IS-IS Refresher

Network Engineering Workshop
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Outline

- Overview
- IS-IS hierarchy, areas and the attached bit
- Network types
- IS-IS packet types
  - Hello, LSPs and SNPs
- Type/Length/Values
- IS-IS for IPv6
  - Single Topology, Multi-Topology
- Applications
- Best practices

What is IS-IS?

- The IS-IS protocol was originally developed by Digital Equipment Corporation (DEC) as a link-state routing protocol for the Open Systems Interconnection (OSI) protocol suit.
  - The OSI suite uses Connectionless Network Service (CLNS) and the Connectionless Network Protocol (CLNP) as the Layer 3 protocol to provide connectionless delivery of data.
  - In the ISO CLNS environment, routers are called Intermediate Systems.
- IS-IS was later extended to support routing of datagrams in the Internet Protocol (IP).
  - This version of IS-IS was then called Integrated IS-IS.

Integrated IS-IS

- Integrated IS-IS is an Interior Gateway Protocol (IGP).
  - IGP protocols are used to distribute IP routing information within an Autonomous System (AS).
- It is a link-state routing protocol, similar to OSPF.
  - Each router distributes information about it's local state to other routers using Link-State PDU (Protocol Data Unit) *or LSPs*.
  - Once each router has received the LSPs from other routers within an AS, it will use Dijkstra's Shortest Path First algorithm to calculate the shortest path to each reachable network segment.

Integrated IS-IS Characteristics

- IS-IS is a classless routing protocol and therefore supports VLSM.
  - VLSM enables better use of IP address space.
- Fast convergence.
  - Partial Route Calculation (PRC) guarantees fast convergence and less CPU usage.
- Excellent scalability
  - IS-IS backbone design is not as strict as OSPF, thereby allowing for easy backbone extension.

IS-IS Hierarchy

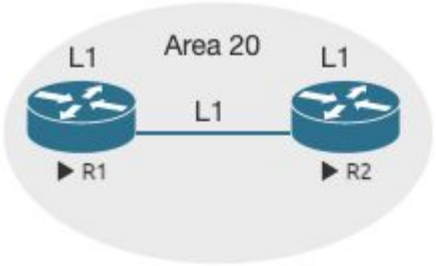
- IS-IS has a 2 layer hierarchy
  - Level-1 (L1)
  - Level-2 (L2)
- The protocol supports three types of routers:
  - L1 routers. They establish adjacencies with L1 or L1L2 routers.
  - L2 routers. They establish adjacencies with L2 or L1L2 routers.
  - L1L2 routers. They are used for inter and intra area routing.
    - Routers will default to L1L2 if the IS-Type is not manually configured.

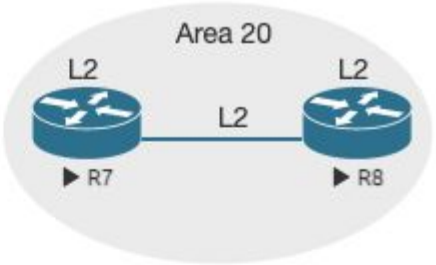
IS-IS Areas

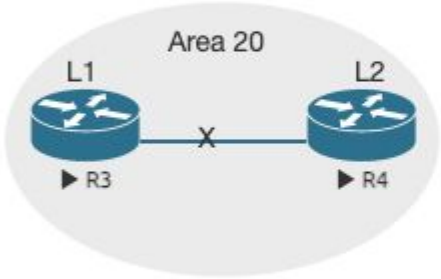
- In OSPF, any of the router's interfaces can be assigned to a particular area. However the concept of an area in IS-IS is different:
  - The entire router sits in an area.
    - It's also possible for a router to be in more than one area at a time.
  - IS-IS has no backbone area.
    - The backbone is formed by L2 routers.
- An IS-IS area only affects the formation of adjacencies between two routers, while a level controls the flooding scope of LSPs.

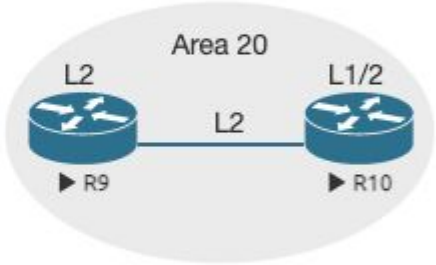
IS-IS adjacencies within the same area

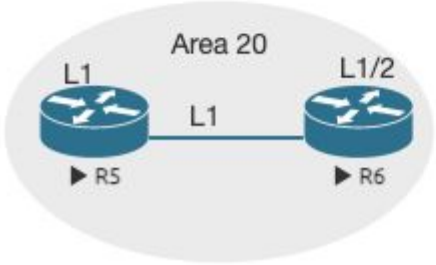
- A L1 router can become adjacent with a L1 or L1L2 router
- A L2 router can become adjacent with a L2 or L1L2 router
- A L1L2 router can become adjacent with L1, L2 or L1L2 routers
- There is no adjacency between L1 and L2 router.

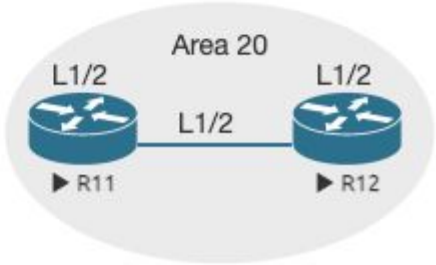






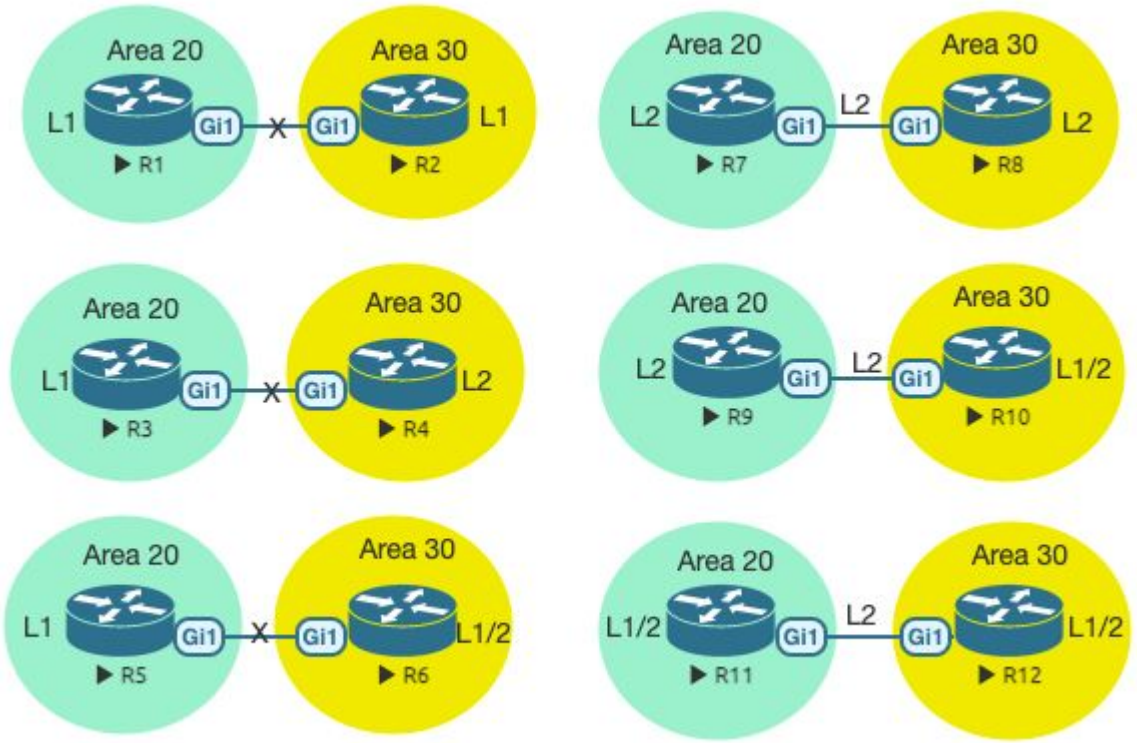






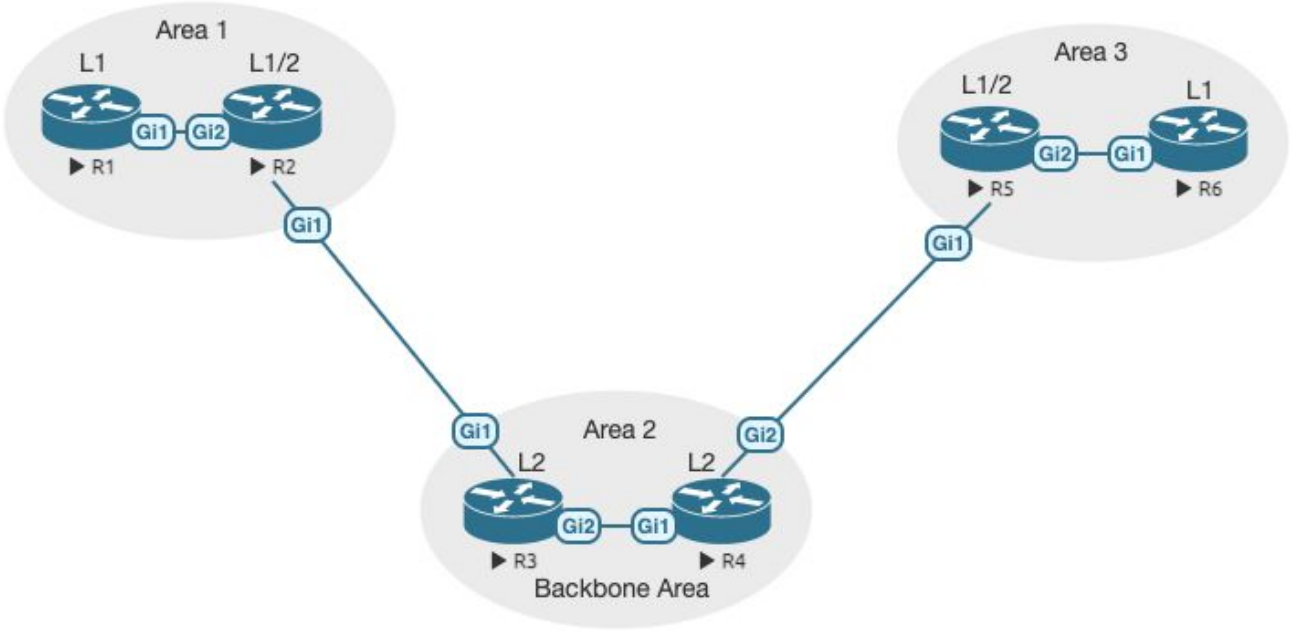
IS-IS adjacencies in different areas

- A L2 router can talk to L2 and L1L2 routers
- A L1L2 router can talk to a L1L2 router.
- There is no adjacency between L1 and L1, L2 or L1L2 routers



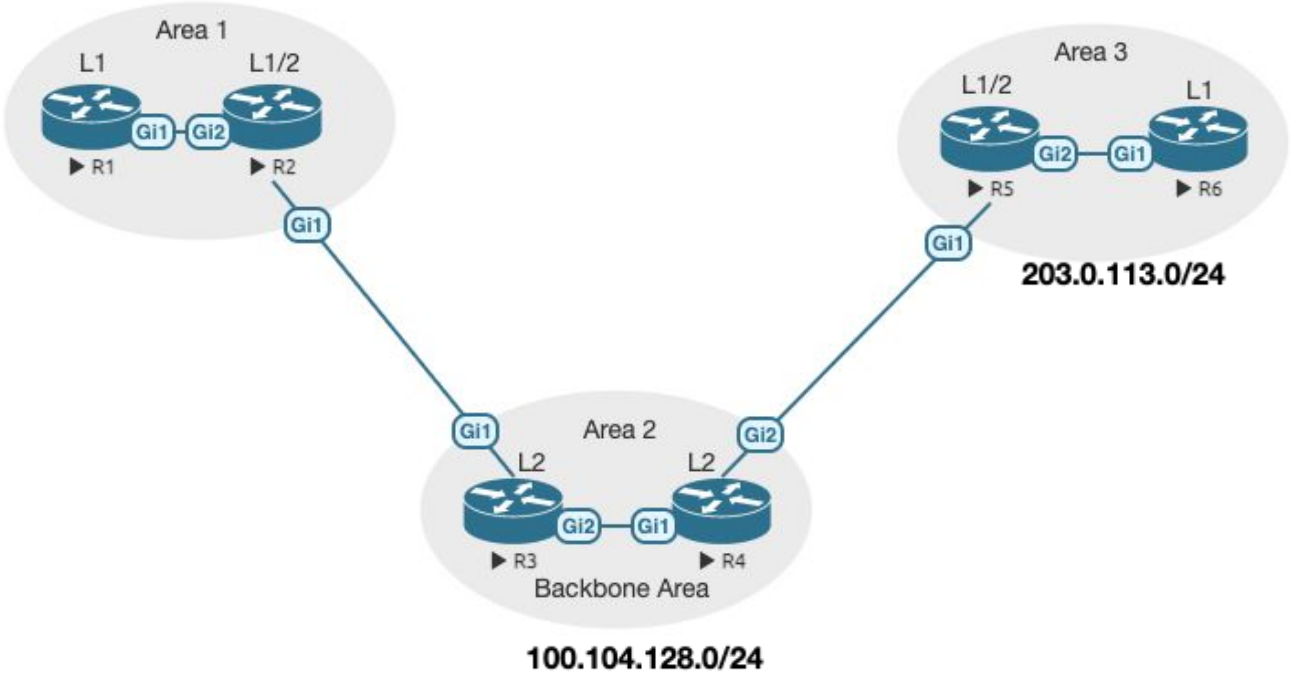
IS-IS Adjacencies

- A L1 router can only talk to L1 routers within its own area
- A L1L2 router can talk to both L1 and L2 routers.
- A L2 router can talk to L2 routers within its own area and in other areas



The Attached Bit

- A L1 router will never learn about prefixes from other areas. So, how does it reach the external destinations?
  - Once a L1L2 router is connected to another area, it sets a special bit in its level 1 LSP called the attached bit.
  - When a level 1 router sees this, it generates a default route that is pointing to the L1L2 router.



Network Types - Broadcast

- This is the default type and is used on multi-access interfaces like ethernet.
- A Designated Intermediate System (DIS) is elected based on highest priority and highest SNPA (MAC) address.
  - The primary purpose is to perform flooding of LSPs to a multicast address hence reduce unneeded flooding.
  - The DIS is similar to OSPF DR. There is no backup DIS in IS-IS.
  - DIS election is preemptive.

Network Types - Point to Point

- This is used where two routers are connected in a point-to-point fashion.
  - It can be used on an ethernet link when only two routers are connected.
- No DIS election is done on point to point network type links.
- L1 and L2 LSPs are directly sent to the neighbor.
- Each LSP has to be ACKed by PSNP. If one is not ACKed, the retransmit timer will trigger a retransmit.
- Cisco and Juniper recommend using point to point type for better convergence.

IS-IS Packet Types

- There are three categories of PDU packets. These are:
  - IS-IS Hello PDU (IIH)
  - Link-State PDU (LSP)
  - Sequence Number PDUs (SNP)
    - Complete Sequence Number PDU (CSNP)
    - Partial Sequence Number PDU (PSNP)

IS-IS Hello PDU

- Hello packets are used by routers to establish and maintain neighbor adjacencies. They have the following sub-categories:
  - Point-to-Point IIH
  - Level 1 LAN IIH
  - Level 2 LAN IIH
- In broadcast networks, DIS election is done using the hello PDU.

IS-IS Link-State PDU

- LSPs carry link state information and are similar to Link State Advertisements (LSAs) used in OSPF.
- Each router generates an LSP for itself and floods it throughout the network.
- There are two types of LSPs.
  - Level-1 LSPs. These are sent by the L1 routers
  - Level-2 LSPs. These are sent by the L2 routers
- A L1L2 router can send both types of LSPs.
- LSPs are stored in Link-State Databases (LSDBs).
  - Separate LSDBs are used for L1 and L2 LSPs.

IS-IS Link State PDU (ctd)

- The LSPs contain information needed to create the full topology of the network. This information includes:
  - Adjacent neighbors
  - One or more prefixes (e.g directly connected networks that are advertised in IS-IS)
  - Metric
- Each LSP has a sequence number that is increased whenever there is a change in the LSP.

Sequence Number PDUs

- Since IS-IS is a link-state routing protocol, it is important that the databases are identical on every router of the same level within the AS.
- SNP (Sequence Number PDU) come in two types:
  - CSNP (Complete SNP): This has a list of all LSPs in the database, it is used to inform other routers that have missing or outdated information.
    - On broadcast networks, CSNP is periodically sent by the DIS.
    - On point-to-point networks, CSNP is only sent during the adjacency establishment.
  - PSNP (Partial SNP): This is used to request one or more LSPs and also to acknowledge the receipt of one or more LSPs.

Type/Length/Value Extensions

- PDUs have a TLV field which makes IS-IS much more extensible than OSPF.
  - Enhancements to IS-IS are achieved through the introduction of new TLV fields.
  - OSPF uses fixed length fields.
- There are several TLVs. Examples include:
  - Area Address TLV
  - Padding TLV
  - Protocols Supported TLV
  - Authentication TLV

Network Entity Title - NET

- It is a unique identifier for each IS and has to be configured manually.
  - Most routing protocols use an IP address as a router ID but IS-IS was not originally developed for IP.
- The NET is an NSAP with the NSEL set to 00.

49.0001.1001.0400.1011.00

Metrics

- IS-IS has four metric values: ***Default Metric, Delay, Expense and Error***.
- Cisco IOS supports only the default metric
  - The default value in Cisco IOS and Junos is 10. This applies to any type of interface (Serial, FE, 1GE, 10GE).
  - By default, narrow metrics are enabled on both Cisco IOS and JunOS.
    - In narrow metrics, the maximum value on any interface is 63 and 1023 per path in the routing table.
  - It's best practice to enable wide metrics. This increases the maximum metric to 16777215.

Single Topology vs Multi Topology

- When working with IPv6 prefixes in IS-IS, you can configure IS-IS to be in a single topology for both IPv4 and IPv6 or to run different topologies for IPv4 and IPv6.
- Single topology has the following characteristics:
  - All IS-IS links need to have both IPv4 and IPv6 addresses as the SPF tree is run independently of prefix information
  - Only one SPF calculation for both address families

Single Topology vs Multi Topology

- Enabling multi-topology mode will have following effect
  - Allow the IPv6 and IPv4 routing information to be carried in separate TLVs so two different Link State Databases (LSDBs).
  - Each router can compute a different Shortest Path Tree (SPT), one for IPv4, and another for IPv6.
  - IPv4 and IPv6 configuration are completely different

Junos Configuration Example

```
[edit interfaces lo0]
root@PE1# show
unit 0 {
    family inet {
        address 100.104.1.11/32;
    }
    family iso {
        address 49.0001.1001.0400.1011.00;
    }
    family inet6 {
        address 2001:db8:1001::100:104:1:11/128;
    }
}
```

```
[edit interfaces]
root@PE1# show
ge-0/0/1 {
    description PE1-P1;
    unit 0 {
        family inet {
            address 100.104.0.25/30;
        }
        family iso;
        family inet6 {
            address 2001:db8:1000::14/127;
        }
    }
}
```

Junos Configuration Example (ctd)

```
[edit protocols isis]
root@PE1# show
topologies ipv6-unicast;
level 2 wide-metrics-only;
interface ge-0/0/1.0 {
    point-to-point;
    level 1 disable;
    level 2 metric 10;
}
interface ge-0/0/2.0 {
    point-to-point;
    level 1 disable;
    level 2 metric 10;
}
interface ge-0/0/4.0 {
    point-to-point;
    level 1 disable;
    level 2 metric 10;
}
interface lo0.0 {
    passive;
}
```

IOS-XE Configuration Example

```
!
router isis AS64496
 net 49.0001.1001.0400.1012.00
 is-type level-2-only
 metric-style wide
 passive-interface Loopback0
 !
 address-family ipv6
  multi-topology
 exit-address-family
!
```

```
!
interface GigabitEthernet1
 description PE2-P2
 ip address 100.104.0.41 255.255.255.252
 ip router isis AS64496
 ipv6 address 2001:DB8:1000::B/127
 ipv6 router isis AS64496
 isis network point-to-point
interface GigabitEthernet2
 description PE2-P4
 ip address 100.104.0.37 255.255.255.252
 ip router isis AS64496
 ipv6 address 2001:DB8:1000::C/127
 ipv6 router isis AS64496
 isis network point-to-point
 !
```

Where does IS-IS belong?

- If you are running both IPv4 and IPv6 in your ISP network.
  - Upto today OSPF still carries IPv4 and IPv6 in different protocols, OSPFv2 and OSPFv3.
- Carrier IP/MPLS networks.
  - Service Providers use IS-IS as the underlay to their MPLS networks.

In conclusion

- Always
  - Enable IPv6 and use it. IPv4 is running out!
  - Use wide metrics
  - Multi-topology
  - Set interface metrics
  - Disable Level-1
  - Derive system IDs from your loopbacks
- MTU must be greater than 1500

Thank you

Any questions?

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