Routing Protocol - IS-IS

What is IS-IS ?

- Intermediate System to Intermediate System intra-domain routing protocol :: IS, ES

- Is a Link State Protocol

- Is a dynamic routing protocol based on SPF routing algorithm

- IS is "OSI speak" for router (i.e., routing protocol for the ISO Connectionless Network Protocol)

- Is an IGP (Interior Gateway Protocol) scalable only for dynamic routing within a domain

- Supports a 2-level hierarchy : level-1 (areas) and level-2 (backbone)

- Integrated IS-IS, also known as Dual IS-IS, was to provide a single routing protocol with the capabilities of routing both Connectionless Network Service (CLNS) and IP

OSPF and IS-IS in Common

- They both maintain a link state database from which a Dijkstra-based SPF algorithm computes a shortest-path tree
- They both use Hello packets to form and maintain adjacencies
- They both use areas to form a two-level hierarchical topology
- They both have the capability of providing address summarization between areas
- They both are classless protocols (support VLSM)
- They both elect a designated router to represent on broadcast networks

Hierarchy of IS-IS : L1 Routers

- OSI IS-IS routing makes use of two-level hierarchical routing :
  The backbone is called level 2 (L2) and areas are called level 1 (L1)
- Intra-area routing
- Neighbors only in the same area
- A routing domain is partitioned into areas and L1 routers have information about their own area
- Can not know the identity of routers or destinations outside of their area
- Level 1-only routers look at the attached-bit in level 1 LSPs to find the closest L1/L2 router in the area
- Use the closest L1/L2 router to exit the area

Hierarchy of IS-IS : L2 Routers

- Inter-area routing

- May have neighbors in other areas

- Know the level 2 topology

- Know which addresses are reachable via each level 2 router

- Do not need to know the topology within any level 1 area, except to the extent that a level 2 router may also be a level 1 router within a single area (called L1/L2 routers and it has L1 and L2 LSDBs)

- Can exchange data packets or routing information directly with external routers located outside of the its area

Hierarchy of IS-IS : L1, L2 Routers
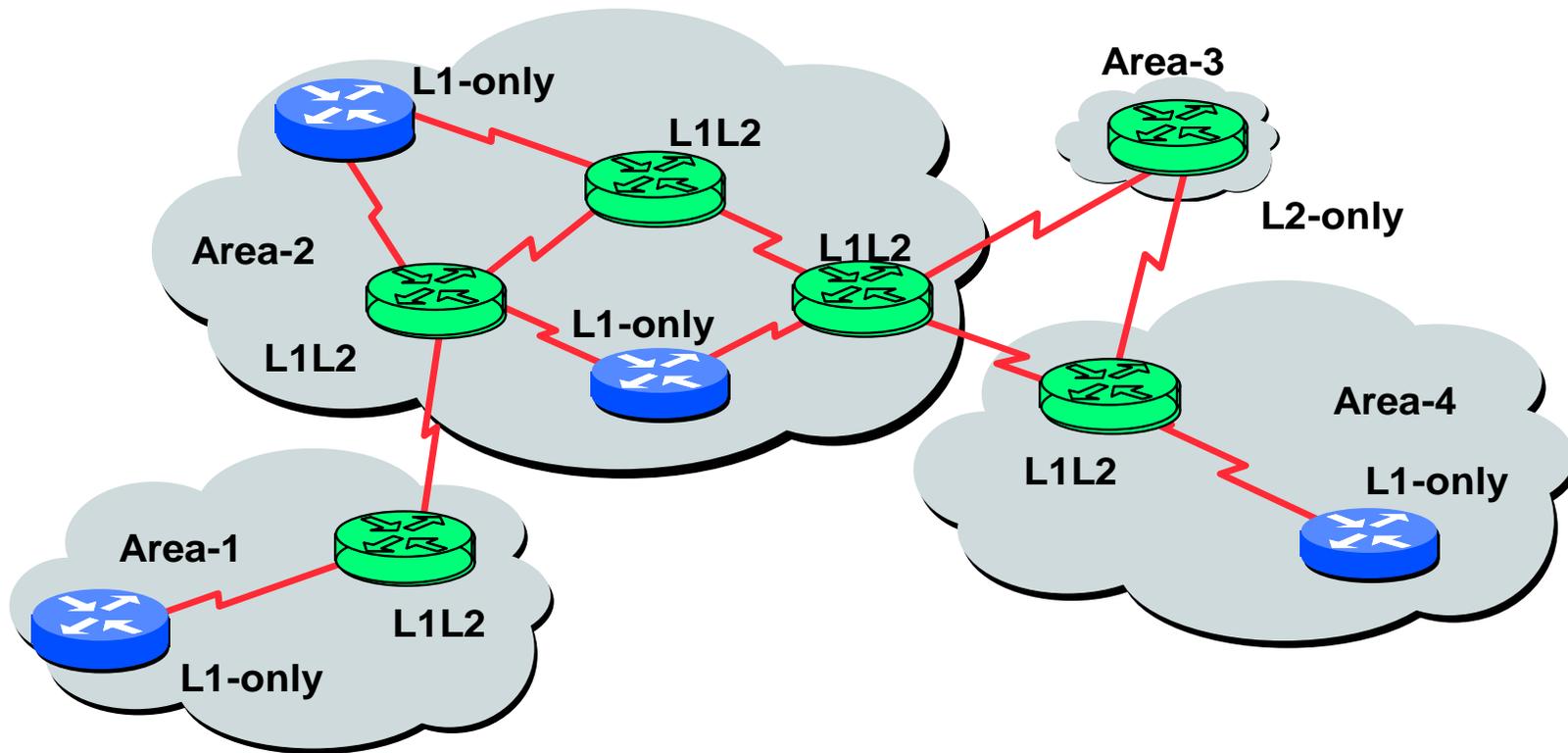
< Level-1, Level-2, & Level-1-2 Routers >

Integrated IS-IS vs. OSPF: area design

OSPF
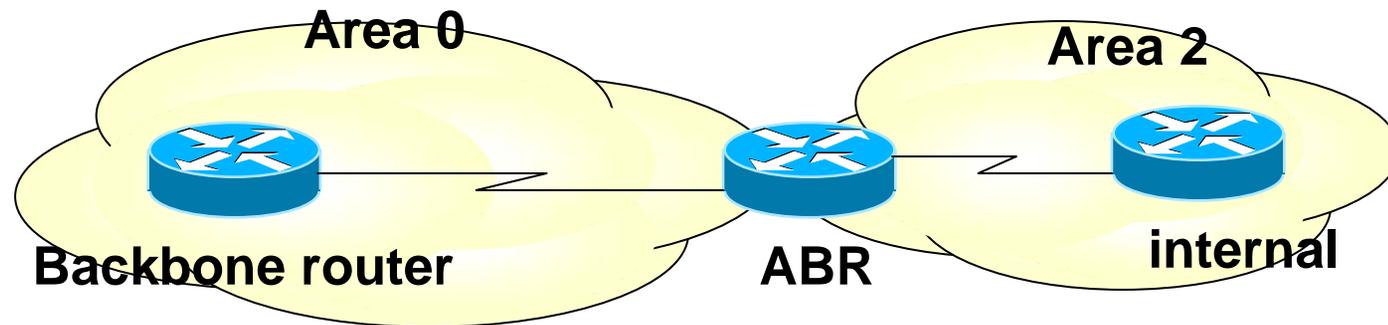
- The border is inside routers (ABRs)
- Each link belongs to one area

Integrated IS-IS vs. OSPF: area design

IS-IS

Area 49.0000   **Area 49.0002**

L1   **L1/L2**   **L1/L2**
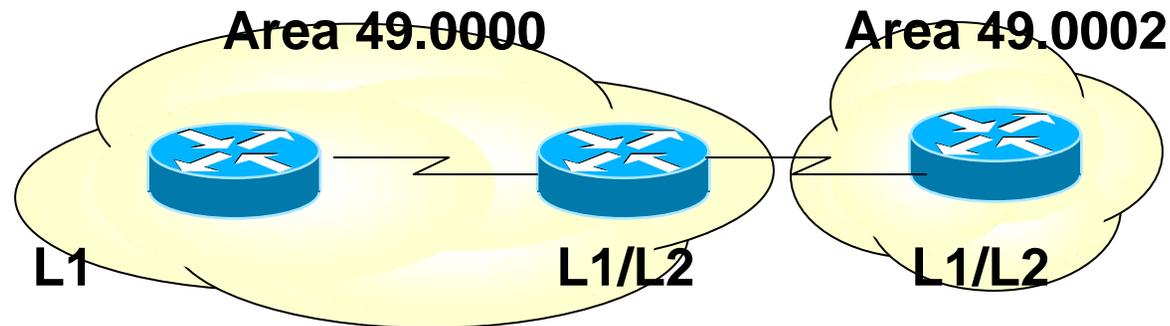
- Each IS-IS router belongs to exactly one area.
- IS-IS is more flexible when extending the backbone.

OSPF Areas
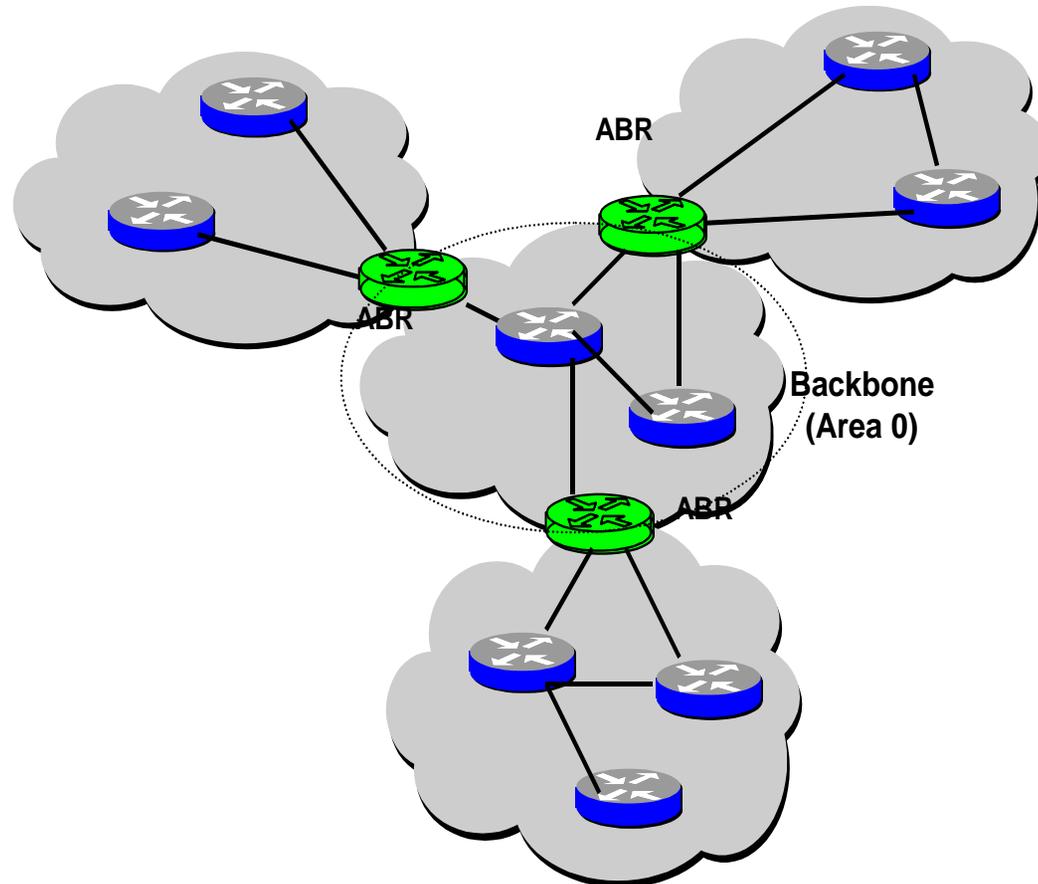
< OSPF Area Borders >

IS-IS Areas
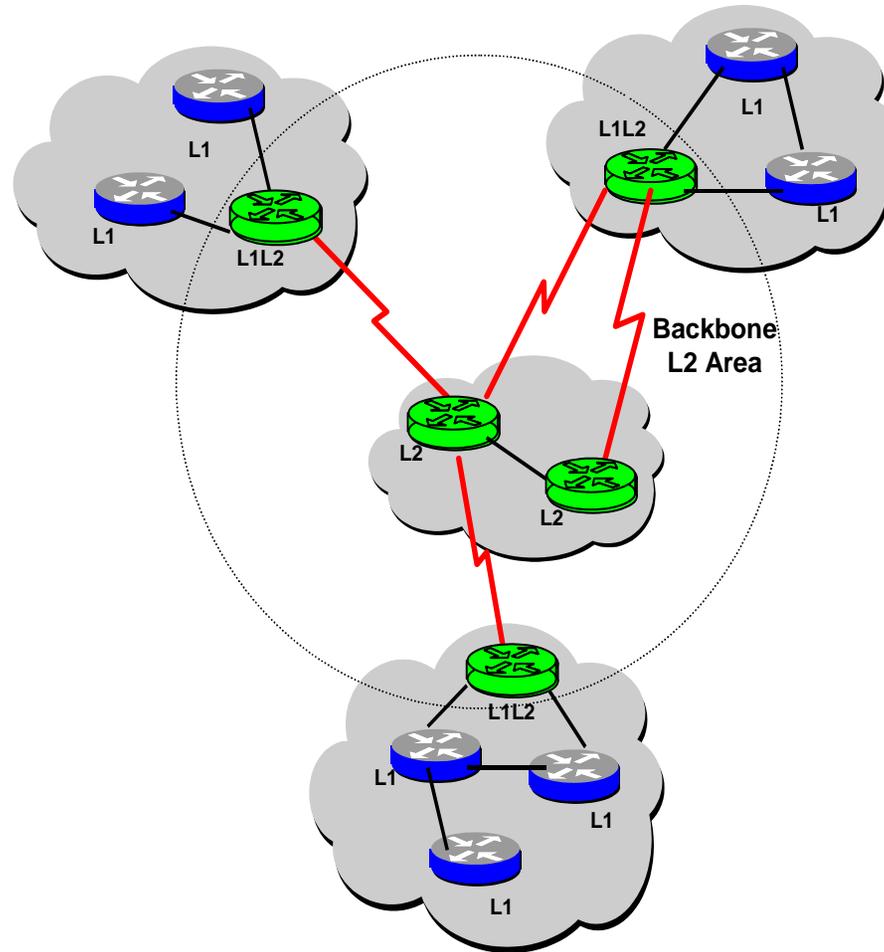
< IS-IS Area >

IS-IS Areas(cont.)

- Area borders are on links, not on routers
- All the routers are completely within an area
- Routers that connect areas are Level 2 routers, and routers that have no direct connectivity to another area are Level 1 routers
- L1 routers are analogous to OSPF nonbackbone internal routers, and L2 routers are analogous to OSPF backbone routers, and L1L2 routers are analogous to OSPF ABRs
- L1L2 routers must maintain both a level 1 link state database and a level 2 link state database
- L1L2 routers do not advertise L2 routes to L1 routers, so L1 routers have no knowledge of destinations outside of its own area. Therefore, L1 routers are similar to routers in an OSPF totally stubby area
- L1L2 routers maintaining separate level 1 and level 2 link state databases will calculate separate SPF trees for the level 1 and level 2 topology

CLNS Addressing

- OSI network-layer addressing is implemented with NSAP addresses.

- The NSAP address identifies any system in the OSI network.

- Various NSAP format are used in various system, as different protocols may use different representations of NSAP.

NSAPs (Network Service Access Points) and Addressing

IDP		DSP		
AFI	IDI	High Order DSP	System ID	NSEL

Variable length area address — 6 bytes — 1 byte

IPD : Initial Domain Part
DSP : Domain Specific Part
AFI : Authority and Format Identifier
NSAP : Network Service Access Point
NSEL : NSAP Selector

Three field in the NSAP

❑**area address : variable-length field (1 – 13 octets)**

❑**System id: ES or IS identifier in an area**

❑NSEL: service identifier

❑CLNS Addressing

Ex) 47.0001.aaaa.bbbb.cccc.00

Area = 47.0001, SysID = aaaa.bbbb.cccc, Nsel = 00

NSAPs (Network Service Access Points) and Addressing

- NET format

49.0007.0000.3090.c7df.00

Area ID = 49.0007, System ID = 0000.3090.c7df, SEL = 00

SEL = 0x00 : the address is a NET, otherwise the address is an NSAP address

Area ID (Area Address)	System ID	NSEL

Used by
level 2 routing

Used by
level 1 routing

similar to OSPF
router ID
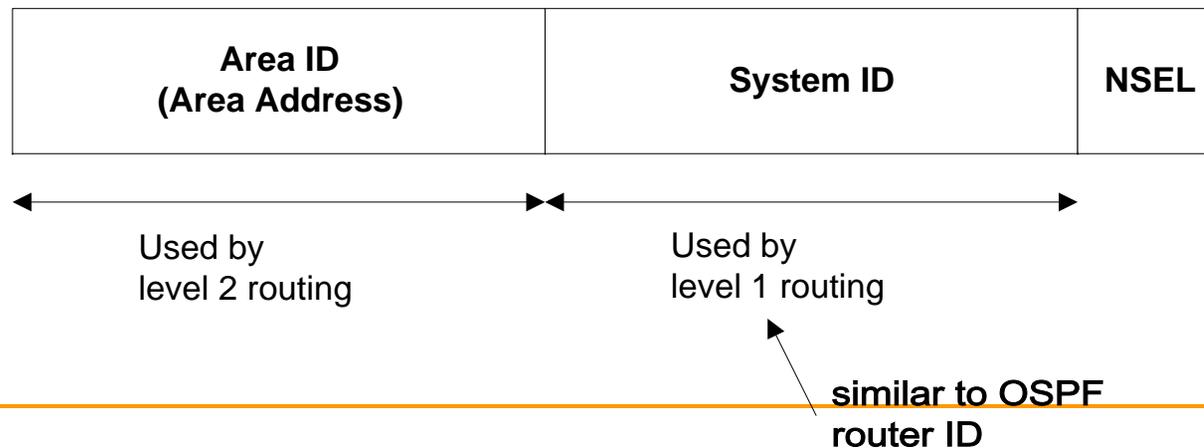
NSAPs (Network Service Access Points) and Addressing

- NSAP is the network layer address for CLNS (Connectionless Network Service) packets

- An NSAP consists of 3 parts, <u>area address</u>, <u>system ID</u>, and <u>n-selector</u>

- All routers in an area must use the same area address

- Each node in an area must have a unique systemID

- All L2 routers in a domain must each have a unique systemID

- Area address is like OSPF area number

- System ID is like an OSPF router ID

NSAPs (Network Service Access Points) and Addressing(cont.)

- System ID is 6 bytes and can use MAC address
- System ID converts your loopback IP address
  192.31.231.16 → 192.031.231.016 → system ID 1920.3123.1016
- NSEL identifies a network service user (transport entity or the IS network entity itself)
- A NET (Network Entity Title) is an NSAP with n-selector 0 (1 byte)
- A NET implies the routing layer of the IS itself (no transport layer)
- If you do just IP routing, use AFI 49. AFI 49 denotes private address space and just number your areas 49.0001…, 49.0002…, 49.0003…, etc

ISIS routing logic

- L1 router: for a destination address, compare the area ID to this area.

    - If not equal, pass to nearest L1/L2 router.
    - If equal, use L1 database to route by system ID

- L1/L2 router: for a destination address, compare the area ID to this area.

    - If not equal, use L2 database to route by area ID
    - If equal, use L1 database to route by system ID

example

Area-3

L1-only

L1L2 R4

R5

L1L2

L2-only

Area-2

L1-only

R6

L1L2 R3

Area-4

L1L2

L1-only

49.00BB.1111.11111.2222.00

R7

Area-1

R2

L1L2

49.00CC.1111.11111.3333.00

R1 L1-only
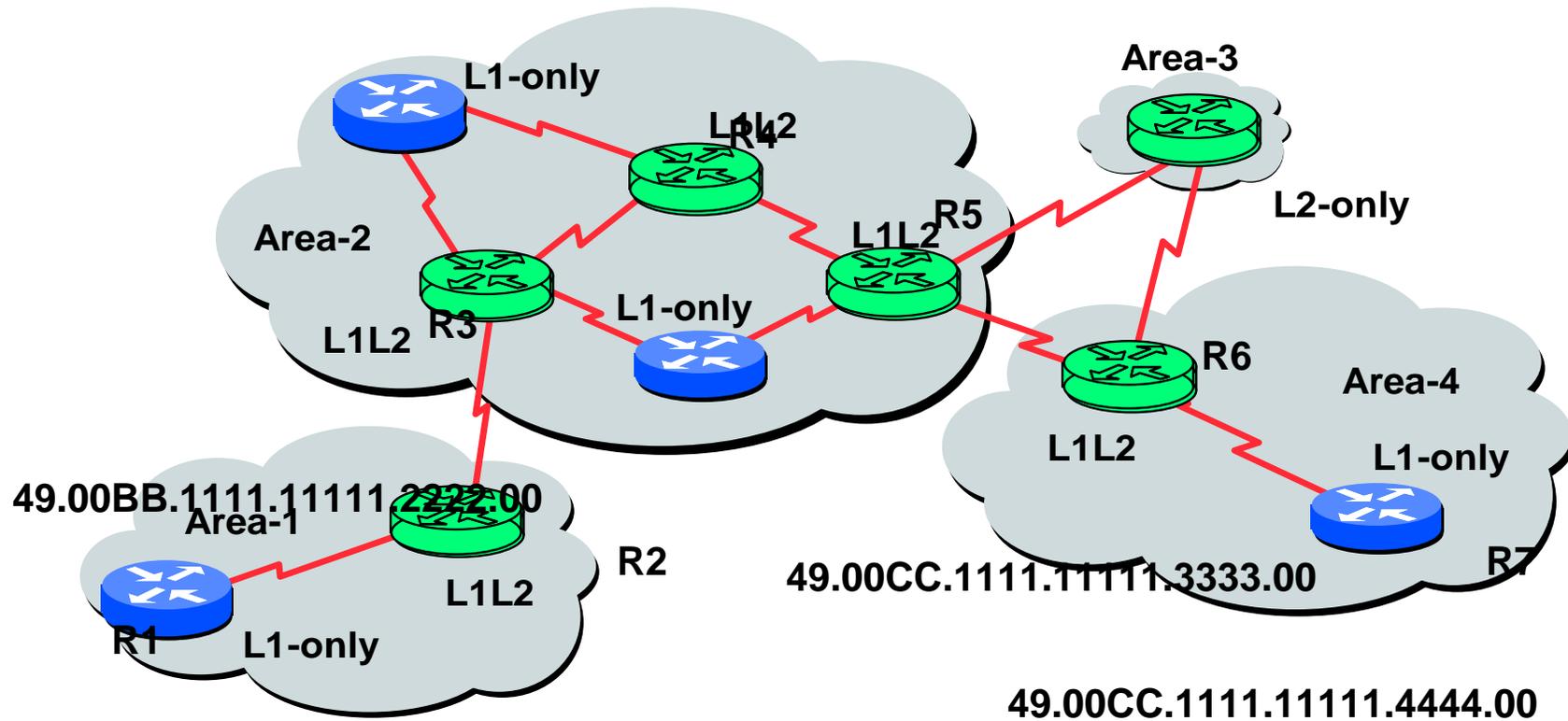
49.00CC.1111.11111.4444.00

< Level-1, Level-2, & Level-1-2 Routers >

49.00BB.1111.11111.1111.00

Types of IS-IS Packets

- IS-IS Hello Packets
  - Used for maintaining adjacencies
  - Sends hello packet every 10 sec, dead interval time is 30 sec
    - ESH
    - ISH
    - IIH
- Link State Packets
  - Called LSPs
  - Contains all information about one router, such as connected IP prefixes, area addresses, etc
  - One LSP per router
- PSNP
  - reqeusting and confirming the link state information.
- CSNP
  - when distribute the compled link state database

IS-IS Operation

- Send Hellos and build adjacencies
- Create an LSP and flood it to neighbors
- Receive all LSPs from neighbors
- Run the SPF algorithm to calculate topology
- Run PRC (Partial Route Calculation) to calculate IP routing info.
- Newly received LSPs trigger SPF and/or PRC calculations

Flooding on a Point-to-Point Link

- Once the adjacency is established, both IS send CSNP

- Missing LSPs are sent by both ISs if not present in the received CSNP(Complete Sequence Number Packet)

- Missing LSPs may be requested through PSNP (Partial Sequence Number Packet)

- LSPs hold for a Remaining Lifetime

- Periodic refresh : ISs resend their LSP at least every 15 minutes

Flooding on a LAN

- On LANs only, there's a Designated Router (DIS)
- DIS has two tasks :
  - Creating and updating the pseudonode LSP
  - Conducting the flooding over the LAN
- DIS is elected for each LAN
- DIS election is based on priority
- When priority is tied, the highest SNPA (MAC address) will be a DIS

Flooding on a LAN(cont.)

- DIS multicasts a full list of LSP descriptions (CSNPs)
- All IS in the LAN check the CSNP against their own LSDB (and may ask specific retransmission with PSNPs)
- No Backup DIS in IS-IS

Strong Points of IS-IS over OSPF

- Scalability
  - Backbone is not an area, but the contiguous collection of ABRs
- Fast-Convergence
  - IS-IS uses less packet types to propagate routing information
- Easy-Troubleshooting
  - All the prefixes are in single LSA packet. This helps tracing all routing
  - information announced by a particular router
- Less Resource Usage
  - IS-IS databases contain one LSP per router in the routing domain

IS-IS Protocol Limitations

- Metrics are 6 bits wide (0 to 63) : Default interface metric is 10 unless manually specified

- All areas are stub areas : Might result in sub-optimal routing between areas

- No filtering allowed : All ISs must have the same view of an area. Use of summary-addresses for IP

IS-IS status

- Show clns
  - Information about the CLNS network
- Show clns protocol
  - Lists the protocol-specific information
- Show clns is-neighbor
  - IS-IS neighbors
- Show clns neighbor
  - Both ES and IS information
- Show isis database
  - LSDB
- Show isis topology
  - ISIS least-cost paths to destination

IS-IS command

- Router#*conf t*
- Router(config)#*router isis*   : enable IS-IS
- Router(config-router)#*net* [network entity title]
  ex) Router(config-router)#*net* 49.0401.2101.8302.8174.00
- Router(config-router)#*is-type* [level-1/level-1-2/level-2-only]
- Router(config-router)#*exit*

- Router(config)#*interface* [interface type] [interface number]
- Router(config-if)#*ip router isis*
- Router(config-if)#*isis circuit-type* [level-1/level-1-2/level-2-only]
  : need to repeat for all interfaces that need to run IS-IS

- Router#*show ip route isis*   : check routing table