

VoLTE IMS SIP registration call flow procedure

CONTENTS

We are going to Explore VoLTE SIP IMS Registration procure in detail with following topics Covered :-

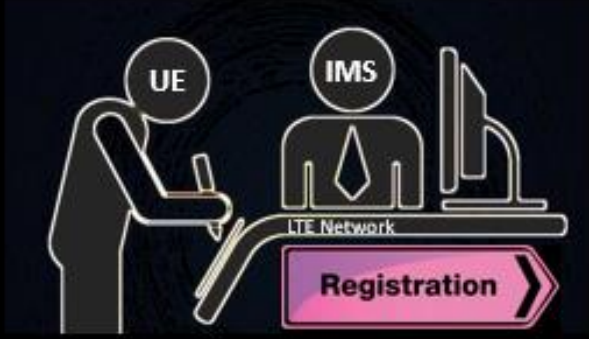
- LTE Attach & Default Internet EPS bearer
- Role of QCI-1 (Voice) , QCI-5 (SIP Signaling) , QCI-6 to 9 (Internet)
- Default Vs Dedicated Bearer in LTE
- Default IMS EPS bearer in LTE
- SIP and IMS Registration
- TAS Registration

VOLTE REGISTRATION

VoLTE Registration

VoLTE UE Behavior

1. LTE Attach
2. IMS Registration
 - Enables VoLTE Services
 - Ex : Calls , SMS , Supplementary Services etc..



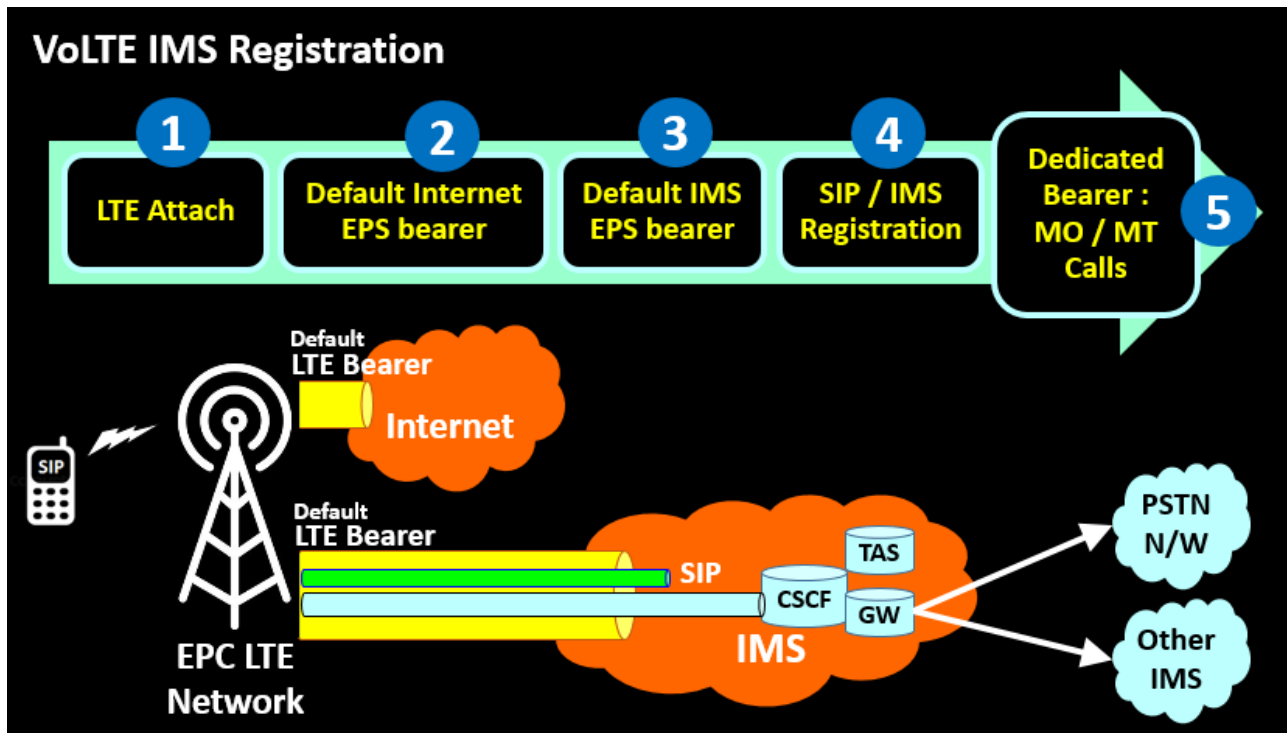
Prior to use VoLTE Service , A user must be attached on LTE Network

Typically Internet APN is connected first followed by IMS APN Connectivity on LTE Network

Next Step will be IMS or SIP Registration which enables user to make Voice / Video calls over VoLTE along with using supplementary services

VoLTE IMS SIP registration call flow procedure

VOLTE IMS REGISTRATION



This Network depicts the UE connectivity to LTE Network . For using VoLTE Services , User need to go thru these Steps :-

- Attaching on LTE network as mentioned in point 1
- 2nd Step will be activating Default Internet EPS bearer post which user will be able use & Access internet
- 3rd Step will be Default IMS EPS bearer activation which will be used for communicating with IMS Network
- This is followed by SIP / IMS Registration where UE will directly communicate to IMS Network , Here LTE Network will only act as Super Highway to relay messages between UE & IMS Network
- Post IMSI Registration , Whenever UE is making MO / MT Calls , Dedicated Bearer will be established on the fly

1st LTE Bearer in Yellow color is for Internet connectivity

2nd LTE Bearer in Yellow color is there for IMS Network , This carries both SIP Signaling used for IMS Registration & Voice calls over Packet LTE Network

Let's discuss them in detail moving ahead

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EPS BEARER

EPS bearer



Default EPS Bearer

- Established during LTE Attach
- Allocate IP address to UE
- **Used for Always connected bearer :-**
 - **Internet Connectivity (QCI : 6-9)**
 - **SIP Signaling Connectivity (QCI : 5)**

Dedicated EPS Bearer

- Established during call
- No IP Address Allocation
- Linked to particular Default EPS Bearer
- Have a specific (usually guaranteed) QoS
- **Used for On-Demand bearer for :-**
 - **Voice Call (QCI : 1)**
 - **Video Call (QCI : 2)**

'Bearer' in the dictionary means "Carrier" or "Porter" which carries something from a point to another point. Under the context of communication technology, I would define the 'Bearer' as a 'pipe line' connecting two or more points in the communication system in which data traffic follow through.

Default EPS Bearer

- This Default bearer is Established during LTE Attach
- It Allocate IP address to UE
- Default EPS Bearer is used for Always connected bearer :- Internet Connectivity (QCI : 6-9) , SIP Signaling Connectivity (QCI : 5)

Now , We will discuss Dedicated EPS Bearer

- Dedicated is Child Bearer which is Established during call
- There is No IP Address Allocated to this bearer , It uses IP address of Parent which is allocated to Default Bearer
- Linked to particular Default EPS Bearer
- This has a specific QoS which is usually guaranteed
- Used for On-Demand bearer for :- Voice Call (QCI : 1) , Video Call (QCI : 2)

VoLTE IMS SIP registration call flow procedure

WHAT IF LTE RADIO IS CONGESTED ??

What if LTE Radio is Congested ??

Priority	QCI	Resource Type	Packet Delay Budget	Packet Error Loss Rate	Example Services
1	5	non-GBR	100ms	10^{-6}	Volte , IMS Signaling
2	1	Guaranteed Bit Rate (GBR)	100ms	10^{-2}	Volte , Conversational Voice
3	3		50ms	10^{-3}	Real Time Gaming, V2X messages
4	2		150ms	10^{-3}	Volte , Conversational Video (Live Streaming)
5	4		300ms	10^{-6}	Non-Conversational Video (Buffered Streaming)
6	6		non-GBR Best Effort	300ms	10^{-6}
7	7	100ms		10^{-3}	
8	8	300ms		10^{-6}	
9	9	300ms		10^{-6}	

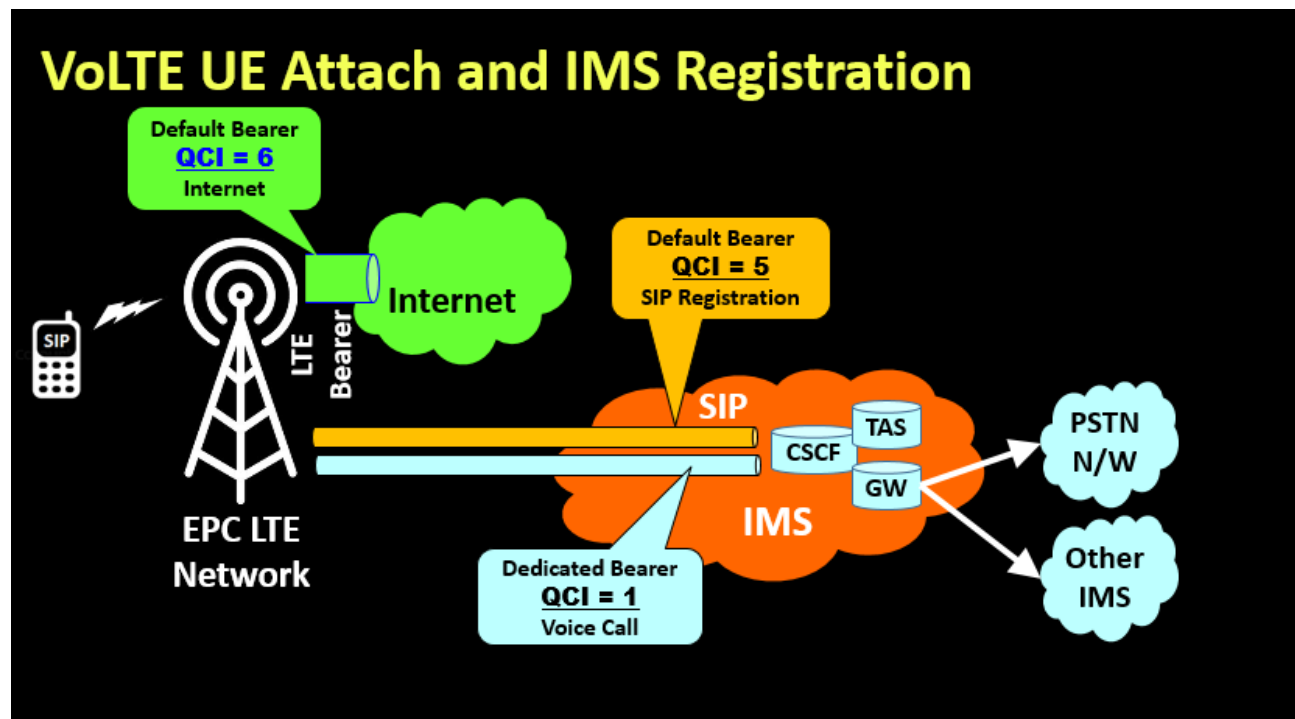
Have you ever thought , What will happen to VoLTE Voice Calls during Radio Congestions ? .. As General principal , Data Internet can wait for some time , But Voice Can't . Voice has to be real-time .

QCI is used during congestion to give Seamless access to critical traffic such as voice and video traffic which can't wait . As the network load will increase, prioritization determines which traffic will pass thru & which one will wait . In such scenarios , Internet traffic running on QCI-6 to 9 will be blocked in case of insufficient resources

- QCI=5 is used for VoLTE IMS Signaling
- QCI=1 is used for VoLTE IMS Voice Call
- QCI=6 to 9 used for Internet . This is always low priority as compared to VoLTE

VoLTE IMS SIP registration call flow procedure

VOLTE UE ATTACH AND IMS REGISTRATION

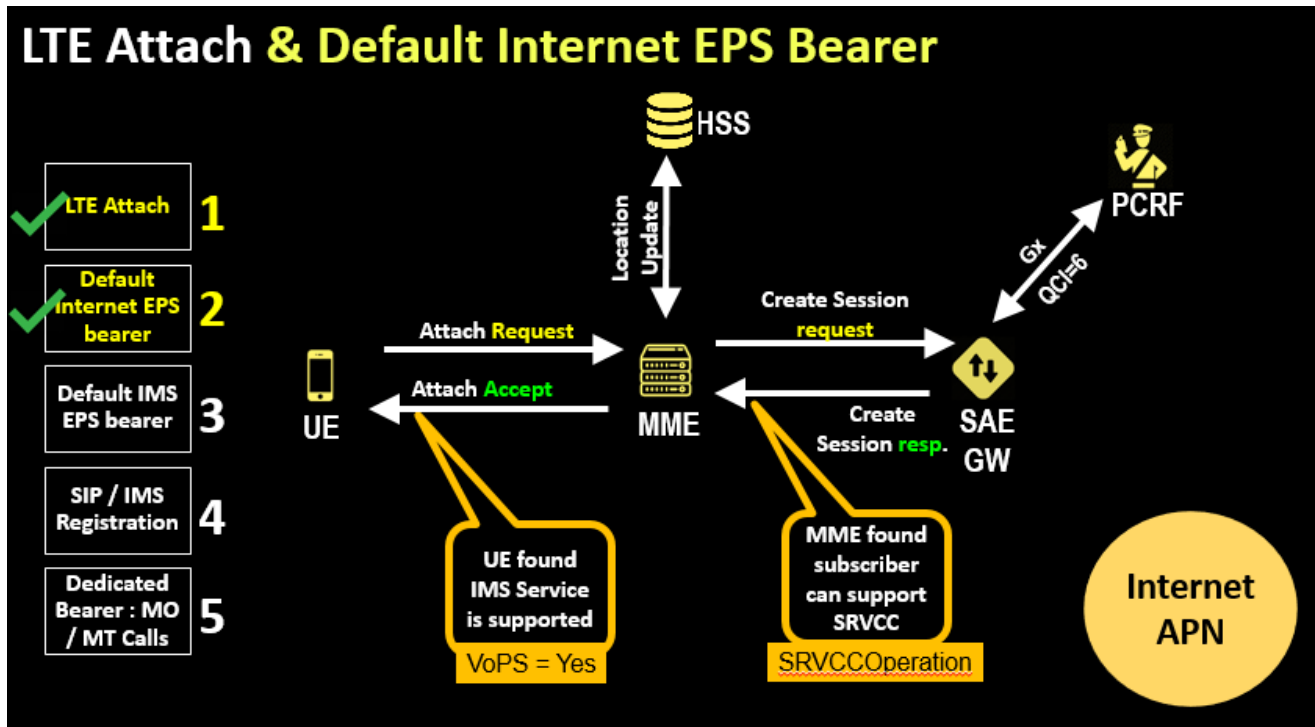


Before we jump onto Call flow , I would like to cover brief concept of QCI Mixed up with Default & dedicated bearer in VoLTE . When the UE is turned on, it establishes a PDN connection with a default APN. Typical operator provides two APNs, i.e., “Internet” APN and the “IMS” APN. The default APN is an “Internet” APN that is used for internet data traffic and its default EPS bearer has a QCI value between 6 to 9 . After the PDN connection is established with the internet APN, the UE attempts additional PDN connection with the IMS well known APN, i.e., “IMS APN”. The IMS APN is preconfigured in the UE and its default EPS bearer has a QCI value of ‘5’ being used for SIP signaling. Once the PDN connection with the IMS APN is completed and the default EPS bearer is successfully created, the UE is able to communicate with the IMS Core for VoLTE call service . We will discuss Attach procedure for IMS APN next Slide

- QCI-6 is a Default Bearer for Internet
- QCI-5 is another Default Bearer for establishing SIP Registration on IMS Network
- QCI-1 is dedicated Bearer established during voice calls , Similarly QCI-2 is established for Video Calls

LTE ATTACH & DEFAULT INTERNET EPS BEARER

VoLTE IMS SIP registration call flow procedure



Let's start with call flow, We can clearly see here :-

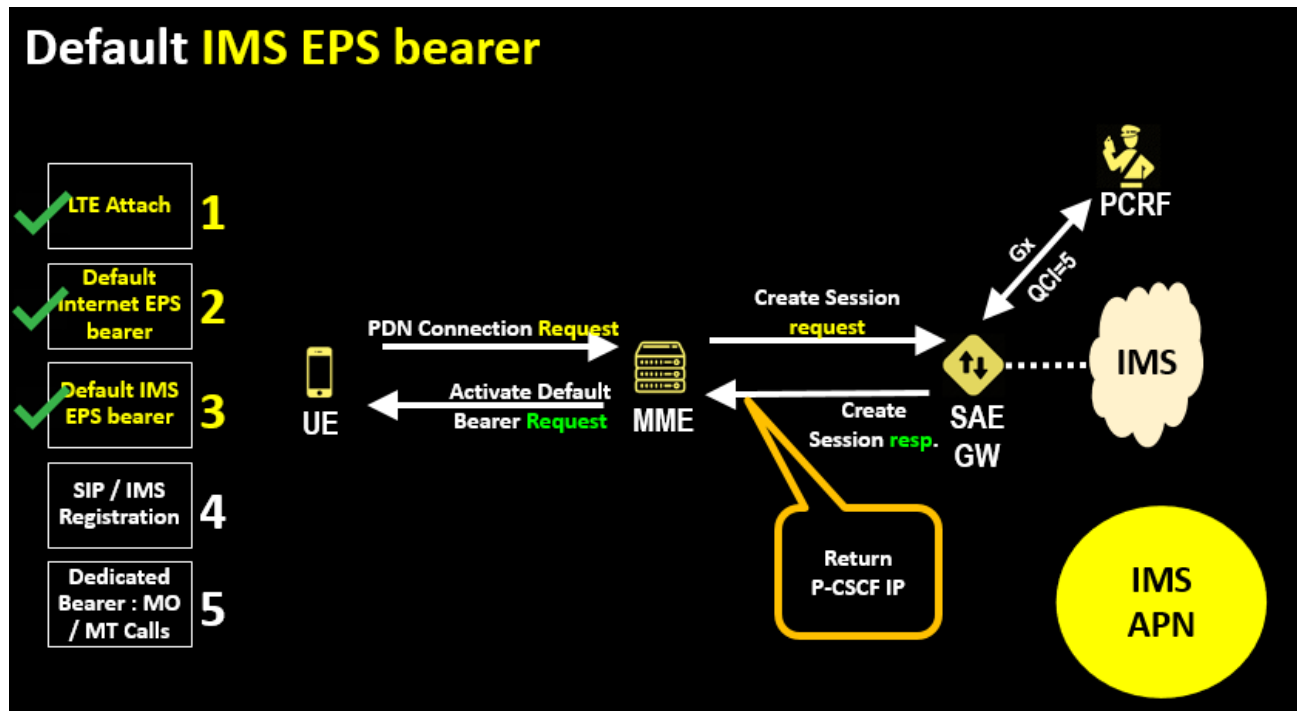
- UE sends Attach Request to MME in LTE Network, the MME sends an Update Location Request message to the HSS
- The HSS acknowledges the Update Location message by sending an Update Location Ack message to the MME, Here HSS Sends back complete profile of user. This profile also confirms to MME whether IMS APN is allowed for user or Not?
- Post Location Update, MME Sends Create Session Request to SGW / PGW
- The PGW will check with PCRF over Gx protocol & checks which QoS & Speed to be allocated to user
- As you are aware, Internet will be allocated Non Guaranteed Bit Rate with QCI between 6 to 9. This is best Effort Quality of service as per Radio conditions
- PGW / SGW will send Create Session response to MME which completes the transaction by completing Attach Process

There are two important information which is told to UE :-

- 1st Critical information is support of VoPS by Network. VoPS stands for Voice over PS Network support. MME confirms UE for VoLTE support by this Parameter
- 2nd important Information is support of SRVCC: This is communicated by Network to UE for support for SRVCC Function by Network

VoLTE IMS SIP registration call flow procedure

DEFAULT IMS EPS BEARER



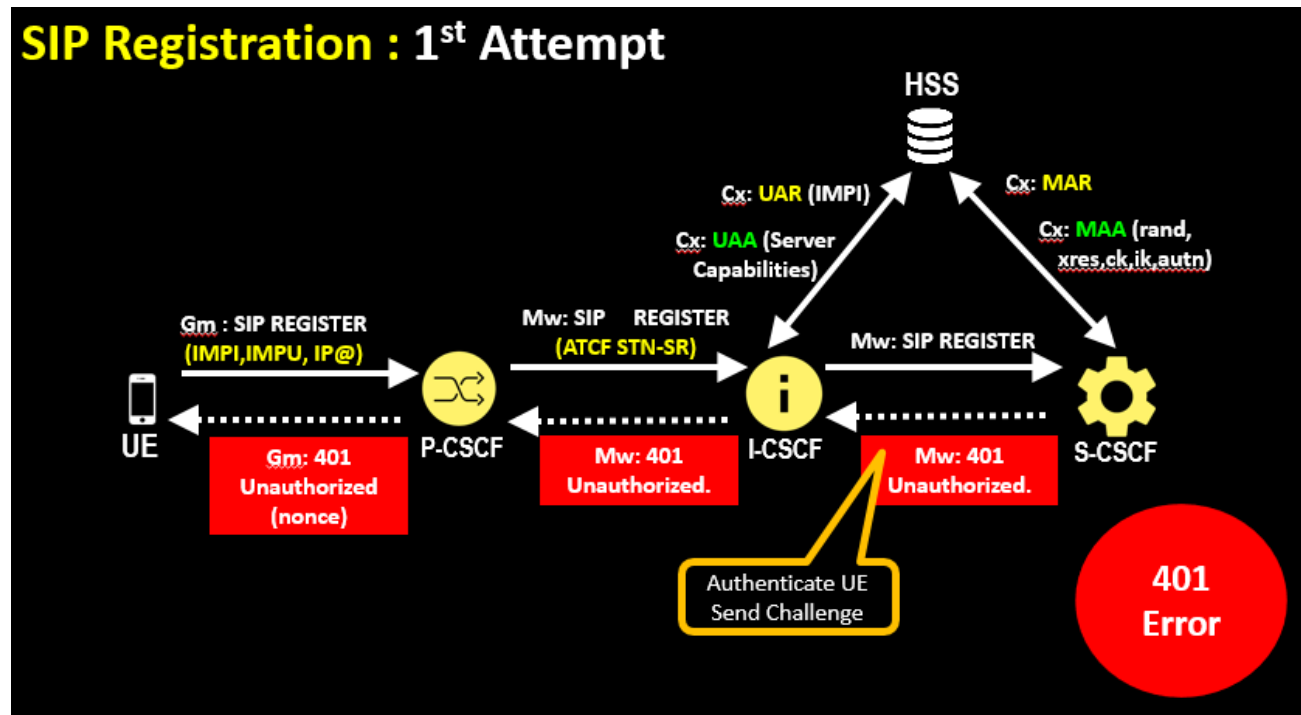
Now User is already connected to Internet , We are going to cover IMS APN Connectivity in this Slide which uses QCI = 5 for prioritized Access even in Congested scenarios

- The UE attempts additional PDN connection with “IMS APN”. The IMS APN is preconfigured in the UE and its default EPS bearer has a QCI value of ‘5’ being used for SIP signaling. Once the PDN connection with the IMS APN is completed and the default EPS bearer is successfully created, the UE is able to communicate with the IMS Core for VoLTE call service.
- UE sends PDN Connection Request to MME in LTE Network with IMS APN , the MME sends Create Session request to SAE GW
- The PGW ask PCRF over Gx on QOS to be supported here , PCRF replies back to PGW with QOS details which contains QCI=5
- SAE GW will send Create Session response to MME which completes the transaction by completing Activate default Bearer Request .

Here , One additional Parameter Protocol Configuration Option (PCO) is used for getting some additional information for a UE about a network that it is connecting to . In this case P-CSCF Address is sent to User with help of PCO Option . As next step , User will connect to P-CSCF for SIP Registration on IMS Network

VoLTE IMS SIP registration call flow procedure

SIP REGISTRATION : 1ST ATTEMPT



Once the UE attaches to the 4G network and the default EPS bearer is created successfully with the IMS APN, the UE registers to the IMS network before accessing the VoLTE service. The IMS registration procedure includes the IMS authentication, e.g., IMS-AKA, and security negotiation between UE and IMS network. After successful IMS registration, the IMS network becomes aware of UE context such as subscription profile, registration status, etc. After the initial IMS registration, the UE shall refresh the IMS registration status by periodically sending re-Registration.

First, the User Agent (UA) on the UE attempts to register with the IMS subsystem using an unauthenticated registration attempt as shown in this screen

- The First message is SIP Register which goes on Path from UE -to-> eNodeB -to-> SAEGW -to-> P-CSCF . The VoLTE UE initiates a SIP REGISTER to the P-CSCF, using the P-CSCF IP Address that was made available during the LTE Attach using PCO Parameter . The SIP Register contains This message includes a Public User ID, the Private User ID, and the home network SIP URI
- Now P-CSCF forward the SIP REGISTER to I-CSCF . The P-CSCF receives the SIP REGISTER request from the UE and inserts a Path header with a SIP-URI identifying the P-CSCF for routing and forwards the request to the I-CSCF. The I-CSCF name is determined via a DNS query or may be pre-configured within the P-CSCF
- Once I-CSCF got the SIP REGISTER message, it talks to HSS to get the detailed subscriber information for the User Authentication . With UAR (Diameter User Authentication Request), 2

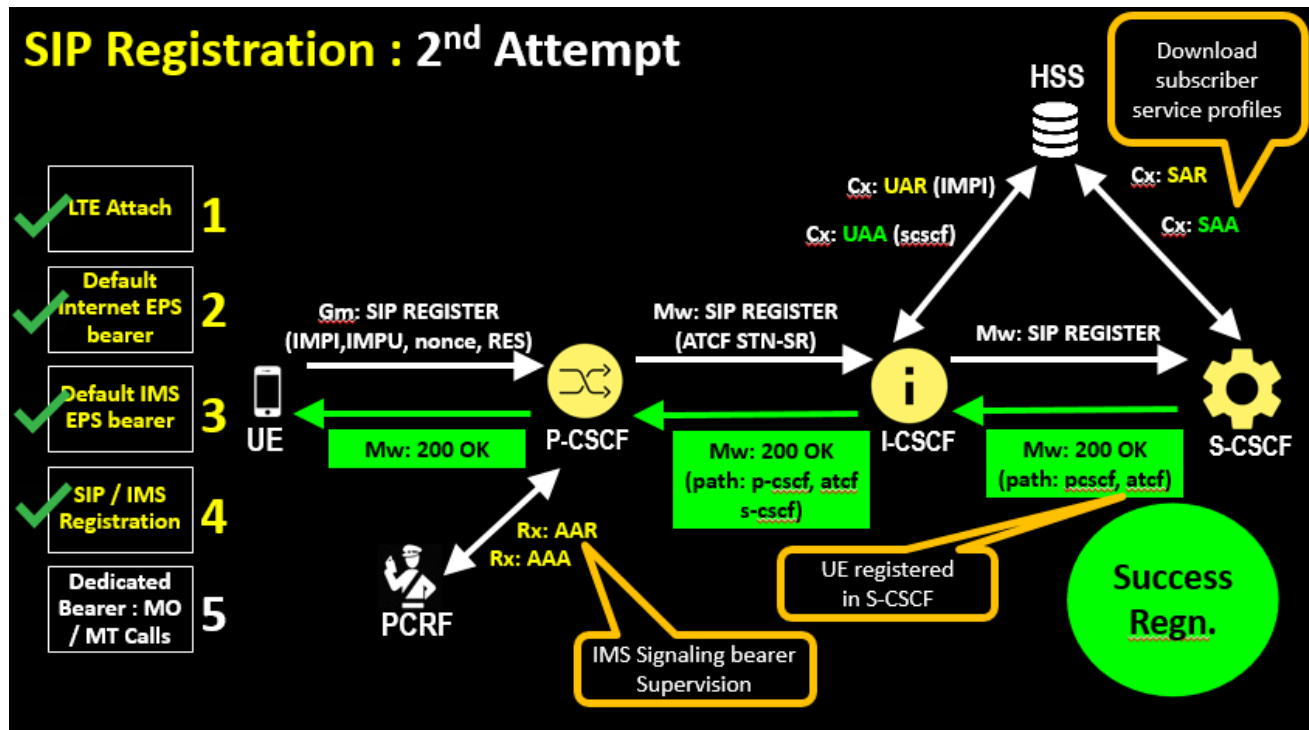
VoLTE IMS SIP registration call flow procedure

things are Retrieved :- 1st One is Authentication information and 2nd one is about S-CSCF information . The I-CSCF queries the HSS using the User Authorization Request for authorization and obtaining the S-CSCF name for the Public User Identity. The HSS validates that the Public User Identity and Private User Identity are valid and not barred . I-CSCF to select an appropriate S-CSCF on basis of HSS Response . Once the S-CSCF is identified, the I-CSCF forwards the SIP REGISTER request to the S-CSCF

- Now I-CSCF forward the REGISTER message to S-CSCF
 - S-CSCF send MAR (Multimedia Authentication Request) to HSS , The S-CSCF identifies that the SIP REGISTER is part of an initial IMS registration with IMS-AKA related security. The S-CSCF initiates a Multimedia Authentication Request to the HSS to retrieve the authentication vectors to perform IMS-AKA security. The HSS stores the related S-CSCF name for the Public User Identity being registered and returns the authentication vectors to the S-CSCF . HSS sends MAA (Multimedia Authentication Answer) to S-CSCF for Selecting & Saving Authentication vectors
 - Now , Something unusual happens here ... The S-CSCF challenges the UE at this point of time . Upon receipt of the IMS AKA authentication vectors, the S-CSCF stores the XRES and replies to the SIP REGISTER request with a 401 Unauthorized response indicating that AKAv1-MD5 is the security mechanism to be used.
 - I-CSCF forward the 401 Unauthorized – Authentication information to P-CSCF which is further forwarded to UE through LTE Access network
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VoLTE IMS SIP registration call flow procedure

SIP REGISTRATION : 2ND ATTEMPT



As we aware , The Previous SIP Register was challenged by S-CSCF & Returned back with Error 401 . Now , UE will send another SIP Register to Network

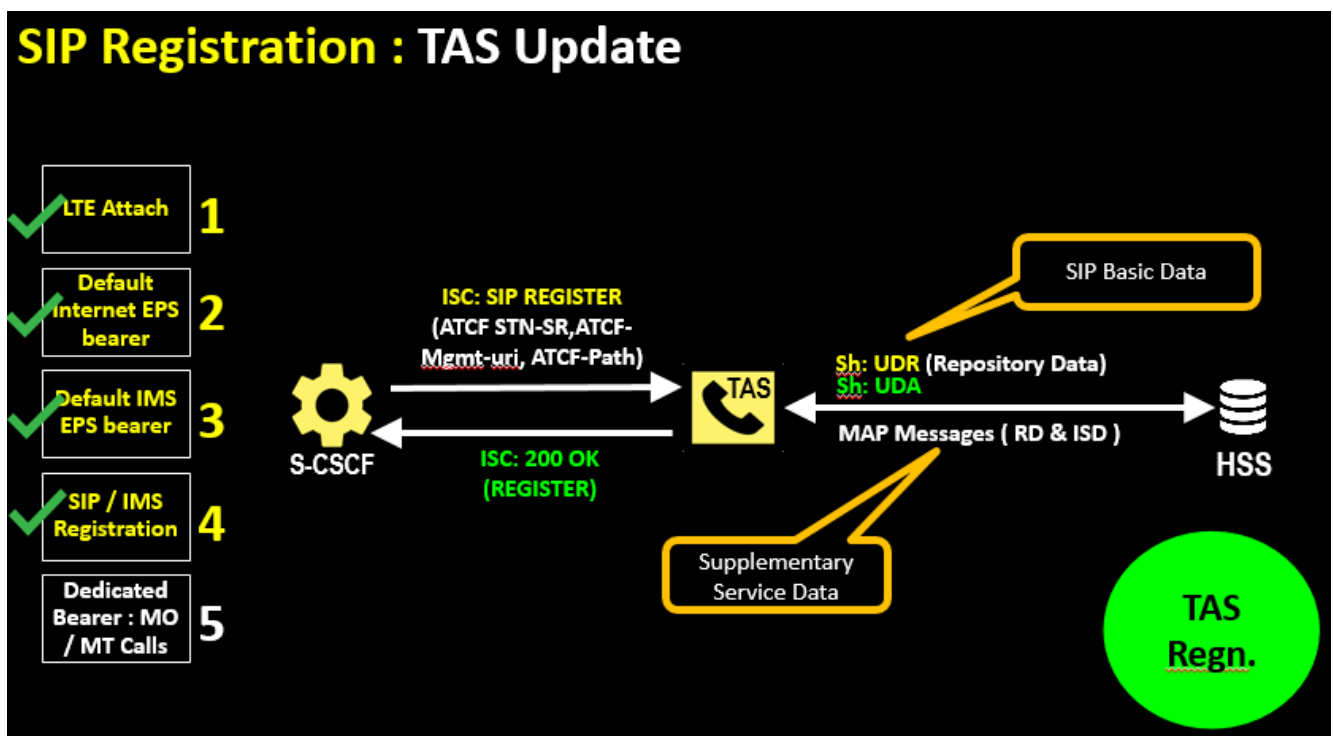
- The UE creates a temporary set of security associations based on parameters received from the P-CSCF (IPSec), and sends a new REGISTER request to the P-CSCF with a populated Authorization header containing the RES indicating that the message is integrity protected
- The P-CSCF checks the temporary security associations, and verifies the security related information received from the UE. This P-CSCF forwards the SIP REGISTER request to the I-CSCF with the RES included.
- The I-CSCF uses the User Authorization Request message to retrieve the S-CSCF name stored within the HSS,
- Now , I-CSCF forwards the request to the relevant S-CSCF
- The S-CSCF checks whether the RES received in the SIP REGISTER and the XRES previously stored match. The S-CSCF then 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.
- S-CSCF sends a 200 OK response to the I-CSCF

VoLTE IMS SIP registration call flow procedure

- On receipt of the 200 OK from the I-CSCF, the P-CSCF changes the temporary set of security associations to a newly established set of security associations. It protects the 200 OK with these associations and sends the 200 OK to the VoLTE UE. All future messages sent to the UE will be protected using the security associations
- P-CSCF sends an AAR message to the PCRF to perform application binding to the default bearer (i.e. the P-CSCF is requesting to be informed in the event of the default bearer being lost/disconnected in order to trigger an IMS de-registration). The PCRF performs the binding and responds with a AAA message to the P-CSCF. Note that if this message is not sent, then IMS relies on other mechanisms to detect loss of the underlying default bearer, i.e., loss of connectivity (e.g. timeouts on trying to signal to the UE for an incoming call or the UE registers in the IMS with a new IP address).

The VoLTE UE is now registered with the IMS network for VoLTE services, with SIP signaling being transported over the default EPC bearer.

SIP REGISTRATION : TAS UPDATE



The Role of Telephony Application Server (TAS) is cater all the Mobility Telephony part services such as address normalization, call diverting, call forwarding, barring, etc. In a nutshell TAS is what makes the VoLTE enhancements on top of the pure VoIP.

VoLTE IMS SIP registration call flow procedure

This procedure is done to update user profile in TAS so that further call handling can be done by TAS

- The S-CSCF entity registers the mobile with the TAS
- The TAS entity sends UDR (User Data Request) to HSS , This is used to retrieve mobile service data
- The Answer is provided by the HSS with UDA (User Data Answer) Message
- Optionally , TAS Updates Profile from HLR for supplementary services with help of MAP Restore Data & Insert Subscriber Data Messages
- Finally , TAS completes SIP-Register by Sending 200 OK to S-CSCF

Now we have covered complete VoLTE IMS SIP Registration with completion of this procedure

SIP REGISTRATION COMPLETION

The image shows a mobile phone interface with a list of steps for SIP Registration Completion on the left and a screenshot of the phone's status bar and settings on the right.

SIP Registration Completion

- 1 LTE Attach
- 2 Default Internet EPS bearer
- 3 Default IMS EPS bearer
- 4 SIP / IMS Registration

Ready

Dedicated Bearer : MO / MT Calls

The screenshot on the right shows the status bar with "VoLTE" and "LTE" symbols. Below it is the "Edit access point" settings screen, which has fields for "Name" and "APN".

Depending upon handset to handset , User will get VoLTE Symbol shown on handset as depicted on screen . In next Video , We will cover Call flows for Mobile Originating & Mobile Terminating call flows for VoLTE