ISIS for ISPs

ISP/IXP Workshops

Configuring ISIS in IOS

- Starting ISIS in IOS

  `router isis [name]`

  Where the optional ***name*** can specify the name of the ISIS process

- ISIS name is unique to the router

  Gives possibility of running multiple instances of ISIS on one router

  ISIS process name is not passed between routers in an AS

  Some ISPs configure the ISIS name to be the same as their BGP Autonomous System Number

  e.g. `router isis as64510`

Configuring ISIS in IOS

- Once ISIS started, other ISP configuration under the ISIS process includes:
  - Capture adjacency changes in the system log

    ```
    log-adjacency-changes
    ```

  - Set metric-style to wide - modern & scalable

    ```
    metric-style wide
    ```

  - Set IS type to level 2 only

    ```
    is-type level-2-only
    ```

  - Set NSAP address

    ```
    net 49.0001.<loopback>.00
    ```

Adding interfaces to ISIS

- To activate ISIS on an interface:

```
interface HSSI 4/0
 ip router isis isp-bb
 isis circuit-type level-2
```

- To disable ISIS 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 ISIS configuration on an interface

  No CLNS run on interface, no interface subnet in the LSDB

Adding interfaces to ISIS

- Scaling ISIS: **`passive-interface default`**

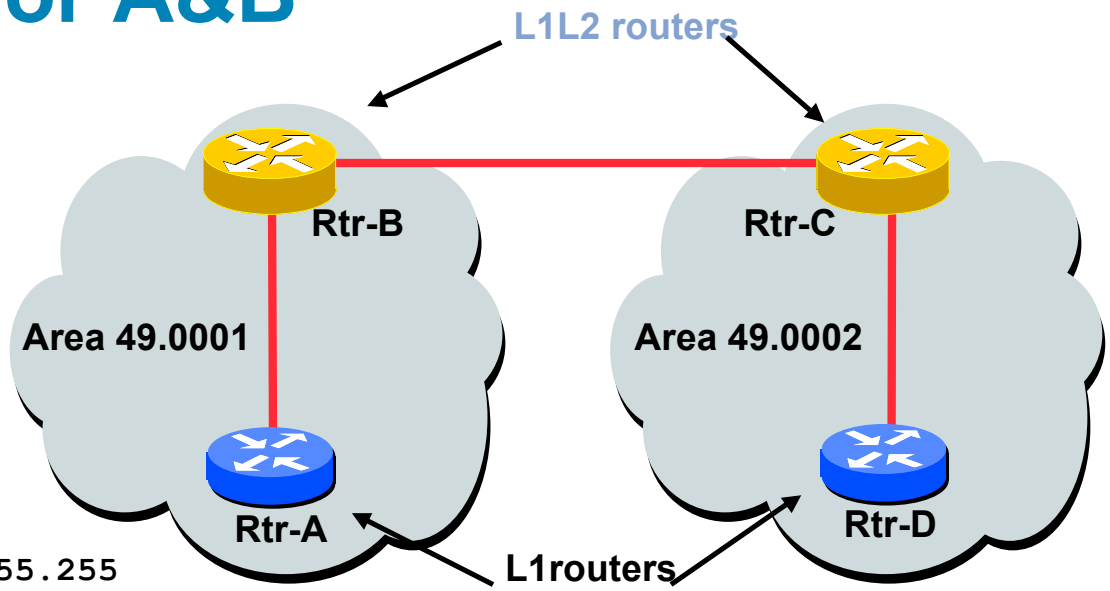
  Disables ISIS processing on all interfaces apart from those marked as no-passive

  Places all IP addresses of all connected interfaces into ISIS

  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
```

Configuration for A&B



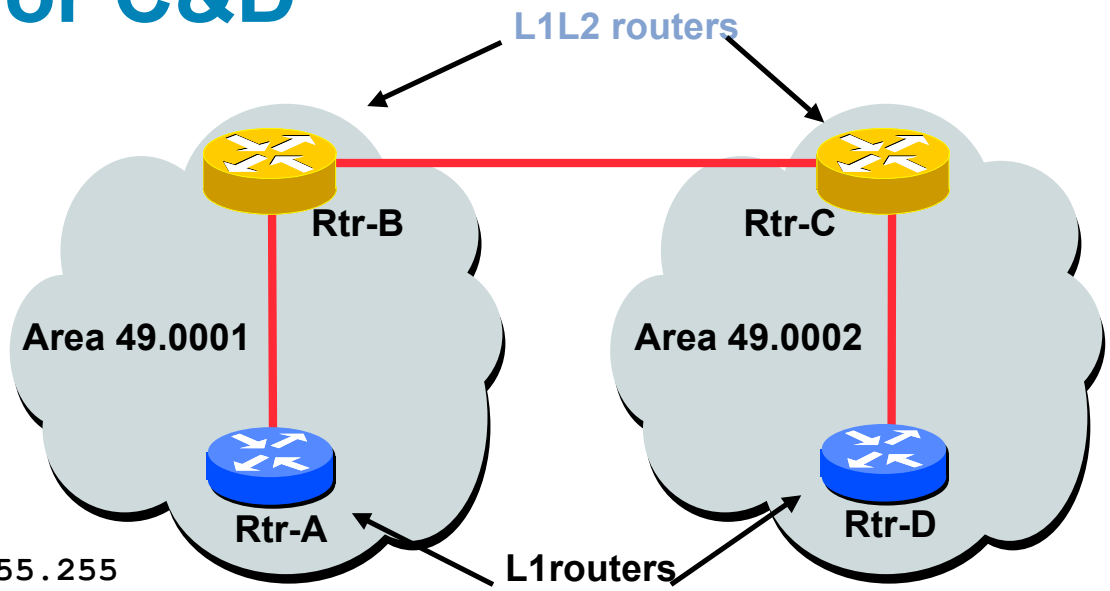
Router-B

```
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
```

Status Commands in ISIS

- 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 ISIS

- 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 ISIS

- 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 ISIS

- 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 ISIS 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
- ISIS 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
    - areas with one single exit point
  - Start with L2-only everywhere is a good choice
  - Future implementation of level-1 areas will be easier
  - Backbone continuity is ensured from start

Narrow to Wide Metrics Transition

- When migrating from narrow to wide metrics, care is required
  - Narrow and wide metrics are NOT compatible with each other
  - Migration is a two stage process, using the “transition” keyword
- Networks using narrow metrics should first configure across all routers:

```
router isis isp
 metric-style transition
```

- Once the whole network is changed to transition support, the metric style can be changed to wide:

```
router isis isp
 metric-style wide
```

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

ISP Best Practices

Extra detailed information

Purging the RIB on link failure

- For routing protocols that are capable of responding to link failures, IOS allows such routing protocols to quickly and more efficiently delete associated routes from the RIB when a link, and the interface is removed from the routing table
- Without this command, the "less efficient" RIB process is used to delete the associated next-hop routes of the failed interface, by default

  If this process has to work through a very large routing table, it can use up a number of CPU cycles and potentially increase convergence time.

```
ip routing protocol purge interface
```

ISIS neighbour authentication

- Create key chains to be used for HMAC-MD5 authentication for both Level-1 and Level-2

```
key chain isis-sec-l1
 key 1
   key-string xxxxx
key chain isis-sec-l2
 key 1
   key-string xxxxx
```

Setting up Loopback Interface

- Create the Loopback interface/Router-ID

  It will NOT have IS-IS running on it because it is not a transit interface

  Disabling IS-IS on it, while announcing the IP prefixes into IS-IS, allows the IS-IS domain to scale because LSP/Hello packets are not unnecessarily generated for the Loopback interface

  An IS-IS metric will NOT be set, which will default the Loopback interface's metric to zero (0).

```
interface loopback0
 ip address 192.168.0.1 255.255.255.255
 ipv6 address 2001:db8:192:168:0:1/128
```

Level-1 Interface Configuration

- Configure addresses and enable ISIS for IPv4 and IPv6

```
interface gigabitethernet0/1
 ip address 192.168.1.1 255.255.255.192
 ipv6 address 2001:db8:192:168:1:1/112
 !
 ip router isis 1
 ipv6 router isis 1
```

- Ensure this interfaces runs at Level-1

```
 isis circuit-type level-1
```

Level-1 Interface: Metrics & Auth

- Set the costs for IPv4 and IPv6

```
interface gigabitethernet0/1
 isis metric 400 level-1
 isis ipv6 metric 400 level-1
```

- Enable HMAC-MD5 for level-1

```
isis authentication mode md5 level-1
```

- Associate the key-chain defined earlier

```
isis authentication key-chain isis-sec-l1 level-1
```

Level-1 Interface: DIS and BFD

- Set this IS to be the DIS in this Level-1 area

  A DIS of 126 (higher than the default of 64) configured on another IS in this area sets it up as the backup DIS

```
interface gigabitethernet0/1
 isis priority 127 level-1
```

- Enable BFD for fast failure detection

  BFD helps reduce the convergence times of IS-IS because link failures will be signalled much quicker

```
interface gigabitethernet0/1
 bfd interval 250 min_rx 250 multiplier 3
```

Level-2 interface

- This interface is used for a trunk link to another PoP forming part of your network-wide backbone

  As such it will be a Level-2 interface, making this router a Level-1/Level-2 IS.

  Metric and authentication are all configured for Level-2

```
interface gigabitethernet0/2
 ip address 192.168.2.1 255.255.255.252
 ipv6 address 2001:db8:192:168:2:1:/126
 ip router isis 1
 ipv6 router isis 1
 isis circuit-type level-2-only
 isis metric 400 level-2
 isis ipv6 metric 400 level-2
 isis authentication mode md5 level-2
 isis authentication key-chain isis-sec-l2 level-2
```

Level 2 interface: more details

- To make this IS-IS BCP more interesting, we will assume this trunk link is a broadcast multi-access link, i.e., Ethernet.
- As this is an Ethernet interface, IS-IS will attempt to elect a DIS when it forms an adjacency

  Because it is running as a point-to-point WAN link, with only 2 IS's on the wire, configuring IS-IS to operate in "point-to-point mode" scales the protocol by reducing the link failure detection times

  Point-to-point mode improves convergence times on Ethernet networks because it:

  - Prevents the election of a DIS on the wire,
  - Prevents the flooding process from using CSNP's for database synchronization
  - Simplifies the SPF computations and reduces the IS's memory footprint due to a smaller topology database.

```
int gi0/2
 isis network point-to-point
```

ISP Best Practices

- We now configure parameters specific to the IS-IS routing protocol

  This covers both IPv4 and IPv6, as IS-IS supports both IP protocols in the same implementation

  ```
  router isis 1
  ```

- Create an NET

  This is made up of a private AFI (49), an area part, a System ID (taken from the padded Loopback interface IP address) and an N-SEL of zero (0).

  ```
  net 49.0001.1921.6800.0001.00
  ```

- Enable HMAC-MD5 authentication

  ```
  authentication mode md5
  authentication key-chain isis-sec-l1 level-1
  authentication key-chain isis-sec-l2 level-2
  ```

ISP Best Practices

- Enable iSPF (incremental SPF).

  This, in the long run, reduces CPU demand because SPF calculations are run only on the affected changes in the SPT.

  As this is a Level-1/Level-2 router, enable iSPF at both levels 60 seconds after the command has been entered into the configuration.

  Note that IOS only supports iSPF for IPv4.

```
ispf level-1-2 60
```

- Enable wide/extended metric support for IS-IS.

  IOS, by default, supports narrow metrics, which means you can define cost values between 1-63. This is not scalable.

  To solve this problem, enable wide metrics, which allows you to define cost values between 1-16777214.

```
metric-style wide
```

ISP Best Practices

- Increase ISIS default metric
  - Default value is 10
  - All interfaces in both L1 and L2 have this value
  - Not useful if configured value is “accidentally” removed - a low priority interface could end up taking full load by mistake
  - Configure a “very large” value as default

```
metric 100000
```

- Disable IIH padding because on high speed links, it may strain huge buffers; and on low speed links, it may waste bandwidth and affect other time sensitive applications, e.g., voice.
  - Disabling IIH padding is safe because IOS will still pad the first 5 IIH's to the full MTU to aid in the discovery of MTU mismatches.

```
no hello padding
```

ISP Best Practices

- Allow the Loopback interface IP address to be carried within IS-IS, while preventing it from being considered in the flooding process.

```
passive-interface Loopback0
```

- Log changes in the state of the adjacencies.

```
log-adjacency-changes
```

- Tell the IS to ignore LSP's with an incorrect data-link checksum, rather than purge them

  Purging LSP's with a bad checksum causes the initiating IS to regenerate that LSP, which could overload the IS if perpetuated in a cycle

  So rather than purge them, ignore them.

```
ignore-lsp-errors
```

ISP Best Practices

- Reduce the amount of control traffic, conserving CPU usage for generation and refreshing of LSP's.

  Do this by increasing the LSP lifetime to its limits.

  ```
  max-lsp-lifetime 65535
  ```

- Reduce the frequency of periodic LSP flooding of the topology, which reduces link utilization

  This is safe because there other mechanisms to guard against persistence of corrupted LSP's in the LSDB.

  ```
  lsp-refresh-interval 65000
  ```

- Customize IS-IS throttling of SPF calculations.

  Good for when you also use BFD for IS-IS.

  These are recommended values for fast convergence.

  ```
  spf-interval 5 1 20
  ```

ISP Best Practices

- Customize IS-IS throttling of PRC calculations.

  PRC calculates routes without performing a full SFP calculation.

  This is done when a change is signaled by another IS, but without a corresponding change in the basic network topology, e.g., the need to reinstall a route in the IS-IS RIB.

  These are recommended values for fast convergence.

  ```
  prc-interval 5 1 20
  ```

- Customize IS-IS throttling of LSP generation.

  These are recommended values for fast convergence.

  ```
  lsp-gen-interval 5 1 20
  ```

ISP Best Practices

- Enable IS-IS fast-flooding of LSP's.

  This tells the IS to always flood the LSP that triggered an SPF before the router actually runs the SPF computation.

  This command used to be 'ip fast-convergence' and has since been replaced from IOS 12.3(7)T.

  Below, we shall tell the IS to flood the first 10 LSP's which invoke the SPF before the SPF computation is started

  ```
  fast-flood 10
  ```

- Enable IS-IS IETF Graceful Restart.

  This ensures an IS going through a control plane switchover continues to forward traffic as if nothing happened

  Software and platform support is limited, so check whether your particular platform/code supports this

  Also, deploy only if it's necessary.

  ```
  nsf ietf
  ```

ISP Best Practices

- Enable BFD support for IS-IS.

  With BFD running on the interface, a failure of the link would signal IS-IS immediately

  IS-IS will then converge accordingly.

  ```
  bfd all-interfaces
  ```

- Tell IS-IS to ignore the attached bit

  The Attached bit is set when an L1/L2 IS learns L1 routes from other L1 routers in the same area

  The Attached bit causes the installation of an IS-IS-learned default route in the IS-IS RIB on L1 routers in the same area, as well as in the forwarding table if IS-IS is the best routing protocol from which the default route was learned – this can lead to suboptimal routing.

  ```
  ignore-attached-bit
  ```

ISP Best Practices

- Wait until iBGP is running before providing transit path

  `set-overload-bit on-startup wait-for-bgp`

  Avoids blackholing traffic on router restart

  Causes ISIS to announce its prefixes with highest possible metric until iBGP is up and running

  When iBGP is running, ISIS metrics return to normal, make the path valid

- Enable the IPv6 address family for in IS-IS.

  `address-family ipv6`

- Enable multi-topology support for IPv6 in IS-IS.

  Multi-topology support allows the IPv4 topology to be independent of that of IPv6

  `multi-topology`

ISP Best Practices

- Things to consider on routers operating as Level-1-only IS's:

  IS-IS BCP techniques under the IS-IS routing process

  In addition to the interface, tell the IS-IS routing process to operate in a Level-1 area only

```
router isis 1
 is-type level-1
```

ISP Best Practices

- Things to consider on routers operating as Level-1 and Level-2 IS's:

  To prevent sub-optimal routing of traffic from L1 IS's in one area to L1 IS's in another area, configure and enable Route Leaking on L1/L2 routers that form the backbone connectivity between two or more different areas

  Route Leaking permits L1/L2 routers to install L1 routes learned from one area into L1 IS's routing/forwarding tables in another area

  This allows for reachability between L1 routers located behind L1/L2 routers in different areas

```
router isis 1
 redistribute isis ip level-2 into level-1 route-map FOO
!
ip prefix-list foo permit 0.0.0.0/0 le 32
!
route-map FOO permit 10
 match ip address prefix-list foo
```

ISP Best Practices

- Doing the same for IPv6:

```
router isis 1
 address-family ipv6
  redistribute isis level-2 into level-1 route-map FOO6
!
ip prefix-list foo6 permit ::/0 le 128
!
route-map FOO6 permit 10
 match ipv6 address prefix-list foo6
!
```

ISP Best Practices

- Summary

  Best practice recommendations are commonly implemented on many ISP backbones

  Ensures efficient and scalable operation of ISIS

ISIS for ISPs

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