

IS-IS for ISPs

ISP Workshops



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Acknowledgements

- This material originated from the Cisco ISP/IXP Workshop Programme developed by Philip Smith & Barry Greene
- Use of these materials is encouraged as long as the source is fully acknowledged and this notice remains in place
- Bug fixes and improvements are welcomed
 - Please email *workshop (at) bgp4all.com*

Philip Smith

Configuring IS-IS in Cisco IOS

□ Starting IS-IS in Cisco IOS

```
router isis [name]
```

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

□ IS-IS name is unique to the router

- Gives possibility of running multiple instances of IS-IS on one router
- IS-IS process name is not passed between routers in an AS
- Some ISPs configure the IS-IS name to be the same as their BGP Autonomous System Number, e.g.

```
router isis as64510
```

Configuring IS-IS in Cisco IOS

- ❑ Once IS-IS started, the other essential configuration under the IS-IS 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 (router-wide configuration)
`is-type level-2-only`
 - Set NET address
`net 49.0001.<loopback>.00`

Adding interfaces to IS-IS

- To activate IS-IS on an interface:

```
interface HSSI 4/0
 ip router isis isp-bb
```

- 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 need for “redistribute connected”
- No IS-IS configuration for an interface:
 - No CLNS is 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
 - NB. This is NOT the same behaviour as for OSPF
 - There 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
```

Originating a default route

- IS-IS can originate a default route

- Unconditionally (i.e. always) with:

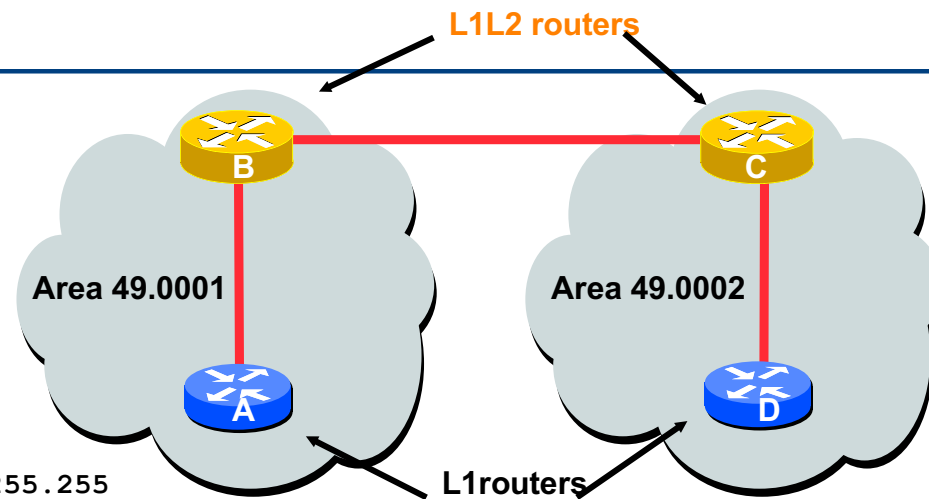
```
router isis isp-bb
  default-information originate
```

- Conditionally (for example, if BGP installs default route into RIB, IS-IS can propagate this default across the backbone):

```
router isis isp-bb
  default-information originate route-map DEFAULT-ORIG
  !
ip prefix-list DEFAULT permit 0.0.0.0/0
  !
route-map DEFAULT-ORIG permit 10
  match ip address prefix-list DEFAULT
```

- NB. This is NOT the same behaviour as for OSPF

L1/L2 example



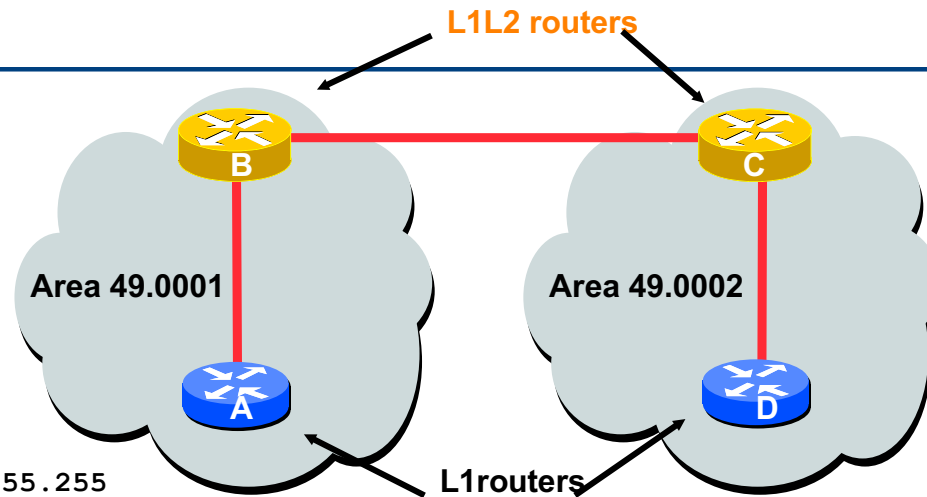
Router B

```
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
!
interface 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
```


L1/L2 example



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 GigabitEthernet3/0
 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 GigabitEthernet6/0
 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 IS-IS

- How to show the global CLNS status as seen by the router:

```
router1>show clns
Global CLNS Information:
  3 Interfaces Enabled for CLNS
  Configuration Timer: 60, Default Holding Timer: 300, Packet Lifetime 64
  ERPDUs requested on locally generated packets
  Running IS-IS in IP/IPv6-only mode (CLNS forwarding not allowed)
  NET: 49.0001.0100.0001.5241.00
```

Status Commands in IS-IS

- How to show the neighbour adjacencies as seen by the router:

```
router1>show clns neigh
```

Tag workshop:

System Id	Interface	SNPA	State	Holdtime	Type	Protocol
Router2	Fa0/0	ca01.420f.0008	Up	7	L2	M-ISIS
Router3	Se1/0	*HDLC*	Up	29	L2	M-ISIS
Router13	Fa0/1	ca0c.4210.0006	Up	7	L2	M-ISIS

- More recent IOSes replace system ID with router hostname – much easier troubleshooting

Status Commands in IS-IS

- How to show the CLNS status on a router interface:

```
router1>show clns interface fast 0/0
FastEthernet0/0 is up, line protocol is up
  Checksums enabled, MTU 1497, Encapsulation SAP
  ERPDUs enabled, min. interval 10 msec.
  CLNS fast switching enabled
  CLNS SSE switching disabled
  DEC compatibility mode OFF for this interface
  Next ESH/ISH in 17 seconds
  Routing Protocol: IS-IS (workshop)
    Circuit Type: level-2
    Interface number 0x0, local circuit ID 0x1
    Level-2 Metric: 2, Priority: 64, Circuit ID: Router2.01
    DR ID: Router2.01
    Level-2 IPv6 Metric: 2
    Number of active level-2 adjacencies: 1
    Next IS-IS LAN Level-2 Hello in 4 seconds
```

Status Commands in IS-IS

- How to display the status of the CLNS protocol on the router:

```
router1#show clns protocol
IS-IS Router: workshop
  System Id: 0100.0001.5241.00  IS-Type: level-2
  Manual area address(es) :
    49.0001
  Routing for area address(es) :
    49.0001
  Interfaces supported by IS-IS:
    Serial11/0 - IP - IPv6 - IPv6
    FastEthernet0/1 - IP - IPv6 - IPv6
    FastEthernet0/0 - IP - IPv6 - IPv6
  Passive interface:
    Loopback0
  Redistribute:
    static (on by default)
  Distance for L2 CLNS routes: 110
  Generate wide metrics: level-2
  Accept wide metrics: level-2
```

Other status commands

- Shows CLNS traffic statistics and activity for the network

```
show clns traffic
```

- Shows the IS-IS link state database

```
show isis database
```

- Shows the IS-IS routing table

```
show isis rib
```

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 (L2) is quite feasible today

Network Design Issues

- Link cost
 - Default on all interface is 10
 - (Compare with OSPF which sets 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 neighbour 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
 - Area would have one single exit point
- Starting with L2-only everywhere is a good choice
 - Future implementation of level-1 areas for network edges 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 still using narrow metrics should first configure transition metrics 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 best common practices (1)

- NET address construction
 - Area and loopback address
- L2
 - Configure globally in IS-IS process
 - L1-L2 and L1 can be used later for scaling large networks
- Wide metrics
 - Narrow metrics are too limiting
 - Needed for IPv6 anyway
- Point-to-point links using broadcast media
 - Declare as point-to-point

ISP best common practices (2)

- Set over-load bit to wait for BGP
 - Vital on router restart to avoid blackholing transit traffic
- Deploying IPv6 in addition to IPv4
 - Recommendation: for greenfield deployments, use single-topology (IOS default) unless an incremental roll-out of IPv6 is intended
 - Multi-topology is useful (IOS-XR default) for an incremental roll-out, and if there should be future differences in topology between IPv4 and IPv6

Advanced IS-IS Configuration



(for experts only)

Developed by Mark Tinka &
Philip Smith

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
```

IS-IS neighbour authentication

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

```
key chain isis-level1
  key 1
    key-string xxxxx
!
key chain isis-level2
  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 IS-IS 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 interface runs at Level-1

```
interface gigabitethernet0/1
 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-level1 level-1
```

Level-1 Interface: DIS and BFD

- Set this IS (router) 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 more quickly

```
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-level2 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.

```
interface GigabitEthernet0/2
 isis network point-to-point
```

IS-IS Process

- 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 as100
```

IS-IS Process

- Create an NET for the IS-IS process:
 - 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
```

IS-IS Process

- Under the IS-IS process enable HMAC-MD5 authentication:

```
authentication mode md5
authentication key-chain isis-level1 level-1
authentication key-chain isis-level2 level-2
```


Advanced Configuration

- 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
```

Advanced Configuration

- 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
```

Advanced Configuration

□ Increase IS-IS 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
```

Advanced Configuration

□ Disable IIH padding

- On high speed links, it may strain huge buffers
- 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
```

Advanced Configuration

- 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
```

Advanced Configuration

- 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
```

Advanced Configuration

- 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
```

Advanced Configuration

- 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
```

- Customize IS-IS throttling of LSP generation.
 - These are recommended values for fast convergence.

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


Advanced Configuration

- 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
```

Advanced Configuration

- 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
```

Advanced Configuration

- 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
```

Advanced Configuration

- 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
```

Advanced Configuration

- 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
```

Advanced Configuration

- Wait until iBGP is running before providing transit path

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

- Avoids blackholing traffic on router restart
- Causes IS-IS 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

Advanced Configuration

- 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 network topology to be independent of that of IPv6

```
multi-topology
```

Advanced Configuration

- 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
```


Advanced Configuration

- 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
```

Advanced Configuration

□ Doing the same for IPv6:

```
router isis 1
  address-family ipv6
    redistribute isis level-2 into level-1 route-map F006
  !
ip prefix-list foo6 permit ::/0 le 128
!
route-map F006 permit 10
  match ipv6 address prefix-list foo6
!
```

Advanced Configuration

□ Summary

- Best practice recommendations are commonly implemented on many ISP backbones
- Ensures efficient and scalable operation of IS-IS

IS-IS for ISPs



ISP Workshops