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1 Scope

The present document describes Domain Name System (DNS) Procedures for the Evolved Packet System. This document covers the Evolved Packet Core gateway node selection using DNS (e.g. SGW and PGW nodes) excluding all User Equipment (UE) initiated DNS-based discovery and selection procedures.

The present document specifies functions, procedures and information which apply to GERAN Iu mode. However, functionality related to GERAN Iu mode is neither maintained nor enhanced.

The present document also describes the Domain Name System (DNS) Procedures for the Evolved Packet System interworking with the 5G System, as specified in 3GPP TS 23.501 [28] and 3GPP TS 23.502 [29].

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.
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- 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] IETF RFC 1034: "DOMAIN NAMES - CONCEPTS AND FACILITIES".
- [3] IETF RFC 1035: "DOMAIN NAMES - IMPLEMENTATION AND SPECIFICATION".
- [4] 3GPP TS 23.003: "Numbering, addressing and identification".
- [5] GSMA PRD IR.67: "DNS Guidelines for Operators" Version 2.1.0.
- [6] IETF RFC 3596: "DNS Extensions to Support IP Version 6".
- [7] IETF RFC 3403: "Dynamic Delegation Discovery System (DDDS) Part Three: The Domain Name System (DNS) Database".
- [8] IETF RFC 2782: "A DNS RR for specifying the location of services (DNS SRV)".
- [9] IETF RFC 3958: "Domain-Based Application Service Location Using SRV RRs and the Dynamic Delegation Discovery Service (DDDS)".
- [10] IETF RFC 3401: "Dynamic Delegation Discovery System (DDDS) Part One: The Comprehensive DDDS".
- [11] 3GPP TS 23.401: "GPRS enhancements for E-UTRAN access".
- [12] 3GPP TS 25.413: "UTRAN Iu interface RANAP signalling".
- [13] IETF RFC 2671: "Extension Mechanisms for DNS (EDNS0)".
- [14] IETF RFC 3402: "Dynamic Delegation Discovery System (DDDS) Part Two: The Algorithm".
- [15] IETF RFC 2308: "Negative Caching of DNS Queries (DNS NCACHE)".
- [16] IETF RFC 3330: "Special Use IPv4 Addresses".
- [17] IETF RFC 3849: "IPv6 Address Prefix Reserved for Documentation".
- [18] 3GPP TS 23.060: "General Packet Radio Service (GPRS); Service Description; Stage 2".

- [19] 3GPP TS 36.413: "Evolved Universal Terrestrial Access Network (E-UTRAN); S1 Application Protocol (S1AP)".
- [20] 3GPP TS 23.216: "Single Radio Voice Call Continuity (SRVCC)".
- [21] 3GPP TS 36.413: "Evolved Universal Terrestrial Radio Access Network (E-UTRAN); S1 Application Protocol (S1AP)".
- [22] 3GPP TS 36.300: " Evolved Universal Terrestrial Radio Access (E-UTRA) and Evolved Universal Terrestrial Radio Access Network (E-UTRAN); Overall description; Stage 2".
- [23] 3GPP TS 29.274: "3GPP Evolved Packet System (EPS); Evolved General Packet Radio Service (GPRS) Tunnelling Protocol for Control plane (GTPv2-C); Stage 3".
- [24] 3GPP2 X.S0057-B: "E-UTRAN - eHRPD Connectivity and Interworking: Core Network Aspects".
- [25] 3GPP TS 23.402: "Architecture enhancements for non-3GPP accesses".
- [26] 3GPP TS 29.244: "Interface between the Control Plane and the User Plane of EPC Nodes; stage 3".
- [27] 3GPP TS 29.272: "Mobility Management Entity (MME) and Serving GPRS Support Node (SGSN) related interfaces based on Diameter protocol".
- [28] 3GPP TS 23.501: "System Architecture for the 5G System; Stage 2".
- [29] 3GPP TS 23.502: "Procedures for the 5G System; Stage 2".
- [30] 3GPP TS 29.273: "Evolved Packet System (EPS); 3GPP EPS AAA interfaces".

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in 3GPP 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 3GPP TR 21.905 [1].

Domain Name System as defined in IETF RFC 1034 [2], IETF RFC 1035[3], and as used in 3GPP in 3GPP TS 23.003 [4] and GSMA PRD IR.67 [5]

The phrase "operators shall provision" in this document is intended to convey what is required to provision in DNS to provide DNS based selection for the corresponding function documented here. If there is a non-DNS procedure in an operator's network for that function then there is no functional requirement for the operator to provision such DNS records.

The term "S4-SGSN" refers to a Release-8 SGSN that has at least one set of S4/S3/S16 interfaces enabled.

The term "Release 8 SGSN supporting only Gn/Gp" refers to a Release 8 or later SGSN that either explicitly does not support S4 interfaces or all S4/S3/S16 interfaces are disabled due to operator policy. Such a node cannot use an SGW but can use a collocated PGW/GGSN. See 3GPP TS 23.401 [11] Annex D for use cases.

The term "Release-8 SGSN" applies to either case.

3.2 Abbreviations

For the purposes of the present document, the abbreviations given in 3GPP 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 3GPP TR 21.905 [1].

DCN	Dedicated Core Network
DDDS	Dynamic Delegation Discovery Service
DNS	Domain Name System
ECGI	E-UTRAN Cell Global Identification
eHRPD	evolved High Rate Packet Data
FQDN	Fully Qualified Domain Name
GUTI	Globally Unique Temporary Identity
HSGW	eHRPD Serving Gateway
LGW	Local Gateway
LIPA	Local IP Access
NR	New Radio
PGW	PDN Gateway
RAI	Routing Area Identity
SGW	Serving Gateway
SIPTO	Selected IP Traffic Offload
TAI	Tracking Area Identity
TAU	Tracking Area Update
TWAN	Trusted WLAN Access Network

4 General DNS Based Node Selection Description

4.1 Resource Records

4.1.1 A and AAAA

The A resource record is used to define IPv4 host address corresponding to fully qualified name of the host as defined in IETF RFC 1035 [3]. The AAAA resource record is used to define IPv6 host address corresponding to fully qualified name of the host as defined in IETF RFC 3596 [6].

It should be noted that in DNS A or AAAA record names, in general, represent a host and its "equivalent" interface. Host names, in general, cannot be used as node names. A node may need to have more than one host name for the simple reason that it can have multiple interfaces for different purposes.

4.1.2 NAPTR

The NAPTR resource record is defined in IETF RFC 3403 [7] and is a powerful tool that allows DNS to be used to lookup services for a wide variety of resource names, which are not in domain name syntax. NAPTR would be used by a client program to rewrite a string into a domain name. The rewrite process is controlled by flags that provide information on how to communicate with the host at the domain name that was the result of the rewrite. If DNS returns multiple NAPTR resource records those can be prioritized using embedded order and preference values defined by the DNS administrator.

The S-NAPTR procedure i.e., the "Straightforward-NAPTR" procedure, is defined in IETF RFC 3958 [9] and describes a Dynamic Delegation Discovery System (DDDS) [10] application procedures on how to resolve a domain name, application service name, and application protocol dynamically to target server and port by using both NAPTR and SRV (see IETF RFC 2782 [8]) resource records. The S-NAPTR also simplifies the use of NAPTR by limiting the NAPTR flags only to "a", "s" and "". Furthermore, only NAPTR "replacement" expressions are allowed, not "regular expressions", during the rewrite process. The changes compared to IETF RFC 3403 [7] NAPTR usage are procedural and are limited only to the resolver. The S-NAPTR use of the NAPTR resource record is exactly the same as defined in IETF RFC 3403 [7] from the DNS server and DNS infrastructure point of view. Additional information on S-NAPTR usage is provided in Annex B and Annex C.

The NAPTR resource record flags "s" and "" allow another layer of indirection in the DNS configuration. The "" flag causes the S-NAPTR procedure to query for new NAPTR resource records from the DNS infrastructure. The "s" flag causes the S-NAPTR procedure to query for an intermediary SRV resource record pointing to A/AAAA resource records. This additional query provides a selection mechanism by which the operator is able to assign different weights to different A/AAAA resource records while larger weights are given a proportionately higher probability of being selected. A DNS server might provide the A/AAAA records together with the SRV resource records as per IETF RFC

2782 [7]. The length of the NAPTR resource record indirection chain enabled using the "" flag is unbounded and may lead to a deep chaining of resource records over time in the DNS configuration. Additional layer of indirection and possible deep chaining both grows the DNS configuration significantly in size and complexity, and also makes the configuration prone to hard to trace errors. The use of NAPTR resource record "" flag pointing to other NAPTR resource records with flag "" is strongly discouraged. Specifically, NAPTR resource flag "" should only be provisioned to point to terminal NAPTR records (i.e., flag "a" or flag "s"). Generally, the use of flag "a" or of flag "s" is encouraged.

4.1.3 SRV

The SRV resource record is defined in IETF RFC 2782 [8] and allows DNS administrators to use pool of servers for a single domain with static load balancing to each server, to move services from host to host, and to designate some hosts as primary servers for a service from a pool of hosts. A resolver can ask for a specific service/protocol combination for a specific domain name and get back a Fully Qualified Domain Names (FQDN) of any available servers.

4.2 Selecting Domain Names

When using the S-NAPTR procedure under the DDDS framework, it becomes essential which domain name gets used for querying the actual NAPTR records. In the S-NAPTR procedure, the Application-Unique String used by the DDDS algorithm is the starting domain name for which the information of the services, protocols and actual canonical node names are sought. Related to the Application-Unique String, the First well-Known Rule of the DDDS algorithm in the S-NAPTR procedure outputs the same domain name that constitutes the Application-Unique String. For each node type in EPC that can be queried for information using the S-NAPTR procedure, the authoritative DNS server for the given domain should be provisioned with unique domain name for each EPC node or other identifier that is explicitly specified by a procedure in this specification (for example one based on APN, TALGUTI, etc) and corresponding NAPTR records. The authoritative DNS server for a given domain shall provision at least the EPC node names that may be exposed to the inter-operator roaming interfaces.

4.3 Identifying Nodes, Services and Protocols

4.3.1 IETF RFC 3958 Service and Protocol service names for 3GPP

Service and protocol service names for the S-NAPTR procedure shall be used in accordance with 3GPP TS 23.003 [4], subclause 19.4.3.

4.3.2 Identification of canonical node names

There are many use cases where it is desirable to select a collocated node in preference to a non-collocated node, or a topologically closer (with respect to the network topology) node in preference to a less topologically closer node. To easily do this action a "canonical" node name shall be employed so that the "canonical" node names from two or more sets of records can be compared to see if nodes are actually the same nodes, or topologically closer nodes.

In DNS neither A or AAAA host names, in general, represent a node name, but rather a set of "equivalent" interfaces. A node may need to have more than one host name for the simple reason that it can have different interfaces for different purposes. For example, a node can have a set of roaming interfaces on a completely different network than the internal network due to security needs. Hence, there are always situations where multiple A/AAAA record sets must exist that implies multiple distinct host names. Therefore, host names, in general, cannot be used as node names.

Instead of creating new DNS records to map a host name to a node name this specification defines how host names shall be constructed and used in S-NAPTR procedure within 3GPP EPC.

The host names shall have form:

<"topon" | "topoff"> . <single-label-interface-name> . <canonical-node-name>

Where the first label is "topon" or "topoff" to indicate whether or not collocated and topologically close node selection shall be preferred, "single-label-interface-name" is a single label used to name a specific interface on a node (e.g. Eth-0, S8, vip, board3), "canonical-node-name" is the canonical node name of a specific node. A node shall have exactly one canonical node name so a host name always includes the unique canonical node name of the node. Hence, when

comparing the host name FQDNs to find out whether the nodes are actually the same, the first two labels of the host name FQDN shall be ignored.

NOTE 1: The canonical node name is not related to canonical name in the CNAME DNS record.

When using host names with "topon" as the first label the canonical node names of nodes shall be hierarchically structured to allow an operator to reflect the topological closeness of two nodes by naming the nodes with canonical node names sharing a common suffix domain name. The number of labels in the common suffix shall represent how close the operator considers them during node selection. The higher the number of labels in the common suffix is, the closer the nodes are. In other words, two topologically closest nodes are those with the longest matching suffix in their respective canonical node names.

The following list contains examples of domain names where canonical node names are in bold:

topon.Eth-0.**gw32.california.west. example.com**

topon.S8.**gw32.california.west. example.com**

topon.vip.**sgw3.oregon.west. example.com m**

topon.board3.**pgw1.cluster1.net27. example.net**

topon.S5.**gw4.cluster1.net27. example.net**

topon.board3.**pgw1.cluster2.net27. example.net**

In the examples above, "Eth-0.gw32.california.west.example.com" and "S8.gw32.california.west. example.com" are two different interfaces on the same node, "gw32.california.west. example.com". On the other hand, "gw4.cluster1.net27.example.net" is topologically closer to "pgw1.cluster1.net27. example.net" (they are both connected to the "cluster1.net27. example.net" subnetwork) than to "pgw1.cluster2.net27. example.net" (only connected to the wider "net.27. example.net" subnetwork.)

Interface names and node names do NOT identify a function in the procedures here. The interface is part of the natural hierarchy within a node and the host name is already returned with the existing DNS records. The approach of identifying a canonical node name from a host name is believed to be simpler and more logical to maintain than creating additional DNS records simply to return a node name.

The topologically aware naming restriction (i.e. the format above using "topon" or "topoff") shall be placed only on all targets/replacements pointing logically to a A/AAAA record sets from the S-NAPTR procedure. These targets/replacements are denoted host names here (following the normal DNS terminology unless a CNAME is used to point to the actual A or AAAA record). This restriction shall NOT apply to any other DNS records the operator may be using.

Specifically, a NAPTR with flag "a" will have a replacement target pointing to the A/AAAA record directly, thus the topologically aware naming restriction on the host name applies to the replacement in the NAPTR record with a flag "a". For the NAPTR flag "s" case the topologically aware naming restriction on the host name applies to the target in the SRV record, and not the NAPTR record replacement. For the NAPTR empty flag "" case the topologically aware naming does not apply any restriction since this is not a host name. Other flags are not used in S-NAPTR.

During DNS provisioning for the S-NAPTR procedure the operator is free to add another layer of indirection using a CNAME record (see section 6.6.2 of IETF RFC 1034 [2]).

While operators shall provision host names in DNS according to the above rules, it is still possible that the host name might be incorrectly configured (i.e. not conforming to the above format with first label of "topon" or "topoff"). For such misconfigured records implementations shall treat the misconfigured host name as valid within the S-NAPTR procedure where that host name was found, but may favor correctly configured records. Misconfigured host name for topological matching and colocation checks shall be treated as if the misconfigured host name had the label "topoff." prepended. Operators shall not depend on this behavior.

The order of using DNS records to contact a node is based on following ordering. When collocation of a pair of node types is explicitly stated as applicable in a procedure, collocation of the nodes shall have high est importance . When topological matching is explicitly stated as applicable in a procedure then topological matching with "topon", is of second highest importance. Then finally the ordering obtained by the S-NAPTR output . When collocation and topological ordering applies, collocated sets of nodes have highest importance, then sets of nodes with "topon" and the most labels in their common suffix, then sets of nodes with "topon" and second most number of labels and so on until

we reach non-colocated nodes with "topoff" and within sets with same colocation or topological order then S-NAPTR order of one of the two nodes is used (specified in the specific procedure). Additional informative clarifications on how S-NAPTR is employed in the context of 3GPP EPC node usage and specifically how topological matching using the "topon" label interacts with S-NAPTR ordering is provided in Annex C.4.

4.3.3 Services from node names or other FQDN identifying a service

4.3.3.1 General

There are potential use cases where a node has a logical name of a peer or other FQDN identifier for a service but does not have the protocols it supports. The NAPTR record for any of the services can be provisioned at the nodes logical name or other FQDN identifier for a service. The node logical name or other FQDN identifier for a service is equal to the domain name under which NAPTR records are provisioned. This allows any core network node to discover the available services based on node's logical name or other FQDN identifier for a service.

4.3.3.2 Procedure

4.3.3.2.1 S-NAPTR Procedure - General

These procedures are employed when any core network node has the FQDN of an entity and needs to find one or more services at that entity.

NOTE: There are three likely sources of the entity name. O&M provisioned, 3GPP specified based on some other identifier of a service (such as GUTI, TAC, IMSI, MISDN etc.), or the canonical node name obtained from a previous S-NAPTR procedure. Note that a node can have more than one name, i.e. an alias, but there shall be only one canonical node name for a node. (CNAME records are a way to create aliases for the canonical node name or any other FQDN as per IETF RFC 1034 [2])

The S-NAPTR procedure requires that DNS NAPTR records shall be consistently provisioned as described in IETF RFC 3958 [9]. This means a NAPTR record for each protocol using "a" flag and the service field populated with the service and proto value may be provisioned. If a more sophisticated load balancing or non-standard ports are desired, NAPTR with "s" flag for each protocol and the corresponding SRV records with relative weighting for each interface need to be provisioned. NAPTR records with empty "" flag records may also be used.

A DNS resolver that intends to use the S-NAPTR procedure shall use the FQDN of the node or a specified FQDN identifier of a service as the Application-Unique String. If all protocols are desired, then the resolver simply runs the S-NAPTR procedure as if all protocols match.

The S-NAPTR procedure logically outputs a list of host names each with a service, protocol, port and a list of IPv4 and IPv6 addresses. This list can be obtained one host name at a time, in a procedure similar to Annex C.2, or a complete ordered list of all nodes, in a procedure similar to Annex C.3. Such a complete list obtained from an S-NAPTR procedure is referred here as a candidate list.

NOTE: The candidate list is valid for at most for finite period of time due to DNS time to live and order of the records can change due to statistical selection. Operators should provision records with reasonable time to live values.

4.3.3.2.2 S-NAPTR Procedure for a canonical node name

One very important special case is S-NAPTR based on a node's canonical node name.

Operators shall provision NAPTR records for all enabled interfaces of a node that are explicitly listed in subclause 19.4.3 of 3GPP TS 23.003 [4] at the FQDN of the node's unique canonical node name.

NOTE 1: Exception to this rule: The NAPTR records for x-3gpp-mme: x- s1-mme and x-3gpp-sgw:x-s1-u from subclause 19.4.3 of 3GPP TS 23.003 [4] are to be considered entirely optional in this release of 3GPP.

With such provisioning by an operator a DNS resolver can at any time use the S-NAPTR procedure with a valid canonical node name to find all interfaces and protocols supported by that node that are listed in subclause 19.4.3 of 3GPP TS 23.003 [4]. This includes interfaces of co-located functions that might not be easily discovered by other means.