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**Source: Huawei, Intel?, Nokia?, vivo?,China Mobile?, Tencent?, ZTE?, Futurewei?, Samsung?, NTT DOCOMO?, Lenovo?....**

**Title: EAS Discovery for Session Breakout connectivity model**

**Document for: Approval**

**Agenda Item: 8.3**

**Work Item / Release: eEDGE\_5GC/Rel-17**

***Abstract of the contribution:*** *This contribution proposes the EAS discovery in case of the session breakout according to conclusion in clause 9.1.4 in TR 23.748.*

# Discussion

This paper is to incorporate solution 22 of TR 23.748 in TS 23.548 clause 6.2.3.

The following discussion is to address the open issues of solution 22 in the TR:

**Open Issue 1: How does the LDNSR maintain a PDU Session context bound to the PDU Session?**

According to clause 6.33.1 of TR 23.748, this issue is left for decision in normative phase. There are 2 possible ways being discussed:

Alternative 1: The LDNSR acting as AF subscribes PDU Session Status from the SMF, and SMF notifies the PDU Session Status to LDNSR

Alternative 2: The SMF invokes a new LDNSR service to provide PDU Session Status to LDNSR

For the first alternative, as the SMF service is used it was claimed no LDNSR service needs to be defined. To support this, before the PDU Session is established, the LDNSR subscribes to SMF for PDU Session Status of PDU sessions with a certain (S-NSSAI, DNN) for any UE. When a PDU Session is established, the SMF sends PDU Session Status notification to the LDSNR according to the subscription, the PDU Session Status notification includes the IP address of the PDU Session and the SMF ID of the PDU session. Later, if the LDNSR needs to send the new EAS information to the SMF, the LDNSR invokes SMF service based on SMF ID. For this alternative,

1. There are no LDNSR discovery and selection as the LDNSR notified to the UE is always the one which subscribed the PDU Session status information. It is unclear if there are more than one LDNSR how the selection is to be decided.
2. How to update the DNS response notification trigger. Several potential optimizations for DNS response handling has been discussed, e.g. the SMF provides the condition to trigger the LDNSR sends some special DNS response, i.e. EAS address, to SMF. The condition may need to be updated after UE mobility, or after ULCL/BP insertion. Without the LDNSR service, it is difficult to update information stored in the LDNSR for the PDU Session.
3. Furthermore, for option 2b, the SMF needs to send DNS response to LDNSR, without LDNSR service, it seems hard to do so with a way compatible to principle of service based interface

The alternative 2 will define a LDNSR service. During PDU Session establishment, the SMF discover and select one LDNSR. After that, it invokes the LDNSR service to create a PDU Session status context in the LDNSR. The SMF may provide callback URI and notification condition to the LDNSR, when the notification condition is matched, the LDNSR sends notification to SMF and provides the EAS information (IP address, FQDN) by using the callback URI. The SMF can update the context created in LDNSR for the PDU Session, e.g. update the notification condition for the EAS information notification.

Based on the above analysis, the alternative 2 is a more flexible solution. Hence, it is recommended that the alternative 2 is adopted as a way forward.

**Proposal 1: A new LDNSR service is defined. The SMF invokes a new LDNSR service to create a context at LDNSR.**

**Open Issue 2: How does the LDNSR inform the SMF of the EAS information?**

In NOTE 3 of clause 6.22.1 in TR 23.748, 2 options are listed:

Alternative1: use SMF service.

Alternative2: use AF influence on traffic routing procedure.

Still, there is another option, which is:

Alternative 3: use notification service of LDNSR, i.e. SMF subscribes to the notification.

Based on proposal 1, option 2 is excluded. Both option 1 and option 3 are possible. Option 3 is proposed, because it doesn’t need new SMF service, and it is aligned with current SBI interface of SMF.

With Option 3, the DNS Query call flow is depicted as following:



Only a LNDSR service is defined. The service includes create, update, notify operation. The subscription is piggybacked in create or update operation.

**Proposal 2: LDNSR service is defined to notify the DNS Response, i.e. new EAS information, to SMF.**

# Proposal

It is proposed to add the following solution to TS 23.548.

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### 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.

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

Localized DNS (L-DNS) resolvers/servers may be locally deployed by MNO or 3rd parties within edge hosting environment, and responsible for resolving the UE DNS queries into a suitable EAS IP address within the Local DN. The L-DNS resolvers/servers may or may not have connectivity with Centralized DNS server depending on the deployment.

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

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

#### 6.2.3.2 EAS discovery procedure

#### 6.2.3.2.1 General

For PDU Session with Session Breakout connectivity model, the source IP address of the UE DNS Query message is an IP address bound with centralized PSA UPF, hence cannot be used by the DNS server to resolve a EAS close to the UE.

Based on UE subscription (e.g. DNN) and/or the operator’s configuration, the DNS Query sent by UE may be handled by a LDNSR, or by a local DNS authoritative server.

For the case that the UE DNS Query is to be handled by LDNSR, the following applies. It is further described in clause 6.2.3.2.2.

- During the PDU Session establishment procedure, the SMF selects a LNDSR and notifies it to the UE as DNS Server. The UE sends DNS Query to the LDNSR. If the AS FQDN in DNS query matches the DNS suffix(s) and/or FQDN(s) provided by the SMF, based on the local configuration, one of the following options is executed by the LDNSR:

- Option A: The LDNSR adds the ECS option into the DNS Query message as defined in RFC 7871[y], and sends the DNS Query message to DNS server. The DNS server resolves the EAS IP address considering the ECS option, and sends the DNS Response to the LDNSR. The ECS option includes a IP address corresponding to DNAI available to UE's location.

- Option B: The LDNSR forwards the DNS Query message to a suitable Local DNS server which responsible for resolving EAS within the corresponding Local DN, and receives DNS Response message from Local DNS server.

- Option C: The LDNSR sends the DNS Query message to SMF and the SMF forwards the DNS Query message to a suitable Local DNS server via a UPF. The Local DNS server sends back the DNS Response message to the LDNSR via the UPF and the SMF.

- When the LDNSR receives DNS Response message, the LDNSR may notify the EAS information (i.e. EAS IP address and optionally the EAS FQDN) to the SMF if the EAS IP address in DNS Response message matches with the notification condition provided by the SMF. The notification condition is the IP address range(s). When the EAS IP address in the DNS response is within the IP address range(s), the LDNSR sends the EAS information to SMF. The SMF may trigger UL CL/BP and L-PSA insertion based on the EAS information.

- The ECS option or the Local DNS server address provided by the SMF to the LDNSR are related to the UE location. The SMF provides them to the LDNSR either when the SMF establishes the association with the LDNSR for the DNS query message handling, or when the LDNSR receives the DNS query message and notify the AS FQDN to SMF. Due to EAS may be located at different place, for different AS FQDN DNS query the associated ECS option or local DNS server address may be different. After the UE mobility, if the provided ECS option or the Local DNS server need be updated, the SMF notify them to the LDNSR.

- If the EAS is located at the Edge Hosting Environment which is unreachable by the LDNSR, the SMF instructs the LDNSR to forward the DNS Query to the SMF for this EAS FQDN.

For the case that the DNS 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 as described in clause 6.2.3.2.3. The SMF is provisioned with the local DNS server address based on configuration or per AF request. Based on the operator’s configuration, one of the following options is executed:

- Option D: When ULCL/BP and Local PSA are inserted, the SMF chooses a local DNS server, and configures it to the UE as new DNS server. The local DNS server is determined based on the DNAI supported by the L-PSA. In addition, the SMF also configures the UL CL 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 resolve it recursively by communicating with other DNS authoritative server.

- Option E: The SMF configures the UL CL/BP and local PSA to forward the DNS Query message with certain FQDN(s) to the local DNS server.

NOTE: Option E requests modification of destination IP address of DNS messages. Whether this is allowed or not is subject to local regulations.

##### 6.2.3.2.2 EAS discovery procedure with LDNSR

This procedure applies to Option A, B and C in clause 6.2.3.2.2.



Figure 6.2.3.2.2-1: EAS discovery procedure with LDNSR

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. The SMF selects LDNSR as described clause 6.3.x (TBD) of TS 23.501[1].

3. The SMF invokes Nldnsr\_DNSContext\_Create Request (UE IP address, callback URI and notification condition, [ECS information], [local DNS server information]) to the selected LDNSR.

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 LDNSR creates a DNS context for the PDU Session, and stores the UE IP address, the callbak URI and notification condition into the context.

The notification condition is the condition for the LDNSR to send EAS related information to SMF when it receives DNS query or DNS response.

- DNS query for ECS options or local DNS server address handling, the SMF sets the notification condition to instruct the LDNSR to send the AS FQDN to the SMF if the AS FQDN in the DNS Query message matches with the FQDN(s) in notification condition.

- DNS query for EAS unreachable by the LDNSR, the SMF sets the notification condition to instruct the LDNSR to send the DNS Query message and AS FQDN in DNS Query message to the SMF if the AS FQDN matches with the FQDN(s) in notification condition.

- DNS response for specific IP address, the SMF sets the notification condition to instruct the LDNSR to send EAS IP address to the SMF if the EAS IP address in the DNS Response message is within one of the IP address range(s) of the notification condition.

The SMF may send the mapping information between ECS information or local DNS server and FQDN per DNAI to the LDNSR before the DNS query message is received at the LDNSR. For each FQDN which is to be discovered at a specific DNAI, the corresponding ECS information or local DNS server information is provided to the LDNSR.

4. The LDNSR invokes the service operation Nldnsr\_DNSContext\_Create Response (IP address of the LDNSR, DNS Context ID).

The DNS Context ID is used by the SMF to update the DNS context stored in the LDNSR. The IP address of the LDNSR is the address which is used to notify UE as DNS Server.

5. The SMF includes the IP address of the LDNSR 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 LDNSR as DNS server for that PDU Session.

6. The SMF invokes Nldnsr\_DNSContext\_Update Request (PDU Session Context ID, notification condition, ECS option or Local DNS Server IP address) to LDNSR.

The update may be triggered by UE mobility, e.g. when UE moves to a new location, or, the update may be triggered by insertion/removal of Local PSA, e.g. to update the notification condition.

7. The LDNSR responds with Nldnsr\_DNSContext\_Update Response.

8. The UE sends DNS Query message to the LDNSR.

9. If the DNS Query message matches the DNS Query notification condition, the LDNSR sends the notification to SMF by invoking Nldnsr\_DNSContext\_Notify Request (AS FQDN, [DNS query message]).

The LDNSR sends the AS FQDN, which is the one UE requested to be resolved in the DNS Query message.

For Option C, the LDNSR also includes the DNS Query message in the request.

10. The SMF responds with Nldnsr\_DNSContext\_Notify Response ().

For Option A, the SMF includes corresponding ECS option in the response message. For Option B, the SMF includes corresponding local DNS Server IP address in the response message.

Step 11 are performed for option A and B and skipped for option C:

11a. The LDNSR handles the DNS Query message received from the UE as the following:

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

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

11b. LDNSR receives DNS Response from the DNS server.

Steps 12 are performed for option C, and skipped for option A and B:

12a. If the UPF used to forward DNS messages between the Local DNS Server and the SMF has not been selected, the SMF selects an UPF and configures the UPF with proper rules for such purpose.

NOTE: The UPF that forwards the DNS Query message can be a UPF different from the Local PSA UPF inserted in step 17.

12b. The SMF forwards the DNS Query message to the Local DNS Server via the UPF.

12c. The local DNS Server sends the DNS Response message to the SMF via UPF.

12d. The SMF invokes Nldnsr\_DNSContext\_Update Request (DNS Context ID, DNS response) to forward the DNS Response message to the LDNSR.

12e. The LDNSR responds with Nldnsr\_DNSContext\_Update response.

13. The LDNSR sends EAS notification to SMF by invoking Nldnsr\_DNSContext\_Notify request (EAS information).

If the EAS IP address in the DNS Response message matches the notification condition, the LDNSR sends the EAS notification to SMF. The EAS information includes EAS IP address. The LDNSR caches the DNS Response message.

14. The SMF invokes Nldnsr\_DNSContext\_Notify Response service operation.

15. The SMF performs UL CL/BP and Local PSA selection and insert UL CL/BP and Local PSA.

Based on received EAS information, the SMF may performs UL CL/BP and Local PSA selection and insertion as described in TS 23.502 [3].

NOTE: The SMF can also perform the old UL CL/BP removal if it is needed.

16. The SMF invokes Nldnsr\_DNSContext\_Update Request (DNS Context ID, forward DNS Response indication).

The forward DNS response indication is used to indicate the LDNSR to forward the cached DNS Response to UE.

17. The LDNSR responds with Nldnsr\_DNSContext\_Update Response.

18. The LDNSR sends the DNS response to UE.

##### 6.2.3.2.3 EAS discovery with local DNS server/resolver

This procedure applies to Option D and E in clause 6.2.3.2.1.



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

1. The SMF inserts ULCL/BP and Local PSA.

 ULCL/BP/Local PSA insertion can be triggered by DNS messages as described in clause 6.2.3.2.2. Or, the SMF may pre-established the ULCL/BP and Local PSA before UE sends out any DNS Query message. The ULCL/BP and Local PSA are inserted as described in TS 23.502 [3].

 When the ULCL/BP and Local PSA are inserted, the SMF configure the ULCL/BP based on which option is to be used for DNS query handling:

- For Option D, the SMF configures the ULCL/BP to forward 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.

- For Option E, the SMF configures the ULCL/BP to forward the DNS query associated with the certain FQDN to the Local PSA, and configure the Local PSA to forward the DNS queries to the dedicated local DNS resolver.

Steps 2 and 3 are performed for option D, and skipped for option E:

2. The SMF sends PDU Session Modification Command (Local DNS Server Address) to UE.

 If, based on operator’s policy, the Local DNS Server IP Address in the local Data Network needs to be notified 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 DNS server for the PDU Session. The UE sends the following DNS Query message to the indicated Local DNS Server.

4. UE sends DNS Query message.

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

- For Option D, 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 ULCL/BP and Local PSA.

- For Option E, the target address of the DNS Query is the IP address of the DNS server configured during PDU Session establishment, e.g. the IP address of LDNSR or a Central DNS server. The ULCL/BP forwards the DNS Query to Local PSA, and the Local PSA forwards the DNS query to Local DNS Resolver, based on AS FQDN in DNS Query.

NOTE 1: If the destination IP address of the DNS Query is not the IP address of the local DNS server, the local DNS server need to ensure the DNS query message is handled same as the DNS query message is not forwarded to local DNS server. For example, the local DNS resolver can modify the destination IP address (e.g. LDNSR IP) of the DNS Query to the IP address of the DNS server, and modifies the source IP address of the DNS Response to the original UE IP address. Whether modification of destination IP address of DNS messages is allowed or not is subject to local regulations.

6. The Local PSA receives DNS Response message from local DNS server, it forwards it to the ULCL/BP, and the ULCL/BP forwards the DNS Response message to UE based on destination IP address of the DNS Response message(i.e. UE IP address).

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