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Signal-Free LISP Multicast  
draft-farinacci-lisp-signal-free-multicast-03

## Abstract

When multicast sources and receivers are active at LISP sites, the core network is required to use native multicast so packets can be delivered from sources to group members. When multicast is not available to connect the multicast sites together, a signal-free mechanism can be used to allow traffic to flow between sites. The mechanism within here uses unicast replication and encapsulation over the core network for the data-plane and uses the LISP mapping database system so encapsulators at the source LISP multicast site can find de-capsulators at the receiver LISP multicast sites.

## 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](#)].

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Signal-Free LISP Multicast

June 2015

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## Table of Contents

<a href="#">1.</a>	Introduction . . . . .	<a href="#">3</a>
<a href="#">2.</a>	Definition of Terms . . . . .	<a href="#">4</a>
<a href="#">3.</a>	Reference Model . . . . .	<a href="#">5</a>
<a href="#">4.</a>	General Procedures . . . . .	<a href="#">6</a>
<a href="#">4.1.</a>	General Receiver-site Procedures . . . . .	<a href="#">7</a>
<a href="#">4.1.1.</a>	Multicast receiver detection . . . . .	<a href="#">7</a>
<a href="#">4.1.2.</a>	Receiver-site Registration . . . . .	<a href="#">7</a>
<a href="#">4.1.3.</a>	Consolidation of the replication-list . . . . .	<a href="#">9</a>
<a href="#">4.2.</a>	General Source-site Procedures . . . . .	<a href="#">9</a>
<a href="#">4.2.1.</a>	Multicast Tree Building at the Source-site . . . . .	<a href="#">9</a>
<a href="#">4.2.2.</a>	Multicast Destination Resolution . . . . .	<a href="#">9</a>
<a href="#">4.3.</a>	General LISP Notification Procedures . . . . .	<a href="#">10</a>
<a href="#">5.</a>	Source Specific Multicast Trees . . . . .	<a href="#">10</a>
<a href="#">5.1.</a>	Source directly connected to Source-ITRs . . . . .	<a href="#">11</a>
<a href="#">5.2.</a>	Source not directly connected to Source-ITRs . . . . .	<a href="#">11</a>
<a href="#">6.</a>	PIM Any Source Multicast Trees . . . . .	<a href="#">11</a>
<a href="#">7.</a>	Signal-Free Multicast for Replication Engineering . . . . .	<a href="#">11</a>
<a href="#">8.</a>	Security Considerations . . . . .	<a href="#">13</a>
<a href="#">9.</a>	IANA Considerations . . . . .	<a href="#">14</a>
<a href="#">10.</a>	Acknowledgements . . . . .	<a href="#">14</a>
<a href="#">11.</a>	References . . . . .	<a href="#">14</a>
<a href="#">11.1.</a>	Normative References . . . . .	<a href="#">14</a>
<a href="#">11.2.</a>	Informative References . . . . .	<a href="#">14</a>
<a href="#">Appendix A.</a>	Document Change Log . . . . .	<a href="#">15</a>
A.1.	Changes to <a href="#">draft-farinacci-lisp-signal-free-multicast-03</a>	15
A.2.	Changes to <a href="#">draft-farinacci-lisp-signal-free-multicast-02</a>	16

A.3. Changes to <a href="#">draft-farinacci-lisp-signal-free-multicast-01</a>	16
A.4. Changes to <a href="#">draft-farinacci-lisp-signal-free-multicast-00</a>	16
Authors' Addresses . . . . .	<a href="#">16</a>

## 1. Introduction

When multicast sources and receivers are active at LISP sites, and the core network between the sites does not provide multicast support, a signal-free mechanism can be used to create an overlay that will allow multicast traffic to flow between sites and connect the multicast trees at the different sites.

The signal-free mechanism here proposed does not extend PIM over the overlay as proposed in [[RFC6831](#)], nor does the mechanism utilize direct signaling between the Receiver-ETRs and Sender-ITRs as described in [[I-D.farinacci-lisp-mr-signaling](#)]. The signal-free mechanism proposed reduces the amount of signaling required between sites to a minimum and is centered around the registration of Receiver-sites for a particular multicast-group or multicast-channel with the LISP Mapping System.

Registrations from the different receiver-sites will be merged at the Mapping System to assemble a multicast-replication-list inclusive of all RLOCs that lead to receivers for a particular multicast-group or multicast-channel. The replication-list for each specific multicast-entry is maintained as a LISP database mapping entry in the Mapping Database.

When the ITR at the source-site receives multicast traffic from sources at its site, the ITR can query the mapping system by issuing Map-Request messages for the (S,G) source and destination addresses in the packets received. The Mapping System will return the RLOC replication-list to the ITR, which the ITR will cache as per standard LISP procedure. Since the core is assumed to not support multicast, the ITR will replicate the multicast traffic for each RLOC on the replication-list and will unicast encapsulate the traffic to each RLOC. The combined function of replicating and encapsulating the traffic to the RLOCs in the replication-list is referred to as "rep-encapsulation" in this document.

The document describes the General Procedures and information encoding that are required at the Receiver-sites and Source-sites to achieve signal-free multicast interconnectivity. The General Procedures for Mapping System Notifications to different sites are also described. A section dedicated to the specific case of SSM trees discusses the implications to the General Procedures for SSM multicast trees over different topological scenarios. At this stage ASM trees are not supported with LISP Signal-Free multicast.

## [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](#)].

Extensions to the definitions in [[RFC6830](#)] for their application to multicast routing are documented in [[RFC6831](#)].

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

The following terms are consistent with the definitions in [[RFC6830](#)] and [[RFC6831](#)]. The terms are specific cases of the general terms and are here defined to facilitate the descriptions and discussions within this particular document.

Source: Multicast source end-point. Host originating multicast packets.

Receiver: Multicast group member end-point. Host joins multicast group as a receiver of multicast packets sent to the group.

Receiver-site: LISP site where multicast receivers are located.

Source-site: LISP site where multicast sources are located.

RP-site: LISP site where an ASM PIM Rendezvous Point is located. The RP-site and the Source-site may be the same in some situations.

Receiver-ETR: LISP xTR at the Receiver-site. This is a multicast ETR.

Source-ITR: LISP xTR at the Source-site. This is a multicast ITR.

RP-xTR: LISP xTR at the RP-site. This is typically a multicast ITR.

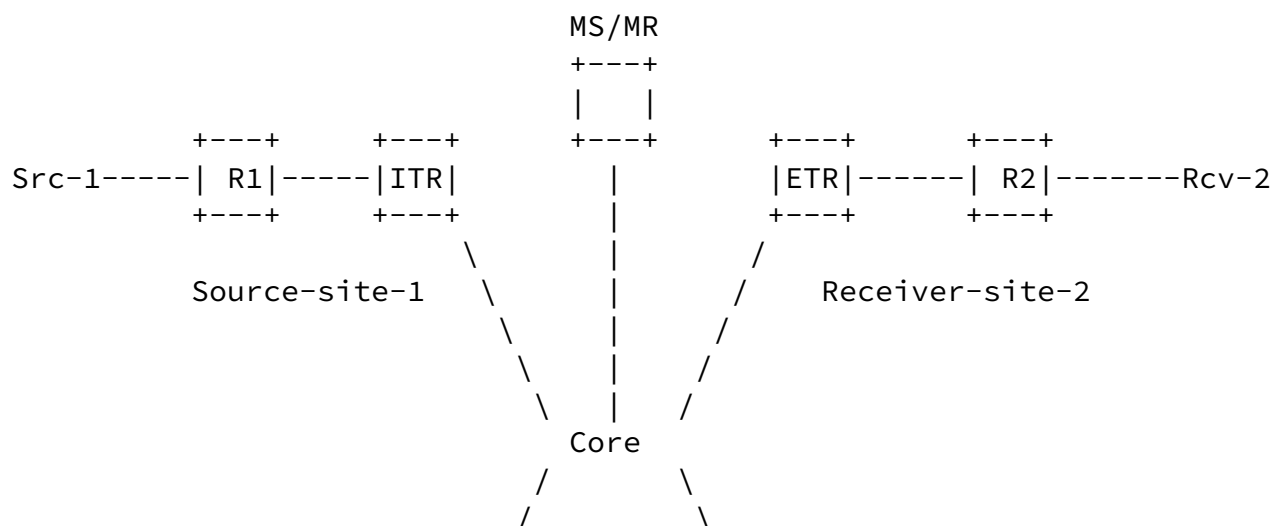
Replication-list: Mapping-entry containing the list of RLOCs that have registered Receivers for a particular multicast-entry.

Multicast-entry: A tuple identifying a multicast tree. Multicast-entries are in the form of (S-prefix, G-prefix).

Rep-encapsulation: The process of replicating and then encapsulating traffic to multiple RLOCs.

### [3.](#) Reference Model

The reference model that will be used for the discussion of the Signal-Free multicast tree interconnection is illustrated in Figure 1.



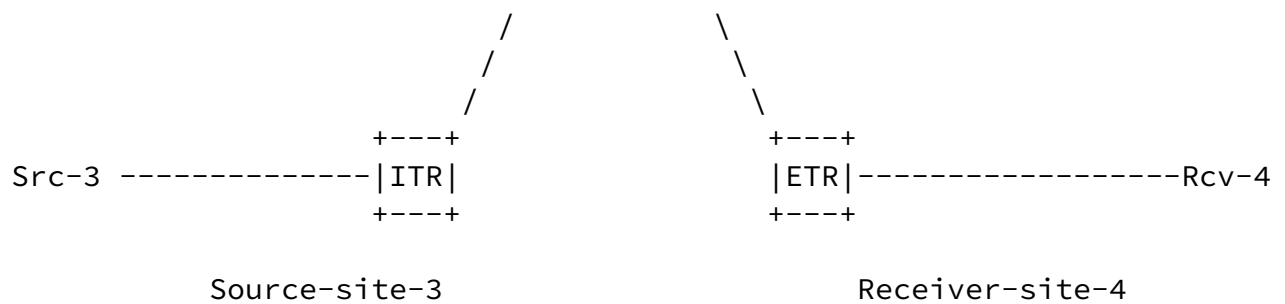


Figure 1: LISP Multicast Generic Reference Model

Sites 1 and 3 are Source-sites.

Source-site-3 presents a Source (Src-3) that is directly connected to the Source-ITR

Source-site-1 presents a Source (Src-1) that is one hop or more away from the Source-ITR

Receiver-site-2 and 4 are receiver sites with not-directly connected and directly connected Receiver end-points respectively

R1 is a router in Source-site-1.

R2 is a PIM router at the Receiver-site.

The Map-Servers and Resolvers are reachable in the RLOC space in the Core, only one is shown for illustration purposes, but these can be many or even part of a DDT tree.

The procedures for interconnecting multicast Trees over an overlay can be broken down into three functional areas:

- o Receiver-site procedures
- o Source-site procedures
- o LISP notification procedures

The receiver site procedures will be common for most tree types and topologies.

The procedures at the source site can vary depending on the type of trees being interconnected as well as based on the topological relation between sources and source-site xTRs. For ASM trees, a special case of the Source-site is the RP-site for which a variation of the Source-site procedures may be necessary if ASM trees are to be supported in future specifications of LISP Signal-Free multicast.

The LISP notification procedures between sites are normalized for the different possible scenarios. Certain scenarios may benefit from a simplified notification mechanism or no notification requirement at all.

#### 4. General Procedures

The interconnection of multicast trees across different LISP sites involves the following procedures to build the necessary multicast distribution trees across sites.

1. The presence of multicast Receiver end-points is detected by the Receiver-ETRs at the Receiver-sites.
2. Receiver-ETRs register their RLOCs as part of the replication-list for the multicast-entry the detected Receivers subscribe to.
3. The Mapping-system merges all receiver-ETR or delivery-group RLOCs to build a comprehensive replication-list inclusive of all Receiver-sites for each multicast-entry.
4. LISP Map-Notify messages should be sent to the Source-ITR informing of any changes in the replication-list.

5. Multicast-tree building at the Source-site is initiated when the Source-ITR receives the LISP Notification.

Once the multicast distribution trees are built, the following forwarding procedures may take place:

1. The Source sends multicast packets to the multicast group destination address.

2. Multicast traffic follows the multicast tree built at the Source-site and makes its way to the Source-ITRs.
3. The Source-ITR will issue a map-request to resolve the replication-list for the multicast-entry.
4. The Mapping System responds to the Source-ITR with a map-reply containing the replication-list for the multicast group requested.
5. The Source-ITR caches the replication-list received in the map-reply for the multicast-entry.
6. Multicast traffic is rep-encapsulated. That is, the packet is replicated for each RLOC in the replication-list and then encapsulated to each one.

#### [4.1.](#) General Receiver-site Procedures

##### [4.1.1.](#) Multicast receiver detection

When the Receiver-ETRs are directly connected to the Receivers (e.g. Receiver-site-4 in Figure 1), the Receiver-ETRs will receive IGMP Reports from the Receivers indicating which group the Receivers wish to subscribe to. Based on these IGMP Reports, the receiver-ETR is made aware of the presence of Receivers as well as which group they are interested in.

When the Receiver-ETRs are several hops away from the Receivers (e.g. Receiver-site-2 in Figure 1), the Receiver-ETRs will receive PIM join messages which will allow the Receiver-ETR to know that there are multicast Receivers at the site and also learn which multicast group the Receivers are for.

##### [4.1.2.](#) Receiver-site Registration

Once the Receiver-ETRs detect the presence of Receivers at the Receiver-site, the Receiver-ETRs will issue Map-Register messages to

include the Receiver-ETR RLOCs in the replication-list for the



multicast-entry the Receivers joined.

The Map-Register message will use the multicast-entry (Source, Group) tuple as its EID record type with the Receiver-ETR RLOCs conforming the locator set.

The EID in the Map-Register message must be encoded using the Multicast Information LCAF type defined in [[I-D.ietf-lisp-lcaf](#)]. The R, L and J bits in the Multicast-info LCAF frame are not used and should be set to zero.

The RLOC in the Map-Register message must be encoded using the Replication List Entry (RLE) LCAF type defined in [[I-D.ietf-lisp-lcaf](#)] with the Level Value fields for all entries set to 128 (decimal).

The encoding described above must be used consistently for Map-Register messages, entries in the Mapping Database, Map-reply messages as well as the map-cache at the Source-ITRs.

The Map-Register messages [[RFC6830](#)] sent by the receiver-ETRs should have the following bits set as here specified:

1. merge-request-bit set to 1. The Map-Register messages must be sent with "Merge Semantics". The Map-Server will receive registrations from a multitude of Receiver-ETRs. The Map-Server will merge the registrations for common EIDs and maintain a consolidated replication-list for each multicast-entry.
2. want-map-notify-bit (M) set to 0. This tells the Mapping System that the receiver-ETR does not expect to receive Map-Notify messages as it does not need to be notified of all changes to the replication-list.
3. proxy-reply-bit (P) set to 1. The merged replication-list is kept in the Map-Servers. By setting the proxy-reply bit, the receiver-ETRs instruct the Mapping-system to proxy reply to map-requests issued for the multicast entries.

Map-Register messages for a particular multicast-entry should be sent for every receiver detected, even if previous receivers have been detected for the particular multicast-entry. This allows the replication-list to remain up to date.

#### [4.1.3.](#) Consolidation of the replication-list

The Map-Server will receive registrations from a multitude of Receiver-ETRs. The Map-Server will merge the registrations for common EIDs and consolidate a replication-list for each multicast-entry.

#### [4.2.](#) General Source-site Procedures

Source-ITRs must register the unicast EIDs of any Sources or Rendezvous Points that may be present on the Source-site. In other words, it is assumed that the Sources and RPs are LISP EIDs.

The registration of the unicast EIDs for the Sources or Rendezvous Points allows the map-server to know where to send Map-Notify messages to. Therefore, the Source-ITR must register the unicast S-prefix EID with the want-map-notify-bit set in order to receive Map-Notify messages whenever there is a change in the replication-list.

##### [4.2.1.](#) Multicast Tree Building at the Source-site

When the source site receives the Map-Notify messages from the mapping system as described in [Section 4.3](#), it will initiate the process of building a multicast distribution tree that will allow the multicast packets from the Source to reach the Source-ITR.

The Source-ITR will issue a PIM join for the multicast-entry for which it received the Map-Notify message. The join will be issued in the direction of the source or in the direction of the RP for the SSM and ASM cases respectively.

##### [4.2.2.](#) Multicast Destination Resolution

On reception of multicast packets, the source-ITR must obtain the replication-list for the (S,G) addresses in the packets.

In order to obtain the replication-list, the Source-ITR must issue a Map-Request message in which the EID is the (S,G) multicast tuple which is encoded using the Multicast Info LCAF type defined in [\[I-D.ietf-lisp-lcaf\]](#).

The Mapping System (most likely the Map-Server) will Map-reply with the merged replication-list maintained in the Mapping System. The Map-reply message must follow the format defined in [\[RFC6830\]](#), its EID must be encoded using the Multicast Info LCAF type and the

corresponding RLOC-records must be encoded using the RLE LCAF type. Both LCAF types defined in [[I-D.ietf-lisp-lcaf](#)].

### [4.3.](#) General LISP Notification Procedures

The Map-Server will issue LISP Map-Notify messages to inform the Source-site of the presence of receivers for a particular multicast group over the overlay.

Updated Map-Notify messages should be issued every time a new registration is received from a Receiver-site. This guarantees that the source-sites are aware of any potential changes in the multicast-distribution-list membership.

The Map-Notify messages carry (S,G) multicast EIDs encoded using the Multicast Info LCAF type defined in [[I-D.ietf-lisp-lcaf](#)].

Map-Notify messages will be sent by the Map-Server to the RLOCs with which the unicast S-prefix EID was registered.

When both the Receiver-sites and the Source-sites register to the same Map-Server, the Map-Server has all the necessary information to send the Map-Notify messages to the Source-site.

When the Map-Servers are distributed in a DDT, the Receiver-sites may register to one Map-Server while the Source-site registers to a different Map-Server. In this scenario, the Map-Server for the receiver sites must resolve the unicast S-prefix EID in the DDT per standard LISP lookup procedures and obtain the necessary information to send the Map-Notify messages to the Source-site. The Map-Notify messages must be sent with an authentication length of 0 as they would not be authenticated.

When the Map-Servers are distributed in a DDT, different Receiver-sites may register to different Map-Servers. This is an unsupported scenario with the currently defined mechanisms.

## [5.](#) Source Specific Multicast Trees

The interconnection of Source Specific Multicast (SSM) Trees across sites will follow the General Receiver-site Procedures described in [Section 4.1](#) on the Receiver-sites.

The Source-site Procedures will vary depending on the topological location of the Source within the Source-site as described in [Section 5.1](#) and [Section 5.2](#) .

### [5.1.](#) Source directly connected to Source-ITRs

When the Source is directly connected to the source-ITR, it is not necessary to trigger signaling to build a local multicast tree at the Source-site. Therefore Map-Notify messages may not be required to initiate building of the multicast tree at the Source-site.

Map-Notify messages are still required to ensure that any changes to the replication-list are communicated to the Source-site so that the map-cache at the Source-ITRs is kept updated.

### [5.2.](#) Source not directly connected to Source-ITRs

The General LISP Notification Procedures described in [Section 4.3](#) must be followed when the Source is not directly connected to the source-ITR. On reception of Map-Notify messages, local multicast signaling must be initiated at the Source-site per the General Source Site Procedures for Multicast Tree building described in [Section 4.2.1](#).

In the SSM case, the IP address of the Source is known and it is also registered with the LISP mapping system. Thus, the mapping system may resolve the mapping for the Source address in order to send Map-Notify messages to the correct source-ITR.

## [6.](#) PIM Any Source Multicast Trees

LISP signal-free multicast will not support ASM Trees at this time. A future revision of this specification may include procedures for PIM ASM support.

PIM ASM in shared-tree only mode could be supported in the scenario

where the root of the shared tree (the PIM RP) is placed at the source site.

## 7. Signal-Free Multicast for Replication Engineering

The mechanisms in this draft can be applied to the LISP Replication-Engineering [[I-D.coras-lisp-re](#)] design. Rather than having the layered LISP-RE RTR hierarchy use signaling mechanisms, the RTRs can register their availability for multicast tree replication via the mapping database system. As stated in [[I-D.coras-lisp-re](#)], the RTR layered hierarchy is used to avoid head-end replication in replicating nodes closest to a multicast source. Rather than have multicast ITRs replicate to each ETR in an RLE entry of a (S,G) mapping database entry, it could replicate to one or more layer-0 RTRs in the LISP-RE hierarchy.

There are two formats an (S,G) mapping database entry could have. One format is a 'complete-format' and the other is a 'filtered-format'. A 'complete-format' entails an (S,G) entry having multiple RLOC records which contain both ETRs that have registered as well as the RTRs at the first level of the LISP-RE hierarchy for the ITR to replicate to. When using 'complete-format', the ITR has the ability to select if it replicates to RTRs or to the registered ETRs at the receiver sites. A 'filtered-format' (S,G) entry is one where the Map-Server returns the RLOC-records that it decides the ITR should use. So replication policy is shifted from the ITRs to the mapping system. The Map-Servers can also decide for a given ITR, if it uses a different set of replication targets per (S,G) entry for which the ITR is replicating for.

The procedure for the LISP-RE RTRs to make themselves available for replication can occur before or after any receivers join an (S,G) entry or any sources send for a particular (S,G) entry. Therefore, newly configured RTR state will be used to create new (S,G) state and inherited into existing (S,G) state. A set of RTRs can register themselves to the mapping system or a third-party can do so on their behalf. When RTR registration occurs, it is done with an (S-prefix, G-prefix) entry so it can advertise its replication services for a wide-range of source/group combinations.

When a Map-Server receives (S,G) registrations from ETRs and

(S-prefix, G-prefix) registrations from RTRs, it has the option of merging the RTR RLOC-records for each (S,G) that is more-specific for the (S-prefix, G-prefix) entry or keep them separate. When merging, a Map-Server is ready to return a 'complete-format' Map-Reply. When keeping the entries separate, the Map-Server can decide what to include in a Map-Reply when a Map-Request is received. It can include a combination of RLOC-records from each entry or decide to use one or the other depending on policy configured.

Here is a specific example of (S,G) and (S-prefix, G-prefix) mapping database entries when a source S is behind an ITR and there are receiver sites joined to (S,G) via ETR1, ETR2, and ETR3. And there exists a LISP-RE hierarchy of RTR1 and RTR2 at level-0 and RTR3 and RTR4 at level-1:

```
EID-record: (S,G)
  RLOC-record: RLE: (ETR1, ETR2, ETR3), p1
EID-record: (S-prefix, G-prefix)
  RLOC-record: RLE: (RTR1(L0), RTR2(L0), RTR3(L1), RTR4(L1)), p1
```

The above entries are in the form of how they were registered and stored in a Map-Server. When a Map-Server uses 'complete-format', a Map-Reply it originates has the mapping record encoded as:

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Moreno & Farinacci	Expires December 10, 2015	[Page 12]
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Internet-Draft	Signal-Free LISP Multicast	June 2015
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```
EID-record: (S,G)
  RLOC-record: RLE: (RTR1(L0), RTR3(L1)), p1
  RLOC-record: RLE: (ETR1, ETR2, ETR3), p1
```

The above Map-Reply allows the ITR to decide if it replicates to the ETRs or if it should replicate only to level-0 RTR1. This decision is left to the ITR since both RLOC-records have priority 1. If the Map-Server wanted to force the ITR to replicate to RTR1, it would set the ETRs RLOC-record to priority greater than 1.

When a Map\_server uses "filtered-format", a Map-Reply it originates has the mapping record encoded as:

```
EID-record: (S,G)
  RLOC-record: RLE: (RTR1(L0), RTR3(L1)), p1
```

An (S,G) entry can contain alternate RTRs. So rather than replicating to multiple RTRs, one of a RTR set may be used based on

the RTR reachability status. An ITR can test reachability status to any layer-0 RTR using RLOC-probing so it can choose one RTR from a set to replicate to. When this is done the RTRs are encoded in different RLOC-records versus together in one RLE RLOC-record. This moves the replication load off the ITRs at the source site to the RTRs inside the network infrastructure. This mechanism can also be used by level-n RTRs to level-n+1 RTRs.

The following mapping would be encoded in a Map-Reply sent by a Map-Server and stored in the ITR. The ITR would use RTR1 until it went unreachable and then switch to use RTR2:

```
EID-record: (S,G)
  RLOC-record: RTR1, p1
  RLOC-record: RTR2, p2
```

## 8. Security Considerations

[I-D.ietf-lisp-sec] defines a set of security mechanisms that provide origin authentication, integrity and anti-replay protection to LISP's EID-to-RLOC mapping data conveyed via mapping lookup process. LISP-SEC also enables verification of authorization on EID-prefix claims in Map-Reply messages.

Additional security mechanisms to protect the LISP Map-Register messages are defined in [[RFC6833](#)].

The security of the Mapping System Infrastructure depends on the particular mapping database used. The [[I-D.ietf-lisp-ddt](#)] specification, as an example, defines a public-key based mechanism

that provides origin authentication and integrity protection to the LISP DDT protocol.

Map-Replies received by the source-ITR can be signed (by the Map-Server) so the ITR knows the replication-list is from a legit source.

Data-plane encryption can be used when doing unicast rep-encapsulation as described in [[I-D.ietf-lisp-crypto](#)]. For further study we will look how to do multicast rep-encapsulation.

## 9. IANA Considerations

This document has no IANA implications

## 10. Acknowledgements

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## 11. References

### 11.1. Normative References

- [RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", [BCP 14](#), [RFC 2119](#), March 1997.
- [RFC3618] Fenner, B. and D. Meyer, "Multicast Source Discovery Protocol (MSDP)", [RFC 3618](#), October 2003.
- [RFC4601] Fenner, B., Handley, M., Holbrook, H., and I. Kouvelas, "Protocol Independent Multicast - Sparse Mode (PIM-SM): Protocol Specification (Revised)", [RFC 4601](#), August 2006.
- [RFC4607] Holbrook, H. and B. Cain, "Source-Specific Multicast for IP", [RFC 4607](#), August 2006.

### 11.2. Informative References

- [I-D.coras-lisp-re]  
Coras, F., Cabellos-Aparicio, A., Domingo-Pascual, J., Maino, F., and D. Farinacci, "LISP Replication Engineering", [draft-coras-lisp-re-07](#) (work in progress), April 2015.

Moreno & Farinacci	Expires December 10, 2015	[Page 14]
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Internet-Draft	Signal-Free LISP Multicast	June 2015
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- [I-D.farinacci-lisp-mr-signaling]  
Farinacci, D. and M. Napierala, "LISP Control-Plane Multicast Signaling", [draft-farinacci-lisp-mr-signaling-06](#) (work in progress), February 2015.



- [I-D.ietf-lisp-crypto]  
Farinacci, D. and B. Weis, "LISP Data-Plane Confidentiality", [draft-ietf-lisp-crypto-01](#) (work in progress), May 2015.
- [I-D.ietf-lisp-ddt]  
Fuller, V., Lewis, D., Ermagan, V., and A. Jain, "LISP Delegated Database Tree", [draft-ietf-lisp-ddt-03](#) (work in progress), April 2015.
- [I-D.ietf-lisp-lcaf]  
Farinacci, D., Meyer, D., and J. Snijders, "LISP Canonical Address Format (LCAF)", [draft-ietf-lisp-lcaf-08](#) (work in progress), April 2015.
- [I-D.ietf-lisp-sec]  
Maino, F., Ermagan, V., Cabellos-Aparicio, A., and D. Saucez, "LISP-Security (LISP-SEC)", [draft-ietf-lisp-sec-08](#) (work in progress), April 2015.
- [RFC6830] Farinacci, D., Fuller, V., Meyer, D., and D. Lewis, "The Locator/ID Separation Protocol (LISP)", [RFC 6830](#), January 2013.
- [RFC6831] Farinacci, D., Meyer, D., Zwiebel, J., and S. Venaas, "The Locator/ID Separation Protocol (LISP) for Multicast Environments", [RFC 6831](#), January 2013.
- [RFC6833] Fuller, V. and D. Farinacci, "Locator/ID Separation Protocol (LISP) Map-Server Interface", [RFC 6833](#), January 2013.

## [Appendix A](#). Document Change Log

### [A.1](#). Changes to [draft-farinacci-lisp-signal-free-multicast-03](#)

- o Posted June 2015.
- o Update references and document timer.

[A.2.](#) Changes to [draft-farinacci-lisp-signal-free-multicast-02](#)

- o Posted December 2014.
- o Added section about how LISP-RE can use the mechanisms from signal-free-multicast so we can avoid head-end replication and avoid signalling across a layered RE topology.

[A.3.](#) Changes to [draft-farinacci-lisp-signal-free-multicast-01](#)

- o Posted June 2014.
- o Changes based on implementation experience of this draft.

[A.4.](#) Changes to [draft-farinacci-lisp-signal-free-multicast-00](#)

- o Posted initial draft February 2014.

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