

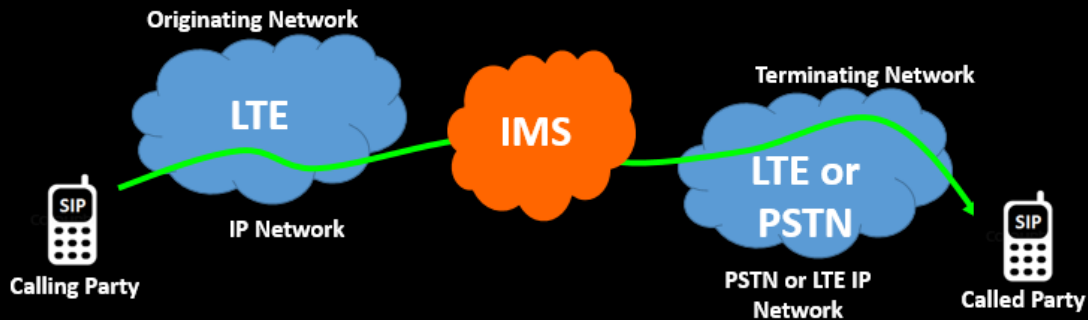
VOLTE IMS ARCHITECTURE

Architecture Overview of VoLTE SIP IMS Architecture, We will cover below topics :-

- VoLTE SIP Handset : SIP Support , UAC , UAS , User Agent , SIP-UA
- Underlying LTE Network : MME , SGW , PGW , PCRF , HSS , Dedicated Bearer , QCI , Default Bearer
- IMS Core : SIP Servers , P-CSCF , I-CSCF , S-CSCF , TAS , MMTEL , BGW , MRF , ATCF , ATGW , IBCF , MGCF , IM-MGW , TrGW

VoLTE IMS Architecture

What is VoLTE ?



IMS enables a packet-based network to provide multiple services on single Control/Service Layers via different access network.

Key Drivers to IMS

- Access agnostic
- Services independent
- Open architecture
- Multi-device
- Vendor independent

As diagram suggest, it's all about carrying voice over LTE Data Network

Since IMS is part of the Third Generation Partnership Project also called as 3GPP, this makes IMS as Standard solution with Pre-Defined Interworking with underlying 3G & 4G Services. Flexibility and expandability would allow Operators to bring new services on-line as those services emerge and evolve. IMS is designed to offer unprecedented convenience for individual and business users.

Along with LTE Network, Operators can harness the true power of IMS which stands for **IP Multimedia Subsystem**. IMS is a standalone system which resides out of the LTE network and connected to PDN Gateway or PGW through SGi interface

The idea of IMS is very old & was very popular around Year 2004, this used to be a failed Concept prior to support of VoLTE Services. In that Era, Originally the concept for an SMS and voice system over LTE using IMS had been opposed by many operators because of the complexity of IMS. They had seen it as far too expensive and burdensome to introduce and maintain. With VoLTE Launch, This again got popular and in Demand now a days with LTE & VoLTE Services

VoLTE IMS Architecture

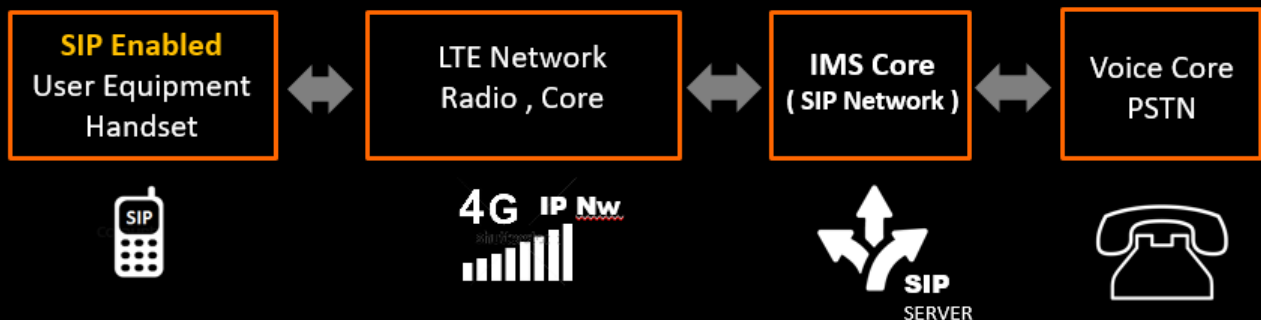
VoLTE Building blocks

VoLTE : Voice over LTE

- Voice calls over a 4G LTE network
- LTE Packet Network used for carrying voice payload over all IP Network

VoLTE Benefits to users

- HD Voice
- Fast Call connection (0.25s)



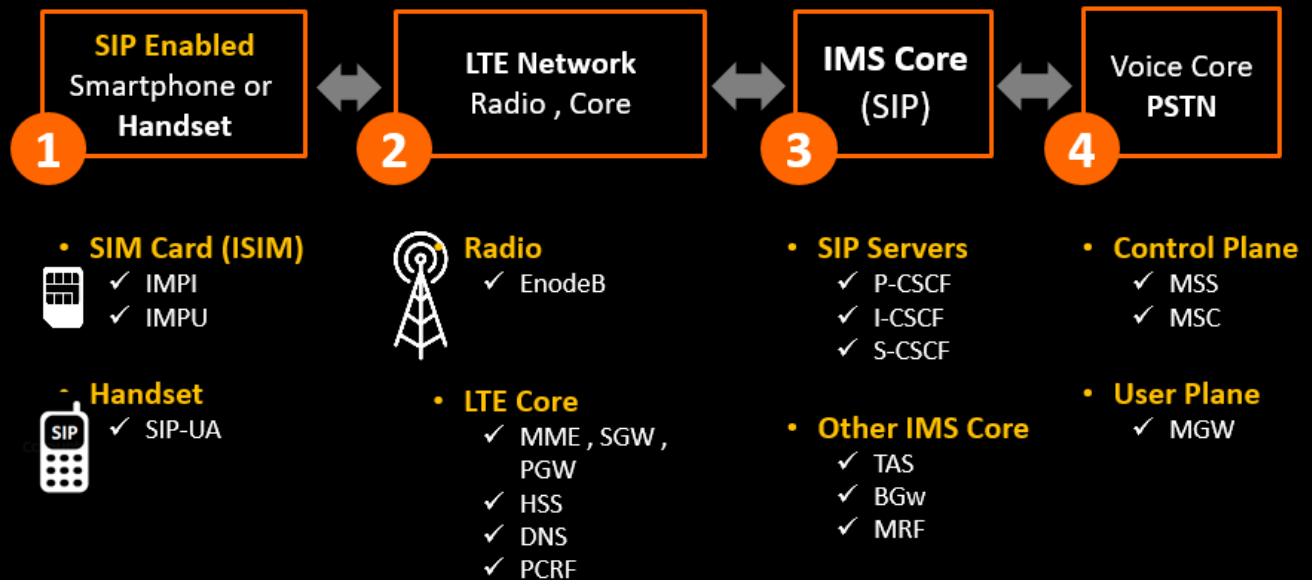
Rather than the 2G or 3G connections which are usually used for voice calls , VoLTE offers voice calls over all IP to IP based 4G Network . We tend to think of 4G as mostly being about downloading, streaming and web browsing, and indeed that's primarily what it's been used for so far, but it can also be used to next Level of Voice Services with IMS

Benefits of VoLTE for End Users

- **Fast Call Setup** – VoLTE can connect calls up to twice as fast as the currently used 2G and 3G Networks . Typical 2G / 3G Call takes 4-6 Seconds while VoLTE Calls requires only 2 Seconds
- **Superior call Experience** – The Greatest advantage of VoLTE is that Voice call quality is superior to 3G or 2G connections . Essentially it's an HD voice call and it's a much richer experience over all. This also offers Improved connectivity
- **Video calling** – It's also theoretically possible to make video calls over 4G, much like a Skype call except you'd just use your mobile number and be able to use the regular dialer and call interface, so you can make and receive video calls from anyone else with VoLTE, rather than relying on separate accounts.
- **Better battery life** – Anyone who currently uses 4G could also find their battery life increased with VoLTE . For a Non-VoLTE call , Handset needs to switch from 4G to underlying 3G or 2G network to receive voice call . This is done using CSFB or Circuit Switch Fall Back technology . This frequent switching of Mobile from 4G to 3G & Vice versa consumes lots of Battery . In VoLTE call , Users Need not to Go to 2G or 3G Network to receive voice call

VoLTE IMS Architecture

VoLTE Network – Building blocks

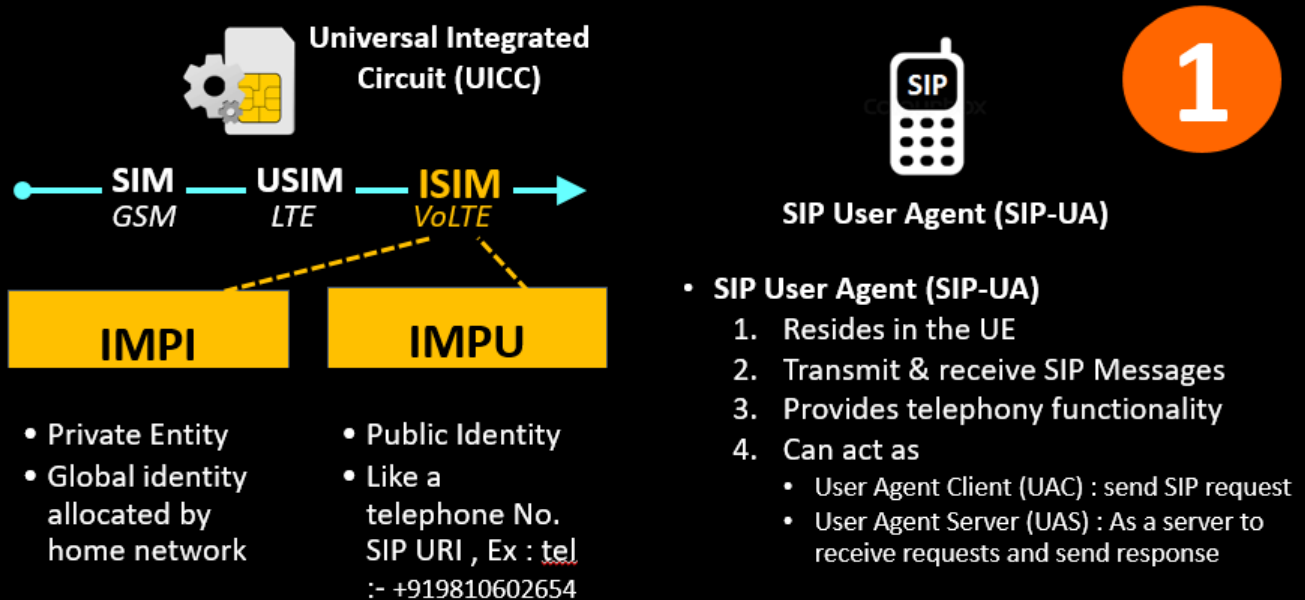


Here , We are going to further Deconstruct End to End VoLTE Network from User Device to IMS Core

1. **SIP Enabled User Equipment** :- This Handset or Smartphone needs to be VoLTE Compliant where SIM should support ISIM & SIP User Agent for making VoLTE Calls based on SIP Technology
2. VoLTE Call requires adaptability from both Handset & **Underlying LTE network** . The 4G or LTE Network also needs to adapt with minor tweaks to support VoLTE
3. IMS Network is sitting on top of underlying LTE Network .. Here **IMS Core** will be interfacing with Traditional LTE Network Nodes such PGW , PCRF & HSS
4. In last on Right hand corner , We are having **PTSN Network** consisting of MSS , MSC & MGW

VoLTE IMS Architecture

1 : VoLTE Handset Components (User Equipment)



For VoLTE to work, User handset must support two critical things : a) SIM Support and b) VoLTE Binary Application in Handset also called as User Agent

Evolution of SIM Cards

SIM also plays crucial role in VoLTE Support, Technical name of SIM is Universal Integrated Circuit (UICC). There are primarily 3 types of SIM Cards :-

1. **Subscriber Identity Module (SIM)** : Traditional SIM. This is an integrated circuit that securely stores the international mobile subscriber identity (IMSI) and the related key used to identify and authenticate subscribers on mobile telephony.
2. **UMTS Subscriber Identity Module (USIM)** : New Age SIM came to support USIM & LTE Networks.
3. **IP Multimedia Services Identity Module (ISIM)** : ISIM identity information used by the VoLTE or IMS subsystem.

VoLTE SIM

- **IP Multimedia Private Identity (IMPI)** : IMPI is a global identity allocated by home network. IMPI contains home operator's domain information.
- **IP Multimedia Public Identity (IMPU)** : IMPU acts like a telephone number which can either be a SIP URI (sip:@) or a tel URI as defined in RFC 39664 (tel :)

Unlike 2G or 3G or LTE, where all handsets are default supporting all available Network, VoLTE requires detailed Handset testing and Certification for Every Handset Make &

VoLTE IMS Architecture

Model . This testing is required as handset manufacturers and operators will be seeking to assure themselves that the underlying protocol features are present and functioning correctly . Operator want to ensure that the underlying IMS and protocol is functioning, and performing as intended, in order to deliver the expected quality of service

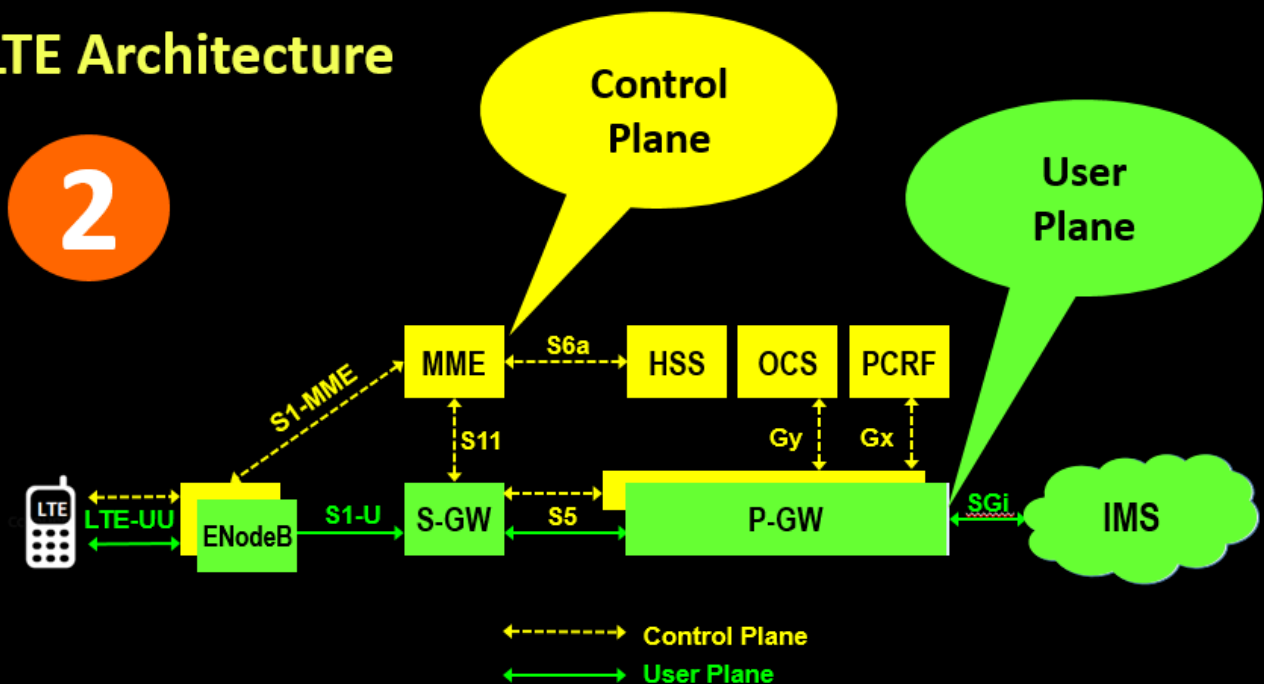
VoLTE Handset

VoLTE Handset hosts Binary Application containing SIP User Agent (SIP-UA) . This resides in the User equipment to transmit & receive SIP messages . It Provides basic telephony functionality & can act in two different roles :-

- User Agent Server (UAS) : Acting as Server to receive requests and send response
- User Agent Client (UAC) : Acting as Client to send SIP request

2 : LTE Architecture

LTE Architecture



I assume you already know LTE Architecture & will not spend too much time here . All Yellow Nodes are control Plane & are responsible for User Authentication . Control plane nodes include ENodeB , MME , HSS , OCS & PCRF

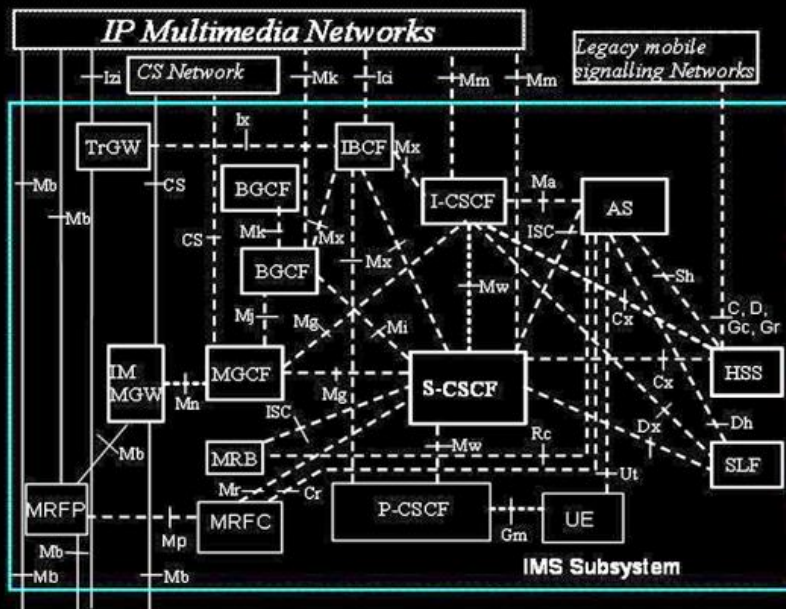
VoLTE IMS Architecture

The Green ones are User Plane which includes ENodeB , SGW & PGW . ENodeB is Radio cell site of LTE Network & is used in both Control & User Plane . PGW is also used for both User & Control Plane traffic

Now , We have covered User Handset & LTE Core Network . Its time to demystify IMS Core network . VoLTE Voice Call Traffic is originated by User Handset & Terminates on IMS Network . LTE Network is just used as Bridge acting as IP Supporting Carrier for this communication

3 : IMS VoLTE Architecture & Specs

IMS VoLTE Architecture & Specs



3GPP
IMS SPECS
3GPP 23.228



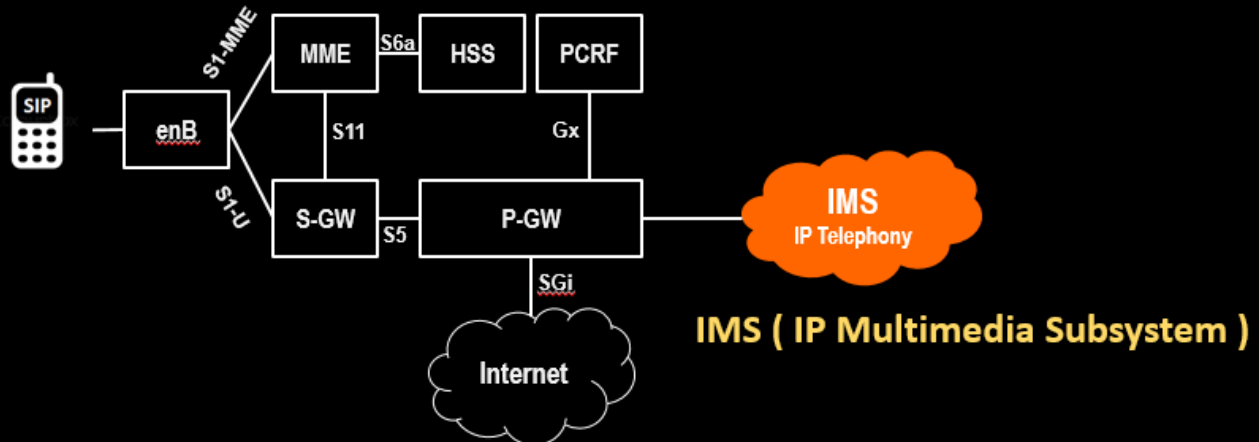
- **GSMA FCM.01**
- **GSMA IR.92**

This is 3GPP IMS Architecture , I am going to simplify this moving ahead & you will be able to understand every individual component

This VoLTE IMS Architecture is covered under @ 3GPP 23.228 . You can also study GSMA Document : GSMA FCM.01 and GSMA IR.92 for further reading

VoLTE IMS Architecture

LTE to VoLTE Journey , Here is IMS



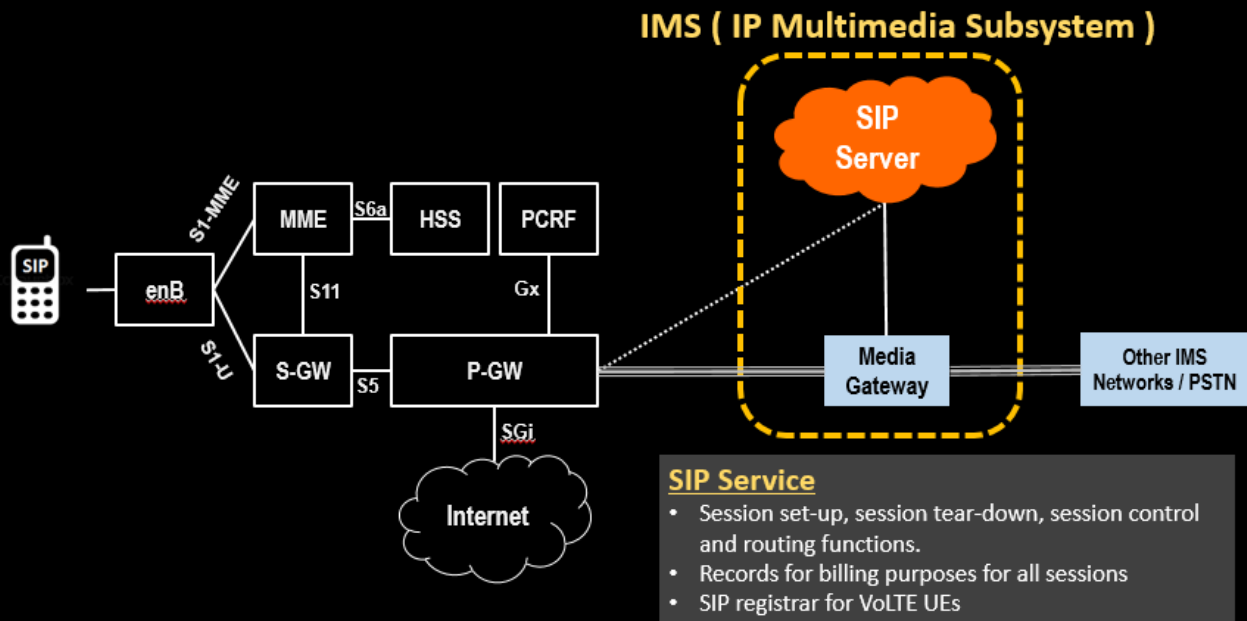
We will start with High level concept of LTE Network & Stitch it together with IMS . This is typical LTE Network which Provides high Speed Internet access . Traffic flows all the way from Mobile handset to EnodeB to SGW to PGW to Internet Cloud

Signaling is controlled by MME and PGW with support of HSS , PCRF . LTE Network is part of Evolved Packet System as shown in diagram here . IMS Core is directly connected to PGW as shown on screen . This is connected over sGi Interface . For LTE Network , IMS or SIP traffic is just another Payload similar to Internet Traffic . LTE PGW doesn't Decode or Interfere this traffic .

LTE is used as Carrier for accessing IMS Services which provides IP Telephony or Voice Services over IP Network , There could be multiple Access type for IMS Network such as Wifi , or Fix Broadband

VoLTE IMS Architecture

SIP Server



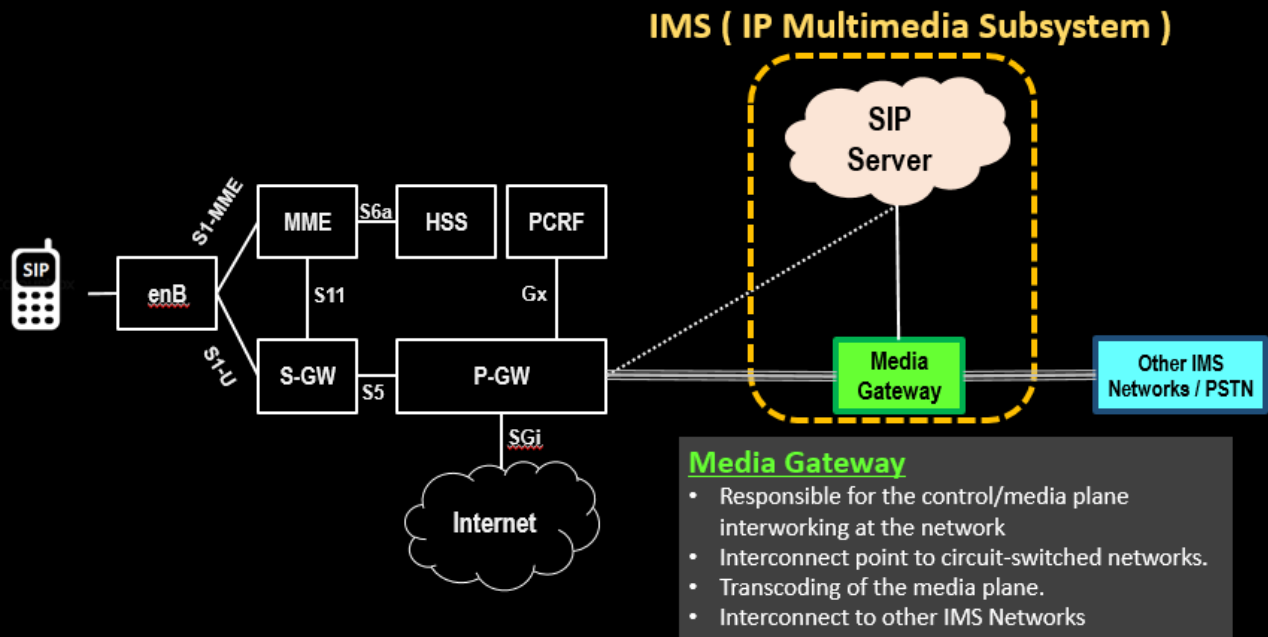
From here onwards , I will start breaking down IMS Cloud in various Bits & Pieces to make it more clear to understand . IMS Core consists of broadly Two Type of Network Elements , First is SIP Infrastructure & Another type of Nodes are Media Gateways . These are tightly coupled under IMS Core Network .

Function of SIP Server

- Users are going to register with SIP Server which is Part of Control Plane & Signaling
- This SIP Server will setup Media Part or Payload of Voice Call with Media Gateway shown in in Blue Color which is further connected to PSTN
- SIP Server is anchoring point for Session set-up, session tear-down, session control and CDR Generation

VoLTE IMS Architecture

Media Gateway



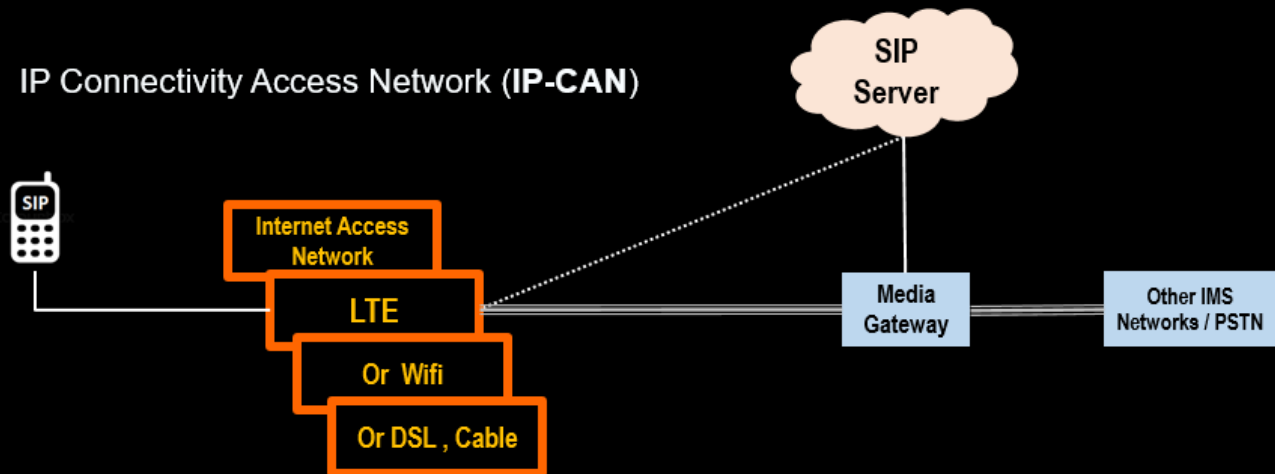
Role of Media Gateway (Highlighted in Green Color in above figure)

- Media Gateway is Responsible for carrying actual voice traffic & handing it over to other Networks . These Media Gateways handles interworking of Voice traffic between IMS & PSTN Networks .
- Any call coming from traditional 2G or 3G or Fix line network is using this Media Gateway as Entry point to IMS Network .

Media Gateway is Interconnect point to circuit-switched networks and Other IMS Network . It also handles Transcoding of the media plane

VoLTE IMS Architecture

Role of IPCAN

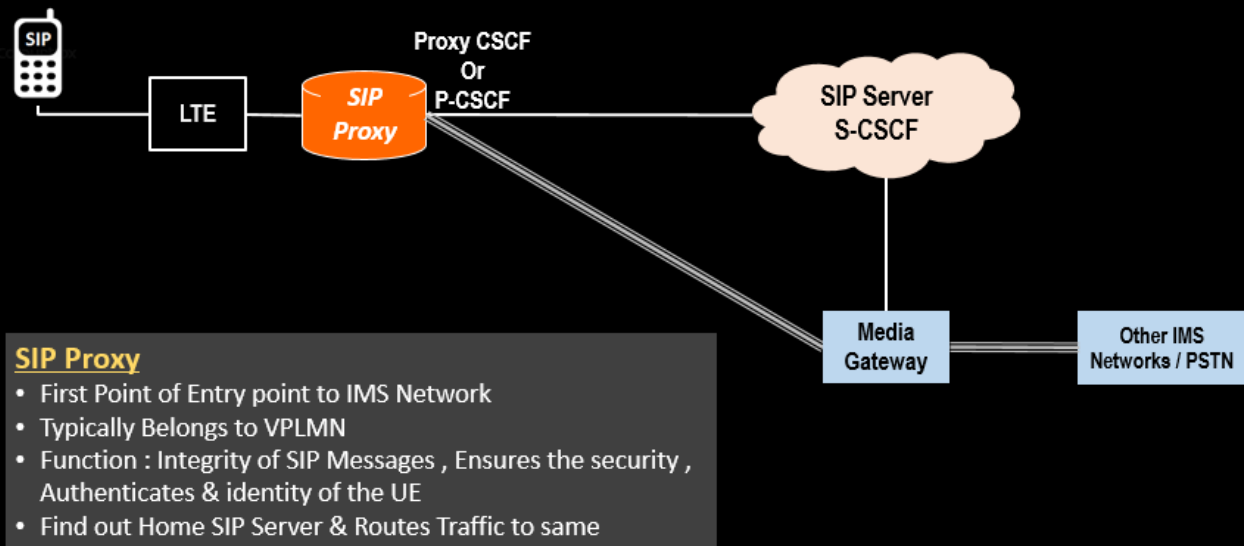


For the sake of easiness , I am using only One Box depicting LTE Network consisting of MME , SGW & PGW . There can be multiple access networks for providing IMS Services such as Wifi , Fix Broadband , DSL & LTE Networks . As long as user handset supports SIP Device & has IP connectivity to reach IMS Network , We can offer IMS Services to User

IPCAN Stands for IP Connectivity Access Network . This is equivalent to Bearer to IP Connectivity established from user towards IMS or Service Network

VoLTE IMS Architecture

The SIP Proxy



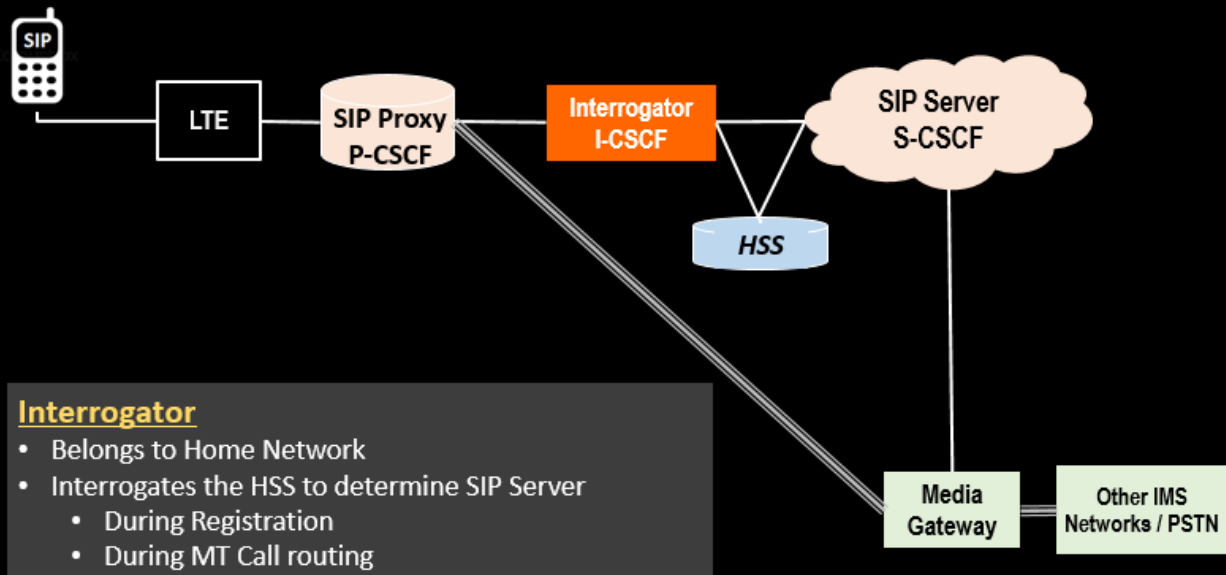
Now , I am going to discuss most critical Element of IMSI Core Network . We call this as CSCF , It stands for Call Session Control Function & act as heart of the IMS system . The CSCF performs all the signaling operations, manages SIP sessions and coordinates with other network entities for session control, service control and resource allocation. It consists of three different entities: the Proxy-CSCF (P-CSCF), the Interrogating-CSCF (I-CSCF) and the Serving-CSCF (S-CSCF).

Task of P-CSCF also known as Proxy-CSCF or Proxy Call Session Control Function

- This SIP Proxy is sitting in Front of SIP Server always
- SIP Proxy is first Point of Entry point to IMS Network is used for various purpose
- This Proxy SIP Server is typically located in Visitor PLMN Network
- This SIP Proxy has several important functions such as a) Validates the correctness of SIP messages b) Ensures the security c) Authenticates & asserts the identity of the UE
- It finds out Home SIP Server & Routes Traffic to same

VoLTE IMS Architecture

The Interrogator



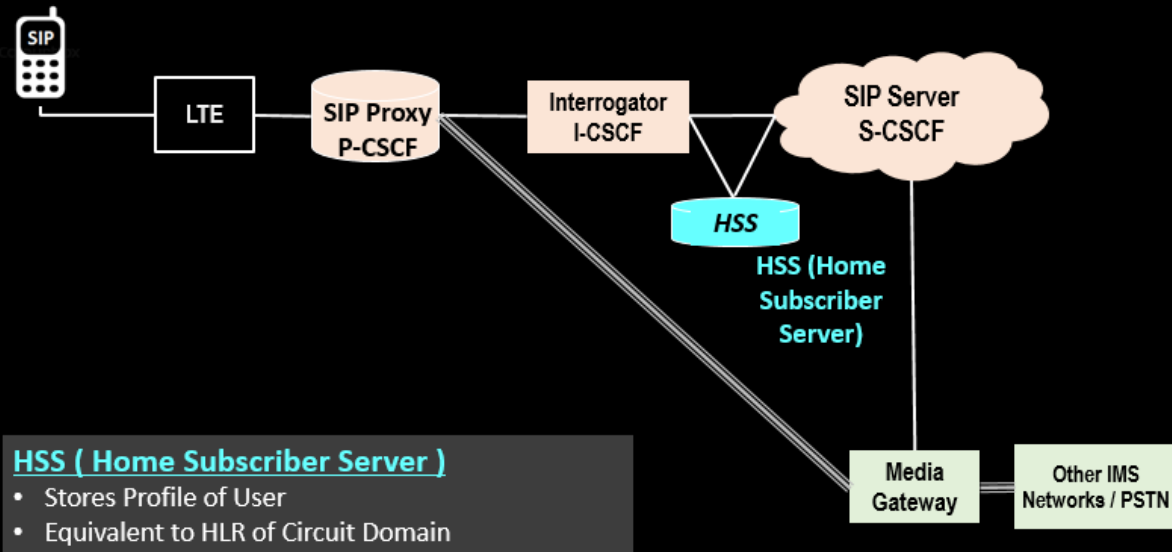
I am adding up two things here One is Interrogator & Another is Home Subscriber Server

I-CSCF or Interrogator CSCF performs below Critical functions :-

- SIP Proxy forwards requests to Interrogator which in-turns finds out where SIP Server to Select
- User may be served by Various SIP Servers , While Only One SIP Servers serves customer
- While SIP Proxy is usually located in Roaming or Visited Network , Interrogator sits in Home Network
- The main tasks of Interrogator is Select Correct SIP Server or Registrar which is going to Server User
- All this communication between Proxy , Interrogator & SIP Server is SIP to SIP to SIP
- I-CSCF queries the HSS using the DIAMETER Cx interface to retrieve the user location and then routes the SIP request to its assigned S-CSCF during below Procedures
 - During Registration
 - During MT Call routing

VoLTE IMS Architecture

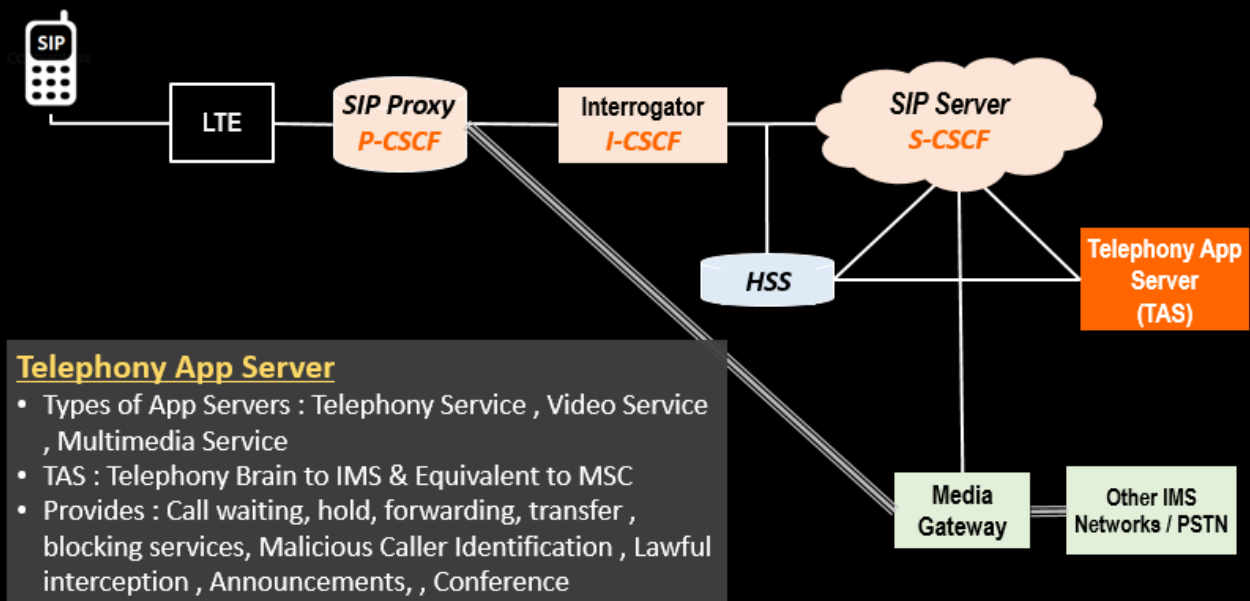
HSS (Home Subscriber Server)



- The HSS is the database of all subscriber and service data
- HSS contains the subscription-related information (user profiles), used by the control layer
- HSS is the master user database that is used for Registration & Authentication in both LTE Network & IMS
- This allows the user to access the packet and circuit domains of the network initially, via IMSI authentication.
- HSS Communication is via Diameter protocol
- For super easy understanding, HSS is used as profile or database of User where all information is saved . This HSS will decide whether you are allowed to use VoLTE or Not , Whether You are allowed to Latch on LTE Network or Not ? Etc..

VoLTE IMS Architecture

The Telephony App Server (TAS)

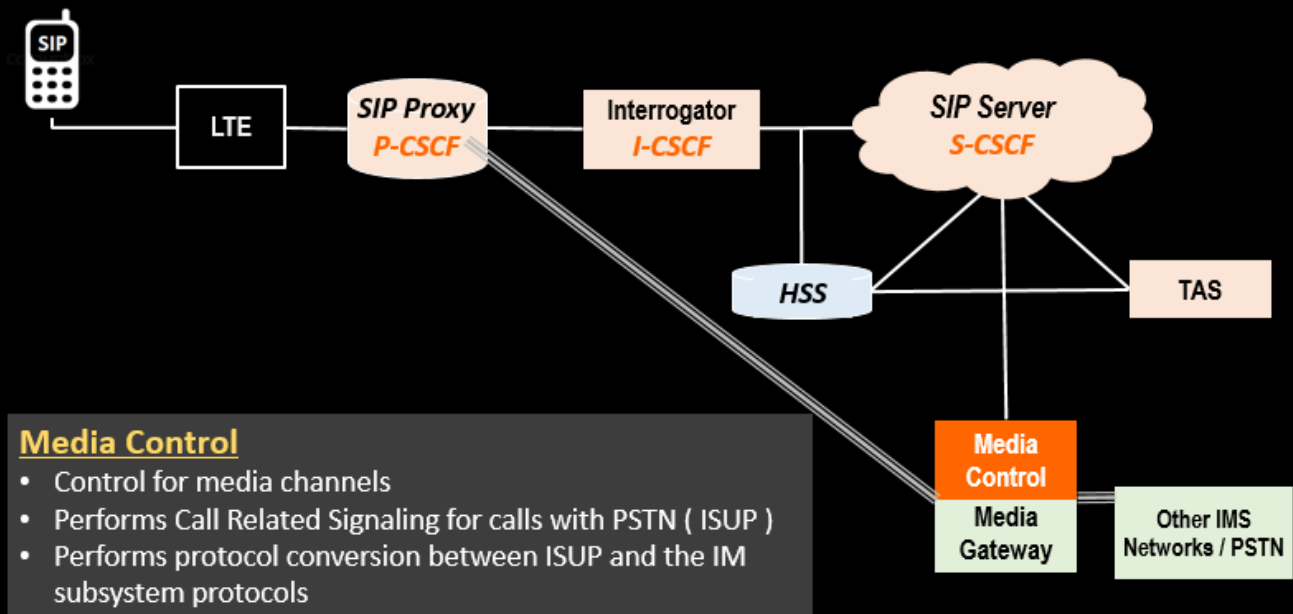


Till now , We discussed IMS Core which is great for handling SIP but this requires App Servers to provide various supplementary services . For example , Voice calls in Mobile network requires Telephony App Server (TAS) . We need similar App servers for other Multimedia services such as Video , Gaming etc.. Application Servers host and execute services, and interface with the S-CSCF using SIP. This allows third party providers an easy integration and deployment of their value added services to the IMS infrastructure.

- IMS was never indented to be limited for voice services , Rather it was designed for multimedia services & voice is only part of same
- IMS is not a service but service facilitator network . Its enables user to access various Applications such as Telephony service
- App Server handles Telephony part
- While SIP Server is still controlling Session such as Initiation , Maintain & Tear down of sessions . It facilitates Telephony Brain to App Server
- TAS is Telephony App Server used for Telephony Service such as Call waiting, Call hold, Call pick up , Call forwarding, Call transfer , Call blocking services, Malicious Caller Identification , Lawful interception , Announcements, Digit collection , Conference call services etc..
- We can various other App Servers such as Video App Server , Conference Bridge Service etc..
- App Servers are not considered part of Core IMS Service

VoLTE IMS Architecture

Media Control



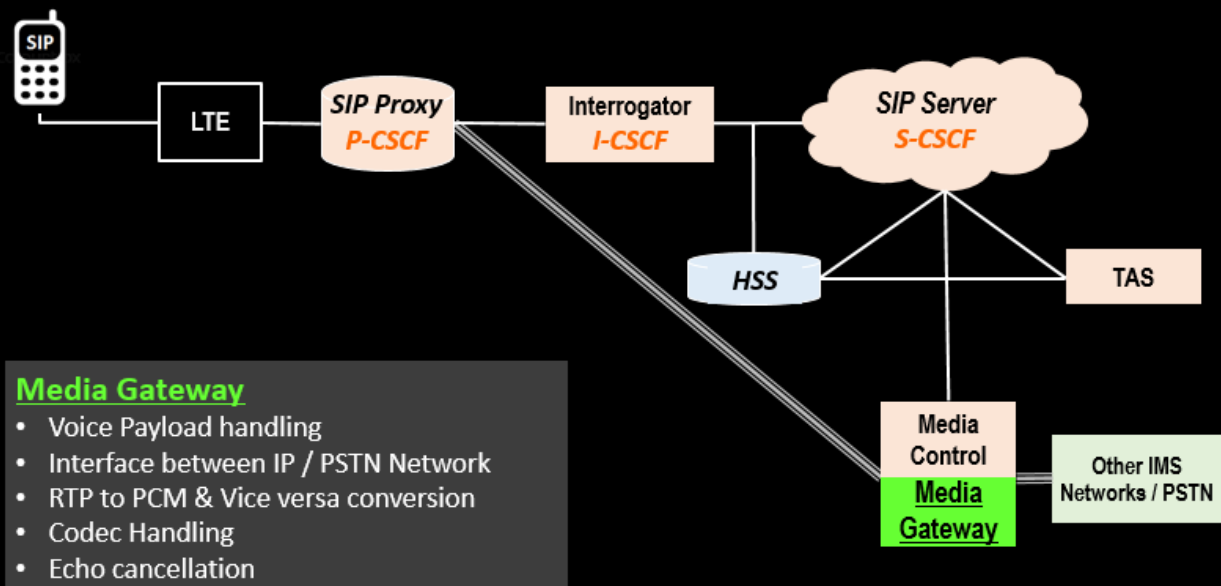
We have split Media functions into two part – Control & Payload function

Media Control is performing critical control plane function for VoLTE Call

- User can make call to PSTN Network or Fix Line Network where Media Control & Gateway is supposed to Speak to PSTN Network over ISUP / SS7 Protocol
- User can also make call to another IMS Networks
- Media Control handles the parts of the call state that pertain to connection control for media channels
- Media Control communicates with the SIP Server and selects the appropriate node depending on the routing number for incoming calls from legacy network
- Media Control also Performs protocol conversion between ISUP and the IM subsystem call control protocols
- It also Controls the MGW resources with a H.248 interface

VoLTE IMS Architecture

Media Gateway

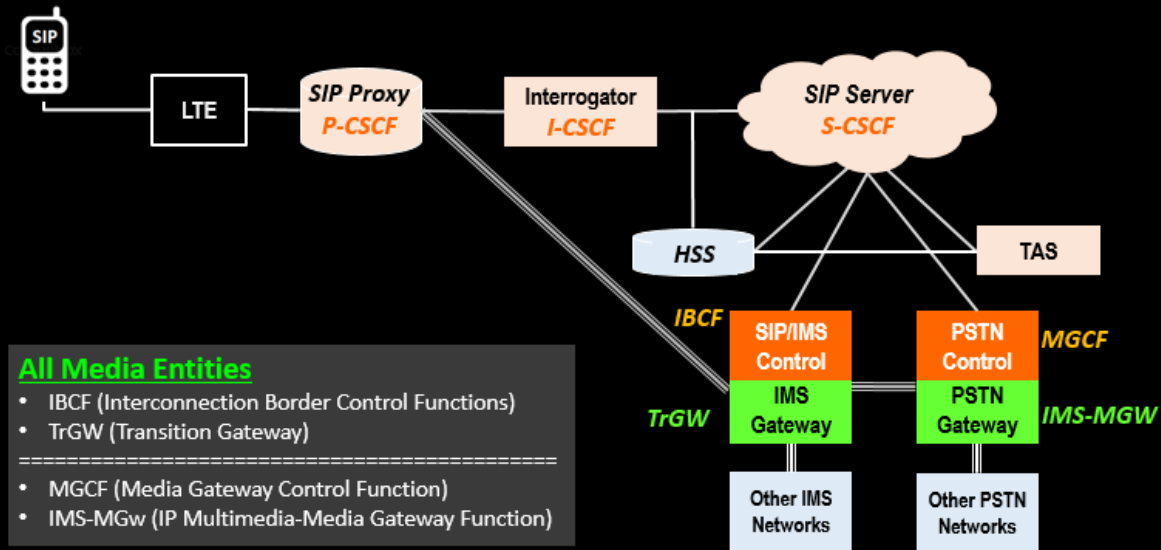


Media Gateway is element responsible for Payload Handling of VoLTE Call with Other Networks such as PSTN or Other IMS Networks

- It Interacts with Control and terminates bearer channels from a switched circuit network and media streams from a packet network (e.g., RTP streams in an IP network)
- Interfaces the media plane of the CS network, by converting between RTP and PCM
- It can also perform media transcoding, when the codecs used do not match (e.g. IMS might use AMR, PSTN might use G.711)
- Other than Media conversion , It also performs bearer control and payload processing using codecs, echo cancellers and Managing other on-board resources

VoLTE IMS Architecture

(IBCF & TrGW) IMS Interconnect , (MGCF & IMS-MGW) PSTN Interconnect
(IBCF & TrGW) , (MGCF & IMS-MGW)



IBCF & TrGW) , (MGCF & IMS-MGW)

Here , I am going to further Expand Media Control & Media Gateway into actual Node functions

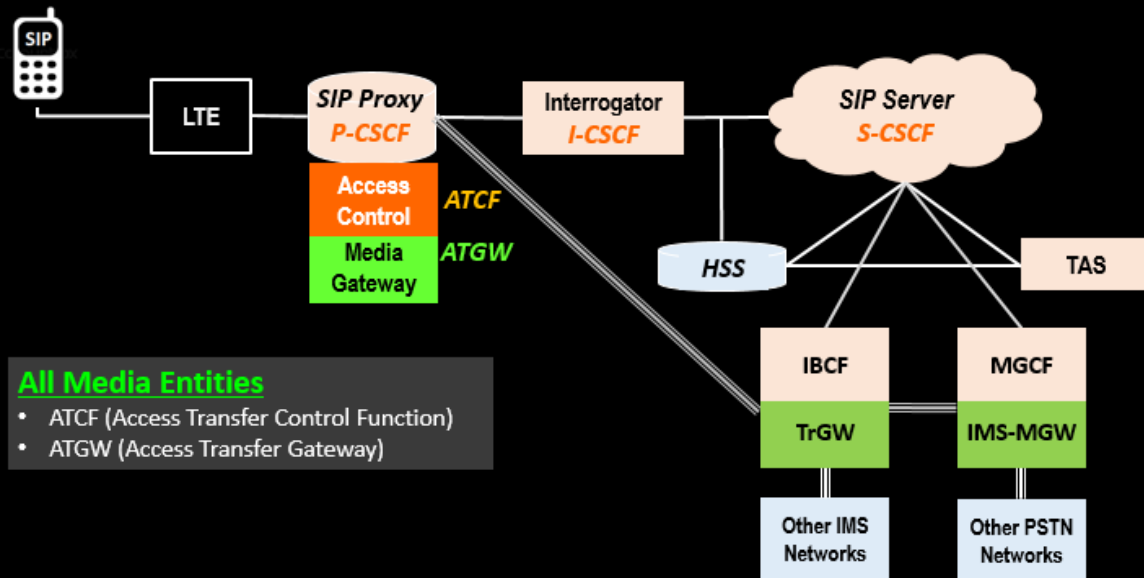
- IMS Gateway which communicates with Other IMS Networks . 3GPP Names of these Nodes are IBCF & TrGW . IBCF is control Plane Entity & TrGW is user Plane Entity
- PSTN Gateway which communicates with PSTN Networks . 3GPP Names of these Nodes are MGCF & IMS-MGW . MGCF is control Plane Entity & IMS-MGW is user Plane Entity

Now , With these Nodes , We can handover calls to any PSTN or IMS Network seamlessly ..

VoLTE IMS Architecture

ATCF & ATGW

ATCF & ATGW



ATCF & ATGW

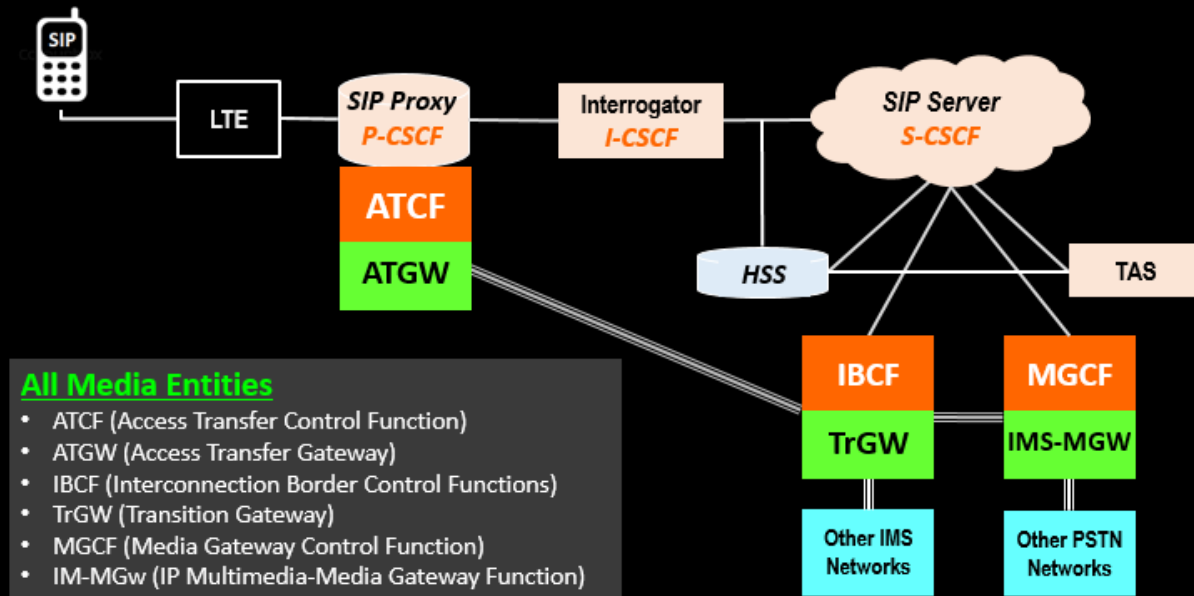
ATCF stands for Access Transfer Control Function , ATGW stands for Access Transfer Gateway

- As name suggest , These both Access nodes reside in serving IMS network (i.e. visited network in the roaming case) , They interact with LTE Network for Media Control & Payload handling
- ATCF handles the Access side Media Control for handing Voice calls with LTE PGW
- ATCF also plays vital role in enabling SRVCC Session Transfer mechanisms
- The ATGW is a media function that is used to anchor the media with LTE PGW

VoLTE IMS Architecture

All Media Entities

All Media Entities



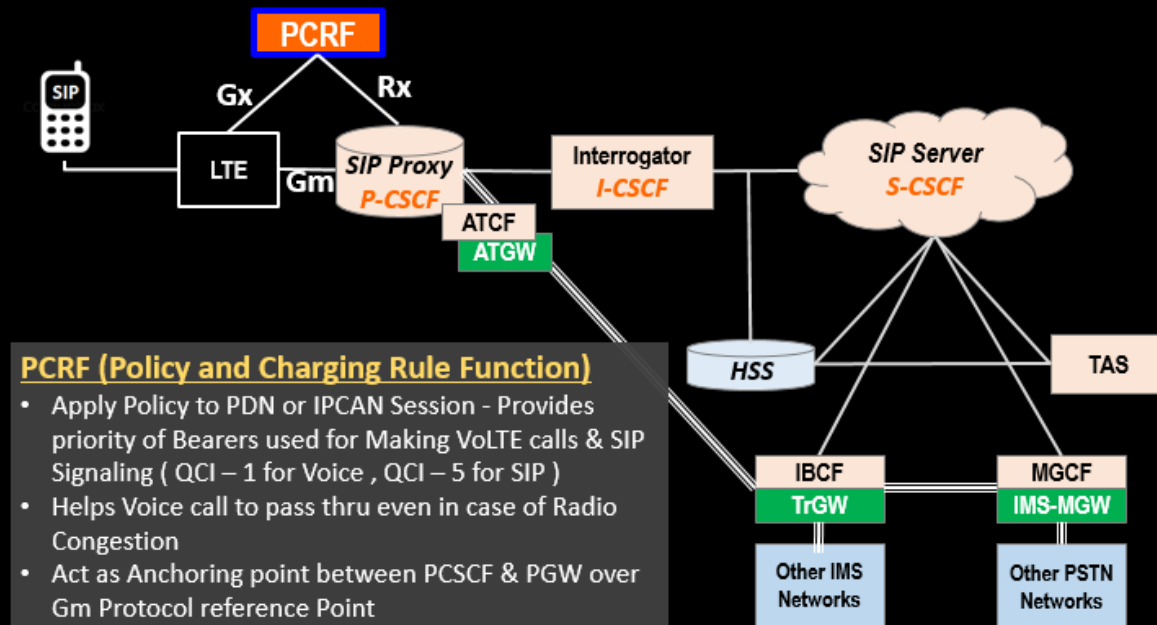
All Media Entities

Now , I am showing you all 3 Media entities in One Screen

- While MGCF & IM-MGW is designed to communicate to PSTN Networks such traditional Voice network running on SS7 or ISUP
- IBCF & TrGW is designed to interwork with Other IMS Networks running on SIP
- This is prime reason for Breaking them into various network Elements . You can also see here ATCF & ATGW on access side

PCRF (Policy and Charging Rule Function)

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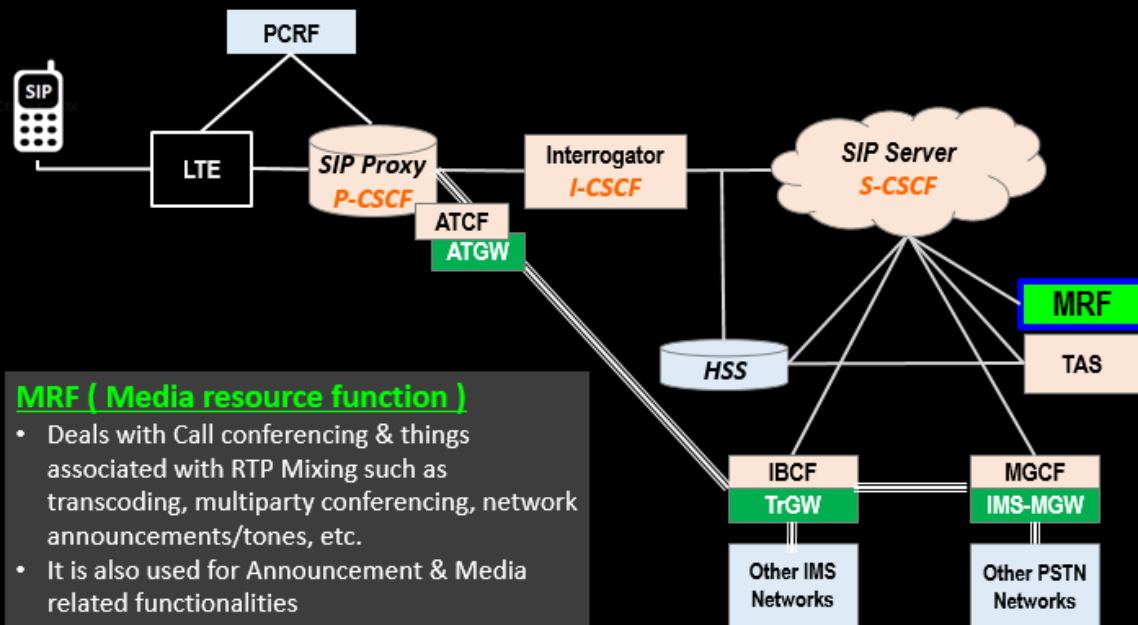


PCRF (Policy and Charging Rule Function)

PCRF : This is used in both IMS & LTE Network . The main purpose of PCRF is to apply Policy to PDN or IPCAN Session . The PCRF provides priority of Bearers used for Making VoLTE calls & SIP Signaling . The QOS Provided by PCRF provides Highest priority to VoLTE voice traffic . This prioritization helps Voice call to pass thru even in case of Radio Congestion . PCRF also anchors communication between PCSCF & PGW over Gm Protocol reference Point

MRF (Media Resource Function)

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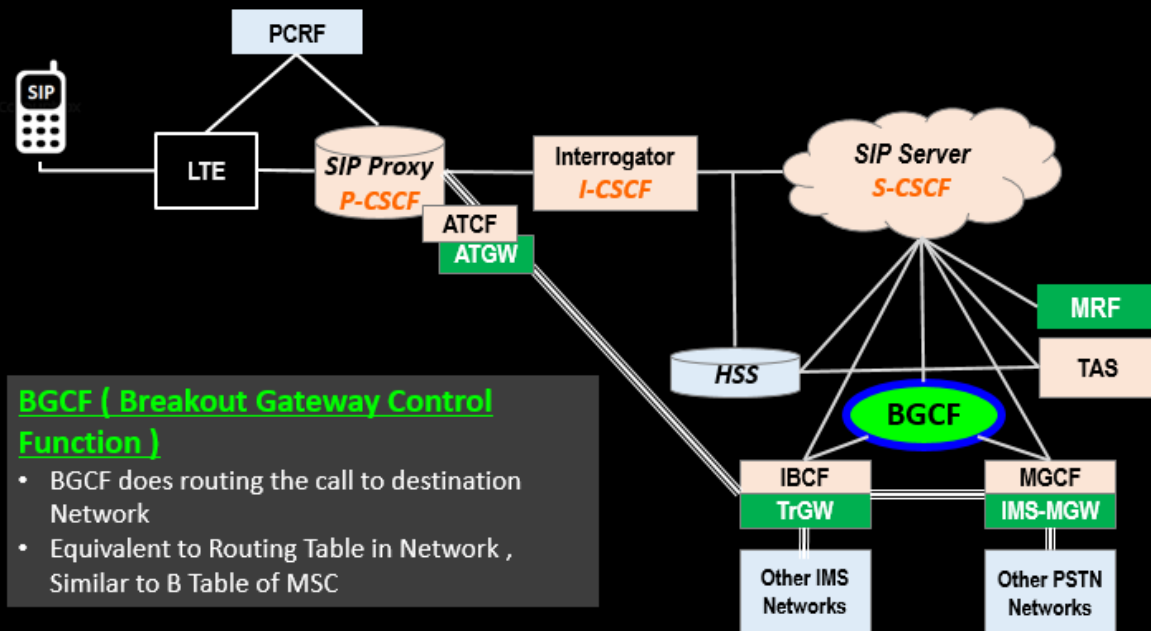
MRF (Media Resource Function)

MRF stands for Media resource function

- MRF is both Gateway & Control function
- It deals with Call conferencing & things associated with RTP Mixing
- It is also used for Announcement & Media related functionalities
- MRF provide media plane processing independent of application types, e.g. transcoding, multiparty conferencing, network announcements/tones, etc.

BGCF .. B Number routing Table

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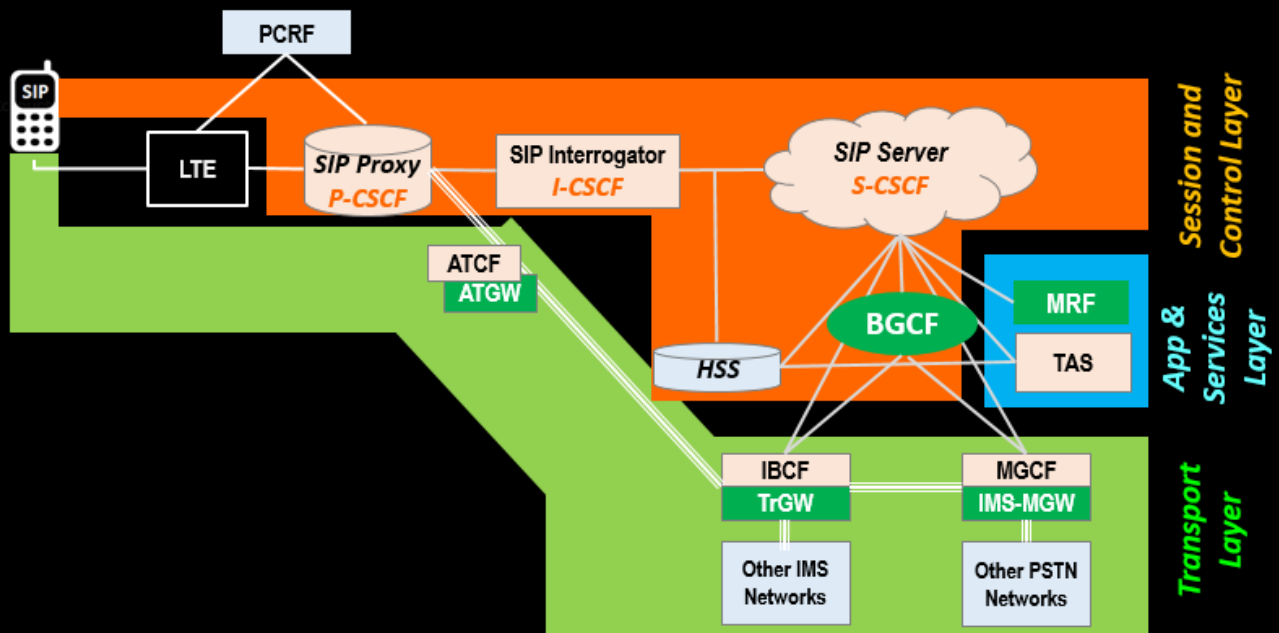
BGCF .. B Number routing Table

BGCF stands for Breakout Gateway Control Function

- Serving CSCF Needs to make decision where to route SIP Message (i.e. To PSTN or to Other SIP Network) , BGCF Simplifies this Job by making these decisions about routing the call to destination Network . This is as Good as Routing Table in Network , Similar to B Table of MSC
- BGCF is responsible for determining the next hop for routing of SIP messages
- For PSTN terminations, the BGCF determines the network in which CS domain breakout is to occur and selects the appropriate MGCF
- For terminations in peer IMS networks, the BGCF selects the appropriate IBCF to handle the interconnect to the peer IMS domain

Complete VoLTE IMS Picture

Complete VoLTE IMS Picture



Complete VoLTE IMS Picture

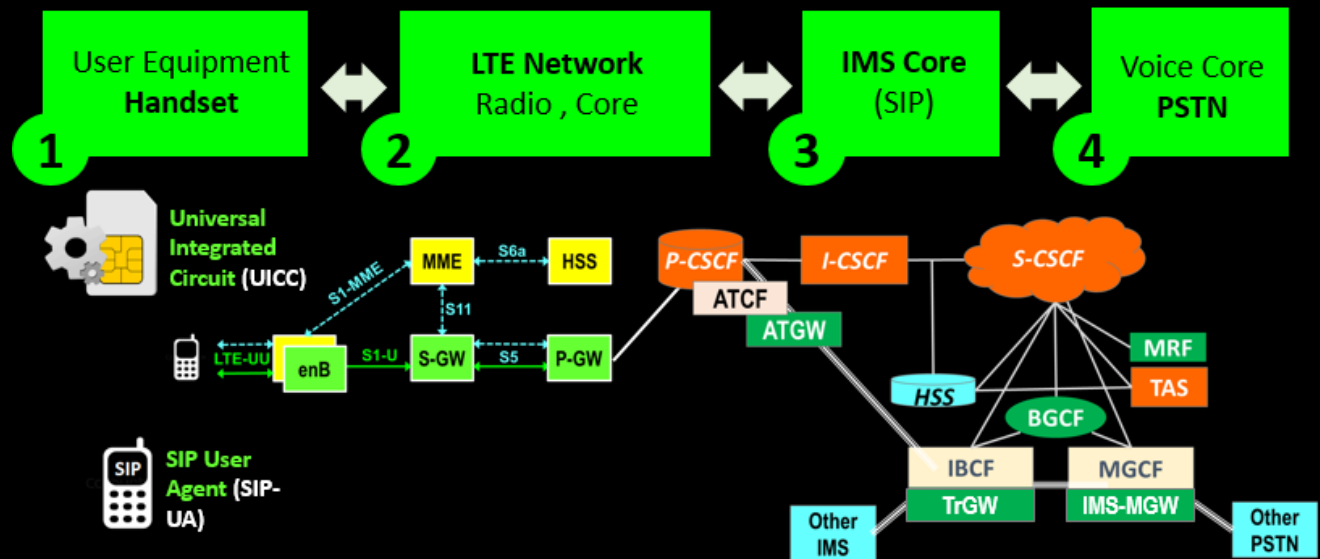
The IMS architecture gives service providers the opportunity to deliver new and better services, with reduced operating costs, across wireless, wireline, and broadband networks. IMS is defined by the Third Generation Partnership Project (3GPP). IMS unifies applications enabled by the Session Initiation Protocol (SIP) to connect traditional telephony services and non-telephony services, such as instant messaging, voice, video streaming, and multimedia messaging. The IMS architecture involves a clear separation of three layers :-

- Transport and Endpoint
- Application Services
- Session and Control

VoLTE IMS Architecture

The Big Picture ..

The Big Picture ..



The Big Picture ..

This is End to End Pictorial View of Complete VoLTE IMS Network where UE is connected to IMS via LTE network