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## Locator/ID Separation Protocol (LISP) Map-Server Interface

### Abstract

This document describes the Mapping Service for the Locator/ID Separation Protocol (LISP), implemented by two new types of LISP-speaking devices -- the LISP Map-Resolver and LISP Map-Server -- that provides a simplified "front end" for one or more Endpoint ID to Routing Locator mapping databases.

By using this service interface and communicating with Map-Resolvers and Map-Servers, LISP Ingress Tunnel Routers and Egress Tunnel Routers are not dependent on the details of mapping database systems, which facilitates experimentation with different database designs. Since these devices implement the "edge" of the LISP infrastructure, connect directly to LISP-capable Internet end sites, and comprise the bulk of LISP-speaking devices, reducing their implementation and operational complexity should also reduce the overall cost and effort of deploying LISP.

### Status of This Memo

This document is not an Internet Standards Track specification; it is published for examination, experimental implementation, and evaluation.

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## 1. Introduction

The Locator/ID Separation Protocol [RFC6830] specifies an architecture and mechanism for replacing the addresses currently used by IP with two separate name spaces: Endpoint IDs (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. Several such databases have been proposed; among them are the Content distribution Overlay Network Service for LISP (LISP-CONS) [LISP-CONS], LISP-NERD (a Not-so-novel EID-to-RLOC Database) [RFC6837], and LISP Alternative Logical Topology (LISP+ALT) [RFC6836].

The LISP Mapping Service defines two new types of LISP-speaking devices: the Map-Resolver, which accepts Map-Requests from an Ingress Tunnel Router (ITR) and "resolves" the EID-to-RLOC mapping using a mapping database; and the Map-Server, which learns authoritative EID-to-RLOC mappings from an Egress Tunnel Router (ETR) and publishes them in a database.

Conceptually, LISP Map-Servers share some of the same basic configuration and maintenance properties as Domain Name System (DNS) [RFC1035] servers; likewise, Map-Resolvers are conceptually similar to DNS caching resolvers. With this in mind, this specification borrows familiar terminology (resolver and server) from the DNS specifications.

Note that while this document assumes a LISP+ALT database mapping infrastructure to illustrate certain aspects of Map-Server and Map-Resolver operation, the Mapping Service interface can (and likely will) be used by ITRs and ETRs to access other mapping database systems as the LISP infrastructure evolves.

Section 5 of this document notes a number of issues with the Map-Server and Map-Resolver design that are not yet completely understood and are subjects of further experimentation.

The LISP Mapping Service is an important component of the LISP toolset. Issues and concerns about the deployment of LISP for Internet traffic are discussed in [RFC6830].

## 2. Definition of Terms

**Map-Server:** A network infrastructure component that learns of EID-Prefix mapping entries from an ETR, via the registration mechanism described below, or some other authoritative source if one exists. A Map-Server publishes these EID-Prefixes in a mapping database.

**Map-Resolver:** A network infrastructure component that accepts LISP Encapsulated Map-Requests, typically from an ITR, and determines whether or not the destination IP address is part of the EID namespace; if it is not, a Negative Map-Reply is returned. Otherwise, the Map-Resolver finds the appropriate EID-to-RLOC mapping by consulting a mapping database system.

**Encapsulated Map-Request:** A LISP Map-Request carried within an Encapsulated Control Message, which 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 to a Map-Resolver and by a Map-Server when forwarding a Map-Request to an ETR.

**Negative Map-Reply:** A LISP Map-Reply that contains an empty Locator-Set. Returned in response to a Map-Request if the destination EID does not exist in the mapping database. Typically, this means that the "EID" being requested is an IP address connected to a non-LISP site.

**Map-Register message:** A LISP message sent by an ETR to a Map-Server to register its associated EID-Prefixes. In addition to the set of EID-Prefixes to register, the message includes one or more RLOCs to be used by the Map-Server when forwarding Map-Requests (re-formatted as Encapsulated Map-Requests) received through the database mapping system. An ETR may request that the Map-Server answer Map-Requests on its behalf by setting the "proxy Map-Reply" flag (P-bit) in the message.

**Map-Notify message:** A LISP message sent by a Map-Server to an ETR to confirm that a Map-Register has been received and processed. An ETR requests that a Map-Notify be returned by setting the "want-map-notify" flag (M-bit) in the Map-Register message. Unlike a Map-Reply, a Map-Notify uses UDP port 4342 for both source and destination.

For definitions of other terms -- notably Map-Request, Map-Reply, Ingress Tunnel Router (ITR), and Egress Tunnel Router (ETR) -- please consult the LISP specification [RFC6830].

### 3. Basic Overview

A Map-Server is a device that publishes EID-Prefixes in a LISP mapping database on behalf of a set of ETRs. When it receives a Map Request (typically from an ITR), it consults the mapping database to find an ETR that can answer with the set of RLOCs for an EID-Prefix. To publish its EID-Prefixes, an ETR periodically sends Map-Register messages to the Map-Server. A Map-Register message contains a list of EID-Prefixes plus a set of RLOCs that can be used to reach the ETR when a Map-Server needs to forward a Map-Request to it.

When LISP+ALT is used as the mapping database, a Map-Server connects to the ALT network and acts as a "last-hop" ALT-Router. Intermediate ALT-Routers forward Map-Requests to the Map-Server that advertises a particular EID-Prefix, and the Map-Server forwards them to the owning ETR, which responds with Map-Reply messages.

A Map-Resolver receives Encapsulated Map-Requests from its client ITRs and uses a mapping database system to find the appropriate ETR to answer those requests. On a LISP+ALT network, a Map-Resolver acts as a "first-hop" ALT-Router. It has Generic Routing Encapsulation (GRE) tunnels configured to other ALT-Routers and uses BGP to learn paths to ETRs for different prefixes in the LISP+ALT database. The Map-Resolver uses this path information to forward Map-Requests over the ALT to the correct ETRs.

Note that while it is conceivable that a Map-Resolver could cache responses to improve performance, issues surrounding cache management will need to be resolved so that doing so will be reliable and practical. As initially deployed, Map-Resolvers will operate only in a non-caching mode, decapsulating and forwarding Encapsulated Map Requests received from ITRs. Any specification of caching functionality is left for future work.

Note that a single device can implement the functions of both a Map-Server and a Map-Resolver, and in many cases the functions will be co-located in that way.

Detailed descriptions of the LISP packet types referenced by this document may be found in [RFC6830].

#### 4. Interactions with Other LISP Components

##### 4.1. ITR EID-to-RLOC Mapping Resolution

An ITR is configured with one or more Map-Resolver addresses. These addresses are "Locators" (or RLOCs) and must be routable on the underlying core network; they must not need to be resolved through LISP EID-to-RLOC mapping, as that would introduce a circular dependency. When using a Map-Resolver, an ITR does not need to connect to any other database mapping system. In particular, the ITR need not connect to the LISP+ALT infrastructure or implement the BGP and GRE protocols that it uses.

An ITR sends an Encapsulated Map-Request to a configured Map-Resolver when it needs an EID-to-RLOC mapping that is not found in its local map-cache. Using the Map-Resolver greatly reduces both the complexity of the ITR implementation and the costs associated with its operation.

In response to an Encapsulated Map-Request, the ITR can expect one of the following:

- o An immediate Negative Map-Reply (with action code of "Natively-Forward", 15-minute Time to Live (TTL)) from the Map-Resolver if the Map-Resolver can determine that the requested EID does not exist. The ITR saves the EID-Prefix returned in the Map-Reply in its cache, marks it as non-LISP-capable, and knows not to attempt LISP encapsulation for destinations matching it.
- o A Negative Map-Reply, with action code of "Natively-Forward", from a Map-Server that is authoritative for an EID-Prefix that matches the requested EID but that does not have an actively registered, more-specific ID-prefix. In this case, the requested EID is said to match a "hole" in the authoritative EID-Prefix. If the requested EID matches a more-specific EID-Prefix that has been delegated by the Map-Server but for which no ETRs are currently registered, a 1-minute TTL is returned. If the requested EID matches a non-delegated part of the authoritative EID-Prefix, then it is not a LISP EID and a 15-minute TTL is returned. See Section 4.2 for discussion of aggregate EID-Prefixes and details of Map-Server EID-Prefix matching.
- o A LISP Map-Reply from the ETR that owns the EID-to-RLOC mapping or possibly from a Map-Server answering on behalf of the ETR. See Section 4.4 for more details on Map-Resolver message processing.

Note that an ITR may be configured to both use a Map-Resolver and to participate in a LISP+ALT logical network. In such a situation, the ITR should send Map-Requests through the ALT network for any EID-Prefix learned via ALT BGP. Such a configuration is expected to be very rare, since there is little benefit to using a Map-Resolver if an ITR is already using LISP+ALT. There would be, for example, no need for such an ITR to send a Map-Request to a possibly non-existent EID (and rely on Negative Map-Replies) if it can consult the ALT database to verify that an EID-Prefix is present before sending that Map-Request.

#### 4.2. EID-Prefix Configuration and ETR Registration

An ETR publishes its EID-Prefixes on a Map-Server by sending LISP Map-Register messages. A Map-Register message includes authentication data, so prior to sending a Map-Register message, the ETR and Map-Server must be configured with a shared secret or other relevant authentication information. A Map-Server's configuration must also include a list of the EID-Prefixes for which each ETR is authoritative. Upon receipt of a Map-Register from an ETR, a Map-Server accepts only EID-Prefixes that are configured for that

ETR. Failure to implement such a check would leave the mapping system vulnerable to trivial EID-Prefix hijacking attacks. As developers and operators gain experience with the mapping system, additional, stronger security measures may be added to the registration process.

In addition to the set of EID-Prefixes defined for each ETR that may register, a Map-Server is typically also configured with one or more aggregate prefixes that define the part of the EID numbering space assigned to it. When LISP+ALT is the database in use, aggregate EID-Prefixes are implemented as discard routes and advertised into ALT BGP. The existence of aggregate EID-Prefixes in a Map-Server's database means that it may receive Map Requests for EID-Prefixes that match an aggregate but do not match a registered prefix; Section 4.3 describes how this is handled.

Map-Register messages are sent periodically from an ETR to a Map-Server with a suggested interval between messages of one minute. A Map-Server should time out and remove an ETR's registration if it has not received a valid Map-Register message within the past three minutes. When first contacting a Map-Server after restart or changes to its EID-to-RLLOC database mappings, an ETR may initially send Map-Register messages at an increased frequency, up to one every 20 seconds. This "quick registration" period is limited to five minutes in duration.

An ETR may request that a Map-Server explicitly acknowledge receipt and processing of a Map-Register message by setting the "want-map-notify" (M-bit) flag. A Map-Server that receives a Map-Register with this flag set will respond with a Map-Notify message. Typical use of this flag by an ETR would be to set it for Map-Register messages sent during the initial "quick registration" with a Map-Server but then set it only occasionally during steady-state maintenance of its association with that Map-Server. Note that the Map-Notify message is sent to UDP destination port 4342, not to the source port specified in the original Map-Register message.

Note that a one-minute minimum registration interval during maintenance of an ETR-Map-Server association places a lower bound on how quickly and how frequently a mapping database entry can be updated. This may have implications for what sorts of mobility can be supported directly by the mapping system; shorter registration intervals or other mechanisms might be needed to support faster mobility in some cases. For a discussion on one way that faster mobility may be implemented for individual devices, please see [LISP-MN].

An ETR may also request, by setting the "proxy Map-Reply" flag (P-bit) in the Map-Register message, that a Map-Server answer Map-Requests instead of forwarding them to the ETR. See [RFC6830] for details on how the Map-Server sets certain flags (such as those indicating whether the message is authoritative and how returned Locators should be treated) when sending a Map-Reply on behalf of an ETR. When an ETR requests proxy reply service, it should include all RLOCs for all ETRs for the EID-Prefix being registered, along with the routable flag ("R-bit") setting for each RLOC. The Map-Server includes all of this information in Map-Reply messages that it sends on behalf of the ETR. This differs from a non-proxy registration, since the latter need only provide one or more RLOCs for a Map-Server to use for forwarding Map-Requests; the registration information is not used in Map-Replies, so it being incomplete is not incorrect.

An ETR that uses a Map-Server to publish its EID-to-RLOC mappings does not need to participate further in the mapping database protocol(s). When using a LISP+ALT mapping database, for example, this means that the ETR does not need to implement GRE or BGP, which greatly simplifies its configuration and reduces its cost of operation.

Note that use of a Map-Server does not preclude an ETR from also connecting to the mapping database (i.e., it could also connect to the LISP+ALT network), but doing so doesn't seem particularly useful, as the whole purpose of using a Map-Server is to avoid the complexity of the mapping database protocols.

#### 4.3. Map-Server Processing

Once a Map-Server has EID-Prefixes registered by its client ETRs, it can accept and process Map-Requests for them.

In response to a Map-Request (received over the ALT if LISP+ALT is in use), the Map-Server first checks to see if the destination EID matches a configured EID-Prefix. If there is no match, the Map-Server returns a Negative Map-Reply with action code "Natively-Forward" and a 15-minute TTL. This may occur if a Map Request is received for a configured aggregate EID-Prefix for which no more-specific EID-Prefix exists; it indicates the presence of a non-LISP "hole" in the aggregate EID-Prefix.

Next, the Map-Server checks to see if any ETRs have registered the matching EID-Prefix. If none are found, then the Map-Server returns a Negative Map-Reply with action code "Natively-Forward" and a 1-minute TTL.

If any of the registered ETRs for the EID-Prefix have requested proxy reply service, then the Map-Server answers the request instead of forwarding it. It returns a Map-Reply with the EID-Prefix, RLOCs, and other information learned through the registration process.

If none of the ETRs have requested proxy reply service, then the Map-Server re-encapsulates and forwards the resulting Encapsulated Map-Request to one of the registered ETRs. It does not otherwise alter the Map-Request, so any Map-Reply sent by the ETR is returned to the RLOC in the Map-Request, not to the Map-Server. Unless also acting as a Map-Resolver, a Map-Server should never receive Map-Replies; any such messages should be discarded without response, perhaps accompanied by the logging of a diagnostic message if the rate of Map-Replies is suggestive of malicious traffic.

#### 4.4. Map-Resolver Processing

Upon receipt of an Encapsulated Map-Request, a Map-Resolver decapsulates the enclosed message and then searches for the requested EID in its local database of mapping entries (statically configured or learned from associated ETRs if the Map-Resolver is also a Map-Server offering proxy reply service). If it finds a matching entry, it returns a LISP Map-Reply with the known mapping.

If the Map-Resolver does not have the mapping entry and if it can determine that the EID is not in the mapping database (for example, if LISP+ALT is used, the Map-Resolver will have an ALT forwarding table that covers the full EID space), it immediately returns a negative LISP Map-Reply, with action code "Natively-Forward" and a 15-minute TTL. To minimize the number of negative cache entries needed by an ITR, the Map-Resolver should return the least-specific prefix that both matches the original query and does not match any EID-Prefix known to exist in the LISP-capable infrastructure.

If the Map-Resolver does not have sufficient information to know whether the EID exists, it needs to forward the Map-Request to another device that has more information about the EID being requested. To do this, it forwards the unencapsulated Map-Request, with the original ITR RLOC as the source, to the mapping database system. Using LISP+ALT, the Map-Resolver is connected to the ALT network and sends the Map-Request to the next ALT hop learned from its ALT BGP neighbors. The Map-Resolver does not send any response to the ITR; since the source RLOC is that of the ITR, the ETR or Map-Server that receives the Map-Request over the ALT and responds will do so directly to the ITR.

#### 4.4.1. Anycast Map-Resolver Operation

A Map-Resolver can be set up to use "anycast", where the same address is assigned to multiple Map-Resolvers and is propagated through IGP routing, to facilitate the use of a topologically close Map-Resolver by each ITR.

Note that Map-Server associations with ETRs should not use anycast addresses, as registrations need to be established between an ETR and a specific set of Map-Servers, each identified by a specific registration association.

#### 5. Open Issues and Considerations

There are a number of issues with the Map-Server and Map-Resolver design that are not yet completely understood. Among these are:

- o Constants, such as those used for Map-Register frequency, retransmission timeouts, retransmission limits, Negative Map-Reply TTLs, et al. are subject to further refinement as more experience with prototype deployment is gained.
- o Convergence time when an EID-to-RLOC mapping changes, and mechanisms for detecting and refreshing or removing stale, cached information.
- o Deployability and complexity tradeoffs of implementing stronger security measures in both EID-Prefix registration and Map-Request/Map-Reply processing.
- o Requirements for additional state in the registration process between Map-Servers and ETRs.

A discussion of other issues surrounding LISP deployment may also be found in Section 15 of [RFC6830].

The authors expect that experimentation on the LISP pilot network will help answer open questions surrounding these and other issues.

## 6. Security Considerations

The 2-way LISP header nonce exchange documented in [RFC6830] can be used to avoid ITR spoofing attacks.

To publish an authoritative EID-to-RLOC mapping with a Map-Server, an ETR includes authentication data that is a hash of the message using a pair-wise shared key. An implementation must support use of HMAC-SHA-1-96 [RFC2104] and should support use of HMAC-SHA-256-128 [RFC6234] (SHA-256 truncated to 128 bits).

During experimental and prototype deployment, all authentication key configuration will be manual. Should LISP and its components be considered for IETF standardization, further work will be required to follow the BCP 107 [RFC4107] recommendations on automated key management.

As noted in Section 4.2, a Map-Server should verify that all EID-Prefixes registered by an ETR match the configuration stored on the Map-Server.

The currently defined authentication mechanism for Map-Register messages does not provide protection against "replay" attacks by a "man-in-the-middle". Additional work is needed in this area.

[LISP-SEC] defines a proposed mechanism for providing origin authentication, integrity, anti-replay protection, and prevention of man-in-the-middle and "overclaiming" attacks on the Map-Request/Map-Reply exchange. Work is ongoing on this and other proposals for resolving these open security issues.

While beyond the scope of securing an individual Map-Server or Map-Resolver, it should be noted that a BGP-based LISP+ALT network (if ALT is used as the mapping database infrastructure) can take advantage of standards work on adding security to BGP.

## 7. References

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## Appendix A. Acknowledgments

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