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| Technical Specification |
| 3rd Generation Partnership Project;Technical Specification Group Services and System Aspects;5G System Enhancements for Edge Computing;Stage 2(Release 17) |
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# Foreword

This Technical Specification has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

Version x.y.z

where:

x the first digit:

1 presented to TSG for information;

2 presented to TSG for approval;

3 or greater indicates TSG approved document under change control.

y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

z the third digit is incremented when editorial only changes have been incorporated in the document.

In drafting the TS/TR, pay particular attention to the use of modal auxiliary verbs! TRs shall not contain any normative provisions.

In the present document, modal verbs have the following meanings:

**shall** indicates a mandatory requirement to do something

**shall not** indicates an interdiction (prohibition) to do something

The constructions "shall" and "shall not" are confined to the context of normative provisions, and do not appear in Technical Reports.

The constructions "must" and "must not" are not used as substitutes for "shall" and "shall not". Their use is avoided insofar as possible, and they are not used in a normative context except in a direct citation from an external, referenced, non-3GPP document, or so as to maintain continuity of style when extending or modifying the provisions of such a referenced document.

**should** indicates a recommendation to do something

**should not** indicates a recommendation not to do something

**may** indicates permission to do something

**need not** indicates permission not to do something

The construction "may not" is ambiguous and is not used in normative elements. The unambiguous constructions "might not" or "shall not" are used instead, depending upon the meaning intended.

**can** indicates that something is possible

**cannot** indicates that something is impossible

The constructions "can" and "cannot" are not substitutes for "may" and "need not".

**will** indicates that something is certain or expected to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document

**will not** indicates that something is certain or expected not to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document

**might** indicates a likelihood that something will happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

**might not** indicates a likelihood that something will not happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

In addition:

**is** (or any other verb in the indicative mood) indicates a statement of fact

**is not** (or any other negative verb in the indicative mood) indicates a statement of fact

The constructions "is" and "is not" do not indicate requirements.

# 1 Scope

The present document defines the Stage 2 specifications for enhancements of 5G System to support Edge Computing.

# 2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non‑specific.

- For a specific reference, subsequent revisions do not apply.

- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] 3GPP TS 23.501: "System architecture for the 5G System (5GS); Stage 2".

[3] 3GPP TS 23.502: "Procedures for the 5G System; Stage 2".

[4] 3GPP TS 23.503: "Policy and Charging Control Framework for the 5G System; Stage 2".

[5] 3GPP TS 23.558: "Architecture for enabling Edge Applications (EA)".

[6] IETF RFC 7871: "Client Subnet in DNS Queries".

[7] 3GPP TS 24.301: "Non-Access-Stratum (NAS) protocol for Evolved Packet System (EPS); Stage 3".

[8] 3GPP TS 24.526: "User Equipment (UE) policies for 5G System (5GS); Stage 3".

# 3 Definitions of terms, symbols and abbreviations

## 3.1 Terms

For the purposes of the present document, the terms given in TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in TR 21.905 [1].

**Edge Application Server:** An Application Server resident in the Edge Hosting Environment.

**Edge Hosting Environment:** An environment providing support required for Edge Application Server's execution.

**Local part of DN:** The set of network entities of a DN that are deployed locally. The local access to the DN provides access to the local part of DN.

## 3.2 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in TR 21.905 [1].

C-DNS Central DNS

C-NEF Central NEF

C-PSA UPF Central PSA UPF

EAS Edge Application Server

EASDF Edge Application Server Discovery Function

EHE Edge Hosting Environment

L-DN Local part of DN

L-DNS Local DNS

L-NEF Local NEF

L-PSA UPF Local PSA UPF

# 4 Reference Architecture and Connectivity Models

Editor's note: Bring assumptions, connectivity models and hosting models from the TR clause 4. Privacy considerations in TR clause 7.12. could also considered here.

## 4.1 General

Editor's note: This chapter refers to TS 23.501 [2], clause 5.13 for an overview of the 3GPP specified functions which are part of 5GC Support to Edge Computing.

Edge Computing enables operator and 3rd party services to be hosted close to the UE's access point of attachment, so as to achieve an efficient service delivery through the reduced end-to-end latency and load on the transport network.

5GS supports Edge Hosting Environment (EHE) deployed in the DN beyond the PSA UPF. An EHE may be under the control of either the operator or 3rd parties.

The Local part of the DN in which EHE is deployed may have user plane connectivity with both a centrally deployed PSA and locally deployed PSA of same DNN. Edge Computing Enablers as described in clause 5.13 of TS 23.501[2], e.g. Local Routing and Traffic Steering, Session and service continuity, AF influenced traffic routing, are leveraged in this specification.

NOTE: Edge Computing for Home Routed roaming scenario is not supported in this release of the specification.

Edge Computing for Local BreakOut roaming scenario is supported, but for AF Guidance to PCF Determination of URSP Rules, the VPLMN has no control on URSP, so cannot influence UE in selecting a specific Edge Computing related DNN and S-NSSAI.

## 4.2 Reference Architecture for Supporting Edge Computing

The reference architectures for supporting Edge Computing are based on the reference architectures specified in clause 4.2 of TS 23.501[2]. The following reference architectures are further depicting the relationship between the 5GS and EHE for non-roaming and LBO roaming scenarios.

Figure 4.2-1 depicts 5GS architecture for non-roaming scenario supporting Edge Computing with UL CL/BP.

NRF

PCF

AF

AMF

SMF

NEF

UE

AN

UPF

(UL CL/ BP)

UPF

(L-PSA)

UPF

(C-PSA)

Local part of DN

Central DN

EAS

Nnrf

Npcf

Namf

Nsmf

N1

N2

N3

N4

N4

N4

N9

N6

N6

EASDF

Naf

Nnef

Neasdf

UDM

Nudm

Figure 4.2-1: 5GS providing access to EAS with UL CL/BP for non-roaming scenario

Figure 4.2-2 depicts 5GS architecture for non-roaming scenario supporting Edge Computing without UL CL/BP.

NRF

PCF

AF

AMF

SMF

NEF

UE

AN

UPF

(PSA)

Local part of DN

EAS

Nnrf

Npcf

Namf

Nsmf

N1

N2

N3

N4

N6

EASDF

Naf

Nnef

Neasdf

UDM

Nudm

Figure 4.2-2: 5GS providing access to EAS without UL CL/BP for non-roaming scenario

Figure 4.2-3 depicts 5GS architecture for LBO roaming scenario supporting Edge Computing with UL CL/BP.

NRF

PCF

AF

AMF

SMF

NEF

UE

AN

UPF

(UL CL/ BP)

UPF

(L-PSA)

UPF

(C-PSA)

Local part of DN

Central DN

EAS

Nnrf

Npcf

Namf

Nsmf

N1

N2

N3

N4

N4

N4

N9

N6

N6

EASDF

Naf

Nnef

Neasdf

PCF

Npcf

UDM

Nudm

VPLMN

HPLMN

Figure 4.2-3: 5GS providing access to EAS with UL CL/BP for LBO roaming scenario

Figure 4.2-4 depicts 5GS architecture for LBO roaming scenario supporting Edge Computing without UL CL/BP.

NRF

PCF

AF

AMF

SMF

NEF

UE

AN

UPF

(PSA)

Local part of DN

EAS

Nnrf

Npcf

Namf

Nsmf

N1

N2

N3

N4

N6

EASDF

Naf

Nnef

Neasdf

PCF

Npcf

UDM

Nudm

VPLMN

HPLMN

Figure 4.2-4: 5GS providing access to EAS without UL CL/BP for LBO roaming scenario

NOTE 1: Only some of the 5GS NFs are shown in the above reference architecture figures. In the above figures, the split between the UPF acting as UL CL/BP and the UPF acting as local PSA is illustrative.

NOTE 2: Only the control plane of EASDF is depicted in the figure, the user plane between the EASDF and the UPF (i.e. over which the DNS messages are exchanged) is part of N6. Additionally, the EADSF may have direct connectivity with the local parts of one or more Data Networks.

## 4.3 Connectivity Models

5GC supports the following connectivity models to enable Edge Computing:

- Distributed Anchor Point: For a PDU session, the PSA UPF is in a local site, i.e. close to the UE location. The PSA UPF may be changed e.g. due to UE mobility and using SSC mode 2 or 3.

- Session Breakout: A PDU Session has a PSA UPF in a central site (C-PSA UPF) and one or more PSA UPF in the local site (L-PSA UPF). The C-PSA UPF provides the IP Anchor Point when UL Classifier is used. The Edge Computing application traffic is selectively diverted to the L-PSA UPF using UL Classifier or multi-homing Branching Point mechanisms. The L-PSA UPF may be changed due to e.g. UE mobility.

- Multiple PDU Sessions: Edge Computing applications use PDU Session(s) with a PSA UPF(s) in local site(s). The rest of applications use PDU Session(s) with PSA UPF(s) in the central site(s). Any PSA UPF may be changed due to e.g. UE mobility and using SSC mode 3 with multiple PDU Sessions.

URSP rules, for steering the mapping between UE applications and PDU Sessions, can be used for any connectivity model and they are required for the Multiple PDU Sessions model.

These three connectivity models are illustrated in Figure 4.3-1:



Figure 4.3-1: 5GC Connectivity Models for Edge Computing

# 5 Functional Description for Supporting Edge Computing

Editor's note: This clause also brings clarity in the high-level relation between the solutions described in this TS and solutions built on SA WG6 Architecture for Enabling Edge Applications.

## 5.1 EASDF

### 5.1.1 Functional Description

The Edge Application Server Discovery Function (EASDF) includes one or more of the following functionalities:

- Registering to NRF for EASDF discovery and selection.

- Handling the DNS messages according to the instruction from the SMF, including:

- Receiving DNS message handling rules from SMF

- Exchanging DNS messages from the UE

- Forwarding DNS messages to C-DNS or L-DNS for DNS query

- Adding ECS option into DNS query for an FQDN

- Notifying EASDF related information to SMF

- Terminates the DNS security, if DoT, DoH or DNS over DTLS is used.

The EASDF has user plane connectivity with the PSA UPF over N6 for the transmission of DNS signalling exchanged with the UE.

Multiple EASDF instances may be deployed within a PLMN.

The interactions between 5GC NF(s) and the EASDF take place within a PLMN.

### 5.1.2 EASDF Discovery and Selection

The EASDF discovery and selection is defined in clause 6.3 in TS 23.501 [2].

# 6 Procedures for Supporting Edge Computing

## 6.1 General

Editor's note: Any requirements on the applications and solution limitations are documented. For the detailed procedures for the management of the connectivity and run-time coordination with the application layer this clause refers to TS 23.502 [3] and to TS 23.503 [4] for the details on the Policy and Charging Control aspects.

## 6.2 EAS Discovery and Re-discovery

### 6.2.1 General

Editor's note: This clause describes general parts including e.g. privacy considerations, which DNS properties that are enabling DNS based Edge AS Discovery, recommendations/limitations for cases that OS/user overrides DNS setting.

In Edge Computing deployment, an application service may be served by multiple Edge Application Servers typically deployed in different sites. These multiple Edge Application Servers that host service may use a single IP address (anycast address) or different IP addresses. To start an Edge Application Service, the UE needs to know the IP address(es) of the Application Server(s) serving the Service. The UE may do a discovery to get the IP address(es) of a suitable Edge Application Server (e.g. the closest one), so that the traffic can be locally routed to the Edge Application Server, and service latency, traffic routing path and user service experience can be optimized.

EAS Discovery is the procedure by which a UE discovers the IP address(es) of a suitable Edge Application Server(s) using Domain Name System (DNS). EAS Re-discovery is the EAS Discovery procedure that takes place when the previously discovered Edge Application Server cannot be used or may have become non-optimal (e.g. at edge relocation).

NOTE 1: This specification describes the discovery procedure based on 5GS NFs as to ensure the UE is served by the application service closest to the UE’s point of attachment. However, this does not exclude other upper layer solution that can be adopted by operator or service provider, like the EAS Discovery procedure defined in TS 23.558 [5], or other alternatives shown in Annex A and Annex B. How those other solutions work, or whether they are able to guarantee the closest application service for the UE, is out of the scope of this specification.

In order to provide a translation of the FQDN of an EAS into the address of an EAS as topologically close as possible to the UE, the Domain Name System may use following information:

- The source IP address of the incoming DNS Query, and/or,

- a EDNS Client Subnet (ECS) option (as defined in RFC 7871 [6]).

NOTE 2: UE IP address can be subject to privacy restrictions, which means that it is not to be sent to Authoritative DNS / DNS Resolvers outside the network operator within ECS option or as Source IP address of the DNS Query. UE source IP address can be protected by using NAT mechanism.

If the UE applications want to discover/access EAS by using the mechanisms defined in this TS, the DNS queries generated by the UE shall be sent to the EASDF as DNS resolver indicated by the SMF.

### 6.2.2 EAS (Re-)discovery over Distributed Anchor Connectivity Model

#### 6.2.2.1 General

#### 6.2.2.2 EAS Discovery Procedure

Editor's note: This clause describes the procedure for Edge AS Discovery over Distributed Anchor connectivity model according to the recommendations in the conclusions in the TR clause 9.1.2 (selected parts from Sol 2/4/5/10).

In order to provide a translation of the FQDN of an EAS into the address of an EAS as close as possible to the UE (where closeness relates to IP forwarding distance), the DNS system uses mechanisms described in clause 6.2.1.

For Distributed Anchor Point connectivity model, in order to provide addressing information to the DNS system that is related to the UE topological location, when a DNS request is sent via the Local PSA UPF,

- either the DNS request is resolved by a DNS resolver, which then adds a DNS ECS option that may be built based on a locally pre-configured value or based on the source IP address of the DNS request; then send the DNS Query to the Authoritative DNS server, which may take into account the DNS ECS option, or

- the DNS request is resolved by a DNS server that is close to the PSA UPF: the Authoritative DNS server may take into account the source IP address of the DNS query.

#### 6.2.2.3 EAS Re-discovery Procedure at Edge Relocation

Editor's note: This clause also describes rediscovery (UE based), and aspects and assumptions based on applicable clause 9.2.2 in the TR.

In order to change the PDU Session Anchor serving a PDU Session of SSC mode 2/3 for a UE, SMF triggers session continuity, service continuity and UP path management procedures as indicated in clause 4.3.5.1 and 4.3.5.2 of TS 23.502[3]. During this procedure, for SSC mode 2/3, it is recommended that the UE applies the following behaviour:

The UE DNS cache should be bound to the IP connection. When the UE detects the PDU Session release or IP address changes, the UE removes the old DNS cache related to removed IP address, for example, the old Edge Application Server address information.

NOTE: UE DNS cache refers to cache at any level (OS and Application). Whether the DNS cache of App is included or influenced depends on application’s behaviour and UE implementation.

With this behaviour, when the establishment of a new PDU Session triggers EAS rediscovery for an application, UE can reselect a new EAS for that application.

For SSC#2, the procedure in clause 4.3.5.1 applies with following differences:

- In Step 3, when the new PDU Session has been established, UE can reselect a new EAS for the application with an EAS Rediscovery procedure if the recommended UE behaviour has been followed.

For SSC#3, the procedure in clause 4.3.5.2 applies with following difference:

- In step 5, the UE can reselect a new EAS for the application with an EAS Rediscovery procedure if the recommended UE behaviour has been followed.

Editor’ Note: the scenario of Change of SSC mode 3 PDU Session Anchor with IPv6 Multi-homed PDU Session as in clause 4.3.5.3 is FFS.

#### 6.2.2.4 Procedure for EAS Discovery with Dynamic PSA Distribution

5GC supports an EAS Discovery procedure that allows that at PDU session establishment the SMF selects a central PSA, regardless if a local PSA is available to the SMF, and then, it allows to dynamically re-anchor the PDU Session and transition to a Distributed Anchor Point model when needed. This is applicable to PDU Sessions type SSC#2.

Editor's note: Whether and how the dynamic re-anchoring is applicable to PDU Sessions type SSC mode 3 is FFS.

This procedure relies on EASDF capability to influence the DNS Query of an Edge Application so that the EAS Discovery considers a candidate UE topological location of a PSA further out in the network than current PSA. The PDU Session re-anchoring to the edge is performed as part of the EAS Discovery procedure.

This procedure requires that the DNS settings provided to the UE for the PDU Session are respected.



Figure 6.2.2.4-1 Application Server Discovery with Dynamic PSA distribution using EASDF

The EAS Discovery procedure with Dynamic PSA distribution using EASDF is described in Figure 6.2.2.4.-1.

The procedure is as follows:

1. PDU session establishment, allocation of an EASDF and sending rules to the EASDF. Steps 1-14 in the procedure 6.2.3.2.2-1 for EAS Discovery Procedure with EASDF for Session breakout Connectivity are applied. If Dynamic PSA distribution applies to the PDU Session, the SMF may have selected a central PSA at PDU session establishment, regardless of whether a local PSA is available:

Editor’s Note: whether step 14 is the correct step is FFS, depending on the progress for procedure in clause 6.2.3.2.2.

 The UE sends a DNS Query message for an FQDN to the EASDF via central PSA. The EASDF checks the DNS Query against the DNS handling Rules in the DNS Context and reports to SMF and/or forwards to DNS for resolution as instructed by these rules. For resolution, it applies Option A or option B in the procedure 6.2.3.2.2-1 or sends the DNS query to a pre-configured DNS server/resolver if none of them applies. When the DNS Response is received, EASDF checks it against the DNS context matching conditions for reporting. If applicable, it reports to SMF the selected EAS and handles the DNS response as instructed by SMF DNS handling rules.

 When no DNS response is sent to the UE, the UE is expected to restart the DNS request over the new PDU Session).

For further details see clause 6.2.3.2.2.

2. SMF determines that the central UPF (PSA) needs to be changed to an Edge UPF (L-PSA), and it triggers one of the procedures to change the PSA of the PDU Session to a distributed anchor:

- Change of SSC mode 2 PDU Session Anchor with different PDU Sessions as in clause 4.3.5.1 of TS 23.502 [3]. The procedure applies with the following differences:

 In step 2, the DNS context for the session is removed from EASDF as part of the PDU Session Release procedure (in step 12 of the PDU Session release procedure in TS 23.502 [3] in 4.3.4.2).

 In step 3, SMF selects and provisions the DNS settings for the new PDU session as required by the procedure for EAS Discovery on Distributed anchor as described in clause 6.2.2.2.

NOTE 1: When new DNS settings do not involve EASDF, new DNS Query will not trigger re-anchoring of the PDU Session to a L-PSA deployed even further out in the network.

Editor’s Note: whether EASDF can be used as DNS resolver for a PDU Session with Distributed anchor connectivity model is FFS.

To remove the Session context in EASDF, SMF invokes Neasdf\_DNSContext\_Delete Request/Response.

NOTE 2: Dynamic re-anchoring to an edge PSA implies that the UE IP address is changed from a UE IP address corresponding to the old (central) PSA to a UE IP address corresponding to the new (edge) PSA for all applications on the PDU session.

NOTE 3: Further re-anchoring (to a central UPF) can be triggered if activity is monitored e.g. if EC application traffic ceases. In that case, EASDF is provided again in the DNS settings for the PDU Session. New EAS Discovery will go to EASDF and be handled as described in Step 1.

3. A new (re)discovery procedure is triggered for the application over the new PSA. (Re)discovery follows the EAS (re)Discovery procedure for distributed anchor connectivity model as in clauses 6.2.2.2. and 6.2.2.3.

4. Application traffic starts via the PDU Session Edge PSA to the EAS selected in Step 4.

### 6.2.3 EAS (Re-)discovery over Session Breakout Connectivity Model

#### 6.2.3.1 General

This clause describes the EAS discovery and re-discovery procedures for PDU Session with Session Breakout connectivity model.

Editor's note: The following C-DNS/L-DNS description will be moved to other more generic clause in future meeting since it applies to all connectivity models.

Central DNS (C-DNS) server is centrally deployed by MNO or 3rd party and is responsible for resolving the UE DNS queries into suitable Edge Application Server (EAS) IP address(es).

Local DNS (L-DNS) resolvers/servers may be locally deployed by MNO or 3rd parties within the Local DN, and is responsible for resolving UE DNS queries into suitable EAS IP address(es) within the local DN. The L-DNS resolvers/servers may or may not have connectivity with C-DNS depending on the deployment.

NOTE 1: The C-DNS server and/or L-DNS resolvers/servers can use an anycast address.

NOTE 2: The C-DNS server or L-DNS resolvers/servers can contact any other DNS servers for recursive queries, which is out of scope of this specification.

Editor's note: The following Session Break Out model descriptions will be moved to other more generic clause in future.

The following Session breakout models are defined:

- Dynamic Session Breakout: ULCL/BP/Local PSA (and their associated traffic filters and forwarding rules) are inserted based on DNS Response provided by the EASDF.

- Pre-established Session Breakout: ULCL/BP/Local PSA (and their associated traffic filters and forwarding rules) are inserted without dependency on the UE sending out DNS queries or data traffic. They are typically inserted based on local configuration or per AF request.

#### 6.2.3.2 EAS Discovery Procedure

Editor's note: This clause describes the procedure for Edge AS Discovery over Session Breakout connectivity model according to the recommendations in the conclusions in the TR clause 9.1.4.

##### 6.2.3.2.1 General

For PDU Session with Session Breakout connectivity model, based on UE subscription (e.g. DNN) and/or the operator's configuration, the DNS Query sent by UE may be handled by an EASDF (see clause 6.2.3.2.2), or by a local or central DNS resolver/server (see clause 6.2.3.2.3).

##### 6.2.3.2.2 EAS Discovery Procedure with EASDF

For the case that the UE DNS Query is to be handled by EASDF, the following applies.

- The AF may provide EAS deployment information to UDR, including the list of FQDNs supported by applications for each DNAI, the IP address range(s) corresponding to each DNAI, and the DNS server identifier (consisting of IP address and port) for each DNAI, as defined in clause 5.6.7 of TS 23.501[2]. The AF may update the information as described in clause 4.3.6.2 of TS 23.502[3].

- During the PDU Session establishment procedure, the SMF gets the EAS deployment information via the PDU Session related policy information from PCF or the SMF is preconfigure with the EAS deployment information the, and the SMF selects an EASDF and provides its address to the UE as the DNS Server to be used for the PDU Session. The UE sends DNS Query to the EASDF. The SMF may configure the EASDF with DNS message handling rules to forward DNS messages of the UE to a relevant DNS server and/or report when detecting DNS messages. The DNS message handling rule includes information used for DNS message detection and associated action(s). It is defined as following:

- Precedence of the DNS message handling rule

- DNS message detection template (includes at least one of the following):

- DNS message type = DNS Query or DNS Response

- If DNS message type = DNS Query

 - Source IP address (i.e. UE IP address)

 - Array of (FQDN ranges)

- If DNS message type = DNS Response

 - Array of FQDN ranges and/or array of EAS IP address ranges

NOTE 1: For DNS message type = Query, the UE IP address provided at DNS context creation is considered if not provided explicitly as part of the template.

- Action(s) (includes at least one action) the possible actions include:

- Report DNS message content to SMF

- Send the DNS message to a preconfigured DNS server/resolver or an indicated DNS server as following (The indicated DNS server is included in the DNS handling rule):

- Including the information to build optional ECS option in the DNS message (The information for the EASDF to build the ECS option is included in the DNS handling rule)

Editor’s Notes: It is FFS whether the information for the EASDF to build the ECS option may contain more than one IP address to deal with following cases: 1) some EAS may be deployed on the part of the DN with public IP addressing space while other EAS may be deployed on the part of the DN with private IP addressing space, 2) there may be multiple candidate L-PSA (+ULCL) UPF: for example some expensive L-PSA at the DU site related with fairly specific applications that are demanding in terms of delays and some more vanilla L-PSA + ULCL UPF that can provide traffic offload but that are more central and cheaper due to a better pooling effect in a more central location, 3) there may be multiple L-PSA UPFs: for example some applications are supposed to be accessed via one DNAI with one L-PSA UPF and the other applications are supposed to be accessed via another DNAI with another L-PSA UPF.

- Replacement of the DNS message target address with the indicated DNS Server Address; if no DNS Server Address is provided by the SMF, then the EASDF is to forward the DNS message to a locally preconfigured DNS server/resolver.

- Buffer the DNS message and report DNS message content to the SMF

- Send the buffered DNS response message to UE.

When the EASDF forwards a DNS request, it shall always ensure it receives the DNS answer (putting its own address as the source of the request)

The SMF may use following information to create DNS message handling rules associated with a PDU session:

- Local configuration associated with the (DNN, S-NSSAI) of the PDU Session, and/or

- EAS deployment information provided by the AF, and/or

- Information derived from the UE location such as candidate L-PSA (s).

- PDU Session information, like PDU Session L-PSA(s) and ULCL/BP

NOTE 2: For example, the SMF can derive the IP address for ECS based on the N6 IP address(es) associated with serving L-PSA(s) locally configured or in the NRF.

NOTE 3: Providing in DNS ECS option an IP address associated with the L-PSA UPF protects the privacy of the (IP address of the) UE.

- If the FQDN in a DNS Query matches the FQDN(s) provided by the SMF, based on instructions by SMF, one of the following options is executed by the EASDF:

- Option A: The EASDF includes the EDNS Client Subnet (ECS) option into the DNS Query message as defined in RFC 7871[6], and sends the DNS Query message to the DNS server for resolving the FQDN. The DNS server may resolve the EAS IP address considering the ECS option, and sends the DNS Response to the EASDF.

- Option B: The EASDF sends the DNS Query message to a Local DNS server which is responsible for resolving the FQDN within the corresponding Local DN. The EASDF receives the DNS Response message from the Local DNS server.

NOTE 4: Option B does not support the scenario where the EASDF has no direct connectivity with the local DNS servers.

 The SMF instructions for a matching FQDN may as well indicate EASDF to contact SMF. SMF then provides the EASDF with a DNS message handling rule.

- If the DNS Query from the UE does not match a DNS message handling rules set by the SMF, then the EASDF may simply forward the DNS Query towards a preconfigured DNS server/resolver for DNS resolution.

- When the EASDF receives a DNS Response message, the EASDF may notify the EAS information (i.e. EAS IP address(es), optionally the EAS FQDN and optionally the corresponding IP address within the ECS DNS option) to the SMF if the DNS message reporting condition (i.e. the EAS IP address or FQDN is within the IP/FQDN range) provided by the SMF is met. The SMF may then trigger UL CL/BP and L-PSA insertion as specified in clause 6.3.3 in TS 23.501 [2] based on the Notification.

 The information to build the ECS option or the Local DNS server address provided by the SMF to the EASDF are part of the DNS message handling rules to handle DNS queries from the UE. This information is related to DNAI(s) for that FQDN(s) for the UE location. The SMF may provide DNS message handling rules to handle DNS queries from the UE to the EASDF when the SMF establishes the association with the EASDF for the UE, and may update the rules at any time when the association exists. For the selection of the candidate DNAI for an FQDN for the UE, the SMF may consider the UE location, network topology and information of EAS deployment information received as part of PDU Session related policy information for the PDU Session while it is provided/modified/deleted as defined in TS 23.503 [4] clause 6.4 or be preconfigured into the SMF. The DNS configuration information is provisioned by the AF via the procedure of AF influence on traffic routing as defined in in clause 5.6.7.1 of TS 23.501 [2] and in clause 4.3.6.2 of TS 23.502 [3].. After the UE mobility, if the provided Information for ECS option or the Local DNS server address needs be updated, the SMF may send an update to DNS message forwarding rules to the EASDF.

Editor's note: The sentence above means that the EASDF gets the FQDN(s) from SMF. How the SMF getting the ECS option needs to be clarified.

Once the UL CL/BP and L-PSA have been inserted, the SMF may decide that the DNS messages for the FQDN are to be handled by local DNS resolver/server from now on. This option is further described in clause 6.2.3.2.3.



Figure 6.2.3.2.2-1: EAS discovery procedure with EASDF

1. UE sends PDU Session Establishment Request to the SMF as shown in step 1 of clause 4.3.2.2.1 of TS 23.502 [3].

2. During the PDU Session Establishment procedure, the SMF selects EASDF as described clause 6.3 of TS 23.501 [2]. The SMF includes the IP address of the EASDF as DNS server in PDU Session Establishment Accept message as in step 11 of clause 4.3.2.2.1 of TS 23.502 [3]. The UE configures the EASDF as DNS server for that PDU Session.

3. The SMF invokes Neasdf\_DNSContext\_Create Request (UE IP address, DNN, callback URI, DNS message handling rules) to the selected EASDF.

 This step is performed before step 11 of PDU Session Establishment procedure in clause 4.3.2.2.1 of TS 23.502 [3].

 The EASDF creates a DNS context for the PDU Session, and stores the UE IP address, the callback URI and DNS message handling rule(s) into the context.

 The EASDF is provisioned with the DNS message handling rule(s), before the DNS Query message is received at the EASDF or as a consequence of the DNS Query reporting.

4. The EASDF invokes the service operation Neasdf\_DNSContext\_Create Response.

Editor's note: How to guarantee that the UE uses the EASDF's IP address for the subsequent DSN Query in step 8 is FFS.

5. The SMF may invoke Neasdf\_DNSContext\_Update Request (EASDF Context ID, DNS message handling rules) to EASDF. The update may be triggered by UE mobility, e.g. when UE moves to a new location, or by a reporting by EASDF of a DNS Query with certain FQDN, or, the update may be triggered by insertion/removal of Local PSA, e.g. to update rules to handle DNS messages from the UE or by new PCC rule information.

6. The EASDF responds with Neasdf\_DNSContext\_Update Response.

7. The UE sends DNS Query message to the EASDF.

8. If the DNS Query message matches a DNS message handling rule for reporting, the EASDF sends the DNS message report to SMF by invoking Neasdf\_DNSContext\_Notify Request.

9. The SMF responds with Neasdf\_DNSContext\_Notify Response.

10.

Editor's note: It is FFS whether UL CL / BP insertion should be mentioned at this step.

11. If DNS message handling rule for the FQDN received in the report need to be updated, e.g. provide updates to information to build the ECS option information, the SMF invokes Neasdf\_DNSContext\_Update Request (DNS message handling rules) to EASDF.

 For Option A, the DNS handling rule includes corresponding IP address to be used to build the ECS option. For Option B, the DNS handling rule includes corresponding local DNS Server IP address. The EASDF may as well be instructed by the DNS handling rule to simply forward the DNS Query to a pre-configured DNS server/resolver.

12. The EASDF responds with Neasdf\_DNSContext\_Update Response.

13. The EASDF handles the DNS Query message received from the UE as the following:

- For Option A, the EASDF adds the ECS option into the DNS Query message as specified in RFC 7871[6] and sends it to C-DNS server;

- For Option B, the EASDF sends the DNS Query message to the Local DNS server.

 If no DNS message detection template within the DNS message handling rule provided by the SMF matches the requested FQDN in the DNS Query, the EASDF may simply send a DNS Query to a pre-configured DNS server/resolver.

14. EASDF receives DNS Responses from the DNS system and determines that a DNS Response can be sent to the UE.

15. The EASDF may send an DNS message reporting to the SMF by invoking Neasdf\_DNSContext\_Notify request including EAS information if the EAS IP address or the FQDN in the DNS Response message matches the reporting condition provided by the SMF. The DNS message reporting may contain multiple EAS IP address if the EASDF has received multiple EAS IP address(es) from the DNS servers it has contacted.

 Per the received DNS message handling rule, the EASDF does not send the DNS Response message to the UE but waits for SMF instructions (in step 18) , i.e. buffering the DNS Response message.

16. The SMF invokes Neasdf\_DNSContext\_Notify Response service operation.

17. The SMF may perform UL CL/BP and Local PSA selection and insert UL CL/BP and Local PSA.

 Based on received EAS information received from the EASDF and other UPF selection criteria, as specified in clause 6.3.3 in TS 23.501 [2], the SMF may determine the DNAI and determine the associated N6 traffic routing information for the DNAI. The SMF may perform UL CL/BP and Local PSA selection and insertion as described in TS 23.502 [3].

18. The SMF invokes Neasdf\_DNSContext\_Update Request (DNS message handling rules).

 The DNS message handling rule indicates the EASDF to send a DNS Response buffered in Step 15 to UE.

19. The EASDF responds with Neasdf\_DNSContext\_Update Response.

20. The EASDF sends the DNS Response to UE.

##### 6.2.3.2.3 EAS Discovery Procedure with Local DNS Server/Resolver

For the case that the DNS message is to be handled by local DNS resolver/server, the DNS Query is routed to the local DNS resolver/server corresponding to the DNAI where the L-PSA connects. The SMF is provisioned with the local DNS server address based on configuration or based on AF request as specified in clause 6.2.3.2.2. Based on the operator's configuration, one of the following options may apply when UL CL/BP and Local PSA have been inserted (during or after PDU Session Establishment):

- Option C: The SMF chooses a local DNS server based on the DNAI corresponding to UE location and Local DNS server deployment, and configures it to the UE as new DNS server. In addition, the SMF also configures traffic routing rule on the UL CL (including e.g. Local DNS server address) or the BP (e.g. the new IP prefix @ Local PSA) to route traffic destined to the local DN including the DNS Query messages to the L-PSA. The local DNS server resolves the DNS Query either locally or recursively by communicating with other DNS servers.

- Option D: If the SMF has been configured that DNS Queries for an FQDN (range) query can be locally routed on the UL CL, then the subsequent DNS queries for the FQDN (range) will be locally routed to a Local DNS server.

NOTE: Option D assumes that ULCL steering is based on L4 information (i.e. DNS port number) and that ULCL has visibility of the DNS traffic (i.e. FQDN in the DNS Query message). The UPF may be instructed by the SMF to apply different forwarding of non-ciphered UL DNS traffic based on the target domain of the DNS Query. Option D requests modification of destination IP address of DNS messages. Whether this is allowed or not is subject to local regulations. Option D does not apply to DoH or DoT messages.



Figure 6.2.3.2.3-1: EAS discovery with local DNS server/resolver

1. The SMF inserts UL CL/BP and Local PSA.

 UL CL/BP/Local PSA insertion can be triggered by DNS messages as described in clause 6.2.3.2.2. Or, the SMF may pre-establish the UL CL/BP and Local PSA before the UE sends out any DNS Query message (e.g. upon UE mobility). In this case, the SMF includes the IP address of Local DNS Server in PDU Session Establishment Accept message as in step 11 of clause 4.3.2.2.1 of TS 23.502[3] or in a network initiated PDU Session Modification procedure. The UE configures the Local DNS Server as DNS server for that PDU Session.

 The UL CL/BP and Local PSA are inserted or changed as described in TS 23.502 [3]. In the case of IPv6 multi-homing, the SMF may also send an IPv6 multi-homed routing rule along with the IPv6 prefix to the UE to influence the selection of the source Prefix for the subsequent DNS queries as described in TS 23.501 [2] clause 5.8.2.2.2.

 When the UL CL/BP and Local PSA are inserted or simultaneously changed, the SMF configure the UL CL/BP for DNS Query handling:

- For Option C, the SMF configures traffic routing rule on the UL CL (including e.g. Local DNS server address) or the BP (e.g. the new IP prefix @ Local PSA) to forward UE packets destined to the local DN to the Local PSA. The packets destined to local DN includes DNS Query messages destined to local DNS Server.

Steps 2 and 3 are performed for option C:

2. If the UL CL/BP and Local PSA are inserted after PDU Session Establishment, the SMF sends PDU Session Modification Command (Local DNS Server Address) to UE.

 If, based on operator's policy or UE’s mobility, the Local DNS Server IP Address in the local Data Network needs to be notified or updated to UE, the SMF sends PDU Session Modification Command (Local DNS Server Address) to UE.

3. The UE responds with PDU Session Modification Complete.

 The UE configures the Local DNS Server as the DNS server for the PDU Session. The UE sends the following DNS Queries to the indicated Local DNS Server.

NOTE 1: The UE does not need to know that the new DNS server is “local”.

4. UE sends a DNS Query message. In the case of IPv6 multi-homing the UE selects the source IP prefix based on the IPv6 multi-homed routing rule provided by SMF.

5. The DNS Query message is forwarded to the local DNS Server and handled as described in following:

- For Option C, the target address of the DNS Query is the IP address of the Local DNS Server. The DNS Query is forwarded to the Local DNS Server by UL CL/BP and Local PSA. The Local DNS Server resolves the FQDN of the DNS query by itself or communicates with other DNS server to recursively resolve the EAS IP address.

- For Option D: The Local PSA sends the DNS traffic to the Local DNS Server that resolves the FQDN target of the DNS query by itself or that communicates with a C-DNS server to recursively resolve the EAS IP address.

NOTE 2: The Local PSA can send the DNS traffic to the Local DNS Server via tunnelling or via IP address replacement. If IP address replacement is used, the SMF instructs the Local PSA to modify the packet's destination IP address (corresponding to EASDF) to that of the target DNS.

6. The Local PSA receives DNS Response message from local DNS server, it forwards it to the UL CL/BP, and the UL CL/BP forwards the DNS Response message to UE.

NOTE 3: If IP address replacement has been enforced at step 5, the Local PSA replaces the source IP address to EASDF IP according to SMF instruction.

If SMF decides to remove the UL CL/BP and Local PSA as defined in TS 23.502[3] clause 4.3.5.5, e.g. due to UE mobility, the SMF sends a PDU Session Modification Command to configure the new address of the DNS server on UE (e.g. to set it to the address of EASDF).

#### 6.2.3.3 EAS Re-discovery Procedure at Edge Relocation

The support for EAS rediscovery indication procedure enables the UE to refresh the cached EAS information. So that the UE can trigger EAS discovery procedure to discover new EAS information.

For PDU Session with Session Breakout connectivity, if the UE indicates its support for this capability to the SMF during the PDU Session Establishment, the SMF may indicate to the UE EAS rediscovery, with optional impact field the UE may need to re-discover the EAS after the insertion/change/removal of an L-PSA based on AF influence or its local configuration using the PDU Session Modification Update.

This procedure is used by the SMF to trigger the EAS rediscovery procedure when a new connection to EAS need to be established. It applies to both Session Breakout using ULCL and Session Breakout using BP.

 

Figure 6.2.3.3-1: EAS re-discovery procedure at Edge relocation

During a previous EAS Discovery procedure on this PDU Session the UE may have cached EAS information (i.e. EAS IP address corresponding to an EAS FQDN) locally, e.g. during the previous connection with the EAS (for more information see Annex C UE considerations for EAS (re)discovery).

1a. Due to the UE mobility the SMF triggers L-PSA insertion, change or removal for the PDU Session. The insertion, change or removal of L-PSA triggers EAS rediscovery.

1b. The AF triggers EAS relocation e.g. due to EAS load balance or maintenance, etc., and informs the SMF the related information as described in clause 4.3.6 AF influence on traffic routing procedure in TS 23.502 [3].

2. This step may be performed as part of step 1a/1b. The SMF performs the network requested PDU Session Modification procedure from the step 3b-11b as defined in clause 4.3.3.2 TS 23.502 [3].

 If the UE has indicated that it supports to refresh old EAS information corresponding to the impact field per the EAS rediscovery indication from network, the SMF may send the impact field with the EAS rediscovery indication. SMF determines the impacted EAS(s) which need be rediscovered as the following:

- If an L-PSA is inserted/relocated/removed, the SMF determines the impacted EAS, which is associated with the local DN to be inserted, relocated or removed and identified by FQDN(s) or IP address range(s) of the old EAS, based on the association between FQDN(s)/IP address range(s) and DNAI received from AF via AF influenced traffic steering enforcement control information in the PCC rules or SMF local configuration on the local DN.

- For AF triggered EAS rediscovery, the AF may indicate the EAS rediscovery for the impacted applications, which are identified by FQDN(s), to the SMF via the AF influence on traffic routing procedure.

 The SMF sends PDU Session Modification Command (EAS rediscovery indication, [impact field]) to UE. The EAS rediscovery indication indicates to refresh the cached EAS information. The impact field is used to identify which EAS(s) information need to be refreshed. The impact field includes the local DN information corresponding to the impacted EAS(s), which are identified by FQDN(s) or IP address range(s) of the old EAS(s). If the impact field is not included, it means all EAS(s) information associated with this PDU Session need to be refreshed.

 The SMF may choose new DNS settings for the PDU Session and if so, it provides them to the UE as new DNS server (see Option C in clause 6.2.3.2.3). Otherwise the UE uses the existing DNS server for EAS rediscovery.

 For the following connection with the EAS(s) for which the EAS rediscovery needs be executed per the received EAS rediscovery indication and impact field, the UE has been instructed not to use the old EAS information stored locally. Instead it should trigger EAS discovery procedure to get new EAS information as defined in clause 6.2.3.2.

NOTE 1: It is conditioned to the UE implementation that the indication and impact field trigger an EAS Rediscovery procedure for the application. If the EAS rediscovery indication is not sent to the UE Application Layer, then DNS query to discover a new EAS is triggered only when then Application Layer DNS cache expires. For more information see Annex C.

NOTE 2: The active connection(s) between the UE and the EAS(s) are not impacted.

### 6.2.4 Support of AF Guidance to PCF Determination of Proper URSP Rules

This clause describes how an Edge Computing related AF may send guidance to PCF determination of proper URSP rules to send to the UE.

NOTE 1: This clause can apply in all deployment models.

An AF related with Edge computing may need to guide PCF determination of proper URSP rules. The guidance sent by the AF may apply to any UE or to a set of UE(s) e.g. identified by a Group Id. The AF may belong to the operator or to a third party.

NOTE 2: Some examples of the delivery of such AF guidance are shown in Annex D.

An AF may deliver such guidance to the PCF via application guidance for URSP determination mechanisms defined in TS 23.502 [3] clause 4.15.6.x. This mechanism is defined only to deliver the guidance to a PCF of the HPLMN of the UE.

The usage of such guidance for URSP generation is defined in TS 23.503 [4] clause 6.6.2.2.

The PCF may use the different guidance received from different AFs and local operator policy to determine the URSP to send to a UE as below:

- Application traffic descriptor and traffic matching priority from the application guidance are used to set the URSP Traffic Descriptor (e.g. Destination FQDNs or a regular expression in the Domain descriptor) and determine the URSP precedence in the URSP rule (defined in Table 6.6.2.1-2);

NOTE 3: when multiple Edge Computing specific parameters for the same application are received, the PCF decides the traffic matching priority Rule precedence value of the URSP rule (defined in Table 6.6.2.1-2).

- Each Route selection parameter from the application guidance is used to set a Route Selection Descriptor as follows:

- DNN and S-NSSAI from the Route selection parameter from the application guidance are used to set the DNN selection, Network Slice selection components in the Route Selection Descriptor of the URSP rule, respectively (defined in Table 6.6.2.1-3);

- Route selection precedence from the application guidance is used to set the Route Selection Descriptor Precedence in the Route Selection Descriptor (defined in Table 6.6.2.1-3);

- The spatial validity condition for the Route selection precedence from the application guidance if any are used to set the Location Criteria in the Route Selection Descriptor of the URSP rule (defined in Table 6.6.2.1-3).

NOTE 4: Since the Validation Criteria are not required to be checked during the lifetime of the PDU Session, it may be left to UE implementation (e.g. URSP re-evaluation at mobility change) how well spatial validity conditions in URSPs restrict the access to a specific (DNN, S-NSSAI) to certain locations.

## 6.3 Edge Relocation

### 6.3.1 General

Edge Relocation refers to the procedures supporting EAS changes and/or PSA UPF relocation.

Edge Relocation may be triggered by an AF request (e.g. due to the load balance between EAS instances in the EHE) or by the network (e.g. due to the UE mobility).

With Edge Relocation, the user plane path may be re-configured to keep it optimized. This may be done by PDU Session re-establishment using SSC mode 2/3 mechanisms or Local PSA UPF relocation using UL CL and BP mechanisms. The corresponding procedures are defined in TS 23.501 [2] and TS 23.502 [3].

Due to Edge Relocation, the UE may need to re-discover a new EAS and establish the connectivity to the new EAS to continue the service. The re-discovery of EAS is specified in clause 6.2.

Edge Relocation may result in AF relocation, for example, as part of initial PDU session establishment, a central AF may be involved, however, due to Edge relocation another AF serving the Edge Applications is selected.

The trigger of Edge relocation by the network is specified in clause 4.3.6.3 of TS 23.502 [3]. Some DNS Discovery procedures in clause 6.2. may also trigger Edge Relocation by the network.

This clause further describes the following procedures:

- Edge Relocation triggered by AF

- Edge Relocation using EAS IP replacement

- Simultaneous connectivity for Source and Target EASs

- Packet buffering for low Packet Loss

- Edge relocation considering User Plane Latency Requirements.

Annex F describes example procedure for EAS relocation on Release 16 capabilities.

### 6.3.2 Edge Relocation with Multiple AFs

Editor's note: This clause refers to TS 23.502 [3] for procedures addressing the multiple AF scenario (e.g. central and distributed AFs for EC) like AF relocation at Edge relocation proposed in clause 9.2.6, and AF provide DNAI and target N6 info to the SMF as concluded in 9.2.3 in TR.

This clause is related to scenarios that distributed EASs deployed at the Edge Data Network and a central AS are relocated and triggered by AF, which also implies AF relocation.

Application Function influence on traffic routing mechanism as described in of TS 23.501 [2] clause 5.6.7 can be applied for multiple AF scenarios. Source AF or target AF to deliver the relocation related information, including target AF ID and notification target address of target AF based on the mechanisms defined in TS 23.502 [3] clause 4.3.6.2 by invoking the Nnef\_TrafficInfluence\_Create or Nnef\_TrafficInfluence\_Update service operation in Step 1.

### 6.3.3 Edge Relocation Using EAS IP Replacement

EAS IP replacement enables the Local PSA UPF to replace the source/old Target EAS IP address and port number with the target/new target EAS IP address and port number for the Destination IP address and Destination Port number field of the uplink traffic and replace the target/new target EAS IP address and port number with the source/old Target EAS IP address and port number for the Source IP address and Source Port number field of the downlink traffic based on the enhanced AF Influence information for EAS IP replacement (i.e. Indication of Enabling EAS IP Replacement, source EAS IP address and port number, target EAS IP address and port number). The source AS IP address and port number are the destination IP address and port number of the uplink traffic, generated by UE, for a service subject to Edge Computing. The source EAS IP address is the one discovered by UE for a service subject to Edge Computing.

EAS IP replacement requires support of TCP/TLS/QUIC context transfer between EASs.

NOTE 1: The feasibility of this requirement, i.e. TCP/TLS/QUIC context transfer between EASs, is unclear and whether third party platforms would support this TCP/TLS/QUIC context transfer between EASs is unknown/not clear.

#### 6.3.3.1 EAS IP Replacement Procedures

##### 6.3.3.1.1 Enabling EAS IP Replacement Procedure by AF

UE

SMF

Remote

PSA

Local

PSA

PCF

NEF

AF

Target

EAS

Source

EAS

UL CL UPF

1. Establish a PDU Session

2. Discover EAS IP address (A Source EAS IP address is resolved by UE)

3. UL traffic (Src IP: UE IP, Dst IP: Source EAS IP) and DL traffic (Src IP: Source EAS IP, Dst IP: UE IP)

4. AF Influence procedure (SMF reconfigures UL CL and Local PSA) or UE Mobility

5. Early/Late Notification with enhancement described in clause 6.3.3.2.2

6b. UL traffic (Src IP: UE IP, Dst IP: Target EAS IP)

DL traffic (Src IP: Target EAS IP, Dst IP: UE IP)

6a. UL traffic (Src IP: UE IP, Dst IP: Source EAS IP) DL traffic (Src IP: Source EAS IP, Dst IP: UE IP)

Figure 6.3.3.1.1-1: Enabling EAS IP Replacement Procedure by AF

NOTE 1: This procedure covers the scenarios that the UE moves from non-EC to EC or the AF decides to enable the EAS IP replacement in the middle of a session.

1. UE requests to establish a PDU Session.

2. UE is preconfigured with the Source EAS IP address or discovers the IP address of the application server for the service subject to Edge Computing, and the Source EAS IP address is returned to the UE via EAS Discovery procedure as described in clause 6.2.

3. UE communicates with the Source EAS.

4. When AF detects that the EAS is capable of runtime context mirroring and an optimal EAS is found, then AF decides to influence the traffic routing in 5GC. The EAS IP replacement information (i.e. Indication of Enabling EAS IP Replacement, source EAS IP address and port number, target EAS IP address and port number) is sent to the SMF within the AF Influence information and the SMF reconfigures the UL CL UPF for local traffic routing and Local PSA with EAS IP replacement information. Or when UE moves to an area where the Local PSA has been configured to enforce EAS IP address replacement.

 UL CL is configured by SMF to forward UL packet to Local PSA if the destination IP address is the Source EAS IP address.

 Local PSA is configured by SMF to enforce the "Outer Header Creation" and "Outer Header Removal" as described in step 5. FARs "Outer Header Creation" and " Outer Header Removal" are reused for such an instruction from SMF to UPF.

 Detailed enhancement to the AF Influence procedure is described in clause 6.3.3.2.

 If a new Local PSA is selected by SMF, the SMF may configure the new Local PSA to buffer the uplink traffic per clause 6.3.5 and enforce the "Outer Header Creation" and "Outer Header Removal" as described in step 6.

5. When Early/Late Notification procedure with enhancement described in clause 6.3.3.2 is triggered, the SMF notifies AF about the target DNAI. Based on the target DNAI, the AF selects a proper target EAS, then the AF triggers to mirror the runtime context between Source EAS and Target EAS. Once the Target EAS is ready, AF responds to SMF about the Target EAS IP information (i.e. Target EAS IP address and port number). During the addition or change of UL CL and Local PSA as described in clause 4.3.5.4 or 4.3.5.6 of TS 23.502 [3], SMF may (re)configure Local PSA for EAS IP address replacement between Source EAS and Target EAS.

6. Local PSA starts to perform "Outer Header Creation" and "Outer Header Removal" FARs as instructed by SMF, which results in EAS IP address replacement:

- For UL traffic, the destination IP address and port number are replaced with the Target EAS IP address and port number;

- For DL traffic, the source IP address and port number are replaced back with the Source EAS IP address and port number.

NOTE 2: In this solution, the PSA UPF need not to understand the logic of EAS IP replacement.

 Then all subsequent uplink traffic of this EC service for this UE is forwarded to the target EAS.

NOTE 3: AF decides when and how to stop the Source EAS from serving the UE based on its local configuration.

##### 6.3.3.1.2 EAS IP Replacement Update upon DNAI and EAS IP Change

UE

SMF

Local PSA2

Local PSA1

PCF

Target UL CL

AF

Old Target EAS

New Target EAS

Source UL CL

Steps 2-3 are same as steps 5-6 described in clause 6.3.3.1.1

1a. UL traffic (Src IP: UE IP, Dst IP: Source EAS IP)

DL traffic (Src IP: Source EAS IP, Dst IP: UE IP)

1b. UL traffic (Src IP: UE IP, Dst IP: Old Target EAS IP)

DL traffic (Src IP: Old Target EAS IP, Dst IP: UE IP)

Figure 6.3.3.1.2-1: EAS IP Replacement Update upon DNAI and EAS IP change

1. For UL traffic, the destination IP address is replaced with the old Target EAS IP address at Local PSA; for DL traffic, the source IP address is replaced back with the Source EAS IP address at Local PSA.

Steps 2-3 are same as steps 5-6 described in clause 6.3.3.1.1 except that the UL CL, Local PSA and Target EAS in clause 6.3.3.1.1 are replaced by target UL CL, Local PSA2 and new Target EAS respectively.

##### 6.3.3.1.3 Disabling EAS IP Replacement Procedure

UE

SMF

Remote

PSA

Local

PSA

PCF

NEF

AF

Old Target EAS

Source

EAS

UL CL

UPF

3. UL traffic (Src IP: UE IP, Dst IP: Source EAS IP) and DL traffic (Src IP: Source EAS IP, Dst IP: UE IP)

2. Due to UE Mobility to a Non-EC environment, Early/Late Notification is triggered, target DNAI is set to empty value, AF knows the UE moves out of EC environment and mirrors the runtime session context from Old Target EAS to Source EAS. Once ready, the AF indicates SMF to disable the EAS IP replacement at Local PSA for the PDU Session.

1a. UL traffic (Src IP: UE IP, Dst IP: Source EAS IP)

DL traffic (Src IP: Source EAS IP, Dst IP: UE IP)

1b. UL traffic (Src IP: UE IP, Dst IP: Old Target EAS IP)

DL traffic (Src IP: Old Target EAS IP, Dst IP: UE IP)

Figure 6.3.3.1.3-1: Disabling EAS IP Replacement Procedure

1. Local PSA performs "Outer Header Creation" and "Outer Header Removal" FARs as instructed by SMF, which results in EAS IP address replacement:

- For UL traffic, the destination IP address and port number are replaced with the old Target EAS IP address and port number;

- For DL traffic, the source IP address and port number are replaced back with the Source EAS IP address and port number.

2. Due to UE Mobility to a Non-EC environment, when Early/Late Notification is triggered for the change from the UP path status where a DNAI applies to a status where no DNAI applies, AF knows the UE moves out of EC environment and mirrors the runtime session context from old Target EAS to Source EAS. Once ready, the AF indicates SMF to disable the local routing at UL CL and the EAS IP replacement at Local PSA for this PDU Session via AF Influence procedure.

3. UL and DL traffic goes through Remote PSA, no EAS IP address replacement happens at Remote PSA.

NOTE 1: AF decides when and how to stop the old Target EAS from serving the UE based on its local configuration. In case of AF relocation, AF doesn’t have to disable the EAS IP Replacement in 5GC.

#### 6.3.3.2 Enhancement to AF Influence

The AF may additionally include the Indication of Enabling EAS IP Replacement, Source and Target EAS IP address(es) and Port number(s) in the Nnef\_TrafficInfluence\_Create/Update request. Based on the Source EAS IP address(es) and Port number(s), the SMF knows which service flow(s) is(are) subject to EAS IP Replacement.

Using Early/Late Notification procedure, the AF sends an/a early/late notification response to the SMF when EAS relocation is completed. The SMF sends the "Outer Header Creation" and "Outer Header Removal" FARs to (target) Local PSA UPF and (target) Local PSA UPF starts the EAS IP address replacement as described in clause 6.3.3.1.

For load balancing purpose, the AF may move some UE(s) from the old Target EAS to the New Target EAS in the same local DN identified by the DNAI. For the abnormal condition of EAS, the AF may move all the UEs being served by the source EAS to a target EAS in the same local DN. For those purposes, the AF needs to include the Indication of Enabling EAS IP Replacement, List of UEs, the source/old Target EAS IP address and port number for the impacted DNAI, the (new) Target EAS IP address and port number for the impacted DNAI in the Nnef\_TrafficInfluence\_Create/Update request.

The additional parameters for enabling the EAS IP Replacement are defined in clause 5.6.7.1 of TS 23.501 [2], clause 4.3.6.3 and 4.3.6.4 of TS 23.502 [3].

### 6.3.4 Simultaneous Connectivity for Source and Target EASs

Editor's note: This clause describes seamless change of Edge AS using simultaneous connectivity for source and target EAS to reduce latency and packet loss. Whether this clause is needed is TBD based on actual contribution inputs.

### 6.3.5 Packet Buffering for Low Packet Loss

Editor's note: This clause describes seamless change of Edge AS using buffering of packets as in clause 9.2.1 to reduce packet loss. This procedure aims at synchronizing between EAS relocation and UL traffic from the UE, ensuring that UL traffic from the UE is sent to the new EAS only when EAS context transfer has been carried out.

This procedure may be applied at change of local PSA. It consists of buffering uplink packets in the target PSA in order to prevent there is packet loss if the application client sends UL packets to a new EAS before the new EAS is prepared to handle them. During the buffering, the old EAS may continue to serve the UE over the former PSA.

Buffering starts upon request by AF and continues till AF indicates otherwise. The EAS relocation procedure (e.g. the migration of the service context) happens at the application layer. That is outside the scope of 3GPP.

As an alternative to this procedure, upper layer solutions can provide the needed synchronization between EAS relocation and UL traffic from the UE.

NOTE: Upper layer solutions may still be needed when there are other EAS relocation scenarios (e.g. EAS (re)selection upon DNS cache entry expiry) not related to PSA change.

Buffering of uplink packets is not meant to apply to all traffic being offloaded at the new PSA but to the traffic identified by the application the rule associated with the buffering request.

Editor's note: Whether Buffering of uplink packets applies to an application traffic depends on the application requirement. It is FFS how to consider the application priorities and apply buffering with the right granularity.



Figure 6.3.5-1: Packet buffering for low packet loss

1. The SMF decides to change the local PSA of a PDU Session with UL CL.

2. The SMF may send an early notification to the AF after target PSA (i.e. PSA2) is selected and waits for a notification response from the AF. The AF may reply in positive to the notification by indicating that buffering of uplink traffic to the target DNAI is needed as long as traffic to the target DNAI is not authorized by the AF . This is e.g. as defined in Steps 1 and 2 of TS 23.502 [3] Figure 4.3.6.3-1.

3. For the procedures with ULCL/BP, the SMF configures the PSA2 as specified in step 2 in clause 4.3.5.6 and step 2 in clause 4.3.5.7 of TS 23.502 [3], which may request the PSA2 to buffer uplink traffic. The PSA1 (i.e. source PSA) keeps receiving downlink traffic from EAS1 and send it to the UE until it is released in step 7.

 For the procedures with SSC mode 3, the SMF configures the PSA2 as specified in step 4 in clause 4.3.5.2 and in step 5-6 in clause 4.3.5.4 of TS 23.502 [3], which may request the PSA2 to buffer uplink traffic.

4. For the procedures with ULCL/BP, the SMF sends an N4 Session Modification Request to the UL CL to update the UL CL rules regarding to the traffic flows that the SMF tries to steer to PSA2..This is e.g. as defined in TS 23.502 [3] Figure 4.3.5.7-1 step 3

5. The SMF sends a Late Notification to the AF. This corresponds e.g. to step 4a-c of TS 23.502 [3] Figure 4.3.6.3-1 and is e.g. also described in step 6 or 7 of TS 23.502 [3] Figure 4.3.5.7-1.

6a A new EAS is selected by the application (e.g. at DNS cache entry expiry, the DNS Query is resolved and the response includes a new EAS that is near the new PSA (PSA2)). Any traffic sent to the new EAS is buffered at PSA2.

6b. The application layer completes the EAS relocation (This corresponds to step 4d of TS 23.502 [3] Figure 4.3.6.3-1). The UE context is completely relocated from the old EAS to new EAS. The old EAS stops to serve the UE

NOTE 2: 6a and 6b are related which implies there is some sort of coordination at application layer that is outside of 3GPP scope.

7. When EAS relocation is completed, the AF sends a notification response to the SMF. This corresponds to step 4e-g of TS 23.502 [3] Figure 4.3.6.3-1(and is e.g. also described in step 6 or 7 of TS 23.502 [3] Figure 4.3.5.7-1) and may indicate that buffering of uplink traffic to the target DNAI is no more needed as traffic to the target DNAI /EAS is now authorized by the AF.

8. (if AF has indicated that buffering of uplink traffic to the target DNAI is no more needed as traffic to the target DNAI /EAS is now authorized by the AF) The SMF updates the PSA2 by indicating the PSA2 to send the buffered uplink packets (step 8b) and to stop buffering.

 The SMF releases PSA1.

### 6.3.6 Edge Relocation Considering User Plane Latency Requirement

Edge relocation may be performed considering user plane latency requirements provided by the AF.

In a network deployment where the estimated user plane latency between the UE and the potential PSA-UPF is known to the SMF, the 5GC provides the enhancement of AF influence to consider the user plane latency requirements requested by the AF so that the SMF decides to relocate the PSA-UPF based on AF requested requirements.

The AF may provide user plane latency requirements to the network via AF traffic influence request as described in TS 23.502 [3], clause 5.2.6.7. The user plane latency requirements may include the following information:

- Maximum allowed user plane latency: The value of this information is the target user plane latency. The SMF may use this value to decide whether edge relocation is needed to ensure that the user plane latency does not exceed the value. The SMF may decide whether to relocate the PSA UPF to satisfy the user plane latency.

- User plane latency preference: This parameter denotes AF preference for the user plane latency. The SMF may decide to (re-)select the PSA UPF considering this parameter.

Editor's note: It is FFS whether this parameter indicates "an indicator denoting the shortest user plane latency preference" or "a value for minimum user plane latency".

The user plane latency requirements requested by AF is informed to the SMF via AF influenced Traffic Steering Enforcement Control (see TS 23.503 [4] clause 6.3.1) in PCC rules. After receiving the user plane latency requirements from AF via PCF, the SMF may take appropriate actions to meet the requirements e.g. by reconfiguring the user plane of the PDU Session as described in the step 6 of Figure 4.3.6.2-1 in TS 23.502 [3].

## 6.4 Network Exposure to Edge Application Server

### 6.4.1 General

Some real time network information, e.g. user path latency, are useful for application layer. In this release, in order to expose network information timely to local AF, the L-PSA UPF may expose network information i.e. QoS monitoring results as defined in TS 23.501 [2], clause 5.33.3, to the local AF.

NOTE 1: Local PSA UPF can expose the QoS monitoring results to local AF via N6. How to deliver the information on N6 is out of SA2 scope.

NOTE 2: Sending QoS monitoring information that has not been properly integrated over time, i.e. with over-high frequency, can increase risk that the application may over-react to instantaneous radio events/conditions e.g. leading to service instability.

### 6.4.2 Network Exposure to Edge Application Server via Local NEF

Local NEF deployed at the edge may be used to support network exposure timely to local AF. The local NEF may support one or more of the functionalities described in TS 23.501 [2] clause 6.2.5.0. and may support a subset of the APIs specified for capability exposure based on local policy. In order to support the network exposure locally, the local NEF shall support event exposure service operation to the local AF. The local NEF selection by AF is described in TS 23.501 [2] clause 6.2.5.0 and 6.3.14.

The local AF subscribes the low latency exposure of QoS Monitoring results to PCF via a local NEF or NEF. If the NEF detects that it is not the most suitable NEF instance to serve the local AF request, it may redirect the AF to a (more) local NEF.

NOTE: If the notifications need to go via the local NEF, then the local NEF needs to be involved in order to be able to map these notifications to the URI where the AF expects to receive them.

The local AF may also subscribe the events via PCF directly. In this case, reporting is done directly from the UPF to the local AF.

Based on the indication of local event notification and operator's policy, the PCF may include an indication of local event notification (including target local NEF address) within the PCC rule that it provides to the SMF.

The SMF sends the QoS monitoring request to the RAN and N4 rules to the L-PSA UPF. N4 rules may indicate the service data flow needs local notification of QoS Monitoring. When GTP-U Path monitoring is used for QoS monitoring, that is also activated if needed. This is as defined in TS 23.501 [2] clauses 5.33.3. When N4 rules indicate the service data flow needs local notification of QoS Monitoring, upon the detection of the QoS monitoring event (e.g. when latency threshold of the QoS flow is reached), the L-PSA UPF sends the notification to the AF via Local NEF.

During UE mobility, the SMF may trigger the L-PSA UPF relocation/reselection and then send the N4 rules to the new L-PSA UPF to indicate the service data flow needs local notification of QoS Monitoring. The UE mobility may also trigger AF relocation or local NEF reselection, then the local AF should update the subscription for local exposure with QoS monitoring results via local NEF, towards the PCF. This updated /new subscription is then propagated via SMF (via PCC rule updates) and then to the L-PSA UPF via N4 rules.

Figure 6.46.2-1: The association establishment between local UPF and local NEF

0. The UE establishes a PDU Session as defined in clause 4.3.2.2.1 of TS 23.502 [3] A Local PSA is used by this PDU Session.

1. The AF initiates an AF session with required QoS procedure as defined in clause 4.15.6.6 of TS 23.502 [3].

 In the request, the AF may subscribe local notification of QoS monitoring for the service data flow to PCF via Local NEF or NEF. For the QoS monitoring, the AF shall include the corresponding QoS monitoring parameters as defined in clause 5.33.3 of TS 23.501 [2].

 The AF may also first initiate an AF Session with PCF and later subscribe to local notification of QoS monitoring to PCF by invoking Npcf\_Authorization\_Subscribe service operation.

 The local AF/ NEF may discover a local NEF based on existing method as specified in TS 23.501 [2] clause 6.2.5.0 and using parameters as those specified in clause 6.3.14. Alternatively, if the NEF detects that it is not the most suitable NEF instance to serve the local AF request, the NEF may redirect the AF to a (more) local NEF. The NEF may use information on the PDU Session Anchor of the PDU Session for this determination.

 The indication for AF request network real-time information is also provided. Then the Local NEF may subscribe the local notification of QoS monitoring to PCF.

2. The PCF makes the policy decision and initiates the PDU Session modification procedure as defined in clause 4.3.3.2 of TS 23.502 [3], step 1b, 3b, 4-8b.

 If the local notification of QoS monitoring is subscribed, the PCF includes the indication of local event notification (including target local NEF address) for the service data flow within the PCC rule.

 If the SMF receives the indication of local event notification form the PCF and the SMF determines that the L-PSA UPF supports such reporting, the SMF sends QoS monitoring parameters and associate them with the target local NEF address to the L-PSA UPF via N4 rules. Otherwise the SMF activates N4 reporting. The PCF may determine that the duplicated notification is required, i.e. both local notification to the AF (i.e. sent from UPF) and central notification (i.e. sent from the PCF/SMF) is required and indicate it to the SMF with the PCC information. In this case, the SMF may activate the N4 reporting together with the direct reporting to the local NEF.

Editor’s Note: the text above needs to be clarified: does it correspond to 2 AF sending QoS monitoring for the same SDF? Is it a realistic use case?

3. The L-PSA UPF obtains QoS monitoring information as defined in TS 23.501 [2] clause 5.33.3.

4. The L-UPF sends the notification related with QoS monitoring information over Nx

Editor's note: It is FFS whether the QoS monitoring result report from L-PSA UPF to local NEF is based on SBI or not.

5. Local NEF reports the real-time network information to local AF by invoking Nnef\_EventExposure\_Notify service operation.

6. Due to e.g. UE mobility, the PSA relocation and/or EAS relocation may happen as described in clause 6.3. During the PSA and/or EAS relocation, the AF or the NEF may trigger a new L-NEF discovery as per step 1.

7. The new AF may initiate a new AF session to the new Local NEF or NEF/PCF to (re-)subscribe the local notification of QoS monitoring as described in steps 2-4.

8. The old AF revokes the AF session with the old local NEF or NEF/PCF.

#### 6.4.2.1 Local NEF discovery

As specified in TS 23.501 [2] clause 6.2.5.0, the NRF may be used by the AF to discover the L-NEF. To become discoverable, the L-NEF registers with an NRF deployed within the operator’s domain where the AF resides.

The AF uses existing procedures as described in TS 23.502 [3], clause 4.17.4 to discover the L-NEF. If the AF only knows the NEF and it initiates a service operation towards this NEF, e.g., a Nnef\_AFSessionWithQoS\_Update\_request procedure , the NEF may re-direct the request to a L-NEF. NEF may use NRF to find a suitable L-NEF for the re-direct and it may return the L-NEF IP Address/FQDN to the AF in the response message.

## 6.5 Support of 3GPP Application Layer Architecture for Enabling Edge Computing

### 6.5.1 General

Editor's note: This clause refers to TS 23.558 [5] for the specifications of the Discovery over the Architecture Enabling Edge Applications.

The 3GPP application layer architecture that is specified in TS 23.558 [5] includes the following functional entities:

- Edge Enabler Client (EEC)

- Edge Configuration Server (ECS)

- Edge Enabler Server (EES)

A UE may host EEC(s) as defined in TS 23.558 [5] and support the ability to receive ECS address(es) from the 5GC and to transfer the ECS address(es) to the EEC(s). In this case, the ECS address provisioning via 5GC is described in clause 6.5.2.

NOTE: The features described in the other clauses of this specification do not require the UE and the network to support the 3GPP application layer architecture that is specified in TS 23.558 [5].

### 6.5.2 ECS Address Provisioning

Editor's note: This clause describes here the procedure agreed in conclusions in 9.1.3.

If the UE hosts an EEC and supports transferring the ECS address received from the 5GC to the EEC, the UE indicates in the PCO at PDU Session establishment or modification that it supports the ability to receive ECS address(es) via NAS and to transfer the ECS Address(es) to the EEC(s).

The ECS Address Configuration Information consists of one or more FQDN(s) and/or IP Address(es) of Edge Configuration Server(s), ECS Provider ID and ECS ID. As described in clause 4.3.2 in TS 23.502 [3], if the UE supports the ability to receive ECS Address Configuration Information via NAS and to transfer the ECS Address(es) to the EEC(s), the UE may receive ECS Address Configuration Information from the SMF via PCO during PDU Session Establishment and/or during PDU Session Modification procedures. The SMF may derive the ECS Address Configuration Information based on local configuration, the UE's location, ECS Provider ID and/or UE subscription information from UDM. The SMF may decide to send updated ECS Address Configuration Information to the UE based on locally configured policy, updated UE subscription information, or a change of UE location. The PDU Session Modification procedure is used to send updated ECS Address Configuration Information to the UE as described in clause 4.3.3 in TS 23.502 [3].

NOTE 1: In home routed sessions, the ECS Address Configuration Information comes from the H-SMF. The traffic to the indicated Edge Configuration Server(s) may be transmitted via a PDU session with local breakout.

NOTE 2: Although the Service Provisioning procedure with the ECS may take place over a HR session, the UE needs to establish an LBO PDU Session to access the EES(s) and EAS(s) in VPLMN. The Service Provisioning procedure is described in TS 23.558 [5].

#### 6.5.2.1 ECS Address Provisioning by a 3rd Party AF

As described in TS 23.558 [5], the Edge Configuration Server can be deployed in the MNO domain or can be deployed in a 3rd party domain by a service provider. If the ECS is deployed in a 3rd party domain by a service provider, a 3rd party AF can use Nnef\_ParameterProvision to provide, update, or delete ECS Address Configuration Information for a UE (See TS 23.502 [3], clause 4.15.6.2).

When the AF uses Nnef\_ParameterProvision to send a new ECS Address Configuration Information to the UDM for a UE (e.g. because on Application layer activity, change of UE location, etc.), the UDM may notify the SMF of the updated ECS Address Configuration Information and the new ECS Address Configuration Information will be sent to the UE in a PDU Session Modification procedure.

Editor's note: It is FFS whether the 3rd party AF would know the GPSI; the possibility to configure the ECS address for all UE in one operation should be considered.

Editor's note: Potential signalling overload is FFS When the AF uses Nnef\_ParameterProvision to send a new ECS Address Information to the UDM for many UE.

# 7 Network Function Services and Descriptions

Editor's note: TBD, this clause is a placeholder for any necessary new Services to be defined in this TS.

## 7.1 EASDF Services

### 7.1.1 General

The following table illustrates the EASDF Services and Service Operations.

Table 7.1.1-1: NF services provided by the EASDF

|  |  |  |  |
| --- | --- | --- | --- |
| Service Name | Service Operations | Operation Semantics | Example Consumer(s) |
| Neasdf\_DNSContext | Create | Request/Response | SMF |
|  | Update | Request/Response | SMF |
|  | Delete | Request/Response | SMF |
|  | Notify | Subscribe/Notify | SMF |

### 7.1.2 Neasdf\_DNSContext service

#### 7.1.2.1 General

**Service description:** This service enables the consumer to create, update, or delete DNS context in EASDF and to Subscribe to DNS signalling related reporting from EASDF.

DNS contexts in EASDF include rules on how EASDF is to handle DNS messages.

#### 7.1.2.2 Neasdf\_DNSContext\_Create service operation

**Service operation name:** Neasdf\_DNSContext\_Create.

**Description:** Create a DNS context in EASDF.

**Input, Required:** UE IP address, DNN, callback URI, DNS message handling rule (DNS message detection, Action(s)).

DNS message detection and Actions(s) are specified in clause 6.2.3.2.2.

**Input, Optional:** None.

**Output, Required:** IP address of the EASDF, EASDF Context ID, Success or Failure.

**Output, Optional:** None.

#### 7.1.2.3 Neasdf\_DNSContext\_Update service operation

**Service operation name:** Neasdf\_DNSContext\_Update.

**Description:** Update the DNS context in EASDF, or indicate EASDF to forward the DNS Response to UE.

**Input, Required:** EASDF Context ID, DNS handling rules.

**Input, Optional:** None.

**Output, Required:** Success or Failure.

**Output, Optional:** None.

#### 7.1.2.4 Neasdf\_DNSContext\_Delete service operation

**Service operation name:** Neasdf\_DNSContext\_Release.

**Description:** Delete the DNS context in EASDF.

**Input, Required:** EASDF Context ID.

**Input, Optional:** None.

**Output, Required:** Success or Failure.

**Output, Optional:** None.

#### 7.1.2.5 Neasdf\_DNSContext\_Notify service operation

**Service operation name:** Neasdf\_DNSContext\_Notify.

**Description:** EASDF reports DNS signalling related information to the consumer when receiving DNS Query or DNS Response.

**Input, Required:** DNS message reporting information (EAS FQDN(s), EAS information specified in clause 6.2.3.2.2).

**Input, Optional:** None.

**Output, Required:** Success or Failure.

**Output, Optional:** None.

Annex A (Informative):
EAS Discovery Using 3rd Party mechanisms

There are different IP discovery mechanisms existing in the application layer. For example, the application client can generate the DNS Query outside of DNS libraries in the OS with DoT, DoH or other over the top mechanisms.

The third party can also deploy a service scheduling server to determine the (E)AS IP address based on the UE's HTTP(S) request. In this case, the DNS firstly resolves the FQDN in the DNS request of the UE into the IP address of the service scheduling server and then the UE contacts the service scheduling server that can provide the IP address of the EAS that the UE is then to contact.

For the Distributed Anchor Point connectivity model, in order to enable EAS discovery by third party mechanisms, the DNS Server or service scheduling server in the third party could be pre-configured with mapping information between the IP address range which can correspond to the Central PSA UPF or other entities (e.g., a NAT server) on the N6 interface and EAS information. In this case, the DNS Server or service scheduling server in the third party can take the source IP address of the UE request as the location information of UE. The DNS and/or service scheduling server pre-configuration can be based on the agreement between the MNO and service provider.

For the Session Breakout connectivity model, based on agreement with the operator, a possible solution for the service scheduling server is as follows:

- The IP address of the service scheduling server can be set as a condition in the ULCL UPF to offload traffic. The IP address of service scheduling server can be pre-configured or resolved by the EASDF based on procedure defined in clause 6.2.2.2.

- NAT server can be deployed in the local DN or local N6 interface, in order that the source IP address of the UE request sent to the service scheduling server can correspond to the UE location related information.

NOTE: Otherwise, the source IP address of the UE request message sent to the third party DNS server / service scheduling server is bound with the central PSA UPF, so it's impossible for the third party DNS server / service scheduling server to know which local EAS address could be allocated to the UE.

Based on the mapping relationship between the IP ranges of UE request and the EAS information, the EAS IP address can be allocated to the UE. The above example is briefly shown in Figure A-1.



Figure A-1: Service scheduling server mechanism for Session Breakout connectivity model

Annex B (Informative):
Application Layer based EAS (Re-)Direction

Editor's note: This is to address application layer based EAS rediscovery procedure as concluded in clause 9.2.3.

During the application relocation, the AF can reselect a new EAS for the UE. Reselection can be triggered by the AF when it receives a UP path change notification or by an internal trigger of the AF (e.g. load balancing, UE location change, etc.). When the new EAS is reselected, the UE is provided the new EAS address via application layer signalling. For example, the UE can receive the URL or FQDN of the new EAS once the application context relocation is complete and then use DNS to resolve the URL or FQDN. The UE can also obtain the new EAS address via HTTP redirection.

NOTE: The Application layer signalling between the AF (or Old EAS) and UE is application specific and is outside the scope of this specification.

Annex C (Informative):
UE Considerations for EAS (re)Discovery

# C.1 General

DNS records obtained from a network resolver contains a time-to-live (TTL) value. This is a hint provided by the network resolver and can be used to determine the length of time that the record is cached. DNS records can be cached in the UE by a system wide stub resolver and by application layer name resolution caches. The application (L7) cache is managed on a per application basis while the OS/system DNS cache is common to applications. Name resolution caches in various applications also have different policies and behaviour. Some applications cache the name records for the length of the application session while others have a time limit. The recommendations here are expected to work if the UE application and OS consider indications from the UE modem layer with respect to DNS settings and DNS caching. Whether and how the UE, application receives and considers indication depends on implementation.

The following clauses describe the appropriate DNS configuration for the EAS (re)-discovery to work in the UE.

# C.2 Impact of IP Addresses for DNS Resolver

The UE can be configured by the 5GC with an IP address for the DNS resolver using ePCO or IPv6 Router Advertisement (RA), DHCPv4 or DHCPv6 as described in TS23.501[2] clause 5.8.2. 5GC can reconfigure the DNS resolver IP address using NAS or IPv6 Router Advertisement (RA). In case of anycast IP address of the DNS resolver, the 5GC can use UL-CL/BP to branch out and the DN is responsible to route to the closest instance of the MNO DNS resolver without having to reconfigure the DNS resolver IP address in the UE.

NOTE: 5GC is likely not to be able to reconfigure the DNS resolver IP address when DHCP is used to configure this information on the UE, e.g. in case of UE split. Applications in the UE can request the DNS resolver configured on the UE to resolve an FQDN. However, applications can also be configured with their own DNS resolver address and can use encrypted messaging based e.g., on DNS over HTTPS (DoH) or, DNS over TLS (DoT). Configuration of application DNS resolvers is out of scope of 5GC. DNS messages delivered over DoT, or DoH might be forwarded transparently to the destination address of DNS resolver in the DNS query. The application DNS resolver can be operated by the 5GC operator or by a third party.

A network interface change or NAS SM EAS rediscovery indication can and should result in the UE OS clearing name/IP address translations in its DNS cache.

If network interface change or NAS SM EAS rediscovery indication does not result in the UE OS clearing name/IP address translations in its DNS cache, an application can continue the L4 connection with the old EAS IP address until DNS cache entry times-out and subsequent DNS EAS address resolution request.

# C.3 UE Considerations for EAS Re-discovery

An application in the UE that complies with EAS (re-)discovery described in this specification is not recommended to override operator-provided DNS settings.

The OS DNS server configuration does not override the operator provided DNS in a UE compliant to the EAS (re-)discovery procedure. This is necessary for the "closest" EAS server to be selected.

NOTE 1: If an OS, user or applications override the operator-provided DNS settings, the DNS resolvers or servers in the third party can take the source IP address of the DNS request as the location information of UE, which can correspond to the remote PSA UPF or other entities (e.g., a NAT server) on the remote/central N6 interface which can lead to a non-optimal choice of the EAS server address.

NOTE 2: If the DNS server configuration in a OS overrides the operator provided DNS, the DNS queries continue to be sent over the correct PDU Session for the application.

Editor’s note: It is FFS whether the UE modem transparently forwards DNS messages for tethered devices that are loosely coupled: more generally it is FFS whether URSP can’t apply to tethered traffic and this is a more general issue than EC.

NOTE 4: If the UE (OS or application) uses a DNS resolver that is different than the one provided by the 5GC, then:

- the Session Breakout connectivity mode, option A and B in clause 6.2.3.2 will not work in case the EASDF is NOT in the DNS resolver chain for recursive DNS resolution.

# C.4 UE Procedures for Session Breakout

In the session breakout connectivity model, the selection of a new session breakout path does not result in a new network interface indication at the UE.

NOTE: In the case of multiple sessions or distributed anchor point connectivity models, when there is a change of network interface, indication of network interface change can and should be used to flush the UE OS DNS cache.

Session breakout results in a NAS SM message indicating the need to redo DNS lookup sent by the SMF to the UE modem. Thus, in order to support some solutions of this specification, it is necessary for the operating system to receive information of EAS rediscovery from the modem when such signalling has been received and clear the DNS cache in UE OS.

# C.5 Split-UE Considerations for EAS (Re-)discovery

For the split-UE (i.e. the TE and ME are separated), information provided by the SMF in the NAS message during the PDU Session Establishment or Modification is provided to the ME, and some MEs cannot provide the NAS provided IP parameters to the TE. i.e. the TE cannot receive that information from the ME because of separation between the TE and ME. Example of information are the DNS configuration or Rediscovery indication.

The TE normally uses the UP-based methods to get IP parameters configuration from the 5G network, i.e. Using DHCPv4 (for IPv4) or DHCPv6 (for IPv6). In order to provide the same EAS (re-) discovery information to the UE via the NAS and UP-based method for the same PDU Session, the same DNS settings should be provided in the DHCP response and in ePCO to the UE. An application in the TE that complies with EAS (re-)discovery described in this specification is not recommended to override operator-provided DNS settings as described in C.3.

Editor’s Note: There may also be issues with steering of the association between applications and PDU Sessions based on URSPs.

For the split-UE, some MEs cannot provide the NAS information requesting UE to redo DNS lookup received from the SMF to the TE or the TE OS.

Annex D (Informative):
Examples of AF Guidance to PCF for Determination of URSP Rules

a) The UE is to use a specific (DNN, S-NSSAI) (e.g. working in SSC mode 2 or 3 with the Distributed Anchor deployment) when trying to reach some domains while it should use another (DNN, S-NSSAI) (e.g. working in SSC mode 1) for other domains. In this example, the AF can indicate two FQDN filters, optionally with corresponding filtering rule priorities, if the FQDN filters overlap. For each FQDN filter, the AF can indicate a corresponding DNN, S-NSSAI.

b) Corporate applications only reachable via a specific (DNN, S-NSSAI) negotiated with the operator; corresponding URSP rules (URSP rules referring to domains of these corporate applications) shall only point to this specific (DNN, S-NSSAI). In this example, the AF can indicate one FQDN filter for the corporate applications. Optionally, the AF can indicate also the corresponding DNN, S-NSSAI for the FQDN filter. If DNN, S-NSSAI is not provided by the AF, the NEF can determine it based on the AF identity.

c) Corporate applications reachable via a (DNN, S-NSSAI) but only in some location; e.g. the corporate applications are only accessible when the UE is in some location corresponding to the corporate premises. In this example, the AF can provide information as in bullet b), and additionally provides where the corporate applications are accessible. URSP Rules will guide the UE select the (DNN, S-NSSAI) when the UE is in the geographical zone.

d) Internet applications not reachable via a specific (DNN, S-NSSAI) negotiated with the operator but that should be only reachable via a general purpose (DNN, S-NSSAI); e.g. traffic of UE(s) of a third party targeting Internet applications is not to be sent to a specific (DNN, S-NSSAI) negotiated with the operator as this traffic is not expected to cross the Intranet of the corporate. In this example, the default operator rules are used generate a "match all" URSP rule with a low filtering rule priority and a corresponding generic purpose DNN, S-NSSAI.

e) Internet applications reachable via both a specific (DNN, S-NSSAI) negotiated with the operator and via a general purpose (DNN, S-NSSAI) for which the third party may want to set preferences between these 2 kinds of connectivity. These preferences may depend on the UE location. In this example, the AF can indicate FQDN filters as in bullet b), but the FQDN filters are for Internet applications. In addition, the AF can indicate where the Internet applications are accessible via the specific DNN, S-NSSAI. In addition, the default operator rules are used generate a "match all" URSP rule with a low filtering rule priority and a generic purpose DNN, S-NSSAI.

f) Combination of bullets c) and e). In this example, the AF can indicate one FQDN filter for corporate applications as in bullet c), and another FQDN filter for Internet applications as in bullet c), In addition, the AF can indicate filtering rule priorities for the FQDN filters, if the FQDN filters overlap.

g) Corporate applications reachable via a (DNN, S-NSSAI) in some location and via another DNN, S-NSSAI in another location; e.g. the corporate applications are only accessible via a location specific corporate DNN, S-NSSAI. In this example, the AF can indicate an FQDN filter as in bullet c), but indicates two or more sets of location conditions for the FQDN filter, and indicates different DNN, S-NSSAI for each. In addition, if the geographical zones overlap, the AF can indicate a Route Selection Descriptor Precedence for each of them.

The examples b) to e) above can correspond to different AF(s) representing different corporate that have different policies. How the rule precedence between rules for different AFs are set in the URSP rules is up to the operator policy.

In the examples above, when a location specific corporate DNN, S-NSSAI has been agreed, as an alternative, the location area where the DNN is accessible can also be set as part of the SLA agreement configured on the NEF.

Annex E (informative):
EPS Interworking Considerations

# E.1 General

5GC is specified to support interworking with EPC. Edge Computing deployments that use interworking need to consider the aspects outlined in this Annex.

# E.2 Distributed Anchor

SSC mode 3 cannot be used when the UE is registered in EPC as 5G-NAS is not available. Re-establishing a PDN connection after releasing an old one can be done in EPS using the "reactivation requested" cause value in EPS bearer context deactivation (see TS 24.301[7] clause 6.4.4.2), if the feature is supported by the EPS network.

# E.3 Multiple Sessions

The URSP rules provided by 5GC to the UE are defined to cover both 5GS as well as EPS when interworking is applied. In EPS there is no possibility to provide new URSP rules to the UE, instead according to TS 23.501 [2], clauses 5.15.5.3 and 5.17.1.2, the URSP rules provided to the UE when it was registered in 5GC can also be used when the UE is registered in EPC if HPLMN uses URSP (see TS 24.526 [8]).

AF guidance of URSPs may not take effect if the UE is in EPS and the UE does not use the URSP rules on EPS (see TS 24.526 [8] 4.4.2 for the use of URSP in EPS). Therefore, it is not deterministic when they will take effect, since PCF could have issued the URSP rules when the UE was on EPS (where URSP rules cannot be sent).

Annex F (Informative):
EAS Relocation on Simultaneous Connectivity over Source and Target PSA

This annex describes how EAS relocation can make use of network capabilities that, at PSA change, provide simultaneous connectivity over the source and the target PSA during a transient period.

At PSA change, simultaneous connectivity to Application over former and new PSA allows the application to build its own EAS relocation solution and minimize the impact on latency:

- If the decision for when to start using a target EAS is taken by the application, this decision can consider application specific aspects, like for example, the time interval between packets or end of a video frame to minimize impact on latency.

- When there are multiple applications on a PDU Session, if connectivity over the former PSA is maintained for some time, each application can schedule EAS relocation to suit the application specific needs without interfering with the other applications.

The procedure is shown in below Figure F-1:



Figure F-1: EAS Relocation on Simultaneous Connectivity over Source and Target PSA

The user has established a PDU Session. This PDU Session has a local PSA (source L-PSA), which could be the PSA of a PDU Session with distributed anchor connectivity or one additional local PSA of a PDU Session with Session Breakout. There has been a EAS Discovery procedure as described in clauses 6.2.2.2 and 6.2.3.2 (the procedure is conditioned to the connectivity model) for one or more applications. Application traffic is served by source EAS over the PDU Session local PSA.

1. User mobility triggers SMF to select a new local PSA (target L-PSA) that is closer to the user at current user location. In this scenario, the re-anchoring procedures that provide Simultaneous Connectivity over Source and Target PSA are described in TS 23.502 [3]:

- For Distributed Anchor, in clause 4.3.5.2 for Change of SSC mode 3 PDU Session Anchor with multiple PDU Sessions, and in clause 4.3.5.3 for Change of SSC mode 3 PDU Session Anchor with IPv6 Multi-homed PDU Session.

- For Session Breakout, in clause 4.3.5.7 for Simultaneous change of Branching Point or UL CL and additional PSA for a PDU Session.

2. When the connectivity is available on target L-PSA, the connectivity via source L-PSA is still available during certain time (that is provisioned and controlled as described in these TS 23.502 [3] procedures). The application traffic can continue to run over the established UE-EAS connections.

3. The EAS Rediscovery Procedures described in clauses 6.2.2.3 and 6.2.3.3 allow the UE to discover a new EAS (i.e. target EAS) for the application that is closer to the UE over the new path (there could be multiple triggers as described in those respective clauses). If multiple applications are being served by this PDU Session, each of them performs rediscovery. This discovery procedure may lead to EAS reselection.

4. New L4 connections may now be established between the UE and the target EAS with the following considerations:

- For Distributed anchor or session breakout with MH, the UE uses the IP address /prefix associated with the target PSA (that is referred to as IP#2 in Figure F-1).

- For Session breakout with ULCL, there has not been connection/IP address change. Same IP address is still used by UE (that is referred to as IP#1 in Figure F-1).

NOTE 1: If Session Breakout is used for connectivity, and if the application wants to build service continuity on simultaneous connections, source EAS and target EAS cannot share the same IP address (e.g. by using anycast).

 EAS Relocation may involve EAS context migration in the case of stateful applications. Examples follow of possible EAS relocation procedures. These are part of the application implementation details and fall out of 3GPP specification scope:

- The Application server can recreate the service context when first contacted by the client using a Context Id: when suitable, the application client sets up a connection to the target EAS including a Context Id. The target EAS uses this Context Id to retrieve the latest service context available and subsequent updates, if needed.

- The Application server can recreate the context when first contacted by the client using a Context Id: the application client sets up a connection to the target EAS but for some time it sends traffic to both, source and target EAS. This way, it triggers the context migration before the actual EAS switch.

- The source Application server is able to provide the client with switching instructions when a new EAS is selected: upon UE request (if UE selected) or as an EAS initiative (if server selected), the source EAS provides the Application client with switching instructions while it continues to serve traffic and drives any context migration towards the selected target EAS.

NOTE 2: This application procedure may be designed to solve EAS relocation in all scenarios, not only when triggered by Edge Relocation, which may simplify the application design.

5. At some point all traffic for all applications in this session are sending traffic to their target EAS only and traffic ceases over the source L- PSA. The source L-PSA is then released. The timers should be set to allow EAS relocation.

6. UE only maintains connection(s) to target EAS(s).

Annex G (Informative):
Change history

|  |
| --- |
| **Change history** |
| **Date** | **Meeting** | **TDoc** | **CR** | **Rev** | **Cat** | **Subject/Comment** | **New version** |
| 2021-03 | SA2#143E | S2-2100114 | - | - | - | Proposed skeleton approved at S2#143E | 0.0.0 |
| 2021-03 | SA2#143E |  |  |  |  | Incorporate approved P-CR: S2-2101087, S2-2101095, S2-2101097, S2-2101098, S2-2101090, S2-2101104, S2-2102000, S2-2002002, S2-2102003, S2-2102004, S2-2102005, S2-2102007, S2-2102009, S2-2102069 | 0.1.0 |
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