March 2023

AMF SELECTION AND SIGNALLING FOR AMF RECOVERY IN AN ENHANCED SERVICE-BASED ARCHITECTURE UTILIZING INDIRECT COMMUNICATIONS IN 5G NETWORKS

Vinod Kamalaraj

Dishant Parikh

Vimal Srivastava

Ravi Shekhar

AMF SELECTION AND SIGNALLING FOR AMF RECOVERY IN AN ENHANCED SERVICE-BASED ARCHITECTURE UTILIZING INDIRECT COMMUNICATIONS IN 5G NETWORKS

AUTHORS:
Vinod Kamalaraj
Dishant Parikh
Vimal Srivastava
Ravi Shekhar

ABSTRACT

Access and Mobility Management Function (AMF) sets and regions, as defined in Release 15 of Third Generation Partnership Project (3GPP) standards, provide for the hierarchical organization of AMFs in which an AMF can belong to a set, and different AMF sets can belong to an AMF region. When an AMF fails, a peer can then search for an AMF in the same set, and if that fails, can then search for an AMF in the same region. 3GPP Release 16 standards introduced the indirect communications that can involve a Service Communication Proxy (SCP). However, the hierarchical discovery of an AMF by an SCP is not fully described in standards. Thus, when AMF reselection is performed through an SCP, information indicating that reselection has occurred and which old AMF was hosting certain user equipment (UE) is not send to the new AMF, which can lead to race conditions. Presented herein are techniques to address such issues through the incorporation of additional information that can be appended to messaging provided to an SCP that can allow the SCP to perform AMF reselection and send the additional information to a newly selected AMF, which allows the new AMF to detect and resolve such race conditions.

DETAILED DESCRIPTION

Release 16 (Rel 16) of Third Generation Partnership Project (3GPP) standards defined a Service Communication Proxy (SCP), which is a node that can act as a proxy for network function (NF) signaling. Access and Mobility Management Function (AMF) sets and regions, as defined in Release 15 of Third Generation Partnership Project (3GPP) standards, provide for the hierarchical organization of AMFs in which an AMF can belong to a set, and different AMF sets can belong to an AMF region. However, NF sets for NFs other than the AMF were introduced in 3GPP Rel 16 standards.

In 3GPP Rel 16 standards, all NFs in the same set have access to the same user equipment (UE) contexts and, if one NF fails or is removed, other NFs in the same set can service requests for the UEs, which provides a resiliency mechanism for NF sets.

In Rel 16, an SCP is a NF that is supposed to make such functionality work seamlessly with the SCP acting as a proxy in messaging, and if a NF is unavailable, the SCP can choose a different NF in the same set to process a service request. To provide such functionality without parsing the whole request, all information required for routing messages are present in messaging headers exchanged with the SCP.

A potential problem with parsing the messages is that the messages themselves can be quite large, with multiple parts. Thus, encoders and decoders used to parse the messages are to be application aware so that defaults are emitted.

However, the hierarchy mechanism for AMFs involving AMF sets and regions introduces a complexity to AMF reselection that can be challenging to address. Recall, for AMF reselection, an AMF set can first be searched to try and find a new AMF, however, if that search fails, the AMF region is to be searched to find a new AMF. The AMF set and region are defined in terms of an AMF-ID, which is not in line with other NF Set definitions. The proper change of an AMF also involves a newly selected AMF being aware of old AMF, which this helps prevent certain race condition, such as, for example, for a scenario in which the Service-Based Architecture (SBA) interface chooses an AMF-B when AMF-A fails, but a GNB chooses an AMF-C.

The old AMF-ID is currently only present in the Java Script Object Notation (JSON) body of a message, which implies that an SCP has to decode and re-encode messages to the AMF in order to be able to identify the old AMF-ID.

Thus, without the techniques proposed herein, an SCP will have to know which messages are destined for an AMF, parse these messages, and then act on them. This becomes more difficult to implement and can cause performance impacts.

This proposal submits that the following information a "Destination-Amf-GUAMI" is to be added to the headers that are either services of an AMF or are a call back to the

AMF. On the SCP, the presence of a "Destination-Amf-GUAMI" can be used to indicate a message destined for an AMF.

In the search for an alternate AMF in the Network Repository Function (NRF), the SCP first parses the Amf-GUAMI to determine the AMF-Set and AMF-Region desired. These are part of a Globally Unique AMF Identifier (GUAMI), also referred to as an AMF-GUAMI, which is formatted as:

<GUAMI> = <MCC><MNC><AMF Region ID><AMF Set ID><AMF Pointer>

For the search by the SCP, if the NF identified by the 3GPP-SBI-Target-ApiRoot is not available, the SCP then queries the NRF for a different AMF in the same set, by using the <AMF Region ID> and the <AMF Set ID>. If no alternates are available, the SCP can query for a different AMF in the same region using the <AMF-Region-ID>. If an alternate is found, the request is forwarded to the alternate NF found. The SCP does not remove or change the Destination-Amf-GUAMI that it receives. The NF that services this request can use the GUAMI to ascertain which AMF originally serviced the UE in question.

Consider an example call flow as shown below in Figure 1, which illustrates how the hierarchy, and any race conditions involving the hierarchy can be resolved in 3GPP Rel 15.0 and for direct communication modes in Rel 16.

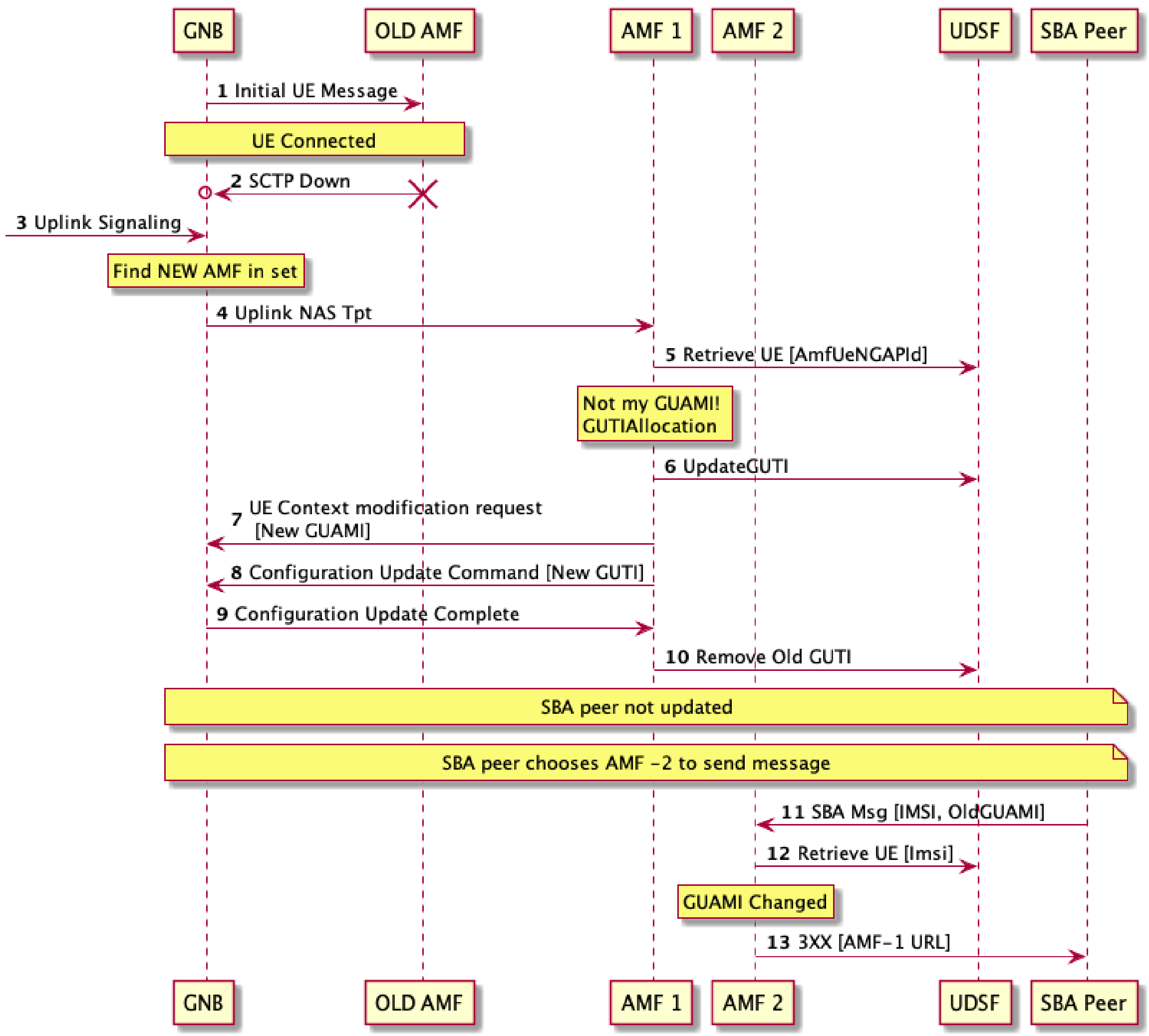

Figure 1: Standards-based Connected Mode AMF Failure Handling

As illustrated for the call flow of Figure 1, the GNB can receive a message from a UE with a Globally Unique Temporary ID (GUTI) pointing to the GUAMI of the old AMF and sends the message to the old AMF. The old AMF, in turn sends a response message to the GNB. This exchange binds the UE to the old AMF in the GNB.

Consider an example in which the Stream Control Transmission Protocol (SCTP) link between the old AMF and the GNB goes down and the GNB marks the old AMF as unavailable.

Thereafter, consider that the UE sends an uplink Non-Access Stratum (NAS) transport message to the GNB, which triggers the GNB to find a different AMF in the same set as the old AMF, AMF-1 in this example, and sends the request to AMF-1. AMF-1 retrieves the UE context from the Unstructured Data Storage Function (UDSF) using the AMF-UE-NGAPID.

On analyzing the GUTI, AMF-1 discovers that the UE did not belong to AMF-1, which triggers AMF-1 to update the GUTI on the UDSF and update the GUAMI of the UE in the GNB by sending a UE Context Modification Request. AMF-1 then updates the UE with a new GUTI and the UE acknowledges the new GUTI. The AMF-1 the removes the old GUTI from the UDSF.

There is no signaling to peer NFs on the change in ownership, as any AMF in the set is supposed to be aware of this change. An SBA peer can detect the old AMF being down, either through a NRF notification or through the timeout of a message, which can then trigger the SBA peer to choose a different AMF in the set, such as AMF-2 in this example, to send a message to the UE.

The AMF-2 can retrieve the UE context from the UDSF. On analysis, however, it discovers that the GUTI is neither AMF-2's or to the old AMF identified by the old GUAMI. From the GUTI analysis, AMF-2 can reconstruct the uniform resource locator (URL) of the equivalent service in AMF-1 and can sends a 307 response, with AMF-1's URL.

In this solution, the hierarchy is resolved by the peer NF and the race condition is resolved by the fact that the GUAMI of the old AMF is known during the processing of the request.

In Rel 16 with Indirect Communication and the SCP, 3GPP standards do not explicitly call out a solution for AMF hierarchical fallback. In 3GPP Technical Specification 23.527, there is mention of using the AMF-SetId and AMF-RegionId as query parameters by an SBA peer, as generally illustrated through Figure 2, below.

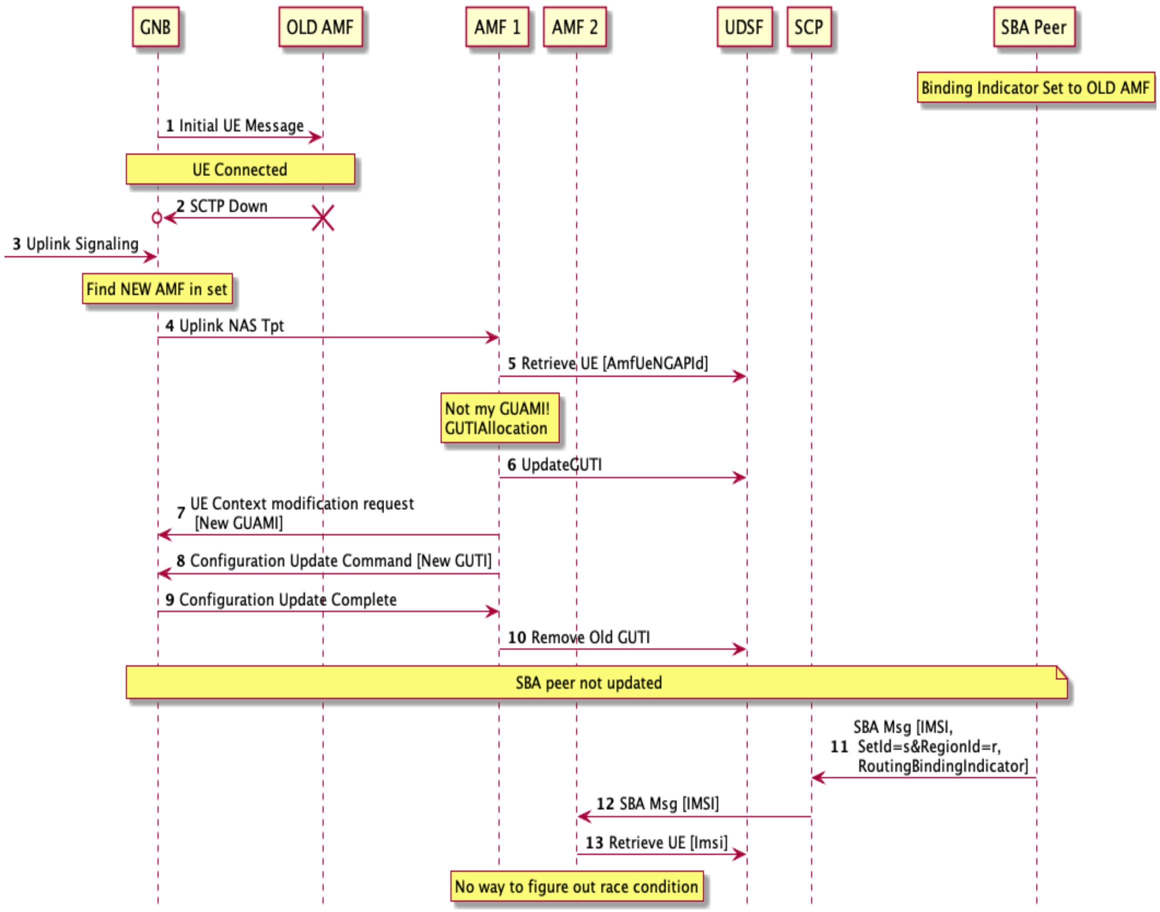

Figure 2: Potential Standards-based Indirect Communication Solution

As illustrated in Figure 2, during registration procedure, the AMF sends its Binding Indicator to the SBA peer and Steps 1-10 can be performed as shown in Figure 1 with no changes. For Figure 2, however, with regard to step 11, consider that the SBA peer attempts to send a message to an AMF and sends the routing-binding-indicator to the current AMF. For peer selection if the node in routing-binding-indicator is unavailable, the SBA peer sets the SetId and RegionId query parameters as part of the Discovery header. The SBA peer doesn't include OldAmfID, as it does not know where the request is going to end up.

At step 12, the SCP is aware that the AMF in the binding indicator is unavailable, but it is not clear how the SCP first queries the NRF top determine if there is a different AMF in the same set or a different AMF in the same region. The binding level could provide a clue, but the potential standards-based solution is not complete in this regard. The query parameters and the binding indicator are removed from the SCP before the request is sent to AMF-2. The SCP cannot add the old AMF information, as it cannot parse or remake the body of the Hypertext Transfer Protocol (HTTP) request, and it doesn't really know the GUAMI of the AMF, just the routing binding parameters.

At step 13, the AMF-2 retrieves the request, however, there is currently no way for AMF-2 to recognize that the original message was meant for the old AMF, and the UE context might have ongoing transactions at AMF-1.

Figure 3, below, is a call flow illustrated techniques of this proposal that provide for addressing the potential race issues for a Rel 16 implementation for indirect communications involving the SCP.

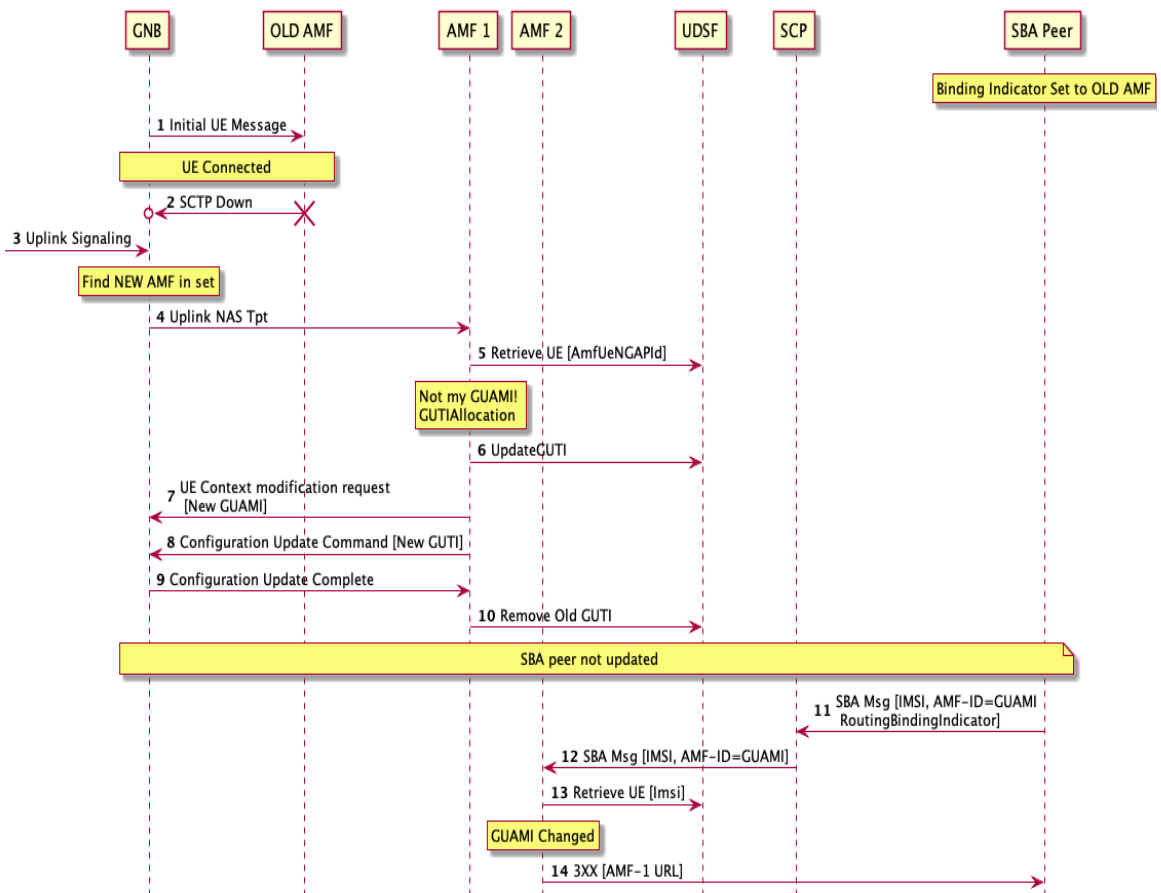

Figure 3: Proposed Solution Call Flow

For the call flow shown in Figure 3, steps 1-10 can be performed as discussed above for Figure 1 with no changes. However, for the solution proposed herein, at step 11, the SBA peer can add a new header to the messaging that indicates the current AMF-ID to the

SCP. At step 12, in the SCP, when the node in the routing binding indicator is unavailable, the AMF-ID header is analyzed and SCP can then query the NRF for a different AMF in the same set, and if it finds one, it uses that AMF. If it doesn't, it searches for a different AMF in the same region. The SCP then sends the request to the chosen AMF. Thereafter, on AMF-2, since the GUAMI of the AMF the SBA peer was trying to reach is available, the race condition can be detected and resolved. Thus, techniques proposed herein may provide a solution to potential race conditions that can be triggered for certain Rel 16 scenarios involving an SCP and AMF reselection.