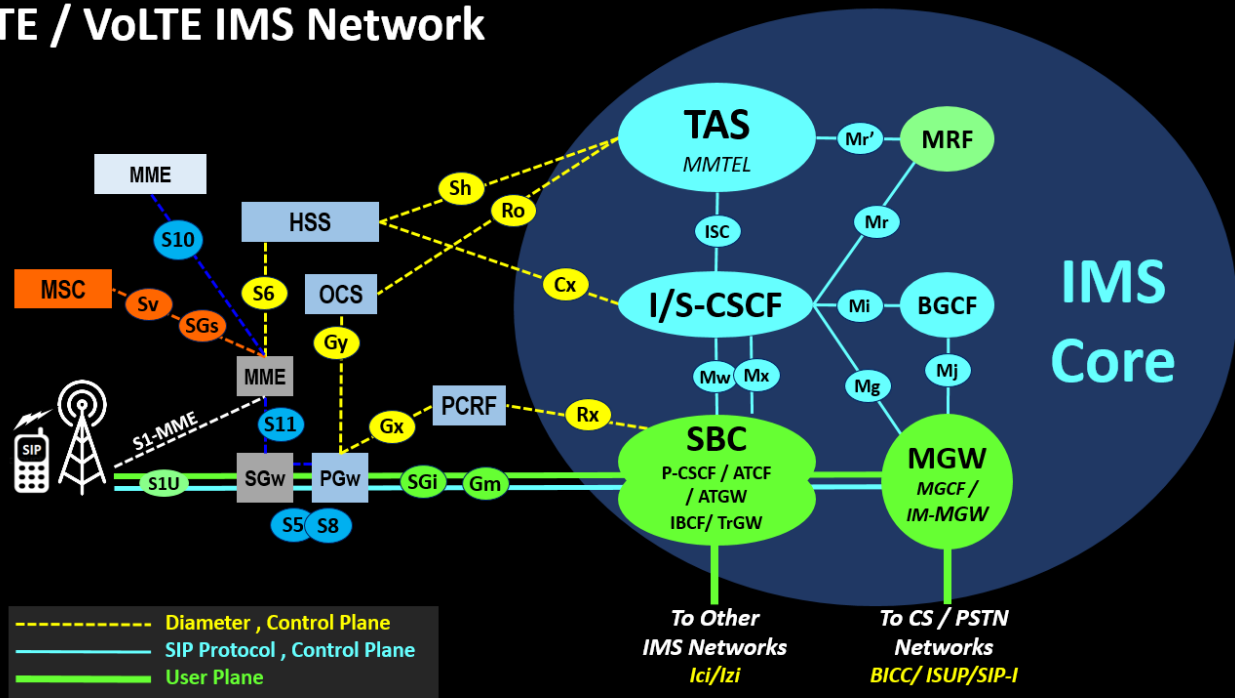


VOLTE INTERFACES , PROTOCOLS & IMS STACK

This Blog contains Complete VoLTE Protocol Guide which contains details of all Links & Interfaces working in VoLTE & LTE Networks including their Protocol Stack

- LTE Control Plane Links : S1MME , S5/S8 , S10 , S11 , S6a , Gx , Gy , X2 , SGs
- LTE User Plane Links : S1U , S5/S8 & SGi
- IMS Control Plane links : Sh , Ro , Cx , Rx , Sv , ISC , Mw , Mg , Mi , Mj , Mr / Mr' , UT , Ici

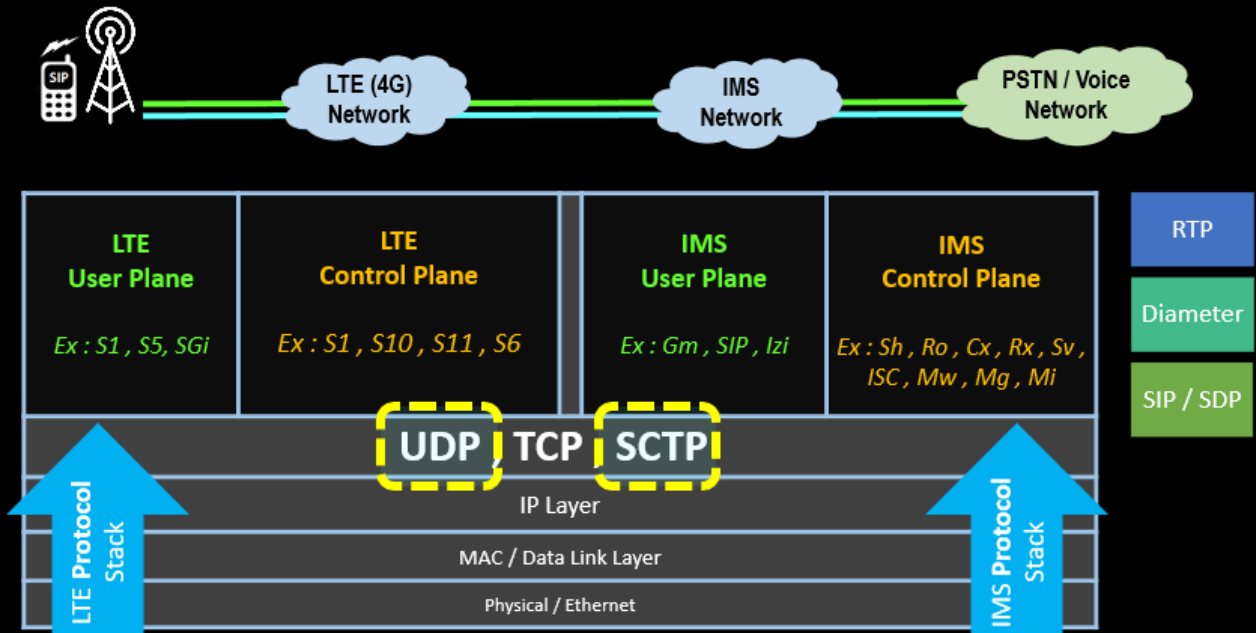
LTE / VoLTE IMS Network



VoLTE Interfaces, Protocols & IMS Stack

LTE / VoLTE IMS Protocols Interfaces

LTE / VoLTE IMS Protocols Interfaces



LTE VoLTE IMS Protocols Interfaces

Here I am going to provide complete **Volte Protocol Guide** which contains details of all Links & Interfaces working in VoLTE & LTE Networks

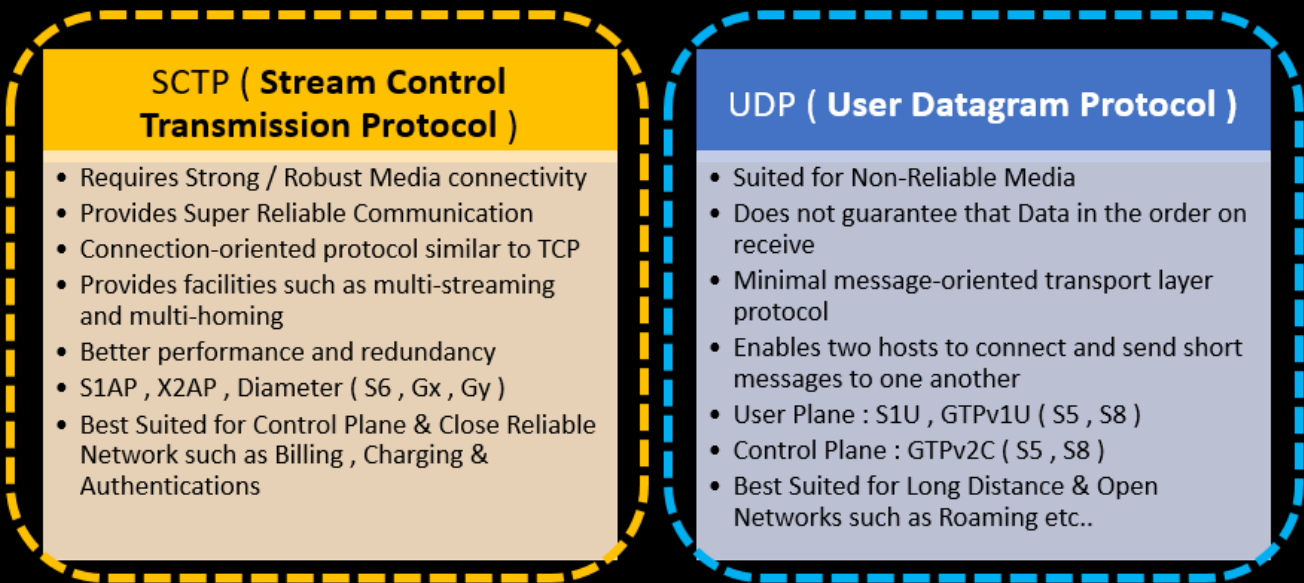
VoLTE Network consists of 3 Network Domains .. 1st One is LTE Network handling user followed by VoLTE Network & finally Interconnectivity with PSTN or CS Network . Since LTE or 4G Network is essential part of basic working of VoLTE IMS Network , I have also included LTE Interfaces , Links & Protocols in this Video to make it more comprehensive in order to give you complete knowledge

A protocol is a system of digital rules for message exchange between telecom Nodes in order for one Node to communicate with another . As visible in Diagram , This is a protocol stack design which shows all the communication Layers for LTE & VoLTE Network . Three Lower layer stacks consists of 1st Layer as Physical Layer followed by MAC or Data Link Layer & then IP Layer

From here onward , All communication for LTE & VoLTE is taken care by **UDP & SCTP protocols** which are again and again used in Network for Multiple purposes . On Top of UDP & SCTP Layer , We run various LTE & VoLTE User and control plane links . The most critical protocols are the Real-time Transport Protocol (RTP) , Diameter , Session Initiation Protocol (SIP) & Session Description Protocol (SDP)

SCTP Vs UDP

SCTP Vs UDP



SCTP Vs UDP

Let's discuss two fundamental low layer protocols used in LTE & VoLTE

1st One is SCTP which stands for **Stream Control Transmission Protocol** which evolved from TCP . SCTP is used to provide guaranteed message delivery . SCTP is extensively used as transport layer for carrying telecom signaling over IP. SCTP provides a reliable transport service that operates at message level . SCTP also allows multiple message streams to be exchanged on a single SCTP connection.

Key features of SCTP Include :-

- Requires Strong / Robust Media connectivity
- Provides Super Reliable Communication
- Connection-oriented protocol similar to TCP
- Provides facilities such as multi-streaming and multi-homing
- Better performance and redundancy
- S1AP , X2AP , Diameter (S6 , Gx , Gy)
- Best Suited for Control Plane & Close Reliable Network such as Billing , Charging & Authentications

UDP Stands for **User Datagram Protocol** which is usually used along with Non Reliable Media and communication involving multiple Operators such as Roaming etc.. Key features of UDP Include :-

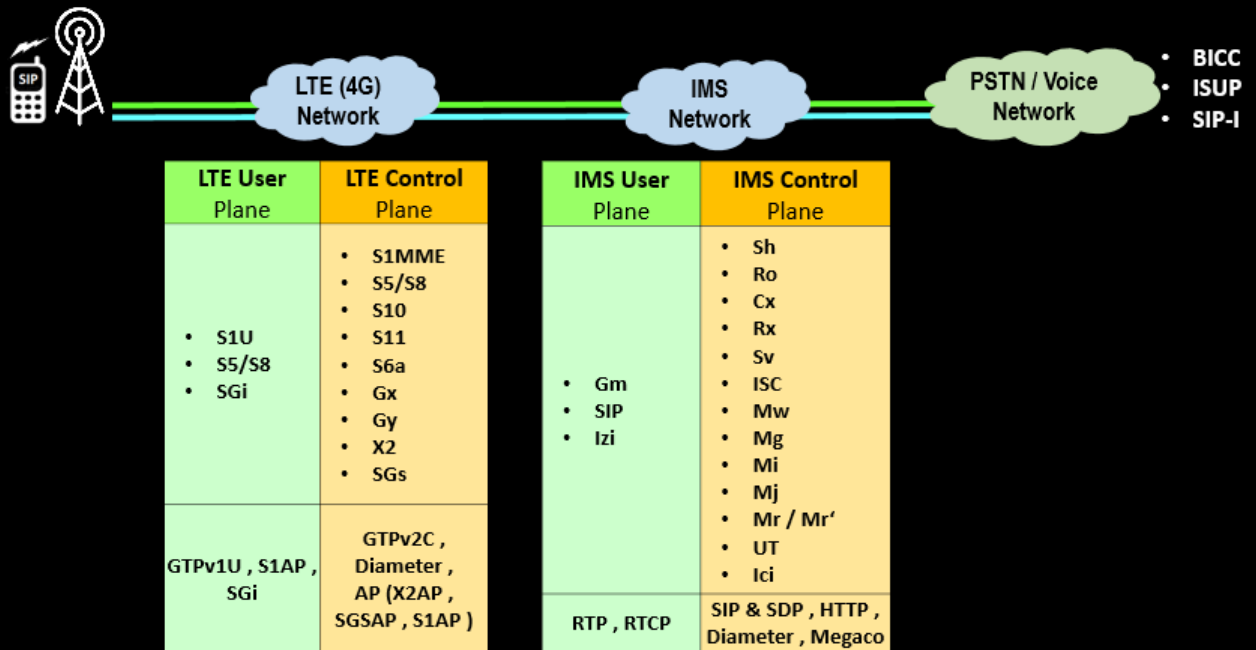
- Suited for Non-Reliable Media
- Does not guarantee that Data in the order on receive

VoLTE Interfaces, Protocols & IMS Stack

- Minimal message-oriented transport layer protocol
- Enables two hosts to connect and send short messages to one another
- User Plane : S1U , GTPv1U (S5 , S8)
- Control Plane : GTPv2C (S5 , S8)
- Best Suited for Long Distance & Open Networks such as Roaming etc..

LTE / IMS Protocols Interfaces & links

LTE / IMS Protocols Interfaces

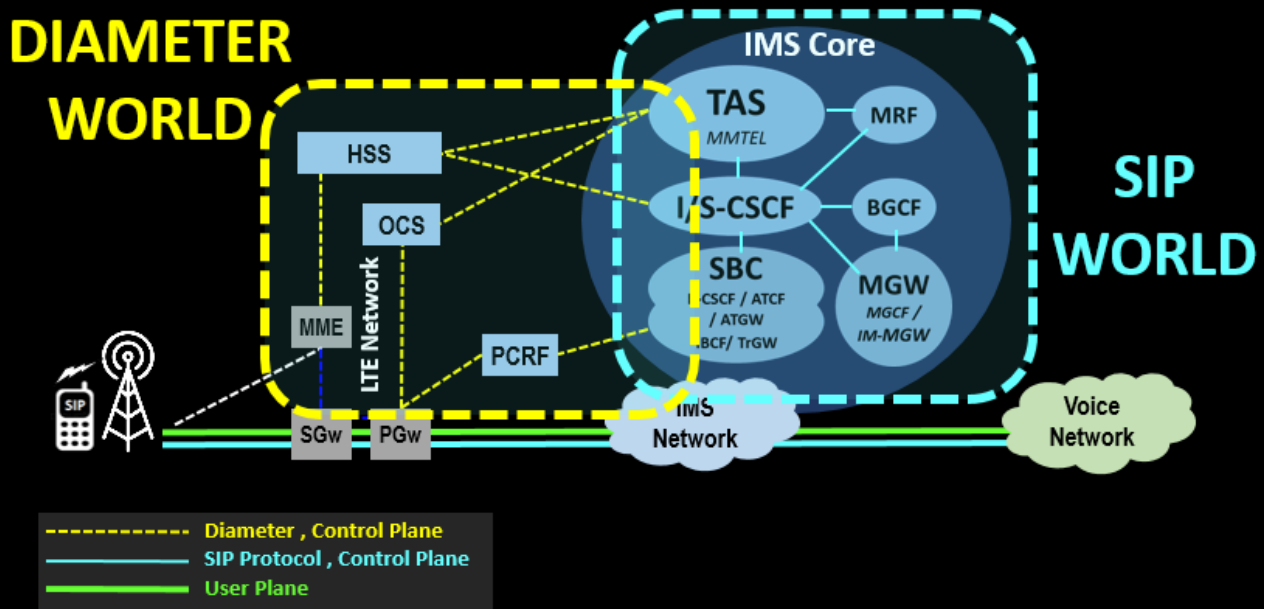


LTE VoLTE IMS Protocols Interfaces

Here is actual list of **Links & Protocols** we are going to Cover for LTE & VoLTE User Plane & Control Plane

VoLTE IMS Connectivity Overview

VoLTE IMS Connectivity Overview



VoLTE IMS Connectivity Overview

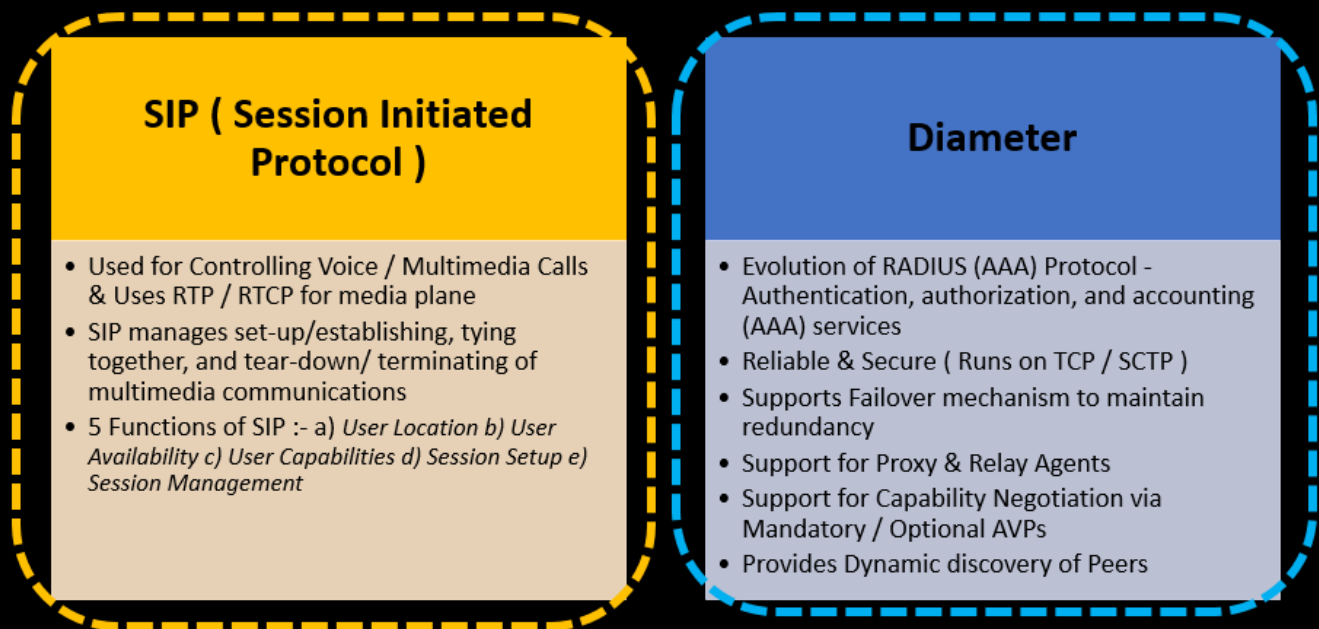
On Left hand side , We can see LTE Network on high level & its components . On Right hand side , We can see VoLTE IMS Network & Its key components .As you can see in Blue Circle , I have grouped few functions in IMS

- **I-CSCF & S-CSCF** are typically deployed within same Server together & they are shown as One Node
- **SBC** consists of many critical functions such as P-CSCF , P-CSCF / ATCF / ATGW / IBCF/ TrGW . They are shown together
- Similarly **Media Gateway** consists of MGCF / IM-MGW

Here , HSS , OCS & PCRF are 3 main components which are used by both LTE Network VoLTE Networks for Inter connectivity . Let's see the High level protocols used in Network . This all Blue links connecting each other works on SIP Protocol . You can see all SIP to SIP communication in entire VoLTE ecosystem . SIP is Chief protocol used for carrying voice over IP without any limitations . All these Yellow connectivity consists of Diameter links which are widely used for control plane signaling , Billing , Charging & Authentication in LTE & IMS Networks

SIP & Diameter Protocols

SIP & Diameter Protocols



SIP & Diameter Protocols

SIP : Session Initiation Protocol (SIP) is a communications protocol that is widely used for managing multimedia communication sessions such as voice and video calls. SIP, therefore is one of the specific protocols that enable voice communication over IP. In a VoLTE call SIP protocol is used to create, modify and terminate sessions, essentially negotiating a session between two users. SIP does not perform transport layer (delivering data) those are done by RTP/RTCP . Key features of SIP Includes :-

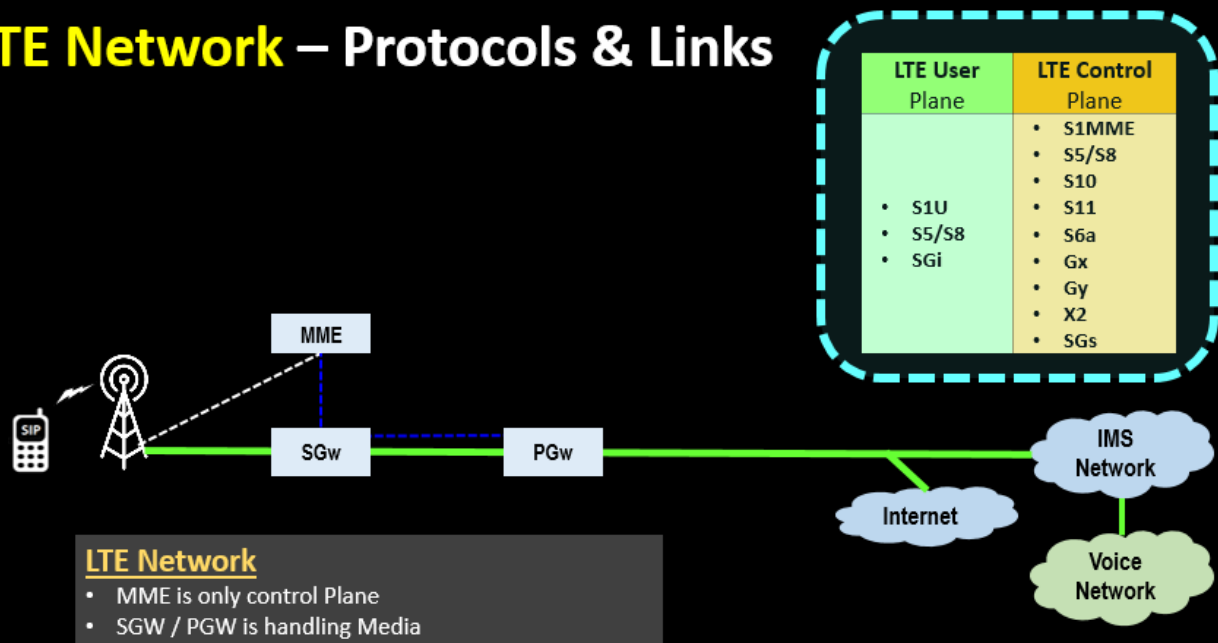
- Used for Controlling Voice / Multimedia Calls & Uses RTP / RTCP for media plane
- SIP manages set-up/establishing, tying together, and tear-down/ terminating of multimedia communications
- 5 Functions of SIP :- a) *User Location* b) *User Availability* c) *User Capabilities* d) *Session Setup* e) *Session Management*

Diameter : Diameter is an authentication, authorization, and accounting protocol for Telecom networks. It evolved from the earlier RADIUS protocol . Key features of Diameter includes :-

- Evolution of RADIUS (AAA) Protocol – Authentication, authorization, and accounting (AAA) services
- Reliable & Secure (Runs on TCP / SCTP)
- Supports Failover mechanism to maintain redundancy
- Support for Proxy & Relay Agents
- Support for Capability Negotiation via Mandatory / Optional AVPs
- Provides Dynamic discovery of Peers

LTE Network – Protocols & Links

LTE Network – Protocols & Links



LTE Network – Protocols & Links

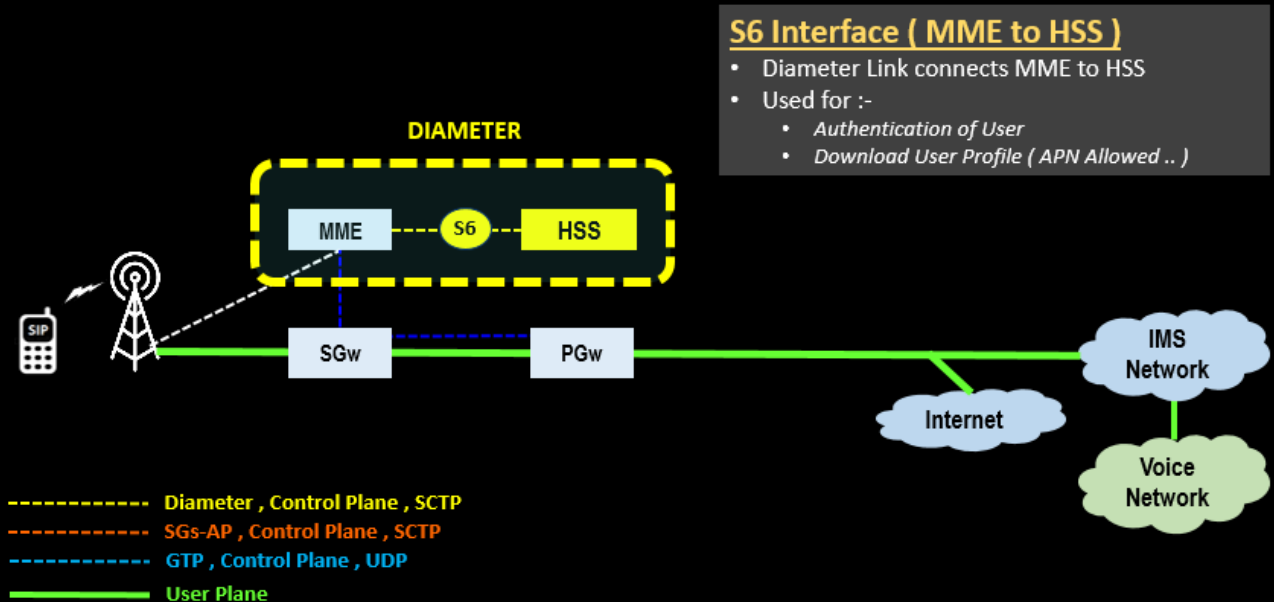
Now , Let's start our journey with base LTE Network . You can see basic Network here which consists of ENodeB equivalent to Cell Site providing Radio coverage , MME used for control Plan traffic & handling Mobility of user

SGW / PGW is also called SAE Gateway used for handling user traffic & uplink of same towards Internet & IMS Network over IP Links

- Key Interfaces for LTE Control includes S1MME , S5/S8 , S10 , S11 , S6a , Gx , Gy , X2 , SGs
- Also there are few user plane links such as S1U , S5/S8 & SGi

S6a – LTE Protocols & Links

S6a – LTE Protocols & Links



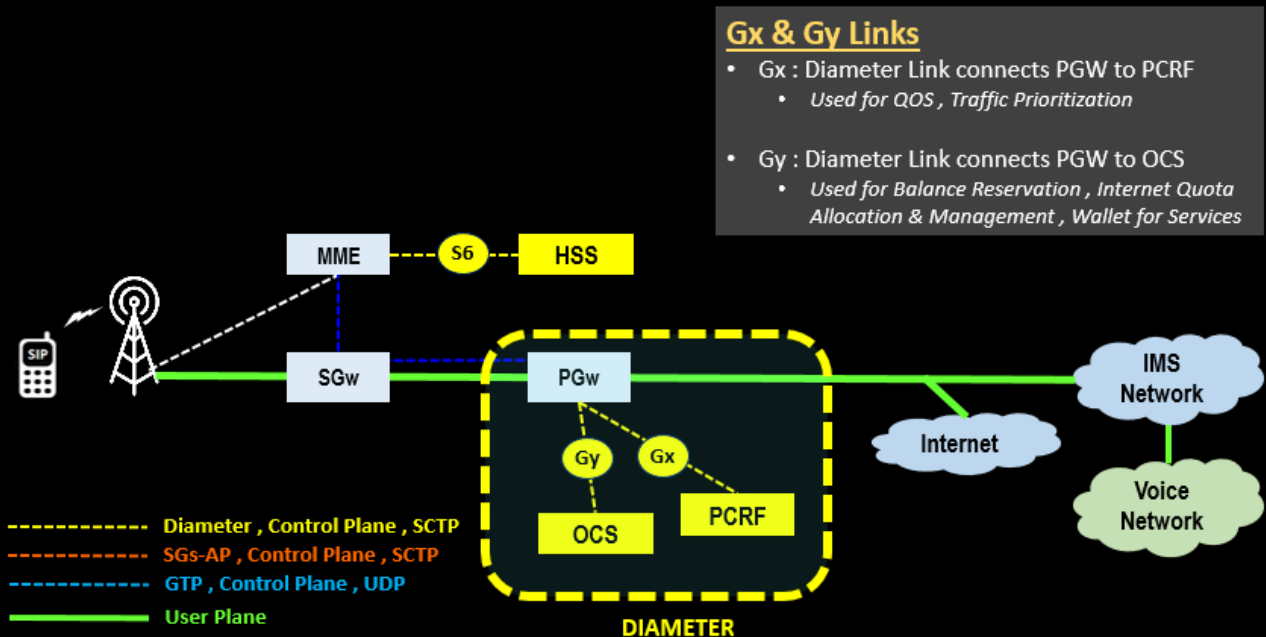
S6a – LTE Protocols & Links

S6 links connect MME to HSS. This is diameter link and is used by MME for checking Subscription and authentication data for authenticating/authorizing user access from HSS .

In Simple words , MME download user profile from HSS with help of s6 link such which APN is allowed or Not ? Whether User can use Internet services or Not ? Whether User can use IMS VoLTE Services or Not ? Whether these services are allowed on Roaming or Not ?

Gx & Gy – LTE Protocols & Links

Gx & Gy – LTE Protocols & Links



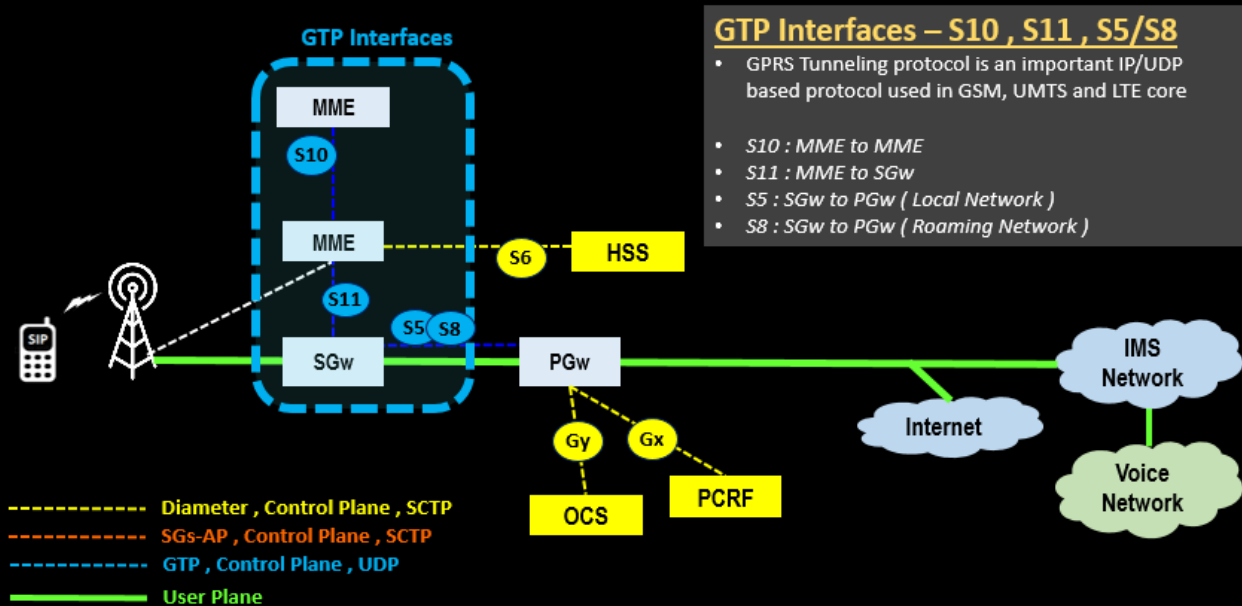
Gx & Gy – LTE Protocols & Links

Gx : The Gx interface is between the PCRF and the PGW, This is also diameter link allowing the PCRF take direct control over the policy enforcement functions of the PGW. This is used for QOS Management . In simple words , Gx Link is used for enforcing Speed of users , For Example , 4G Users will be provided 100 Mbps download speed & Once user consumes all Internet Quota , Speed will be reduced or throttled to 128 kbps by PCRF over Gx Links

Gy : Gy is between Online Charging System (OCS) and PGW , This is also diameter link allowing online credit control for service data flow based charging. In simple words , This is used for Getting Internet Quota reserved & Decrement on Prepaid System

GTP Interfaces – LTE Protocols & Links

GTP Interfaces – LTE Protocols & Links



GTP Interfaces – LTE Protocols & Links

These GTP Based Interfaces .

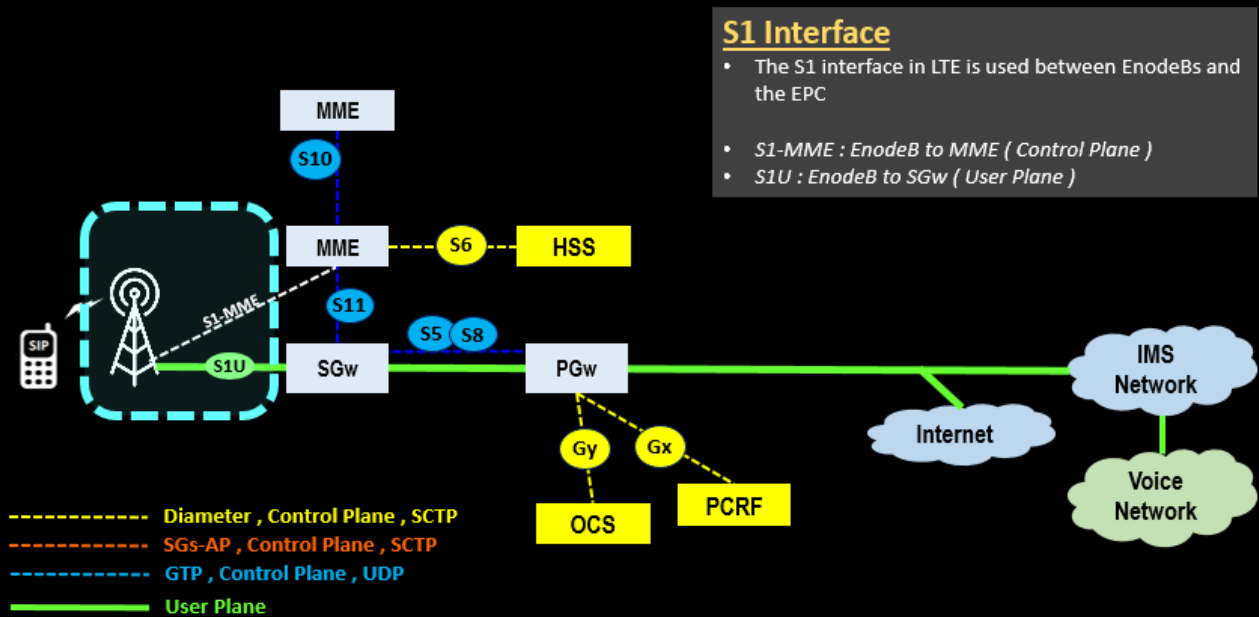
S10 : S10 is used for MME to MME connectivity . This is a control interface between the MMEs which is used for handover & context transfer

S11 : This is the interface between the MME and S-GW in an LTE network . This handles functions for bearer creation , Deletion , paging coordination & mobility management

s5/s8 : The S5 interface provides user plane tunneling and tunnel management between SGW and PGW. This is based on GTP Protocol & is responsible for both Control and User plane . s5 is Internal to Network whereas s8 is used for Roaming Scenarios

S1MME / S1U – LTE Protocols & Links

S1MME / S1U – LTE Protocols & Links



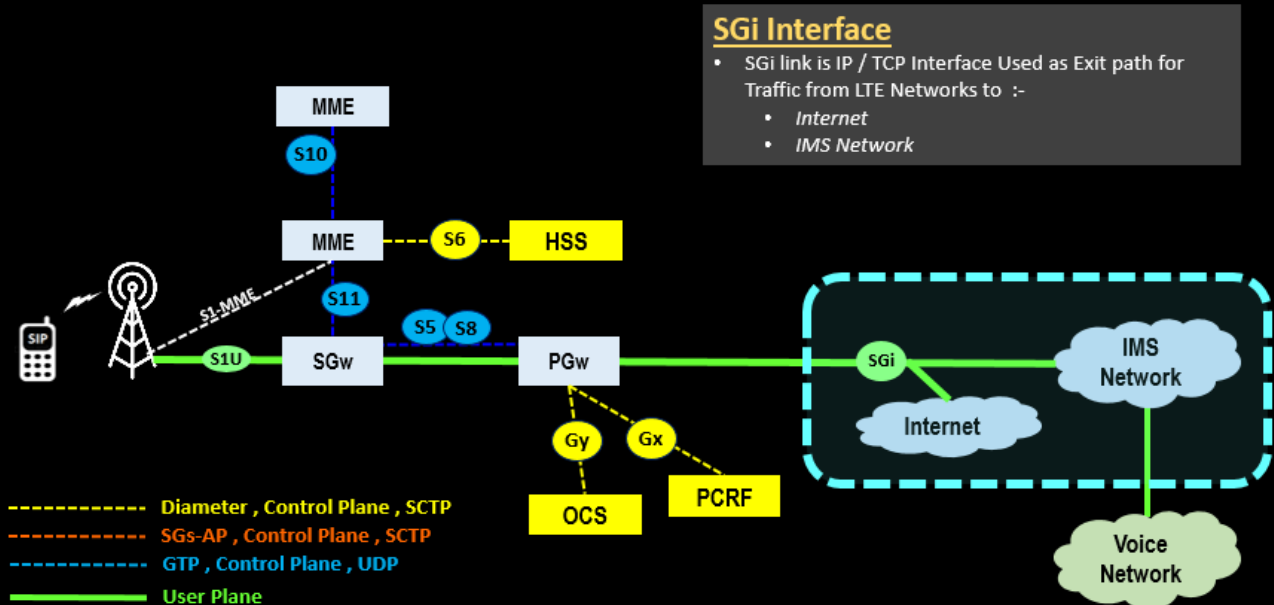
S1MME , S1U – LTE Protocols & Links

S1 contains two links .. S1 MME & S1U

- S1MME connects ENodeB to MME & is used for control plane signaling
- S1 U – Interface handles S1 user plane data for each bearer between the ENodeB and SGW

SGi Link – LTE Protocols & Links

SGi Link – LTE Protocols & Links

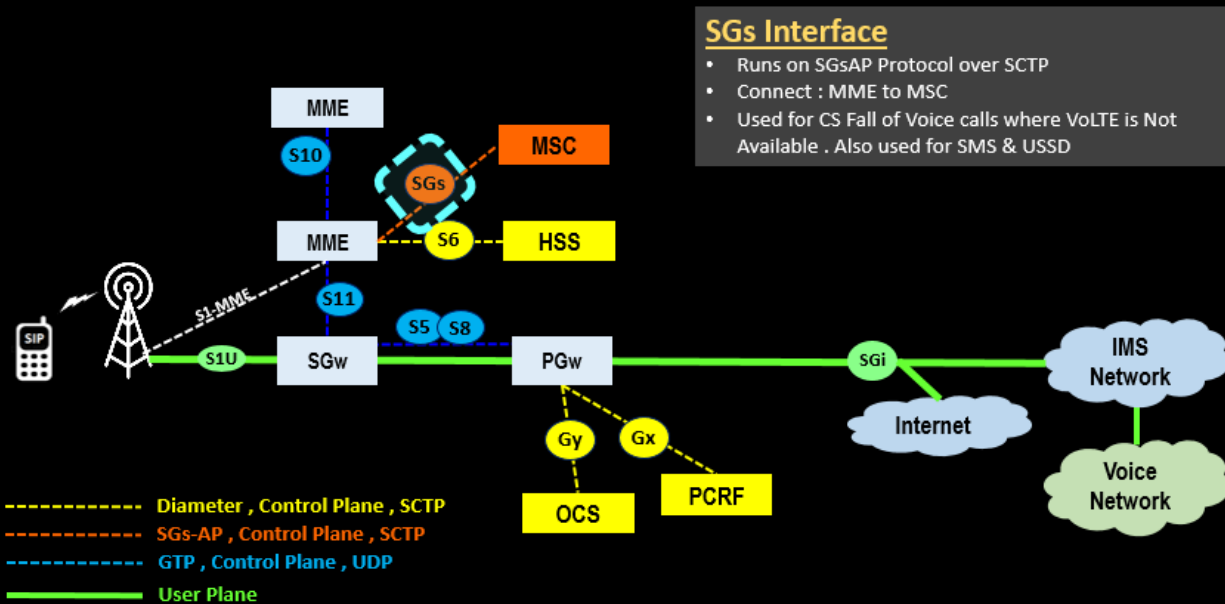


SGi Link – LTE Protocols & Links

SGi : This SGi interface is used between PGW towards internet or IMS Network . This is highway for Exit traffic from LTE Network

SGs Link – LTE Protocols & Links

SGs Link – LTE Protocols & Links

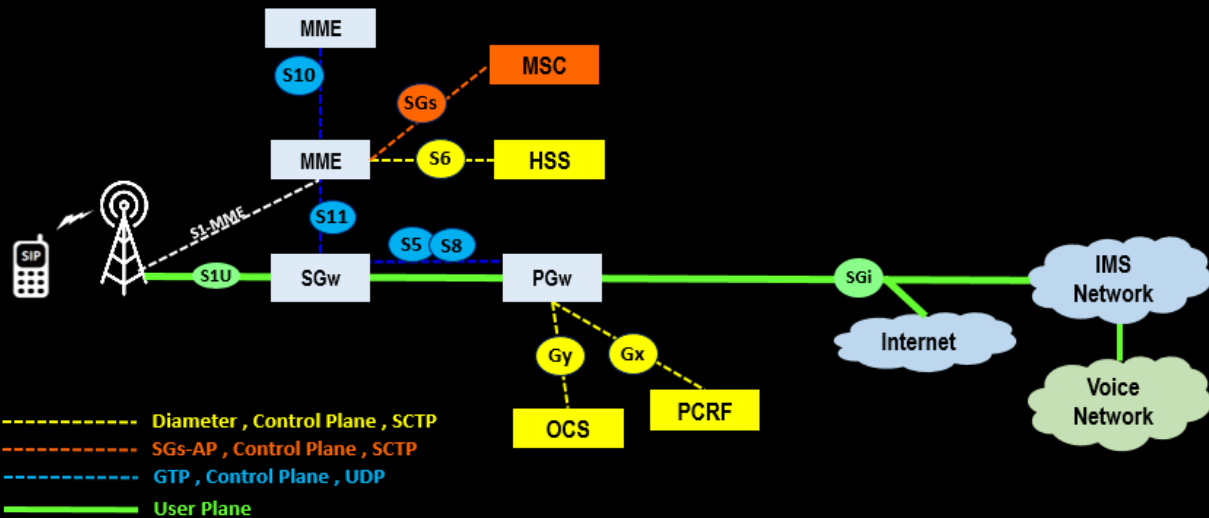


SGs Link – LTE Protocols & Links

SGs : The SGs interface is used for connectivity between LTE MME to 2G (GERAN) / 3G (UTRAN) MSCs . Prior to VoLTE launch , This link was playing critical role in 4G Network by enabling voice via CSFB function & also enabled SMS as well

Complete LTE Network – Protocols & Links

Complete LTE Network – Protocols & Links

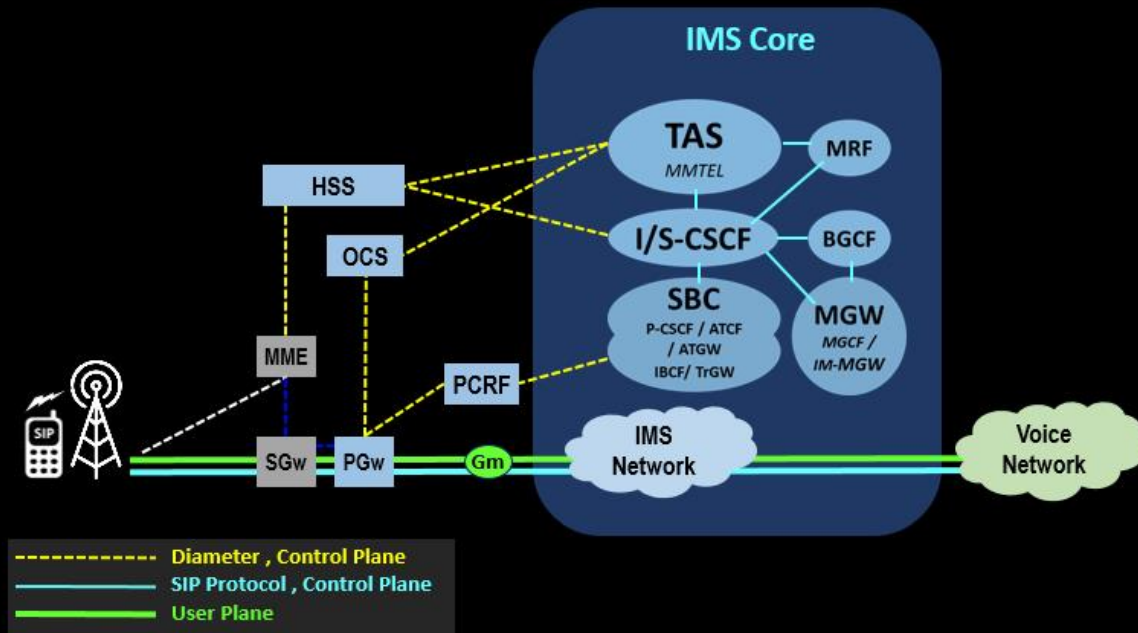


Complete LTE Network – Protocols & Links

This diagram shows LTE Network Architecture & Links used in 4G network . Most of Control plane links are based on Diameter & GTP is used to carry Payload traffic

VoLTE IMS Connectivity Overview

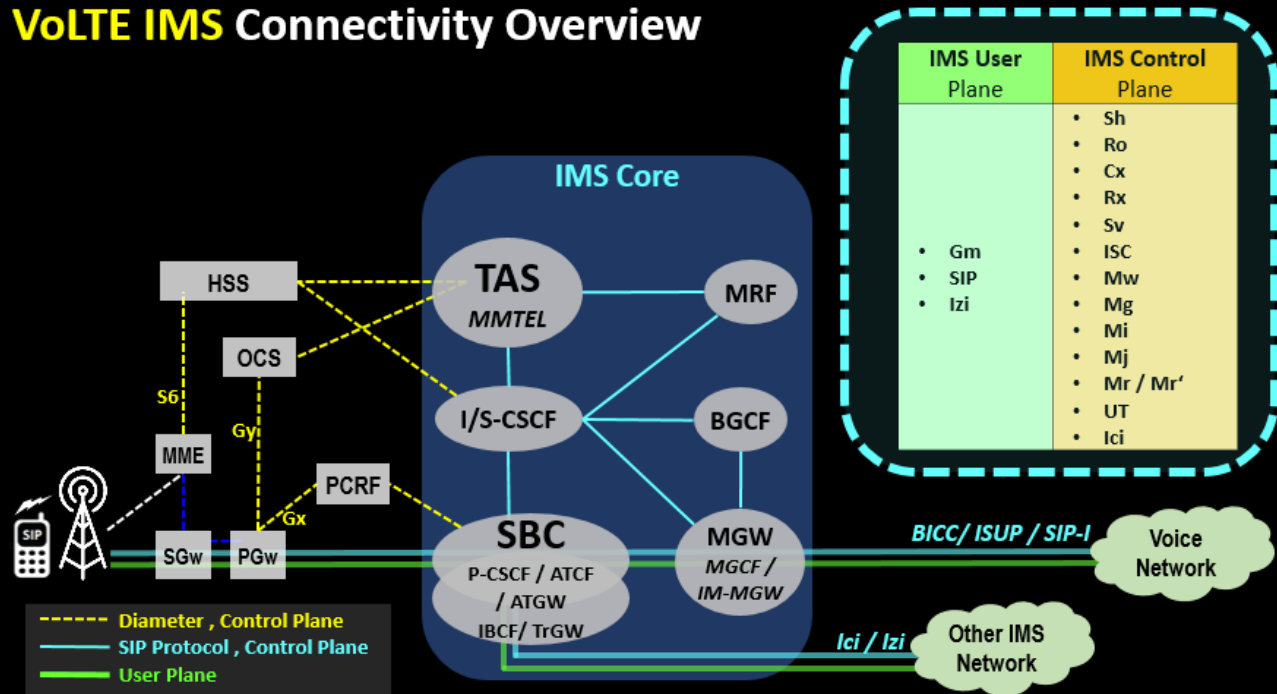
VoLTE IMS Connectivity Overview



VoLTE IMS Connectivity Overview (2)

Now , We have completed VoLTE Interfaces & Links , Let's Quickly jump to VoLTE IMS Interfaces ..

VoLTE IMS Connectivity Overview



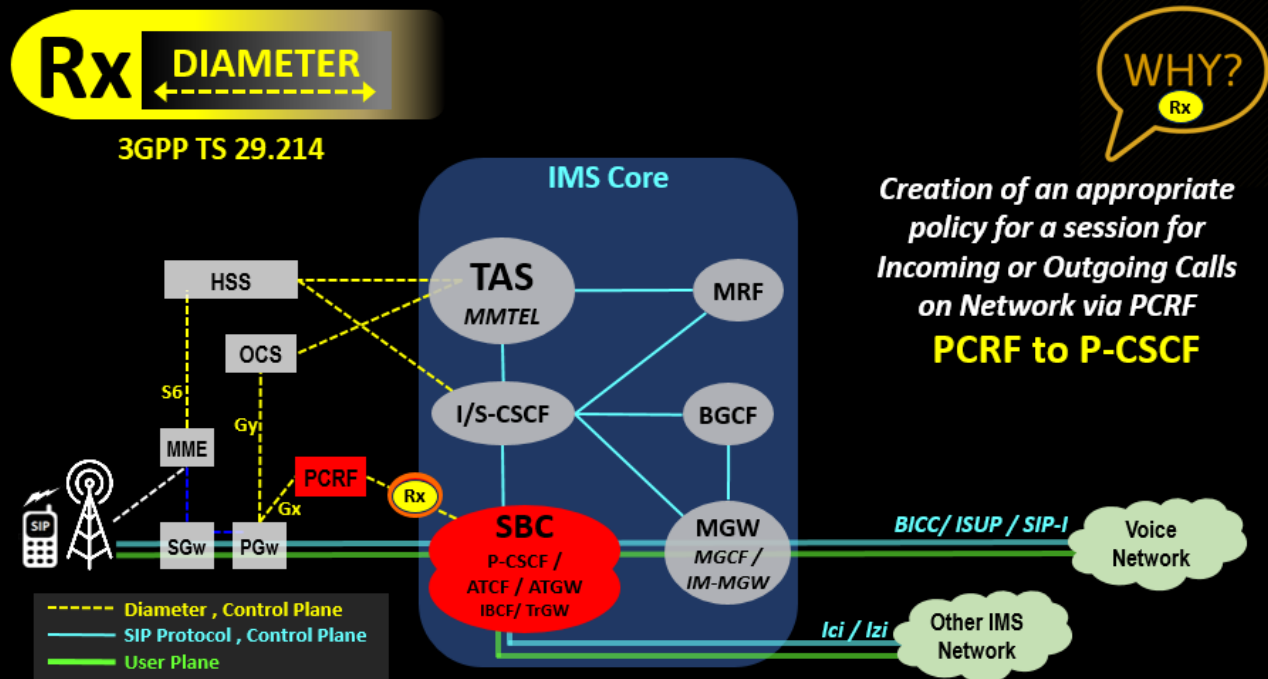
VoLTE IMS Connectivity Overview – with IMS Links Highlighted

Above diagram shows connectivity in 4G & IMS VoLTE Network . We are going to understand each and every link in detail here . Diameter & SIP is prominent protocol used in IMS network . We will starting with Diameter links and take this journey to SIP links

- **IMS Control Plane** consists of Sh , Ro , Cx , Rx , Sv , ISC , Mw , Mg , Mi , Mj , Mr / Mr' , UT , Ici
- **IMS User Plane** consists of Gm , SIP , Izi links

VoLTE Interfaces, Protocols & IMS Stack

Rx VoLTE IMS Link



Rx VoLTE IMS Link

- **Link :** Rx
- **Protocol :** Diameter
- **Specs Reference :** 3GPP TS 29.214
- **Nodes Connected :** PCRF – P-CSCF
- **Purpose :** Creation of an appropriate policy for a session for Incoming or Outgoing Calls on Network via PCRF

Rx interface is Bridge between IMS Network & Packet Core . The Rx Interface is used between the P-CSCF and the PCRF allowing the request of an appropriate policy for a session for setting up Incoming & Outgoing Voice call . This Rx Interface is used to control the establishment of any type of Incoming or Outgoing Calls , and thereby authorize and control resource usage in the access networks . Rx uses Diameter protocol . You can find more details on Rx Interface under 3GPP TS 29.214 Specs

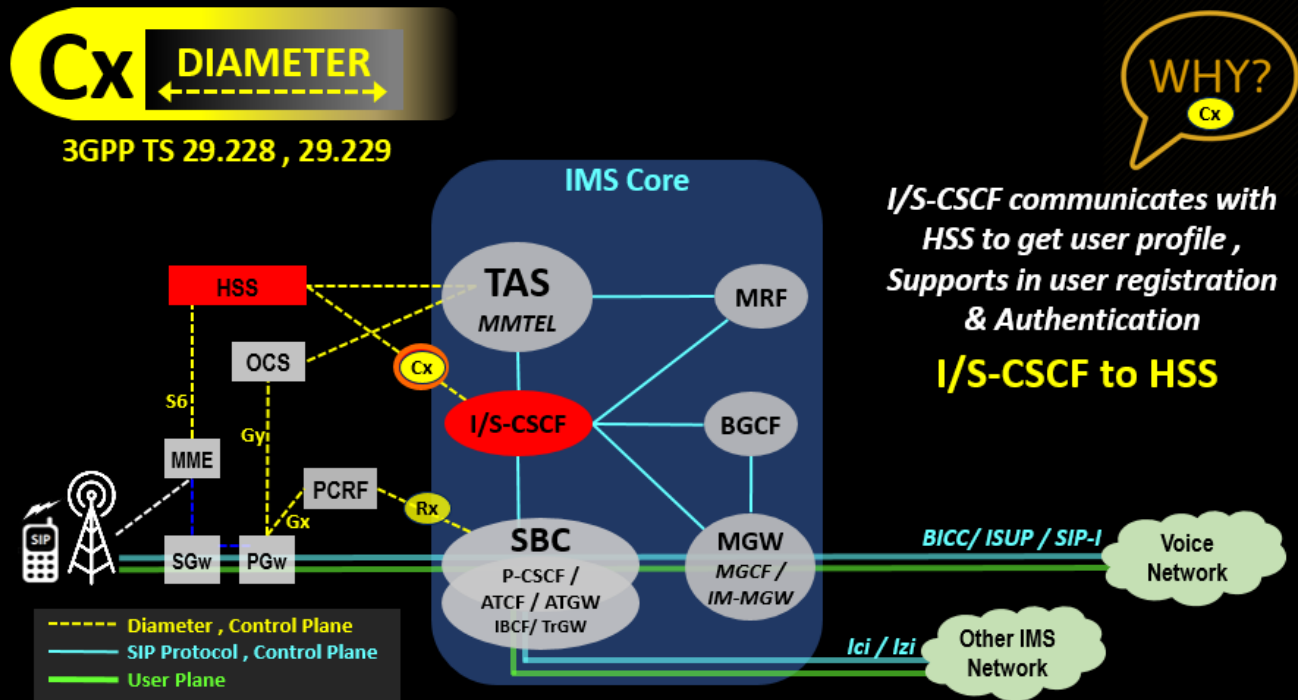
Typical Messages in Rx includes AA & Auth Request / response / terminate between P-CSCF & PCRF . Other Messages getting exchanged on Cx Interfaces are :-

- AA-Request (AAR)
- AA-Answer (AAA)
- Re-Auth-Request (RAR)
- Re-Auth-Answer (RAA)
- Session-Termination-Request (STR)
- Session-Termination-Answer (STA)

VoLTE Interfaces, Protocols & IMS Stack

- Abort-Session-Request (ASR)
- Abort-Session-Answer (ASA)

Cx VoLTE IMS Link



Cx VoLTE IMS Link

- **Link :** Cx
- **Protocol :** Diameter
- **Specs Reference :** 3GPP TS 29.228 , 29.229
- **Nodes Connected :** I/S-CSCF – HSS
- **Purpose :** I/S-CSCF communicates with HSS to get user profile , Supports in user registration & Authentication

You can find more details on Cx Interface under 3GPP TS 29.228 Specs . The Cx Interface is used between the I/S CSCF and HSS for downloading Subscriber data to the S-CSCF from HSS . It enable IMS registration and passing of subscriber data to the S-CSCF. Cx uses Diameter protocol .

Typical Messages in Cx includes UAR / MAR / SAR used during Registration of IMS User in Network . For Instance , I-CSCF talks to HSS to get the detailed subscriber information for the User Authentication . S-CSCF send MAR (Multimedia Authentication Request) to HSS as part of an initial IMS registration with IMS-AKA related security . The S-CSCF also

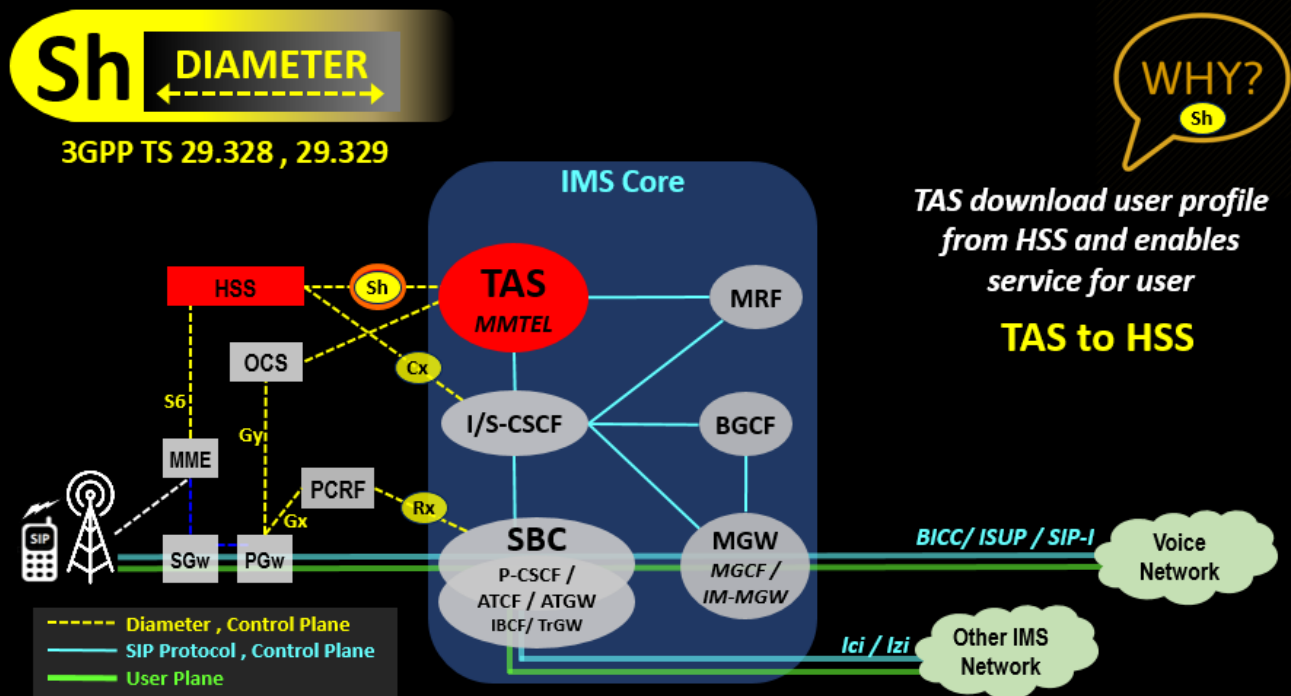
VoLTE Interfaces, Protocols & IMS Stack

performs the SAR (Server Assignment Request) procedure to the HSS to download the relevant user profile and register the VoLTE UE. The S-CSCF stores the route header of the P-CSCF and binds this to the contact address of the VoLTE UE, this is used for routing to the VoLTE UE in future messages

Other Messages getting exchanged on Cx Interfaces are :-

- User-Authorization-Request(UAR)
- User-Authorization-Answer(UAA)
- Server-Assignment-Request(SAR)
- Server-Assignment-Answer(SAA)
- Location-Info-Request(LIR)
- Location-Info-Answer(LIA)
- Multimedia-Authentication-Request(MAR)
- Multimedia-Authentication-Answer(MAA)
- Registration-Termination-Request(RTR)
- Registration-Termination-Answer(RTA)
- Push-Profile-Request(PPR)
- Push-Profile-Answer(PPA)

Sh VoLTE IMS Link



Sh VoLTE IMS Link

VoLTE Interfaces, Protocols & IMS Stack

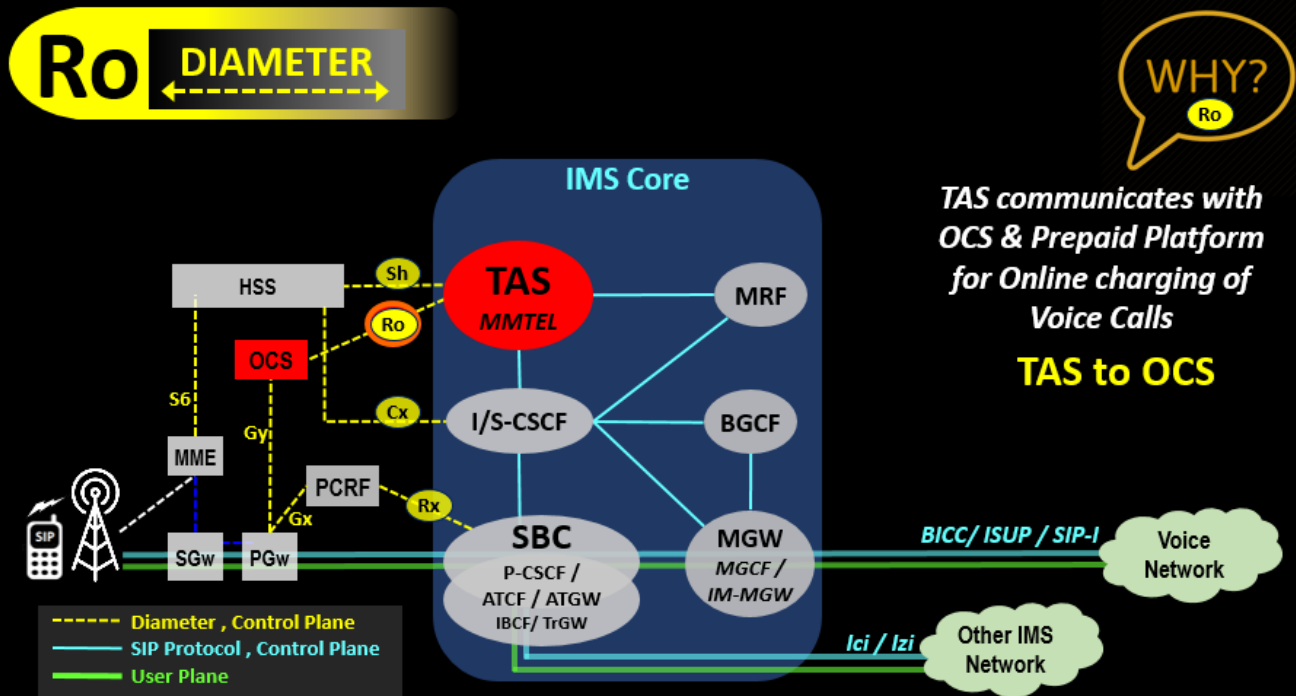
- **Link : Sh**
- **Protocol : Diameter**
- **Specs Reference : 3GPP TS 29.328 , 29.329**
- **Nodes Connected : TAS – HSS**
- **Purpose : TAS download user profile from HSS and enables service for user**

You can find more details on Sh Interface under 3GPP TS 29.328 Specs . The Sh Interface is used between the TAS and HSS to Support exchange of User Profile information such as service related information, user location information or charging function info . It enable service and subscriber related information to be passed from HSS to TAS . This is somehow Equivalent to Location Update between HSS & TAS . Sh uses Diameter protocol . Typical Messages in Cx includes UDR / UDA used during Registration of IMS User in Network :-

- User-Data-Request(UDR)
 - User-Data-Answer(UDA)
 - Profile-Update-Request(PUR)
 - Profile-Update-Answer(PUA)
 - Subscribe-Notifications-Request(SNR)
 - Subscribe-Notifications-Answer(SNA)
 - Push-Notification-Request(PNR)
 - Push-Notification-Answer(PNA)
-

VoLTE Interfaces, Protocols & IMS Stack

Ro VoLTE IMS Link



Ro VoLTE IMS Link

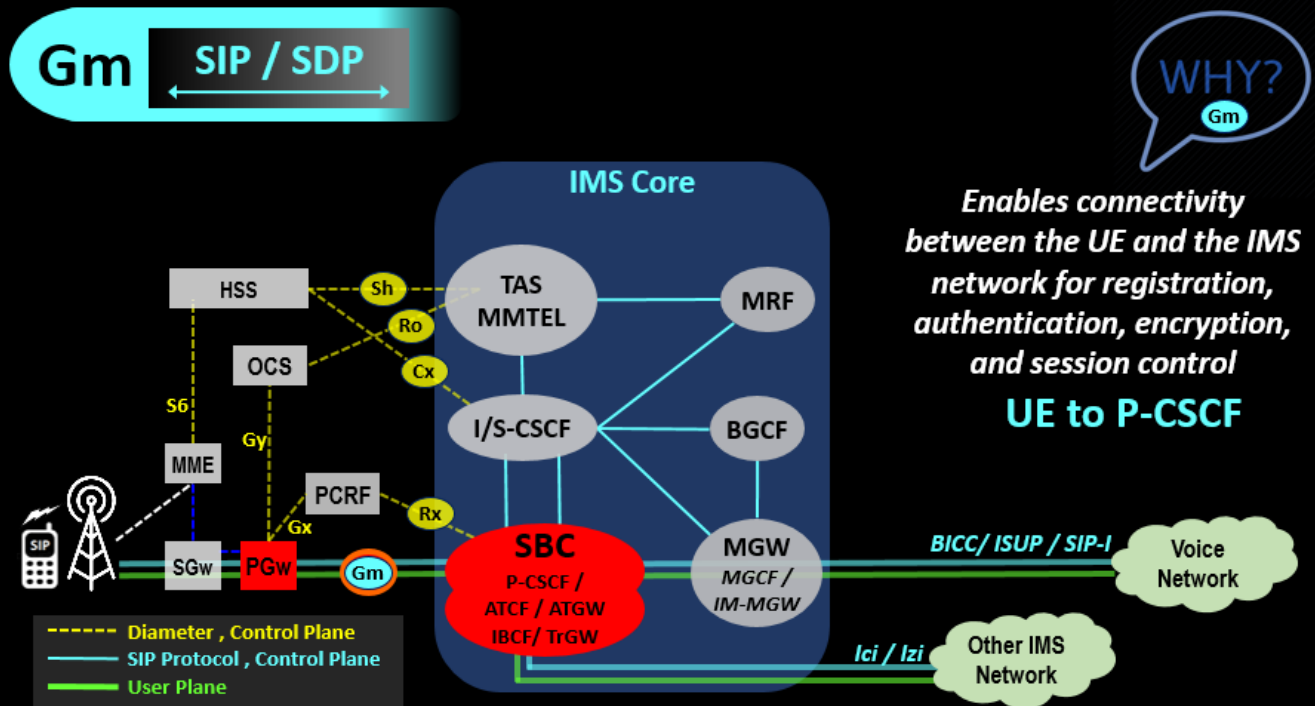
- **Link : Ro**
- **Protocol : Diameter**
- **Nodes Connected : TAS – OCS**
- **Purpose : TAS communicates with OCS & Prepaid Platform for Online charging of Voice Calls**

For any voice call, The charging function needs to perform credit control before allowing call to mature. With help of Ro Interface, TAS communicates with OCS Platform which performs Online charging of call. Ro Interface also works on Diameter protocol.

For Operators, where Ro Interface is not supported on OCS or IN, As alternative SS7 based CAMEL Protocol is also used. With CAMEL Interface, VoLTE Charging is done in similar way as done in Circuit Core Network with help of SS7 Protocol.

VoLTE Interfaces, Protocols & IMS Stack

Gm SIP VoLTE IMS Link



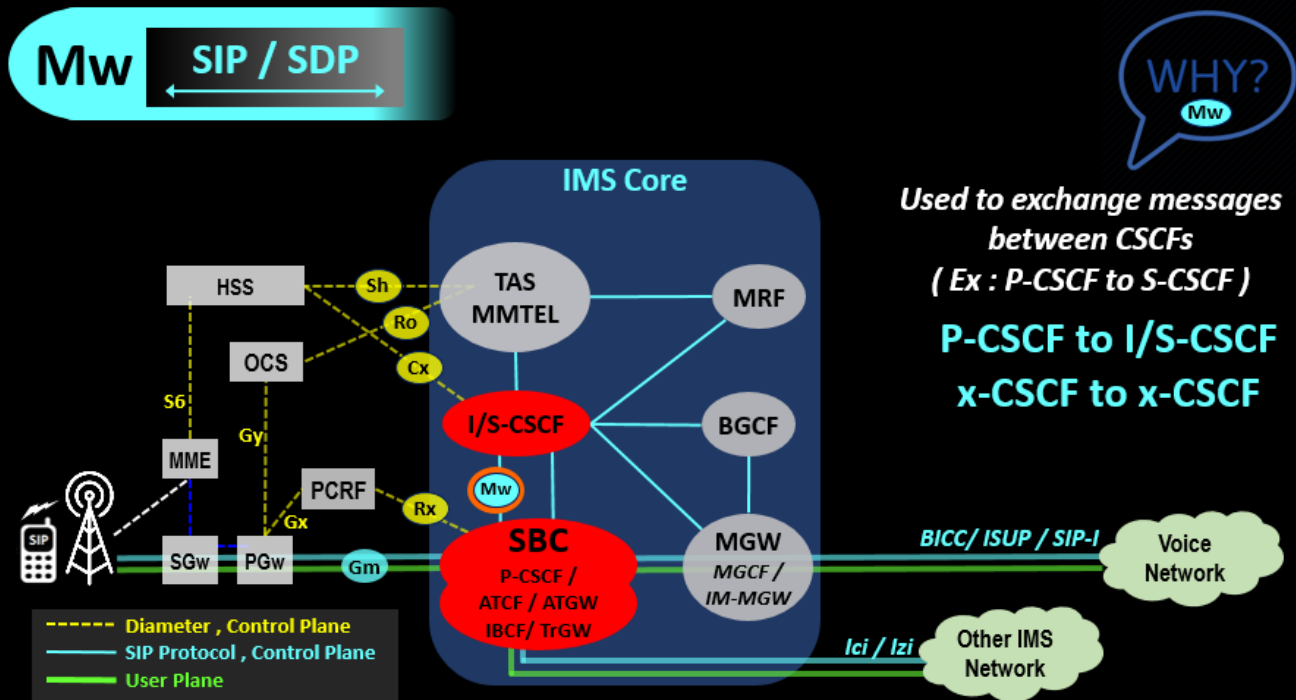
Gm SIP VoLTE IMS Link

- **Link :** Gm
- **Protocol :** SIP/SDP
- **Specs Reference :** 3GPP TS 24.229
- **Nodes Connected :** UE – P-CSCF
- **Purpose :** Enables connectivity between the UE and the IMS network for registration, authentication, encryption, and session control

Gm Interface is key to all User based communication . The Gm Interface is used between the UE (User) and P-CSCF for all purpose viz .. Registration / De-Registration / Incoming – Outgoing Calls / SIP Signaling / or any type of communication between User to IMS Network . For security reasons, the Gm and Mw Interfaces are physically separate. This Interface also carries Authentication, encryption, and complete session control. Gm uses SIP & SDP protocol

VoLTE Interfaces, Protocols & IMS Stack

Mw SIP VoLTE IMS Link



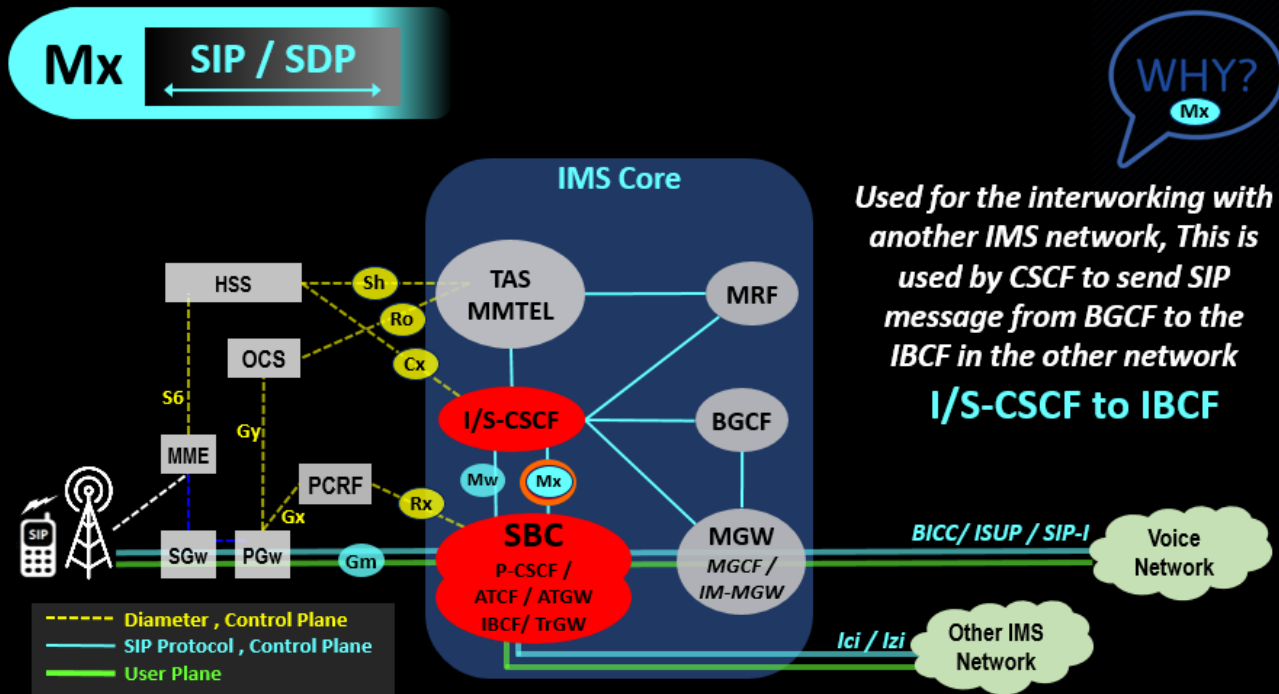
Mw SIP VoLTE IMS Link

- **Link :** Mw
- **Protocol :** SIP/SDP
- **Specs Reference :** 3GPP TS 24.229
- **Nodes Connected :** x-CSCF – x-CSCF
- **Purpose :** Used to exchange messages between CSCFs (Ex : P-CSCF to S-CSCF)

The Mw Interface is used between a CSCF Nodes to another CSCF Node within the IMS core network . Typically SBC Hosts P-CSCF which gets connected to I/S-CSCF via this Mw Protocol . Mw uses SIP and SDP Protocols for enabling these connectivity . You can find more details on Mw Interface under 3GPP TS 24.229

VoLTE Interfaces, Protocols & IMS Stack

Mx SIP VoLTE IMS Link



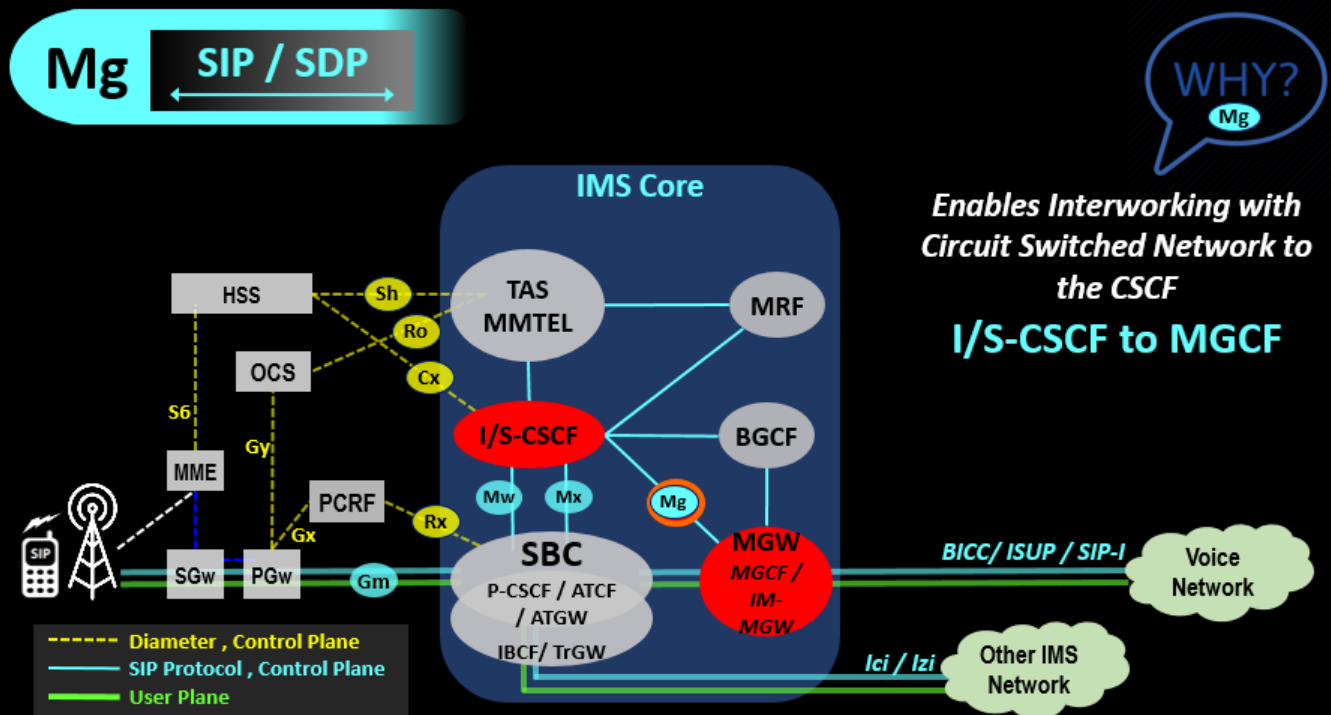
Mx SIP VoLTE IMS Link

- **Link :** Mx
- **Protocol :** SIP/SDP
- **Specs Reference :** 3GPP TS 24.229
- **Nodes Connected :** x-CSCF – IBCF
- **Purpose :** Used for the interworking with another IMS network, This is used by CSCF to send SIP message from BGCF to the IBCF in the other network

This is Mx Interface which is used between CSCF and IBCF . It plays vital role for the interworking with another IMS network. It Provides interworking with another IMS network when the BGCF has determined that a breakout should occur into the other IMS network. This Carries SIP message from the BGCF to the IBCF in the other network . The protocols used on the Mx Interface are SIP and SDP and are defined in 3GPP TS 24.229

VoLTE Interfaces, Protocols & IMS Stack

Mg SIP VoLTE IMS Link

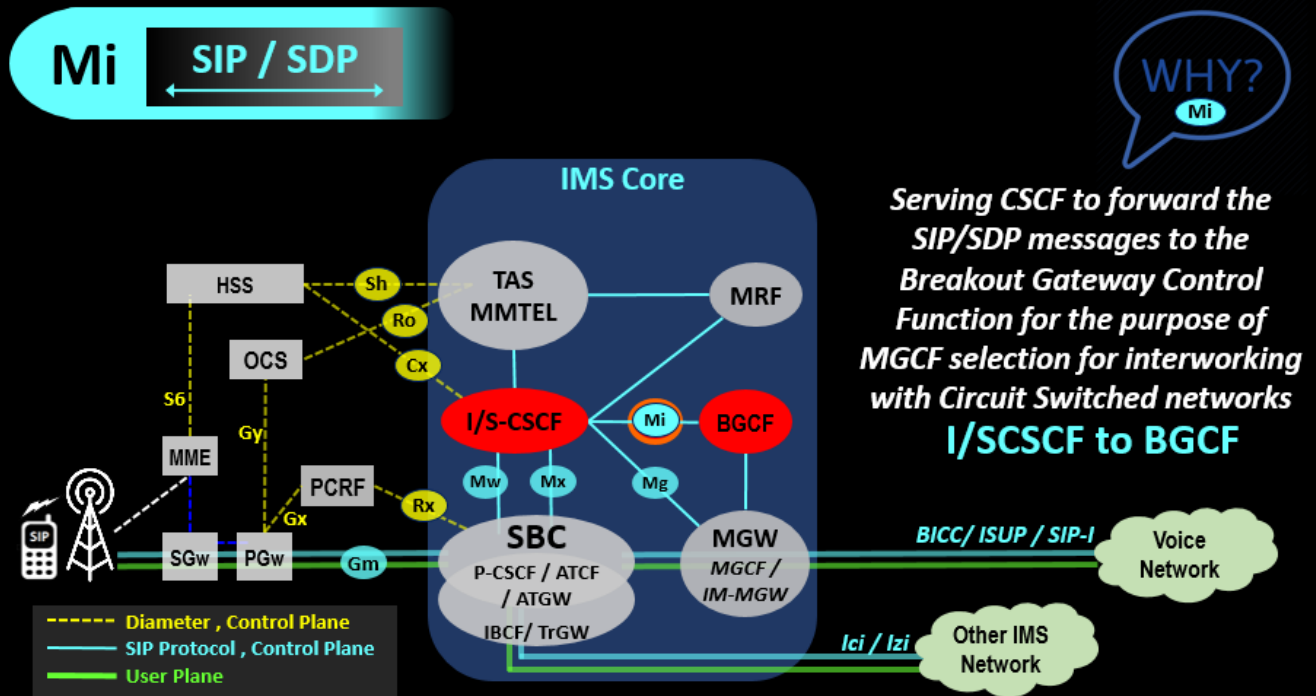


Mg SIP VoLTE IMS Link

- **Link :** Mg
- **Protocol :** SIP/SDP
- **Specs Reference :** 3GPP TS 24.229
- **Nodes Connected :** xCSCF – MGCF
- **Purpose :** Enables Interworking with Circuit Switched Network to the CSCF

The Mg Interface is used to convey SIP messages between an S/I-CSCF and an MGCF for signaling purposes . This is used for exchanging Signaling between CSCF & Media Gateway for Call coming and Going towards Circuit core Networks . This Interface also works on SIP and SDP protocols defined in 3GPP TS 24.229 specs

Mi SIP VoLTE IMS Link

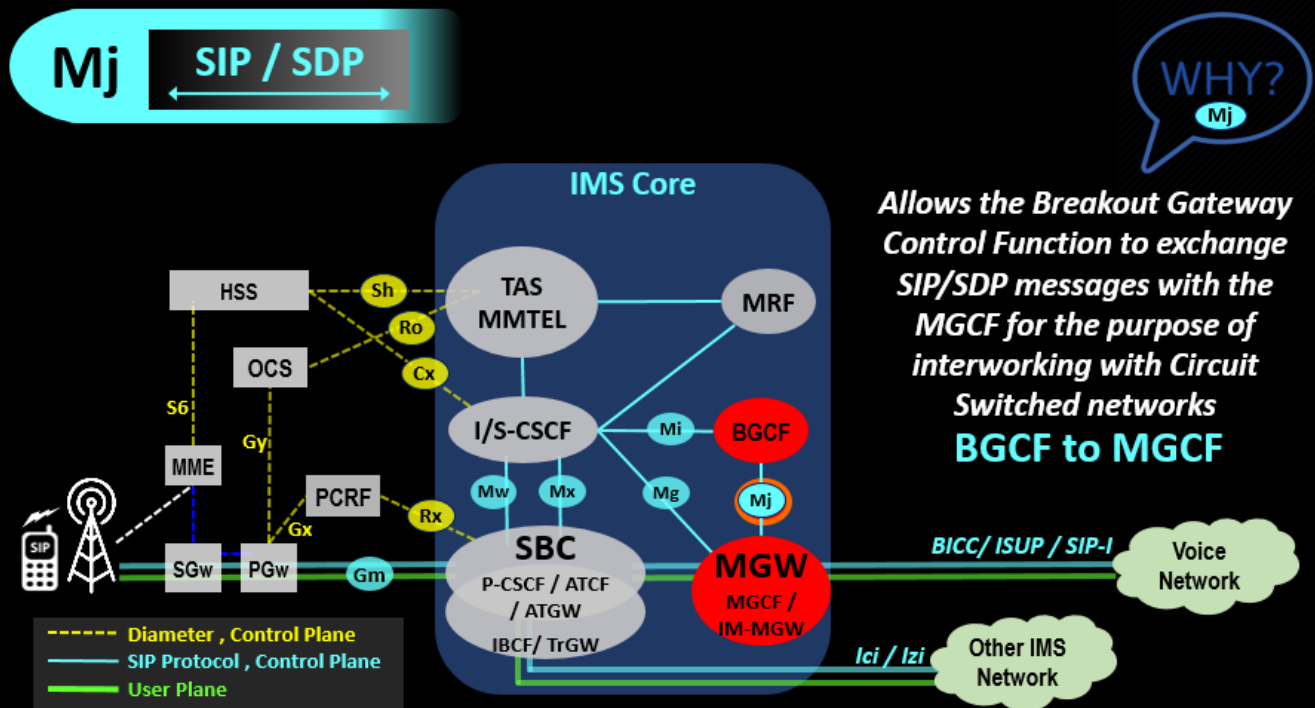


Mi SIP VoLTE IMS Link

- **Link :** Mi
- **Protocol :** SIP/SDP
- **Specs Reference :** 3GPP TS 24.229
- **Nodes Connected :** xCSCF – BGCF
- **Purpose :** Serving CSCF to forward the SIP/SDP messages to the Breakout Gateway Control Function for the purpose of MGCF selection for interworking with Circuit Switched networks

Mi Interface is also based on SIP & is specific under 3GPP TS 24.229 Specs . The Mi Interface is used to Exchanges messages between S-CSCF and BGCF for interworking with the PSTN . It allows the Serving CSCF to forward the SIP/SDP messages to the Breakout Gateway Control Function for the purpose of MGCF selection for interworking with Circuit Switched networks

Mj SIP VoLTE IMS Link



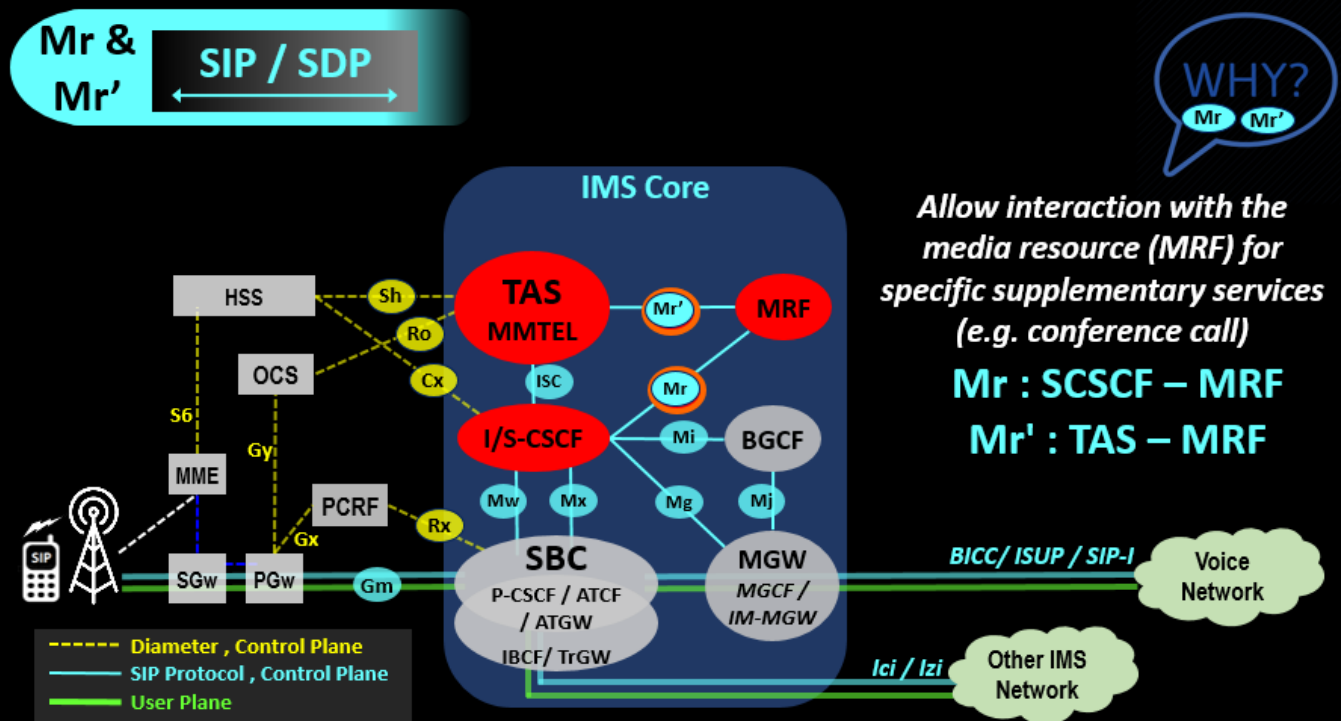
Mj SIP VoLTE IMS Link

- **Link :** Mj
- **Protocol :** SIP/SDP
- **Specs Reference :** 3GPP TS 24.229
- **Nodes Connected :** BGCF – MGCF
- **Purpose :** Allows the Breakout Gateway Control Function to exchange SIP/SDP messages with the MGCF for the purpose of interworking with Circuit Switched networks

This another BGCF based Interface between BGCF & MGCF . This is used to convey SIP messages between a BGCF and an MGCF for interworking with Circuit Switched networks . It carries Exchange of sessions with an MGCF that the BGCF has selected to provide session breakout to the PSTN or Circuit Switched Networks . The protocols used on the Mj interface are SIP and SDP and are defined in 3GPP TS 24.22

VoLTE Interfaces, Protocols & IMS Stack

Mr & Mr' VoLTE IMS Link



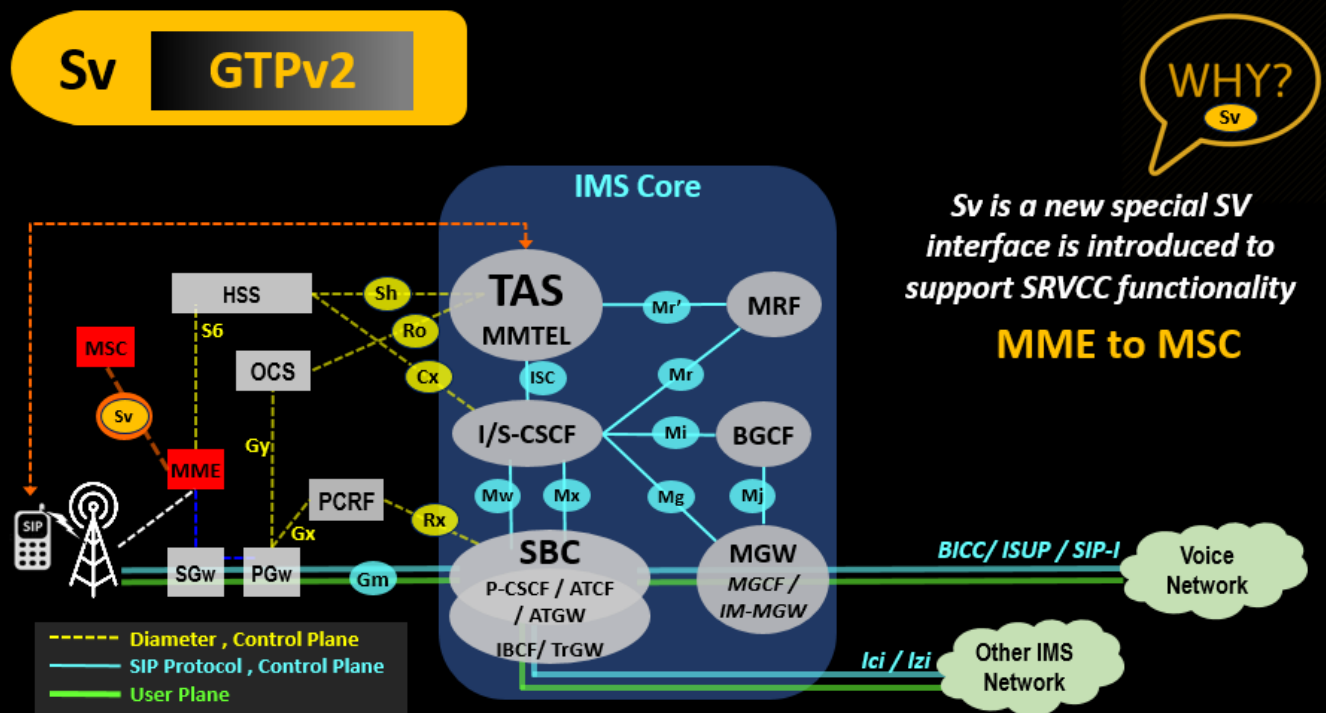
Mr & Mr' VoLTE IMS Link

- **Link :** Mr & Mr'
- **Protocol :** SIP/SDP
- **Specs Reference :** 3GPP TS 24.229 , 3GPP TS 24.880
- **Nodes Connected :**
 - Mr : SCSCF – MRF
 - Mr' : TAS – MRF
- **Purpose :** Allow interaction with the media resource for specific supplementary services (e.g. conference call)

As you are aware , MRF deals with Announcement & Media related functionalities such as transcoding, multiparty conferencing, network announcements/tones, etc. . There are 2 Interfaces providing MRF connectivity to SCSCF & TAS . First One is Mr interface between MRF to S-CSCF and 2nd One is Mr' (Mr Apostrophe) interface between MRF and TAS (Telephony Application Server) . These interfaces allow interaction with the media resource for specific supplementary services (e.g. conference call) on Control Plane

VoLTE Interfaces, Protocols & IMS Stack

Sv VoLTE IMS Link (GTPv2)



Sv VoLTE IMS Link (GTPv2)

Sv : Sv is a new special SV interface is introduced between the MME and the MSC to support SRVCC functionality . This runs on GTPv2 protocol . Refer to my another Blog on SRVCC for more details of this link & functionality