Introduction to ISIS

ISP/IXP Workshops

IS-IS Standards History

- ISO 10589 specifies OSI IS-IS routing protocol for CLNS traffic

  A Link State protocol with a 2 level hierarchical architecture

  Type/Length/Value (TLV) options to enhance the protocol

- RFC 1195 added IP support

  Integrated IS-IS

  I/IS-IS runs on top of the Data Link Layer

  Requires CLNP to be configured

- RFC5308 adds IPv6 address family support to IS-IS

- RFC5120 defines Multi-Topology concept for IS-IS

  Permits IPv4 and IPv6 topologies which are not identical

  (Required during staged roll-out of IPv6 on existing IPv4 infrastructure)

ISIS Levels

- ISIS 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

ISIS Levels

- ## Level-1 router

    Has neighbours only on the same area

    Has a level-1 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.

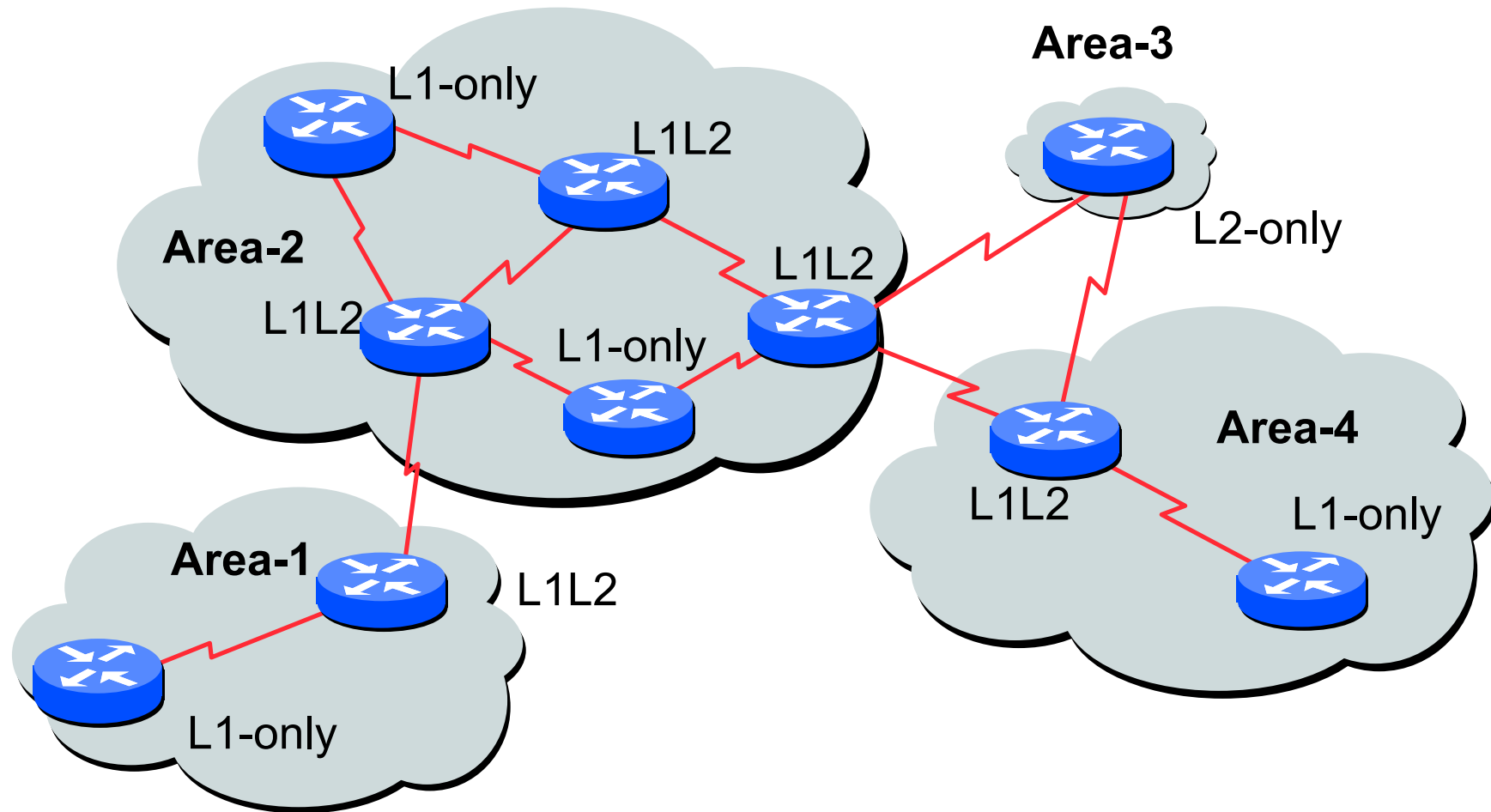   Has two separate LSDBs: level-1 LSDB & level-2 LSDB

Backbone & Areas

- ISIS does not have a backbone area as such (like OSPF)

- Instead the backbone is the contiguous collection of Level-2 capable routers

- ISIS area borders are on links, not routers

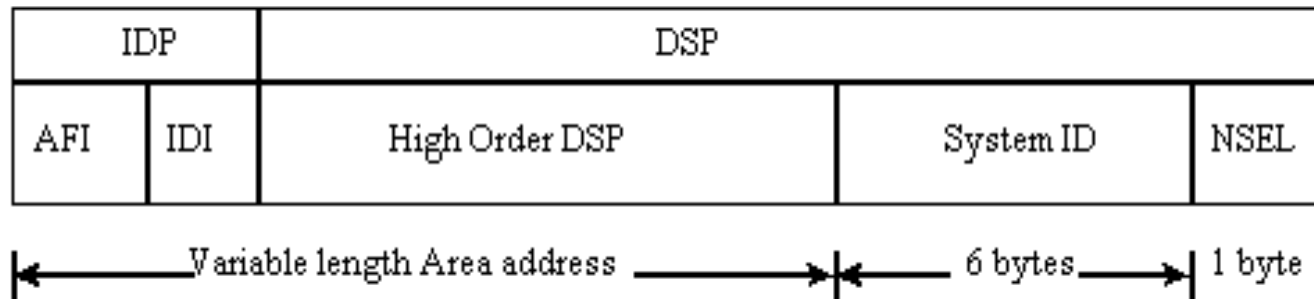- Each router is identified with a unique Network Entity Title (NET)

    - NET is a Network Service Access Point (NSAP) where the n-selector is 0

    - (Compare with each router having a unique Router-ID with IP routing protocols)

L1, L2, and L1L2 Routers

NSAP and Addressing

IDP		DSP		
AFI	IDI	High Order DSP	System ID	NSEL

Variable length Area address ⟶ ⟵ 6 bytes ⟶ 1 byte

- NSAP: Network Service Access Point
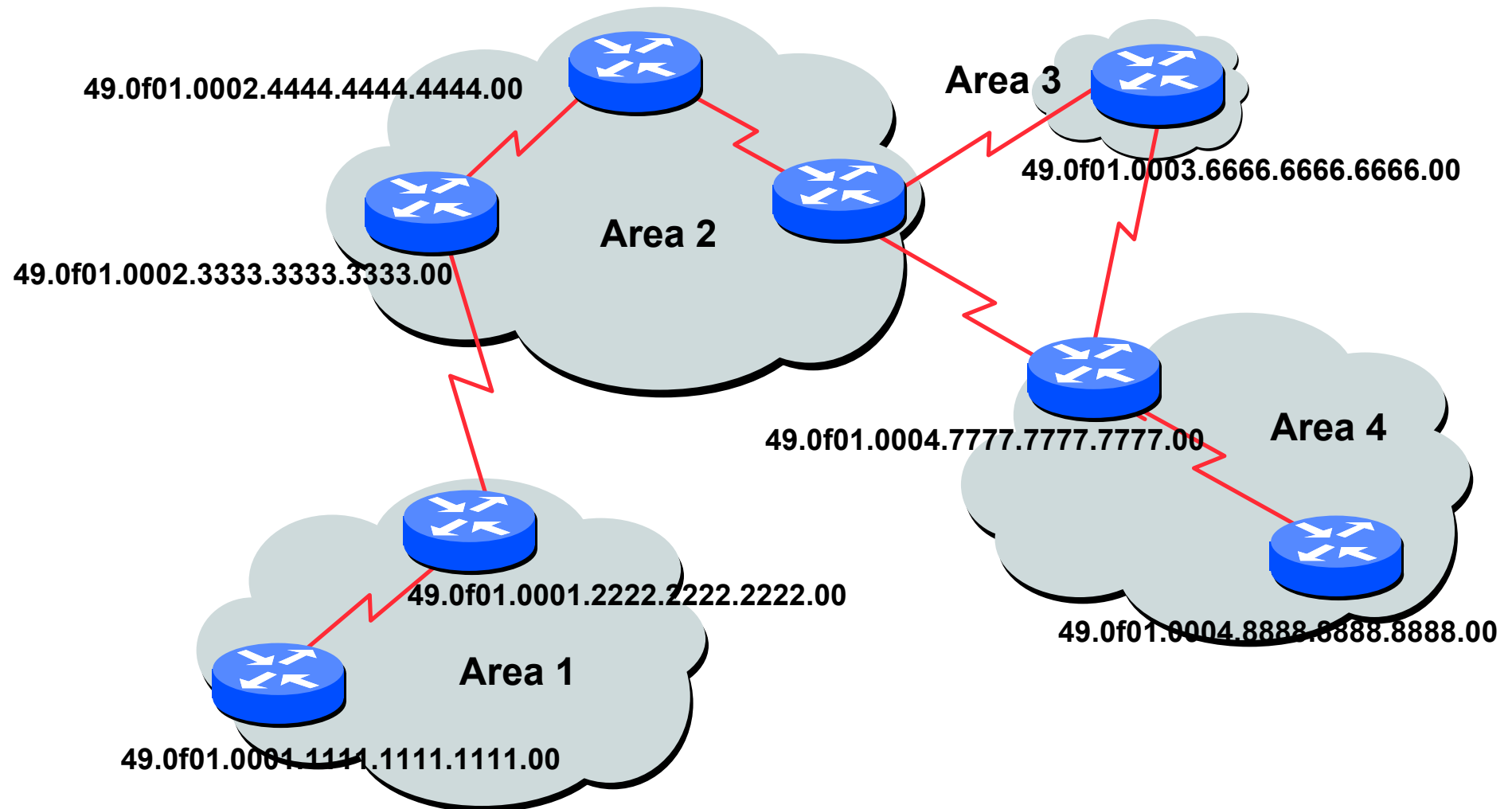
  Total length between 8 and 20 bytes

  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

An Addressing Example

49.0f01.0002.4444.4444.4444.00

Area 3

49.0f01.0003.6666.6666.6666.00

Area 2

49.0f01.0002.3333.3333.3333.00

49.0f01.0004.7777.7777.7777.00

Area 4

49.0f01.0001.2222.2222.2222.00

49.0f01.0004.8888.8888.8888.00

Area 1

49.0f01.0001.1111.1111.1111.00

Addressing Common Practices

- ISPs typically choose NSAP addresses thus:

  First 8 bits – pick a number (usually 49)

  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

Addressing & Design Practices

- ISPs usually only use one area

    Multiple areas only come into consideration once the network is several hundred routers big

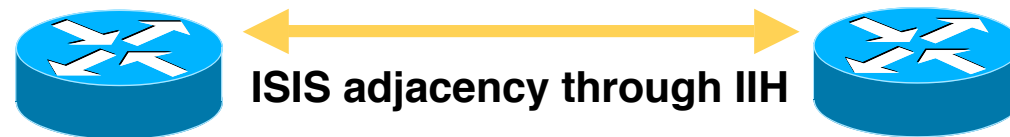- NET begins with 49

    "Private" address range

- All routers are in L2 only

    Note that IOS default is L1L2

    Set L2 under ISIS generic configuration (can also be done per interface)

Adjacencies

- Hello Protocol Data Units (PDUs) are exchanged between routers to form adjacencies

ISIS adjacency through IIH

- Area addresses are exchanged in IIH PDUs

  Intermediate-System to Intermediate System Hello PDUs

  (PDU is ISIS equivalent of a packet)

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)

The ISIS LSP

- LSPs have a Fixed Header and TLV coded contents

- The LSP header contains

  LSP-id   Sequence number

  Remaining Lifetime   Checksum

  Type of LSP (level-1, level-2)

  Attached bit   Overload bit

- The LSP contents are coded as TLV (Type, Length, Value)

  Area addresses

  IS neighbours

  Authentication Information

Link State Database Content

- Each router maintains a separate LSDB for level-1 and level-2 LSPs

- The LSDB contains:

    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

- All routers get all LSPs

- Each LSP has a sequence number

- There are 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

- Each LAN has a Designated Router (DIS)

- The DIS has two tasks

    Conducting the flooding over the LAN

    Creating and updating a special LSP describing the LAN topology (Pseudonode LSP)

- 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 for the other

    Tie break is by the highest MAC address

Flooding on a LAN

- DIS conducts the flooding over the LAN

- DIS multicasts CSNP every 10 seconds

- All routers on 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 the LSDB is large, multiple CSNPs are sent**

- **Used on 2 occasions:**

    Periodic multicast by DIS (every 10 seconds) to synchronise the 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

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 network is so large requiring the use of areas, use summary-addresses

- >400 routers in the backbone is quite doable

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 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
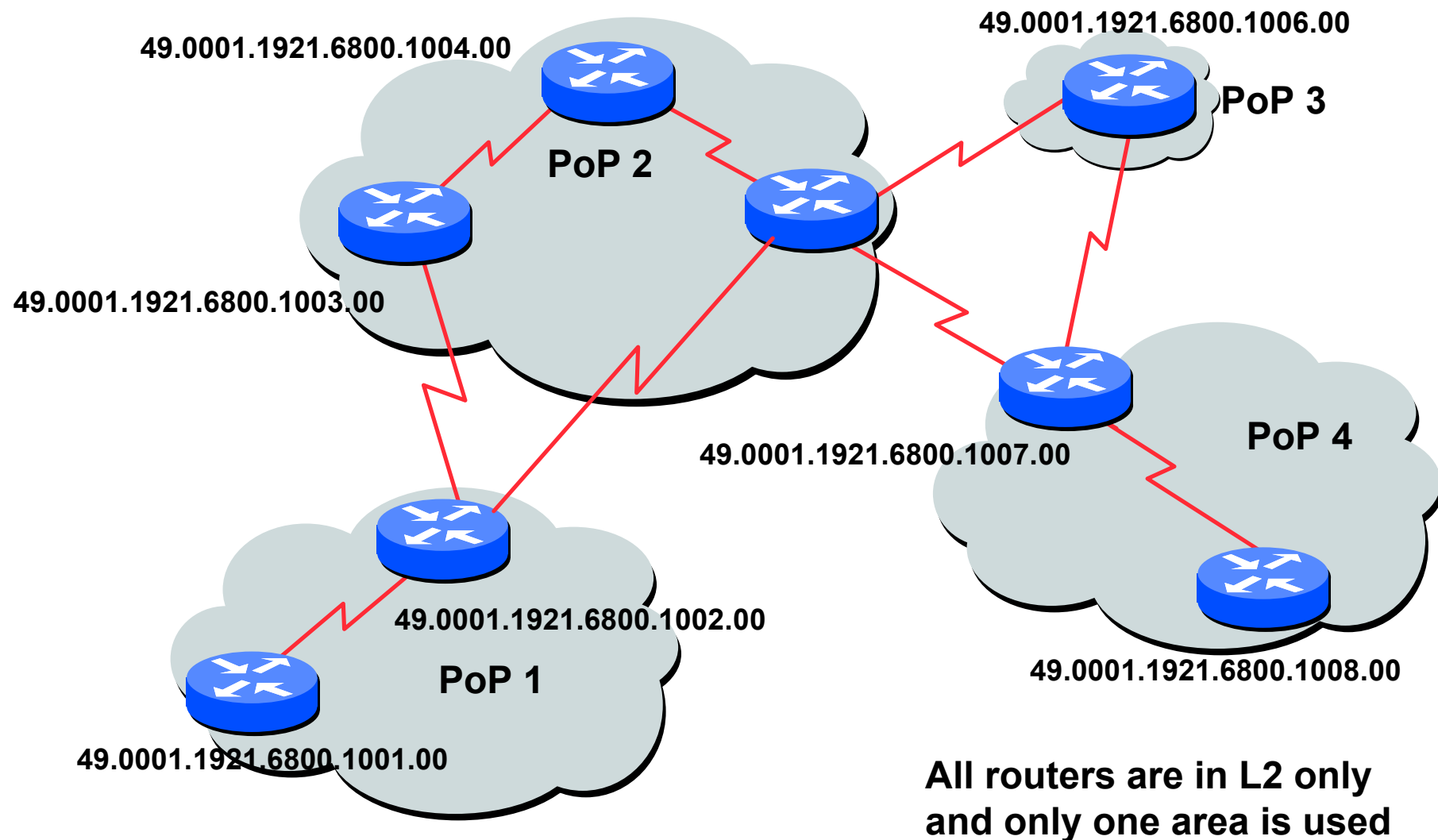
    areas with one single exit point

- Start with L2-only everywhere

    Future implementation of level-1 areas will be easier

    Backbone continuity is ensured from start

Typical ISP Design

49.0001.1921.6800.1004.00

49.0001.1921.6800.1006.00

PoP 3

PoP 2

49.0001.1921.6800.1003.00

49.0001.1921.6800.1007.00

PoP 4

49.0001.1921.6800.1002.00

PoP 1

49.0001.1921.6800.1008.00

49.0001.1921.6800.1001.00

**All routers are in L2 only
and only one area is used**

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