VOLTE IMS KPI & PERFORMANCE

We are going to cover complete list of VoLTE IMS KPI and performance Indicators . This includes :-

VoLTE IMS Control Plane KPI

- RSR : Registration Success Ratio (%)
- CSSR : Call Setup Success Rate (%)
- CST : Call Setup Time (s)
- MHT/ACD : Average Call duration (s)

VoLTE IMS User Plane KPI

- Mute Rate (%)
- MOS Score (1-5)
- RTP Packet Loss (%)
- One Way Calls (%)

Packet Core 4G Network LTE KPI

- Volte Attach Success Rate (%)

- VoLTE QCI=5 Paging Success Rate (%)
- Dedicated Bearer Activation Success Rate (%)
- IMS IP POOL Utilization (%)
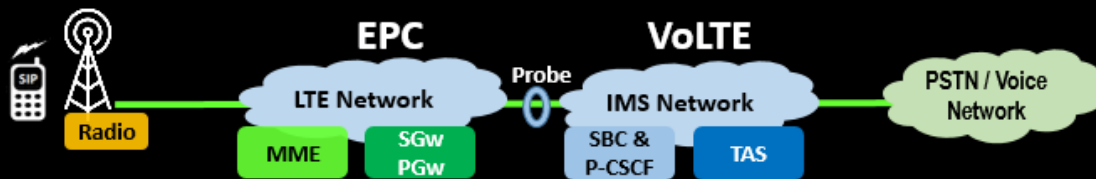- Create Bearer Success Rate (%)

Radio VoLTE KPI

- Call Drop rate (%)
- SRVCC Success Rate (%)
- Handover SR (%)

VoLTE KPI – Node Wise

**3GPP TS 32.454
3GPP TS 32.409
GSMA IR.42**

Welcome to this tutorial of KPI & Performance Indicators for VoLTE IMS Network . KPI stands for Key Performance Indicator & KPI is a type of performance measurement that helps you understand how your network is performing . In simple words , This represents the result and Score card of your Network . Every Operator decide which set of KPIs to be monitored based on market situations & network state . Here , I am covering exhaustive mandatory KPI list which is used almost everywhere in all the Operators ranging from AT&T USA to Korea to Japan to India to Middle East & Europe . The KPIs are classified into various categories such as Accessibility , Retainability , Integrity , Availability , Reliability , Utilization , Mobility etc..
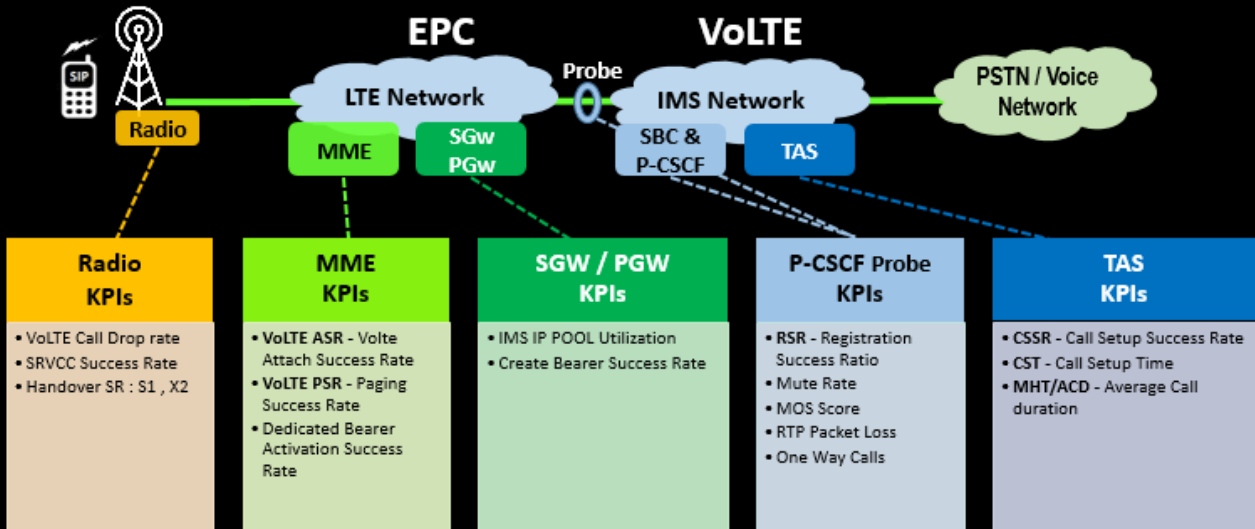
- For End to End VoLTE IMS network performance , You need KPI & Counters from all Network elements responsible to provide VoLTE IMS Service . This involves KPIs from S-CSCF / TAS which typically governs Signaling & call routing function
- Similarly KPIs of SBC & P-CSCF will provide you Insights of User plane which carries actual voice speech . You can see quality of voice payload traffic such as MOS , Mute Calls , One Way Calls etc .. by looking on these SBC KPI .
- Few Operator uses External probes to get these KPIs as well .
- On Other hand , You also need to see KPIs of Packet Core and Radio which plays vital role in maintaining user Mobility & dedicated bearer used for VoLTE IMS Service
- I am going to cover enough material on VoLTE KPI for General understanding , However you can refer Specs **3GPP TS 32.454 , TS 32.409 & GSMA IR.42** for advanced studies

VoLTE IMS KPIs & Performance indicators

VoLTE IMS KPIs & Performance indicators

3GPP TS 32.454
3GPP TS 32.409
GSMA IR.42

Radio KPIs
- VoLTE Call Drop rate
- SRVCC Success Rate
- Handover SR : S1 , X2

MME KPIs
- VoLTE ASR - Volte Attach Success Rate
- VoLTE PSR - Paging Success Rate
- Dedicated Bearer Activation Success Rate

SGW / PGW KPIs
- IMS IP POOL Utilization
- Create Bearer Success Rate

P-CSCF Probe KPIs
- RSR - Registration Success Ratio
- Mute Rate
- MOS Score
- RTP Packet Loss
- One Way Calls

TAS KPIs
- CSSR - Call Setup Success Rate
- CST - Call Setup Time
- MHT/ACD – Average Call duration

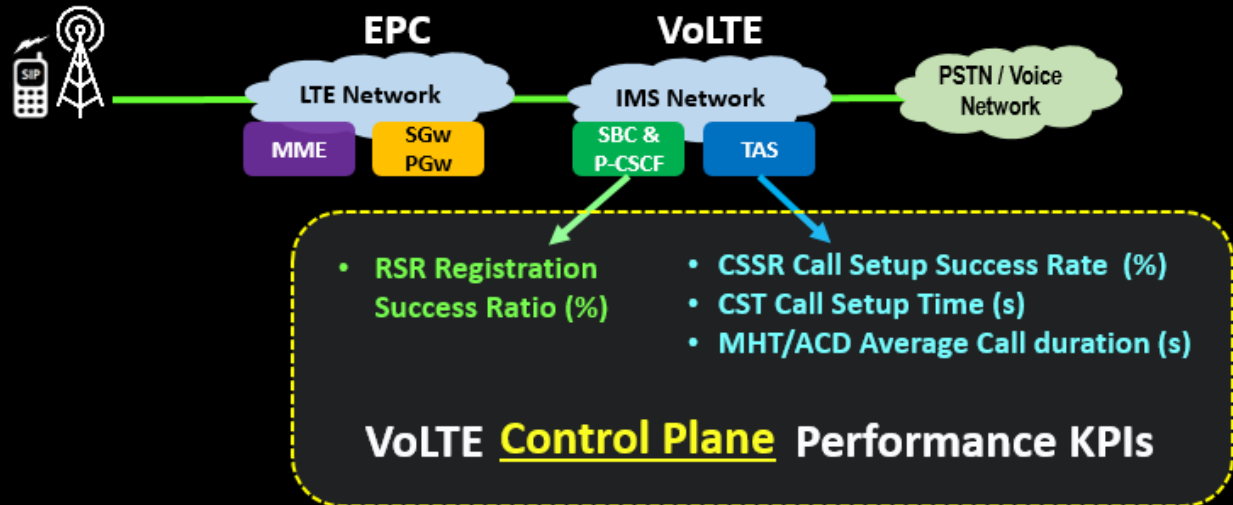These are Real KPIs used for VoLTE IMS Network :-

- The 1st One is **TAS KPIs** which provides clear insight on Signaling related KPIs such as CSSR – Call Setup Success Rate , CST – Call Setup Time & MHT/ACD – Average Call duration
- The 2nd One is **SBC KPIs** which gives us plenty of User Plane KPIs related with Speech Quality such as MOS Score , Mute Rate , RTP Packet Loss & One Way Calls
- This One is SGW / PGW KPI which gives us Bearer specific intelligence & KPIs
- Next One is **MME / SGW / PGW KPIs** provides us Attach , Mobility & Paging specific KPIs such as VoLTE ASR – Volte Attach Success Rate , VoLTE PSR – Paging Success Rate , Dedicated Bearer Activation Success Rate
- The last but most critical are **Radio KPIs** provided by EnodeB . These covers VoLTE Call Drop rate , SRVCC Success Rate , Handover SR : S1 , X2

Let's understand these KPIs in Detail moving ahead

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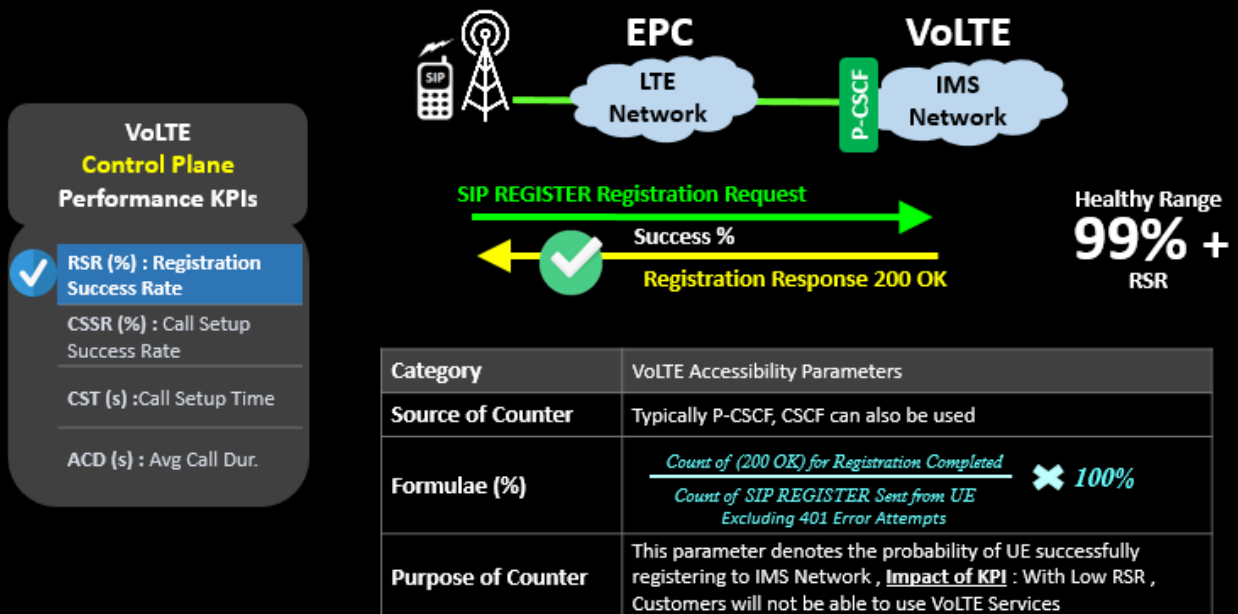**VoLTE Control Plane Performance KPIs**

We will start with detailed understanding of VoLTE Control Plane Performance KPIs .
These are generated by P-CSCF & TAS

- **P-CSCF KPI**
  - RSR which stands for Registration Success Ratio (%)
- **TAS Generates rest of KPIs such as**
  - CSSR Call Setup Success Rate (%)
  - CST Call Setup Time (s)
  - MHT/ACD Average Call duration (s)

RSR – VoLTE Registration Success Rate (%)

RSR – VoLTE Registration Success Rate (%)

RSR is also called as Registration Success Rate . This is key KPI used to depict the probability of UE successfully registering to IMS Network ,If this KPI is degraded , Customers will not be able to use VoLTE Services due failures in Registration .

RSR is calculated as % of SIP Registration Request getting successful . Once Registration is successful , The IMS network will reply back with 200 OK Message back to UE . Please Note , The First SIP REGISTER request will always fail with Error 401 which is part of call flow . Refer my another tutorial on SIP Registration for more details on same . While Calculating RSR , We exclude & ignore 401 Failures and Consider all other SIP Errors for calculation of RSR
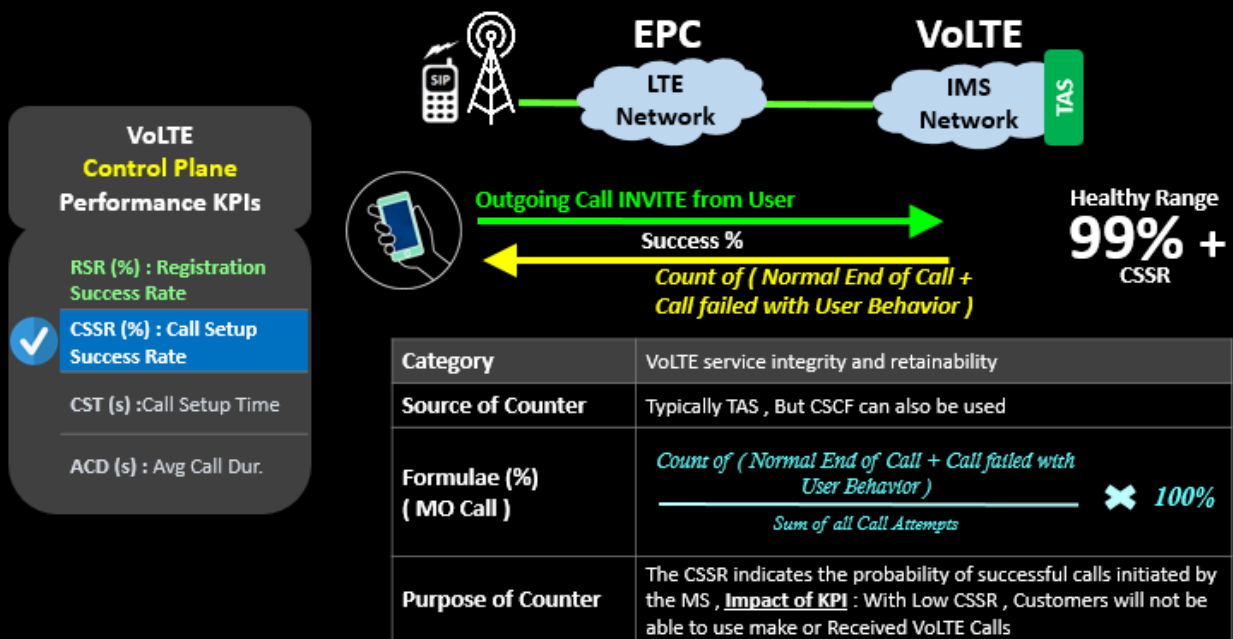
- This is measured in % . The healthy value of RSR is 99%+
- This KPI is categorized under family of Accessibility KPIs
- Source of this KPI is P-CSCF , However , this can also be generated by S-CSCF

Here is actual Call flow where request goes all the way from UE to P-CSCF to IMS Core & 200 OK Response is tagged as successful

CSSR – Call Setup Success Rate – MO , MT (%)

CSSR – Call Setup Success Rate – MO , MT (%)

CSSR tells you how easily users are able to make or receive calls on VoLTE Network . CSSR stands for Call Setup Success Rate . This is calculated separately for Outgoing MO & Incoming MT Calls . The CSSR indicates the probability of successful calls initiated or received by the user . With Low CSSR , Customers will not be able to use make or Received VoLTE Calls .

Outgoing or MO Call CSSR is calculated as % Calls of able to use network without any problem . Here we count calls failed due to user behavior such Busy , not reachable etc.. also in Normal Call ending or success . Calls failed due to Network issues will be treated as failure and will degrade CSSR
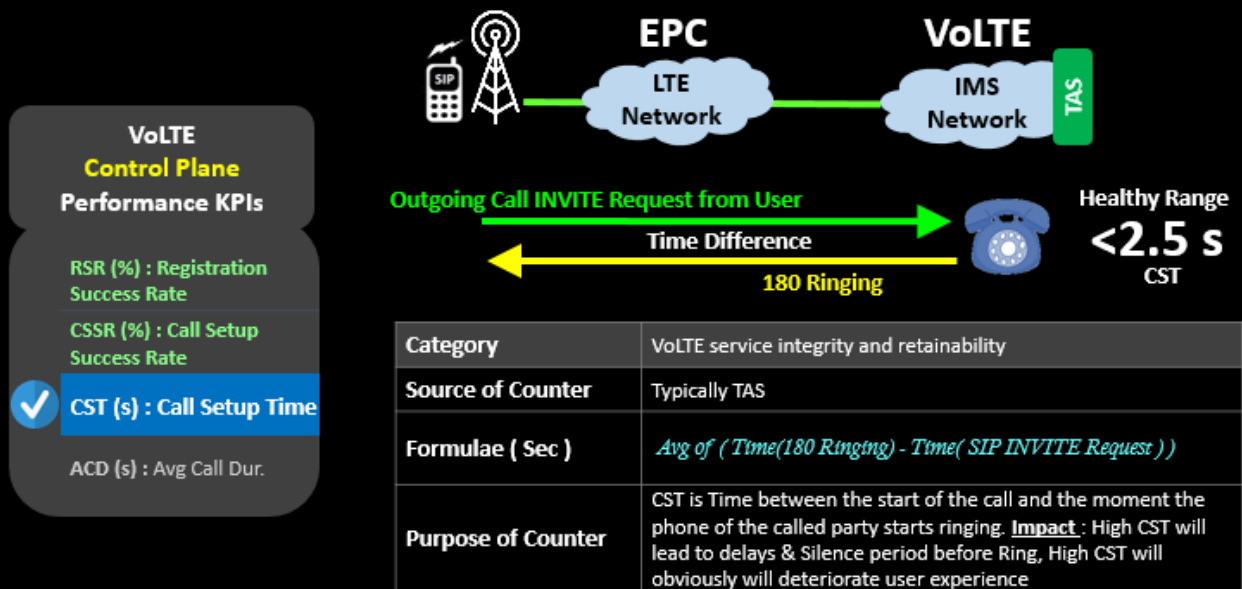
- This is measured in % . The healthy value of CSSR is 99%+
- This KPI is categorized under family of Integrity and retainability KPIs
- Typical Source of this KPI is TAS , However , this can also be generated by P-CSCF

Here is actual Call flow which shows request gone thru handset & responses from IMS Network

CST – Call Setup Time (s)

CST – Call Setup Time (s)

The 3rd critical KPI in IMS VoLTE Network is CST or Call Setup Time . CST is overall length of time required to establish a circuit-switched call between users . CST is Time between the start of the call and the moment the phone of the called party starts ringing. In other words CST or PDD is considered as the time required for call to pass thru Network and reaches B Party User . This is calculated as Difference between Ringing Time to Invite Time . High CST will lead to delays & Silence period before Ring, High CST will obviously will deteriorate user experience

- This is measured in Seconds . The healthy value of CST is Less than 2.5s
- This KPI is categorized under family of Integrity and retainability KPIs
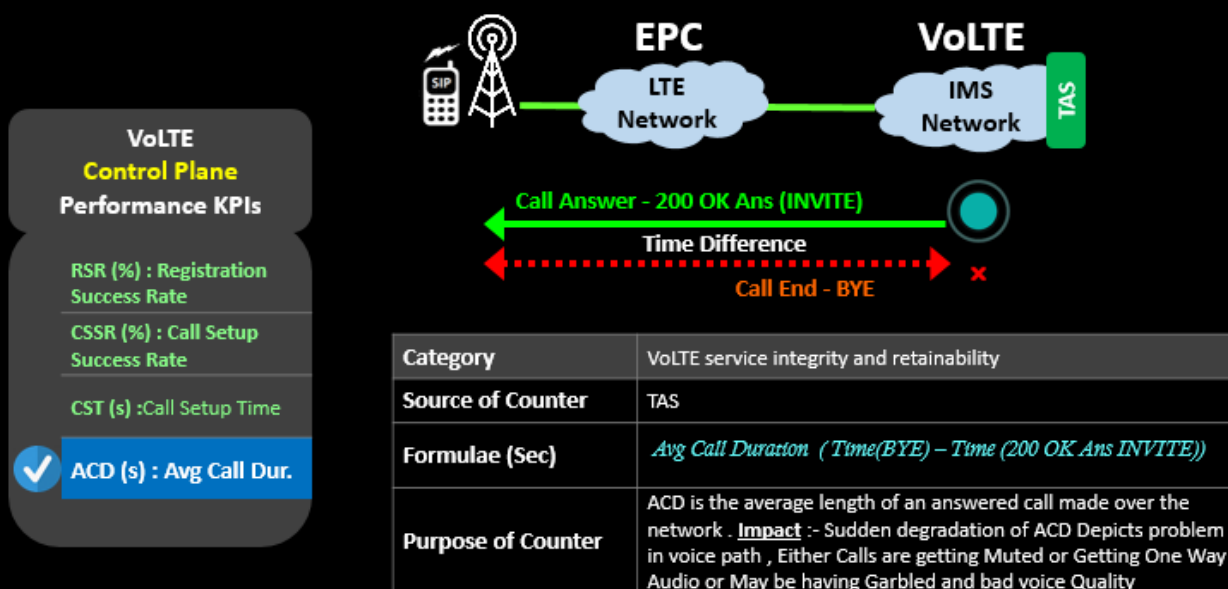- Typical Source of this KPI is TAS

There could very high CST which degrades user experience due to below reasons :-

- B party user is not in VoLTE , It will use 2G / 3G and CSFB for which Call Setup time is high
- B Party is Idle & Need to connect with Paging Required
- B Party is in low coverage
- Congestion in B Party Radio or Network
- High Re-Transmission & High Latency in Network
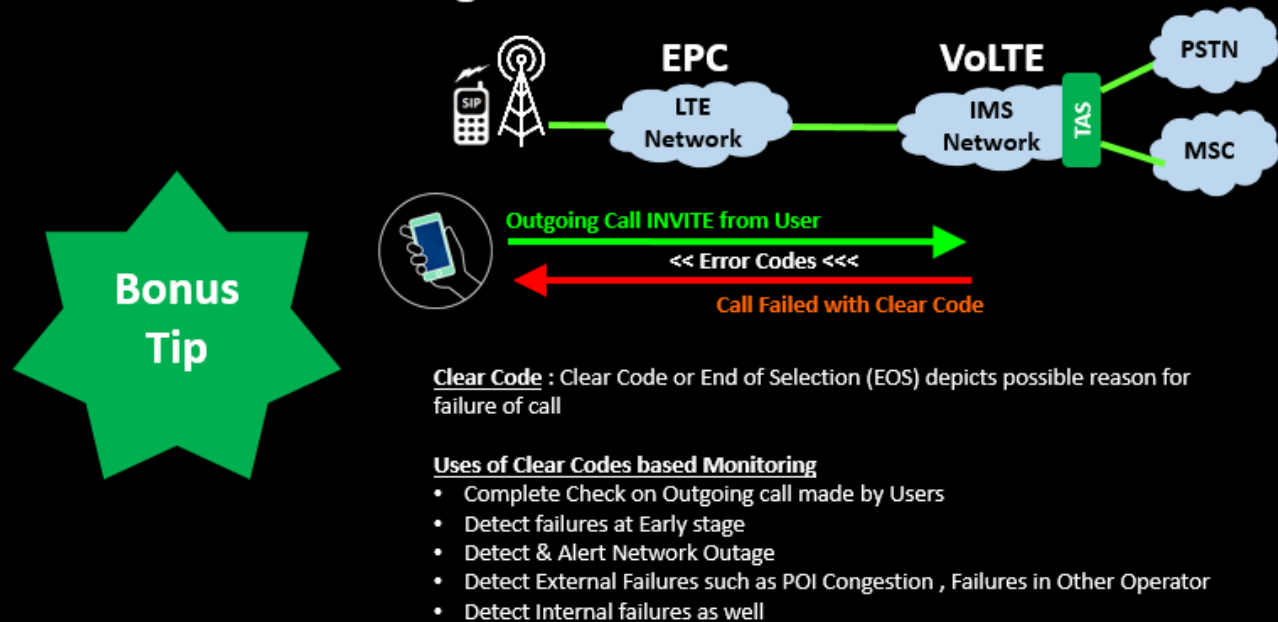
MHT or ACD – Average Call Duration (s)

MHT or ACD – Average Call Duration (s)

Let's discuss Mean Holding time or Average Call Duration . ACD is the average length of an answered call made over the network . This KPI falls under family of Control plane but reveals very important information about user plane , Let's take example , If Avg Call Duration have reduced in your network , This means that calls are being answered but there is some issue with Speech path . Low ACD or Low MHT shows either calls are getting mute or Its One Way Speech or Voice Quality is very bad leading to users forced to disconnect the call much earlier

Clear Code Monitoring in TAS

Clear Code Monitoring in TAS

Monitoring Clear Codes generated by TAS is best way to know health and Pulse of Network . By Definition … A clear code is the identifier code of the reason to clear a call . This not only tells us about Internal Network Call failures but also Highlights failures happening out side in other Operator Networks as well .

Clear Code or End of Selection (EOS) Report depicts possible reason for failure of call . This is complete list of cause codes which tell us exact reason why call failed . Let's take example , If we see sudden spike in CC34 No Circuit Channel Available .. This shows congestion in Network where calls are not able to move ahead .

Benefits Uses of Clear Codes based Monitoring

- It provides Complete Check on Outgoing call made by Users both External / Internal
- It Detect failures at Early stage , Any major outbreak of Clear codes gives us Alert on Network Outage

You can get list of clear Codes from Specs GSM 04.08 (Annexure H)

001 Unassigned (unallocated) number
002 No route to specific transit network
003 No route to destination
004 Send special info tone
005 Misdialled trunk prefix
006 Channel unacceptable

007 Call awarded and being delivered in establ.channel
008 Operator determined barring
009 Preemption – circuit reserved for reuse
016 Normal call clearing
017 User busy
018 No user responding
019 No answer from user (user alerted)
020 Subscriber absent
021 Call rejected
022 Number changed
026 Non-selected user clearing
027 Destination out of order
028 Invalid number format
029 Facility rejected
030 Response to STATUS ENQUIRY
031 Normal, unspecified
034 No circuit/channel available
038 Network out of order
039 Permanent frame mode connection out of service
040 Permanent frame mode connection operational
041 Temporary failure
042 Switching equipment congestion
043 Access information discarded
044 Requested channel/circuit not available
046 Precedence call blocked
047 Resource unavailable
049 Requested facility not subscribed
050 Requested facility not subscribed
053 Outgoing calls barred within CUG
055 Incoming calls barred within CUG
057 Bearer capability not authorized
058 Bearer capability not presently available
062 Inconsistency in designed outg. access inf. and subscr. class
063 Service or option not available, unspecified
065 Bearer capability not implemented
066 Channel type not implemented
068 ACM equal to or greater than ACMmax
069 Req.facility not implemented
069 Requested facility not implemented
070 Only restricted digital bearer cap. is available
079 Service or option not implemented, unspecified
081 Invalid call reference value
082 Identified channel does not exist
083 A suspended call exists, but this call identity does not
084 Call identity in use
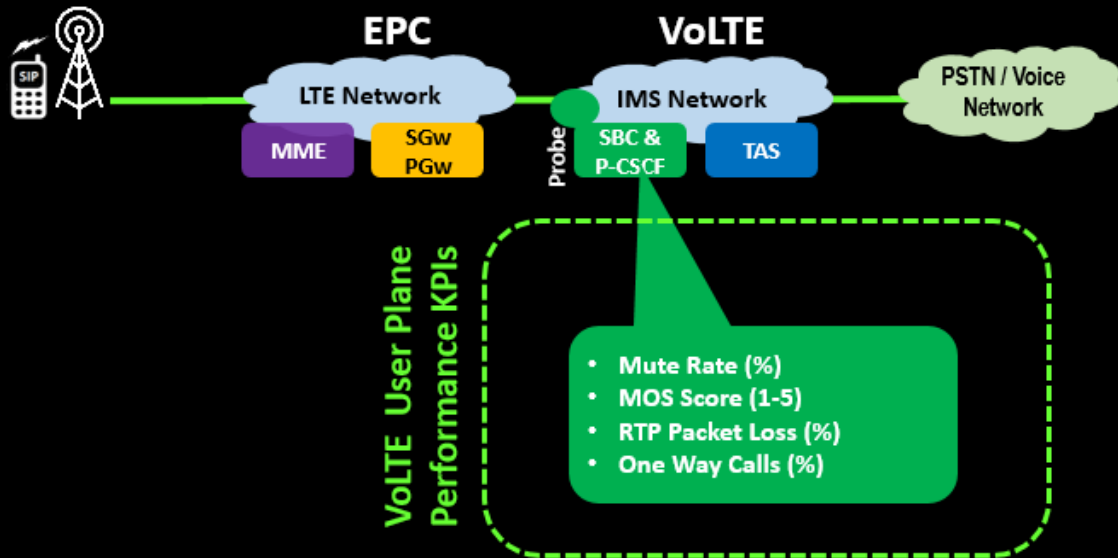
VoLTE IMS KPIs & Performance Indicators

085 No call suspended
086 Call having the requested call identity has been cleared
087 User not member of CUG
088 Incompatible destination
090 Non-existing CUG
091 Invalid transit network selection
095 Invalid message, unspecified
096 Mandatory information element is missing
097 Message type non-existing or not implemented
098 Message incompatible with call state or mesg type non-existent or not implemented
099 Information element non-existent or not implemented
100 Invalid information element contents
101 Message not compatible with call state
102 Recovery on timer expiry
103 Parameter non-existent or not implemented – passed on
110 Message with unrecognized parameter discarded "Protocol error, unspecified
113 Interworking, unspecified

VoLTE User Plane Performance KPIs

VoLTE User Plane Performance KPIs

3GPP TS 32.454
3GPP TS 32.409
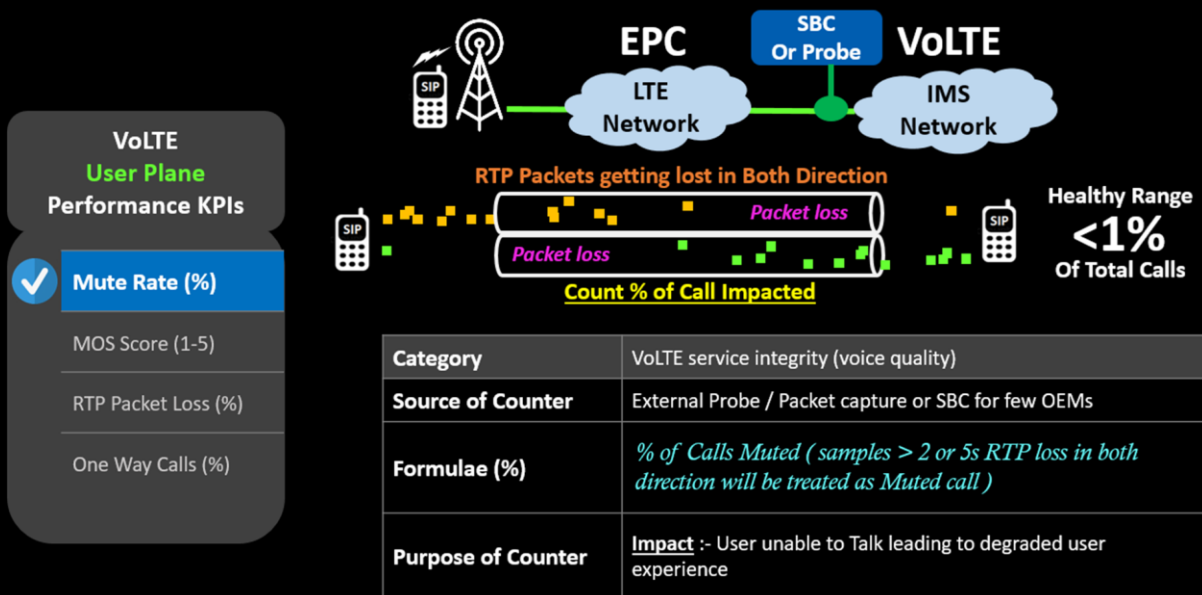GSMA IR.42

VoLTE User Plane Performance KPIs

Now , We will discuss understanding of VoLTE User Plane Performance KPIs . These are generated by SBC / P-CSCF or External Packet Captures Probes deployed in network

- **Mute Rate (%)**
- **MOS Score (1-5)**
- **RTP Packet Loss (%)**
- **One Way Calls (%)**

VoLTE Mute Rate (%)

VoLTE Mute Rate (%)

Mute Calls is measurement of % of Calls where call are getting mute in both direction . Going by Formulae ,this is *% of Calls Muted i.e. samples > 2 or 5s RTP loss in both direction will be treated as Muted call*
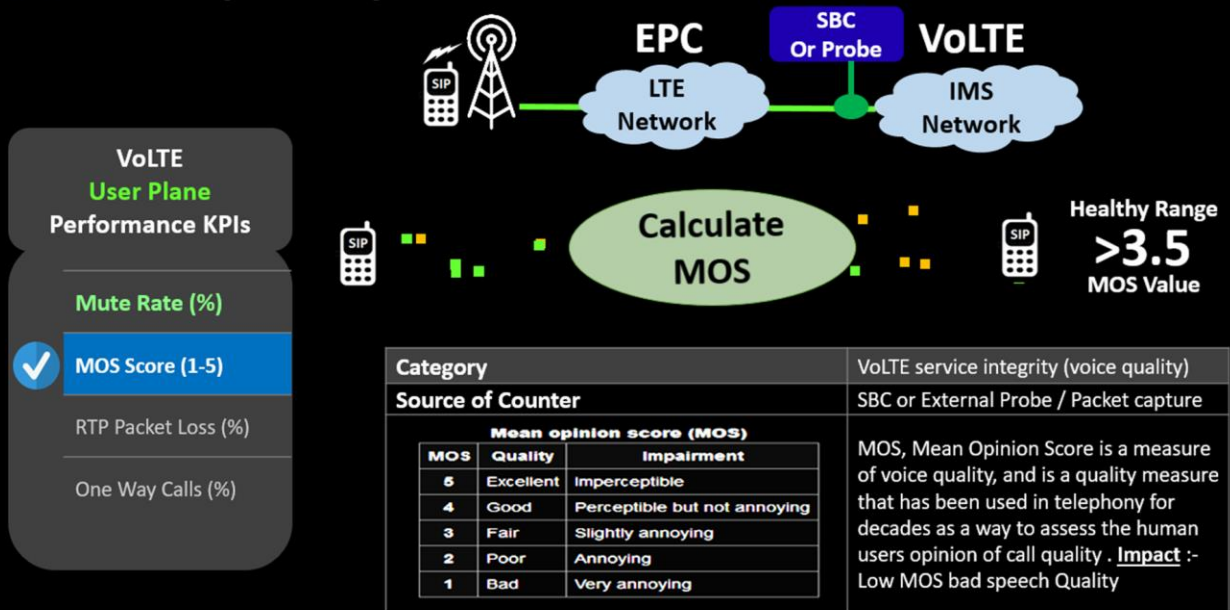
Here also , This value of RTP Packets missing varies from 2 to 5 Seconds operator to Operator . Unavailability of Packets for 2 Seconds is very aggressive value & 5 Seconds is bit relaxed

- This is measured in % . The healthy value of mute call is less than 1%
- This KPI is categorized under family of VoLTE service integrity (voice quality)
- This KPI is generated in External Probes monitoring RTP Packets or SBC

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VoLTE IMS KPIs & Performance Indicators

MOS Score (1 to 5)

MOS Score (1 to 5)

The Most Important Metric of Mean Opinion Score is a measure of voice quality, MOS has been used in telephony for decades as a way to assess the human users opinion of call quality .A Low MOS tell us that speech Quality is bad .

MOS is expressed in numeric from 1 to 5 , 1 being the worst and 5 the best. MOS is very very subjective, as it is based figures that result from what is perceived by people

The Mean Opinion Score Values

- **5** – Perfect. Like face-to-face conversation
- **4** – Fair , Some Quality issues , but sound still clear. This is (supposedly) the range for cell phones.
- **3** – Annoying
- **2** – Very annoying. Nearly impossible to communicate
- **1** – Impossible to communicate

Our Target should be to keep MOS Better than 3.5 & Its is measured by SBC Typically

By its very name "Opinion", the MOS, Mean Opinion Score was a subjective measurement used to test the listener's perception of the voice quality, and clarity of the communication . During measurement , All factors are taken in account such as Listening Quality , Transmission Quality , Conversational Quality

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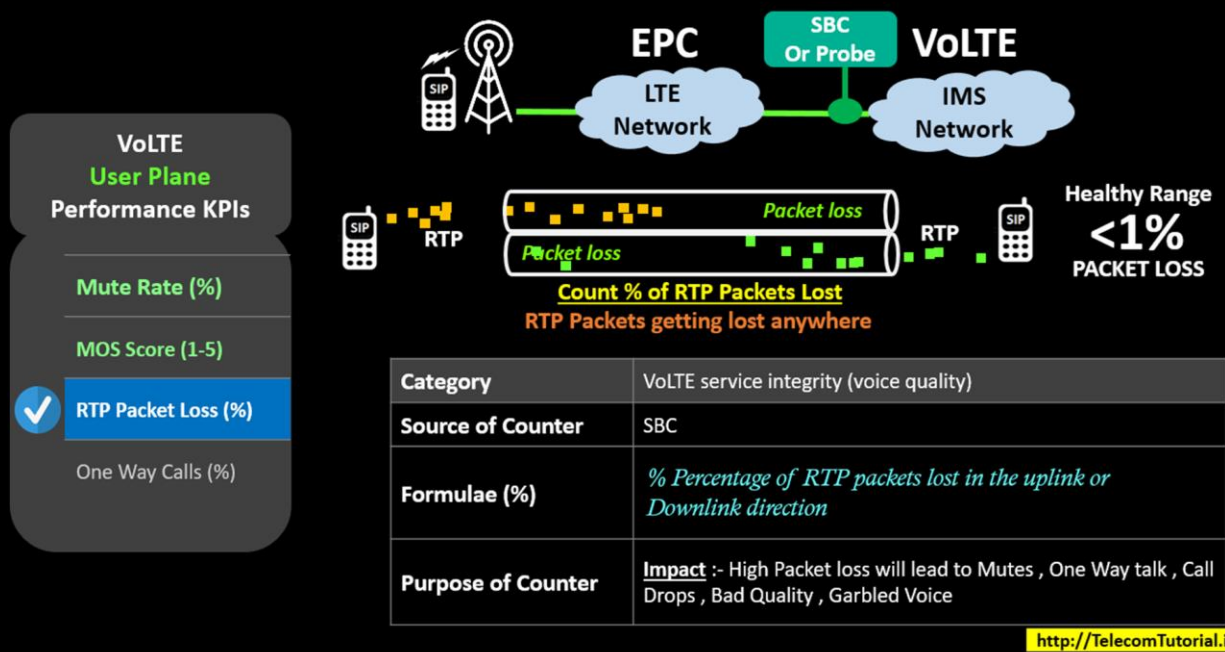
VoLTE IMS KPIs & Performance Indicators

It's important to understand that the MOS score is measured on a relative scale, built on a variety of factors that can affect voice quality. Because of this, there are many factors that can affect the MOS score on VoIP system that would not be a factor on a regular phone line. These include :-

- Bandwidth
- Jitter
- Latency
- Packet Loss
- Codec Used

VoLTE RTP Packet Loss %

VoLTE RTP Packet Loss %

EPC	SBC Or Probe	VoLTE
LTE Network		IMS Network

Count % of RTP Packets Lost
RTP Packets getting lost anywhere

Healthy Range
<1% PACKET LOSS

Category	VoLTE service integrity (voice quality)
Source of Counter	SBC
Formulae (%)	*% Percentage of RTP packets lost in the uplink or Downlink direction*
Purpose of Counter	**Impact** :- High Packet loss will lead to Mutes , One Way talk , Call Drops , Bad Quality , Garbled Voice

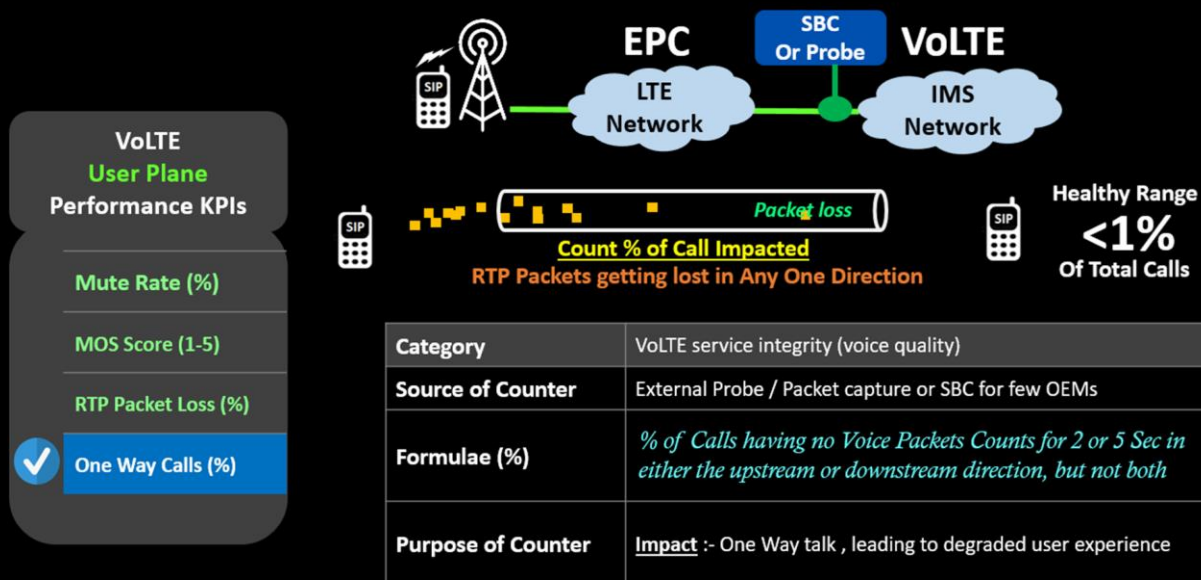http://TelecomTutorial.info

VoLTE RTP Packet Loss %

VoLTE RTP Packet Loss is another important KPIs which measures *% Percentage of RTP packets lost in the uplink or Downlink direction .* High Packet loss will lead to Mutes , One Way talk , Call Drops , Bad Quality , Garbled Voice . In total , This problem is mother of evils for Bad Quality on VoLTE IMS Network

- RTP Packet Loss is measured in % . The healthy value is less than 1%
- This KPI is categorized under family of VoLTE service integrity (voice quality)
- This KPI is generated in SBC

One Way Calls (%)

One Way Calls (%)

One Way Calls is measurement of % of Calls where call are getting mute in any one direction . Going by Formulae , This is *% of Calls having no Voice RTP Packets Counts for 2 or 5 Sec in either the upstream or downstream direction, but not both* . High number of one way call will lead to very bad user experience
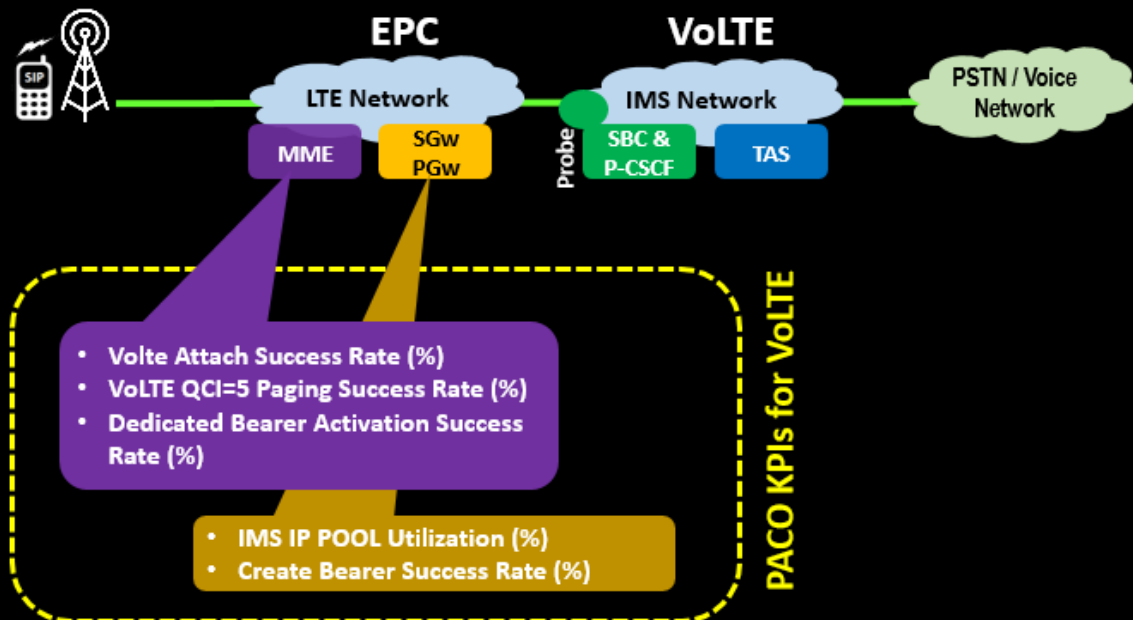
This value of RTP Packets missing varies from 2 to 5 Seconds operator to Operator . Unavailability of Packets for 2 Seconds is very aggressive value & 5 Seconds is bit relaxed

- This is measured in % . The healthy value of One way call is less than 1%
- This KPI is categorized under family of VoLTE service integrity (voice quality)
- This KPI is generated in External Probes monitoring RTP Packets or SBC

LTE / 4G – VoLTE KPIs & Performance indicators

LTE 4G – VoLTE KPIs & Performance indicators

Let's discuss other KPIs being generated by Packet Capture network

MME Generates counter / KPIs associated with Mobility & Attach :-

- VoLTE Attach Success Rate (%)
- VoLTE QCI=5 Paging Success Rate (%)
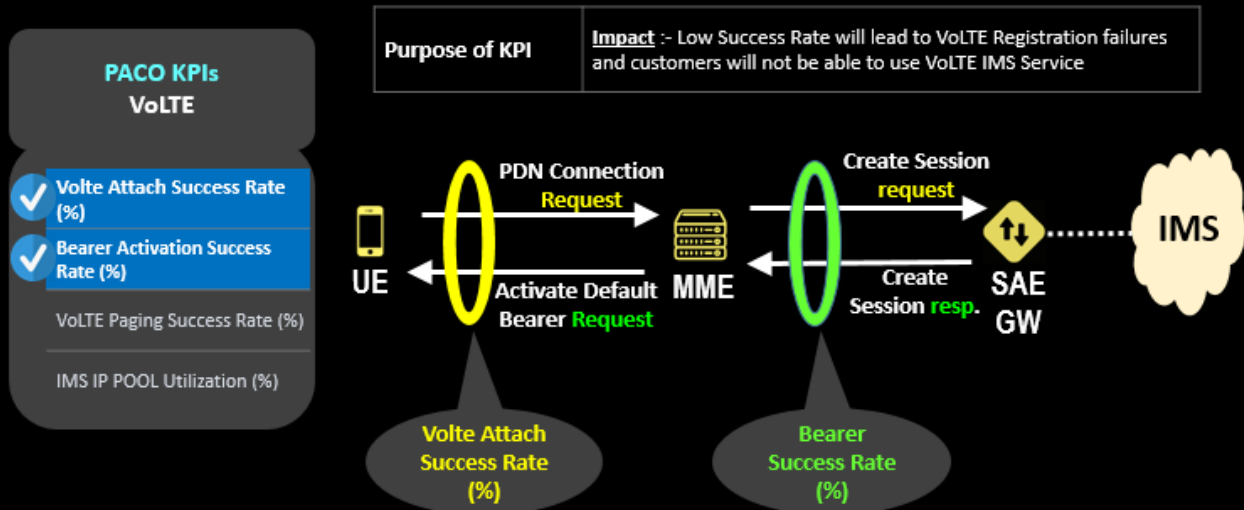- Dedicated Bearer Activation Success Rate (%)

SGw / PGw also Generates counters associated with Bearers :-

- IMS IP POOL Utilization (%)
- Create Bearer Success Rate (%)

VoLTE Attach Success Rate (%) &
VoLTE Bearer Activation Success Rate (%)

VoLTE Attach Success Rate (%) & VoLTE Bearer Activation Success Rate (%)

VoLTE Attach Success Rate (%) & VoLTE Bearer Activation Success Rate (%)
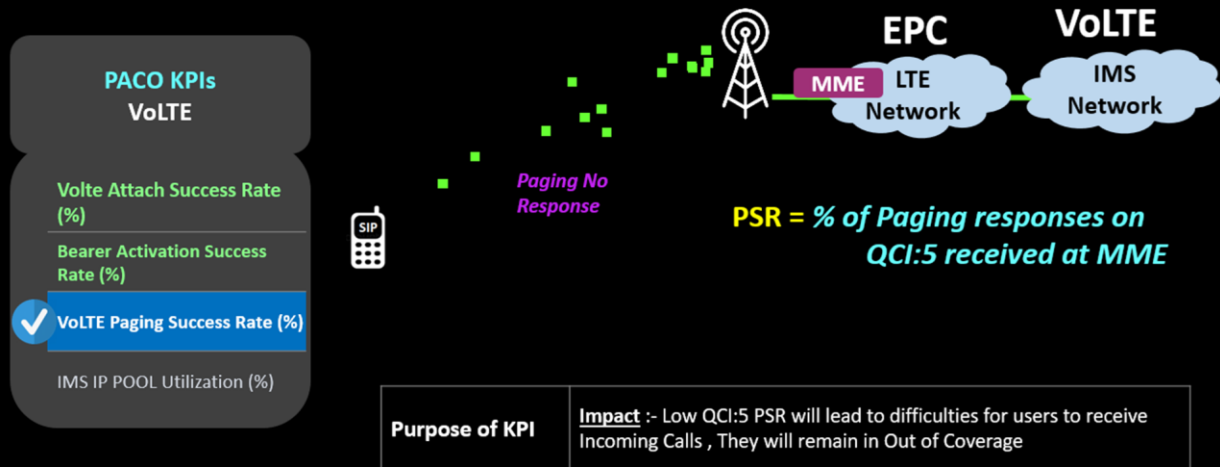
Let's understand 2 important VoLTE IMS KPIs generated on MME / SGW ..

1. VoLTE Attach Success Rate : % of PDN Connect Request responded successfully by MME for IMS APN (This is equivalent to Attach Request – Response)
2. VoLTE Bearer Activation Success Rate : % of Create Session request got successful

VoLTE PSR – Paging Success Rate (%)

VoLTE PSR - Paging Success Rate (%)

PACO KPIs
VoLTE

Volte Attach Success Rate (%)

Bearer Activation Success Rate (%)

✔ **VoLTE Paging Success Rate (%)**

IMS IP POOL Utilization (%)

Paging No Response

EPC

VoLTE

MME LTE Network

IMS Network

PSR = % of Paging responses on QCI:5 received at MME

Purpose of KPI | **Impact** :- Low QCI:5 PSR will lead to difficulties for users to receive Incoming Calls , They will remain in Out of Coverage

http://TelecomTutorial.info
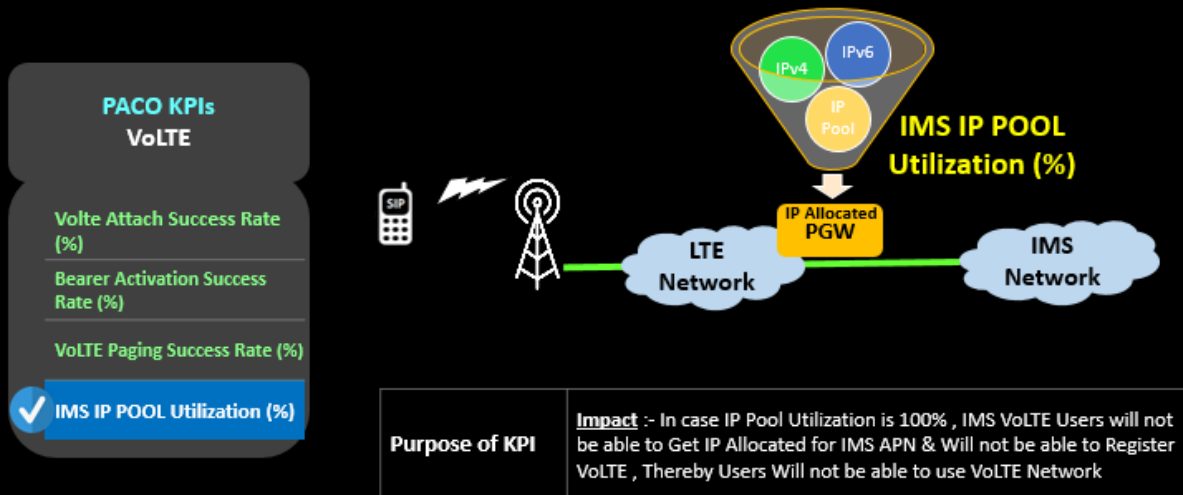
VoLTE PSR – Paging Success Rate (%)

VoLTE PSR : VoLTE Paging Success Rate is rate of successful page responses to First and Repeated Page Attempts made for QCI=5 . Paging Success Rate is just like any paging request which is used to trace down user sitting idle out there in Field . For Every incoming call to VoLTE user , Paging is sent by MME to user on QCI=5 so that SIP Messages for Incoming calls can be sent to user

- Low VoLTE PSR means user will not be able to receive VoLTE Incoming calls .
- In case of Paging failure , T-ADS will happen and call be attempted on CS Fall Back .
- More Number of T-ADS will hint us problem with VoLTE Paging

VoLTE IMS IP POOL Utilization (%)
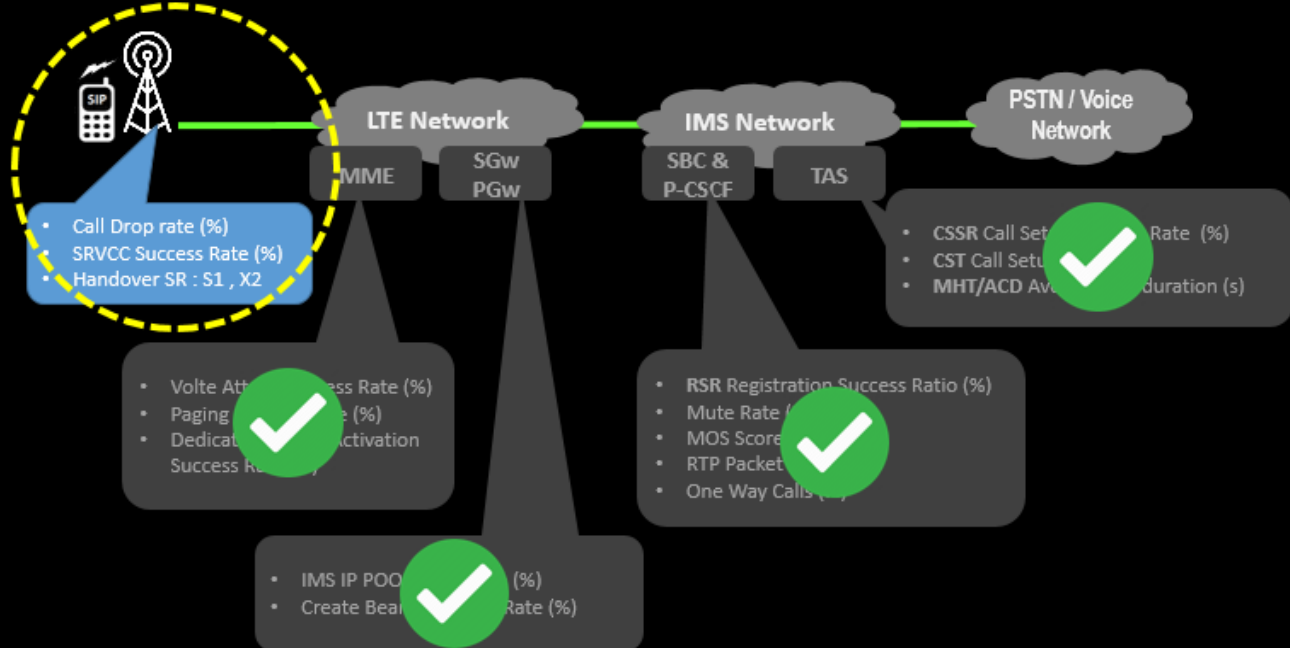

VoLTE IMS IP POOL Utilization (%)

Just like Internet APN , There is IP Pool allocated to IMS APN as well . For any Dedicated bearer establishment for VoLTE Services , IP is allocated by PGW from this IP Pool of IMS APN . In case IP Pool Utilization is 100% , IMS VoLTE Users will not be able to Get IP Allocated for IMS APN & Will not be able to Register VoLTE , Thereby Users Will not be able to use VoLTE Network

We can allocate both IPv6 or IPv4 IP Pool to user for IMS

Radio / EnodeB KPIs

Radio – EnodeB KPIs

Radio Network EnodeB is also generating few critical KPIs required for overall health of VoLTE IMS Network . These KPIs are :-

- Call Drop rate (%) : This tells us % of calls getting dropped abnormally . This is calculated on QCI=5 Bearers dropped abnormally
- SRVCC Success Rate (%) : This tells us % of calls successfully transferred with SRVCC from VoLTE to 2G / 3G Network once user is moving on low LTE Coverage Zone
- Handover SR (%) : Handover Success Rate on S1 & X2 is key to Mobility Services for VoLTE . This is measured at EnodeB

With this , Our KPI Journey is complete , Hope this will bring more value for you