

IS-IS



Introduction

Why IS-IS?

- ❑ Link State IGP Protocol
- ❑ Over CLNP (ISO protocol) not IP, so harder to attack
- ❑ Very simple to configure
- ❑ All the power of OSPF and you can get as many knobs if you want, but don't
- ❑ Almost no one uses IS-IS, only the world's largest ISPs (and clueful enterprises)
- ❑ IPv6 Support is natural
- ❑ And it does not lock you in to a vendor

Converting to/from IS-IS

- ❑ IGP's are 'ships in the night' i.e. they are quite independent
- ❑ You want to convert from OSPF to IS-IS?
- ❑ Leave OSPF configuration as is
- ❑ Configure IS-IS
- ❑ Carefully inspect IS-IS database etc
- ❑ Turn off OSPF
- ❑ AOL did it without dropping a packet, see

<http://nanog.org/meetings/nanog29/abstracts.php?pt=Njg2Jm5hbm9nMjk=&nm=nanog29>

Simple (& real) IS-IS Configuration

```
router isis RGnet
  net 47.0042.0001.0000.0000.0004.0002.1981.8015.0000.00
  is-type level-2
  log-adjacency-changes
  metric-style wide
  passive-interface Loopback 0

interface Loopback 0
  ip address 198.180.150.252 255.255.255.255
  ipv6 address 2001:418:8006::252/121

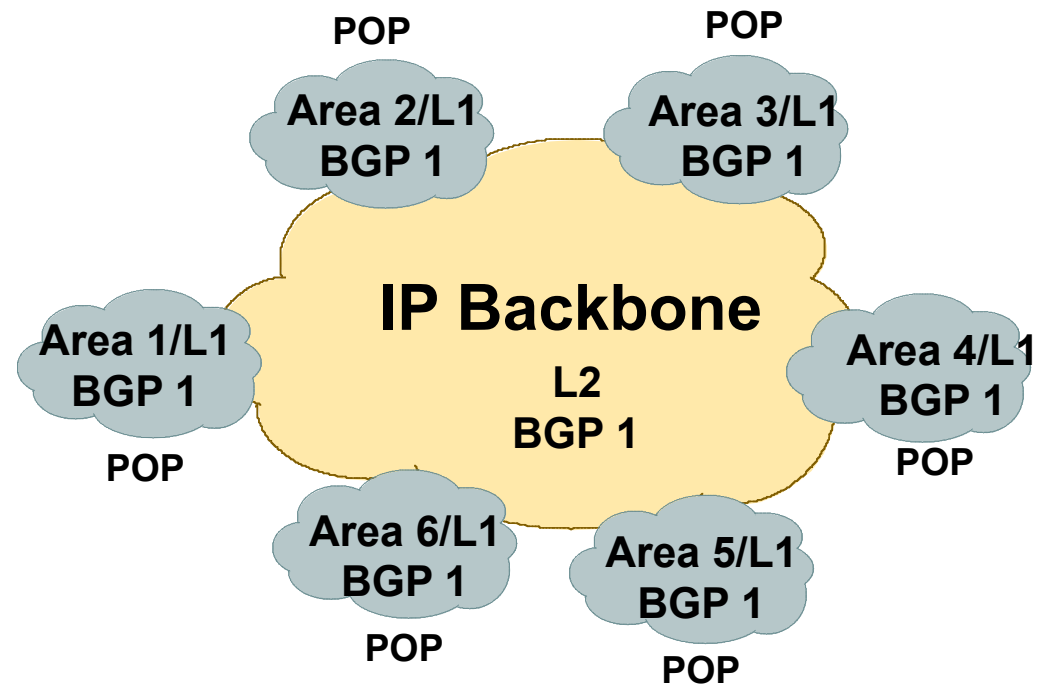
interface GigabitEthernet 0/1
  ip address 198.180.150.121 255.255.255.128
  ipv6 address 2001:418:8006::121/121
  isis circuit-type
  ip router isis RGnet
  isis metric 1 level-2
  isis circuit-type level-2
```

IS-IS Standards History

- ❑ ISO 10589 specifies OSI IS-IS routing protocol for CLNS traffic
 - Tag/Length/Value (TLV) options to enhance the protocol
 - A Link State protocol with a 2 level hierarchical architecture.
- ❑ RFC 1195 added IP support
 - I/IS-IS runs on top of the Data Link Layer
 - Requires CLNP to be configured
- ❑ Internet Draft defines how to add IPv6 address family support to IS-IS
 - www.ietf.org/internet-drafts/draft-ietf-isis-ipv6-07.txt
- ❑ Internet Draft introduces Multi-Topology concept for IS-IS
 - www.ietf.org/internet-drafts/draft-ietf-isis-wg-multi-topology-12.txt

Very Large Scale IS-IS Design

- When you have over 200+ routers



IS-IS Levels

- IS-IS has a 2 layer hierarchy
 - Level-2 (the backbone)
 - Level-1 (the areas)
- A router can be
 - Level-1 (L1) router
 - Level-2 (L2) router
 - Level-1-2 (L1L2) router

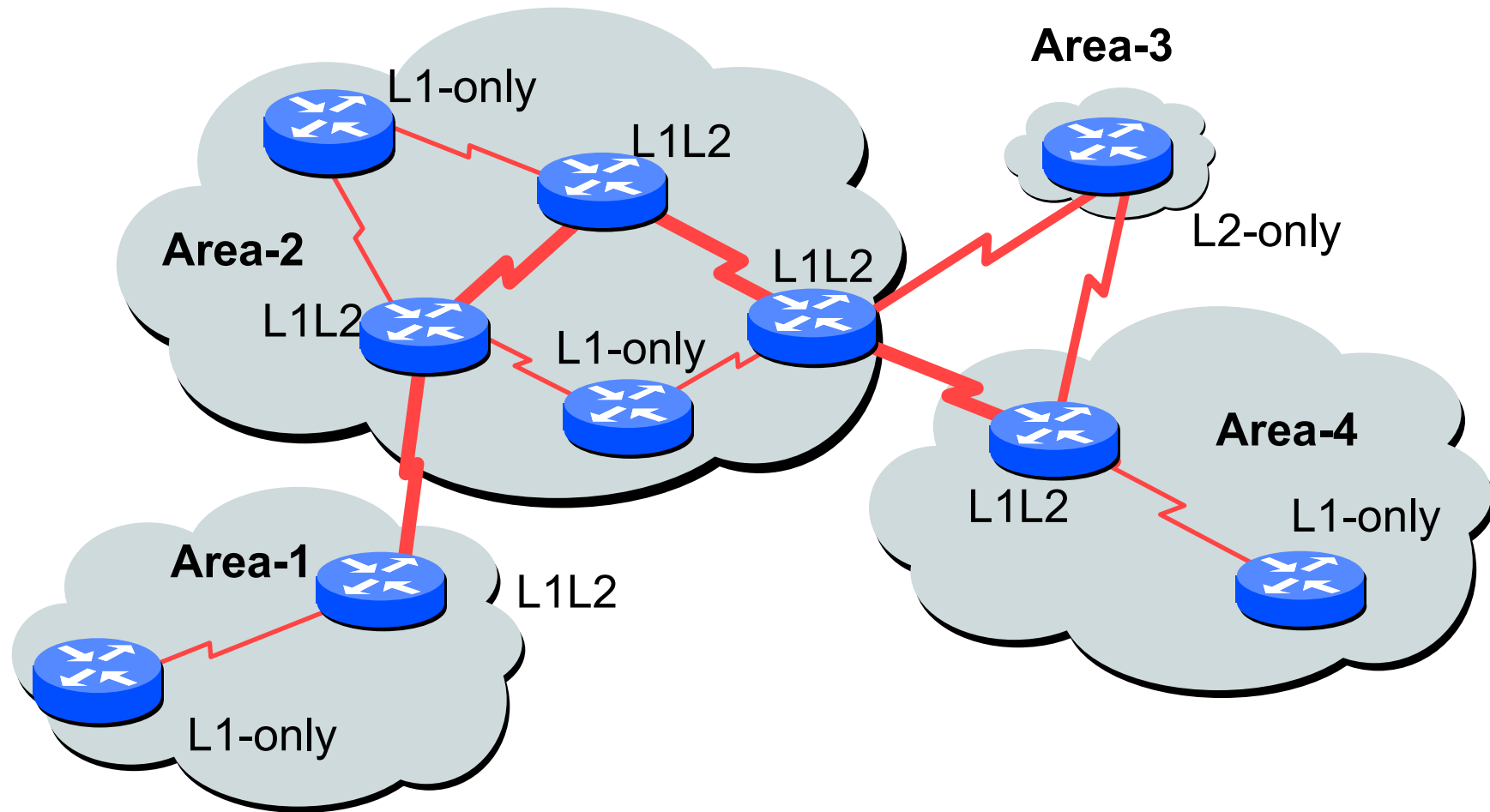
IS-IS Levels

- Level-1 router
 - Has neighbours only on the same area
 - Has a level-1 Link State Data Base (LSDB) with all routing information for the area
- Level-2 router
 - May have neighbours in the same or other areas
 - Has a Level-2 LSDB with all routing information about inter-area
- Level-1-2 router
 - May have neighbours on any area.
 - Has two separate LSDBs: level-1 LSDB & level-2 LSDB

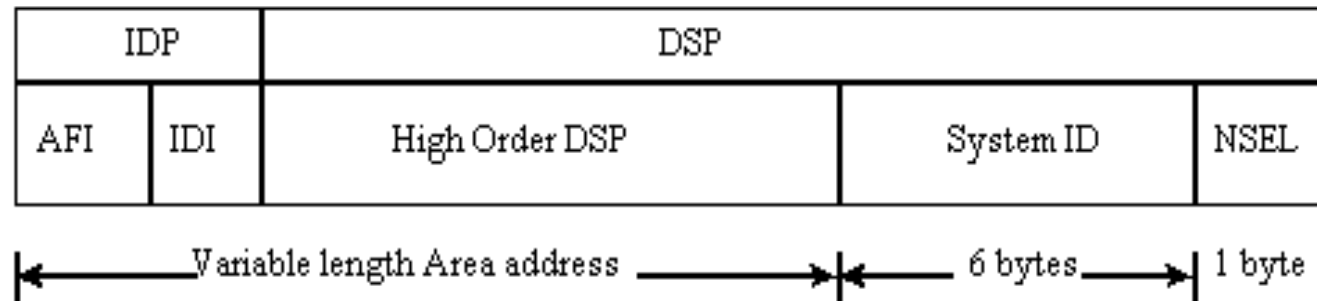
Backbone & Areas

- ❑ IS-IS does not have a backbone area as such (like OSPF)
- ❑ Instead the backbone is the contiguous collection of Level-2 capable routers
- ❑ IS-IS area borders are on links, not routers
- ❑ Each router is identified with Network Entity Title (NET)
 - NET is an NSAP where the n-selector is 0

L1, L2, and L1L2 Routers



NSAP and Addressing

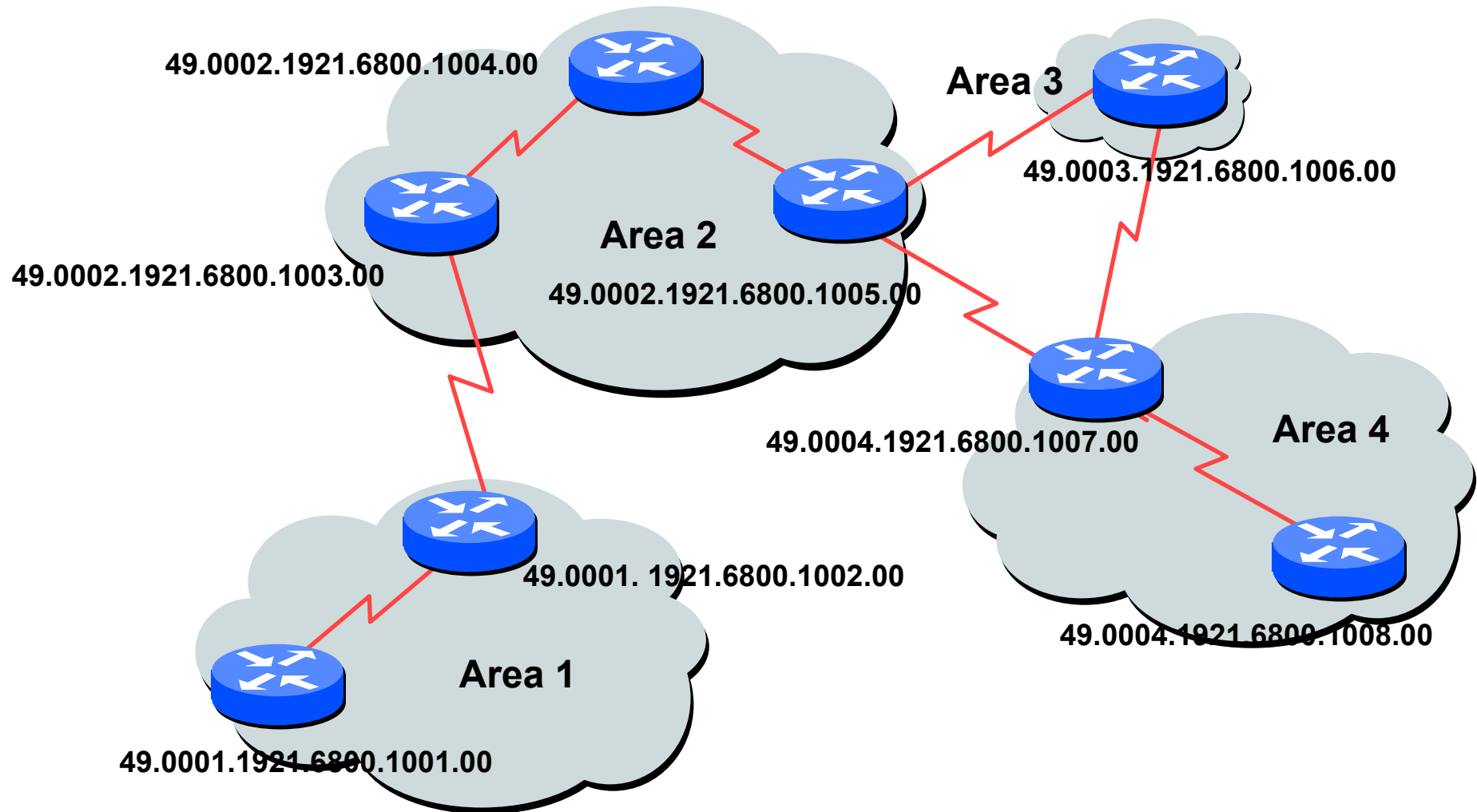


- NSAP: Network Service Access Point
 - Total length between 8 and 20 bytes
 - Area Address: variable length field (up to 13 bytes)
 - System ID: defines an ES or IS in an area.
 - NSEL: N-selector. identifies a network service user (transport entity or the IS network entity itself)
- NET: the address of the network entity itself

Addressing Common Practices

- ISPs typically choose NSAP addresses thus:
 - First 8 bits – pick a number
 - Next 16 bits – area
 - Next 48 bits – router loopback address
 - Final 8 bits – zero
- Example:
 - NSAP: 49.0001.1921.6800.1001.00
 - Router: 192.168.1.1 (loopback) in Area 1

An Addressing Example



Adjacencies

- Hello PDU IIHs are exchanged between routers to form adjacencies



- Area addresses are exchanged in IIH PDUs

Link State PDU (LSP)

- Each router creates an LSP and floods it to neighbours
- A level-1 router will create level-1 LSP(s)
- A level-2 router will create level-2 LSP(s)
- A level-1-2 router will create
 - level-1 LSP(s) and
 - level-2 LSP(s)

LSP Contents

- The LSP contents are coded as TLV (Type, Length, Value)
 - Area addresses
 - IS neighbors
 - Authentication Info

LSDB content

- ❑ Each router maintains a separate Link State Database (LSDB) for level-1 and level-2 LSPs
- ❑ LSP headers and contents
- ❑ SRM bits: set per interface when router has to flood this LSP
- ❑ SSN bits: set per interface when router has to send a PSNP for this LSP

Flooding of LSPs

- New LSPs are flooded to all neighbors
- It is necessary that all routers get all LSPs
- Each LSP has a sequence number
- 2 kinds of flooding
 - Flooding on a p2p link
 - Flooding on LAN

Flooding on a p2p link

- ❑ Once the adjacency is established both routers send CSNP packet
- ❑ Missing LSPs are sent by both routers if not present in the received CSNP
- ❑ Missing LSPs may be requested through PSNP

Flooding on a LAN

- ❑ There's a Designated IS-IS Router (DIS)
- ❑ DIS election is based on priority
 - Best practice is to select two routers and give them higher priority – then in case of failure one provides deterministic backup to the other
- ❑ Tie break is by the highest MAC address
- ❑ DIS has two tasks
 - Conducting the flooding over the LAN
 - Creating and updating a special LSP describing the LAN topology (Pseudonode LSP)
- ❑ Pseudo-node represents LAN (created by the DIS)

Flooding on a LAN

- ❑ DIS conducts the flooding over the LAN
- ❑ DIS multicasts CSNP every 10 seconds
- ❑ All routers in the LAN check the CSNP against their own LSDB (and may ask specific re-transmissions with PSNPs)

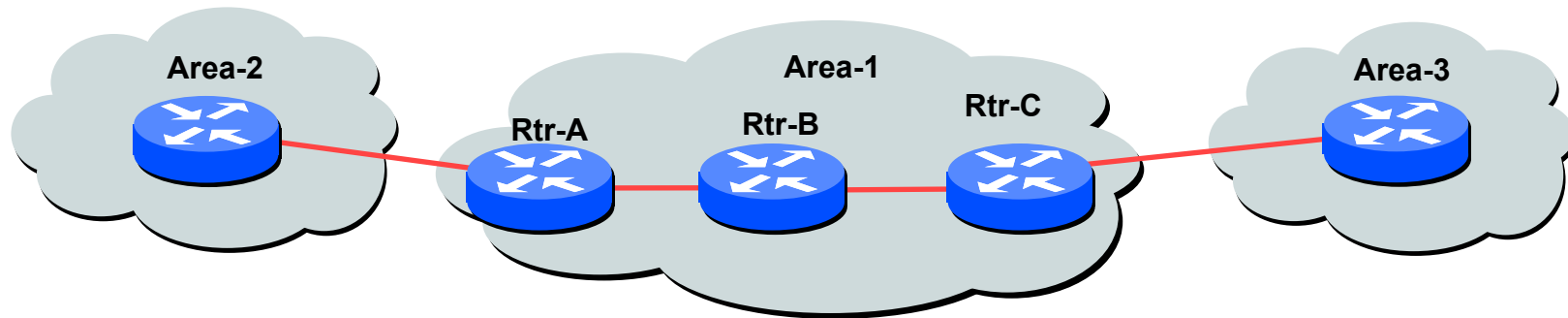
Complete Sequence Number PDU

- ❑ Describes all LSPs in your LSDB (in range)
- ❑ If LSDB is large, multiple CSNPs are sent
- ❑ Used at 2 occasions
 - Periodic multicast by DIS (every 10 seconds) to synchronise LSDB over LAN subnets
 - On p2p links when link comes up

Partial Sequence Number PDUs

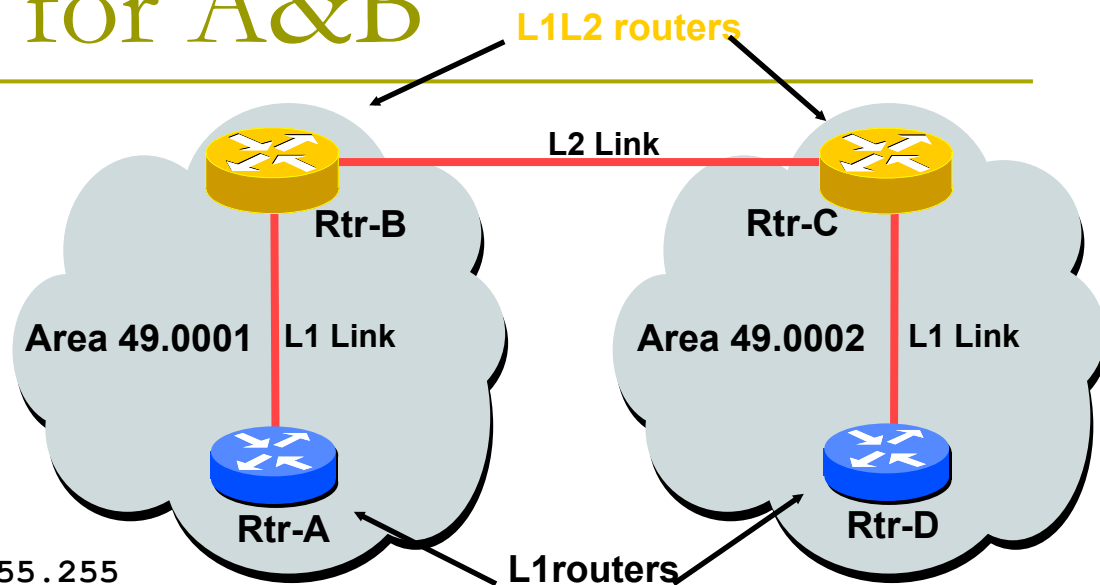
- PSNPs Exchanged on p2p links (ACKs)
- Two functions
 - Acknowledge receipt of an LSP
 - Request transmission of latest LSP
- PSNPs describe LSPs by its header
 - LSP identifier
 - Sequence number
 - Remaining lifetime
 - LSP checksum

Configuration



- L1, L2, L1-L2
 - By default Cisco routers will be L1L2 routers
 - Routers can be manually configured to behave as
 - Level-1 only, Level-2 only, Level-1-2
 - This is what most ISPs and enterprises/campuses do
 - Configuration can be done per interface or at the router level

Configuration for A&B



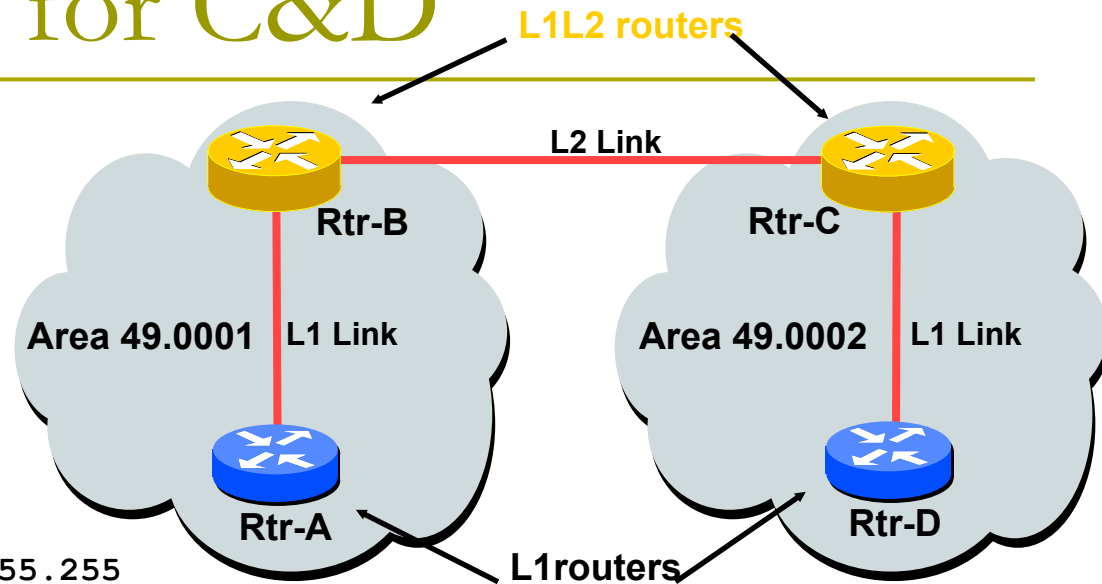
Router-B

```
Interface Loopback0
 ip address 192.168.1.1 255.255.255.255
!
Interface Pos2/0/0
 ip address 192.168.222.1 255.255.255.0
 ip router isis
 isis circuit-type level-2
!
FastEthernet4/0/0
 ip address 192.168.120.10 255.255.255.0
 ip router isis
 isis circuit-type level-1
!
router isis
 passive-interface Loopback0
 net 49.0001.1921.6800.1001.00
```

Router-A

```
Interface Loopback0
 ip address 192.168.1.5 255.255.255.255
!
interface FastEthernet0/0
 ip address 192.168.120.5 255.255.255.0
 ip router isis
!
router isis
 is-type level-1
 passive-interface Loopback0
 net 49.0001.1921.6800.1005.00
```

Configuration for C&D



Router-C

```
Interface Loopback0
 ip address 192.168.2.2 255.255.255.255
!
Interface Pos1/0/0
 ip address 192.168.222.2 255.255.255.0
 ip router isis
 isis circuit-type level-2
!
interface Fddi3/0
 ip address 192.168.111.2 255.255.255.0
 ip router isis
 isis circuit-type level-1
!
router isis
 passive-interface Loopback0
 net 49.0002.1921.6800.2002.00
```

Router-D

```
Interface Loopback0
 ip address 192.168.2.4 255.255.255.255
!
interface Fddi6/0
 ip address 192.168.111.4 255.255.255.0
 ip router isis
!
router isis
 is-type level-1
 passive-interface Loopback0
 net 49.0002.1921.6800.2004.00
```

Adding interfaces to IS-IS

- ❑ To activate IS-IS on an interface:
 - `interface FastEthernet 4/0`
 - `ip route isis isp-bb`
 - `isis circuit-type level-2`
- ❑ To disable IS-IS on an interface:
 - `router isis isp-bb`
 - `passive-interface GigabitEthernet 0/0`
 - Disables CLNS on that interface
 - Puts the interface subnet address into the LSDB
- ❑ No IS-IS configuration on an interface
 - No CLNS run on interface, no interface subnet in the LSDB

Adding interfaces to IS-IS

- **Scaling IS-IS: passive-interface default**
 - Disables IS-IS processing on all interfaces apart from those marked as no-passive
 - Places all IP addresses of all connected interfaces into IS-IS
 - Must be at least one non-passive interface:

```
router isis isp-bb
  passive-interface default
  no passive-interface GigabitEthernet 0/0
```

```
interface GigabitEthernet 0/0
  ip router isis isp-bb
  isis metric 1 level-2
```

Status Commands in IS-IS

- Show clns
 - Shows the global CLNS status as seen on the router, e.g.

```
Rtr-B>show clns
```

```
Global CLNS Information:
```

```
 2 Interfaces Enabled for CLNS
```

```
NET: 49.0001.1921.6800.1001.00
```

```
Configuration Timer: 60, Default Holding Timer: 300, Packet  
Lifetime 64
```

```
ERPDU's requested on locally generated packets
```

```
Intermediate system operation enabled (forwarding allowed)
```

```
IS-IS level-1-2 Router:
```

```
  Routing for Area: 49.0001
```

Status Commands in IS-IS

□ Show clns neighbors

- Shows the neighbour adjacencies as seen by the router:

```
Rtr-B> show clns neighbors
```

System Id	SNPA	Interface	State	Holdtime	Type	Protocol
1921.6800.2002	*PPP*	PO2/0/0	Up	29	L2	IS-IS
1921.6800.1005	00e0.1492.2c00	Fa4/0/0	Up	9	L1	IS-IS

- More recent IOSes replace system ID with router hostname – ease of troubleshooting

Status Commands in IS-IS

- Show clns interface
 - Shows the CLNS status on a router interface:

```
Rtr-B> show clns interface POS2/0/0
POS2/0/0 is up, line protocol is up
  Checksums enabled, MTU 4470, Encapsulation PPP
  ERPDUs enabled, min. interval 10 msec.
  RDPDUs enabled, min. interval 100 msec., Addr Mask enabled
  Congestion Experienced bit set at 4 packets
  DEC compatibility mode OFF for this interface
  Next ESH/ISH in 47 seconds
  Routing Protocol: IS-IS
    Circuit Type: level-1-2
    Interface number 0x0, local circuit ID 0x100
    Level-1 Metric: 10, Priority: 64, Circuit ID: 1921.6800.2002.00
    Number of active level-1 adjacencies: 0
    Level-2 Metric: 10, Priority: 64, Circuit ID: 1921.6800.1001.00
    Number of active level-2 adjacencies: 1
    Next IS-IS Hello in 2 seconds
```

Status Commands in IS-IS

- Show CLNS protocol
 - Displays the status of the CLNS protocol on the router:

```
Rtr-B> show clns protocol
IS-IS Router: <Null Tag>
  System Id: 1921.6800.1001.00   IS-Type: level-1-2
  Manual area address(es) :
    49.0001
  Routing for area address(es) :
    49.0001
  Interfaces supported by IS-IS:
    FastEthernet4/0/0 - IP
    POS2/0/0 - IP
  Redistributing:
    static
  Distance: 110
```


Other status commands

- “show clns traffic”
 - Shows CLNS traffic statistics and activity for the network
- “show isis database”
 - Shows the IS-IS link state database
 - i.e. the “routing table”

Network Design Issues

- ❑ As in all IP network designs, the key issue is the addressing lay-out
- ❑ IS-IS supports a large number of routers in a single area
- ❑ When using areas, use summary-addresses
- ❑ >400 routers in the backbone is quite doable

Network Design Issues

- ❑ Possible link cost
 - Default on all interface is 10
 - (Compare with OSPF which set cost according to link bandwidth)
 - Manually configured according to routing strategy
- ❑ Summary address cost
 - Equal to the best more specific cost
 - Plus cost to reach neighbor of best specific
- ❑ Backbone has to be contiguous
 - Ensure continuity by redundancy
- ❑ Area partitioning
 - Design so that backbone can **NOT** be partitioned

Scaling Issues

- Areas vs. single area
 - Use areas where
 - sub-optimal routing is not an issue
 - so trading efficiency for very very large scale
 - areas have only single exit points
 - Start with L2-only everywhere is a good choice
 - Future implementation of level-1 areas will be easier
 - Backbone continuity is ensured from start

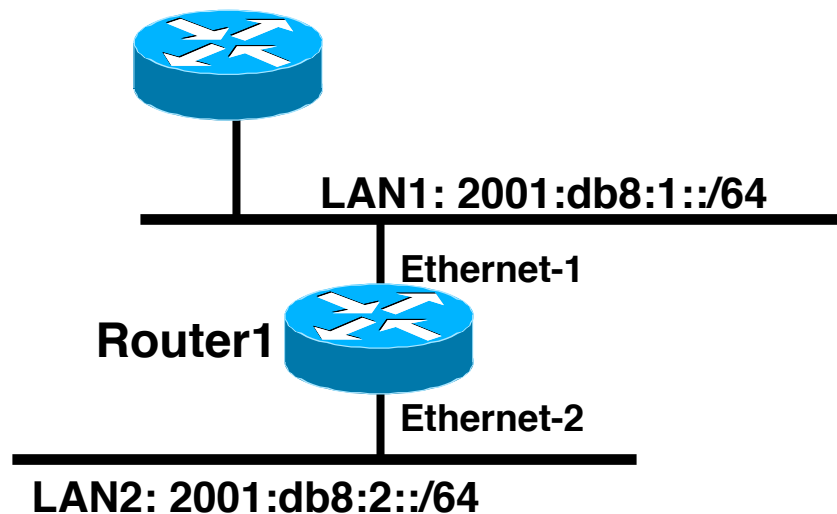
IS-IS for IPv6



IS-IS for IPv6

- ❑ 2 Tag/Length/Values added to introduce IPv6 routing
- ❑ IPv6 Reachability TLV (0xEC)
 - External bit
 - Equivalent to IP Internal/External Reachability TLV's
- ❑ IPv6 Interface Address TLV (0xE8)
 - For Hello PDUs, must contain the Link-Local address
 - For LSP, must only contain the non-Link Local address
- ❑ IPv6 NLPID (0x8E) is advertised by IPv6 enabled routers

IOS IS-IS dual IP configuration



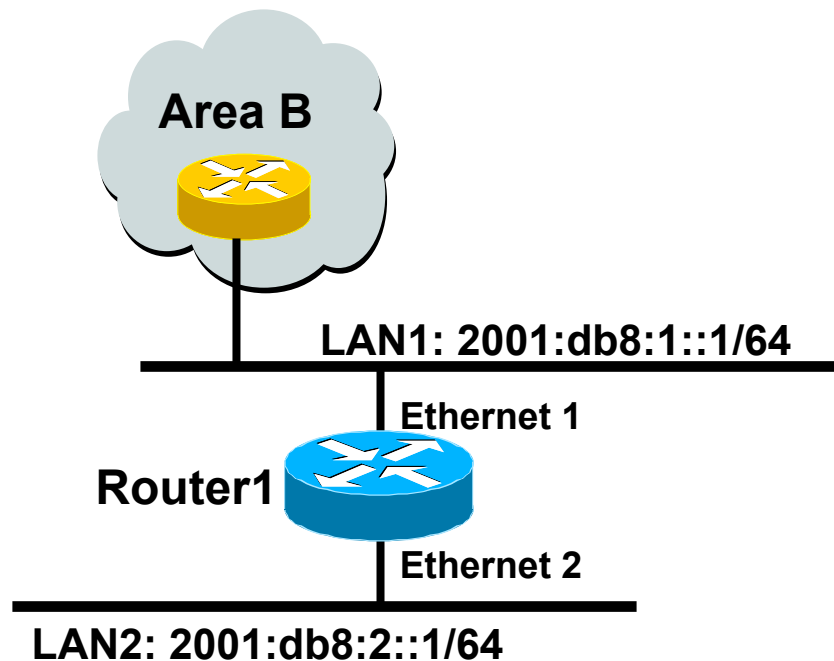
Dual IPv4/IPv6 configuration.
Redistributing both IPv6 static routes
and IPv4 static routes.

```
Router1#  
interface ethernet-1  
  ip address 10.1.1.1 255.255.255.0  
  ipv6 address 2001:db8:1::1/64  
  ip router isis  
  ipv6 router isis  
  
interface ethernet-2  
  ip address 10.2.1.1 255.255.255.0  
  ipv6 address 2001:db8:2::1/64  
  ip router isis  
  ipv6 router isis  
  
router isis  
  address-family ipv6  
    redistribute static  
  exit-address-family  
  net 42.0001.0000.0000.072c.00  
  redistribute static
```

Multi-Topology IS-IS extensions

- ❑ IS-IS for IPv6 assumes that the IPv6 topology is the same as the IPv4 topology
 - Single SPF running, multiple address families
 - Some networks may be like this, but many others are not
- ❑ Multi-Topology IS-IS solves this problem
 - New TLV attributes introduced
 - New Multi-Topology ID #2 for IPv6 Routing Topology
 - Two topologies now maintained:
 - ❑ ISO/IPv4 Routing Topology (MT ID #0)
 - ❑ IPv6 Routing Topology (MT ID #2)

Multi-Topology IS-IS configuration example (IOS)



- ❑ The optional keyword `transition` may be used for transitioning existing IS-IS IPv6 single SPF mode to MT IS-IS
- ❑ Wide metric is mandated for Multi-Topology to work

```
Router1#
interface Ethernet 1
 ip address 10.1.1.1 255.255.255.0
 ipv6 address 2001:db8:1::1/64
 ip router isis
 ipv6 router isis
 isis ipv6 metric 20

interface Ethernet 2
 ip address 10.2.1.1 255.255.255.0
 ipv6 address 2001:db8:2::1/64
 ip router isis
 ipv6 router isis
 isis ipv6 metric 20

router isis
 net 42.0001.0000.0000.072c.00
 metric-style wide
 !
 address-family ipv6
 multi-topology
 exit-address-family
```

ISP common practices

- NSAP address construction
 - Area and loopback address
- L2
 - L1-L2 and L1 used later for scaling
- Wide metrics
 - Narrow metrics are too limiting
- Deploying IPv6 in addition to IPv4
 - Multi-topology is recommended – gives increased flexibility should there be future differences in topology

Summary

- You have learned about:
 - IS-IS for IPv4
 - L1, L2 and L1L2 routers
 - IS-IS areas
 - IS-IS configuration and status commands
 - IS-IS extensions for IPv6
 - ISP common practices