

EN-DC / MR-DC

- [Secondary Node Addition \(SCG Add\)](#)
- [Secondary Node Modification \(SCG Mod on same gNB\) – MN Initiated](#)
 - [Secondary Node Modification \(SCG Mod on same gNB\) – SN Initiated with MN Involved](#)
 - [Secondary Node Modification \(SCG Mod on same gNB\) – SN Initiated without MN Involved](#)
 - [Secondary Node Modification \(SCG Mod on same gNB\) – Continued from previous](#)
 - [Secondary Node Modification \(SCG Mod on same gNB\) – Continued from previous](#)
- [Secondary Node Release \(SCG Release\) – MN/SN Initiated](#)
- [Secondary Node Change \(SCG handover\) – MN Initiated](#)
- [Secondary Node Change \(SCG handover\) – SN Initiated](#)
- [Inter-MN Handover \(with/without SN change\)](#)
- [MN to eNB/gNB Change](#)
- [eNB/gNB to MN Change](#)
- [RRC Transfer \(when split SRB is utilized\)](#)
- [RRC Transfer \(For special cases in red below\)](#)
- [Secondary RAT Usage Reporting](#)
- [Inter-System Handover](#)
- [Supported Handover b/w MR-DC](#)

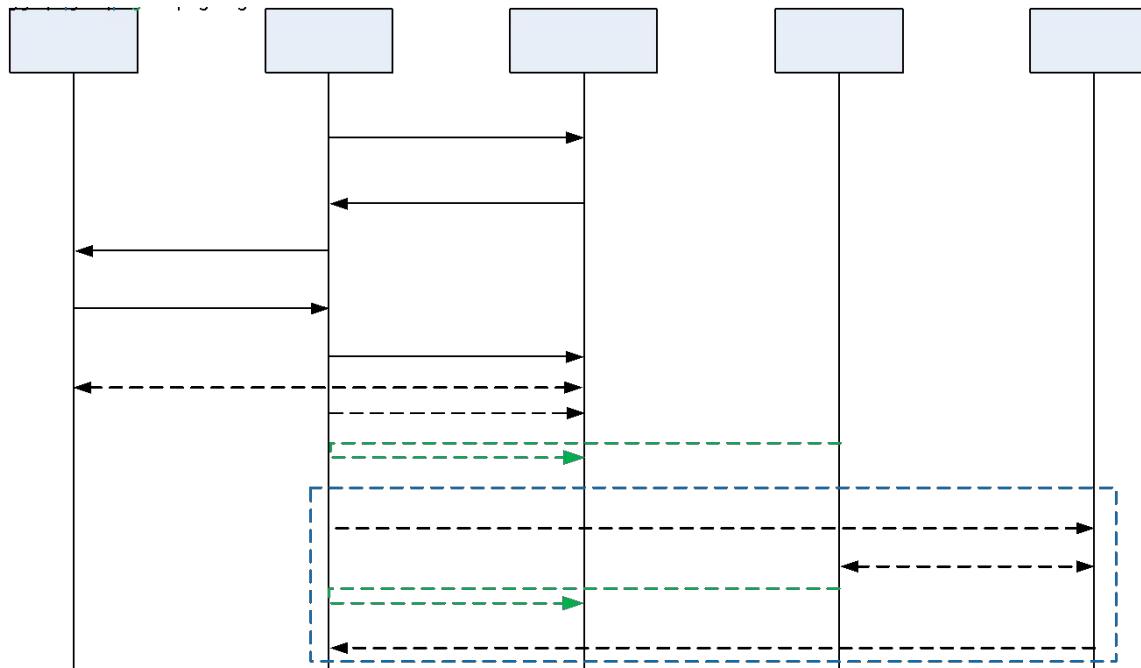
VoLTE

- Local
 - [VoLTE UE Attachment and IMS Registration message sequence](#)
 - [VoLTE UE Attachment and IMS Registration message sequence – Continued from previous](#)
 - [VoLTE UE Initiated Detach & IMS Deregistration](#)
 - [VoLTE to VoLTE MO Call](#)
 - [VoLTE to VoLTE MT Call](#)
 - [VoLTE to VoLTE Call Clearing \(Initiating Side Sequence\)](#)
 - [VoLTE to VoLTE Call Clearing \(Receiving Side Sequence\)](#)
 - [VoLTE MO to CS Call](#)
 - [VoLTE MT to CS Call](#)
 - [VoLTE to CS Call Clearing \(VoLTE Side Initiated\)](#)
 - [VoLTE to CS Call Clearing \(VoLTE is Receiving side\)](#)
 - [QCI to DSCP Recommended Mapping](#)
- Interconnect
 - [VoLTE Interconnect Architecture](#)
 - [VoLTE UE to Peer IMS Call \(MO\)](#)
 - [VoLTE UE to Peer IMS Call \(MT\)](#)
 - [VoLTE UE to Peer IMS Call Clearing \(VoLTE side initiated\)](#)
 - [VoLTE UE to Peer IMS Call Clearing \(VoLTE side receiving\)](#)
- Roaming
 - [Roaming VoLTE Architecture](#)
 - [Roaming VoLTE UE Attach](#)
 - [Roaming VoLTE UE Initial IMS Registration](#)
 - [Roaming VoLTE UE IMS Deregistration](#)
 - [Roaming VoLTE UE Initiated Detach](#)
 - [Roaming VoLTE to VoLTE MO Call](#)
 - [Roaming VoLTE to VoLTE MT Call](#)
 - [Roaming VoLTE to VoLTE Call Clearing \(Initiated by Roamer\)](#)
 - [Roaming VoLTE to VoLTE Call Clearing \(Received by Roamer\)](#)
- [VoLTE Packet Drops](#)

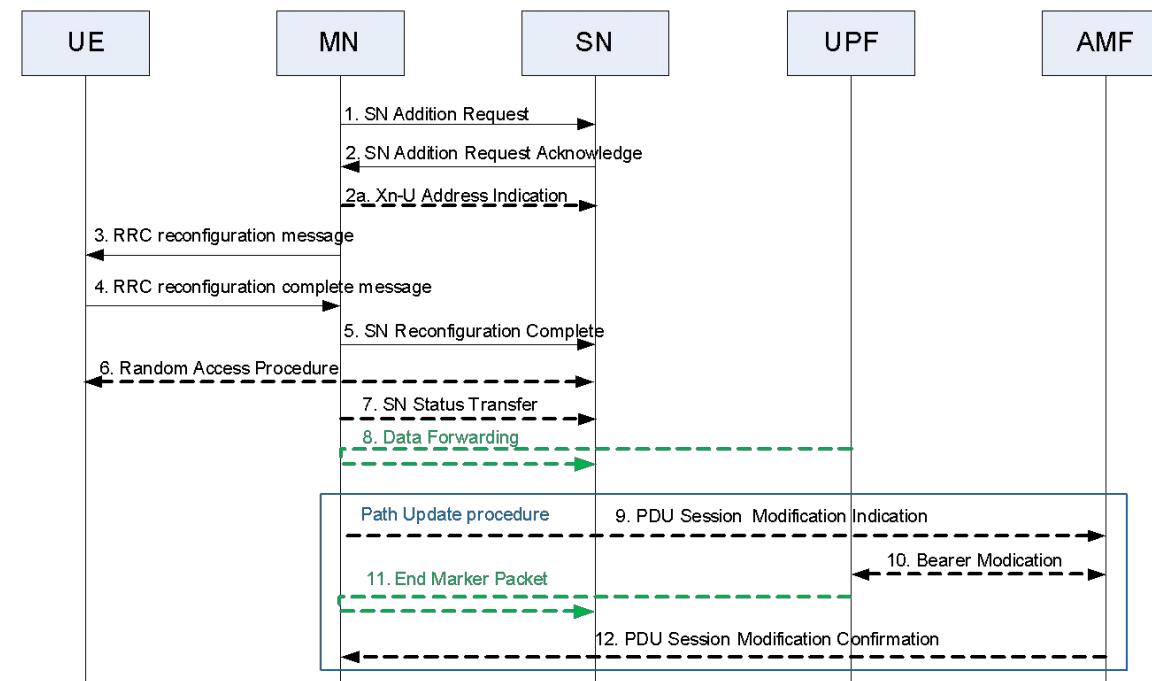
You are free to use/modify/share the contents. Please update the version number if you do so.

Procedure	Secondary Node Addition (SCG Add)
Specification	37.340
Section	10.2 [TS 37.340 V16.5.0]

EN-DC

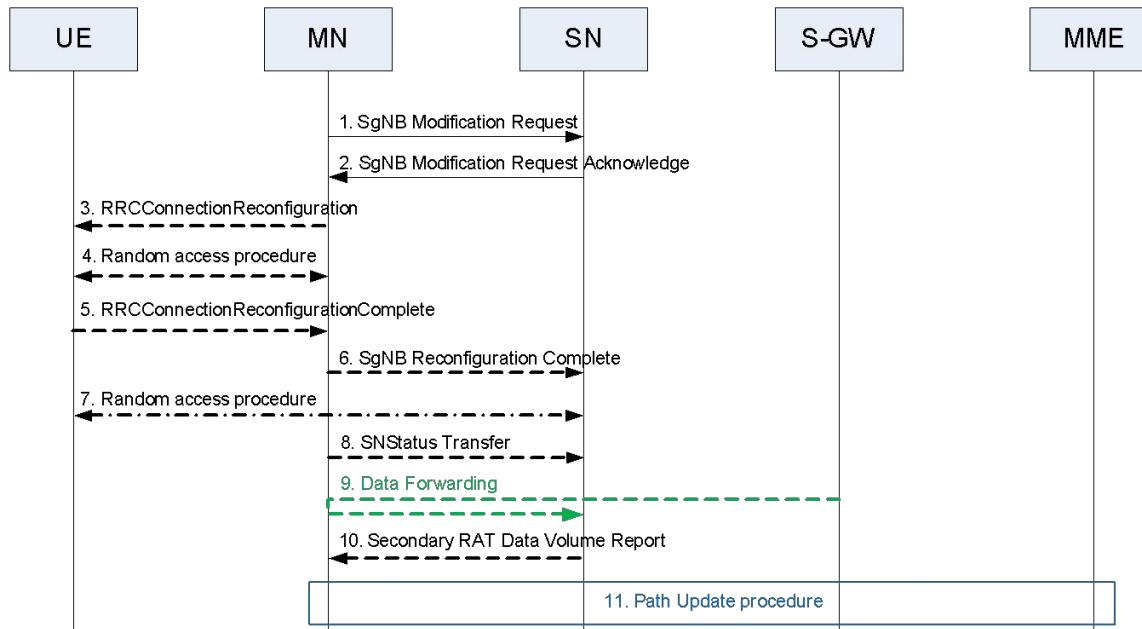


MR-DC with 5GC

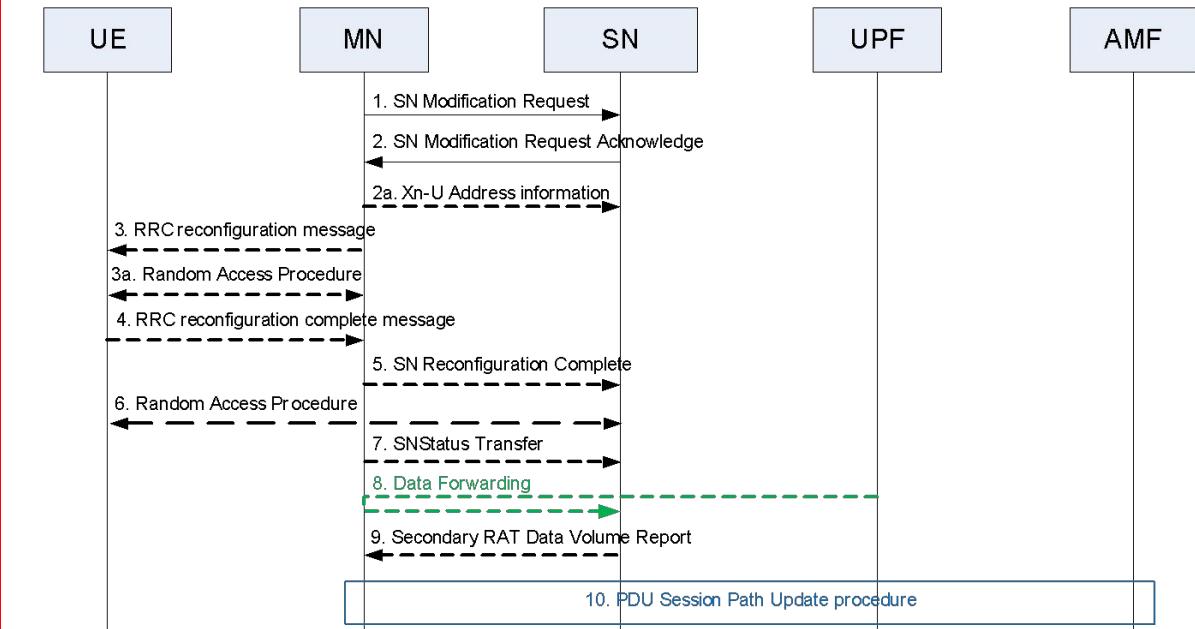


Procedure	Secondary Node Modification (SCG Mod on same gNB)
Specification	37.340
Section	10.3 [TS 37.340 V16.5.0]

EN-DC



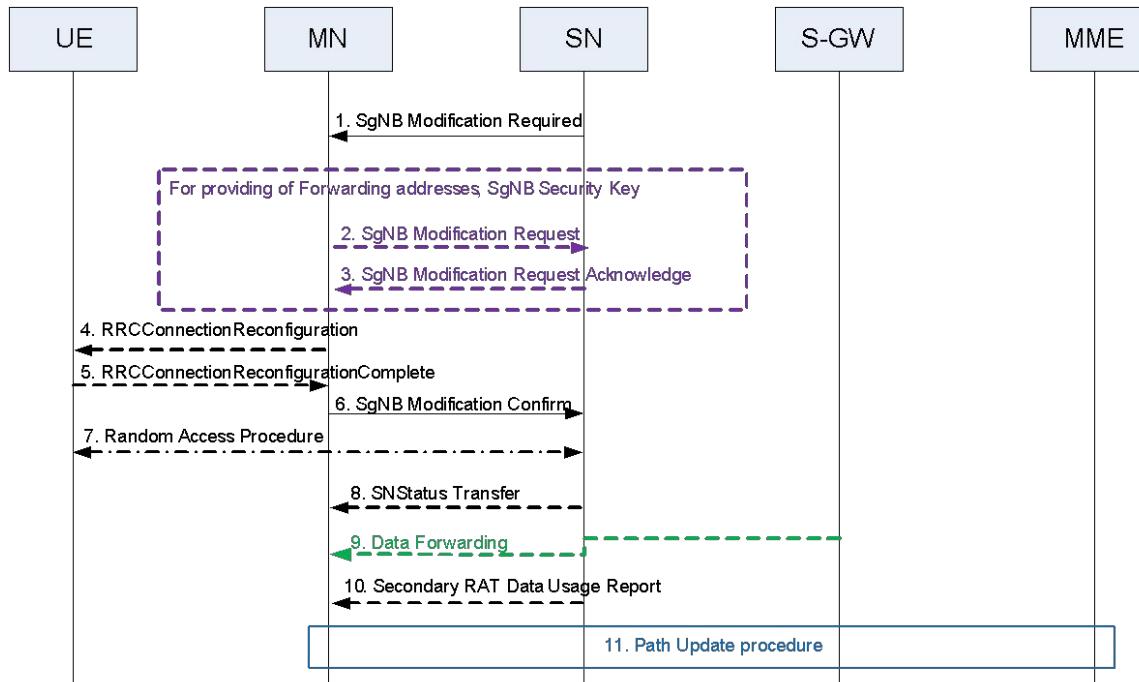
MR-DC with 5GC



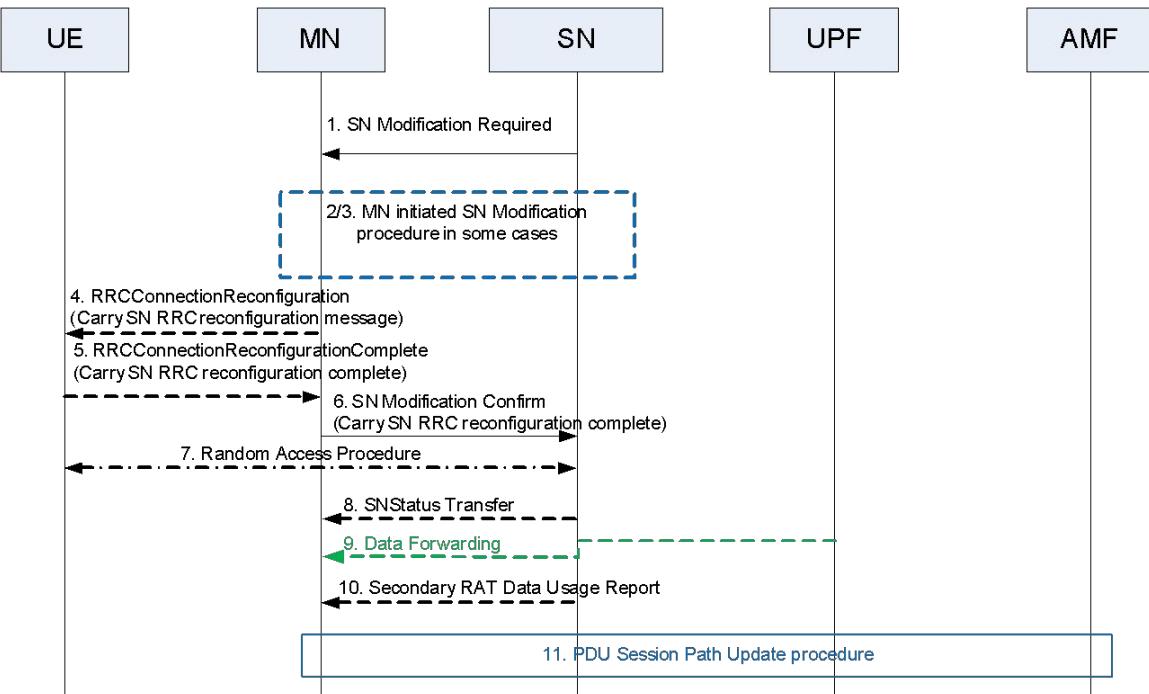
MN-Initiated SN Modification

Procedure	Secondary Node Modification (SCG Mod on same gNB)
Specification	37.340
Section	10.3 [TS 37.340 V16.5.0]

EN-DC



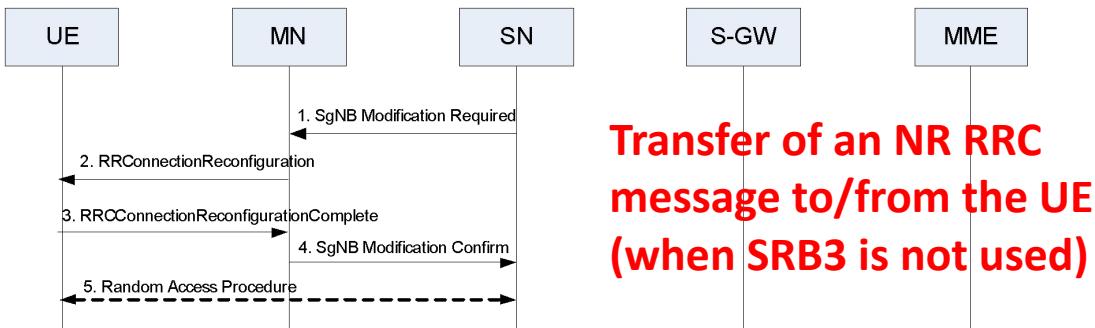
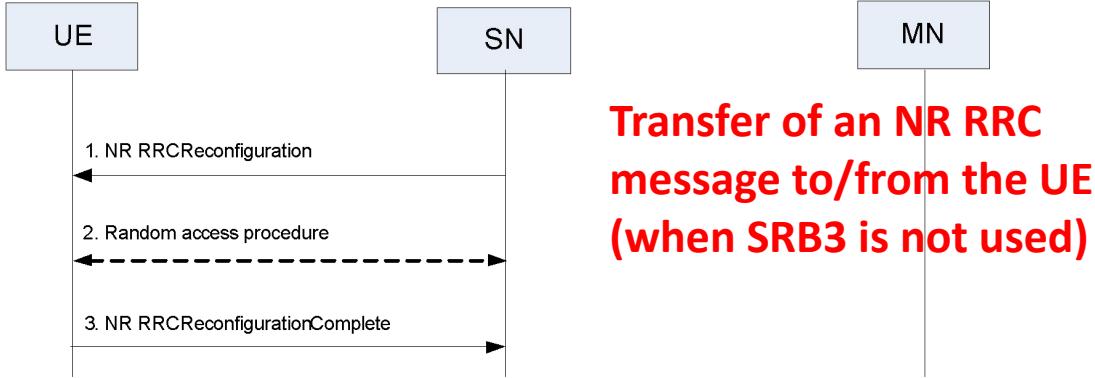
MR-DC with 5GC



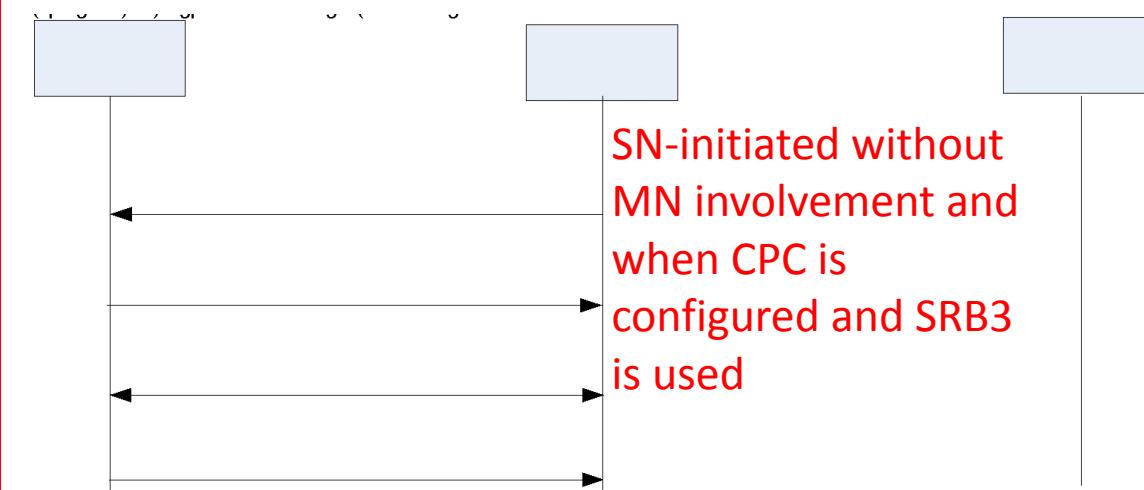
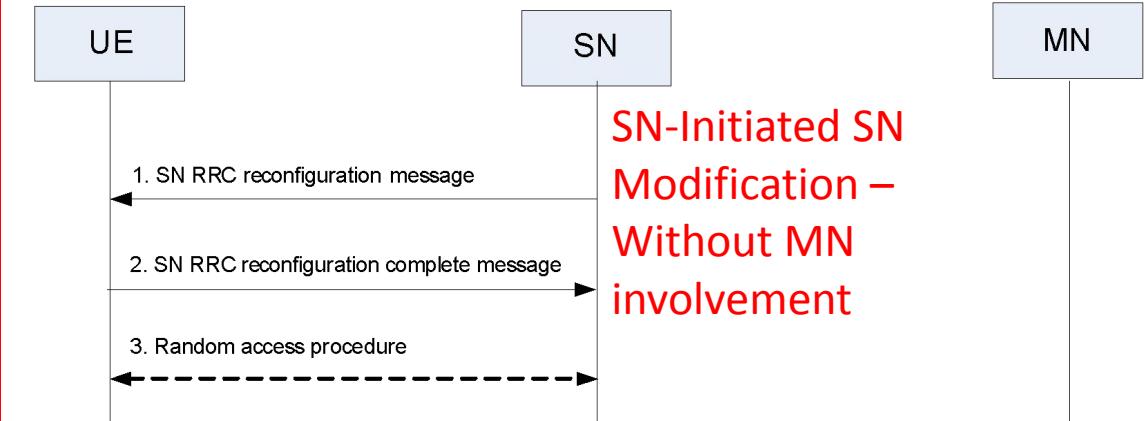
SN-Initiated SN Modification (with MN Involvement)

Procedure	Secondary Node Modification (SCG Mod on same gNB)
Specification	37.340
Section	10.3 [TS 37.340 V16.5.0]

EN-DC



MR-DC with 5GC



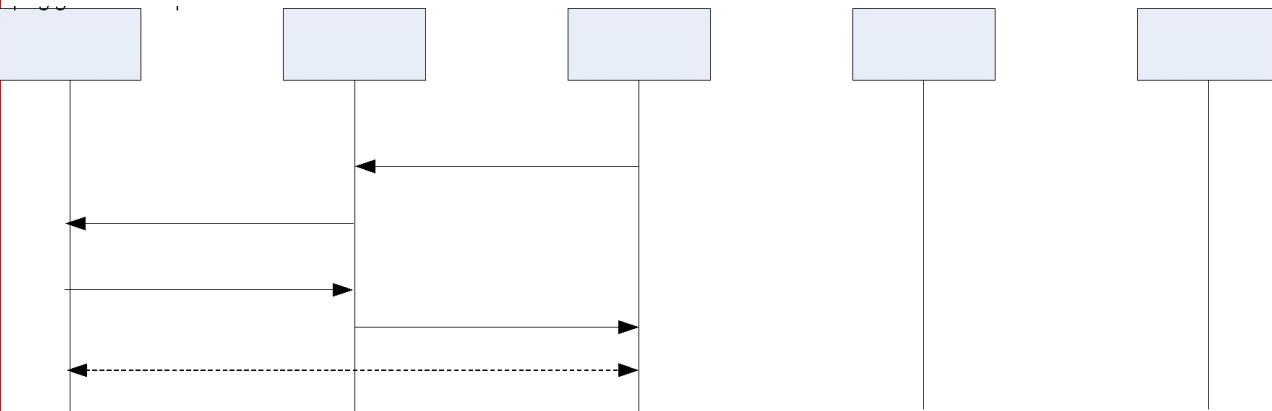
SN-Initiated SN Modification (without MN Involvement)

Procedure	Secondary Node Modification (SCG Mod on same gNB)
Specification	37.340
Section	10.3 [TS 37.340 V16.5.0]

EN-DC

Continued from previous

MR-DC with 5GC



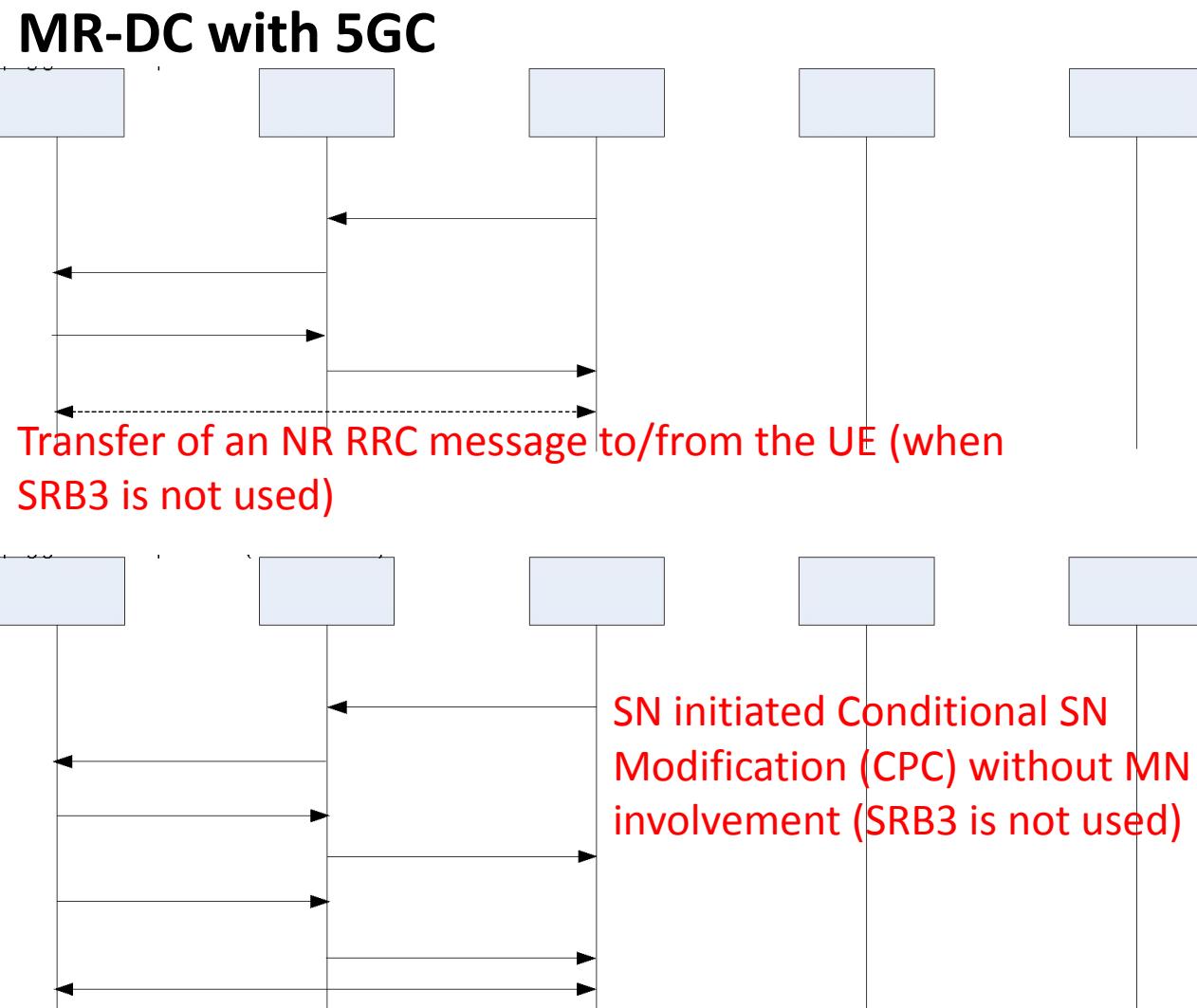
Transfer of an NR RRC message to/from the UE (when SRB3 is not used)

SN-Initiated SN Modification (without MN Involvement)

Procedure	Secondary Node Modification (SCG Mod on same gNB)
Specification	37.340
Section	10.3 [TS 37.340 V16.5.0]

EN-DC

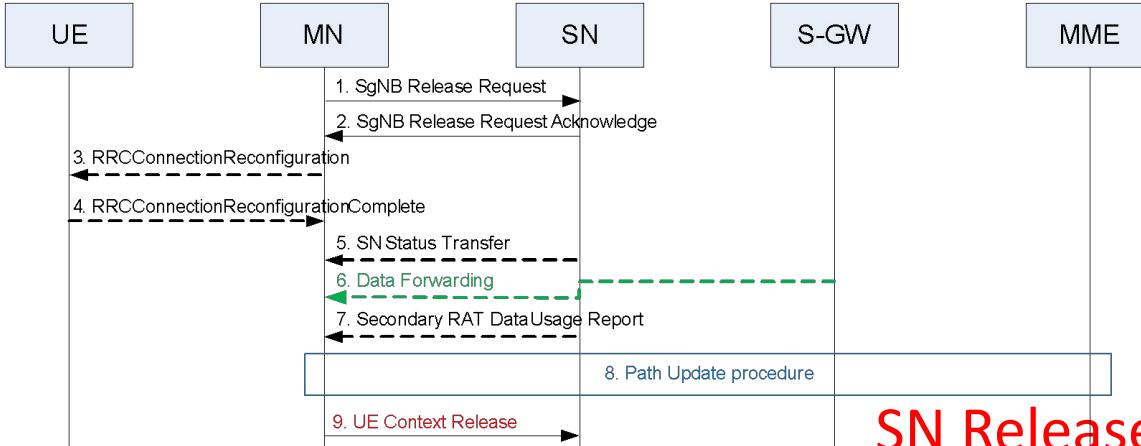
Continued from previous



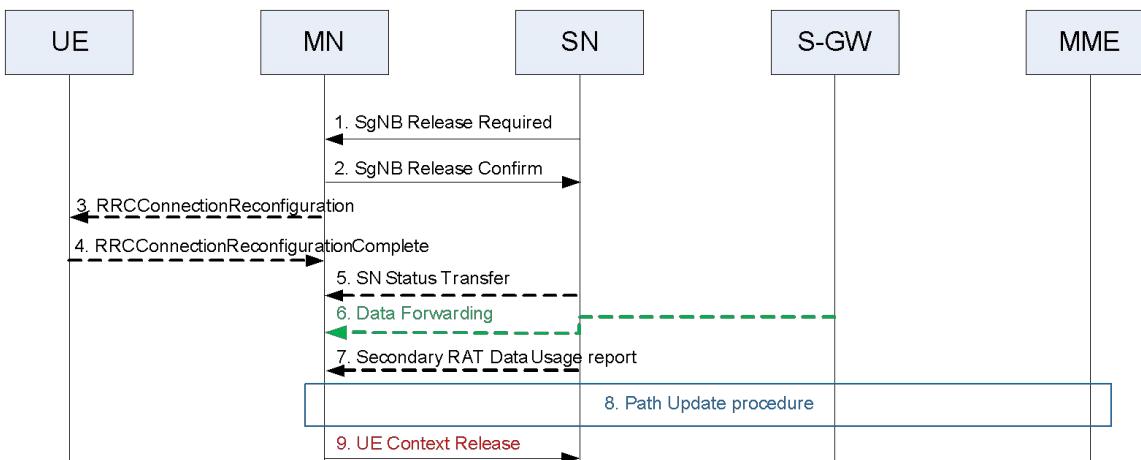
SN-Initiated SN Modification (without MN Involvement)

Procedure	Secondary Node Release (SCG Release)
Specification	37.340
Section	10.4 [TS 37.340 V16.5.0]

EN-DC

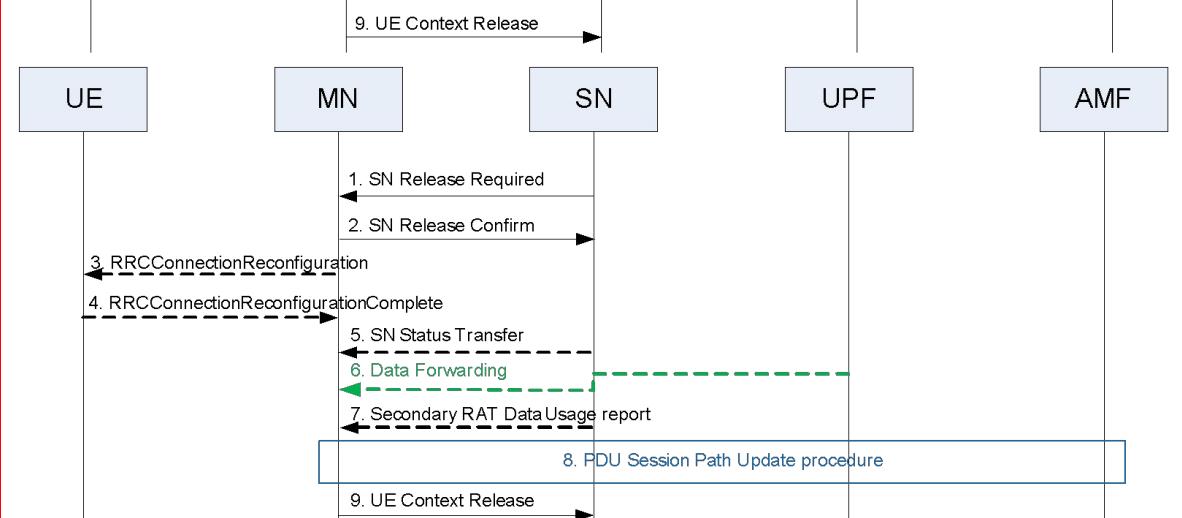
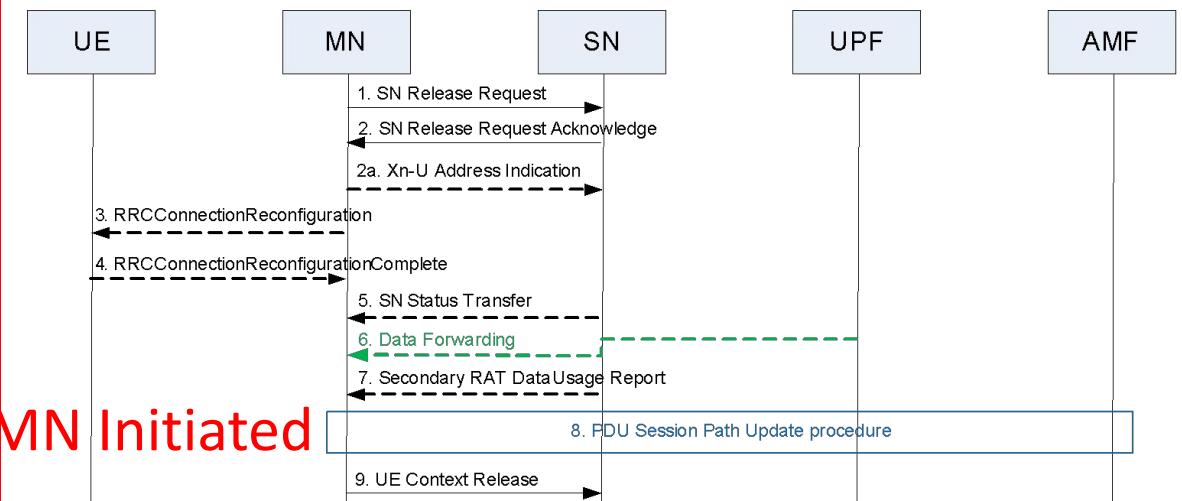


SN Release – MN Initiated



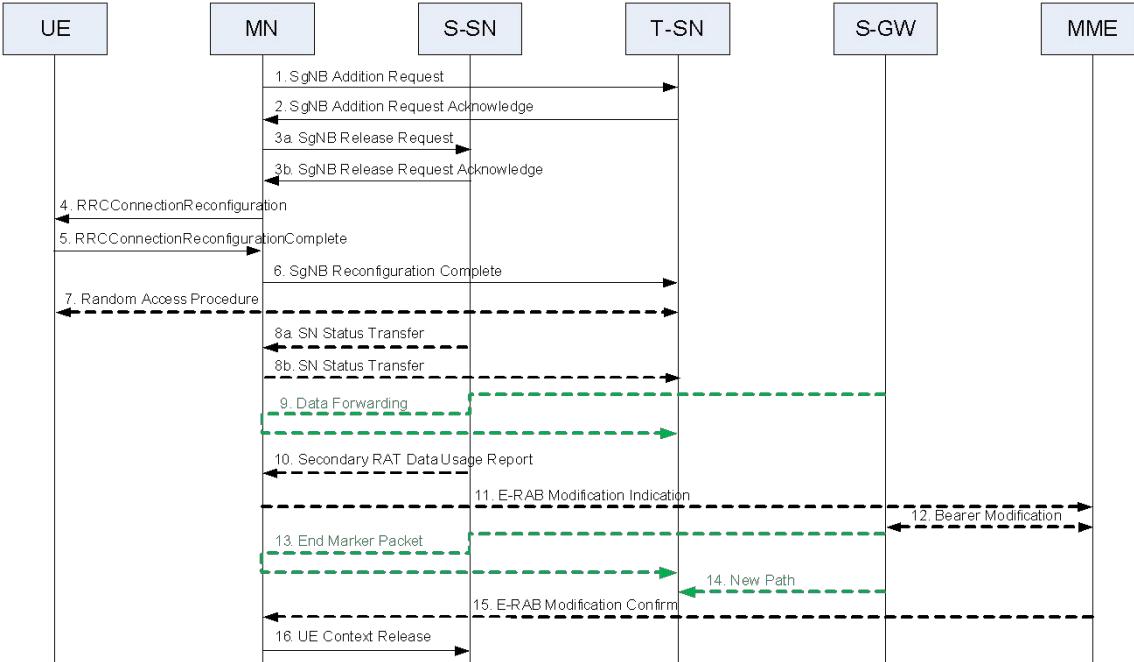
SN Release – SN Initiated

MR-DC with 5GC

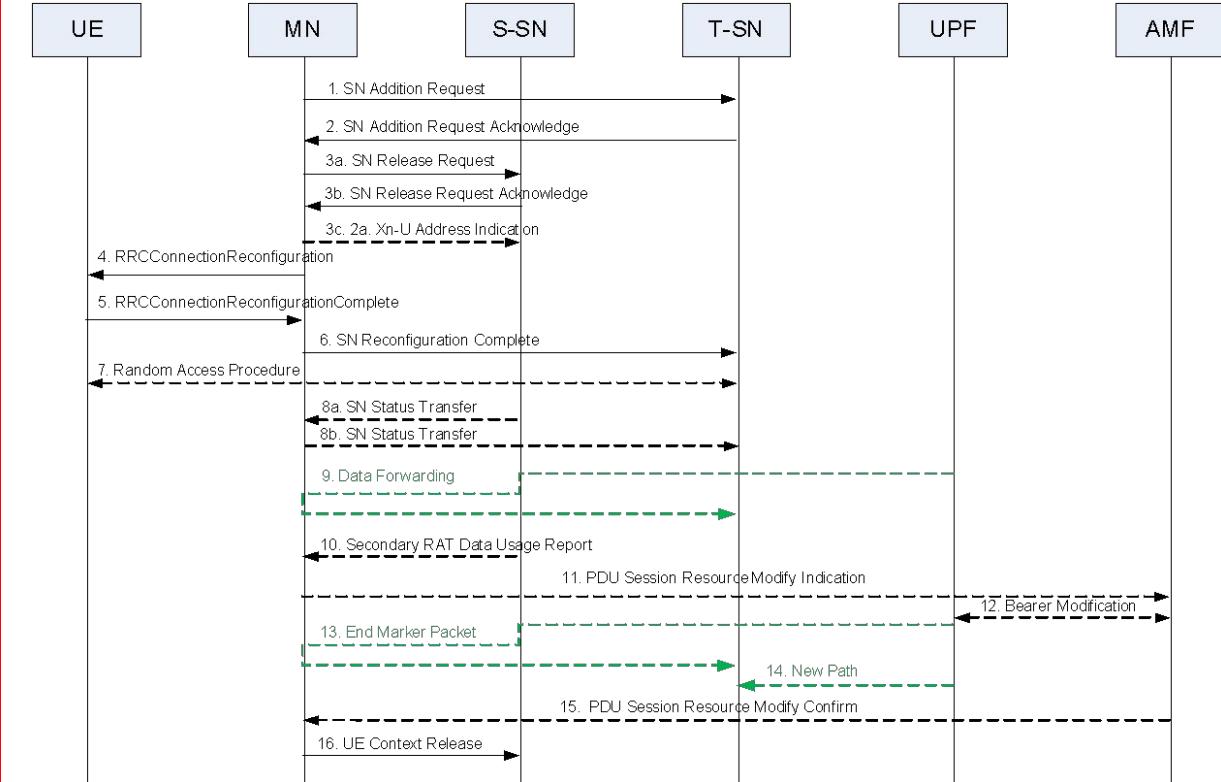


Procedure	Secondary Node Change (SCG handover) – MN Initiated
Specification	37.340
Section	10.5 [TS 37.340 V16.5.0]

EN-DC



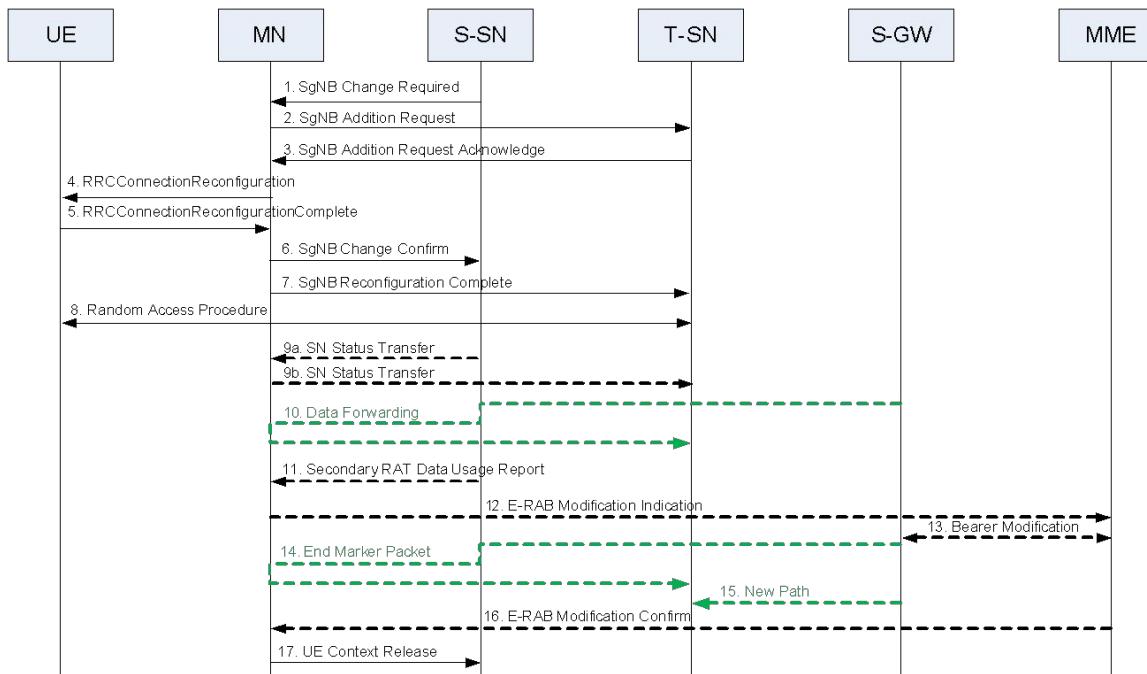
MR-DC with 5GC



Procedure

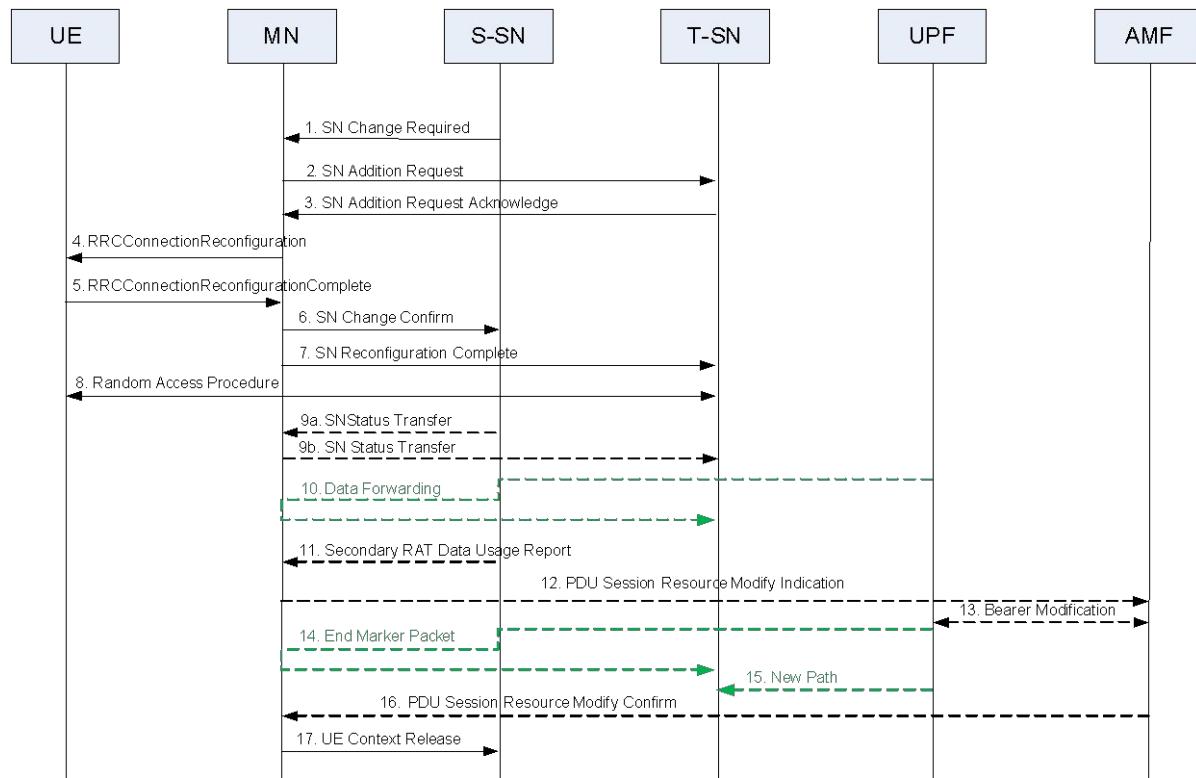
Specification

Section

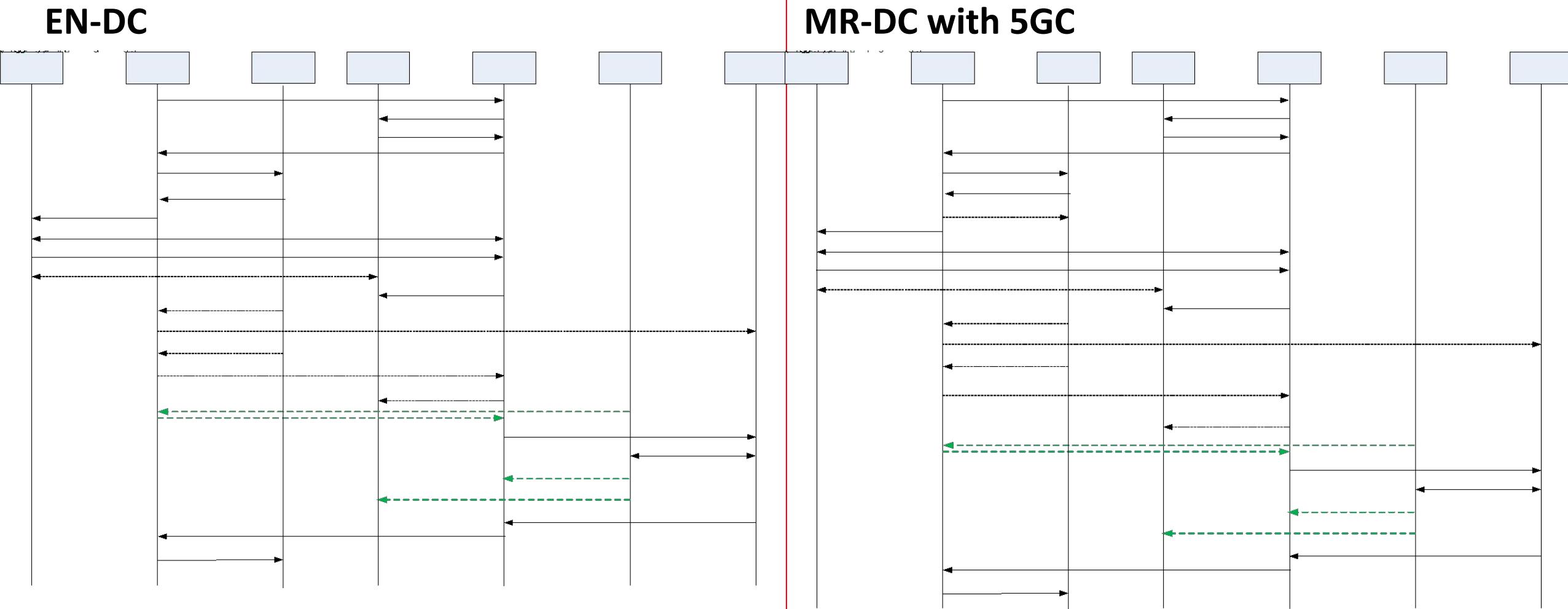
EN-DC**Secondary Node Change (SCG handover) – SN Initiated**

37.340

10.5 [TS 37.340 V16.5.0]

MR-DC with 5GC

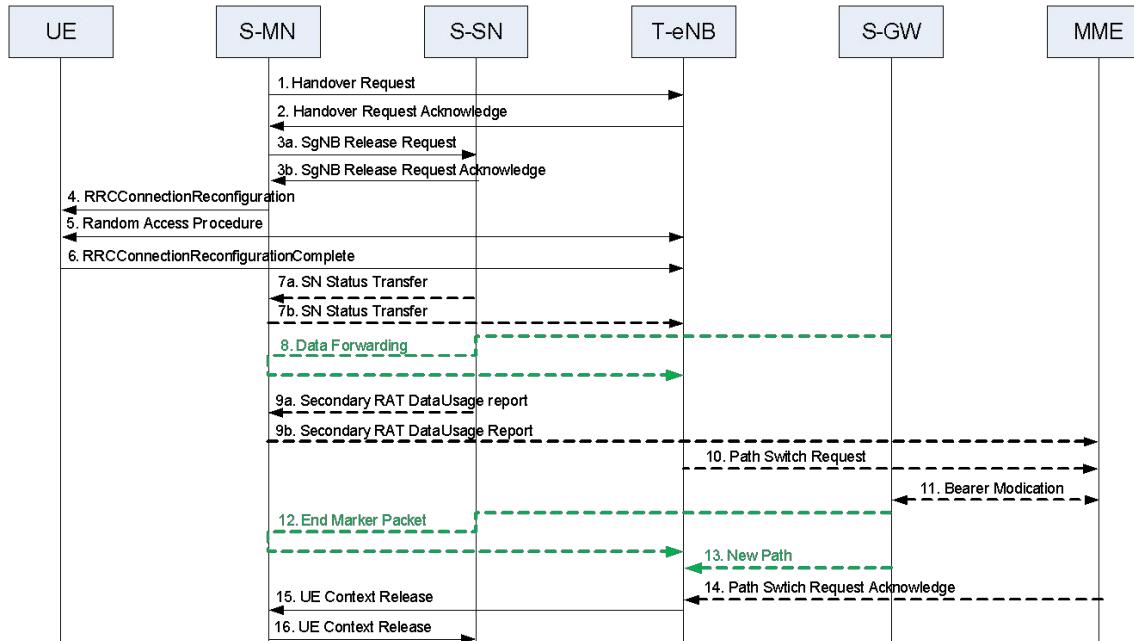
Procedure	Inter-MN Handover (with/without SN change)
Specification	37.340
Section	10.7 [TS 37.340 V16.5.0]



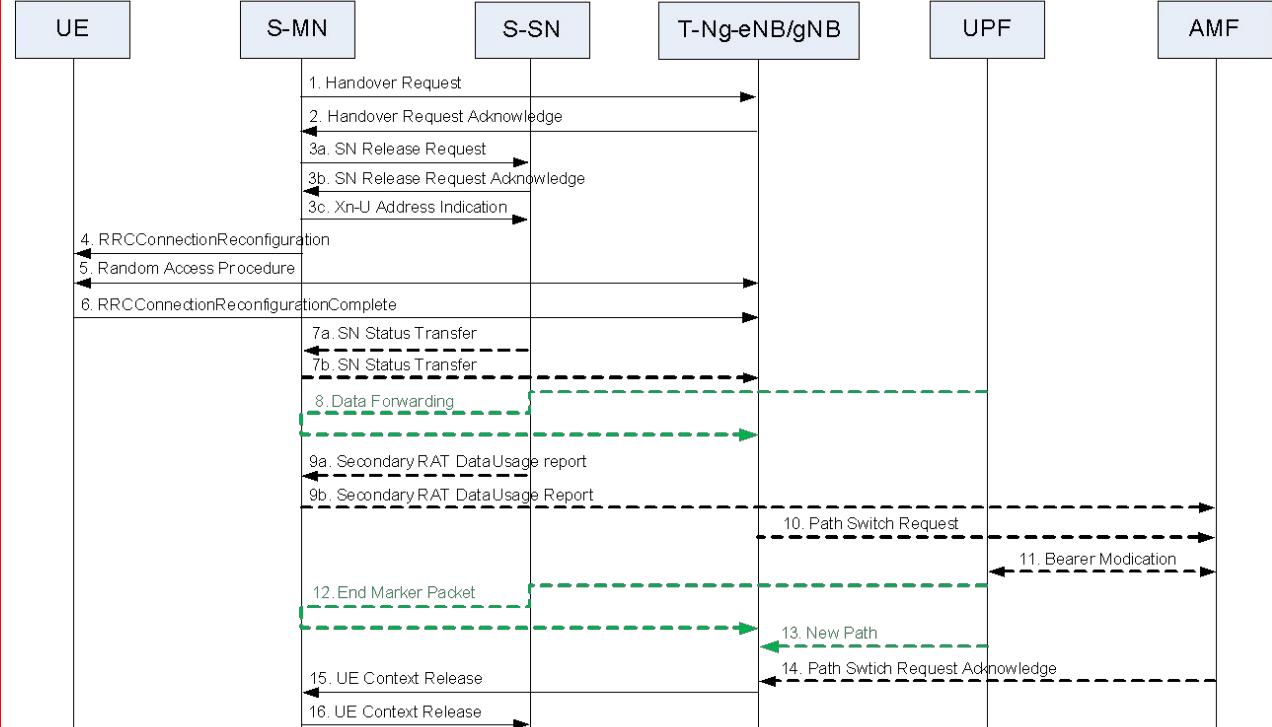
If SN change is not required, then assume that target SN is same as source SN

Procedure	MN to eNB/gNB Change
Specification	37.340
Section	10.8 [TS 37.340 V16.5.0]

EN-DC

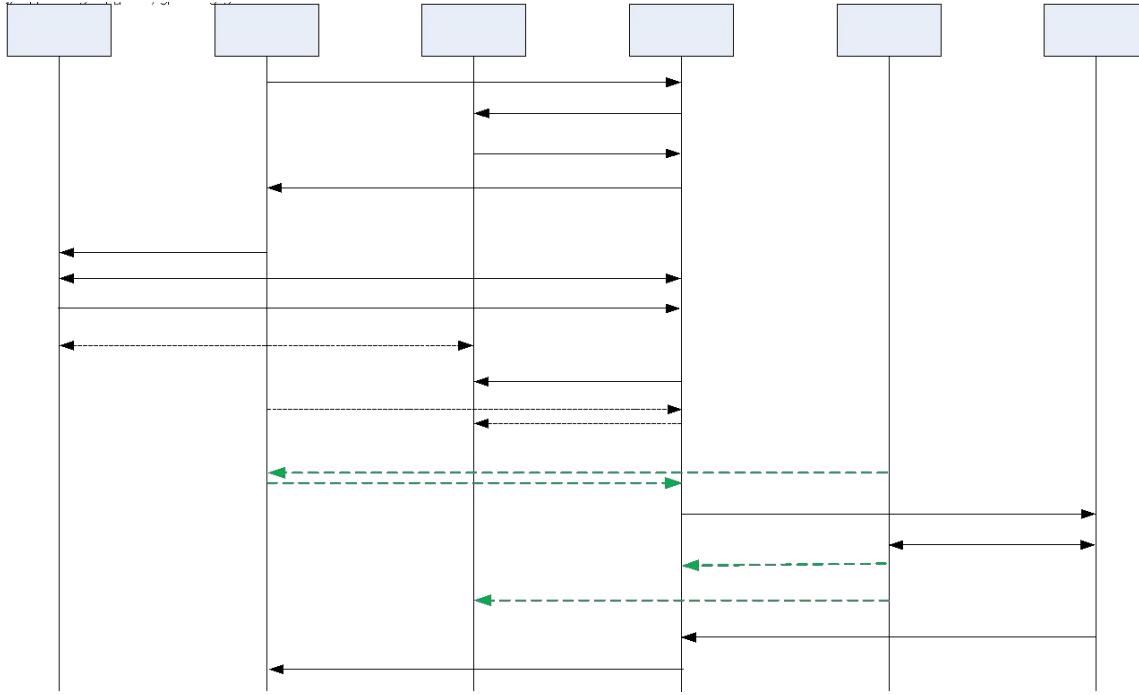


MR-DC with 5GC

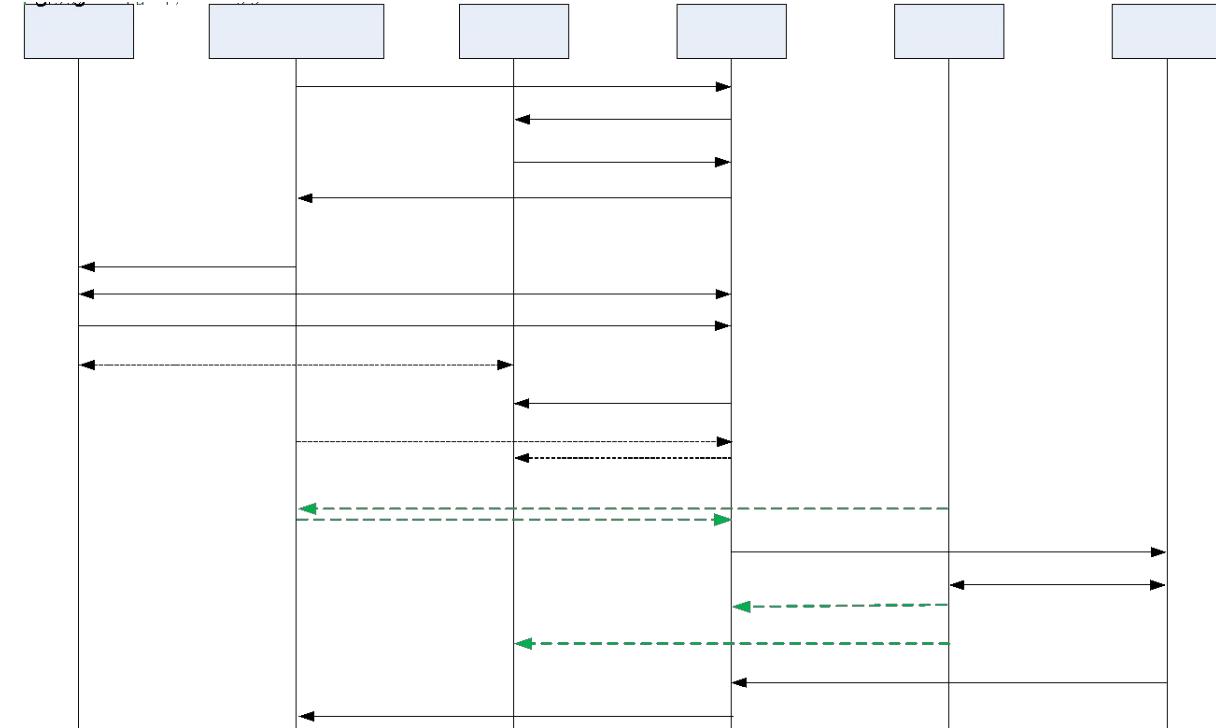


Procedure	eNB/gNB to MN Change
Specification	37.340
Section	10.9 [TS 37.340 V16.5.0]

EN-DC

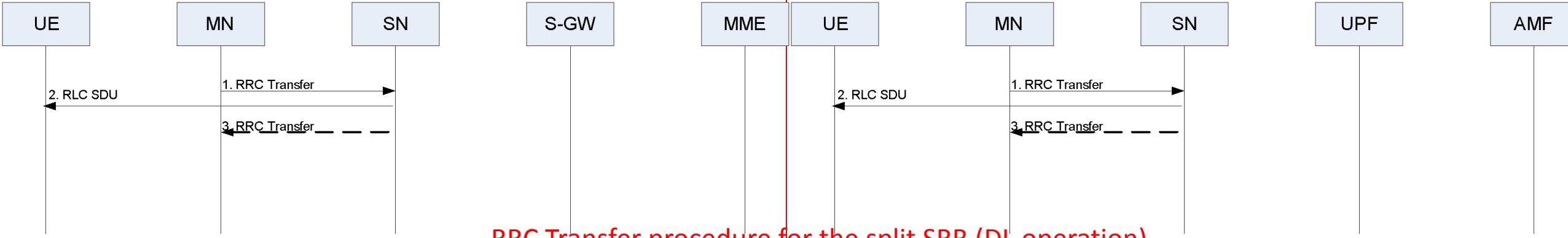


MR-DC with 5GC

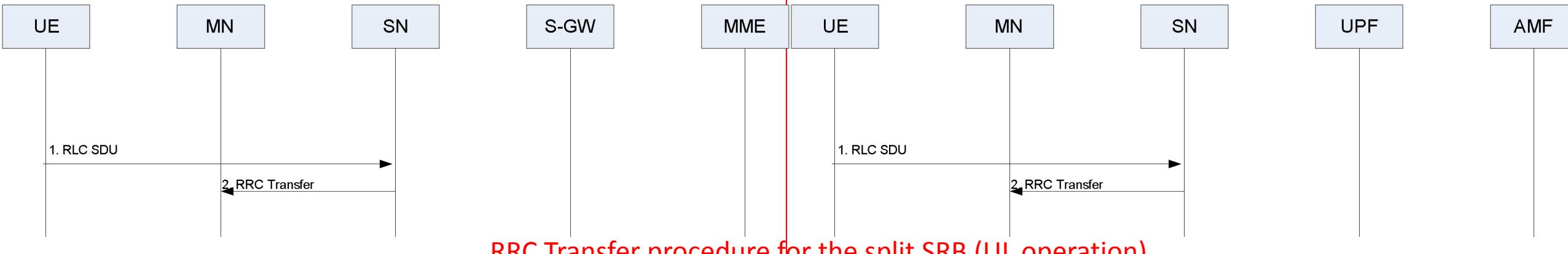


Procedure	RRC Transfer (when split SRB is utilized)
Specification	37.340
Section	10.10 [TS 37.340 V16.5.0]

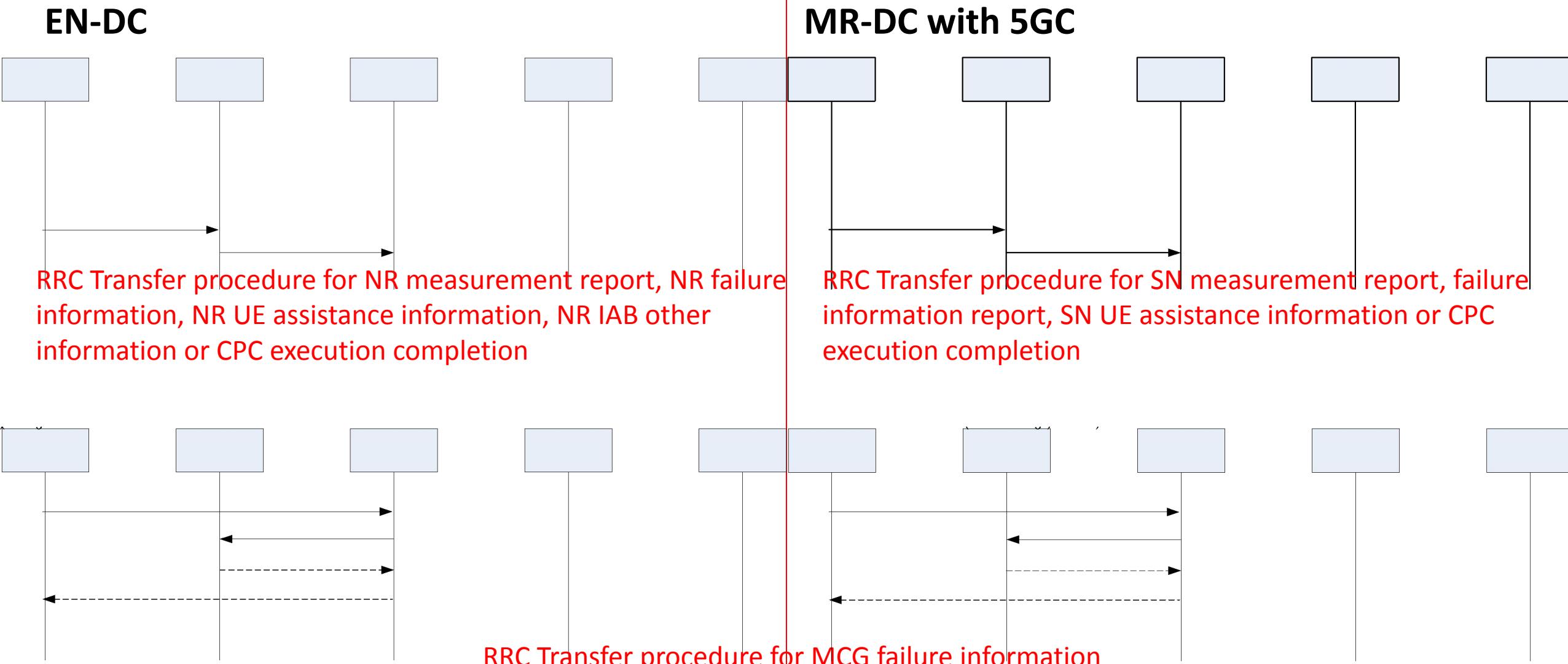
EN-DC



MR-DC with 5GC



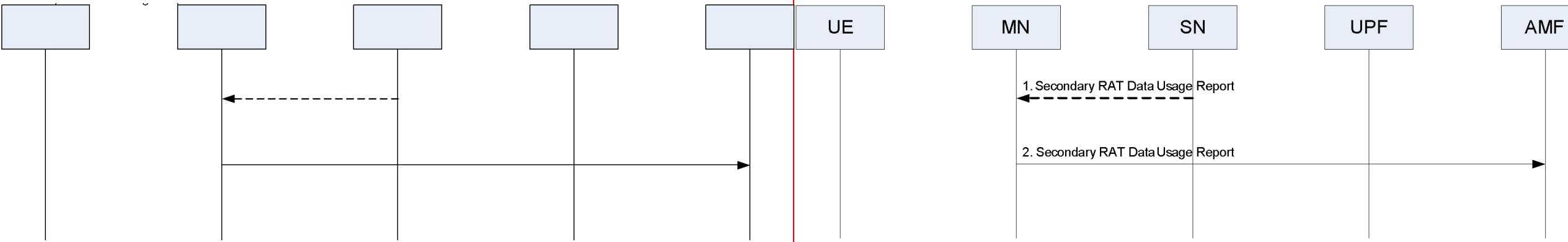
Procedure	RRC Transfer (For special cases in red below)
Specification	37.340
Section	10.10 [TS 37.340 V16.5.0]



Procedure	Secondary RAT Usage Reporting
Specification	37.340
Section	10.11 [TS 37.340 V16.5.0]

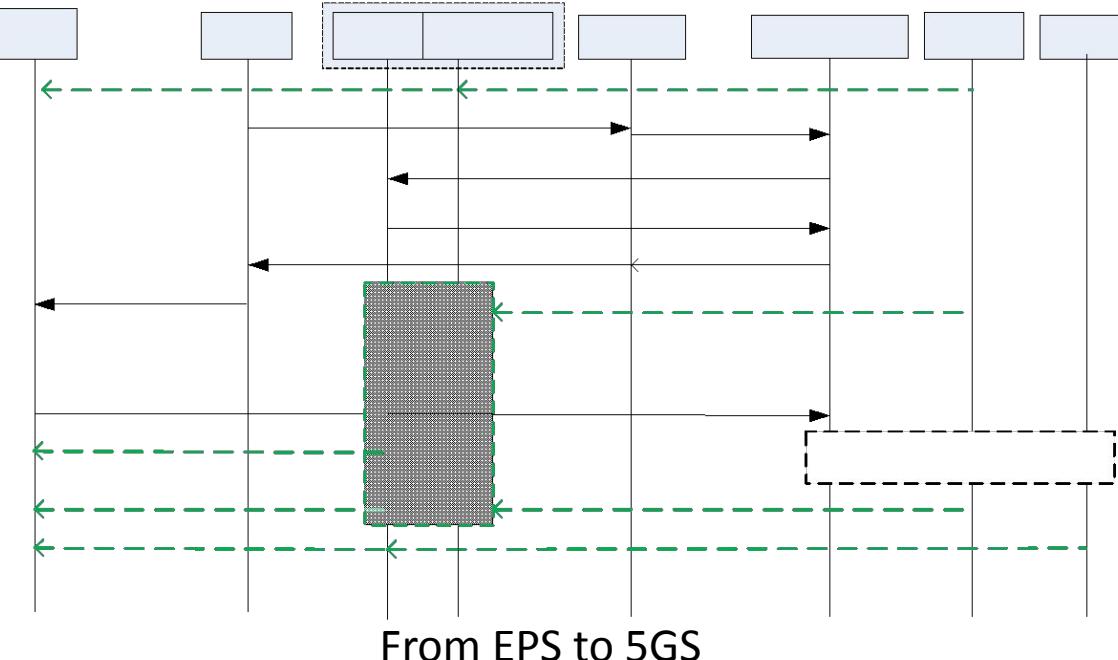
EN-DC

MR-DC with 5GC

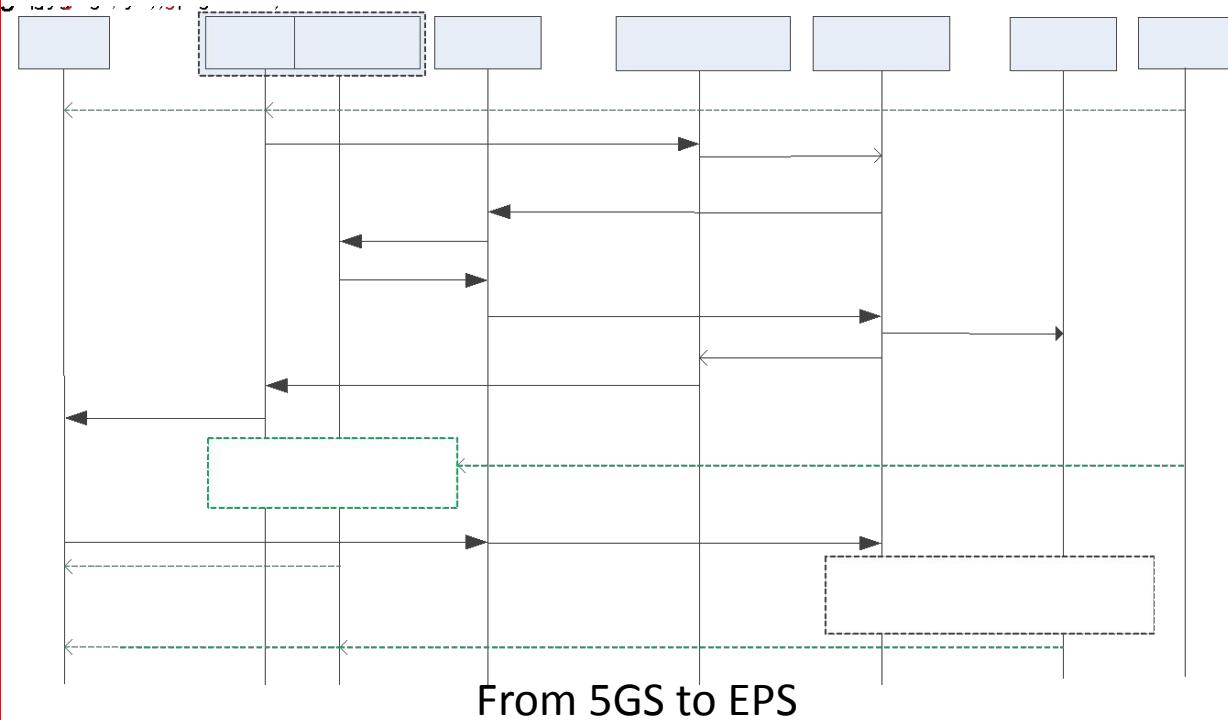


Procedure	Inter-System Handover
Specification	37.340
Section	10.16 [TS 37.340 V16.5.0]

EN-DC



MR-DC with 5GC

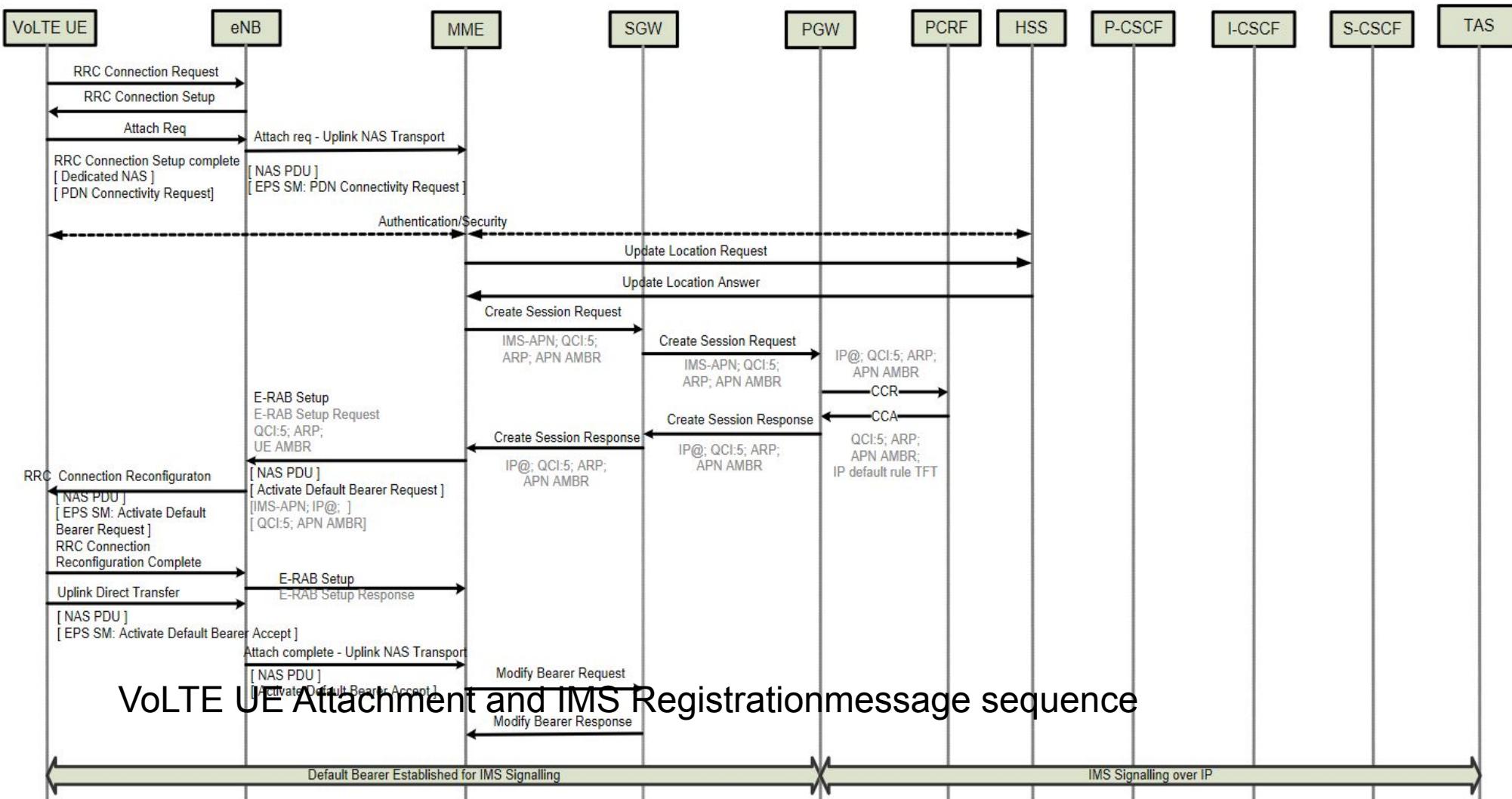


Procedure	Supported Handover b/w MR-DC
Specification	37.340
Section	Appendix B [TS 37.340 V16.5.0]

Table B-1: Supported MR-DC handover scenarios.

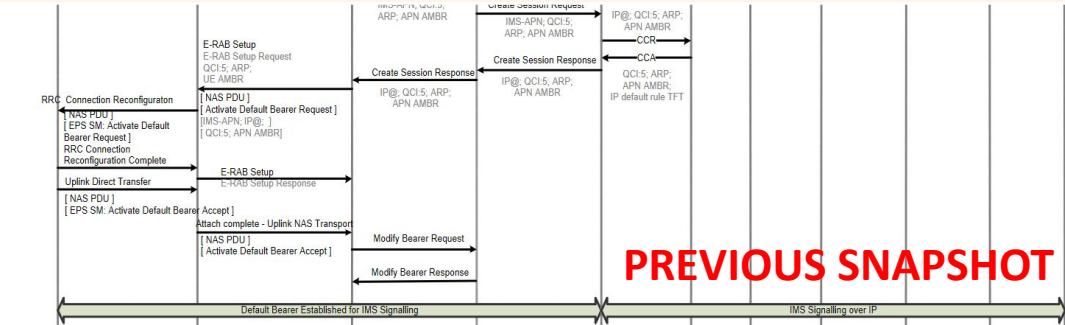
To (column) HO from (row)	E-UTRA with EPC	E-UTRA with 5GC	NR	GERAN or UTRAN	EN-DC	NGEN-DC	NE-DC	NR-DC
E-UTRA with EPC	YES	YES	YES	YES	YES	NO	NO	NO
E-UTRA with 5GC	YES	YES	YES	NO	NO	YES	NO	NO
NR	YES	YES	YES	NOTE 1	YES	NO	YES	YES
GERAN or UTRAN	YES	NO	NO	YES	NO	NO	NO	NO
EN-DC	YES	YES	YES	YES	YES	NO	NO	NO
NGEN-DC	YES	YES	YES	NO	NO	YES	NO	NO
NE-DC	YES	YES	YES	NOTE 1	NO	NO	YES	NO
NR-DC	YES	YES	YES	NOTE 1	NO	NO	NO	YES

Procedure	VoLTE UE Attachment and IMS Registration message sequence
Specification	https://www.gsma.com/futurenetworks/wp-content/uploads/2014/05/FCM.01-v1.1.pdf
Section	Figure 3

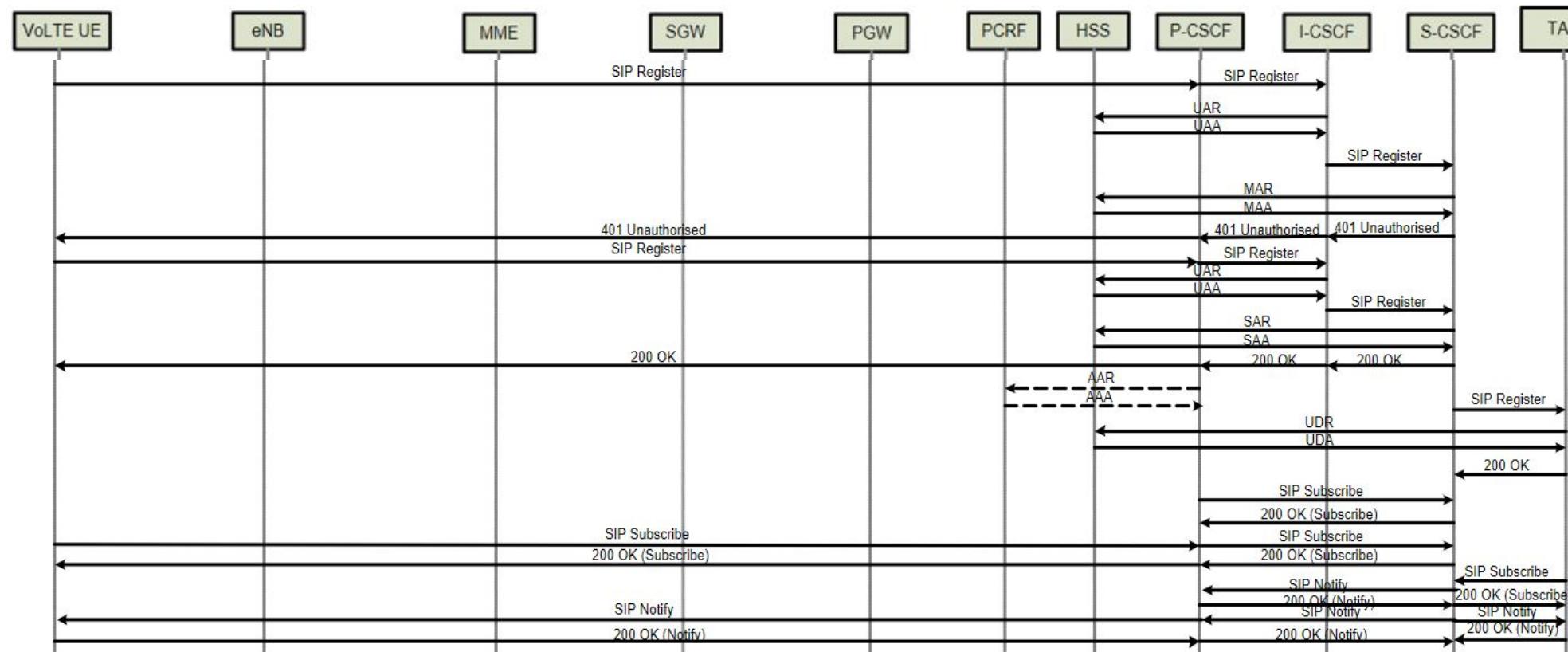


Procedure	VoLTE UE Attachment and IMS Registration message sequence
Specification	https://www.gsma.com/futurenetworks/wp-content/uploads/2014/05/FCM.01-v1.1.pdf
Section	Figure 3

CONTINUED



PREVIOUS SNAPSHOT



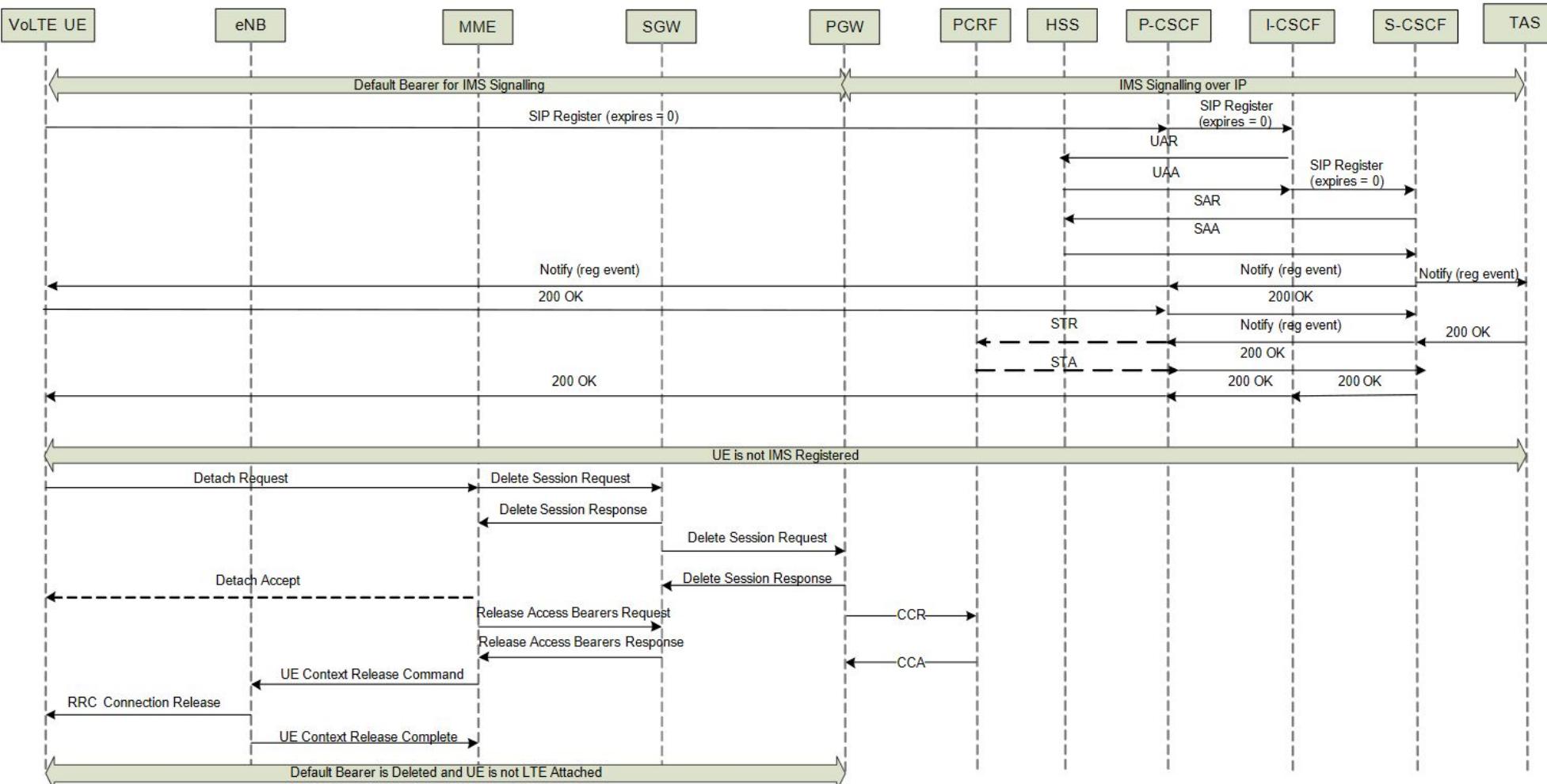
Procedure

Specification

VoLTE UE Initiated Detach & IMS Deregistration

Section

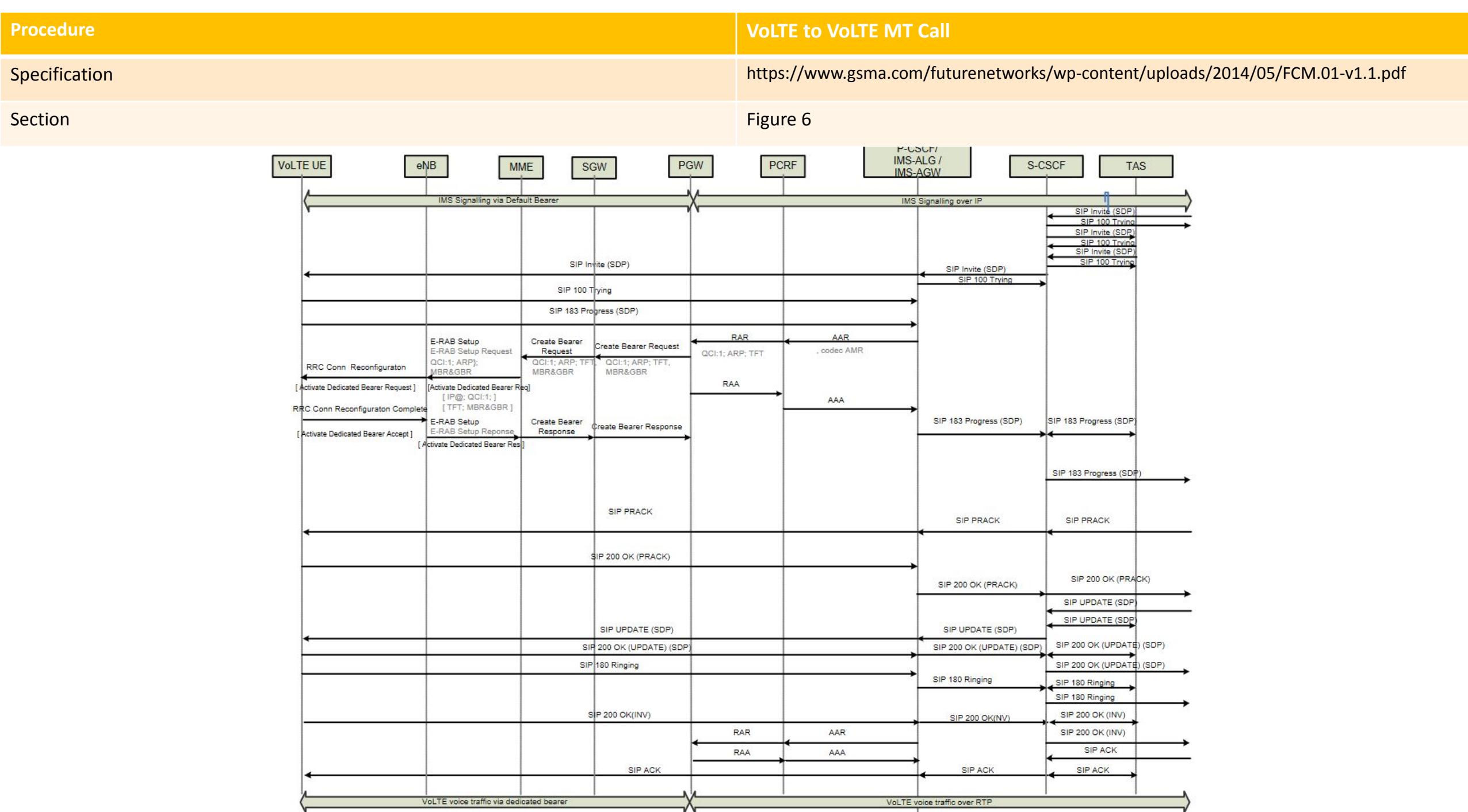
Figure 4

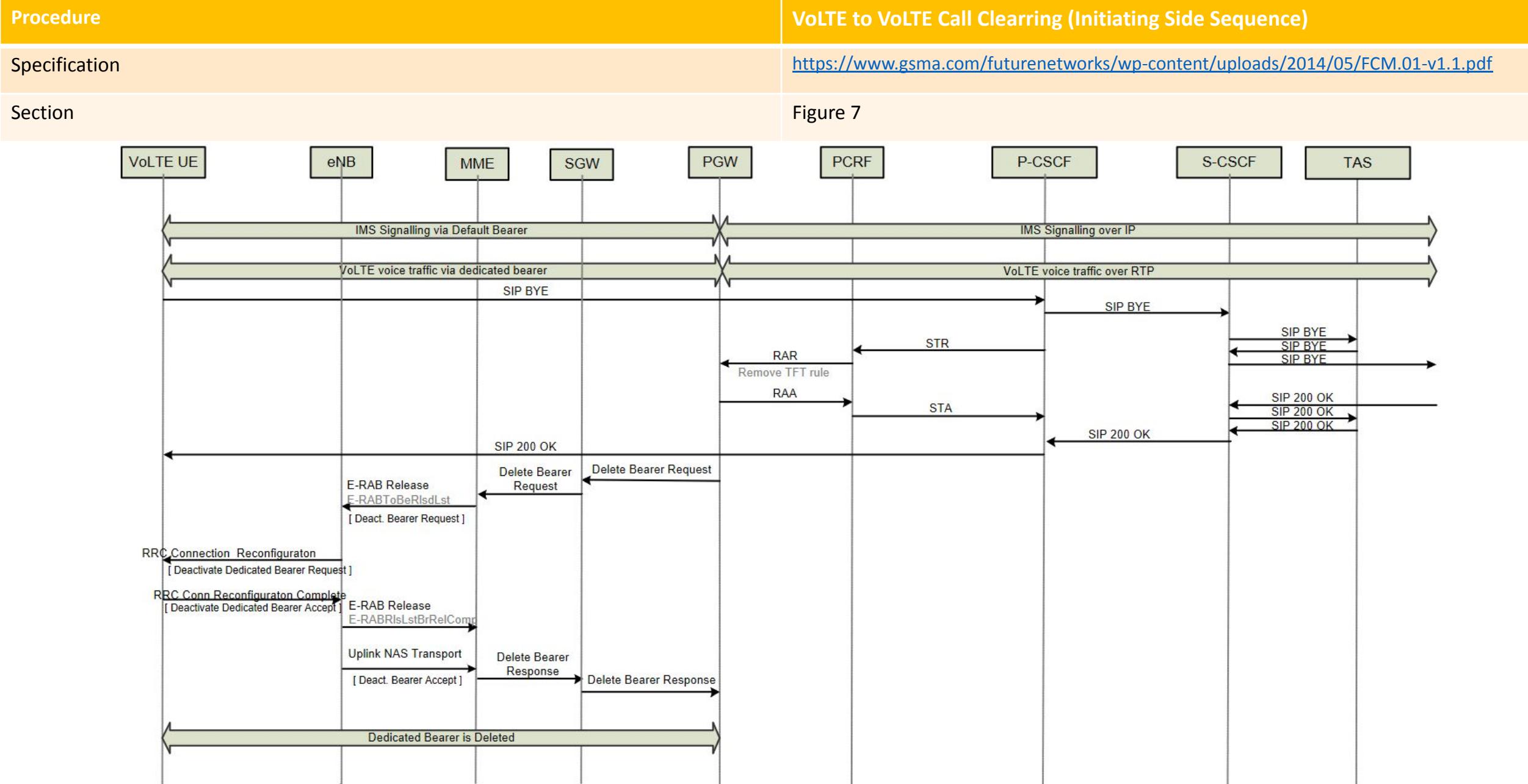


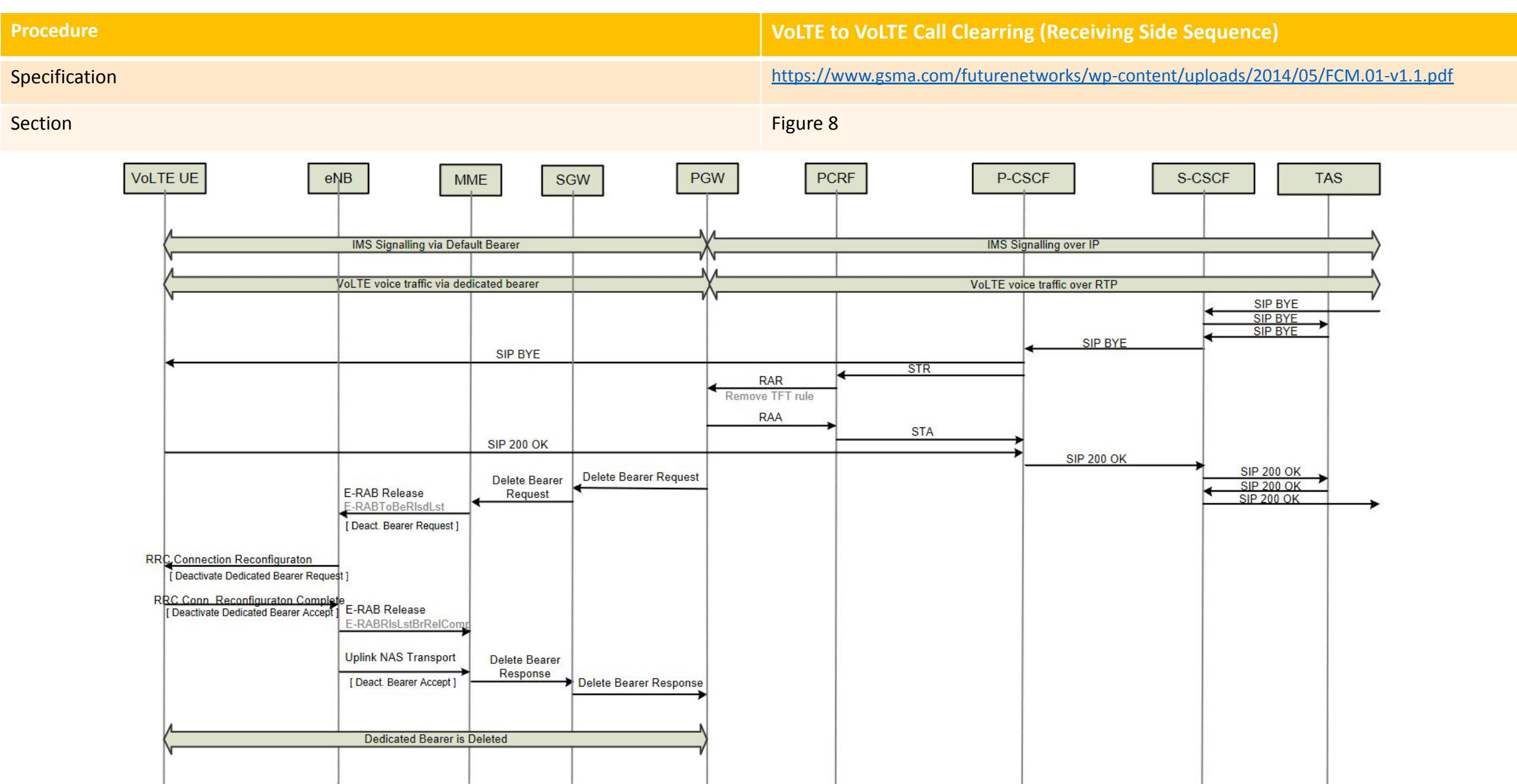
This sequence diagram illustrates the signaling flow for a VoLTE to VoLTE MO Call across various network components. The participants include the VoLTE UE, eNB, MME, SGW, PGW, PCRF, P-CSCF/IMS-ALG/IMS-AGW, S-CSCF, and TAS.

Signaling Flow:

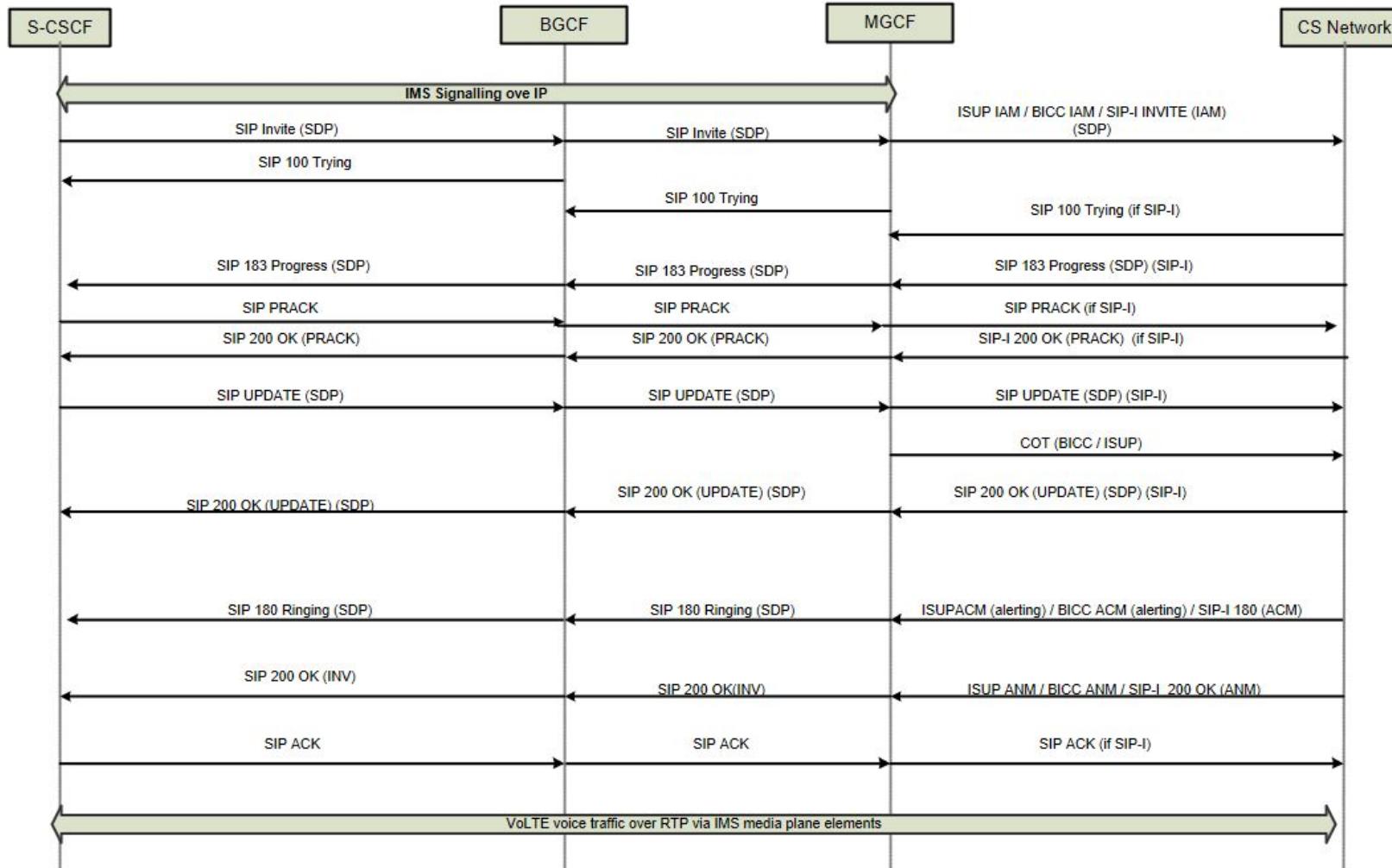
- Initial Signaling:** The VoLTE UE initiates an IMS Signalling via Default Bearer to the eNB. The eNB then sends SIP Invite (SDP) and SIP 100 Trying to the P-CSCF/IMS-ALG/IMS-AGW. The P-CSCF/IMS-ALG/IMS-AGW returns SIP Invite (SDP) and SIP 100 Trying to the eNB.
- E-RAB Setup:** The eNB sends an E-RAB Setup E-RAB Setup Request (QCI:1; ARP; MBR&GBR) to the MME. The MME responds with a Create Bearer Request (QCI:1; ARP; TFT, MBR&GBR). The eNB then sends an RRC Conn Reconfiguration (Activate Dedicated Bearer Request [IP@; QCI:1; TFT; MBR&GBR]) to the VoLTE UE. The VoLTE UE returns an RRC Conn Reconfiguration Complete (Activate Dedicated Bearer Accept) to the eNB. The eNB sends an E-RAB Setup E-RAB Setup Response (Activate Dedicated Bearer Res) to the MME. The MME returns a Create Bearer Response to the eNB.
- Bearer Management:** The eNB sends a Create Bearer Request (QCI:1; ARP; TFT, MBR&GBR) to the PGW. The PGW returns a RAR (QCI:1; ARP, TFT) to the eNB. The eNB sends an AAA message to the PCRF. The PCRF returns an AAR (codec AMR) to the eNB. The eNB then sends an RAA (QCI:1; ARP, TFT) to the PGW. The PGW returns an AAA message to the eNB. The eNB sends a SIP 183 Progress (SDP) to the P-CSCF/IMS-ALG/IMS-AGW. The P-CSCF/IMS-ALG/IMS-AGW returns a SIP 183 Progress (SDP) to the eNB.
- Call Control:** The eNB sends SIP 183 Progress (SDP), SIP PRACK, SIP 200 OK (PRACK), SIP UPDATE (SDP), SIP 200 OK (UPDATE) (SDP), SIP UPDATE (SDP), SIP UPDATE (SDP), SIP 200 OK (UPDATE) (SDP), SIP 200 OK (UPDATE) (SDP), SIP 180 Ringing, SIP 180 Ringing, SIP 200 OK (INV), SIP 200 OK (INV), SIP 200 OK (INV), SIP 200 OK (INV), SIP ACK, and SIP ACK messages to the VoLTE UE.
- Media Path:** The VoLTE UE initiates VoLTE voice traffic via dedicated bearer. The eNB, MME, SGW, PGW, PCRF, P-CSCF/IMS-ALG/IMS-AGW, S-CSCF, and TAS are involved in the IMS Signalling over IP path. The TAS handles the VoLTE voice traffic over RTP via IMS media plans elements.





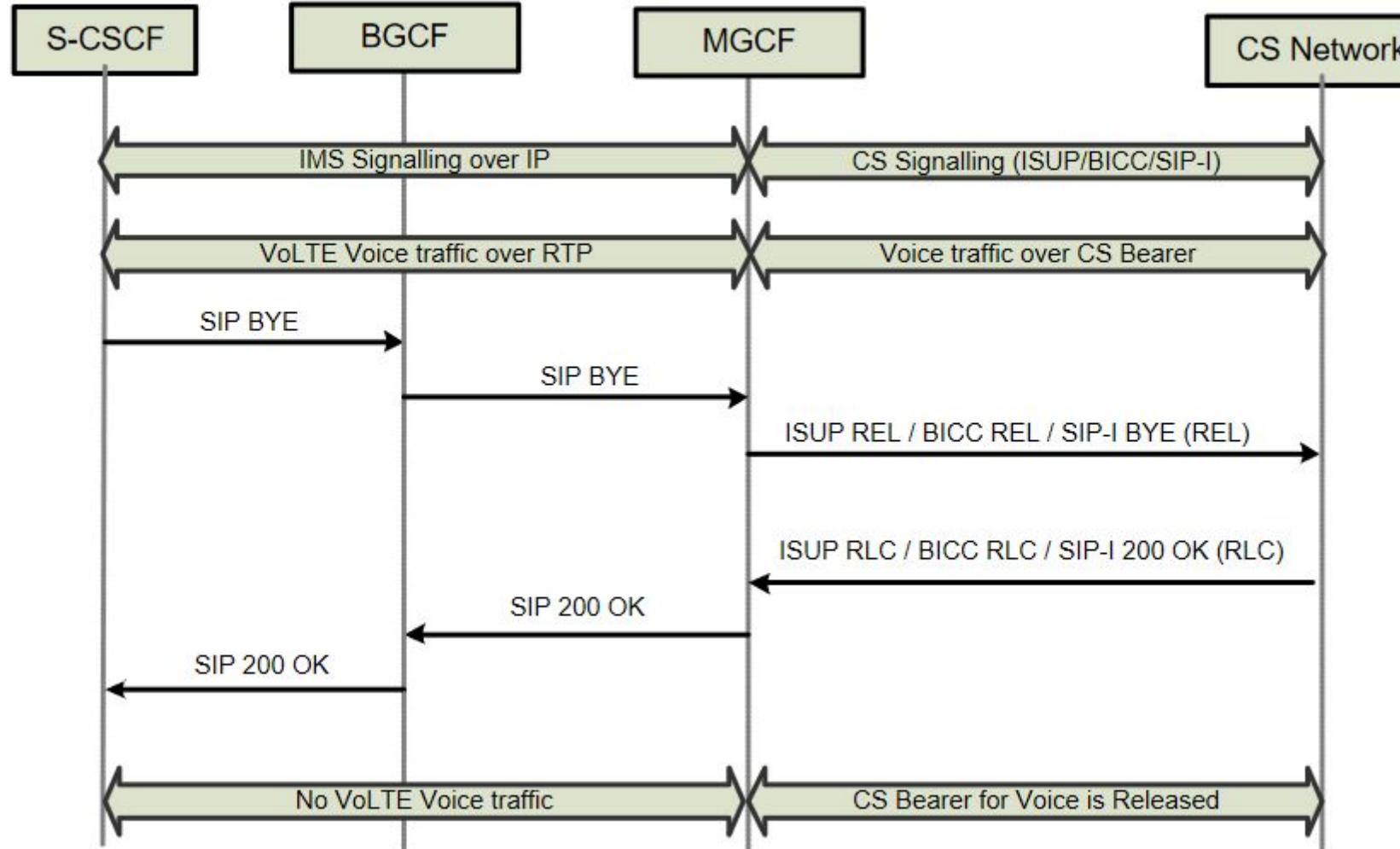


Procedure	VoLTE MO to CS Call
Specification	https://www.gsma.com/futurenetworks/wp-content/uploads/2014/05/FCM.01-v1.1.pdf
Section	Figure 9

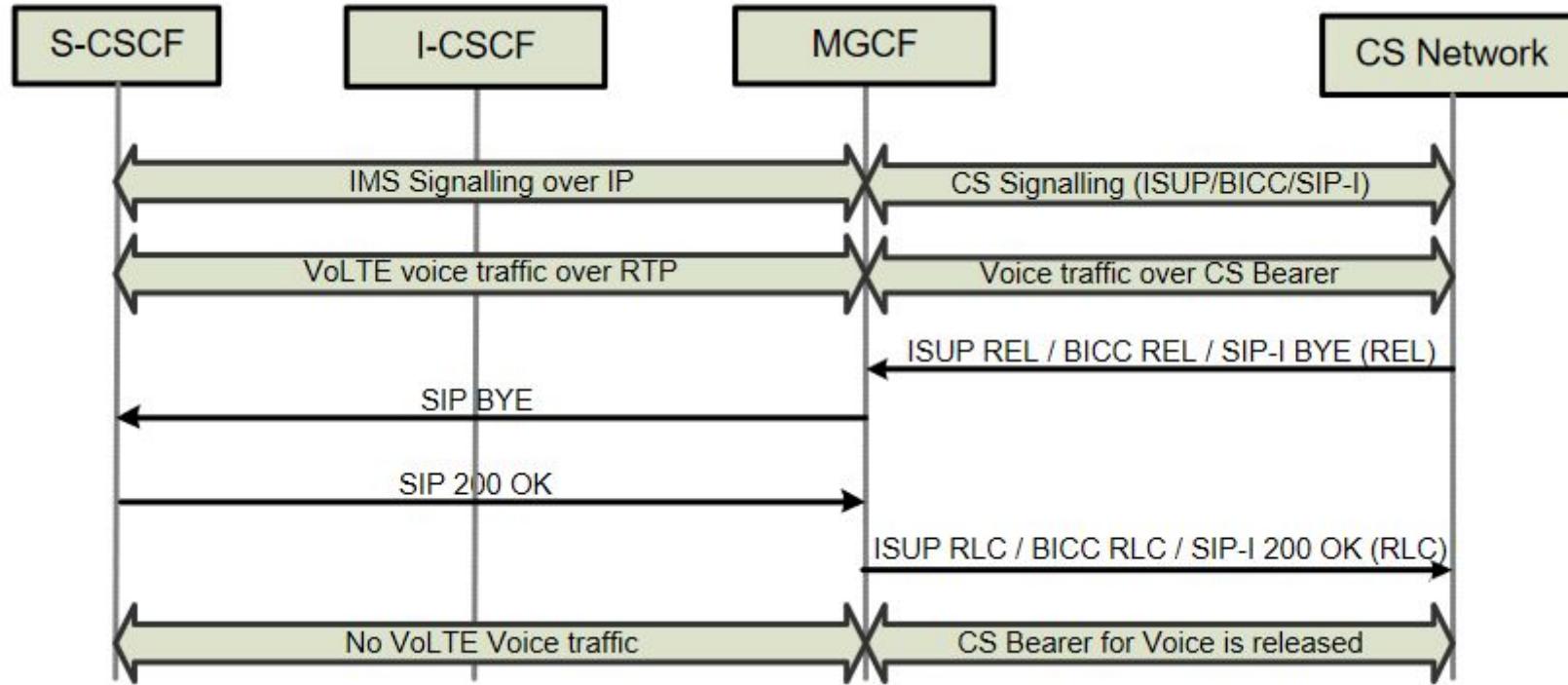


Procedure	VoLTE MT to CS Call
Specification	https://www.gsma.com/futurenetworks/wp-content/uploads/2014/05/FCM.01-v1.1.pdf
Section	Figure 10
	<pre> sequenceDiagram participant S as S-CSCF participant I as I-CSCF participant MGCF participant CS as CS Network S->>I: SIP Invite (SDP) I->>S: SIP 100 Trying MGCF->>CS: ISUP IAM / BICC IAM / SIP-I INVITE (IAM) CS->>MGCF: SIP 100 Trying (if SIP-I) S->>I: SIP 183 Progress (SDP) I->>S: SIP 183 Progress (SDP) MGCF->>CS: SIP 183 Progress (SDP) (SIP-I) CS->>MGCF: SIP PRACK (if SIP-I) S->>I: SIP 200 OK (PRACK) I->>S: SIP 200 OK (PRACK) (if SIP-I) MGCF->>CS: SIP UPDATE (SDP) (if SIP-I) CS->>MGCF: ISUP / BICC COT S->>I: SIP UPDATE (SDP) I->>S: SIP 200 OK (UPDATE) (SDP) MGCF->>CS: SIP 200 OK (UPDATE) (SDP) (SIP-I) CS->>MGCF: SIP 200 OK (UPDATE) (SDP) (SIP-I) S->>I: SIP 180 Ringing I->>S: SIP 180 Ringing MGCF->>CS: ISUPACM (alerting) / BICC ACM (alerting) / SIP-I 180 (ACM) CS->>MGCF: ISUP ANM / BICC ANM / SIP-I 200 OK (ANM) S->>I: SIP 200 OK (INV) I->>S: SIP 200 OK(INV) MGCF->>CS: SIP ACK (if SIP-I) CS->>MGCF: SIP ACK MGCF->>S: VoLTE voice traffic over RTP via IMS media plane elements </pre> <p>The diagram illustrates the signaling flow for a VoLTE MT to CS Call. It shows interactions between the S-CSCF, I-CSCF, MGCF, and CS Network. The process begins with an SIP Invite (SDP) from the S-CSCF to the I-CSCF. The I-CSCF returns a SIP 100 Trying response. The MGCF sends an ISUP IAM / BICC IAM / SIP-I INVITE (IAM) to the CS Network, which returns a SIP 100 Trying (if SIP-I) response. Subsequent steps involve SIP 183 Progress (SDP) messages, SIP PRACK, SIP 200 OK (PRACK), SIP UPDATE (SDP), and ISUP / BICC COT messages. The process continues with SIP 180 Ringing, SIP 200 OK (UPDATE), SIP ACK, and finally VoLTE voice traffic over RTP via IMS media plane elements.</p>

Procedure	VoLTE to CS Call Clearing (VoLTE Side Initiated)
Specification	https://www.gsma.com/futurenetworks/wp-content/uploads/2014/05/FCM.01-v1.1.pdf
Section	Figure 11



Procedure	VoLTE to CS Call Clearing (VoLTE is Receiving side)
Specification	https://www.gsma.com/futurenetworks/wp-content/uploads/2014/05/FCM.01-v1.1.pdf
Section	Figure 12



Procedure	QCI to DSCP Recommended Mapping
Specification	https://www.gsma.com/futurenetworks/wp-content/uploads/2014/05/FCM.01-v1.1.pdf
Section	Table 3 (3.7.4)

3.7.4 Mapping between QCI and DiffServ

GSMA PRD IR.34 [48] section 6.2 describes the different traffic classes that are used. These are shown in Table 3.

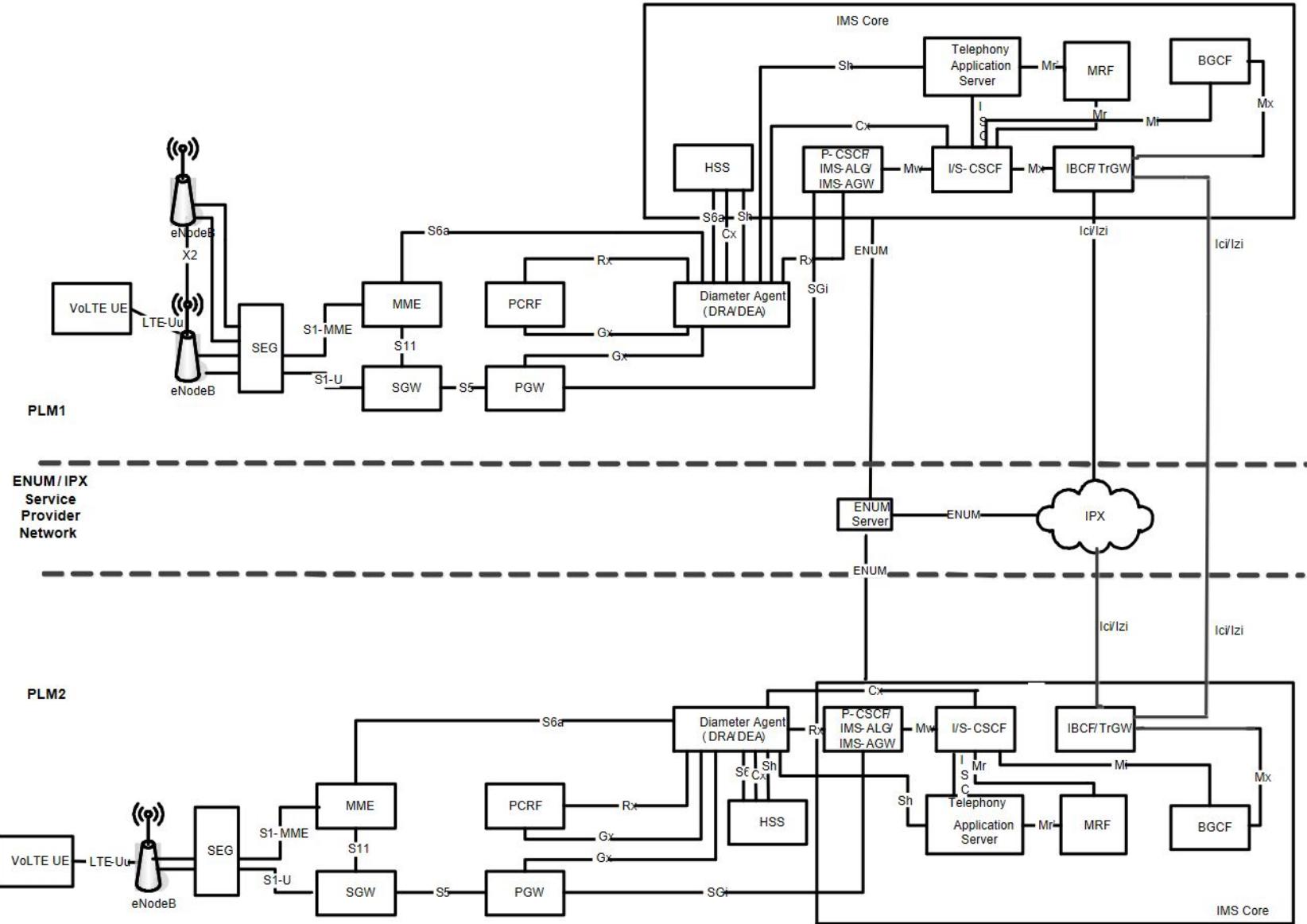
QCI	QoS Information			IP transport	
	Traffic Class	THP	Signalling indication	Diffserv PHB	DSCP
1					
2	Conversational	N/A	N/A	EF	101110
3					
4	Streaming	N/A	N/A	AF41	100010
5		1	Yes (see note)	AF31	011010
6	Interactive		No	AF32	011100
7		2	No	AF21	010010

V1.0

8		3	No	AF11	001010
9	Background	N/A	N/A	BE	000000

Table 3: EPC QoS information and mapping to DSCP

Procedure	VoLTE Interconnect Architecture
Specification	https://www.gsma.com/futurenetworks/wp-content/uploads/2014/05/FCM.01-v1.1.pdf
Section	Figure 15



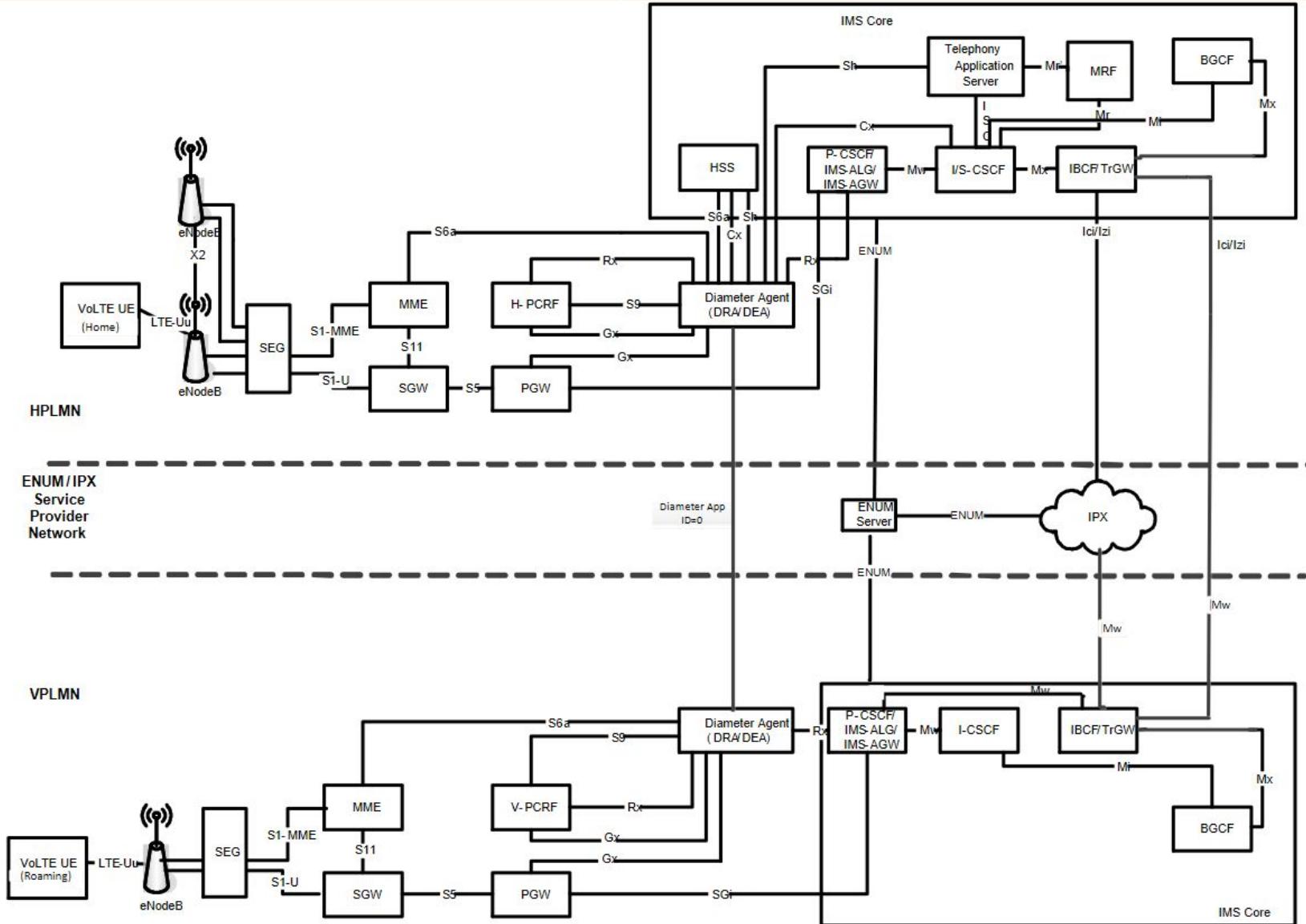
Procedure	VoLTE UE to Peer IMS Call (MO)
Specification	https://www.gsma.com/futurenetworks/wp-content/uploads/2014/05/FCM.01-v1.1.pdf
Section	Figure 16
	<pre> sequenceDiagram participant S_CSCF as S-CSCF participant BGCF as BGCF participant IBCF as IBCF/ TrGW participant PeerIMS as Peer IMS Network S_CSCF->>BGCF: SIP Invite (SDP) BGCF->>IBCF: SIP Invite (SDP) IBCF->>PeerIMS: SIP Invite (SDP) PeerIMS->>IBCF: SIP 100 Trying IBCF->>PeerIMS: SIP 100 Trying PeerIMS->>IBCF: SIP 100 Trying IBCF->>PeerIMS: SIP 183 Progress)(SDP) PeerIMS->>IBCF: SIP PRACK IBCF->>PeerIMS: SIP PRACK PeerIMS->>IBCF: SIP 200 OK(PRACK) IBCF->>PeerIMS: SIP 200 OK(PRACK) PeerIMS->>IBCF: SIP UPDATE (SDP) IBCF->>PeerIMS: SIP UPDATE (SDP) PeerIMS->>IBCF: SIP 200 OK(UPDATE) (SDP) IBCF->>PeerIMS: SIP 180 Ringing PeerIMS->>IBCF: SIP 200 OK (INV) IBCF->>PeerIMS: SIP ACK PeerIMS->>IBCF: SIP ACK Note over IBCF, PeerIMS: VoLTE voice traffic over RTP via IMS media plane elements </pre> <p>The diagram illustrates the sequence of SIP messages exchanged between the S-CSCF, BGCF, IBCF/TrGW, and the Peer IMS Network during a VoLTE UE to Peer IMS Call (MO). The process begins with the S-CSCF initiating a SIP Invite (SDP) to the BGCF. The BGCF then forwards this message to the IBCF/TrGW. The IBCF/TrGW sends a SIP Invite (SDP) to the Peer IMS Network. In response, the Peer IMS Network returns a SIP 100 Trying message to the IBCF/TrGW. The IBCF/TrGW then sends its own SIP 100 Trying message back to the Peer IMS Network. This is followed by a series of SIP 183 Progress(SDP) messages from the IBCF/TrGW to the Peer IMS Network, each acknowledged by a SIP PRACK from the Peer IMS Network. Subsequent SIP 200 OK(PRACK) messages are exchanged between the IBCF/TrGW and the Peer IMS Network. The process continues with SIP UPDATE (SDP) messages, SIP 200 OK(UPDATE) (SDP) acknowledgments, and SIP 180 Ringing messages. Finally, the Peer IMS Network sends a SIP 200 OK (INV) message, which is acknowledged by a SIP ACK from the IBCF/TrGW. The IBCF/TrGW also sends its own SIP ACK message. A note at the bottom indicates that VoLTE voice traffic is carried over RTP via the IMS media plane elements.</p>

Procedure	VoLTE UE to Peer IMS Call (MT)
Specification	https://www.gsma.com/futurenetworks/wp-content/uploads/2014/05/FCM.01-v1.1.pdf
Section	Figure 17
	<pre> sequenceDiagram participant S as S-CSCF participant I as I-CSCF participant GW as IBCF/ TrGW participant P as Peer IMS Network S->>I: SIP Invite (SDP) activate I I->>GW: SIP Invite (SDP) GW->>P: SIP Invite (SDP) P->>GW: SIP 100 Trying GW->>I: SIP 100 Trying I->>S: SIP 100 Trying S->>I: SIP 183 Progress (SDP) activate I I->>GW: SIP 183 Progress (SDP) GW->>P: SIP 183 Progress (SDP) P->>GW: SIP PRACK GW->>I: SIP PRACK I->>S: SIP 200 OK (PRACK) S->>I: SIP UPDATE (SDP) activate I I->>GW: SIP UPDATE (SDP) GW->>P: SIP UPDATE (SDP) P->>GW: SIP 200 OK (UPDATE) (SDP) GW->>I: SIP 200 OK (UPDATE) (SDP) I->>S: SIP 180 Ringing S->>I: SIP 180 Ringing I->>GW: SIP 180 Ringing GW->>P: SIP 180 Ringing P->>GW: SIP 200 OK (INV) GW->>I: SIP 200 OK (INV) I->>S: SIP 200 OK (INV) S->>I: SIP ACK activate I I->>GW: SIP ACK GW->>P: SIP ACK P->>GW: VoLTE voice traffic over RTP via IMS media plane elements GW->>I: VoLTE voice traffic over RTP via IMS media plane elements I->>S: VoLTE voice traffic over RTP via IMS media plane elements </pre> <p>The diagram illustrates the sequence of SIP messages exchanged between the S-CSCF, I-CSCF, IBCF/TrGW, and Peer IMS Network during a VoLTE UE to Peer IMS Call (MT). The process begins with the S-CSCF initiating a SIP Invite (SDP) to the I-CSCF. The I-CSCF then forwards this message to the IBCF/TrGW, which in turn sends it to the Peer IMS Network. The Peer IMS Network returns a SIP 100 Trying response to the IBCF/TrGW. The IBCF/TrGW sends a SIP 100 Trying response back to the I-CSCF, which then returns a SIP 100 Trying response to the S-CSCF. Subsequent steps include SIP 183 Progress (SDP), SIP PRACK, SIP 200 OK (PRACK), SIP UPDATE (SDP), SIP 200 OK (UPDATE) (SDP), SIP 180 Ringing, SIP 200 OK (INV), SIP ACK, and finally VoLTE voice traffic over RTP via IMS media plane elements.</p>

Procedure	VoLTE UE to Peer IMS Call Clearing (VoLTE side initiated)
Specification	https://www.gsma.com/futurenetworks/wp-content/uploads/2014/05/FCM.01-v1.1.pdf
Section	Figure 18
	<pre> sequenceDiagram participant S_CSCF as S-CSCF participant BGCF as BGCF participant IBCF as IBCF / TrGW participant PeerIMS as Peer IMS Network S_CSCF->>BGCF: SIP BYE activate BGCF BGCF->>IBCF: SIP BYE activate IBCF IBCF->>PeerIMS: SIP BYE activate PeerIMS PeerIMS->>IBCF: SIP 200 OK deactivate PeerIMS IBCF->>BGCF: SIP 200 OK deactivate IBCF BGCF->>S_CSCF: SIP 200 OK deactivate BGCF Note over S_CSCF, BGCF, IBCF, PeerIMS: Dedicated bearer has been released. </pre> <p>The diagram illustrates the sequence of SIP messages for clearing a call initiated from the VoLTE side. It involves four entities: S-CSCF, BGCF, IBCF / TrGW, and Peer IMS Network.</p> <ul style="list-style-type: none"> S-CSCF to BGCF: SIP BYE BGCF to IBCF: SIP BYE IBCF to Peer IMS Network: SIP BYE Peer IMS Network to IBCF: SIP 200 OK IBCF to BGCF: SIP 200 OK BGCF to S-CSCF: SIP 200 OK Final Note: Dedicated bearer has been released.

Procedure	VoLTE UE to Peer IMS Call Clearing (VoLTE side receiving)		
Specification	https://www.gsma.com/futurenetworks/wp-content/uploads/2014/05/FCM.01-v1.1.pdf		
Section	Figure 19		
	<pre> sequenceDiagram participant S_CSCF as S-CSCF participant I_CSCF as I-CSCF participant IBCF as IBCF / TrGW participant PeerIMS as Peer IMS Network S_CSCF->>I_CSCF: IMS Signalling over IP activate I_CSCF I_CSCF->>IBCF: SIP BYE activate IBCF IBCF->>PeerIMS: SIP BYE activate PeerIMS PeerIMS->>IBCF: 200 OK activate IBCF IBCF->>S_CSCF: SIP 200 OK activate S_CSCF S_CSCF->>PeerIMS: 200 OK activate PeerIMS PeerIMS->>S_CSCF: Dedicated bearer has been released deactivate S_CSCF deactivate I_CSCF deactivate IBCF deactivate PeerIMS </pre> <p>The diagram illustrates the sequence of messages for call clearing from the VoLTE UE side. It involves four entities: S-CSCF, I-CSCF, IBCF / TrGW, and Peer IMS Network. The process starts with the S-CSCF sending 'IMS Signalling over IP' to the I-CSCF. The I-CSCF then sends 'SIP BYE' to the IBCF / TrGW. The IBCF / TrGW sends 'SIP BYE' to the Peer IMS Network. The Peer IMS Network responds with '200 OK' to the IBCF / TrGW. The IBCF / TrGW returns 'SIP 200 OK' to the S-CSCF. Finally, the S-CSCF sends '200 OK' to the Peer IMS Network, and the Peer IMS Network returns 'Dedicated bearer has been released' to the S-CSCF.</p>		

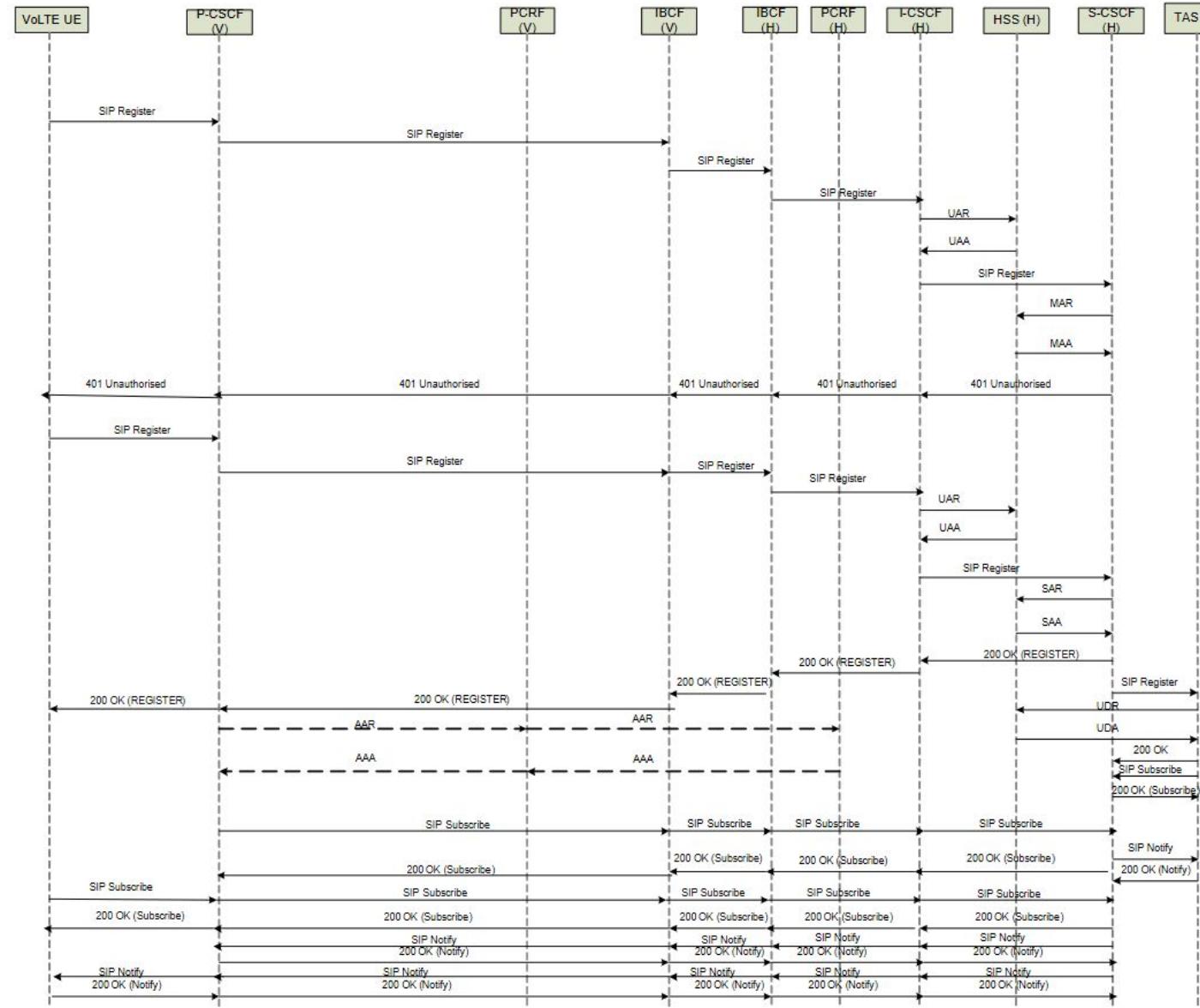
Procedure	Roaming VoLTE Architecture
Specification	https://www.gsma.com/futurenetworks/wp-content/uploads/2014/05/FCM.01-v1.1.pdf
Section	Figure 20



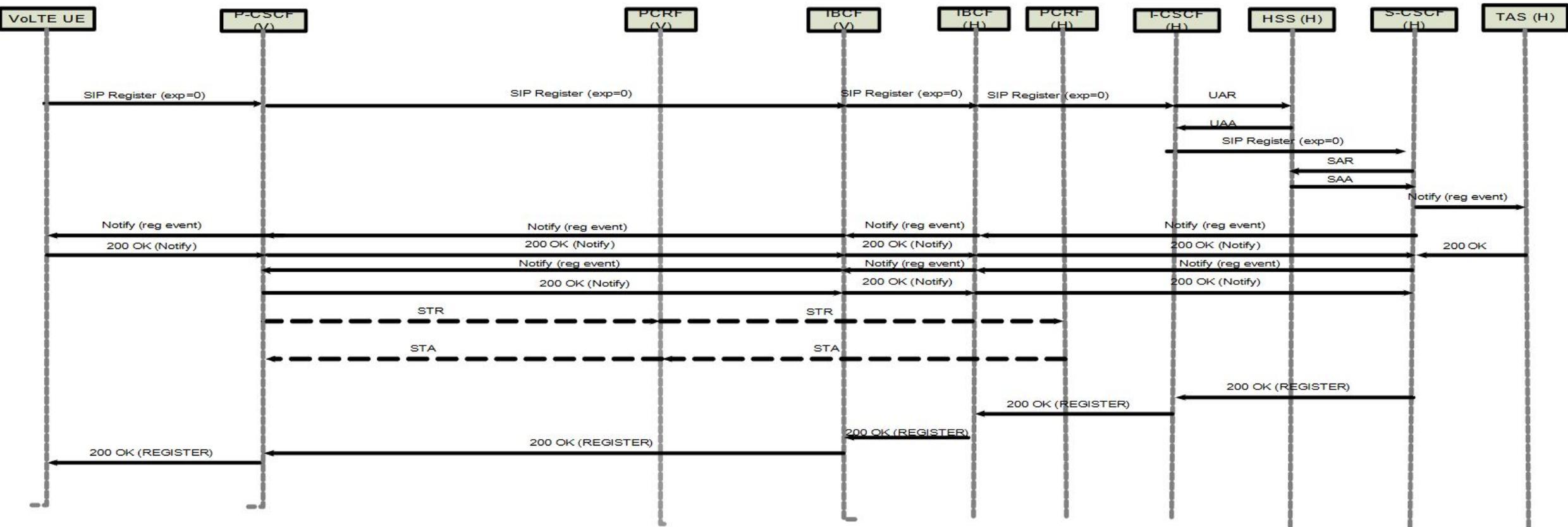
Procedure	Roaming VoLTE UE Attach
Specification	https://www.gsma.com/futurenetworks/wp-content/uploads/2014/05/FCM.01-v1.1.pdf
Section	Figure 21
	<pre> sequenceDiagram participant VoLTEUE participant eNB participant MME participant SGW participant PGW participant PCRFV participant PCRFH participant HSSH VoLTEUE->>eNB: RRC Connection Request eNB->>VoLTEUE: RRC Connection Setup VoLTEUE->>MME: Attach Req MME->>SGW: Attach req - Uplink NAS Transport SGW->>PGW: [NAS PDU] PGW->>PCRFV: [EPS SM: PDN Connectivity Request] PCRFV->>PCRFH: Authentication/Security PCRFH->>HSSH: Update Location Request HSSH->>PCRFH: Update Location Answer PCRFH->>PGW: Create Session Request PGW->>PCRFV: IMS-APN; QCI:5; ARP; APN AMBR PCRFV->>PCRFH: Create Session Request PCRFH->>PGW: IMS-APN; QCI:5; ARP; APN AMBR PGW->>CCR1: CCR CCR1->>IPAMBR1: IP@; QCI:5; ARP; APN AMBR IPAMBR1->>CCR1: CCA CCR1->>CCR2: CCR CCR2->>IPAMBR2: IP@; QCI:5; ARP; APN AMBR IPAMBR2->>CCR2: CCA CCR2->>PCRFH: Create Session Response PCRFH->>PGW: IP@; QCI:5; ARP; APN AMBR; IP default rule TFT PGW->>MME: Create Session Response MME->>VoLTEUE: E-RAB Setup MME->>VoLTEUE: E-RAB Setup Request MME->>VoLTEUE: QCI:5; ARP; UE AMBR VoLTEUE->>MME: [NAS PDU] MME->>VoLTEUE: [EPS SM: Activate Default Bearer Request] MME->>SGW: [IMS-APN; IP@;] MME->>SGW: [QCI:5; APN AMBR] SGW->>PGW: IP@; QCI:5; ARP; APN AMBR PGW->>MME: E-RAB Setup Response MME->>VoLTEUE: RRC Connection Reconfiguration VoLTEUE->>MME: [NAS PDU] MME->>VoLTEUE: [EPS SM: Activate Default Bearer Request] VoLTEUE->>MME: E-RAB Setup MME->>VoLTEUE: E-RAB Setup Response VoLTEUE->>eNB: Uplink Direct Transfer VoLTEUE->>eNB: [NAS PDU] eNB->>VoLTEUE: [EPS SM: Activate Default Bearer Accept] VoLTEUE->>MME: Attach complete - Uplink NAS Transport MME->>VoLTEUE: [NAS PDU] VoLTEUE->>MME: [Activate Default Bearer Accept] MME->>SGW: Modify Bearer Request SGW->>PGW: PGW->>MME: Modify Bearer Response MME->>VoLTEUE: Default Bearer Established for IMS Signalling MME->>VoLTEUE: IMS Signalling over IP </pre> <p>The sequence diagram illustrates the roaming VoLTE UE attach process across various network nodes. It begins with the VoLTE UE sending an RRC Connection Request to the eNB. The eNB responds with RRC Connection Setup. The VoLTE UE then sends an Attach Request to the MME. The MME initiates an Attach request via Uplink NAS Transport to the SGW. The SGW forwards the [NAS PDU] to the PGW, which also carries an [EPS SM: PDN Connectivity Request]. The PGW performs authentication and security, then sends an Update Location Request to the PCRF (V) and an Update Location Answer back to the MME. The PCRF (V) creates a session request to the PCRF (H), which then creates a session response to the PGW. The PGW returns a Create Session Response to the MME, containing QoS parameters (QCI:5, ARP, APN AMBR) and IP default rule TFT. The MME then sends E-RAB Setup and E-RAB Setup Request to the VoLTE UE, along with QoS parameters (QCI:5, ARP, UE AMBR). The VoLTE UE responds with [NAS PDU] and [EPS SM: Activate Default Bearer Request]. The MME sends the same information to the SGW. The SGW then sends IP@; QCI:5; ARP; APN AMBR to the PGW. The PGW returns an E-RAB Setup Response to the MME. The MME performs RRC Connection Reconfiguration on the VoLTE UE, which then sends Uplink Direct Transfer, [NAS PDU], and [EPS SM: Activate Default Bearer Accept] to the eNB. The eNB returns E-RAB Setup and E-RAB Setup Response to the VoLTE UE. Finally, the VoLTE UE sends Attach complete - Uplink NAS Transport to the MME, which then sends [NAS PDU] and [Activate Default Bearer Accept] to the VoLTE UE. The MME sends Modify Bearer Request to the SGW, which then sends Modify Bearer Response to the MME. The MME concludes the process by sending Default Bearer Established for IMS Signalling and IMS Signalling over IP to the VoLTE UE.</p>

Procedure	Roaming VoLTE UE Initial IMS Registration
Specification	https://www.gsma.com/futurenetworks/wp-content/uploads/2014/05/FCM.01-v1.1.pdf
Section	Figure 22

Figure 22



Procedure	Roaming VoLTE UE IMS Deregistration
Specification	https://www.gsma.com/futurenetworks/wp-content/uploads/2014/05/FCM.01-v1.1.pdf
Section	Figure 23



Procedure	Roaming VoLTE UE Initiated Detach
Specification	https://www.gsma.com/futurenetworks/wp-content/uploads/2014/05/FCM.01-v1.1.pdf
Section	Figure 24
	<pre> sequenceDiagram participant VoLTEUE as VoLTE UE participant eNB as eNB participant MME as MME participant SGW as SGW participant PGW as PGW participant PCRFV as PCRF (V) participant PCRFH as PCRF (H) participant HSSH as HSS (H) VoLTEUE->>eNB: Detach Request eNB->>MME: Delete Session Request MME->>SGW: Delete Session Response SGW->>PGW: Delete Session Request PGW->>PCRFV: Delete Session Response PCRFV->>PCRFH: CCR PCRFH->>PCRFV: CCR PCRFH->>HSSH: CCA PCRFV->>PCRFH: CCA MME->>VoLTEUE: Detach Accept VoLTEUE->>SGW: Release Access Bearer Request SGW->>MME: Release Access Bearer Response MME->>VoLTEUE: UE Context Release Command VoLTEUE->>eNB: RRC Connection Release eNB-->>VoLTEUE: UE Context Release Complete activate Note Note-->>VoLTEUE: Default Bearer is Deleted and UE is not LTE Attached deactivate Note </pre> <p>The sequence diagram illustrates the roaming VoLTE UE initiated detach process. It begins with the VoLTE UE sending a 'Detach Request' to the eNB. The eNB then sends a 'Delete Session Request' to the MME. The MME responds with a 'Delete Session Response' to the SGW. The SGW sends a 'Delete Session Request' to the PGW. The PGW responds with a 'Delete Session Response' to the PCRF (V). The PCRF (V) then sends a 'CCR' (Context Release Command) to the PCRF (H). The PCRF (H) also sends a 'CCR' back to the PCRF (V). Simultaneously, the PCRF (H) sends a 'CCA' (Context Change Acknowledgment) to the HSS (H). The MME receives a 'Detach Accept' from the VoLTE UE and sends a 'Release Access Bearer Request' to the SGW. The SGW returns a 'Release Access Bearer Response' to the MME. The MME then sends a 'UE Context Release Command' to the VoLTE UE. The VoLTE UE responds with an 'RRC Connection Release' to the eNB. Finally, the eNB sends a 'UE Context Release Complete' back to the VoLTE UE. A note at the bottom indicates that the 'Default Bearer is Deleted and UE is not LTE Attached'.</p>

Procedure	Roaming VoLTE to VoLTE MO Call
Specification	https://www.gsma.com/futurenetworks/wp-content/uploads/2014/05/FCM.01-v1.1.pdf
Section	Figure 25
	<p>The sequence diagram illustrates the call setup process between the VolTE UE and various network components. The process begins with the VolTE UE sending a SIP Invite (SDP) to the PGW. The PGW then forwards this message to the PCRF (v). The PCRF (v) sends a SIP 100 Trying response back to the VolTE UE. Subsequent SIP Invite (SDP) messages are exchanged between the VolTE UE and the PCRF (v). The PCRF (v) also sends SIP 100 Trying responses to the VolTE UE. The P-CSCF/IMS-ALG/IMS-AGW, IBCF (V), IBCF (H), PCRF (H), S-CSCF, and TAS are involved in the AAA and AAR (Authentication and Authorization Request) exchange. The S-CSCF sends SIP PRACK and SIP 200 OK (PRACK) messages to the VolTE UE. The TAS is involved in the final SIP ACK exchange. The diagram also indicates the flow of VolTE voice traffic via a dedicated bearer and over RTP via IMS media plane elements.</p>

Procedure	Roaming VoLTE to VoLTE MT Call
Specification	https://www.gsma.com/futurenetworks/wp-content/uploads/2014/05/FCM.01-v1.1.pdf
Section	Figure 26
	<p>The sequence diagram illustrates the signaling flow for a roaming VoLTE to VoLTE MT call. It shows the exchange of SIP messages (Invite, Progress, PRACK, UPDATE, ACK) and AAA messages (AAR, RAA, AAA) between the VoLTE UE, PGW, PCRF (V), P-CSCF/IMS-ALG/IMS-AGW, IBCF (V), IBCF (H), PCRF (H), S-CSCF, TAS, and TAS. The diagram also indicates the flow of VOLTE voice traffic via a dedicated bearer and over RTP via IMS media plane elements.</p> <pre> sequenceDiagram participant VoLTEUE as VoLTE UE participant PGW as PGW participant PCRFV as PCRF (V) participant PCRFH as PCRF (H) participant PIMS as P-CSCF/IMS-ALG / IMS-AGW participant IBCFV as IBCF (V) participant IBCFH as IBCF (H) participant SCSCF as S-CSCF participant TAS1 as TAS participant TAS2 as TAS VoLTEUE->>PGW: SIP Invite (SDP) PGW->>VoLTEUE: SIP 100 Trying VoLTEUE->>PCRFV: SIP Invite (SDP) PCRFV->>VoLTEUE: SIP 100 Trying VoLTEUE->>PIMS: SIP Invite (SDP) PIMS->>VoLTEUE: SIP 100 Trying VoLTEUE->>IBCFV: SIP Invite (SDP) IBCFV->>VoLTEUE: SIP 100 Trying VoLTEUE->>IBCFH: SIP Invite (SDP) IBCFH->>VoLTEUE: SIP 100 Trying VoLTEUE->>PCRFH: SIP Invite (SDP) PCRFH->>VoLTEUE: SIP 100 Trying VoLTEUE->>SCSCF: SIP Invite (SDP) SCSCF->>VoLTEUE: SIP 100 Trying VoLTEUE->>TAS1: SIP Invite (SDP) TAS1->>VoLTEUE: SIP 100 Trying VoLTEUE->>TAS2: SIP Invite (SDP) TAS2->>VoLTEUE: SIP 100 Trying VoLTEUE->>IBCFV: SIP 183 Progress (SDP) IBCFV->>VoLTEUE: SIP 183 Progress (SDP) VoLTEUE->>IBCFH: SIP 183 Progress (SDP) IBCFH->>VoLTEUE: SIP 183 Progress (SDP) VoLTEUE->>SCSCF: SIP 183 Progress (SDP) SCSCF->>VoLTEUE: SIP 183 Progress (SDP) VoLTEUE->>TAS1: SIP 183 Progress (SDP) TAS1->>VoLTEUE: SIP 183 Progress (SDP) VoLTEUE->>TAS2: SIP 183 Progress (SDP) TAS2->>VoLTEUE: SIP 183 Progress (SDP) PCRFV->>AAA: AAR AAA->>PCRFV: RAA PCRFV->>AAA: AAA AAA->>PCRFV: RAA PCRFV->>IBCFV: SIP PRACK IBCFV->>PCRFV: SIP PRACK PCRFV->>IBCFH: SIP PRACK IBCFH->>PCRFV: SIP PRACK PCRFV->>SCSCF: SIP PRACK SCSCF->>PCRFV: SIP PRACK PCRFV->>TAS1: SIP PRACK TAS1->>PCRFV: SIP 200 OK (PRACK) PCRFV->>IBCFV: SIP 200 OK (PRACK) IBCFV->>PCRFV: SIP 200 OK (PRACK) PCRFV->>IBCFH: SIP 200 OK (PRACK) IBCFH->>PCRFV: SIP 200 OK (PRACK) PCRFV->>SCSCF: SIP 200 OK (PRACK) SCSCF->>PCRFV: SIP 200 OK (PRACK) PCRFV->>TAS1: SIP 200 OK (PRACK) TAS1->>PCRFV: SIP UPDATE (SDP) PCRFV->>IBCFV: SIP UPDATE (SDP) IBCFV->>PCRFV: SIP UPDATE (SDP) PCRFV->>IBCFH: SIP UPDATE (SDP) IBCFH->>PCRFV: SIP UPDATE (SDP) PCRFV->>SCSCF: SIP UPDATE (SDP) SCSCF->>PCRFV: SIP UPDATE (SDP) PCRFV->>TAS1: SIP UPDATE (SDP) TAS1->>PCRFV: SIP 200 OK (UPDATE) (SDP) PCRFV->>IBCFV: SIP 200 OK (UPDATE) (SDP) IBCFV->>PCRFV: SIP 200 OK (UPDATE) (SDP) PCRFV->>IBCFH: SIP 200 OK (UPDATE) (SDP) IBCFH->>PCRFV: SIP 200 OK (UPDATE) (SDP) PCRFV->>SCSCF: SIP 200 OK (UPDATE) (SDP) SCSCF->>PCRFV: SIP 200 OK (UPDATE) (SDP) PCRFV->>TAS1: SIP 200 OK (UPDATE) (SDP) TAS1->>PCRFV: SIP 180 Ringing PCRFV->>IBCFV: SIP 180 Ringing IBCFV->>PCRFV: SIP 180 Ringing PCRFV->>IBCFH: SIP 180 Ringing IBCFH->>PCRFV: SIP 180 Ringing PCRFV->>SCSCF: SIP 180 Ringing SCSCF->>PCRFV: SIP 180 Ringing PCRFV->>TAS1: SIP 180 Ringing TAS1->>PCRFV: SIP 200 OK (INV) PCRFV->>IBCFV: SIP 200 OK (INV) IBCFV->>PCRFV: SIP 200 OK (INV) PCRFV->>IBCFH: SIP 200 OK (INV) IBCFH->>PCRFV: SIP 200 OK (INV) PCRFV->>SCSCF: SIP 200 OK (INV) SCSCF->>PCRFV: SIP 200 OK (INV) PCRFV->>TAS1: SIP 200 OK (INV) TAS1->>PCRFV: SIP ACK PCRFV->>IBCFV: SIP ACK IBCFV->>PCRFV: SIP ACK PCRFV->>IBCFH: SIP ACK IBCFH->>PCRFV: SIP ACK PCRFV->>SCSCF: SIP ACK SCSCF->>PCRFV: SIP ACK PCRFV->>TAS1: SIP ACK TAS1->>PCRFV: SIP ACK </pre> <p>VOLTE voice traffic via dedicated bearer</p> <p>VOLTE voice traffic over RTP via IMS media plane elements</p>

Procedure	Roaming VoLTE to VoLTE Call Clearing (Initiated by Roamer)
Specification	https://www.gsma.com/futurenetworks/wp-content/uploads/2014/05/FCM.01-v1.1.pdf
Section	Figure 27
	<pre> sequenceDiagram participant VoLTEUE as VoLTE UE participant PGW as PGW participant PCRFV as PCRF (V) participant PCRFH as PCRF (H) participant PIMS as P-CSCF/IMS-AGW/IMS-ALG participant IBCFV as IBCF (V) participant IBCFH as IBCF (H) participant SCSCF as S-CSCF participant TAS as TAS VoLTEUE->>PGW: SIP BYE PGW->>PCRFV: SIP BYE PCRFV->>PIMS: SIP BYE PIMS->>IBCFV: SIP BYE IBCFV->>IBCFH: SIP BYE IBCFH->>PCRFH: SIP BYE PCRFH->>SCSCF: SIP BYE SCSCF->>TAS: SIP BYE TAS->>SCSCF: SIP BYE SCSCF->>TAS: SIP BYE TAS->>SCSCF: SIP BYE PCRFV->>VoLTEUE: STR IBCFV->>IBCFH: STR IBCFH->>SCSCF: STA SCSCF->>TAS: STA TAS->>SCSCF: RAR SCSCF->>TAS: RAA TAS->>SCSCF: STA SCSCF->>TAS: STA SCSCF->>PIMS: SIP 200 OK PIMS->>IBCFV: SIP 200 OK IBCFV->>IBCFH: SIP 200 OK IBCFH->>SCSCF: SIP 200 OK SCSCF->>TAS: SIP 200 OK TAS->>SCSCF: SIP 200 OK SCSCF->>TAS: SIP 200 OK TAS->>SCSCF: SIP 200 OK SCSCF->>TAS: SIP 200 OK </pre> <p>The sequence diagram illustrates the roaming VoLTE to VoLTE call clearing process initiated by the Roamer. It shows the flow of SIP messages between the VoLTE UE, PGW, PCRF (V), P-CSCF/IMS-AGW/IMS-ALG, IBCF (V), IBCF (H), PCRF (H), S-CSCF, and TAS. Key messages include SIP BYE, SIP 200 OK, and various Session Transfer Request (STR) and Session Transfer Acknowledgment (STA) messages.</p>

Procedure	Roaming VoLTE to VoLTE Call Clearing (Received by Roamer)
Specification	https://www.gsma.com/futurenetworks/wp-content/uploads/2014/05/FCM.01-v1.1.pdf
Section	Figure 28
	<pre> sequenceDiagram participant VoLTEUE as VoLTE UE participant PGW participant PCRFV as PCRF (V) participant PCRFH as PCRF (H) participant PIMS as P-CSCF/IMS-AGW/IMS-ALG participant IBCFV as IBCF (V) participant IBCFH as IBCF (H) participant SCSCF as S-CSCF participant TAS VoLTEUE->>PGW: SIP BYE PGW->>PCRFV: SIP BYE PCRFV->>PIMS: SIP BYE PIMS->>IBCFV: SIP BYE IBCFV->>IBCFH: SIP BYE IBCFH->>PCRFH: SIP BYE PCRFH->>SCSCF: SIP BYE SCSCF->>TAS: SIP BYE PCRFV->>VoLTEUE: STR IBCFH->>IBCFV: STR SCSCF->>TAS: STA TAS->>SCSCF: RAR SCSCF->>TAS: RAA TAS->>IBCFV: STA IBCFV->>SCSCF: SIP 200 OK SCSCF->>IBCFV: SIP 200 OK IBCFH->>IBCFV: SIP 200 OK IBCFV->>SCSCF: SIP 200 OK SCSCF->>IBCFV: SIP 200 OK PCRFH->>SCSCF: SIP 200 OK SCSCF->>PCRFH: SIP 200 OK SCSCF->>TAS: SIP 200 OK TAS->>SCSCF: SIP 200 OK SCSCF->>TAS: SIP 200 OK </pre> <p>The sequence diagram illustrates the roaming VoLTE to VoLTE call clearing process. It shows the flow of SIP BYE messages from the VoLTE UE through various network nodes (PGW, PCRF (V), P-CSCF/IMS-AGW/IMS-ALG, IBCF (V), IBCF (H), PCRF (H), S-CSCF, and TAS) to clear the call. The diagram also includes ACKNOWLEDGE (STR) messages, REQUEST ACKNOWLEDGE (RAA) messages, and SIP 200 OK responses exchanged between the S-CSCF and the roaming network nodes.</p>

Procedure	VoLTE Packet Drops
Specification	https://www.gsma.com/futurenetworks/wp-content/uploads/2014/05/FCM.01-v1.1.pdf
Section	6.1.2.2

6.1.2.2 VoLTE UE exceeds the link MTU-size – IP Layer fragmentation – Packets dropped

Title	VoLTE UE exceeds the link MTU-size – IP Layer fragmentation – Packets dropped
Reference ID	ID_Device_02
Priority	High
Date Submitted	08/07/2013
Date Modified	08/07/2013
Overview	IP fragmentation may occur between the UE and the PGW if the UE sends packets that exceed the maximum link MTU size that is supported in the network as part of IP configuration. IP fragmentation is not recommended by 3GPP due to significant transmission overhead. If the UE exceeds the limit and IP fragmentation is not supported in the EPC, the result is packet loss.
Status	Closed
Detailed Description	<p>3GPP TS 23.060 [3] Annex C provides information related to Link MTU considerations. The maximum size of the link MTU size is currently set to 1500 octets. Taking into account the headers for GTP packets that may be further encapsulated within an IPSec tunnel, the overall UE link MTU size is set at 1358 octets.</p> <p>The link MTU size of the network can be requested by the UE in the Protocol Configuration Options (PCO) during LTE Attach. This enables the UE to discover the link MTU size and be compatible with the network IP configuration.</p> <p>It has been discovered that not all UE's request the link MTU size, and regularly exceed this limit when sending SIP messages (e.g. particularly in downloadable clients). If the network does not support procedures for IP fragmentation, then the packets are discarded which in turn results in loss of VoLTE functionality.</p>
Solution	<p>VoLTE UE's shall request the link MTU size from the network (requested in the PCO during attach) and utilise this value when transmitting data packets.</p> <p>NOTE: For IPv6 implementations, the link MTU size is present in the IPv6 Router Advertisement.</p>