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OPTIMIZING HANDOVERS IN 5G NETWORKS BY REDUCING N4 INTERACTIONS

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ABSTRACT

Handover operations within a 3rd Generation Partnership Project (3GPP) fifth generation (5G) telecommunications environment may be inefficient and unnecessarily consume resources. To address such challenges, techniques are presented herein that optimize handovers through, for example, improving handover latency, avoiding unnecessary N4 interactions, and avoiding additional resource allocations in a User Plane Function (UPF). Additionally, in a home routed roaming case the presented techniques avoid extra resource allocations on a Home UPF (HUPF).

DETAILED DESCRIPTION

The 3rd Generation Partnership Project (3GPP) fifth generation (5G) to Evolved Packet System (EPS) handover call flows that are defined in the 3GPP Technical Specification (TS) 23.502 identify that upon receiving a Nsmf_PDUSession_Context Request from an Access and Mobility Management Function (AMF), a Session Management Function (SMF) goes to a User Plane Function (UPF) to allocate a 3GPP fourth generation (4G) tunnels for each of the existing 5G flows . The tunnel information is then sent to the AMF in a Nsmf_PDUSession_Context Response. The AMF passes that information on to a Mobility Management Entity (MME) which then forwards the information (i.e., a SMF Control Tunnel Endpoint Identifier (TEID)(i.e., a C-TEID) and a UPF User TEID (U-TEID)) in a Modify Bearer Request later in the cycle to a Serving Gateway (SGW). The SGW then forwards the bearer information to the SMF along with the SGW-U TEID. The SMF then initiates the switching of a data path from a Next Generation NodeB (gNB) to the SGW.

The process that was described above may be optimized, according to the techniques that are presented herein which will be described an illustrated in the narrative that is presented below, to avoid unnecessary N4 interactions by rewiring the UPF ↔ gNB tunnel to a UPF ↔ SGW-U.

During a 5G Protocol Data Unit (PDU) session establishment, a data path is established as shown in Figure 1, below.

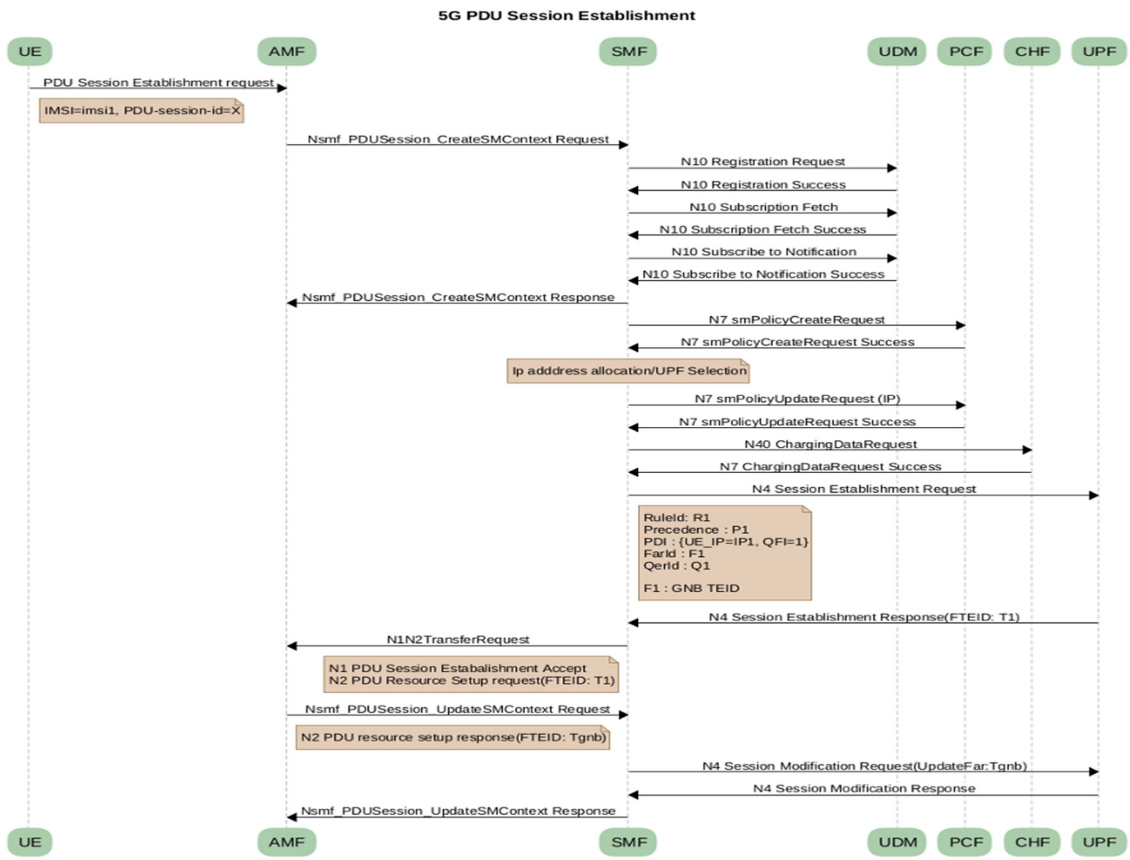

Figure 1: 5G PDU Session Establishment

The 5G quality of service (QoS) model is based on QoS flows. The 5G QoS model supports both QoS flows that require a guaranteed flow bit rate (i.e., Guaranteed Bit Rate (GBR) QoS Flows) and QoS flows that do not require a guaranteed flow bit rate (i.e., non-GBR QoS Flows).

The QoS flow is the finest granularity of QoS differentiation in the PDU Session. A QoS Flow ID (QFI) is used to identify a QoS flow in a 5G System. User plane traffic with the same QFI within a PDU session receives the same traffic forwarding treatment (e.g., scheduling, admission threshold, etc.). The QFI is carried in an encapsulation header on an N3 interface (and an N9 interface) without any changes to the end-to-end (E2E) packet header. A QFI is used for all of the PDU session types and the QFI is unique within a PDU session. The QFI may be dynamically assigned or it may be equal to the 5G QoS Identifier (5QI, see, for example, clause 5.7.2.1 of the 3GPP TS 23.501).

Within a 5G system (5GS), a QoS flow is controlled by the SMF and may be preconfigured, or established, through either the PDU Session Establishment procedure or the PDU Session Modification procedure.

A QoS flow is characterized by:

- A QoS profile that is provided by the SMF to the Access Network (AN) through the AMF over the N2 reference point or preconfigured in the AN;
- One or more QoS rule(s) and optional QoS flow level QoS parameters (as specified in the 3GPP TS 24.501) that are associated with the QoS rule(s) which may be provided by the SMF to the user equipment (UE) through the AMF over the N1 reference point and/or derived by the UE by applying reflective QoS control; and
- One or more uplink (UL) and downlink (DL) Packet Detection Rules (PDRs) that are provided by the SMF to the UPF.

Within a 5GS, a QoS flow that is associated with the default QoS rule is required to be established for a PDU session and remains established throughout the lifetime of the PDU session. Such a QoS flow should be a Non-GBR QoS Flow (further details of which are described in clause 5.7.2.7 of the 3GPP TS 23.501).

A QoS flow is associated with QoS requirements as specified by QoS parameters and QoS characteristics.

It is important to note that the QoS flow that is associated with the default QoS rule provides the UE with connectivity throughout the lifetime of the PDU session. Possible interworking with an EPS motivates the recommendation for such a QoS flow to be of type non-GBR.

PDRs that are sent to a UPF during N4 session establishment have an associated QFI and a UPF creates the data path association using the QFI.

Figure 2, below, depicts elements of the call flow for 5G to 4G handover.

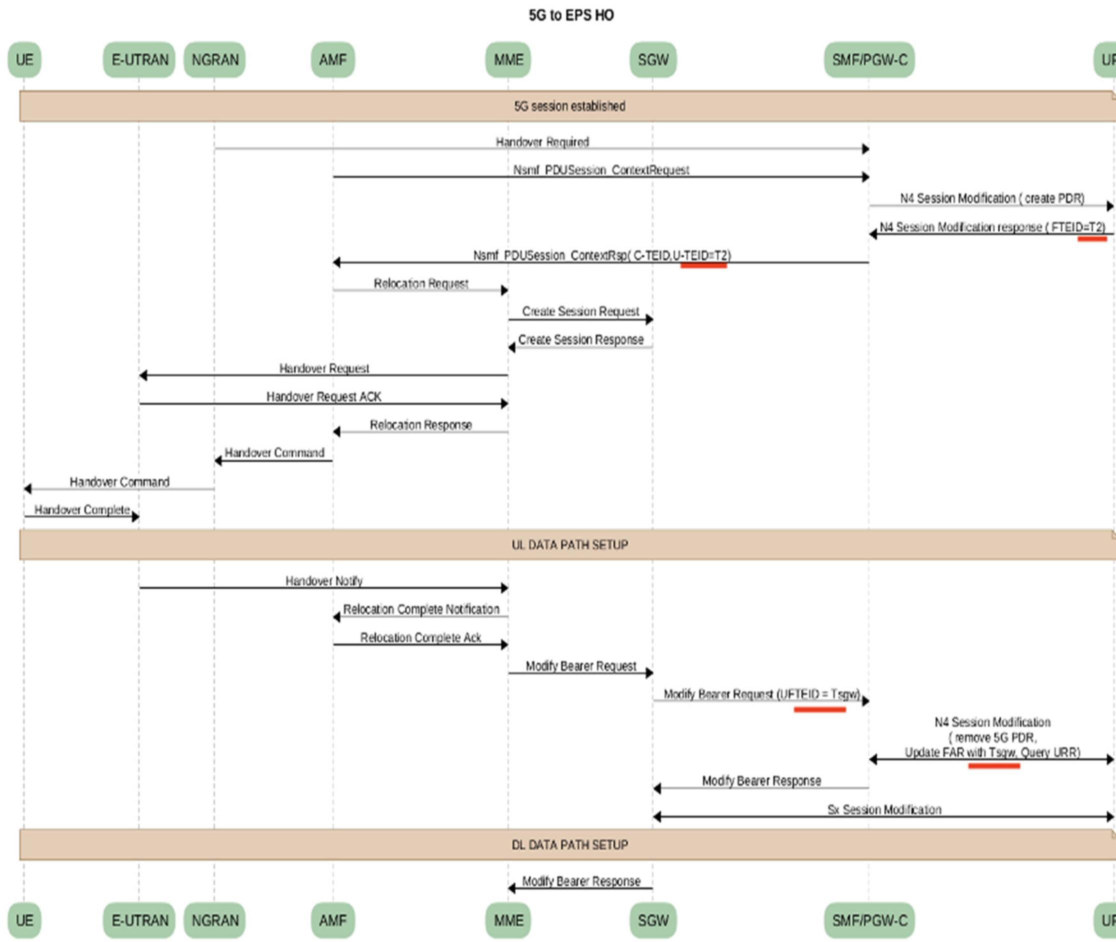

Figure 2: 5G to 4G Handover

As depicted in Figure 2, above, upon receiving a Nsmf_PDUSession_Context Request from an AMF a SMF goes to a UPF to allocate 4G tunnels for each of the existing 5G flows. The tunnel information is then sent to the AMF in a Nsmf_PDUSession_ContextRsp. The AMF passes on this information to an MME which then forwards the information (i.e., a SMF C-TEID and a UPF U-TEID) in a Modify Bearer Request later in the cycle to an SGW. The SGW forwards the bearer information to the SMF along with the SGW-U TEID. The SMF then initiates the switching of a data path from a gNB to the SGW (elements of which are illustrated in Figure 3, below). This call flow involves two N4 legs , deletion of 5G resources and creation of 4G resources in UPF which is unnecessary.

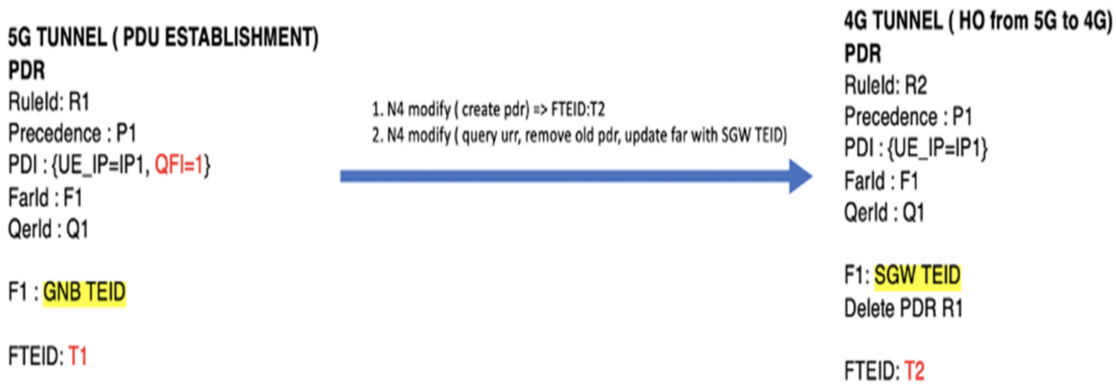

Figure 3: Data Path Switching

To address the types of challenges that were noted above, techniques are presented herein that support optimizing the call flow that was described and illustrated above. Aspects of the presented techniques support two different optimization options.

Under a first optimization option, during PDU establishment, for EPS interworking sessions, an additional PDR is created without any QFI association for 4G. Forwarding Action Rules (FARs) and QoS Enforcement Rules (QERs) that are associated to 5G PDRs are also associated with the corresponding 4G PDRs. Importantly, a 4G PDR is given a lower precedence than a 5G PDR.

During handover, a first N4 leg is skipped and UPF 5G tunnel TEID is provided as a 4G UPF tunnel TEID to a SGW through an AMF and a MME. Upon receiving a Modify Bearer Request (MBR) from the SGW later in the call flow, the precedence of the PDRs are swapped so that uplink traffic from the eNB matches the 4G PDRs after handover. Downlink FAR is modified with SGW-U TEID.

Similarly, during handover to 5G it is only necessary to swap the PDR precedence values and update the associated FARs with the gNB TEID. Figure 4, below, depicts elements of an optimized call flow for 5G to 4G handover according to aspects of the techniques presented herein.

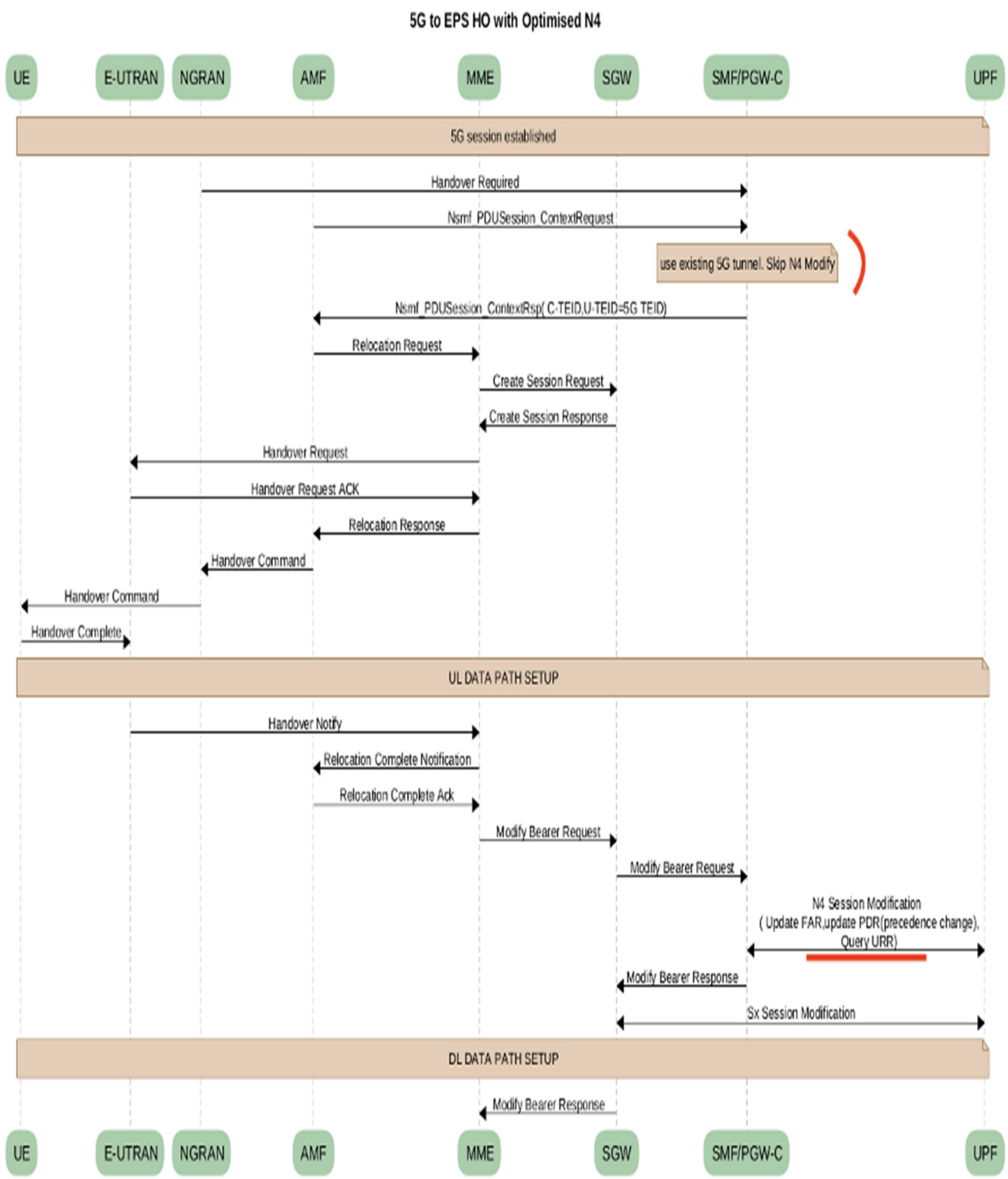

Figure 4: Optimized 5G to 4G Handover

Figure 5, below, depicts elements of an optimized data path switching according to aspects of the techniques presented herein.

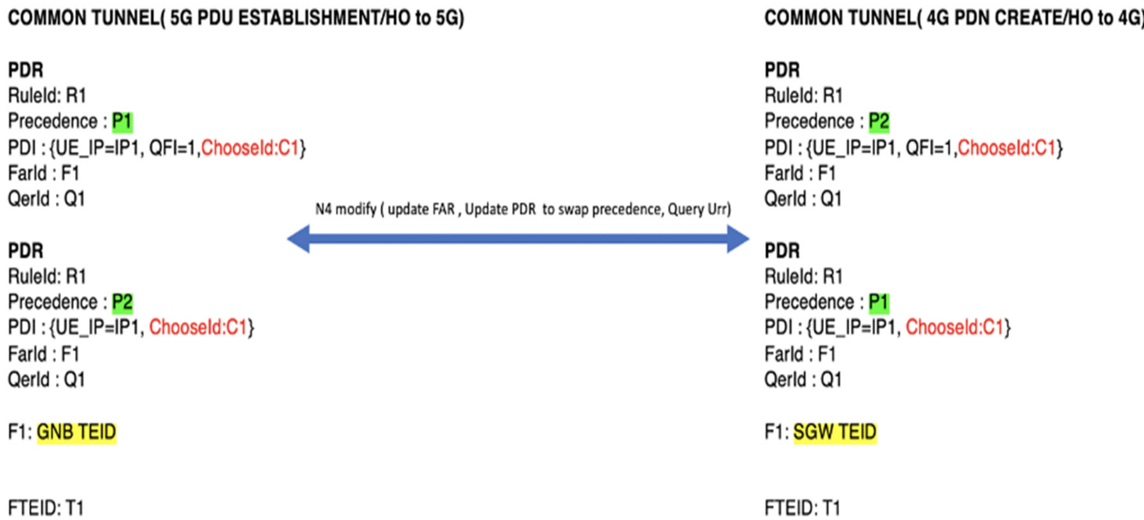

Figure 5: Optimized Data Path Switching

A second optimization option employs a non-standard approach. According to the different standards, the value of a QFI lies within a range from 0 to 63. Under the second optimization option, a spare bit is employed and a QFI of 64 is used to indicate no QFI mapping. Such an approach is used only for 4G or Wi-Fi. In brief, a UPF interprets a QFI of 64 as indicating no QFI.

During a 5G PDU establishment process, each PDR is additionally associated with a QFI of 64. A QER that is mapped to a PDR has a QFI value of 1. Thus, uplink traffic with a matching Service Data Flow (SDF), with or without a QFI, is mapped to such a PDR. This way, following handover to 4G it is only necessary to update the SGW TEID in an associated FAR and change the QFI in a QER to 64. Similarly, during any subsequent handover to 5G it is only necessary to update the FAR with a gNB TEID and update the QFI in a QER to 1.

Such an optimization becomes more critical in a case of home routed roaming because the Home SMF (HSMF) must pre-allocate a 4G tunnel and send it to a Visited SMF (VSMF) during a create leg or as part of a Policy Control Function (PCF)-initiated dedicated bearer creation. Pre-allocating a tunnel is a waste of resources and the techniques presented herein address such a problem by reusing an existing tunnel and also reducing the complexity.

Aspects of the techniques presented herein may be further explicated with reference to the illustrative call flows that are presented in Figures 6 through 9, below. For example, Figure 6 depicts elements of a standards-based home routed PDU establishment process. Next, Figure 7 depicts elements of a home routed PDU establishment process with optimized N4 interactions according to a first option of the techniques presented herein. Further, Figure 8 depicts elements of a 5G to 4G handover process with optimized N4 interactions for home routed roaming according to a first option of the techniques presented herein. Finally, Figure 9 depicts elements of a home routed PDU establishment process with optimized N4 interactions according to a second option of the techniques presented herein.

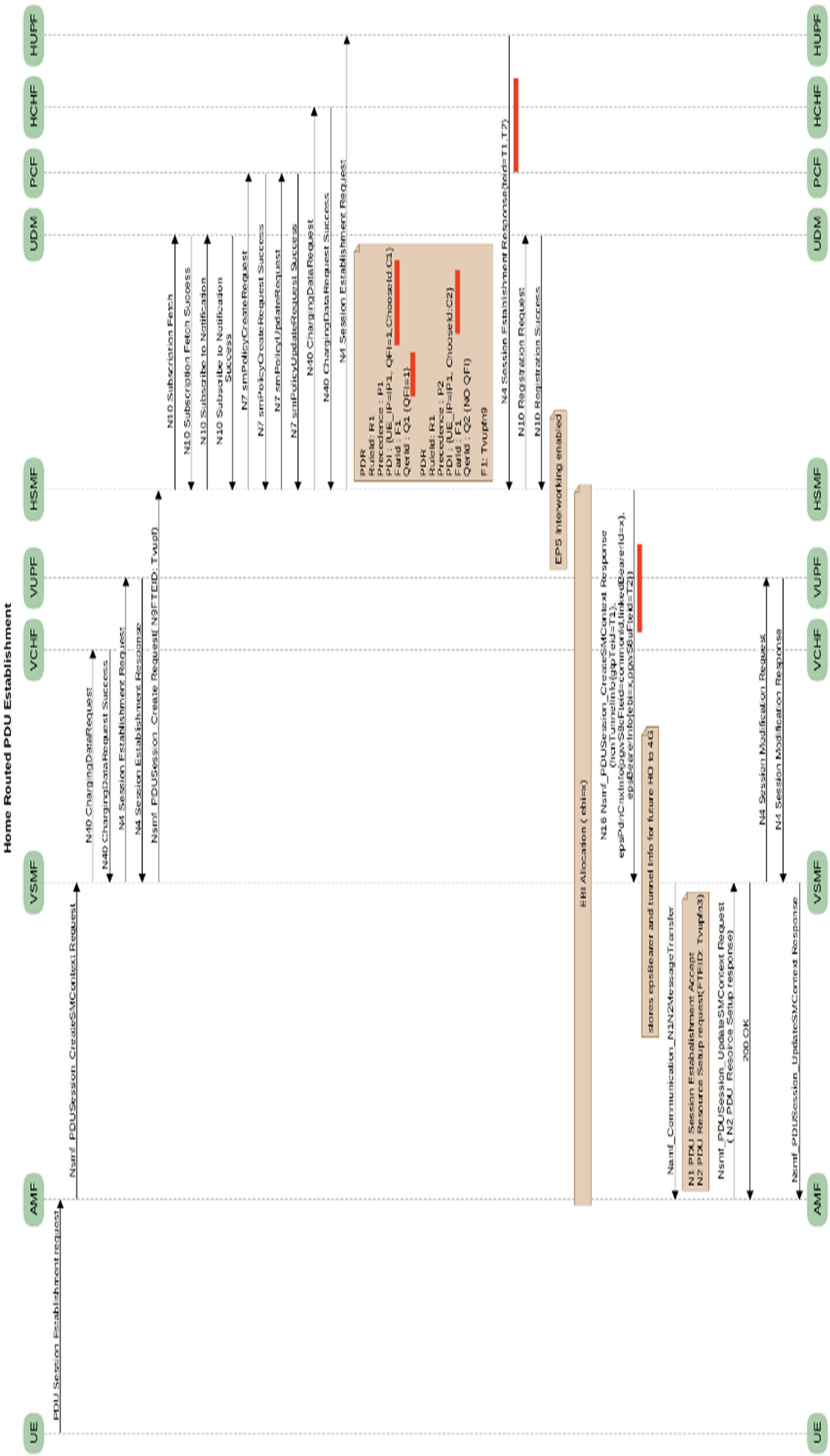

Figure 6: Standards-Based Home Routed PDU Establishment

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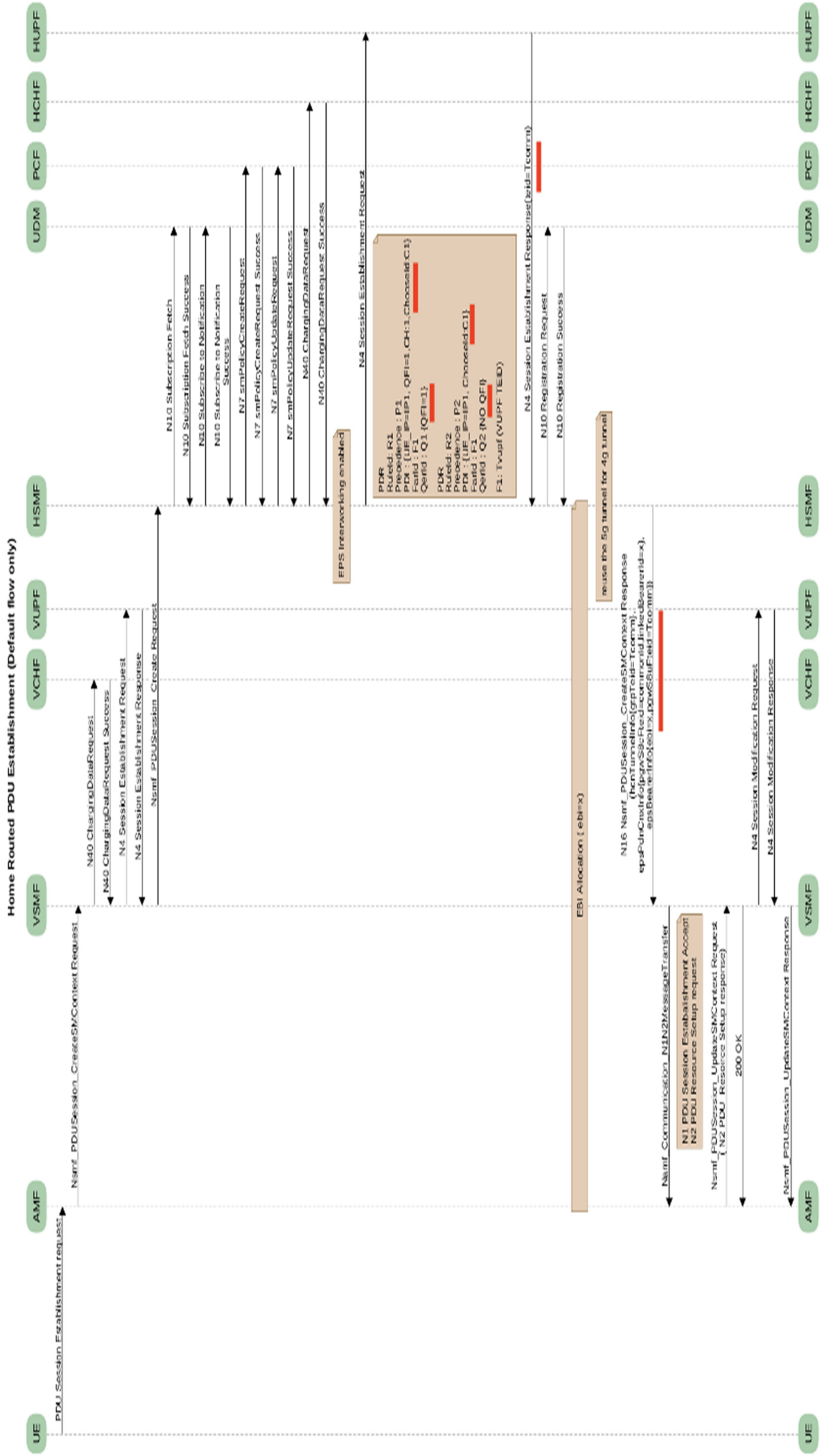

Figure 7: Home Routed PDU Establishment Optimized According to Option 1

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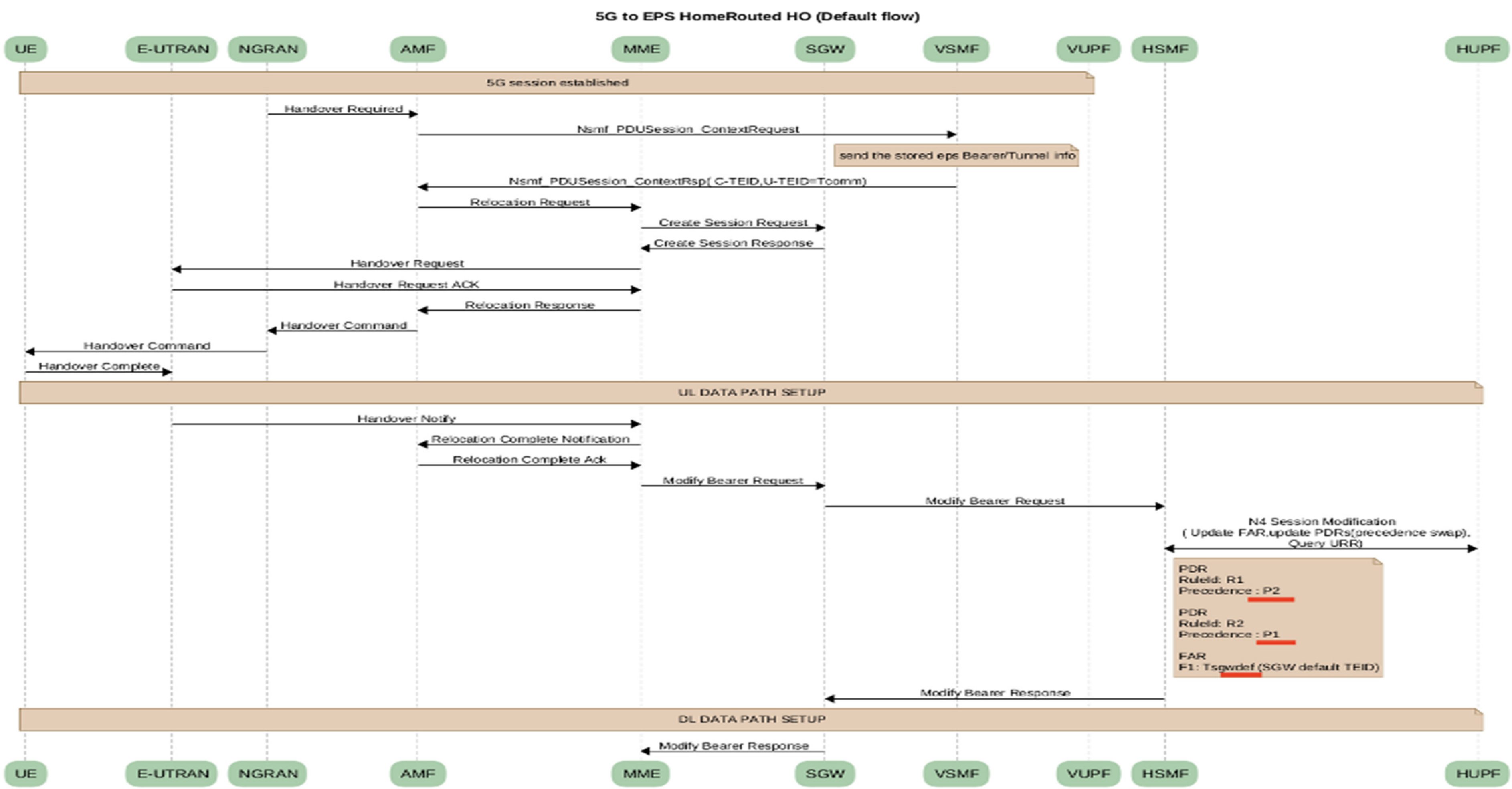

Figure 8: 5G to 4G Handover Optimized According to Option 1

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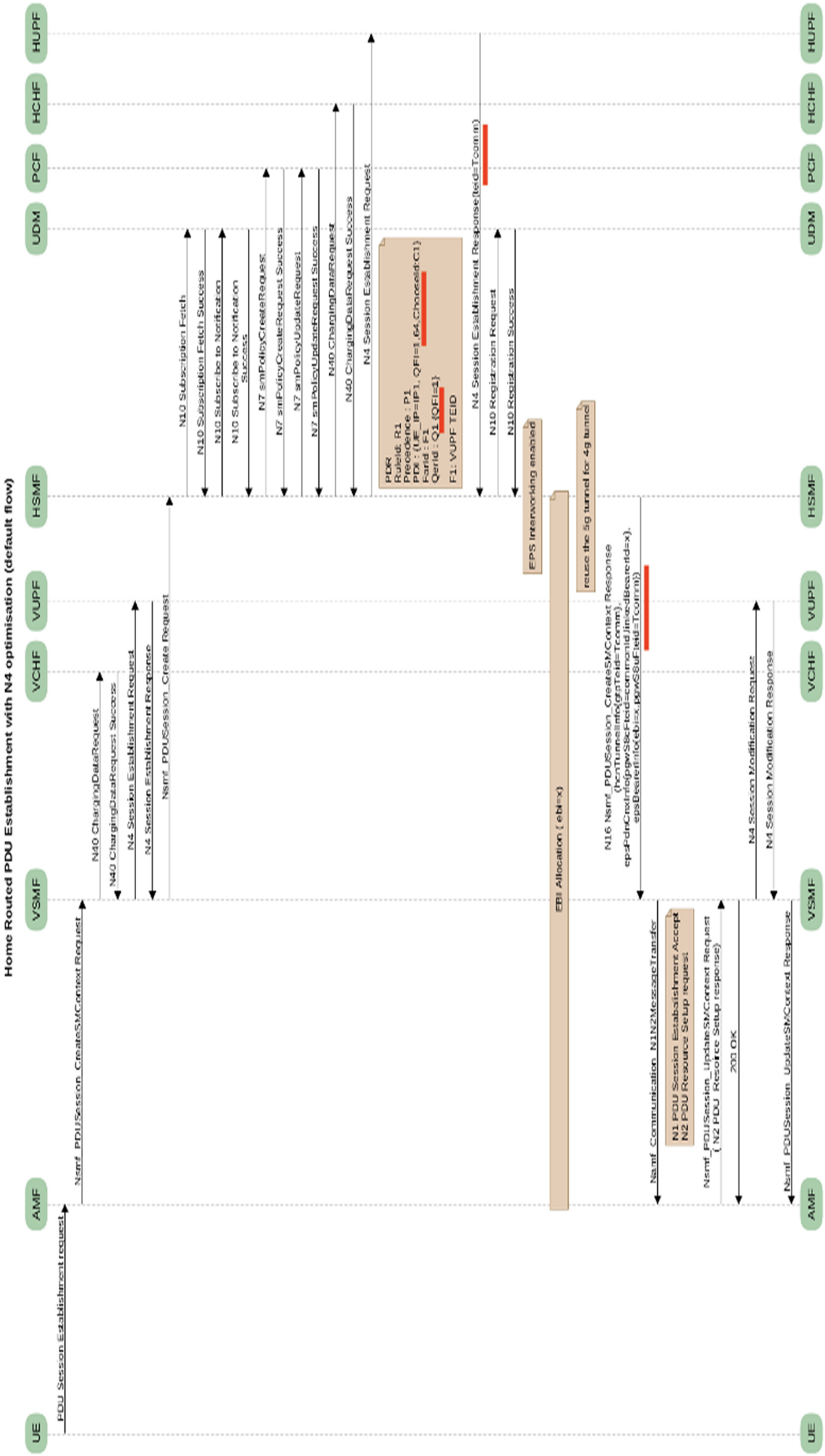

Figure 9: Home Routed PDU Establishment Optimized According to Option 2

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In summary, techniques have been presented herein that optimize handovers within a 3GPP 5G telecommunications environment through, for example, improving handover latency, avoiding unnecessary N4 interactions, and avoiding additional resource allocations in a UPF. Additionally, in a home routed roaming case the presented techniques avoid extra resource allocations on a Home UPF (HUPF).