**3GPP TSG-WG SA2 Meeting #141E e-meeting *S2-2007006r11***

**Elbonia, Oct 12 – 23, 2020 (revision of S2-200xxxx)**

**Source: Huawei, HiSilicon, Intel**

**Title: KI#1: Update Solution#22 to resolve ENs not related to LDNSR placement**

**Document for: Approval**

**Agenda Item: 8.3**

**Work Item / Release: FS\_enh\_EC / Rel-17**

*Abstract: This contribution proposes to update Solution#22 to resolve the ENs not related to LDNSR placement.*

# 1. Discussion

This contribution proposes to update solution#22 to resolve ENs other than those related to LDNSR placement. *(LDNSR placement related ENs are discussed in S2-200xxxx KI#1: LDNSR placement in solution 22).*

The contribution focuses on resolving the following 3 ENs and one issue of option 3b:

1. Editor’s Note: it is FFS whether Dynamic UL CL/L-PSA insertion can apply in HR case.

For PDU Session that corresponds to the AF request, the PCF provides the SMF with a PCC rule that is mainly generated based on the AF request. The PCC rule contains the information about the DNAI(s) towards which the traffic routing should apply, which will influence SMF to insert ULCL/BP and configure traffic steering at UPF.

According to the Clause 5.6.7 defined in the 23.501, the Application Function influence on traffic routing for R15/R16 does not apply to HR case.

*5.6.7 Application Function influence on traffic routing*

*5.6.7.1 General*

*The content of this clause applies to non-roaming and to LBO deployments i.e. to cases where the involved entities (AF, PCF, SMF, UPF) belong to the Serving PLMN or AF belongs to a third party with which the Serving PLMN has an agreement. AF influence on traffic routing does not apply in the case of Home Routed deployments. PCF shall not apply AF requests to influence traffic routing to PDU Sessions established in Home Routed mode.*

It is proposed that the UL CL/BP/L-PSA insertion described in this solution does not support HR case in this Release. A Note is proposed to replace this EN:

 ***NOTE: UL CL/BP/L-PSA insertion in HR case is not supported in this Release.***

1. Editor’s Note: it is FFS whether the alternative is needed where LDNSR could be instructed to notify SMF when ECS is in the DNS response.

On the two alternatives:

- The SMF may also provide the IP range(s) that shall trigger the LDNSR to notify SMF when the IP address (of EAS) in DNS response is within one of these the IP range(s).

- LDNSR could be instructed to notify SMF when ECS is in the DNS response.

In alternative 1, the SMF can use a wildcard IP range to indicate teh LDNSR to notify SMF for any DNS resposne. The benefits is not clear to add another alternative to trigger the notification based on ECS option in the DNS reponse, considering whether the ECS option is included in DNS response is up to the DNS server according to the RFC 7871:

*Its response would also contain an ECS option, clearly indicating that the server made use of this information, and that the answer is tied to the client's network.*

Further, reporting SMF based on the existance of ECS option will cause unnecessary signals even in case an ULCL has already been inserted.

It is proposed to remove the second alternative and the EN.

1. Editor’s Note: it is FFS whether the LDNSR fetches from SMF information needed to build ECS or whether the SMF pushes this information (e.g. when UE has moved to an area where new traffic offload conditions may take place).

Both of the two options can optimize the signal number between LDNSR and SMF, depends on how often UE uses the EC services. It is proposed to keep both options and SMF can decide which one is applied based on local configuration of the operator.

1. Changes to Option 3b:

In option 3b, there were some description on how L-DNS handle those DNS queries that cannot be resolved locally. It was mentioned the DNS messages will be send back to ULCL than to remote PSA UPF for further resolution.

*If the L-DNS cannot resolve the IP address for the requested FQDN of EAS and the L-DNS is not connected to the C-DNS, it responds to the local DNS resolver with DNS Response without including the IP address of EAS or indicating that it could not resolve the FQDN.*

*....*

*- The local DNS resolver forwards the original DNS request (the one that had originally arrived from the UL CL/BP UPF) back to the UL CL/BP UPF.*

*- The UL CL/BP UPF forwards the original DNS Request from local DNS resolver to the remote PSA UPF via N9.*

This make significant impacts to ULCL since the ULCL need to clarify the downlink packet (i.e. the unresovled DNS message) from other DL traffic and forward it to remote PSA. How to deal with that is not clear since currently ULCL only do for uplink traffic. It proposed to remove the above procedure from option 3b.

# 2. Text Proposal

It is proposed to capture the following changes in TR 23.748.

\* \* \* \* First change \* \* \* \*

## 6.22 Solution #22: DNS based EAS discovery supporting session breakout

This solution is for Key Issue #1 on DNS based EAS discovery supporting session breakout.

### 6.22.1 Description

#### 6.22.1.1 Deployment assumption of the solution

Centralized DNS (C-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 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 C-DNS server depending on the deployment. The L-DNS resolvers/servers may be deployed by MNO or 3rd parties.

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

NOTE 2: The C-DNS server or L-DNS resolvers/servers may contact any other DNS servers for recursive queries, which is out of control of 5GS and not described in the solution apart that the authoritative DNS server may support the DNS ECS option. The C-DNS server or L-DNS resolvers/servers can be different from the authoritative DNS server for the target domain name.



Figure 6.22.1.1-1: Target deployment scenario of the solution

The solution requires a new Functionality, an enhanced DNS Forwarder here referred to as "LDNSR". LDNSR supports Edge AS Discovery using DNS using knowledge of the 5GC connectivity of the UE.

Editor's note: It's FFS whether the LDNSR is part of PSA UPF or a standalone 5GC NF.

#### 6.22.1.2 PDU session establishment

When the UE sets up a PDU session a PSA is allocated: this PSA may be a central PSA.

ULCL/BP/local PSA insertion can be triggered by user traffic ("dynamic ULCL/BP/Local PSA insertion") or by other means before user traffic ("pre-established ULCL/BP/Local PSA insertion"):

- Pre-established ULCL/BP/Local PSA insertion can be done before the UE sends out actual DNS queries or traffic to be locally routed, e.g. at PDU Session establishment or be triggered by AF influence on routing related PCC rules. SMF sets up filters in ULCL/BP for steering to Local PSA of both the edge application traffic and the DNS messages towards L-DNS.

 When the L-DNS resolvers/servers do not have connectivity with C-DNS servers, specific mechanisms need to nevertheless support DNS translation for domains not corresponding to the edge resources (DNS requests not targeting the edge application domain). Alternative options are further described in clause 6.22.2.

NOTE 3: Encrypted DNS traffic requires that only L3/L4 filters can be used in ULCL/BP (e.g. DNS Query destination IP address is used) for DNS traffic detection/ steering. Same filters can be used at all locations if Anycast addresses are used for L-DNS.

- Dynamic ULCL/BP/Local PSA insertion is triggered by the DNS messages related with EAS FQDN resolution. It requires LDNSR involvement and different modes are possible. LDNSR behaviour is described below.

NOTE 4: The pre-established option can be combined with options using LDNSR if it is not wanted that all DNS traffic is handled in the L-DNS in deployment.

#### 6.22.1.3 DNS resolution with Pre-established UL CL/BP/L-PSA

5G core functions (PCF, UDR) can be configured by AF traffic influence routing with the list of DNAIs and IP addresses where the edge application servers are deployed and the traffic filters corresponding to the service to be steered. These apply to all services to be steered including DNS messages. The traffic filters may include the IP address or FQDN of the Local DN deployed service, L-DNS IP address.

Traffic can be steered based on ULCL/BP filters for all DNS messages (DoH, DoT, Do53), and traffic to applications (to EAS).

In the configuration phase, traffic filters for each Local DN deployed service and the DNAI are configured using AF traffic influenced routes. PCF stores the list of traffic filters for each DNAI. This uses 3GPP Rel-16 mechanisms.

During PDU session establishment, traffic filters are installed in ULCL/BP using 3GPP Rel-16 mechanisms.

The UE may be configured with local DNS resolver IP address per UE interface(e.g. per (DNN, S-NSSAI) using PCO, or use application specific DNS configurations (DoH, VPN), This may be further refined by other solutions.

The pre-established traffic filters are used to steer DNS requests to the closest Local DN or DNAI for EAS discovery. The L-DNS may add an edns-client-subnet (ECS) EDNS0 option before using recursive requests to reach an authoritative DNS server for the target domain.

#### 6.22.1.4 DNS resolution before and after Dynamic UL CL/BP /L-PSA insertion

The LDNSR is configured as DNS server to the UE during PDU session establishment by SMF via PCO.

LDNSR have visibility of the DNS parameters. In case DoT [10], DoH [11] or DNS over DTLS[x1] is used, LDNSR terminates the DNS security. The LDNSR is operated by the serving PLMN. LDNSR does not apply in case the security (e.g. for DoT) of the interaction between the UE and its DNS server shall be terminated in a 3rd party (corporate) domain.

NOTE: UL CL/BP/L-PSA insertion in HR case is not supported in Release 17.

The EAS discovery can happen in two phases:

**- Phase 1: Before Dynamic UL CL/BP/L-PSA insertion**

 **Option 1:** LDNSR receives UL DNS query, inserts an ECS option, which includes an IP address/prefix obtained from SMF, into the DNS query and sends to C-DNS. The ECS option is related with the user location and possibly the requested FQDN.

 **Option 2a:** LDNSR receives UL DNS query, and it forwards the UL DNS Query to a L-DNS. The L-DNS address is related with the user location and possibly requested FQDN.

 **Option 2b:** LDNSR receives UL DNS query determines the L-DNS address but cannot send traffic to the L-DNS directly. This is further described in clause 6.22.2.

For the above options, SMF maps user location into DNAI/Local PSA for the Application Traffic. That may reuse exsiting information defined in R16:

- Information of the topology of UPFs and N6 accesses to the DNs.

- Application Layer information received via AF influence on routing API.

- PDU Session information, e.g. any PDU Session Local PSA.

And then, depending on the option, SMF provides to LDNSR either a L-DNS (options 2a&b) or ECS (option 1) related to the selected DNAI/Local PSA.

For above options, the SMF is notified by the LDNSR when conditions on the DNS response are met. These conditions are set by the SMF. Upon such notifications the SMF triggers UL CL/L-PSA insertion. In order to support different scenarios, LDNSR may be requested to notify SMF based on, EAS IP address in DNS response and/or FQDN.

As an optimization and if DNS request is sent in clear, SMF may optionally configure UL CL to local route some subsequent DNS queries based on FQDNs supported by the Local DN/DNAI. This corresponds to option 3 described as part of phase 2 below.

**- Phase 2: After Dynamic UL CL/BP/L-PSA is inserted**

 Unless configured to be locally routed (see option 3), LDNSR receives subsequent DNS Queries.

 For queries related to that same FQDN from same UE, LDNSR can follow the procedure as described in Options 1&2 above (e.g. when previous decisions should be reconsidered).

 For requests related to new FQDNs, the process is as described in Phase 1. The information of the already inserted UL CL/BP/ Local PSA can also be considered in Option 1 & 2 above.

 When LDNSR is configured to apply UE redirect for an FQDN, ULCL has also been configured by SMF to locally divert to Local PSA the DNS Queries to L-DNS (e.g. on Destination IP address).

 **Option 3:**

 **Option 3a:** the SMF notifies the UE with the address of local DNS resolver or L-DNS server through PCO in PDU session modification command. And SMF is responsible for the DNS address selection based on location, subscription and/or local policy. The ULCL forwards the DNS query to the local PSA based solely on inspection of L3/L4 information on packet header. UPF(PSA) routes the DNS query to the local DNS resolver or L-DNS server. The DNS query can be processed in local DNS resolver or L-DNS server based on current DNS mechanism. The local DNS resolver or L-DNS server may do recursive DNS resolution to other DNS servers.

 **Option 3b:** If in Phase 1, the SMF has configured that a FQDN query can be locally routed on the UL CL, then the subsequent DNS queries for the FQDN will be locally routed to the Local DNS Resolver. The local DNS resolver receives and handles the DNS Query that is addressing LDNSR: modifies the packet's destination IP address (corresponding to LDNSR) to that of the L-DNS and stores the original IP address (LDNSR IP) and the packet's source IP address (corresponding to UE's IP address) to its own (i.e. the local DNS resolver's) IP address and stores the original source IP address (UE IP) for later processing. The local DNS resolver then forwards the modified DNS request to the L-DNS, if the L-DNS can resolve the IP address, it responds to the local DNS resolver with the IP address of EAS; otherwise, it does recursive DNS resolution.

NOTE: Option 3b assumes that either ULCL steering is based on L4 information (i.e. DNS port number) or 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 request. To support this the UPF would only need to support FQDN domain based PDR.

NOTE: The Local DNS Resolver can be deployed in an operator-controlled domain

The above options for the EAS discovery using LDNSR can be described in Figure 6.22.1.4-1.



Figure 6.22.1.4-1: Options for the EAS discovery using LDNSR for PDU session breakout

### 6.22.2 Procedures



Figure 6.22.2-1: DNS resolving in session breakout scenario

The AF may provide EAS deployment information to UDR via Nnef\_TrafficInfluence, this includes FQDNs, IP addresses/prefixes, Local DNS resolver/server IP address per DNAI.

The SMF gets the information from PCF (PCC rule) during PDU session establishment. During PDU Session Establishment procedure, the address of C-DNS server or LDNSR is provided by SMF via PCO to UE (LDNSR is provided if Dynamic UL CL/L-PSA insertion applies). Steps 1 - 6 are processed for each DNS request if UL CL/BP is not inserted or if UL CL/BP is not configured to locally route DNS query to local PSA after insertion.

For the "pre-established" ULCL/BP/L-PSA scenario, the SMF performs UL CL/BP/L-PSA selection and insertion based on UE location and sets up uplink filter rule on UL CL/BP. Steps 1and 8 are processed for each DNS request if UL CL/BP is configured to route DNS query to Local PSA. . Also Steps 1 and 8 are processed for each DNS request in the dynamic case for option 3. Step7 may happen any time, and among other, it may update the Local DNS Revolver/L-DNS in the UE. The procedures in 6.22.1.3 may be used to configure L-DNS address in UE using PCO during PDU Session Establishment.

The SMF may provide to the LDNSR

 Option 1: The ECS option (IP address corresponding to DNAI available to UE's location).

 Option 2a: The address of L-DNS server serving the DNAI available to UE's location.

 Option 2b: Indicates LDNSR to forward DNS query with FQDN(s) corresponding to DNAI which has no direct connectivity to LDNSR.

Editor's note: It is FFS whether at PDU session establishment, the SMF needs to notify the LDNSR AF (without involving NEF or PCF) on PDU Session Status including SMF ID, GPSI and UE IP address. This need depends on the nature of the interface between SMF and LDNSR.

Based on the UE location, at PDU session establishment and during UE mobility the SMF may provide the LDNSR with ECS option and L-DNS server address for the relevant FQDNs.

The SMF may also provide the IP range(s) that shall trigger the LDNSR to notify SMF when the IP address (of EAS) in DNS response is within one of these the IP range(s). LDNSR could also be instructed to notify SMF when certain FQDN in the DNS response is matched.

At PDU session establishment and during UE mobility, the SMF may provide the LDNSR with the FQDNs that, when received in the DNS query, will trigger the LDNSR to fetch the forwarding parameters from the SMF (option 1 and 2a) or forward the DNS query to the SMF (option 2b) in step 3 of the following procedure.

1. The UE sends a DNS query including the requested FQDN.

2. If an ULCL/BP exists and the DNS query matches the uplink filter rule on UL CL/BP to route the DNS query to Local PSA, then step 3 to 6 are skipped. Otherwise the PSA1 UPF forwards the received DNS query to the LDNSR.

3. Based on the configuration received from the SMF for the FQDN in the DNS query, the LDNSR determines the forwarding parameters:

 Option 1: The IP address to add as ECS DNS option. This IP address may correspond to the DNAI/Local PSA selected by the SMF for the UE location and a target domain.

 Option 2a (with direct connectivity between LDNSR and L-DNS): The address of L-DNS server towards which to propagate a DNS request. This L-DNS address may correspond to the DNAI associated by the SMF with the UE location and a target domain..

 Option 2b (without direct connectivity between LDNSR and L-DNS): The LDNSR requests the SMF to forward a DNS query (in step 5).

 The LDSNR may have these forwarding parameters as part of the instructions received from SMF before or may fetch these forwarding parameters from the SMF by providing the FQDN to the SMF in this step.

4a-4b: Option 1: The LDNSR adds the IPv4 subnet or IPv4 address or IPv6 prefix provisioned by SMF in step 3 as ECS option as specified in RFC 7871 and sends it to C-DNS server. The C-DNS returns the DNS response including EAS IP address.

4c-4d: Option 2a (with direct connectivity between LDNSR and L-DNS): the LDNSR sends the DNS query to the L-DNS server provisioned by SMF and get the DNS response including the EAS IP address.

For both 4a-4b and 4c-4d, After receiving the DNS response, the LDNSR may notify SMF with IP address of EAS and FQDN if certain criteria set by SMF are matched, e.g., the IP address of EAS in DNS response is within the IP range(s) indicated by SMF, or the FQDN is matched. Then, SMF decides whether to trigger the insertion of the ULCL/Local PSA.

5a. The SMF decides DNAI and performs UL CL/L-PSA selection and set up. The DNAI and UL CL/Local PSA2  are selected based on the information provided by LDNSR to ensure the selected local PSA and EAS are corresponding to same DNAI.

 Option 2b: If the LDNSR requested the SMF to forward the DNS query in step 3, the SMF sends the DNS query to the address of the local DNS server via the Local PSA2 . The SMF configures the Local PSA2  to forward the DNS response to the SMF. When receiving the DNS response, the SMF forwards it to the LDNSR. After receiving the DNS response, the LDNSR may notify the SMF with IP address of EAS as in option 1 and 2a. The SMF may perform update of the ULCL/L-PSA based on this notification as in option 1 and 2a..

 Optionally, the SMF may configure the L-DNS address into ULCL to be diverted to L-PSA. In order to redirect subsequent DNS queries directly to the L-DNS, the LDNSR acts as an iterative DNS server and redirects the DNS Query to the L-DNS selected for the UE Location by responding with a referral to the UE. This triggers the UE to send a new DNS query towards the L-DNS.

 As an optimization, the SMF may configure uplink forwarding rules on UL CL to route the traffic and (if the SMF is configured to determine that the DNS traffic is not encrypted) subsequent DNS queries for FQDNs corresponding to the DNAI to the Local PSA2  (as option 3a in step 7).

5b. In the case of IPv6 multi-homing, the SMF notifies the UE of the availability of the new IP prefix @ PSA2  using an IPv6 Router Advertisement message (RFC 4861 [32]). Optionally, in this RA message, the SMF may notify UE the new address of DNS server (RFC 8106 [33]) and indicate the UE to contact with DHCP server to get the DNS-related configuration information (RFC 4861 [32]), which is used to select DNS server for a target FQDN (RFC 6731 [26]).

 Also, the SMF sends 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(RFC 4191 [29]) as described in TS 23.501 [2] clause 5.8.2.2.2. The SMF may re-configure the UE for the Source IP prefix @ PSA1.

6. The LDNSR sends DNS response to UE via PSA1.

 In the case of IPv6 multi-homing, if the DNS-related information is configured on UE, the UE decides the DNS server to use for the subsequent DNS queries. Otherwise, the UE uses the DNS server address provided in the PCO during PDU session establishment. Further, the UE selects the source IP prefix based on the IPv6 multi-homed routing rule provided by SMF.

7. The SMF may send PDU session modification command with the local DNS resolver/L-DNS server address via ePCO to the UE. And then the UE updates the DNS server address accordingly.

8. Option 3a and "pre-established" case: Based on the uplink forwarding rules, if an ULCL exists and the query matches the uplink filter rule on UL CL, the UL CL route the DNS query to local PSA , and then local N6 routing forwards to Local DN. If no filter is present in ULCL, the DNS request is routed to PSA-1. AF influenced routes with anycast service address may be used to provision PCF which is then used during PDU session establishment to setup traffic filters in ULCL. All application traffic including Do53, DoT and DoH requests are steered using this mechanism.

 The DNS query may be routed to a local DNS resolver/L-DNS which then resolves the DNS Query or forwards it for resolution. It may derive an ECS option (using locally configured value or the source address/prefix of the received DNS request), then send the DNS query to Authoritative DNS server using the ECS option. Alternatively, the DNS query may be routed to C-DNS via Local N6 or DN. The deployment should ensure the DNS query packet has topologically correct UE source address when DNS resolver gets it, e.g. via NAT in Local DN. See Figure 6.22.1.4-1.

 The local DNS resolver or C-DNS server sends DNS response to the UE by retracing the forward path.

 Option 3b:

a. The local DNS resolver modifies the packet's destination IP address (corresponding to LDNSR) to that of the L-DNS and stores the original IP address (LDNSR-IP) and the packet's source IP address (corresponding to UE's IP address) to its own (i.e. the local DNS resolver's) IP address and stores the original source IP address (UE-IP) for later processing.

b. The local DNS resolver then forwards the modified DNS request to the L-DNS and processes as follows:

- If the L-DNS can resolve the IP address for the requested FQDN of EAS, it responds to the local DNS resolver with the desired IP address of the local EAS.

- If the L-DNS cannot resolve the IP address for the requested FQDN of EAS but it is connected to a C-DNS, it communicates with the C-DNS to recursively resolve the EAS IP address.

NOTE 6: Option 1 and 2 can be still applicable in Phase 2 if the requested FQDN is not configured to be local routed on the UL CL or the DNS traffic is encrypted.

NOTE 7: Option 3 can be applied when SMF is configured to know that there is connectivity between local DN and central DN.

#### 6.22.2.1 Mapping of GPSI from UE IP address

Editor's note: This whole clause is FFS. If the LDNSR is part of UPF, the clause is not needed. This also relates to the FFS whether the SMF provides the ECS option / address of L-DNS server during PDU session establishment or during UE mobility or whether the LDNSR fetches the information from SMF;

The LDNSR AF subscribes to the NEF on "PDU Session Status" events for the UE (TS 23.502 [3] Table 4.15.3.1-1); the LDNSR AF uses the GPSI to identify the UE (TS 23.502 [3] clause 5.2.6.2.2 Nnef\_EventExposure\_Subscribe operation). The subscription can be done contextually with AF influence on traffic routing (TS 23.502 [3] clause 4.3.6.1).

At PDU Session establishment the SMF notifies the AF on the PduSessionStatus including the SMF ID, the UE IP address (TS 29.508 [31] clause 4.2.2.2) and the GPSI. Finally, the LDNSR AF stores the association between GPSI and UE IP address and the SMF ID. This option does not have any new requirement to 3GPP specifications.

### 6.22.3 Impacts on services, entities and interfaces

**UE:**

- In case of IPv6 multi-homing, the UE receives the DNS-related configuration information for the PDU Session and selects the DNS server to be used for DNS queries of a specific FQDN.

**SMF:**

- Configure UE with the address of LDNSR as the DNS server during PDU session establishment via PCO.

- the SMF provides the LDNSR with:

- Option 1: the IP address to add as ECS DNS option.

- Option 2a (with direct connectivity between LDNSR and L-DNS): the address of L-DNS server towards which to propagate a DNS request.

- Option 2b (without direct connectivity between LDNSR and L-DNS) the requirement (with relevant filters) to forward a DNS request to the SMF

- Conditions on the DNS response that request LDNSR to notify the SMF

- Dynamically (upon LDNSR notifications) inserts ULCL and local PSA and optionally configures the traffic routing rule to ULCL/BP for subsequent DNS queries targeting FQDNs supported by the DNAI.

- In case of IPv6 multi-homing, the SMF indicates the UE to contact the DHCP server to get the DNS-related configuration information for the PDU Session.

**UPF:**

UPF as an ULCL:

- Optionally, the ULCL is configured with uplink forwarding rules to route the traffic and DNS queries for FQDNs ranges to the Local PSA WG2 (assuming DNS traffic is not ciphered).

**LDNSR:**

- LDNSR is a standalone Network Function.

- performs the role of a DNS Resolver and performs interactions with the SMF via service based interface.

- the LDNSR is configured by the SMF with:

- Option 1: the IP address to add as ECS DNS option.

- Option 2a (with direct connectivity between LDNSR and L-DNS): the address of L-DNS server towards which to propagate a DNS request.

- Option 2b (without direct connectivity between LDNSR and L-DNS) the requirement (with relevant filters) to forward a DNS request to the SMF

- Conditions on the DNS response that request LDNSR to notify the SMF

- The handling of DNS message in the LDNSR:

- Option 1: the LDNSR adds ECS option in DNS query message.

- Option 2a: the LDNSR redirects the DNS query to the L-DNS.

- Option 2b: the LDNSR forwards the DNS query to the SMF and receives the DNS response from SMF.

- The LDNSR may be provided with the IP range(s) and indicated by SMF to notify the IP address of EAS (in DNS response) to SMF if the IP address of EAS in DNS response matches the IP range(s). The LDNSR may also notify the IP address and FQDN in the DNS response to SMF if FQDN is matched.

**Local DNS Resolver:**

- Option 3b: Store the original DNS Request from UE, generate a DNS Request by modifying the source and destination IP addresses of the UE originated DNS Request and send the DNS Request to L-DNS Server.

NOTE: Whether the IP address modification in DNS Request as proposed in option3b can be used in deployment or not is subject to local regulations.

**PCF**

- Optionally allow AF to provide PCF with Traffic Influence routing per service address

\* \* \* \* End of changes \* \* \* \*