IS-IS versions

- IS-IS
  - ISO 10589
  - OSI network layer routing protocol
  - Works only with
    - CLNS / CLNP
    - OSI Network protocol for connectionless services

- Integrated IS-IS
  - RFC 1195
  - Integration of IP addresses into OSI CLNP reference model
  - Three operation modes:
    - Pure CLNS
    - Pure IP
    - Mixed CLNS/IP
  - Operation is always based on CLNS model

IS-IS

- Linkstate protocol like OSPF
- Dijkstra SPF
- Operates directly on top of link layer
- Parallel to IP
  - Pros: Independent of IP addressing
  - Cons: Difficulties with ATM null encapsulation (TCP ACK falls within 48 bytes with null encaps otherwise 56 bytes → two cells)
- Uses SNAPs in L2 addressing
  - Sub Network Point of Attachment (MAC, VC, DLCI)
- Supports
  - Point-to-point links
  - Broadcast links
- Uses multicast MAC addresses in communication

Addressing

- IS-IS uses OSI addressing at L3
- Network Service Access Point (NSAP)
  - Also used in ATM, CMIP ...
  - Conceptually max 20 byte long address format
  - Different structuring depending on sponsoring organisation and usage

<table>
<thead>
<tr>
<th>NSAP Addresses</th>
<th>Address Domain</th>
<th>Authority</th>
<th>AFI</th>
</tr>
</thead>
<tbody>
<tr>
<td>X.121 (K.25)</td>
<td>ITU-TSB</td>
<td>36-37</td>
<td></td>
</tr>
<tr>
<td>ISO Data Country Code (IOC)</td>
<td>National Standard Bodies</td>
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</tr>
<tr>
<td>E.164 (ISDN)</td>
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<td>ISO Basic International Code Designator (ICD)</td>
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<tr>
<td>Local</td>
<td></td>
<td>48-49</td>
<td></td>
</tr>
</tbody>
</table>

IS-IS NSAP Addressing

- Special version of NSAP address – Network Entity Title (NET)
- Area ID defines the L2 or L1 area the router belongs to
- System ID is unique identifier of system within the area
- Same functionality as OSPF router-ID
- Selector is internal process ID with IP routers this is always 00

System ID | Selector | Area ID | Level
---------|----------|--------|-----
00        | 00       | 00     | 00  

S-38.3192 Network Service Provisioning

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Addressing

- Administration of SysID is similar to administration of Router-ID
  - It should be unique within domain
  - Replaces cause problems for SPF
    - SPF is executed over sysIDs not over prefixes
  - It should be easily understandable (helps troubleshooting)
  - One convention is to use IP address of the loopback interface as the source for this information (like in OSPF)

- Loopback IP address: 10.100.100.4
  - Hex encoded zeroes at front: 0000.0A64.6404
  - Hex encoded zeroes at end: 0A64.6404.0000
  - Positional decimal coding: 0101.0010.0004
  - Direct decimal coding: 1010.0100.4000

Area

- IS-IS area is determined by router NET
  - Router can have multiple NETs
  - Resulting multiple partial adjacencies
  - Area boundary is the logical boundary defined by the adjacencies
  - There are no adjacency over particular link
- Two types of areas
  - L2 e.g. Backbone
  - L1 e.g. Non-backbone
- Three types of routers
  - L1 router
  - L2 router
  - L1/L2 router

Broadcast support

- Problem of scaling the number of adjacencies
  - But is this really a problem
    - With OSPF: YES
    - With IS-IS: NO
  - Broadcast networks are not that nice in SPF calculations due to ghost nodes
  - Make broadcast links point-to-point when it is used at such
  - Adjacency is formed between each router which fulfills area requirements on the same link
  - Exponential increase of adjacencies over the number of nodes sharing the link and area
  - Pseudonode emulation
    - Link is emulated as a node with zero cost
    - Implemented as designated router (DR) / Designated Intermediate System (DIS)
    - Reflector of routing information
    - Adjacencies only to DIS / DIS

- IS-IS
  - Only one intermediate system acts as a pseudonode
  - L2 multicast addresses used
    - 0180.0000.0014
    - 0180.0000.0015
  - Everybody hears everybody
  - Fullmesh of adjacencies

- OSPF
  - Two routers act as pseudonodes
    - Designated Router
    - Backup Designated Router
  - L3 multicast addresses used
    - 224.0.0.5: AllSPFRouters
    - 224.0.0.6: AllDRouters
IS-IS and OSPF

- IS-IS
  - Operates on top of L2 interface
  - NLPID coded
  - Link state operation
  - Dijkstra SPF
  - Two level hierarchy
    - Level-1
    - Level-2
    - Area border on links
    - Pseudonode emulation on LANs
    - Designated Router (DIS)
    - Support for IP added later on

- OSPF
  - Operates on top of IP
  - Protocol 89
  - Link state operation
  - Dijkstra SPF
  - Two level hierarchy
    - Backbone
    - Other area
    - Area border on nodes
    - Split nodes
    - Pseudonode emulation on LANs
    - Designated Router (DR)
    - Backup Designated Router (BDR)

IS-IS vs OSPF

- OSPF
  - Packet format is variable
  - Positional fields with 32-bit alignment
  - Link State Database (LSDB) presented as LSAs
  - Content mixture of positional coding and TLV coding
  - Unknown LSA types are discarded (not flooded)

- IS-IS
  - Positional header with TLV-coded messages
  - No particular alignment
  - Link State Database (LSDB) presented as LSPs
  - Content TLV coded
  - Unknown messages are ignored (flooded)
  - Actual information about the network is in TLVs
  - Easily extensible to new features

OSPF LSDB

- Built from the Link State Advertisements (LSA)
- Separate protocol elements and state machines handle the synchronization
  - LS Update
    - LSA grouped into LSUpdates during flooding
    - LSUpdates are built individually at each hop based on accepted LSAs
  - LS Acknowledge
    - Each LSA has to be acknowledged otherwise they are retransmitted
  - LS Request
    - Missing or outdated information can be updated from the neighbor
  - Database description
    - LSDB structure as LS headers

OSPF State Machine

- Four phases
  - Neighbour enquiry
    - Init + 2-way: Hello protocol
    - Database initialization
      - Exchange + Loading: DD
      - Database synchronization
        - Exchange + Loading: LS request, LS update, LS acknowledge
        - Flooding
          - Full: LS update, LS acknowledge

LSA types

- OSPF contains separate LSA type for each different information element
  - Tightly coded message structures
  - Optimized for 32bit processing
  - LSAs are valid only on certain points of network and areas
  - Unknown LSA types are rejected
  - Flooding is based only on accepted LSAs

OSPF LSDB

- Built from Link State PDUs (LSP)
  - LSPs are basically TLV triplets
  - Type (Code) defines the format of value
  - Length defines the length of TLV
  - Informational element to be processed
  - LSP carries several TLV coded elements (default maximum 1492 bytes per LSP)
  - LSPs are flooded as is
    - Information is delivered intact from the originator to all of the routers in the area
    - If router does not support certain TLV it just ignores the TLV
    - Gradual update of capabilities
**IS-IS LSDB**

- Simple state machine
  - Neighbour enquiry
  - Hello protocol
- Database synchronization and Flooding
  - Complete Sequence Number PDUs
  - Partial Sequence number PDUs
  - Link State PDUs
- Synchronization is based on periodical descriptions of complete database

**Some IP related TLVs**

- Area Addresses (C=1)
  - List of all AIDs present at sender
- Neighbors (C=2)
  - List of sender’s neighbors (SysID)
- Protocols supported (C=129)
  - NLPRIDs of supported protocols:
    - IPv4 = 204
- IP Interface Addresses (C=132)
  - IP addresses of IS-IS interfaces on the sender
- IP Internal Reachability (C=128)
  - IP prefixes directly connected to sender and their metrics
- Extended IS Reachability (C=22)
  - Similar than neighbors but wide metrics
- IP External Reachability (C=130)
  - IP prefixes external to (IS-IS domain)
- Extended IS Reachability (C=22)
  - Similar than neighbors but wide metrics
- Extended IP Reachability (C=135)
  - Same as Internal and External but with wide metrics

**Overload**

- In large carrier networks restarting a router causes reload in
  - IGP
    - Fast convergence (few tens of seconds)
    - IS-IS faster than OSPF due to its simpler state machine
  - BGP
    - Slow convergence if default free (may take minutes to load all the prefixes)
  - Overload bit in IS-IS makes router present in the network but not candidate for forwarding transit traffic
    - Timed clearing of overload bit is common feature in NOS
  - Causes new calculation of SPF when bit is cleared

**OSPF vs IS-IS**

- OSPF
  - Complex
  - Easier to manage
  - Default behavior is to do everything that adjacent is capable
  - Difficult to add new features
  - Good area control
  - Dependent on 32bit IP addresses
  - Architectural dependency
    - OSPFv3 changes this
- IS-IS
  - Less complex
  - Difficult to manage advanced features
  - Responds routing policies
  - Default behavior is to do anything but basic LS / SPF
  - Easier to add new features
  - Scalable on single area
  - Good for carrier environments
  - No architectural dependency to IP addresses