



EPOC

Engagement and Performance
Operations Center

IPv6 - Routing



ESnet

ENERGY SCIENCES NETWORK

Progress Bar:

4:00p - 4:45p

Questions or Discussion topics?

IPv6 Routing - Unit Overview

- Navigate through routing protocols specific to IPv6.
- Learn effective strategies for handling IPv6 in both IGP and EGP scenarios.

IPv6 Routing - Overview

- Routing topologies are the *mostly* the same as IPv4
- Protocols typically require an upgrade
- Routing best practices are *mostly* the same

IPv6 Routing - IPv6 Best Practices

- Start with an address plan
 - /64 - Subnet
 - /56 - Per customer
 - /48 - Per site
 - Larger chunks on nibble boundaries (/32, /36, /40, /44, /48)
 - Consider the network in the future. Give yourself room.
 - Prefix announcements - Never smaller than a /48
 - P2P Prefixes:
 - /64's are okay to use
- Router Interfaces
 - Avoid using the leading zero, use ::1 instead
 - Host/router support/behavior is inconsistent

MANRS - BGP

MANRS Implementation Guide for Network Operators

Mutually Agreed Norms for Routing Security (MANRS) is a global initiative, supported by the [Global Cyber Alliance](#), that provides crucial fixes to reduce the most common routing threats. MANRS offers specific actions via four programs for [Network Operators](#), [Internet Exchange Points](#), [CDN and Cloud Providers](#), and [Equipment Vendors](#).

IPv6 Routing - Static Routes

- Juniper:
 - IPv4: set routing-options static route \$prefix next-hop \$nextHop
 - IPv6: set routing-options rib inet6.0 static route \$prefix next-hop \$nextHop
- Cisco:
 - IPv4: ip route \$prefix \$nextHop
 - IPv6: ipv6 route \$prefix \$nextHop
 - If you haven't already: insert "ipv6 unicast-routing" under global configuration to enable routing v6

IPv6 Routing - Dynamic Routing Protocols

- Covered:
 - OSPFv3
 - IS-IS
 - BGP
- Not Covered:
 - EIGRP
 - RIPng

IPv6 Routing - OSPFv3 Overview

- Fundamental OSPF mechanisms and algorithms unchanged
- Packet and LSA formats are different
- Runs per-link (OSPFv3) rather than per-subnet (OSPFv2)
- Multiple instances on a single link
- Interfaces can have multiple IPv6 addresses
- FF02::5 (all OSPF routers), FF02::6 (all OSPF DRs)
- Neighbor Authentication done with IPsec (AH)
- IPv4 RIDs, Area IDs, and LSA IDs

IPv6 Routing - OSPFv2 vs OSPFv3 Similarities

- Both are link-state Interior Gateway Protocol(IGP)routing protocols,
- Same administrative distance of 110
- Both use a 2-level hierarchy with Area 0.0.0.0 at the core
- Area Border Routers(ABRs) and Autonomous System Boundary Routers (ASBRs) are the same
- Shortest Path First (SPF) calculations within each area are the same
- Metrics based on interface bandwidth are the same
- Both have 5 common protocol packet types:
 - Hello
 - Database description(DBD)
 - Link-state request (LSR)
 - Link-state update (LSU)
 - Link-state acknowledgment (LSA)
- They use similar interface types:
 - Broadcast
 - P2P
 - P2MP
 - NBMA
 - Virtual-Links
- LSA flooding and aging timers are the same

IPv6 Routing - OSPFv2 vs OSPFv3 Differences

- Different address families
 - OSPFv2 - IPv4-only
 - OSPFv3 - IPv6-only or IPv4/IPv6
- OSPFv3 introduces new LSA types
- OSPFv3 has different packet format
- OSPFv3 uses different flooding scope bits(U/S2/S1)
- OSPFv3 adjacencies are formed over link-local IPv6 communications
- OSPFv3 runs per-link rather than per-subnet
- OSPFv3 supports multiple instances on a single link
- Interfaces can have multiple IPv6 addresses
- OSPFv3 uses the following multicast addresses
 - FF02::5 (all OSPF routers)
 - FF02::6(all OSPF DRs)
- OSPFv3 Neighbor Authentication done with IPsec (AH)
- OSPFv3 Router ID (RID) requires manual configuration (32 bit number)

IPv6 Routing - OSPFv3 LSA's

OSPFv3 LSA TYPE	LSA NAME	OSPFv2 LSA TYPE	LSA NAME
0x2001	Router LSA	1	Router LSA
0x2002	Network LSA	2	Network LSA
0x2003	Inter-Area Prefix LSA	3	Summary LSA
0x2004	Inter-Area Router LSA	4	ASBR Summary LSA
0x4005	AS-External LSA	5	AS-External LSA
0x2006	Multicast LSA	6	Multicast LSA
0x2007	Not-So-Stubby-Area LSA	7	Not-So-Stubby-Area LSA
0x0008	Link LSA		
0x2009	Intra-Area Prefix LSA		

IPv6 Routing - OSPFv3 LSA Scope

0 = LINK LOCAL ONLY

2 = AREA ONLY

4 = ENTIRE AUTONOMOUS SYSTEM

IPv6 Routing - OSPFv3 Examples (Juniper)

- `set protocols ospfv3 area 0 interface $interface`
- `set protocols ospfv3 area 0 interface $passiveInterface passive`
- `set protocols ospfv3 area 0 interface $interface2 metric 10`

IPv6 Routing - OSPFv3 Examples (Cisco)

- Protocol/Area Config
 - ipv6 router ospf \$instance
 - router-id \$routerID
 - area 0
- Interface Config
 - interface \$interface
 - ipv6 address \$v6Address
 - ipv6 ospf \$instance area 0
 - ipv6 ospf network point-to-point

IPv6 Routing - OSPFv3 Useful Commands (Juniper)

show ospf3 overview

show ospf3 interface \$interface

show ospf3 neighbor

show ospf3 backup neighbor

show ospf3 database

show ospf3 statistics

show ospf3 route

IPv6 Routing - OSPFv3 Useful Commands (Cisco)

show ipv6 protocols

show ipv6 ospf

show ipv6 ospf interface brief

show ipv6 ospf interface \$interface

show ipv6 ospf neighbor

show ipv6 ospf database

show ipv6 route ospf

Show ipv6 interface \$interface

IPv6 Routing - IS-IS Overview

- IS-IS is an extendable link-state intra-domain routing protocol
- 2-level hierarchical architecture
 - Level 1 router - Responsible for intra-area routing (within an area)
 - Level 2 router - Responsible for inter-area routing (between areas)
 - Level 1/2 router - Responsible for intra/inter area routing
- IPv6 supported out of the box
- Support for the following:
 - Single Topology
 - Multi-Topology
 - Multi-Instance

IPv6 Routing - IS-IS Examples (Juniper)

Juniper:

- `set protocols isis topologies ipv6-unicast`
- `set protocols isis interface $p2pInterface point-to-point`
- `set protocols isis interface $passiveInterface passive`
- `set protocols isis level 2 wide-metrics-only`
- `set protocols isis level 1 disable`
- `set protocols isis reference-bandwidth 1000g`

IPv6 Routing - IS-IS Examples (Cisco)

```
router isis $topologyName
is-type level-2-only
net $isoAddress
log adjacency changes
address-family ipv4 neighbors $neighborIP
metric-style wide
redistribute connected
redistribute static
adjacency-check disable
!
address-family ipv6 neighbors $neighborIP
metric-style wide
single-topology
redistribute connected
redistribute static
adjacency-check disable
```

```
!
interface $interface
circuit-type level-2-only
point-to-point
address-family ipv4 neighbors $neighborIP
metric 5
!
address-family ipv6 multicast
metric 5
!
```

IPv6 Routing - IS-IS Useful Commands (Juniper)

- `show isis overview`
- `show isis interface`
- `show isis interface $interface`
- `show isis adjacency`
- `show isis database`
- `show isis route`
- `show isis authentication`

IPv6 Routing - IS-IS Useful Commands (Cisco)

- `show isis neighbors`
- `show isis database`
- `show isis rib`
- `show isis topology`

IPv6 Routing - BGP Overview

- Multiprotocol Extensions for BGP-4 (RFC 4760)
- New optional and non-transitive attributes (NLRI)
 - MP_REACH_NLRI(attribute code:14)
 - MP_UNREACH_NLRI (attribute code: 15)
- Address Family Identifier (AFI=2) for IPv6
- Still uses port 179/TCP
 - Peerings over IPv4 and IPv6 supported.
- Link local addresses or global neighbors \$neighborIP addresses can be used for next-hop
- 32-bit router ID required if no IPv4 interfaces
 - Used as tie-breaker - sent in OPEN messages

IPv6 Routing - BGP Overview Continued

- Next hop reachability is very important in BGP
- If the next hop is inaccessible, the routes learned via BGP will not be installed in the routing table
- Link-local address as a next-hop is only set if the BGP peer is also on a link-local address

IPv6 Routing - BGP Peering Examples (Juniper)

- `set routing-options rib inet6.0 static route $prefix discard`
- `set protocols bgp group $GROUP type external`
- `set protocols bgp group $GROUP family inet6 neighbors $neighborIP`
- `set protocols bgp group $GROUP neighbor $neighborIP description "PEERING - ROUTER-LOC - DEVICE/PORT NUMBER"`
- `set protocols bgp group $GROUP neighbor $neighborIP import $GROUP-V6-IN`
- `set protocols bgp group $GROUP neighbor $neighborIP authentication-key $authKey`
- `set protocols bgp group $GROUP neighbor $neighborIP export $GROUP-V6-OUT`
- `set protocols bgp group $GROUP neighbor $neighborIP peer-as $peerAS`

IPv6 Routing - BGP Policy Examples (Juniper)

- set policy-options prefix-list \$HOME-INSTITUTION-V6 \$prefix
- set policy-options policy-statement PEERING-LOC-V6-IN term ACCEPT then local-preference 100
- set policy-options policy-statement PEERING-LOC-V6-IN term ACCEPT then community set \$PEERING
- set policy-options policy-statement PEERING-LOC-V6-IN term ACCEPT then accept
- set policy-options policy-statement PEERING-LOC-V6-OUT term 1 from protocol static
- set policy-options policy-statement PEERING-LOC-V6-OUT term 1 from prefix-list \$HOME-INSTITUTION-V6
- set policy-options policy-statement PEERING-LOC-V6-OUT term 1 then accept
- set policy-options policy-statement PEERING-LOC-V6-OUT term reject then reject
- set policy-options community \$PEERING members \$localAS:\$peerAS

IPv6 Routing - BGP Peering Examples (Cisco)

```
router bgp $localAS
  bgp router-id $routerID
  address-family ipv4 neighbors
  $neighborIP
    bgp origin-as validation enable
  !
  address-family ipv6 neighbors
  $neighborIP
    bgp origin-as validation enable
```

```
neighbor-group $neighborGroup
  remote-as $remoteAS
  $sourceInterface
  address-family ipv6 neighbors
  $neighborIP
    bestpath origin-as allow invalid
    route-policy $group-in in
    route-policy ebgp-announce-v6 out
```

IPv6 Routing - BGP Policy Examples (Cisco)

```
route-policy $peering-in-v6
  set local-preference 100
  set community $peering
  if destination in $homeInstitution-IPv6
  then
    drop
  endif
  pass
End-policy
community-set from-commodity
  $localAS:$peerAS
```

```
route-policy $peering-out-v6
  if destination in $homeInstitution-IPv6 then
    pass
  else
    drop
  endif
end-policy
```

IPv6 Routing - BGP Useful Commands (Juniper)

- `show bgp summary`
- `show bgp neighbor $neighborIP`
- `show bgp group summary`
- `show bgp group $group`
- `show route advertising-protocol bgp $neighborIP`
- `show bgp receive-protocol bgp $neighborIP`

IPv6 Routing - BGP Useful Commands (Cisco)

- `show bgp ipv6 summary`
- `show bgp ipv6 neighbors`
- `show bgp ipv6 neighbors $neighborIP received-routes`
- `show bgp ipv6 neighbors $neighborIP routes`
- `show bgp ipv6 neighbors $neighborIP advertised-routes`
- `show bgp ipv6 neighbors $neighborIP paths`

IPv6 Routing - Gateway Redundancy (HSRP)

- Behavior *mostly* similar to IPv4
- RA's sent from active router
- Changes: Neighbor Advertisement, Router Advertisement, and ICMPv6 redirect
- No need to configure GW on hosts manually
- Uses virtual IP using link local address (FE80::)

IPv6 Routing - Gateway Redundancy (VRRP)

- Must use VRRPv3, no support for IPv6 in VRRPv2
- VRRPv3 supports IPv4 and IPv6
- Uses IPv6 multicast address FF02::12
- Check release notes for support