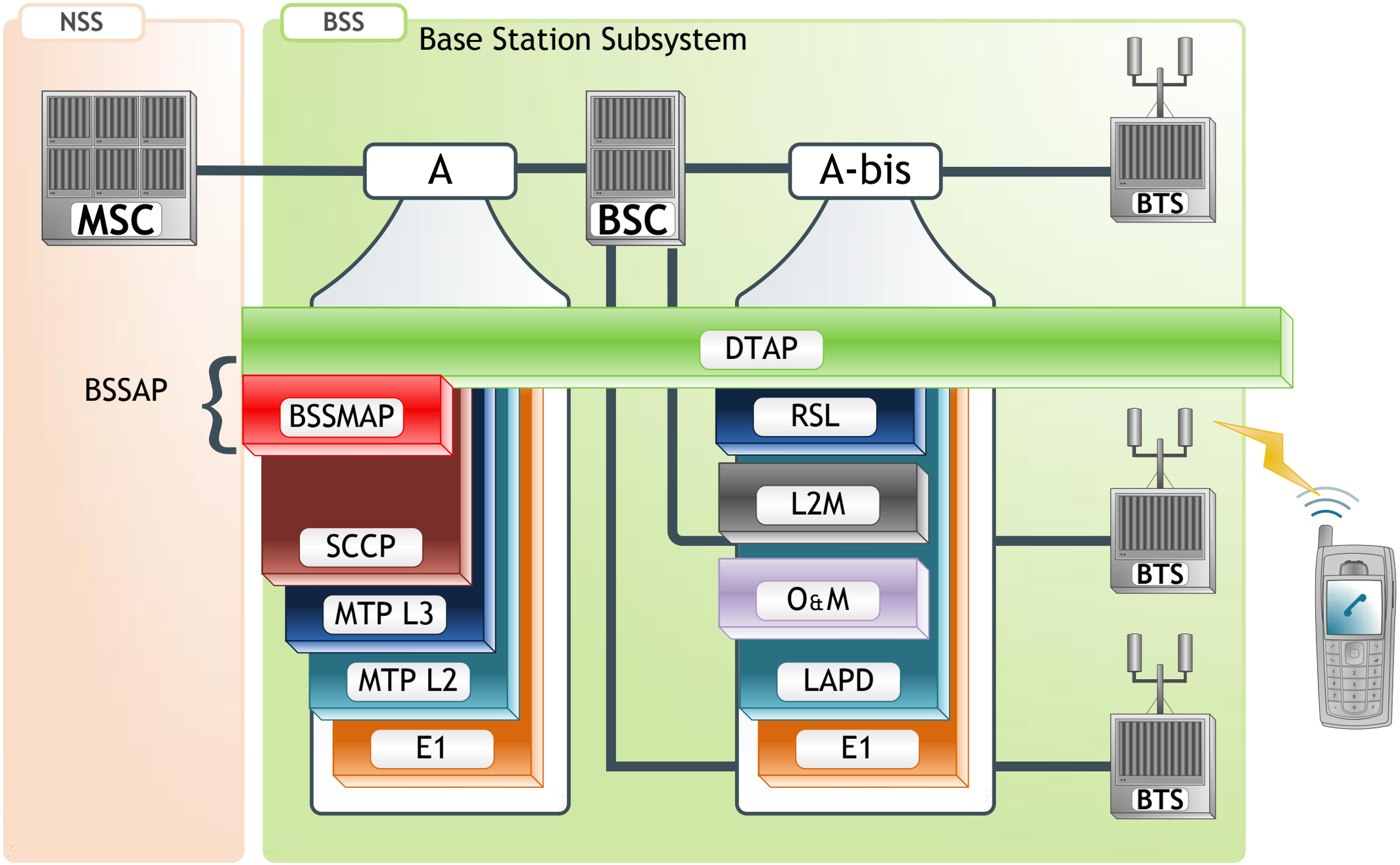
Overview of 2G and 3G mobile networks

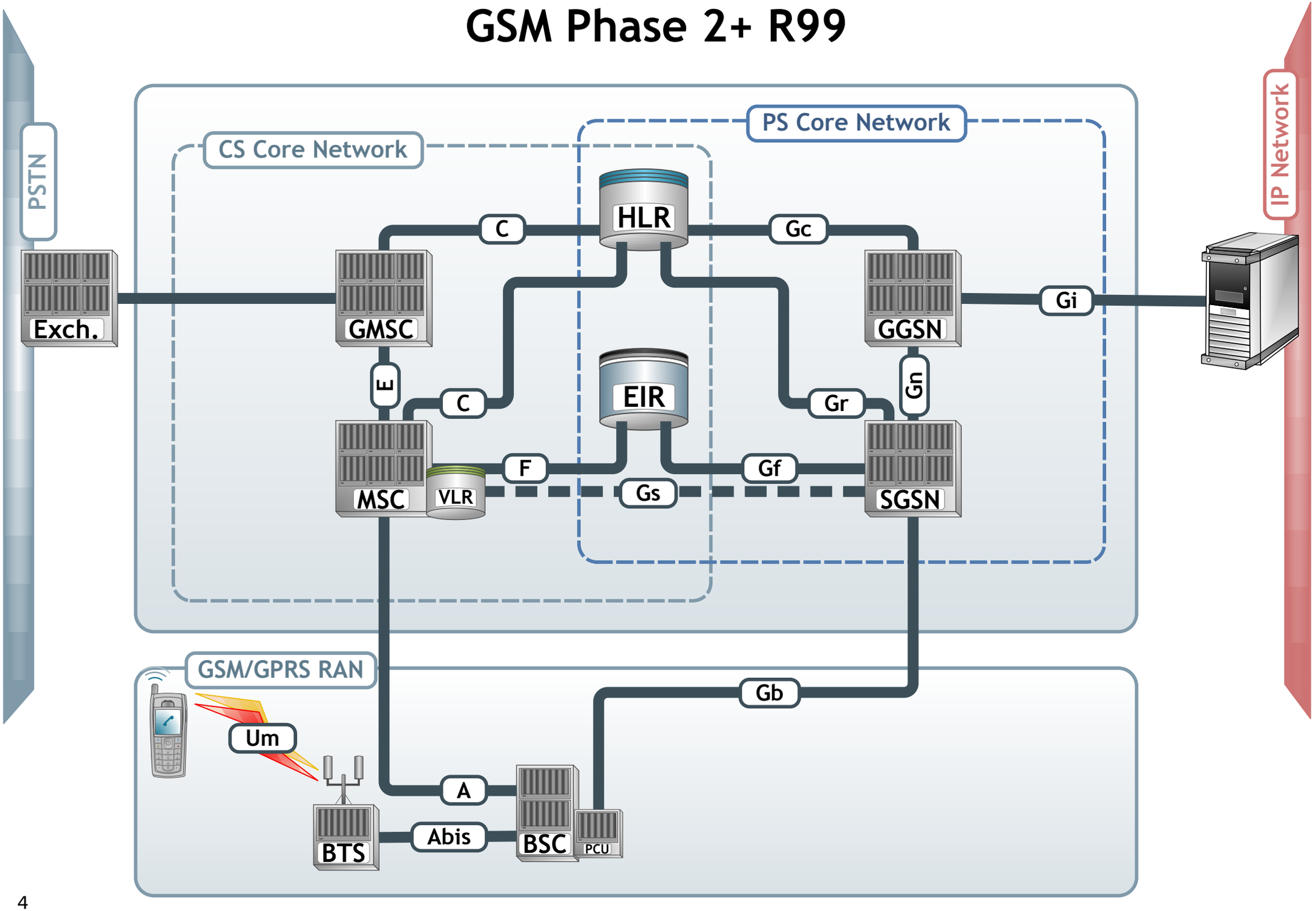
Network Switching Subsystem (NSS)



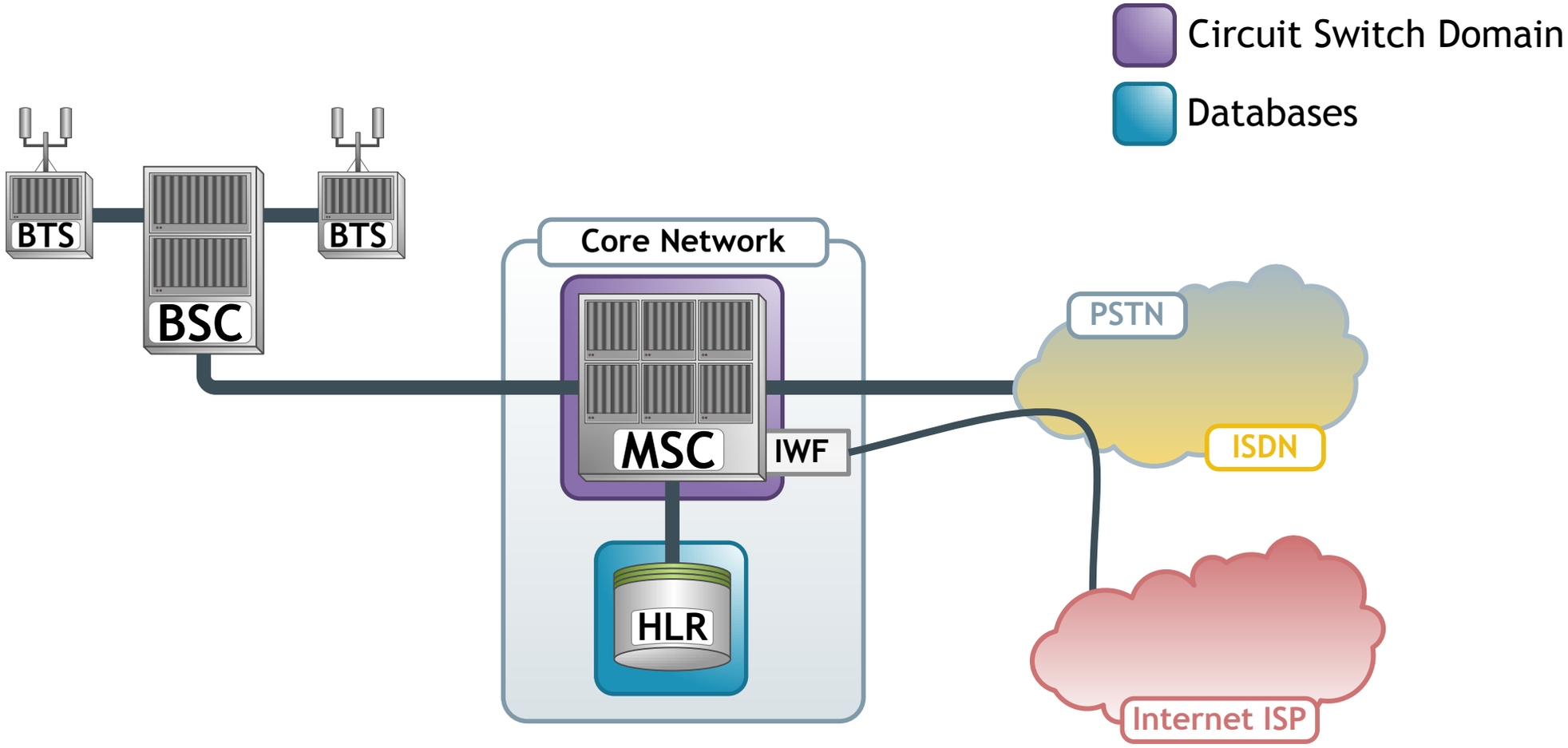
Base Station Subsystem (BSS)



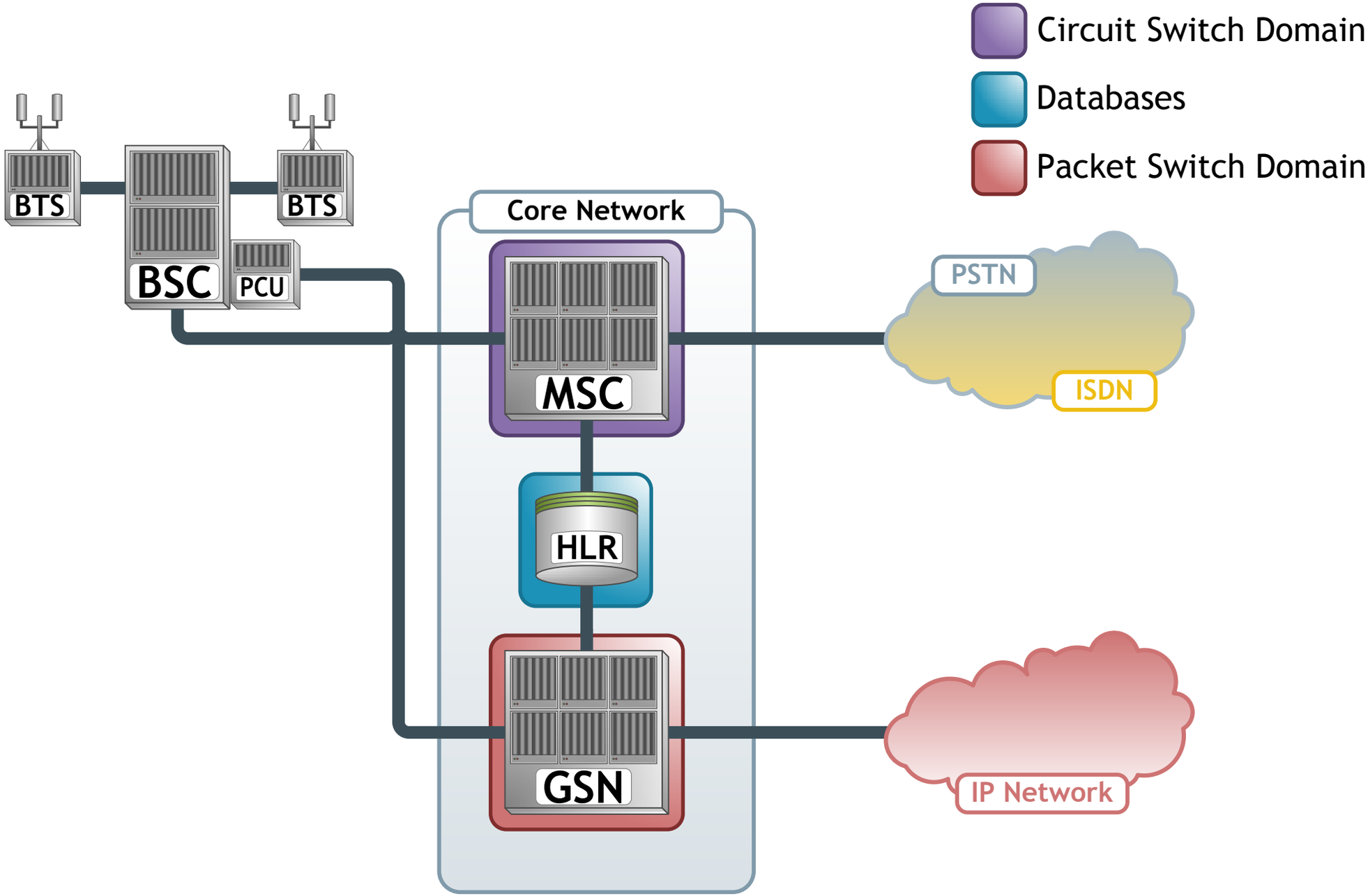
GSM Phase 2+ R99



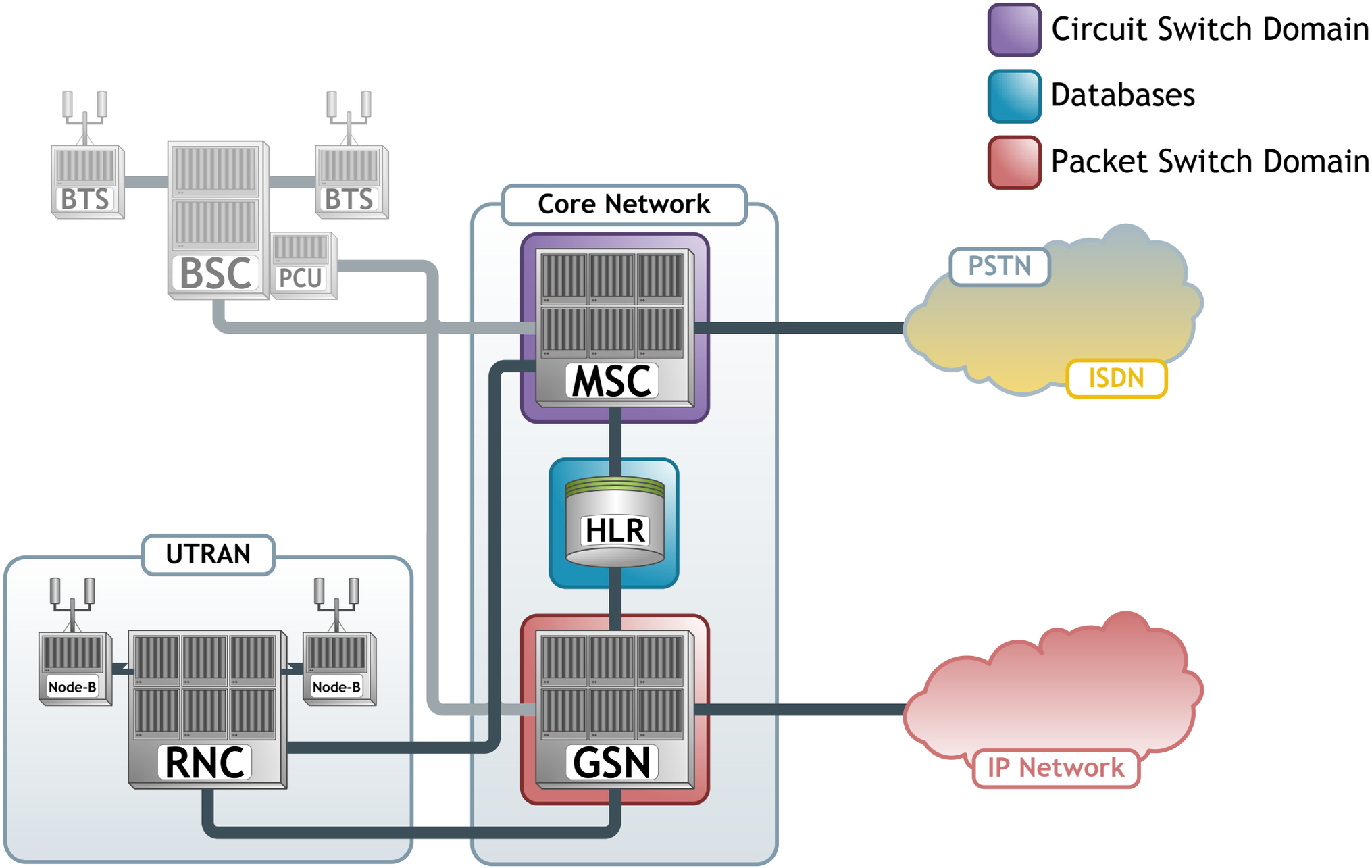
GSM Network Concept



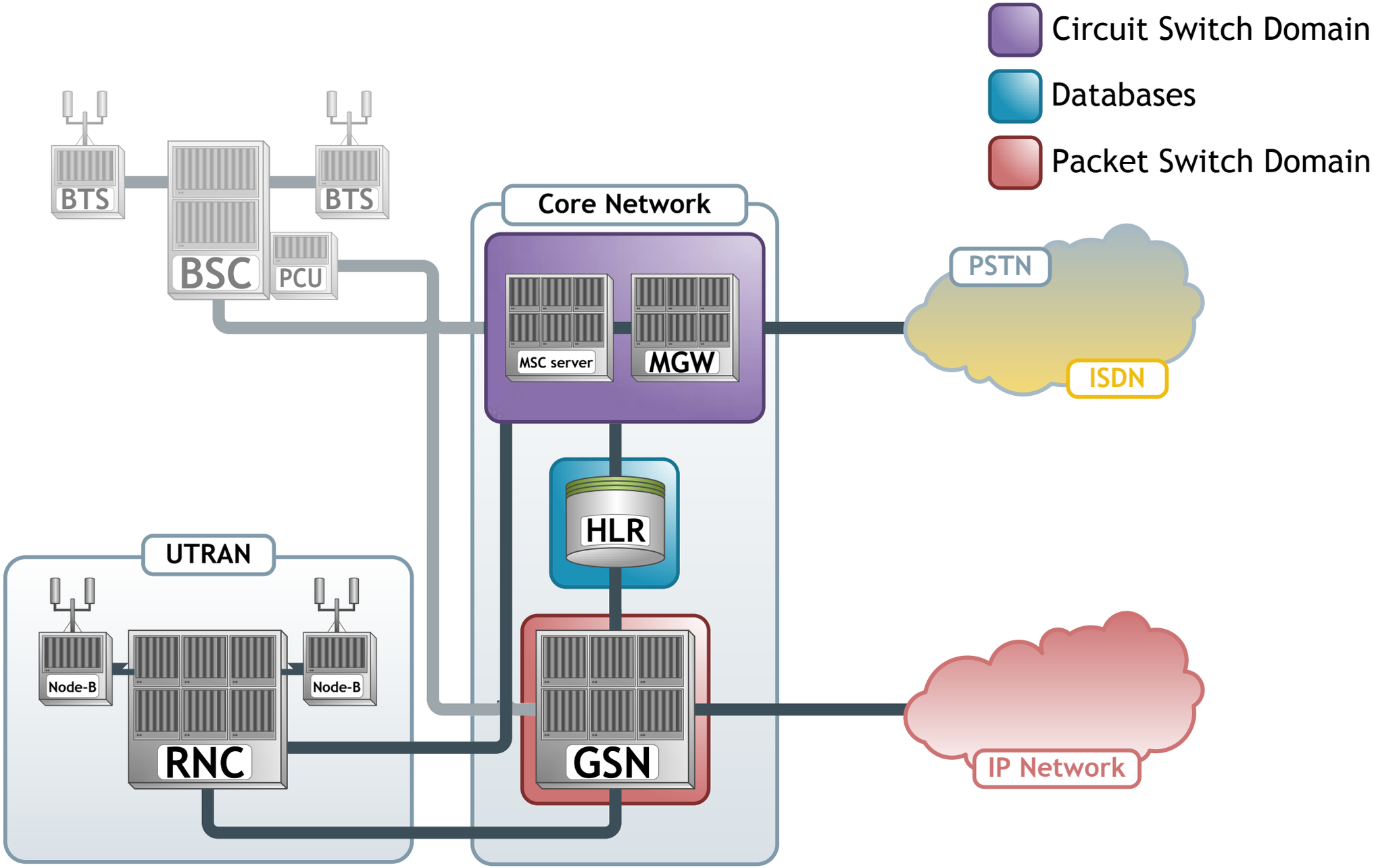
GPRS Network Concept



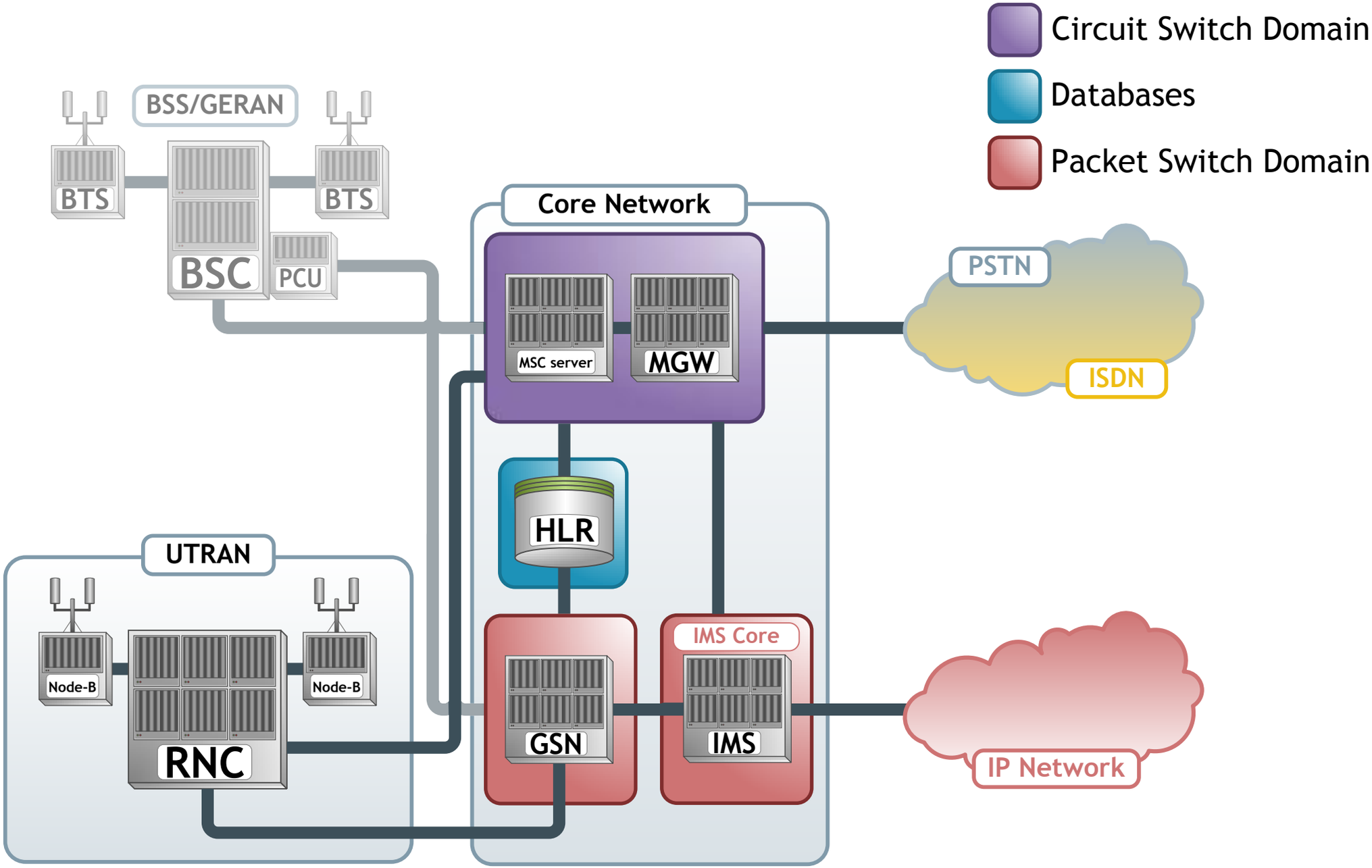
UMTS Network Concept (R99)



UMTS Network Concept (R4)



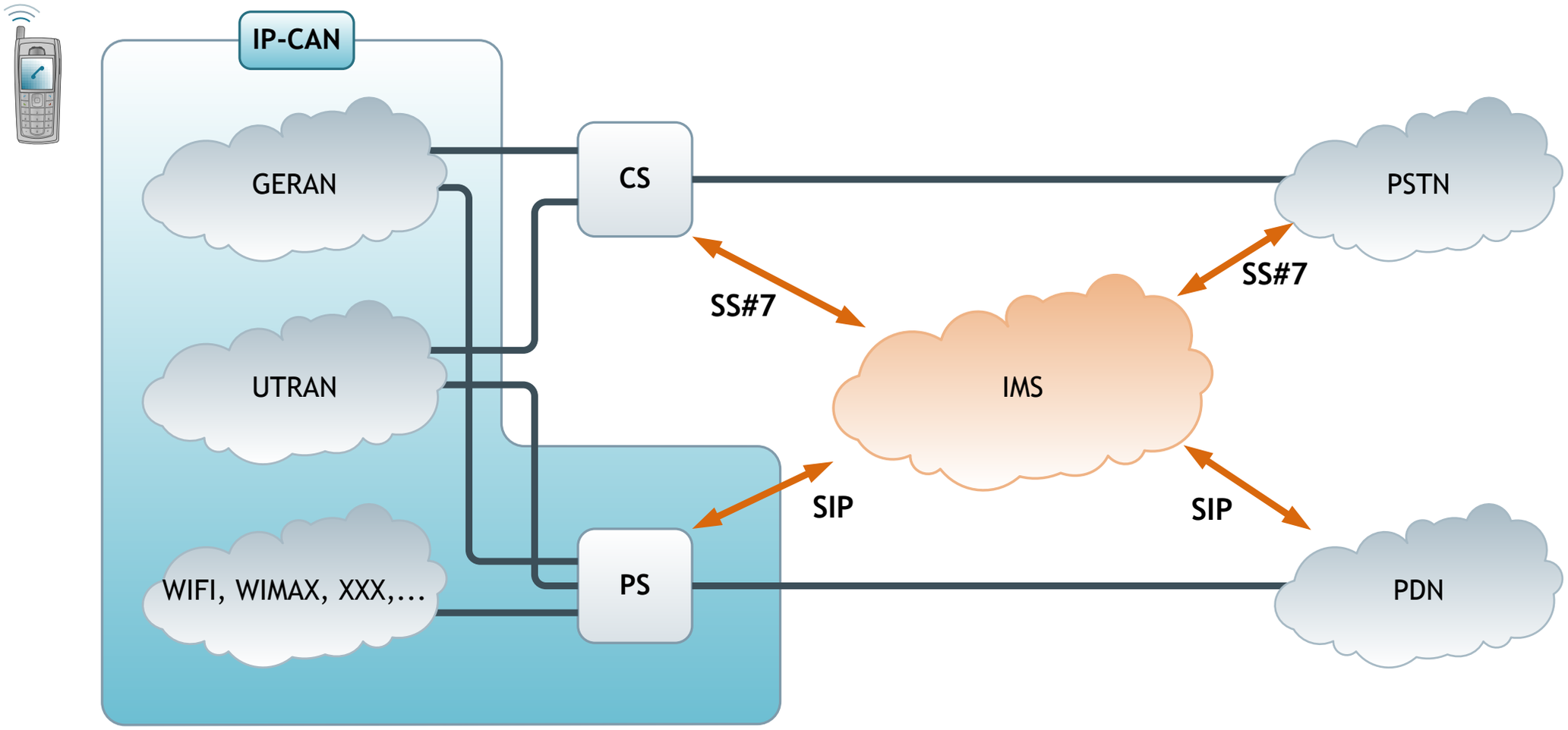
UMTS Network Concept (R5)



IMS Architecture

What is IMS?

- IMS is a global, access independent and standard-based IP connectivity and service control architecture that enables various types of multimedia services to end user using common Internet-based protocols.

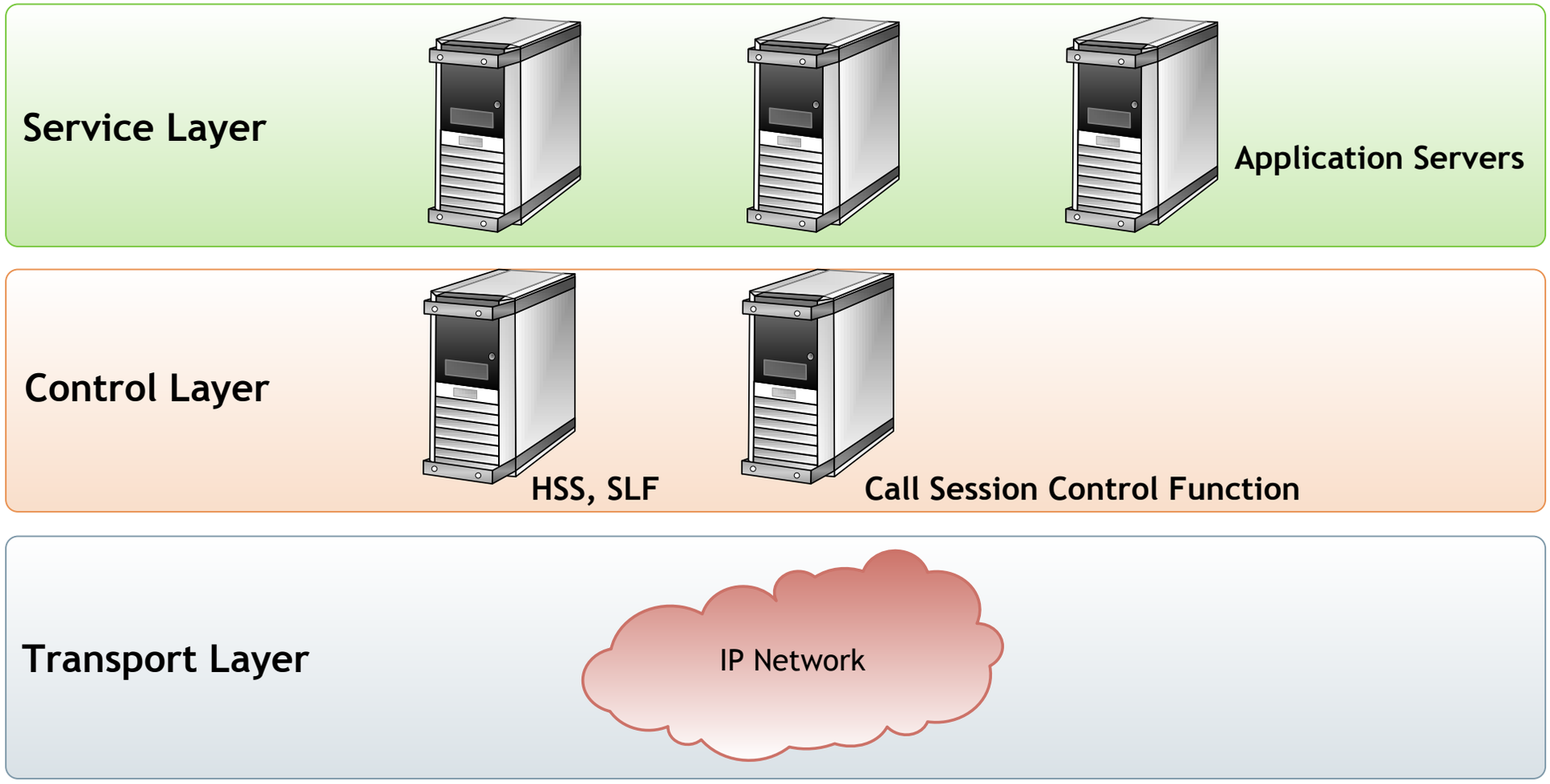


IP-CAN: IP Connectivity Access Network
GERAN: GSM Edge Radio Access Network
UTRAN: UMTS Terrestrial Radio Access Network
IMS: IP Multimedia Subsystem
PSTN: Public Switched Telephone Network

IMS requirements

- Support for establishing IP Multimedia Sessions
- Support for a mechanism to negotiate Quality of Service
- Support for interworking with the Internet and circuit-switched networks
- Support for roaming
- Support for rapid service creation without requiring standardization
- Support access from networks other than GPRS (RELEASE 6)

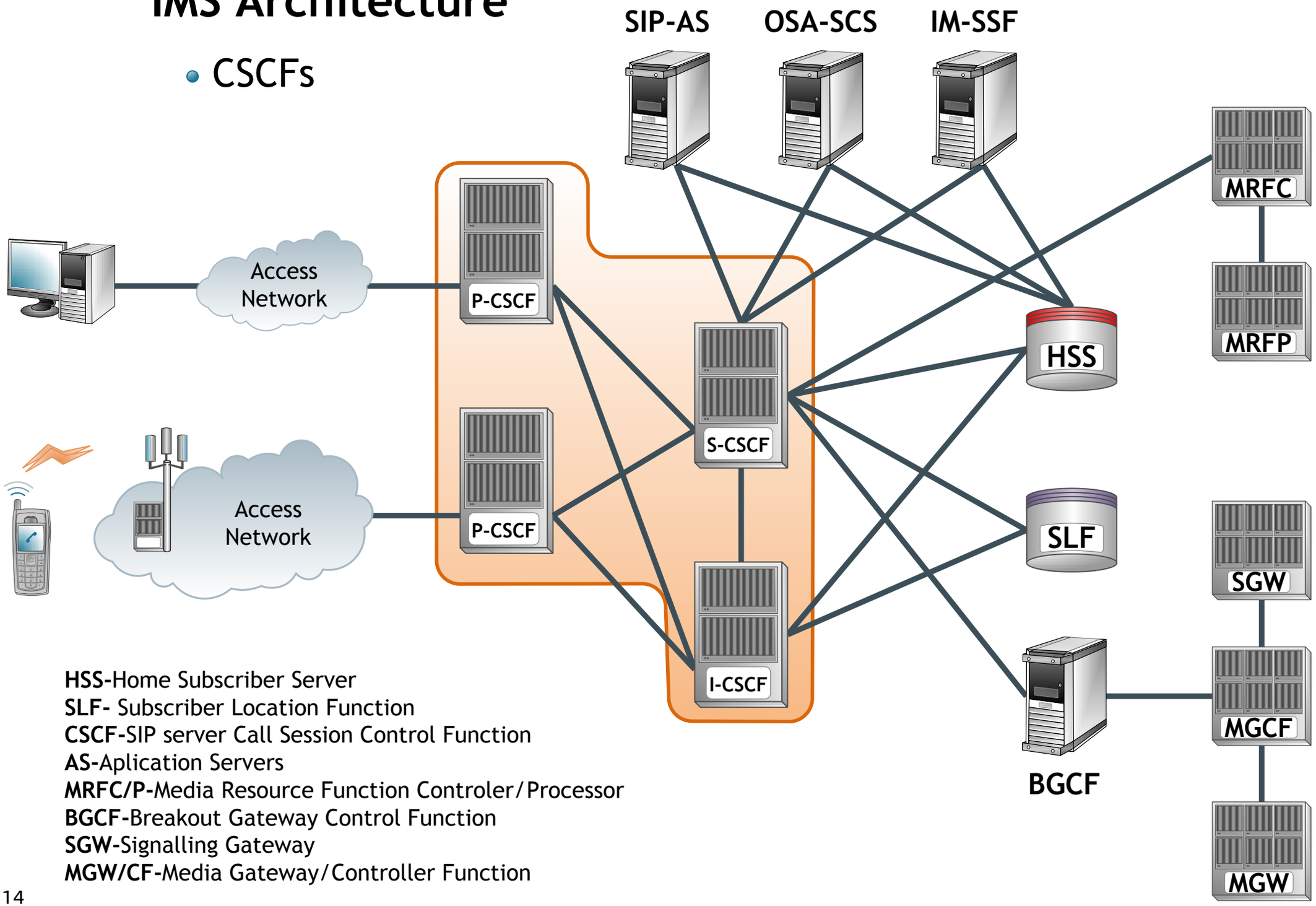
Layers



HSS: Home Subscriber Server
SLF: Subscriber Location Function
GGSN: Gateway GPRS Support Node

IMS Architecture

- CSCFs



HSS-Home Subscriber Server
SLF- Subscriber Location Function
CSCF-SIP server Call Session Control Function
AS-Aplication Servers
MRFC/P-Media Resource Function Controler/Processor
BGCF-Breakout Gateway Control Function
SGW-Signalling Gateway
MGW/CF-Media Gateway/Controller Function

The CSCF

- Call Session Control Function:
  - SIP server (essential node in IMS)
  - Processes SIP signaling in the IMS
  - Three types depending on the functionality:

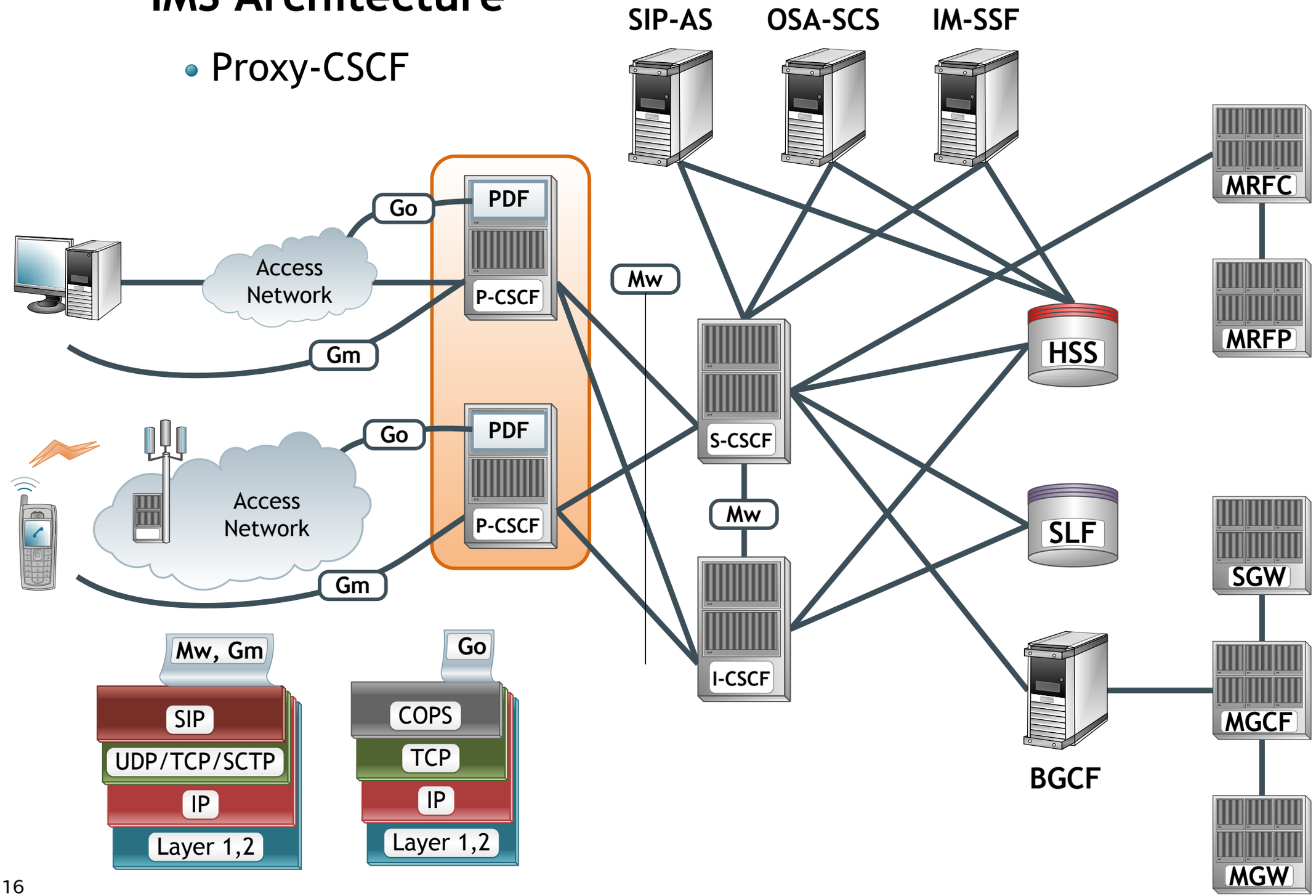
P-CSCF - Proxy CSCF

I-CSCF - Interrogating-CSCF

S-CSCF - Serving-CSCF

IMS Architecture

- Proxy-CSCF

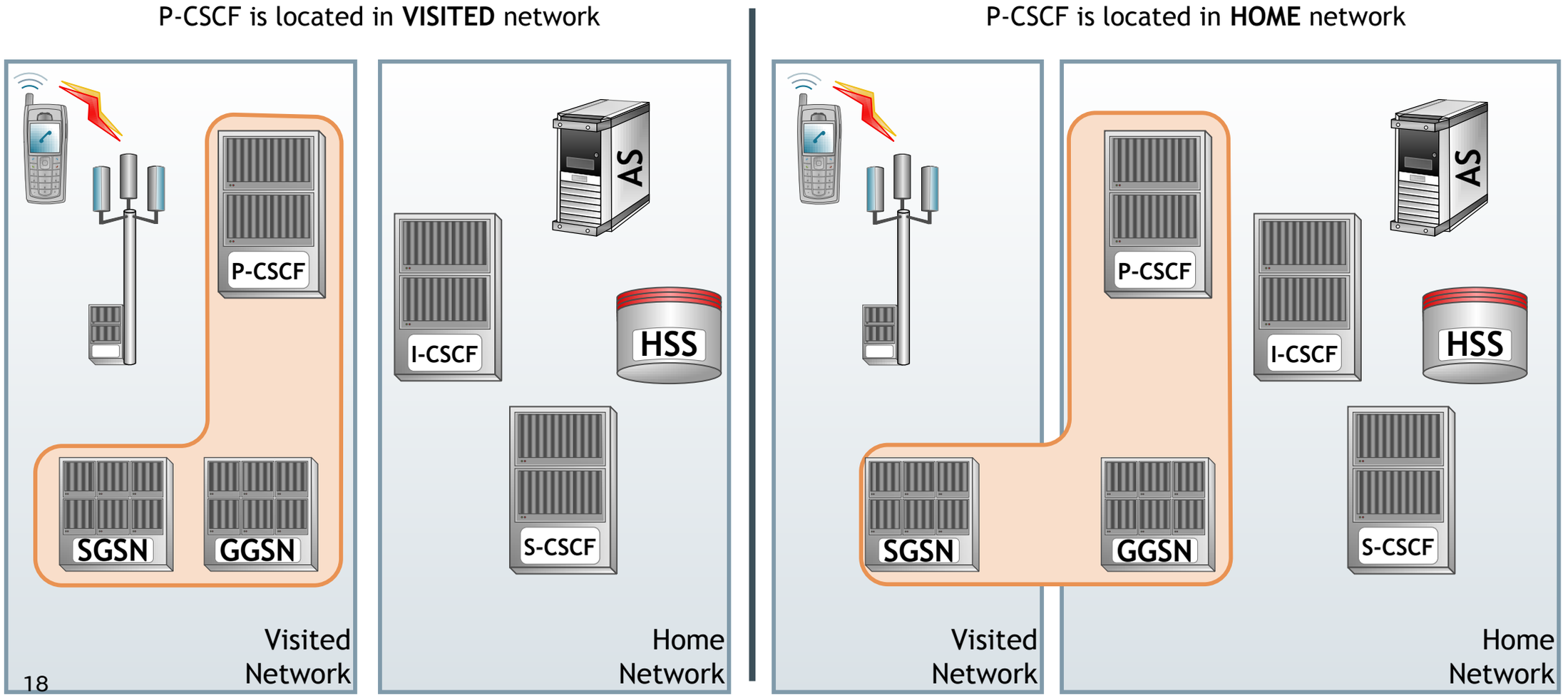


The P-CSCF

- Proxy-Call Session Control Function:
  - First point of contact between the IMS terminal and network
  - Outbound/Inbound SIP proxy server
  - Allocated to the terminal during IMS registration
  - Security function
  - Includes a compressor and a decompressor of SIP messages
  - May include PDF (Policy Decision Function)
  - Emergency session detection
  - Generation of accounting information

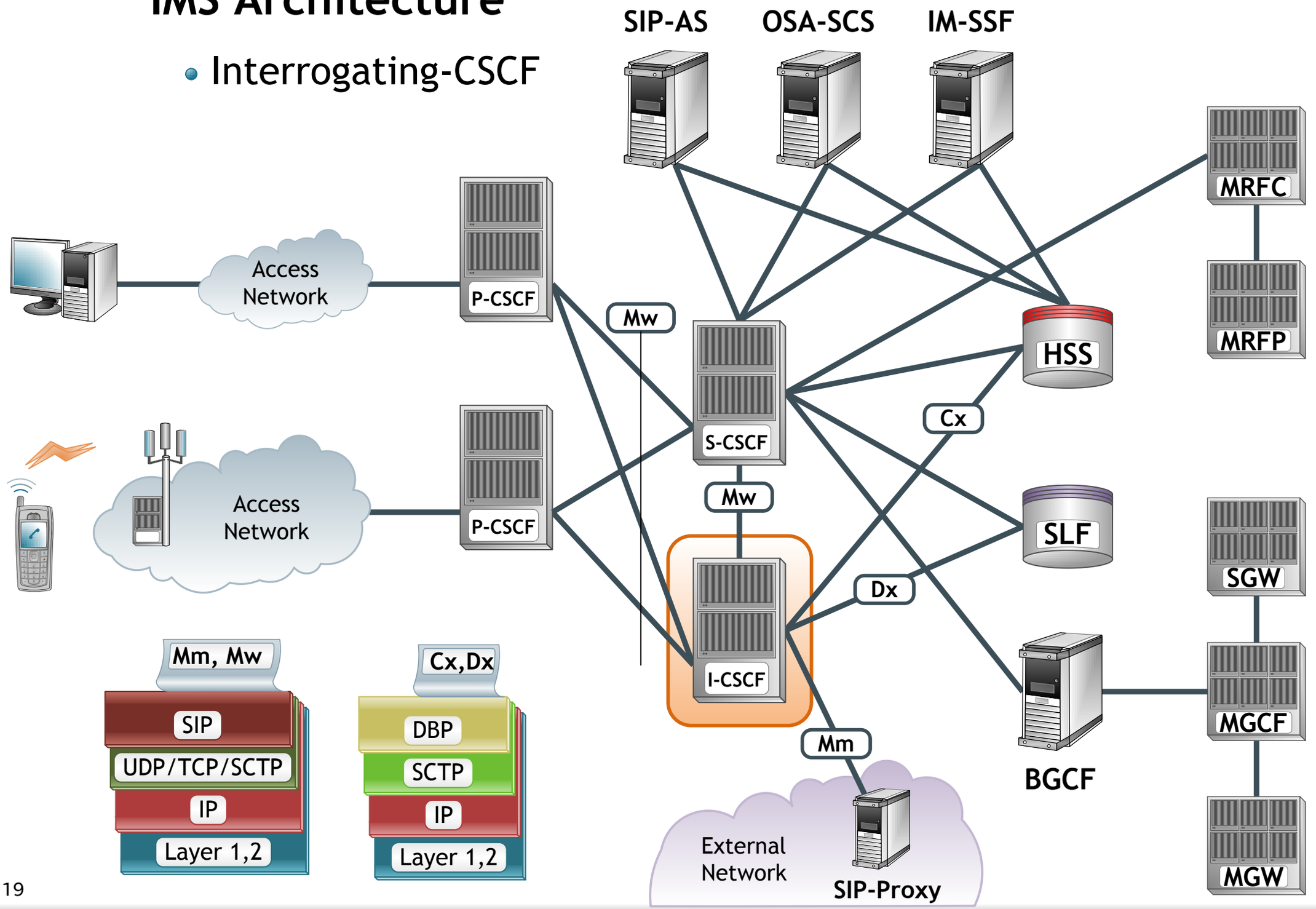
The P-CSCF location

- Either in the visited network or in the home network.
- In case GPRS access network:
  - P-CSCF located in the same network as GGSN (home, visited).



IMS Architecture

- Interrogating-CSCF

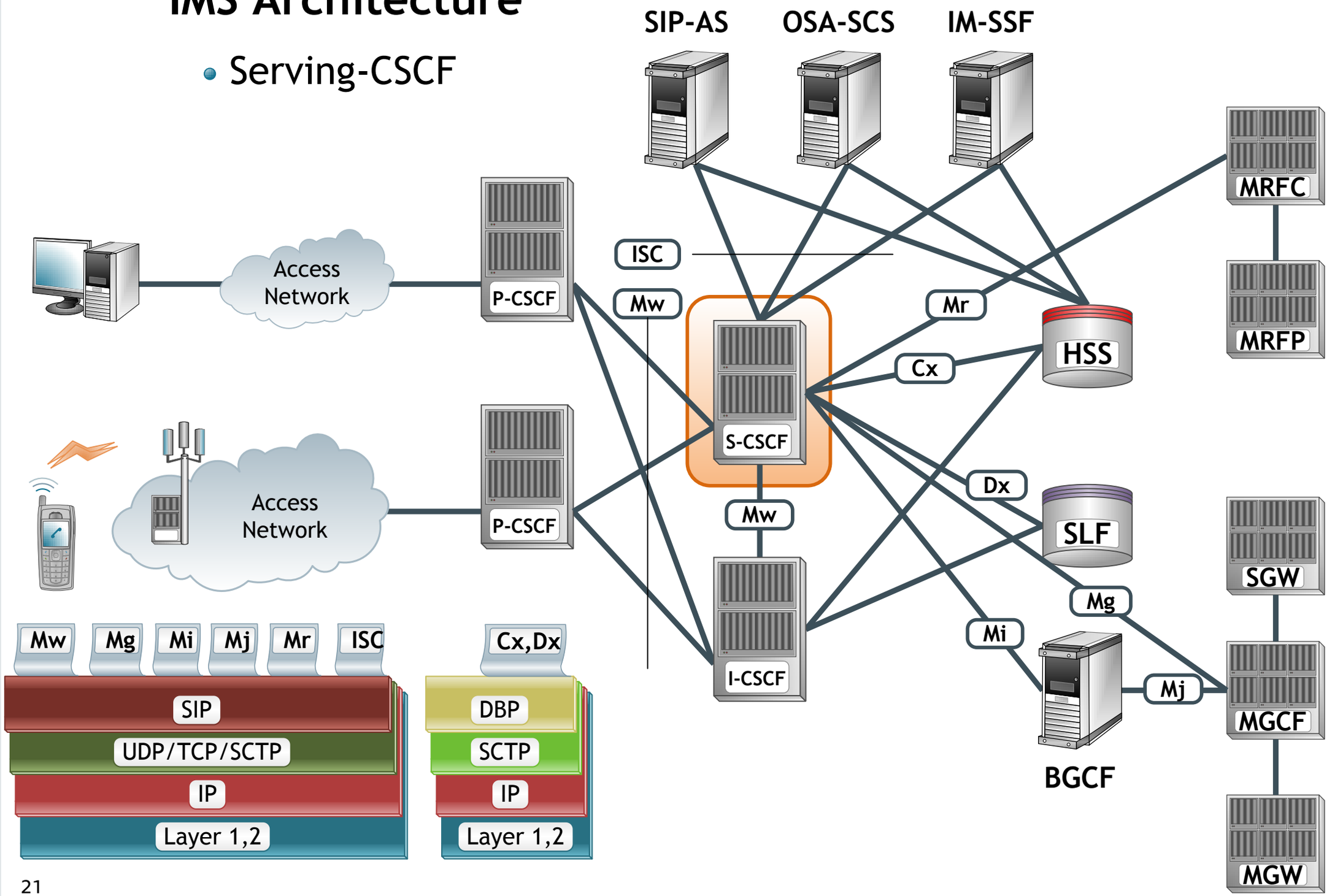


The I-CSCF

- Interrogating-Call Session Control Function:
  - Contact point within operator's network for all terminating sessions that are destined to a SIP-user who is currently registered in that PLMN.
  - Assigning S-CSCF - upon reception of registration request from UE. The name of the next hop (S-CSCF) obtains from HSS
  - Authorization of subscribers:
    - roaming agreement
    - allowed user
  - Routing incoming requests further to an assigned S-CSCF
  - Generation of accouting information

IMS Architecture

- Serving-CSCF

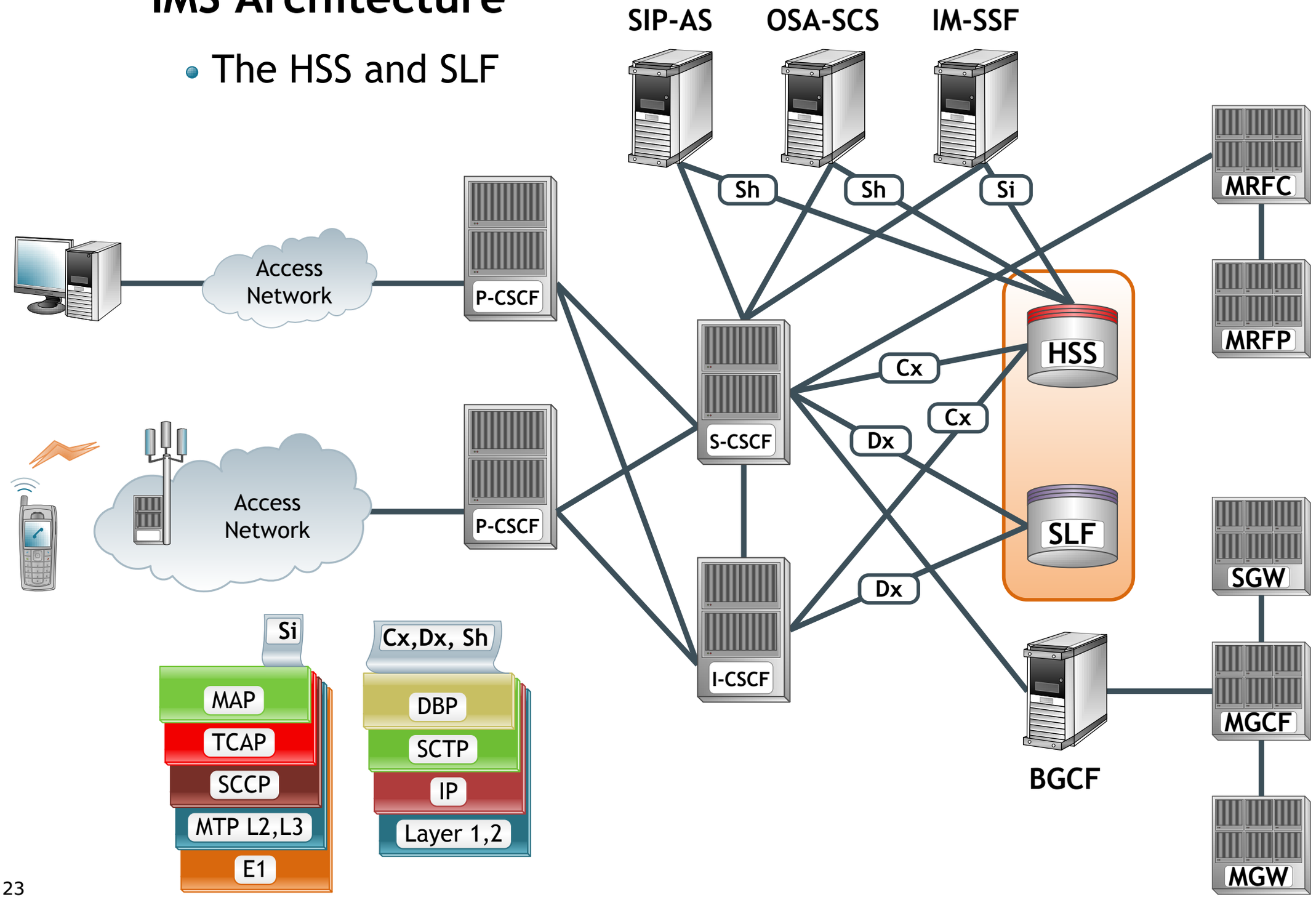


The S-CSCF

- Serving-Call Session Control Function:
  - Central node of the IMS signaling plane. It represents the registrar of regular SIP-networks within 3GPP-network environment.
  - Responsible for:
    - Registration
    - Routing decisions
    - Storing service profiles
    - Service logic invocation
    - Relaying SIP-calls to PSTN-destinations to the BGCF for MGCF-selection
    - Communication with the MRFC to handle multimedia calls
    - Generation of accouting information

IMS Architecture

- The HSS and SLF



Databases: HSS

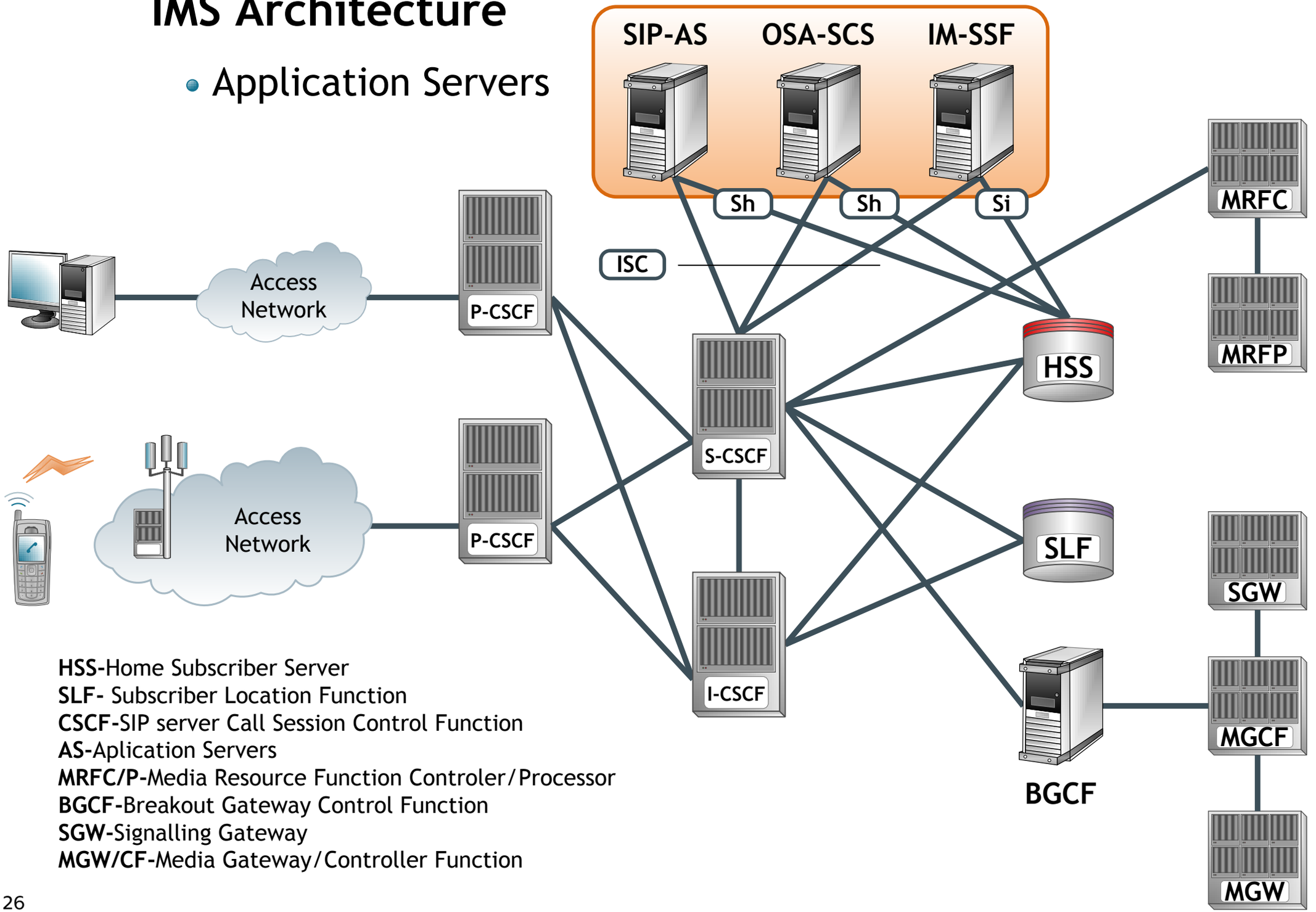
- Home Subscriber Server:
  - Central repository for user-related information
  - Evolution of the HLR from GSM
  - Location information
  - Security information (authentication and authorization info.)
  - User profile information (enable services)
  - S-CSCF allocated to the user

Databases: SLF

- Subscription Locator Function:
  - Only in case of more than one HSS
  - Simple database
  - Maps users' address to HSSs
    - Node queries the SLF with user's address as the input obtains HSS address that contains all the information related to that user as the output

IMS Architecture

- Application Servers



HSS-Home Subscriber Server
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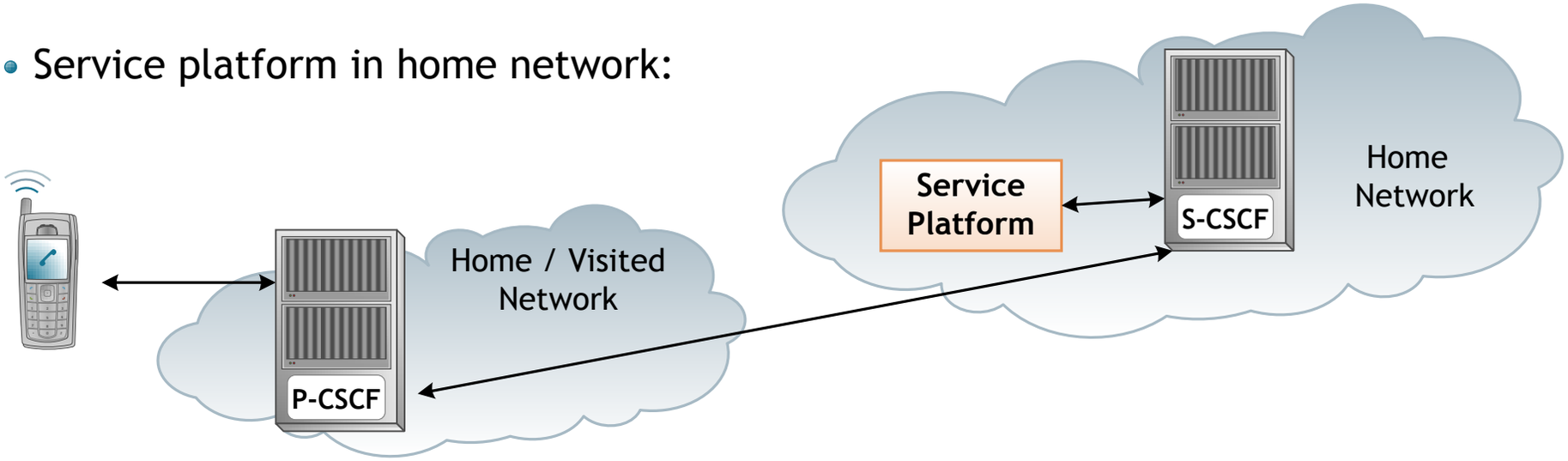
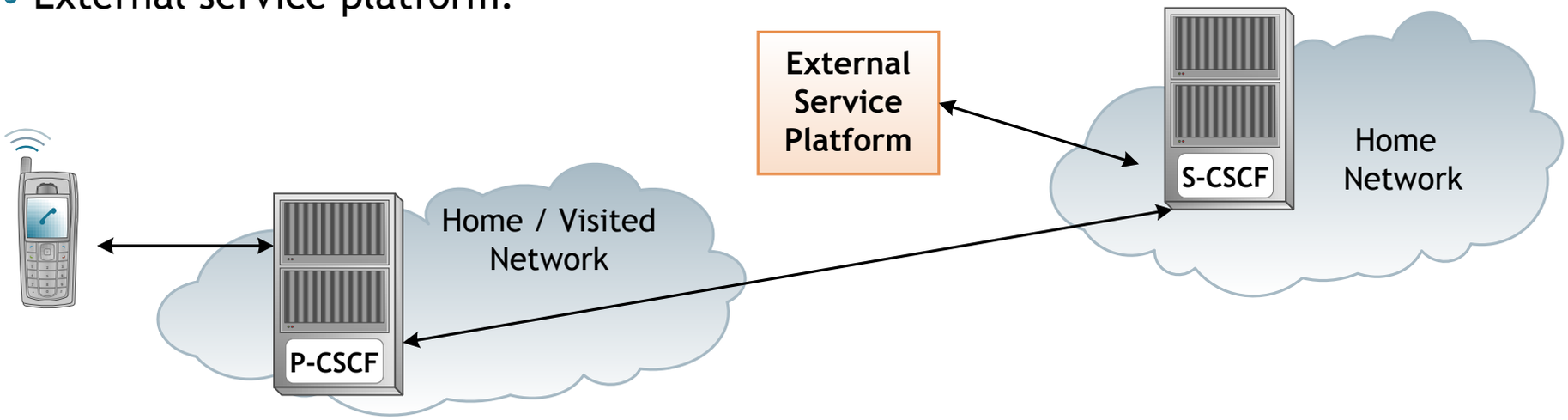
MGW/CF-Media Gateway/Controller Function

Service platforms

- Service platform in home network:



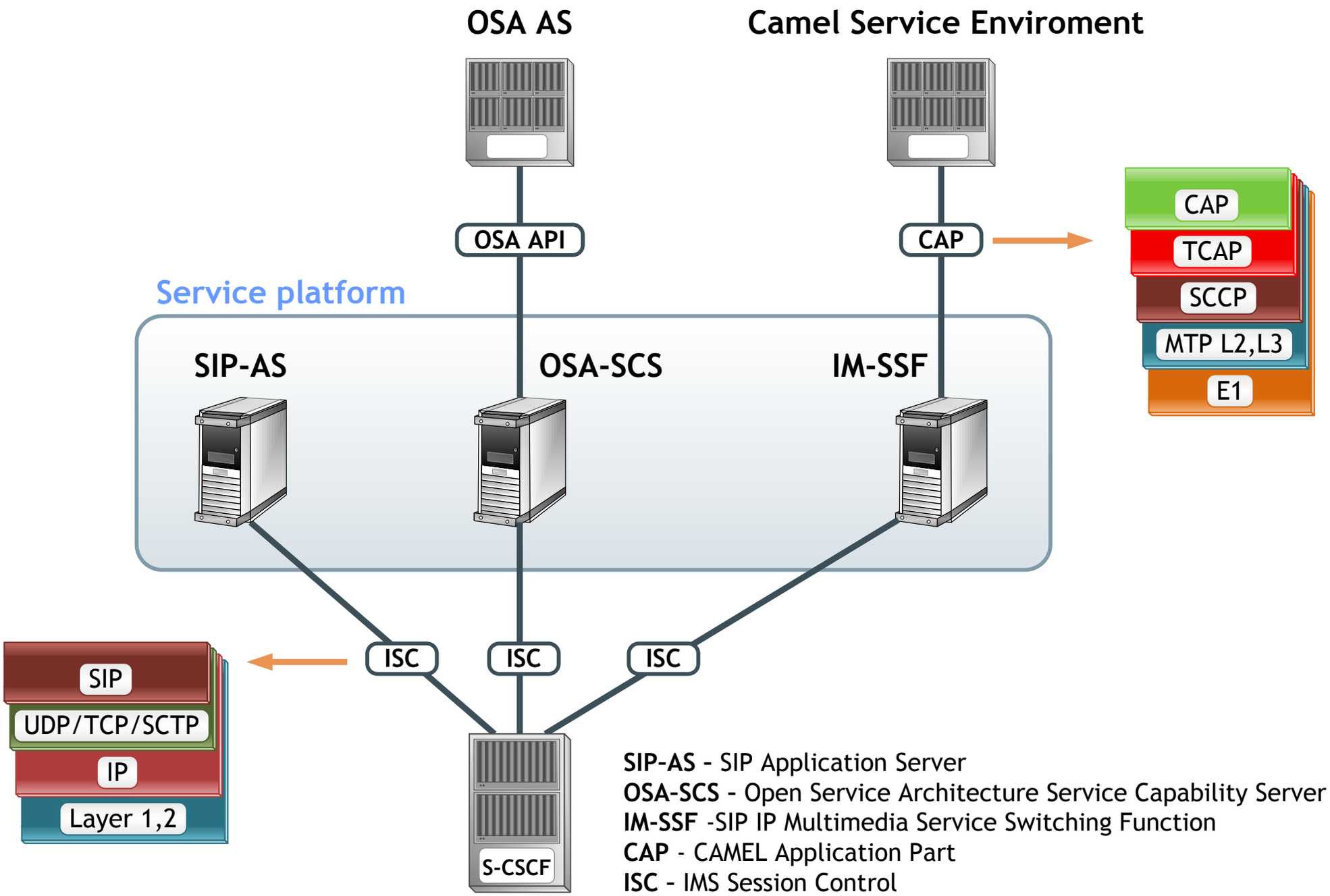
- External service platform:



Application Servers

- Entities that provide value-added multimedia services in the IMS (Presence, Push to talk over Cellular...)
- Main functions:
  - Process an incoming SIP session received from IMS
  - Capability to originate SIP requests
  - Generation of accounting information

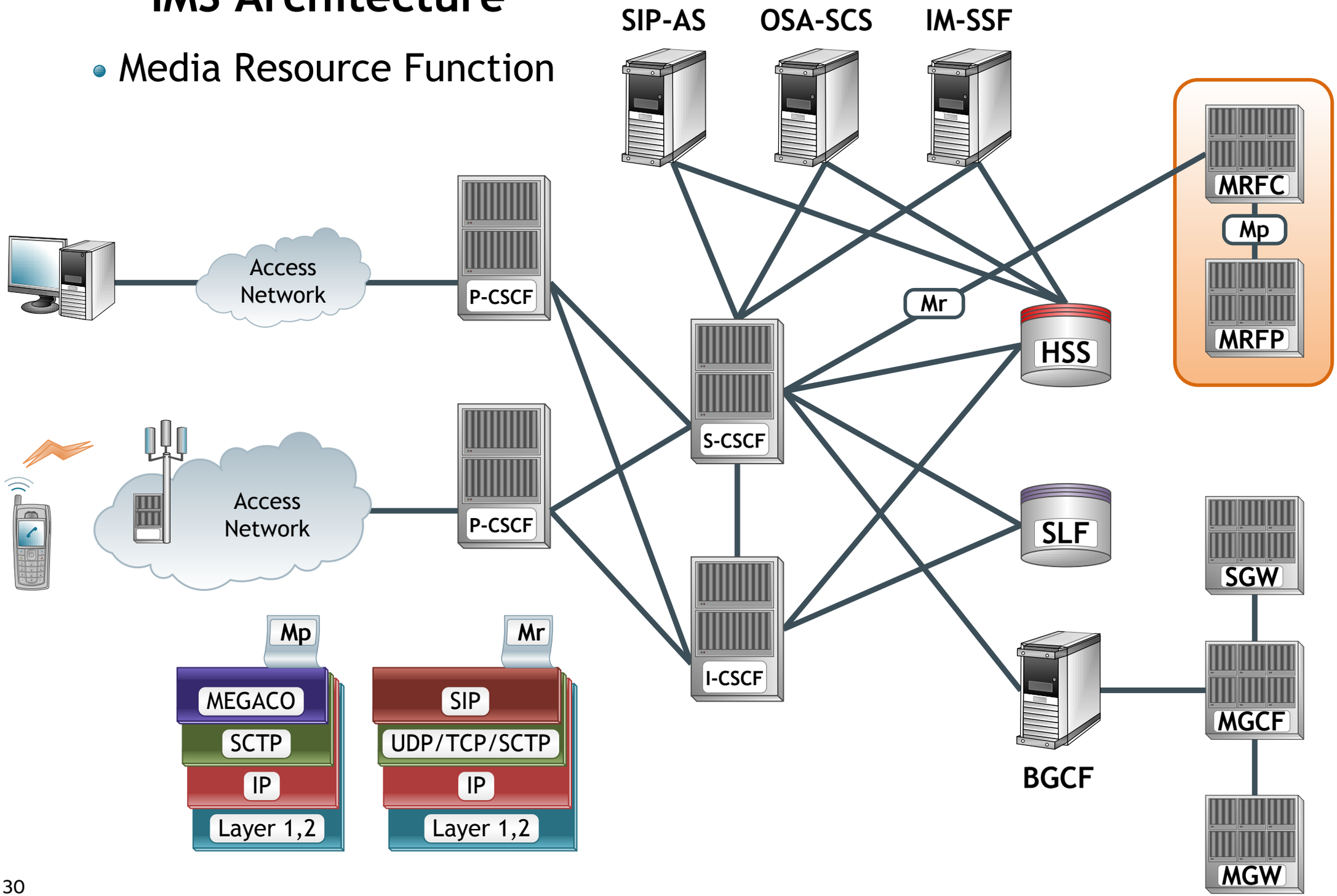
Three type of Application Servers



SIP-AS - SIP Application Server
OSA-SCS - Open Service Architecture Service Capability Server
IM-SSF -SIP IP Multimedia Service Switching Function
CAP - CAMEL Application Part
ISC - IMS Session Control
API - Application Programming Interface

IMS Architecture

- Media Resource Function



Media Resource Function

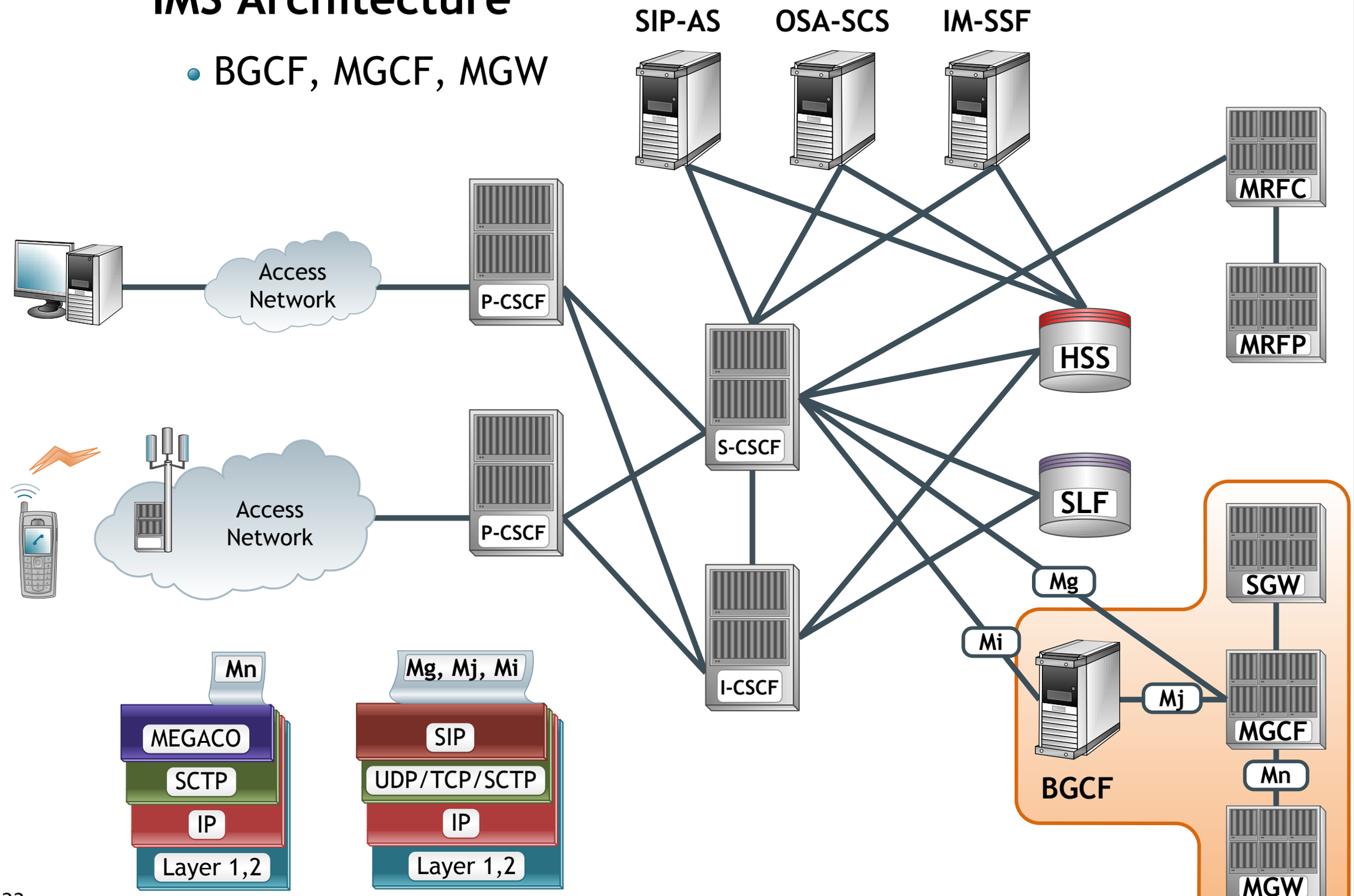
- Provide resource of media in the home network
- Always located in home network

- MRFControler
  - Acts as SIP User Agent
  - Contains SIP interface to S-CSCF
  - Controls resources in MRFP, via H.248 MEGACO
  - Generation of accounting information

- MRFProcessor
  - Mixing of incoming media streams (for multiple parties)
  - Media Stream Source (for multimedia announcements)
  - Media stream processing (transcoding between codecs, media analysis)

IMS Architecture

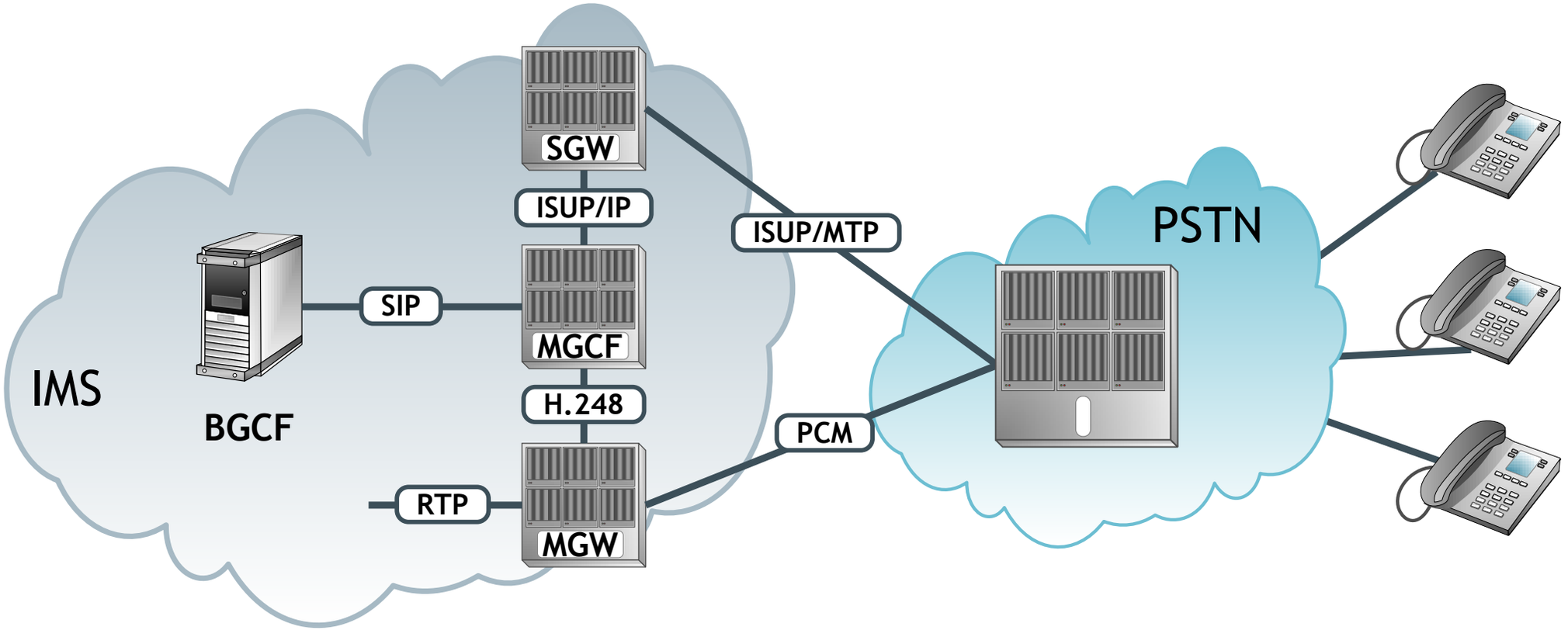
- BGCF, MGCF, MGW



BGCF, MGCF, MGW

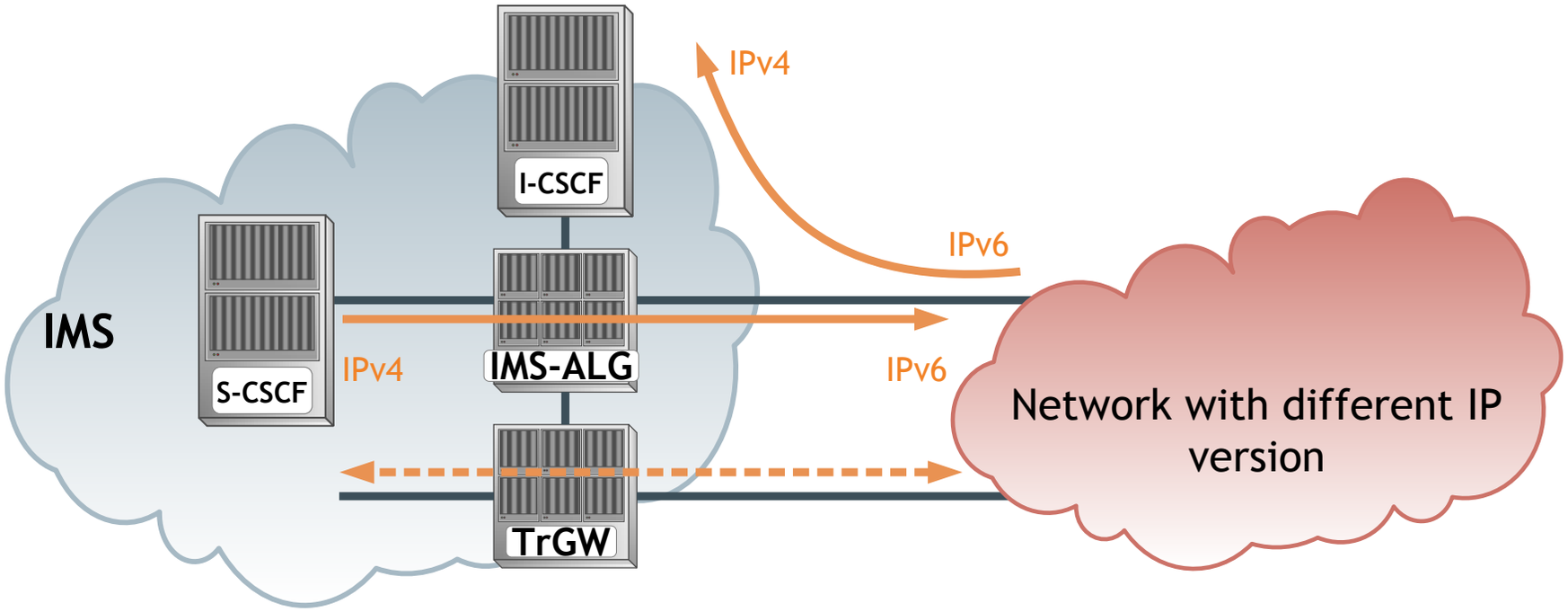
- MGCF (Media Gateway Control Function)
  - Required for interworking between IMS and PSTN
  - Protocol conversion between SIP protocol and ISUP or BICC (Bearer Independent Control Function).
  - Send converted request via SGW to CS CN.
  - Control MGW (Media Gateway), that provides user-plane link between CS CN and IMS.
- MGW (Media Gateway)
  - Terminates bearer channel from CS CN networks.
  - Terminates media stream from backbone network (RTP from IP networks).
  - Provides conversion, transcoding and signal processing.
  - Able to provide tones and announcements for CS users.
- BGCF (Breakout Gateway Control Function)
  - Act upon request from the S-CSCF for calls towards the PSTN
  - For SIP-sessions which are destined to the PSTN select the MGCF where breakout from an IP-network to the PSTN shall occur

Interworking Functions



- For breaking out S-CSCF send SIP request to BGCF
- Breakout in the same network or another
- BGCF selects MGCF to handle the session

IPv4 and IPv6 Interworking



IMS-ALG (Application Layer GW)

- Acts as SIP B2BUA by maintaining two sig.legs.
- One towards the internal IMS net. Other towards the other net. Each legs are running over diff. IPv.
- Changing IP and ports in SDP.
- Interfaces to I-CSCF for incoming traffic, S-CSCF for outgoing.

TrGW (Transition GW)

- Translation IPv4 and IPv6 at the media level (e.g., RTP, RTCP).

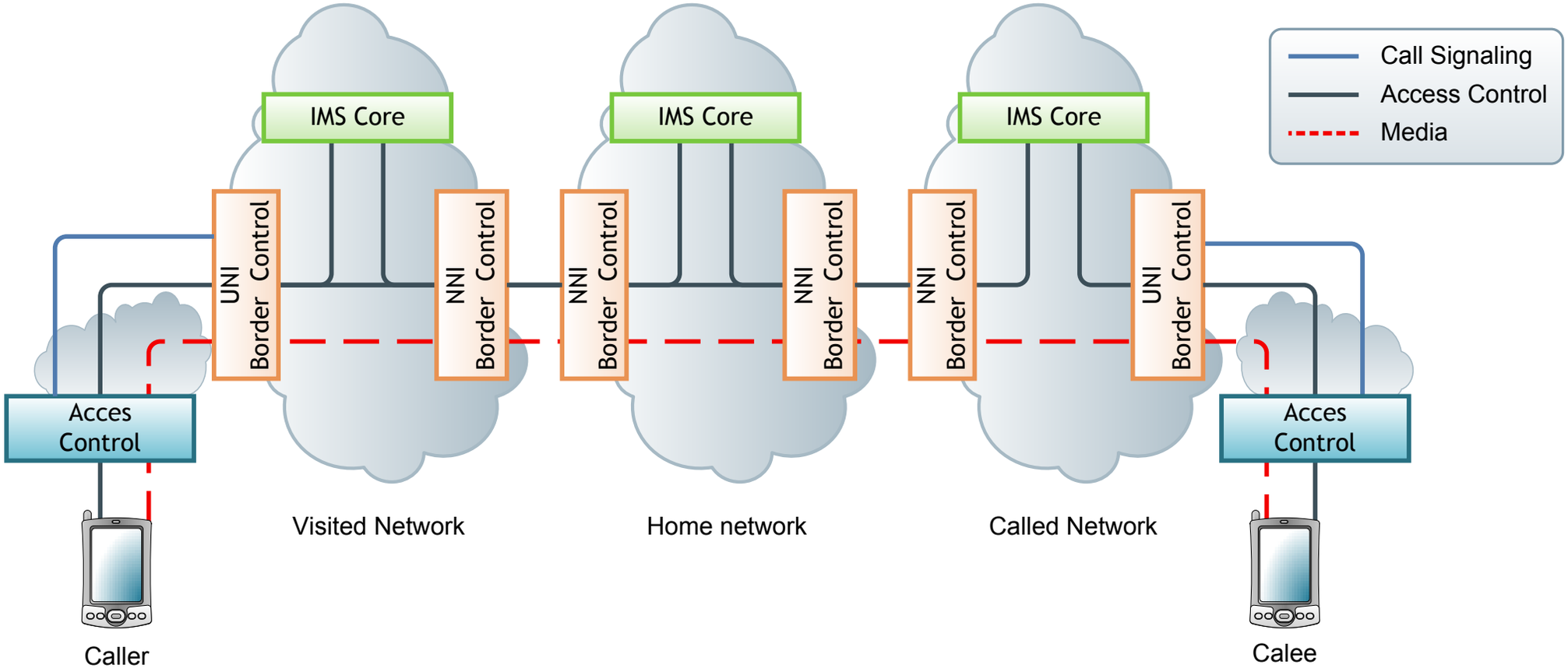
Signalling

Media

SBC - Session Border Control

SBC is not a standardized set of functions. It‘s existence arise when voice and multimedia services are overlaid on IP infrastructure. Main tasks:

- security and prevention of service abuse to ensure QoS
- monitoring for regulatory and billing purposes
- resolution of VoIP protocol problems arising from the widespread use of firewalls, NAT and also different types and versions of protocols



Protocol Diameter

Agenda

- Introducing
- Diameter network elements
- Diameter base protocol
- Base commands
- Common AVPs, Result codes, Error handling
- Diameter applications in IMS
  - Diameter on Cx/Dx interface
  - Diameter on Sh/Dh interface
  - Diameter on Rf interface
  - Diameter on Ro interface

What is Diameter?

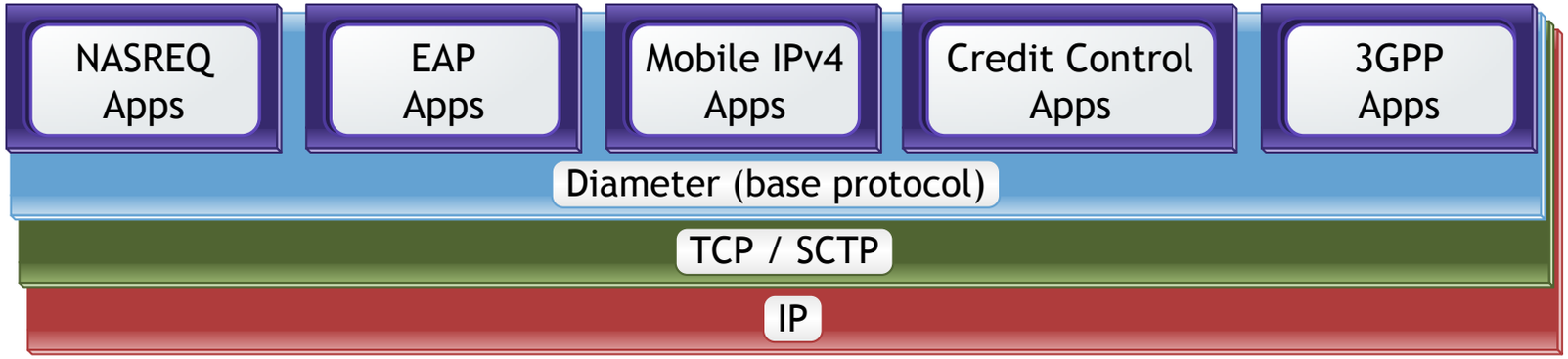
- AAA protocol
  - Authentication: verification of the identity of an entity (subject)
  - Authorization: decision if a requesting entity (subject) will be allowed access to a resource (object).
  - Accounting: collecting information on resource usage for the purpose of capacity planning, auditing, billing or cost allocation.

History And Basic Facts

- Developed by IETF
  - Last release of basic protocol - September 2003
- Created on basics of protocol RADIUS
  - RADIUS - AAA protocol, Diameter=2xRADIUS
- Base protocol support modular architecture
- Applications are protocols based on Diameter basic protocol, they are not programs

Base Protocol Versus Applications

- The base protocol provides support for the reliable transport and delivery of messages
- The base protocol must be used along with an applications



Why is Diameter better than Radius?

- Using more reliable transport protocols (TCP/SCTP)
- Secure communications with IPsec or TLS
- Larger address spaces for attributes and commands (RADIUS-1 octet, Diameter-3 octets for commands and 4 octets for attributes)
- Added end-to-end security
- Better failure detections and failover methods
- Allows server initiated messages in base protocol
- Easier extensions by new applications, commands or attributes

Other Diameter Characteristics

- Agent support
- Built in basic support for user sessions and accounting
- Request/Answer mechanism of communication
- Backward compatibility with RADIUS
  - Diameter translation nodes must extend RADIUS message by attributes needed by Diameter
- Hop-by-hop security
  - Security between nodes
- Static (manual configuration) or dynamic discovery of peer (SRVLOC and DNS)

Diameter Extensions

- All new extensions must be confirmed by IANA
- Diameter protocol can be extended by:
  - Defining new AVP values (allocating of a new value)
  - Creating new AVPs (allocating of a new AVP code)
  - Creating new authentication/authorization applications (allocating of a new vendor specific Application-ID, defining new commands or add new mandatory AVPs)
  - Creating new accounting applications (allocating of a new vendor specific Application-ID, defining new commands or add new mandatory AVPs)
  - Application authentication procedures (adding new AVP values)

References

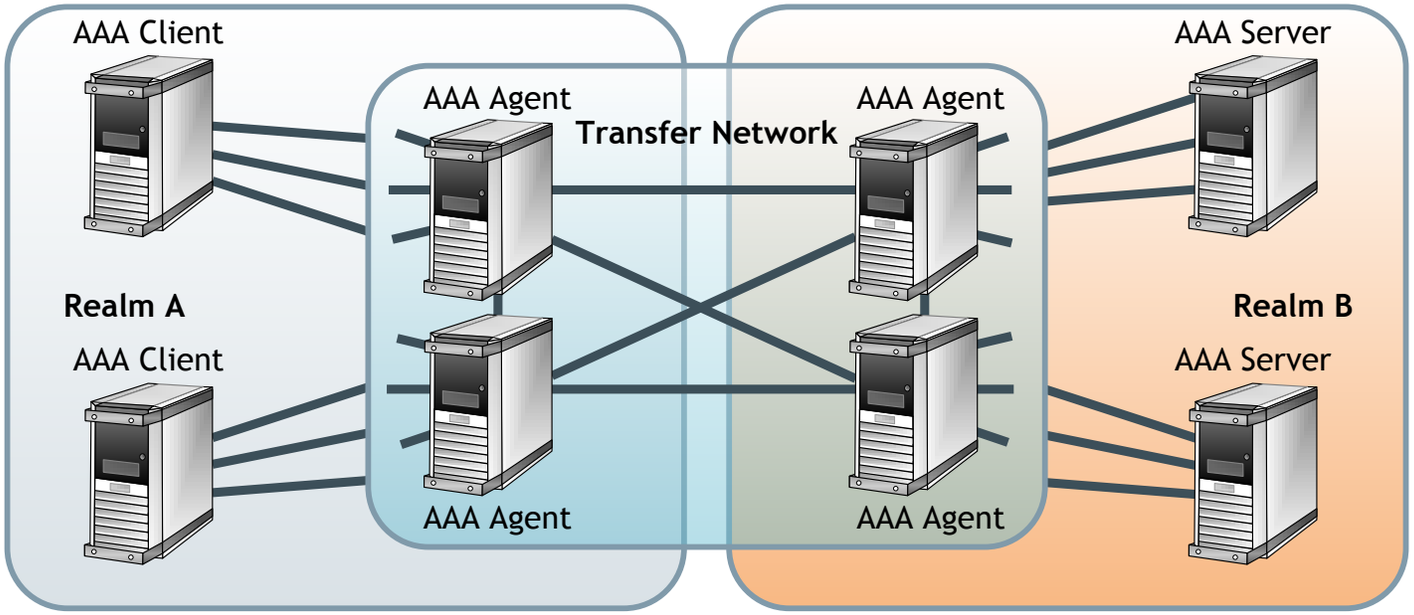
- [RFC 3588] Diameter Base Protocol
- [RFC 4004] Diameter Mobile IPv4 Application
- [RFC 4005] Diameter Network Access Server Application
- [RFC 4006] Diameter Credit-Control Application
- [3GPP TS 32.260] IP Multimedia Subsystem charging
- [ETSI TS 129 229] Cx and Dx interfaces based on the Diameter protocol
- [ETSI TS 129 329] Sh interface based on the Diameter protocol
- [ETSI TS 129 109] Zh and Zn Interfaces based on the Diameter protocol
- [3GPP TS 32.299] Diameter charging applications
- [3GPP TS 32.296] Online Charging System: Applications and interfaces

Structure of Diameter Network 1/2

- Diameter network consist of realms and nodes
- Realm matches part of nodes to a domain, which is defined by second part of NAI
  - abc@example.net (user identity–abc, realm–example.net)
  - Node is common name for equipment in Diameter network
- Each node has
  - Peer Table (other nodes near by)
  - Realm-Based Routing Table (realm name + forwarding peer)

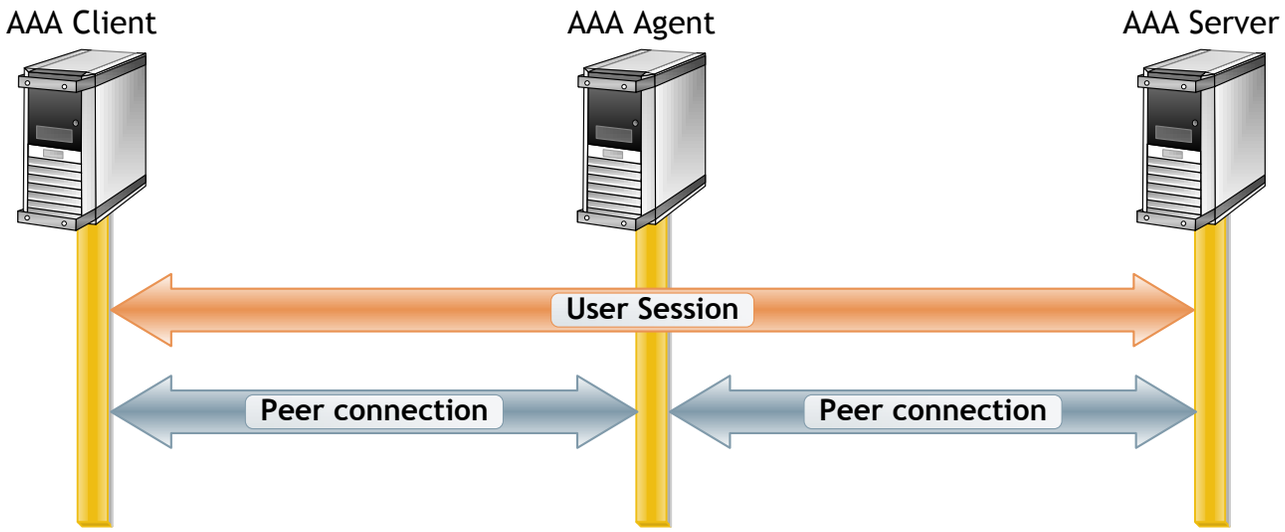
Structure of Diameter Network 2/2

- Three types of Diameter nodes
  - Diameter Clients
  - Diameter Servers
  - Diameter Agents
- Servers and Clients are ending equipment
- Agents creates “transfer network”



Peer to Peer Versus Client/Server

- Peer to Peer
  - Each node is connected minimally to 2 peers per realm (primary and secondary peers)
  - Creates connection and takes care of them
- Client/Server
  - At application layers
  - Transport of messages have P2P principal, but behavior of Diameter application is commonly based on Client/Server principal
  - Creates sessions

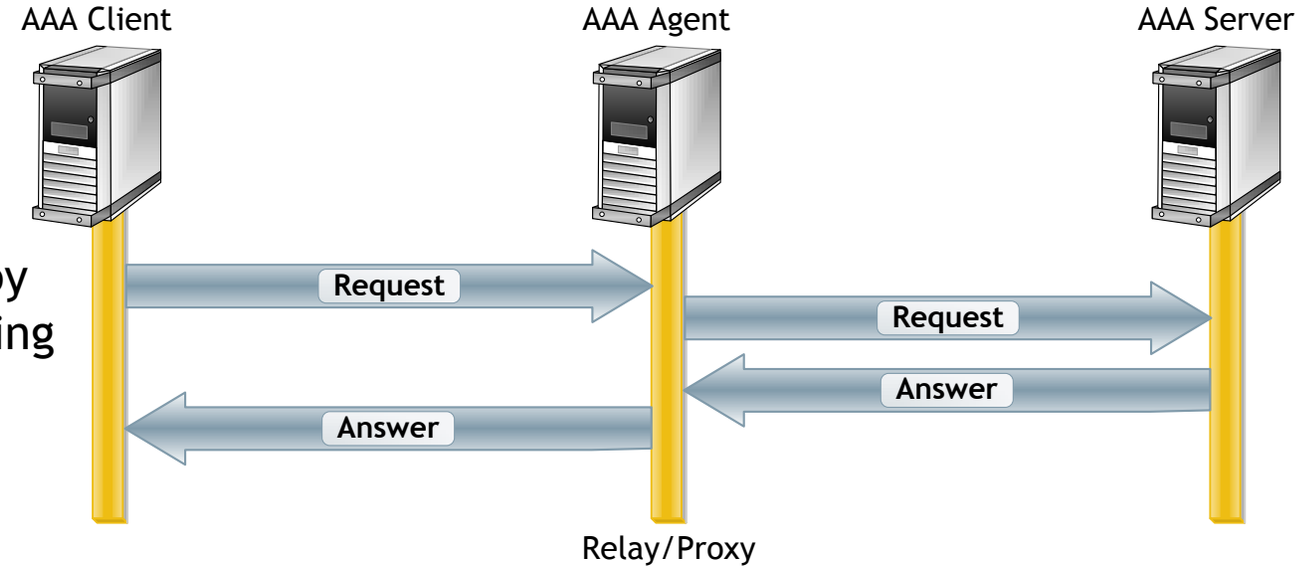


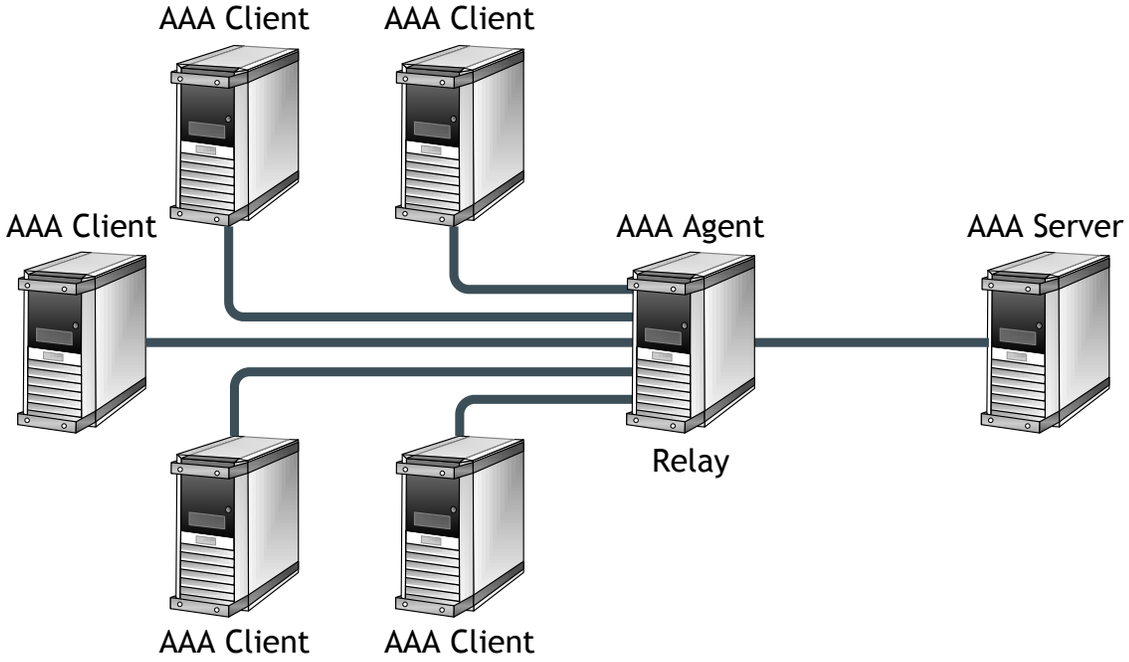
Types of Diameter Nodes

- Diameter client
  - a device at the edge of the network that performs access control in case of authentication and authorization or generates accounting data or provides both functionalities
- Diameter server
  - handles authentication, authorization requests or accounting requests or both functionalities for a particular realm
- Diameter agent
  - provides either relay, proxy, redirect or translation services

Diameter Agents 1/3

- Relay Agent
  - Route messages to other Diameter nodes
  - Modify Diameter messages by inserting and removing routing information
  - Concentrator
- Proxy Agent
  - Route messages like relay agent
  - Can modify messages to implement policy enforcement



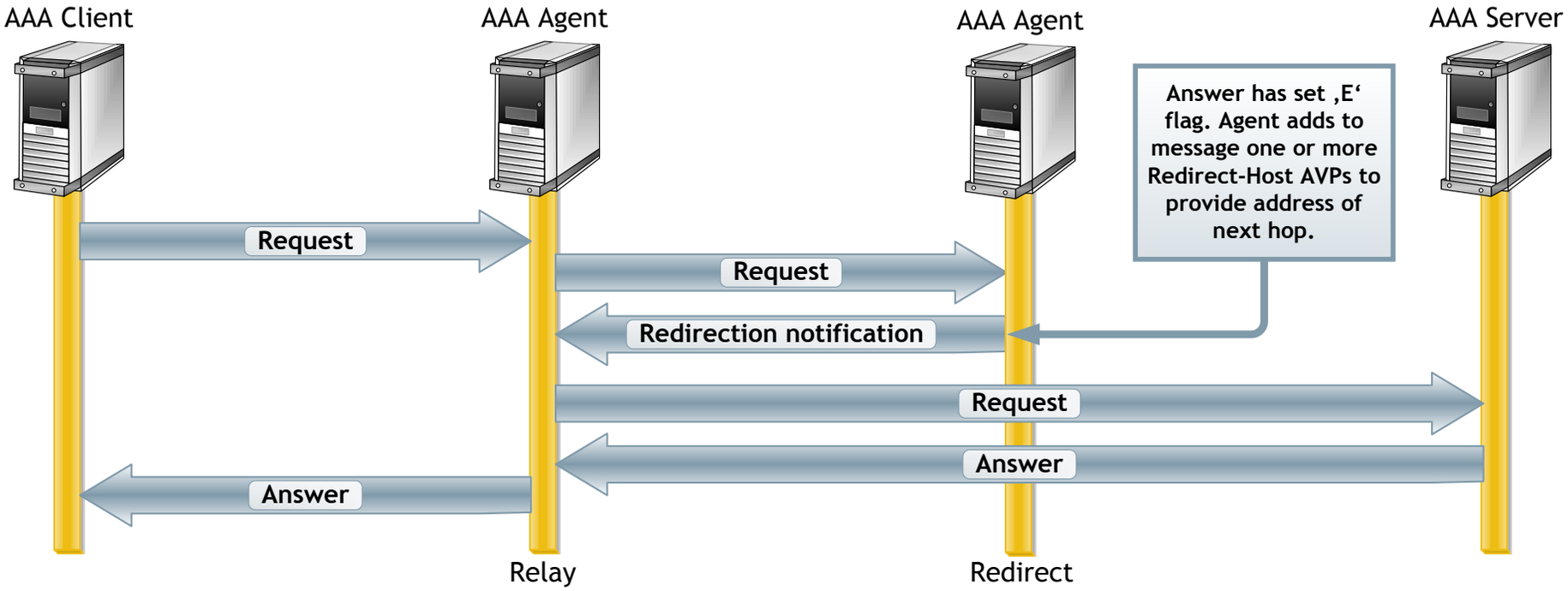


Note: Both use Peer and Realm Routing Table for decisions, where the will be forwarded

Diameter Agents 2/3

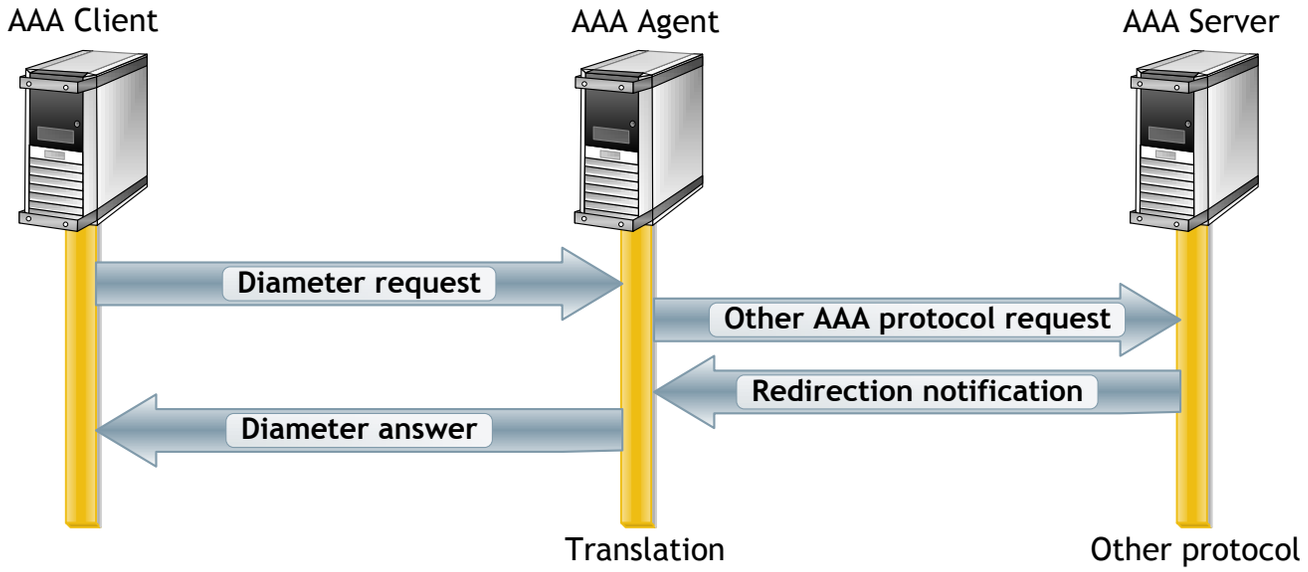
- Redirect Agent
  - For centralized routing configuration
  - Do not relay messages
  - Relay agent do not know realm example.com→forward message to default route (Redirect agent)
  - Redirect agent returns a redirect notification, as well as contact information of the next hop (Redirect-Host AVP)

Establishing a transport connection with next node, if one doesn't already exist, and forwards the request to it.



Diameter Agents 3/3

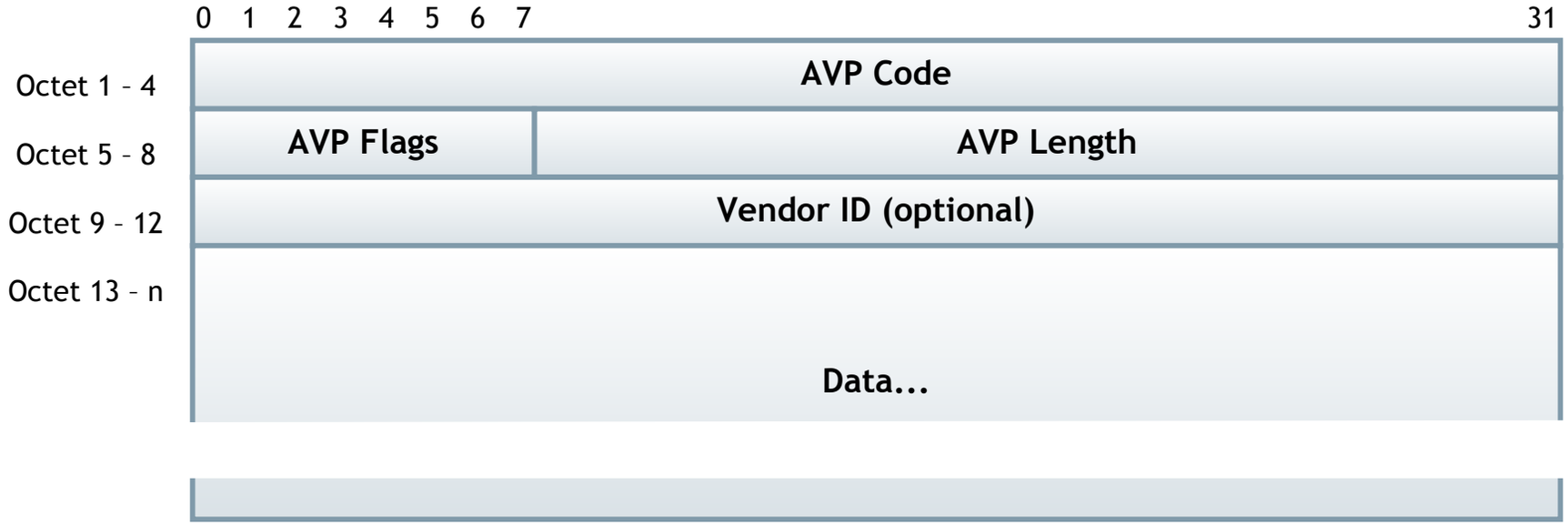
- Translation Agent
  - Provides translation between two protocols
  - RADIUS ↔ Diameter
  - TACACS+ ↔ Diameter
  - In applications where communication with other AAA protocol is requested
  - Used in applications where using or migration from other system to Diameter solution is not profitable for his complexity or economical reasons
  - Agent adds missing parameters, reorders headers values and enlarge or reduce parameter values to concrete AAA protocol format requirements



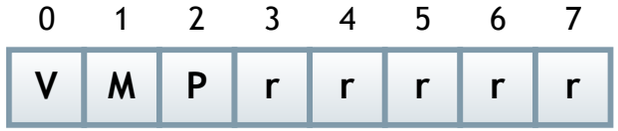
Diameter node

- Each node have Peer and Realm-Based Routing Table
- Each node must queued sent request messages
  - Message is erased from queue when answer matching with request is received
  - When link failure to peer is detected, all messages sent to this peer are retransmitted
- Relay, proxy and translation agent must maintain transaction state
- Proxy agent that wish to limit resources must maintain session state.
- Translation agent must be session stateful

AVP Format

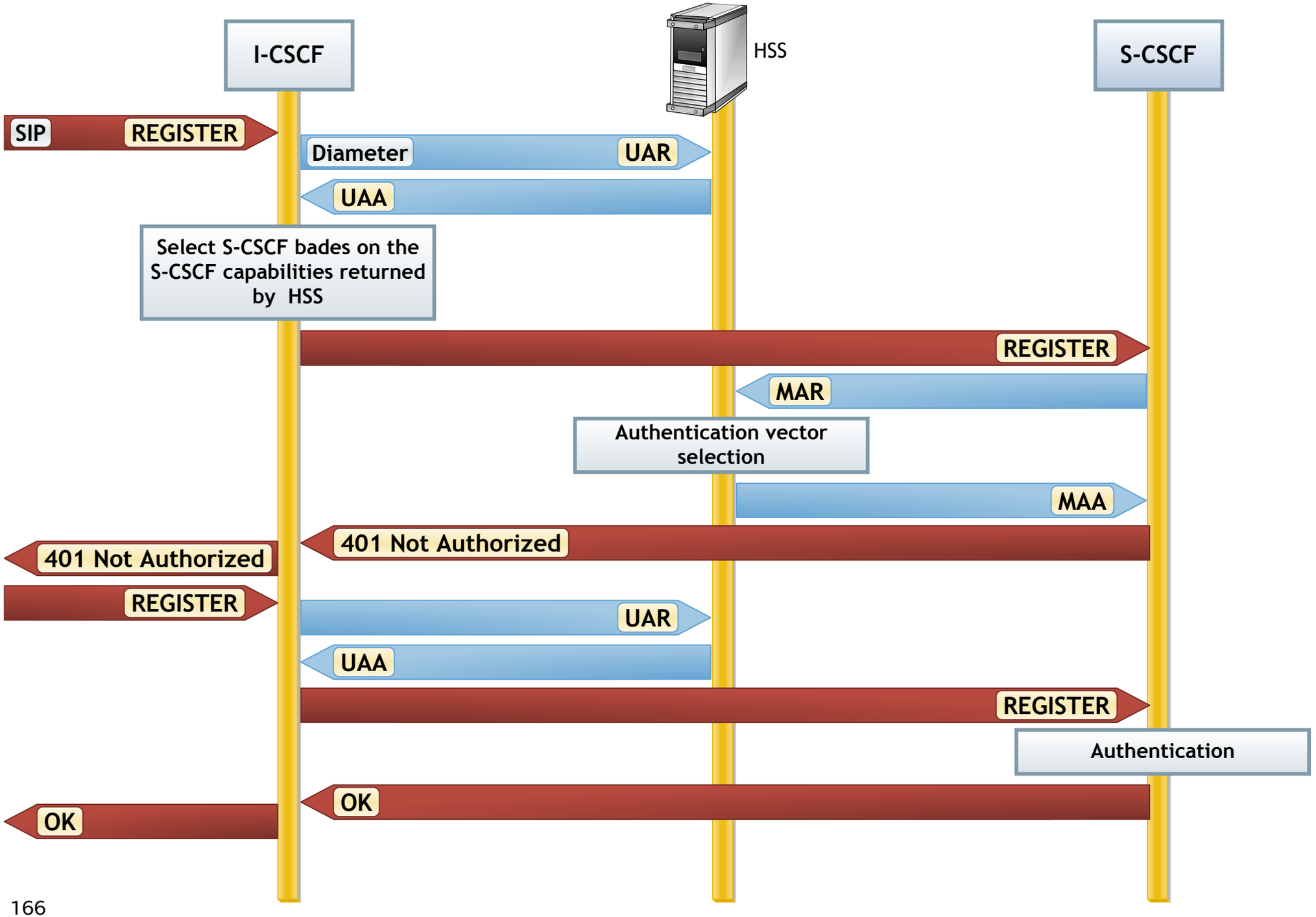


- AVP Flags Field

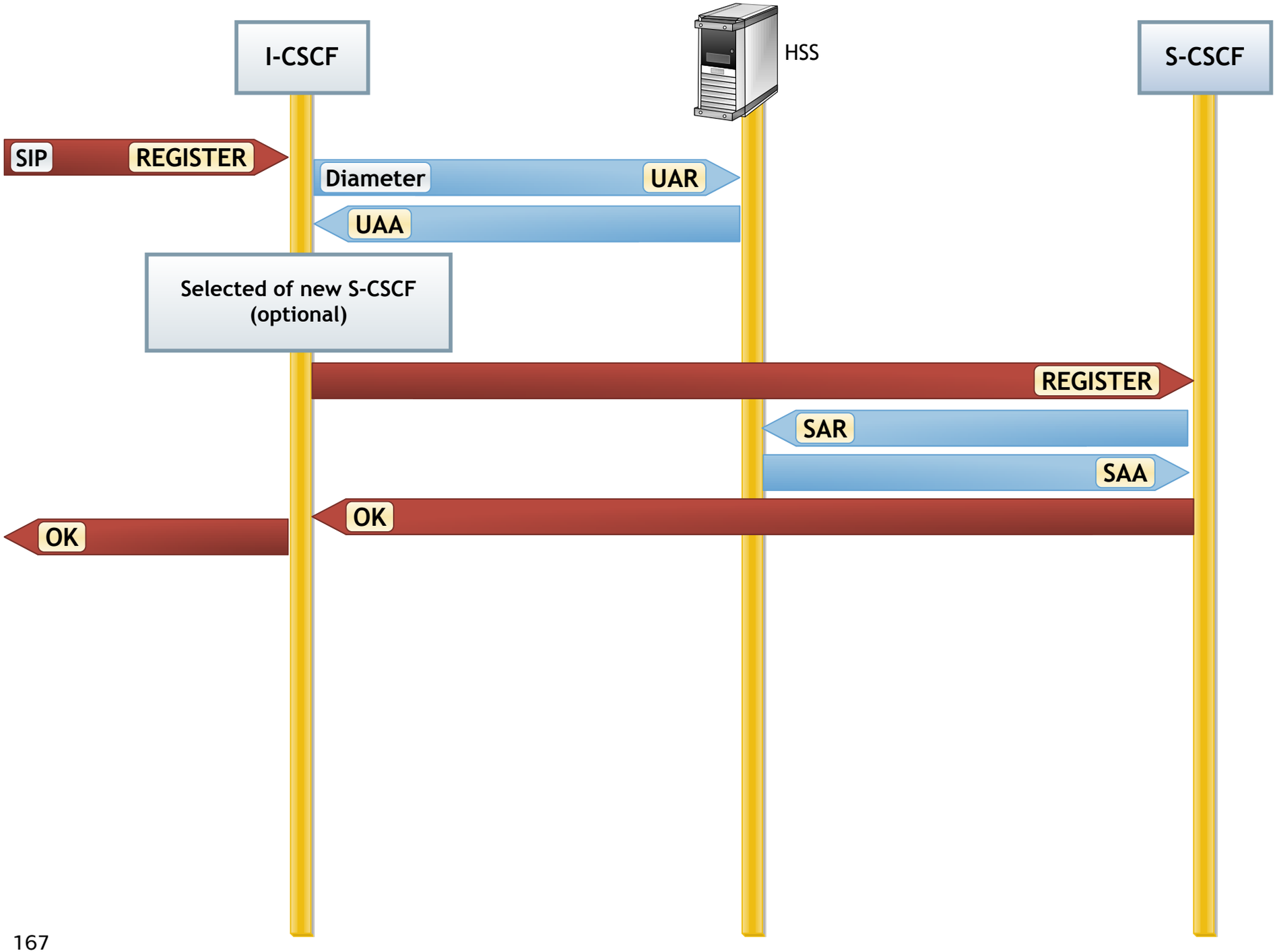


- V – Vendor-Specific bit
- M – Mandatory bit
- P – Protected bit
- r – reserved bit

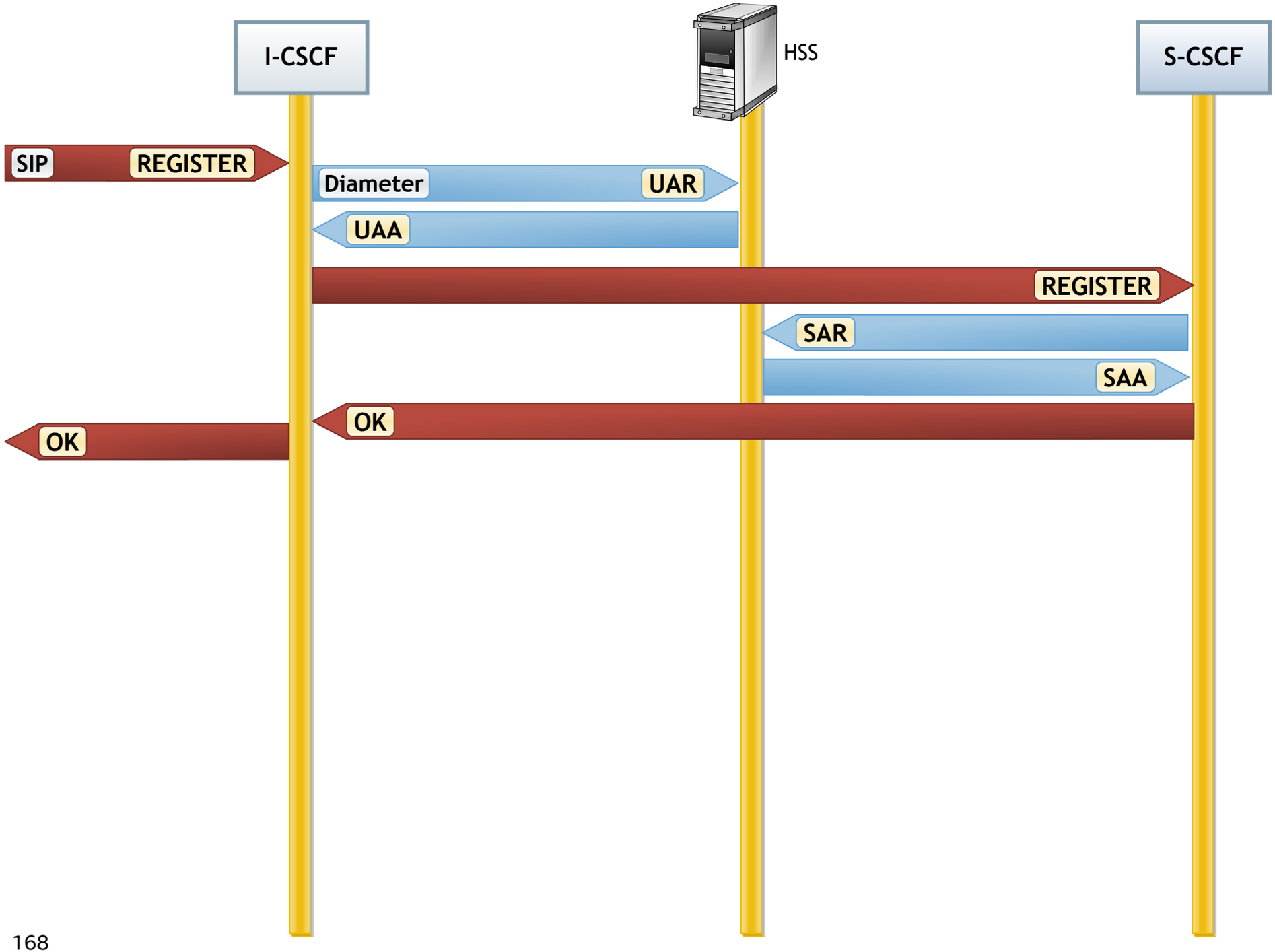
Registration - User Not Registered



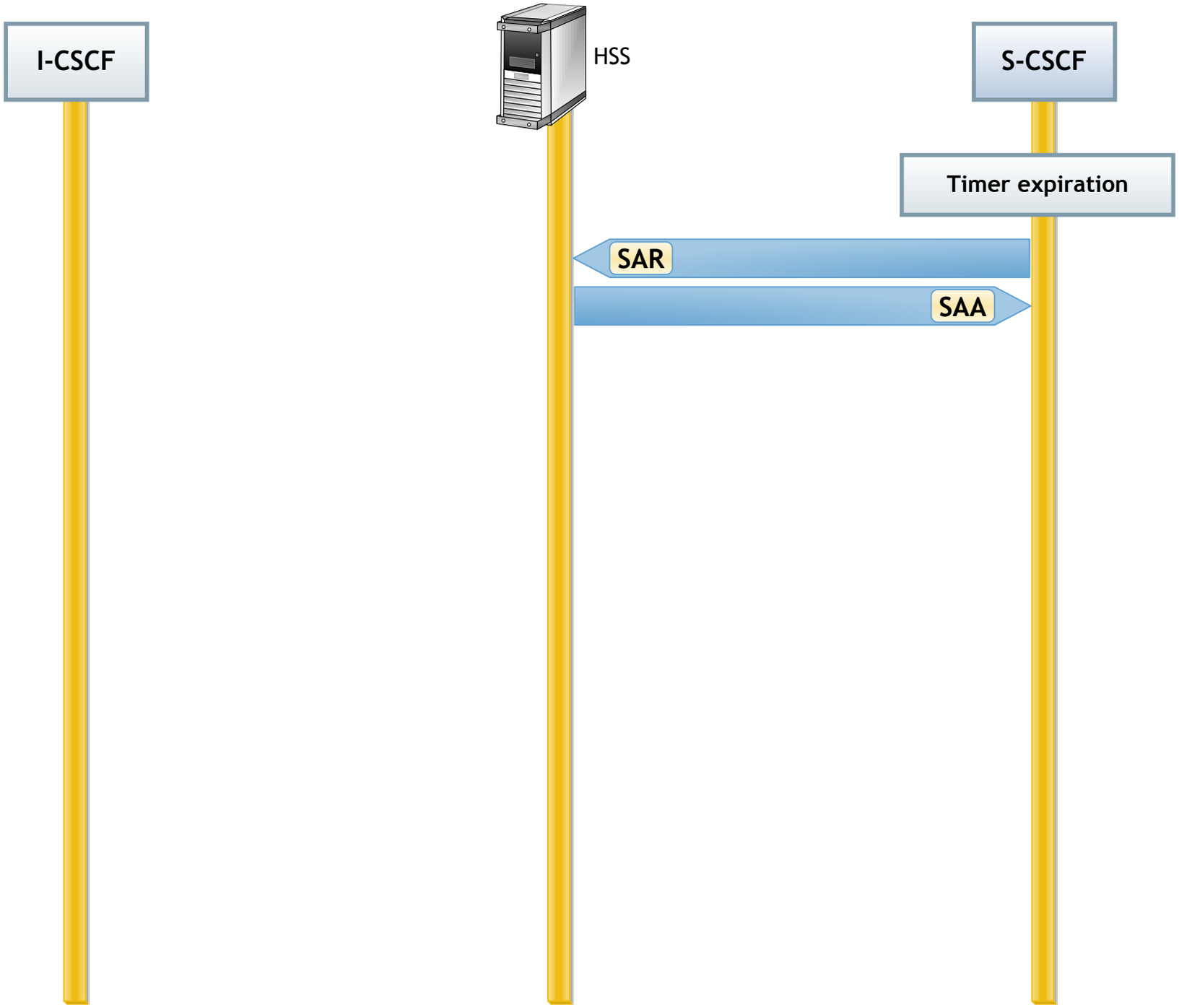
Registration - user currently registered



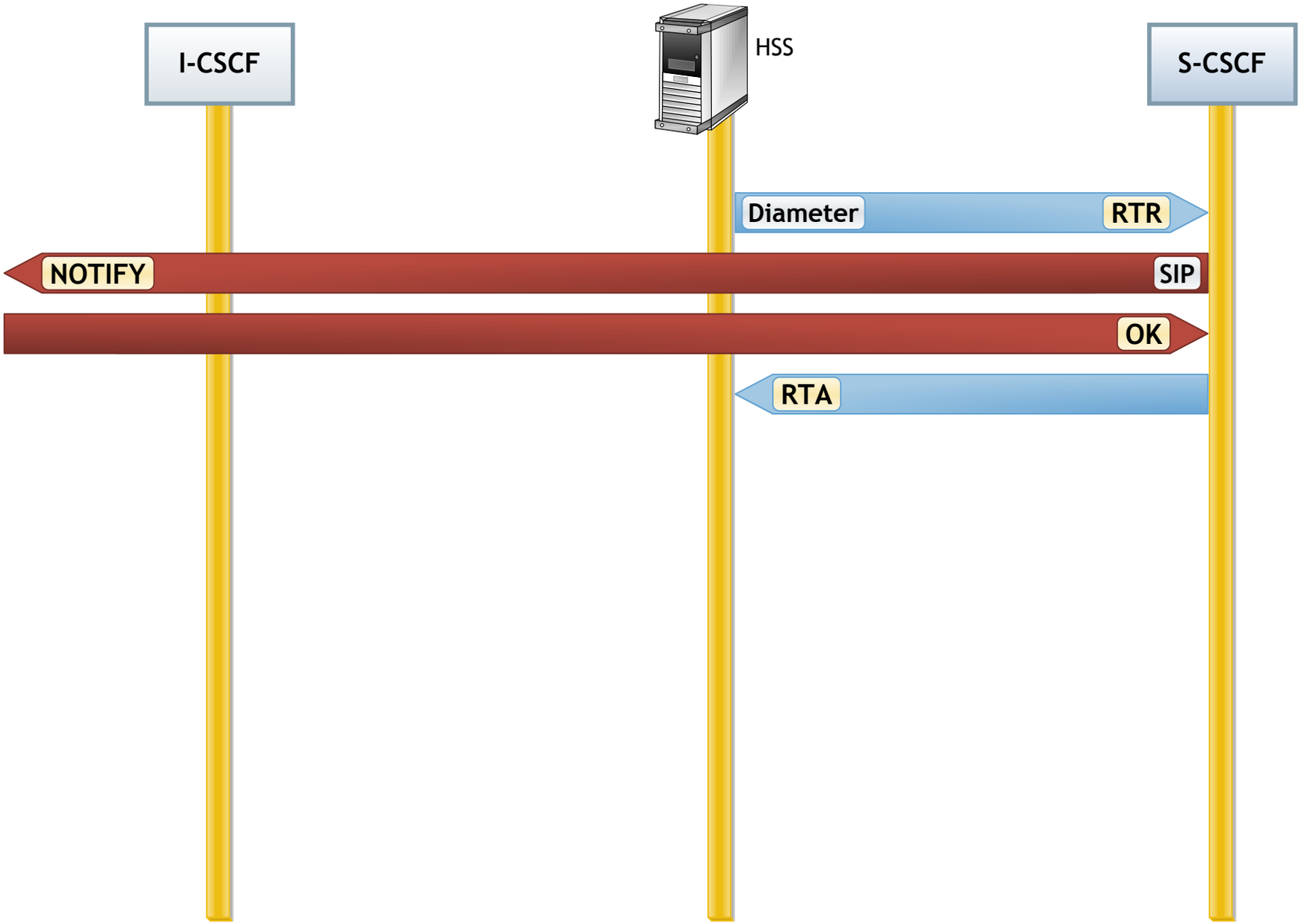
Mobile initiated de-registration



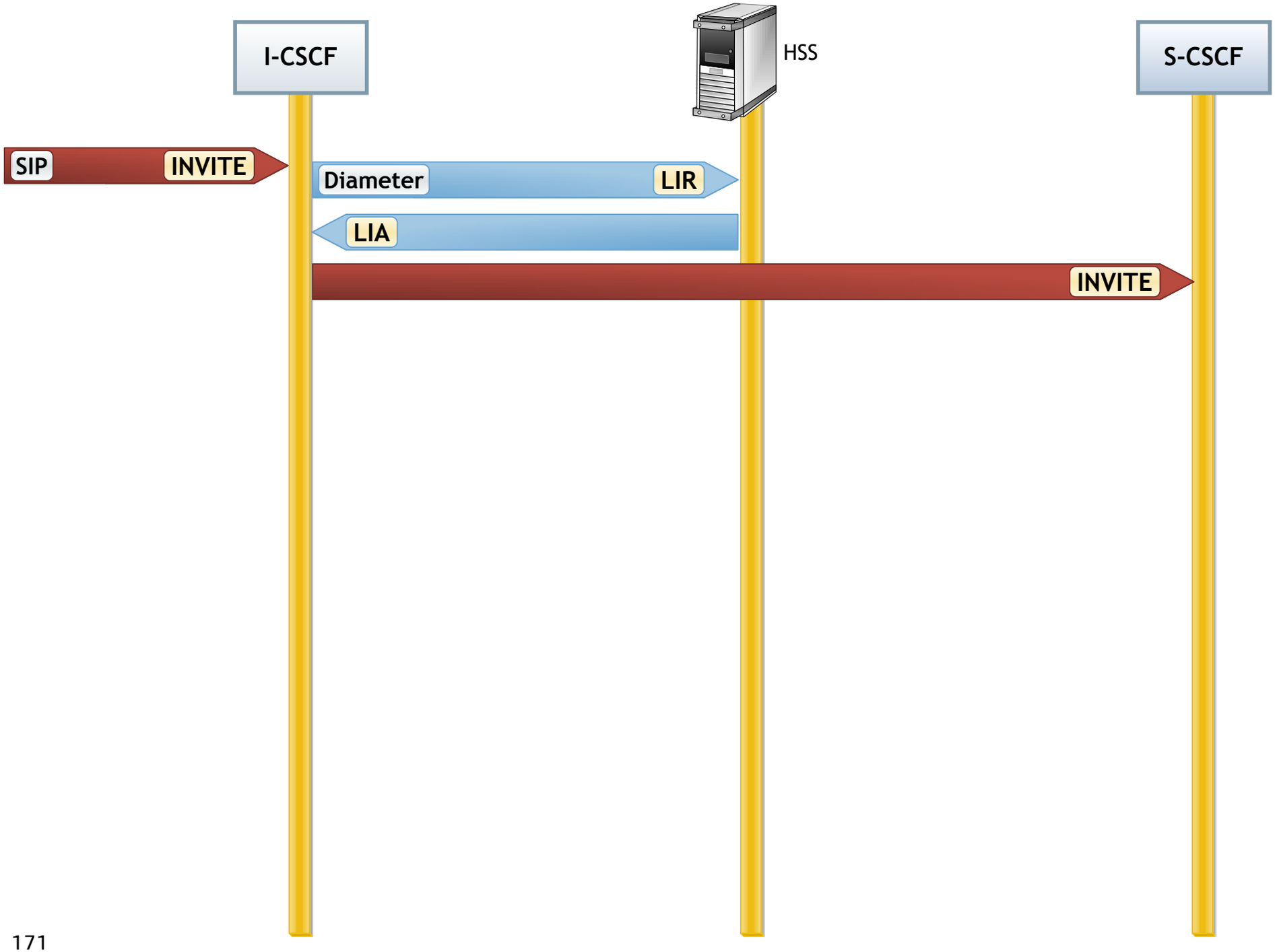
Network initiated de-registration - Registration time out



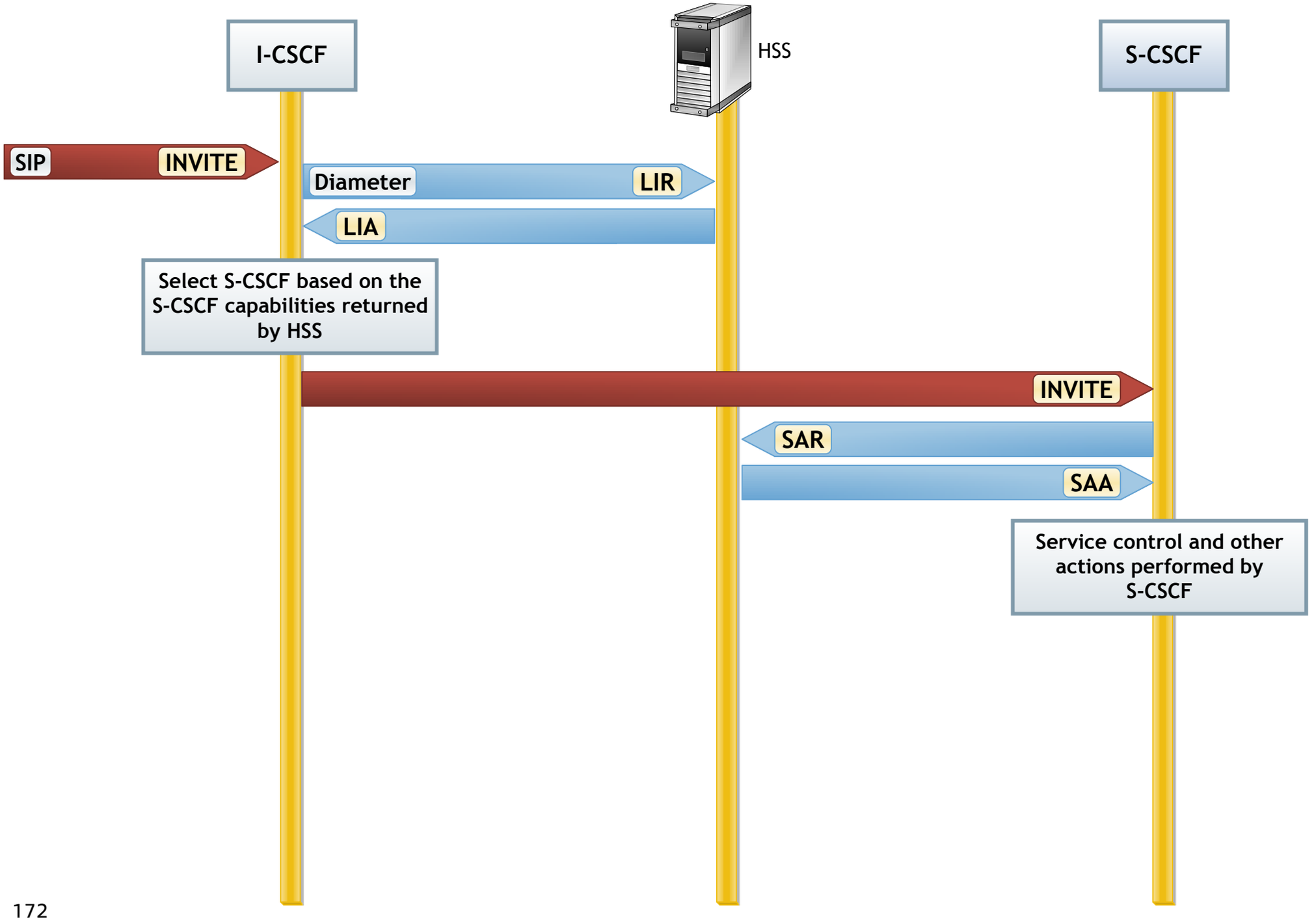
Network initiated de-registration - Administrative de-registration



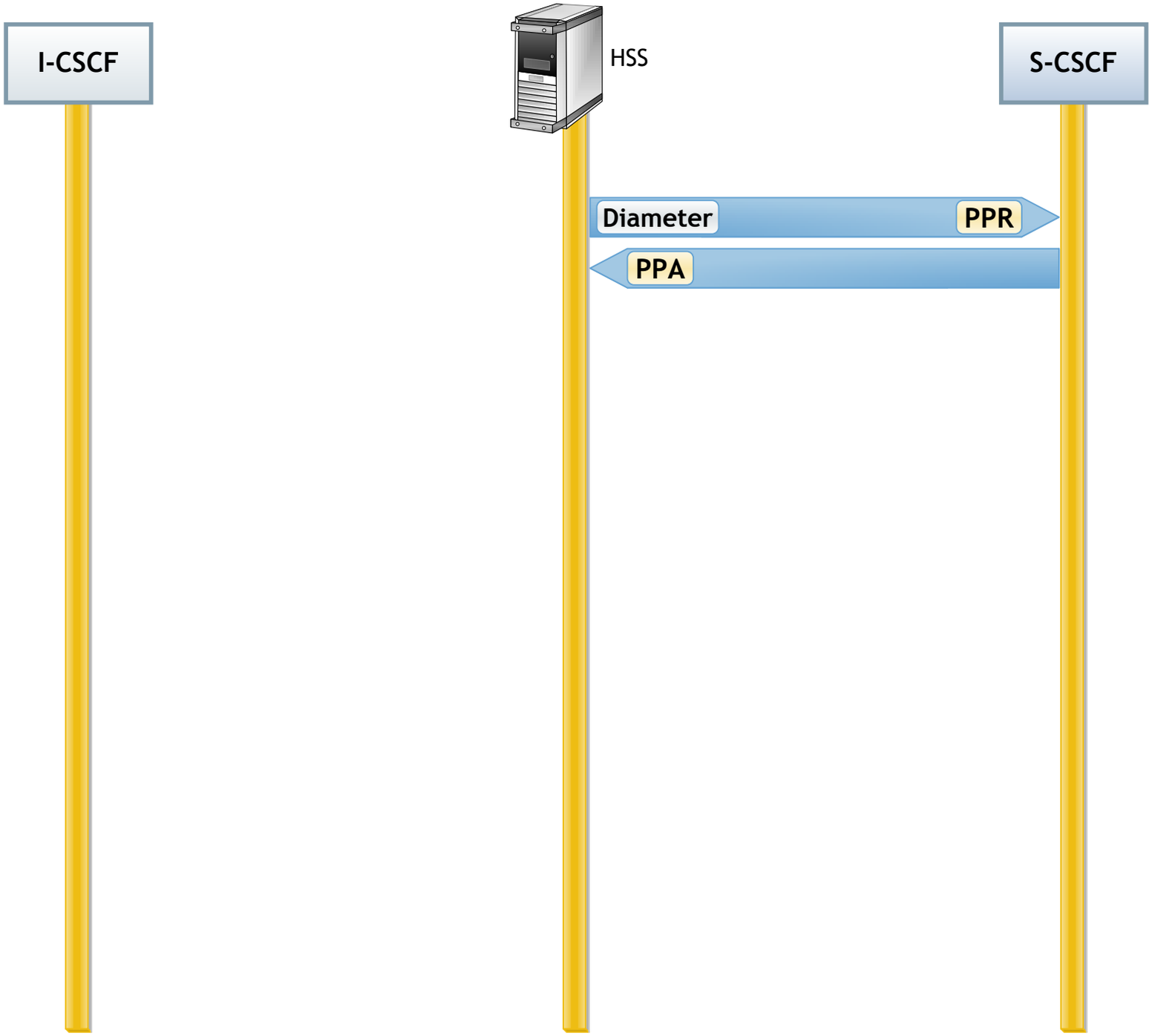
MT SIP session set-up



MT SIP session set-up to non-registered user



User profile update



Application on Sh/Dh interface

- Sh interface is between AS and HSS.
- From AAA Diameter functionality Sh interface utilizes only Authorization and Authentizarion. Accounting functionality is not supported over Sh interface.

- Dh interface is between AS and SLF.
- Generally it is connection between Diameter client and Diameter redirect server, so only Sh interface will be described.

Operations on Sh Interface

- User data handling procedures
  - The download of data from the HSS to an AS.
  - The update of data in the HSS.
- Subscription/notification procedures
  - An AS can subscribe to receive notifications from the HSS of changes in data.
  - The HSS can notify an AS of changes in data for which the AS previously had subscribed.

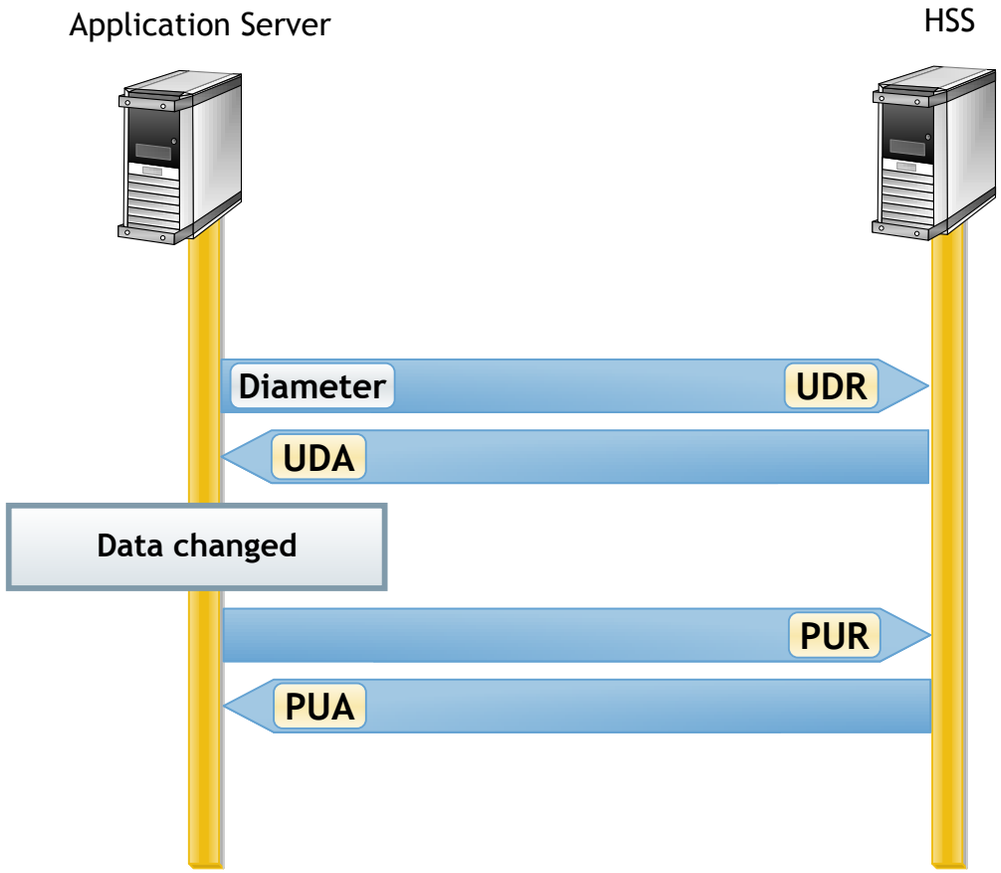
User Data Handling Procedures

- Data read
  - Invoked by AS to read transparent and/or non-transparent data for a specified user from the HSS.
  - Mapped to User-Data-Request/Answer (UDR/UDA)
  - UDR – contains identity for which profile and part of profile data are requested
  - UDA – returns requested data, if it is possible.
- Data update
  - Invoked by AS to update the transparent (repository) data stored at the HSS or to update the Public Service Identity Activation State in the HSS.
  - Mapped to Profile-Update-Request/Answer (PUR/PUA
  - PUR - contains identity for which profile and part of profile data will be updated in HSS.
  - PUA – returns result of update.

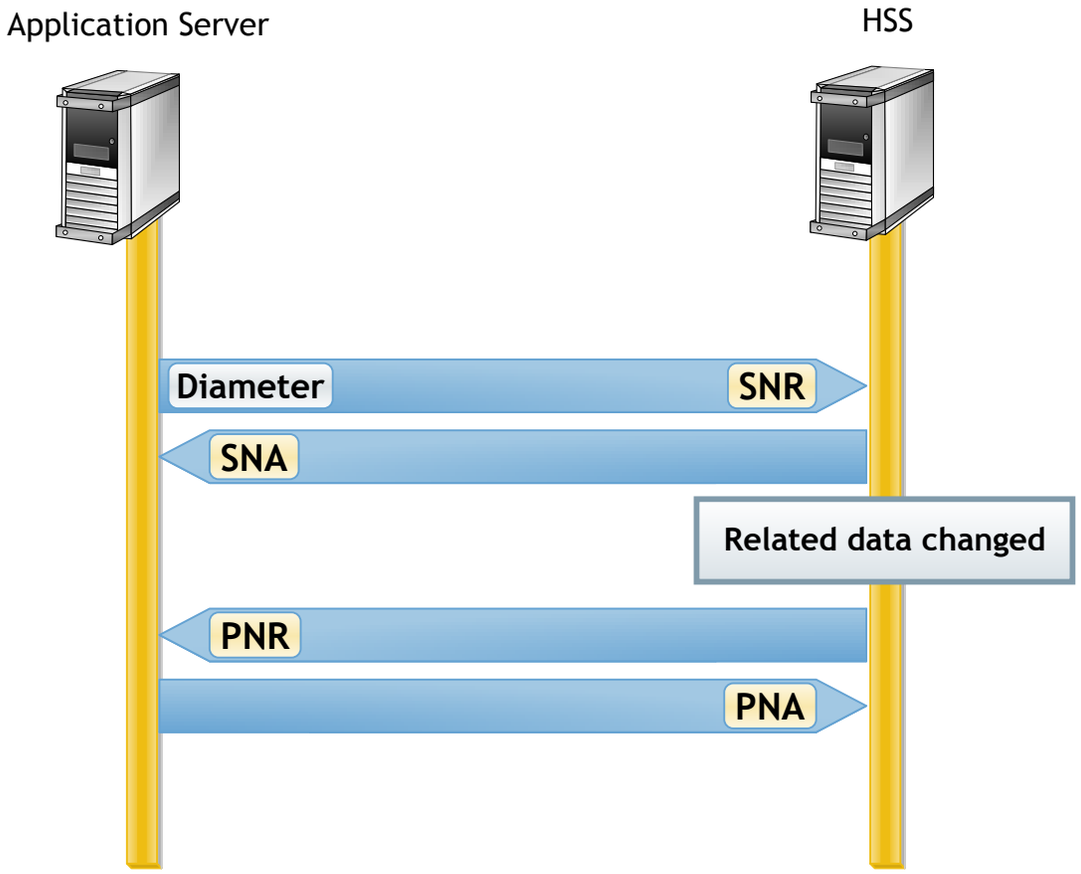
Subscription/notification procedures

- Subscription to notifications
  - Invoked by AS to subscribe notifications when particular transparent and/or non-transparent data for a specified Public User Identity or Public Service Identity is updated, from the HSS.
  - Mapped to Subscribe-Notifications-Request/Answer (SNR/SNA).
  - SNR – contains information about registration or deregistration of sending notifications about change in specified profile data
  - SNA – returns result of registration or deregistration of sending notifications.
- Notifications
  - Invoked by HSS to inform the AS of changes in transparent and/or non-transparent data to which the AS has previously subscribed to receive Notifications for.
  - Mapped to Push-Notification-Request/Answer (PNR/PNA)
  - PNR – contains identity for which profile data was changed and sending notification is requested and changed data too.
  - PNA – returns result of receiving changed profile data.

User Data Handling

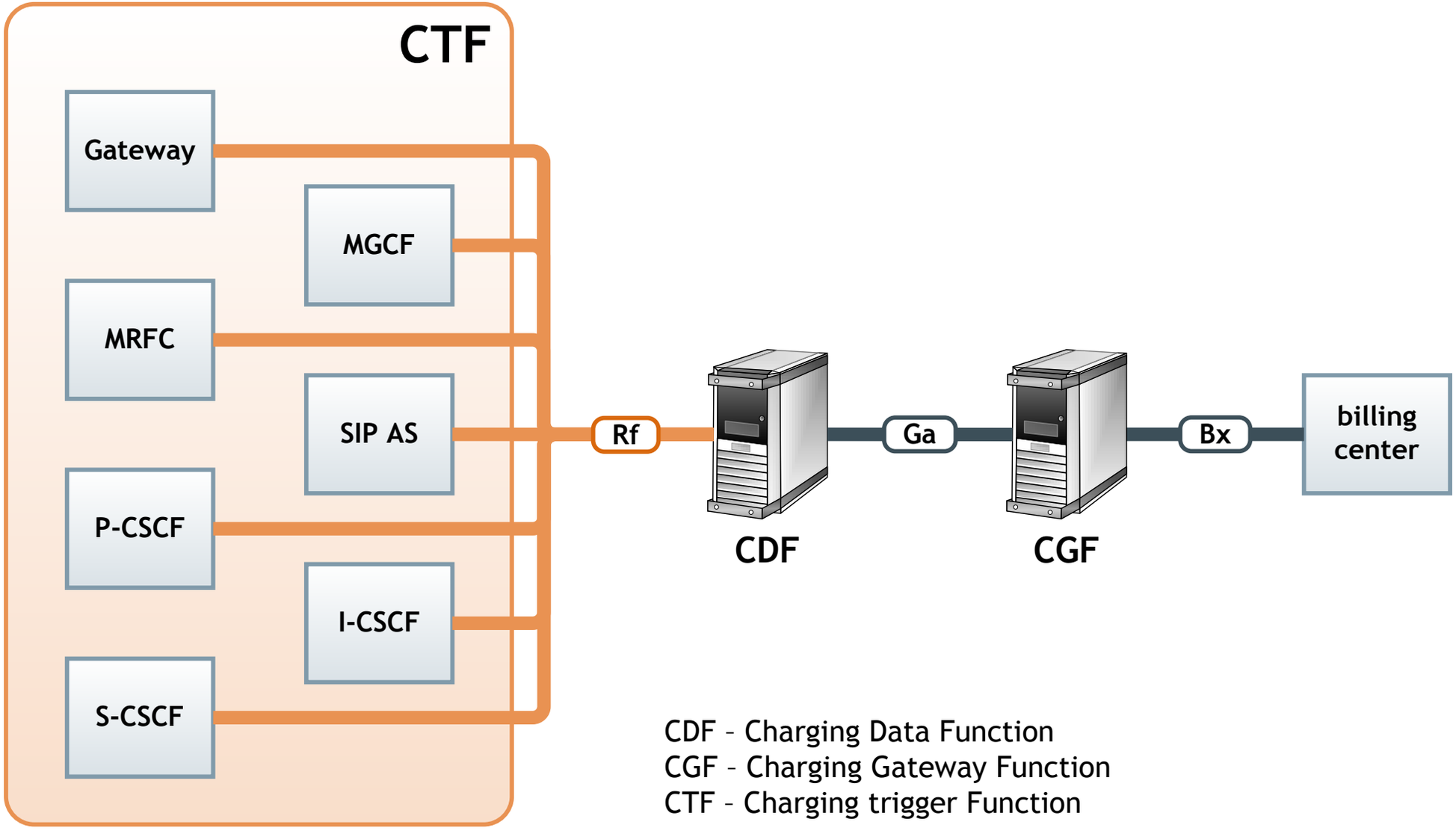


Notifications



Offline Charging Application on Rf Interface

- Charging mechanism where charging information does not affect, in real-time, the service rendered.
- Charging information is generating by many of IMS entities

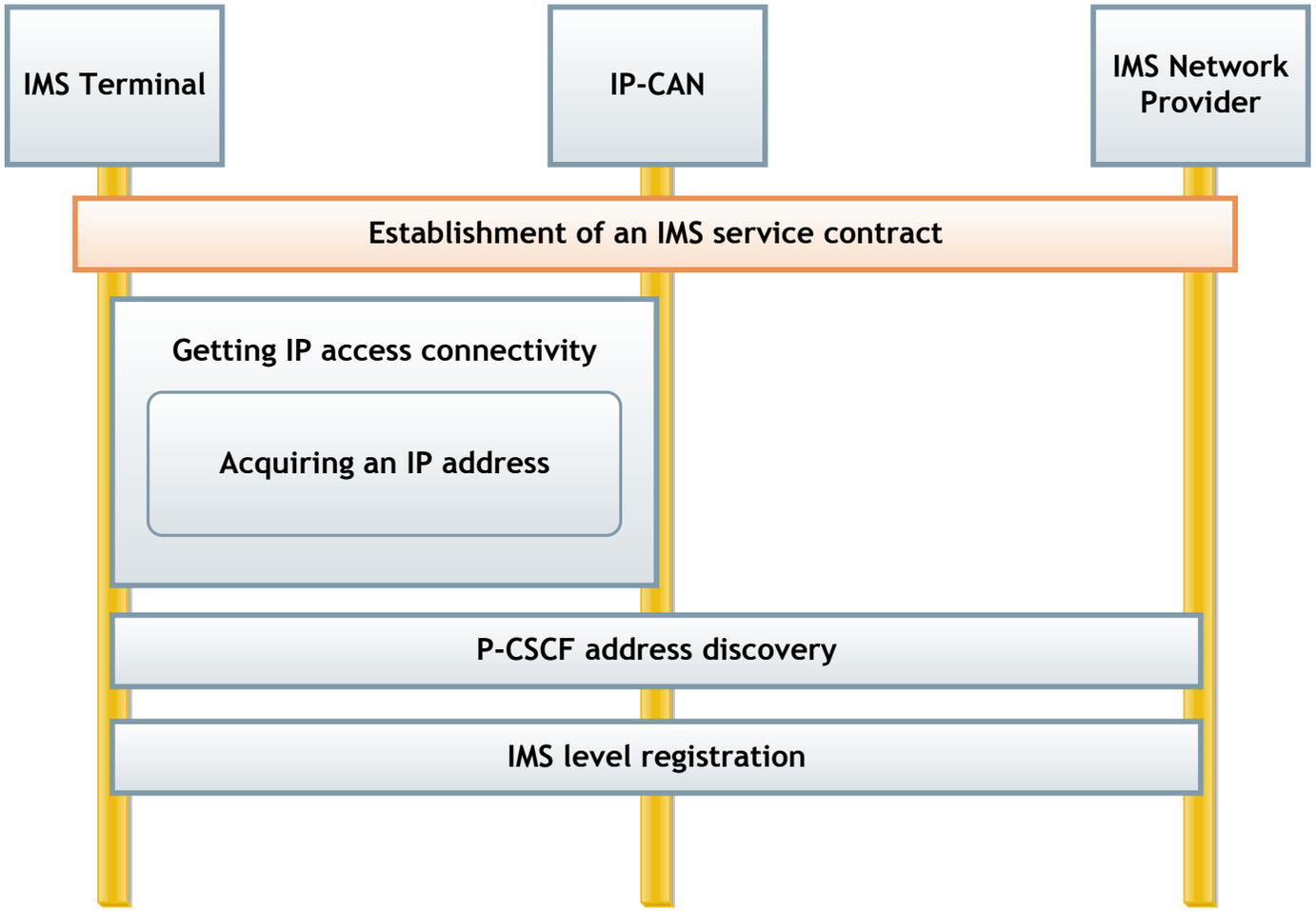


CDF – Charging Data Function
CGF – Charging Gateway Function
CTF – Charging trigger Function

Basic procedures

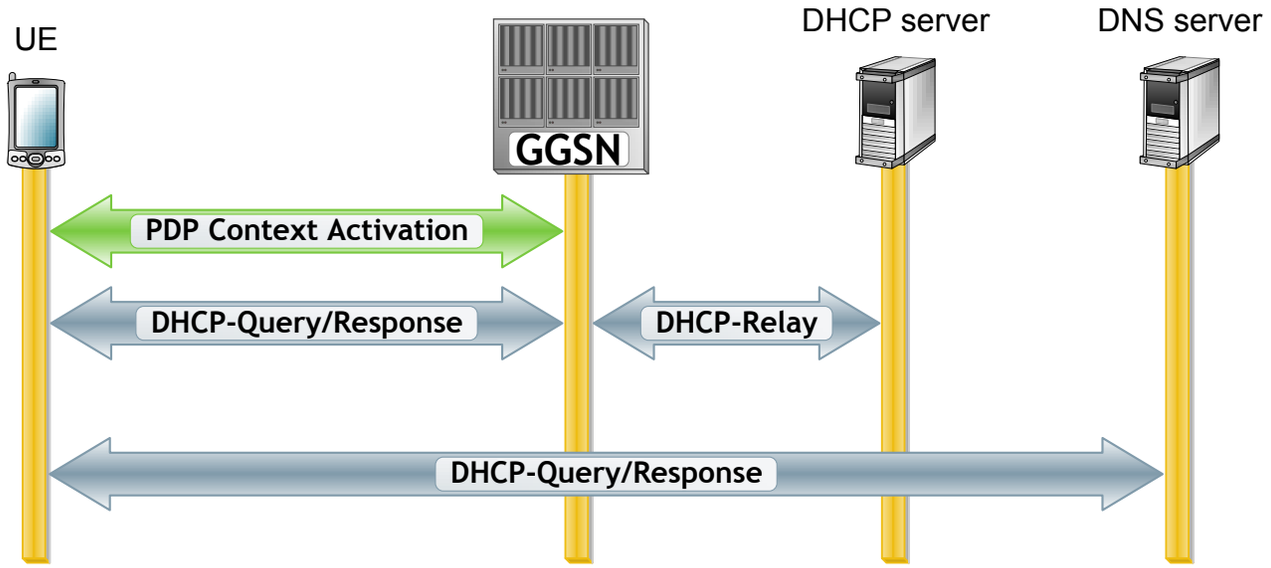
IMS basic procedures

- Prerequisites for IMS operation

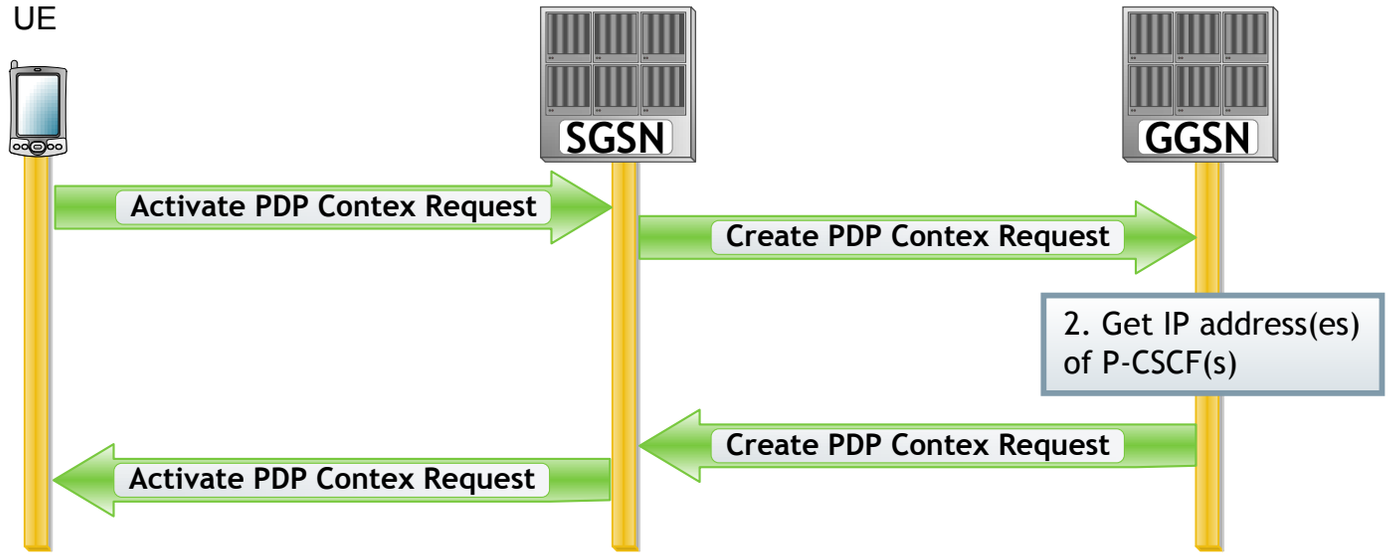


P-CSCF address discavery

P-CSCF discavery using DHCP and DNS

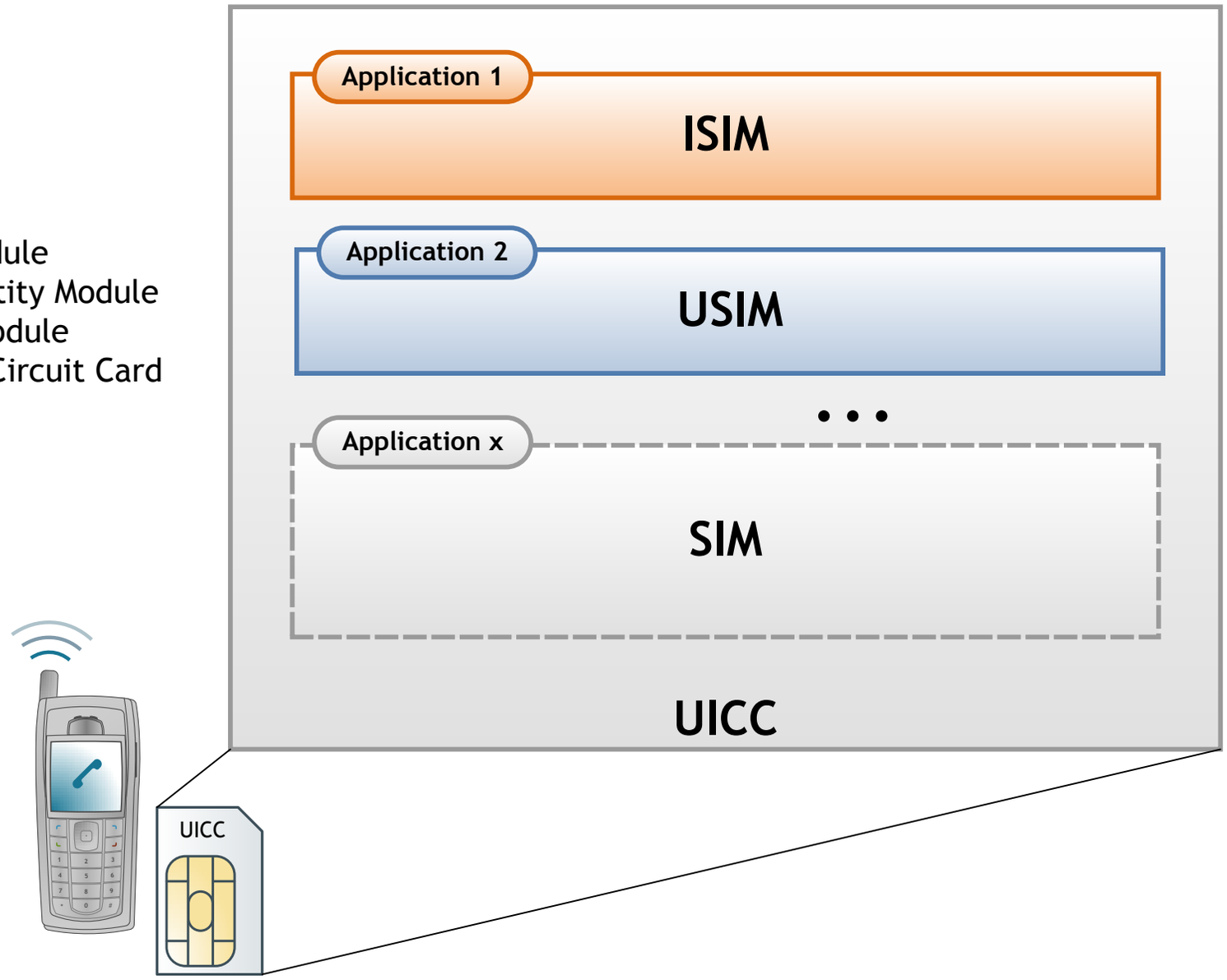


P-CSCF discavery using GPRS signalling – PDP context activation



Univerzal Integrated Circuid Card - UICC

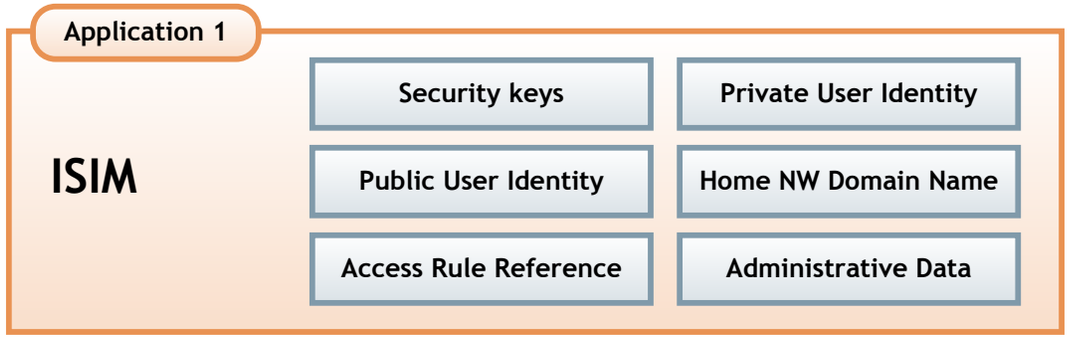
SIM – Subscriber Identity Module
USIM – UMTS Subscriber Identity Module
ISIM – IMS Service Identity Module
UICC – Universal Integrated Circuit Card



UICC is a physically secure device that can be inserted and removed from UE, there may be one or more application in.

UICC identity modules

- ISIM (IMS Service Identity Module)
  - Is an application residing on the UICC
  - Stores IMS specific subscriber data mainly provisioned by an IMS operator
  - Most of the stored data are needed when a user performs an IMS registration



- USIM (UMTS Subscriber Identity Module)
  - As ISIM, it‘s an application residing on the UICC
  - There are included specific data for access to UMTS network. Especially information for access to PS domain are required.

ISIM and private identity

- The private user identity will take form of a Network Access Identifier (NAI) defined in [RFC2486]
- The private user identity will be contained in all registration requests passed from the UE to the home network.
- The private user identity will be authenticated only during registration of the user (including re-registration and de-registration).
- The S-CSCF will need to obtain and store the private user identity on registration and on unregistered termination.
- The private user identity will not be used for routing of SIP messages.
- The private user identity will be permanently allocated to a user and securely stored in an IMS Identity Module (ISIM) application- The private user identity will be valid for the duration of the user's subscription within the home network.
- It will not be possible for the UE to modify the private user identity.
- The HSS will need to store the private user identity.
- The private user identity will optionally be present in charging records based on operator policies.

Example of NAI: form_user@realm

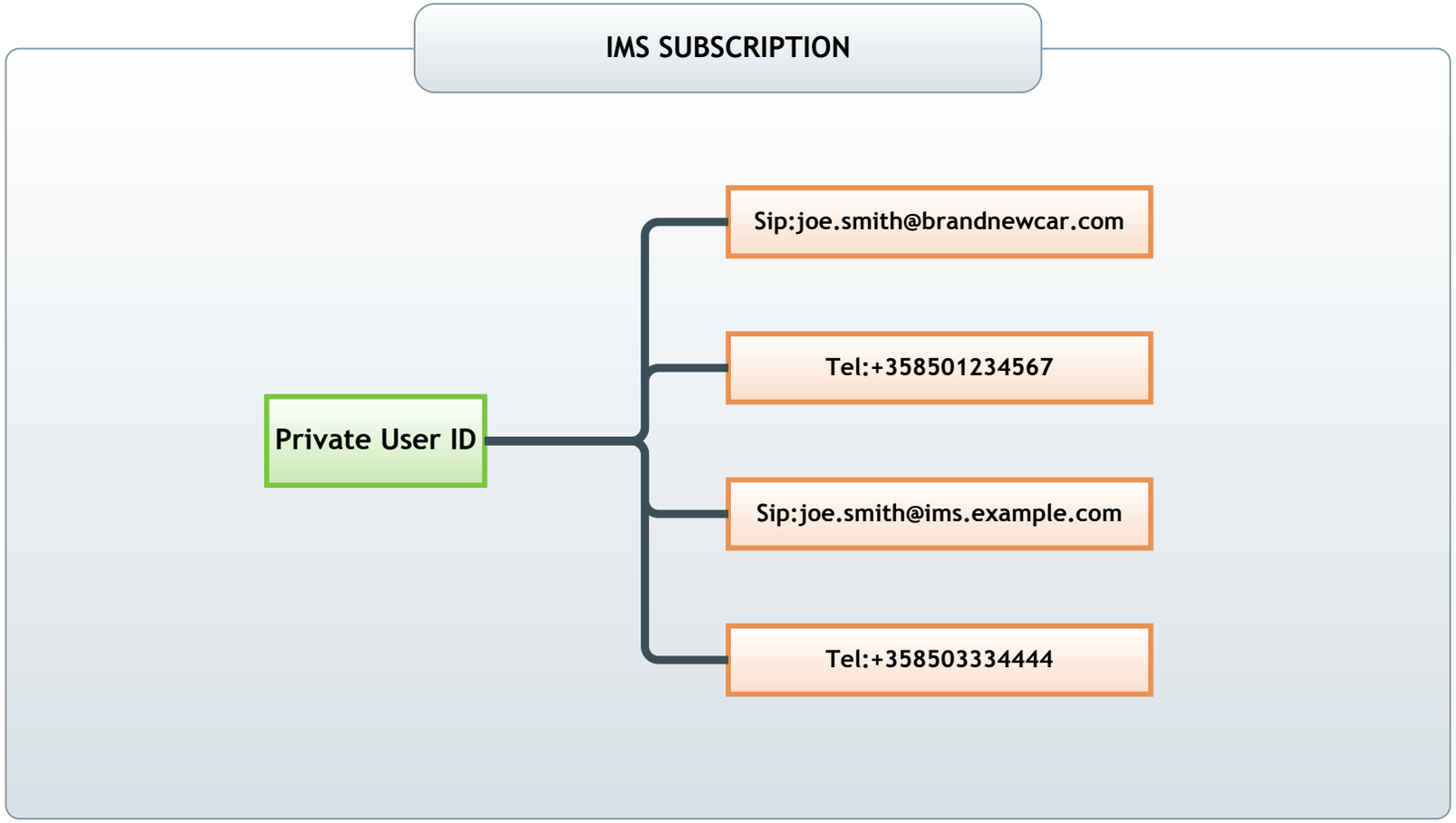
ISIM and Public User Identity

- The public user identity/identities will take the form of either a SIP Uniform Resource Identifier (URI) or a telephone Uniform Resource Locator (tel URL) format.
- At least one public user identity will be securely stored in an ISIM application.
- It will not be possible for the UE to modify the public user identity.
- A public user identity will be registered before the identity can be used to originate IMS sessions and IMS sessions-unrelated procedures (e.g., MESSAGE, SUBSCRIBE, NOTIFY).
- It will be possible to register multiple public user identities through one single UE request.
- The network will not authenticate public user identities during registration.

Example of SIP URI: **Sip:Jan.Novak@example.com**

Example of tel URL: **Tel:+35850 1234567**

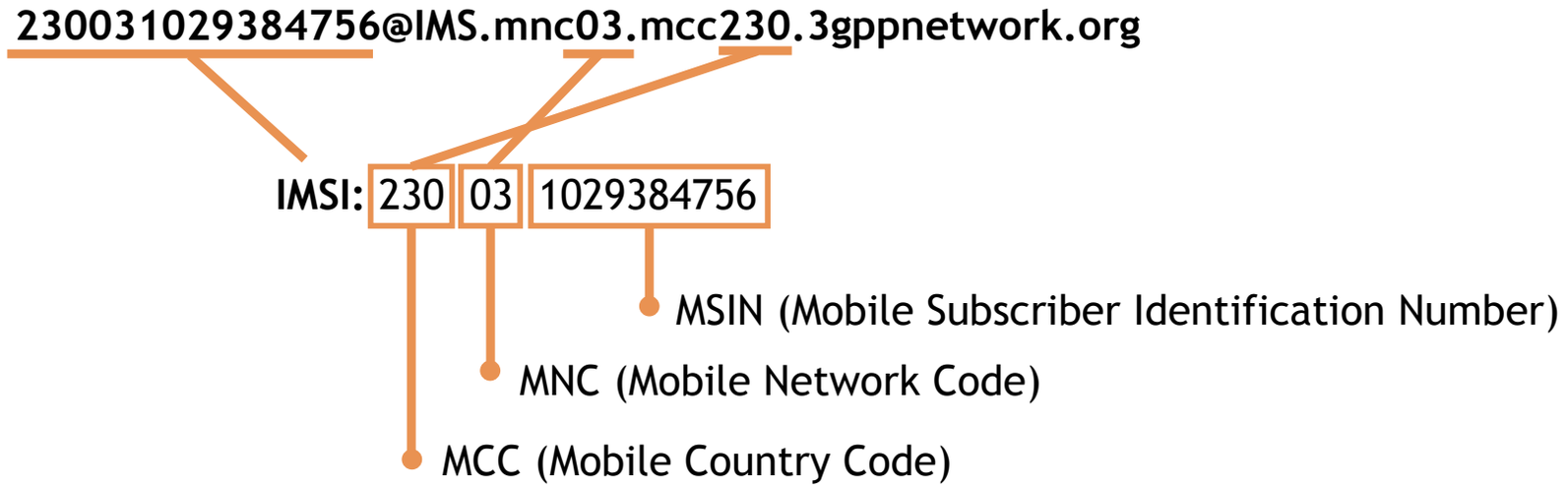
Relationship between user identities



User identities for USIM

- There is a lot of UE in the market place which doesn‘t support the ISIM application therefore private and public user identity must be derived from information stored on USIM.

- **Private user identity**
- It is derived from IMSI (International Mobile Subscriber Identity)
- Format of private user identity: **<IMSI>@IMS.mnc<MNC>.mcc<MCC>.3gppnetwork.org**



- **Temporary public user identity**
- It is used only for registration purpose to obtain implicitly registered public user identities. It take the form of SIP URI and the derivation method is the same like private user identity.

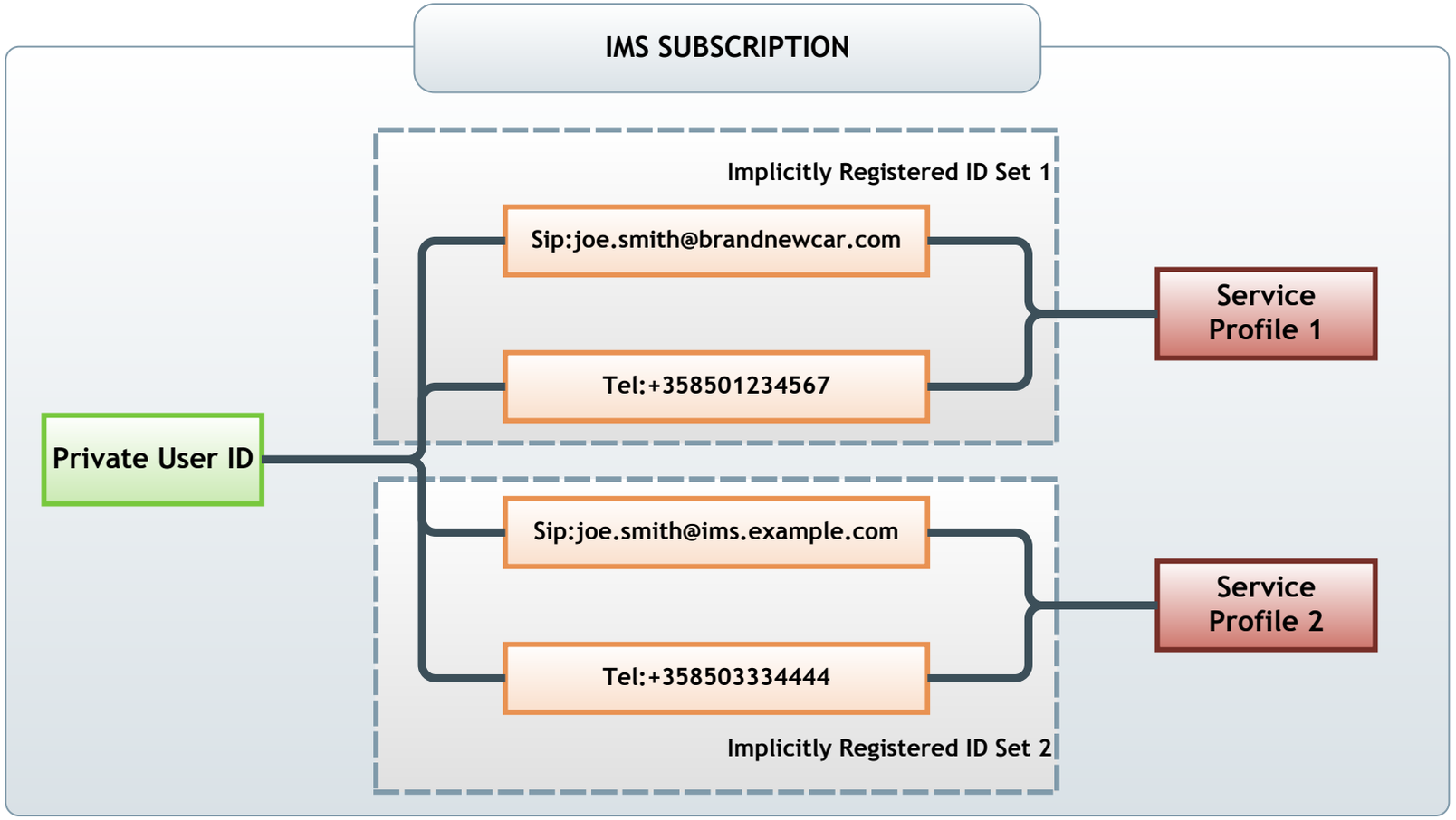
sip: IMSI@MCC.MNC.IMSI.”3gppnetwork.org”

Registration of multiple user identities

IETF SIP REGISTRATION

- SIP allows one PUI to be registered at a time
- If a user has more than one public user identity than has to register every PUI individually it would bring time and radio source consuming
- 3GPP SIP RFG developed a mechanism to register more than one public user identity at a time…implicit registration
- Implicit registration set is group of public user identities that are registered via single registration request

Mechanism to register multiple user identities



- When one of the PUI within the set is registered, all PUI associated with the implicit registration set are registered at the same time.
- When one of the PUI within the set is deregistred , all PUI that have been registered are implicitly de-registered at the same time.
- To get implicitly registered PUI, UE must send SUBSCRIBE request.
- When S-CSCF receives this request it will return the implicitly registered PUI in NOTIFY request.

Sharing single user identity

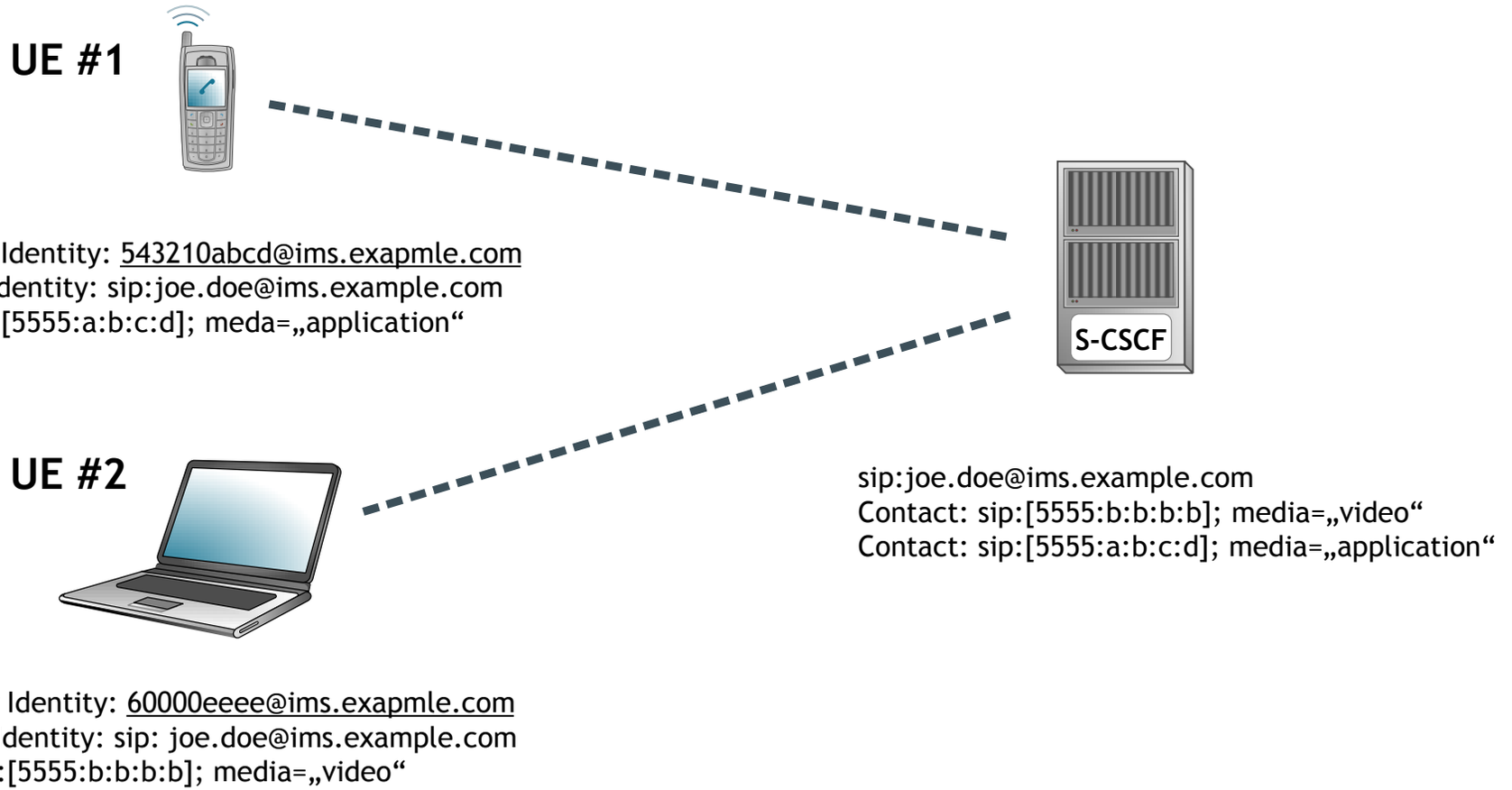
GSM

- In the traditional CS every single user has her own MSISDN number that is used to reach user.
- It is not possible to use multiple terminals with the same MSISDN simultaneously.

IMS

- Release 6 IMS allows users to register the same public user identity from a number of items of UE.
- User is able to indicate her preferences regarding a single UE at the registration phase.
- Different registrations can be differentiated by means of the private user identity and the used IP address.

Sharing single user identity



- Someone is calling Joe, his S-CSCF makes the decision as to which UE is going to be contacted in the first place.
- Decision is done based on the preference given at the registration phase
- In addition preferences-based routing, the S-CSCF may perform forking.

Sequential and parallel forking

IMS registration (ISIM is used)

- User binds a Public User Identity to a contact address. (REGISTER request)
- The home network authenticates the user
- The user authenticates the home network
- The home network authorizes the SIP registration and the usage of IMS resources
- If P-CSCF is alocated in visited network, the existing roaming agreement must be verifed.
- The IMS terminal and the P-CSCF negotiates the security mechanism that will be in place for subsequent signaling
- The P-CSCF and the IMS terminal establish a set of security associations that protect the integrity of SIP messages sent between the P-CSCF and the terminal
- Both the IMS terminal and the P-CSCF upload to each other the algoritms used for compression of SIP messages

IMS registration - REGISTER (1)

```
REGISTER sip:homel.net SIP/2.0
Via: SIP/2.0/UDP [1080::8:800:200C:417A];comp=sigcomp;branch=z9hG4bK9h9ab

Max-Forwards: 70
P-Access-Network-Info: 3GPP-UTRAN-TDD;
                    utran-cell-id-3gpp=C359A3913B20E
From:<sip:alice@homel.net>;tag=s8732n
To: <sip:alice@homel.net>
Contact:<sip:[1080::8:800:200C:417A];comp=sigcomp>;expires=600000
Call-ID: 23fi571ju
Authorization: Digest username="alice_private@homel.net",
             realm="homel.net", nonce="",
             uri="sip:home1.net", response=""
Security-Client: ipsec-3gpp; alg=hmac-sha-1-96;
               spi-c=3929102; spi-s=0293020;
               port-c:3333; port-s=5059

Require: sec-agree
Proxy-Require: sec-agree
Cseq: 1 REGISTER
Supported: path
Content-Lengt h: 0
```

IMS registration - REGISTER (2)

```
REGISTER sip:homel.net SIP/2.0
Via: SIP/2.O/UDP pcscf1.visitedl.net;branch=z9hG4bKoh2qrz,
     SIP/2.0/UDP [1080::8:800:200C:417A];comp=sigcomp;branch=z9hG4bK9h9ab

Max-Forwards: 69
P-Access-Network-Info: 3GPP-UTRAN-TDD;
                       utran-cell-id-3gpp=C359A3913B20E

Path: <sip:term@pcscf1.visitedl.net;lr>
Require: Path
P-Visited-Network-ID: "Visited 1 Network"
P-Charging-Vector: icid-value="W34h6dlg"
From:<sip:alice@homel.net>;tag=s8732n
To: <sip:alice@homel.net>
Contact:<sip:[1080::8:800:200C:417A];comp=sigcomp>;expires=600000
Call-ID: 23fi571ju

Authorization: Digest username="alice_private@homel.net",
               realm="homel.net", nonce="",
               uri="sip:home1.net", response="",integrity-protected="no"

Cseq: 1 REGISTER
Supported: path
Content-Lengt h: 0
```

IMS registration - REGISTER (5)

```
REGISTER sip:homel.net SIP/2.0
Via: SIP/2.O/UDP icscf1.homel.net;branch=z9hG4bKealdof,
     SIP/2.O/UDP pcscf1.visitedl.net;branch=z9hG4bKoh2qrz,
     SIP/2.O/UDP [1080::8:800:200C:417A];comp=sigcomp; branch=z9hG4bK9h9ab

Max-Forwards: 68
P-Access-Network-Info: 3GPP-UTRAN-TDD;
                       utran-cell-id-3gpp=C359A3913B20E
From:<sip:alice@homel.net>;tag=s8732n
To: <sip:alice@homel.net>
Contact:<sip: [1080::8:800:200C:417A];comp=sigcomp>;expires=600000
Call-ID: 23fi571ju
Authorization: Digest username="alice_private@homel.net",
              realm="homel.net", nonce="",
              uri="sip:homel.net", response"", integrityprotected="no"

Require: path
Supported: path
Path: <sip:term@pcscf1.visitedl.net;lr>
P-Visited-Network-ID: "Visited 1 Network"
P-Charging-Vector: icid-value="W34h6dlg"
Cseq: 1 REGISTER
Content-Length: 0
```

IMS registration - 401 UNAUTHORIZED (9)

```
SIP/2.0 401 Unauthorized
Via: SIP/2.O/UDP pcscf1.visitedl.net;branch=z9hG4bKoh2qrz,
     SIP/2.0/UDP [1080::8:800:200C:417A];comp=sigcomp;branch=z9hG4bK9h9ab

From:<sip:alice@homel.net>;tag=s8732n
To: <sip:alice@homel.net>
Contact:<sip:[1080::8:800:200C:417A];comp=sigcomp>;expires=600000
Call-ID: 23fi571ju

WWW-Authenticate: Digest realm="home1.net",
                  nonce="dcd98b7102dd2i0e8blld0f600bfb0c093", algorithm=AKAvl-MD5,
                  ik= "00112233445566778899aabbccddeeff",
                  ck="ffeeddccbbaa11222334455667788 99"
Cseq: 1 REGISTER
Content-Lengt h: 0
```

IMS registration - 401 UNAUTHORIZED (10)

```
SIP/2.0 401 Unauthorized
Via: SIP/2.0/UDP [1080::8:800:200C:417A];comp=sigcomp;branch=z9hG4bK9h9ab
From:<sip:alice@homel.net>;tag=s8732n
To:<sip:alice@homel.net>;tag=409sp3
Call-ID: 23fi571ju
WWW-Authenticate: Digest realm="home1.net",
                  nonce="dcd98b7102dd2i0e8blld0f600bfb0c093", algorithm=AKAvl-MD5

Security-Server: ipsec-3gpp; q=0.1; alg=hmac-sha-l-96;
                 spi-c=909767; spi-s=421909;
                 port-c:4444; port-s=5058
Cseq: 1 REGISTER
Content-Length: 0
```

IMS registration - REGISTER (11)

```
REGISTER sip:homel.net SIP/2.0
Via: SIP/2.0/UDP [1080::8:800:200C:417A]:5059;comp=sigcomp; branch=z9hG4bK9h9ab

Max-Forwards: 70
P-Access-Network-Info: 3GPP-UTRAN-TDD;
                    utran-cell-id-3gpp=C359A3913B20E

From: <sip:alice@homel.net>;tag=s8732n
To:<sip:alice@homel.net>
Contact:<sip:[1080::8:800:200C:417A]:5059;comp=sigcomp>;expires=600000
Call-ID: 23fi571ju
Authorization: Digest username="alice_private@homel.net",
             realm="homel.net",
             nonce="dcd98b7102dd2f0e8blld0f600bfb0c093",
             algorithm=AKAvl-MD5,uri="sip:homel.net",
             response="6629fae49393a05397450978507c4ef1"

Security-Verify: ipsec-3gpp; q=0.1; alg=hmac-sha-l-96;
               spi-c=909767; spi-s=421909;
               portc:4444; port-s=5058

Require: sec-agree
Proxy-Require: sec-agree
Cseq: 2 REGISTER
Supported: path
Content-Length: 0
```

IMS registration - REGISTER (12)

```
REGISTER sip:homel.net SIP/2.0
Via: SIP/2.O/UDP pcscf1.visitedl.net;branch=z9hG4bKoh2qrz,
     SIP/2.0/UDP [1080::8:800:200C:417A];comp=sigcomp;branch=z9hG4bK9h9ab

Max-Forwards: 69
P-Access-Network-Info: 3GPP-UTRAN-TDD;
                       utran-cell-id-3gpp=C359A3913B20E

Path: <sip:term@pcscf1.visitedl.net;lr>
Require: Path
P-Visited-Network-ID: "Visited 1 Network"
P-Charging-Vector: icid-value="W34h6dlg"
From:<sip:alice@homel.net>;tag=s8732n
To: <sip:alice@homel.net>
Contact:<sip:[1080::8:800:200C:417A];comp=sigcomp>;expires=600000
Call-ID: 23fi571ju

Authorization: Digest username="alice_private@homel.net",
               realm="homel.net", nonce="dcd98b7102dd2i0e8blld0f600bfb0c093",
               algorithm=AKAvl-MD5, uri="sip:home1.net",
               response="6629fae49393a05397450978507c4ef1",integrity-protected="yes"

Cseq: 2 REGISTER
Supported: path
Content-Lengt h: 0
```

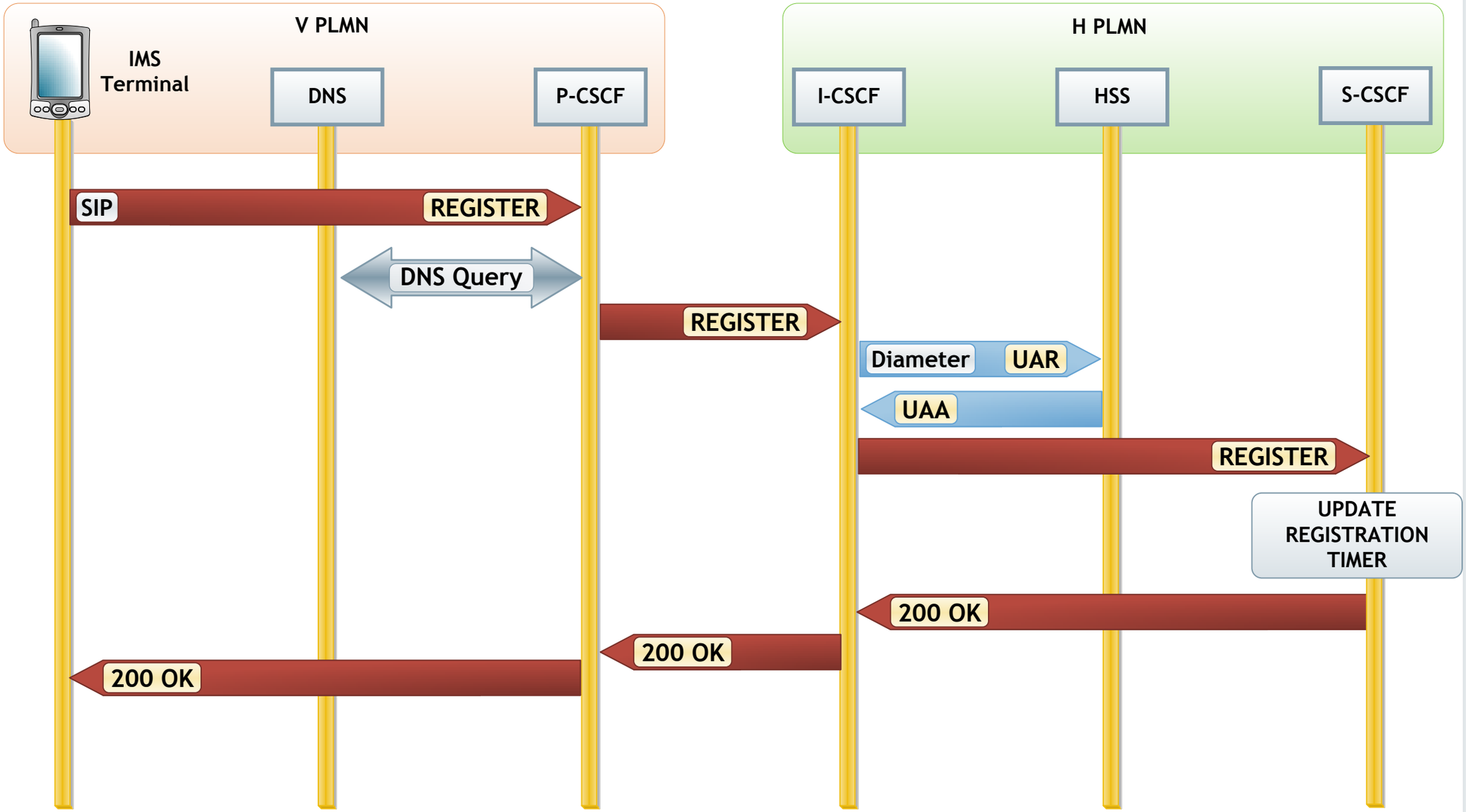
IMS registration - REGISTER (15)

```
REGISTER sip:homel.net SIP/2.0
Via: SIP/2.0/UDP icscf1.homel.net;branch=z9hG4bKealdof,
Via:SIP/2.0/UDP pcscf1.visitedl.net;branch=z9hG4bKoh2qrz,
Via: SIP/2.0/UDP[1080::8:800:200C:417A]:5059;comp=sigcomp;branch=z9hG4bK9h9ab

Max-Forwards: 68
P-Access-Network-Info: 3GPPUTRAN-TDD;
                    utran-cell-id-3gpp=C359A3913B20E
From:<sip:alice@homel.net>;tag=s8732n
To: <sip:alice@homel.net>
Contact:<sip:[1080::8:800:200C:417A]:5059;comp=sigcomp>;expires=600000
Call-ID: 23fi571ju
Authorization: Digest username="alice_private@homel.net",
             realm="homel.net",
             nonce="dcd98b7102dd2f0e8blld0f600bfb0c093",
             algorithm=AKAvl-MD5,uri="sip:homel.net",
             response="6629fae49393a05397450978507c4ef1",
             integrity-protected="yes"

Require: path
Supported: path
Path: <sip:term@pcscf1.visitedl.net;lr>
P-Visited-Network-ID: "Visited 1 Network"
P-Charging-Vector: icid-value="W34h6dlg"
Cseq: 2 REGISTER
Content-Length: 0
```

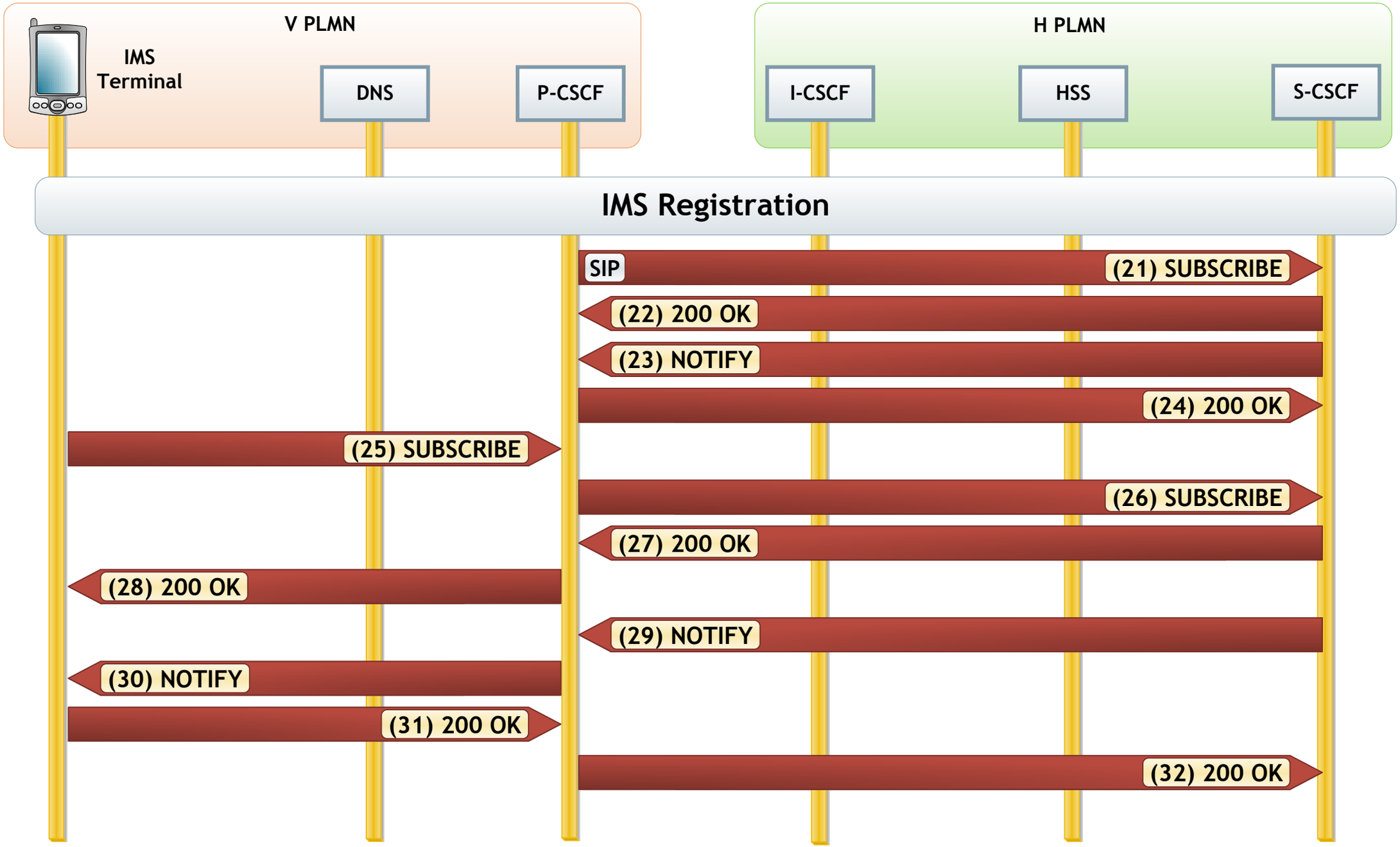
IMS registration - 200 OK (20)

```
SIP/2.0 200 OK
Via: SIP/2.0/UDP [1080::8:800:200C:417A]:5059;comp=sigcomp;branch=z9hG4bK9h9ab

Path: <sip:term@pcscf1.visitedl.net;lr>
Service-Route: <sip:orig@scscf1.homel.net;lr>
From: <sip:alice@homel.net>;tag=s8732n
To: <sip:alice@homel.net>;tag=409sp3
Call-ID: 23fi571ju
Contact: <sip:[1080::8:800:200C:417A]:5059;comp=sigcomp>;expires=600000
Cseq: 2 REGISTER
Date: Wed, 21 January 2004 18:19:20 GMT

P-Associated-URI: <sip:alice-family@homel.net>,<sip:alice-business@homel.net>,
                  <sip:+1-212-555-1234@homel.net;user=phone>
Content-Length: 0
```

Registration: User currently registered



Subscription for the registration Event State

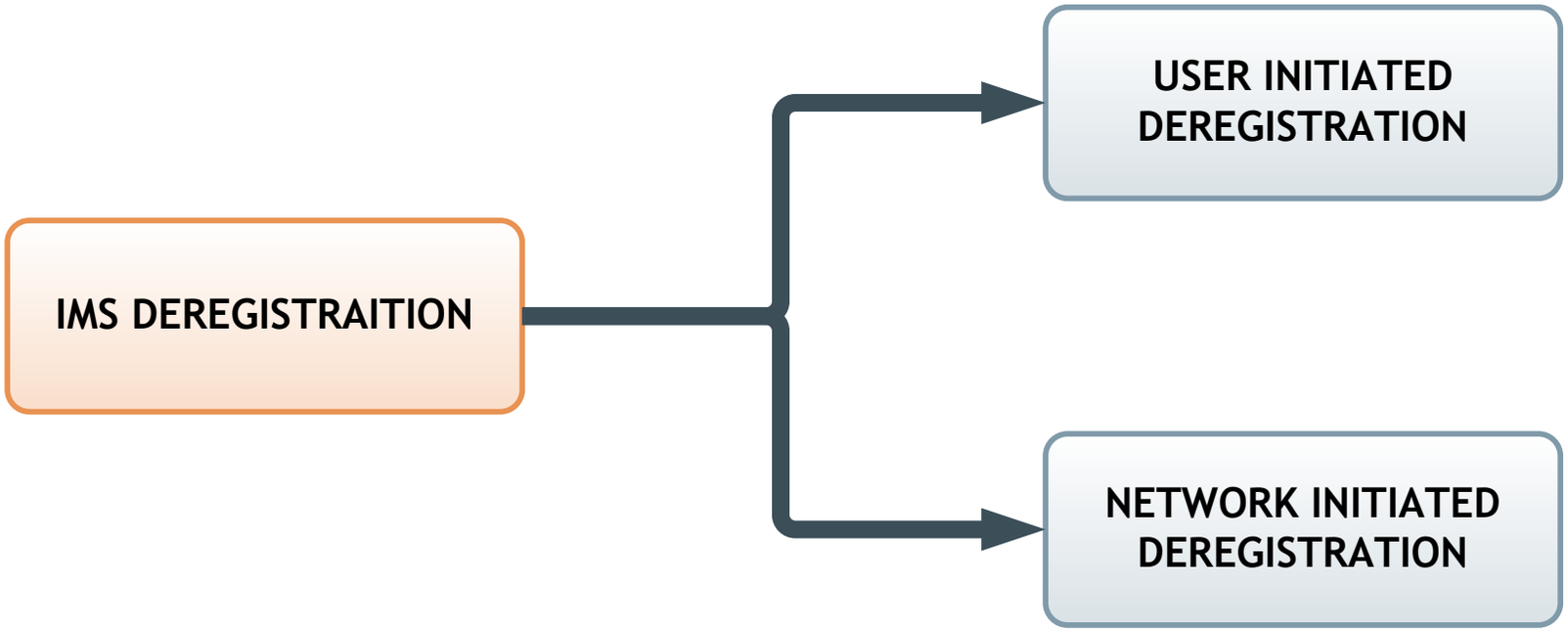


This figure is follow-up to previous figure refered as User not registered

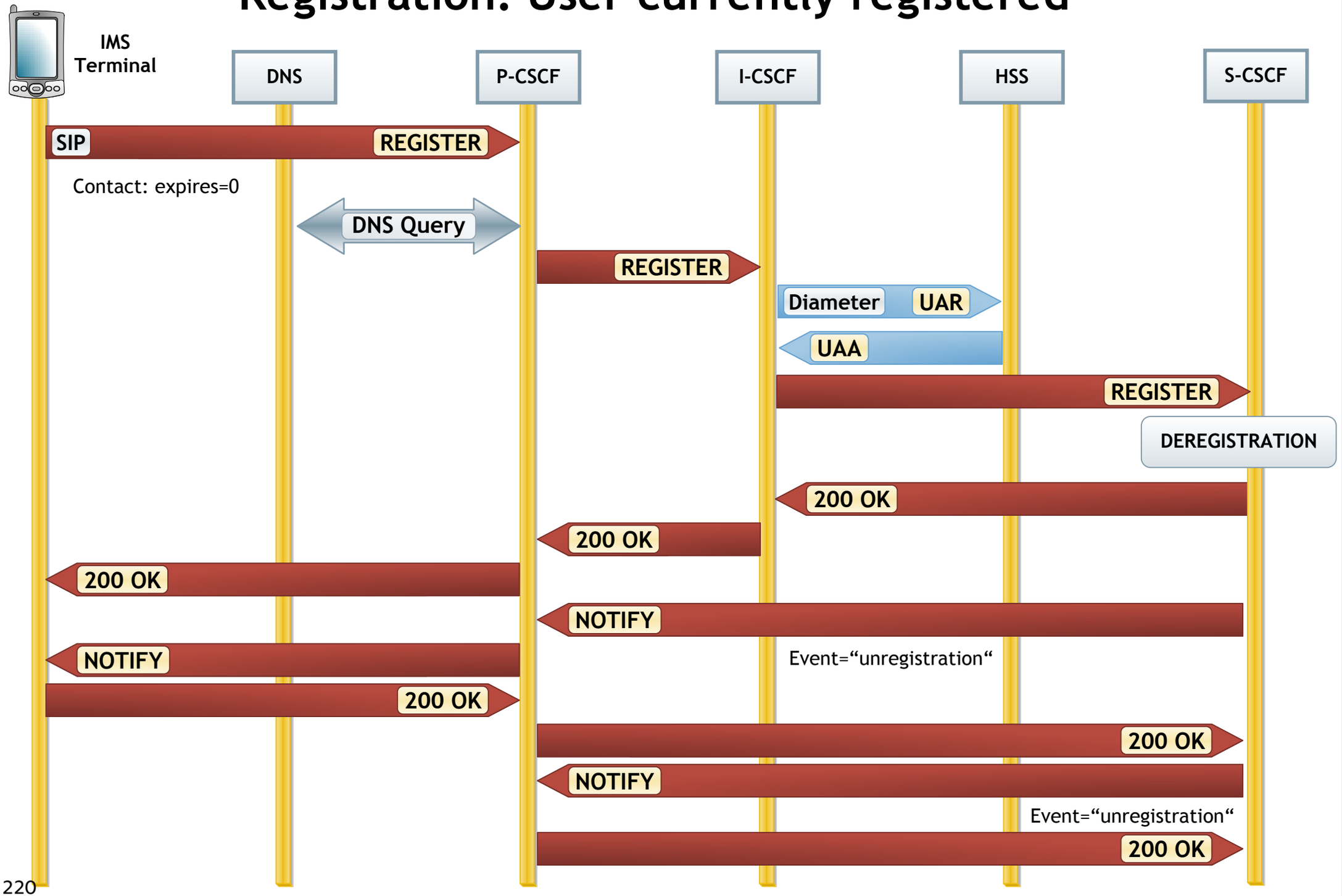
(25) SUBSCRIBE SIP message

```
SUBSCRIBE sip:alice@homel.net SIP/2.0
Via: SIP/2.0/UDP [1080::8:800:200C:417A]:5059;comp=sigcomp;
branch=z9hG4bK9h9ab
Max-Forwards: 70
Route: <sip:pcscf1.visitedl.net:5058;lr;comp=sigcomp>,
<sip:orig@scscf1.homel.net;lr>
P-Preferred-Identity: "Alice Bell" <sip:alice@homel.net>
Privacy: none
P-Access-Network-Info: 3GPP-UTRAN-TDD;
                       utran-cell-id-3gpp=C359A3913B20E
From: <sip:alice@homel.net>;tag=d9211
To:<sip:alice@homel.net>
Call-ID: b89rjhnedlrfjflslj40a222
Require: sec-agree
Proxy-Require: sec-agree
Cseq: 61
SUBSCRIBE Event: reg
Expires: 600000
Accept: application/reginfo+xml
Security-Verify: ipsec-3gpp; q=0.1; alg=hmac-sha-l-96;
                 spi-c=98765432; spi-s=909767;
port-c=5057; port-s=5058
Contact:<sip:[1080::8:800:200C:417A]:5059;comp=sigcomp>
Content-Length: 0
```

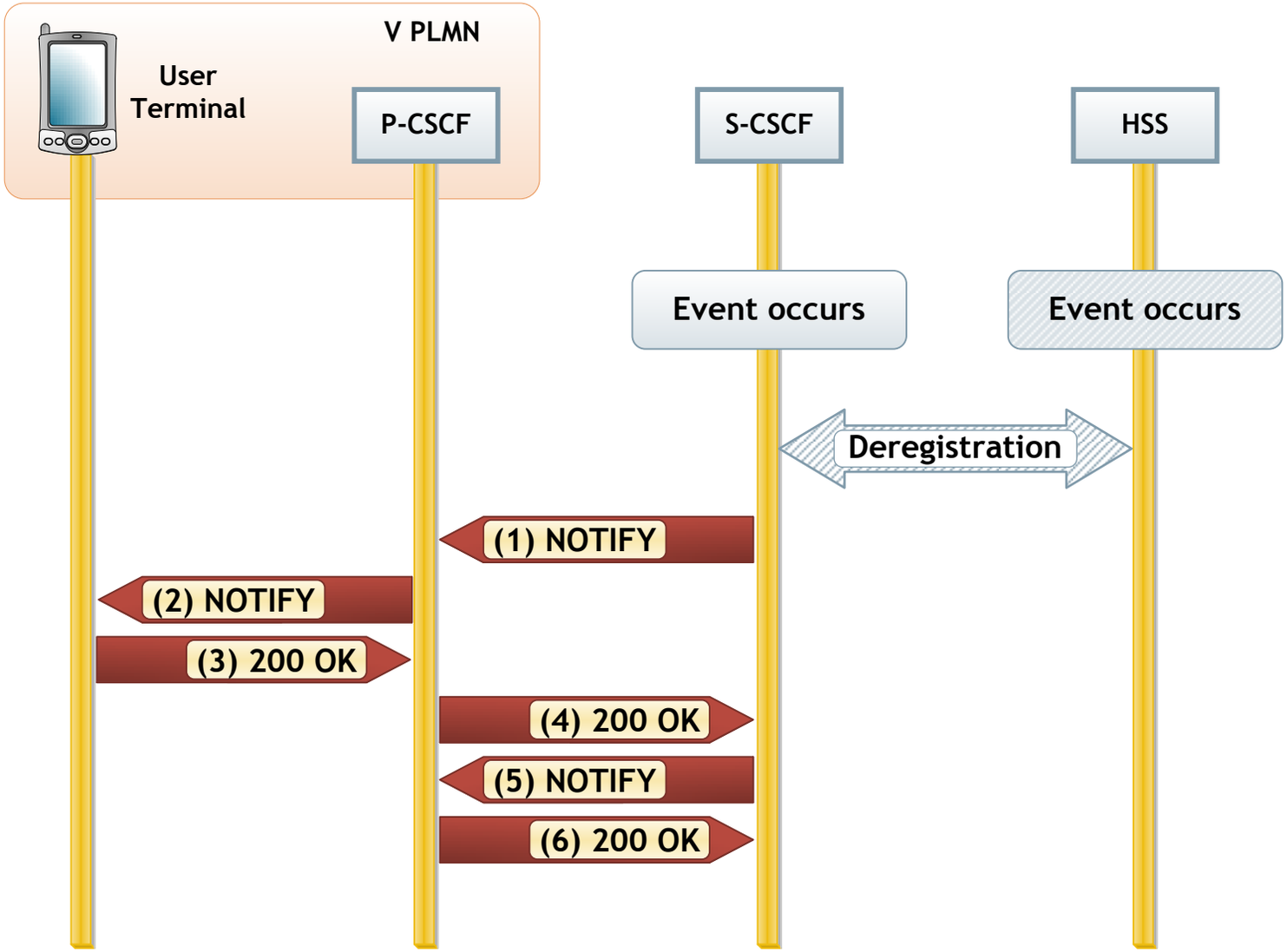
Deregistration



Registration: User currently registered



Network initialed deregistration

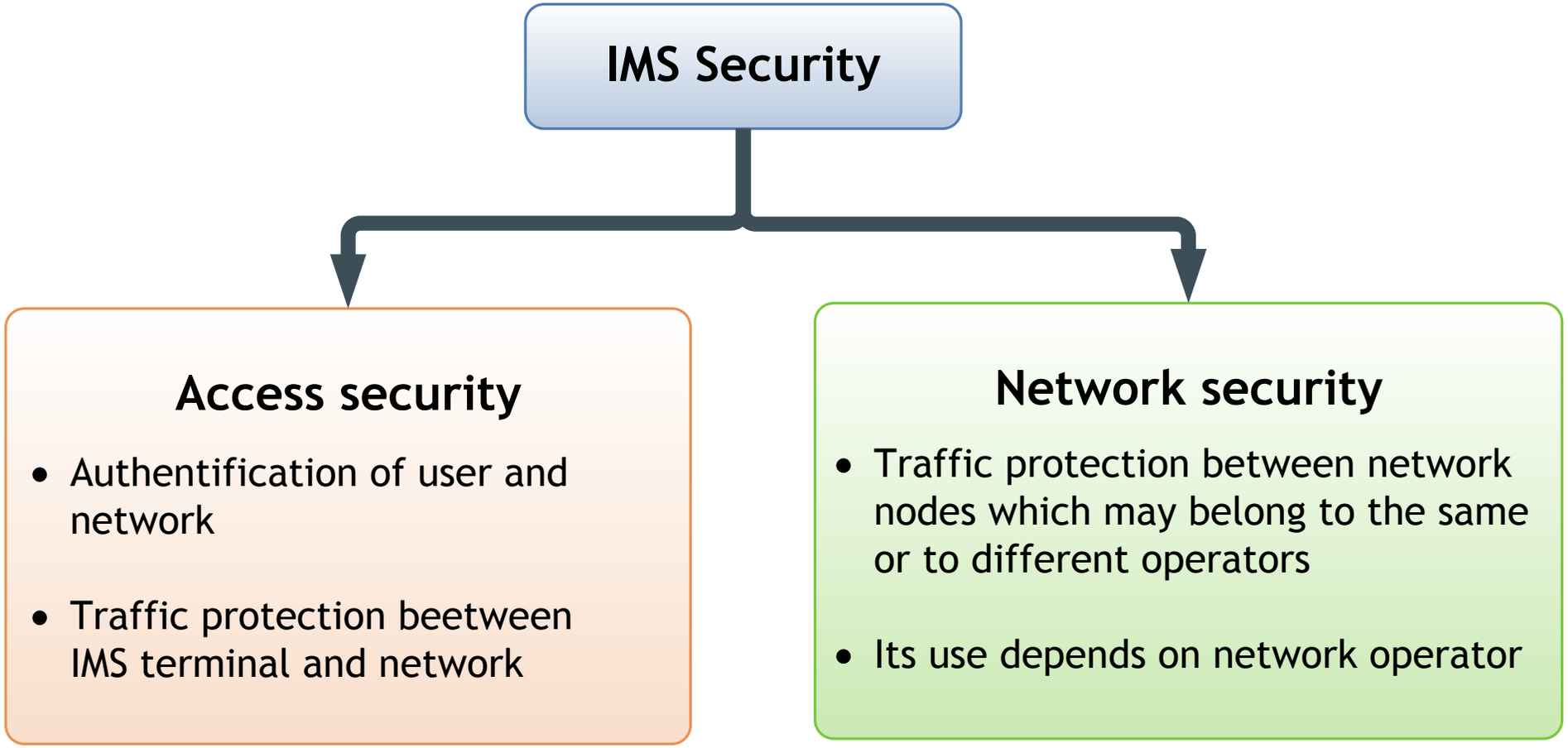


XML content example of NOTIFY message for deregistration

```
<?xml version="1.0"?>
<reginfo xmlns="urn:ietf:params:xml:ns:reginfo" version="l" state="full">

<registration aor="sip:alice@homel.net" id="lla" state=„terminated">
 <contact id="542"state=" terminated " event=„deactivated">
  <uri>sip: [1080::8:800:200C:417A]</uri>
 </contact>
</registration>

<registration aor="sip:alice-family@homel.net"id="llb" state=" terminated ">
 <contact id="543"state=" terminated " event=" deactivated " >
  <uri>sip:[1080::8:800:200C:417A]</uri>
 </contact>
</registration>

<registration aor="tel:+1-212-555-1234" id="llc"state=" terminated">
 <contact id="544" state=" terminated "event=" deactivated " >
  <uri>sip:[1080::8:800:200C:417A] </uri>
 </contact>
</registration>
</reginfo>
```

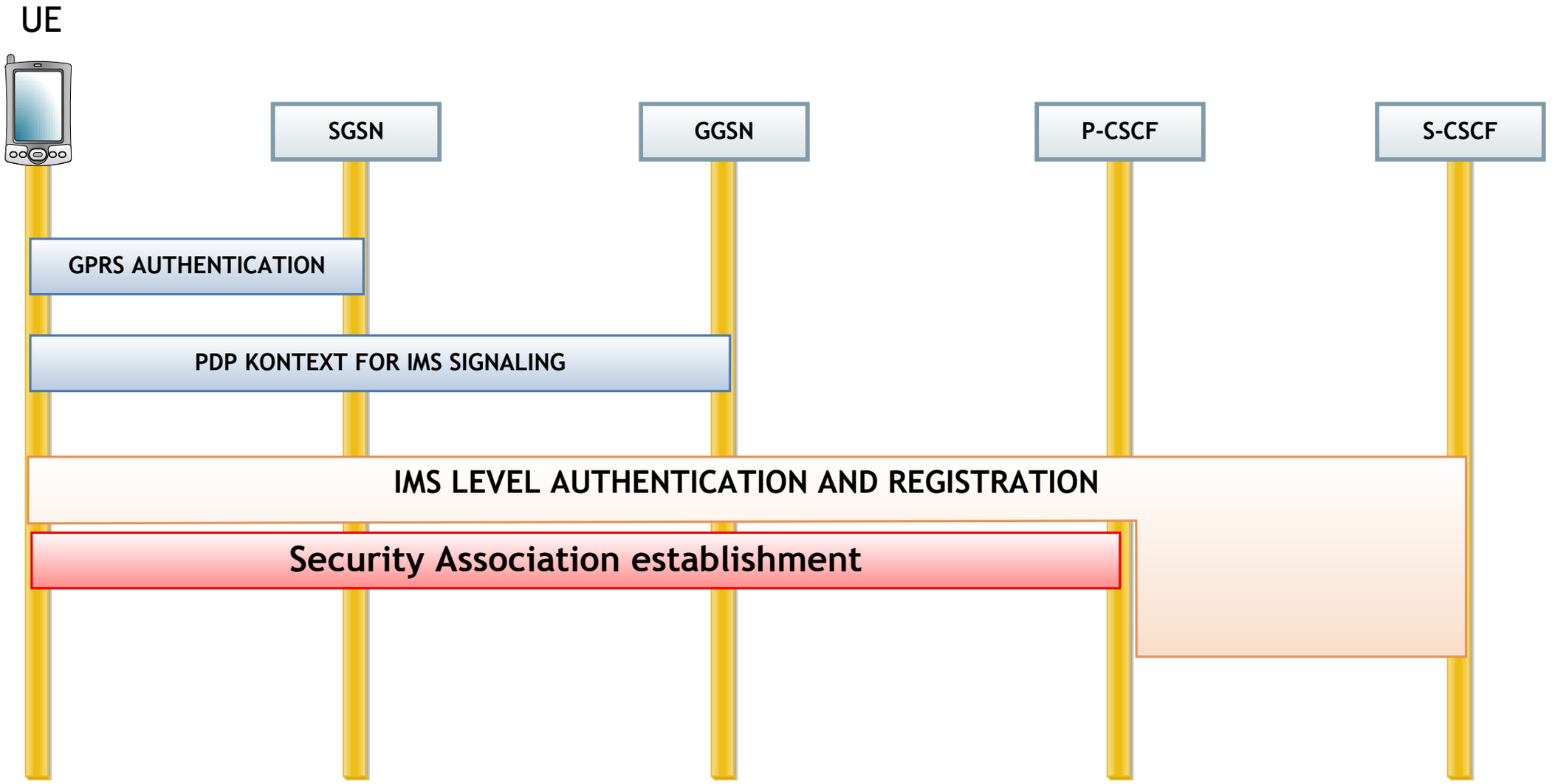
Security

Security in IMS Network



Access security in IMS

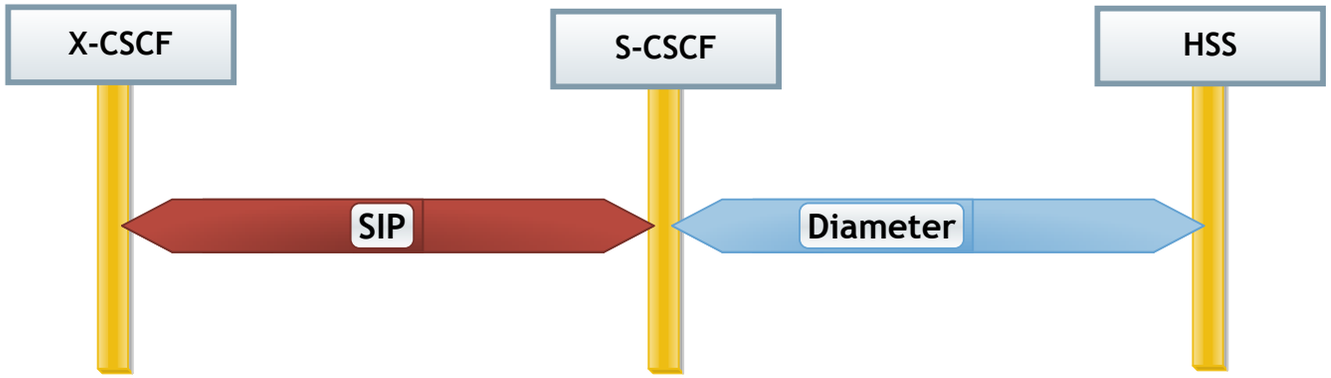
Two-Pass authentication



Access security in IMS

Authentication and Authorization with ISIM

- HSS and ISIM share secret key
- HSS generates AVs (Authentication Vectors)
- S-CSCF assigned to the user takes the role of the authenticator.



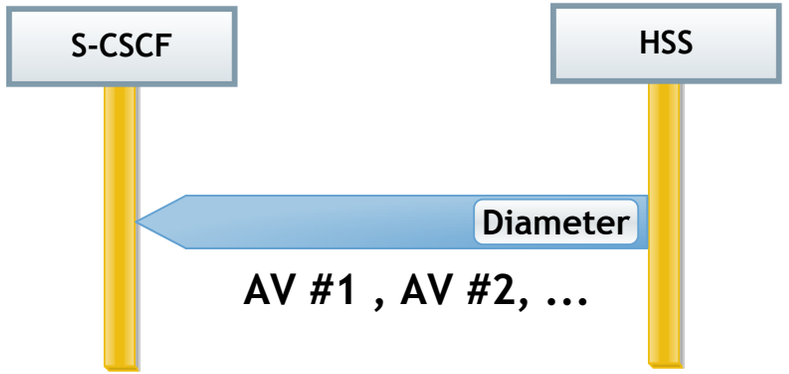
- For authentication two new SIP header fields are introduced (WWW-Authenticate header, Authorization header)

Authentication Vectors

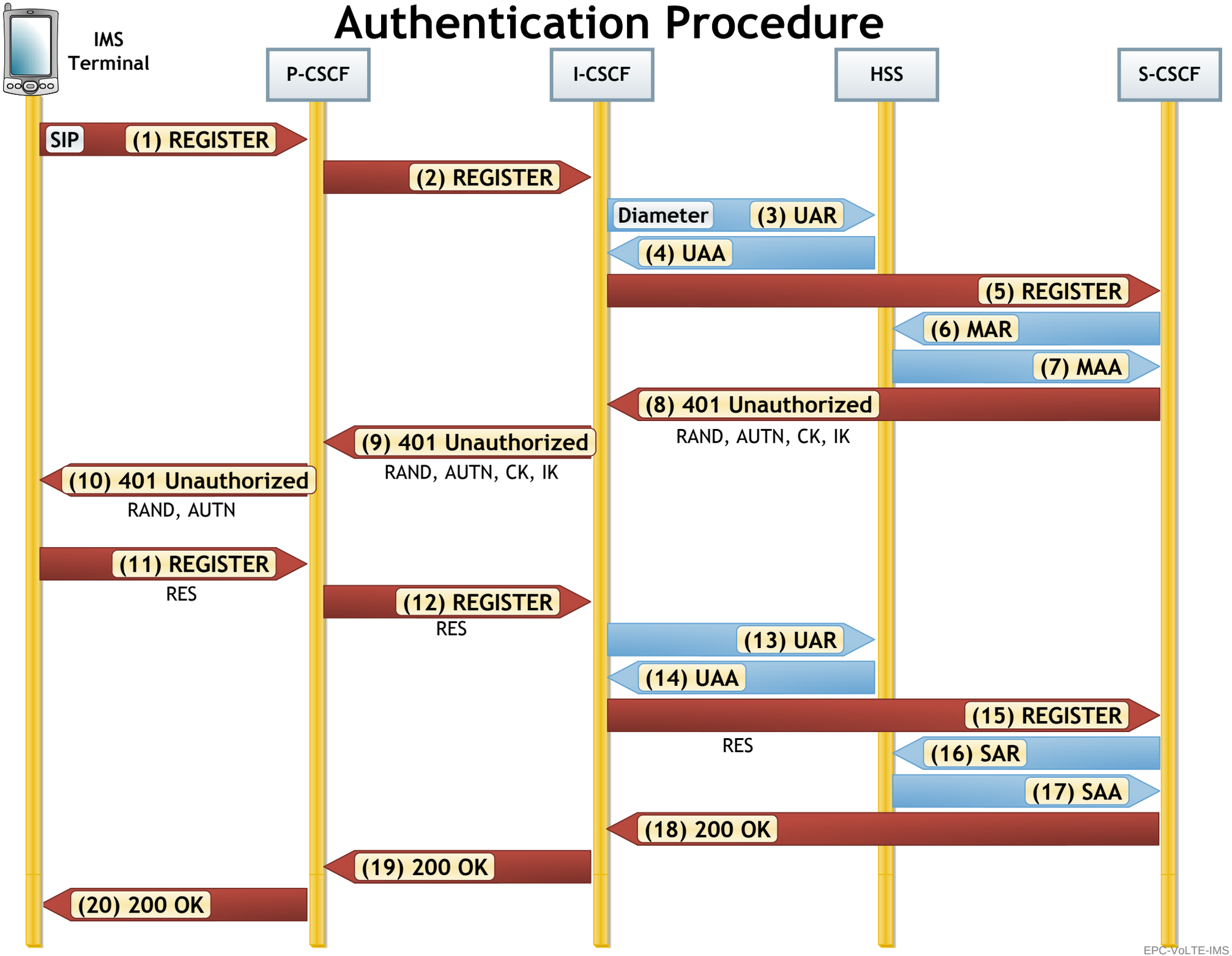
Authentication Vector is generated by HSS and is sent to S-CSCF. To avoid the HSS overload the S-CSCF downloads several vectors together.

Authentication vector #[X]

- RAND (Random challange)
- XRES (Expected answer)
- IK (Integrity Key)
- CK (Ciphering Key)
- AUTN (Network Authentication Token)



Authentication Procedure



Authorization header field 1/2

```
REGISTER sip:homel.net SIP/2.0
Via: SIP/2.0/UDP [1080::8:800:200C:417A];comp=sigcomp;branch=z9hG4bK9h9ab

Max-Forwards: 70
P-Access-Network-Info: 3GPP-UTRAN-TDD;
                    utran-cell-id-3gpp=C359A3913B20E
From:<sip:alice@homel.net>;tag=s8732n
To: <sip:alice@homel.net>
Contact:<sip:[1080::8:800:200C:417A];comp=sigcomp>;expires=600000
Call-ID: 23fi571ju
Authorization: Digest username="alice_private@homel.net",
             realm="homel.net", nonce="",
             uri="sip:home1.net", response=""
Security-Client: ipsec-3gpp; alg=hmac-sha-1-96;
               spi-c=3929102; spi-s=0293020;
               port-c:3333; port-s=5059

Require: sec-agree
Proxy-Require: sec-agree
Cseq: 1 REGISTER
Supported: path
Content-Lengt h: 0
```

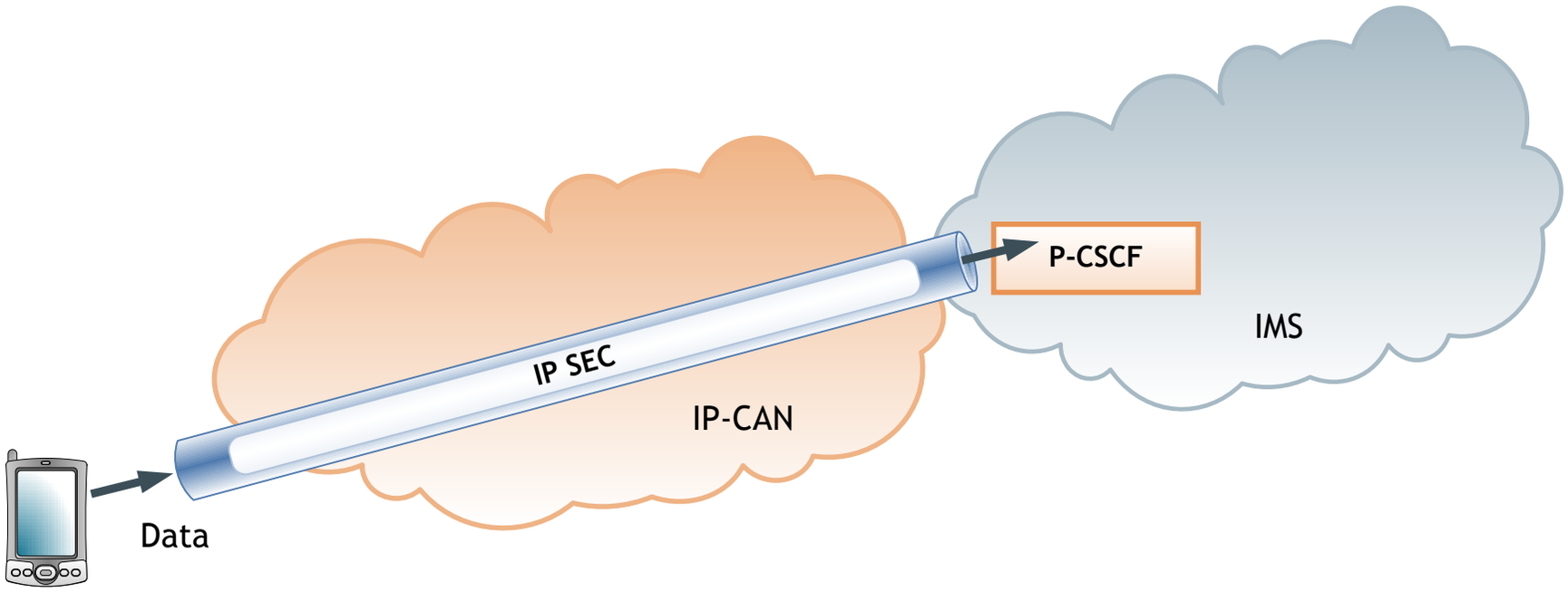
WWW-Authenticate header field

```
SIP/2.0 401 Unauthorized
Via: SIP/2.0/UDP [1080::8:800:200C:417A];comp=sigcomp;
                 branch=z9hG4bK9h9ab
From: <sip:aliceShomel.net>;tag=s8732n
To: <sip:aliceOhomel.net>;tag=409sp3
Call-ID: 23fi571ju
WWW-Authenticate: Digest realm="home1.net",
                  nonce="dcd98b7102dd2i0e8blld0f600bfb0c093",
                  algorithm=AKAvl-MD5
Security-Server: ipsec-3gpp; q=0.1; alg=hmac-sha-l-96;
                 spi-c=909767; spi-s=421909;
                 port-c:4444; port-s=5058
Cseq: 1 REGISTER
Content-Length: 0
```

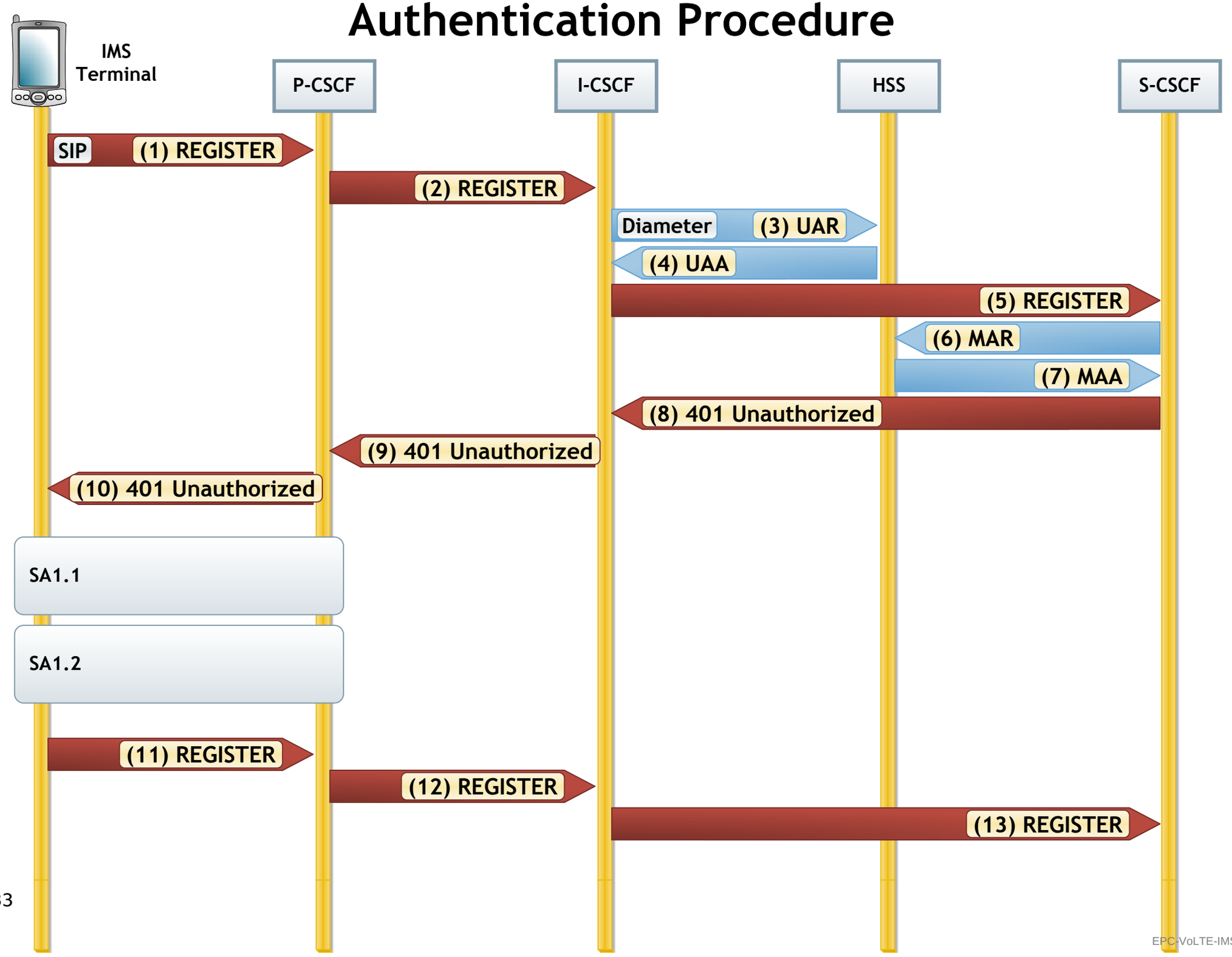
Authorization header field 2/2

```
REGISTER sip:homel.net SIP/2.0
Via: SIP/2.0/UDP [1080::8:800:200C:417A]:5059;comp=sigcomp;
                 branch=z9hG4bK9h9ab
Max-Forwards: 70
P-Access-Network-Info: 3GPP-UTRAN-TDD;
                       utran-cell-id-3gpp=C359A3913B20E
From: <sip:alice@homel.net>;tag=s8732n
To: <sip:aliceQhomel.net>
Contact: <sip:[1080::8:800:200C:417A]:5059;comp=sigcomp>
        ;expires=600000
Call-ID: 23fi571ju
Authorization: Digest username="alice_private@homel.net",
               realm="homel.net",
               nonce="dcd98b7102dd2f0e8blld0f600bfb0c093",
               algorithm=AKAvl-MD5,
               uri="sip:homel.net",
               response="6629fae49393a05397450978507c4ef1"
Security-Verify: ipsec-3gpp; q=0.1; alg=hmac-sha-l-96;
                 spi-c=909767; spi-s=421909; port-c:4444;
                 port-s=5058
Require: sec-agree
Proxy-Require: sec-agree
```

Security between IMS terminal and P-CSCF



Authentication Procedure



SA establishment - initial Register (1)

```
REGISTER sip:homel.net SIP/2.0
Via: SIP/2.0/UDP [1080::8:800:200C:417A];comp=sigcomp;
     branch=z9hG4bK9h9ab Max-Forwards: 70
P-Access-Network-Info: 3GPP-UTRAN-TDD;
                       utran-cell-id-3gpp=C359A3913B20E From:
<sip:aliceOhomel.net>;tag=s8732n To: <sip:alice@homel.net> Contact:
<sip:[1080::8:800:200C:417A];comp=sigcomp>
           ;expires=600000
Call-ID: 23fi571ju
Authorization: Digest username="alice_private<3homel.net",
               realm="homel.net", nonce="",
                uri="sip:home1.net", response=""

Security-Client: ipsec-3gpp; alg=hmac-sha-l-96;
                 spi-c=3929102; spi-s=0293020;
                 port-c:3333; port-s=5059

Require: sec-agree
Proxy-Require: sec-agree
```

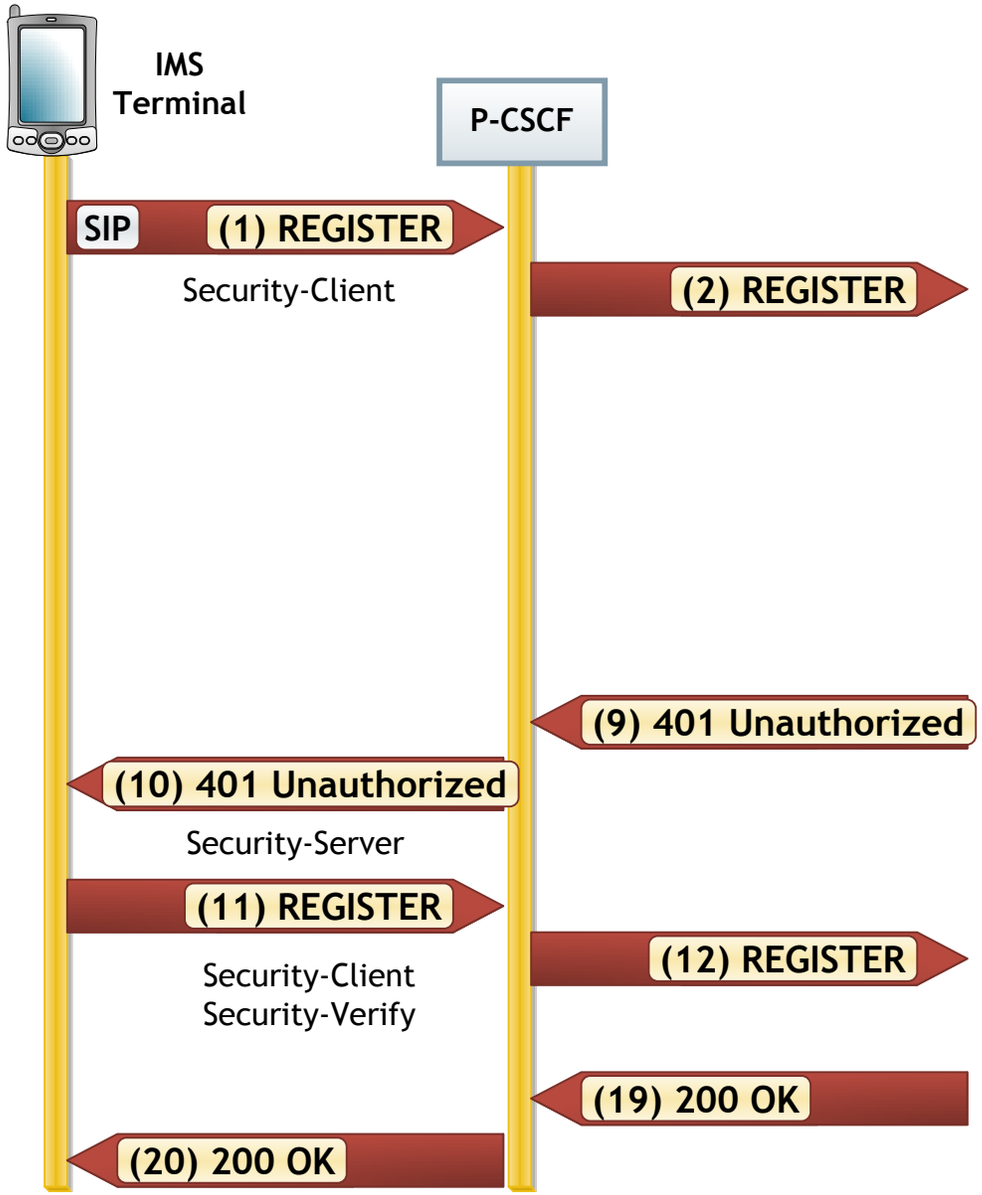
SA establishment - 401 Unauthorized (10)

```
SIP/2.0 401 Unauthorized
Via: SIP/2.0/UDP [1080::8:800:200C:417A];comp=sigcomp;
                branch=z9hG4bK9h9ab
From: <sip:aliceShomel.net>;tag=s8732n
To: <sip:aliceOhomel.net>;tag=409sp3
Call-ID: 23fi571ju
WWW-Authenticate: Digest realm="home1.net",
                  nonce="dcd98b7102dd2i0e8blld0f600bfb0c093",
                  algorithm=AKAv1-MD5
Security-Server: ipsec-3gpp; q=0.1; alg=hmac-sha-1-96;
                spi-c=909767; spi-s=421909;
                port-c:4444; port-s=5058
Cseq: 1 REGISTER
Content-Length: 0
```

SA establishment - second Register (11)

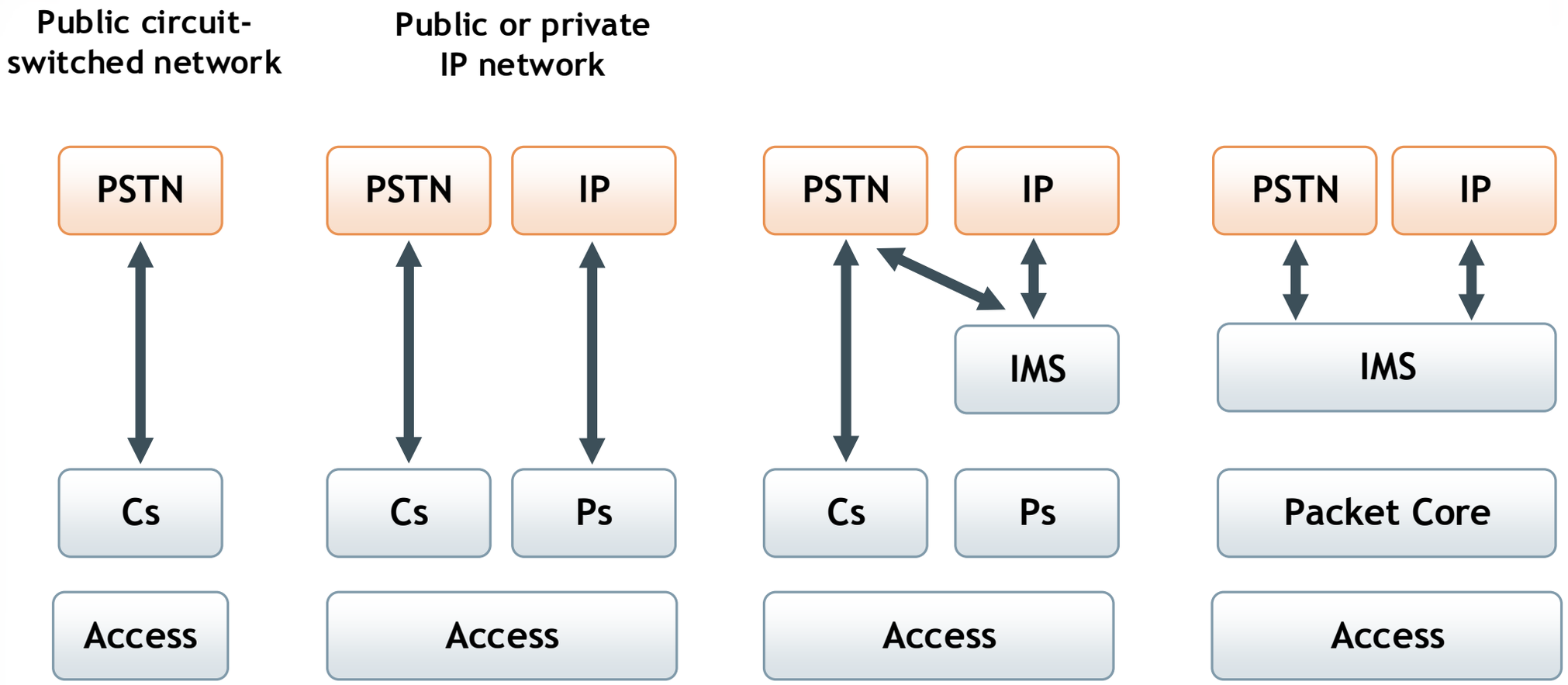
```
REGISTER sip:homel.net SIP/2.0
Via: SIP/2.0/UDP [1080::8:800:200C:417A]:5059;comp=sigcomp;branch=z9hG4bK9h9ab

Max-Forwards: 70
P-Access-Network-Info:3GPP-UTRAN-TDD;
                    utran-cell-id-3gpp=C359A3913B20E
From: <sip:alice@homel.net>;tag=s8732n
To:<sip:alice@homel.net>
Contact:<sip:[1080::8:800:200C:417A]:5059;comp=sigcomp>;expires=600000
Call-ID: 23fi571ju
Authorization: Digest username="alice_private@homel.net",
             realm="homel.net",
             nonce="dcd98b7102dd2f0e8blld0f600bfb0c093",
             algorithm=AKAvl-MD5,uri="sip:homel.net",
             response="6629fae49393a05397450978507c4ef1"

Security-Verify: ipsec-3gpp; q=0.1; alg=hmac-sha-l-96;
               spi-c=909767; spi-s=421909;
               portc:4444; port-s=5058

Security-Client: ipsec-3gpp; alg=hmac-sha-l-96;
               spi-c=3929102; spi-s=0293020;
               port-c:3333; port-s=5059

Require: sec-agree
Proxy-Require: sec-agree
Cseq: 2 REGISTER
Supported: path
Content-Length: 0
```

Headers field in SA establishment



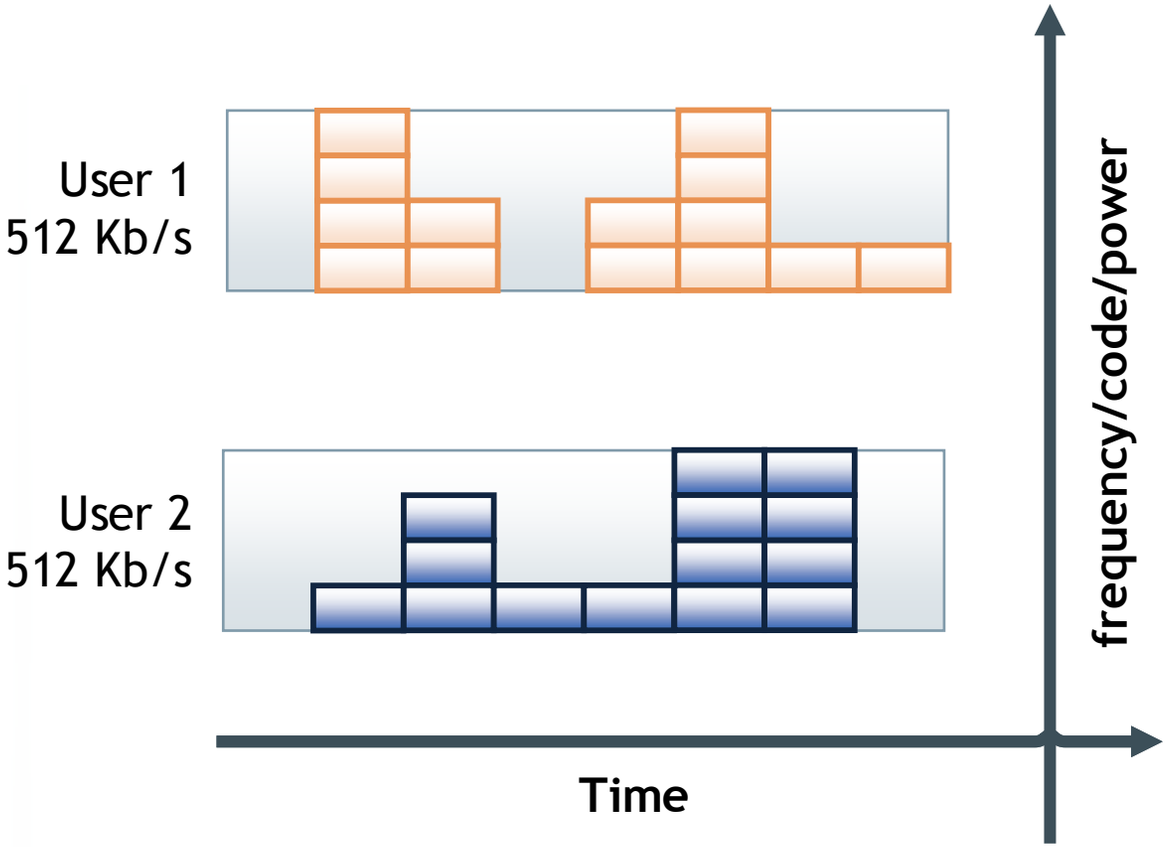
EPC & Volte network system architecture

Evolution of network architecture

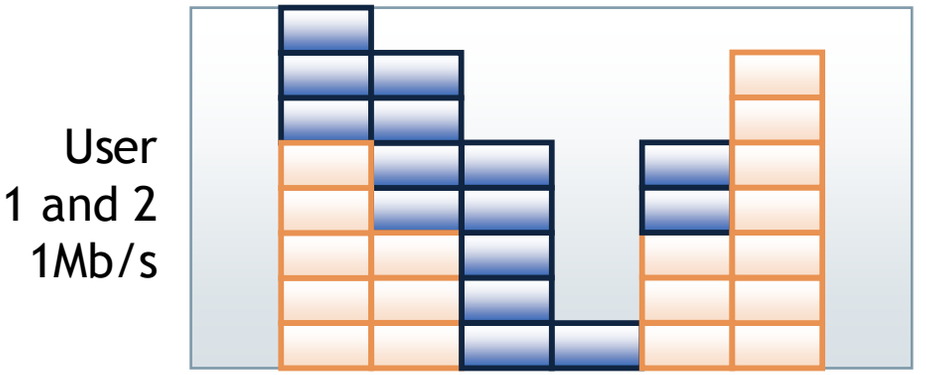


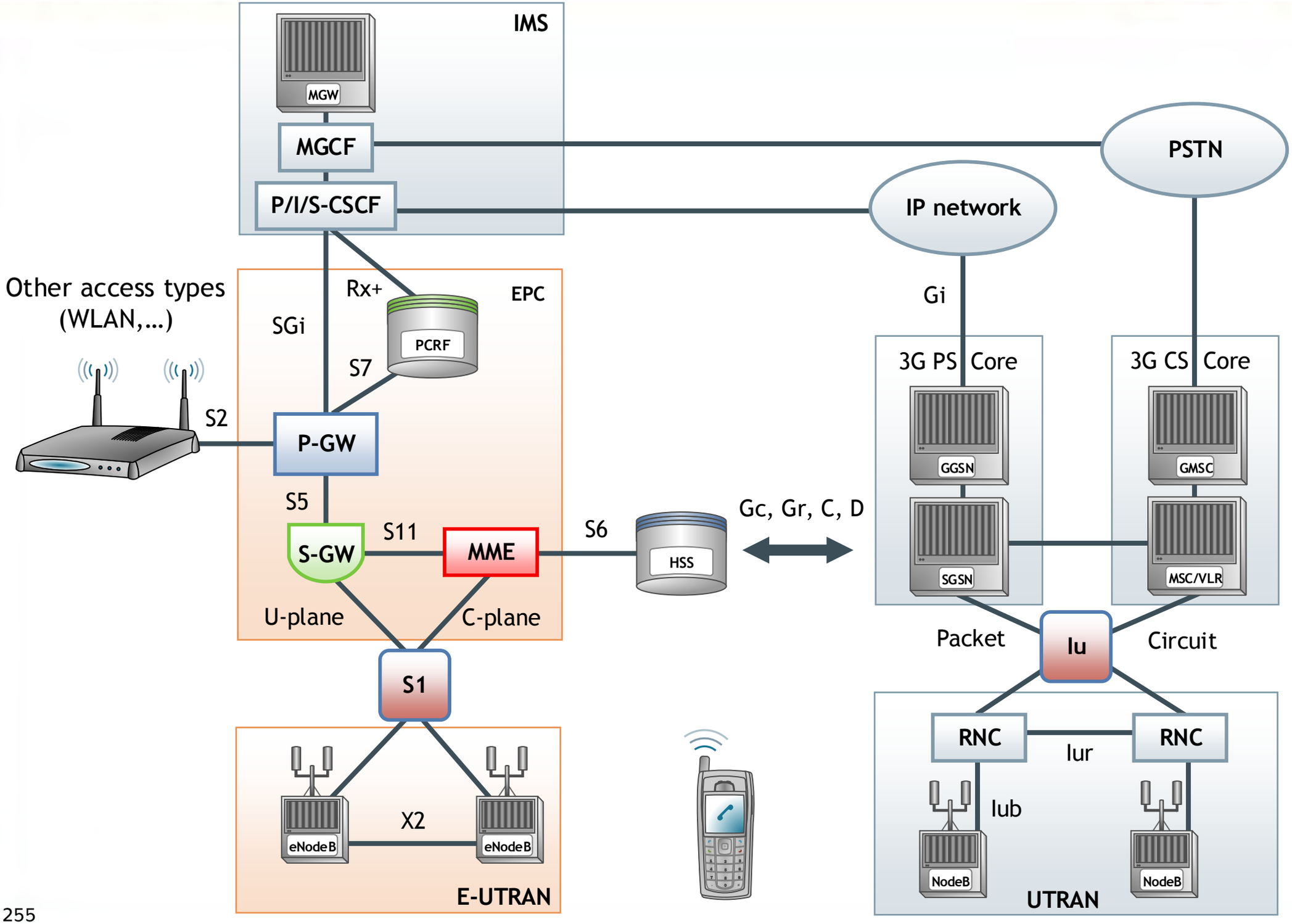
Dedicated versus shared resource allocation

Dedicated radio resource allocation

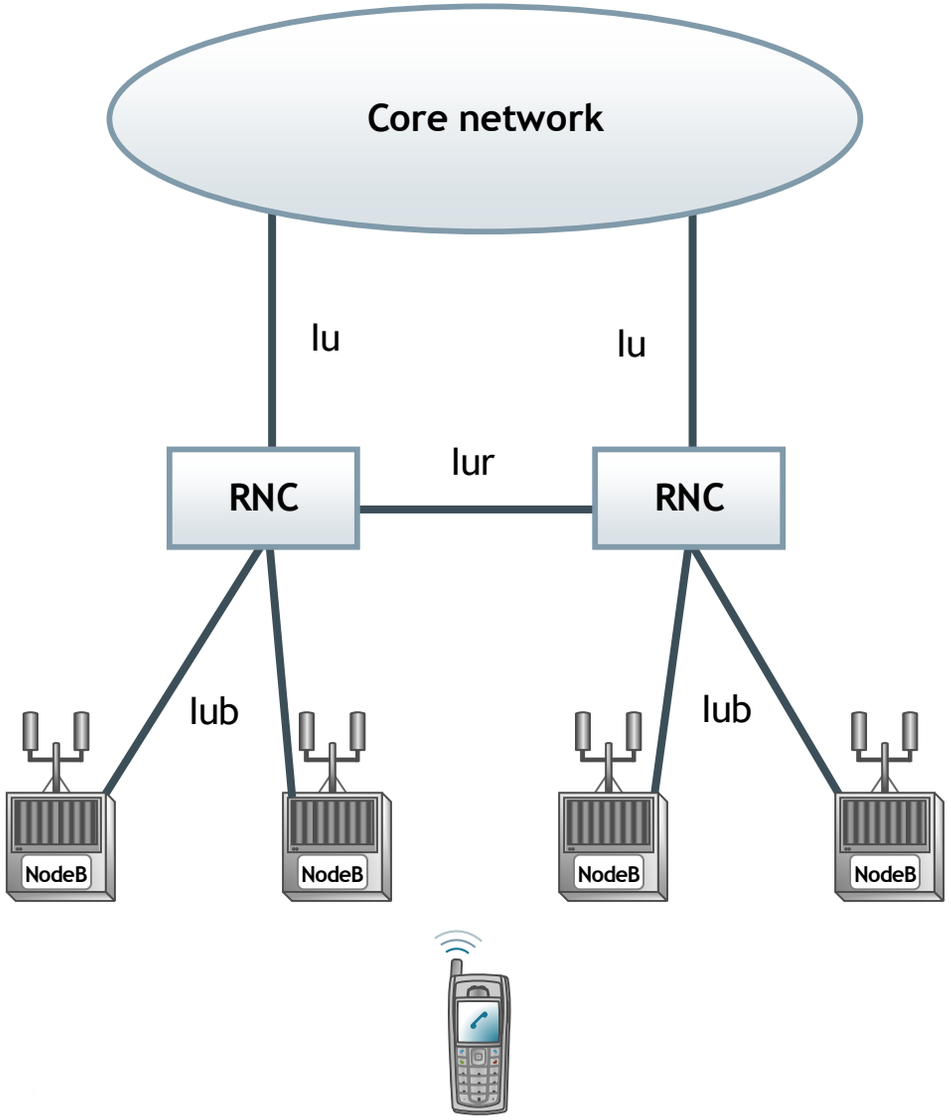


Shared radio resource allocation

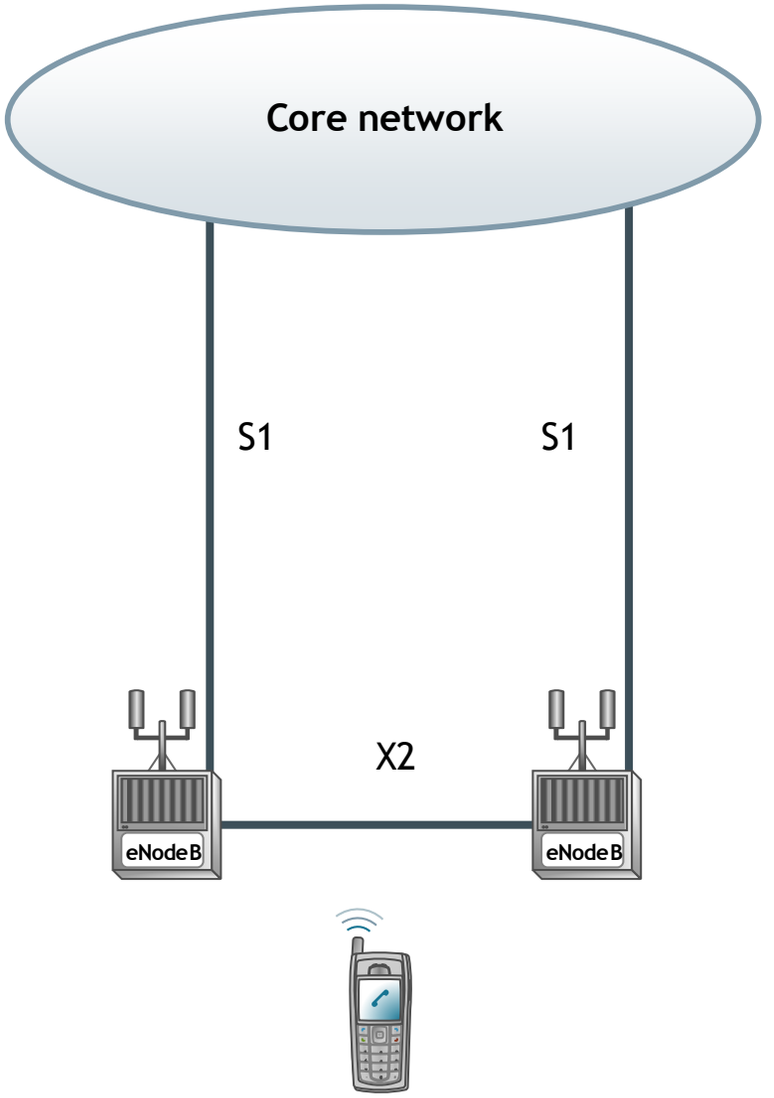



IMS
MGW
MGCF
P/I/S-CSCF
PSTN
IP network
Gi
Other access types
(WLAN,...)
Rx+
EPC
SGi
PCRF
S7
S2
P-GW
S5
S-GW
S11
MME
S6
HSS
Gc, Gr, C, D
3G PS Core
GGSN
SGSN
3G CS Core
GMSC
MSC/VLR
U-plane
C-plane
Packet
Iu
Circuit
S1
RNC
Iur
RNC
Iub
X2
eNodeB
eNodeB
NodeB
NodeB
E-UTRAN
UTRAN

UTRAN vs E-UTRAN

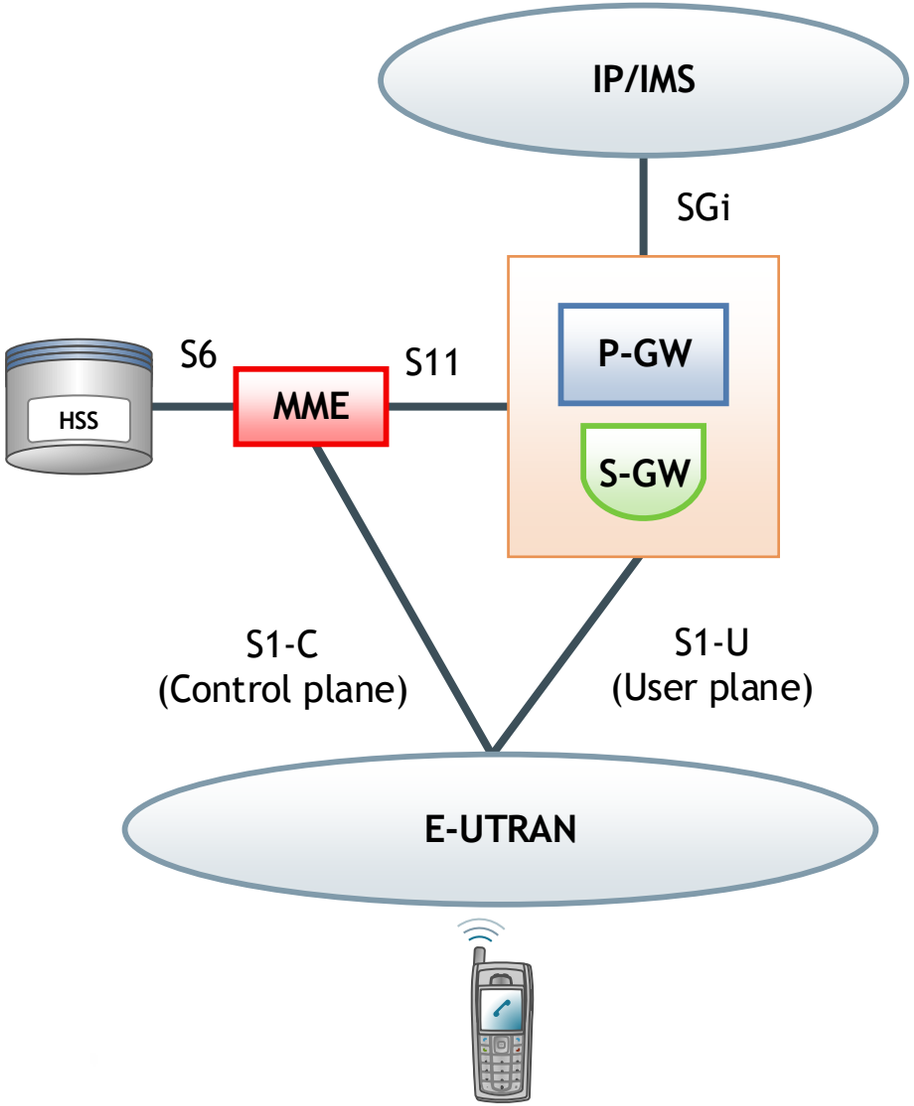


UTRAN architecture

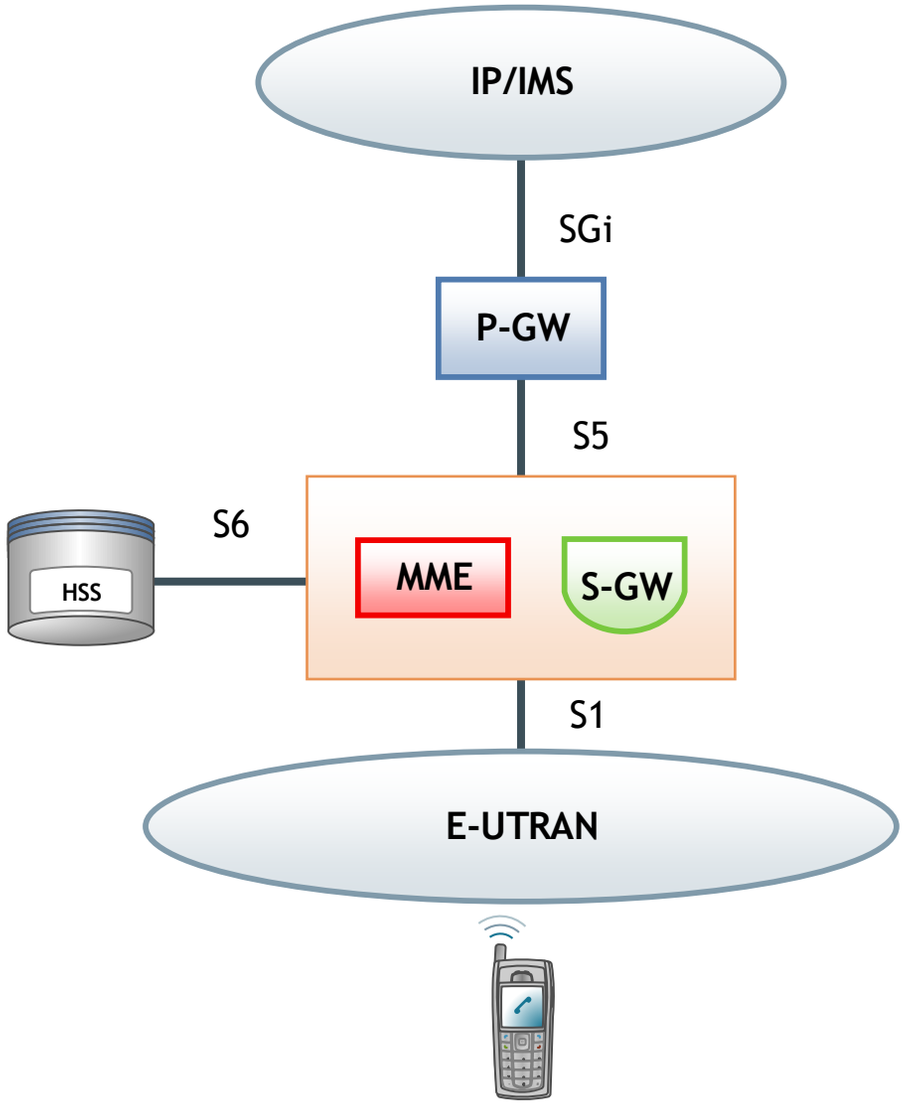


E-UTRAN architecture

Physical nodes & functions merging

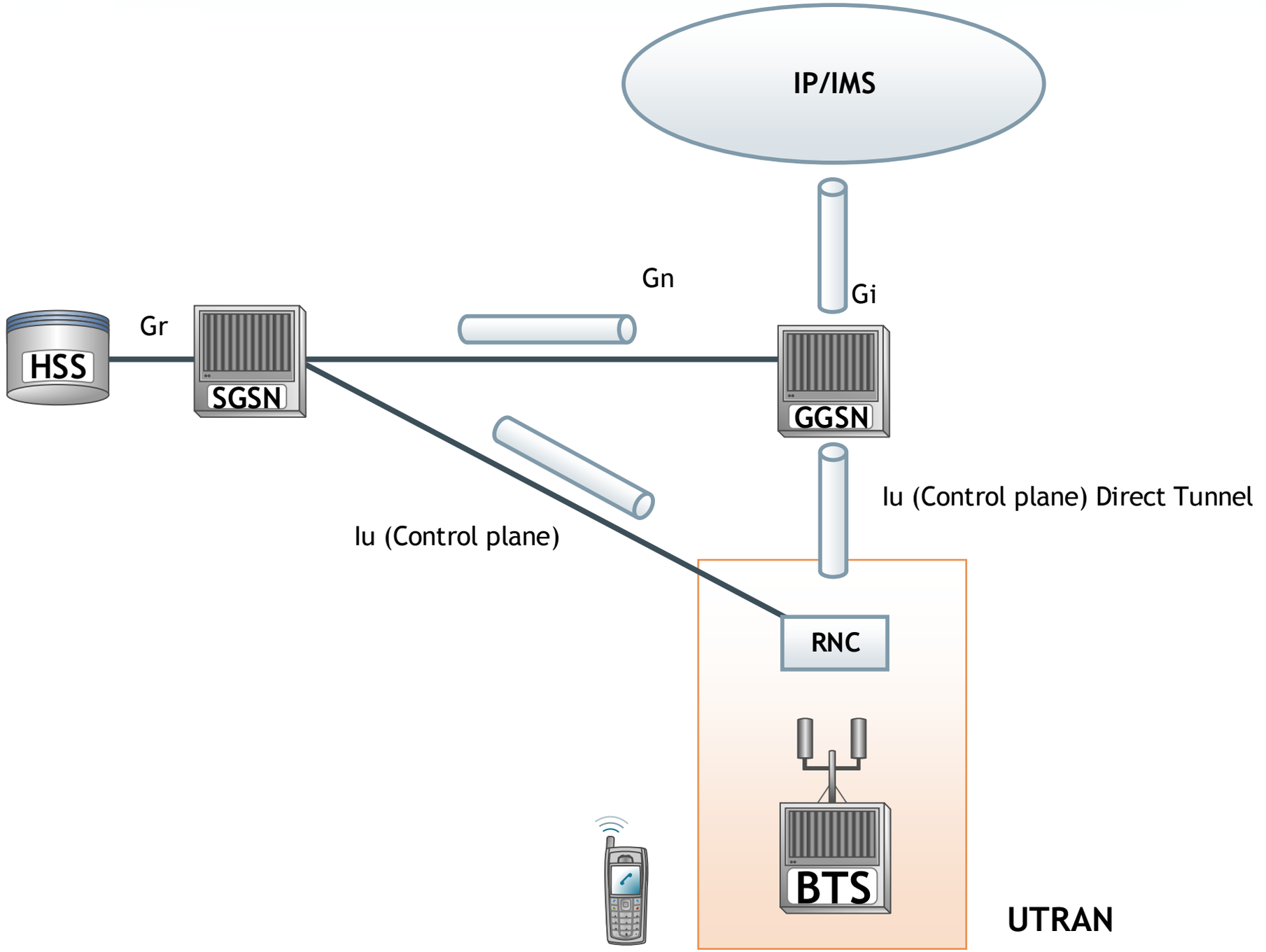


Merging the two gateways

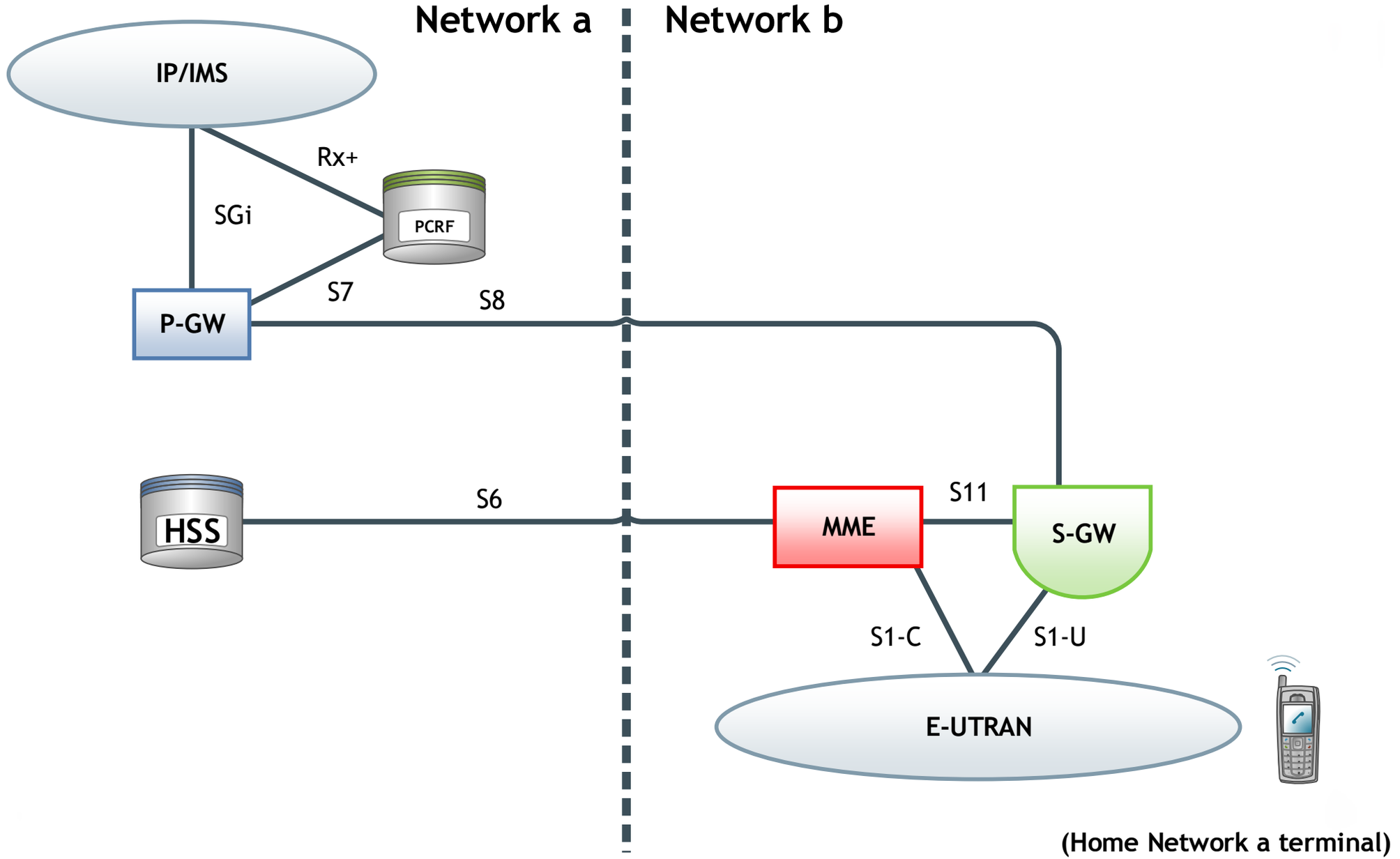


Merging S1 Control and User planes

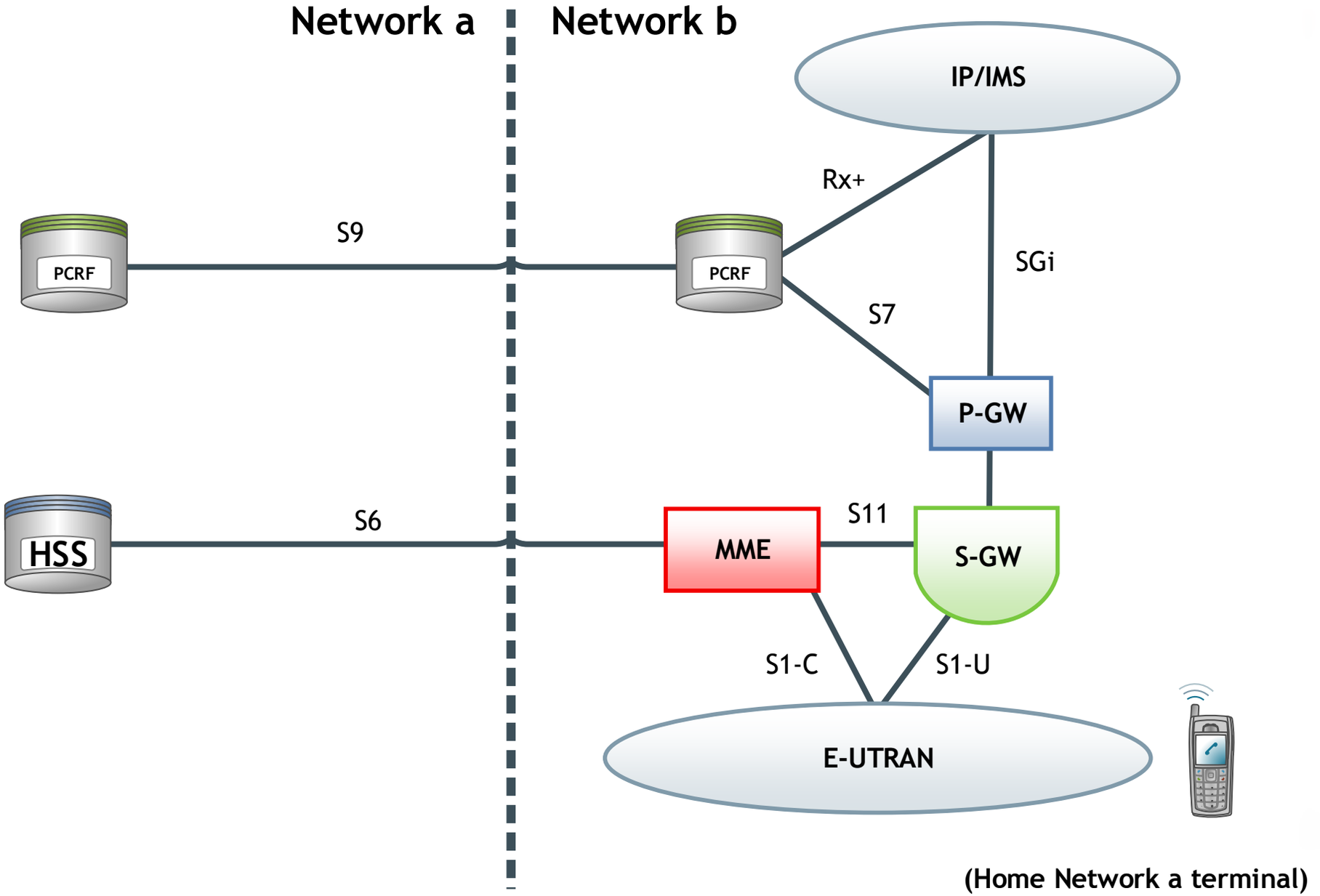
Direct tunnel



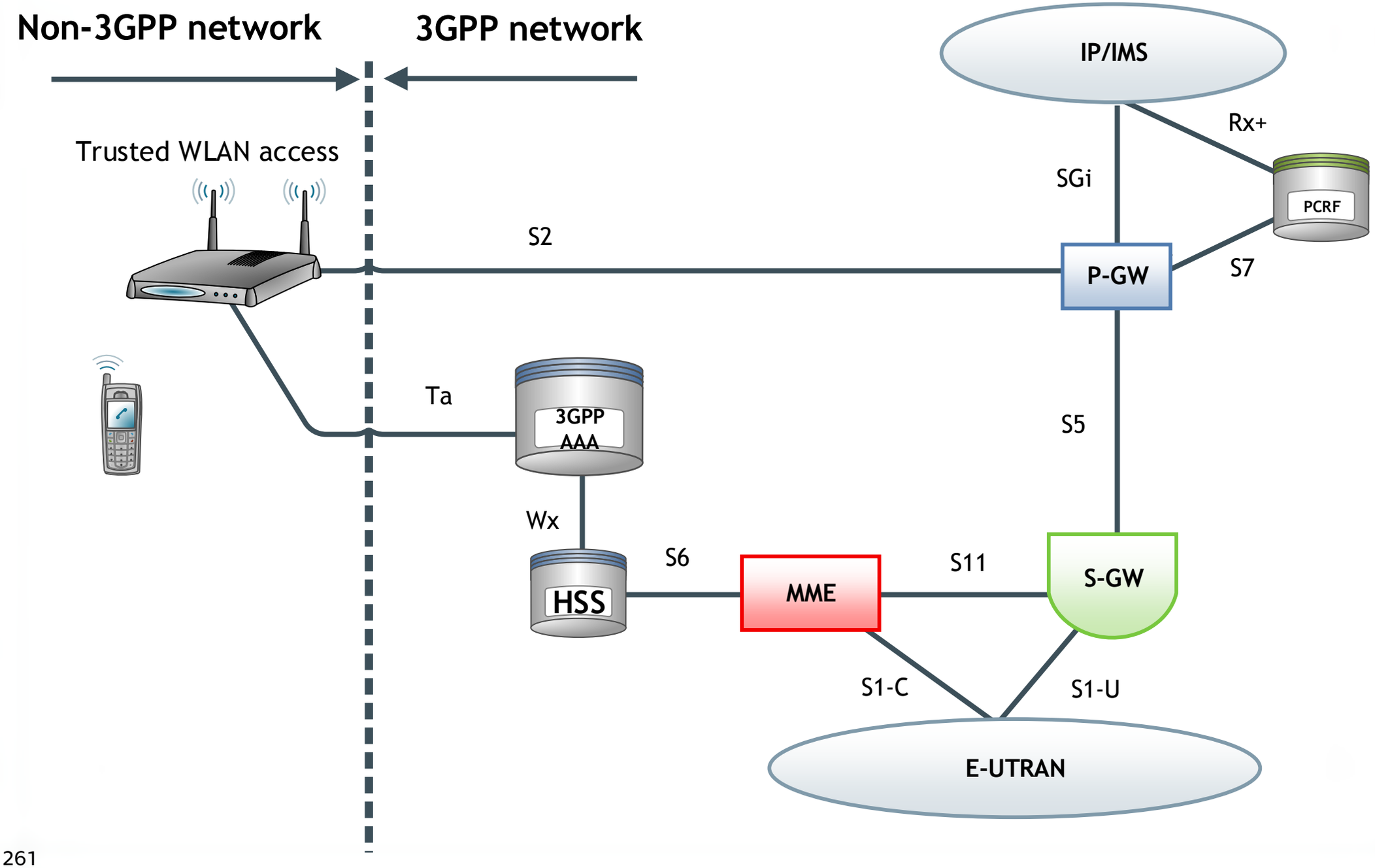
Basic EPC roaming



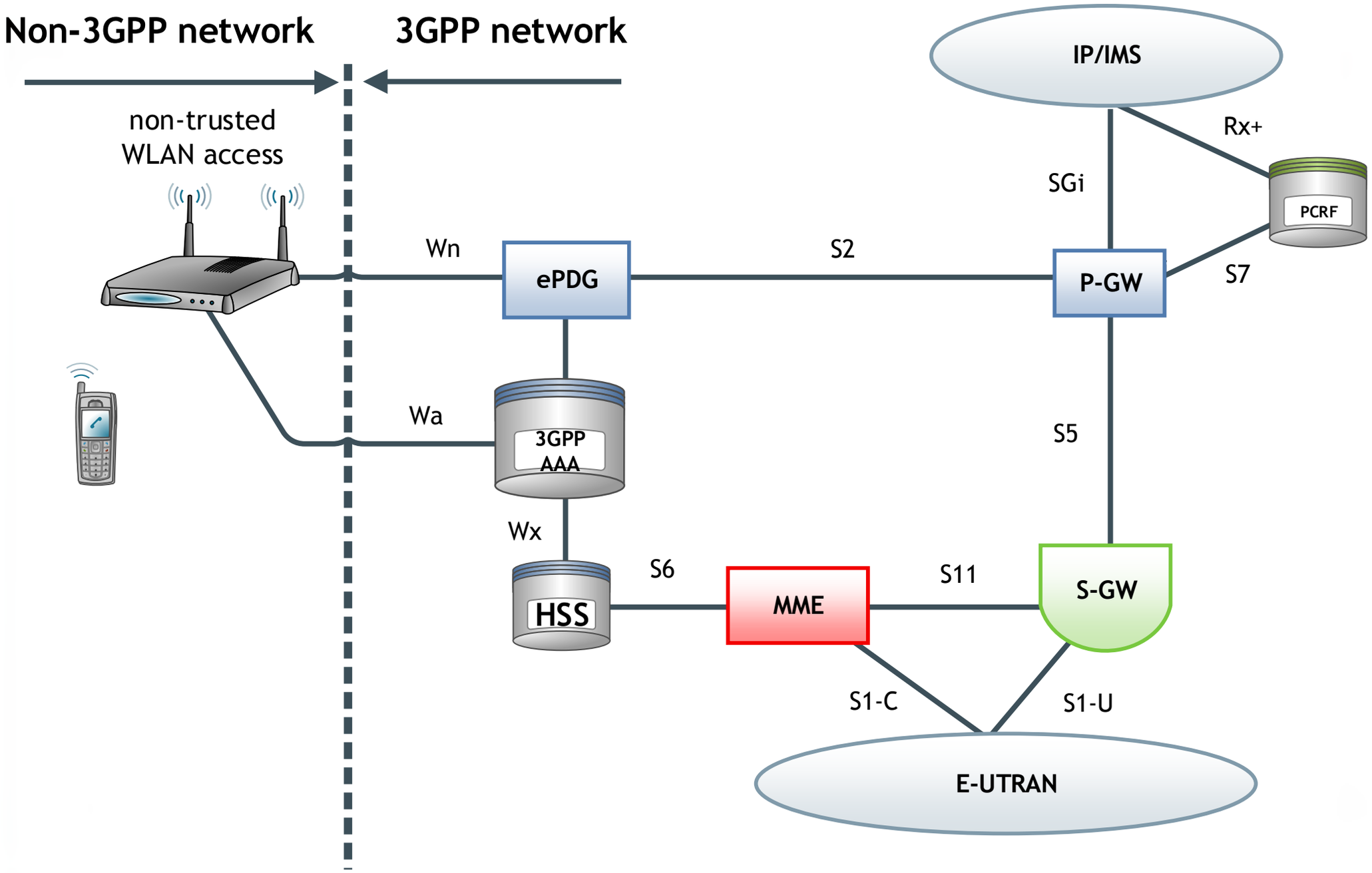
Local breakout EPC roaming



Trusted WLAN access

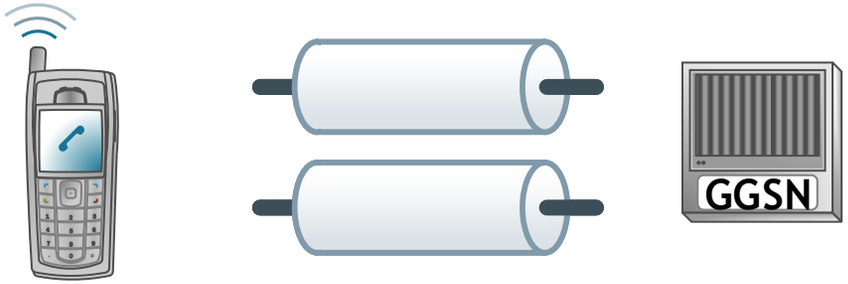


Non-trusted WLAN access



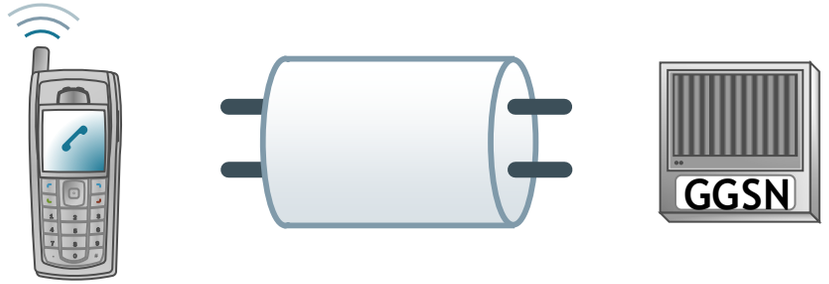
Flow based charging

1 PDP bearers = 1 QoS flow
PDP-based charging



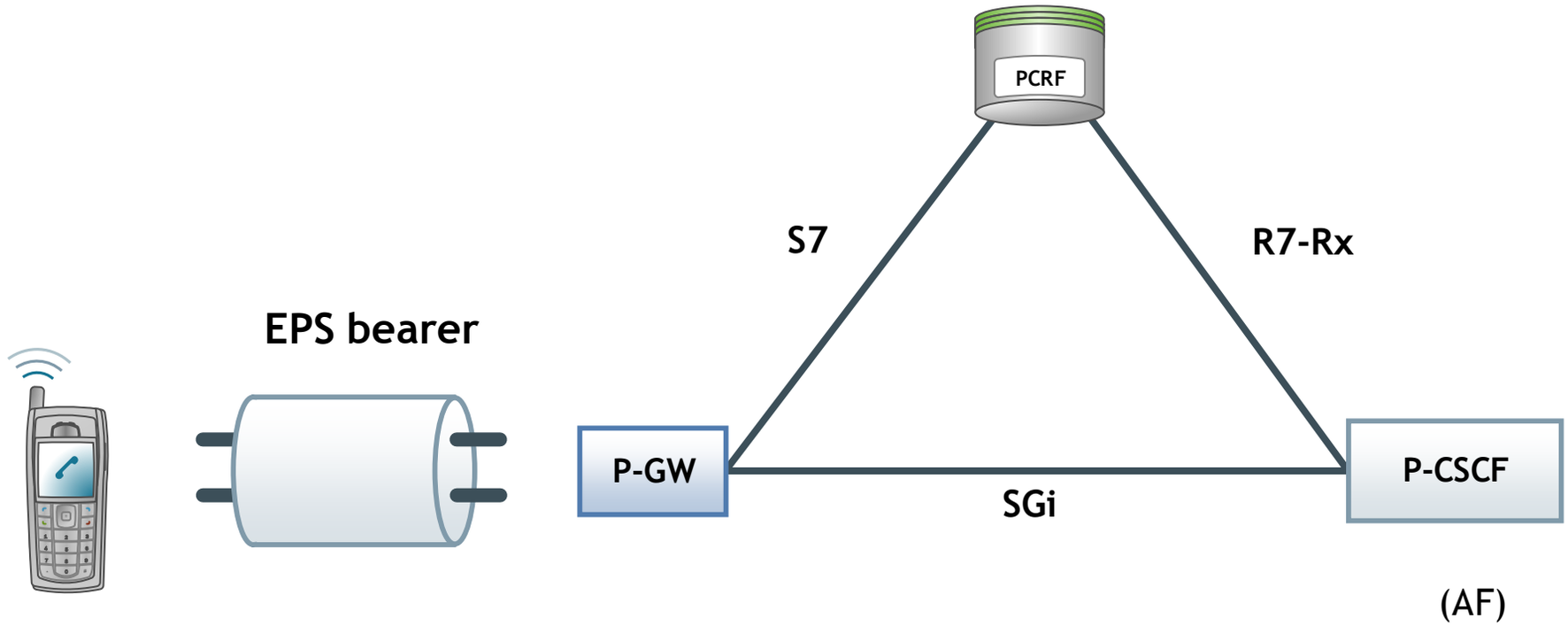
Up toUMTS R5

1 PDP bearers = n service flows
Flow-based charging



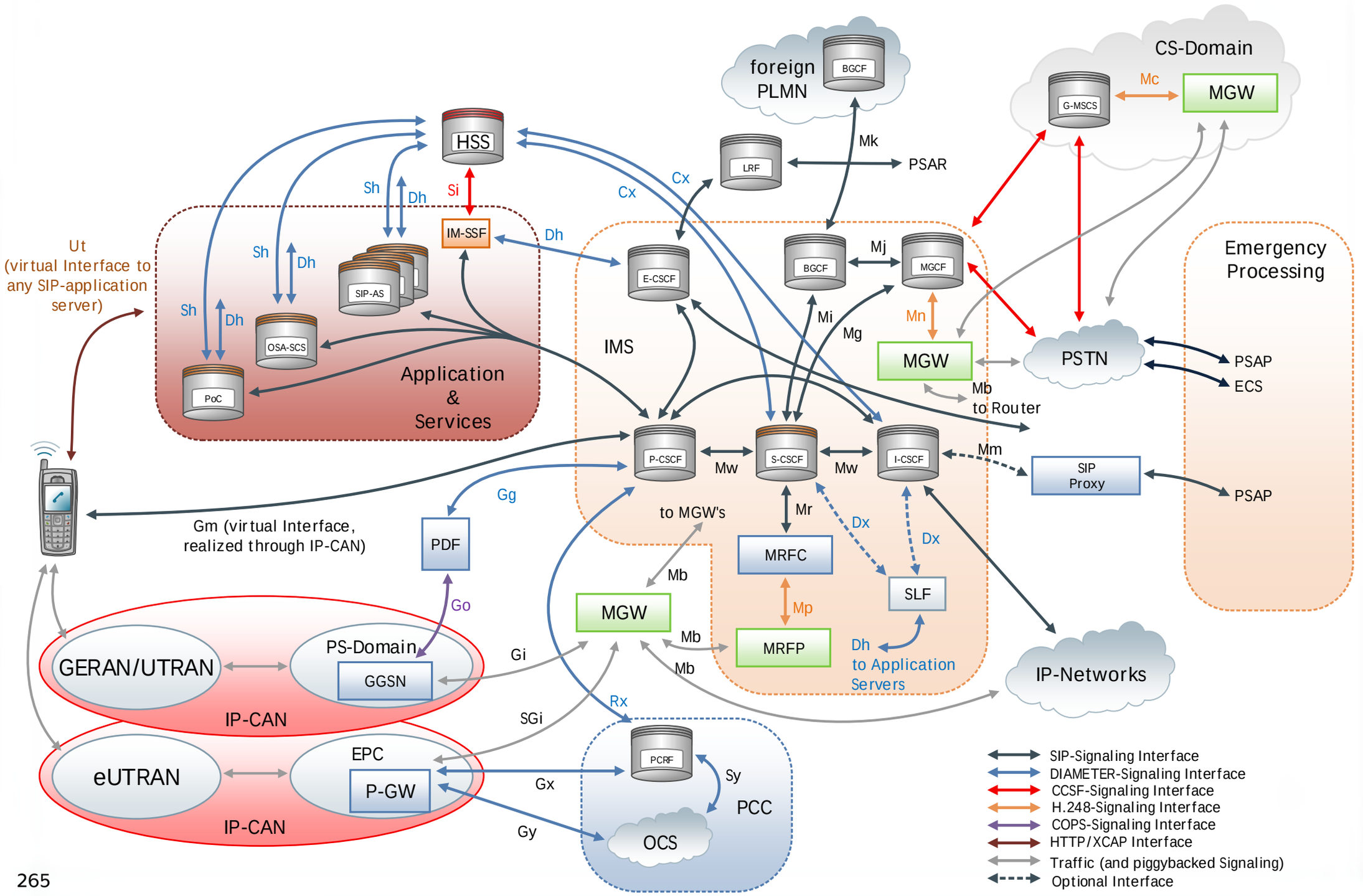
UMTS R6 enchancement

EPC & PCC



SIP session control

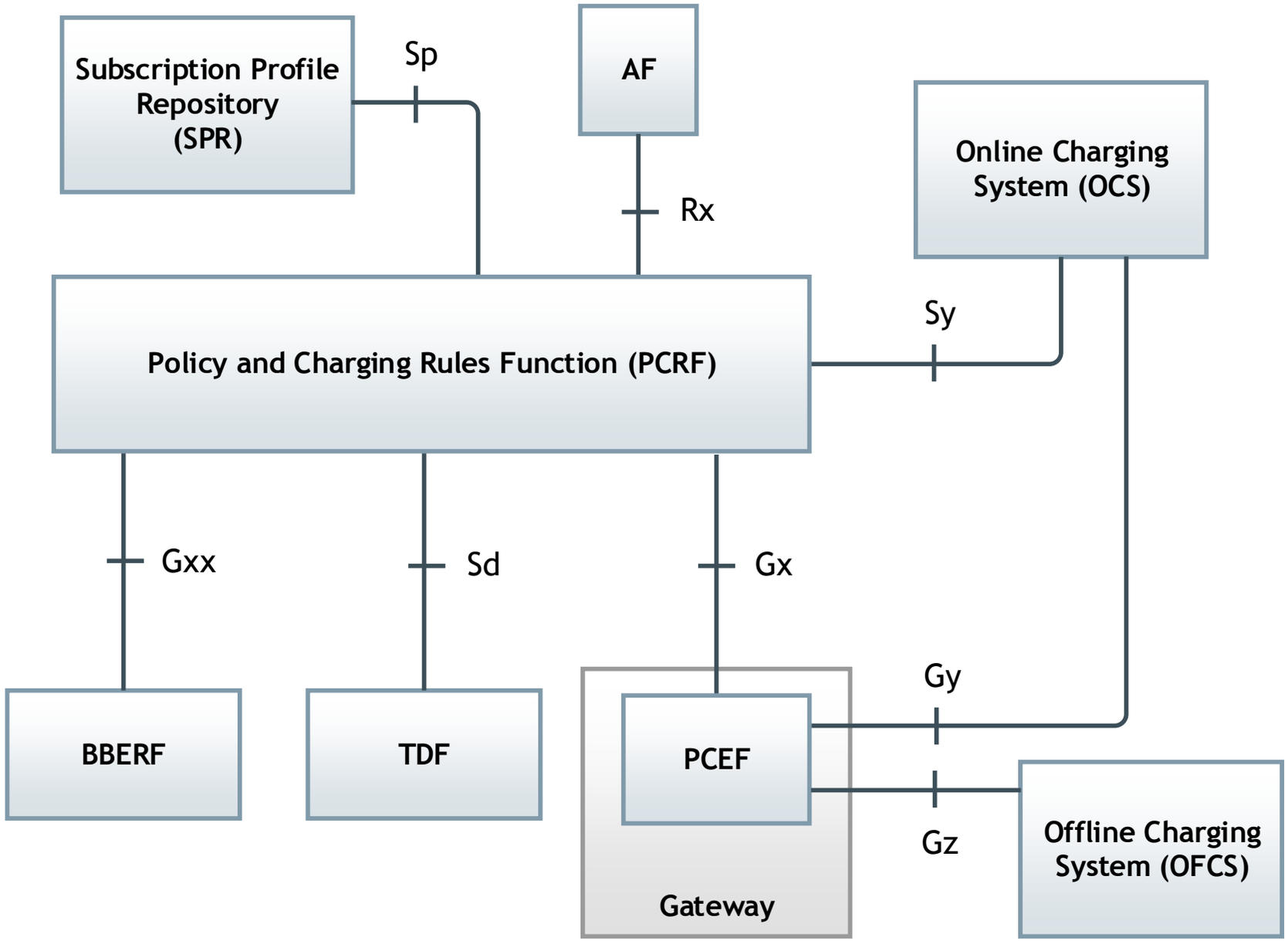
IMS – the Detailed View



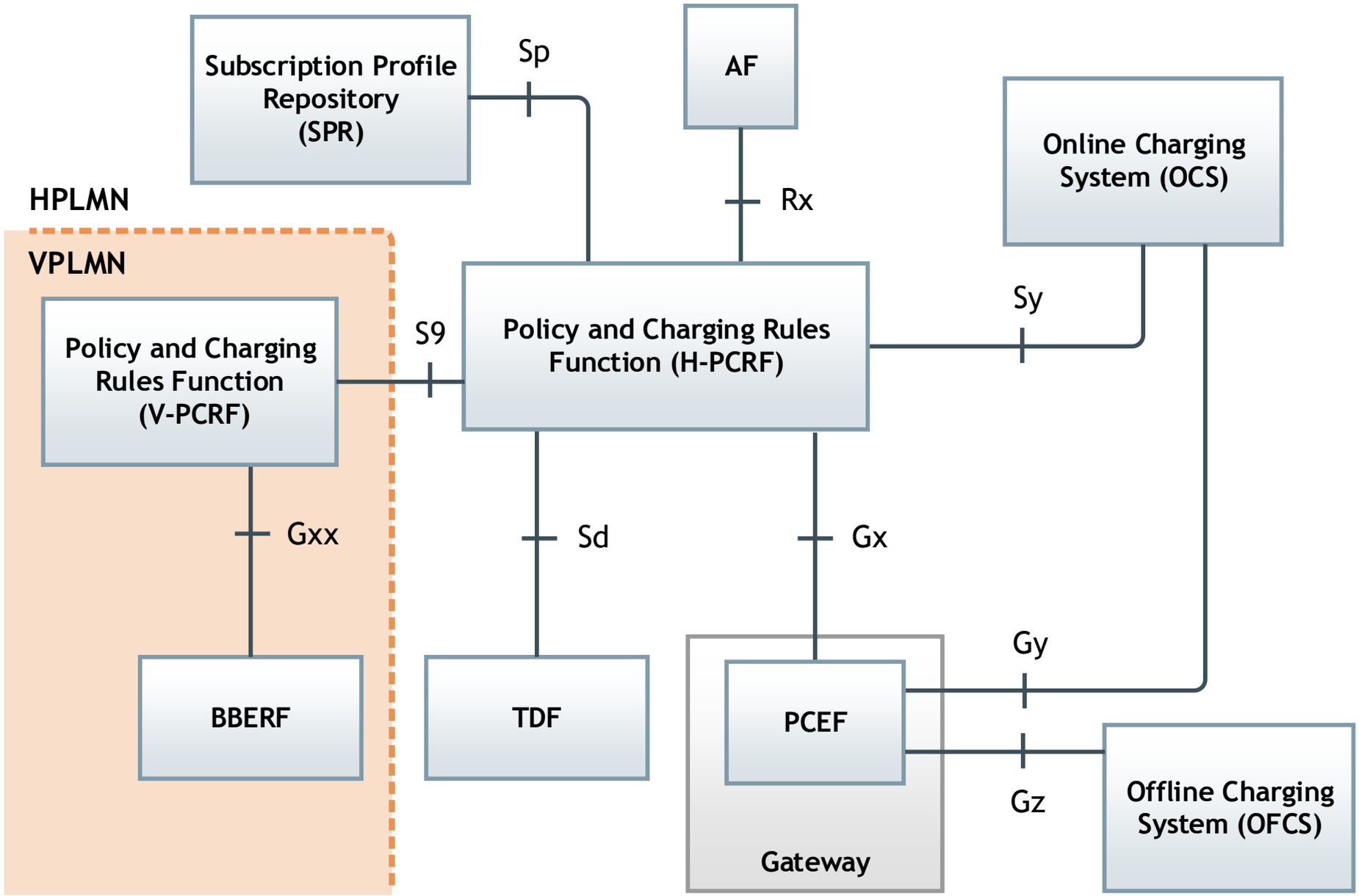
Policy and Charging Rules FunctionPCRF

- 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 providet towards the Policy and Charging Enforcement Function (PCEF).
- not responsible for credit management

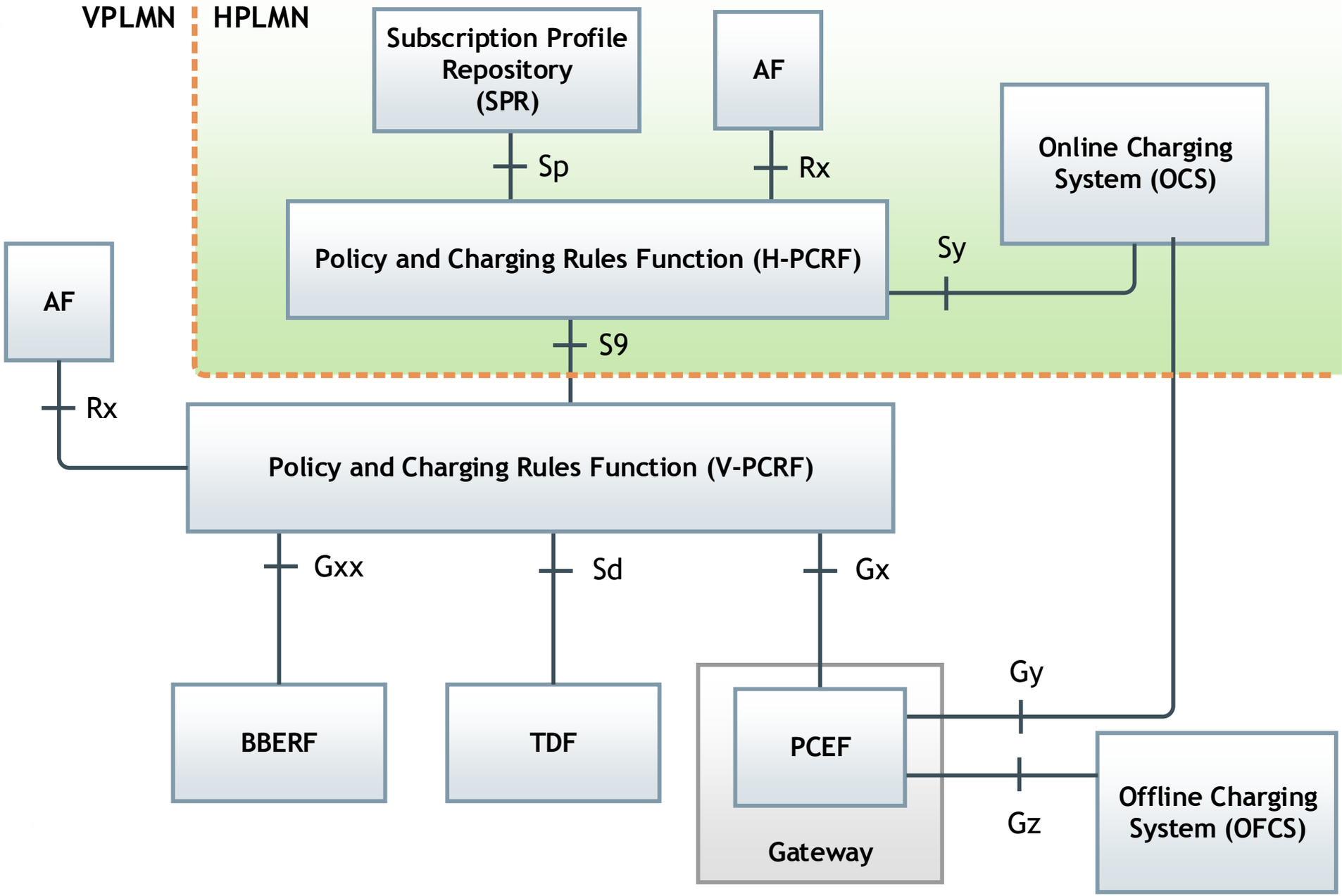
Overal PCC architecture (non-roaming)



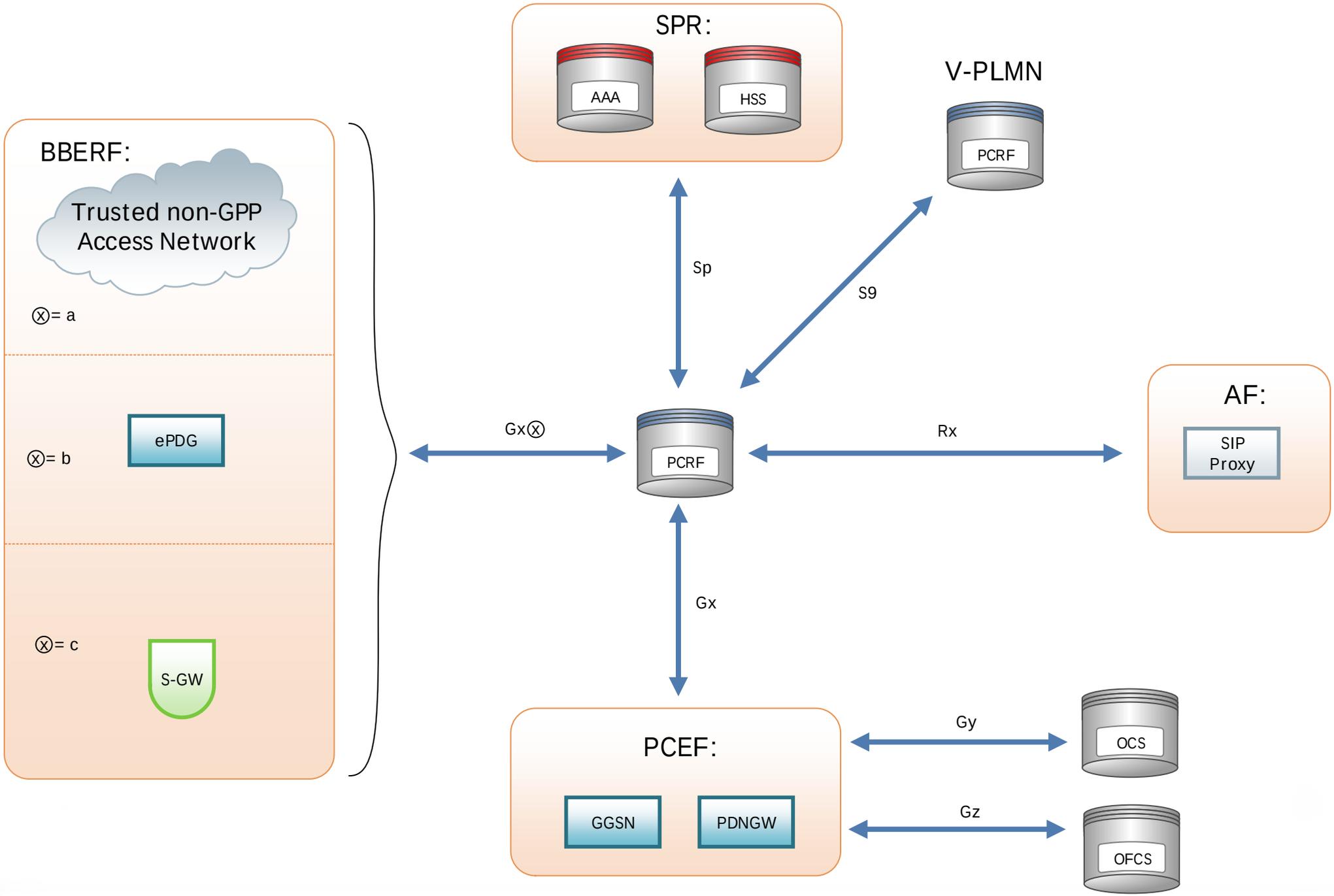
Roaming - home routed access



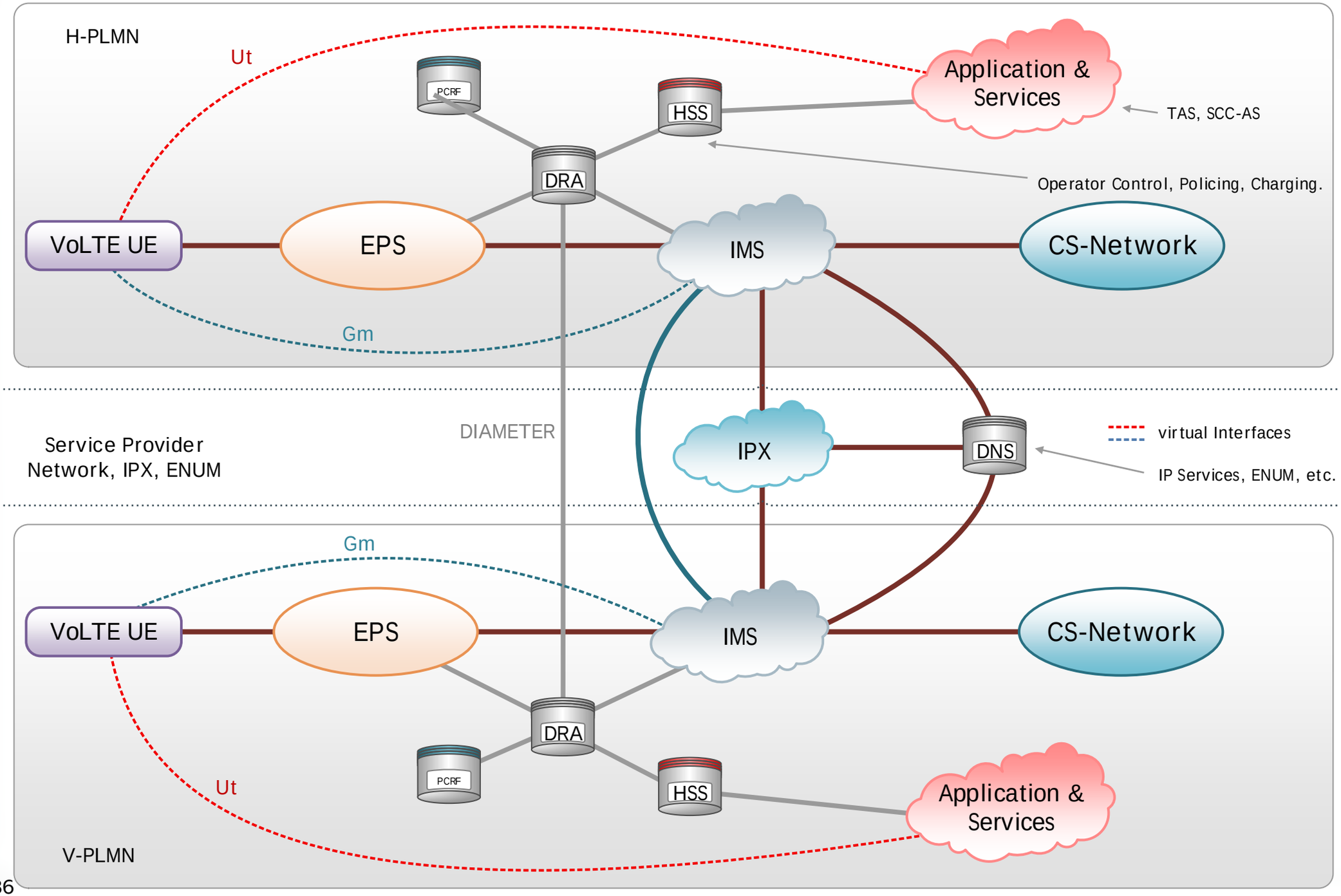
Roaming - local breakout



Policy and charging



VoLTE - Overall Logical Architecture



VoLTE vs. VoIP

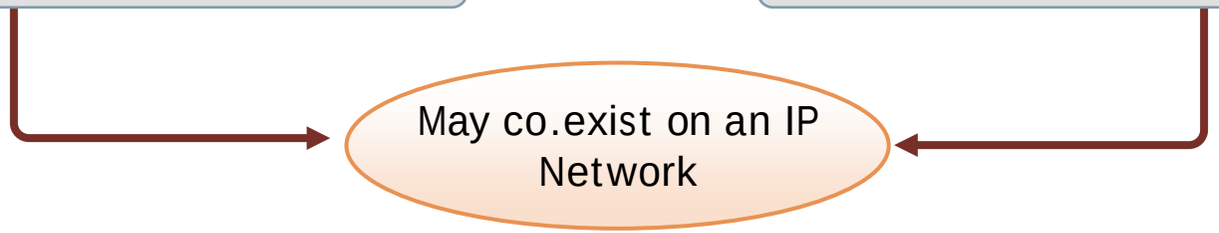
VoIP

vs

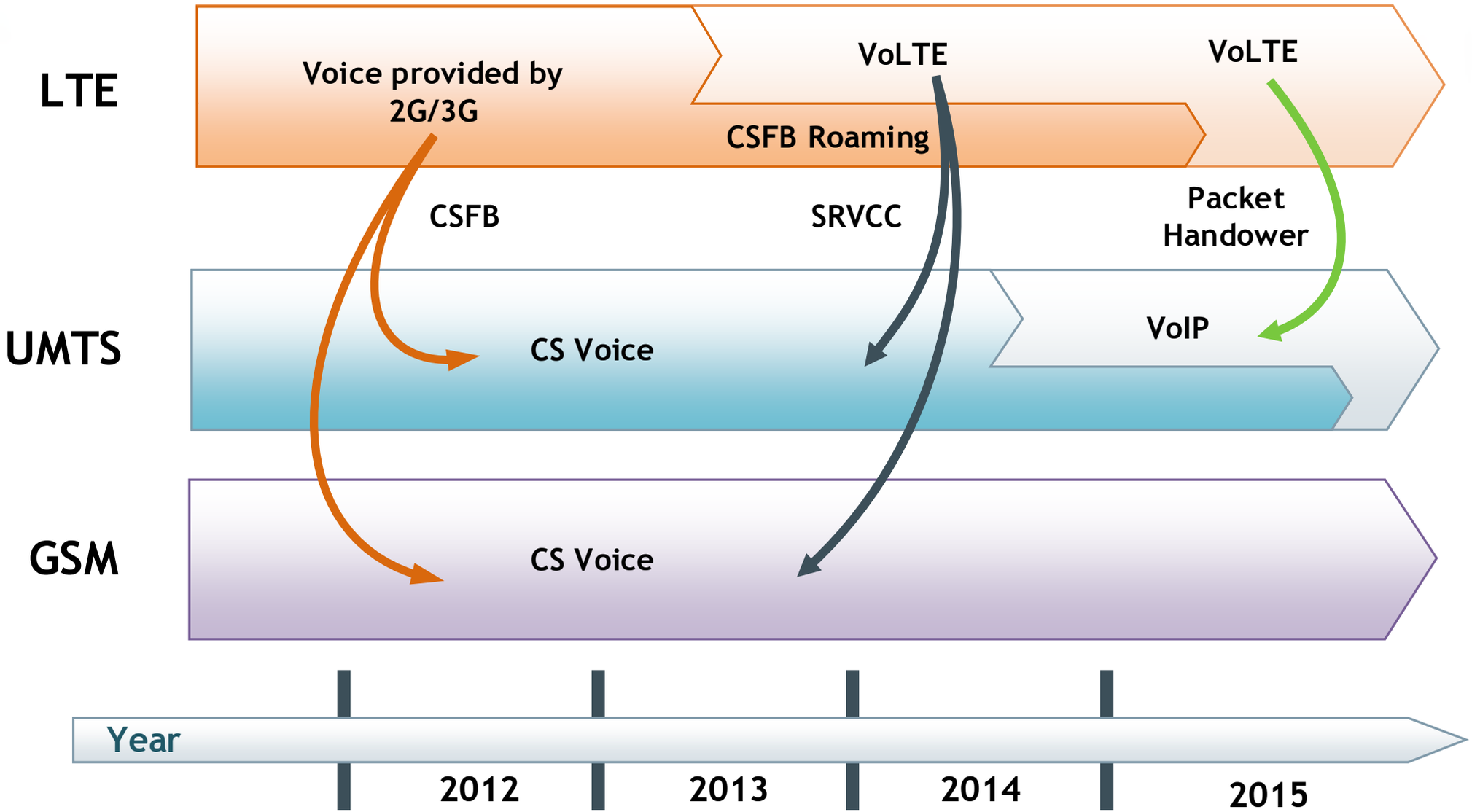
VoLTE

- Generic term for vioce over packet networks (IP)
- Synonyms are „IP Telephon“, „Internet telephony“, „Voice over Broadband (VoBB)“, etc.
- Traditional provided over (W)LAN, DSL lines
- Defines a family of internet technologies, protocol and transmision technologies for voice communication and multimedia sessions

- Term defined in 2010 by GSMA for Voice and messaging services provided over LTE delivery pkatform
- Based on the „One Voice“ initiative
- E2E voice and SMS ecosystem using the IP Multimedia Subsystem (IMS) as basis
- Also covers Roaming and Interconnection interfaces
- Profiling 3GPP specs for MMTel to create a common voice and SMS service offering for LTE networks
  =>Rich Communication Suite (RCS) extends that offering towards Multimedia services (e.g. Presence IM, content sharing et.)

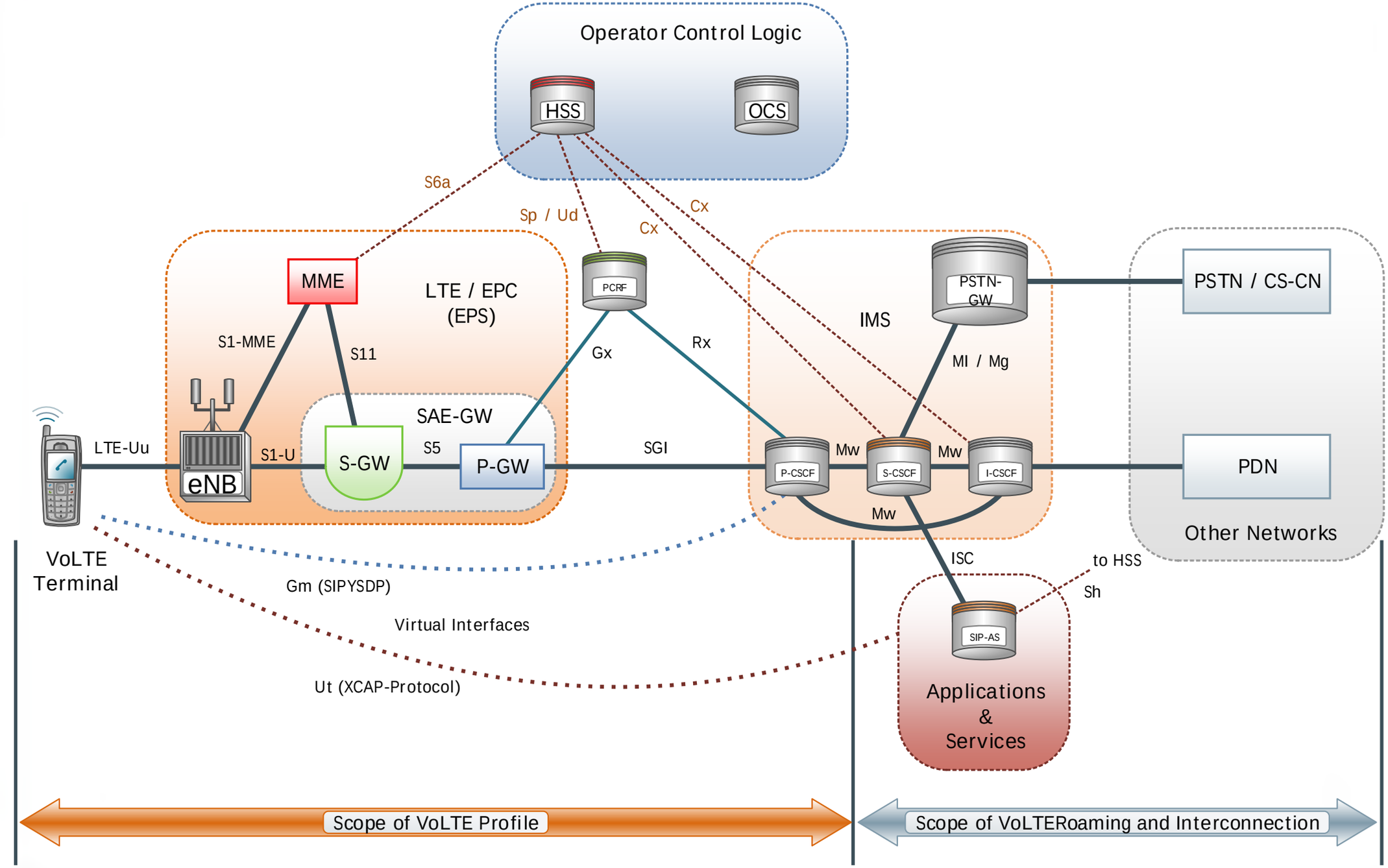


Voice evolution

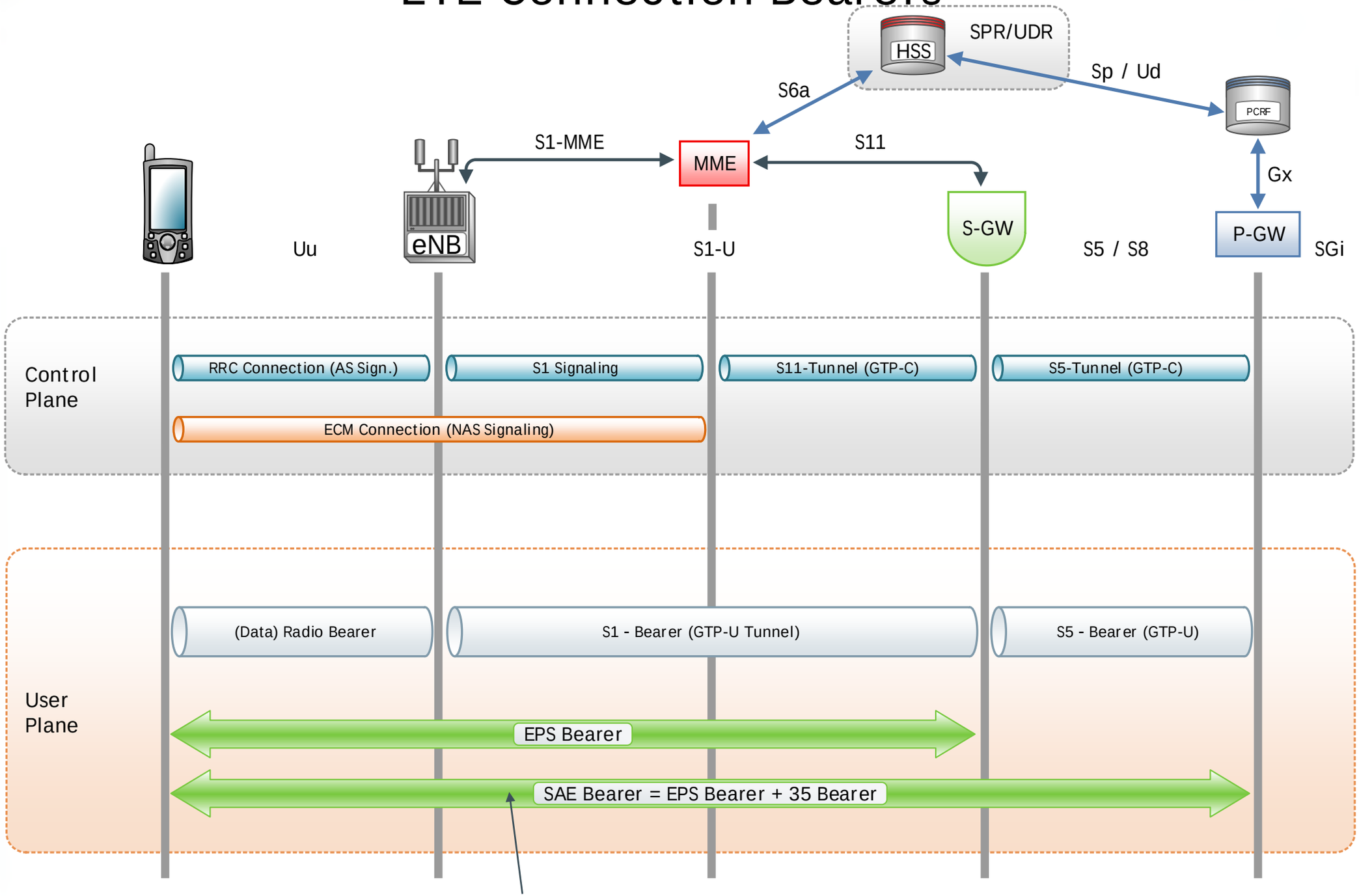


CSFB: Circuit Switched Fallback
SRCV: Single radio Voice Call Continuity (if LTE coverage ends)

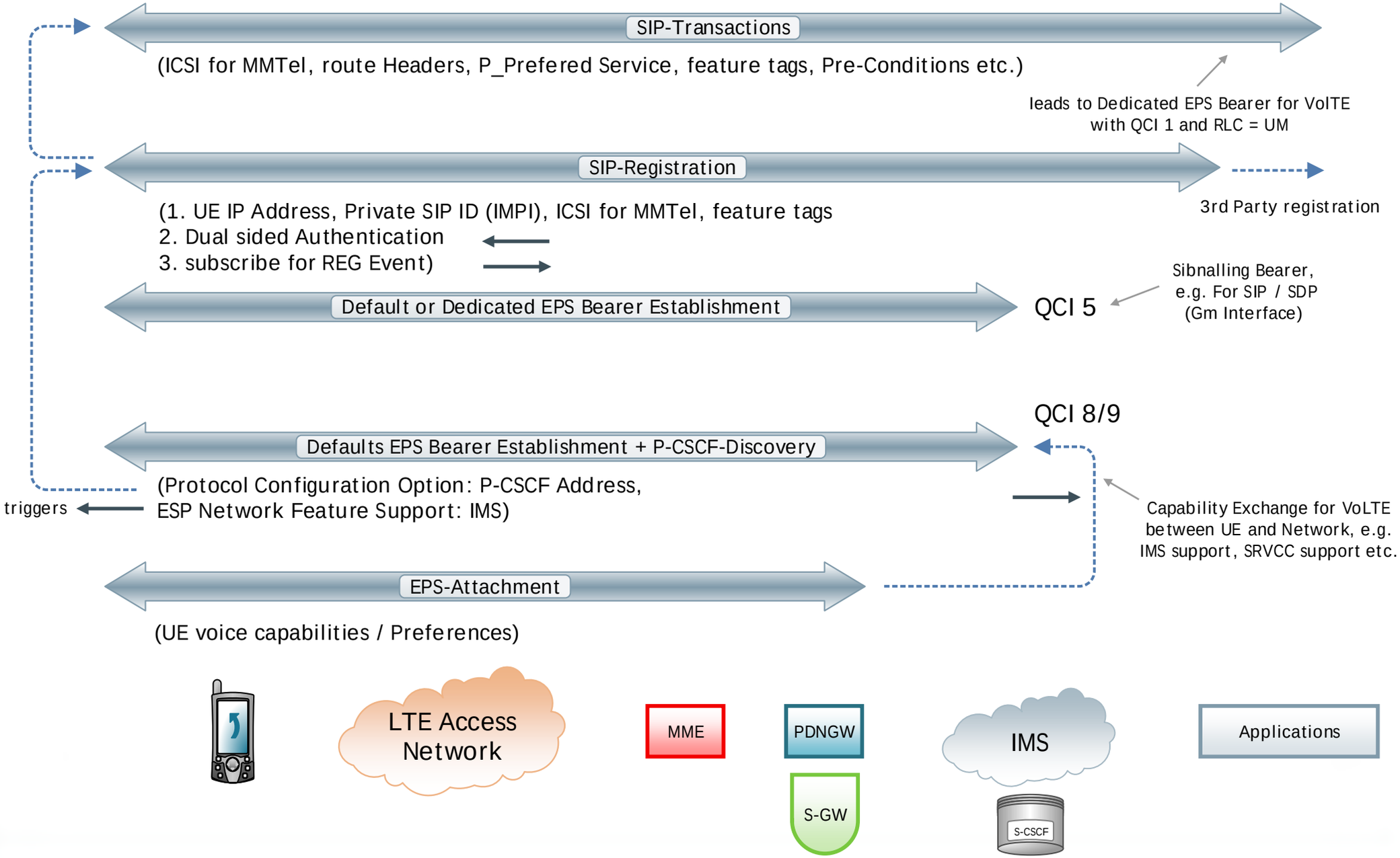
VoLTE Architecture Overview – The Main Components



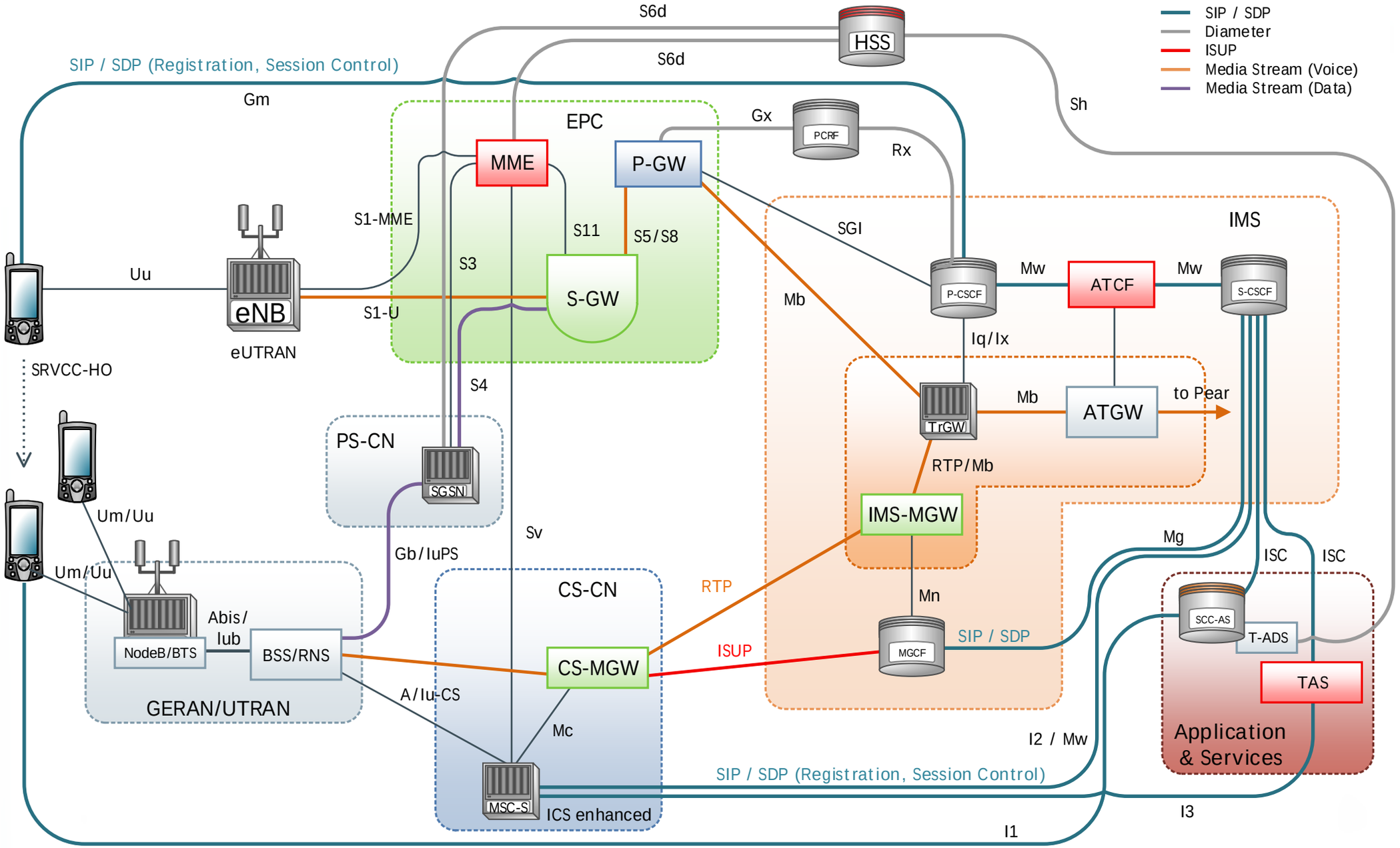
LTE Connection Bearers



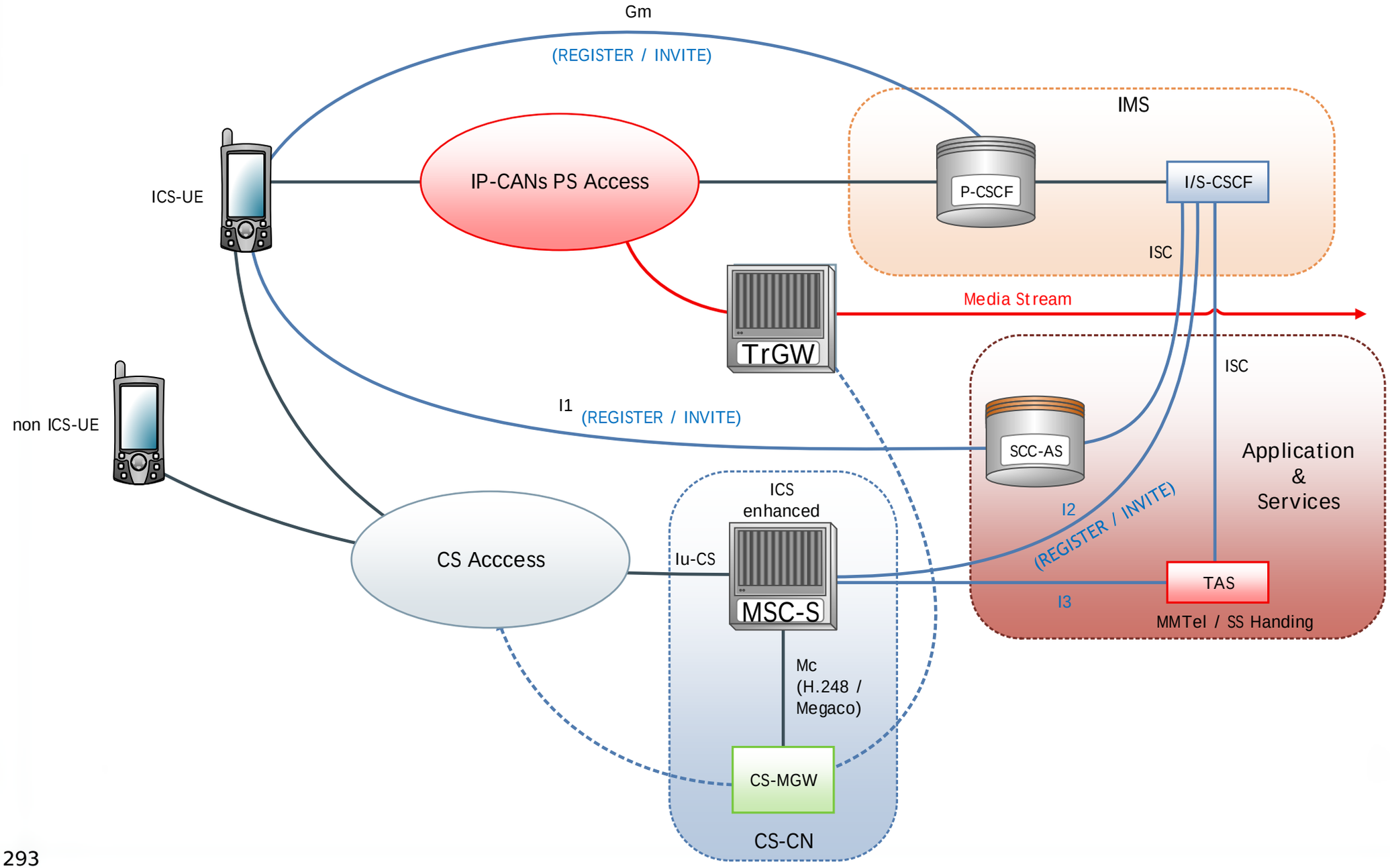
UEs way to registration



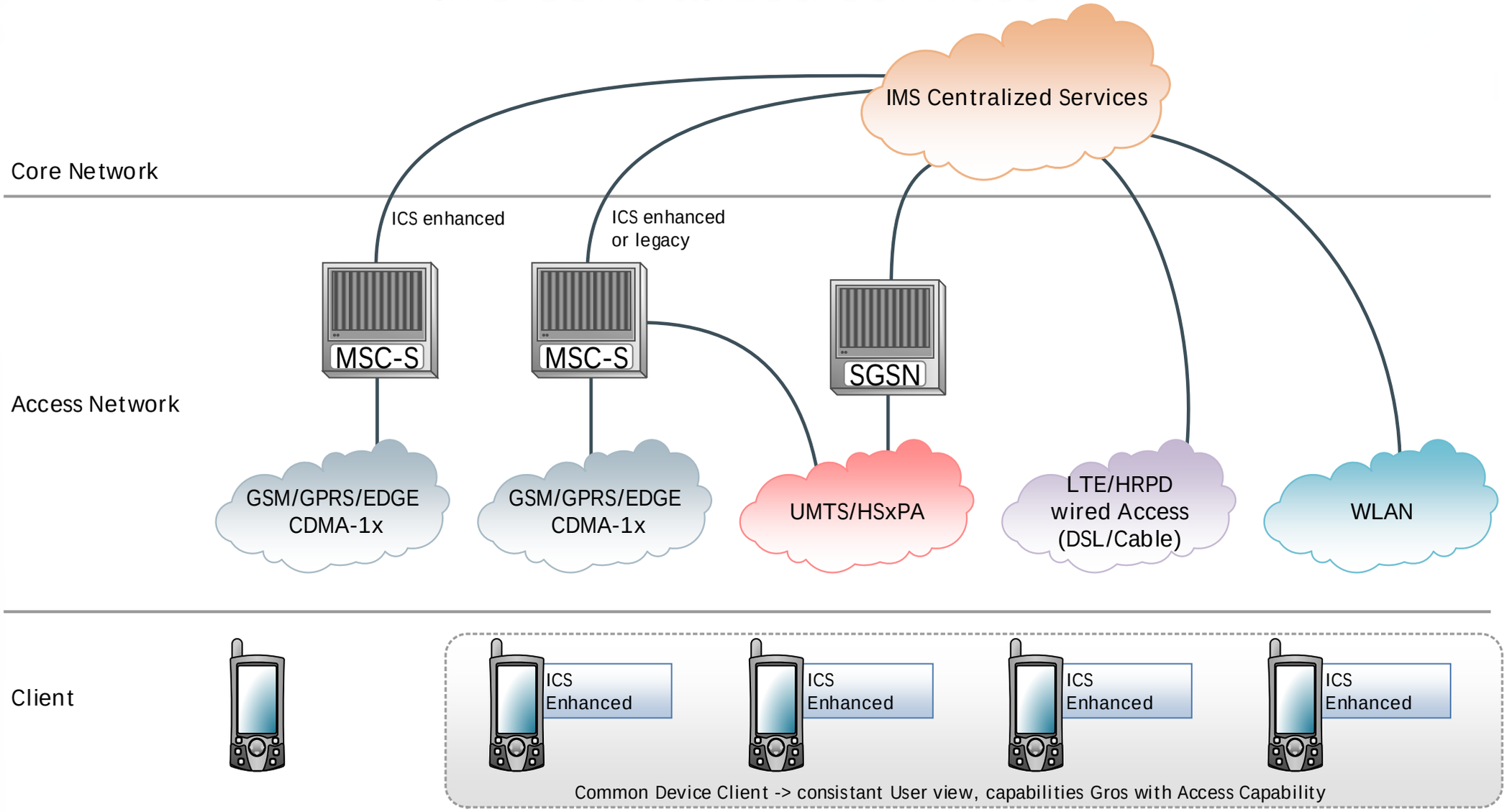
LTE Voice Architecture with IMS



Architecture for IMS Service Centralization and Continuity

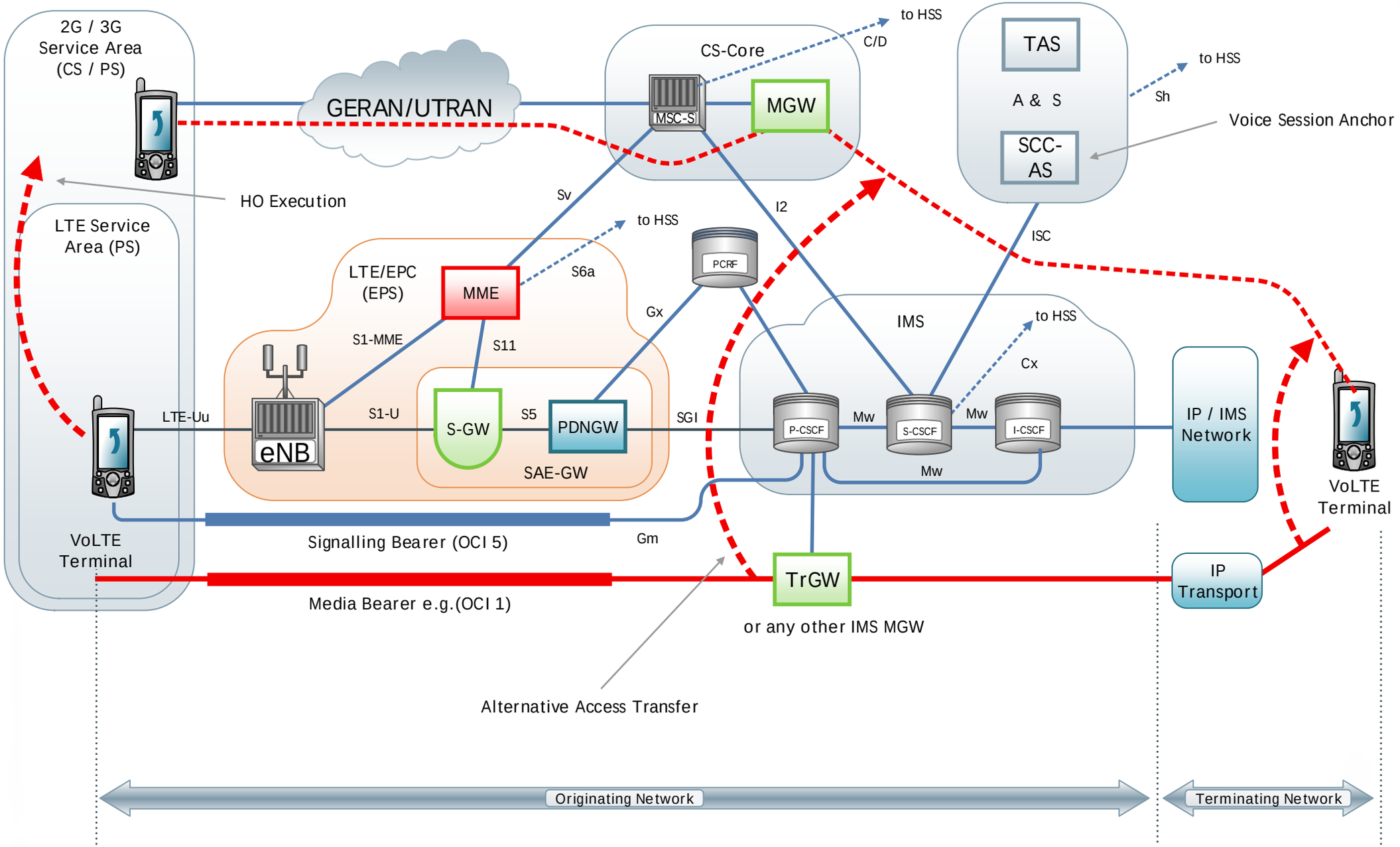


IMS Centralized Services

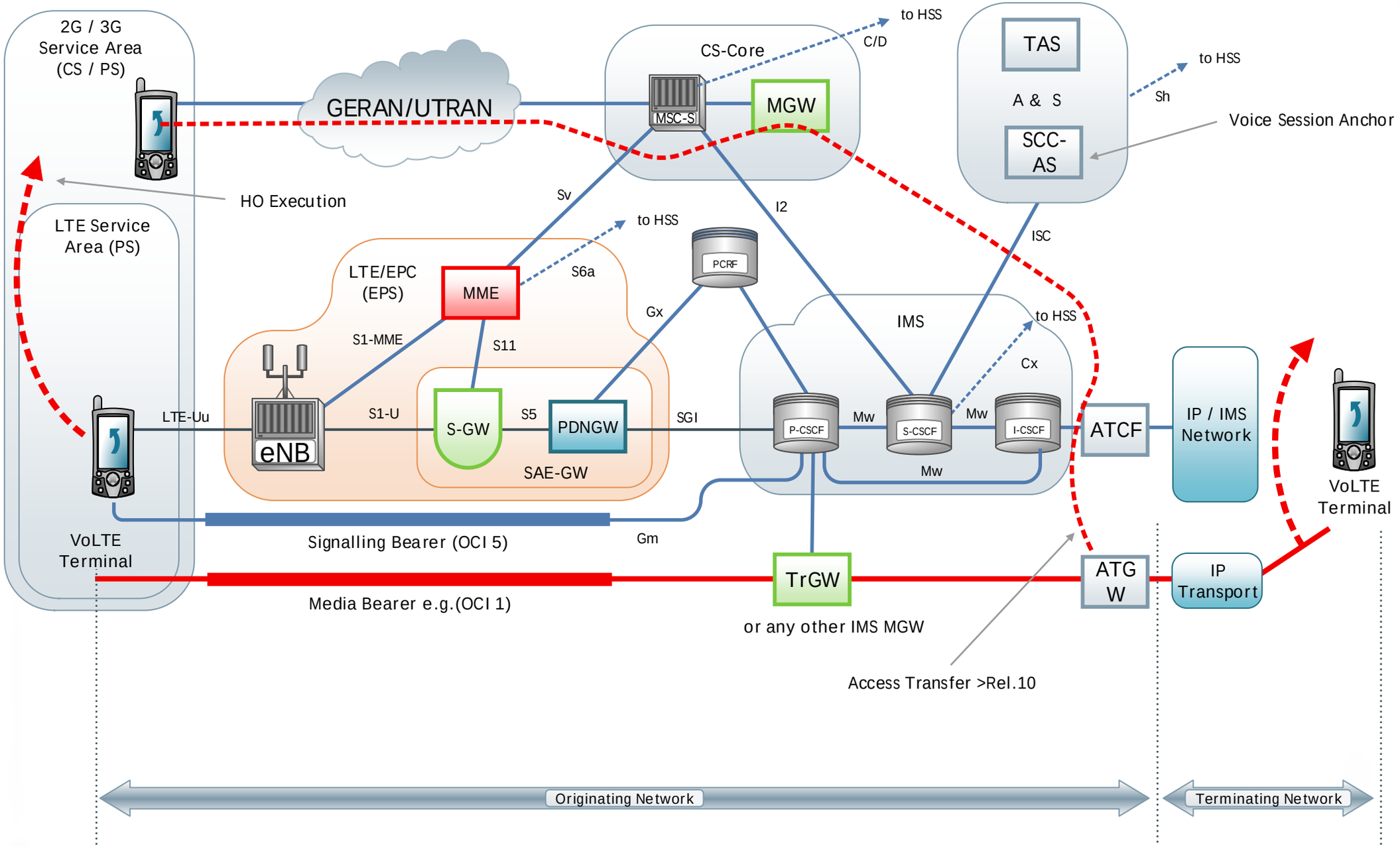


Centralized Services				
	CS Voice Cs equiv. MMTEL SS	CS Voice Partlal MMTEL SS Data IP Services	CS Voice Full MMTEL SS High Speed Data Rich IP Services IMS Video	QoS VoIP/VoLTE Full MMTEL SS High Speed Data Rich IP Services IMS Video Realtime Services	VoIP Full MMTEL SS High Speed Data Rich IP Services IMS Video

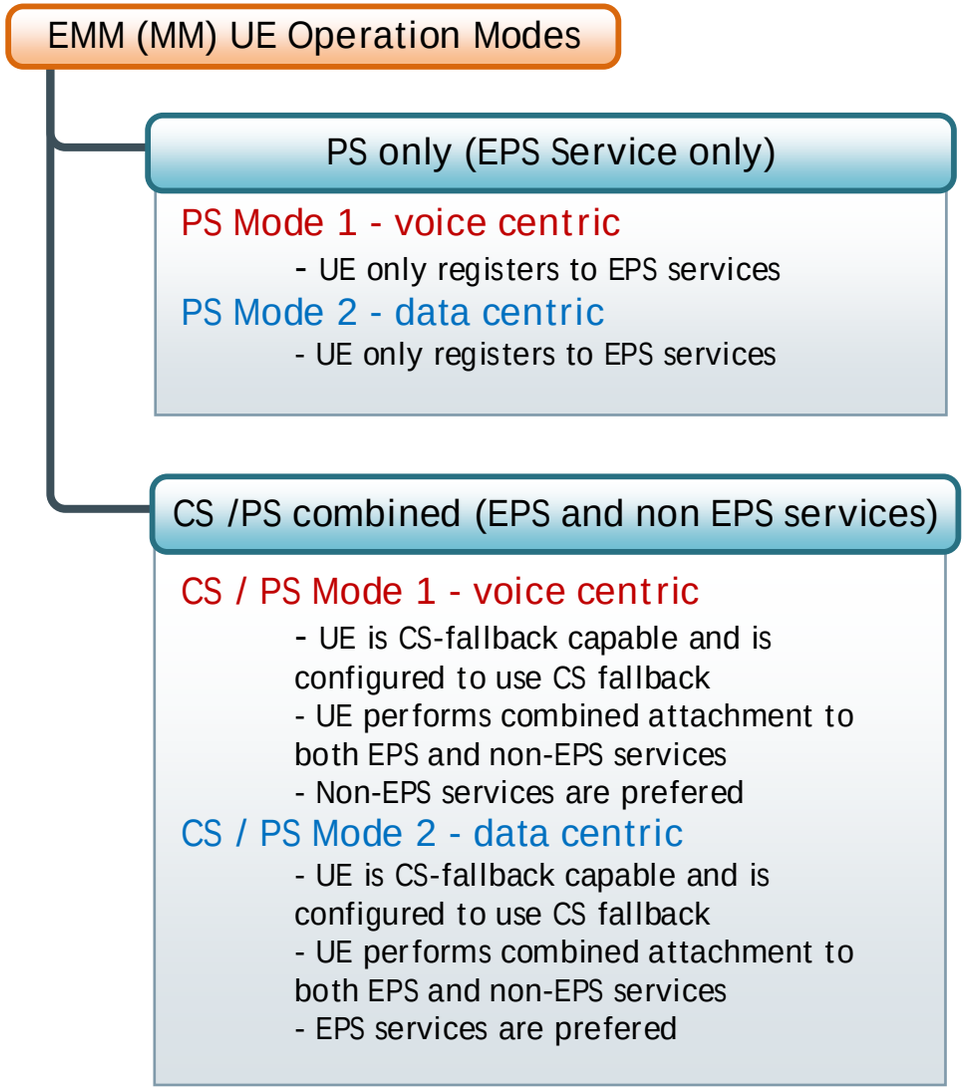
SRVCC Rel8


2G / 3G
Service Area
(CS / PS)
GERAN/UTRAN
CS-Core
MSC-S
MGW
to HSS
C/D
TAS
A & S
SCC-
AS
to HSS
Sh
Voice Session Anchor
HO Execution
Sv
I2
ISC
LTE Service
Area (PS)
to HSS
PCRF
LTE/EPC
(EPS)
MME
S6a
Gx
IMS
to HSS
Cx
S1-MME
S11
LTE-Uu
S1-U
S-GW
S5
PDNGW
SGI
P-CSCF
Mw
S-CSCF
Mw
I-CSCF
IP / IMS
Network
eNB
SAE-GW
Mw
VoLTE
Terminal
VoLTE
Terminal
Signalling Bearer (OCI 5)
Gm
IP
Transport
TrGW
Media Bearer e.g.(OCI 1)
or any other IMS MGW
Alternative Access Transfer
Originating Network
Terminating Network

SRVCC Rel10


2G / 3G
Service Area
(CS / PS)
GERAN/UTRAN
CS-Core
MSC-S
MGW
to HSS
C/D
TAS
A & S
SCC-
AS
to HSS
Sh
Voice Session Anchor
HO Execution
LTE Service
Area (PS)
Sv
I2
ISC
to HSS
PCRF
LTE/EPC
(EPS)
MME
S6a
Gx
IMS
to HSS
S1-MME
S11
Cx
LTE-Uu
S1-U
S-GW
S5
PDNGW
SGI
P-CSCF
Mw
S-CSCF
Mw
I-CSCF
ATCF
IP / IMS
Network
eNB
SAE-GW
Mw
VoLTE
Terminal
VoLTE
Terminal
Signalling Bearer (OCI 5)
Gm
TrGW
ATG
W
IP
Transport
Media Bearer e.g.(OCI 1)
or any other IMS MGW
Access Transfer >Rel.10
Originating Network
Terminating Network

UE Mode of Operation



- UE may receive IMS availability info in ATTACH ACCEPT message from MME
- SMS services (e.g. OTA) must be provided through the IMS

- If the UE prefers CSFB, then it performs the combined ATTACH
- SMS Services are also pssible after the combined ATTACH Accept from MSC for 'non EPS services
- If the UE gets an Indication that VoIP-IMS is supported although it has attachmed to CS-domain, it still can perform MOC via IMS and MTC requiest CSFB depending on Core
- If the UE „likes“ SMS via MSC, then it must also perform the combined ATTACH for EPS and non EPS Services

- Note: Non-EPS Services are legacy CS-Domain Services like SMS or voice call
- Botton Line: The voice centric Mobile and card relying on CS-SMS figure out by trial and error if SGs-interface is supported between MME and legacy MSC. The ATTACH ACCEPT or TRACKING AREA UPDATE ACCEPT informs the UE if CS-domain isavailable for voice and/or SMS-only
- A voice centric UE having combined attached (EPS + non EPS services incl. SMS) can detach from MSC-voice support once the IMS is supported through Tracking Area Update procedure => SMS is by legacy CS-domain and MOC/MTC is performed through IMS

UE Usage Setting:

0 Voice Centriv

1 Data Centric

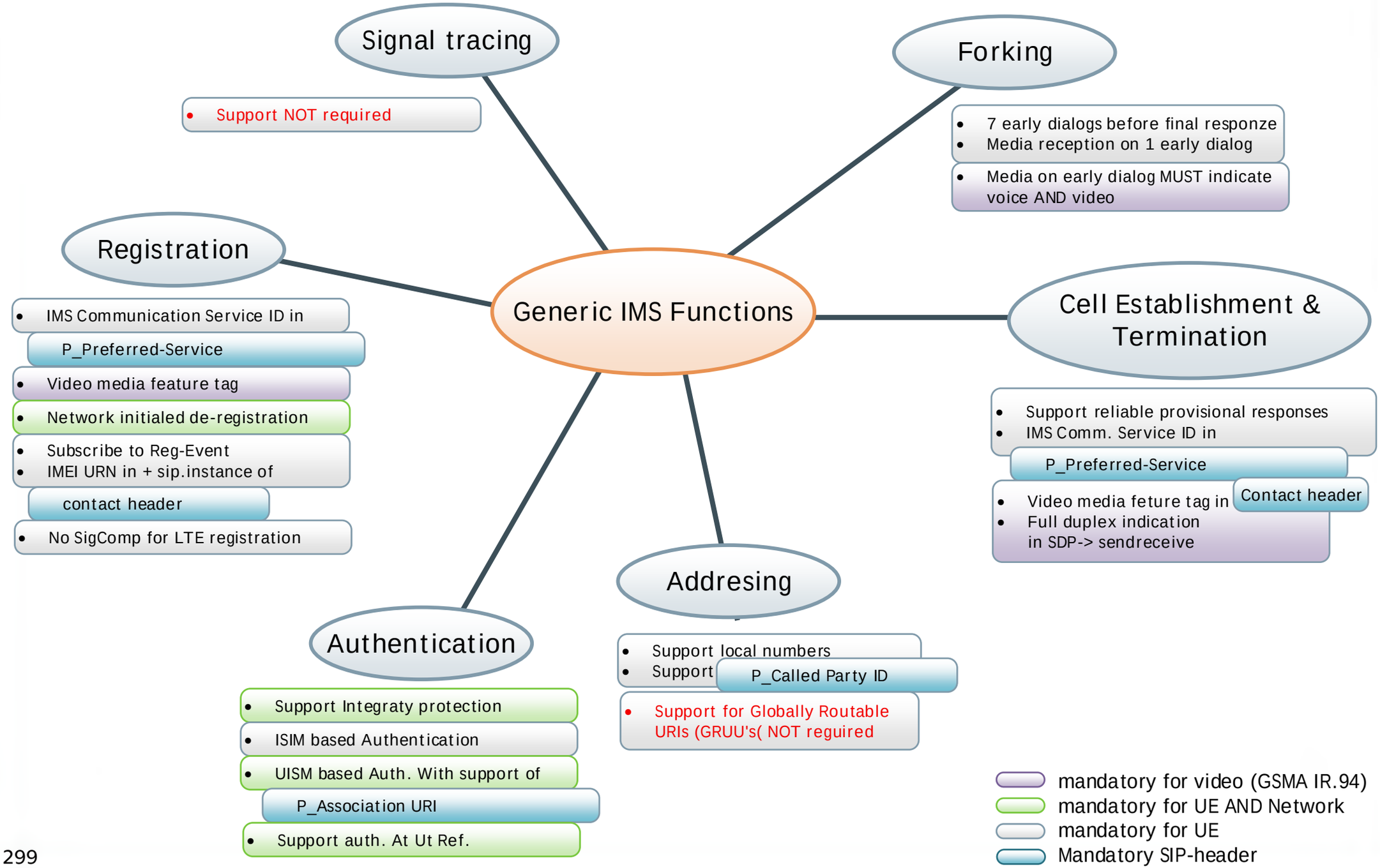
IMS based VoLTE - A Brief Comparison

Service		VOLTE	CSFB	OTT
Standards	Global Roaming	Y	Y	N
	Interoperability	Y	Y	N
	QoS & Regulatory (e.g. Emergencies)	Y	Y	N
Rich Media	Path to IP-Based Rich Communications	Y	N	Y
	Simultaneous 4G LTE Data & Voice	Y	N	Y
	Extensible fot IP Service Innovation	Y	N	Y
Evolved Voice	HD, Web / App Integration	Y	N	Y
	KPIs (reliability, Billing, Security, et.)	Y	Y	N
	2G / 3G Integration / Fallback	Y	Y	N

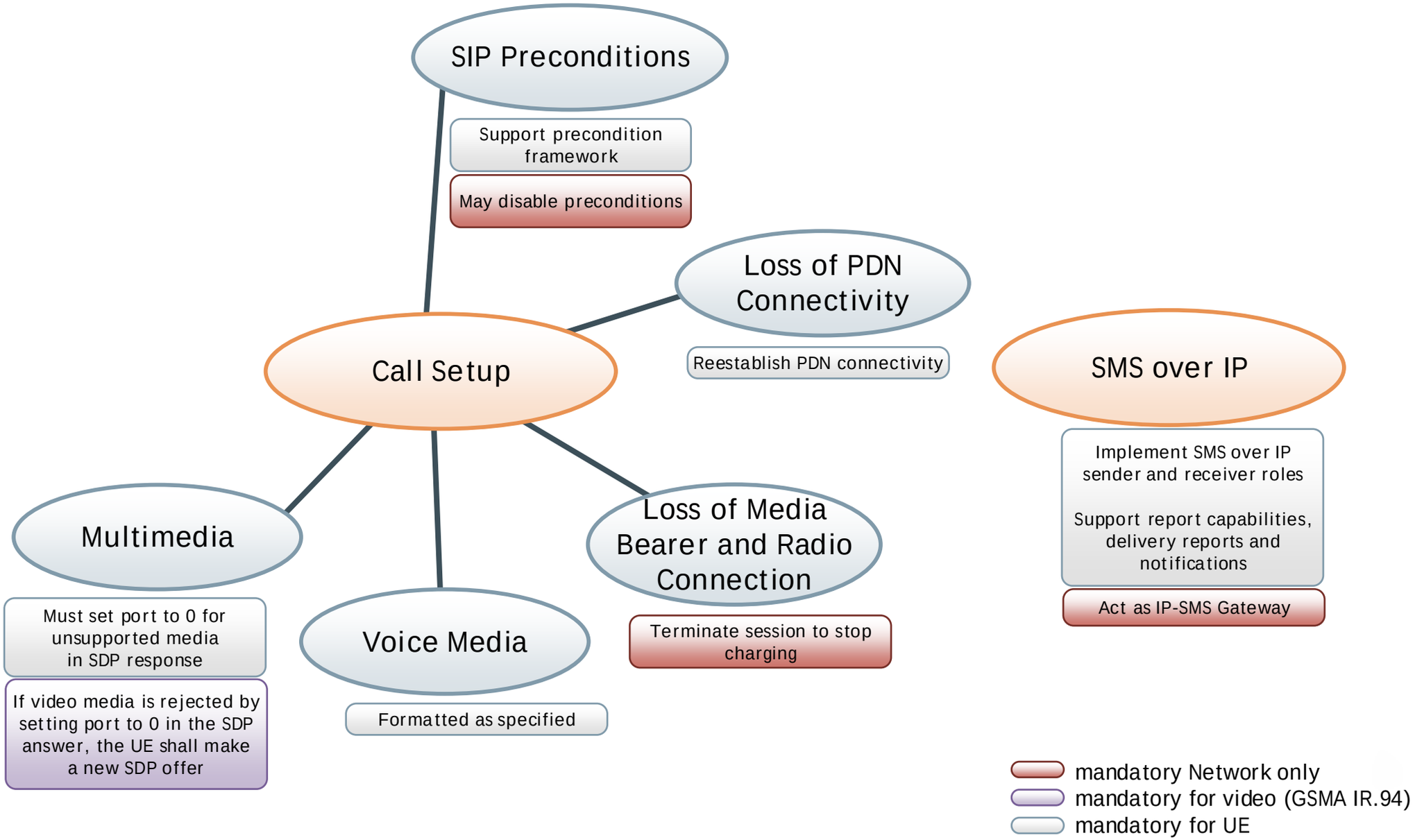
Signale Radio Voice Call Continuity (SRVCC)
SRVCC Evolution (e SRVCC, aSRVCC, r SRVCC, v SRVCC)

3GPP Rel. 8	- eUTRAN 3GPP2 1xCS - eUTRAN 3GPP2 UTRAN / GERAN CS Access / UTRAN (HSPA) - Voice call anchoring in IMS Service Centralization an Continuity
3GPP Rel. 9	- added IMS emergency call to Rel.8 features
3GPP Rel. 10	- IMS Registration for non ICS enhaced UE's (supported by ICS enhaced MSC server) - added SRVC PC-SC transfer in alerting phase (aSRVCC) - Voice Media anchoring in VPLMN if applicable (eSRVCC)
3GPP Rel. 11	- added video call continuity LTE 3G / SC (vSRVCC) - interface enhacements for video bearer signaling on S5 / S11 /Sv /Gx / Gxx - added reverse SRVCC (rSRVCC) - UTRAN / GERAN (CS) eUTRAN / Utran (HSPA) (PS) - Update to Geran an UTRAN specs

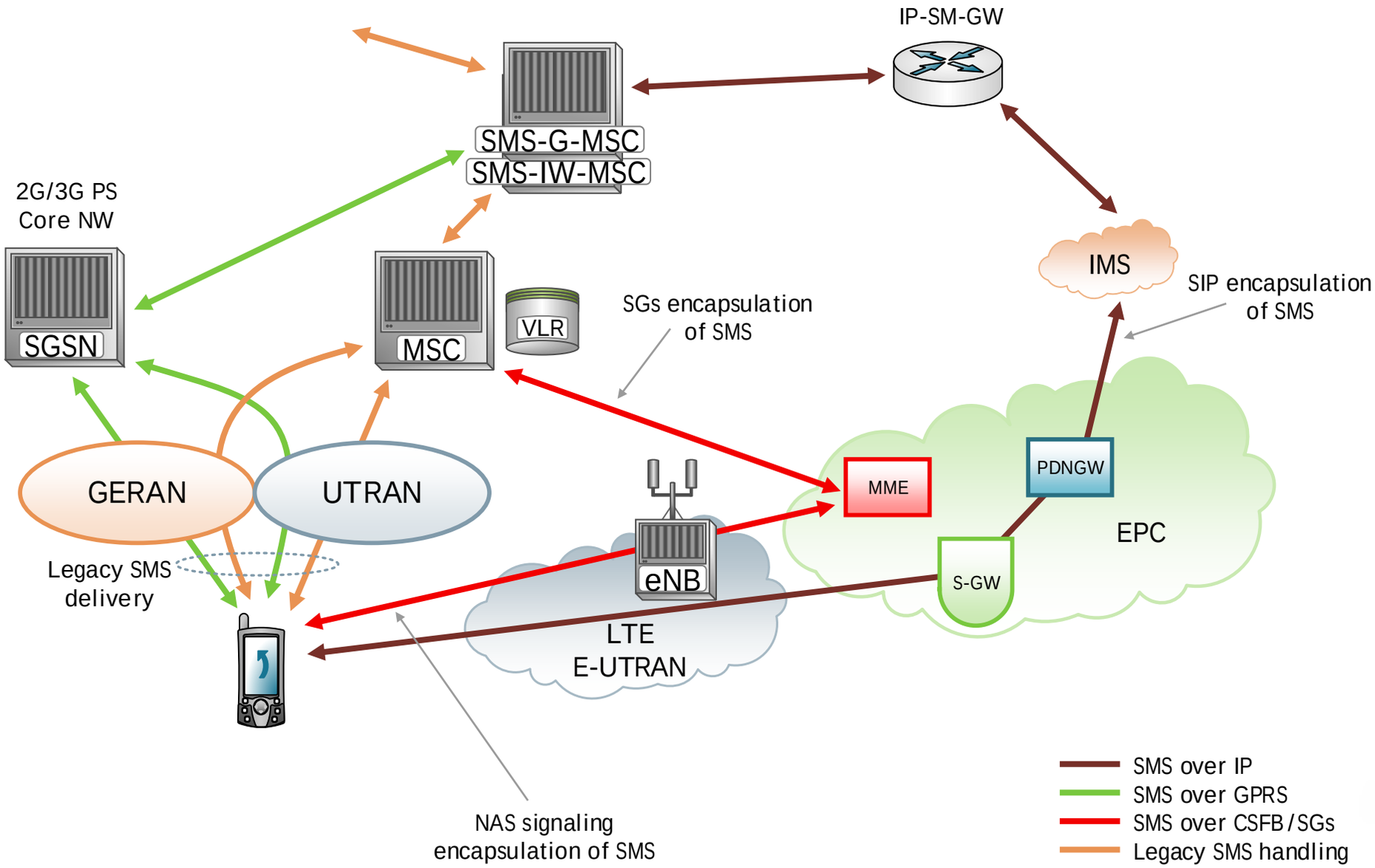
VoLTE services overview



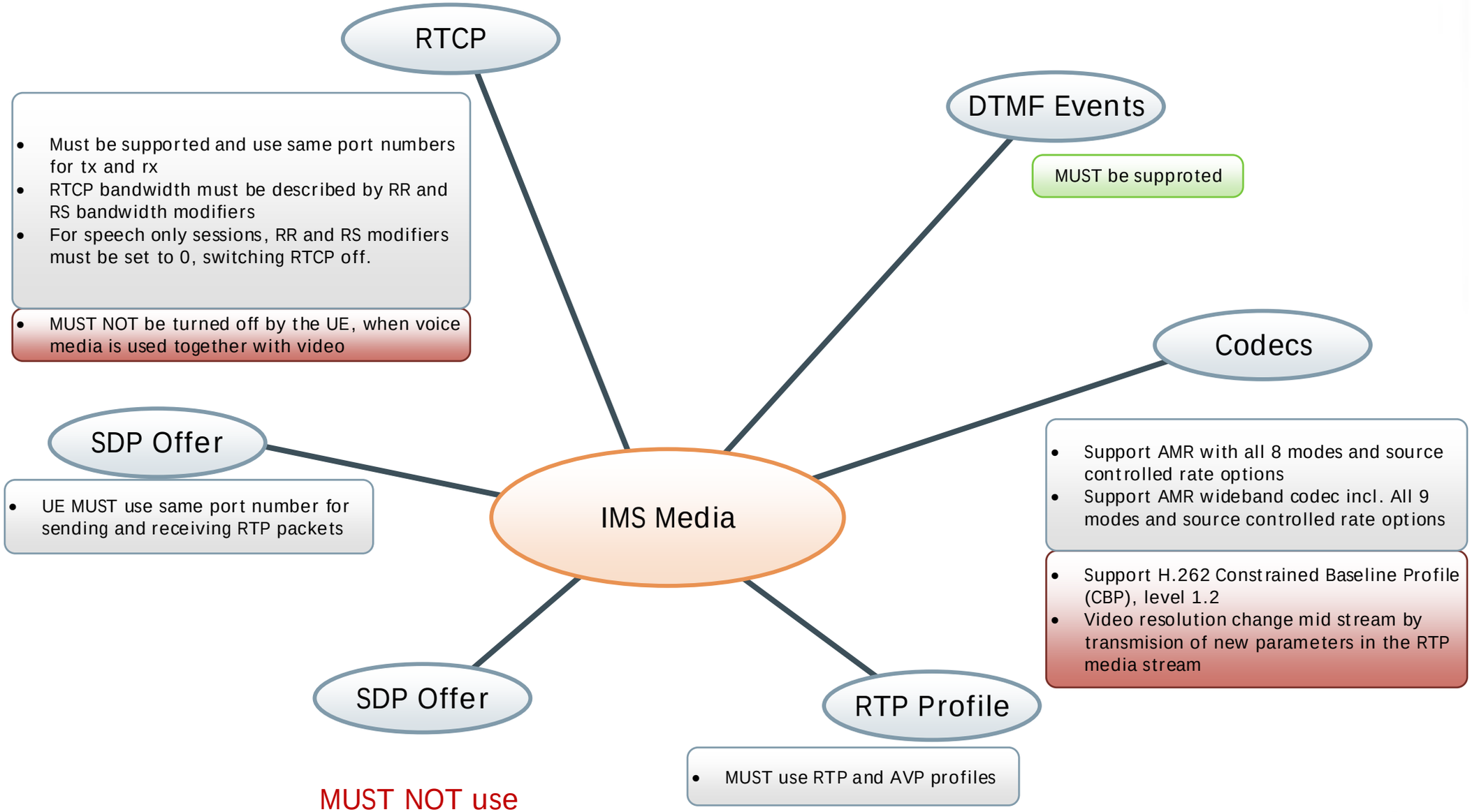
Call setup and SMSoIP



EPC SMS handling



IMS Media requirements

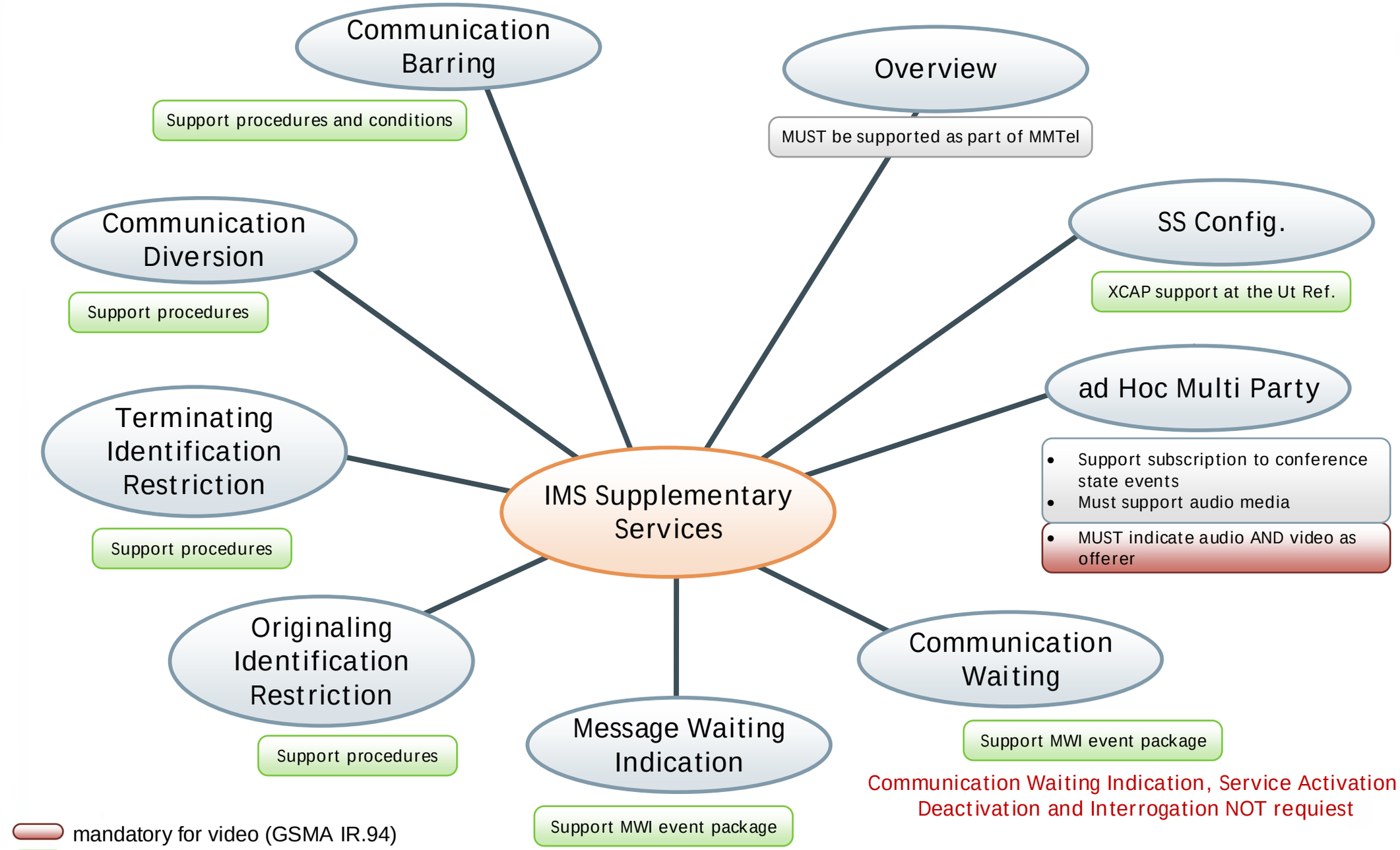


IMS Mandatory Media for VoLTE Services - UE View

Media Requirements	Mandatory UE Functions	Specifications
Audio Codecs	Support AMR with all 8 modes and source controlled rate options	3GTS 26.071, 26.090, 26.073, 26.104, 26.093
	Support AMR wideband codec incl. All 9 modes and source controlled rate operation	3GTS 26.114, 26.171. 26.190, 26.173, 26.204, 26.193
Video Codecs	Support H.262 Constrained Baseline Profile (CBP), level 1.2	3GTS 26.114, GSMA IR94
	Video resolution change mid stream by transmission of parameters in the RTP media stream	GSMA IR94
RTP Profile	Must use RTP and AVP profiles	RFCP 3551
SDP Offer	Must NOT use SDPCapNeg framework	Draft-ietf-mmusic-sdp-capability-negotiation
Data Transfer	UE must use same port number for sending and receiving RTP packets	
RTCP	Must be supported and use same port numbers for tx and rx	
	RTCP bandwith must be described by RR and RS bandwith modifiers	
	For speech only session, RR and RS modifiers must be set to 0, switching STCP off	
	For speech be turned off by the UE, when voice media is used together with video	GSMA IR94
DTMF Events	Must NOT use SDPCapNeg framework	3GTS 26.114

XXX Video

IMS supplementary services



Supplementory Service			IMS various	MMTel 3GTS 24.173	VoLTE GSMA IR.92	PSTN/ISDN 3GTS 29.163
Calling line identification presentation	CLIP	3GTS 29.163				Y
Calling line identification restriction	CLIR	3GTS 29.163				Y
Connected line presentation	COLP	3GTS 29.163				Y
Connected line restriction	COLR	3GTS 29.163				Y
Originating Identification Presentation	OIP	3GTS 24.607	Y	Y	Y	
Originating Identification Restriction	OIR	3GTS 24.607	Y	Y	Y	
Terminationg Identification Presentation	TIP	3GTS 24.608	Y	Y	Y	
Terminationg Identification Restriction	TIR	3GTS 24.608	Y	Y	Y	
Direct Dialling In	DDI	3GTS 29.163				Y
Malicious cell Identification	MCID	3GTS 29.163	Y			Y
Subaddresing	SUB	3GTS 29.163				Y
Communication Drivers	CDIV	3GTS 24.604	Y	Y	Y	
Communication Forwarding Unconditional	CFU	3GTS 24.604	Y		Y	Y
Communication Forwarding on Busy user	CFB	3GTS 24.604	Y		Y	Y
Communication Forwarding on no Replay	CFNR	3GTS 24.604	Y		Y	Y
Communication Forw: on Suscriber Not Reachable	CFNRc	3GTS 24.604	Y		Y	
Communication Deflection	CD	3GTS 24.604	Y			Y
Communication Forwarding on Not Logged-in	CFNL	3GTS 24.604	Y		Y	
Communication Diversion Notification	CDIVN	3GTS 24.604	Y			
Call / Communication Hold	HOLD	3GTS 24.610		Y	Y	Y
Communication Barring	CB	3GTS 24.611	Y	Y	Y	
Incoming Communication Barring	ICB	3GTS 24.611	Y		Y	
Anonymous Call / Communication Rejection	ACR	3GTS 24.611				Y
Rejection Communication Barring	OCB	3GTS 24.611	Y		Y	

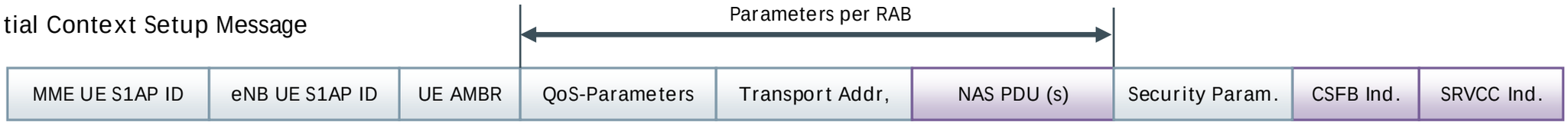
Fixed acces interworking - mandatory
Fixed acces interworking - recommended
Fixed acces interworking - otional

Supplementory Service			IMS various	MMTel 3GTS 24.173	VoLTE GSMA IR.92	PSTN/ISDN 3GTS 29.163
Message Waiting Indication	MWI	3GTS 24.606	Y	Y	Y	
Conference	CONF	3GTS 24.605	Y	Y		Y
Explicit Call / Communication Transfer	ECT	3GTS 24.629	Y	Y		Y
		3GTS 29.163				
XCAP over Ut interface of Manipulating GN Services		3GTS 24.623		Y	Y	
Advice of Charge	AOC	3GTS 24.647		Y		
Closed User Groups	CUG	3GTS 24.654		Y		Y
Three Party	3PTY	3GTS 24.605	Y	Y		Y
Flexible Alert	FA	3GTS 24.239		Y		
Communication / Call Waiting	CW	3GTS 24.615	Y	Y	Y	Y
Completion of Communications to Busy Subscribers	CCBS	3GTS 24.642	Y	Y		Y
Completion of Communications to No Reply	CCR	3GTS 24.642	Y	Y		Y
Completion of Communications Not Logged In			Y	Y		
Customized Alerting Tones	CAT	3GTS 24.182		Y		Y
Customized Ringing Signal	CRS	3GTS 24.183	Y	Y		
Personal Network Management	PNM	3GTS 24.259		Y		
Unstructed Supplementary Service Dataflection	USSD	3GTS 24.390		Y		
Ad Hoc Multi Party Conference	MPTY	3GTS 24.605			Y	
Terminal Portability	TP	3GTS 29.163				Y
Multi-Level Precedence and Pre-emption	MLPP	3GTS 29.163				Y
Global Virtual Network Service	GVNS	3GTS 29.163				Y
International telecommunication charge card	ITCC	3GTS 29.163				Y
Reverse Charging	REV	3GTS 29.163				Y
User-to-User Signalling	UUS	3GTS 29.163				Y
Multiple Subscriber Number	MNS	3GTS 29.163				Y

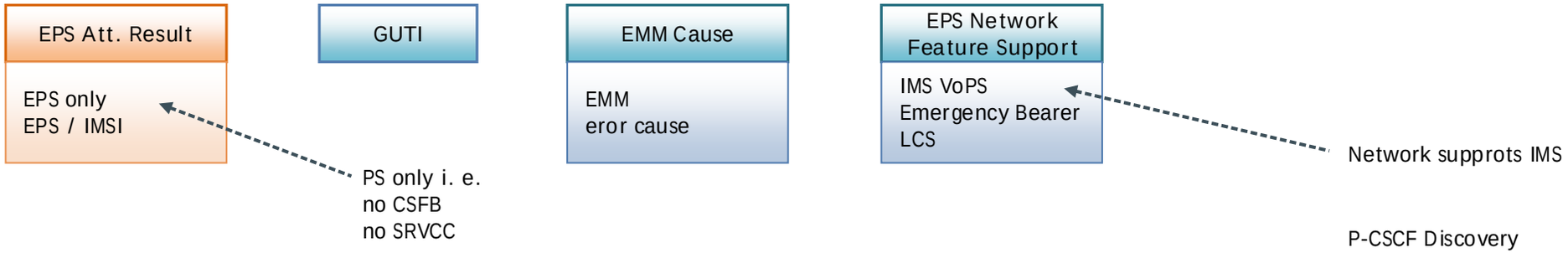
Fixed acces interworking - mandatory
Fixed acces interworking - recommended
Fixed acces interworking - otional

Network Capabilities and UE configuration with ATT_ACC

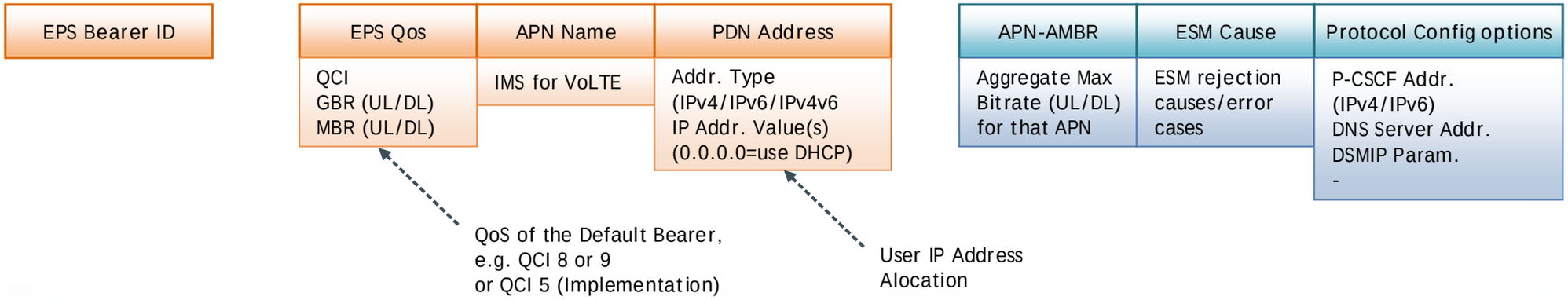
Initial Context Setup Message



Attachment Accept Message



Attachment Accept Message



VolTE related Message Details
UE Capability indication during Attachment Request

Initial UE Message

eNB UE S1AP ID	NAS PDU	TAI	eUTRAN CGI	RRC Est. Cause	Options ...

Attachment Request Message

EPS Attach Type	Key Identifier	Mobile Identity	UE Network Capability	ESM Message Container	Options ...
EPS Attach EPS / IMSI Emergency			Support Alg. for encription and Integrity Protection		

PS only i. e.
no CSFB
no SRVCC

MS Network Capability	MS Classmark2	MS Classmark3	Supported Codecs	Voice Domain Preference
ISR support SRVCC support EPC support rSRVCC support				UE Usage: - Voice Centric - Data centric Voice preference: - CS Voiece only - PS Voiece only - CS Prefered PS 2nd - PS Prefered CS 2nd

Implicit:
UE supports IMS

UE supports SRVCC to 2G/3G or vSRVCC to 3G

UE supports SRVCC to GERAN

PDN Connectivity Prequest

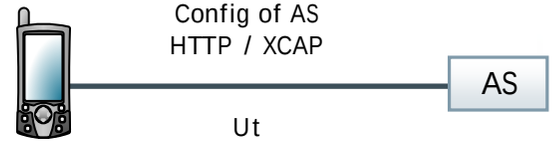
EPS Bearer ID	Request Type	PDN Type	APN	Protocol Config. Options
	Initial Request Handover Emergency	IPv4 IPv6 Ipv4v6		Rquest of IP Addresses: - Ipv4 / Ipv6 - P-CSCF Discovery

Mandatory for VoLTE:
- AMR with all 8 modes and rate options.
- Wideband AMR with all 9 modes and rate options.
- Video: H.262 CBP level 1 2

Reception mandatory for VoLTE UE optional for Network

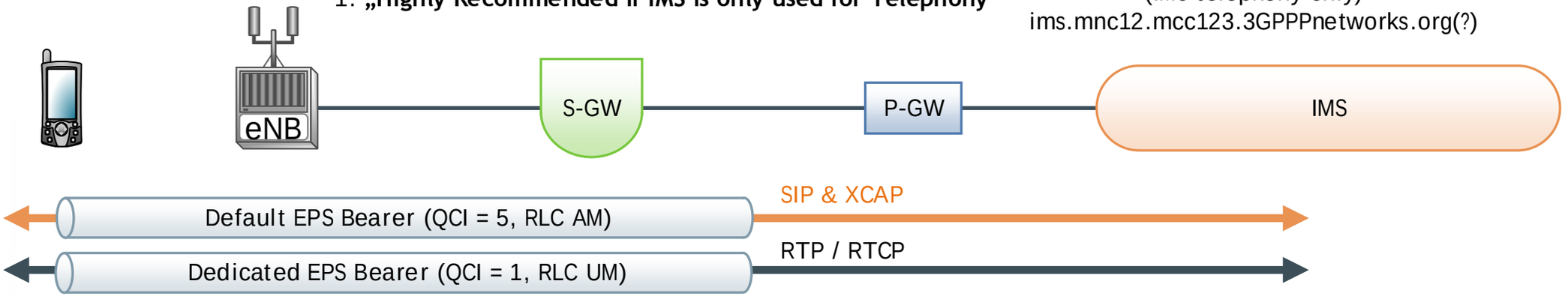
Bearer Configurations - 2 models

PRD IR.92



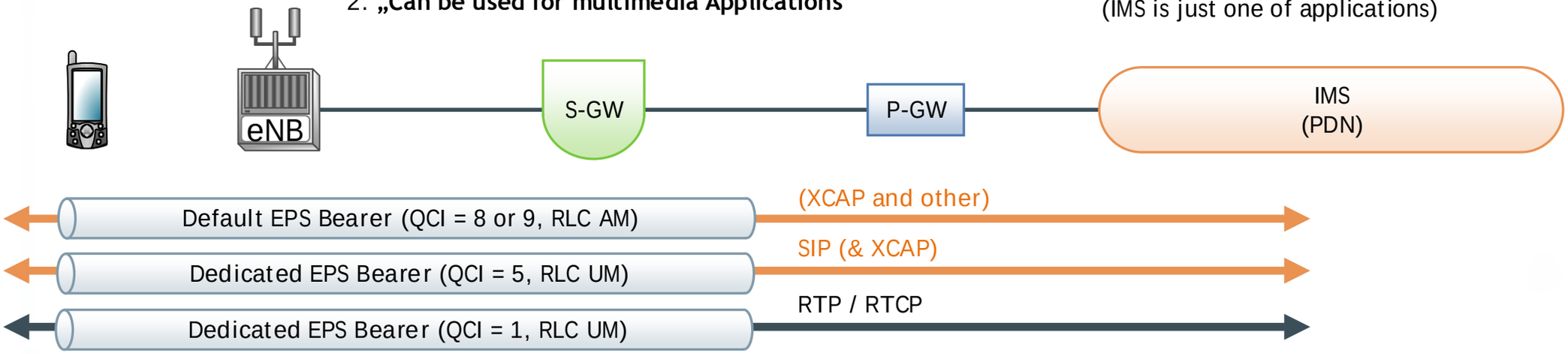
1. **„Highly Recommended if IMS is only used for Telephony“**

„Well-known“ APN
(IMS telephony only)
ims.mnc12.mcc123.3GPPPnetworks.org(?)



2. **„Can be used for multimedia Applications“**

Multi-purpose APN
(IMS is just one of applications)



SIP extensions in IMS

- extensions negotiated by SIP headers:
  - supported
  - require
  - unsupported

Caller preferences

- RFC 3841
  - AcceptContact – describes desired destination
  - RejectContact – contacts/UAs to avoid
  - RequestDisposition – specify the request handling

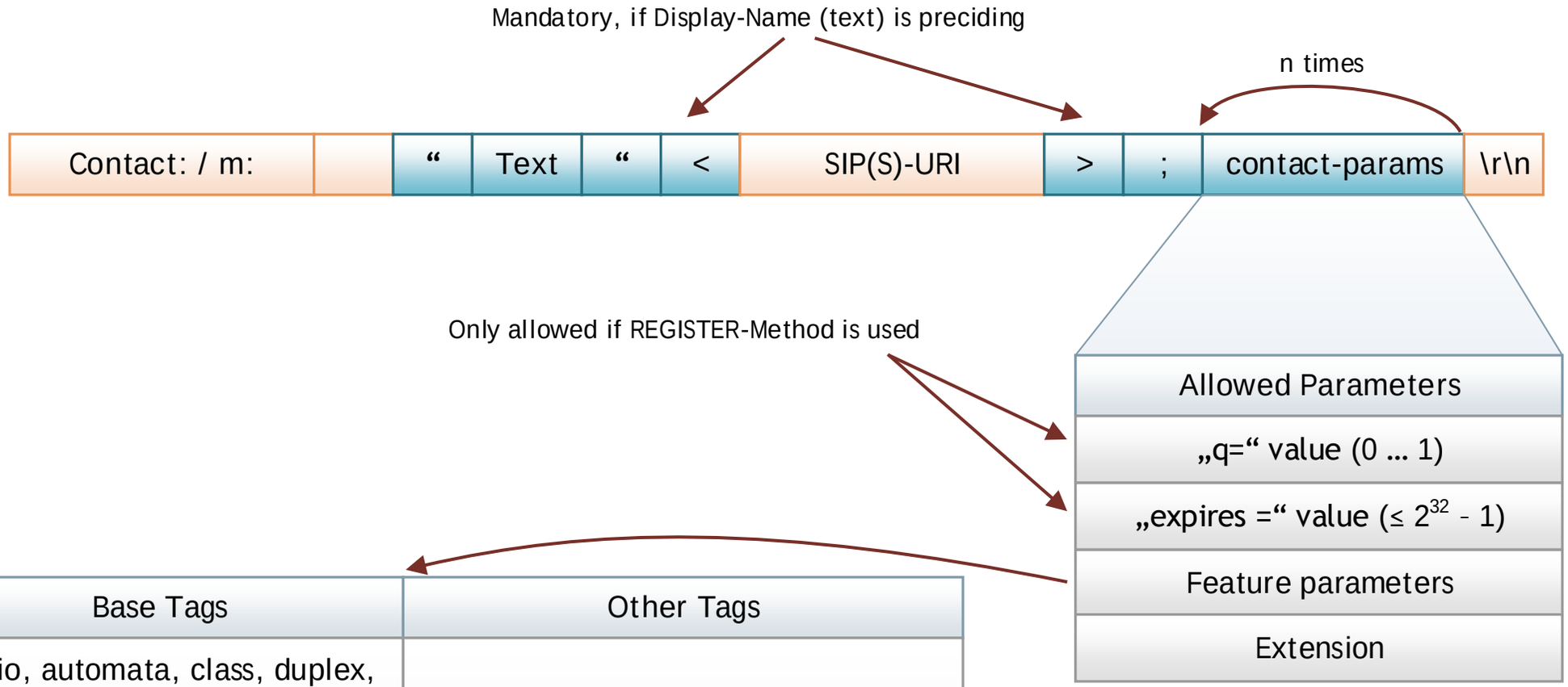
```
AcceptContact:*;mobility="fixed"
   ;events="!presence,messagesummary"
   ;language="en,de";description="<PC>"
   ;+sip.newparam
   ;+rangeparam="#4:+5.125"
```

UA capabilities

- RFC 3840
  - UA describes its capabilities in the Contact header

```
Contact:
<sip:user@host.example.com>;audio;video
   ;actor="msgtaker"; automata;mobility="fixed"
   ;methods="INVITE,BYE,OPTIONS,ACK,CANCEL"
```

The „Contact:“ Header Field



Base Tags	Other Tags
audio, automata, class, duplex, data, control, mobility, description, events, priority, methods, schemes, application, video, language, type,isfocus, actor, text, extensions	„+“ **flag**-name e.g. + sip.interface, + g.3gpp.smsip, ...

Example:

```
Contact: <sip:262015947002185@10.108.215.64:5060:q=0.8;
+g.3gpp.icsi-ref=urn:urn-7:3gpp-service-oms.icsi.mmtel,urn:urn-7:3gpp-service.ims.icsi.mmtel.gsma.videocall;
audio;video;+sip.instance=urn:uuid:8ac16f7a-416b-30d2-94a9-e7cfb045eca7>
```

some RCS spec. Contact & Accept contact headers content

- Image Share +g.3gpp.iariref=”urn%3Aurn7%3A3gppapplication.ims.iari.gsmais”
- Video Share +g.3gpp.csvoice
- Chat +g.3gpp.iariref=”urn%3Aurn7%3A3gppapplication.ims.iari.rcse.im”
- Full Store and Forward Group Chat
  +g.3gpp.iariref=”urn%3Aurn7%3A3gppapplication.ims.iari.rcs.fullsfgroupchat”
- File Transfer +g.3gpp.iariref=”urn%3Aurn7%3A3gppapplication.ims.iari.rcse.ft”
- File Transfer Thumbnail
  +g.3gpp.iariref=”urn%3Aurn7%3A3gppapplication.ims.iari.rcs.ftthumb”
- File Transfer Store and Forward
  +g.3gpp.iariref=”urn%3Aurn7%3A3gppapplication.ims.iari.rcs.ftstandfw”
- File Transfer via HTTP +g.3gpp.iariref=”urn%3Aurn7%3A3gppapplication.ims.iari.rcs.fthttp”
- IP Based Standalone messaging +g.3gpp.icsiref=”urn%3Aurn7%3A3gppservice
  .ims.icsi.oma.cpm.msg,urn%3Aurn7%3A3gppservice.ims.icsi.oma.cpm.largemsg”
- Video Share outside of a voice call
  +g.3gpp.iariref=”urn:urn7:3gppapplication.ims.iari.gsmavs”
- Social presence information +g.3gpp.iariref=”urn%3Aurn7%3A3gppapplication.ims.iari.rcse.sp”
- IP Voice Call (as per MMTEL) +g.3gpp.icsiref=”urn%3Aurn7%3A3gppservice.ims.icsi.mmtel”
- IP Video Call (as per MMTEL)
  +g.3gpp.icsiref=”urn%3Aurn7%3A3gppservice.ims.icsi.mmtel”;video

continue…

- RCS IP Voice Call +g.gsma.rcs.ipcall
- RCS IP Video Call +g.gsma.rcs.ipcall;video
- RCS IP Video Call where video media cannot be removed by the user +g.gsma.rcs.ipvideocallonly
- Geolocation PUSH +g.3gpp.iariref=”urn%3Aurn7%3A3gppapplication.ims.iari.rcs.geopush”
- Geolocation PULL +g.3gpp.iariref=”urn%3Aurn7%3A3gppapplication.ims.iari.rcs.geopull”
- Geolocation PULL using File Transfer +g.3gpp.iariref=”urn%3Aurn7%3A3gppapplication.ims.iari.rcs.geopullft”
- Service Provider specific service +g.3gpp.iariref=”urn%3Aurn7%3A3gppapplication.ims.iari.rcs.mnc<mnc>.mcc<mcc>.<service name>”
- ThirdParty specific service +g.3gpp.iariref=”urn%3Aurn7%3A3gppapplication.ims.iari.rcs.ext.<identifier>”

Event notification

- RFC 3265
- UA can obtain a status of specified resource
- SUBSCRIBE + NOTIFY
- allowevents header
- used by P-CSCF for user registration event or by UA to watch his own registration

State publication

- RFC 3903
- PUBLISH method

Instant messaging

- RFC 3428
  - MESSAGE method
- Single message vs messaging session
  - SIP-MESSAGE for single messages
  - Message Session Relay Protocol (MSRP) for instant messaging session

Call transfer

- RFC 3515
- REFER method
  - ReferTo header

Early media

- RFC 5009
- PEarlyMedia header field with the “supported” parameter

Reliability of provisional responses

- RFC 3262
  - PRACK method
    - Rseq header
    - 100rel option

Session description updating & SDP Preconditions support

- PRACK + UPDATE + Preconditions in SDP
  - allows QOS requirements assurance

```
...SDP...
a=curr:qos local none
a=curr:qos remote sendrecv
a=des:qos mandatory local sendrecv
a=des:qos mandatory remote sendrecv
...SDP...
```

The m-line Attribute

Data Type	Integer (dec) for RTP or transport-specific / media-type specific encoding (typ. Alphanumeric)
Lenght Constraint	7 bit for RTP or transport-specific
Defined Values	0 ... 127 or transport specific

Data Type	alphanumeric
Lenght Constraint	N/A
Defined Values (MIME)	Application, audio, image, message, mode, multipart, text, video, data, control

m = media-type | port-No | transport | payload-type-list | <cr><if>

Data Type	Integer (dec)
Lenght Constraint	16 bit
Value Range	0 ,,, (2^{16} -1)

Data Type	alphanumeric
Lenght Constraint	N/A
Defined Values	RTP/AVP, RTP/AVPE, RTP/SAVP, TBCP, TCP, TCP/BFCP, TCP/MSRP, TCP/RTP/AVP, TCP/TLS/BFCP, TCP/TLS/MSRP, UDP, UDPTL

Example:
m = audio 4000 RTP/AVP 0 3 8

P-headers

- RFCs - 7315, 3325, 6050, 3313, 4457
- P-Charging-Vector
- P-Charging-Function-Address
- P-Visited-Network-ID
- P-Access-Network-Info
- P-Called-Party-ID
- P-Associated-URI
- P-User-Database
- P-Profile-Key
- P-Media-Authorization
- P-Prefered-Service
- P-Prefered-Identity
- P-Asserted-Identity

P-Charging-Vector

- collection of charging information
- IMS Charging Identity (ICID)
- or the address of the SIP proxy that creates the ICID value
- Inter Operator Identifier (IOI)
  - Added by P-CSCF in most cases

P-Charging-Function-Address

- Addresses of the charging functions (who collects the CDR)
- May be filled during the establishment of a dialog or as a standalone transaction, and informs each proxy involved in a transaction

P-Visited-Network-ID

- Identification of the visited network
- Home network accepts the registration according to roaming agreements
- Added by P-CSCF in most cases

P-Access-Network-Info

- radio access technology
- cell identity
- added by UA in most cases

Security mechanisms

- P-CSCF establishes a secure tunnel with UE
- Secrets read from SIM
- Security-Server & Security-Verify headers

Source-routing mechanisms

- serviceroute header in the OK from REGISTRAR (during registration)
- induces UAs route header content for later dialogues

Path

- RFC 3327
- P-CSCF ads the path header in most cases
  - P-CSCF address obtained dynamically by
    - NAS signalling during UE network attach
    - DHCP
    - (may be also hard-configured at SIP client)

Globally Routable User Agent URIs

- GRUUs - RFC 5627
- help to maintain the actual binding public UA identity and its actual specific instance (instance specific URI)
- Two types of GRUU
  - GRUUs That Expose the Underlying AOR
    - sip:alice@example.com;gr=kjh29x97us97d
  - GRUUs That Hide the Underlying AOR
    - sip:asd887f9dfkk76690@example.com;gr
- GRUU is obtained from REGISTRAR during registration