IPv6 @ Cisco

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Agenda

- IPv6 Business Case
- IPv6 Protocols & Standards
- Integration and Transition
- Cisco IOS IPv6 Roadmap
- IPv6 Deployment scenarios

IPv6 - So what's really changed ?!

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- **Expanded Address Space**

  Address length quadrupled to 16 bytes

- **Header Format Simplification**

  Fixed length, optional headers are daisy-chained
  IPv6 header is twice as long (40 bytes) as IPv4 header without options (20 bytes)

- **No checksumming at the IP network layer**

- **No hop-by-hop segmentation**

  Path MTU discovery

- **64 bits aligned**

- **Authentication and Privacy Capabilities**

  IPsec is mandated

- **No more broadcast**

IPv4 & IPv6 Header Comparison

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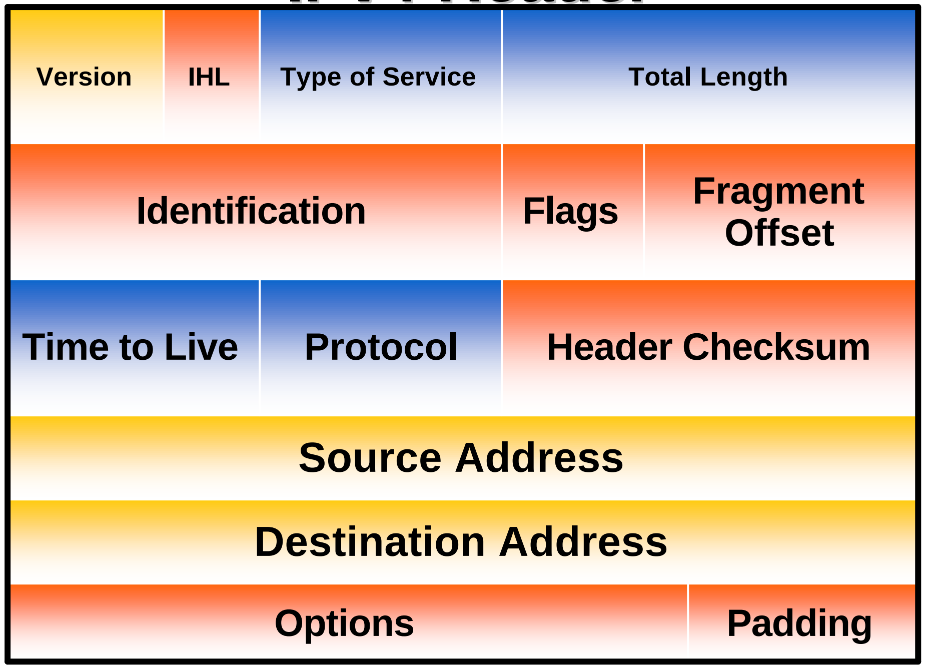
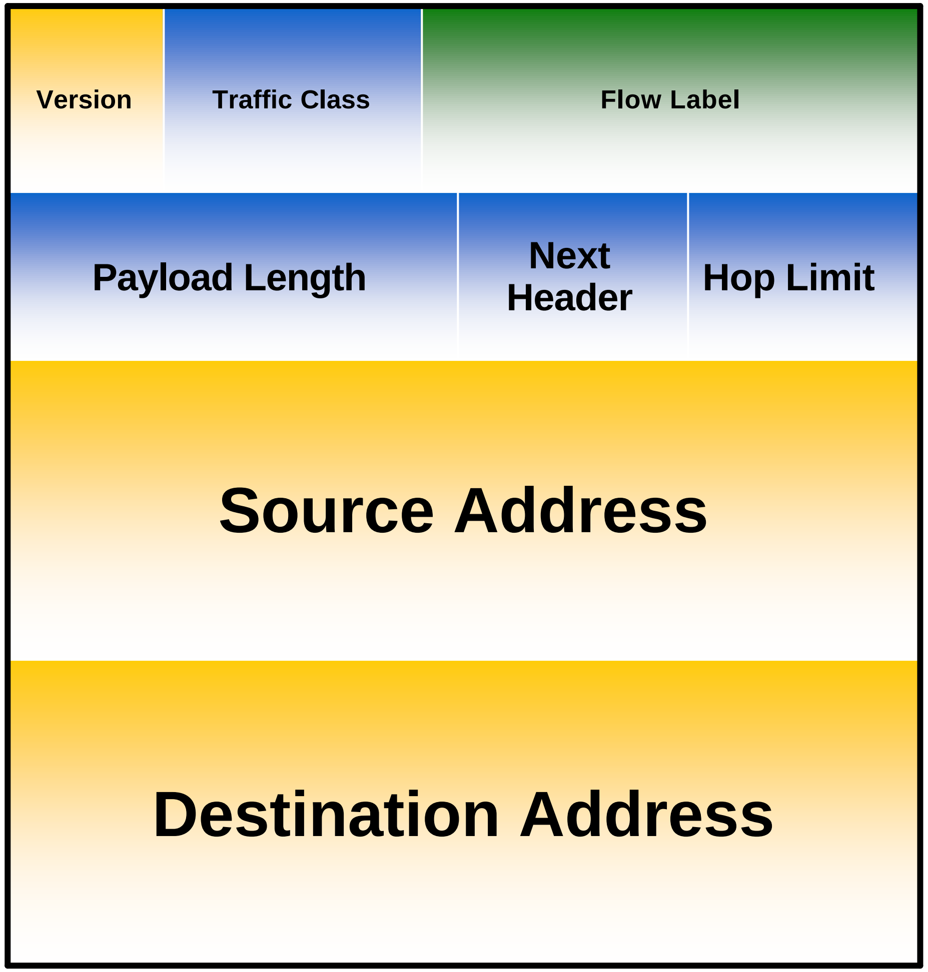
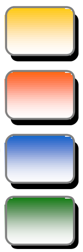
IPv4 Header



IPv6 Header



Legend



- field’s name kept from IPv4 to IPv6
- fields not kept in IPv6
- Name & position changed in IPv6
- New field in IPv6

How Was IPv6 Address Size Chosen?

- **Some wanted fixed-length, 64-bit addresses**

  Easily good for 10^{12} sites, 10^{15} nodes, at .0001 allocation efficiency (3 orders of magnitude more than IPv6 requirement)

  Minimizes growth of per-packet header overhead

  Efficient for software processing

- **Some wanted variable-length, up to 160 bits**

  Compatible with OSI NSAP addressing plans

  Big enough for auto-configuration using IEEE 802 addresses

  Could start with addresses shorter than 64 bits & grow later

- **Settled on fixed-length, 128-bit addresses**

  (340,282,366,920,938,463,463,374,607,431,768,211,456 in all!)

IPv6 Addressing

- **IPv6 Addressing rules are covered by multiples RFC's**
  - **Architecture defined by RFC 3513 (obsoletes RFC 2373)**
- **Address Types are :**
  - **Unicast : One to One (Global, Link local, Site local, Compatible)**
  - **Anycast : One to Nearest (Allocated from Unicast)**
  - **Multicast : One to Many**
  - **Reserved**
- **A single interface may be assigned multiple IPv6 addresses of any type (unicast, anycast, multicast)**
  - **No Broadcast Address -> Use Multicast**

IPv6 Address Representation

- **16-bit fields in case insensitive colon hexadecimal representation**

  2031:0000:130F:0000:0000:09C0:876A:130B

- **Leading zeros in a field are optional:**

  2031:0:130F:0:0:9C0:876A:130B

- **Successive fields of 0 represented as ::, but only once in an address:**
  - **2031:0:130F::9C0:876A:130B**
  - **2031::130F::9C0:876A:130B**
  - **0:0:0:0:0:0:0:1 => ::1**
  - **0:0:0:0:0:0:0:0 => ::**

- **IPv4-compatible address representation**
  - **0:0:0:0:0:0:192.168.30.1 = ::192.168.30.1 = ::C0A8:1E01**

IPv6 Addressing

- Prefix Format (PF) Allocation

  PF = 0000 0000 : Reserved

  PF = 001 : Aggregatable Global Unicast Address

  PF = 1111 1110 10 : Link Local Use Addresses (FE80::/10)

  PF = 1111 1110 11 : Site Local Use Addresses (FEC)::/10)

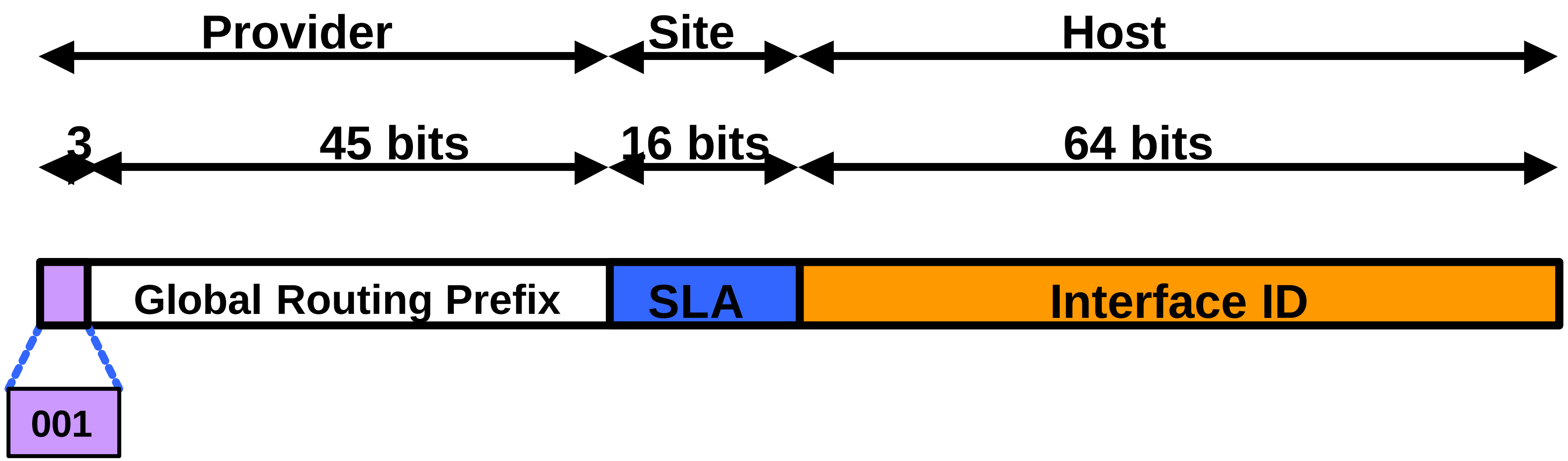
  PF = 1111 1111 : Multicast Addresses (FF00::/8)

  Other values are currently Unassigned (approx. 7/8th of total)

- All Prefix Formats have to support EUI-64 bits Interface ID setting

  But Multicast

Aggregatable Global Unicast Addresses



- Aggregatable Global Unicast addresses are:

  Addresses for generic use of IPv6

  Structured as a hierarchy to keep the aggregation

- See RFC 3513

Address Allocation Policy

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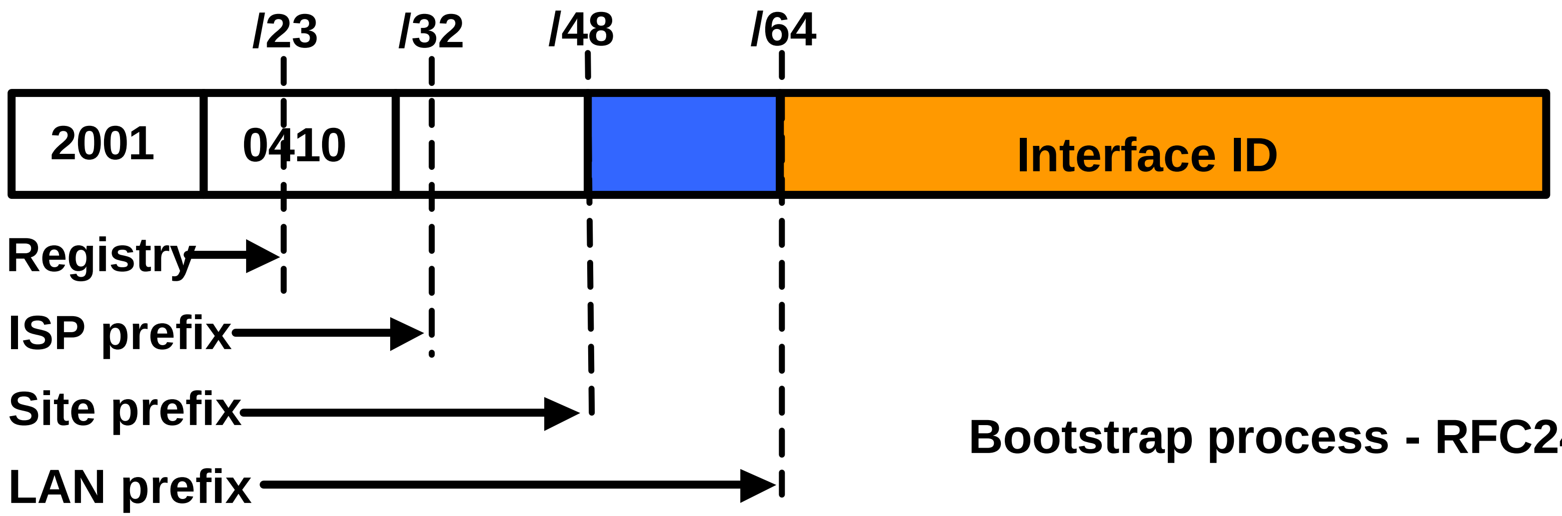

Bootstrap process - RFC2450

- **The allocation process is under reviewed by the Registries:**

  IANA allocates 2001::/16 to registries

  Each registry gets a /23 prefix from IANA

  Formely, all ISP were getting a /35

  With the new policy, Registry allocates a /32 prefix to an IPv6 ISP

  Then the ISP allocates a /48 prefix to each customer (or potentially /64)

  ftp://ftp.cs.duke.edu/pub/narten/ietf/global-ipv6-assign-2002-06-26.txt

Interface IDs

- Lowest-order 64-bit field of unicast address may be assigned in several different ways:
  - auto-configured from a 64-bit EUI-64, or expanded from a 48-bit MAC address (e.g., Ethernet address)
  - auto-generated pseudo-random number (to address privacy concerns)
  - assigned via DHCP
  - manually configured

IPv6 Address Privacy (RFC 3041)

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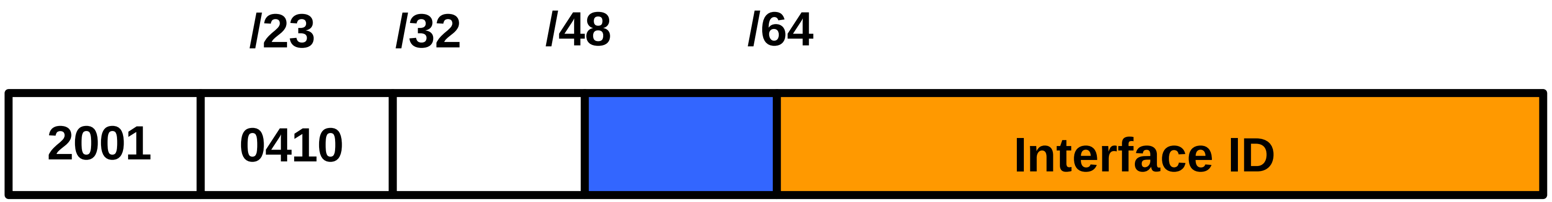
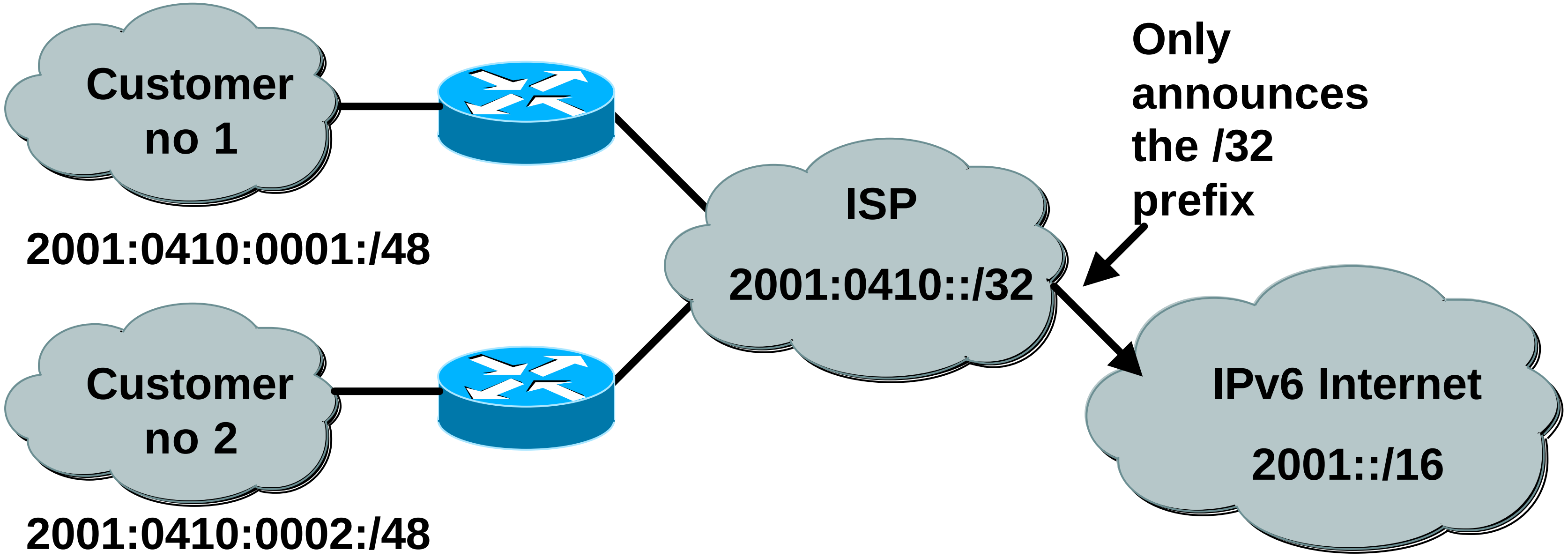


- Temporary addresses for IPv6 host client application, eg. Web browser
    - Inhibit device/user tracking but is also a potential issue
        - More difficult to scan all IP addresses on a subnet but port scan is identical when an address is known
    - Random 64 bit interface ID, run DAD before using it
    - Rate of change based on local policy
    - Implemented on Microsoft Windows XP
    - From RFC 3041: "…interface identifier …facilitates the tracking of individual devices (and thus potentially users)…"

Hierarchical Addressing & Aggregation



- Larger address space enables:
  - Aggregation of prefixes announced in the global routing table.
  - Efficient and scalable routing.
- But current Multi-Homing schemes break the model

Link-Local & Site-Local Unicast Addresses

- **Link-local addresses for use during auto-configuration and when no routers are present:**

1111 1110 10	0	interface ID

- **Site-local addresses for independence from Global Reachability, similar to IPv4 private address space**

  RFC3513 specifies 54 bits for SLA field but SL may get deprecated by IPv6 WG soon

1111 1110 11	SLA*	interface ID

6to4 and ISATAP Addresses

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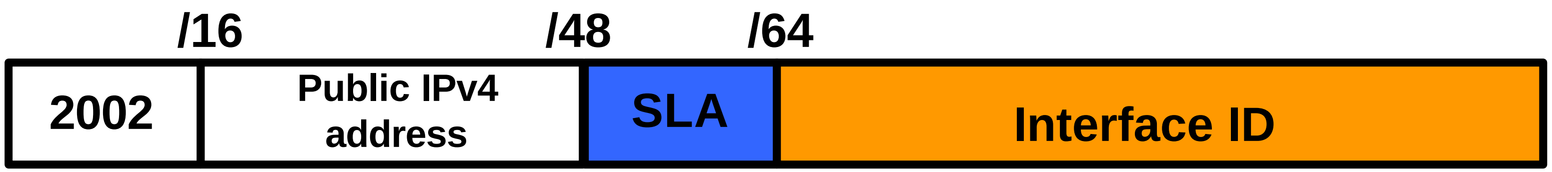
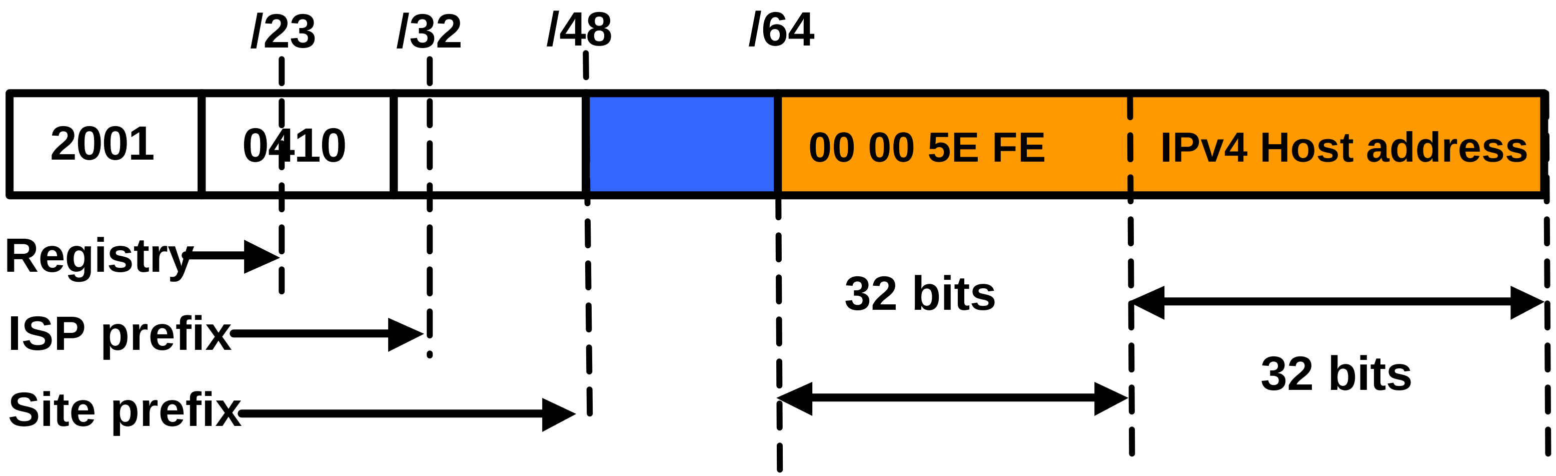
- 6to4 (RFC 3056) – WAN tunneling



- ISATAP (Draft) – Campus tunneling



Expanded Address Space
Multicast Addresses (RFC 3513)

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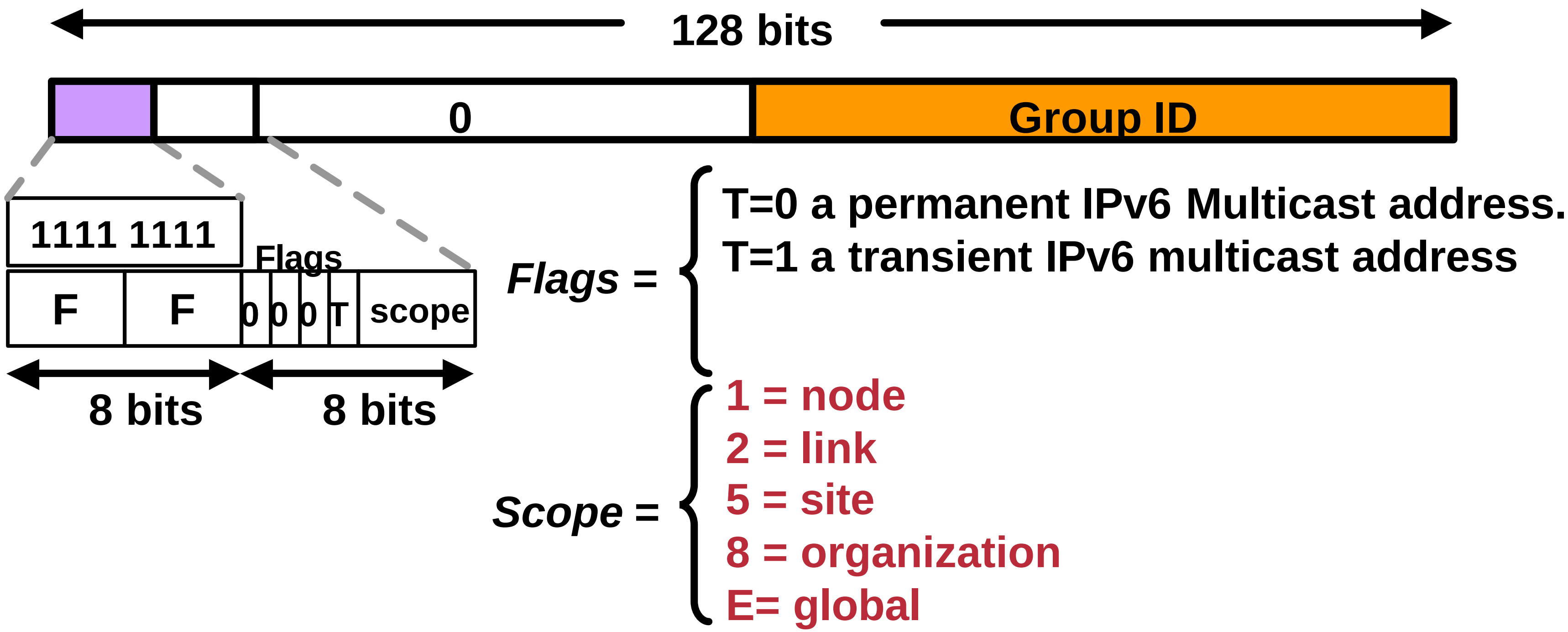

- **Multicast is used in the context of one-to-many.**

Multicast Address Examples

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- **All Nodes Addresses:**

  FF01:0:0:0:0:0:0:1

  FF02:0:0:0:0:0:0:1

- **All Routers Addresses:**

  FF01:0:0:0:0:0:0:2

  FF02:0:0:0:0:0:0:2

  FF05:0:0:0:0:0:0:2

- **OSPv3:**

  AllSPFRouters : FF02::5

  AllDRouters : FF02::6

- **Solicited-Node Address:**

  FF02:0:0:0:0:1:FFXX:XXXX

  Concatenation of prefix FF02:0:0:0:0:1:FF00::/104 with the low-order 24 bits of an address (unicast or anycast)

more on IPv6 Addressing

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80 bits	16 bits	32 bits
0000……………………………….0000	0000	IPv4 Address

IPv6 Addresses with Embedded IPv4 Addresses

80 bits	16 bits	32 bits
0000……………………………….0000	FFFF	IPv4 Address

IPv4 mapped IPv6 address

IPv6 Addressing Examples

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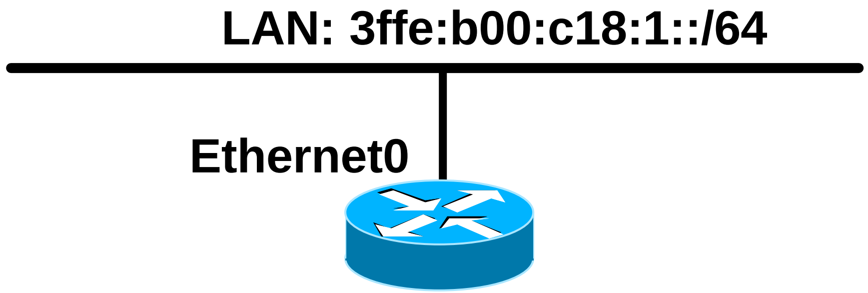


```
interface Ethernet0
 ipv6 address 2001:410:213:1::/64 eui-64
```

MAC address: 0060.3e47.1530

```
router# show ipv6 interface Ethernet0
Ethernet0 is up, line protocol is up
  IPv6 is enabled, link-local address is FE80::260:3EFF:FE47:1530
Global unicast address(es):
    2001:410:213:1:260:3EFF:FE47:1530, subnet is 2001:410:213:1::/64
  Joined group address(es):
    FF02::1:FF47:1530
    FF02::1
    FF02::2
  MTU is 1500 bytes
```

6BONE

- **The 6bone is an IPv6 testbed setup to assist in the evolution and deployment of IPv6 in the Internet.**

  The 6bone is a virtual network layered on top of portions of the physical IPv4-based Internet to support routing of IPv6 packets, as that function has not yet been integrated into many production routers. The network is composed of islands that can directly support IPv6 packets, linked by virtual point-to-point links called "tunnels". The tunnel endpoints are typically workstation-class machines having operating system support for Ipv6.

- **Over 50 countries are currently involved**
- **Registry, maps and other information may be found on http://www.6bone.net/**

6Bone Addressing

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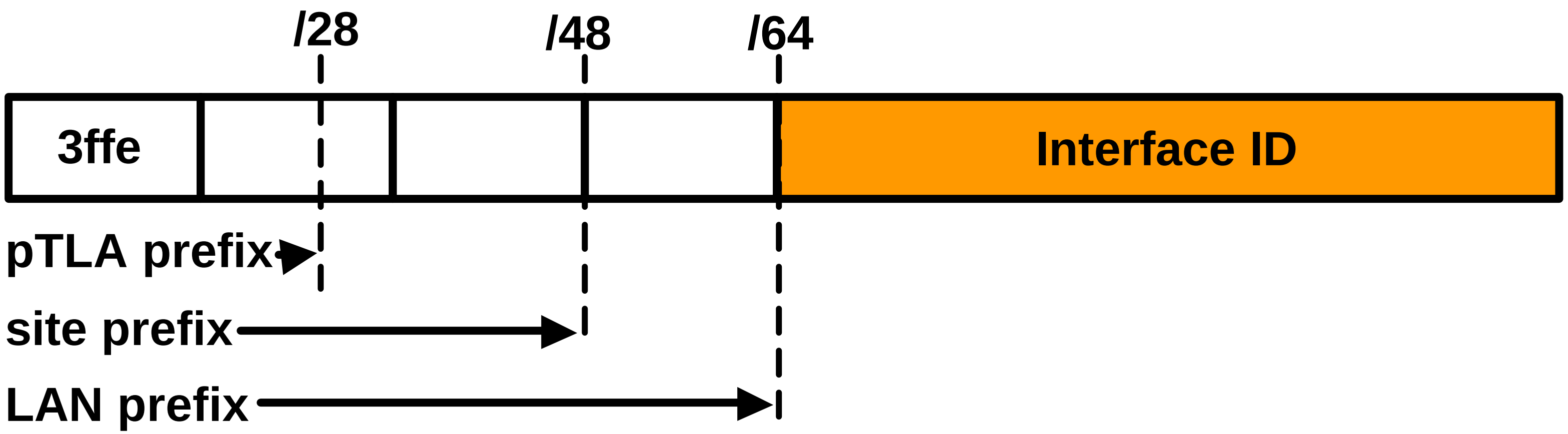

- 6Bone address space defined in RFC2471 uses 3FFE::/16

  A pTLA receives a /28 prefix

  A site receives a /48 prefix

  A LAN receives a /64 prefix

- Guidelines for routing on 6bone - RFC2772

6Bone Topology

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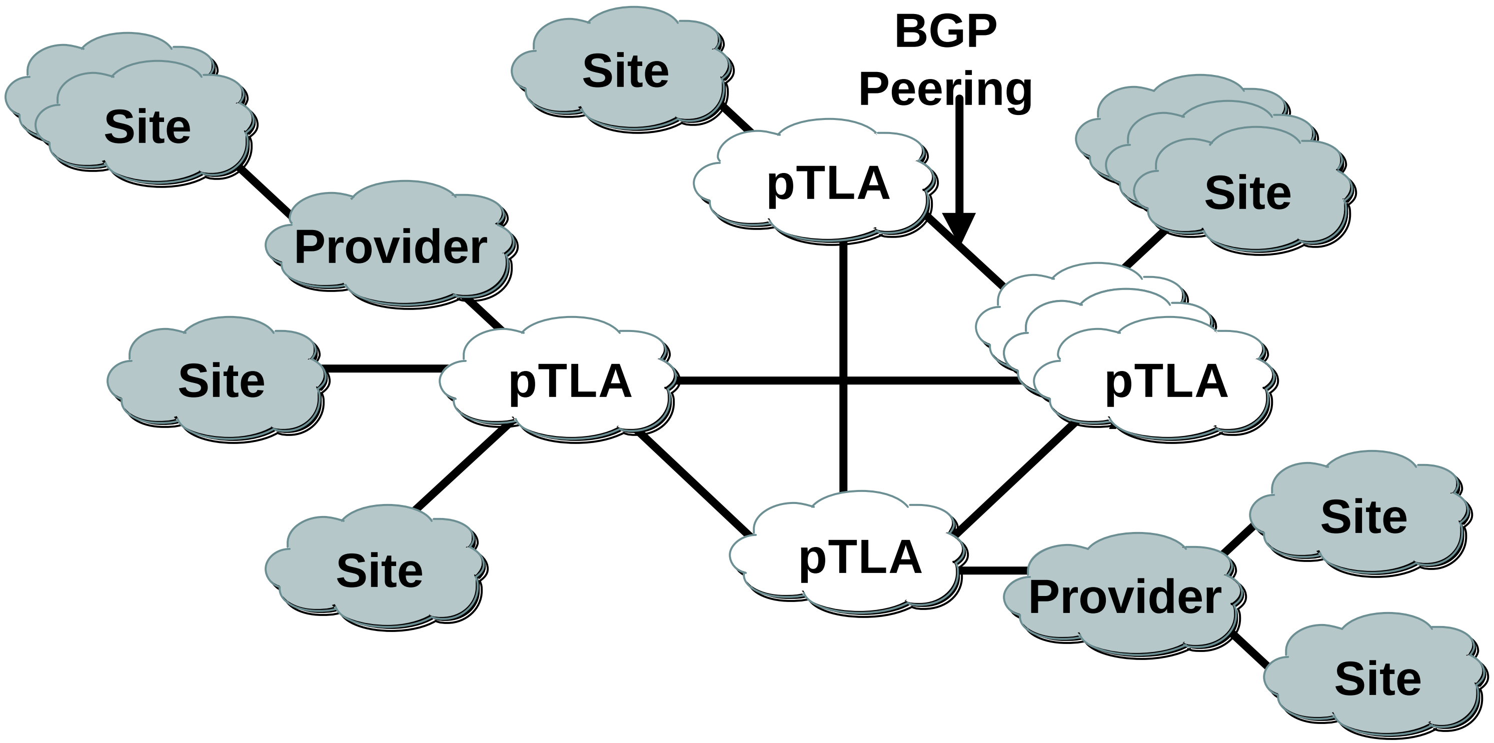
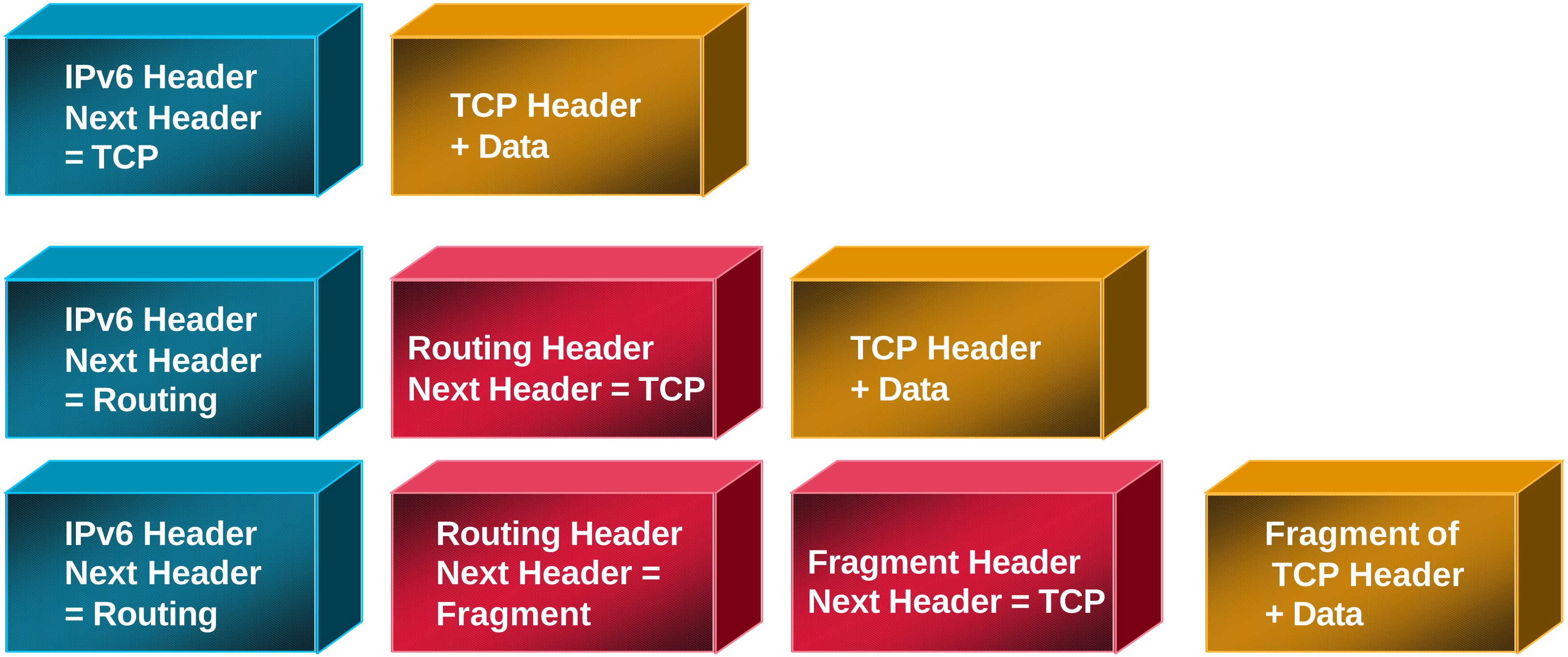


- **6Bone is a test bed network with hundreds of sites from 50 countries**
- **The 6Bone topology is a hierarchy of providers**
- **First-level nodes are backbone nodes called pseudo Top-Level Aggregator (pTLA)**

IPv6 Header Options (RFC 2460)



- Processed only by node identified in IPv6 Destination Address field => much lower overhead than IPv4 options

  exception: Hop-by-Hop Options header

- Eliminated IPv4's 40-octet limit on options

  in IPv6, limit is total packet size, or Path MTU in some cases

IPv6 Header Options (RFC2460)

- **Currently defined Headers should appear in the following order**

  IPv6 header

  Hop-by-Hop Options header

  Destination Options header

  Routing header

  Fragment header

  Authentication header (RFC 1826)

  Encapsulating Security Payload header (RFC 1827)

  Destination Options header

  upper-layer header

IPv6 and Path MTU Discovery

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- **Definitions:**

link MTU	**a link's maximum transmission unit,**
path MTU	**the minimum MTU of all the links in a path between a source and a destination**

- **Minimum link MTU for IPv6 is 1280 octets (68 octets for IPv4)**

  On links with MTU < 1280, link-specific fragmentation and reassembly must be used

- **Implementations are expected to perform path MTU discovery to send packets bigger than 1280 octets:**

  for each dest., start by assuming MTU of first-hop link

  if a packet reaches a link in which it cannot fit, will invoke ICMP "packet too big" message to source, reporting the link's MTU; MTU is cached by source for specific destination

- **Minimal implementation can omit path MTU discovery as long as all packets kept = 1280 octets – e.g., in a boot ROM**

Neighbor Discovery (RFC 2461)

- **Protocol built on top of ICMPv6 (RFC 2463)**
  - **Combination of IPv4 protocols (ARP, ICMP,…)**
- **Neighbor Discovery:**
  - **Determines the link-layer address of a neighbor on the same link, Duplicate Address Detection**
  - **Finds neighbor routers, Keeps track of neighbors**
- **Defines 5 ICMPv6 packet types**
  - **Router Solicitation / Router Advertisements**
  - **Neighbor Solicitation / Neighbor Advertisements**
  - **Redirect**

IPv6 Auto-Configuration

- **Stateless (RFC2462)**

  Host autonomously configures its own Link-Local address

  Router solicitation are sent by booting nodes to request RAs for configuring the interfaces.

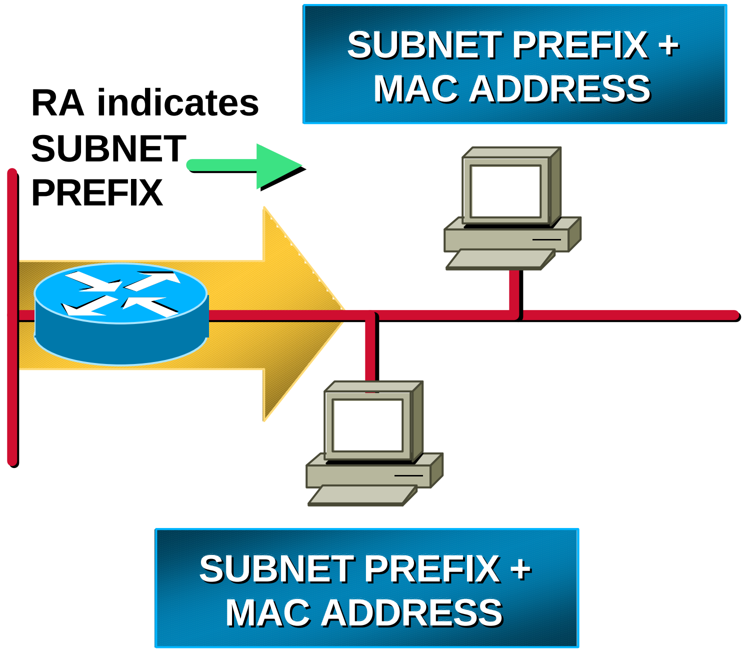
- **Stateful**

  DHCPv6 (under definition at IETF)

- **Renumbering**

  Hosts renumbering is done by modifying the RA to announce the old prefix with a short lifetime and the new prefix.

  Router renumbering protocol (RFC 2894), to allow domain-interior routers to learn of prefix introduction / withdrawal



At boot time, an IPv6 host build a Link-Local address, then its global IPv6 address(es) from RA

Stateless Autoconfiguration

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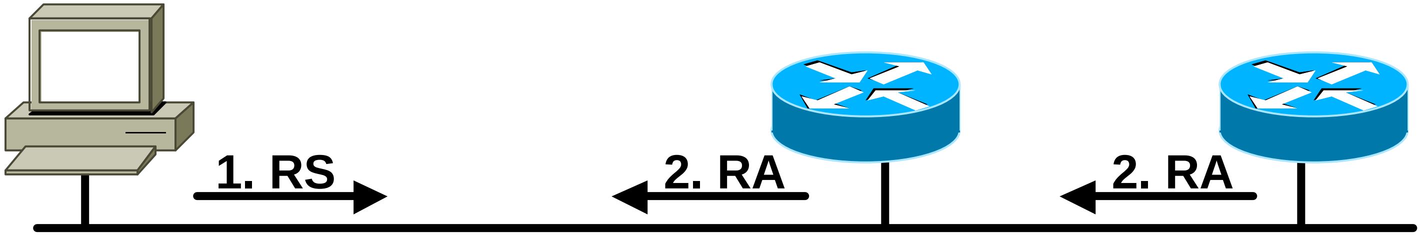

1 - ICMP Type = 133 (RS)

Src = ::

Dst = All-Routers multicast Address

query= please send RA

2 - ICMP Type = 134 (RA)

Src = Router Link-local Address

Dst = All-nodes multicast address

Data= options, prefix, lifetime, autoconfig flag

Router solicitations are sent by booting nodes to request RAs for configuring the interfaces.

Duplicate Address Detection

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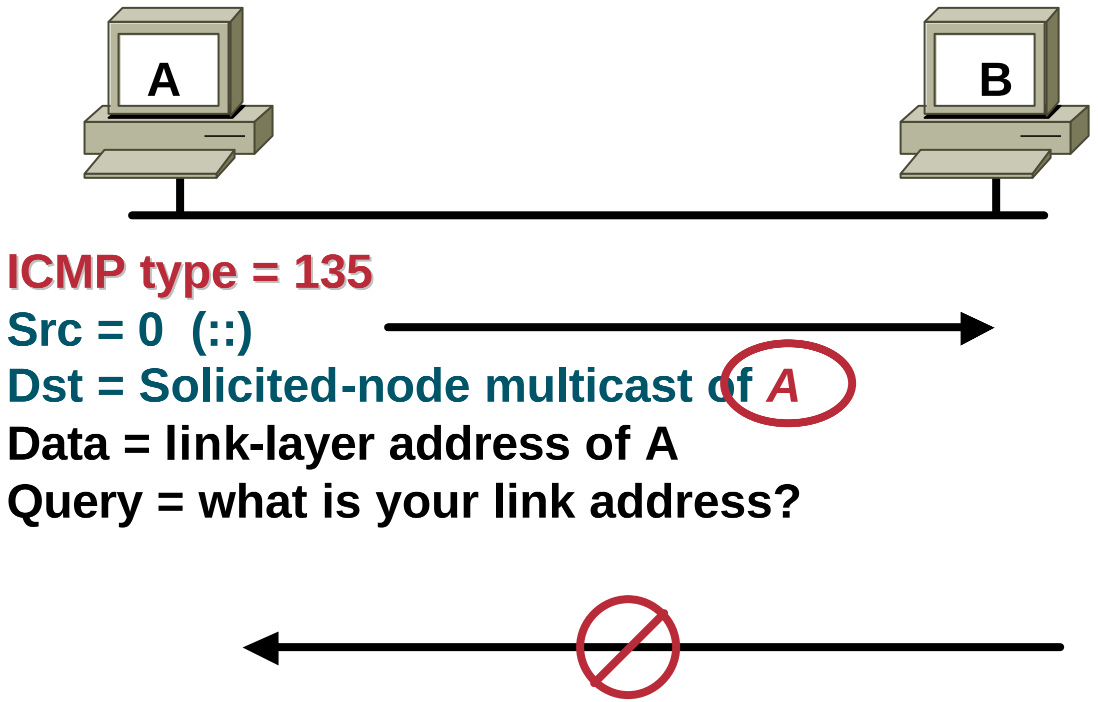

Duplicate Address Detection (DAD) uses neighbor solicitation to verify the existence of an address to be configured.

Routing in IPv6

- As in IPv4, IPv6 has 2 families of routing protocols: IGP and EGP, and still uses the longest-prefix match routing algorithm
- IGP
  - RIPng (RFC 2080)
  - Cisco EIGRP for IPv6
  - OSPFv3 (RFC 2740)
  - Integrated IS-ISv6 (draft-ietf-isis-ipv6-02)
- EGP : MP-BGP4 (RFC 2858 and RFC 2545)
- Cisco IOS supports all of them
  - Pick one meeting your objectives

OSPFv3 overview

- OSPFv3 is OSPF for IPv6 (RFC 2740)
- Based on OSPFv2, with enhancements
- Distributes IPv6 prefixes
- Runs directly over IPv6
- Ships-in-the-night with OSPFv2

Differences from OSPFv2

- Runs over a link, not a subnet
  - Multiple instances per link
- Topology not IPv6-specific
  - – Router ID
  - – Link ID
- Standard authentication mechanisms
- Uses link local addresses
- Generalized flooding scope
- Two new LSA types

OSPFv3 configuration example

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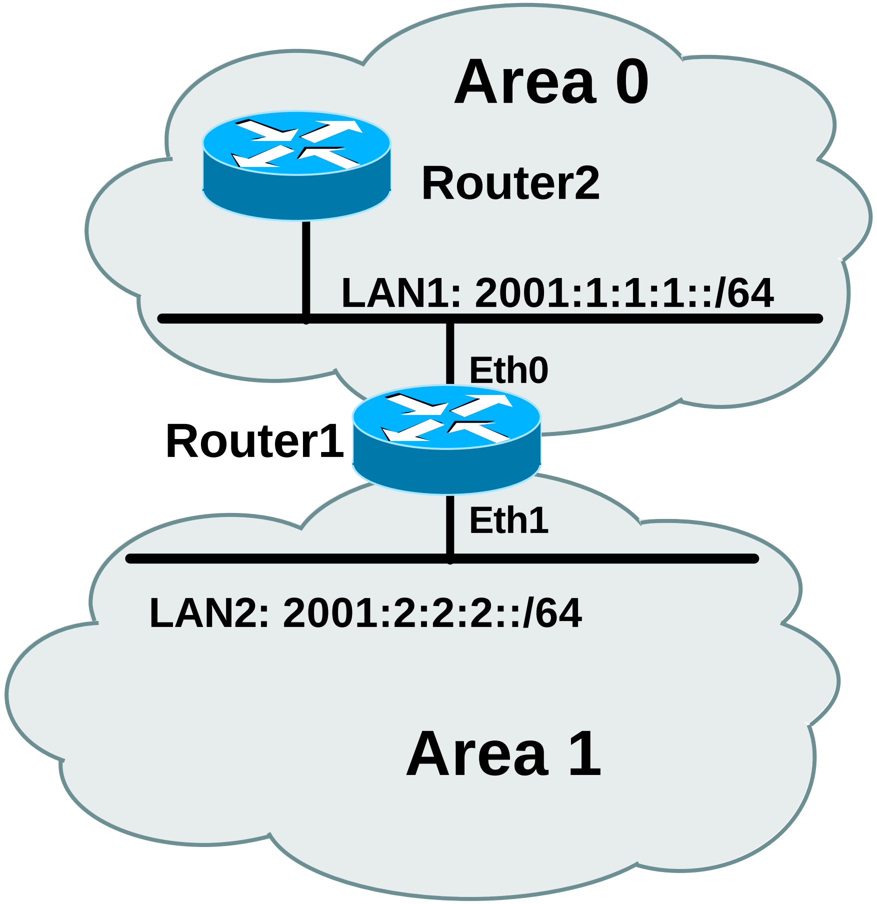
```
Router1#
 interface Ethernet0
   ipv6 address 2001:1:1:1::1/64
  ipv6 ospf 1 area 0

  interface Ethernet1
    ipv6 address 2001:2:2:2::2/64
   ipv6 ospf 1 area 1

  ipv6 router ospf 1
   router-id 1.1.1.1
   area 1 range 2001:2:2::/48
```



IS-IS Standards

- IETF IS-IS for IP Internets WG
    - http://www.ietf.org/html.charters/isis-charter.html
- ISO 10589 specifies OSI IS-IS routing protocol for CLNS traffic
    - Tag/Length/Value (TLV) options to enhance the protocol
    - A Link State protocol with a 2 level hierarchical architecture.
- RFC 1195 added IP support, also known as Integrated IS-IS (I/IS-IS)
    - I/IS-IS runs on top of the Data Link Layer
    - Requires CLNP to be configured
- Draft RFC defines how to add IPv6 address family support to IS-IS
    - http://www.ietf.org/internet-drafts/draft-ietf-isis-ipv6-05.txt
- Draft RFC introduces Multi-Topology concept for IS-IS
    - http://www.ietf.org/internet-drafts/draft-ietf-isis-wg-multi-topology-06.txt

IS-IS for IPv6

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- 2 Tag/Length/Values added to introduce IPv6 routing
- IPv6 Reachability TLV (0xEC)
  - External bit
  - Equivalent to IP Internal/External Reachability TLV's
- IPv6 Interface Address TLV (0xE8)
  - For Hello PDUs, must contain the Link-Local address
  - For LSP, must only contain the non-Link Local address
- IPv6 NLPID (0x8E) is advertised by IPv6 enabled routers

Cisco IOS IS-IS dual IP configuration

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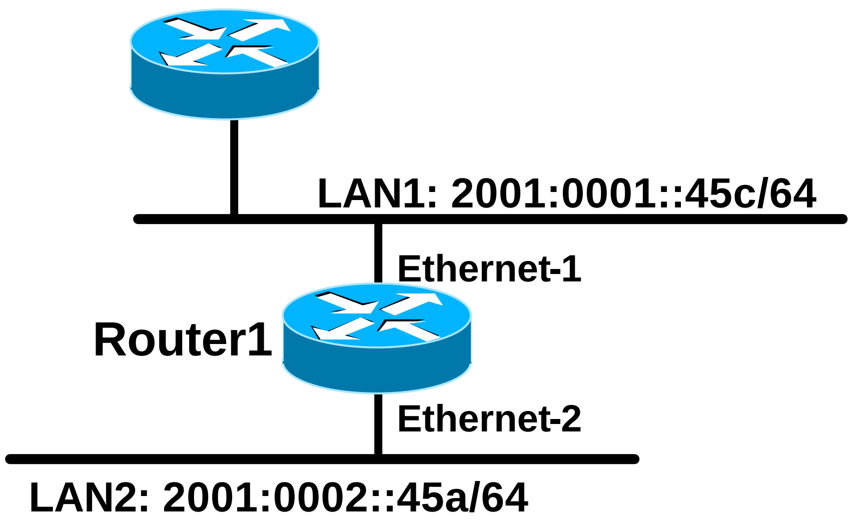

Dual IPv4/IPv6 configuration.
Redistributing both IPv6 static routes and IPv4 static routes.

```
Router1#
 interface ethernet-1
     ip address 10.1.1.1 255.255.255.0
     ipv6 address 2001:0001::45c/64
     ip router isis
     ipv6 router isis

  interface ethernet-2
     ip address 10.2.1.1 255.255.255.0
     ipv6 address 2001:0002::45a/64
     ip router isis
     ipv6 router isis

  router isis
      address-family ipv6
      redistribute static
      exit-address-family
      net 42.0001.0000.0000.072c.00
      redistribute static
```

Multi-Topology IS-IS extensions

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- **New TLVs attributes for Multi-Topology extensions.**

  ***Multi-topology TLV*: contains one or more multi-topology ID in which the router participates. It is theoretically possible to advertise an infinite number of topologies. This TLV is included in IIH and the first fragment of a LSP.**

  ***MT Intermediate Systems TLV*: this TLV appears as many times as the number of topologies a node supports. A MT ID is added to the extended IS reachability TLV type 22.**

  ***Multi-Topology Reachable IPv4 Prefixes TLV*: this TLV appears as many times as the number of IPv4 announced by an IS for a give n MT ID. Its structure is aligned with the extended IS Reachability TLV Type 236 and add a MT ID.**

  ***Multi-Topology Reachable IPv6 Prefixes TLV*: this TLV appears as many times as the number of IPv6 announced by an IS for a given MT ID. Its structure is aligned with the extended IS Reachability TLV Type 236 and add a MT ID.**

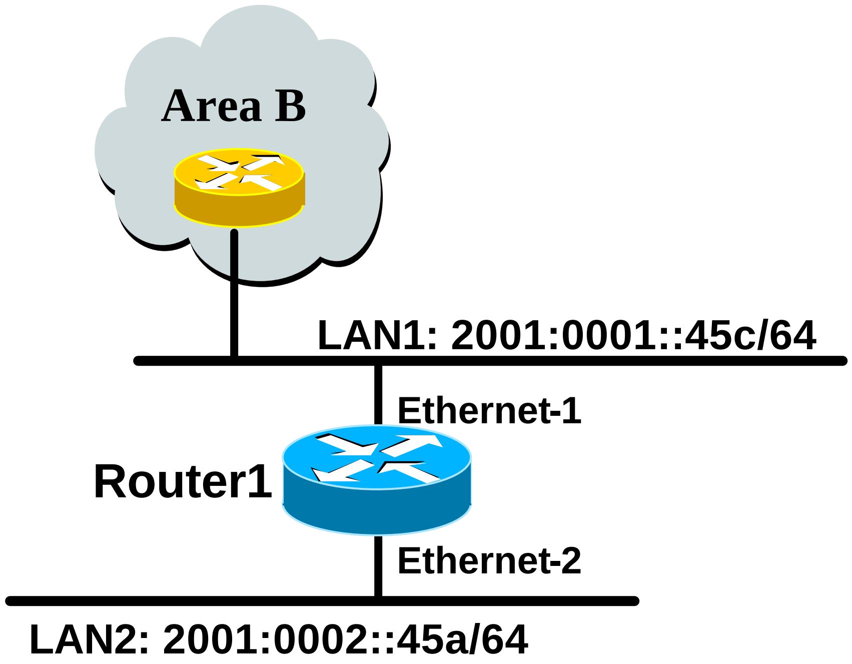
- **Multi-Topology ID Values**

  Multi-Topology ID (MT ID) standardized and in use in Cisco IOS:

  MT ID #0 – “standard” topology for IPv4/CLNS

  MT ID #2 – IPv6 Routing Topology.

Cisco IOS Multi-Topology IS-IS configuration example




```
Router1#
 interface ethernet-1
    ip address 10.1.1.1 255.255.255.0
    ipv6 address 2001:0001::45c/64
    ip router isis
    ipv6 router isis
    isis ipv6 metric 20

 interface ethernet-2
    ip address 10.2.1.1 255.255.255.0
    ipv6 address 2001:0002::45a/64
    ip router isis
    ipv6 router isis
    isis ipv6 metric 20

router isis
net 49.0000.0100.0000.0000.0500
metric-style wide
!
address-family ipv6
multi-topology
exit-address-family
```

- **The optional keyword *transition* may be used for transitioning existing IS-IS IPv6 single SPF mode to MT IS-IS.**
- **Wide metric is mandated for Multi-Topology to work.**

Multi-Protocol BGP for IPv6 – RFC2545

- **IPv6 specific extensions:**

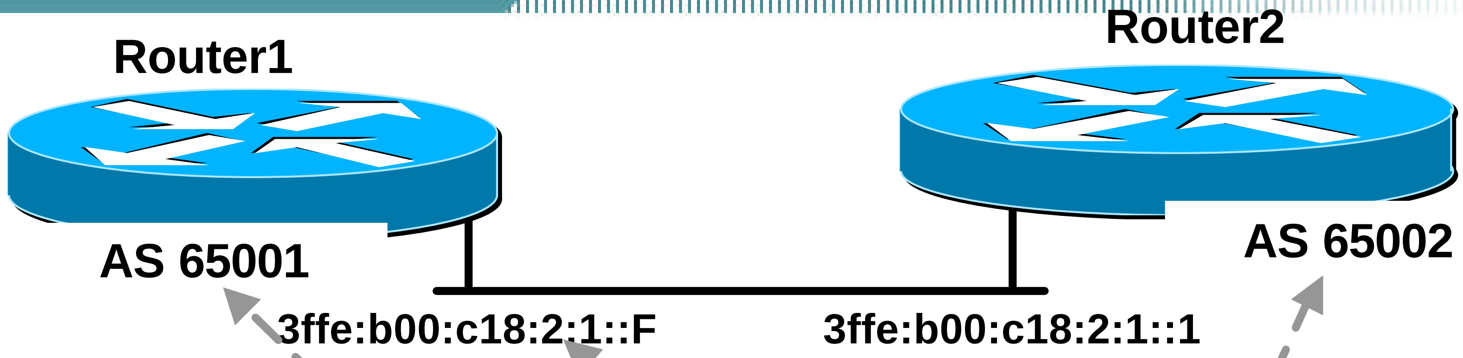
  Scoped addresses: Next-hop contains a global IPv6 address and/or potentially a link-local address

  NEXT_HOP and NLRI are expressed as IPv6 addresses and prefix.

  Address Family Information (AFI) = 2 (IPv6)

  - Sub-AFI = 1 (NLRI is used for unicast)
  - Sub-AFI = 2 (NLRI is used for multicast RPF check)
  - Sub-AFI = 3 (NLRI is used for both unicast and multicast RPF check)
  - Sub-AFI = 4 (label)

A Simple MP-BGP Session




```
Router1#
interface Ethernet0
 ipv6 address 3FFE:B00:C18:2:1::F/64
!
router bgp 65001
 bgp router-id 10.10.10.1
 no bgp default ipv4-unicast
 neighbor 3FFE:B00:C18:2:1::1 remote-as 65002
 address-family ipv6
  neighbor 3FFE:B00:C18:2:1::1 activate
  neighbor 3FFE:B00:C18:2:1::1 prefix-list bgp65002in in
  neighbor 3FFE:B00:C18:2:1::1 prefix-list bgp65002out out
  exit-address-family
```

IPv4 versus IPv6 Multicast

IP Service	IPv4 Solution	IPv6 Solution
Address Range	32-bit, class D	128-bit
Routing	Protocol Independent All IGPs,and BGP4+	Protocol Independent All IGPs,and BGP4+ with v6 mcast SAFI
Forwarding	PIM-DM, PIM-SM, PIM-SSM, PIM-bidir	PIM-SM, PIM-SSM, PIM-bidir
Group Management	IGMPv1, v2, v3	MLDv1, v2
Domain Control	Boundary/Border	Scope Identifier
Interdomain Solutions	MSDP across Independent PIM Domains	Single RP within Globally Shared Domains

Multicast Listener Discover – MLD

- MLD is equivalent to IGMP in IPv4
- MLD messages are transported over ICMPv6
- Version number confusion:
    - MLDv1 corresponds to IGMPv2
        - RFC 2710
    - MLDv2 corresponds to IGMPv3, needed for SSM
        - draft-vida-mld-v2-06.txt
- MLD snooping
    - draft-ietf-magma-snoop-04.txt
- CGMP for v6 under consideration

IP Routing for Multicast

- RPF based on reachability to v6 source same as with v4 multicast
- RPF still protocol independent:

  Static routes, mroutes

  Unicast RIB: BGP, ISIS, OSPF, EIGRP, RIP, etc

  Multi-protocol BGP (mBGP)

  - support for v6 mcast sub-address family
  - provide translate function for non-supporting peers

IP Routing for Multicast

RPF Route Selction Rules:

I. look up the longest mask route from the available route sources:

1. static mroutes.
2. MBGP RIB,
3. unicast RIB,

II.If more than one of these three sources returns a route with the same longest mask then select amongst these routes the one with the lowest (= best) distance.

III. If the distance is equal on multiple entries:

Select static mroute over MBGP over unicast RIB

IPv6 Multicast Forwarding

- **PIM-Sparse Mode (PIM-SM)**

  draft-ietf-pim-sm-v2-new-06.txt,

- **PIM-Source Specific Mode (PIM-SSM)**

  draft-ietf-ssm-overview-03.txt (v6 SSM needs MLDv2)

  unicast prefix based multicast addresses ff30::/12

  -> SSM range is ff3X::/32

  -> current allocation is from ff3X::/96

- **PIM-bidirectional Mode (PIM-bidir)**

  draft-ietf-pim-bidir-04.txt

RP mapping mechanisms for PIM-SM

- **Static RP assignment**
- **BSR**
- **Auto-RP – no current draft**

Domain Control

- **Definitions:**
  - –A **PIM domain** is topology served by common RP for all sources and receivers of same group.
  - –A **routing domain** is consistent with AS.
- **Its necessary to constrain the PIM messages, rp-mappings, and data for groups within the PIM domain:**
  - –In IPv4 we used multicast boundary/ BSR border
  - –In IPv6 we use scopes and zones

IPv6 Scoping support

- **Scopes: draft-ietf-ipngwg-addr-arch-v3-11.txt**

  Example scopes:

  link-local (2)

  site-local (5)

  global (E or 14)

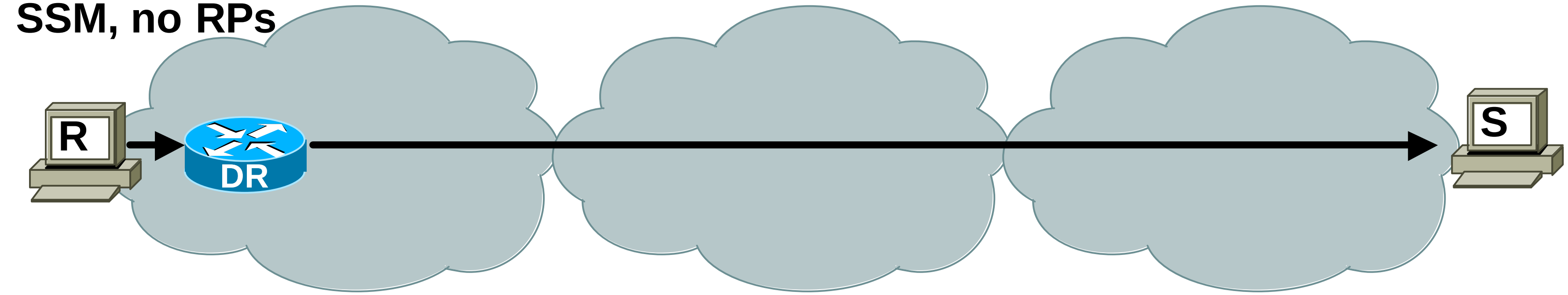
- **Zone is a connected region of topology of a given scope**
- **Initial implementation similar to v4 boundaries:**
  - **Can configure interface with zone and scope**

```
ipv6 zone <zoneid> scope <2-15>    CAUTION: This is
                                   still being worked.
```

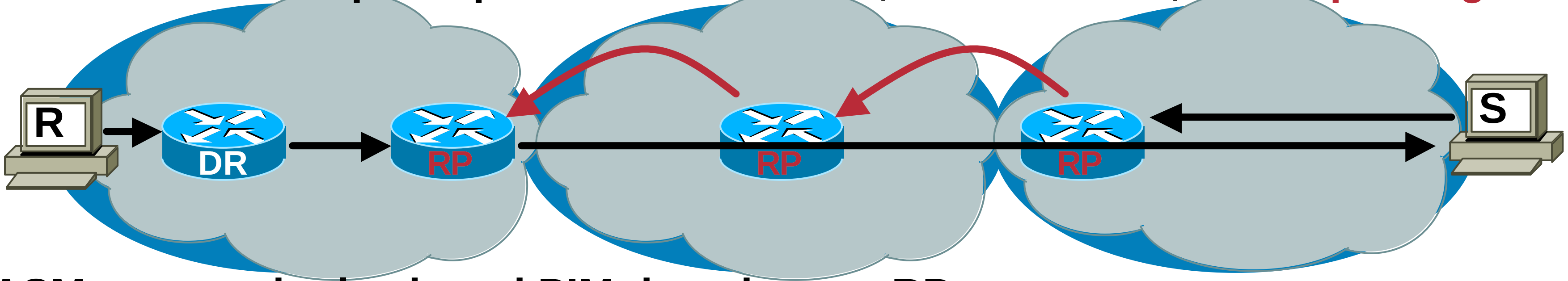
  - **PIM messages and data traffic within that scope are ignored on that interface**
  - **Initially a zone can only contain one interface**

IPv6 Multicast Inter-domain Options

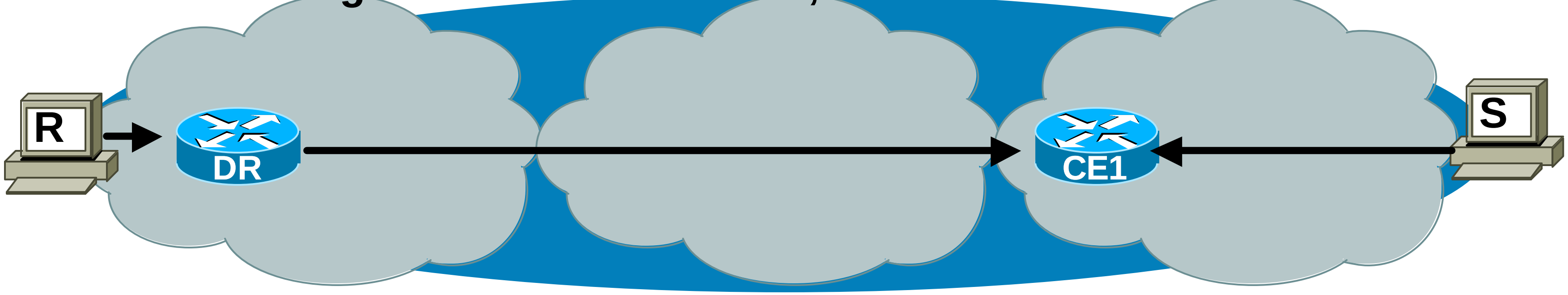
SSM, no RPs



ASM across multiple separate PIM domains, each with RP, MSDP peering



ASM across single shared PIM domain, one RP



Configuring Cisco IOS IPv6 Multicast

Group mode determines how to forward, compared to interface mode in v4.

By default all interfaces are PIM enabled unless explicitly disabled.

Config for PIM-SSM:

```
!
ipv6 multicast-routing
!
```

Config for PIM-SM:

```
!
ipv6 multicast-routing
ipv6 pim rp-address <v6_address>
!
```

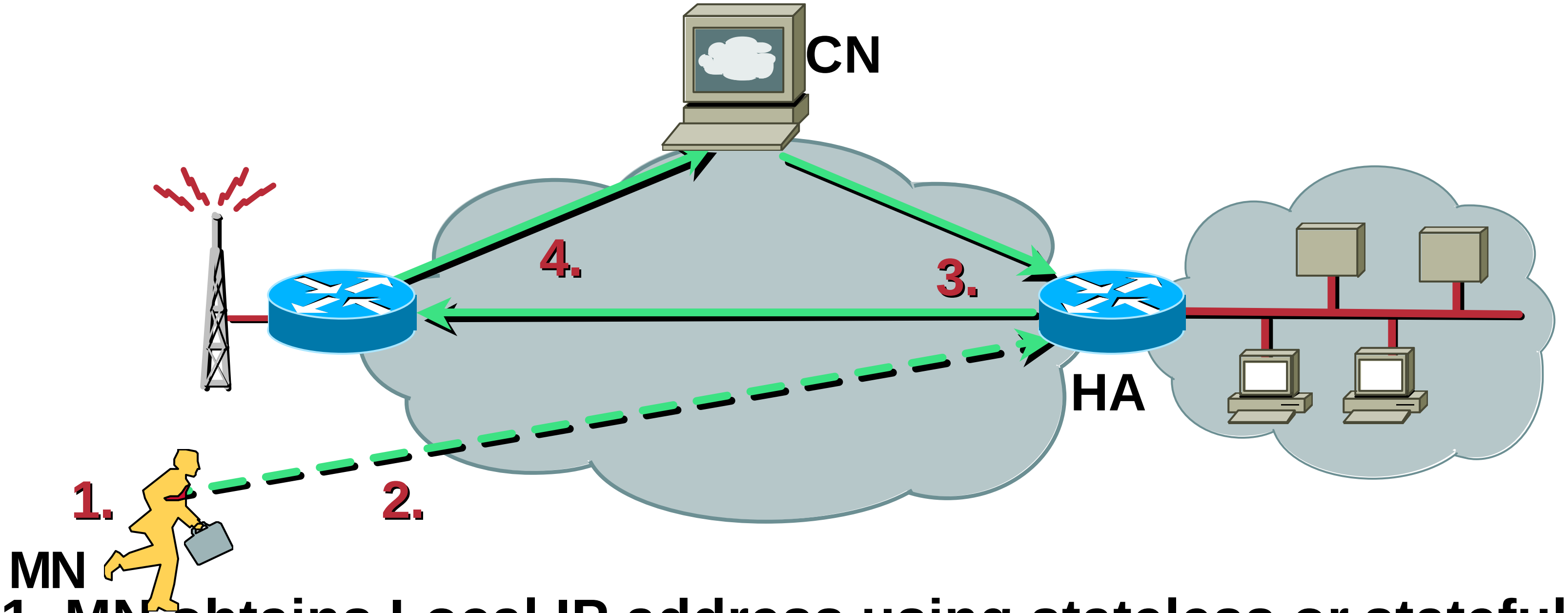
Config for PIM-bidir:

```
!
ipv6 multicast-routing
ipv6 pim rp-address <v6-address> bidir
!
```

Disable PIM on an interface

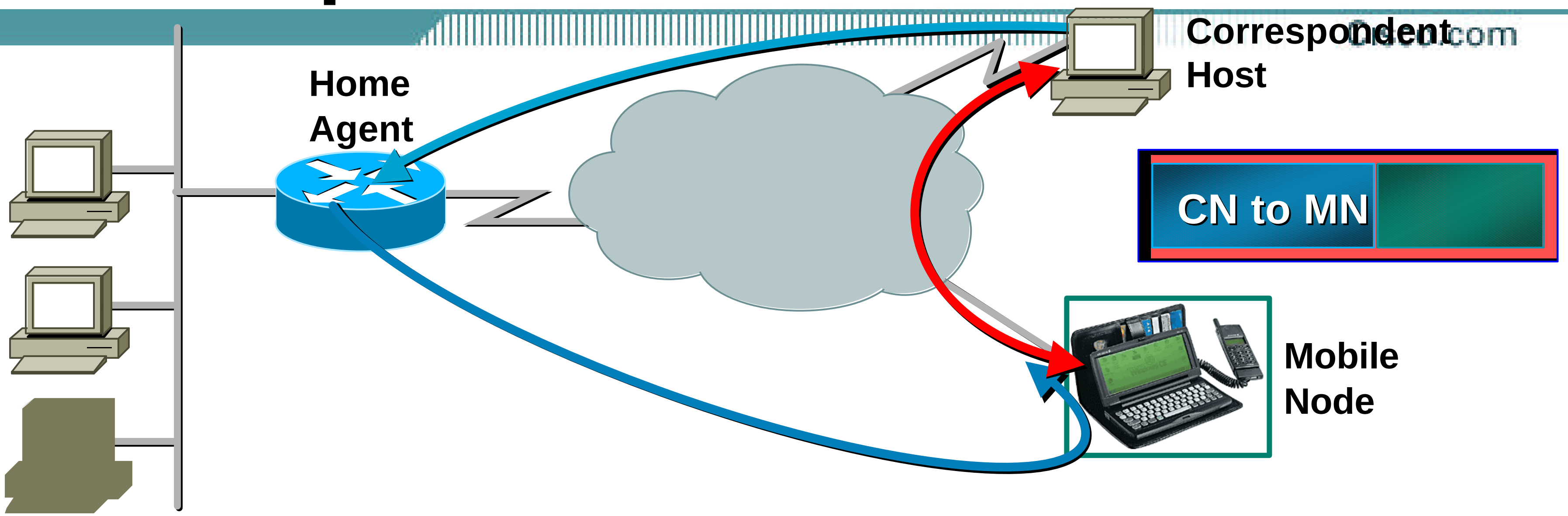
```
!
interface ethernet 0
 no ipv6 pim
!
```

Overview of Mobile IPv6 Functionality



- 1. MN obtains Local IP address using stateless or stateful autoconfiguration – Neighbor Discovery
- 2. MN registers with HA by sending a Binding Update
- 3. HA intercepts traffic for registered MN and tunnels packets from CN to MN
- 4. MN sends packets from CN directly or via HA using Tunnel

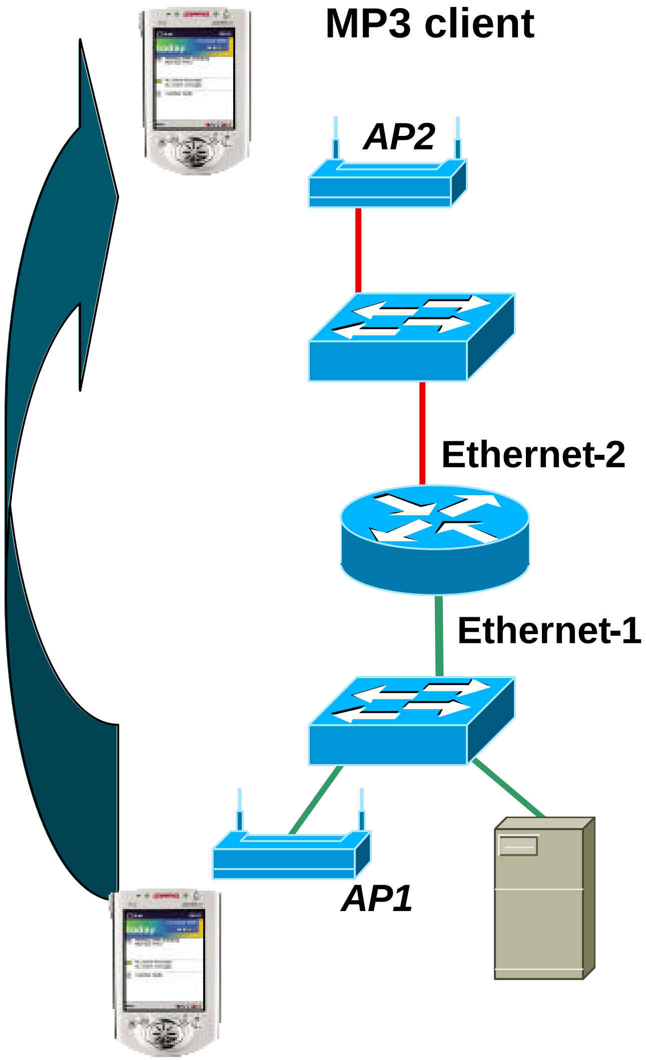
Route Optimization



- **Traffic is routed directly from the CN to the MN**
- **Binding Update *SHOULD* be part of every IPv6 node implementation**
- **IPv4 also has route optimization but CN needs enhanced IP stack and Key management is a problem**
- **Security Issues –**

  Shared Key or PKI Problem and We need a Scalable Solution

Cisco IOS Mobile IPv6 Home Agent Technology Preview



- MIPv6 Home Agent Technology Preview release built on IETF MIPv6 draft 20
  - Initial release was ID-13
  - Available on Cisco 2600, 3600, 3700 and 7200 series
  - Adding DAD and DHAD
  - IPsec support planned for a later stage
  - waiting for IETF MIPv6 WG completion
  - Binding update can be filtered by source address using ACL
- Only available for testing and experiment

  Tested with BSD, Linux and Windows MIPv6 client

```
Router1# ipv6 unicast-routing
Router1# ipv6 mobile
Router1# interface ethernet-1
     ipv6 address 2001:0001::45c/64
     ipv6 mobile home-agent enable
Router1# interface ethernet-2
     ipv6 address 2001:0002::45a/64
     ipv6 mobile home-agent enable
```

IPv6 Security

- IPsec standards apply to both IPv4 and IPv6
- All implementations required to support authentication and encryption headers (“IPsec”)
- Authentication separate from encryption for use in situations where encryption is prohibited or prohibitively expensive
- Key distribution protocols are not yet defined (independent of IP v4/v6)
- Support for manual key configuration required

IP Quality of Service Reminder

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Two basic approaches developed by IETF:

- **“Integrated Service” (int-serv)**

  fine-grain (per-flow), quantitative promises (e.g., x bits per second), uses RSVP signaling

- **“Differentiated Service” (diff-serv)**

  coarse-grain (per-class), qualitative promises (e.g., higher priority), no explicit signaling

Signaled diff-serv (RFC 2998)

  – uses RSVP for signaling with course-grained qualitative aggregate markings

  – allows for policy control without requiring per-router state overhead

IPv6 Support for Int-Serv

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- 20-bit Flow Label field to identify specific flows needing special QoS
  - each source chooses its own Flow Label values; routers use Source Addr + Flow Label to identify distinct flows
  - Flow Label value of 0 used when no special QoS requested (the common case today)
- This part of IPv6 is not standardized yet, and may well change semantics in the future

  http://www.ietf.org/internet-drafts/draft-ietf-ipv6-flow-label-07.txt

IPv6 Support for Diff-Serv

- **8-bit Traffic Class field to identify specific classes of packets needing special QoS**
  - **same as new definition of IPv4 Type-of-Service byte**
  - **may be initialized by source or by router enroute; may be rewritten by routers enroute**
  - **traffic Class value of 0 used when no special QoS requested (the common case today)**

IPv6 and DNS

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	IPv4	IPv6
Hostname to IP address	**A record:** www.abc.test. A 192.168.30.1	**AAAA record:** www.abc.test AAAA 3FFE:B00:C18:1::2
IP address to hostname	**PTR record:** 1.30.168.192.in-addr.arpa. PTR www.abc.test.	**PTR record:** 2.0.0.0.0.0.0.0.0.0.0.0.0.0.0.0.1.0.0.0.8.1.c.0. 0.0.b.0.e.f.f.3.ip6.arpa PTR www.abc.test.

IPv6 Technology Scope

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IP Service	IPv4 Solution	IPv6 Solution
Addressing Range	32-bit, Network Address Translation	128-bit, Multiple Scopes
Autoconfiguration	DHCP	Serverless, Reconfiguration, DHCP
Security	IPSec	IPSec Mandated, works End-to-End
Mobility	Mobile IP	Mobile IP with Direct Routing
Quality-of-Service	Differentiated Service, Integrated Service	Differentiated Service, Integrated Service
IP Multicast	IGMP/PIM/Multicast BGP	MLD/PIM/Multicast BGP,Scope Identifier

IPv6 Standards

- Core IPv6 specifications are IETF Draft Standards => well-tested & stable

  currently have 5 Draft Standards, 32 Proposed

  started to compile an IPv6 Node Requirements spec

- Some important auxilliary standards are less mature

  e.g., mobile IPv6, MIBS, scoped addressing,…

  for an up-to-date status: playground.sun.com/ipv6

- 3GPP UMTS Rel. 5 cellular wireless standards mandate IPv6; also being considered by 3GPP2

IPv6 Current Status - Standardisation

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- **Several key components now on Standards Track:**

Specification (RFC2460)	Neighbour Discovery (RFC2461)
ICMPv6 (RFC2463)	IPv6 Addresses (RFC2373/4/5)
RIP (RFC2080)	BGP (RFC2545)
IGMPv6 (RFC2710)	OSPF (RFC2740)
Router Alert (RFC2711)	Jumbograms (RFC2675)
Autoconfiguration (RFC2462)	

IPv6 over:	PPP (RFC2023)	Ethernet (RFC2464)
	FDDI (RFC2467)	Token Ring (RFC2470)
	NBMA(RFC2491)	ATM (RFC2492)
	Frame Relay (RFC2590)	ARCnet (RFC2549)

Prioritizing IETF IPv6 WG Work

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(1) Finishing work-in-progress:

Default address selection
Address architecture
Basic & advanced APIs
ICMPv6 update
Router preferences
Cellular hosts requirements
Node information queries
DAD fixes to privacy address, autoconf and/or address architecture

(2) Important and urgent for deployment:

DNS discovery
Prefix delegation
IPv6 MIBs

Prioritizing IPv6 WG Work (cont.)

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(3) Important but not quite so urgent:
- Flow label specification
- Scoped address architecture
- IPv6-over-3GPP-PDP-contexts spec
- IPv6 node requirements

(4) important but perhaps better handled in other WGs:
- secure, robust plug-and-play
- multi-link subnet specification
- anycast architecture
- routing protocol updates to handle IPv6 scoping

(5) important and already handled in other WGs:
- site multihoming
- IPv4 coexistence / interoperability / transition
- DHCPv6
- mobile IPv6

Status of Other IPv6-Related WG in the IETF

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- **NGtrans (Next Generation Transition)**

  Major reorganization, moving from "tool development" to "IPv6 network operation"

- **v6Ops**
- **DHCP (dynamic host configuration)**

  DHCPv6 spec very close to Proposed Standard (at last!)

- **Multi6 (multihoming for IPv6)**

  Little progress

- **Mobile IP**

  Binding-update authentication issue of mobile IPv6 resolved;
  expect Proposed Standard soon(?)

Questions?

More Information

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- **CCO IPv6 - http://www.cisco.com/ipv6**
- **The ABC of IPv6**

  http://www.cisco.com/en/US/products/sw/iosswrel/products_abc_ios_overview.html
- **IPv6 e-Learning [requires CCO username/password]**

  http://www.cisco.com/warp/customer/732/Tech/ipv6/elearning/
- **IPv6 Access Services :**

  http://www.cisco.com/warp/public/732/Tech/ipv6/docs/ipv6_access_wp_v2.pdf
- **ICMPv6 Packet Types and Codes TechNote:**

  http://www.cisco.com/warp/customer/105/icmpv6codes.html
- **Cisco IOS IPv6 Product Manager – pgrosset@cisco.com**

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