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OPTIMIZED AND CONVERGED PACKET CORE GATEWAY SELECTION FOR 5G USER IN E-UTRAN COVERAGE

Vivek Agarwal

Om Prakash Suthar

Raghavendra Suryanarayanarao

Rajaneesh Shetty

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ABSTRACT

Mobile service providers are deploying 5G technology with network slicing to enable different business use cases. Presented herein are techniques to implement network slicing. In a first technique, a 1:1 mapping is made between the s-Network Slice Selection Assistance Information (NSSAI) subscribed by the User Equipment (UE) in the 5G network to the UE usage type (UUT) in the Home Subscriber Server (HSS), along with the subscribed priority of the slices per UE. This is sent to the Mobility Management Entity (MME). In a second technique, an N:1 mapping between is made between the s-NSSAI's subscribed by the UE in the 5G network to the UUT in the HSS, along with the subscribed priority of the slices per UE. The same is sent to the MME as a unique UUT value which is an operator specific value.

DETAILED DESCRIPTION

For a 5G User Equipment (UE) in an E-UTRAN, the network has to understand 5G UE capabilities along with its subscription and the Access Point Name (APN)/Data Network Name (DNN) used by the UE and chose appropriate gateways for seamless inter-working. There is a problem of optimized gateway selection when E-UTRAN coverage is widely prevalent whereas 5G radio is overlay with spotty coverage.

1. When a 5G user is connected to the 4G network, the 4G core network considers mainly the UE Access Point Name (APN) and the UE capabilities to select a Packet Gateway Control Plane + Session Management Function (PGW-c + SMF) combination node. Often this mechanism works fine for simple 5G deployments.
2. For 5G deployments with multiple slices where the UE is subscribed to multiple slices, there are multiple groups of (PGW-c + SMF) nodes that can cater to a UE

on the 4G side. Selecting the right node becomes important as the UE handovers from 4G to 5G and session continuity (due to N26 interface) would mean that the UE is not mapped to the right slice on the 5G network, thereby impacting the service continuity during mobility and therefore Quality of Experience (QoE) for the UE under such scenarios.

3. The operator may prefer not to have multiple DNNs/APNs to cater to different slices as it is a significant overhead and impact to the network. The service provider prefers to leverage the existing network capabilities and parameters with a new algorithm for appropriate node selection.

The problem is highlighted in Figure 1 below.

The UE would have selected 5GC Network Slice #2 had it started the Protocol Data Unit (PDU) session establishment in 5G and connected first to the 5G network. But as shown, the UE first latched on to the 4G network and started the data session in the 4G network and later moved from the 4G network to the 5G network. Because of the poor gateway selection mechanism existing today in 4G networks, the PGW-C + SMF combo node selection in 4G network for the UE is corresponding to slice #1 on 5G network and not to the appropriate/subscribed slice for the UE, i.e., Slice #2 which was intended to be selected even in the 4G network. When the UE moves from the 4G network coverage to the 5G network coverage in connected/Idle mode, for these UE's even in 5G network, the slice selection will not be appropriate and will be slice #1, thereby reducing the QoE for the UE in the 5G network.

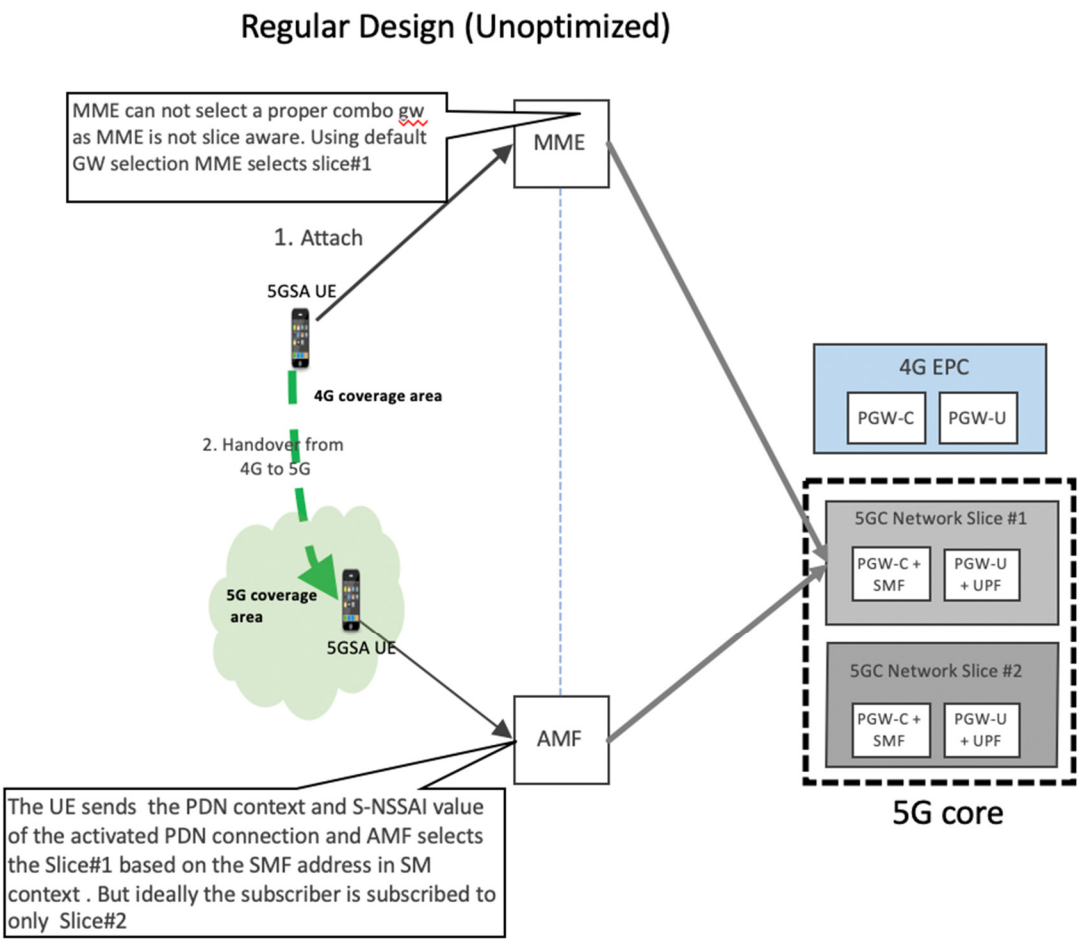

Figure 1

When a 5G subscriber attaches to the 4G network, the correct (PGW +SMF) combo node selection based on the slice subscription of the UE is important. But the 4G network is not slice aware. When a 5G subscriber attaches in the 4G network, the Mobility Management Entity (MME) has to select the right slice from a set of Network Slice Selection Assistance Information (NSSAI) values present in the 5G subscription for that UE. Again, since the 4G network is not slice aware, a solution is presented herein to select the correct slice.

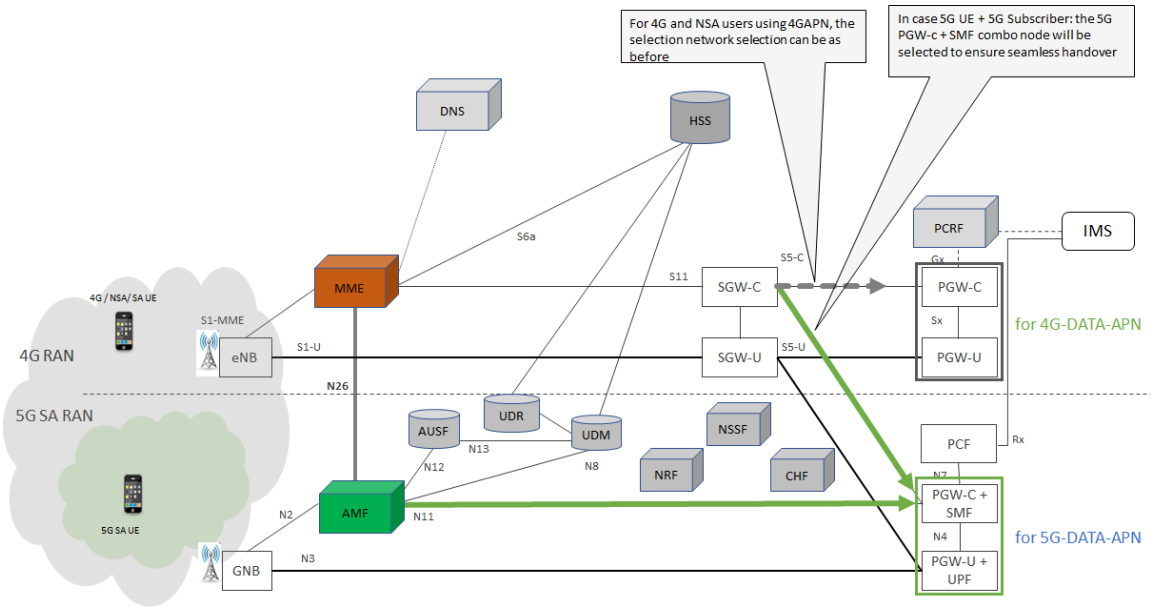

Figure 2

Figure 2 above is referenced for purposes of the two options presented below.

Option 1:

In this option, the UE usage type (UUT) attribute value pair (AVP) with priority in the Update Location Answer (ULA) message and a combination of UUT and network service parameters in the Domain Name System (DNS) response message.

The following example is described.

Below is the slice table for the 5G network. The particular user in the picture is subscribed to UUT 150,180. This mapping table is maintained by the Home Subscriber Server + Unified Data Management (HSS+UDM) operator and configured accordingly.

UUT	SNSSAI	Subscriber profile	Subscription	DNN	Slice type	Priority
150	[SST= 1, SD = 500]	Gold- eMBB	Subscribed	5G-cisco.com	Default	2
160	[SST= 1, SD = 600]	Silver- eMBB	Not-Subscribed	5G-cisco.com	non-default	3
170	[SST= 1, SD = 700]	Bronze- eMBB	Not-Subscribed	5G-cisco.com	non-default	4
180	[SST= 2, SD = 800]	Gold- URLLC	Subscribed	5G-cisco.com	non-default	1

Step1 :ULR --> ULA
ULA -->

UUT profile -Grouped AVP
150-priority2
280-priority1

Step 2:- DNS request --> NAPTR [5G.data.jp]
Step 3:- DNS response --> x-3gpp-pgw:x-s5-gtp+nc-smf+ue-150 - 1.1.1.1
x-3gpp-pgw:x-s5-gtp+nc-smf+ue-160 - 2.2.2.2
x-3gpp-pgw:x-s5-gtp+nc-smf+ue-170 - 3.3.3.3
x-3gpp-pgw:x-s5-gtp+nc-smf+ue-280 - 4.4.4.4

Step4:- MME --> SMF+PGW - 280 [MME compares the UUT and based on priority Mapping received from HSS + UDM]

Two new parameter enhancements are introduced for option 1.

1) Grouped AVP in ULA message. As per the 3GPP TS 29.272 , UE usage type is defined as follows

7.3.202 UE-Usage-Type

The UE-Usage-Type AVP is of type Unsigned32. This value shall indicate the usage characteristics of the UE that enables the selection of a specific Dedicated Core Network (DCN). See clause 4.3.25 of 3GPP TS 23.401 [2].

The allowed values of UE-Usage-Type shall be in the range of 0 to 255.

Values in the range of 0 to 127 are standardized and defined as follows:

0: Spare, for future use

...

127: Spare, for future use

Values in the range of 128 to 255 are operator-specific.

Our proposal for the new UE usage type AVP is as follows

UE Usage type ::= <AVP header: X >

***[Usage-Identifier]**
[UE-Usage-type]
[Priority]

2) A new service parameter proposal in DNS response:- As per the procedures defined in the current 3GPP DNS Specification, TS 29.303, the MME can either select a combined SMF+PGW node via DNS using the nc-nr parameter or it can select a dedicated core network based on the **UE usage type** value (DECOR feature). However, if the MME needs to select a combined PGW+ SMF and also select a specific SMF+PGW node within a network slice set, then no solution exists. Thus, an enhancement is presented herein to the DNS service parameters in the Name Authority Pointer (NAPTR) response.

In the DNS NAPTR Response/Answer, there are service parameters that can be included which allow the MME application to choose either criterion for gateway node selection:

1. Service parameter x-3gpp-pgw:x-s5-gtp+nc-smf" - [network capability indicating UE is DCNR capable with which MME can select a combination PGW+SMF node]
2. Service parameter x-3gpp-pgw:x-s5-gtp+ue-1.2.3 - [UUT - UE usage type indicated in the subscription data with which MME can select a dedicated gateway/core node]

Proposed enhancement within the Service parameter of DNS NAPTR Response/Answer:
The service-parameter in the DNS NAPTR response should indicate a combination of the UUT and nc-smf (+nc and +ue) as shown in an example below:

- **Ex: x-3gpp-pgw:x-s5-gtp+nc-smf+ue-1.2.3**

An example workflow is depicted in Figure 3 below.

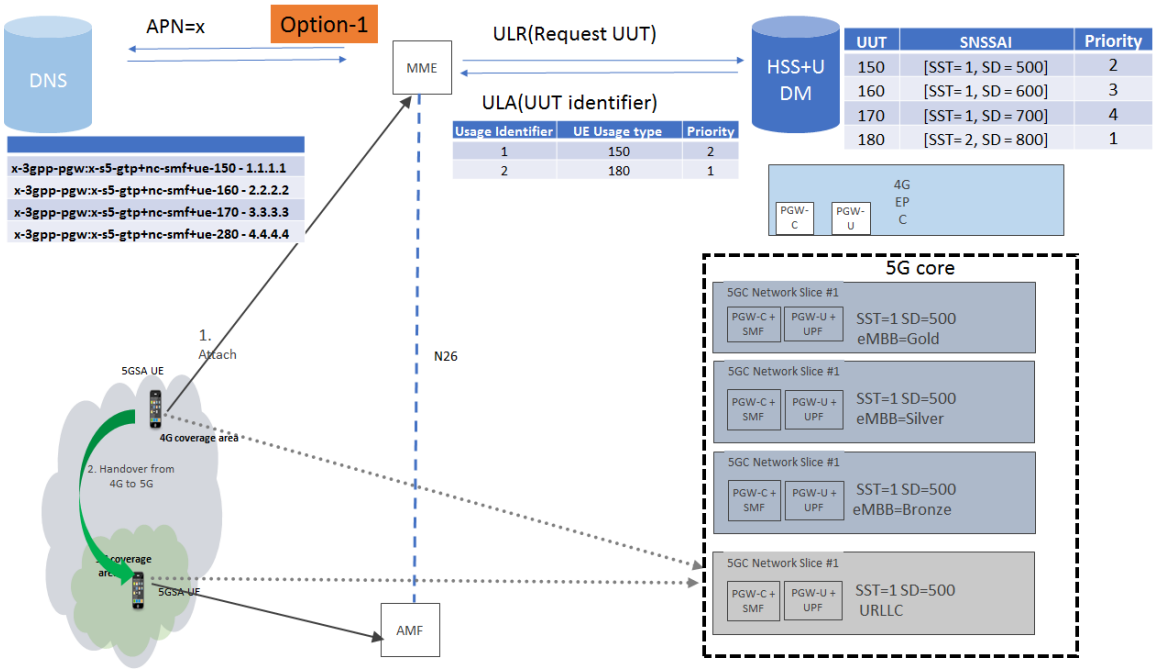

Figure 3

A flow chart depicting the operations of Option 1 is set forth below in Figure 4.

Option1 - 5GC slice selection utilizing the Priotizing UUT value in ULA

5G subscriber has multiple slices for a single DNN . example slice mapping in 5g as follows	

UUT	SNSSAI	Subscriberprofile	Subscription	DNN	Slice type	Priority
150	[SST= 1, SD = 500]	Gold- eMBB	Subscribed	5G-cisco.com	Default	2
160	[SST= 1, SD = 600]	Silver- eMBB	Not-Subscribed	5G-cisco.com	non-default	3
170	[SST= 1, SD = 700]	Bronze- eMBB	Not-Subscribed	5G-cisco.com	non-default	4
180	[SST= 2, SD = 800]	Gold- URLLC	Subscribed	5G-cisco.com	non-default	1

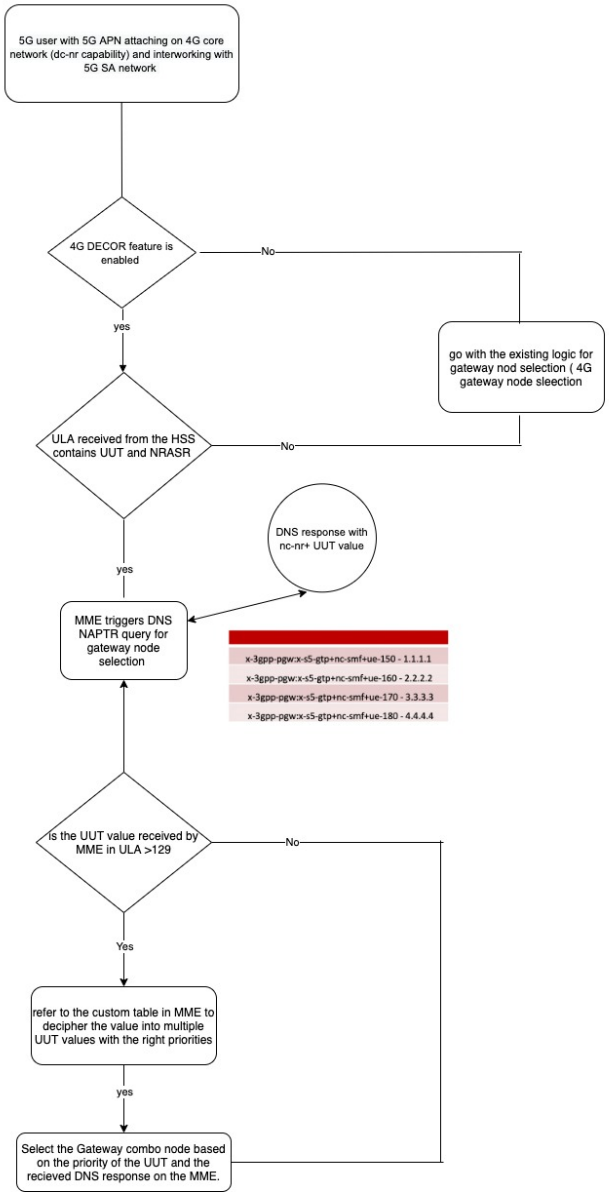

Figure 4

Option 2:

In this option, instead of the HSS+UDM maintaining the slice to UUT mapping, this custom mapping table is maintained at the MME node (such as at the MME operator policy level). In this option, the Operator specific value of UUT is employed, which ranges from 127-255.

The mapping table in the MME may take the form of:

Subscriber	NSSAI1(UUT-MME)	NSSAI2(UUT-MME)	NSSAI3(UUT-MME)	UUT Value(HSS)
UE1	x			129
UE2		x		130
UE3			x	131
UE4	x	x		132
UE5		x	x	133
UE6	x	x	x	134
Legend			High-Priority	

When the MME receives the DNS response with the combined PGW+SMF and a UUT value, the MME will refer to the table and select the gateway node with the highest value.

An example workflow for Option is shown in Figure 5 below.

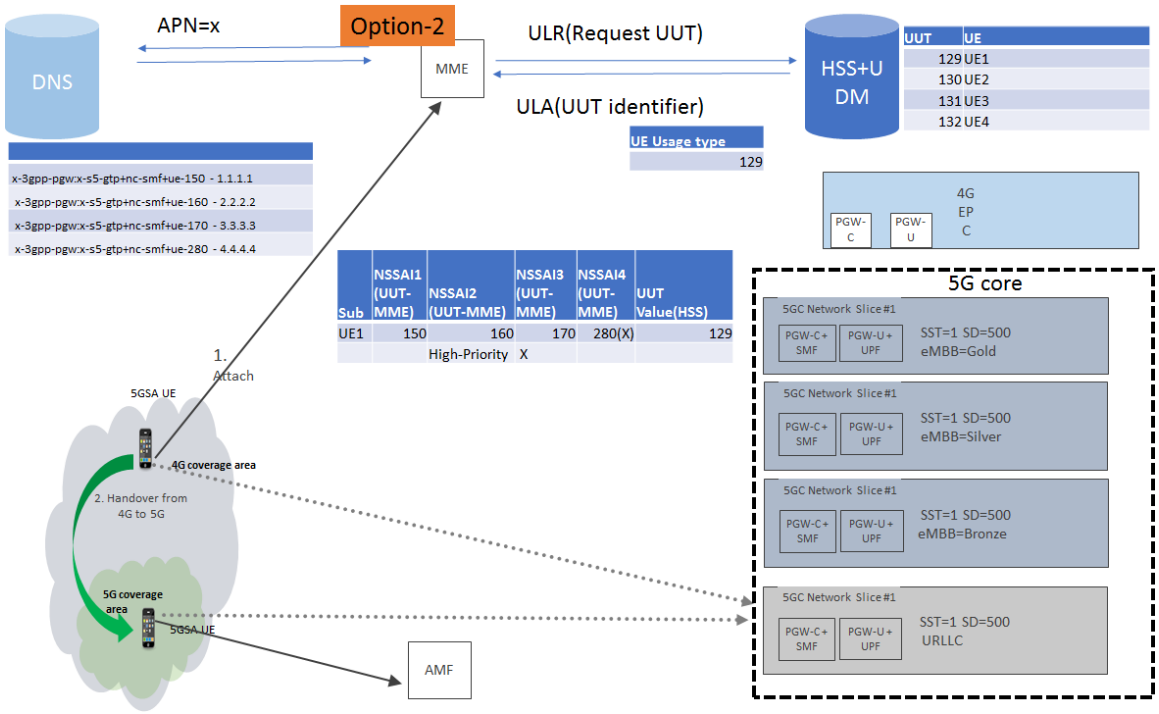

Figure 5

Accordingly, presented herein is a method or an algorithm to map multiple slices (NSSAI's) to which a user is subscribed in a 5G network to UE Usage Type (UUT) in the 4G network. In addition, a method is provided to enhance the HSS capability to send a Grouped UUT identifier AVP as proposed in Option 1 so that the MME is aware of the multiple slices subscription for the UE in the 5G network. Further still, a method is provided to introduce a new service-parameter which is a combination of nc-nr and UUT (+nc and +ue) from the DNS in the APN Fully Qualified Domain Name (FQDN) NAPTR response. A method is also provided to set and select a UUT value based on priority/preference using a response from the HSS and DNS (this is needed when multiple slices for a user in 5G gets mapped to multiple UUTs in 4G). Further, a method is provided to maintain a custom/pre-defined table at MME to have a list of mapped operator-specific UUT values along with priority/preference and use the specific UUT value received from the HSS and DNS during the GW selection as part of Attach/Packet Data Network (PDN) connectivity procedure in 4G. Finally, a method is provided to adapt to a failover to next priority NSSAI (UUT value in 4G) value and its corresponding GWs and proceed with the

PDN connection procedure in case the high priority UUT based GWs were inaccessible or failed during DNS resolution.

In summary, operators who are introducing full 5G services with 5G use cases making use of the full capabilities of 5G with multiple slices in their network, will face the problem of selecting the right slice when the subscriber moves from 4G to 5GS. Two options are presented herein. In a first option, a 1:1 mapping is made between the s-NSSAI's subscribed by the UE in the 5G network to the UUT in the HSS, along with the subscribed priority of the slices per UE. This is sent to the MME. This involves some enhancements to the ULA message structure (on the S6a interface) and enhanced logic in the MME for node selection. In a second option, an N:1 mapping between is made between the s-NSSAI's subscribed by the UE in the 5G network to the UUT in HSS, along with the subscribed priority of the slices per UE. The same is sent to the MME as a unique UUT value which is an operator specific value. This involves enhancements in MME logic to select the right gateway node based on the received UUT by HSS.