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Locator/ID Separation Protocol Delegated Database Tree (LISP-DDT)  
Referral Internet Groper (RIG)

Abstract

A simple tool called the Locator/ID Separation Protocol Delegated Database Tree (LISP-DDT) Referral Internet Groper (RIG), also referred to in this document as "rig", can be used to query the LISP-DDT hierarchy. This document describes how the "rig" tool works.

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## 1. Introduction

"The Locator/ID Separation Protocol (LISP)" [RFC6830] specifies an architecture and mechanism for replacing the semantics of an address currently used by IP with two separate namespaces: Endpoint Identifiers (EIDs), used within sites; and Routing Locators (RLOCs), used on the transit networks that make up the Internet infrastructure. To achieve this separation, LISP defines protocol mechanisms for mapping from EIDs to RLOCs. In addition, LISP assumes the existence of a database to store and propagate those mappings globally. This document focuses on the LISP Delegated Database Tree (LISP-DDT) [RFC8111] mapping database system.

The "rig" tool is a manual management tool to query the LISP-DDT mapping database hierarchy. It can be run by all devices that implement LISP, including Ingress Tunnel Routers (ITRs), Egress Tunnel Routers (ETRs), Proxy ITRs (PITRs), Proxy ETRs (PETRs), Map-Resolvers, Map-Servers, and LISP-DDT nodes, as well as by a host system at either a LISP-capable or non-LISP-capable site.

The LISP-DDT "rig" tool is similar to the "LISP Internet Groper" ("lig") tool [RFC6835] in that they are both diagnostic tools to query a database. However, the "rig" tool is used to find Map-Servers serving an EID-prefix, specifically within a LISP-DDT mapping database framework. And "lig" can be used on top of any mapping database system to retrieve locators used for packet encapsulation.

## 2. Requirements Language

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in BCP 14 [RFC2119] [RFC8174] when, and only when, they appear in all capitals, as shown here.

## 3. Definitions of Terms

**Endpoint Identifier (EID):** a 32-bit (for IPv4) or 128-bit (for IPv6) value (or an address encoded per [RFC8060]) used in the source and destination address fields of the first (innermost) LISP header of a packet. The host obtains a destination EID the same way it obtains a destination address today -- for example, through a Domain Name System (DNS) [RFC1034] lookup or a Session Initiation Protocol (SIP) [RFC3261] exchange. The source EID is obtained via existing mechanisms used to set a host's "local" IP address. An EID used on the public Internet must have the same properties as any other IP address used in that manner; this means, among other things, that it must be globally unique. An EID is allocated to a host from an EID-prefix block associated with the site where the host is located. An EID can be used by a host to refer to other hosts. EIDs MUST NOT be used as LISP RLOCs. Note that EID blocks MAY be assigned in a hierarchical manner, independent of the network topology, to facilitate scaling of the mapping database. In addition, an EID block assigned to a site may have site-local structure (subnetting) for routing within the site; this structure is not visible to the global routing system. In theory, the bit string that represents an EID for one device can represent an RLOC for a different device. As the architecture is realized, if a given bit string is both an RLOC and an EID, it must refer to the same entity in both cases. When used in "discussions" with other Locator/ID separation proposals, a LISP EID will be called an "LEID". Throughout this document, any references to "EID" refer to an LEID.

**Extended EID (XEID):** a LISP EID, optionally extended with a non-zero Instance ID (IID) if the EID is intended for use in a context where it may not be a unique value, such as in a Virtual Private Network where private address space [RFC1918] is used. See Section 5.5 of [RFC6830] for more discussion of IIDs.

**Routing Locator (RLOC):** an IPv4 [RFC791] or IPv6 [RFC2460] address of an Egress Tunnel Router (ETR). An RLOC is the output of an EID-to-RLOC mapping lookup. An EID maps to one or more RLOCs. Typically, RLOCs are numbered from topologically aggregatable blocks that are assigned to a site at each point to which it

attaches to the global Internet; where the topology is defined by the connectivity of provider networks, RLOCs can be thought of as Provider-Assigned (PA) addresses. Multiple RLOCs can be assigned to the same ETR device or to multiple ETR devices at a site.

**DDT node:** a network infrastructure component responsible for specific XEID-prefix(es) and for the delegation of more-specific sub-prefixes to other DDT nodes.

**DDT client:** a network infrastructure component that sends DDT Map-Request messages and implements the iterative following of Map-Referral results. Typically, a DDT client will be a Map-Resolver (as defined by [RFC6833]), but it is also possible for an ITR to implement DDT client functionality. A DDT client can be a device that is originating "rig" requests.

**DDT Map-Server:** a DDT node that also implements Map-Server functionality (forwarding Map-Requests and/or returning Map-Replies if offering a proxy Map-Reply service) for a subset of its delegated prefixes. Map-Server functions, including proxying Map-Replies, are described in [RFC6833].

**DDT Map-Resolver:** a network infrastructure element that accepts a Map-Request, adds the XEID to its lookup queue, then queries one or more DDT nodes for the requested EID, following returned referrals until it receives one with the MS-ACK action code [RFC8111]. This indicates that the Map-Request has been sent to a Map-Server that will forward it to an ETR that, in turn, will provide a Map-Reply to the original sender. A DDT Map-Resolver maintains both (1) a cache of Map-Referral message results (termed the "referral cache") containing RLOCs for DDT nodes responsible for XEID-prefixes of interest and (2) a lookup queue of XEIDs that are being resolved through iterative querying of DDT nodes.

**Encapsulated Map-Request:** a LISP Map-Request that is carried within an Encapsulated Control Message (ECM) and that has an additional LISP header prepended. Sent to UDP destination port 4342. The "outer" addresses are globally routable IP addresses, also known as RLOCs. Used by an ITR when sending a Map-Request to a Map-Resolver and by a Map-Server when forwarding a Map-Request to an ETR as documented in [RFC6833].

**Map-Referral:** a LISP message sent by a DDT node when it receives a DDT Map-Request for an XEID that matches a configured XEID-prefix delegation. A non-Negative Map-Referral message includes a "referral" -- a set of RLOCs for DDT nodes that have more information about the sub-prefix; a DDT client "follows the

referral" by sending another DDT Map-Request to one of those RLOCs to obtain either an answer or another referral to DDT nodes responsible for a more-specific XEID-prefix.

Authoritative XEID-prefix: an XEID-prefix delegated to a DDT node and for which the DDT node may provide further delegations of more-specific sub-prefixes.

#### 4. Basic Overview

LISP-DDT [RFC8111] is a hierarchical distributed database that embodies the delegation of authority to provide mappings from LISP EIDs to RLOCs. It is a statically defined distribution of the EID namespace among a set of LISP-speaking servers called "DDT nodes". Each DDT node is configured as "authoritative" for one or more EID-prefixes, along with the set of RLOCs for Map-Servers or "child" DDT nodes to which more-specific EID-prefixes are delegated.

Map-Resolvers send Map-Requests to the DDT hierarchy and maintain referral caches by receiving Map-Referral messages from DDT nodes. Map-Resolvers follow the DDT hierarchy for a given EID lookup based on the EID-prefix and delegation referrals contained in the Map-Referral messages. The "rig" tool is intended to perform the same operation as that of a Map-Resolver but to also be used as a management tool for the network administrator.

When the "rig" command is run, an Encapsulated Control Message Map-Request is sent for a destination EID. When a LISP-DDT Map-Referral is returned, the contents are displayed to the user. The information displayed includes:

- o A delegated EID-prefix configured in a DDT node or a configured site EID-prefix in a DDT Map-Server that matches the requested EID.
- o The type of DDT node that sent the Map-Referral.
- o The action code and TTL set by the sender of the Map-Referral.
- o The referral RLOC addresses from the Map-Referral message.
- o A round-trip-time estimate for the ECM-Map-Request / Map-Referral message exchange.

A possible syntax for a "rig" command MAY be:

```
rig [instance-id <iid>] <eid> to <ddt-node> [follow-all-referrals]
```

Parameter descriptions:

[instance-id <iid>]: <iid> is the IID portion of the XEID used as a VPN identifier or for other future purposes. When the DDT hierarchy is not configured with IIDs, this argument is omitted from the command line.

<eid>: <eid> is either a Fully Qualified Domain Name or a destination EID that is being queried in the LISP-DDT mapping database.

<ddt-node>: <ddt-node> is the RLOC address of any DDT node in the DDT hierarchy. This can be the DDT root node, a DDT transit node, or a DDT Map-Server.

[follow-all-referrals]: When this keyword is used, each referral RLOC is queried so "rig" can descend the entire DDT hierarchy starting from the node <ddt-node>. When this keyword is not used, one of the referral RLOCs will be selected to descend a branch of the DDT hierarchy.

The "rig" utility not only shows branches of the delegation hierarchy but can also report:

- o When a DDT Map-Server would forward a Map-Request to the ETRs at a registered LISP site. This is known as an "MS-ACK" action.
- o When a DDT Map-Server sends a Negative Map-Referral indicating that a requested EID is configured but not registered to the mapping database system. This is known as an "MS-NOT-REGISTERED" action.
- o When a DDT node is sending referrals for a transit or leaf node in the hierarchy. These are known as "NODE-REFERRAL" and "MS-REFERRAL" actions, respectively.
- o When a DDT node finds a hole in the address space that has not been allocated or configured in the delegation hierarchy. This is typically associated with a hole in a DDT node's configured authoritative prefix. This is known as a "DELEGATION-HOLE" action.

- o When a DDT node finds a hole in the address space that has not been allocated or configured in the delegation hierarchy at all. This is typically associated with a hole that is outside of a DDT node's authoritative prefix. This is known as a "NOT-AUTHORITATIVE" action.

Refer to [RFC8111] for more details about Map-Referral actions.

## 5. Implementation Details

The Cisco LISP prototype implementations on IOS and NX-OS have "rig" support for IPv4 and IPv6 EIDs in either the default instance or a non-zero IID.

The IOS syntax is:

```
rig [instance-id <iid>] <eid> to <ddt-node> [follow-all-referrals]
```

The NX-OS syntax is:

```
rig [instance-id <iid>] { <hostname> | {<eid> | <eid6>} }  
to { <ddt-hostname> | {<ddt> | <ddt6>} }
```

Here is some sample IOS output:

```
Router# rig 12.0.1.1 to 1.1.1.1
```

```
Send Map-Request to DDT-node 1.1.1.1 ... node referral, rtt: 0 ms  
EID-prefix: [0] 12.0.0.0/16, ttl: 1440  
referrals: 2.2.2.2
```

```
Send Map-Request to DDT-node 2.2.2.2 ... node referral, rtt: 0 ms  
EID-prefix: [0] 12.0.1.0/24, ttl: 1440  
referrals: 4.4.4.4, 5.5.5.5
```

```
Send Map-Request to DDT-node 4.4.4.4 ... map-server acknowledgement,  
rtt: 0 ms  
EID-prefix: [0] 12.0.1.0/28, ttl: 1440  
referrals: 4.4.4.4, 5.5.5.5
```

```
Router# rig 12.0.1.1 to 1.1.1.1 follow-all-referrals
```

```
Send Map-Request to DDT-node 1.1.1.1 ... node referral, rtt: 4 ms  
EID-prefix: [0] 12.0.0.0/16, ttl: 1440  
referrals: 2.2.2.2
```

```
Send Map-Request to DDT-node 2.2.2.2 ... node referral, rtt: 0 ms
EID-prefix: [0] 12.0.1.0/24, ttl: 1440
referrals: 4.4.4.4, 5.5.5.5

Send Map-Request to DDT-node 4.4.4.4 ... map-server acknowledgement,
rtt: 0 ms
EID-prefix: [0] 12.0.1.0/28, ttl: 1440
referrals: 4.4.4.4, 5.5.5.5

Send Map-Request to DDT-node 5.5.5.5 ... map-server acknowledgement,
rtt: 0 ms
EID-prefix: [0] 12.0.1.0/28, ttl: 1440
referrals: 4.4.4.4, 5.5.5.5
```

No more referrals to pursue.

Here is some sample NX-OS output:

```
Router# rig 12.0.1.1 to 1.1.1.1

rig LISP-DDT hierarchy for EID [0] 12.0.1.1
Send Map-Request to DDT-node 1.1.1.1 ... replied, rtt: 0.003509 secs
EID-prefix [0] *, ttl: 1440, action: node-referral, referrals:
  2.2.2.2, priority/weight: 0/0

Send Map-Request to DDT-node 2.2.2.2 ... replied, rtt: 0.003173 secs
EID-prefix [0] 12.0.0.0/20, ttl: 1440, action: node-referral,
referrals:
  3.3.3.3, priority/weight: 0/0

Send Map-Request to DDT-node 3.3.3.3 ... replied, rtt: 0.004145 secs
EID-prefix [0] 12.0.1.0/24, ttl: 1440, action: node-referral,
referrals:
  5.5.5.5, priority/weight: 0/0
  6.6.6.6, priority/weight: 0/0

Send Map-Request to DDT-node 6.6.6.6 ... replied, rtt: 0.005800 secs
EID-prefix [0] 12.0.1.0/28, ttl: 1440, action: ms-ack, referrals:
  5.5.5.5, priority/weight: 0/0
  6.6.6.6, priority/weight: 0/0
```



## 6. Security Considerations

The use of "rig" does not affect the security of the LISP infrastructure, as it is simply a tool that facilitates diagnostic querying. See [RFC6830], [RFC6833], [RFC7835], and [RFC8111] for descriptions of the security properties of the LISP infrastructure.

LISP "rig" provides easy access to the information in the public mapping database. Therefore, it is important to protect the mapping information for private use. This can be provided by disallowing access to specific mapping entries or placing such entries in a private mapping database system.

## 7. IANA Considerations

This document does not require any IANA actions.

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