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Uberlay Interconnection of Multiple LISP overlays
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Abstract

This document describes the use of the Locator/ID Separation Protocol (LISP) to interconnect multiple disparate and independent network overlays by using a transit overlay. The transit overlay is referred to as the "uberlay" and provides connectivity and control plane abstraction between different overlays. Each network overlay may use different control and data plane approaches and may be managed by a different organization. Structuring the network into multiple network overlays enables the interworking of different overlay approaches to data and control plane methods. The different network overlays are autonomous from a control and data plane perspective, this in turn enables failure survivability across overlay domains. This document specifies the mechanisms and procedures for the distribution of control plane information across overlay sites and in the uberlay as well as the lookup and forwarding procedures for unicast and multicast traffic within and across overlays. The specification also defines the procedures to support inter-overlay mobility of EIDs and their integration with the intra-overlay EID mobility procedures defined in draft-ietf-lisp-eid-mobility.

Requirements Language

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC2119].

Status of This Memo

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Table of Contents

1. Introduction	3
2. Definition of Terms	3
3. Interconnecting multiple LISP site-overlays via the Uberlay .	4
4. General Procedures	7
4.1. Control Plane Procedures	8
4.1.1. Split-horizon at the Border xTRs	9
4.2. Resolution and Forwarding Procedures	10
4.2.1. Multi-overlay requests at border xTR	11
4.3. Default EID registration and treatment	11
5. Multicast Specific Procedures	12
5.1. Inter-site-overlay Control Plane Procedures for Signal-free multicast	12
5.2. Border xTR Resolution and Forwarding procedures for Signal-free multicast	13
6. Inter site-overlay Mobility Procedures	13
7. Virtual Private Network (VPN) Considerations	15
8. IANA Considerations	15
9. Acknowledgements	15
10. References	15

10.1. Normative References	15
10.2. Informative References	16
Authors' Addresses	18

1. Introduction

The main motivation for this specification is to provide a methodology for the interconnection of LISP domains that may use disparate control and/or data plane approaches. For instance, one domain may use native LISP encapsulation for its data plane and a DDT based mapping system, while another domain may use VXLAN-GPE encapsulation and a mapping system based on [I-D.farinacci-lisp-decent]. Furthermore, one domain may use an IPv4 RLOC space and the other domain may use an IPv6 RLOC space and there may not be connectivity between the domains at the RLOC level. We propose a method to interconnect and enable interoperability between these disparate LISP overlay networks by connecting them to a common transit LISP overlay.

In order to provide interworking across implementations of overlays that may use different control and data plane approaches, a LISP network may be structured as a collection of site-overlays interconnected by a transit area. Each site-overlay is a fully functional overlay network and has its own set of Map Servers and Map Resolvers. Site-overlays share a border xTR with a transit area. Connectivity between site-overlays is provided via the transit area which we will refer to as "The Uberlay". This specification describes the Control Plane and Forwarding procedures for the implementation of an Uberlay connected multi-overlay LISP network. This approach to the structure of a LISP network may also enable regional failure survivability and fault isolation.

2. Definition of Terms

LISP related terms, notably Map-Request, Map-Reply, Ingress Tunnel Router (ITR), Egress Tunnel Router (ETR), Map-Server (MS) and Map-Resolver (MR) are defined in the LISP specification [RFC6830].

Terms defining interactions with the LISP Mapping System are defined in [RFC6833].

Terms related to the procedures for signal free multicast are defined in [RFC8378].

The following terms are here defined to facilitate the descriptions and discussions within this particular document.

Site-Overlay - Overlay network at a specific area or domain. This overlay network has a dedicated Mapping System.

Border-xTR - xTR that connects a site-overlay to one or more uberlays.

xTR - LISP Tunnel Router as defined in [RFC6833]. An xTR connects end-points to the site-overlay.

Local Mapping System - Mapping system of the site-overlay

Uberlay - Overlay network that interconnects different site-overlays to each other. The Uberlay has a dedicated Mapping System and creates an overlay amongst the border xTRs which connect different site-overlays.

Uberlay Mapping System - Autonomous mapping system dedicated to the uberlay.

Site-Overlay EIDs - Also referred to as local site-overlay EIDs, these are the EIDs that are connected to xTRs in a particular site-overlay and are registered in their own local site-overlay mapping system. These EIDs will also be registered in the uberlay but not in the remote site-overlay mapping systems.

Remote site-overlay EIDs - These are EIDs connected and registered in site-overlays other than the local site-overlay.

Local site-overlay EIDs - These are EIDs connected and registered in the local site-overlay.

3. Interconnecting multiple LISP site-overlays via the Uberlay

A LISP network can be structured as a collection of LISP site-overlays that are interconnected by one or more LISP Uberlays.

A LISP site-overlay is an overlay network that has its own set of xTRs, its own dedicated Mapping System and it may have a dedicated RLOC space, separate from that of other site-overlays or the uberlay. A LISP uberlay is also an overlay network with its own set of xTRs, its own dedicated Mapping System and it may have its own dedicated RLOC space. When the RLOC spaces are dedicated, RLOC routes in the local underlay do not leak across to the underlay of other site-overlays.

A site-overlay will have xTRs and Border xTRs. The xTRs provide connectivity to the local site-overlay EIDs, which are the EIDs that are locally connected to the overlay-site. The Border xTRs are Re-

encapsulating Tunnel Routers (RTRs) that connect the site-overlays to the LIISP Uberlay in the transit network. xTRs participate in one site-overlay and one site-overlay only. Border xTRs participate in the mapping system of the site-overlay it resides in and the mapping system of the uberlay it connects the site-overlay to. Border xTRs may be shared by more than one site-overlay.

The different site-overlays can be interconnected by an uberlay. The uberlay consists of a dedicated Mapping System and the set of Border xTRs that connect the participating site-overlays to the Uberlay and the Uberlay Mapping System.

Each site-overlay will have its own set of Map Servers and Map Resolvers (MS/MRs) which operate as an autonomous Mapping System. The Uberlay Mapping System is also autonomous and includes all necessary Map Servers and Map Resolvers. Any of the Mapping Systems, in site-overlays or in the Uberlay, follow the control plane specification in [RFC6833] and may be structured as a Distributed Delegation Tree (DDT) per [RFC8111] for the purposes of horizontal scaling or other optimizations within each Mapping System.

The MS/MRs can be co-located with the border-xTRs of the site-overlay. When a Border xTR services more than one site-overlay, and the MS/MRs are instantiated on the Border xTR, logical instances of MS/MRs must be dedicated to each site-overlay.

This specification defines the interaction between the Mapping Systems of the site-overlays and the uberlay to deliver a multi-overlay hierarchical network. The forwarding procedures relevant to the border xTRs are also specified. Figure 1 illustrates the multi-overlay network.

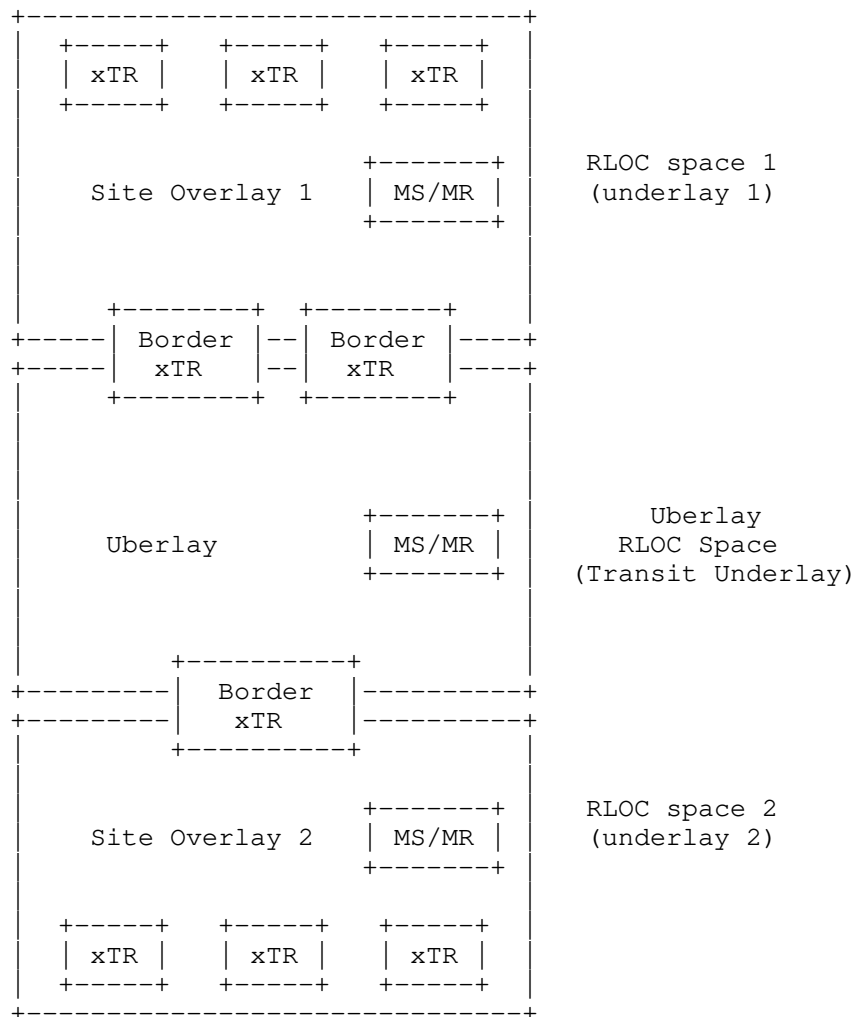


Figure 1. Site-overlays connected via Uberlay

Structuring the LISP network as multiple site-overlays interconnected by an uberlay delivers the following benefits:

- o Enable the interworking of diverse site-overlay implementations in which different mapping systems and encapsulations may be used.

- o Enhanced resiliency through regional failure survivability. Failures in one site-overlay or failures in a portion of the underlay should not affect other site-overlays.
- o Reduce the state of the site-overlay control plane. The site-overlay control plane will only maintain state for EIDs that are connected to xTRs within the site-overlay. These EIDs are referred to as local site-overlay EIDs in this specification. Remote site-overlay EIDs will not be explicitly registered within the site-overlay.
- o Separate the RLOC space of the different site-overlays as well as the uberlay RLOC space. Each site-overlay will only need reachability to its own RLOCs, making the RLOCs private to the site-overlay. Similarly, the uberlay RLOC space does not require knowledge of site-overlay specific RLOCs. This simplifies the underlay routing protocol structure and reduces the state that must be handled and maintained by the underlay routing protocols.
- o Reduced latency for local site-overlay EID registrations may be achieved when xTRs and Map Servers are topologically close. Topological proximity is expected when the RLOC spaces for the different overlays are kept separate.
- o Reduced latency for local site-overlay EID lookups may be achieved when xTRs, Map Resolvers and Map Servers are topologically close. Topological proximity is expected when the RLOC spaces for the different overlays are kept separate.
- o Creates a multicast replication hierarchy where the Border RTRs serve as the points of multicast replication for multicast traffic that spans multiple site-overlays.
- o Creates a distributed structure of RTRs that can be leveraged for the deployment of NAT traversal in the RLOC space.

4. General Procedures

A site-overlay maintains state only for its local site-overlay EIDs and RLOCs. Tunnels never cross site-overlay or uberlay boundaries. Remote site-overlay EIDs are reachable at the source site-overlay via a default mapping which will steer all traffic destined to remote site-overlay EIDs to the border xTRs where it can be handed off to the uberlay. The uberlay maintains state for the EIDs of all interconnected site-overlays and will steer traffic from the source site-overlay to the destination site-overlay by encapsulating the traffic from the source site-overlay border xTR to the destination site-overlay border xTR. Thus, forwarding is achieved by

concatenating overlays and doing Re-encapsulation at the border xTRs to forward the traffic from the Ingress site-overlay to the Egress site-overlay via the Uberlay.

Inter-site communication is achieved by encapsulating traffic destined to remote site-overlay EIDs to the border xTRs following the mapping registered for the default EID-prefix, rather than having to maintain state for remote site-overlay EIDs. Traffic will be decapsulated at the border xTRs and a lookup in the uberlay mapping system will determine the site-overlay to which traffic is to be re-encapsulated. The lookup should return the uberlay RLOCs for the border xTRs of the site-overlay where the destination EID is located. At the border xTR of the destination site, traffic will be decapsulated, a lookup in the local destination site-overlay Mapping System will take place and traffic will be re-encapsulated to the xTR that connects to the destination EID.

Traffic for non-LISP sites, or for EIDs not registered in any site-overlay, will also be forwarded to the border xTR where it will be forwarded or dropped as appropriate.

4.1. Control Plane Procedures

Local EIDs must be registered by the xTRs into the local Mapping System of the site-overlay. Intra-site communication follows the standard procedures of registration, resolution, caching and encapsulation defined in [I-D.ietf-lisp-rfc6830bis] and [I-D.ietf-lisp-rfc6833bis] amongst the xTRs within the local site-overlay.

The border xTRs at a site-overlay should have a local site-overlay RLOC-set and will also have an uberlay RLOC-set. The local site-overlay RLOC-set is in the private site-overlay RLOC space and is used by the border xTRs as the RLOC set for any mappings it may register with the site-overlay Mapping System. The uberlay RLOC-set for the border-xTRs of a particular site-overlay are the RLOCs to reach the site-overlay in the uberlay RLOC space. The border xTR will use the uberlay RLOC-set in any mappings it may register with the uberlay Mapping System. It is possible for a deployment to connect the RLOC spaces of the site-overlays and the uberlay, it is also possible in the scenario of a common RLOC space for the uberlay and local site-overlay RLOC sets to be one and the same. Any implementation of this specification should support disjoint RLOC spaces or joint RLOC spaces.

The border xTRs must register a default EID-prefix as specified in Section 4.3 with the local site-overlay Mapping System. Remote EIDs will be generally reachable by xTRs in a site-overlay using the

default EID mapping registered by the border xTRs. This is expected to be the mapping used for most communications to remote site-overlay EIDs. Remote site-overlay EIDs may be registered with the local site-overlay Mapping System for the purposes of supporting inter-overlay EID mobility as specified in Section 6, these mappings will be preferred over the default EID mapping whenever present.

Local EIDs registered with the site-overlay mapping system must also be registered with the Uberlay Mapping System. The registration of the local site-overlay EIDs with the uberlay Mapping System is originated by the Border xTRs. The local site-overlay EIDs SHOULD be aggregated into the shortest covering prefix possible before being registered with the uberlay Mapping System. How this aggregation is achieved is implementation specific.

In order to be able to register the local site-overlay EIDs with the uberlay Mapping System, the border xTRs must subscribe to all EIDs registered in their local site-overlay Mapping System. This is a subscription to 0.0.0.0/0 (or 0::/0) with the N-bit set as specified in [I-D.ietf-lisp-pubsub]. The subscription populates all local site-overlay EID mappings in the map-cache of the border xTRs.

Once received through the subscription, the local site-overlay EIDs in the map-cache at the border xTRs must be registered by the border xTRs with the uberlay Mapping System. The local site-overlay EIDs will be registered using the 'uberlay' RLOC-set for the registering border xTR.

Following [I-D.ietf-lisp-eid-mobility], the border xTRs will also subscribe to any EID prefixes it registers with the uberlay Mapping System. This allows the border xTRs to get Map Notify messages from the uberlay Mapping System for EID prefixes that may move from their local site-overlay to a remote site-overlay.

4.1.1. Split-horizon at the Border xTRs

Remote site-overlay EIDs may be learnt at a border xTR due to resolution of a remote destination EID or due to a mobility event as specified in Section 6. Remote site-overlay EIDs learnt from the uberlay will be installed in the map-cache of the border xTR with the corresponding remote uberlay RLOC-set for the remote border xTR. When these remote site-overlay EIDs are learnt as a consequence of the map-notify messages defined in the Inter-overlay mobility procedures in Section 6, the EIDs will also be registered with the local site-overlay mapping system using the local site-overlay RLOC-set for the border-xTR. The remote site-overlay EIDs registered with the local site-overlay mapping system will be learnt back at the border xTR because of the border xTR's subscription to all local

site-overlay EIDs. This can cause the mapping for the remote EID that is installed in the border xTR map-cache to flip flop between the uberlay RLOC-set and the local site-overlay RLOC-set.

In order to avoid this flip flopping a split horizon procedure must be implemented. When a mapping received at the border xTR (as part of its subscription to all local site-overlay EID prefixes) has the local site-overlay RLOC-set for the border xTR, the mapping received in the subscription corresponds to a remote site-overlay EID and should be ignored by the border xTR. The mapping should not be installed in the map-cache of the border xTR and the EIDs in the mapping should not be advertised to the uberlay. More robust split horizon mechanisms can be proposed in future revisions of this specification.

4.2. Resolution and Forwarding Procedures

Intra-site communication follows the standard procedures of registration, resolution, caching and encapsulation defined in [I-D.ietf-lisp-rfc6830bis] and [I-D.ietf-lisp-rfc6833bis] amongst the xTRs within the local site-overlay.

Inter-site communication is achieved by encapsulating traffic destined to remote site-overlay EIDs from the xTRs to the border xTRs. Traffic will be decapsulated at the border xTRs and a lookup in the uberlay mapping system will determine the site-overlay to which traffic is to be re-encapsulated. The lookup should return the uberlay RLOCs for the border xTRs of the site-overlay where the destination EID is located. At the border xTR of the destination overlay-site, traffic will be de-capsulated, and re-encapsulated to the destination xTR, just like an RTR does. The border xTR already has the destination EID in its cache per its subscription to all local site-overlay EIDs.

When receiving encapsulated traffic, a border xTR will de-capsulate the traffic and will do a lookup for the destination EID in its map cache. If the destination EID is present in the map cache, the traffic is forwarded and no lookup takes place. If the destination EID is not present in the cache, the destination EID is not in any local site-overlay connected to the border xTR, in which case the border xTR will issue a map-request to all Uberlay Mapping Systems it is connected to. The criteria to determine which Mapping Systems are Uberlay Mapping Systems is simply to select those Mapping Systems with which the border xTR doesn't hold a subscription to 0.0.0.0/0 (or 0::/0).

4.2.1. Multi-overlay requests at border xTR

Border xTRs may query all Mapping Systems in all uberlays it participates in. The border xTR will then chose based on longest prefix match the more specific EID mapping provided by any of the Mapping Systems. This procedure could also include site-overlay Mapping Systems, however those are not expected to be queried as the border xTR subscribes to all EIDs in the site-overlays and the presence of the mappings in the cache will prevent any lookups. The processing of Map Requests following the multi-domain request logic works as follows:

1. The Border xTR sends a map request for the prefix that it intends to resolve to each of the Mapping Systems it participates in.
2. The Border xTR receives Map Replies from each of the different Mapping Systems it sent requests to. The Border xTR will treat the replies differently depending on their contents:
 - * Negative Map Replies are ignored and discarded unless all Map Replies are Negative, then the border xTR follows the procedures specified in [RFC6833] for Negative Map Replies.
 - * Map Replies with RLOCs that belong to the requesting border xTR are ignored.
 - * Map Replies with EID prefixes that are not already in the map cache of the border xTR are accepted and cached.
 - * If the prefix already exists in the cache/routing table and the source of the prefix is another reply from the multi-domain request, the RLOCs received in the mapping are added to the RLOC set cached for the prefix.

When following these rules when processing multi-domain requests, the Border xTR guarantees proper discovery and use of destination prefixes, that will be associated with their corresponding overlay fabric. By ignoring the negative replies the procedure works regardless of whether the Mapping Systems of multiple fabrics have consistent configurations or operate individually without being aware of the whole addressing space in the overlay fabric.

4.3. Default EID registration and treatment

Border xTRs will register a mapping to be used as a default mapping to handle the forwarding of traffic destined to any EIDs that are not explicitly registered. These mappings will be registered in the local site-overlay Mapping System of each site-overlay. The RLOCs

for the mappings will be the site-overlay RLOCs of the border xTR. This registration is intended to instruct the Mapping System to follow the procedures in [RFC6833] for Negative Map Replies and calculate the broadest non-registered EID prefix that includes the requested destination EID and issue a map-reply with the calculated EID and the RLOCs registered by the border xTRs. The map-reply may have a shorter TTL to accommodate any changes in the registrations.

The instruction to the Mapping System can be encoded as the registration of a 0.0.0.0/0 (or 0::/0) EID or it can be encoded as the registration of an agreed upon distinguished name such as "Default". In either case, the registration will contain the RLOC set desired for the default handling.

5. Multicast Specific Procedures

This specification will focus on the procedures necessary to extend signal-free multicast [RFC8378] across multiple site-overlays interconnected with an uberlay. The specification will focus on the extensions of the Sender and Receiver site procedures

5.1. Inter-site-overlay Control Plane Procedures for Signal-free multicast

1. At the listener sites, xTRs with multicast listeners will follow the receiver site procedures described in [RFC8378]. A replication list will be built and registered on the site-overlay Mapping System for the multicast channel being joined by the listeners.
2. The Mapping System for the listener site-overlay will send Map-Notify messages towards the multicast source or RP per [RFC8378]. The multicast source or RP is reachable via the border-xTRs of the listener site-overlay via the default EID mapping registered in the listener site-overlay.
3. Upon reception of the Map-Notify in the previous step, the listener site-overlay border-xTR will register the multicast EID with the uberlay Mapping System using the uberlay RLOCs for its site-overlay as the RLOC set for the mapping being registered. Only one of the RLOCs in the set should be active in the registration per the procedures in [RFC8378]. A replication tree is built in the uberlay as specified in [RFC8378].
4. After the listener site-overlay border-xTR registers the multicast EID with the uberlay Mapping system, the uberlay MS will send a Map-Notify toward the multicast source per [RFC8378]

5. Upon reception of the Map-Notify in the previous step, the border xTR at the source site-overlay registers its interest in the multicast EID with the source site-overlay Mapping System following the procedures described in [RFC8378].

5.2. Border xTR Resolution and Forwarding procedures for Signal-free multicast

The mapping resolution procedures for multicast EIDs at border xTRs fall within the scope of the mechanisms specified in Section 4. The Map-replies obtained from the lookup will follow the behavior specified in [RFC8378] for signal-free multicast.

Forwarding will also follow the General Procedures specified in Section 4 without alteration. It is worth noting that the concatenation of overlays between listener sites, uberlay and sender site-overlays creates a convenient replication structure where the border xTRs act as the replication points to form an optimized end-to-end multi-level replication tree [Ref to Replication Engineering draft].

6. Inter site-overlay Mobility Procedures

The receiver and sender site procedures defined in [I-D.ietf-lisp-eid-mobility] apply without change to each site-overlay and to the uberlay. Border xTRs are connected to two or more overlay networks which are following the mobility procedures. An away table is defined at the border xTR for each overlay network it participates in. In order to illustrate the procedures required, this specification describes a scenario where a border xTR has one local site-overlay away table and one uberlay facing away table. The procedures for mobility described in this section are extensible to border xTRs participating in more than two overlays.

When a map notify for an EID is received at an xTR, an away entry is created on the receiving side table. Any away entries for the specific EID in other tables on the same LISP node (xTR or RTR) must be removed. This general rule addresses convergence necessary for a first move as well as any subsequent moves (moves that take place after the away tables are already populated with entries for the moving EID due to previous moves).

The following set of procedures highlights any additions to the mobility procedures defined in [I-D.ietf-lisp-eid-mobility]:

1. Detect the roaming EID per the mechanisms described in [I-D.ietf-lisp-eid-mobility] and register the EID with the site-overlay Mapping System at the landing site-overlay

2. The site-overlay Mapping System at the landing site-overlay must send a Map-Notify to the last registrant xTR (if it is local to the site-overlay) and to the border xTR as the border xTR subscribes to all EIDs in the site-overlay.
3. The border xTR will install an entry for the moved host in the local away table of the border xTR.
4. The border xTR from the landing site-overlay will register the roaming EID with the uberlay Mapping System using the uberlay RLOC-set for the landing site-overlay
5. The Uberlay Map Server will send Map-Notify messages to the border xTRs at the departure site-overlay as specified in [I-D.ietf-lisp-eid-mobility] (border xTR with the previously registered RLOCs).
6. Upon reception of the Map-Notify, the border xTR must check if the Map-Notify is for an EID-prefix that is covered by a broader or equal EID-prefix that is locally registered. Local registration is determined by the presence of the broader or equal EID prefix in the map-cache of the border xTR.
7. If the roaming EID-prefix received in the Map-Notify is not covered under a previously registered EID-prefix in the local site-overlay, the EID-prefix is a newly registered prefix and no further action is required.
8. If the roaming EID-prefix received in the Map-Notify is covered under a registered EID-prefix, the Map-Notify is due to a move event. In this case, the site-overlay border xTR must register the roaming EID prefix in the site-overlay mapping system using the site-overlay facing RLOC-set of the border-xTRs. The roaming EID-prefix must also be installed in the uberlay facing away table of the border xTR at the departure site-overlay.
9. The departure site-overlay Map-Server will send Map-Notify messages to the xTRs at the departure site-overlay as specified in [I-D.ietf-lisp-eid-mobility] (edge xTRs with the previously registered RLOCs).
10. When the site-overlay xTR at the departure site-overlay receives the Map-Notify from the border xTR, it will include the EID prefix received in the Map-Notify in its away table per the procedures described in [I-D.ietf-lisp-eid-mobility].
11. Data triggered Solicit Map Requests (SMRs) will be initiated in the different site-overlays and the uberlay as traffic matches

the different away tables. As specified in [I-D.ietf-lisp-eid-mobility], these SMRs notify the different ITRs involved in communications with the roaming EID that they must issue a new Map-Request to the mapping system to renew their mappings for the roaming EID.

7. Virtual Private Network (VPN) Considerations

When supporting multiple Instance IDs as specified in [I-D.ietf-lisp-vpn] the Instance IDs range is divided in two sets. A reuse-set that can be used in each site-overlay and a global-set used across site-overlays and the uberlay.

Instance-IDs that are local to a site-overlay should only provide intra-overlay connectivity and are in the site-overlay mapping system only for VPN use for the xTRs in the site-overlay. When the VPN reaches across site-overlays, then the global-set instance-IDs are in the uberlay mapping system as well as each site-overlay mapping system where the VPN members exist.

8. IANA Considerations

This document has no IANA implications

9. Acknowledgements

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