Data Center Network Discovery Protocols

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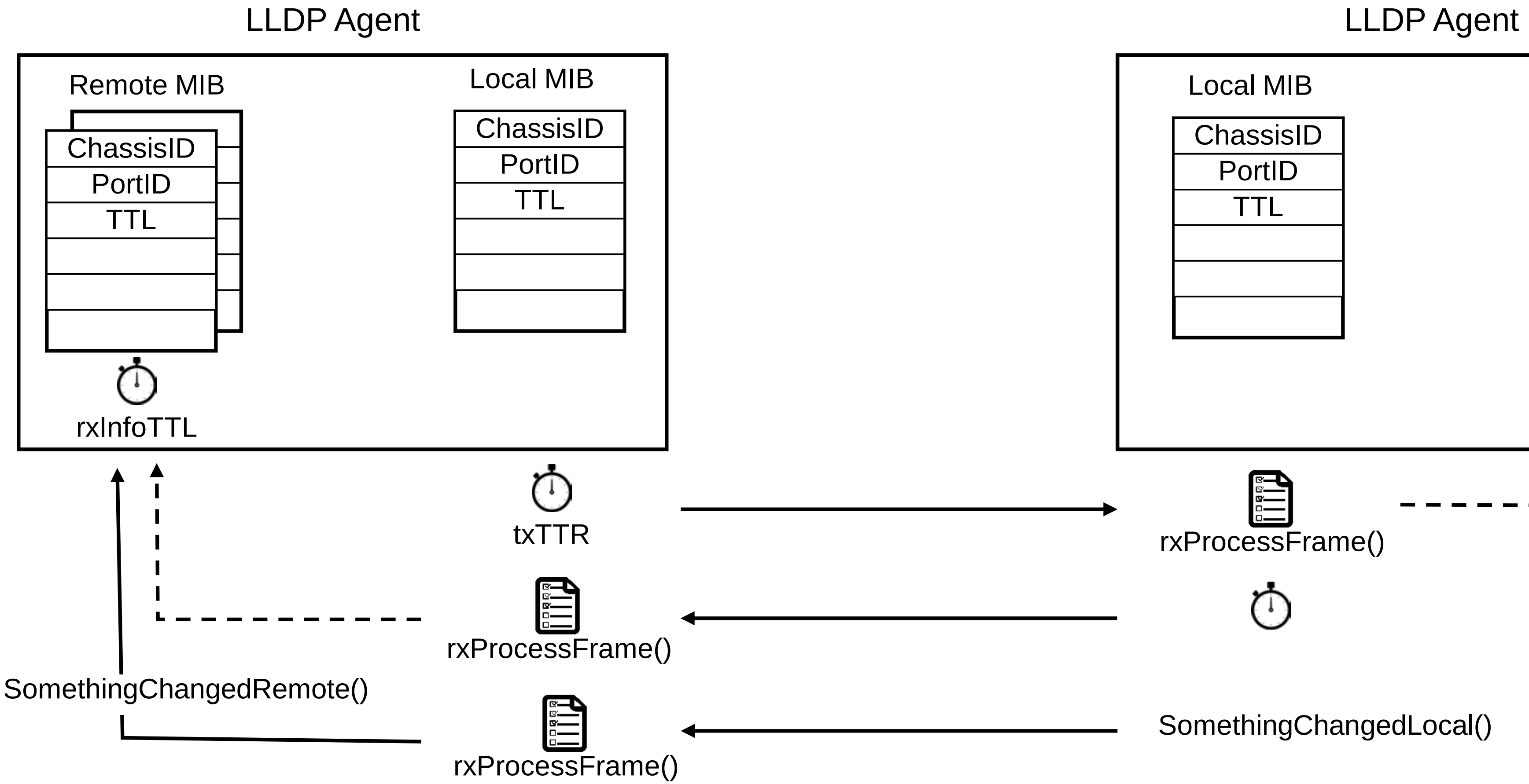
Discovery Protocols

- New IETF work on Link State Vector Routing (lsvr) has resulting in development of a discovery protocol called Layer 3 Data Link (l3dl) also IETF bgp group has a contribution for neighbor discovery protocol
  - The lsvr draft in progress draft-ietf-lsvr-l3dl-00
  - The idr contribution draft-xu-idr-neighbor-autodiscovery-11
- Work recently completed at IEEE on extensions to Virtual Station Interface Discovery and Configuration Protocol (vdp) in 802.1Q-2018 clauses 40, 41, and 43 plus the new amendment 802.1Qcy-2019 (extends VDP to cover IP addressing for split NVE or NVO3)
- Work in progress at IEEE on Auto Attach (P802.1Qcj) which is currently described for Provider Backbone Bridges, however could also be applied to EVPN environments.
  - Open source for LLDP auto attach is at: https://github.com/auto-attach/aa-lldpd
  - Provides discovery of VID to I-SID mapping for BEBs attaching to servers
- Proposed new IEEE project on LLDPv2 (802.1QBdh)
  - Main purpose is to extend LLDPv2 to support the requirements for lsvr discovery and to support more TLVs
  - The LLDPv2 project will be an amendment of 802.1AB-2016 (P802.1ABdh)
  - The LLDPv2 project will allow LLDPv2 to send multiple frame databases
  - LLDPv2 will be backward compatible with LLDPv1
  - LLDPv2 will also add new TLVs to support discovery of IP and MPLS addressing
  - LLDPv2 by be sufficient to fill most of the discovery needs without the additional protocols

Objectives for New LLDPv2 Method

- Support LLDP databases larger than a single frame
  - IETF is working on discovery database sizes around 64K octets
- Support the ability to limit the LLDP frame size to meet timing constraints imposed by some TSN applications
  - Do we need to split TLVs over multiple PDUs?
- Support the ability to communicate with an LLDPv1 implementation
  - Only the first (base) LLDPDU would be exchanged between and LLDPv1 and LLDPv2 implementation
- Support shared media
  - Both for the base database and extension database PDUs
- Ensure the integrity of the full set of TLVs is received by partner
  - This can be useful in v1 implementations as well
  - Do we also need to provide a means to authenticate the LLDP database? The IETF has this requirement.
- Support pacing of frames to receivers to prevent overloading low level network firmware
  - Historically OSPF and IS-IS have had problems from lack of flow and congestion management
- Reduce network traffic by reducing periodic transmission to the minimum
  - Only update the base LLDPv1 PDU periodically
  - Update other PDUs only when they have changed
- Reduce the computational load required by LLDPv2 receivers to update and validate the database
- Other optimizations and considerations which may be useful
  - Multiple manifests
  - Larger TLVs
  - TLVs spanning multiple extension database PDUs
  - Database authentication

Current LLDP Operation



NOTE: Remote and Local MIBs are databases that must fit within a single frame length PDU

Replace all values of the Remote MIB with contents of LLDPDU when something changes

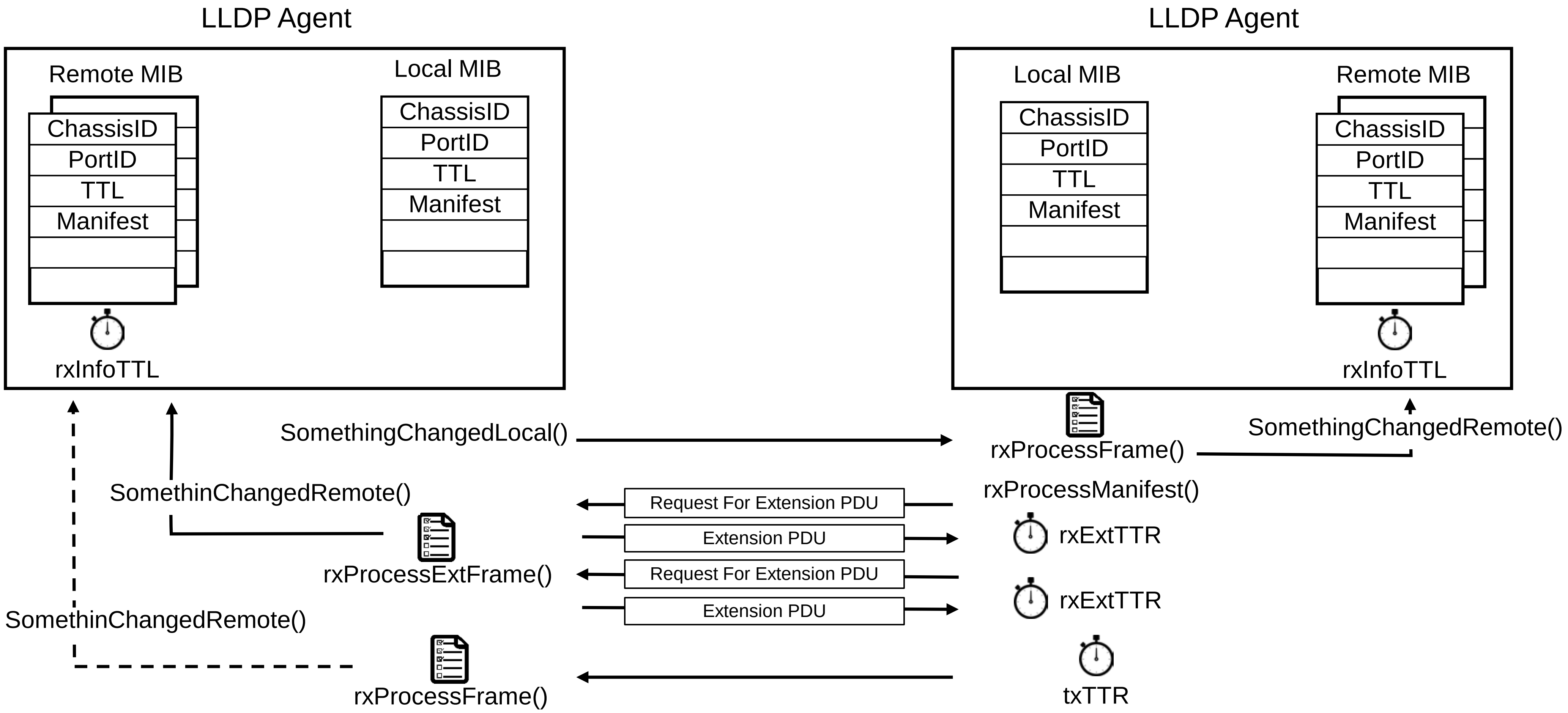
Proposal

- Define the current LLDPv1 database as the base database
  - Has a size not to exceed a single frame (an LLDPDU is a single frame)
  - The base database is exchanged as a single LLDPDUv1
  - Define an LLDPv2 extension database as a database of size 1-n frames described by an LLDPv2 manifest
  - An extension database is exchanged by a set of PDUs identified by the LLDPv2 manifest
  - An LLDPv2 manifest is encoded in an manifest TLV and must be carried in the base database
  - If no manifest TLV is present in the base database then no extension databases exist
  - The upper limit to the number of frames is determined by the LLDPv1 TLV size limit (512) and the format of the manifest
- The manifest TLV defines:
  - A way to uniquely identify each frame in the extension database
- Transmission of extension PDUs is controlled by the receiver by using explicit requests to the sender
  - Extension PDUs are transmitted from the source LLDPv2 Agent to a unicast destination determined by the request
  - A LLDPv2 receiving agent may only have a single extension PDU request pending at a time
  - Each extension PDU requests may ask for as many PDUs as desired
  - The receiving agent may use multiple extension PDU requests to pace frame reception

Proposal Continued

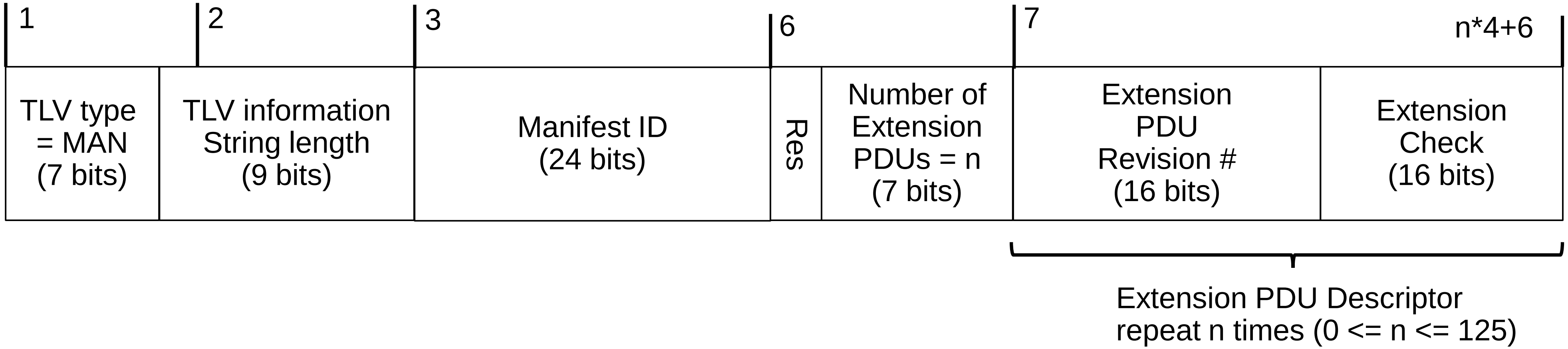
- The new LLDPDUv2s will be ignored by LLDPv1
  - Since the extension PDUs are unicast, an LLDPv1 will never receive any extension PDUs
- Each extension PDU needs to have a mandatory format:
  - Each extension PDU contains the first two mandatory TLVs of a LLDPDUv1 (ChassisID + PortID)
  - Each extension PDU contains a new TLV that identifies the PDU
- A new Request for Extension (RFE) message is sent from receiving peer to load an extension database
  - Support multiple peers on a shared media
  - Loading an extension database at the receiver LLDPv2 is at the systems discretion
  - Extension databases are not multicast and are loaded based on receiver paced RFE message
  - The receiver only load an extension database of interest when it determines it’s current database is out of date
  - Transmitters only periodically send the 1st PDU
  - TTL in 1st PDU relates to all extension PDUs
- Options
  - Multiple Extensions databases could be supported

Alternative LLDPv2 Operation Proposal



NOTE: Send LLDPDUv1 as specified by LLDPv1 when something changes and periodically
Only send extension LLDPDUv2s when explicitly requested by a RFE
Only issue RFE when manifest shows the local copy is out of date

Example Manifest TLV

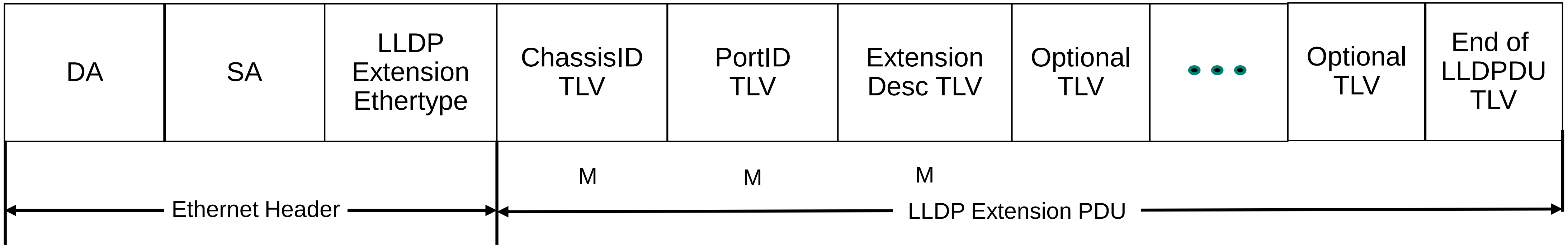


1	2	3	6		7	n*4+6
TLV type = MAN (7 bits)	TLV information String length (9 bits)	Manifest ID (24 bits)	Res	Number of Extension PDUs = n (7 bits)	Extension PDU Revision # (16 bits)	Extension Check (16 bits)

Extension PDU Descriptor
repeat n times (0 <= n <= 125)

- Manifest ID identifies the extension database (for present a single constant chosen by committee (i.e. an CID, 0x1, etc))
  - This may be used in the future for determining if a receiver wishes to load the extension database
- Number of extension PDUs indicates the number of valid PDU descriptors in the manifest
  - Some implementations may fix the manifest TLV size however load it with a variable number of PDUs
- Each Extension PDU is identified by a:
  - PDU number which is implied by the index to the location of the PDU Descriptor
  - PDU revision which is updated each time something changes in the PDU (16 bit mod 64K)
  - PDU check sum contains a 16 check. Possible options for this check are:
    - the low order 16 bits of a SHA-256 or MD5 hash of the frame
    - a CRC16 calculation of the frame
- Implicit encoding of the PDU number provides the smallest possible extension PDU descriptor allowing the largest possible extension database size
  - Since the PDU number is implicitly encoded inserting or deleting a PDU from the middle of the extension database is a relatively expensive operation.

Extension PDU



– LLDP Extension Ethertype

  – Since extensions are not multicast and only delivered on request no new Ethertype is required, though one could be used if desired

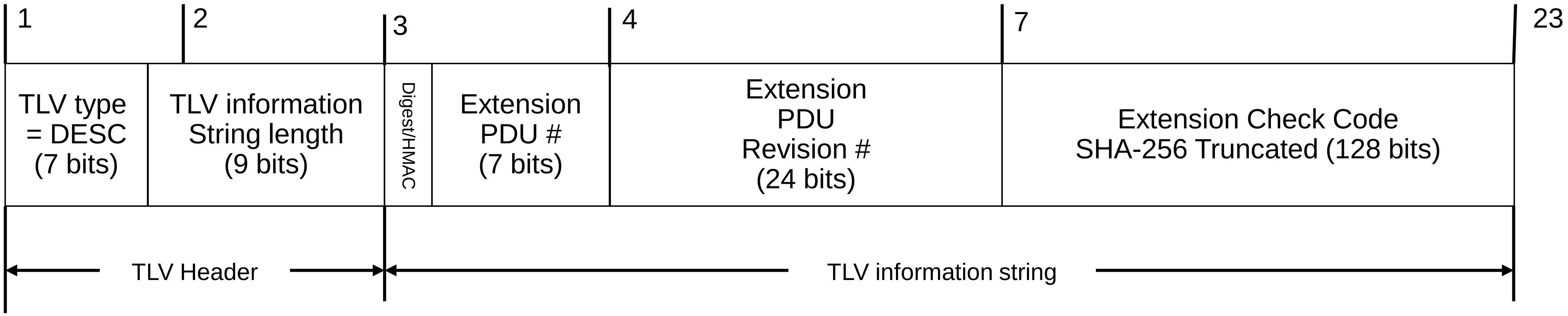
– Chassis ID + Port ID are mandatory

  – Note TTL from 1st PDU should apply and is not needed here

– Extension Description TLV is mandatory

  – Identifies this Extension PDU, the PDU revision, and the PDU hash

Extension Description TLV



1
2
3
4
7
23

TLV type = DESC (7 bits)

TLV information String length (9 bits)

Digest/HMAC

Extension PDU # (7 bits)

Extension PDU Revision # (24 bits)

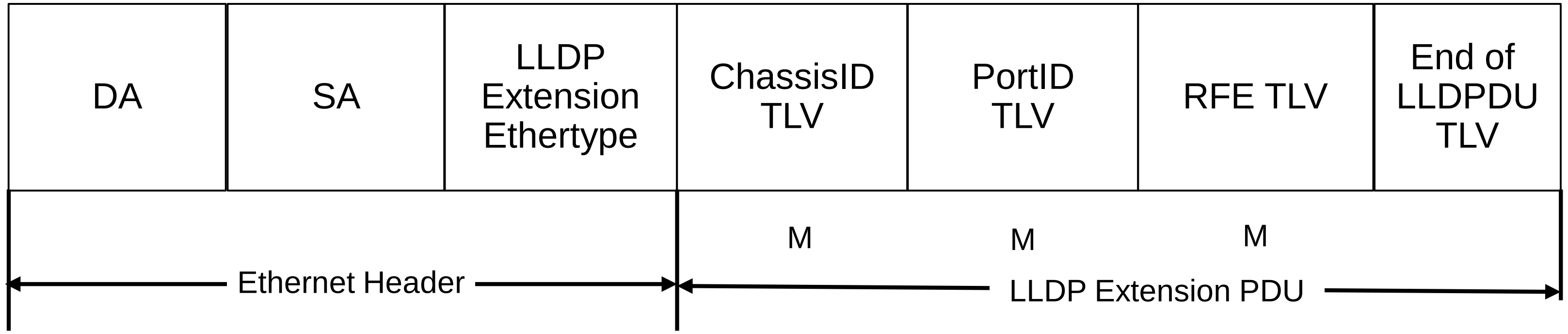
Extension Check Code SHA-256 Truncated (128 bits)

TLV Header

TLV information string

- Extension PDU # is the designation number for this PDU
  - The PDU number is in the range from 1 – 126
  - PDU number 0 may be used to include a descriptor TLV in the base database
- Digest/HMAC indicates of the Check Code computation includes a key
- Extension PDU Revision # is the long revision #
  - The low 16 bits of this number are used as the revision in the manifest TLV
- Extension PDU Hash
  - The check is computed over all TLVs within the PDU including the extension description TLV
  - The Hash may be used as an HMAC if the two devices have already exchanged keys. In this case the TLV along with certificates will be hashed.

Request For Extension PDUs



DA	SA	LLDP Extension Ethertype	ChassisID TLV	PortID TLV	RFE TLV	End of LLDPDU TLV
			M	M	M	

– Since these are unicast to the source of the base database they would only arrive at an LLDPv1 agent as a result of a bug

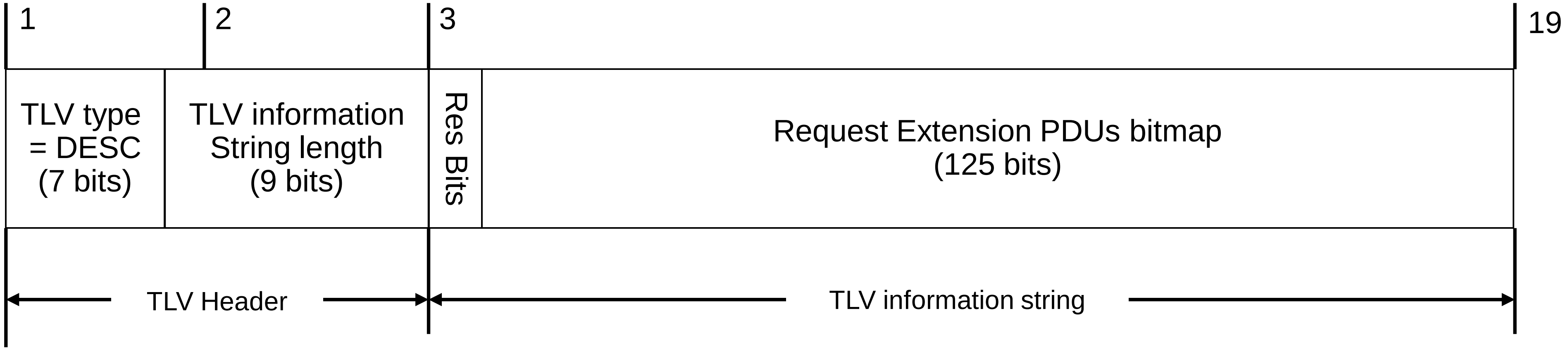
  – Using a new Ethertype will prevent a transmission error for corrupting an LLDPv1 database

– ChasssisID and PortID are mandatory

– Request for Extension PDU TLVs

  – Identifies extension PDUs that need to be set by peer

Request Extension PDUs TLV



1

2

3

19

TLV type = DESC (7 bits)

TLV information String length (9 bits)

Res Bits

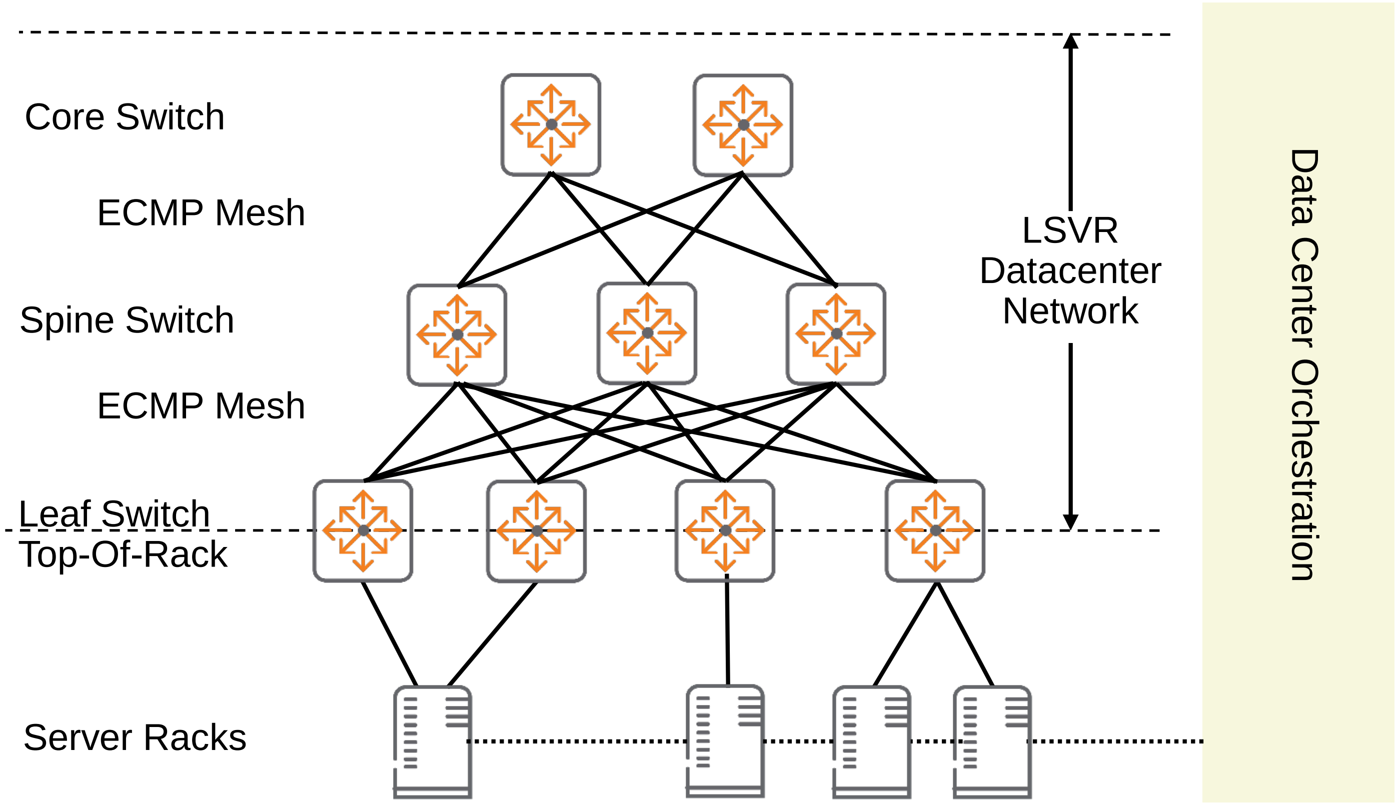
Request Extension PDUs bitmap (125 bits)

TLV Header

TLV information string

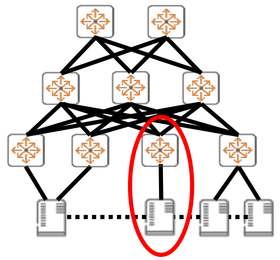
- Request for extension PDUs
  - Multiple RFEs may be used to pace the frames at the receiver by withholding RFEs
  - A single RFE may request multiple frames if the receiver has sufficient buffer for them
- Extension LLDPDUs are not multicast, instead they are unicast frames
  - The frames are sent to the SA address within the RFE PDU
  - On a shared media each individual LLDP Agent must provide independent requests for extension frames
  - This allows the individual receivers to pace PDUs at rates that match their ability to handle the reception
  - Since LLDPv2 Extension PDUs are unicast they will not interfere with LLDPv1 implementations which will never issue RFEs

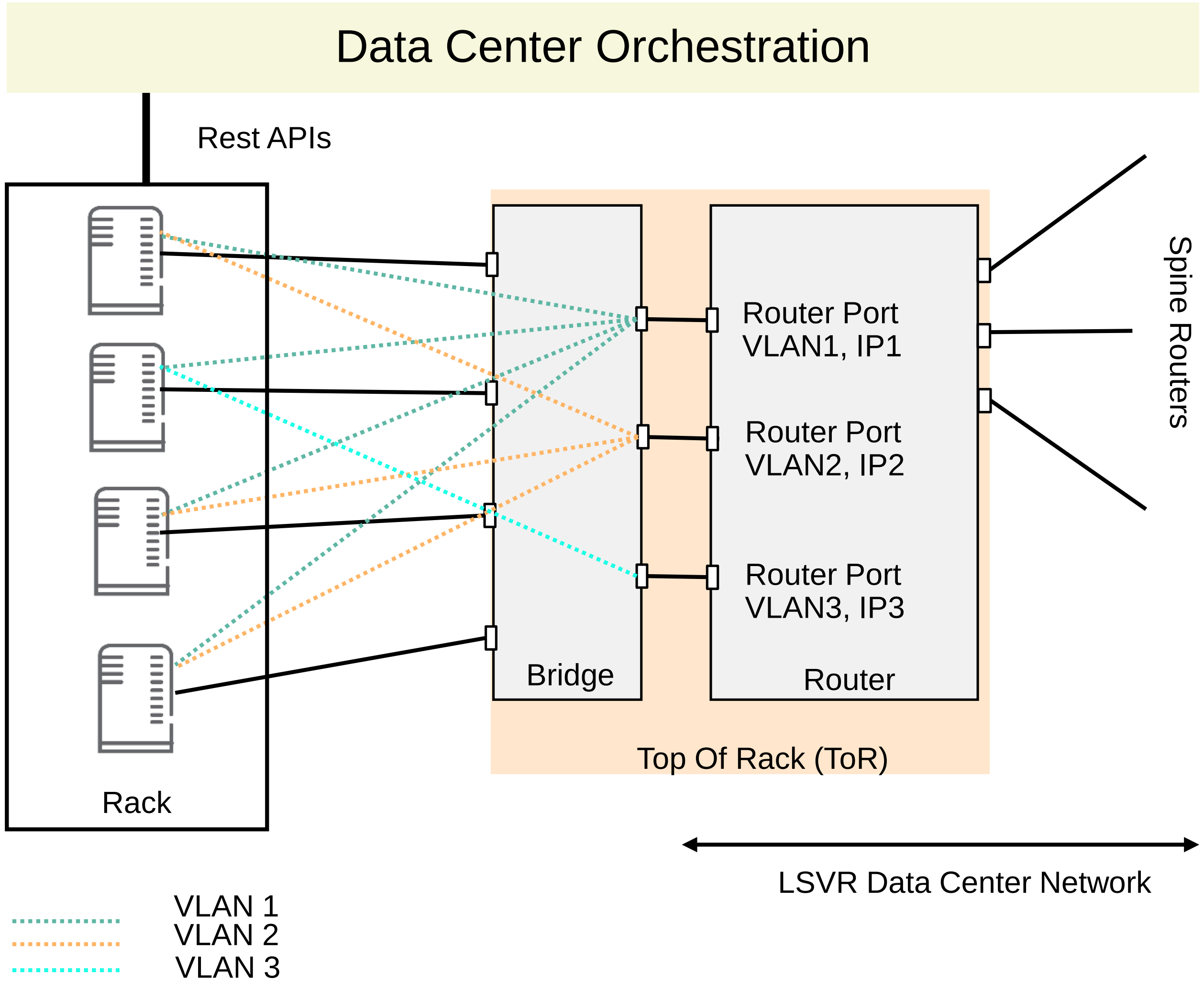
Datacenter Network Using LSVR



- Most datacenters are configured as 2-3 layer Clos networks using ECMP for distribution over the mesh and LAGs/M-LAGs for server attachment
- Typically these networks provide an IPv4/IPv6 topology organized with ToR and Spine switches within Pods (around 8-128 racks)
- Servers at the network edge manage virtual and tenant networks which are encapsulated into the IP packets for transmission over the data center
- The orchestrator controls the creation of the virtual and tenant networks along with coupling to services

Typical Server and Switch Rack Configuration





– Here the Bridge portion of the Top Of Rack Switch couples physical ports to each server in the rack

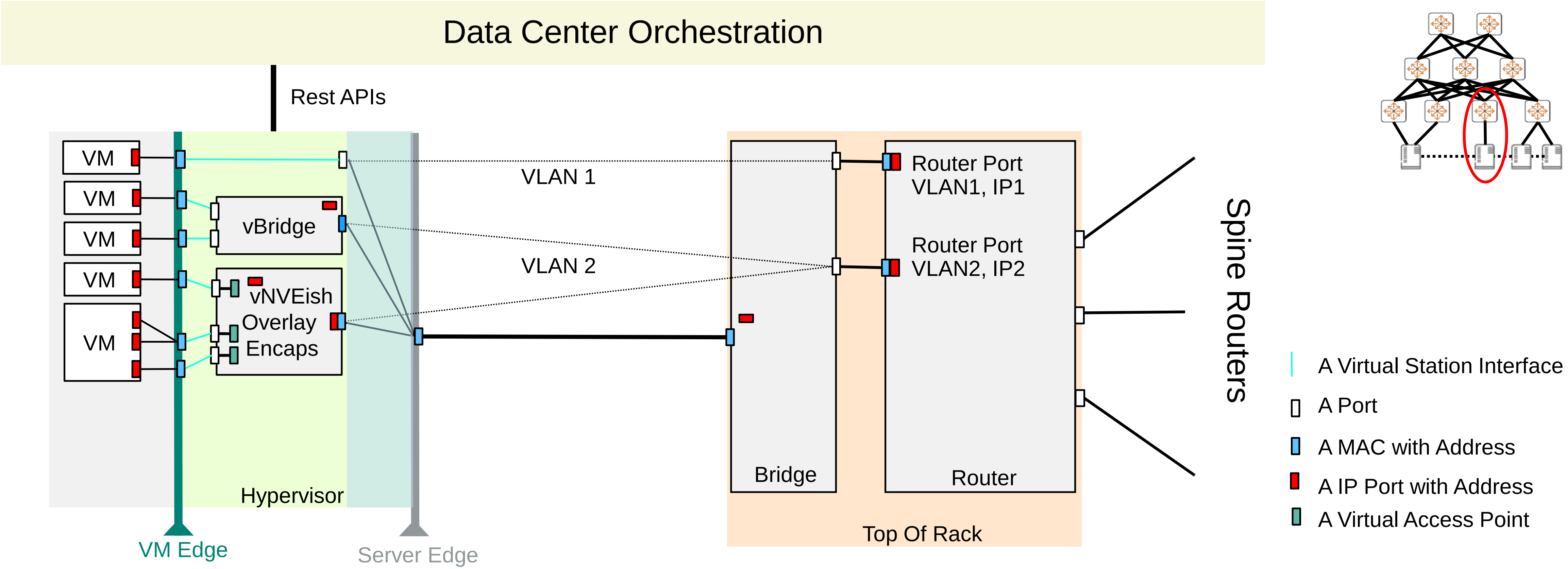
– Over the Bridge Ports VLANs are distributed to each server

– For each VLAN within the rack an IP subnet is assigned

– Each router port in the Top Of Rack is coupled to a single VLAN which is mapped onto an IP subnet

– Protocols within the switch (in this case LSVR) advertise the subnets available within the rack to the rest of the network

Server Network Interfaces – Virtual Machines (i.e. VMWare)



Data Center Orchestration

Rest APIs

VM

VM

VM

VM

VM

vBridge

vNVEish Overlay Encaps

Hypervisor

VM Edge

Server Edge

VLAN 1

VLAN 2

Bridge

Router Port VLAN1, IP1

Router Port VLAN2, IP2

Router

Top Of Rack

Spine Routers

| A Virtual Station Interface

▯ A Port

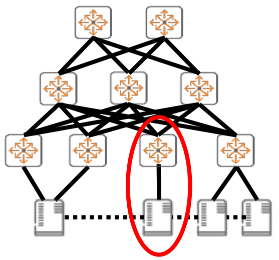
🟦 A MAC with Address

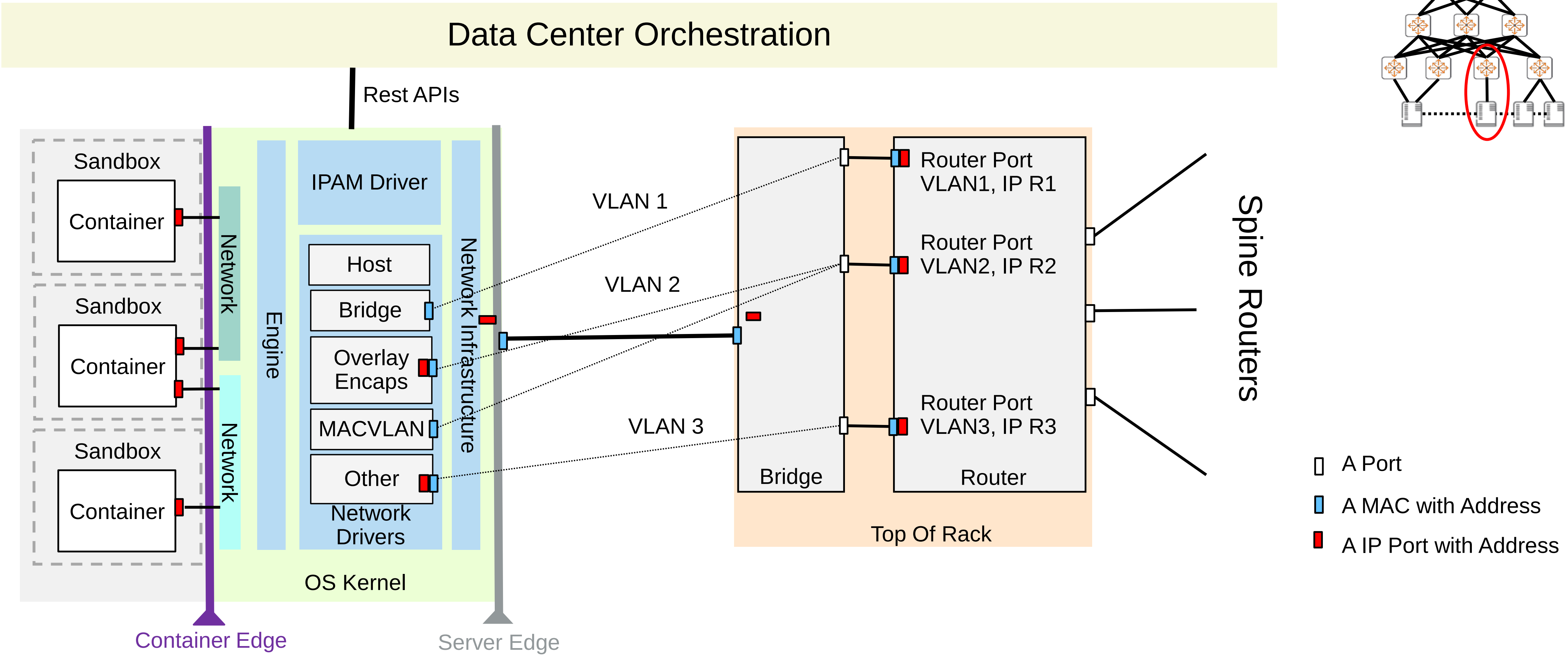
🟥 A IP Port with Address

🟩 A Virtual Access Point

- Virtual Station Interface (VSI, defined in IEEE Std 802.1Q-2018): is an internal LAN which connects between a virtual NIC and a virtual Bridge Port
- Virtual Access Point (VAP): A logical connection point on the Network Virtualization Edge (NVE) for connecting a Tenant System to a virtual network
- DC network is a simple IP underlay network. For scaling L3 encapsulations are supported using “NVE like” procedures within the server controlled by Data Center Orchestration

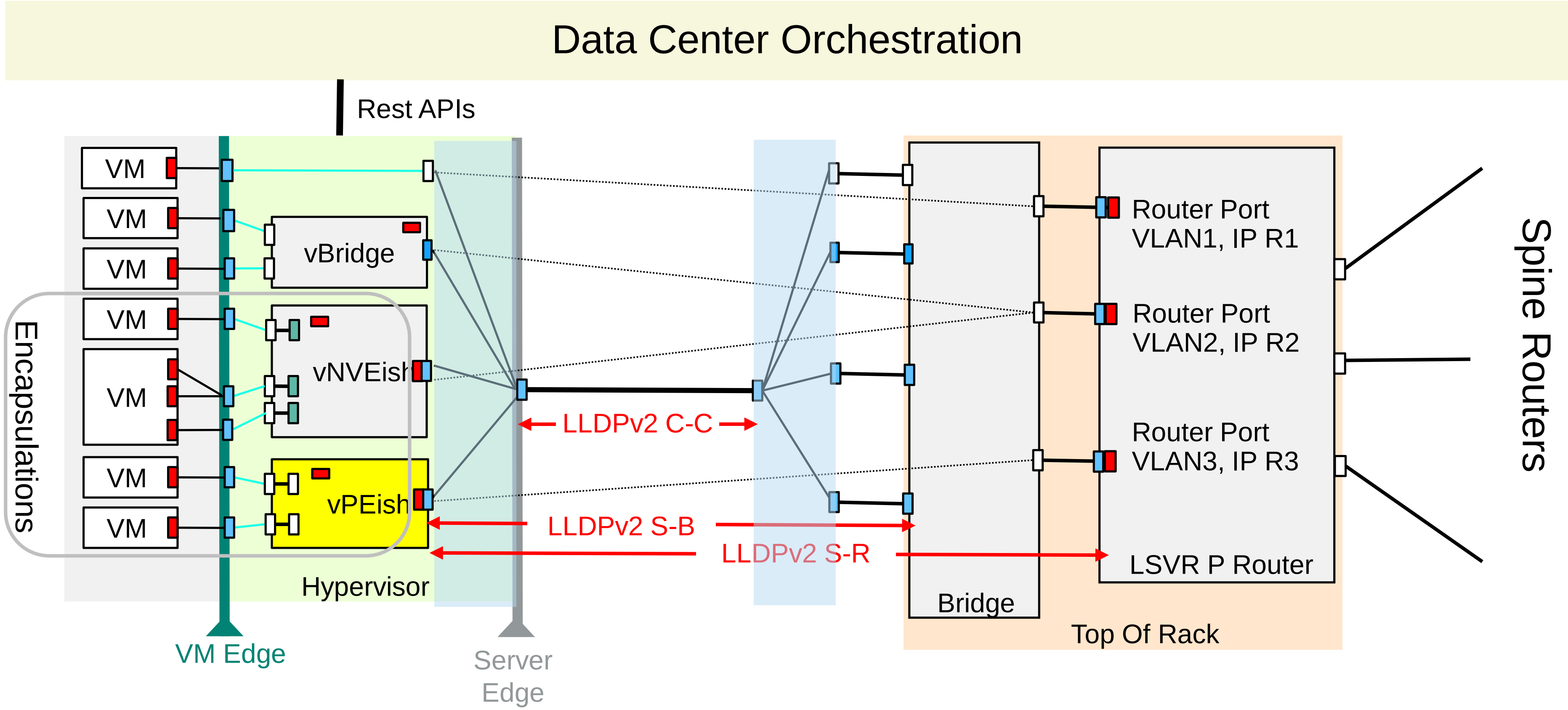
Server Network Interfaces – Containers (i.e. Docker)

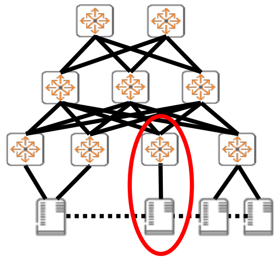




- Container Solutions use Linux Namespaces and Groups to isolate containers
- These solutions provide a variety of network connections, though use an overlay for large scale datacenters
- DC network is a simple IP network. For scaling L3 encapsulations are supported using “NVE like” procedures within the server controlled by Data Center Orchestration

Discover Protocol Termination Points for LLDPv2





C-C: Server S-Channels
S-B: Server to Bridge
S-R: Server to Router

- Currently LLDPv2 is specified to operate at two levels within a Server. These are between the Server and the adjacent Top Of Rack switch (S-B) and over an S-Channel to a Virtual Edge (PE-B).
- The IETF L3DL protocol is specified to operate between end system ports (PR-R). LLDPv2 could also take this path by choosing a destination MAC that passes through Bridges rather than contained at Bridges
- For the typical case where there are no other Bridges except those embedded in the Server and ToR it is un-necessary to pass LLDP through the Bridge layer. Instead, the Router control plane just needs an API to the LLDPv2 database.

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