LISP - Locator/ID Separation Protocol

Luigi Iannone
Road Map

- Historical Notes

- LISP Data Plane
  - RFC 6830

- LISP Control Plane
  - RFC 6833; RFC 6836; RFC 6837; draft-ietf-lisp-ddt-01.txt

- LISP-Interworking
  - RFC 6832

- The Big Picture
“Addressing can follow topology
or
topology can follow addressing. Choose one.”

Rekhter’s Law
Does the Internet Really Scale?

CAIDA’s IPv4 AS Core
AS-level INTERNET GRAPH
Skitter January 2000

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2000

2014
Is it the Internet growth sustainable???

http://bgp.potaroo.net/as2.0/bgp-active.html
The Proactive Routing Architecture: Do you speak BGP?
Routing in the Internet today is like putting direction signs about every city in the world at every crossing.
Routing in the Internet today is like putting direction signs about **every** city in the world at every crossing............
Root of the BGP’s FIB inflation problem
No... it is not just natural Internet growth

BGP Forwarding Information Base (FIB) and Churn Explosion:
PI (Provider Independent) prefix assignment
Multi-homing
Traffic-Engineering
Security
Remember the YouTube incident?

http://bgp.potaroo.net/as2.0/bgp-active.html

IPv4
IPv6
Monolithic...

“Addressing can follow topology
or
topology can follow addressing. Choose one.”

Rekhter’s Law
The Location is the ID, the ID is the Location

- The overloaded IP address Semantic

- An IP Address tells:
  - Who you are
    - Hi! I am Luigi Iannone 46, Rue Barrault 75013 Paris France
  - Where you are
    - Hi! I am Luigi Iannone 46, Rue Barrault 75013 Paris France

- This design was OK in the 70s-80s
  - Because was easier to implement
  - Because the Internet was a small academic network of networks
Internet’s Scaling Issues

“It is commonly recognized that today’s Internet routing and addressing system is facing serious scaling problems.”

"The Research Group has rough consensus that separating identity from location is desirable and technically feasible. However, the Research Group does NOT have consensus on the best engineering approach to such an identity/location split."

Along with a plethora of proposals:

- **Locator/ID Separation Protocol (LISP)**
- Routing Architecture for the Next Generation Internet (**RANGI**)
- Internet Vastly Improved Plumbing (**Ivip**)
- Hierarchical IPv4 Framework (**hIPv4**)
- Name Overlay (**NOL**) Service for Scalable Internet Routing
- Compact Routing in a Locator Identifier Mapping System (**CRM**)
- Layered Mapping System (**LMS**)
- Two-Phased Mapping
- Global Locator, Local Locator, and Identifier Split (**GLI-Split**)
- Tunneled Inter-Domain Routing (**TIDR**)
- Identifier-Locator Network Protocol (**ILNP**)
- Enhanced Efficiency of Mapping Distribution protocols in Map-and-Encap Schemes (**EEMDP**)
- Evolution
- Name-Based Sockets
- Routing and Addressing in Networks with Global Enterprise Recursion (**IRON-RANGER**)
- Hierarchical Architecture for Internet Routing (**HAIR**)

From RFC 6115: Recommendation for a Routing Architecture
LISP Data Plane (RFC 6830)
At the border of ID and Location

Identifier Space

Locator Space

Internet (DFZ)

ITR/ETR
Ingress/Egress Tunnel Routers (xTRs)
Life of a Packet in a LISP World..
Life of a Packet in a LISP World
Life of a Packet in a LISP World..

- Bindings between ID and Locators: *Mappings*
  - $EID_x \rightarrow RLOC^1_{EID_x}$, $RLOC^2_{EID_x}$
  - $EID_y \rightarrow RLOC^1_{EID_y}$, $RLOC^2_{EID_y}$
Life of a Packet in a LISP World.

- Bindings between ID and Locators: \textit{Mappings}
  - $\text{EID}_x \rightarrow \text{RLOC}^1_{\text{EID}_x}$, $\text{RLOC}^2_{\text{EID}_x}$
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Life of a Packet in a LISP World..

- Bindings between ID and Locators: *Mappings*
  - EID\(_x\) ➔ RLOC\(^1\)\(_{EID_x}\) RLOC\(^2\)\(_{EID_x}\)
  - EID\(_y\) ➔ RLOC\(^1\)\(_{EID_y}\) RLOC\(^2\)\(_{EID_y}\)
Map & Encap Operations: source side
Map & Encap Operations: source side

<table>
<thead>
<tr>
<th>Version</th>
<th>IHL</th>
<th>Type of Service</th>
<th>Total Length</th>
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<th>Destination EID</th>
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Forwarding using EIDs (Normal IP packets)
Map & Encap Operations: source side

Forwarding using EIDs (Normal IP packets)

Internet

Symbols:
- L: Length
- N: Nonce
- I: Instance ID
- E: EID
- V: Version
- I: Identification
- F: Flags
- V: Version
- S: Source EID
- P: Destination EID
Map & Encap Operations: source side

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Map & Encap Operations: source side

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| Identification | Flags | Fragment Offset |
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| Time to Live | Protocol | Header Checksum |
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| Source EID |
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| Destination EID |
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| Source Port = xxxx | Dest Port = 4341 |
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| UDP Length | UDP Checksum |
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| Source Routing Locator |
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| Destination Routing Locator |
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Luigi Iannone
Telecom ParisTech
LISP Mini Tutorial
Map & Encap Operations: source side

LISP-Database:
- Contains mappings “owned” locally
- Used to select source RLOC

\[ EID_s - Prefix \Rightarrow (RLOC_{EID_s}^1, RLOC_{EID_s}^2) \]
Map & Encap Operations: source side

LISP-Database:
- Contains mappings “owned” locally
- Used to select source RLOC

\[ EID_s - Prefix \Rightarrow (RLOC_{EID_s}^1, RLOC_{EID_s}^2) \]
Where does LISP find the Mappings?

Mapping Distribution System:
- Queried to retrieve mappings
- Used to select Destination RLOC

\[ EID_d - \text{Prefix} \Rightarrow (RLOC_{EID_d}^1, RLOC_{EID_d}^2) \]

Where is located EID_d?

DB

Internet

DB

(ALT, CONS, EMACS, DHT, NERD, TREE => DDT)
Where does LISP store the Mappings?

LISP-Cache:
- Queried before the Mapping system
- Mapping system queried only in case of miss
- Used to select Destination RLOC

Mapping Distribution System
(ALT, CONS, EMACS, DHT, NERD, TREE => DDT)
Map & Encap Operations: destination side
Map & Encap Operations: destination side

<table>
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<tr>
<th>0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1</th>
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Forwarding using EIDs (Normal IP packets)

Forwarding using RLOCs (LISP Encapsulation)
Map & Encap Operations: destination side

Consistency Checks:

- Check DB: Am I the correct RLOC for the destination EID?
Map & Encap Operations: destination side

Consistency Checks:
- Check DB: Am I the correct RLOC for the destination EID?
LISP Mapping Distribution System

LISP-MS (RFC 6833)
LISP+ALT (RFC 6836)
LISP-NERD (RFC 6837)
LISP-DDT (draft-ietf-lisp-ddt-01.txt)
MS: A Mapping System API Terminology

Map-Request(EID)

Map-Reply(EID: <RLOC1,...>)

Map-Register(EID: <RLOC1,...>)

Map-Notify(EID: <RLOC1,...>)
### Existing/Proposed Mapping Distribution Systems

<table>
<thead>
<tr>
<th>Mapping System</th>
<th>Distribution Model</th>
<th>Propagated Information</th>
<th>Aggregation</th>
<th>Sensitive to Churn</th>
</tr>
</thead>
<tbody>
<tr>
<td>LISP-DHT</td>
<td>Pull</td>
<td>EID-Prefix</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>LISP Distributed Hash Table</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LISP-CONS</td>
<td>Hybrid</td>
<td>EID-Prefix</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Content distribution Overlay Network Service</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>LISP-EMACS</td>
<td>Pull</td>
<td>-</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>EID Mapping multicast Across Cooperating Systems</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>LISP-NERD</td>
<td>Push</td>
<td>Entire Mapping Database</td>
<td>No</td>
<td>No (updates on a fixed time schedule)</td>
</tr>
<tr>
<td>Not so novel EID-to-RLOC Database</td>
<td></td>
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</tr>
<tr>
<td>LISP+ALT</td>
<td>Hybrid</td>
<td>EID-Prefix</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>LISP ALternative Topology</td>
<td></td>
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<tr>
<td>LISP-TREE (DDT)</td>
<td>Pull</td>
<td>EID-Prefix</td>
<td>Yes</td>
<td>No</td>
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<tr>
<td>DNS-Based lookup infrastructure</td>
<td></td>
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</table>
LISP-NERD
Not-so-novel Eid-to-Rloc Database

- Centralized approach based on one (or more) authority(ies)
  - xTRs periodic update request
  - Updates contain all mappings

- Pros
  - Simple
    - Bootstrap
    - Data Center
    - Private Deployments

- Cons
  - Not scalable
  - Static
LISP+ALT
Alternative Logical Topology

- BGP over GRE overlay
  - EID-Prefix (aggregated) advertisements
  - Map-Request routed on the overlay

- Pros
  - Based on existing well-known technology

- Cons
  - PITA

![Diagram of Mapping Distribution System with MS/MR nodes connected by lines, labeled as ALT-Router and BGP over GRE Session.]
LISP+ALT Failure

- Used on an international testbed (www.lisp4.net)
  - Rapidly resulted in very cumbersome maintenance

www.lisp4.net
- DNS-Like logical hierarchy
  - EID-Prefix more specific delegated
  - Delegation is statically configured

- Pros
  - Easy maintenance
  - Economics
  - Security

- Cons
  - manual configuration
  - static tree

DDT Node

... Logical Delegation
**LISP-DDT Configuration**

- **MR**
  - Static pointer to root

- **DDT Nodes**
  - Static pointers to children authoritative of more-specific (leafs are MS)

- **ETR**
  - Registers to statically configured MS
1. ITR sends Map-Request to its configured MR
2. MR sends Map-Request to configured Root Server
3. Root Server sends back Map-Referral to configured DDT Node authoritative on more specific
4. Repeat 2 and 3 until MS reached
5. MR sends Map-Request to authoritative MS
6. MS sends back Map-Reply with requested mapping to MR
7. MR sends Map-Reply with requested mapping to ITR
1. ITR sends Map-Request to its configured MR

2. MR sends Map-Request to configured Root Server

3. Root Server sends back Map-Referral to configured DDT Node authoritative on more specific

4. Repeat 2 and 3 until MS reached

5. MR sends Map-Request to authoritative MS

6. MS sends back Map-Reply with requested mapping to MR

7. MR sends Map-Reply with requested mapping to ITR
1. ITR sends Map-Request to its configured MR
2. MR sends Map-Request to configured Root Server
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Telecom ParisTech
Luigi Iannone
LISP
LISP-DDT
Mapping Retrieval (cold start)
1. ITR sends Map-Request to its configured MR
2. MR sends Map-Request to configured Root Server
3. Root Server sends back Map-Referral to configured DDT Node authoritative on more specific

LISP-DDT
Mapping Retrieval (cold start)

1. ITR sends Map-Request to its configured MR
2. MR sends Map-Request to configured Root Server
3. Root Server sends back Map-Referral to configured DDT Node authoritative on more specific

LISP-DDT
Mapping Retrieval (cold start)
1. ITR sends Map-Request to its configured MR
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4. Repeat 2 and 3 until MS reached

LISP-DDT
Mapping Retrieval (cold start)
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4. Repeat 2 and 3 until MS reached
5. MR sends Map-Request to authoritative MS
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7. MR sends Map-Reply with requested mapping to ITR
1. ITR sends Map-Request to its configured MR
2. MR sends Map-Request to cached authoritative MS
3. MS sends back Map-Reply with requested mapping to MR
4. MR sends Map-Reply with requested mapping to ITR
LISP-Interworking (RFC 6832)
The problem of Interworking between LISP and Legacy Internet

- How to forward packets from an ITR to a non-LISP site?
- How to forward packets from a non-LISP site to an EID?
The problem of Interworking between LISP and Legacy Internet

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The problem of Interworking between LISP and Legacy Internet

- How to forward packets from an ITR to a non-LISP site?
- How to forward packets from a non-LISP site to an EID?
Proxy-xTRs (PxTRs)

- Proxy-ITR (PITR) - Gateway from Legacy to LISP Internet
  - Announce large aggregates of EID-Prefixes into the legacy BGP
- Proxy-ETR (PETR) - Gateway from LISP to Legacy Internet
  - Could a static configuration (similar to default route)
  - Could be obtained from Mapping System
PxTRs and asymmetric traffic flow
PxTRs and asymmetric traffic flow
PxTRs and asymmetric traffic flow
PxTRs and asymmetric traffic flow
PxTRs and asymmetric traffic flow

Diagram showing LISP and Legacy Internet with ASx, ASj, and ASy, along with EIDs and RLOCs.
PxTRs and asymmetric traffic flow
PxTRs and asymmetric traffic flow
PxTRs and asymmetric traffic flow
PxTRs and asymmetric traffic flow
PxTRs and asymmetric traffic flow
Few Pointers...

- datatracker.ietf.org/wg/lisp/
- www.lisp4.net
- www.openlisp.org
- www.lisp-lab.org