5G Standalone Access: Registration Procedure

Click on individual messages names and actions boxes for a detailed description.

Preconditions

1:RRC_IDLE

The UE is in RRC idle state

2:UE Context

The UE context already exists at the Old AMF.

5G-NR RRC Connection Setup

3:Msg1: Preamble

Zadoff-Chu sequence

The UE picks a random preamble. The preamble is referenced with the Random Access Preamble Id (RAPID). The preamble transmission is a Zadoff-Chu sequence.

4:T300

Start T300 to await the RRC Setup message from the network.

5:Start decoding the PDCCH for the RA-RNTI

In response to a PRACH transmission, a UE attempts to detect a DCI Format 1_0 with CRC scrambled by a the RA-RNTI corresponding to the RACH transmission. The UE looks for message during a configured window of length ra-ResponseWindow.

6:Allocate Temporary C-RNTI

The Temporary C-RNTI assignment will be signaled to the UE in the Random Access Response message.

7:PDCCH DCI Format 1_0 [RA-RNTI]

Frequency domain resource assignment,
Time domain resource assignment,
Downlink MCS

The RA-RNTI scrambled DCI message signals the frequency and time resources assigned for the transmission of the Transport Block containing the Random Access Response message.

8:Msg2: Random Access Response

Timing Advance Command,
UL Grant = { Frequency hopping flag, Msg3 PUSCH frequency+time resource allocation, Uplink MCS, TPC command, CSI request},
Temporary C-RNTI

The UE detects a DCI Format 1_0 with CRC scrambled by the corresponding RA-RNTI and receives a transport block in a corresponding PDSCH. The RAR carries the timing advance, uplink grant and the Temporary C-RNTI assignment.

9:ue-identity = Random number between 0 and 2^39-1

UE picks a random identity that will be used during contention resolution.

10:Extract UL Grant from the RAR

The uplink allocation contained in the RAR will be used to transmit Msg3 (RRC Setup Request).

11:Msg3: RRCSetupRequest

ue-Identity,
establishmentCause

The RRC Setup Request is sent with the random ue-Identity and an establishment cause.

12:PDCCH DCI Format 1_0 [C-RNTI]

Frequency domain resource assignment,
Time domain resource assignment,
Downlink MCS

The C-RNTI scrambled DCI message signals the frequency and time resources assigned for the transmission of the Transport Block containing the RRC Setup message.

13:Setup SRB1

Signaling Radio Bearer 1 is configured.

14:Msg4: RRCSetup

radioBearerConfig {srb-ToAddModList},
masterCellGroup {cellGroupId, rlc-BearerToAddModList, mac-CellGroupConfig, physicalCellGroupConfig}

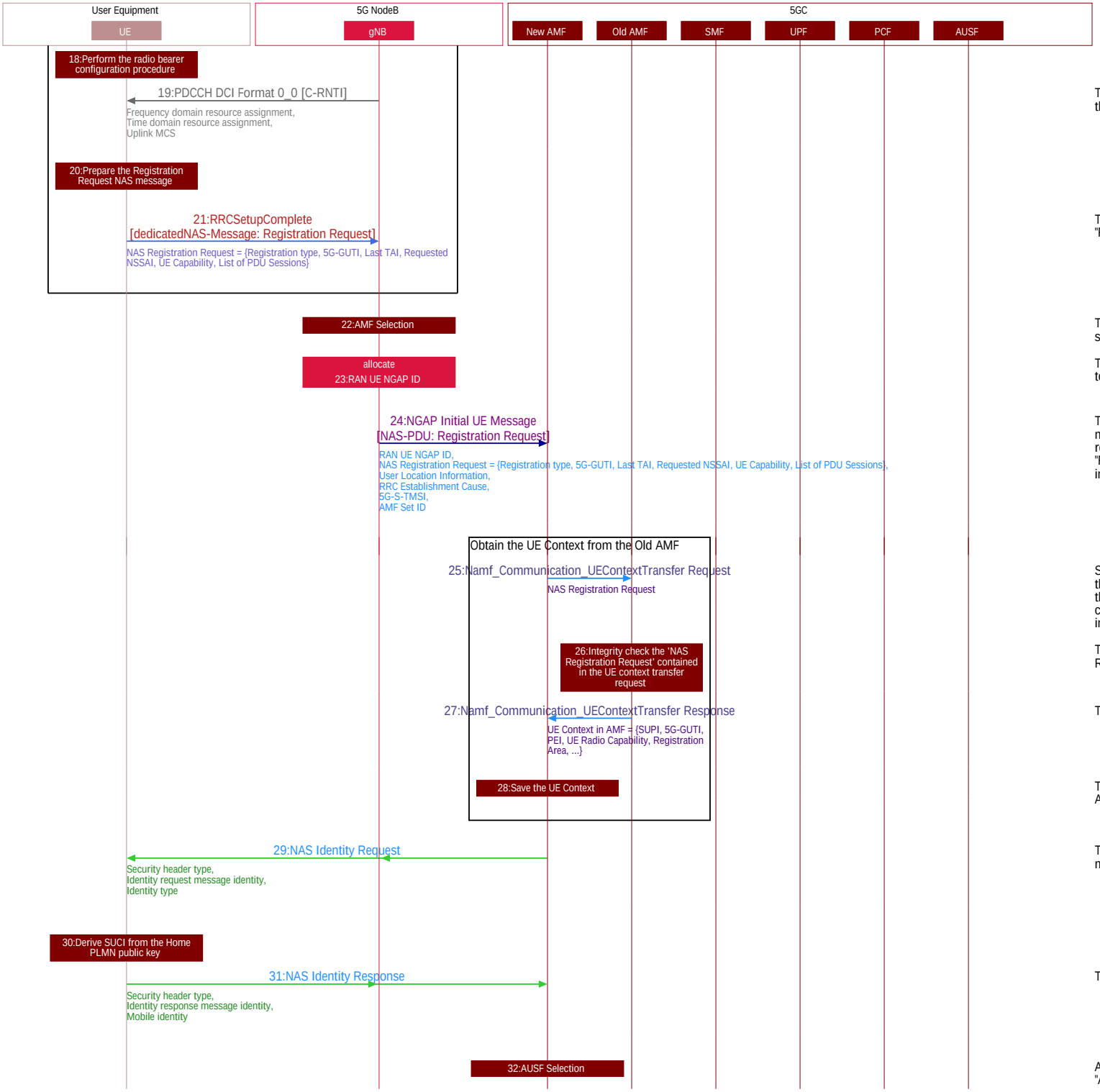
The RRC Setup message is sent to setup SRB1 and the master cell. The message carries the radioBearerConfig and masterCellGroup information elements.

15:T300

The UE stops T300 as it has received the RRC Setup message.

16:RRC_CONNECTED

17:Perform the cell group configuration procedure



The gNB assigns uplink resource to the UE so that it can send the RRC Setup Complete message.

The UE sends the RRC Setup Complete message with a "Registration Request" in the dedicatedNAS-Message field.

The gNB selects the Access and Mobility Function (AMF) for this session.

The gNB allocates a "RAN UE NGAP ID". The AMF will use this id to address the UE context on the gNB.

The gNB sends the Initial UE Message to the selected AMF. The message carries the "Registration Request" message that was received from the UE in the RRC Setup Complete message. The "RAN UE NGAP ID" and the "RRC Establishment Cause" are also included in the message.

Since the 5G-GUTI was included in the Registration Request and the serving AMF has changed since last Registration procedure, the new AMF requests context transfer from the old AMF. The complete NAS registration message received from the UE is included in the context request.

The AMF performs an integrity check on the Registration Request to guard against malicious attacks.

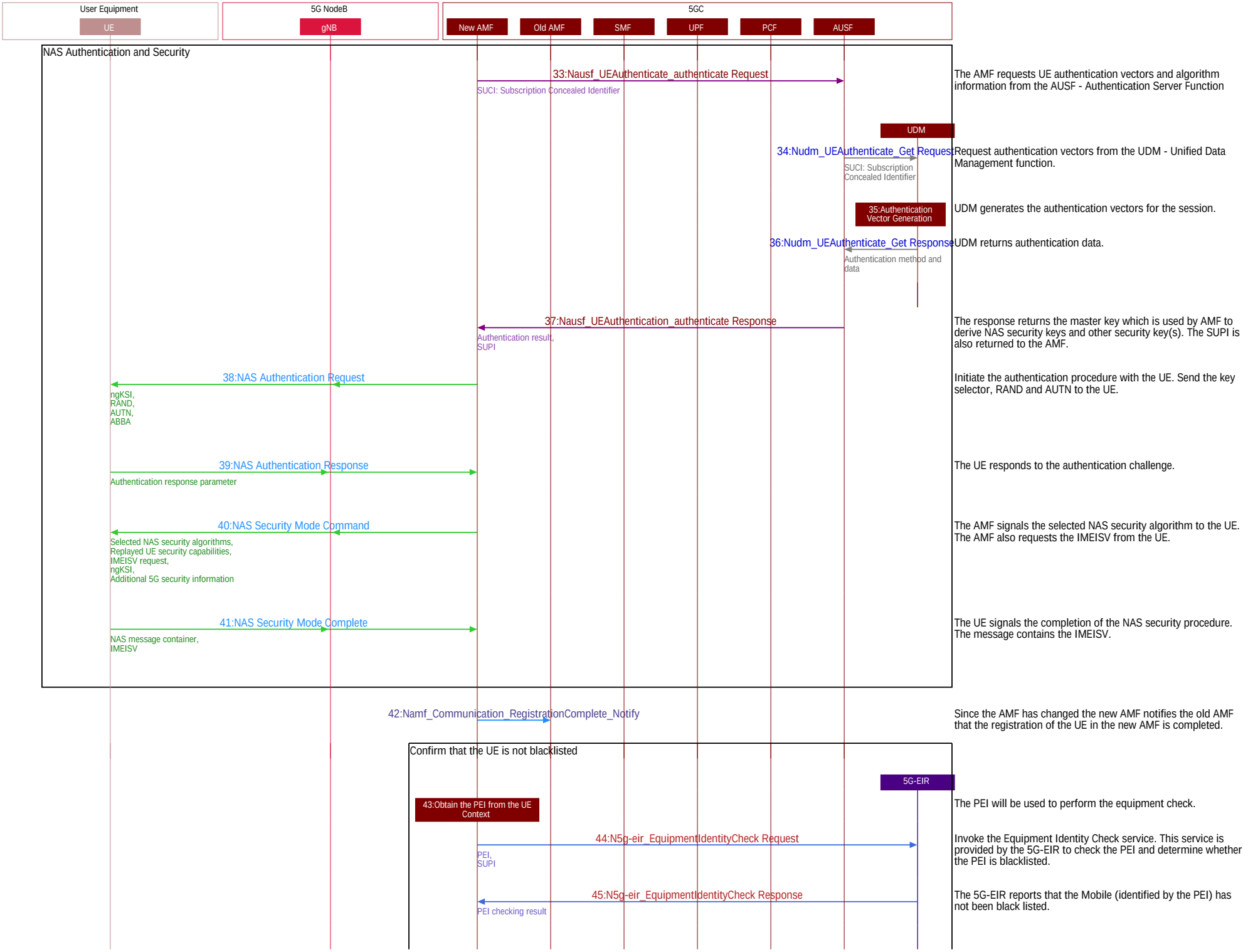
The Old AMF passes the AMF UE Context to the new AMF.

The AMF saves the UE context that was obtained from the Old AMF.

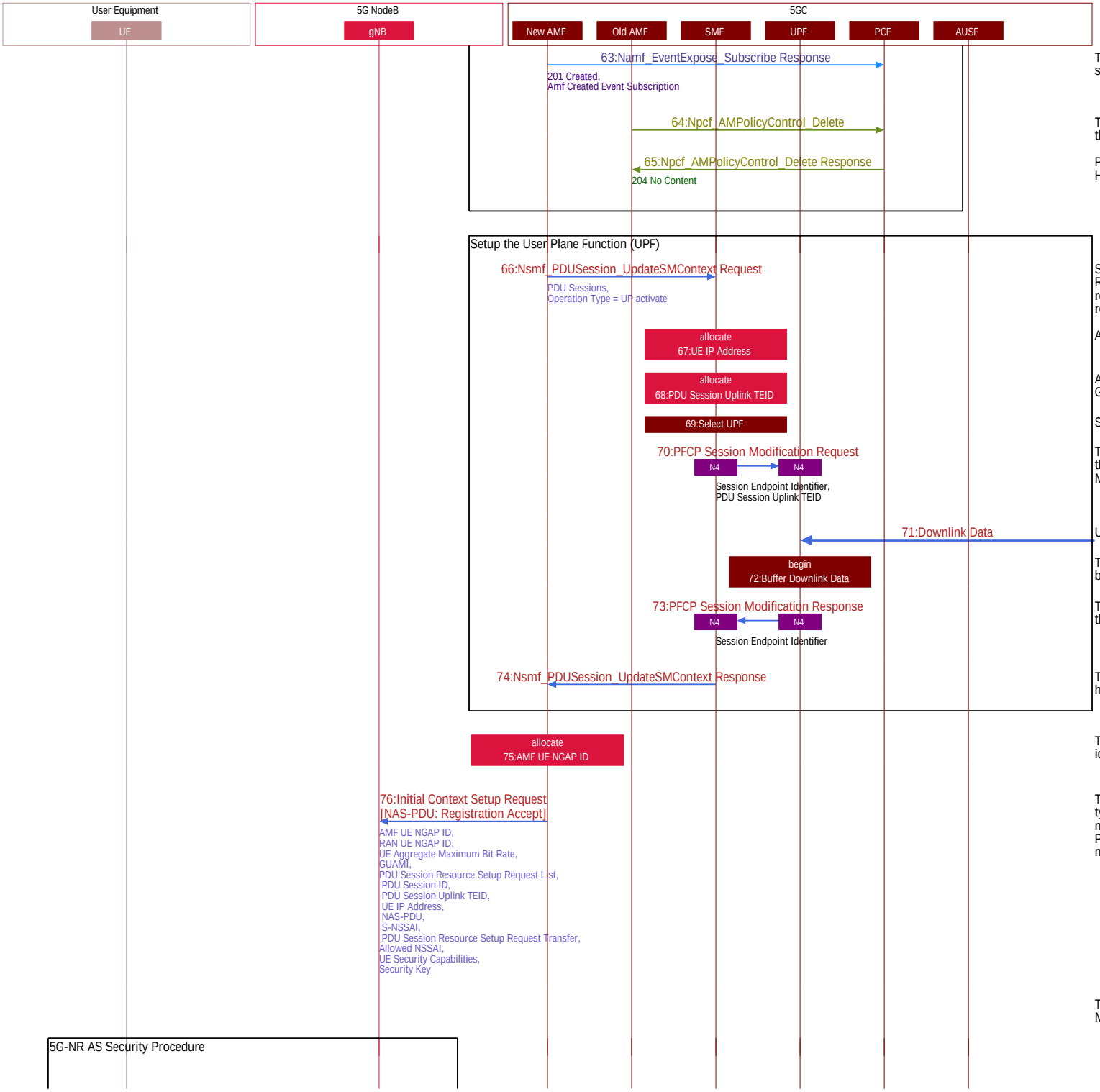
The New AMF requests UE Identity (SUCI) from the UE via a NAS message.

The UE responds to the Identity Request.

Authentication is needed for the UE. The AMF selects "Authentication Server Function" based on the SUCI.


User Equipment
UE
5G NodeB
gNB
5GC
New AMF
Old AMF
SMF
UPF
PCF
AUSF
NAS Authentication and Security
33:Nausf_UEAuthenticate_authenticate Request
SUCI: Subscription Concealed Identifier
The AMF requests UE authentication vectors and algorithm information from the AUSF - Authentication Server Function
UDM
34:Nudm_UEAuthenticate_Get Request
SUCI: Subscription Concealed Identifier
Request authentication vectors from the UDM - Unified Data Management function.
35:Authentication Vector Generation
UDM generates the authentication vectors for the session.
36:Nudm_UEAuthenticate_Get Response
Authentication method and data
UDM returns authentication data.
37:Nausf_UEAuthentication_authenticate Response
Authentication result, SUPI
The response returns the master key which is used by AMF to derive NAS security keys and other security key(s). The SUPI is also returned to the AMF.
38:NAS Authentication Request
ngKSI, RAND, AUTN, ABBA
Initiate the authentication procedure with the UE. Send the key selector, RAND and AUTN to the UE.
39:NAS Authentication Response
Authentication response parameter
The UE responds to the authentication challenge.
40:NAS Security Mode Command
Selected NAS security algorithms, Replayed UE security capabilities, IMEISV request, ngKSI, Additional 5G security information
The AMF signals the selected NAS security algorithm to the UE. The AMF also requests the IMEISV from the UE.
41:NAS Security Mode Complete
NAS message container, IMEISV
The UE signals the completion of the NAS security procedure. The message contains the IMEISV.
42:Namf_Communication_RegistrationComplete_Notify
Since the AMF has changed the new AMF notifies the old AMF that the registration of the UE in the new AMF is completed.
Confirm that the UE is not blacklisted
5G-EIR
43:Obtain the PEI from the UE Context
The PEI will be used to perform the equipment check.
44:N5g-eir_EquipmentIdentityCheck Request
PEI, SUPI
Invoke the Equipment Identity Check service. This service is provided by the 5G-EIR to check the PEI and determine whether the PEI is blacklisted.
45:N5g-eir_EquipmentIdentityCheck Response
PEI checking result
The 5G-EIR reports that the Mobile (identified by the PEI) has not been black listed.


User Equipment
UE
5G NodeB
gNB
5GC
New AMF
Old AMF
SMF
UPF
PCF
AUSF
5G-EIR
Register with the UDM and obtain the subscription data
46:UDM Selection
Select the Unified Data Management service entity.
UDM
47:Nudm_UEContextManagement_Registration Request
PUT,
Amf 3Gpp Access Registration = { AMF Instance Id, Supported Features, PEI, dereg Callback Uri, ...}
Since the AMF has changed, the New AMF registers with the UDM.
48:Nudm_UEContextManagement_Registration Response
204 No Content
A response code of "204 No Content" signals registration success.
49:Nudm_SubscriberDataManagement_Get Request
GET,
Requested data = Access and Mobility Subscription data
The AMF retrieves the Access and Mobility Subscription data.
50:Nudm_SubscriberDataManagement_Get Response
Access and Mobility Subscription data = {Supported Features, GPSI array, Network Slice Selection Info, ...}
UDM responds with the requested data.
51:Nudm_SubscriberDataManagement_Get Request
GET,
Requested data = SMF Selection Subscription data
The AMF retrieves the SMF Selection Subscription data.
52:Nudm_SubscriberDataManagement_Get Response
SMF Selection Subscription data = {Supported Features, List of S-NSSAIs and associated information}
UDM responds with the requested data.
53:Nudm_SubscriberDataManagement_Get Request
GET,
Requested data = UE context in SMF data
The AMF retrieves the UE context in SMF data.
54:Nudm_SubscriberDataManagement_Get Response
UE context in SMF data = {PDU Session Information, FQDNs for EPC Interworking}
UDM responds with the requested data.
55:Create UE Context
Create the AMF UE context for the user.
56:Nudm_UEContextManagement_Deregistration_Notify
The old AMF is notified that it is no longer serving the user. The UDM sends a POST request to the callbackReference (deregCallbackUri field in Amf3GppAccessRegistration) as provided by the Old AMF during the registration.
57:Nsmf_PDUSession_ReleaseSMContext
SUPI,
PDU Session ID
The Old AMF the SMF that it is no longer associated with the specified PDU Session.
58:Delete UE context
Remove the AMF context.
Update policy association with the PCF. The PCF registers for AMF events.
59:PCF Selection
Select the Policy and Charging Function service entity.
60:Npcf_AMPolicyControl_Create Request
The AMF contacts the PCF to create a policy association and retrieve the UE policy and/or Access and Mobility control policy.
61:Npcf_AMPolicyControl_Create Response
Policy Association Request = { SUPI, GPSI, PEI, User Location, ...}
The PCF responds with the policy association information.
62:Namf_EventExpose_Subscribe Request
The PCF registers for events like "Location Report", "Registration State Report" and "Communication Failure Report".



The AMF responds with "201 Created" to signal successful subscription.

The Old AMF requests that the policy association is deleted as the corresponding UE context is terminated.

PCF signals the successful delete with the "204 No Content" HTTP response code.

Since "List Of PDU Sessions To Be Activated" was included in the Registration Request, the New AMF initiates PDU Session reactivation. The Session Management Function (SMF) is requested to setup a new session.

Assign a UE address for the PDU session

Allocate a TEID that the gNB should use when sending uplink GTP PDUs to the UPF.

Select a user data plane for the user

The Packet Forwarding Control Protocol (PFCP) is used between the SMF control plane and the UPF data plane. The Session Modification is signaled to the data plane.

UPF has started receiving data destined to the UE.

The UPF needs to buffer the data as the PDU session has not been established at the gNB and the UE.

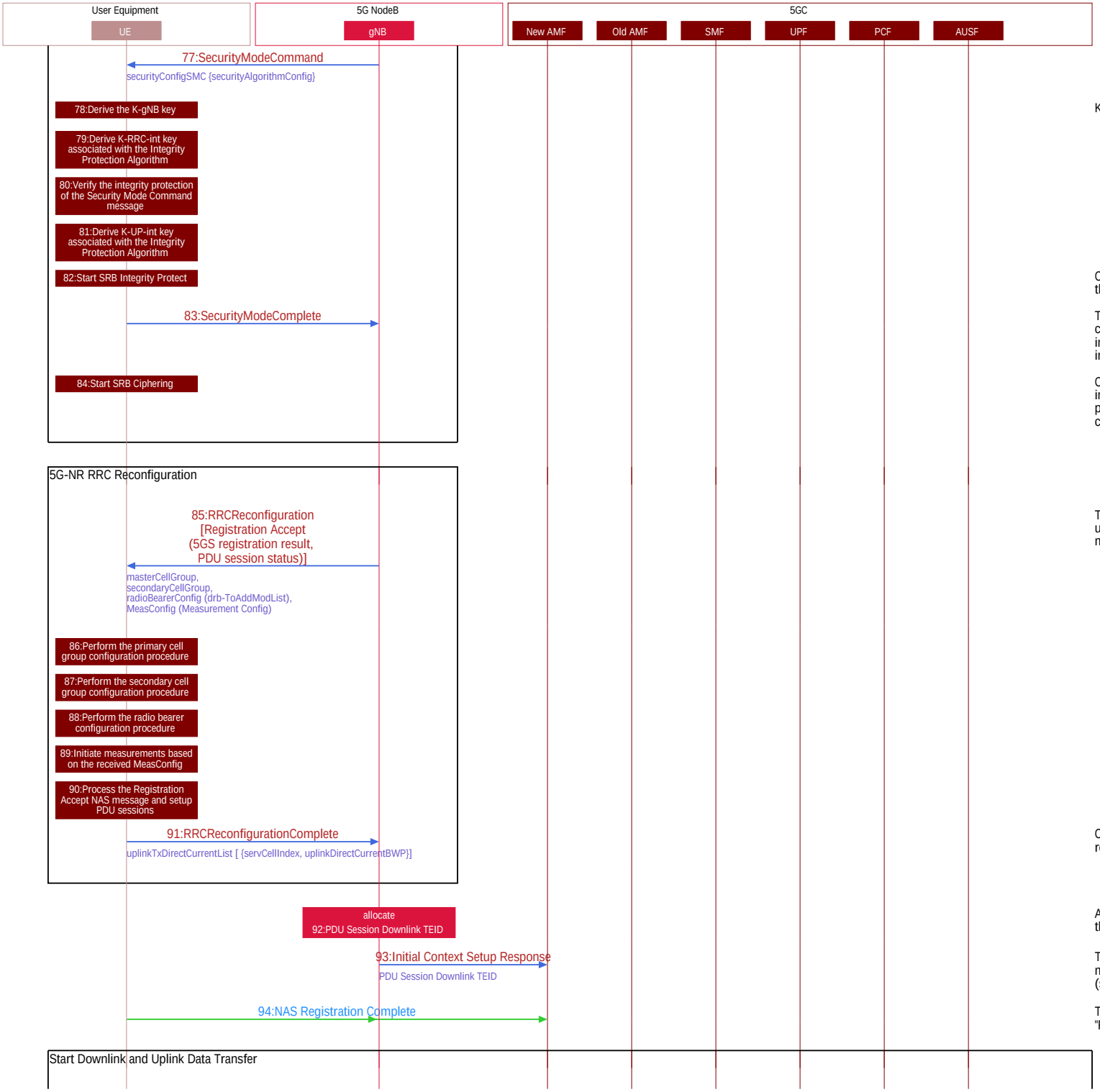
The UPF data plane responds back to the SMF control plane after the session modification has been completed.

The SMF informs the AMF that the Session Management context has been updated.

The AMF allocates an "AMF UE NGAP ID". The gNB will use this id to address the UE context on the AMF.

The AMF initiates a session setup with the gNB. The message typically contains the Registration Accept NAS message. The message carries one or more PDU Session setup requests. Each PDU session is addressed with the "PDU Session ID". The message also carries the uplink TEID for every PDU session.

The message also carries the "AMF UE NGAP ID", "UE Aggregate Maximum Bit Rate", UE security capabilities and security key.



K-gNB is a key derived by UE and AMF from K-AMF.

Configure lower layers to apply SRB integrity protection using the indicated algorithm and the K-RRC-int key immediately.

The security mode complete message confirms the successful completion of the security mode command. This message is integrity protected but not ciphered. Ciphering will start immediately after sending this message.

Configure lower layers to apply SRB ciphering using the indicated algorithm, the K-RRC-enc key after completing the procedure. The Security Mode Complete message is not ciphered.

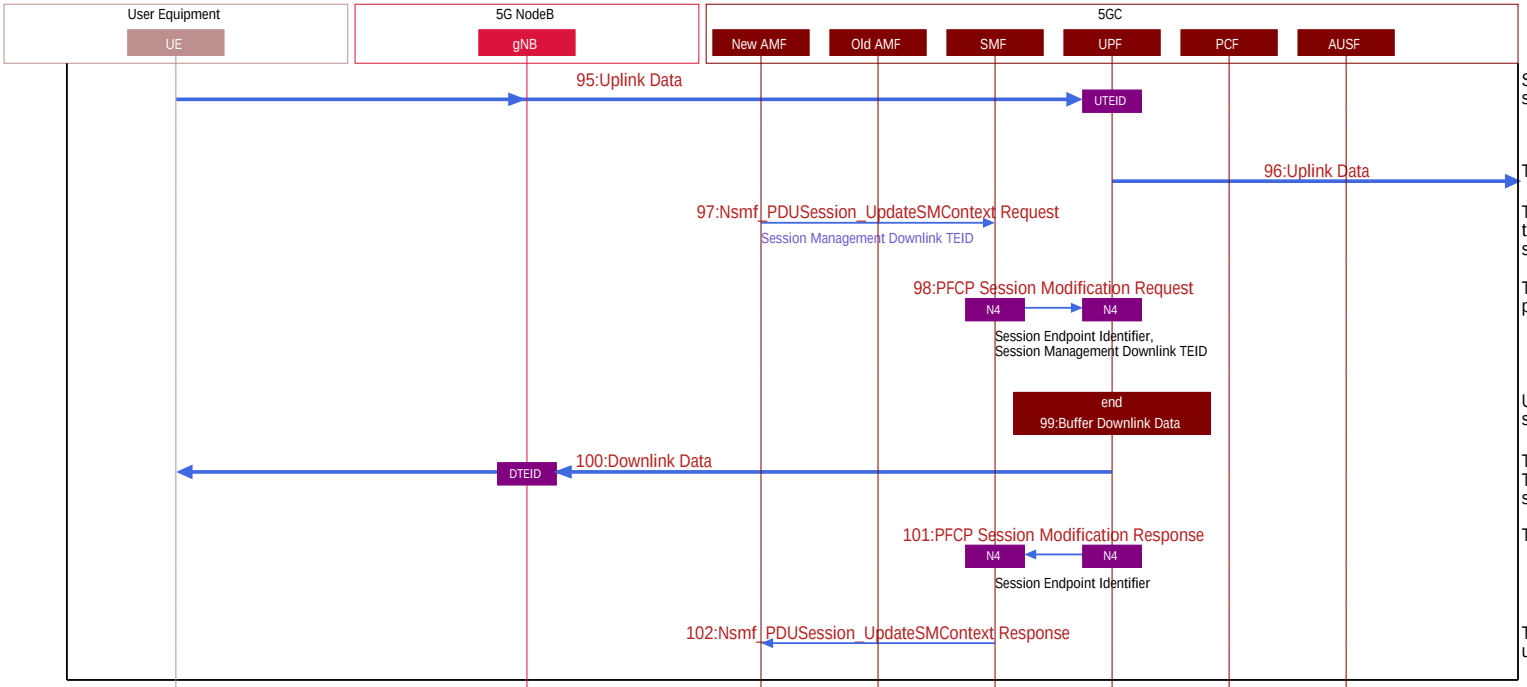
The RRC Reconfiguration message is sent to the UE for setting up radio bearers, setup a secondary cell and initiate UE measurements.

Confirm the successful completion of an RRC connection reconfiguration.

Allocate the TEID that the UPF will use to send downlink data to the gNB.

The gNB signals the successful setup of PDU sessions. The message also carries the Downlink TEID that should be used (specified per PDU session).

The UE signals the completion of the registration via the "Registration Complete" message to the AMF.



Since the uplink path has been setup completely, the UE starts sending data. The gNB sends the UE data to the Uplink TEID.

The UPF starts sending the data to the Internet.

The AMF modifies the Session Management Context based on the updates from the gNB. The Downlink TEIDs for all the PDU sessions will be passed to the SMF.

The SMF control plane signals session updates to the UPF data plane.

UPF can stop the data buffering as a downlink path has been setup.

The UPF sends the buffered data to the gNB using the Downlink TEID for the PDU session. All new downlink data also takes the same path.

The UPF data plane responds back to SMF control plane.

The SMF notifies the AMF that session management context update is complete.

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