QuickTime™ and a
decompressor
are needed to see this picture.

LISP: An Architectural Solution to Multi-homing, Traffic Engineering, and Internet Route Scaling

Dave Meyer & Dino Farinacci

LISP Designers:

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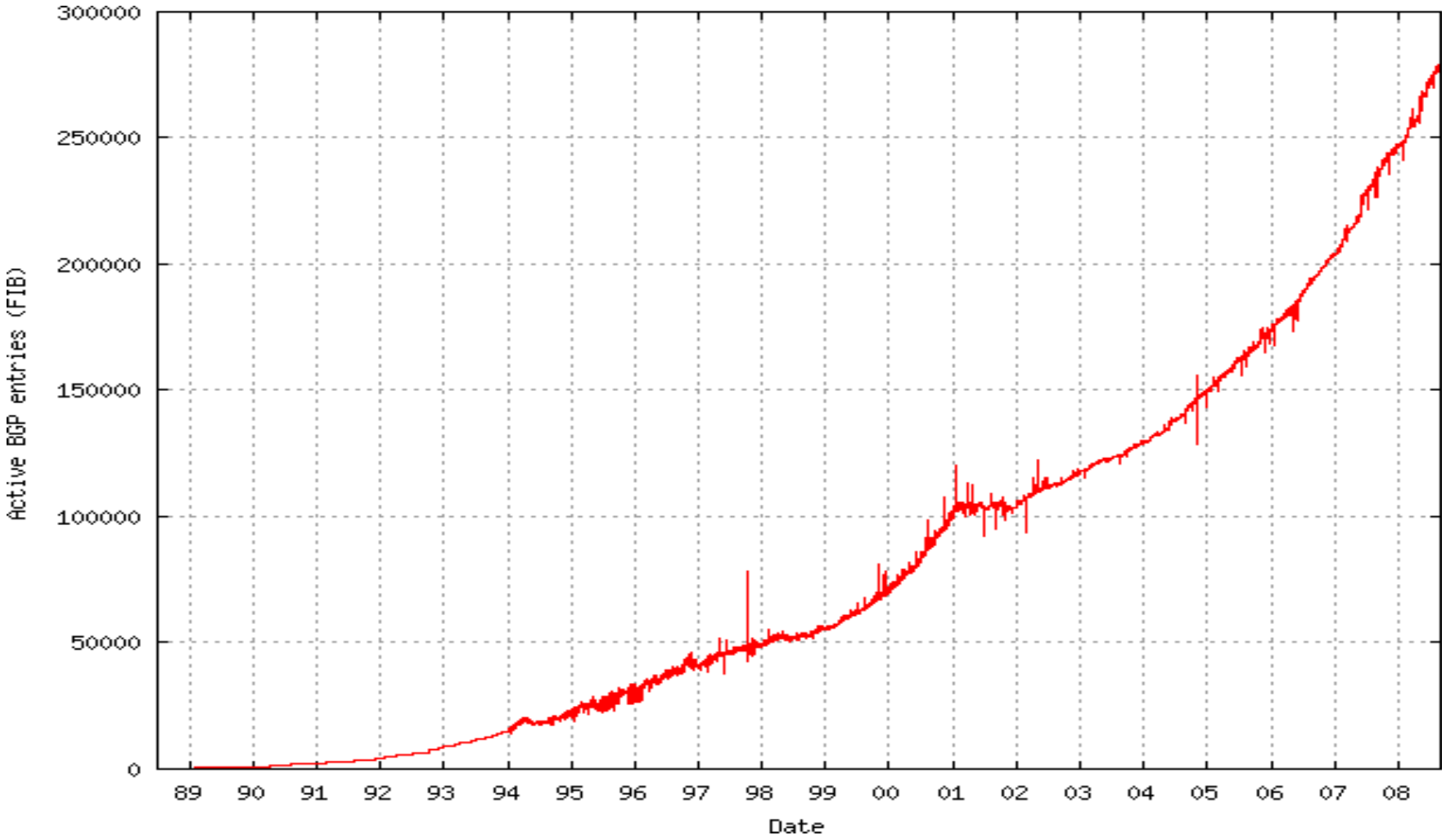
Agenda

- Problem Statement
- Architectural Concepts
  - Separating Identity and Location
  - Map-n-Encap to Implement Level of Indirection
- Unicast & Multicast Data Plane Operation
- Mapping Database Mechanism
  - LISP-ALT
- Locator Reachability
- Interworking LISP Sites and Legacy Sites
- Deployment Status
  - Present Prototype Implementation
  - Present World-Wide LISP Pilot Network
- Q&A

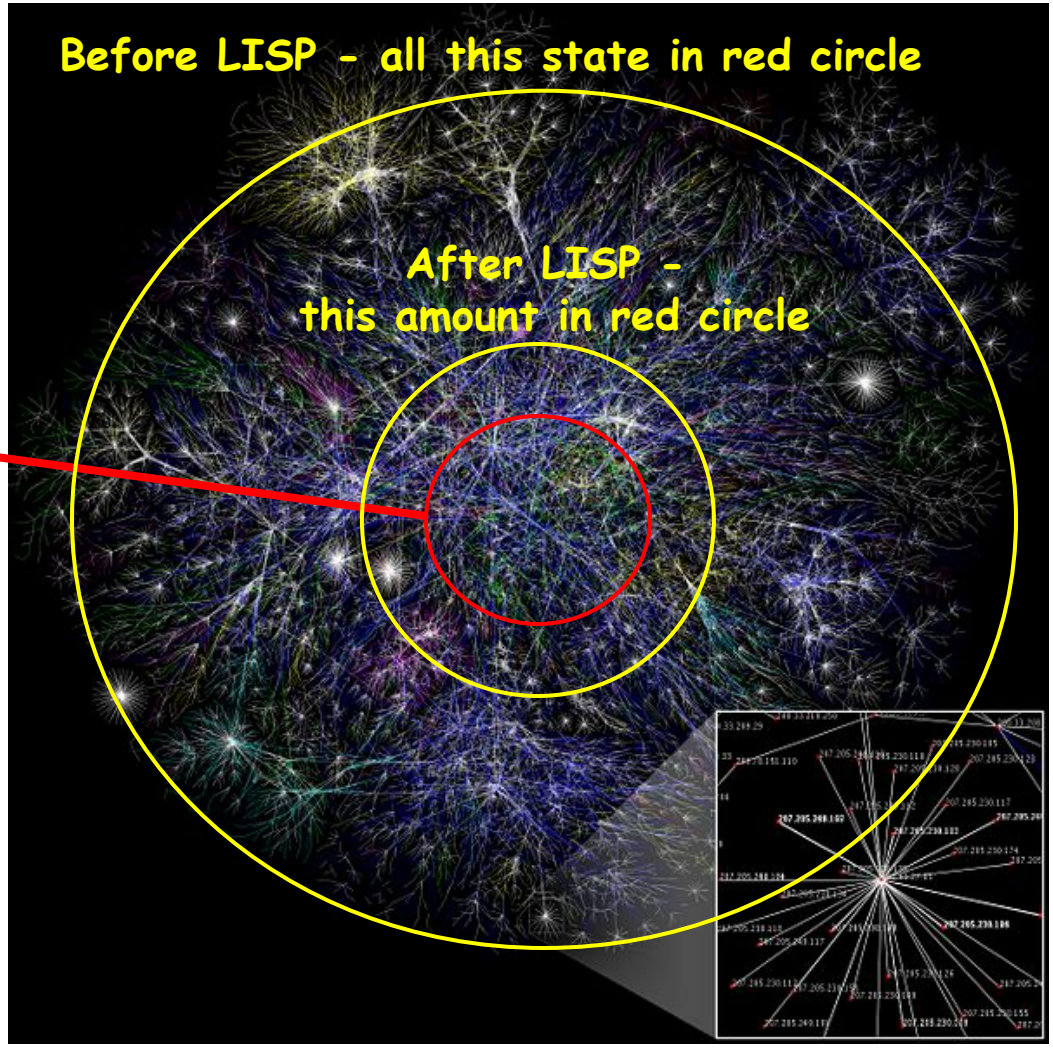
Problem Statement

- What provoked this?
  - Stimulated by problem statement effort at the Amsterdam IAB Routing Workshop on October 2006
    - RFC 4984
  - More info on problem statement:
    - http://www.vaf.net/~vaf/apricot-plenary.pdf

Scaling Internet Routing State



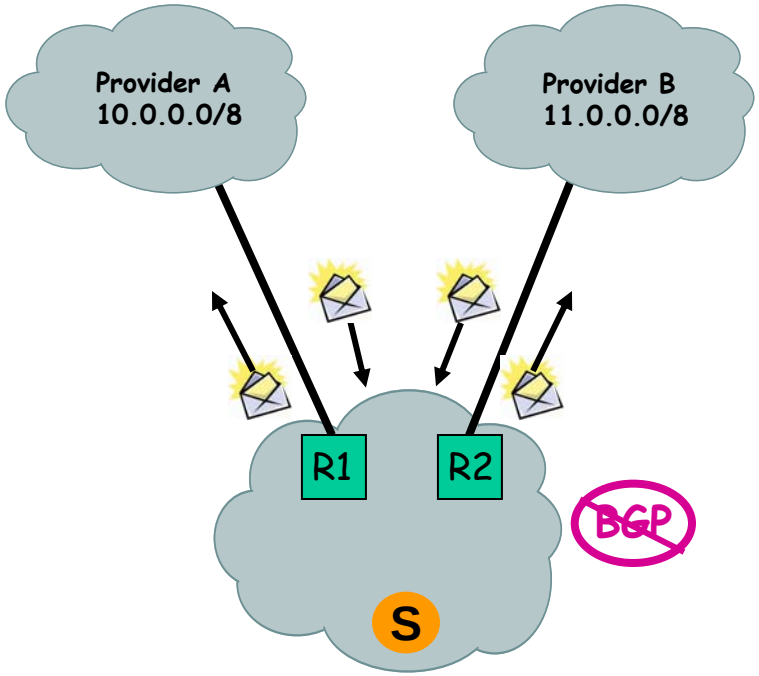
Routing Table Size Problem



10^7 routes

A 16-bit number!

Growth in Multi-Homing



(1) Improve site multi-homing

a) Can control egress with IGP routing

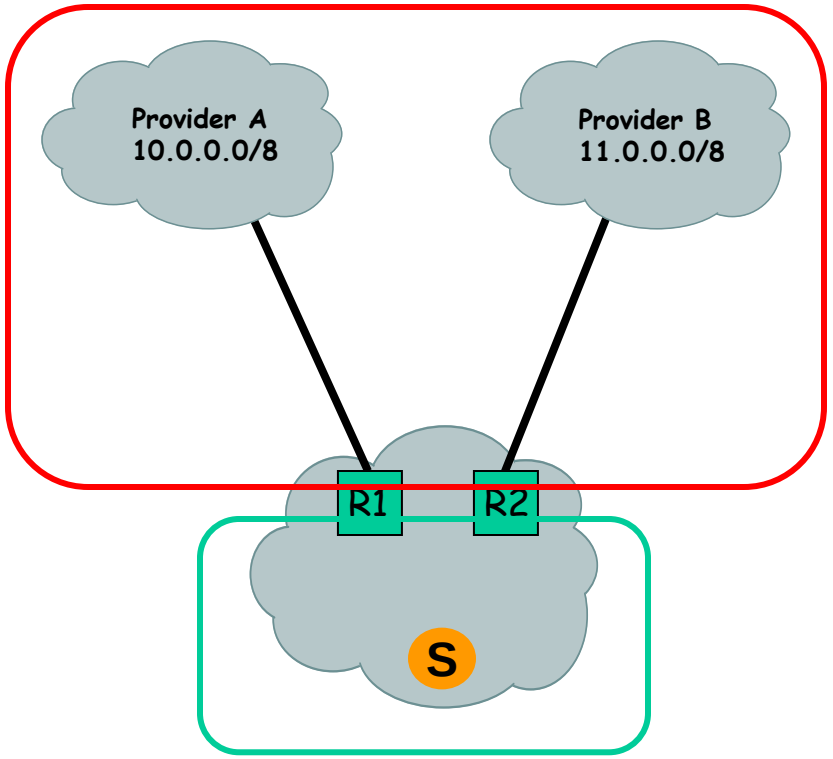
b) Hard to control ingress without more specific route injection

c) Desire to be low OpEx multi-homed (avoid complex protocols, no outsourcing)

(2) Improve ISP multi-homing

a) Same problem for providers, can control egress but not ingress, more specific routing only tool to circumvent BGP path selection

Growth in Multi-Homing



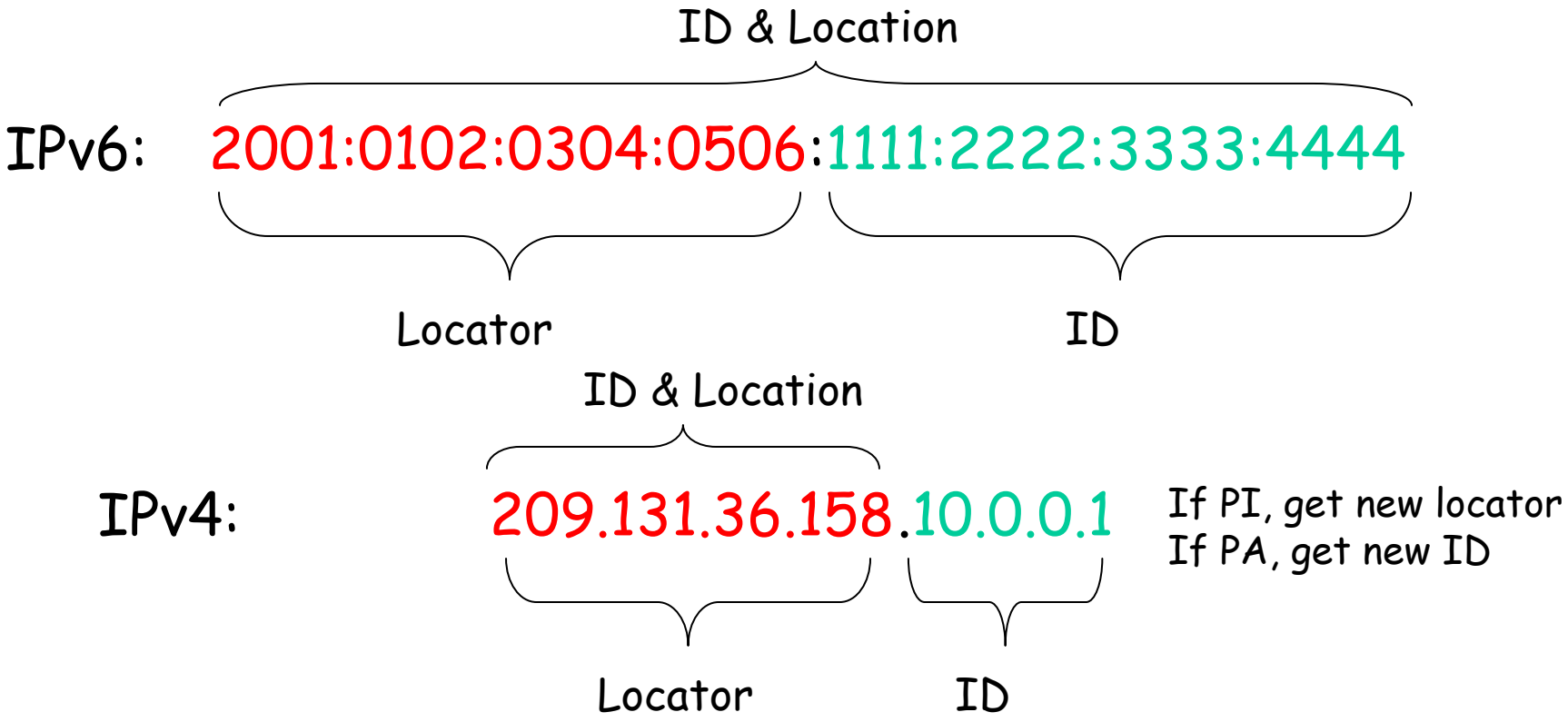
(3) Decouple site addressing from provider
- a) Avoid renumbering when site changes providers
- b) Site host and router addressing decoupled from core topology

(4) Add new addressing domains
- a) From possibly separate allocation entities

(5) Do 1) through 4) and reduce the size of the core routing tables

Separating (or adding) an Address

Changing the semantics of the IP address



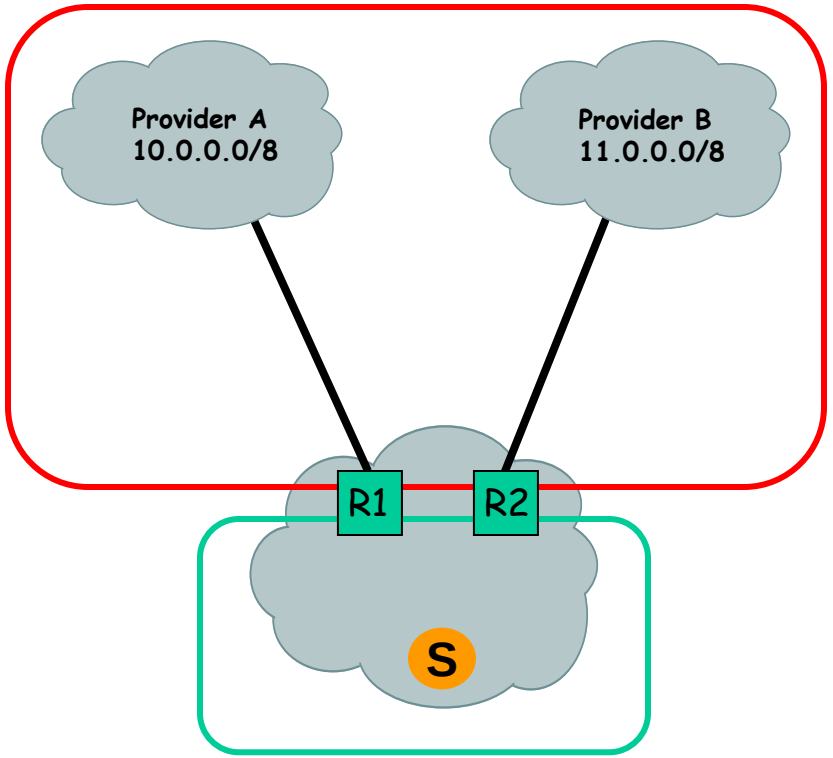
Why the Separation?

- *Level of Indirection* allows us to:
  - Keep either ID or Location fixed while changing the other
  - Create separate namespaces which can have different allocation properties
- By keeping IDs fixed
  - Assign fixed addresses that never change to hosts and routers at a site
- You can change Locators
  - Now the sites can change providers
  - Now the hosts can move

Some Brief Definitions

- IDs or EIDs
  - End-site addresses for hosts and routers at the site
  - They go in DNS records
  - Generally not globally routed on underlying infrastructure
  - New namespace
- RLOCs or Locators
  - Infrastructure addresses for LISP routers and ISP routers
  - Hosts do not know about them
  - They are globally routed and aggregated along the Internet connectivity topology
  - Existing namespace

Multi-Level Addressing



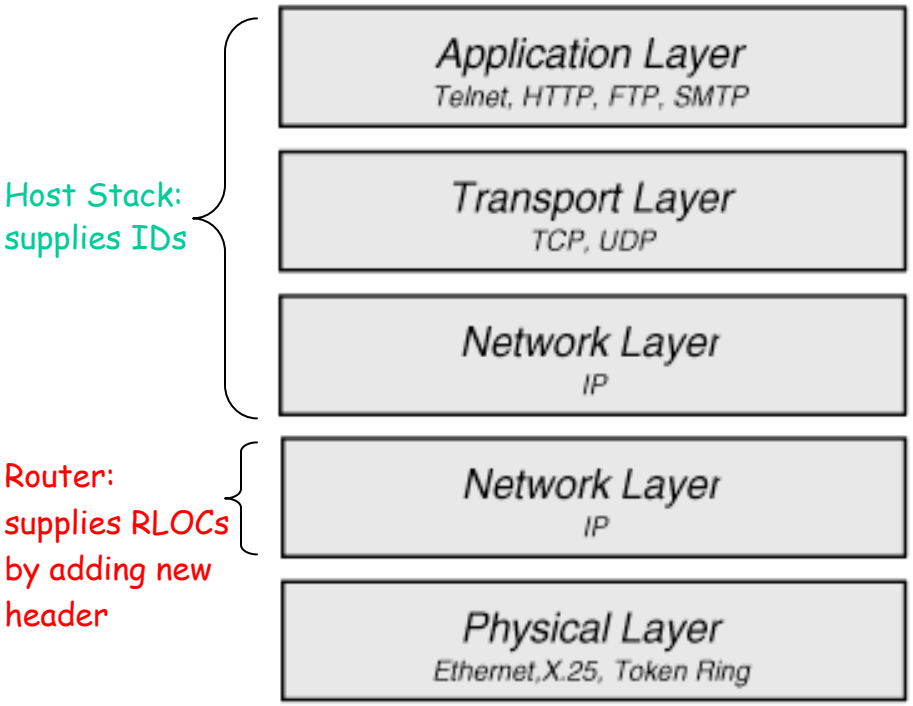
RLOCs used in the core

EIDs are inside of sites

What is LISP?

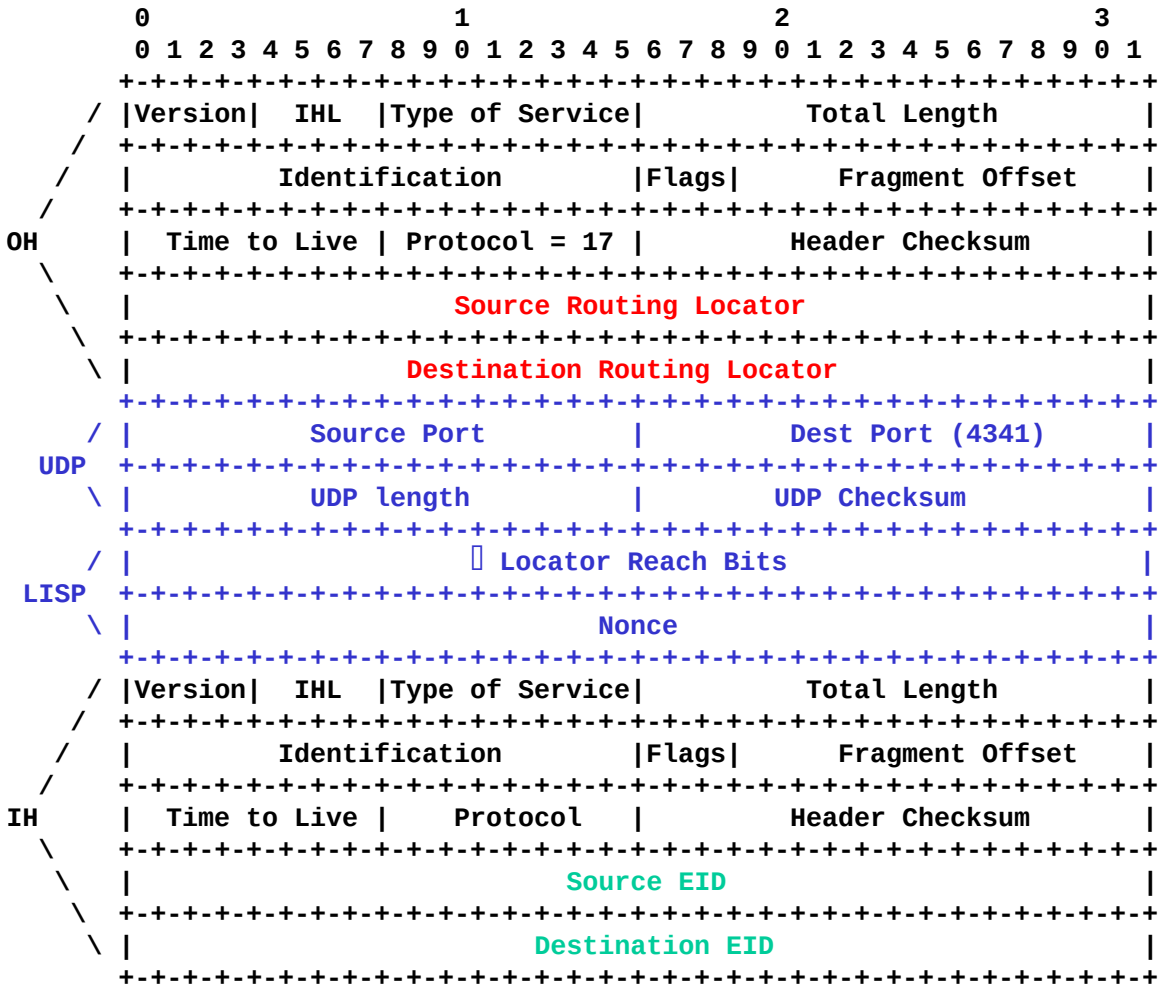
- Locator/ID Separation Protocol
- Ground rules for LISP
  - Network-based solution
  - No changes to hosts whatsoever
  - No new addressing changes to site devices
  - Very few configuration file changes
  - Imperative to be incrementally deployable
  - Address family agnostic

What is LISP?

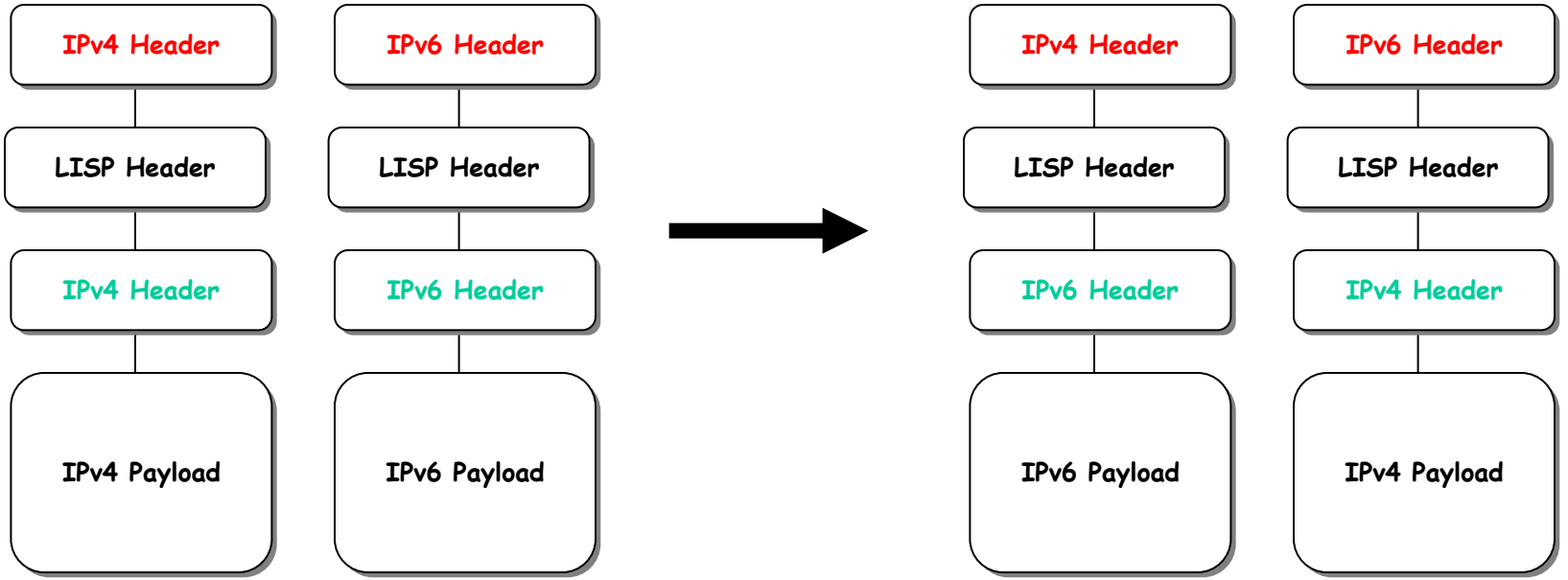


"Jack-Up" or "Map-n-Encap"

draft-farinacci-lisp-11.txt



LISP for IPv6 Transition



Legend:

EIDs -> Green

Locators -> Red

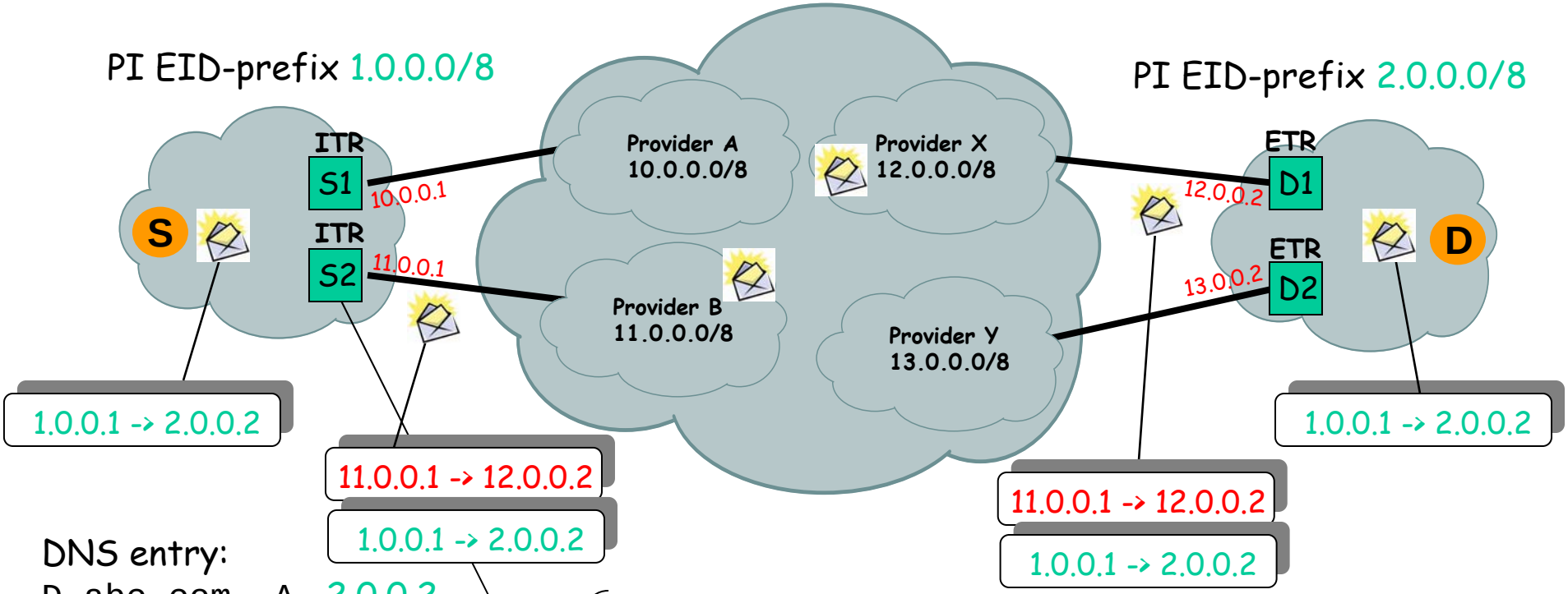
What is LISP?

- Data plane
  - Design for encapsulation and tunnel router placement
  - Design for locator reachability
  - Data-triggered mapping service
- Control plane
  - Design for a scalable mapping service
  - Examples are: CONS, NERD, ALT, EMACS

LISP Network Elements

- Ingress Tunnel Router (ITR)
  - Finds EID to RLOC mapping
  - Encapsulates to Locators at source site
- Egress Tunnel Router (ETR)
  - Owns EID to RLOC mapping
  - Decapsulates at destination site
- xTR
  - Term used when not referring to directionality
  - Basically a LISP router

Unicast Packet Forwarding



DNS entry:
D.abc.com A 2.0.0.2

Mapping Entry
- EID-prefix: 2.0.0.0/8
- Locator-set:
  - 12.0.0.2, priority: 1, weight: 50 (D1)
  - 13.0.0.2, priority: 1, weight: 50 (D2)

Policy controlled by destination site

Legend:
- EIDs -> Green
- Locators -> Red

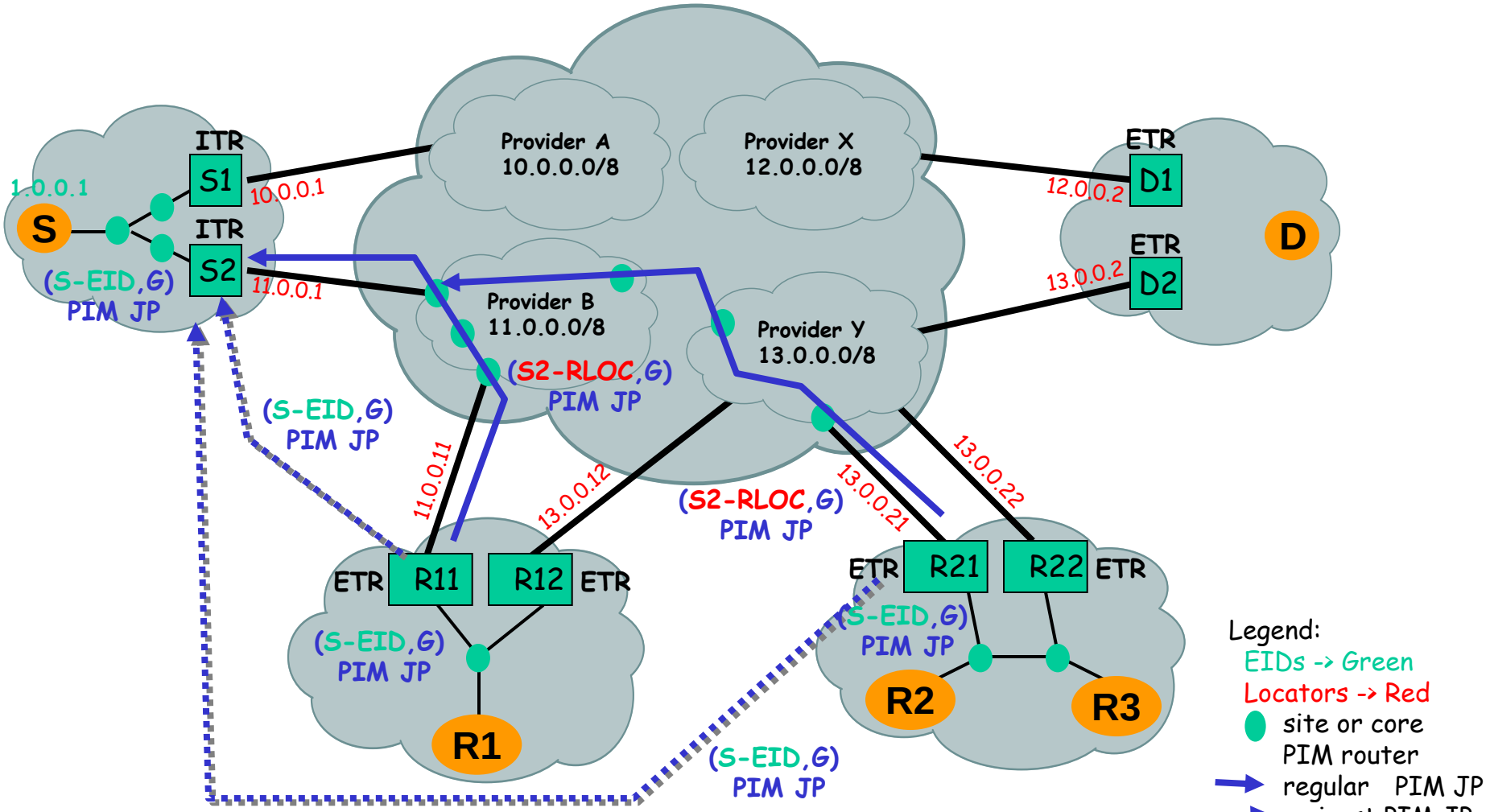
Multicast Packet Forwarding

- Keep EID state out of core network
- No head-end replication at source site
- Packets only go to receiver sites
- No changes to hosts, site routers, core routers
- Use existing protocols
- Support PIM SSM, don't preclude ASM & Bidir
- Have separate unicast and multicast policies

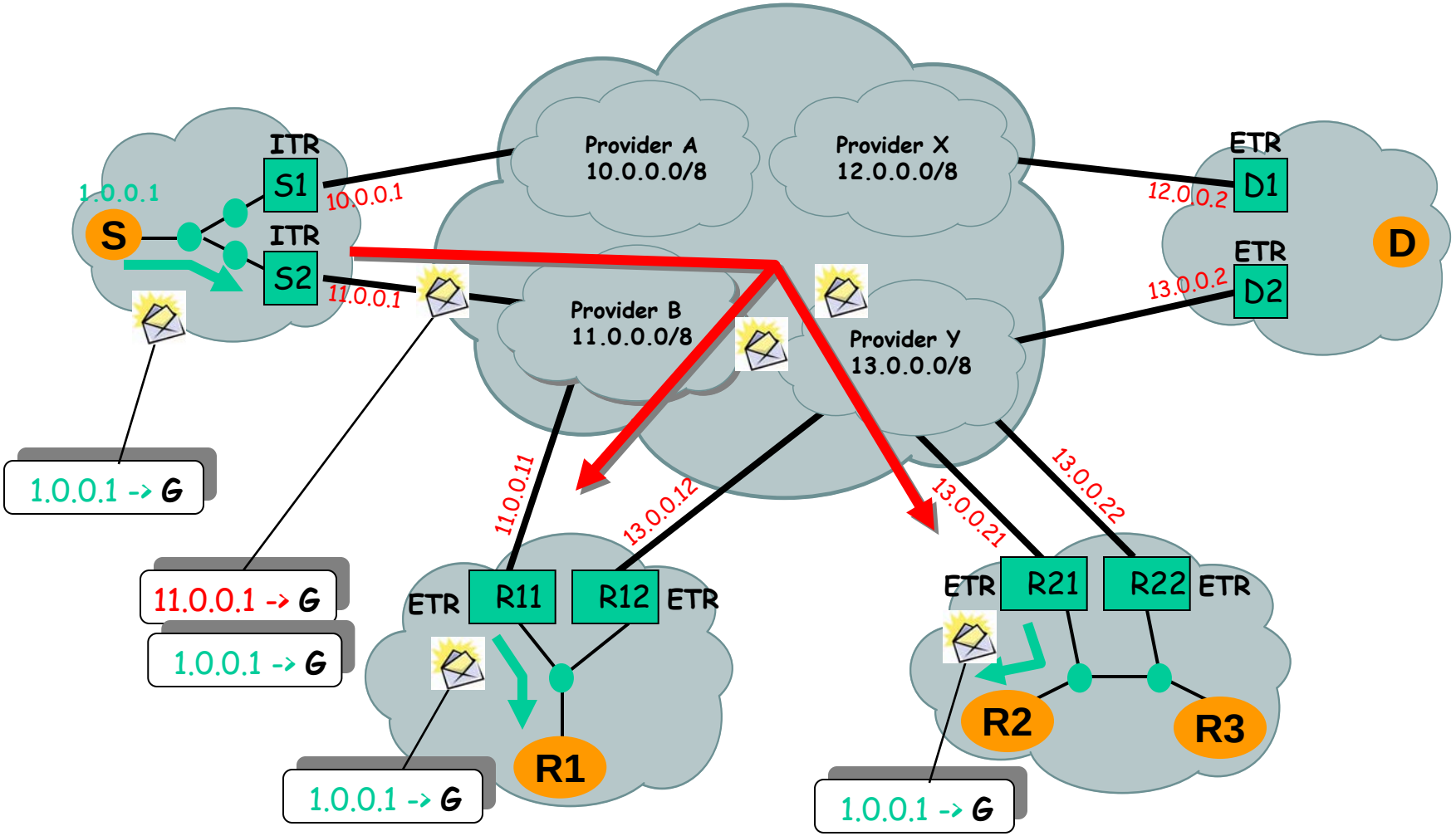
Multicast Packet Forwarding

- Group addresses have neither ID or Location semantics
  - G is topologically opaque - can be used everywhere
- (S-EID, G)
  - S-EID is source host
  - G is group address receivers join to
  - State resides in source and receiver sites
- (S-RLOC, G)
  - S-RLOC is ITR on multicast tree
  - G is group address receivers join to
  - State resides in core

Multicast Packet Forwarding



Multicast Packet Forwarding



When the xTR has no Mapping

- Need a scalable EID to Locator mapping lookup mechanism
- Network based solutions
  - Have query/reply latency
  - Can have packet loss characteristics
  - Or, have a full table like BGP does
- How does one design a scalable Mapping Service?

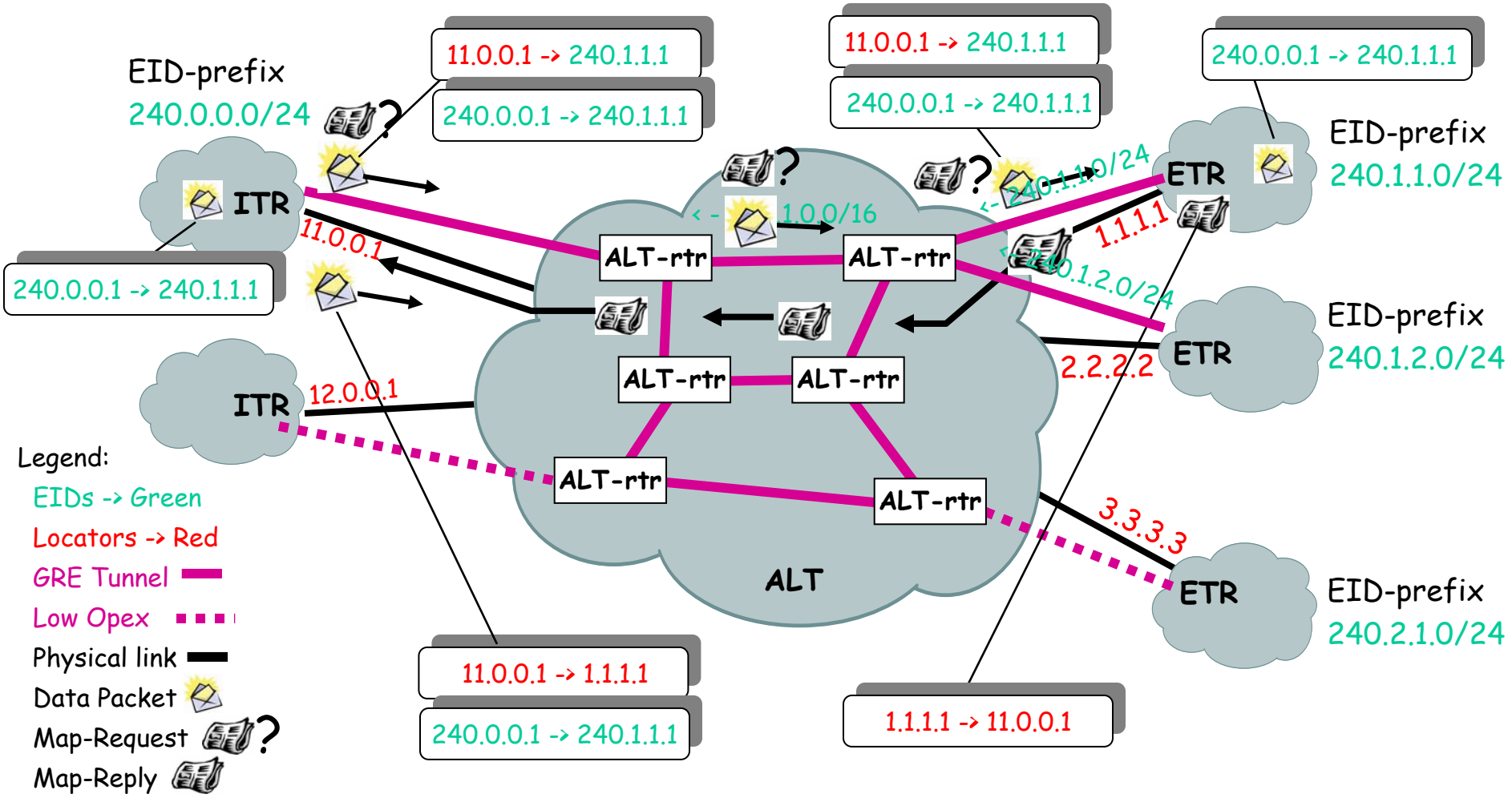
Mapping Database Designs

- You need a "map" before you can "encap"
- We have designed several mapping database protocols
  - CONS, NERD, EMACS, ALT
  - Tradeoff push versus pull benefit/cost
  - Needs to be scalable to 10^{10} entries
- ALT has the most promise
  - We are deploying ALT

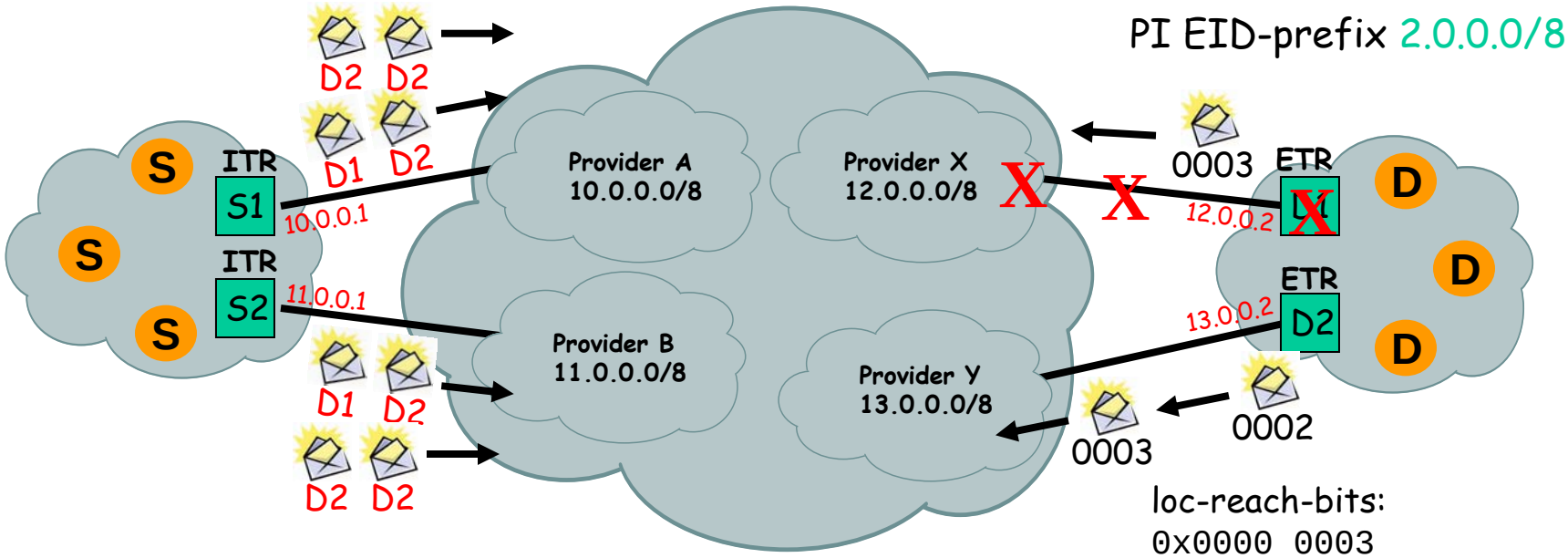
What is LISP+ALT?

- EID namespace is used at the site
- RLOC namespace is used in the Internet core
- Mappings need to be authoritative and reside at site ETRs
- Advertise EID-prefixes in BGP on an alternate topology of GRE tunnels
- ITRs get mappings by routing Map-Requests on ALT topology
- ETRs respond with Map-Replies

How LISP+ALT Works



Locator Reachability



Mapping Entry

EID-prefix: 2.0.0.0/8

Locator-set:

12.0.0.2, priority: 1, weight: 50 (D1) -> ordinal 0

13.0.0.2, priority: 1, weight: 50 (D2) -> ordinal 1

```
  7654 3210
b'xxxx xxxx'
```

Legend:

EIDs -> Green

Locators -> Red

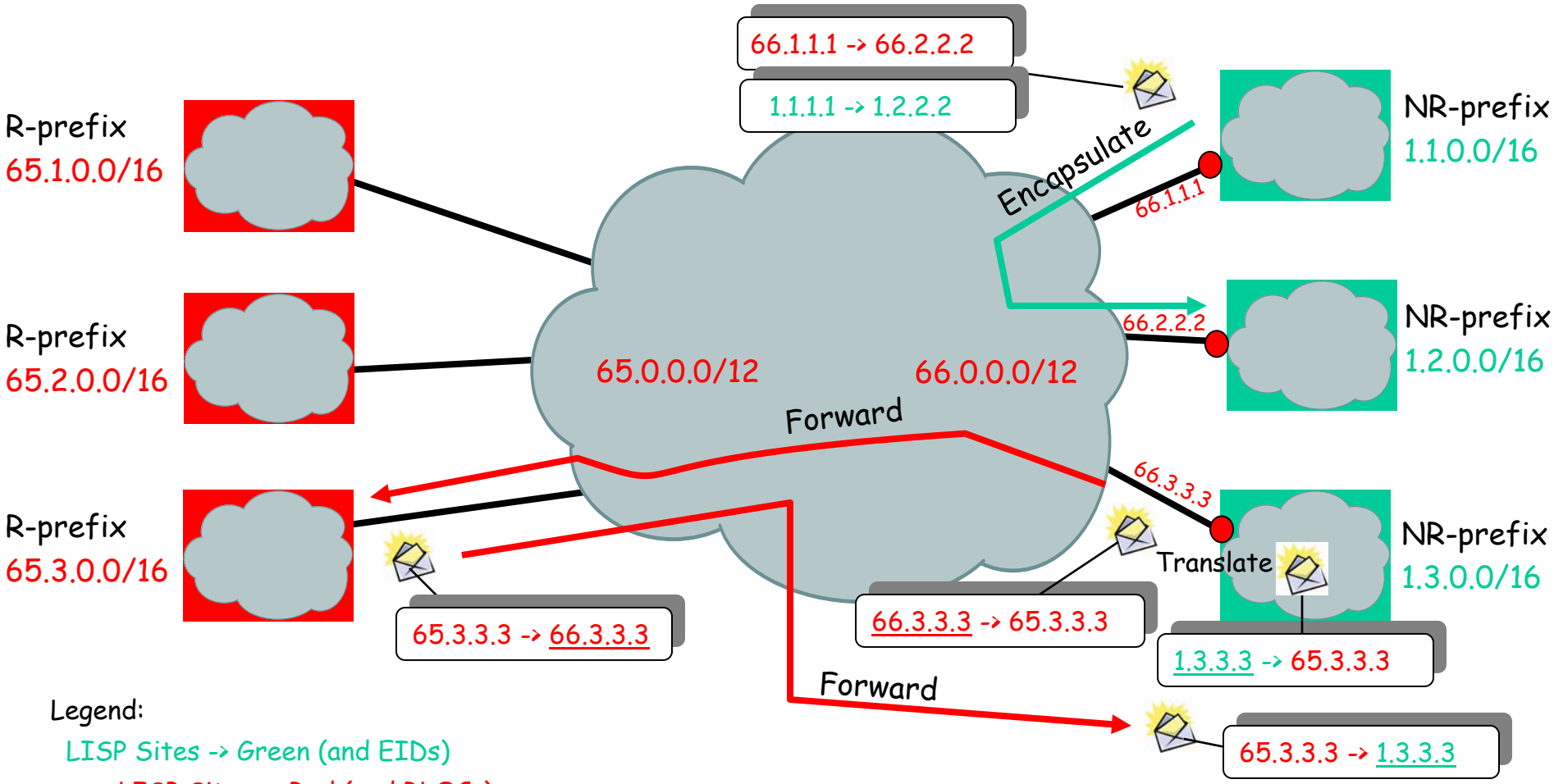
LISP Interworking

- LISP will not be widely deployed day-1
- Need a way for LISP-capable sites to communicate with rest of Internet
- Two basic Techniques
  - LISP Network Address Translators (LISP-NAT)
  - Proxy Tunnel Routers (PTRs)

LISP Interworking

- These combinations must be supported
  - Non-LISP site to non-LISP site
    - Today's Internet
  - LISP site to LISP site
    - Encapsulation over IPv4 makes this work
    - IPv4-over-IPv4 or IPv6-over-IPv4
  - LISP-R site to non-LISP site
    - When LISP site has PI or PA routable addresses
  - LISP-NR site to non-LISP site
    - When LISP site has PI or PA non-routable addresses

Interworking using LISP-NAT



Legend:

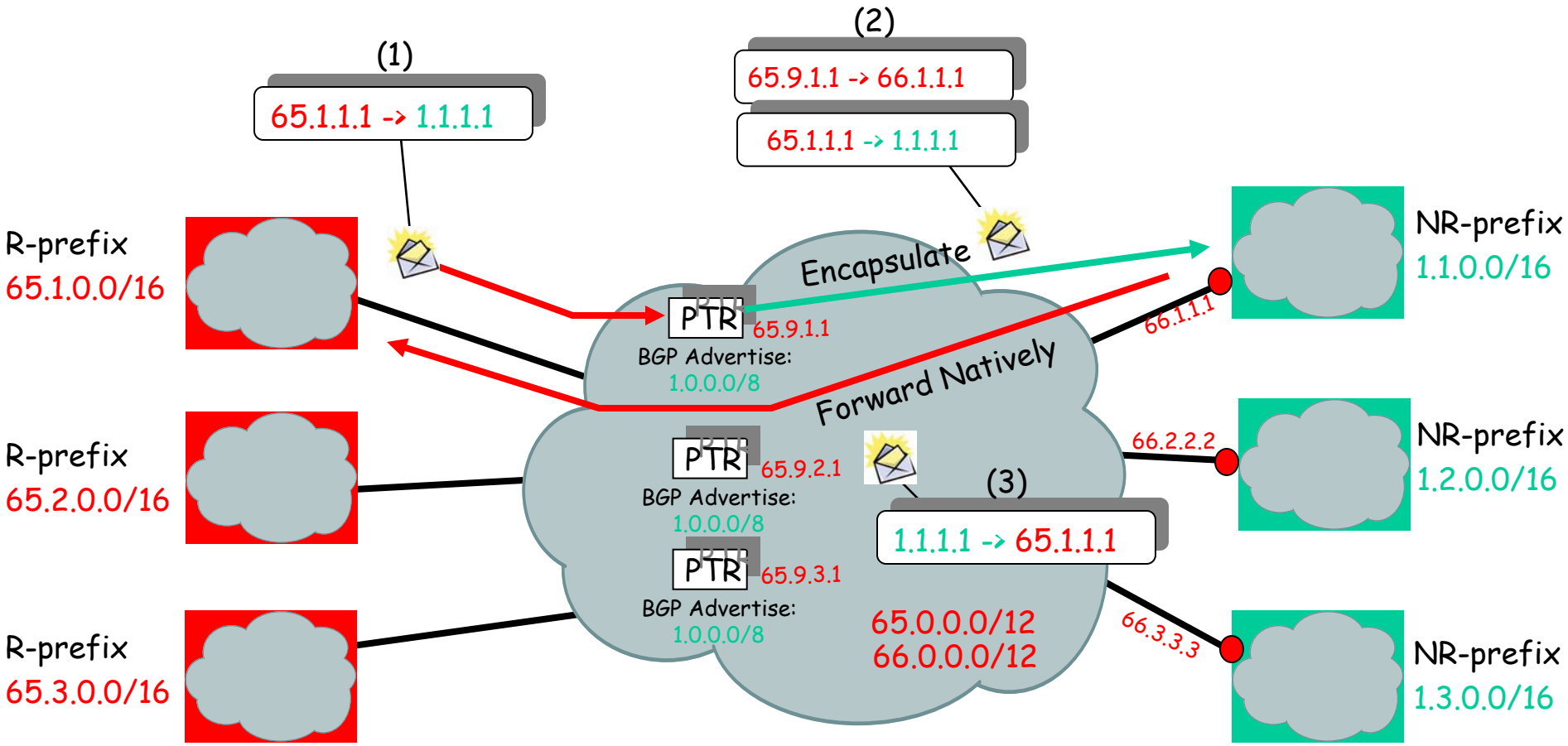
LISP Sites -> Green (and EIDs)

non-LISP Sites -> Red (and RLOCs)

xTR

Local/Uncoordinated Solution

Interworking using PTRs



Infrastructure Solution

Legend:

LISP Sites -> Green (and EIDs)

non-LISP Sites -> Red (and RLOCs)

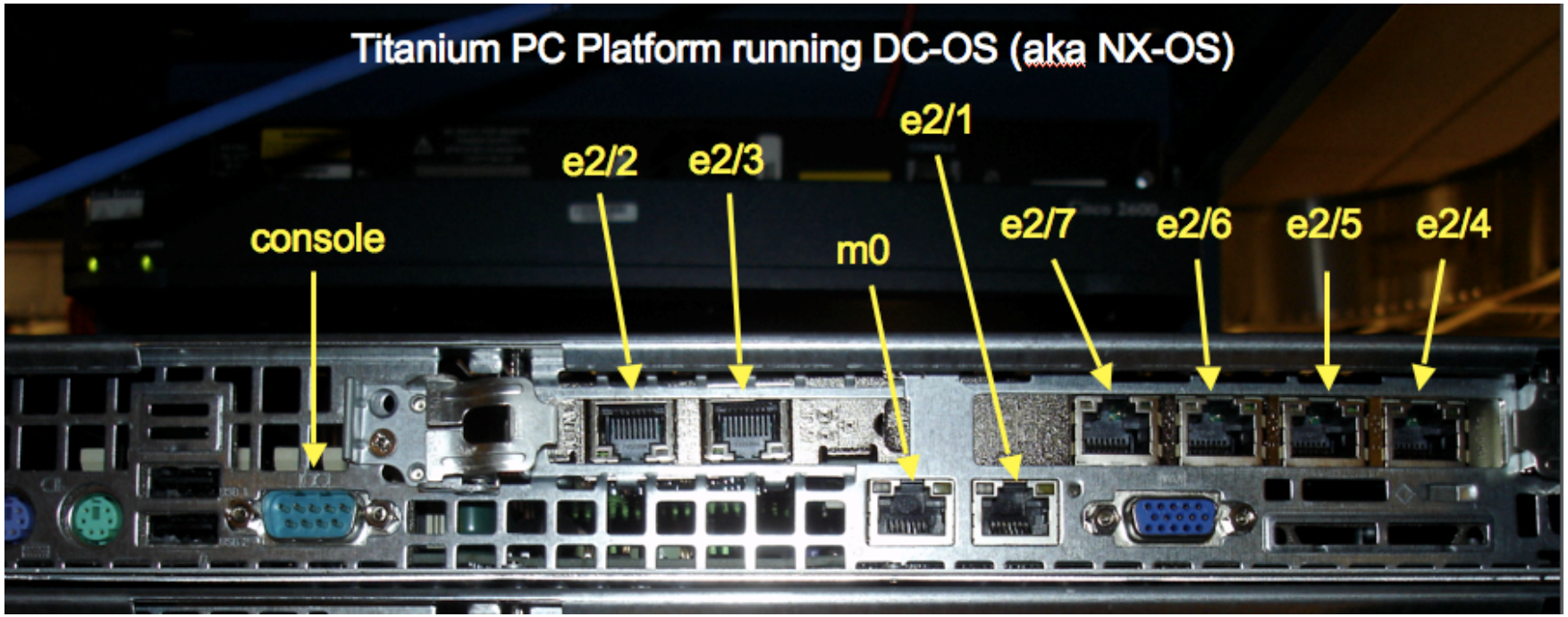
xTR

Prototype Implementation

- cisco has a LISP prototype implementation
- Supports:
  `draft-farinacci-lisp-11.txt`
  `draft-fuller-lisp-alt-03.txt`
  `draft-lewis-lisp-interworking-02.txt`
- Software switching only
- Supports LISP for both IPv4 and IPv6
  - ITR, ETR, and PTR
  - LISP-NAT for IPv4 only

Platform and OS

- NX-OS runs on Linux
- Used as a research platform
- Can run on Nexus 7K/5K & Service Blades



Implementation Schedule

- Started implementation at Prague IETF
  - March 2007
- Implementation put on pilot network
  - July 2007
- Since then released over 90 release builds
  - Releases occur on demand with new features and bug fixes concurrently
- We have phased testing
  - Unit/System Test done in development
  - Alpha test done on pilot network by Dave/Darrel/Vince/John/Andrew
  - Beta test done on pilot network by volunteers

Other Coding Efforts

- IOS implementation under-way
  - Loc/ID split functionality
- Considering IOS-XR implementation
  - TE-ITR/TE-ETR functionality
- OpenLISP implementation been available for FreeBSD a while and being updated
  - For testing the specs
- Considering native Linux implementation
- Any other efforts?

LISP Deployment

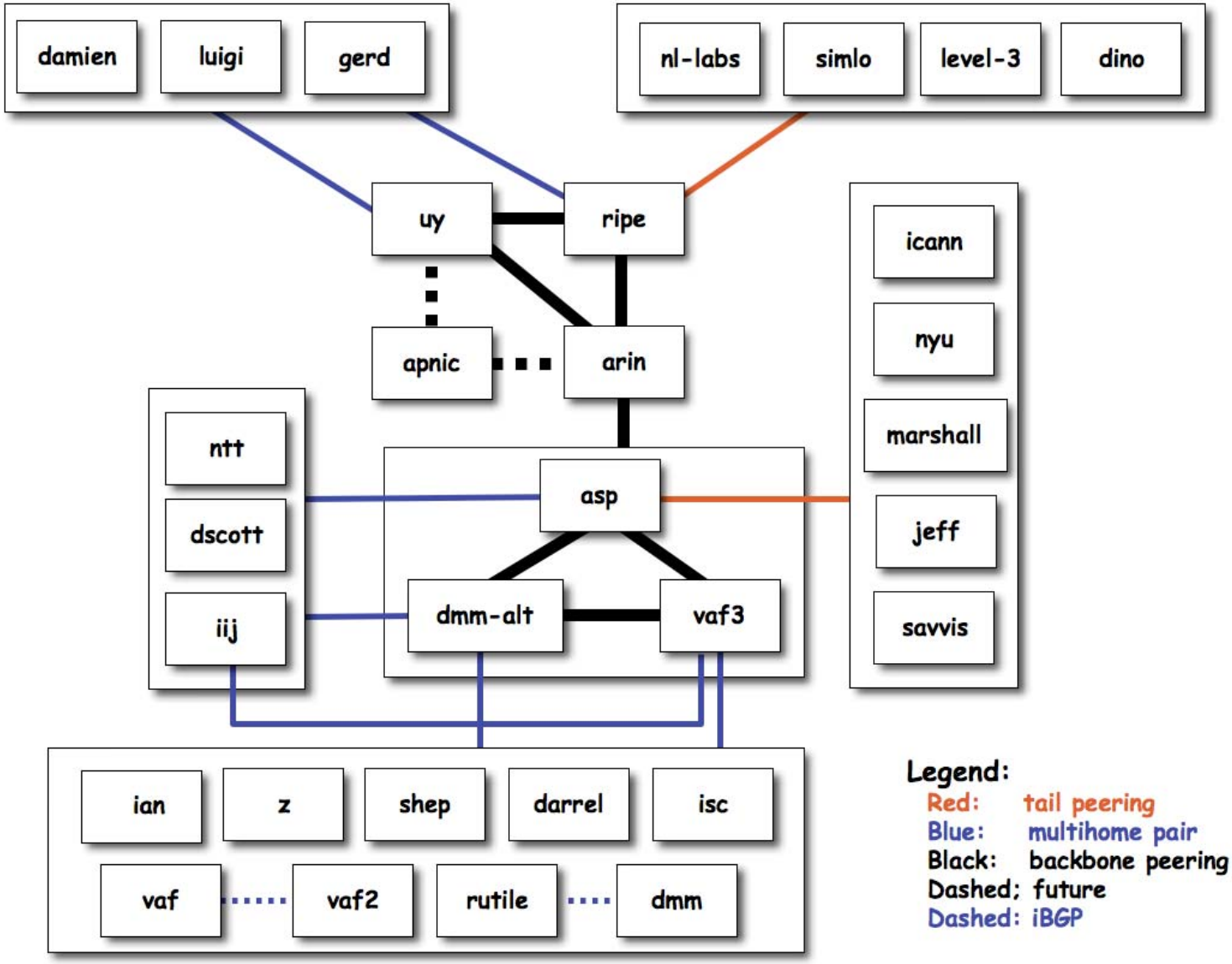
- LISP Pilot Network Operational
  - Deployed for nearly 2 years
  - ~24 sites across 5 countries
    - US, UK, BE, JP, UY
  - Uses the NX-OS Titanium Platform
    - IOS and OpenLISP platforms to be added
  - EID-Prefixes used
    - `153.16.0.0/16` and `2610:00d0::/32`
  - RLOCs used
    - Current site attachment points to the Internet

LISP Deployment

- LISP-ALT Infrastructure Built
  - GRE tunnels numbered out of `240.0.0.0/4`
  - LISP-ALT uses 32-bit AS numbers
    - Format is `32656.x` (ASDot notation)
  - EID-prefixes BGP advertised from 'lisp' VRF
  - RLOCs in default VRF

LISP-ALT Peering Topology

Wed Jan 14 16:04:18 PST 2009



Naming & Addressing

- Domain name `lisp4.net`
  - Contains hosts and routers from IPv4 EID space
- Domain name `lisp6.net`
  - Contains hosts and routers from IPv6 EID space

Naming & Addressing

- IPv4 EID Assignments from `153.16.0.0/16`
  - North America `153.16.0.0/20`
    - /22 for regions in the US
  - Europe `153.16.32.0/20`
  - Asia `153.16.64.0/20`
    - /21 for regions in Asia
  - Africa `153.16.96.0/20`
  - Latin America `153.16.128.0/20`
  - Reserved `153.16.{160,192,224}.0/20`

Naming & Addressing

- IPv6 EID Assignments from 2610:00d0::/32
  - 2610:00d0:x000::/36
    - x is continent
  - 2610:00d0:xy00::/40
    - y is region in continent x
  - 2610:00d0:xy00::/48
    - Sites allocate out of /48

LISP Deployment

- LISP Interworking Deployed
  - Have LISP 1-to-1 address translation working
    - `http://www.translate.lisp4.net`
  - Proxy Tunnel Router (PTR)
    - IPv4 PTRs:
      - Andrew, ISC, and UY
    - IPv6 PTRs:
      - Dave (UofO), ISC, and UY
    - `http://www.lisp6.net` reachable through IPv6 PTR
    - `http://www.ptr.lisp4.net` reachable through IPv4 PTR

Other Uses for LISP

- SLBs in Data Centers
  - ETRs directly connected to servers
  - ITRs at Data Center edge
- A/V Mobile Truck Roll
  - Avoid renumber at each event
- BGP-free Core
  - Intra-AS avoiding storing external routes
  - RLOCs are PE routers
- Building topological hierarchy with flat addressing
  - MAC addressing in L2 networks
- MAC address mobility for "extended subnets"
- In an environment of shortage address supply

Open Policy for LISP

- It's been >2 years since the IAB Routing & Addressing WS
  - Some of us committed to working in the IETF and IRTF in an open environment
- This is not a Cisco only effort
  - We have approached and recruited others
  - There are no patents (cisco has no IPR on this)
  - All documents are Internet Drafts
- We need and seek new designers, implementors, and testers
- We need research analysis
- We want this to be an open effort!

Internet Drafts

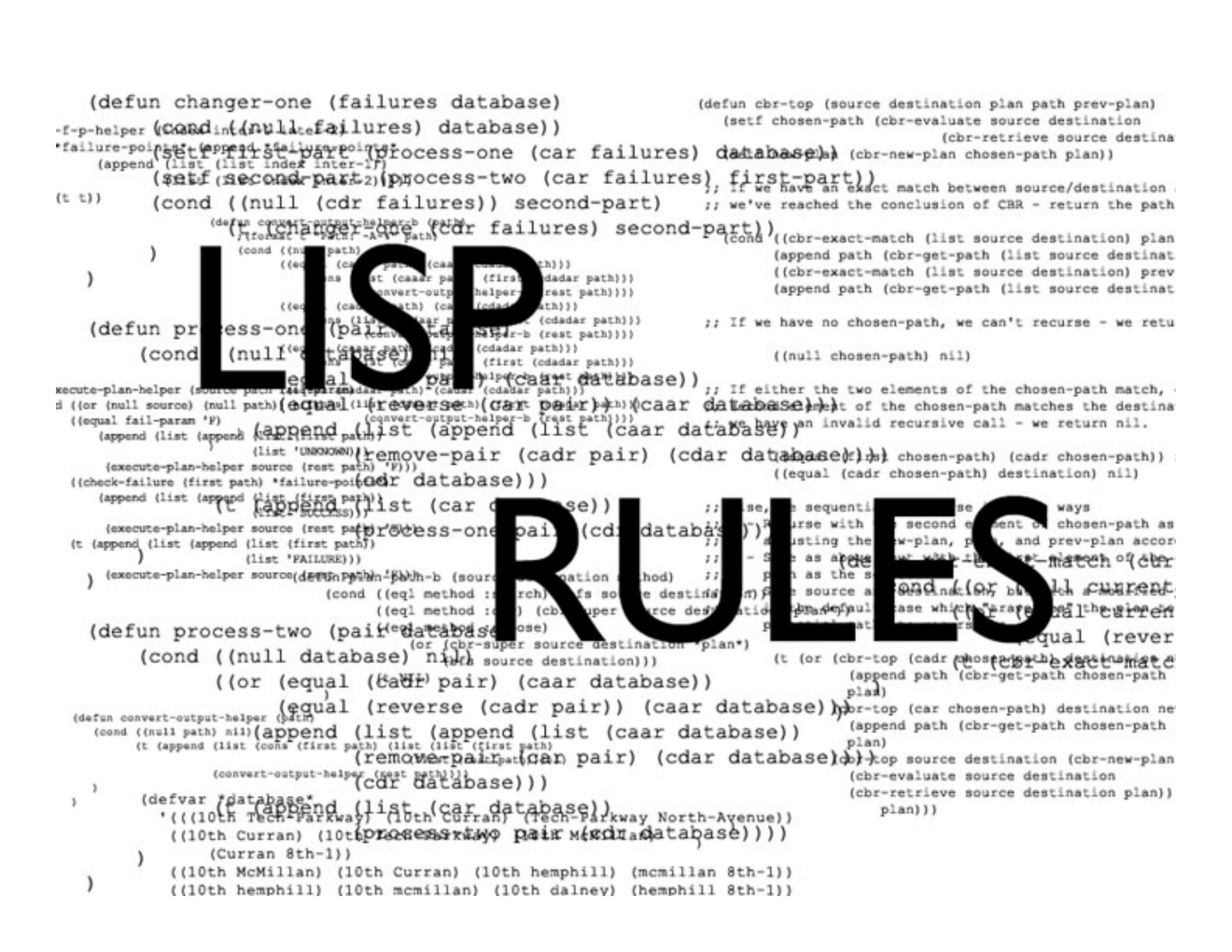
draft-farinacci-lisp-11.txt
draft-farinacci-lisp-multicast-01.txt
draft-fuller-lisp-alt-03.txt
draft-lewis-lisp-interworking-02.txt
draft-meyer-lisp-eid-block-01.txt
draft-meyer-loc-id-implications-01.txt

draft-mathy-lisp-dht-00.txt
draft-iannone-openlisp-implementation-02.txt
draft-brim-lisp-analysis-00.txt

draft-meyer-lisp-cons-04.txt
draft-lear-lisp-nerd-04.txt
draft-curran-lisp-emacs-00.txt

References

- Public mailing list:
  `lisp@ietf.org`
- More info at:
  `http://www.lisp4.net`
  `http://www.lisp6.net`


LISP
RULES