



# Dynamic User Plane Selection

- [Revision History, on page 1](#)
- [Feature Description, on page 1](#)

## Revision History



**Note** Revision history details are not provided for features introduced before release 21.24.

Revision Details	Release
First introduced	Pre 21.24

## Feature Description

In a Multi-access Edge Computing (MEC) architecture, selecting an edge User Plane (UP) is key to providing low latency and maximum bandwidth efficiency. The location information of the user equipment (UE) is used to select an UP. For selecting an edge UP, two levels of granularity are considered, they are as follows:

- E-UTRAN Cell Global Identifier (ECGI) or Cell Global Identification (CGI) offers the lowest level of granularity.
- Tracking Area Identifier (TAI) or Routing Area Identity (RAI) or Service Area Identifier (SAI) offers the next level of granularity.
- TAI-SAI-RAI-ECGI offers fixed priority of TAI, SAI, RAI and ECGI in which ULI type is matched when more than one ULI type is received.

### Architecture

To select a UP based on the location parameter of the upcoming session, a DNS Name Authority Pointer (NAPTR) query including TAI/RAI /SAI or ECGI/CGI is sent to the DNS Server. The DNS (NAPTR) Response contains a list of UP IPs. To select an UP from this list, a Load Control Information (LCI) and session count is applied to shortlist.

In this feature, the virtual APN selection is also enabled along with the dynamic UP selection. As a result, APN is selected based on the specified criteria. The selection criteria for the Virtual APN can also be based on location, for example, the Radio Admission Control (RAC) range.

Dynamic UP selection is done based on the **configure fqdn postfix** CLI command and the type of selected APN. If the type is ECGI or CGI, then a DNS Straightforward NAPTR (S-NAPTR) query is sent based on the cell ID. If the type is configured as tracking or routing area, then TAI or RAI or SAI is used for DNS (S-NAPTR) query.

To get the list of associated sx peers, UP group from the selected APN is used. The UP IPs in DNS (S-NAPTR) response is matched with the list of sx peers in the group. The peer that is either loaded least or have least sessions is selected from this list.

If ULI contains unsupported location data, Dynamic UP selection happens based on the RAI IE that comes outside ULI.

### How it Works

This section describes the sequence of operation.

1. For P-GW, GGSN, or SAEGW, Fully Qualified Domain Names (FQDN) in UP, which contains **fqdn-postfix** and FQDN type (EGCI/CGI or TAI/RAI/SAI) are configured at APN level.
2. During an s6b interface protocol based authorization, the **fqdn-postfix** value in the authorization response is used (applicable for P-GW, GGSN, or SAEGW services only).
3. The DNS (S-NAPTR) query is sent to the DNS server.




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**Note** The DNS (S-NAPTR) is generated based on the type(E-CGI | RAI-TAI-SAI | TAI-SAI-RAI-ECGI) configured in uplane fqdn at apn level for GGSN.

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4. The response that is received from the DNS server is matched for service **x-3gpp-upf:x-sxb** for P-GW/GGSN/SAEGW(Collapsed) and **x-3gpp-upf:x-sxa** for S-GW.
5. The matching DNS (S-NAPTR) response is processed recursively for UP IPs.
6.
  - If enabled, the processed IPs are shortlisted for LCI based UP selection.
  - Or else, the processed IPs are shortlisted for session count based UP selection (with or without LCI).
7. If none of the UP IPs present in the response match with the associated sx peers, then, it leads to a session creation failure.
8. For S-GW dynamic UP selection, the DNS client context must be same as **sgw-service** context.
9. If there is a successful DNS response for S-GW dynamic UP selection, UPs are selected from the DNS dynamic list of UP addresses. If there is DNS failure (DNS response is empty without any UP address or DNS time-out), the UP selection falls back to the statically configured APN profile based user-plane-groups functionality.

**Note**

- Pure S-GW multi-PDNs work with independent DNS based UP selection.
- S-GW relocation use cases work with independent DNS based UP selection during a handover. If user-plane-group is configured under apn-profile, dynamic UP selection takes preference.
- After the DNS (NAPTR) query is sent, there are a few seconds of delay (equivalent to tx + rx ) to receive the response.
- If the DNS server is not reachable, the session establishment might be delayed upto a maximum of 30 seconds before it uses the legacy method to select an UP.

The following sections describe various scenarios that are associated with the Dynamic UP Selection feature.

**P-GW Dynamic UP Selection Having Virtual APN with Associated IP Pool**

This section describes the sequence of operation for P-GW to dynamically select an UP having a virtual APN with an associated IP pool.

1. As part of the create session handling, PGW-C selects a virtual APN based on the TAC range.
2. The DNS (S-NAPTR) query is sent to the DNS server based on the configuration of the selected APN.
3. The response that is received from the DNS server is matched for service. The records with matching service fields are considered for selection.
4. The UP IPs that are part of a configured IP pool and present in the response are matched with the associated sx peers that are based on the UP group of the selected APN.
5. From the matching list, P-GW selects the UP that is the least loaded.

**P-GW Dynamic UP Selection Having Virtual APN without Associated IP Pool**

This section describes the sequence of operation for P-GW to dynamically select an UP having a virtual APN without an associated IP pool.

1. As part of the create session handling, PGW-C selects a virtual APN based on the TAC range.
2. The DNS (S-NAPTR) query is sent to the DNS server based on the configuration of the selected APN.
3. The response that is received from the DNS server is matched for service. The records with matching service fields are considered for selection.
4. The UP IPs that are part of any public IP pool and present in the response are matched with the associated sx peers that are based on the UP group of the selected APN.
5. From the matching list, P-GW selects the UP that is the least loaded.

**S-GW Dynamic UP Selection for Successful DNS Response**

This section describes the sequence of operation for S-GW to dynamically select an UP after receiving a successful response from the DNS server.

1. After an UE in a tracking area (or Cell ID) sends an attach request to S-GW with Dynamic ECGI, RAI-TAI-SAI | TAI-SAI-RAI-ECGI based UP selection feature is enabled and the DNS (S-NAPTR) query is sent to the DNS server.

2. S-GW receives the query response from the DNS server, which contains the list of UP IPs.
3. From the list of UP IPs, S-GW selects the UP that is the least loaded.

#### **S-GW Dynamic UP Selection for DNS Response Time-out**

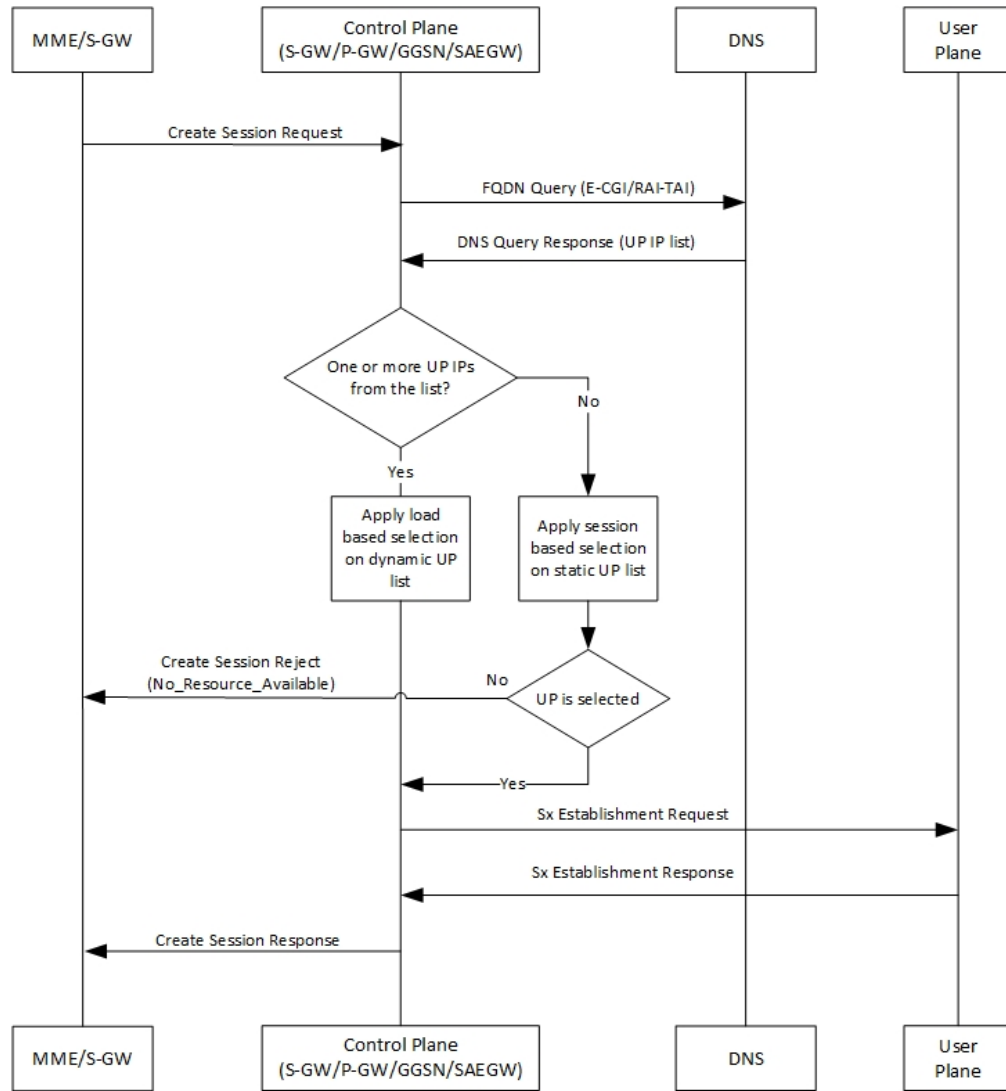
This section describe the sequence of operation for S-GW to dynamically select an UP after the DNS server time-out or the server sends a negative response.

1. The S-GW sends the DNS (S-NAPTR) query to the DNS server.
2. If there is a DNS server time-out or the server sends a negative response after the DNS (S-NAPTR) query is sent to the DNS server, then S-GW selects an UP from the apn-profile UP group that are configured with static IPs.
3. From the list of UP IPs, S-GW selects the UP that is the least loaded.

#### **Call Flows**

This section includes the following call flows.

#### **DNS Query Generation and Response Handling Call Flow**



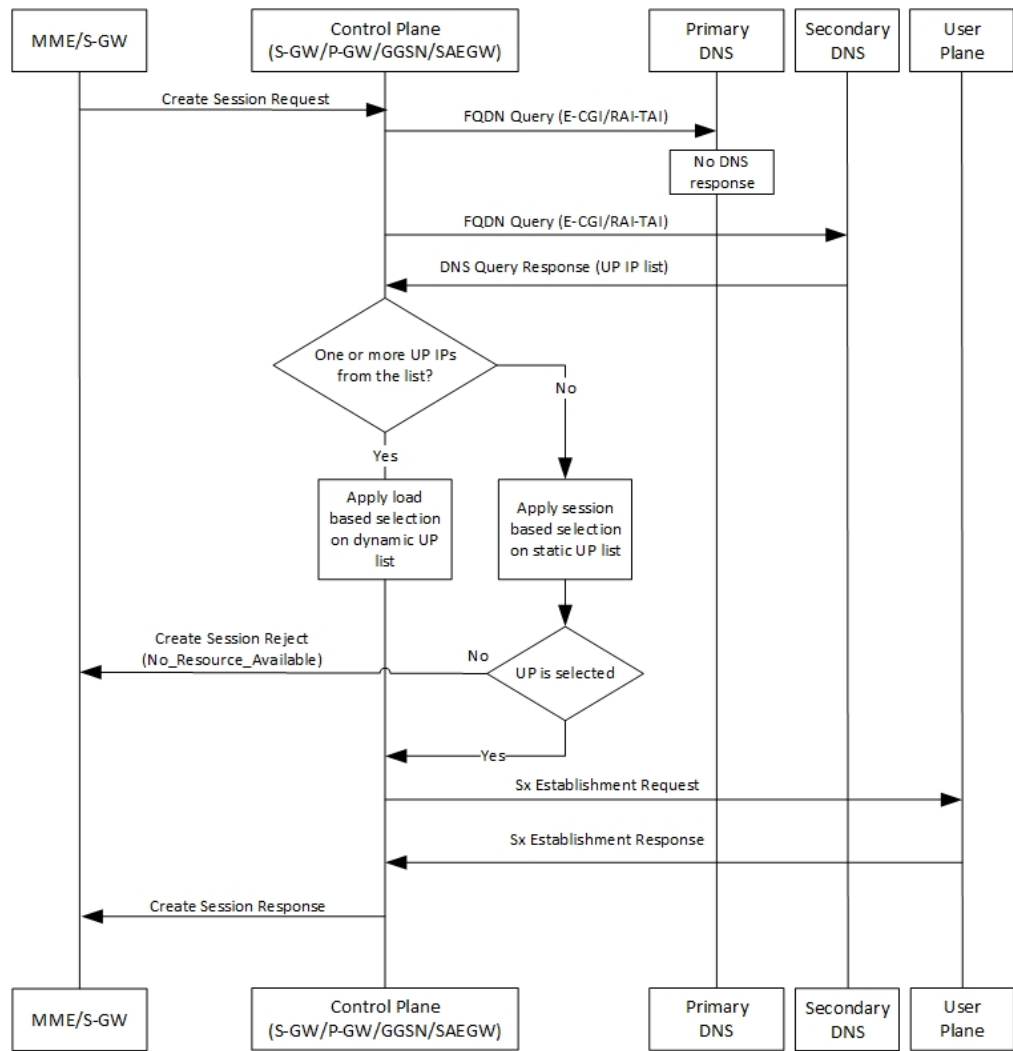
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Table 1: DNS Query Generation and Response Handling Call Flow

Step	Description
1	MME or S-GW sends a Create Session Request message to the Control Plane (S-GW, P-GW, GGSN, or SAEGW).
2	Control Plane (CP) sends an FQDN query (E-CGI or TAI-RAI -SAI or TAI-SAI-RAI-ECGI) to the DNS server.
3	CP receives the response to the FQDN query with a list of UP IPs.

Step	Description
4	<ul style="list-style-type: none"> <li>• If there are one or more UP IPs in the received list, CP applies LCI to the dynamic IP list to select an UP IP.</li> <li>• Or else, CP applies session count to the static IP list to select an UP IP.</li> </ul>
5	<ul style="list-style-type: none"> <li>• If an UP is selected, CP sends an Sx Establishment Request message is sent to UP (skip to step 6).</li> <li>• Or else, a Create Session Reject message is sent to MME or S-GW.</li> </ul>
6	UP responds and sends an Sx Establishment Response message to CP.
7	CP sends a Create Session Response message to MME or S-GW.

#### DNS Query Timeout for Primary DNS Call Flow



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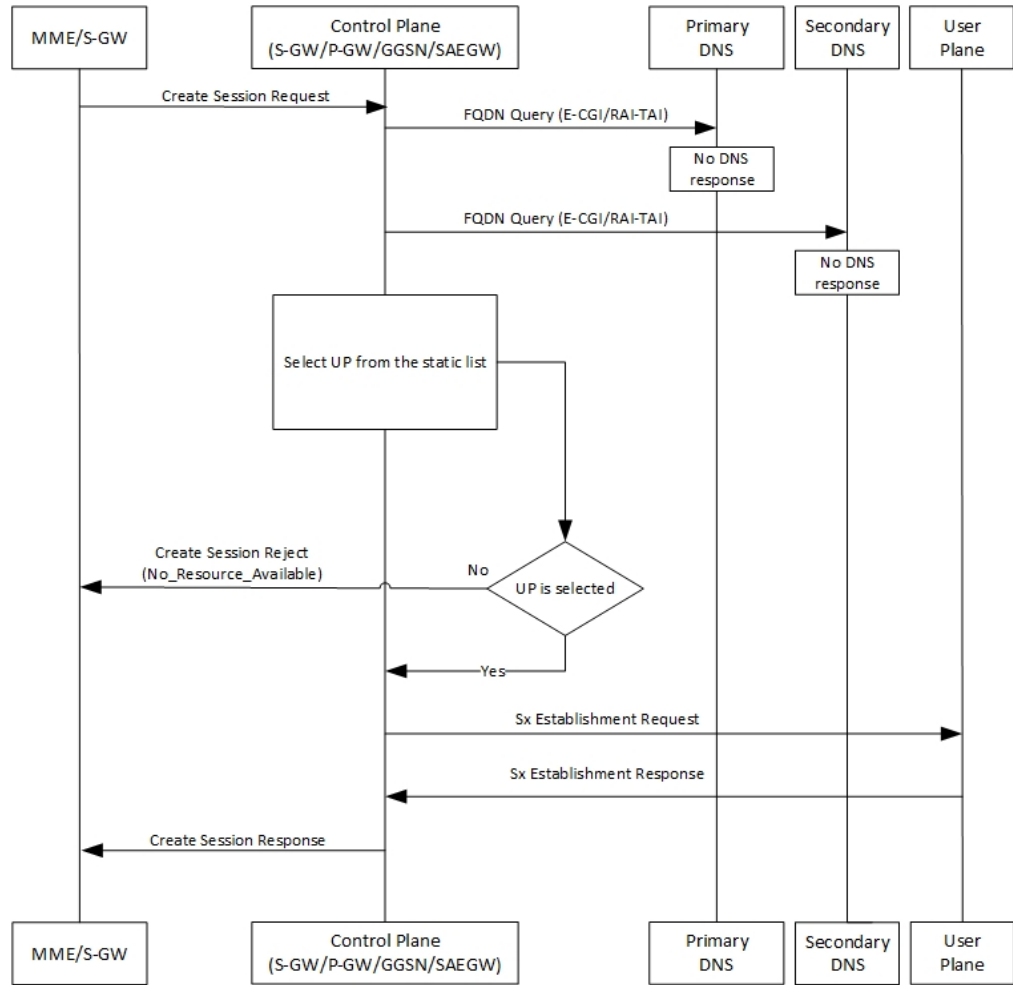
Table 2: DNS Query Timeout for Primary DNS Call Flow

Step	Description
1	MME or S-GW sends a Create Session Request message to the Control Plane (S-GW, P-GW, GGSN, or SAEGW).
2	Control Plane (CP) sends an FQDN query (E-CGI or TAI-RAI-SAI or TAI-SAI-RAI-ECGI) to the primary DNS server.
3	When there is no response to the query from the primary DNS server due to a time-out, CP retries to send the FQDN query to the secondary DNS server.
4	CP receives the response to the FQDN query from the secondary DNS server with a list of UP IPs.

Step	Description
5	<ul style="list-style-type: none"><li>• If there are one or more UP IPs in the received list, CP applies LCI to the dynamic IP list to select an UP IP.</li><li>• Or else, CP applies session count to the static IP list to select an UP IP.</li></ul>
6	<ul style="list-style-type: none"><li>• If an UP is selected, CP sends an Sx Establishment Request message is sent to UP (skip to step 7).</li><li>• Or else, a Create Session Reject message is sent to MME or S-GW.</li></ul>
7	UP responds and sends an Sx Establishment Response message to CP.
8	CP sends a Create Session Response message to MME or S-GW.



**DNS Query Timeout for Primary and Secondary DNS Call Flow**



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**Table 3: DNS Query Timeout for Primary and Secondary DNS Call Flow**

Step	Description
1	MME or S-GW sends a Create Session Request message to the Control Plane (S-GW, P-GW, GGSN, or SAEGW).
2	Control Plane (CP) sends an FQDN query (E-CGI or TAI-RAI-SAI or TAI-SAI-RAI-ECGI) to the primary DNS server.
3	When there is no response to the query from the primary DNS server due to a time-out, CP retries to send the FQDN query to the secondary DNS server.
4	When there is no response to the query from the secondary DNS server also, CP selects an UP IP from the list of static IPs.

Step	Description
5	<ul style="list-style-type: none"> <li>• If an UP is selected, CP sends an Sx Establishment Request message is sent to UP (skip to step 6).</li> <li>• Or else, a Create Session Reject message is sent to MME or S-GW.</li> </ul>
6	UP responds and sends an Sx Establishment Response message to CP.
7	CP sends a Create Session Response message to MME or S-GW.

### Limitations

The Dynamic UP Selection feature has the following limitations:

- It's applicable for P-GW, S-GW, and SAEGW only.
- For SR and ICSR, no specific parameters are stored. If **smgr** is reset, the configured values are pushed again from **sessctrl**.
- Any changes to the DNS Server in not considered.
- Number of IPs handled for UP are limited to six, and this list of IPs can be a combination of IPv4 and IPv6 addresses.

### Configuring the Dynamic User Plane Selection Feature

This section describes how to configure the Dynamic User Plane Selection feature.

#### Configuring CLI commands for P-GW or GGSN

```

configure
  context context_name
    apn apn_name
      user-plane-fqdn
        user-plane-fqdn fqdn_postfix_string type [ E-CGI | RAI-TAI -SAI |
TAI-SAI-RAI-ECGI ]
      end

```

#### NOTES:

- **user-plane-fqdn** Enables use of locally configured FQDN-postfix for dynamic UP selection (DNS-based).
- **E-CGI** Configures FQDN query type as E-CGI for UP selection
- **RAI-TAI-SAI** Configures FQDN query type as RAI-TAI-SAI for UP selection.
- **TAI-SAI-RAI-ECGI**: Configures FQDN query type as TAI-SAI-RAI-ECGI for UP selection.

#### Configuring CLI Commands for S-GW

```

configure
  context context_name
    sgw-service sgw-service_name
      user-plane-fqdn
        user-plane-fqdn fqdn_postfix_string type [ E-CGI | RAI-TAI -SAI |
TAI-SAI-RAI-ECGI ]
      end

```

**NOTES:**

- **user-plane-fqdn** Enables use of locally configured FQDN-postfix for dynamic UP selection (DNS based).
- **E-CGI** Configures FQDN query type as E-CGI for UP selection.
- **RAI-TAI-SAI** Configures FQDN query type as RAI-TAI-SAI for UP selection.
- **TAI-SAI-RAI-ECGI**: Configures FQDN query type as TAI-SAI-RAI-ECGI for UP selection.

**Boxer Configurations**

This section describes the following boxer configurations and restrictions.

1. DNS Client must be configured and associated with P-GW and GGSN service.
2. UP FQDN must be configured in APN.
3. IP addresses of the primary and secondary DNS servers must be configured in the ISP context.
4. UP FQDN must be configured in S-GW service for S-GW dynamic UP selection.

**DNS Server Configurations**

This section describes the following guidelines and restrictions to configure an external DNS server:

1. DNS must be configured for NAPTR to record for ECFI/CGI/TAI/RAI/SAI, as applicable.
2. NAPTR record must have service field as "**x-3gpp-upf:x-sxb**" for P-GW/SAEGW (Collapsed) and GGSN service and "**x-3gpp-upf:x-sxa**" for S-GW.
3. NAPTR record must have flags as **a** to indicate that the replacement string is FQDN for A or AAAA records.

The following CLI commands represent a sample DNS server configuration:

```

$ORIGIN 3gppnetwork.org.
$TTL 60          ; Put the Default
                 TTL in seconds here (Its 1 day currently)
3gppnetwork.org. IN SOA  nsbng.3gppnetwork.org. root.3gppnetwork.org.
(
273 ; serial
7200 ; refresh (2 hours)
3600 ; retry (1 hour)
86400 ; expire (1 day)
43200 ; minimum (12 hours)

```

```

)

      NS
      nsbng.3gppnetwork.org.

ns AAAA 3001::41

;CUPS NAPTR Records Start From Here

;TAI NAPTR Records

tac-lb89.tac-hb67.tac.epc.mnc365.mcc214.3gppnetwork.org. IN NAPTR 1 1 "a"
"x-3gpp-upf:x-sxb" ""
      uplane-address1-v4.3gppnetwork.org.

tac-lb89.tac-hb67.tac.epc.mnc365.mcc214.3gppnetwork.org. IN NAPTR 1 1 "a"
"x-3gpp-upf:x-sxb" ""
      uplane-address1-v6.3gppnetwork.org.

tac-lb89.tac-hb67.tac.epc.mnc365.mcc214.3gppnetwork.org. IN NAPTR 1 1 "a"
"x-3gpp-upf:x-sxa" ""
      uplane-address1-v4.3gppnetwork.org.

tac-lb89.tac-hb67.tac.epc.mnc365.mcc214.3gppnetwork.org. IN NAPTR 1 1 "a"
"x-3gpp-upf:x-sxa" ""
      uplane-address1-v6.3gppnetwork.org.

;RAI NAPTR Records

rac34.lac-lb34.lac-hb12.mnc365.mcc214.3gppnetwork.org. IN NAPTR 1 1 "a" "x-3gpp-upf:x-sxb"
""
      uplane-address1-v4.3gppnetwork.org
.
rac34.lac-lb34.lac-hb12.mnc365.mcc214.3gppnetwork.org. IN NAPTR 1 2 "a" "x-3gpp-upf:x-sxb"
""
      uplane-address1-v6.3gppnetwork.org.

;SAI NAPTR Records

sac1234.lac-lb34.lac-hb12.mnc365.mcc214.3gppnetwork.org. IN NAPTR 1 1 'a'
'x-3gpp-upf:x-sxb' ''
      uplane-address1-v4.3gppnetwork.org.

sac1234.lac-lb34.lac-hb12.mnc365.mcc214.3gppnetwork.org. IN NAPTR 1 2 'a'
'x-3gpp-upf:x-sxb' ''
      uplane-address1-v6.3gppnetwork.org.

;ECGI NAPTR Records

eci-b167.eci-b245.eci-b323.eci-b401.eci.epc.mnc365.mcc214.3gppnetwork.org. IN NAPTR 1 1
"a" "x-3gpp-upf:x-sxb" ""
      uplane-address1-v4.3gppnetwork.org.

eci-b167.eci-b245.eci-b323.eci-b401.eci.epc.mnc365.mcc214.3gppnetwork.org. IN NAPTR 1 1
"a" "x-3gpp-upf:x-sxb" ""
      uplane-address1-v6.3gppnetwork.org.

;CGI NAPTR Records

ci-lb34.ci-hb12.ci.lac-lb34.lac-hb12.lac.ggsn.mnc365.mcc214.3gppnetwork.org. IN NAPTR
1 1
      "a" "x-3gpp-upf:x-sxb" ""
      uplane-address1-v4.3gppnetwork.org.

ci-lb34.ci-hb12.ci.lac-lb34.lac-hb12.lac.ggsn.mnc365.mcc214.3gppnetwork.org. IN NAPTR
1 1

```

```

    "a" "x-3gpp-upf:x-sxb" ""s
    uplane-address1-v6.3gppnetwork.org.

;A Records

uplane-address1-v4 100 IN
    A 209.165.200.225

;uplane-address1-v4 100 IN A
    209.165.200.225

uplane-address1-v4 100 IN
    A 209.165.200.225

;uplane-address2-v4 100 IN
    A 209.165.200.225

;AAAA Records

uplane-address1-v6 100 IN
    AAAA 1::1:111

uplane-address1-v6 100 IN
    AAAA 1111::1:111

;uplane-address2-v6 100 IN
    AAAA 1111::1:111

```

### S6b Configuration (Optional)

This section describes guidelines to configure an external S6b to support custom attribute **aaa-uplane-fqdn** and to provide **fqdn\_post\_fix\_string**.

#### AA-Answer

```

apn-config
uplane-fqdn

```

### Interface

The following sections describe the format for the DNS query and response.

#### DNS (S-NAPTR) Query Format

This section describes the format for the DNS (S-NAPTR) query message.



**Important** SAI based FQDN is proprietary formatted and not as per the 3GPP Standard 23.003 19.4.2 Fully Qualified Domain Names.

Network Node	Query format
S-GW-C	<p><b>ECGI based</b></p> <p>eci b1&lt;ECI byte-1&gt;.eci b2&lt;ECI-byte-2&gt;. Eci b3&lt;ECI byte-3&gt;</p> <p>.eci b4&lt;ECI-byte-4&gt;.eci.epc.mnc &lt;MNC.mcc&lt;MCC&gt;.3gppnetwork.org</p> <p><b>TAI based</b></p> <p>tac lb&lt;TAC low byte&gt;.tac hb&lt;TAC-high-byte&gt;</p> <p>.tac.epc.mnc&lt;MNC&gt;.mcc&lt;MCC&gt;.3gppnetwork.org</p>

Network Node	Query format
P-GW-C	<p><b>ECGI based</b></p> <p>eci-b1&lt;TAC-byte-1&gt;.eci-b2 &lt;ECI-byte-2&gt;.Eci-b3&lt;TAC-byte-3&gt; .eci-b4&lt;ECI-byte-4&gt;.eci.epc.mnc&lt;MNC&gt; .mcc&lt;MCC&gt;.3gppnetwork.org</p> <p><b>TAI based</b></p> <p>tac-lb&lt;TAC-low-byte&gt;.tac-hb&lt;TAC-high-byte&gt; .tac.epc.mnc&lt;MNC&gt;.mcc&lt;MCC&gt;.3gppnetwork.org</p>
GGSN-C	<p><b>CGI based</b></p> <p>ci-lb&lt;CI-low-byte&gt;.ci-hb&lt;CI-high-byte&gt; .eci.lac-lb&lt;LAC-low-byte&gt;.lac-hb&lt;LAC-high-byte&gt; .lac.ggsn.mnc&lt;MNC&gt;.mcc&lt;MCC&gt;.3gppnetwork.org</p> <p><b>RAI based</b></p> <p>rac&lt;RAC&gt;.lac-lb&lt;LAC-low-byte&gt; .lac-hb&lt;LAC-high-byte&gt;.lac.ggsn.mnc&lt;MNC&gt; .mcc&lt;MCC&gt;.3gppnetwork.org</p> <p><b>SAI based</b></p> <p>sac&lt;SAC&gt;.lac-lb&lt;LAC-low-byte&gt;. lac-hb&lt;LAC-high-byte&gt;.lac.ggsn mnc&lt;MNC&gt;.mcc&lt;MCC&gt;.3gppnetwork.org</p>
SAEGW-C (Collapsed)	<p><b>ECGI based</b></p> <p>eci-b1&lt;TAC-byte-1&gt;.eci-b2&lt;ECI-byte-2&gt; .Eci-b3&lt;TAC-byte-3&gt;.eci-b4&lt;ECI-byte-4&gt; .eci.epc.mnc&lt;MNC&gt;.mcc&lt;MCC&gt;.3gppnetwork.org</p> <p><b>TAI based</b></p> <p>tac-lb&lt;TAC-low-byte&gt; .tac-hb&lt;TAC-high-byte&gt;.tac.epc.mnc &lt;MNC&gt;.mcc&lt;MCC&gt;.3gppnetwork.org</p> <p><b>SAI Based</b></p> <p>sac&lt;SAC&gt;.lac lb&lt;LAC low byte&gt; .lac hb&lt;LAC-high-byte&gt;.lac.epc. mnc&lt;MNC&gt;.mcc&lt;MCC&gt;.3gppnetwork.org</p>

**DNS (S-NAPTR) Response Format**

This section describes a sample format for DNS (S-NAPTR) response message.

Query ID : 22290

Type : Response

Question : NAPTR ?  
ci-lb34.ci-hb12.ci.lac-lb34.lac-hb12.lac.ggsn.mnc365.mcc214.3gppnetwork.org.

Answer :

Name :  
ci-lb34.ci-hb12.ci.lac-lb34.lac-hb12.lac.ggsn.mnc365.mcc214.3gppnetwork.org.

TTL : 60

Type : NAPTR

Order : 1

Preference : 1

Flags : a

Service : x-3gpp-upf:x-sxb

Regexp :

Replacement : uplane-address2.3gppnetwork.org.

Name :  
ci-lb34.ci-hb12.ci.lac-lb34.lac-hb12.lac.ggsn.mnc365.mcc214.3gppnetwork.org.

TTL : 60

Type : NAPTR

Order : 1

Preference : 1

Flags : a

Service : x-3gpp-upf:x-sxb

Regexp :

Replacement : uplane-address1.3gppnetwork.org.

Query ID : 44640

Type : Query

Question : A?  
uplane-address2.3gppnetwork.org.

Query ID : 55480

Type : Query

Question : A?  
uplane-address1.3gppnetwork.org.

Query ID : 55480

Type :  
Response

Question : A?  
uplane-address1.3gppnetwork.org.

Answer :

Name : uplane-address1.3gppnetwork.org.

TTL : 100

Type : A



```

Address : 20.20.20.108
Query ID           : 44640

Type              :
Response

Question          : A?
                  uplane-address2.3gppnetwork.org.

Answer            :

Name              :
                  uplane-address2.3gppnetwork.org.

TTL               : 100

Type              : A

Address : 209.165.200.225

```

### Show Commands

This section describes the available show commands for the Dynamic UP Selection feature.

#### **show apn name** *apn\_name*

This show command can be used to check the following values:

- FQDN of APN
- Type of FQDN

#### **show sgw-service** *sgw-service\_name*

This show command can be used to check the following values:

- FQDN of APN
- Type of FQDN

### Statistics

This section provides information about the show CLI commands available to collect the statistics.

The following is a sample partial output for **show saegw-service statistics all** and **show saegw-service statistics name SAEGW21** CLI commands.

```
Dynamic Uplane Selection Statistics:
  Attempted           :      x
  Successful          :      x
  Failure             :      x
  Peer not Found     :      x
  Negative DNS response :      x
  DNS timed out      :      x
  Unsolicited UP Selection Response:  x
  DNS Query Response post DNS timeout: x
```

The following is a sample partial output for **show saegw-service statistics all function sgw** CLI command.

```
Dynamic Uplane Selection Statistics:
  Attempted:           7
  Successful          4
  Failure:            3
    Mismatch DNS response: 1
    Negative DNS response: 1
    DNS timed out:      1
    Unsolicited UP Selection Response: 1
  DNS Query Response post DNS timeout: 1
```

## Bulk Statistics

### saegw schema

Use this schema to collect the following bulk statistics pertaining to the Dynamic User Plane Selection feature:

- saegw-dyn-up-attempt
- saegw-dyn-up-attempt
- saegw-dyn-up-success
- saegw-dyn-up-success
- saegw-dyn-up-failure
- saegw-dyn-up-failure
- saegw-dyn-up-peer-not-found
- saegw-dyn-up-peer-not-found
- saegw-dyn-up-dns-timeout
- saegw-dyn-up-dns-timeout
- saegw-dyn-up-neg-resp
- saegw-dyn-up-neg-resp