



Routing II

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Outline

- Intermediate-System to Intermediate-System (IS-IS)
- Border Gateway Protocol (BGP)
- IPv6 Routing



IS-IS

- Intermediate-System to Intermediate-System (IS-IS)
- Integrated IS-IS (Support both TCP/IP and Connectionless Network Protocol: CLNP)
- Link State routing protocol
- Terminology
 - End systems (ES) → Host
 - Intermediate System (IS) → Router



Timeline OSPF and IS-IS

1985	Originated by DEC phase V
1987	IS-IS (from DEC) selected by ANSI as OSI intradomain protocol (CLNP only)
1988	OSPF work begins, loosely based on IS-IS
1989	OSPF v.1 RFC published IS-IS becomes ISO proposed standard
1990-1991	Dual-mode IS-IS RFC published; OSPF v.2 RFC published
1992	Most run OSPF (Very few deploy IS-IS)
1994	Large ISPs need an IGP; IS-IS is recommended
1995	ISPs begin deployment of IS-IS (popular)
1996-1998	many ISPs switch from OSPF to IS-IS
1998-2000	many extensions for both protocols

OSI: Two Network Services, Two Network Protocols

OSI Reference Model	OSI Protocol Suite				
Application	CMIP DS FTAM MHS VTP ASES ACSE ROSE RTSE CCRSE ...				
Presentation	Presentation Service/Presentation Protocol				
Session	Session Service/Session Protocol				
Transport	TP0	TP1	TP2	TP3	TP4
Network	IS-IS	CONP/CMNS		ES-IS	CLNP/CLNS
Data Link	IEEE 802.2	IEEE 802.3	IEEE 802.5/ Token Ring		FDDI X.25
Physical	IEEE 802.3 Hardware	Token Ring Hardware	FDDI Hardware		X.25 Hardware



OSI: Two Network Services, Two Network Protocols

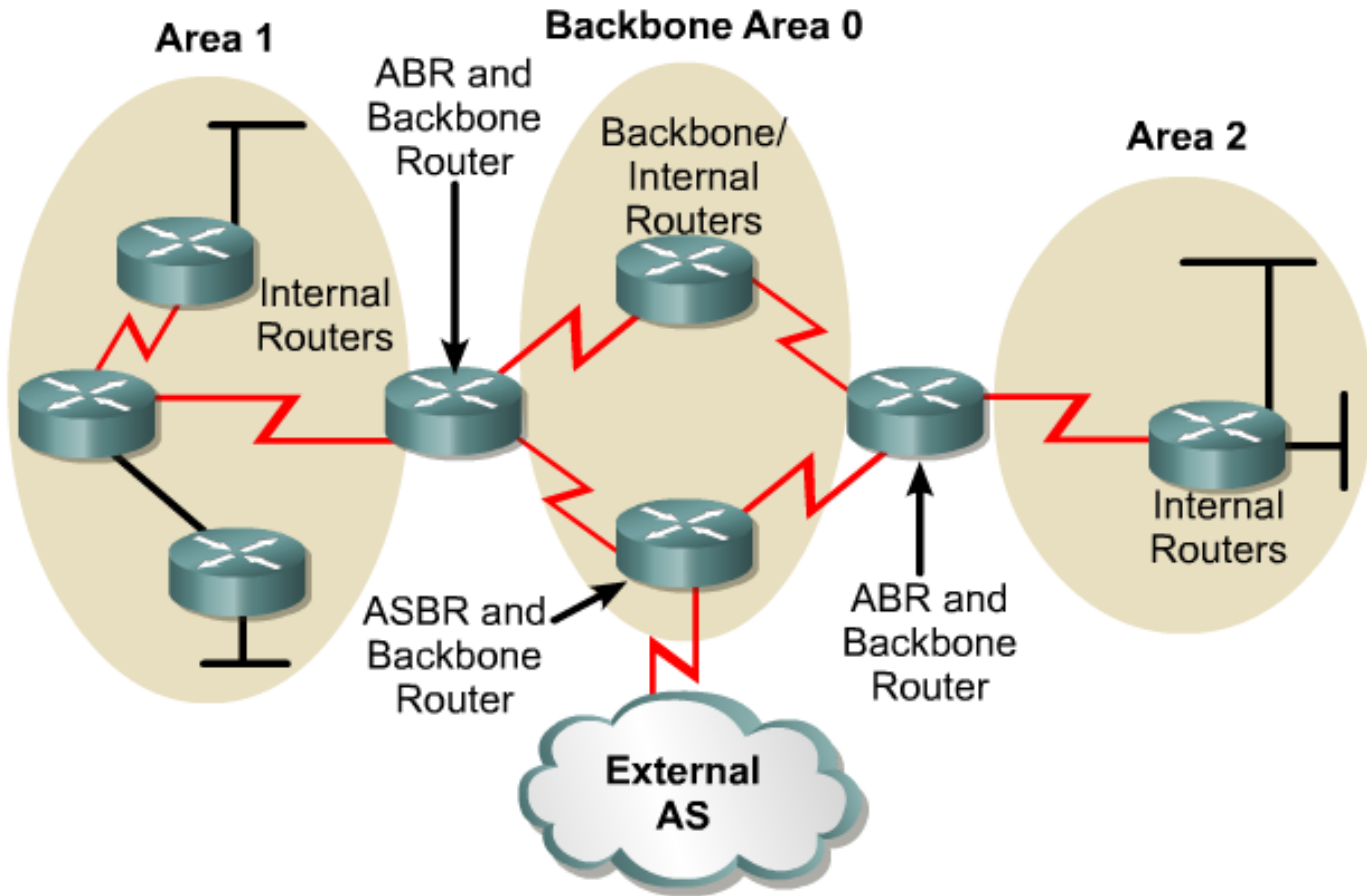
- CMNS (Connection Mode Network Service)
 - Requires establishment of a path @transport layer
 - CONP (Connection-Oriented Network Protocol)
- CLNS (Connectionless Network Service)
 - Datagram support, No circuit establishment
 - CLNP (Connectionless Network Protocol)



IS-IS Routers

- Level 1 IS (L1 IS, router)
 - Analogous to OSPF Internal non-backbone router (Totally Stubby)
 - Responsible for routing to End System (ES) inside an area.
- Level 2 IS (L2 IS, router)
 - Analogous to OSPF Internal Backbone router
 - Responsible for routing between areas
- Level 1 and 2 IS (L1-L2 IS, router)
 - Analogous to OSPF Area Border Router (ABR router)
 - Participate in both L1 intra-area routing and L2 inter-area routing.

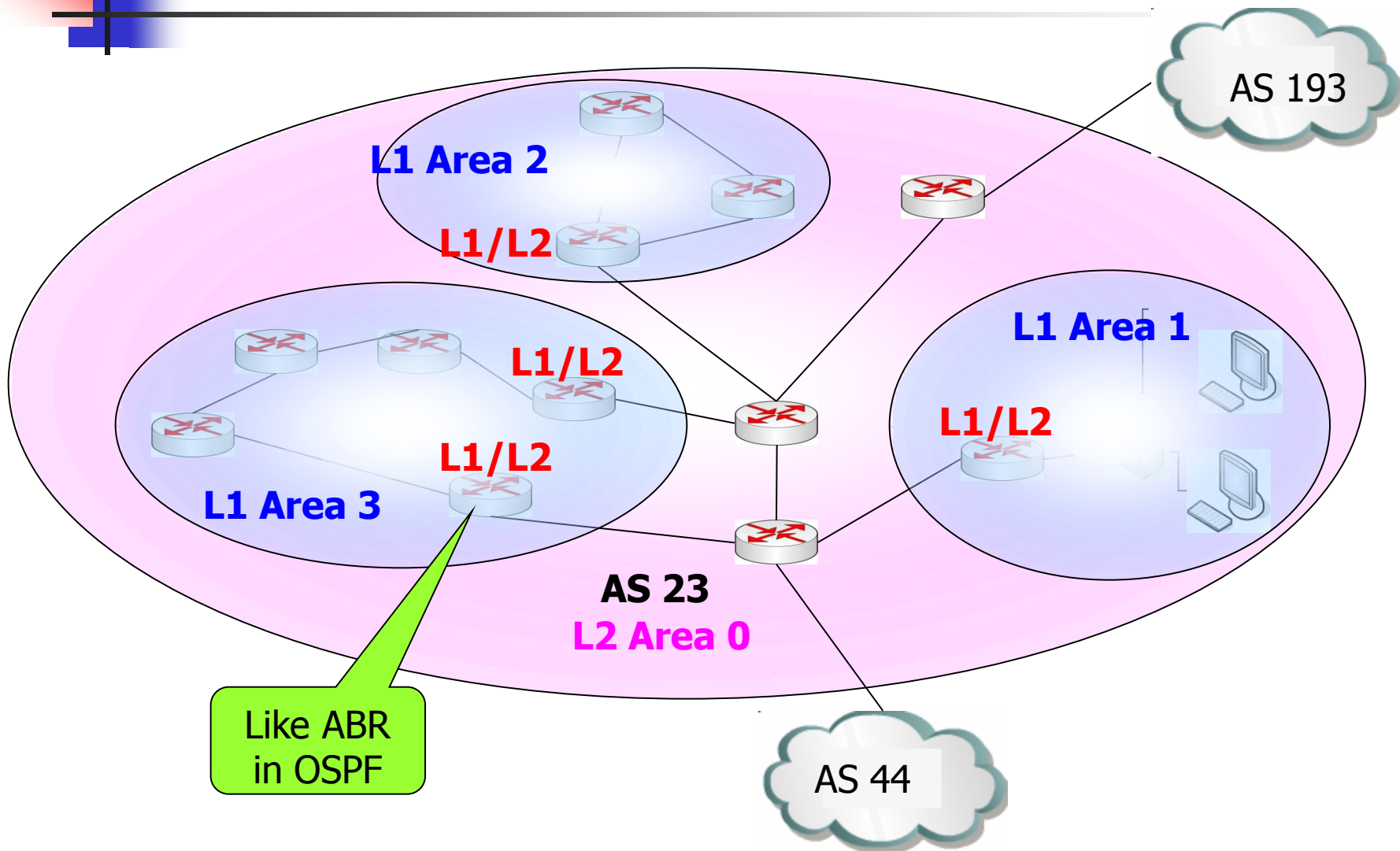
OSPF Area



ABR: Area Border Router

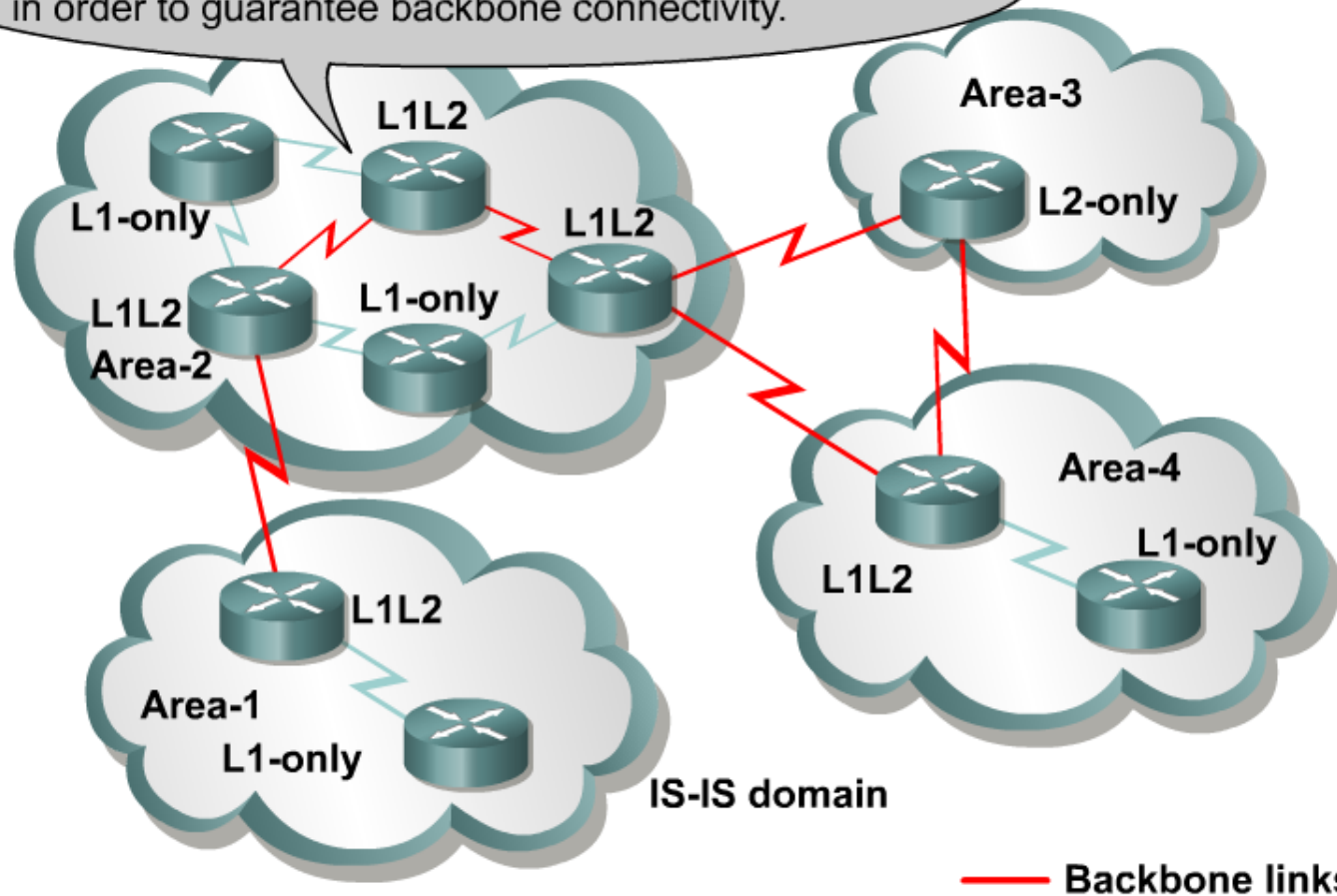
ASBR: Autonomous System Border Router

IS-IS Area



IS-IS Area

This router must behave as an L2 as well as L1 router in order to guarantee backbone connectivity.

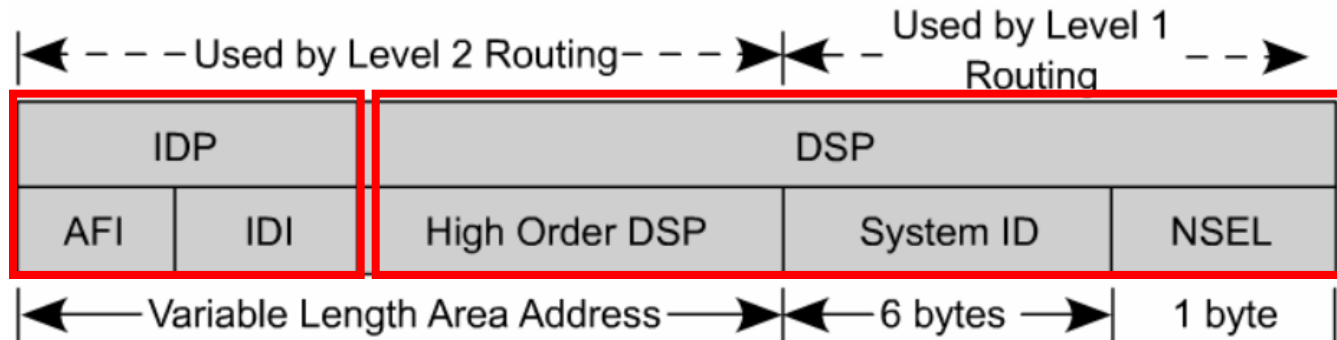




Data Encapsulation & Addressing

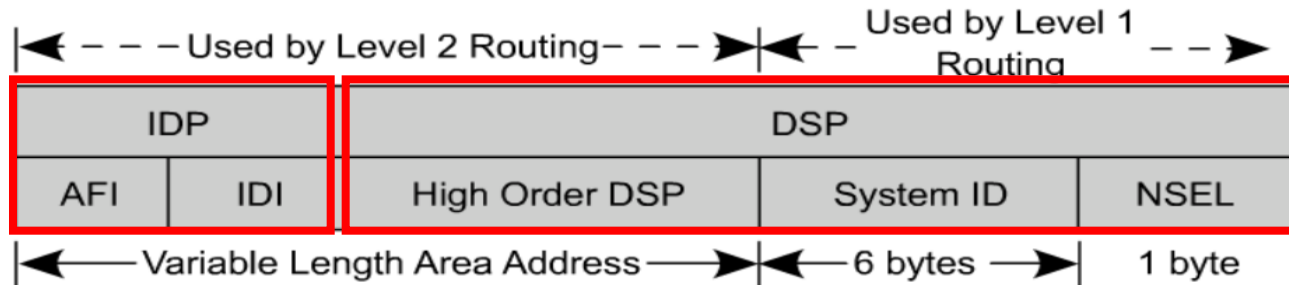
- IS-IS messages are not carried in IP datagrams
- Message called Protocol Data Units (PDU)
- Encapsulated directly in Data Link Layer frames
- SNPA (Subnetwork Point of Attachment)
 - → Data Link Address

IS-IS address format



- Hierarchical Address
 - IDP: Initial Domain Part
 - DSP: Domain Specific Part
- OSI network layer addressing is done through the NSAP (Network Service Access Point)
- Represented in hexadecimal (up to 40 hex digits)

IS-IS address format



Variable Length Add.

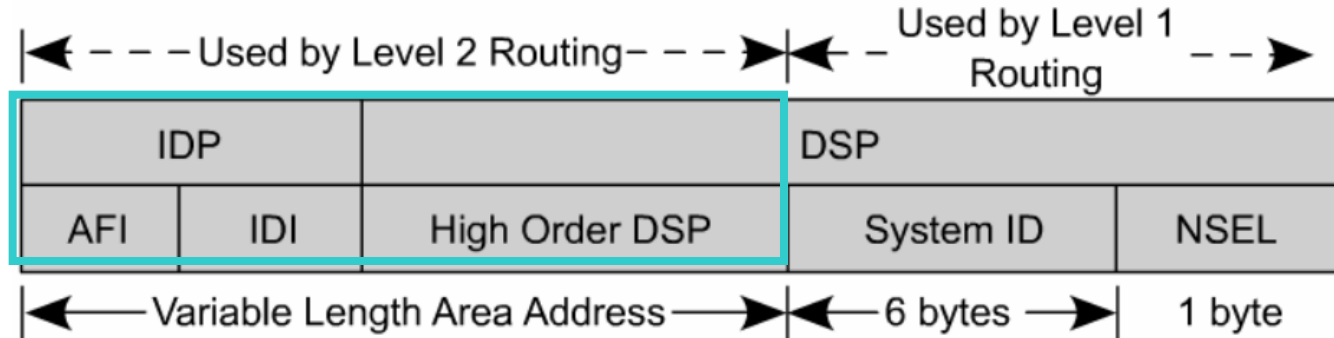
Area System ID SEL
07.000.3090.c7df.00
 (a)

Domain Area System ID SEL
47.0004.30ac.0007.0000.3090.c7df.00
 (b)

AFI ICD DFI AAI Reserved RDI Area System ID SEL
47.0005.80.0000a7.0000.ffdd.0007.0000.3090.c7df.00
 (c)

Cisco format: Area – System ID – NSEL (always 00 on ISs)
 49.0001.2222.2222.2222.00

NSAPs – Cisco Format

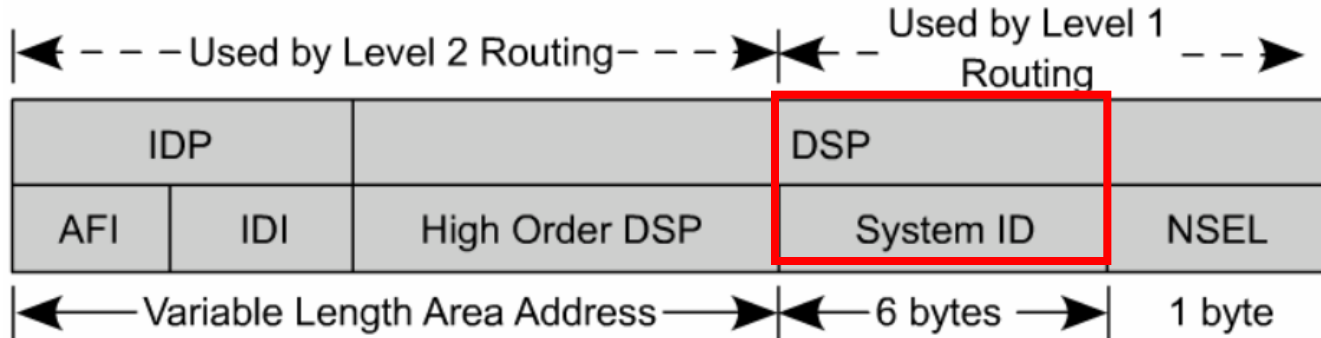


NSAP

Area – System ID – NSEL
49.0001.2222.2222.2222.00

- Area
- Add. starting with 49 (AFI=49) are considered private IP add.
 - Routed by IS-IS
 - Should not be advertised to other CLNS networks (outside this IS-IS domain)
- Additional 2 bytes (HODSP) added for the area ID
- All routers in the same area must have the same area add.

NSAPs – Cisco Format

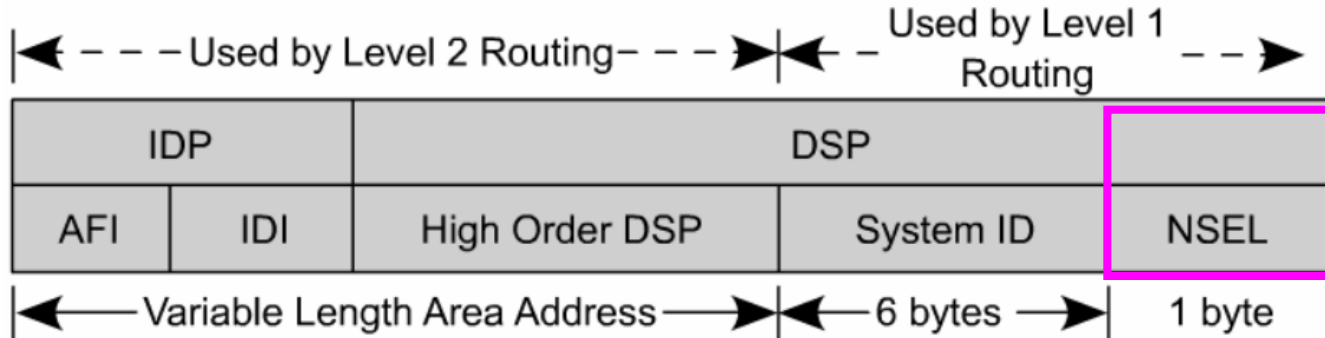


NSAP

Area – System ID – NSEL
49.0001.2222.2222.2222.00

- **System ID**
- Same no. of bytes throughout the domain. Cisco fixes@ 6 bytes.
- Customary can be
 - MAC address from the router
 - IP address of loopback interface
 - 192.168.111.3 -> 192.168.111.003 -> 1921.6811.1003
- Each device (IS and ES) must have a unique System ID within the area.

NSAPs – Cisco Format



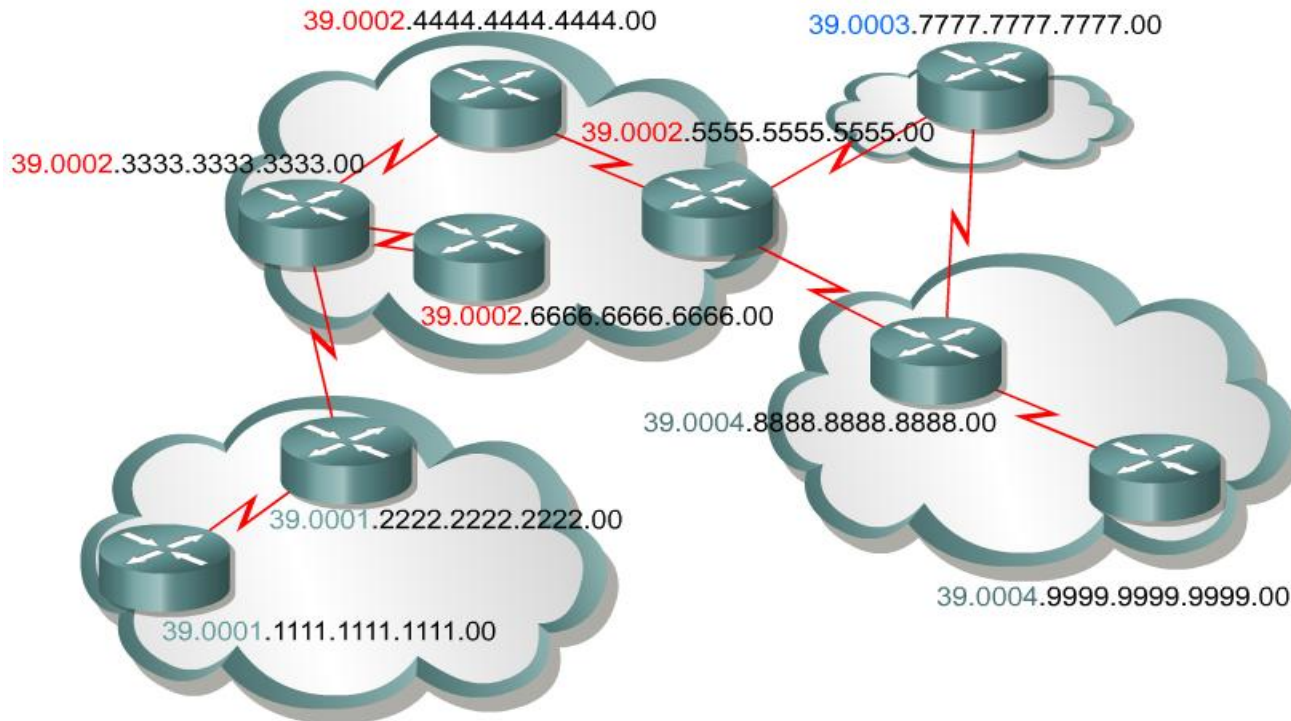
NSAP

Area – System ID – NSEL

49.0001.2222.2222.2222.00

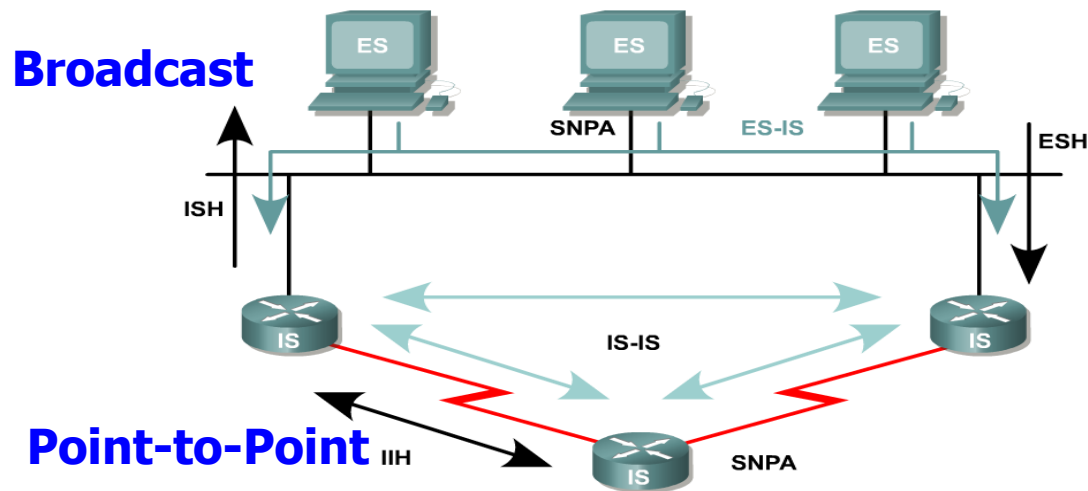
- NSEL (NSAP Selector)
- NSEL is a service identifier like port or socket in TCP/IP.
- Not used in routing decisions.
- NSEL = 00 means the device itself (the network level address)
- The NSAP with a NSEL = 00
 - ▣ is known as a Network Entity Title (NET)

NSAP (NETs)



Example: NSAP **39.0002.aaaa.bbbb.cccc.00**
Area ID is **39.0002**
System ID is **aaaa.bbbb.cccc (4444.4444.4444)**
NSAP selector byte is **00**

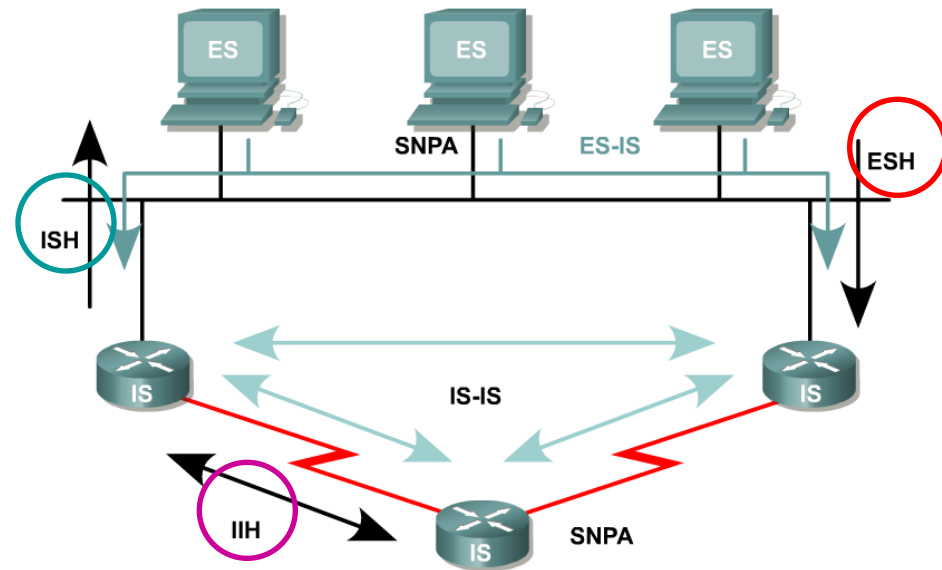
Network Representation



- In OSI, only two main types of physical links:
 - **Broadcast:** usually LANs
 - **Nonbroadcast:** Point-to-Point, Multipoint, and dynamically established links (WAN links)
- Thus, IS-IS supports only
 - **Broadcast** (LAN) and **Point-to-Point** (for all other media)

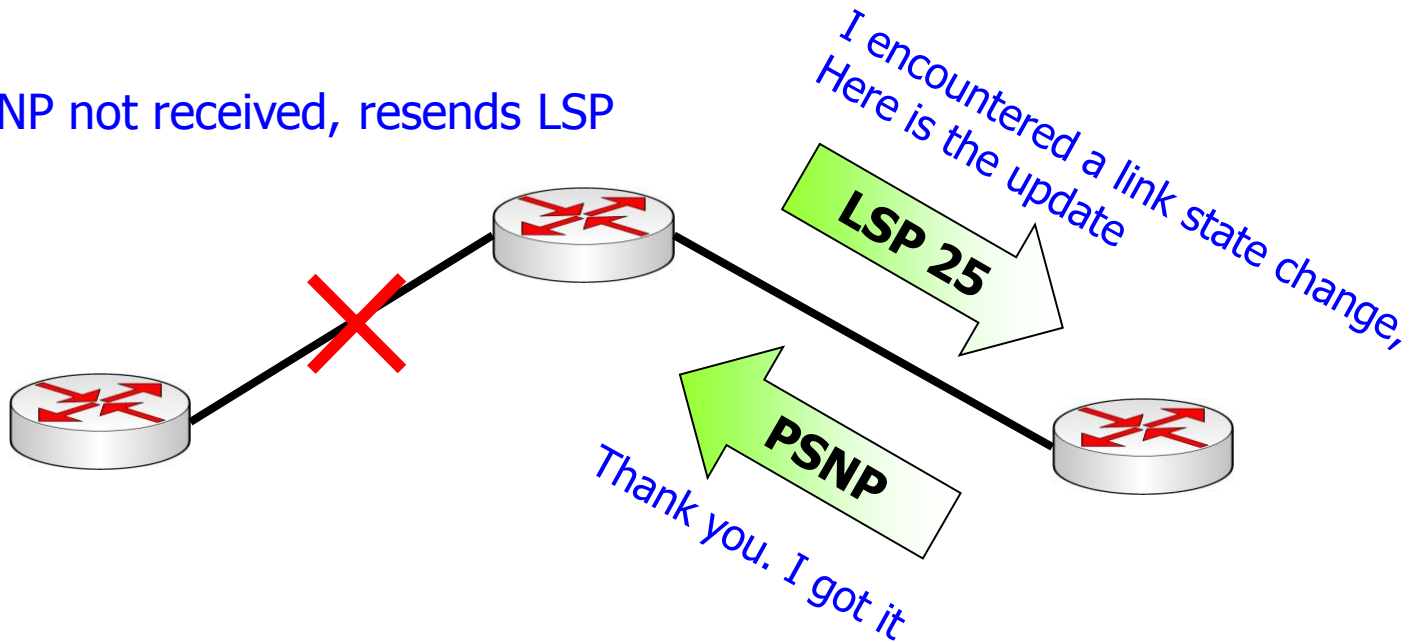
Hello Message

- To establish adjacencies with other routers (ISs) and ESs
 - ▣ Uses Hello PDUs.
- 3-type of Hello PDUs:
 - ▣ ESH, sent by ES to an IS
 - ▣ ISH, sent by IS to an ES
 - ▣ IIH, used between two ISs (normally transmitted every 10 seconds)



Synchronization and Update Process

If PSNP not received, resends LSP



LSP: Link State PDU

PSNP: Partial Sequence Number PDU

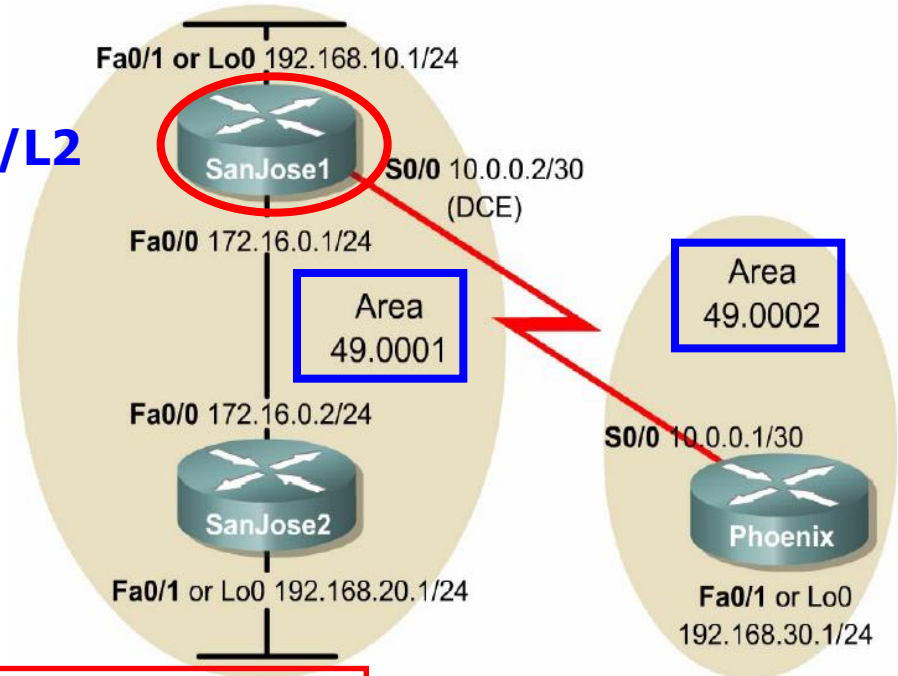


IS-IS Routing Process

- Divided into four stages:
 - Update process
 - Decision -- Uses Dijkstra's algorithm to build a SPT (Shortest Path Tree)
 - Forwarding -- forwarding table
 - Receive

Example: IP route @ SanJose1

L1/L2



```
SanJose1#show ip route
```

```
Gateway of last resort is not set
```

```
i L2 192.168.30.0/24 [115/20] via 10.0.0.1, Serial0/0
```

```
C 192.168.10.0/24 is directly connected, FastEthernet0/1  
172.16.0.0/24 is subnetted, 1 subnets
```

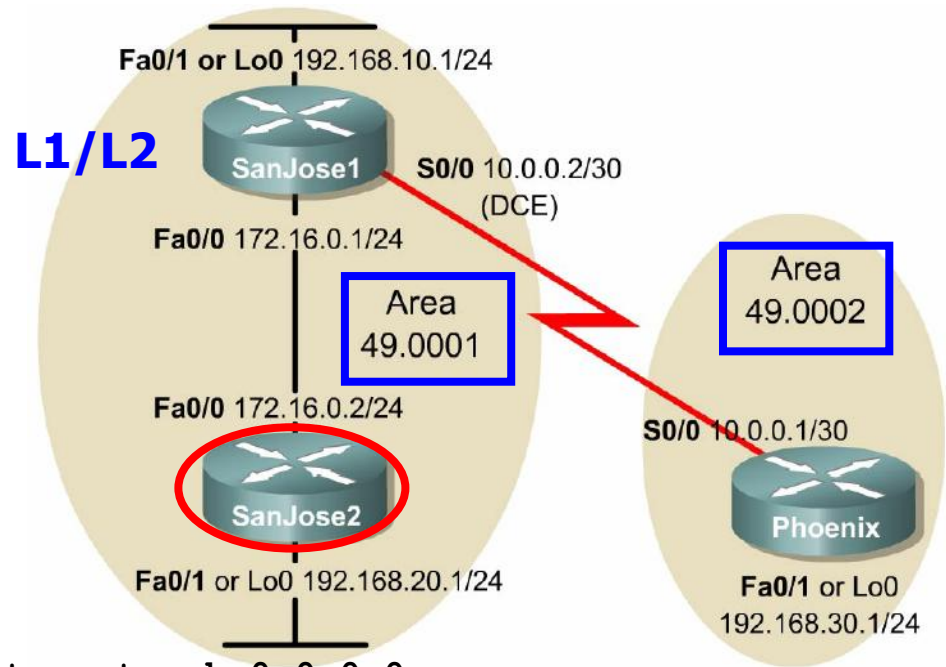
```
C 172.16.0.0 is directly connected, FastEthernet0/0
```

```
i L1 192.168.20.0/24 [115/20] via 172.16.0.2, FastEthernet0/0
```

```
10.0.0.0/30 is subnetted, 1 subnets
```

```
C 10.0.0.0 is directly connected, Serial0/0
```

Example: IP route @ SanJose2



```
SanJose2#show ip route
```

```
Gateway of last resort is 172.16.0.1 to network 0.0.0.0
```

```
i L1 192.168.10.0/24 [115/20] via 172.16.0.1, FastEthernet0/0
```

```
172.16.0.0/24 is subnetted, 1 subnets
```

```
C 172.16.0.0 is directly connected, FastEthernet0/0
```

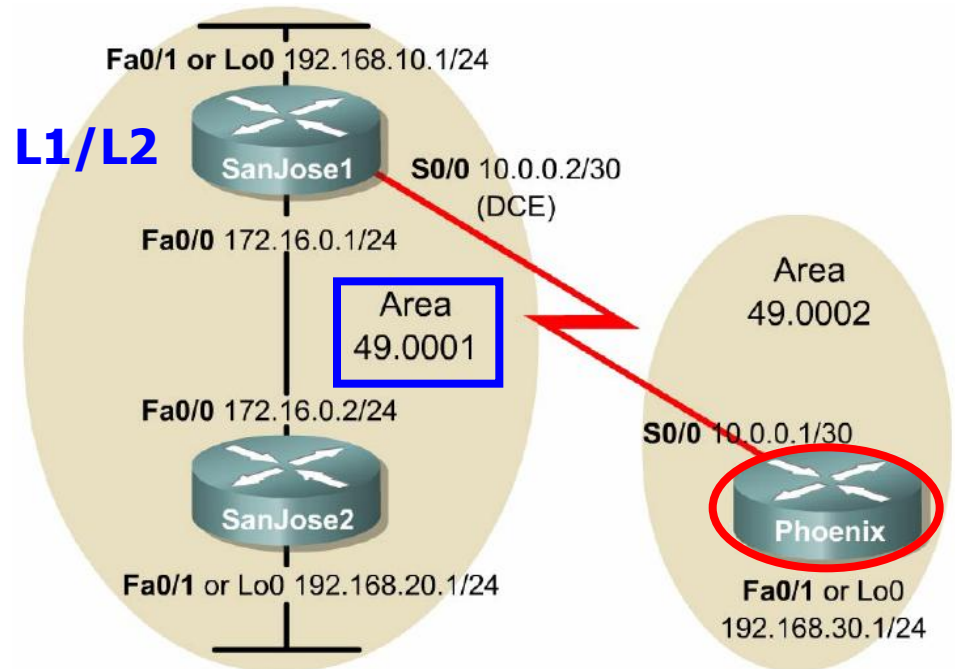
```
C 192.168.20.0/24 is directly connected, FastEthernet0/1
```

```
10.0.0.0/30 is subnetted, 1 subnets
```

```
i L1 10.0.0.0 [115/20] via 172.16.0.1, FastEthernet0/0
```

```
i*L1 0.0.0.0/0 [115/10] via 172.16.0.1, FastEthernet0/0
```

Example: IP route @ Phoenix



```
Phoenix#show ip route
```

```
Gateway of last resort is not set
```

```
C 192.168.30.0/24 is directly connected, FastEthernet0/1
```

```
i L2 192.168.10.0/24 [115/20] via 10.0.0.2, Serial0/0
```

```
172.16.0.0/24 is subnetted, 1 subnets
```

```
i L2 172.16.0.0 [115/20] via 10.0.0.2, Serial0/0
```

```
i L2 192.168.20.0/24 [115/30] via 10.0.0.2, Serial0/0
```

```
10.0.0.0/30 is subnetted, 1 subnets
```

```
C 10.0.0.0 is directly connected, Serial0/0
```