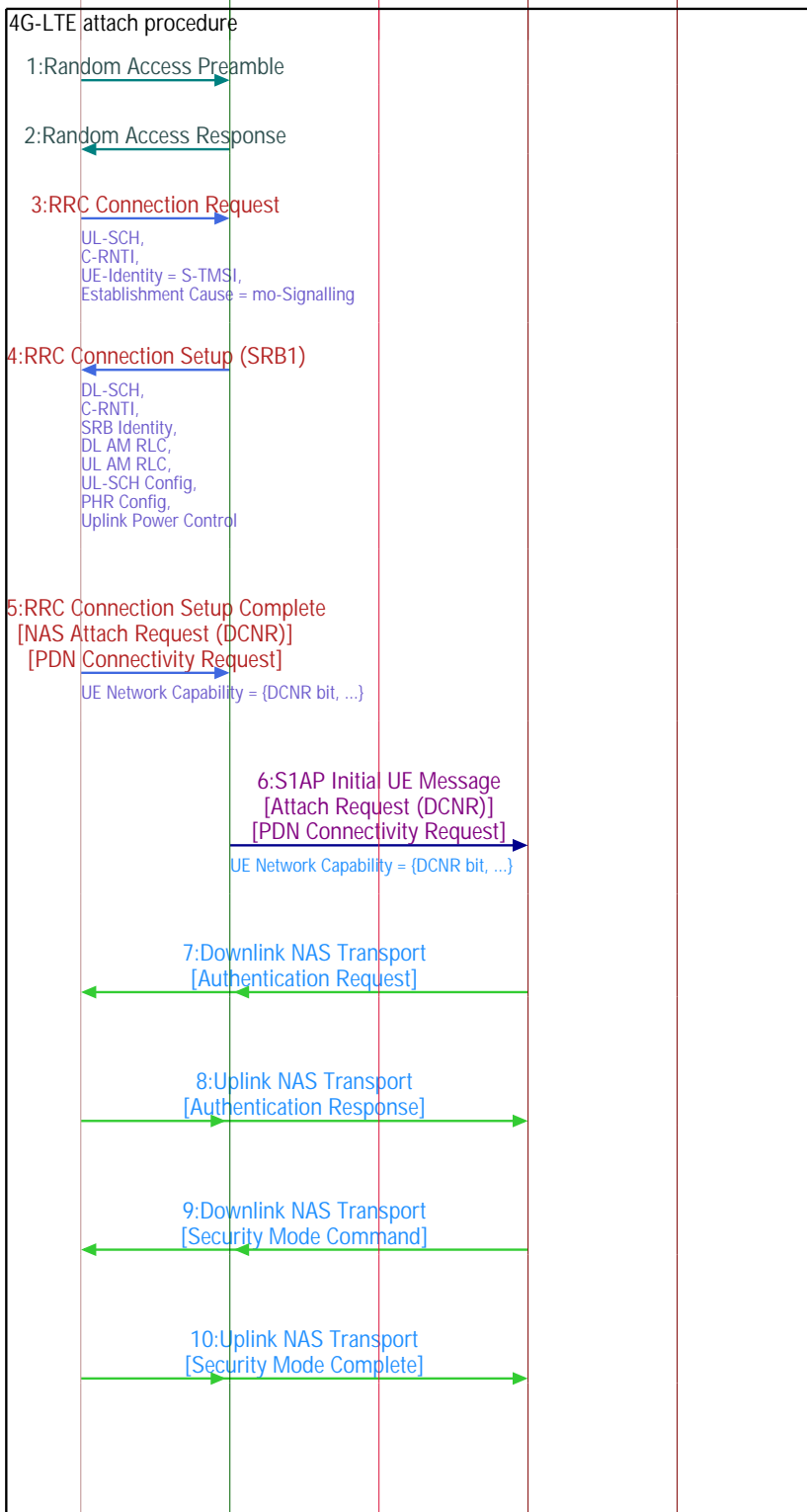




LTE eNB - 5G gNB dual connectivity (EN-DC)

E-UTRAN New Radio - Dual Connectivity (EN-DC) is a technology that enables introduction of 5G services and data rates in a predominantly 4G network. UEs supporting EN-DC can connect simultaneously to LTE eNB and 5G-NR gNB. This approach permits cellular providers to roll out 5G services without the expense of a full scale 5G Core Network. 5G gNBs can be introduced early in areas with high traffic congestion.

An EN-DC enabled UE first registers for service with the 4G EPC. The UE also starts reporting measurements on 5G frequencies. If the signal quality for the UE will support a 5G service, the LTE eNB communicates with the 5G-NR gNB to assign resources for a 5G bearer. The 5G-NR resource assignment is then signaled to the UE via an LTE RRC Connection Reconfiguration message. Once the RRC Connection Reconfiguration procedure is completed, the UE simultaneously connects to the 4G and 5G networks.



The terminal initiates a new session with the randomly selected preamble.

The eNodeB responds to the preamble with the "Random Access Response" message on the DL-SCH.

The UE uses a UL-SCH allocation to send the RRC Connection Request message.

eNodeB responds with an RRC Connection Setup message on the DL-SCH.

The UE signals the completion of the RRC connection. The message carries the NAS Attach Request. The DCNR bit in the "UE Network Capability" IE is set. This signals to the 4G Core Network that the UE supports dual connectivity with 4G-LTE and 5G-NR.

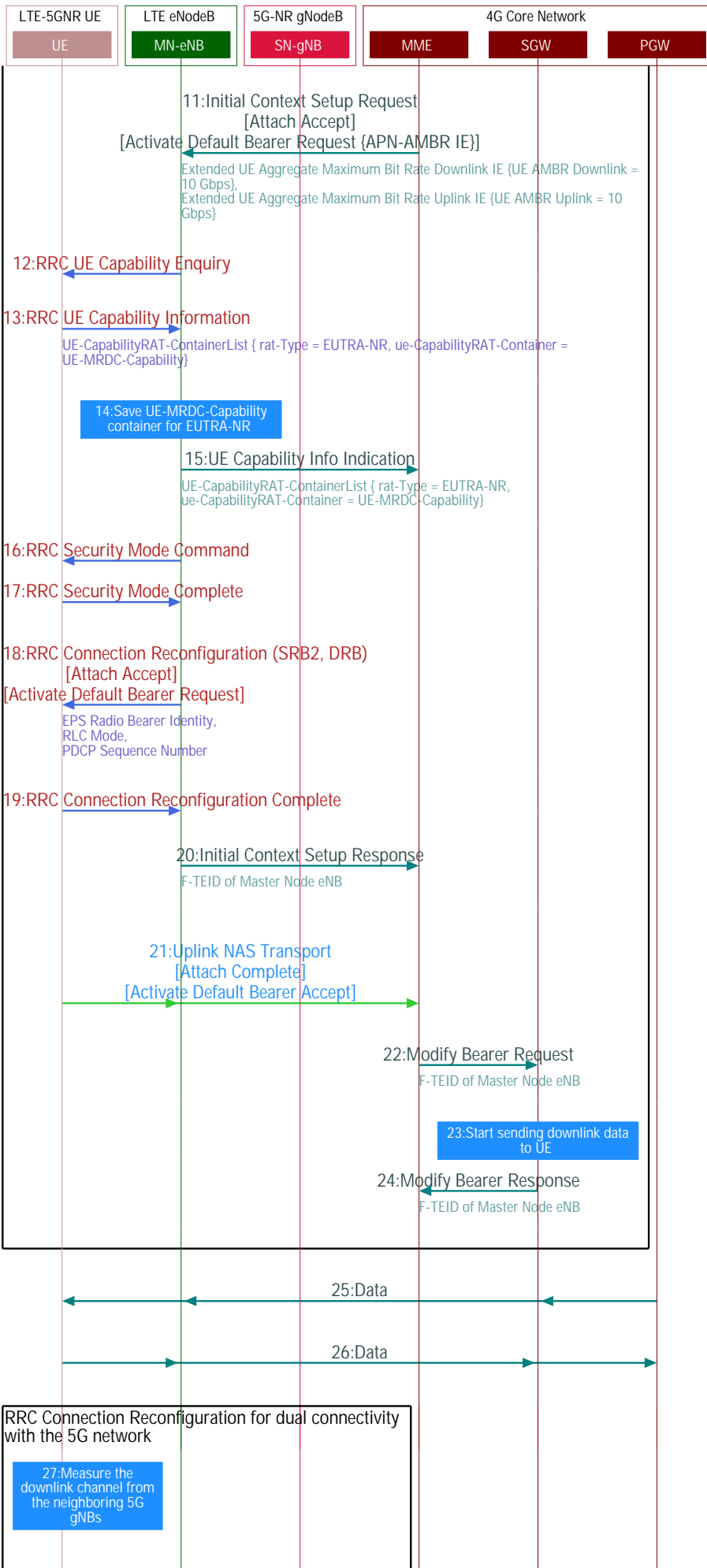
The NAS messages from the UE are signaled to the Core Network via the Initial UE message.

MME initiates the authentication procedure

Authentication is successfully completed.

MME initiates NAS level security procedure.

NAS level security procedure is completed. From this point, all communication between MME and UE will be encrypted.



MME responds back to the eNodeB with a message containing three messages: S1AP Initial Context Setup Request, NAS Attach Accept and Activate Default Bearer Request. 5G downlink and uplink data rates are signaled via Extended UE-AMBR Downlink and Uplink Information Elements.

MME has not sent UE capabilities so the eNodeB asks the UE for "UE Capabilities".

UE reports that it supports the EUTRA-NR radio access technology. EUTRA-NR specific capabilities are specified in the UE-MRDC-Capability container.

UE capabilities are also passed to the MME.

Setup security between the eNodeB and the UE

Ciphering is enabled in both directions.

The RRC Connection Reconfiguration message is sent to activate the default radio bearer. The message also carries the Attach Accept message as NAS Payload.

UE signals the completion of the RRC Connection Reconfiguration.

eNodeB responds back to the Initial Context Setup message. The message also contains the GTP TEID that should be used for sending downlink data to the eNodeB.

UE signals the completion of Attach and default bearer activation.

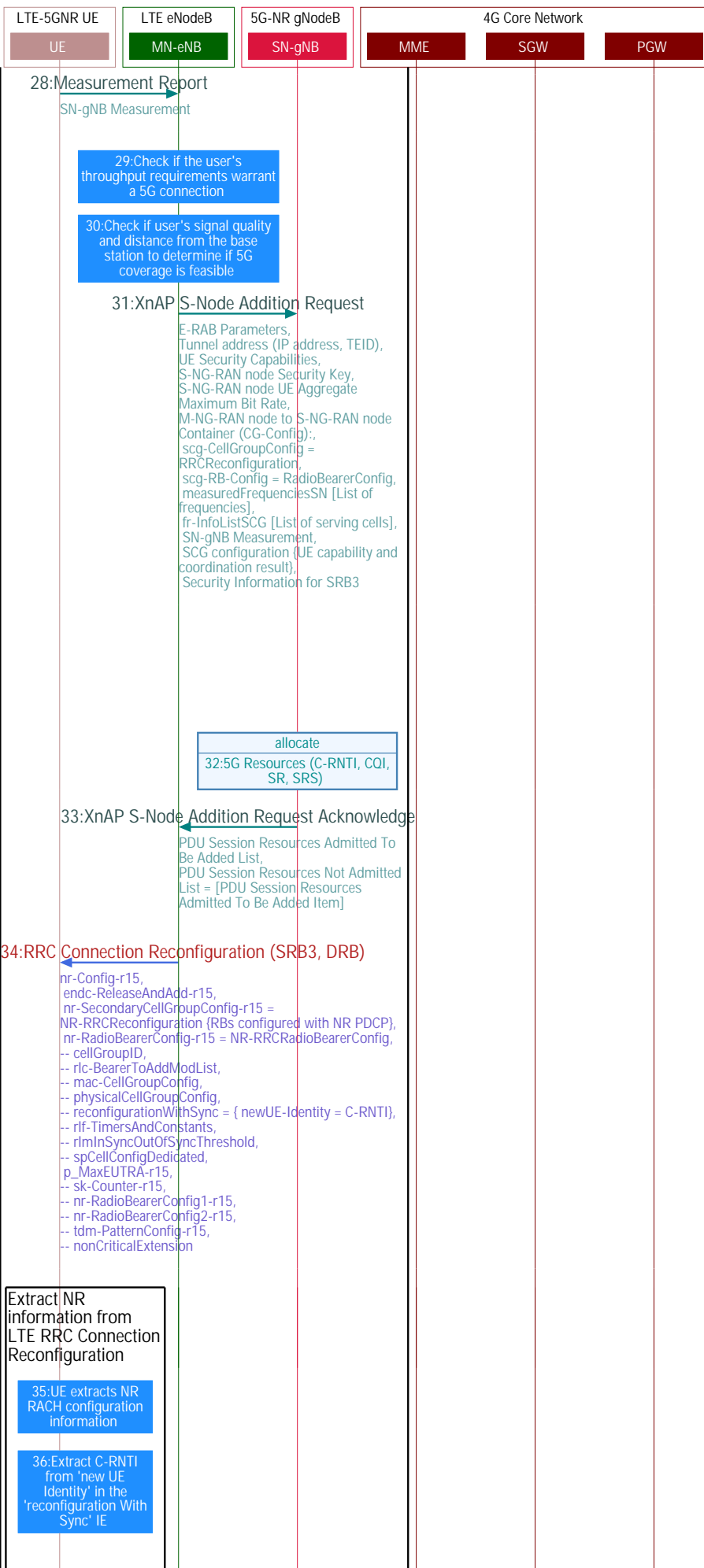
MME modifies the bearer and sends the TEID to use for downlink data.

Respond back to MME.

Downlink data is flowing on the default bearer.

Uplink data is flowing on the default bearer.

UE measures 5G-AN cell signal quality



5G signal quality is reported back to 4G eNB.

The 4G LTE eNodeB decides to add the 5G-NR base station as a secondary node. The eNodeB sends a Secondary Node Addition Request to the gNodeB. The message carries the RRC and Radio Bearer configuration. UE capabilities and security information are also included in the message.

The network indicates whether the UE shall use either KeNB (master node key) or S-KgNB (secondary node key) for the 5G DRB.

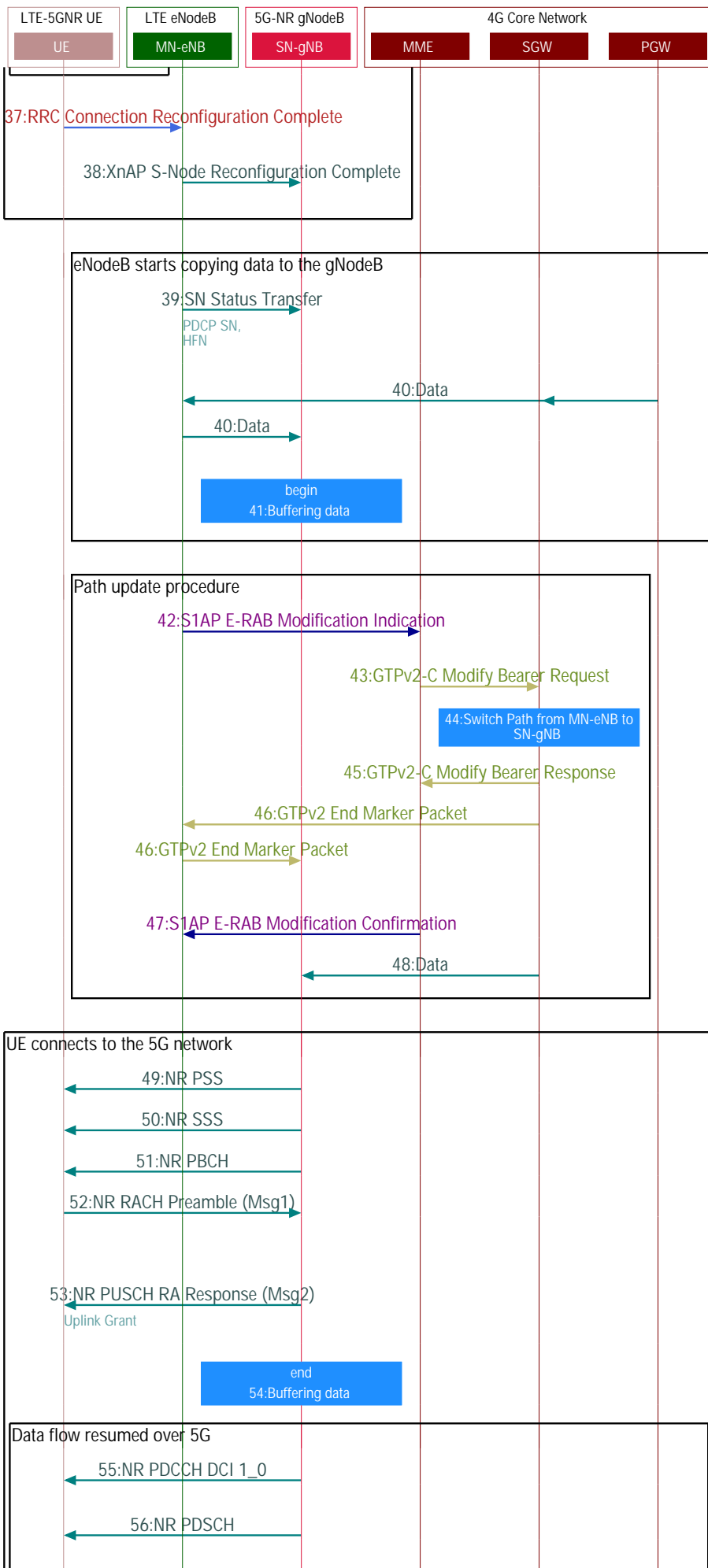
Allocate the 5G radio resources needed for the secondary session.

The gNodeB responds with information about the radio resources and bearers admitted with the 5G network.

The 4G eNodeB sends an RRC Connection Reconfiguration to the UE. The message assigns 5G radio resources to the UE.

Extract the 5G NR RACH information parameters that will be needed to access the 5G network.

Extract the C-RNTI assigned for 5G access.



The UE signals the receipt of the RRC Connection Reconfiguration to the LTE eNodeB.

The 4G eNodeB informs the secondary node (gNodeB) about the reconfiguration complete.

eNodeB informs the gNodeB about the PDCP SN and HFN for all the bearers that are being transferred to 5G.

SGW is sending data to the MN-eNB. The MN-eNB keeps forwarding that data to the SN-gNB.

At this point, the gNodeB is buffering the data as the UE has not established the 5G path.

Notify the MME that the data bearer is being switched from 4G-LTE to 5G-NR.

MME updates the bearer at the SGW.

Switching the data path from the eNodeB to gNodeB.

Respond back to the MME.

Send the End Marker to the eNodeB. This marks the end of data transmission to the 4G-eNodeB. Subsequent data transmissions will be towards the 5G-gNodeB.

MME responds back the eNodeB.

Data is now being sent directly to the 5G-gNodeB.

UE acquires the 5G-NR Primary Synchronization Signal.

UE acquires the 5G-NR Secondary Synchronization Signal.

UE acquires the 5G-NR Broadcast Channel.

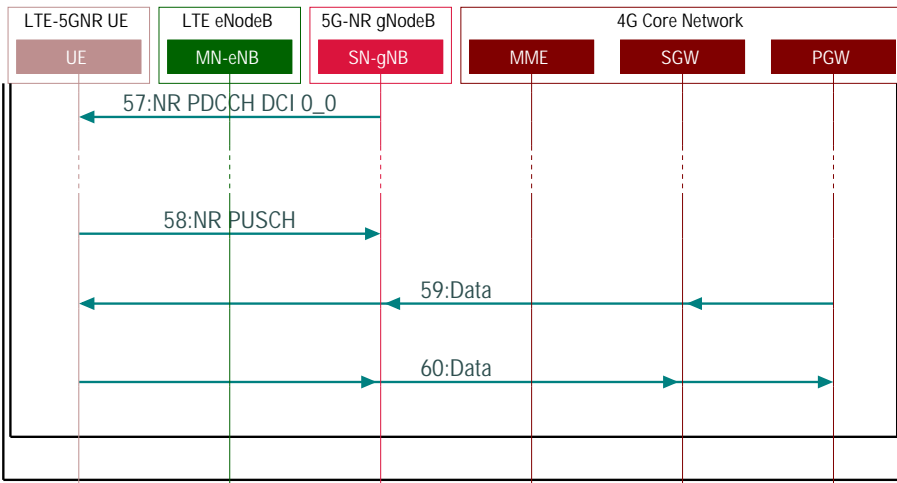
The UE initiates the random-access procedure with the 5G gNodeB. Non-contention based random-access will be attempted if the preamble assignment was received in the RRC Connection Reconfiguration message.

The 5G secondary node gNodeB responds with an RA Response. The message also carries an uplink grant for Msg3 transmission.

The gNodeB stops buffering data and starts data transmission.

NR PDCCH signals downlink resource block allocations for PDSCH

The eNodeB transmits the PDSCH.



gNodeB assigns uplink resource blocks.

The UT receives the DCH 0_0 grant and transmits the PUSCH in the uplink direction.

Data is now being directly routed from the 4G SGW to the 5G gNodeB.

Uplink data is being transported from the 5G gNodeB to the 4G SGW.