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Advanced Cisco Networking Academy – Configuring a Network with the IS-IS Routing Protocol

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Purpose

This lab is intended to demonstrate an understanding of the IS-IS routing protocol and its many inticracies. The lab entails setting up multiple IS-IS areas, intended to show off the modular way in which the protocol is designed.

Background

Intermediate System to Intermediate System, or IS-IS, is an interior gateway link-state routing protocol. Unlike most routing protocols, it was standardized by the International Standards Organization instead of the IETF. More specifically, its most recent version is defined in ISO/IEC 10589:2002.

IS-IS has a somewhat confusing history. It was originally written in the late 1980s as a proprietary standard at the Digital Equipment Corporation, but ISO began development on an open standard version of the protocol soon after. In February 1990, the IETF (who, again, didn't develop the protocol) officially republished a draft/prototype version of IS-IS (then called ISO Development Protocol 10589) under RFC 1142. IETF also modified IS-IS to work with their own Internet Protocol (IP) standards in a version called Integrated IS-IS, which was specified under RFC 1195. This document was later archived when the protocol was officially standardized under ISO/IEC 10589:1992. Ten years later, the protocol was updated and has remained the same ever since (see above).

The "Intermediate System" in the protocol's name refers to ISO's terminology for a router. ISO has their own terminology for several different networking terms, including "end system" for a host, "circuit" for a link, and "adjacency" for a neighbor connection between routers. IS-IS supports two different types of adjacencies: broadcast (LAN) adjacencies and point-to-point adjacencies.

Open Shortest Path First (OSPF) is a routing protocol that uses link state advertisements to automatically build a network topology and provide end-to-end connectivity across networks. It was developed by the IETF. OSPF has two widely used versions: OSPFv2 and OPSFv3, which operate similarly but use IPv4 and IPv6 addresses respectively. OSPFv2 is specified in RFC 2328 and OSPFv3 is specified in RFC 5320.

IS-IS routers can be set up to support intermediate systems in three different ways: Level 1, Level 2, and Level 1-2. Level 1 routers, also known as station routers, are designed to route only within their own area. Level 2 routers, also known as backbone routers, are designed to route between areas. Level 1-2 routers work on both Level 1 and Level 2 and allow routers on either level to communicate with each other.

Multiple IS-IS processes can be run on the same router through the use of area tags, which function much like OSPF process IDs. Unlike process IDs, however, area tags can be made up of alphanumeric characters instead of just numbers.

IS-IS uniquely identifies routers, areas, and processes using Network Entity Titles, or NETs. NETs are formatted like so: `aa.bbbb.cccc.cccc.cccc.dd`. The first section is the Authority and Format Identifier, or AFI, which specifies how the address is controlled and structured. The most common AFI is 49, which is used for private networks. The second section is the Area ID and is used by routers to identify their own area and the areas of other routers for the purposes of Level 1 and 2 routing. The third section is the System ID, which uniquely identifies an entire router across an entire network, and functions much like an OSPF router ID. The final section is the N-Selector, which is used to uniquely identify network services and is always set to `00` for the purposes of IS-IS routing.

IS-IS has a variety of packet types for communication packets. Hello Protocol Data Units (PDUs) are used to establish adjacencies between routers. Link State PDUs (LSPs) are used to exchange routing information and can be fragmented in cases where a lot of information needs to be exchanged. LSPs contain data in a Type-Length-Value (TLV) format and come with a header that contains the source router's system ID and fragmentation information. A few notable TLV values have been added to LSPs over the years, especially TLVs 22 and 135, which contain wider metric values to allow more complex topologies. IS-IS also uses Complete Sequence Number PDUs (CSNP) and Partial Sequence Number PDUs (PSNP) to ensure that all routers in a network have the same LSP information. The DIS periodically sends out a CNSP that contains all LSP IDs, and other routers will send PNSP requests for specific LSPs if they find any differences in their own databases.

IS-IS and OSPF are very similar routing protocols with a few key differences. Both protocols are interior routing protocols, meaning that they are meant for routing within a single autonomous system. Both protocols also use Djikstra's algorithm for finding the optimal route through a network. OSPF is specific to IP routing while IS-IS supports both IP and Connectionless Network Protocol (CLNP), which is an ISO standard that is often considered an equivalent to IP. This was especially useful in the networking world when IPv6 was becoming widely adopted, as OSPF had to be rewritten (see OSPFv3) to support IPv6 but IS-IS could handle the new addressing standard without any issues. OSPF has a wider variety of operation modes and has exclusive modes such as point-to-multipoint and point-to-multipoint non-broadcast. OSPF also requires all routers to be connected to a core backbone area (area 0) while IS-IS has no such requirement, allowing IS-IS topologies to take more complex shapes. IS-IS and OSPF also differ in how they handle areas, as IS-IS handles areas in terms of entire routers while OSPF handles areas in terms of specific interfaces. IS-IS and OSPF also display neighbor information differently, as IS-IS displays the hostnames of neighboring routers while OSPF only displays their router IDs. This is made possible through TLV 137, a value stored in IS-IS LSPs. Having router hostnames displayed in an IS-IS database can make debugging much easier for network engineers and administrators.

Lab Summary

This lab entails setting up six routers with IS-IS in three different areas using a linear topology. The topology is symmetrical, with a Level 1 router on each edge connected to a Level-1-2 router and Level 2 router on each side. These routers are split into three areas, with Area 2 built entirely in Level 2 and Areas 1 and 3 containing the Level 1-2 and Level 1 routers. The Level 1 routers are connected to the hosts and assign an IP automatically with a DHCP server.

Lab Commands

```
Router(config-if): ip router isis <area-tag>
```

Configures IS-IS to be used on an interface with the specified area tag.

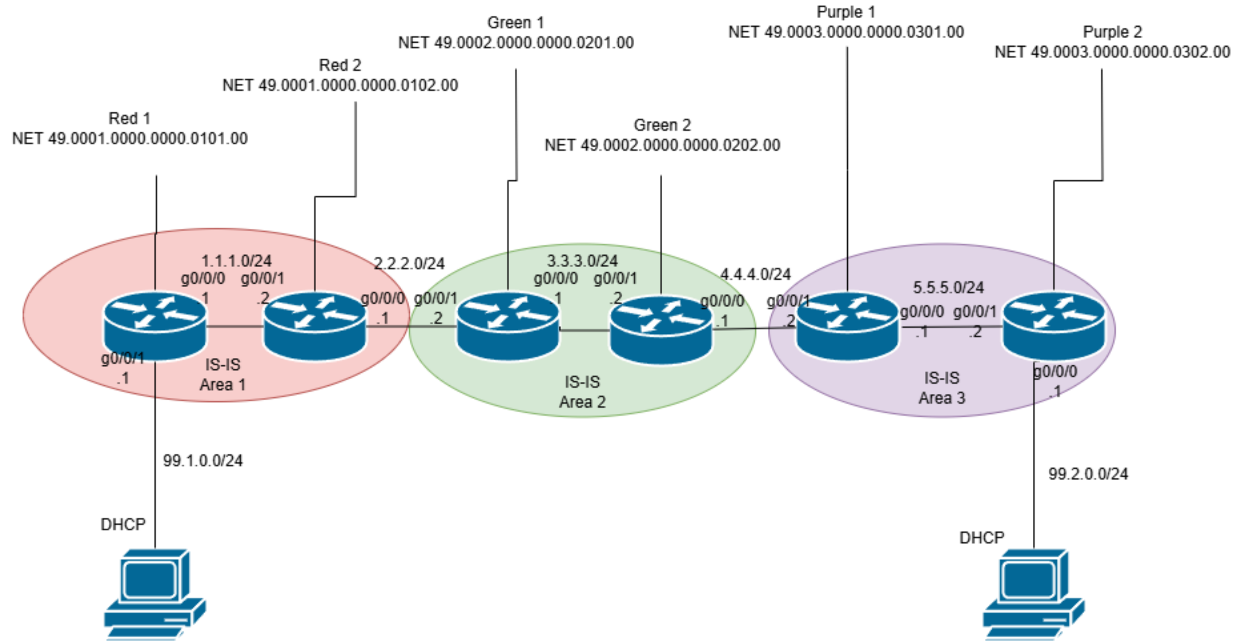
```
Router(config): router isis <area-tag>
```

Enters IS-IS configuration mode with the specified area tag.

```
Router(config-router): metric-style wide
```

Configures IS-IS to use a 32-bit metric field instead of the default “narrow” 10-bit field.
`Router(config-router): net 49.0001.1111.2222.3333.00`
Configures an IS-IS NET (Network Entity Title) with an AFI of `49` (used for private networks), and Area ID of `0001`, a System ID of `1111.2222.3333`, and an N-Selector of `00`.
`Router(config-router): is-type [level-1 | level-1-2 | level-2-only]`
Configures the router to route in Level 1 and/or Level 2. Cisco routers default to routing on both levels.

Network Diagram



Configurations

Red-1:

```
version 16.9
service timestamps debug datetime msec
service timestamps log datetime msec
platform qfp utilization monitor load 80
platform punt-keepalive disable-kernel-core
hostname Red1
boot-start-marker
boot-end-marker
vrf definition Mgmt-intf
 address-family ipv4
 exit-address-family
 address-family ipv6
 exit-address-family
no aaa new-model
ip dhcp pool POOL1
 network 99.1.0.0 255.255.255.0
 default-router 99.1.0.1
login on-success log
subscriber templating
vtp domain cisco
```

```
vtp mode transparent
multilink bundle-name authenticated
license udi pid ISR4321/K9 sn FLM240608PJ
no license smart enable
diagnostic bootup level minimal
spanning-tree extend system-id
redundancy
 mode none
interface GigabitEthernet0/0/0
 ip address 1.1.1.1 255.255.255.0
 ip router isis
 negotiation auto
interface GigabitEthernet0/0/1
 ip address 99.1.0.1 255.255.255.0
 ip router isis
 negotiation auto
interface Serial0/1/0
 no ip address
 shutdown
interface Serial0/1/1
 no ip address
 shutdown
interface GigabitEthernet0/2/0
 no ip address
 shutdown
 negotiation auto
interface GigabitEthernet0/2/1
 no ip address
 shutdown
 negotiation auto
interface GigabitEthernet0
 vrf forwarding Mgmt-intf
 no ip address
 shutdown
 negotiation auto
router isis
 net 49.0001.0000.0000.0101.00
 is-type level-1
 metric-style wide
ip forward-protocol nd
ip http server
ip http authentication local
ip http secure-server
ip tftp source-interface GigabitEthernet0
control-plane
line con 0
 transport input none
 stopbits 1
line aux 0
 stopbits 1
line vty 0 4
 login
```

```
end
```

Red 2:

```
version 16.9
service timestamps debug datetime msec
service timestamps log datetime msec
platform qfp utilization monitor load 80
platform punt-keepalive disable-kernel-core
hostname Red2
boot-start-marker
boot-end-marker
vrf definition Mgmt-intf
 address-family ipv4
 exit-address-family
 address-family ipv6
 exit-address-family
no aaa new-model
login on-success log
subscriber templating
vtp domain cisco
vtp mode transparent
multilink bundle-name authenticated
license udi pid ISR4321/K9 sn FLM2406090M
no license smart enable
diagnostic bootup level minimal
spanning-tree extend system-id
redundancy
 mode none
interface GigabitEthernet0/0/0
 ip address 2.2.2.1 255.255.255.0
 ip router isis
 negotiation auto
interface GigabitEthernet0/0/1
 ip address 1.1.1.2 255.255.255.0
 ip router isis
 negotiation auto
interface Serial0/1/0
interface Serial0/1/1
interface GigabitEthernet0
 vrf forwarding Mgmt-intf
 no ip address
 shutdown
 negotiation auto
router isis
 net 49.0001.0000.0000.0102.00
 metric-style wide
ip forward-protocol nd
ip http server
ip http authentication local
ip http secure-server
ip tftp source-interface GigabitEthernet0
control-plane
```

```
line con 0
 transport input none
 stopbits 1
line aux 0
 stopbits 1
line vty 0 4
 login
end
```

Green 1:

```
version 16.9
service timestamps debug datetime msec
service timestamps log datetime msec
platform qfp utilization monitor load 80
platform punt-keepalive disable-kernel-core
hostname Green1
boot-start-marker
boot-end-marker
vrf definition Mgmt-intf
 address-family ipv4
 exit-address-family
 address-family ipv6
 exit-address-family
no aaa new-model
login on-success log
subscriber templating
vtp domain cisco
vtp mode transparent
multilink bundle-name authenticated
license udi pid ISR4321/K9 sn FLM240608H7
no license smart enable
diagnostic bootup level minimal
spanning-tree extend system-id
redundancy
 mode none
interface GigabitEthernet0/0/0
 ip address 3.3.3.1 255.255.255.0
 ip router isis
 negotiation auto
interface GigabitEthernet0/0/1
 ip address 2.2.2.2 255.255.255.0
 ip router isis
 negotiation auto
interface Serial0/1/0
 no ip address
 shutdown
interface Serial0/1/1
 no ip address
 shutdown
interface GigabitEthernet0
 vrf forwarding Mgmt-intf
 no ip address
```

```
 shutdown
 negotiation auto
router isis
 net 49.0002.0000.0000.0201.00
 is-type level-2-only
 metric-style wide
ip forward-protocol nd
ip http server
ip http authentication local
ip http secure-server
ip tftp source-interface GigabitEthernet0
control-plane
line con 0
 transport input none
 stopbits 1
line aux 0
 stopbits 1
line vty 0 4
 login
end
```

Green 2:

```
version 16.9
service timestamps debug datetime msec
service timestamps log datetime msec
platform qfp utilization monitor load 80
platform punt-keepalive disable-kernel-core
hostname Green2
boot-start-marker
boot-end-marker
vrf definition Mgmt-intf
 address-family ipv4
 exit-address-family
 address-family ipv6
 exit-address-family
no aaa new-model
login on-success log
subscriber templating
vtp domain cisco
vtp mode transparent
multilink bundle-name authenticated
license udi pid ISR4321/K9 sn FDO21482HZX
license boot level appxk9
no license smart enable
diagnostic bootup level minimal
spanning-tree extend system-id
redundancy
 mode none
interface GigabitEthernet0/0/0
 ip address 4.4.4.1 255.255.255.0
 ip router isis
 negotiation auto
```

```
interface GigabitEthernet0/0/1
 ip address 3.3.3.2 255.255.255.0
 ip router isis
 negotiation auto
interface Serial0/1/0
 no ip address
 shutdown
interface Serial0/1/1
 no ip address
 shutdown
interface GigabitEthernet0
 vrf forwarding Mgmt-intf
 no ip address
 shutdown
 negotiation auto
router isis
 net 49.0002.0000.0000.0202.00
 is-type level-2-only
 metric-style wide
ip forward-protocol nd
ip http server
ip http authentication local
ip http secure-server
ip tftp source-interface GigabitEthernet0
control-plane
line con 0
 transport input none
 stopbits 1
line aux 0
 stopbits 1
line vty 0 4
 login
end
```

Purple 1:

```
version 16.9
service timestamps debug datetime msec
service timestamps log datetime msec
platform qfp utilization monitor load 80
platform punt-keepalive disable-kernel-core
hostname Purple1
boot-start-marker
boot-end-marker
vrf definition Mgmt-intf
 address-family ipv4
 exit-address-family
 address-family ipv6
 exit-address-family
no aaa new-model
login on-success log
subscriber templating
vtp domain cisco
```

```
vtp mode transparent
multilink bundle-name authenticated
license udi pid ISR4321/K9 sn FDO21482DWJ
license boot level appxk9
no license smart enable
diagnostic bootup level minimal
spanning-tree extend system-id
redundancy
 mode none
interface GigabitEthernet0/0/0
 ip address 5.5.5.1 255.255.255.0
 ip router isis
 negotiation auto
interface GigabitEthernet0/0/1
 ip address 4.4.4.2 255.255.255.0
 ip router isis
 negotiation auto
interface Serial0/1/0
 no ip address
 shutdown
interface Serial0/1/1
 no ip address
 shutdown
interface GigabitEthernet0
 vrf forwarding Mgmt-intf
 no ip address
 shutdown
 negotiation auto
router isis
 net 49.0003.0000.0000.0301.00
 metric-style wide
ip forward-protocol nd
ip http server
ip http authentication local
ip http secure-server
ip tftp source-interface GigabitEthernet0
control-plane
line con 0
 transport input none
 stopbits 1
line aux 0
 stopbits 1
line vty 0 4
 login
end
```

Purple 2:

```
version 16.9
service timestamps debug datetime msec
service timestamps log datetime msec
platform qfp utilization monitor load 80
platform punt-keepalive disable-kernel-core
```

```
hostname Purple2
boot-start-marker
boot-end-marker
vrf definition Mgmt-intf
 address-family ipv4
 exit-address-family
 address-family ipv6
 exit-address-family
no aaa new-model
ip dhcp pool POOL2
 network 99.2.0.0 255.255.255.0
 default-router 99.2.0.1
login on-success log
subscriber templating
vtp domain cisco
vtp mode transparent
multilink bundle-name authenticated
license udi pid ISR4321/K9 sn FDO214414VU
no license smart enable
diagnostic bootup level minimal
spanning-tree extend system-id
redundancy
 mode none
interface GigabitEthernet0/0/0
 ip address 99.2.0.1 255.255.255.0
 ip router isis
 negotiation auto
interface GigabitEthernet0/0/1
 ip address 5.5.5.2 255.255.255.0
 ip router isis
 negotiation auto
interface Serial0/1/0
 no ip address
 shutdown
interface Serial0/1/1
 no ip address
 shutdown
interface GigabitEthernet0/2/0
 no ip address
 shutdown
 negotiation auto
interface GigabitEthernet0/2/1
 no ip address
 shutdown
 negotiation auto
interface GigabitEthernet0
 vrf forwarding Mgmt-intf
 no ip address
 shutdown
 negotiation auto
router isis
 net 49.0003.0000.0000.0302.00
```

```
 is-type level-1
 metric-style wide
ip forward-protocol nd
ip http server
ip http authentication local
ip http secure-server
ip tftp source-interface GigabitEthernet0
control-plane
line con 0
 transport input none
 stopbits 1
line aux 0
 stopbits 1
line vty 0 4
 login
end
```

Problems

We originally confused IS-IS areas with IS-IS area tags and configured three separate area tags throughout the network. As IS-IS area tags work like OSPF process IDs and don't share network information between each other, this resulted in the failure of the network. We fixed this by instead assigning the router's area as part of its NET.

Conclusion

To wrap up, I now have a much greater understanding of the IS-IS routing protocol and its inticracies, including how NETs work and how both layers of IS-IS route and communicate with each other across areas. I am now confident that I could use this routing protocol in an enterprise environment to route using complex topologies.

Signoff