



Routing II

รศ.ดร. อนันต์ ผลเพิ่ม

Asso. Prof. Anan Phonphoem, Ph.D.

anan.p@ku.ac.th

<http://www.cpe.ku.ac.th/~anan>

Computer Engineering Department
Kasetsart University, Bangkok, Thailand



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)

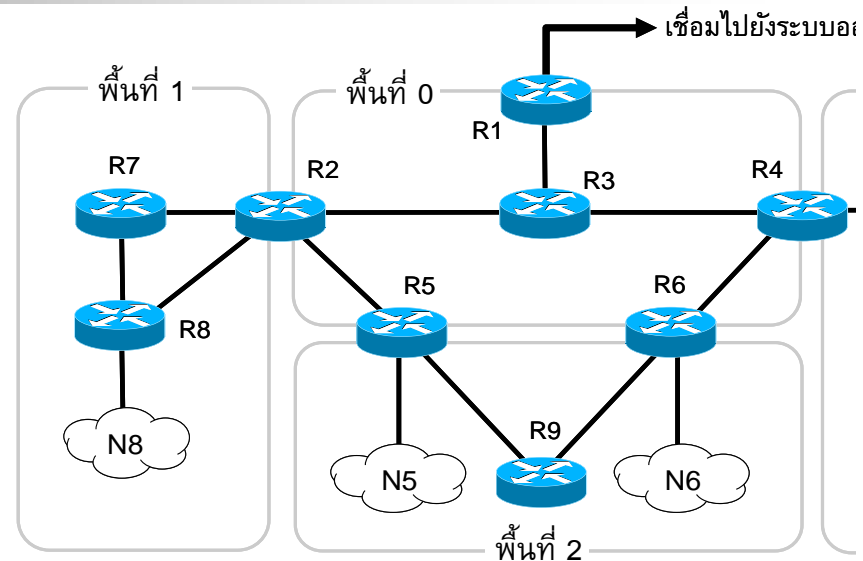
- Analogous to OSPF Internal non-backbone router (Totally Stubby)
- Responsible for routing to End System (ES) inside an area.

- Level 2 IS (L2 IS, router)

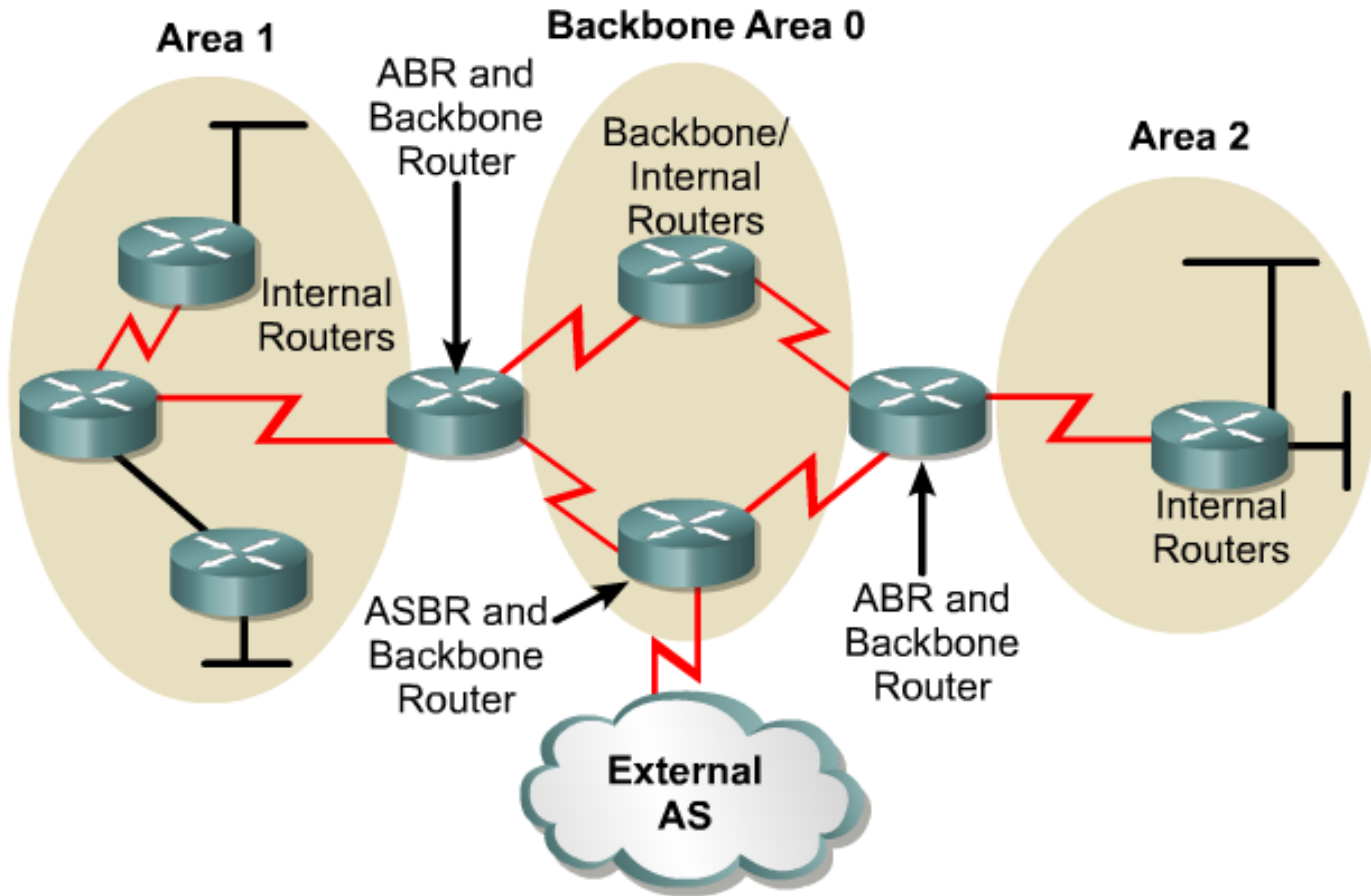
- Analogous to OSPF Internal Backbone router
- Responsible for routing between areas

- 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.



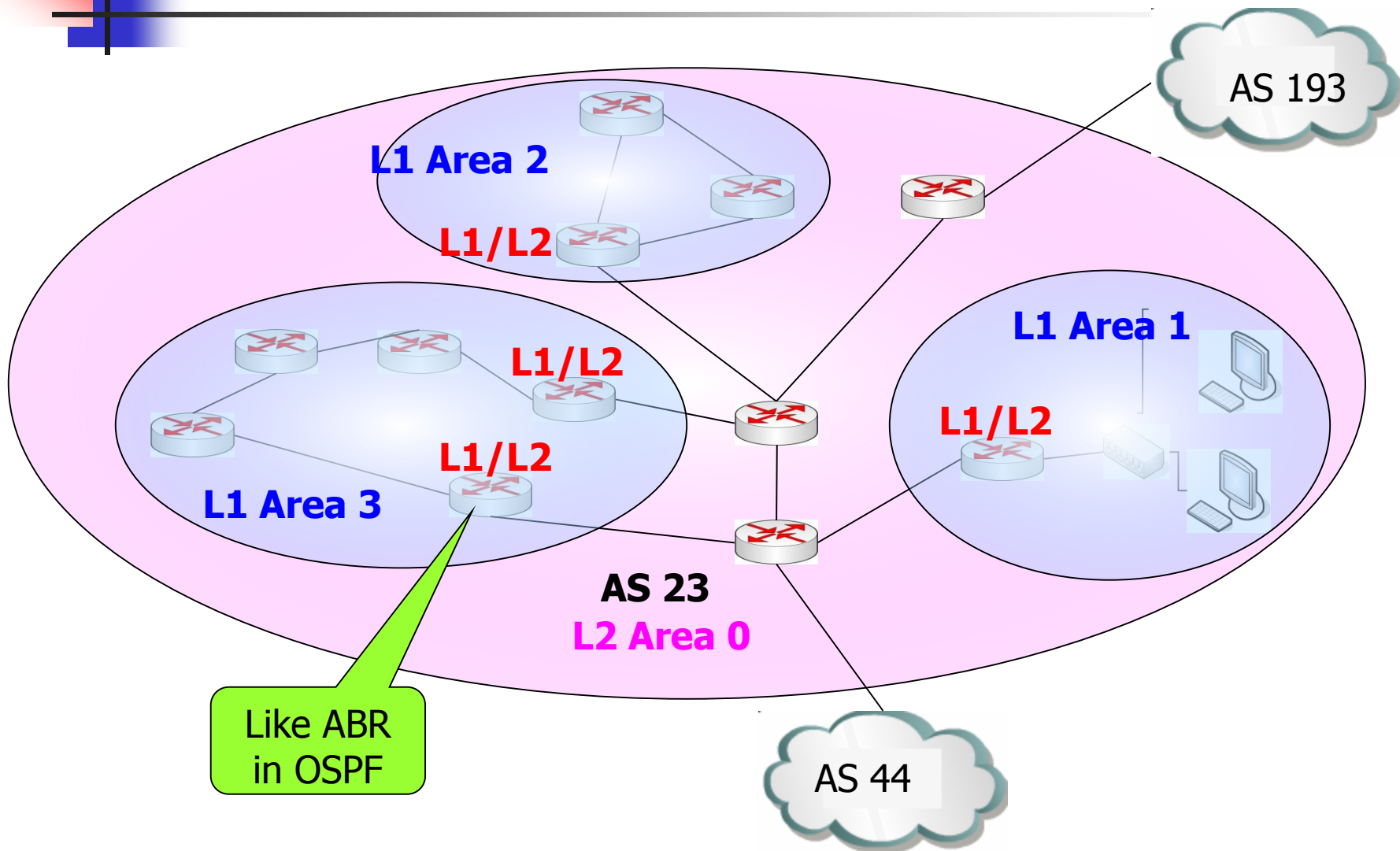
OSPF Area



ABR: Area Border Router

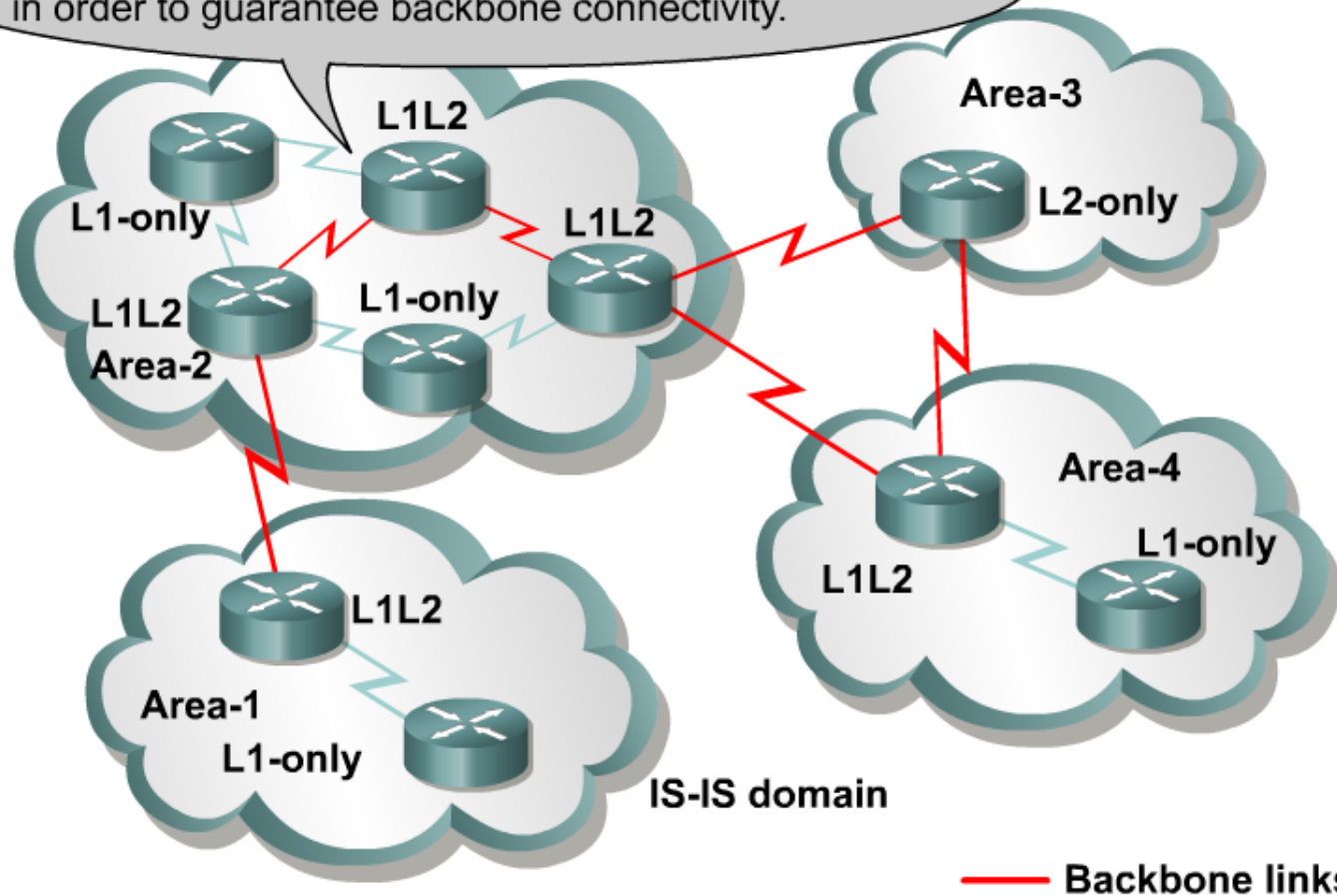
ASBR: Autonomous System Border Router

IS-IS Area



IS-IS Area

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

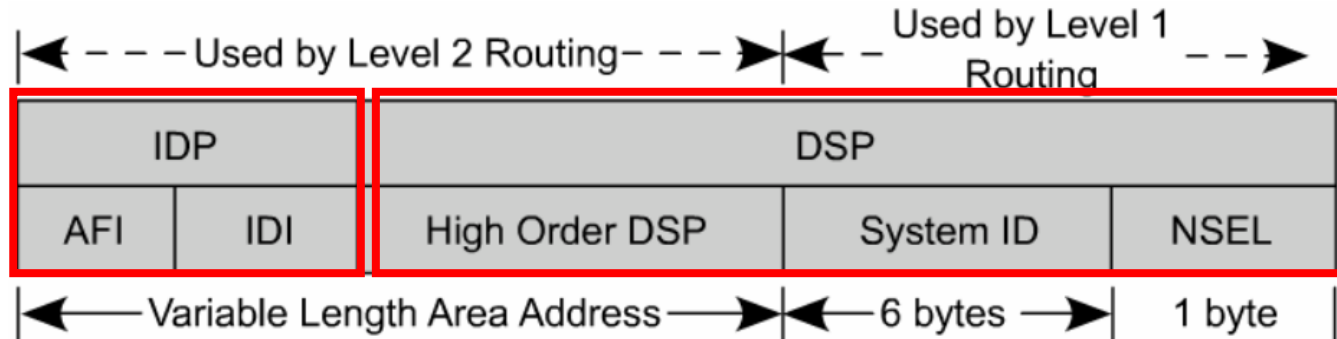




Data Encapsulation & Addressing

- 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

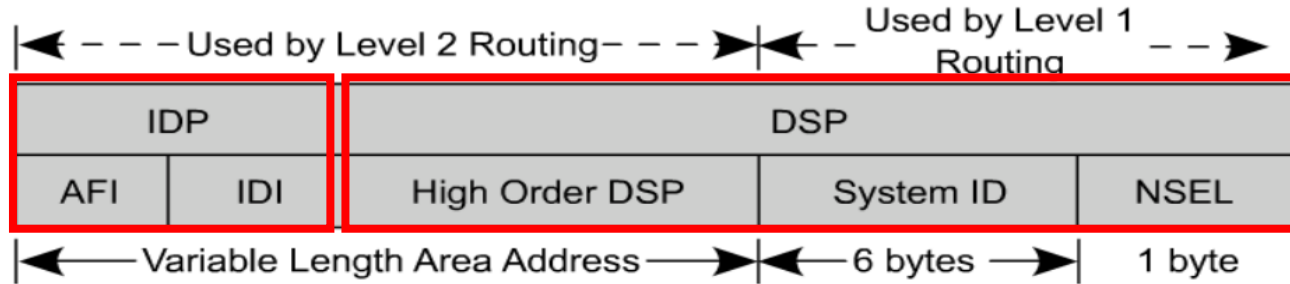
IS-IS address format



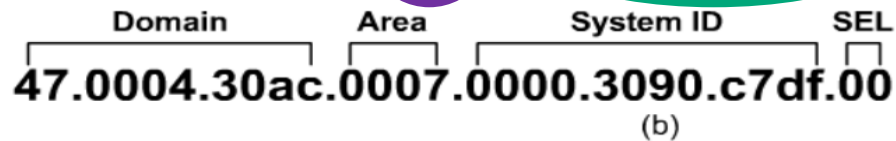
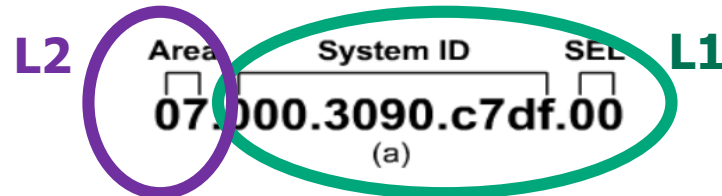
NSAP

- 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

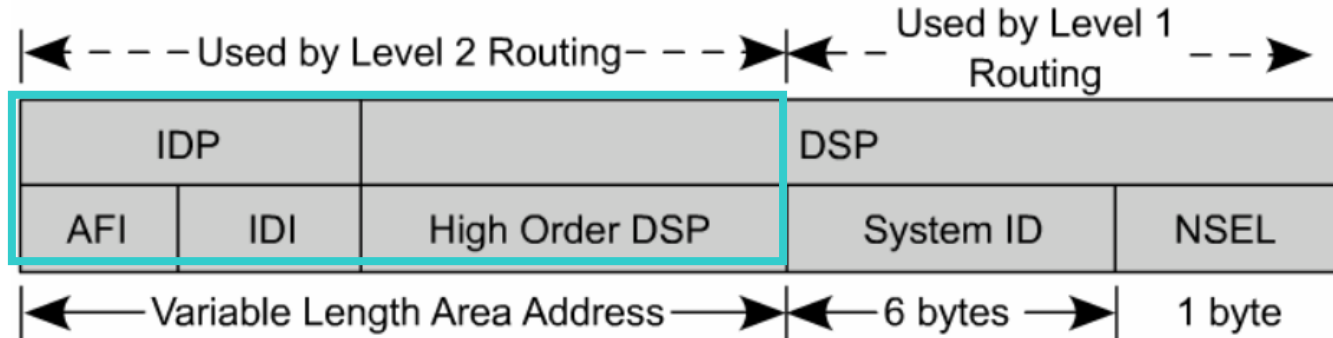


Variable Length Add.



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

NSAPs – Cisco Format



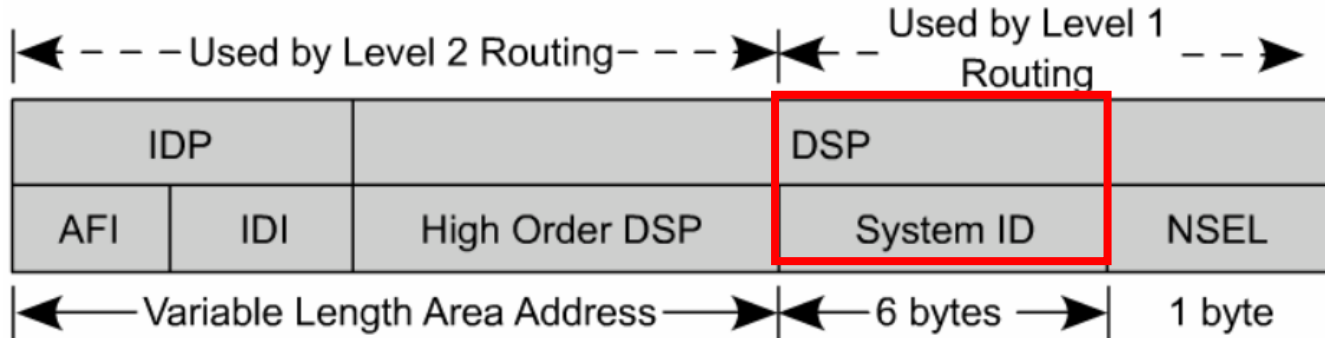
NSAP

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



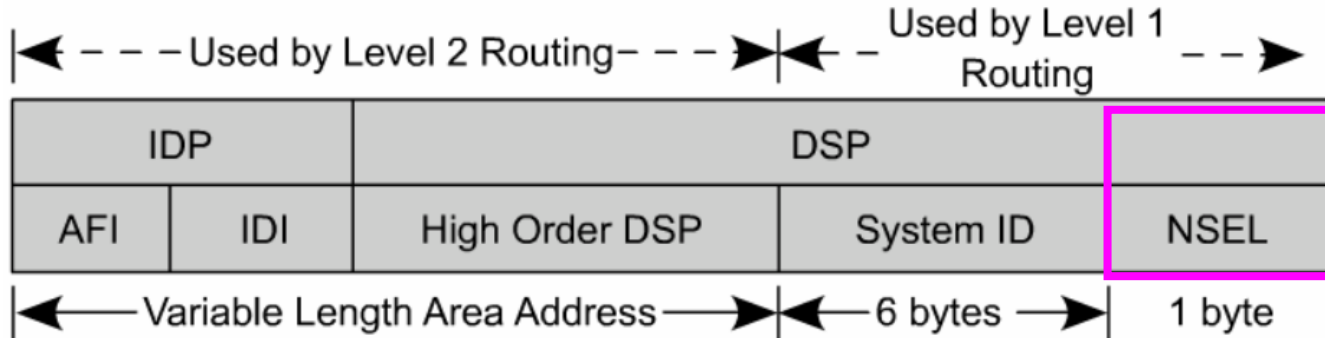
NSAP

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



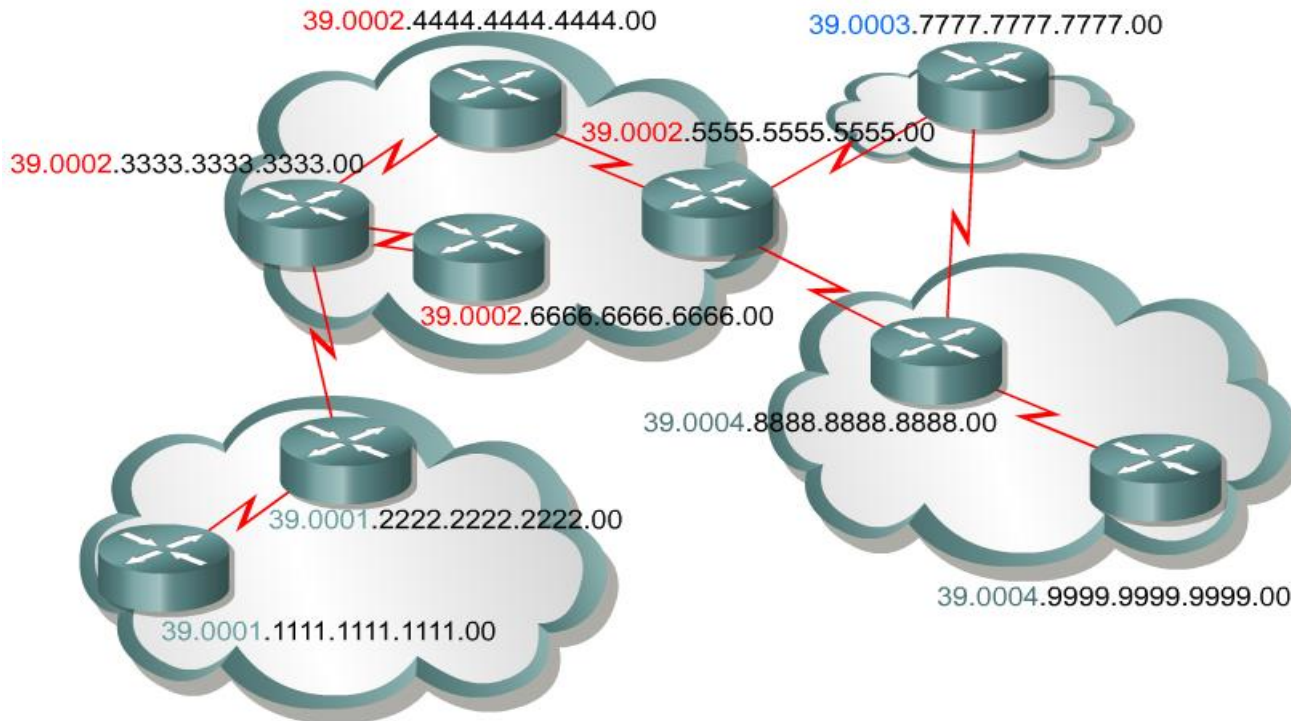
NSAP

Area – System ID – NSEL
49.0001.2222.2222.2222.00

NSEL (NSAP Selector)

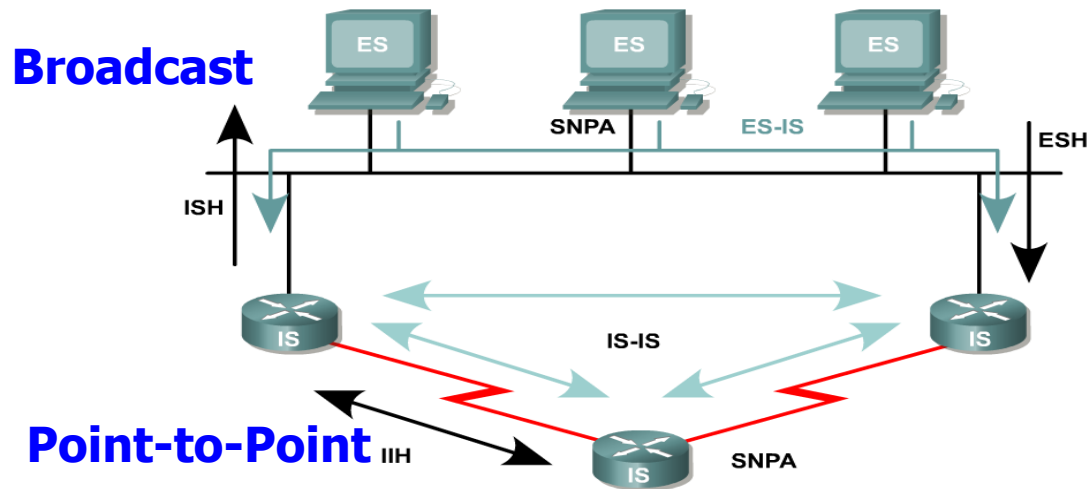
- NSEL is a service identifier like port or socket in TCP/IP.
- Not used in routing decisions.
- NSEL = 00 means the device itself (the network level address)
- The NSAP with a NSEL = 00
 - is known as a Network Entity Title (NET)

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**

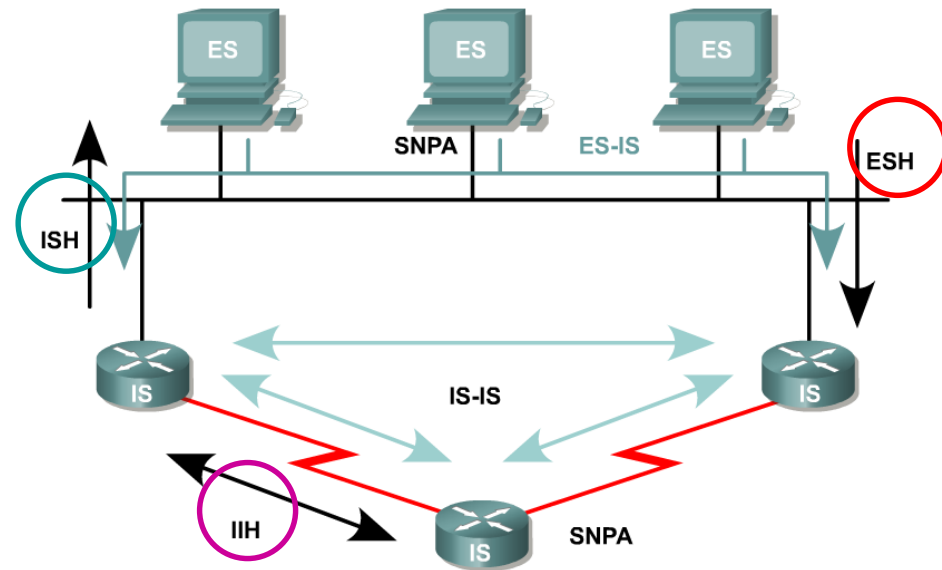
Network Representation



- 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)

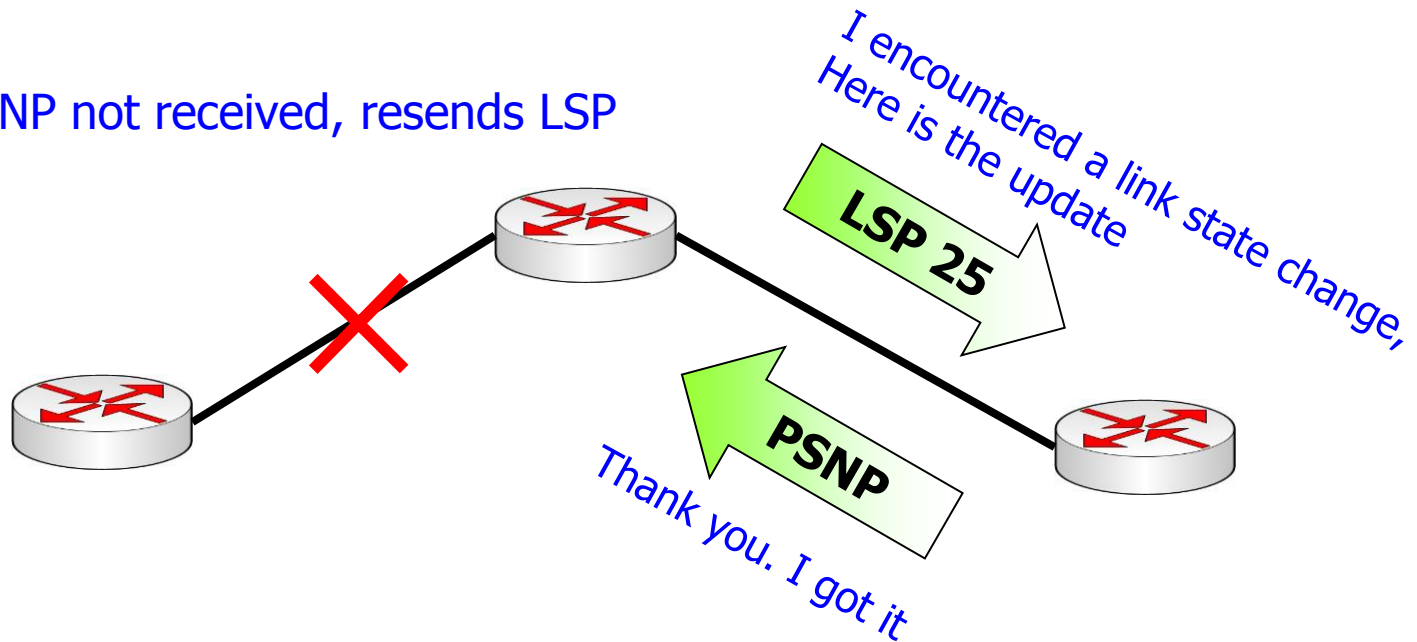
Hello Message

- 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

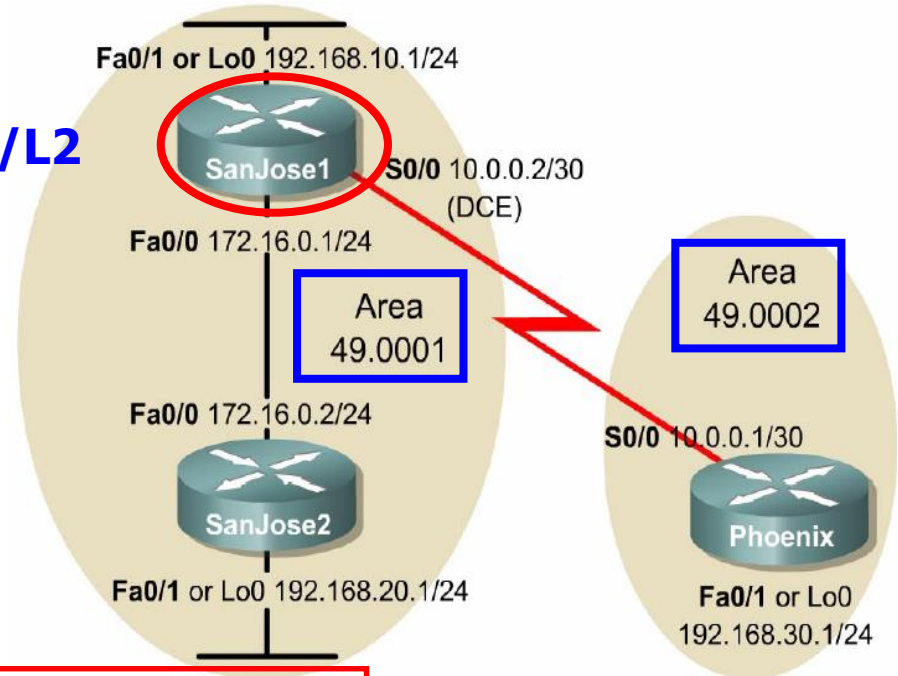


IS-IS Routing Process

- 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
```

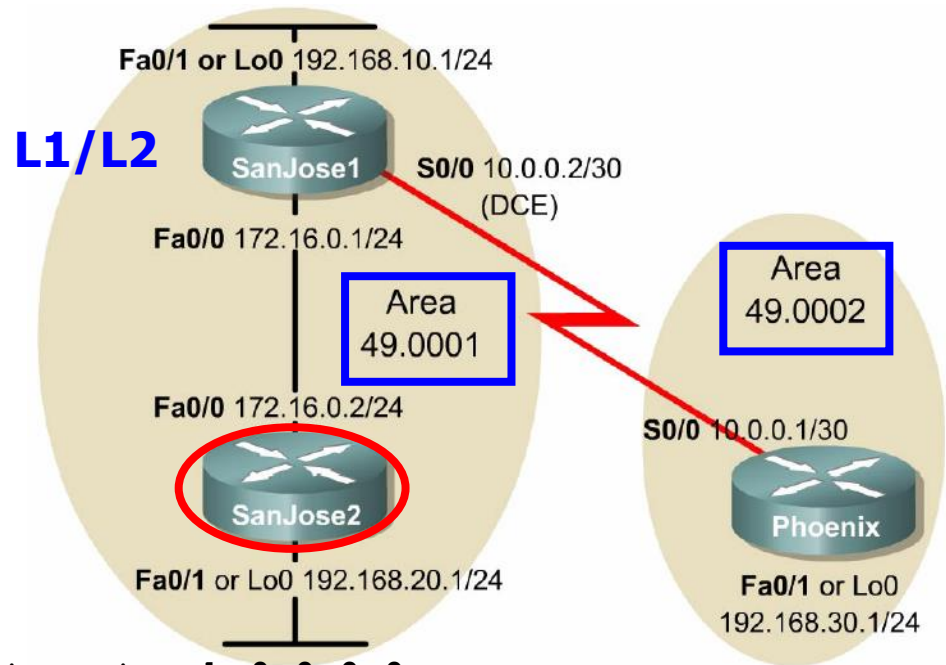
```
C 172.16.0.0 is directly connected, FastEthernet0/0
```

```
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
```

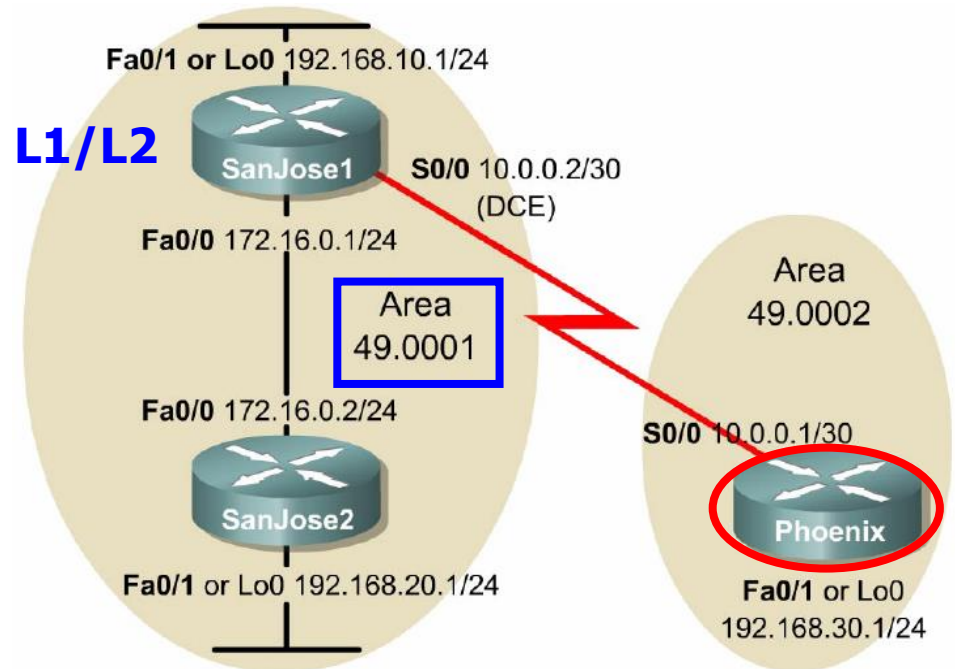
```
C 192.168.20.0/24 is directly connected, FastEthernet0/1
```

```
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
```