# Enabling virtual networking for CNFs using SDN

Luis F. Gonzalez (Universidad Carlos III de Madrid)

Ivan Vidal (Universidad Carlos II de Madrid)
Francisco Valera (Universidad Carlos III de Madrid)
Diego R. Lopez (Telefónica I+D)
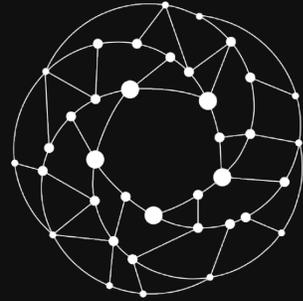
OSM, Kubernetes & Virtual Networking

Can we currently support CNFs networking in K8s clusters?

How does K8s connect workloads?

- Kubernetes networking model:
  - 'Pods on a node can communicate with all pods on all nodes without NAT'.
  - Agents on a node (e.g., system daemons, kubelet) can communicate with all pods on that node.

- CNI Plugins used to implement K8s networking.

- Flat-networking approaches to connect pods.

- Services used to expose applications outside a cluster.

- Current CNI solutions do not provide a native way to create virtual networks in K8s clusters.

How does K8s connect workloads?

What we want:

CNF$_a$ — VL1 — CNF$_b$ — VL2 — CNF$_c$

What we have:

CNF$_a$ — IP communications — CNF$_b$ — CNF$_c$
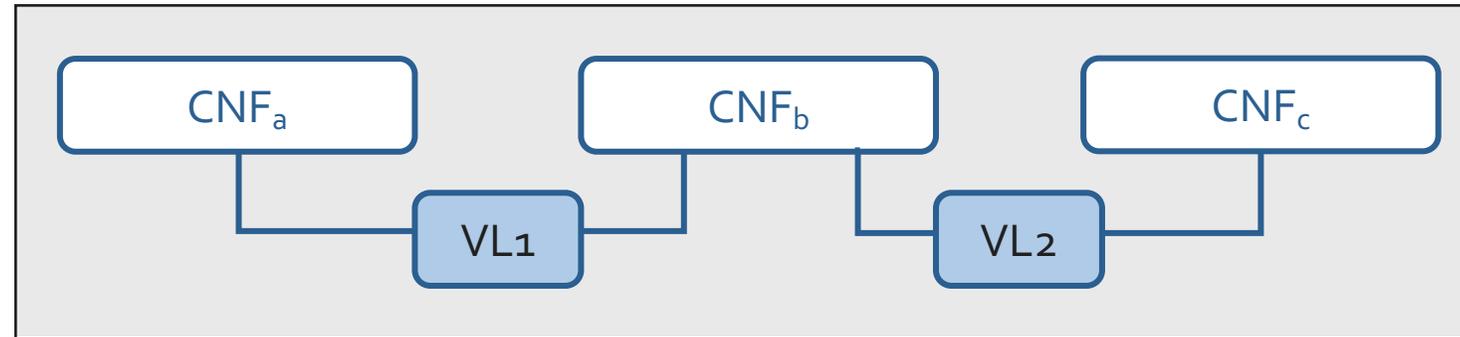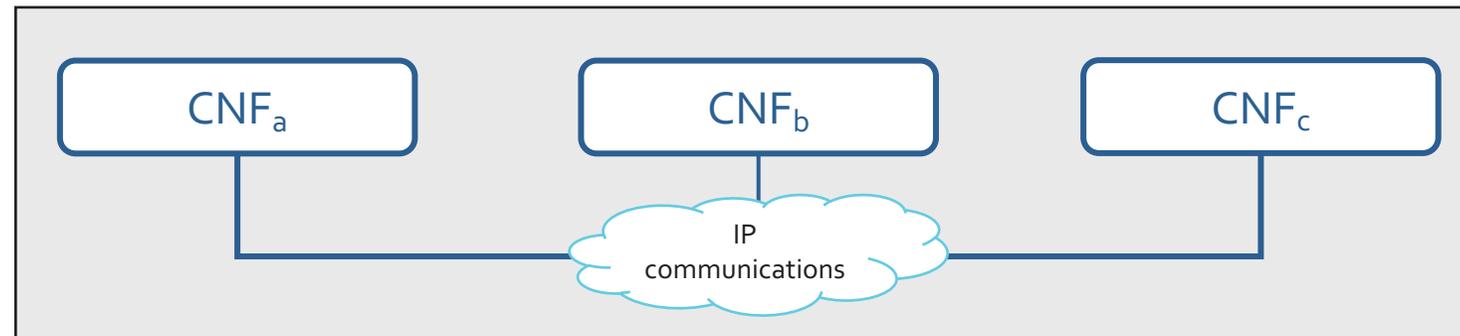
Deploying CNF in Kubernetes with OSM

- Current OSM versions support the deployment of CNFs.

- CNFs are expected to be connected to a VIM Network (outside of the scope of K8s).

- There is no native support for virtual networks in K8s clusters, unlike other solutions like OpenStack.

- Severely limits the functional deployment of NSes based on CNFs in K8s clusters!
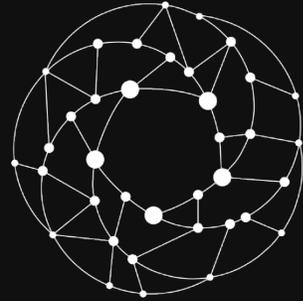
Link Layer Secure connectivity for Microservice platforms: L2S-M

A virtual networking solution for K8s clusters deployed as a service

What is L2S-M?

- L2S-M is a solution that at providing complementary networking functionalities to the standard Kubernetes CNI approach.

- L2S-M allows the management of virtual networks in Kubernetes by using SDN.

- Developed as a Kubernetes Operator, it allows to create "OpenStack-like" virtual networks that workloads (pods) can attach to.

- This solution can be used in multiple environments: not only in datacentres, but also in networks where mobile compute nodes are present.


Link Layer Link

VNF

VNF

Kubernetes Node

INTERNET/ PRIVATE NETWORK

Kubernetes Node
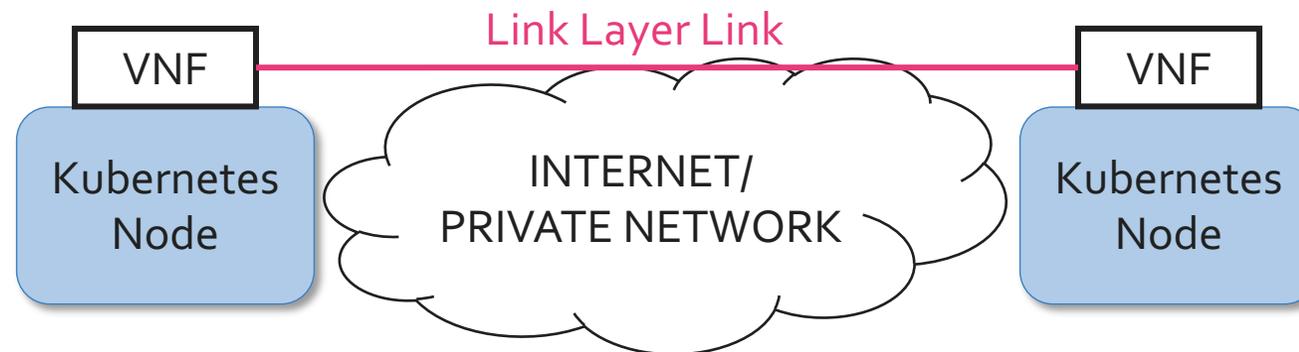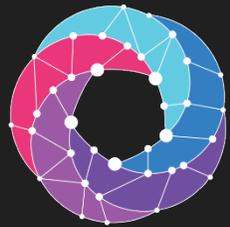
What is L2S-M?

Reference Figure

Legend:
- **L2S-VS** — L2S-M Programmable Virtual Switch (pod)
- **PS** — Programmable Physical Switch
- **CNF** — Cloud Network Function (K8s Workload)
- Control Plane Communications
- K8s management Communications
- Data Plane Communications

K8s Events

K8s Control Plane: K8s Kubelet and apiserver — L2S-M Operator — SDN Controller

CNI Plugin Interface

Access Ports

K8s Node
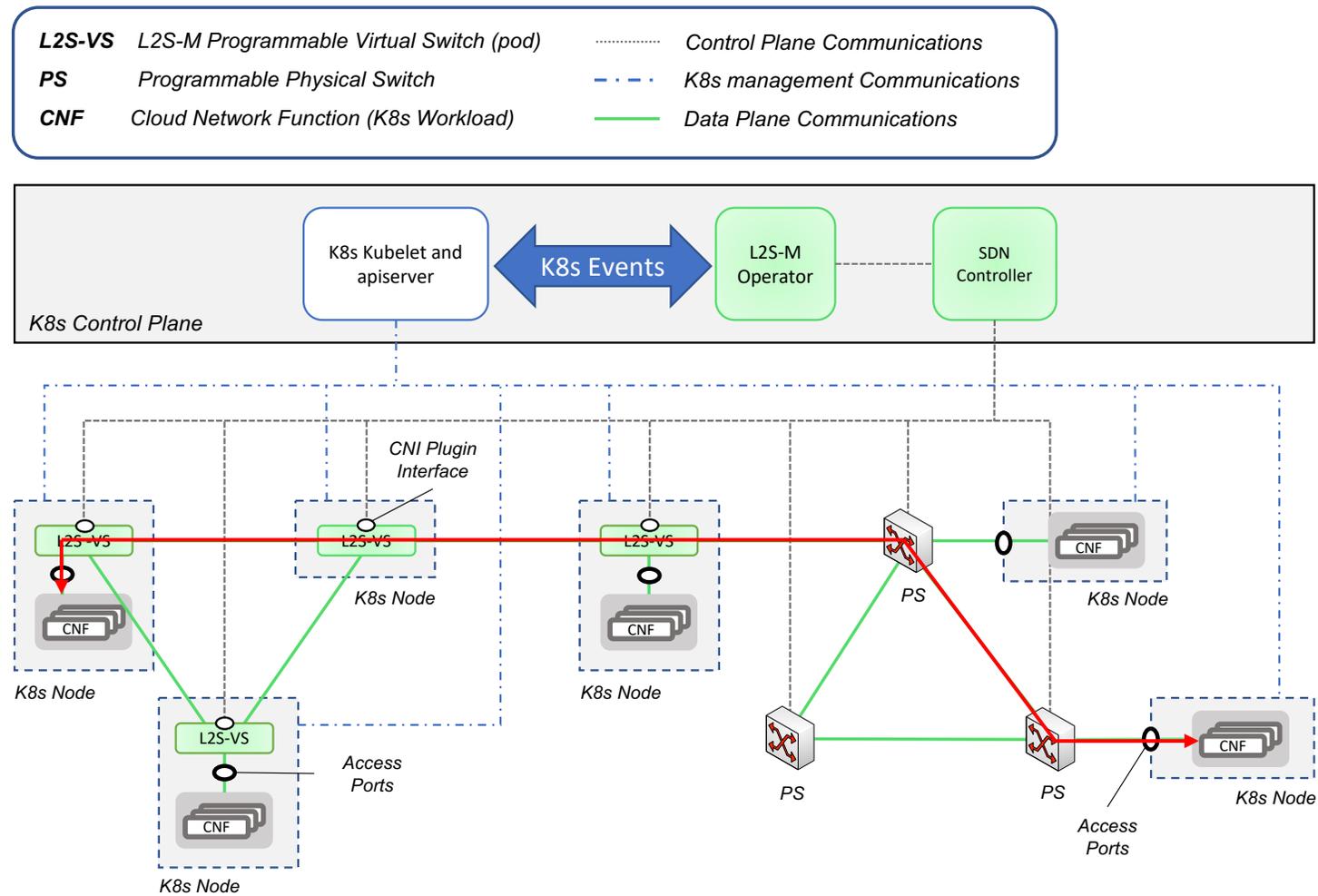
What are virtual networks in L2S-M?

- Virtual networks are defined using the "Network Attachment Definition" CRD from Multus.

- The corresponding Multus annotation in a pod descriptor attaches a pod into the desired virtual networks.

- One additional interface per network will be available in the pod, maintaining the CNI plugin interface intact.

- **This approach does not interfere with standard K8s connectivity and services.**

```
apiVersion: "k8s.cni.cncf.io/v1"
kind: NetworkAttachmentDefinition
metadata:
  name: my-first-network
spec:
  config: '{
      "cniVersion": "0.3.0",
      "type": "host-device",
      "device": "l2sm-vNet"
   }'
```

```
annotations:
  k8s.v1.cni.cncf.io/networks: my-first-network
```

L2S-M: Advantages and challenges

Advantages

❑ Provision of full networking capabilities, as well as direct control of communications between microservices.

❑ Solution embedded into Kubernetes as an operator.

❑ Minimal changes required to perform in a Kubernetes cluster.

❑ Compatible with all Kubernetes elements (services, deployments, Stateful applications...).

❑ L2S-M concepts can potentially be applied to support inter-cluster communications.

Considerations and challenges

❑ Requires basic knowledge in K8s and its networking model.

❑ It is mandatory that platform managers have control of their infrastructure to manage virtual interfaces in the hosts.

❑ Currently it does not support multiple namespace deployments (all pods must be in the same namespace).

❑ SDN application to provide virtual network layer isolation is currently under implementation (I.e., the current version of L2S-M uses a simple-switch implementation).

❑ Management of the L2S-M overlay

Research projects that currently use L2S-M:

- ➤ FISHY Project (H2020 project)
- ➤ TRUE 5G (Spanish National project)

L2S-M is a collaborative work by the following organizations:

- ➤ Universidad Carlos III de Madrid
- ➤ Telefónica I+D
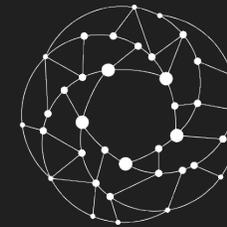
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References and where is L2S-M used

[1] Gonzalez, L. F.; Vidal, I.; Valera, F.; Lopez, D. R. Link Layer Connectivity as a Service for Ad-hoc Microservice Platforms. IEEE Networks. *January* **2022**.

https://ieeexplore.ieee.org/document/9740640

[2] Vidal, I.; Nogales, B.; Lopez, D.; Rodríguez, J.; Valera, F.; Azcorra, A. A Secure Link-Layer Connectivity Platform for Multi-Site NFV Services. *Electronics* **2021**, *10*, 1868.

https://doi.org/10.3390/electronics10151868
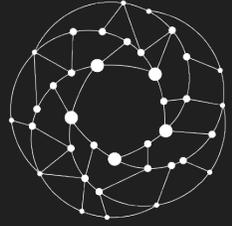
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Want to check out L2S-M?

Just scan the following QR code, or use the link below:

http://l2sm.io

If you want more info about the origins of L2S-M, check our IEEE Network paper:

https://ieeexplore.ieee.org/document/9740640
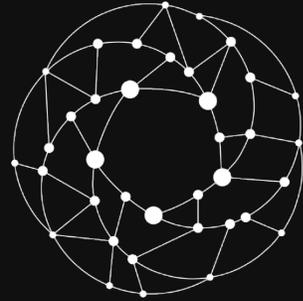
Enabling CNF deployment with OSM in K8s clusters

Feature #10921 (In design phase)

CONNECTIVITY AMONG CNFs USING SDN

- Kubernetes has a flat approach to the networking model, and it does not natively support the creation of virtual (isolated) networks.

- To properly deploy network services in a Kubernetes cluster, there must be a way to create, manage and delete virtual networks that Cloud Native Virtual Network Functions (CNF) are able to attach to.

- The proposed feature will allow the lifecycle management of layer 2 virtual networks for CNFs in Kubernetes clusters by using SDN technology.

- These networks will provide convenient layer 2 isolation between workloads. SDN will allow the use of any switching fabric present in the Kubernetes cluster, either physical or virtual.

More info at: https://osm.etsi.org/gitlab/osm/features/-/issues/10921
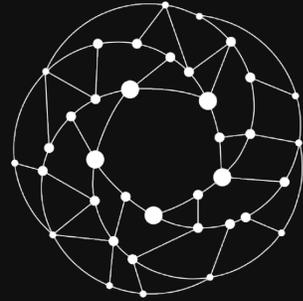
Design proposal for the feature

Let's combine OSM and L2S-M to deploy CNFs in K8s clusters

Deploying an NS example in a K8s cluster

- In the following example, a tenant desires to deploy the following Network Service (NS) over a K8s cluster using OSM as its MANO:
  - Two CNFs must be interconnected through a Virtual Link (VL_1)

Initial considerations
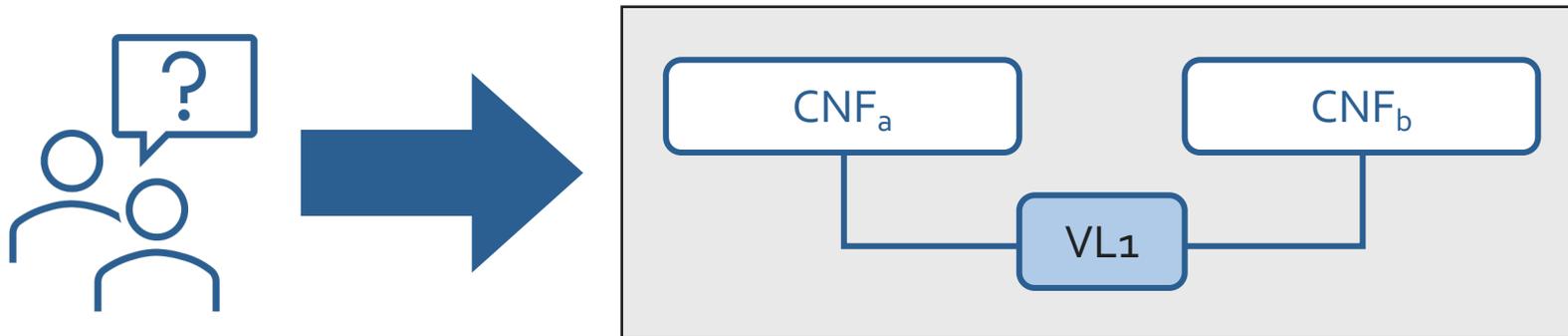
For this feature, we assume the following statements:

- An installation of the L2S-M operator is available on a K8s cluster.
  - The operator manages the virtual networks in the cluster.

- An infrastructure of programmable switches (virtual/physical) is available in the cluster.

- The infrastructure is registered in an SDN controller deployed in the cluster
  - Its deployment is performed by the L2S-M operator
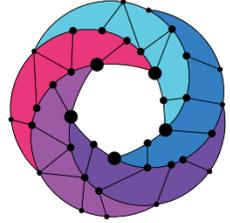
Operational Flow

1) The OSM send VL_1 creation in the K8s cluster.

- A new yaml descriptor should be defined in order to create this network.
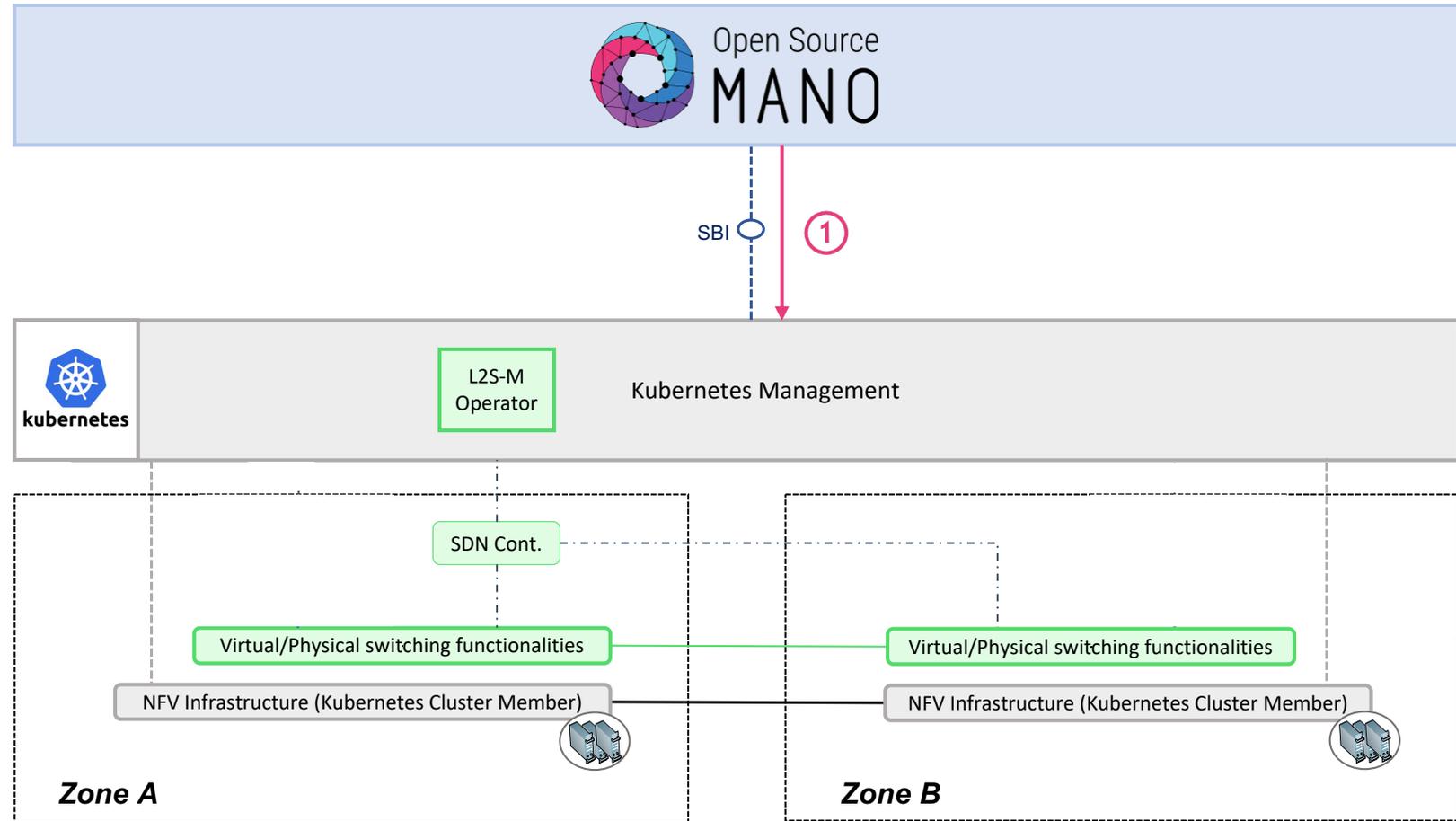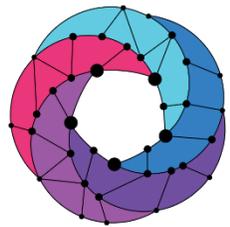
Operational Flow

2) The L2S-M Operator creates the VL_1, i.e., creates the representation of a virtual network inside the cluster
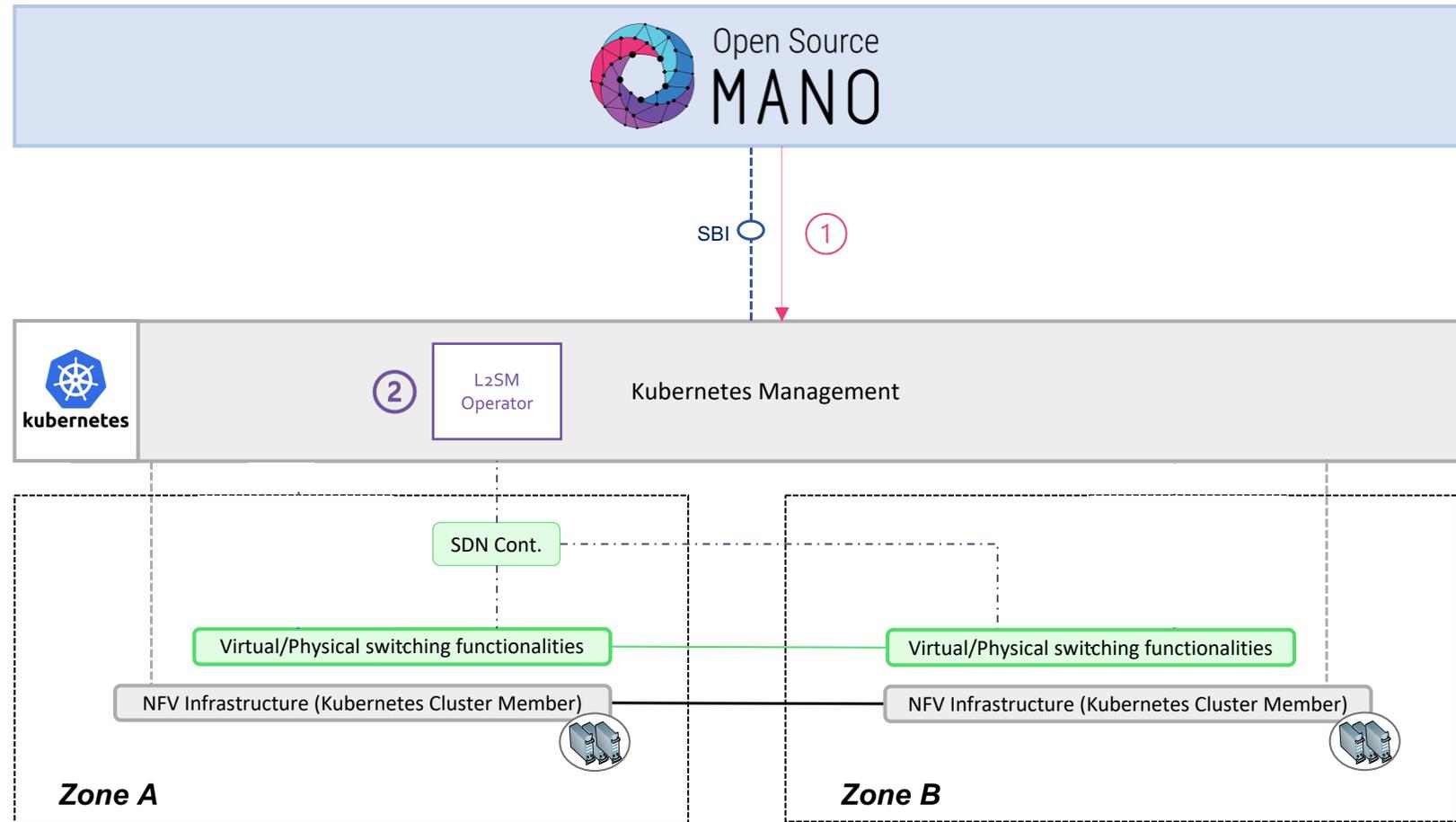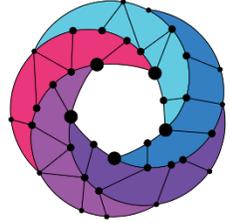
# Operational Flow

3) OSM sends the instruction to deploy CNF_a attached to VL_1

4) OSM sends the instruction to deploy CNF_b attached to VL_1

Current KNF descriptors in OSM should be modified to introduce the VL in the K8s descriptor to be compatible with L2S-M
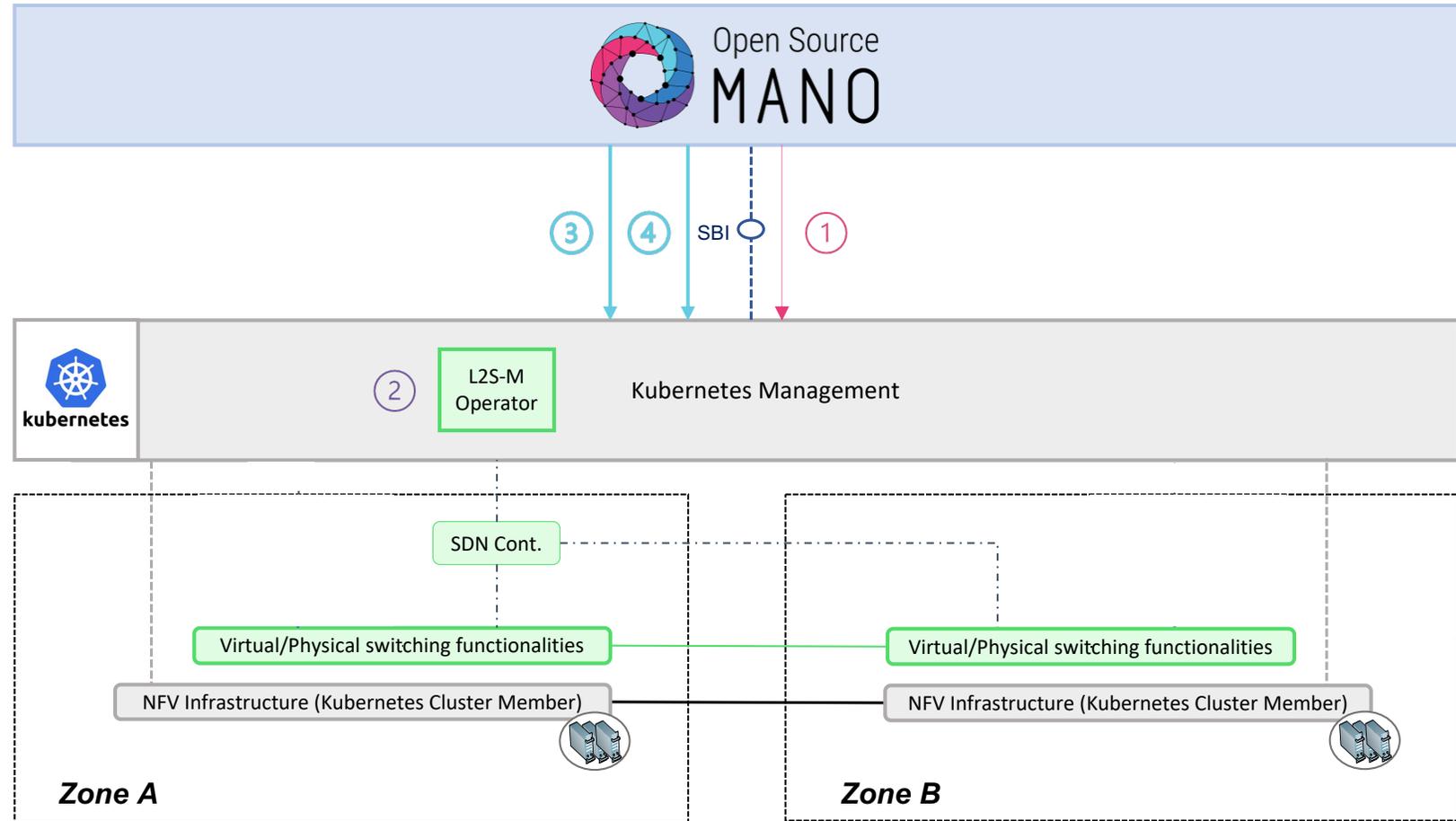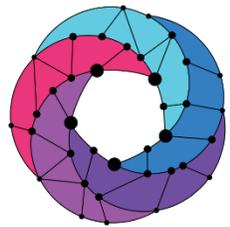
Operational Flow

5) Kubernetes instantiates CNF$_a$ and attaches it to the Virtual/Physical switching functionality

6) Kubernetes does the same for CNF$_b$
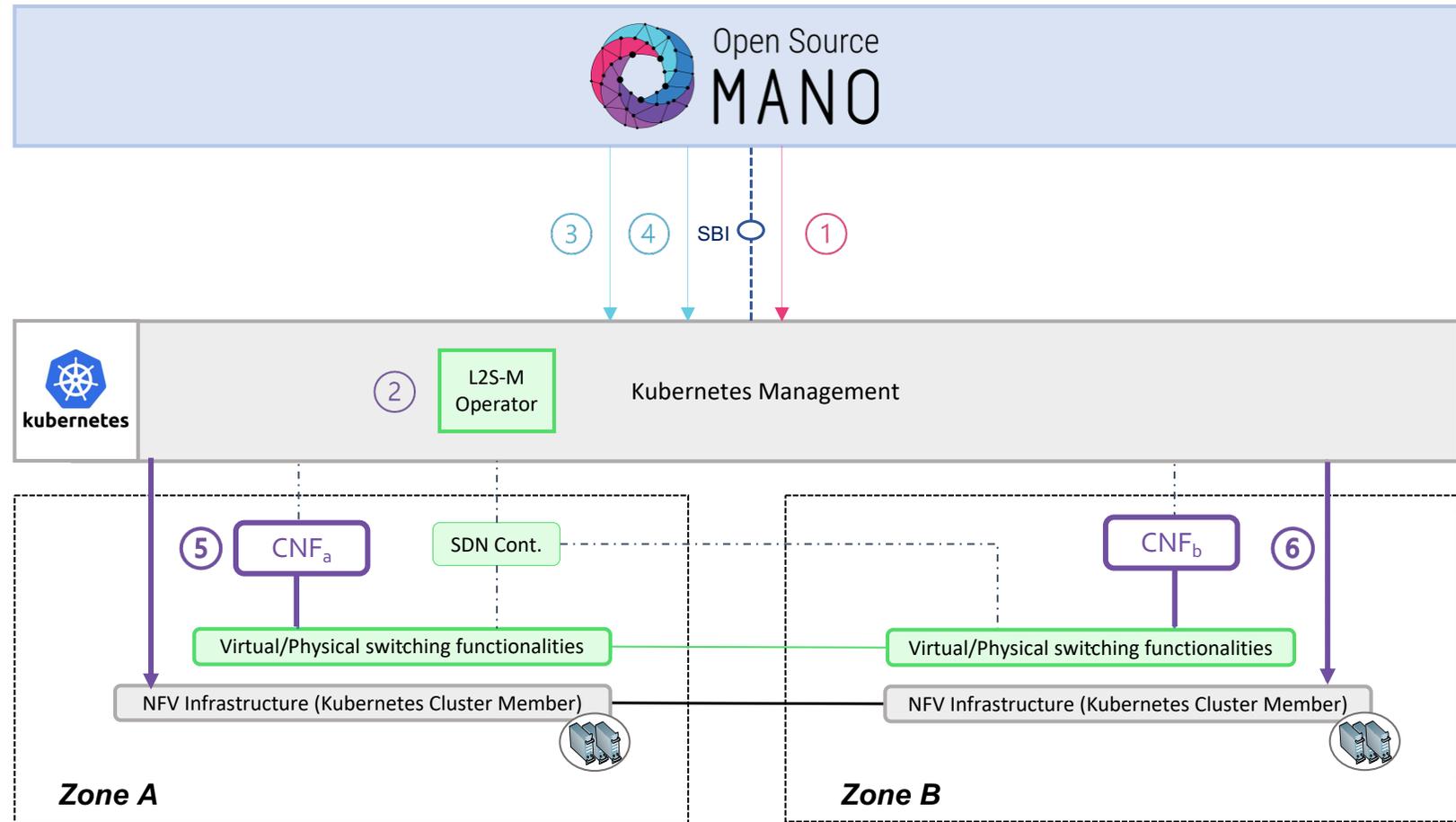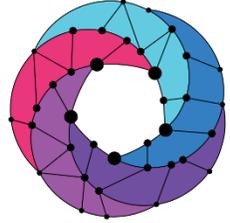
Operational Flow

7) L2S-M operator sends to the SDN Controller the associated port and network of each CNF.

8) The SDN controller writes the OpenFlow rules on the switches*.

* The connectivity is performed through the Flannel (or cluster's CNI Plugin) interface
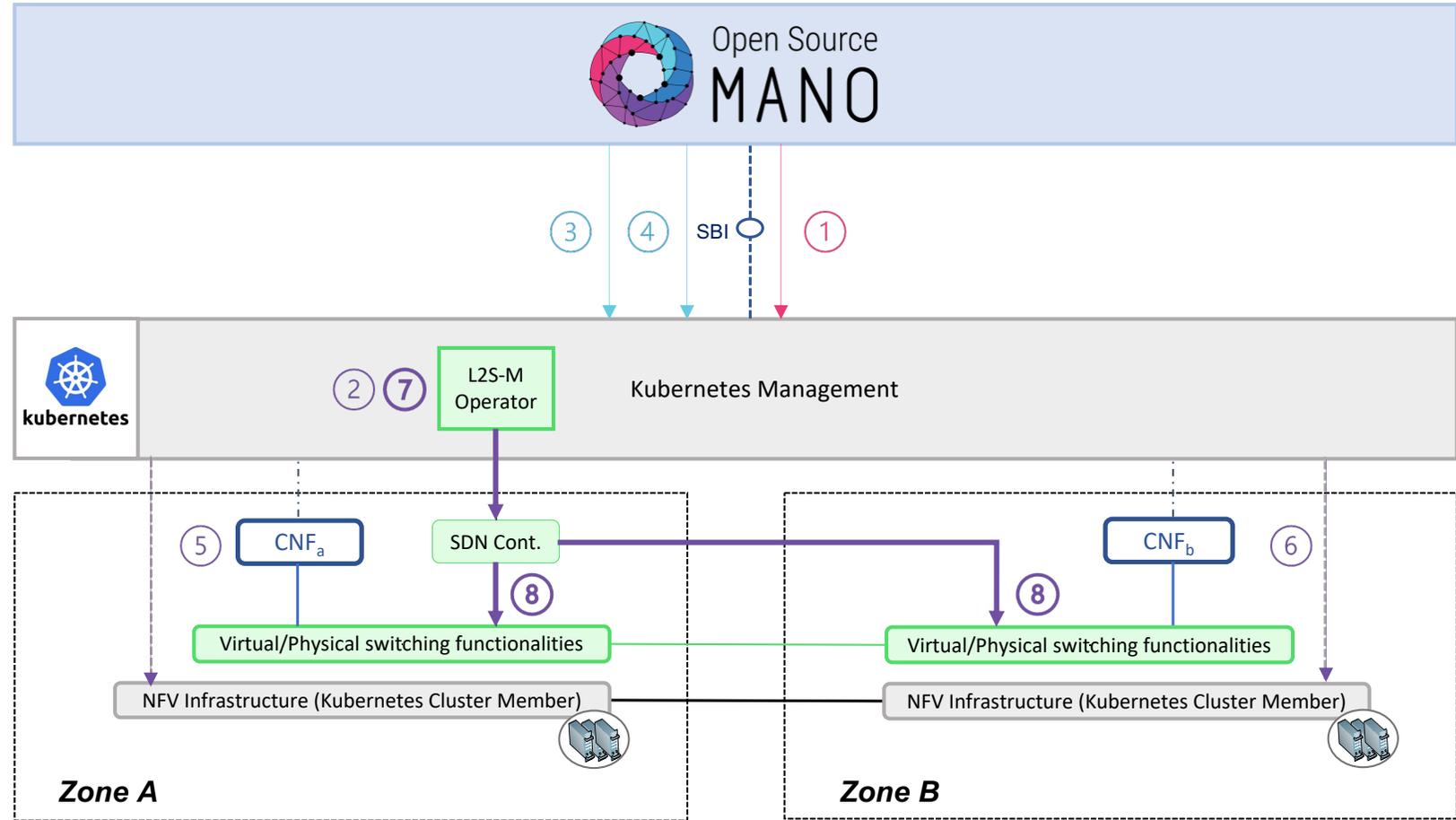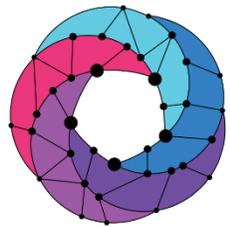
Operational Flow

After the operation, the CNFs are deployed, being interconnected at layer-2 through the Virtual Link VL_1.

* The connectivity is performed through the Flannel (or cluster's CNI Plugin) interface
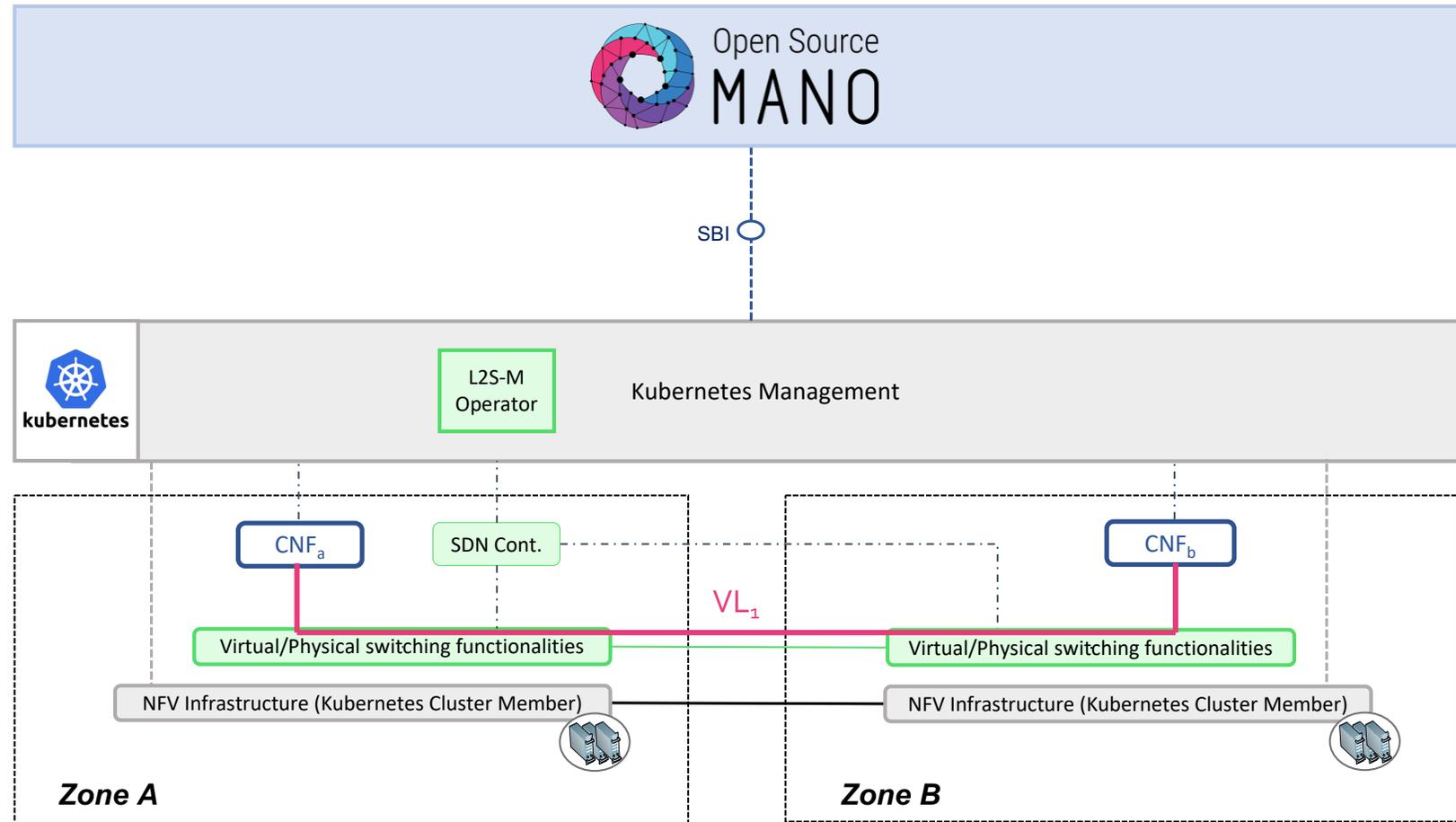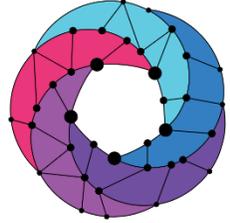
Operational Flow

9) OSM sends the configuration info (Juju charms, etc.) to both CNFs deployed in the cluster, (e.g., by using the Flannel interfaces of the CNFs)


* The connectivity is performed through the Flannel (or cluster's CNI Plugin) interface
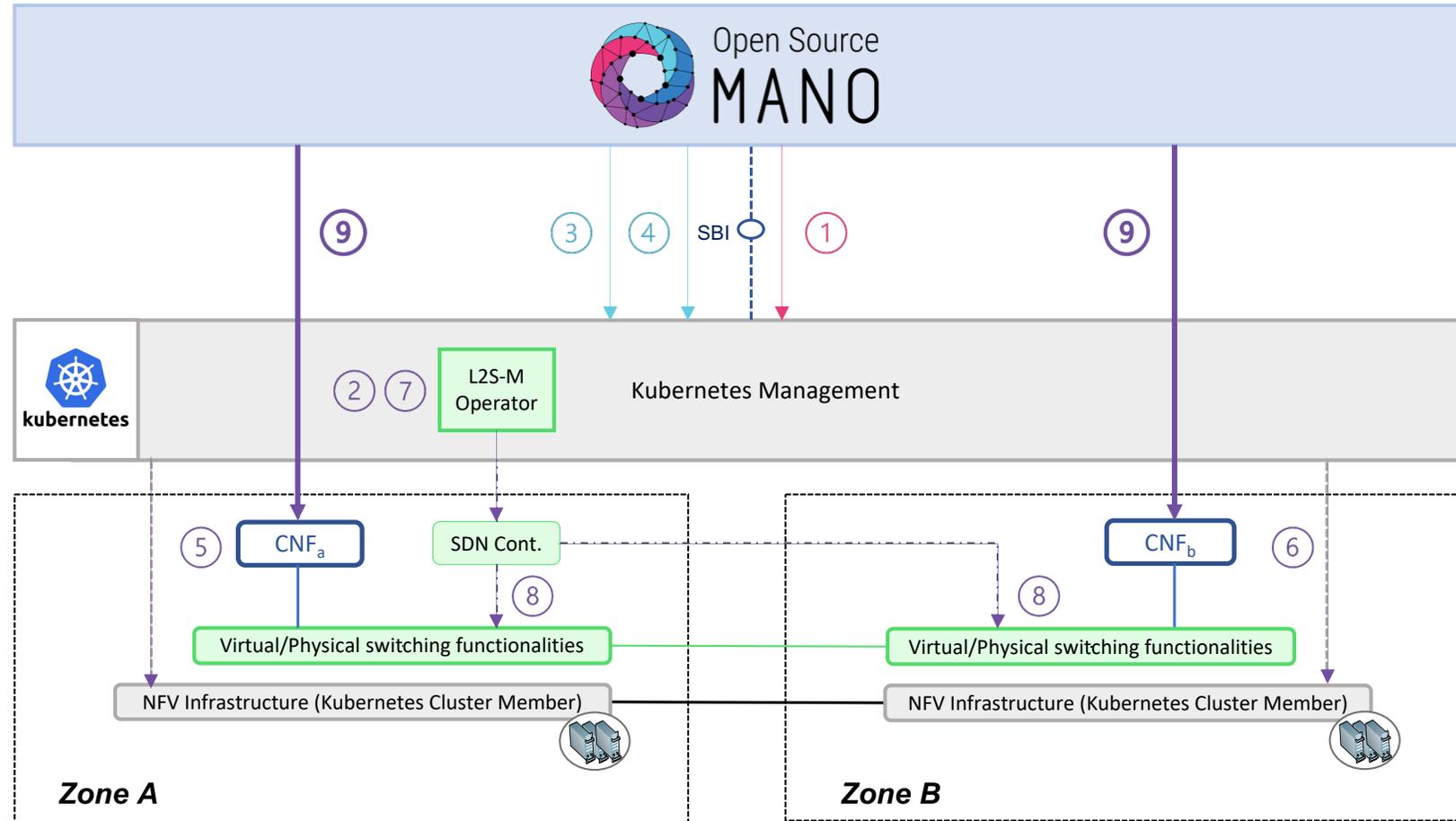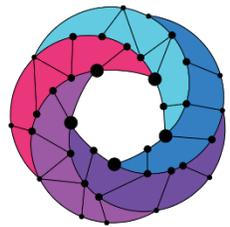
Operational Flow

After the operation, the NS is fully deployed in the K8s cluster.
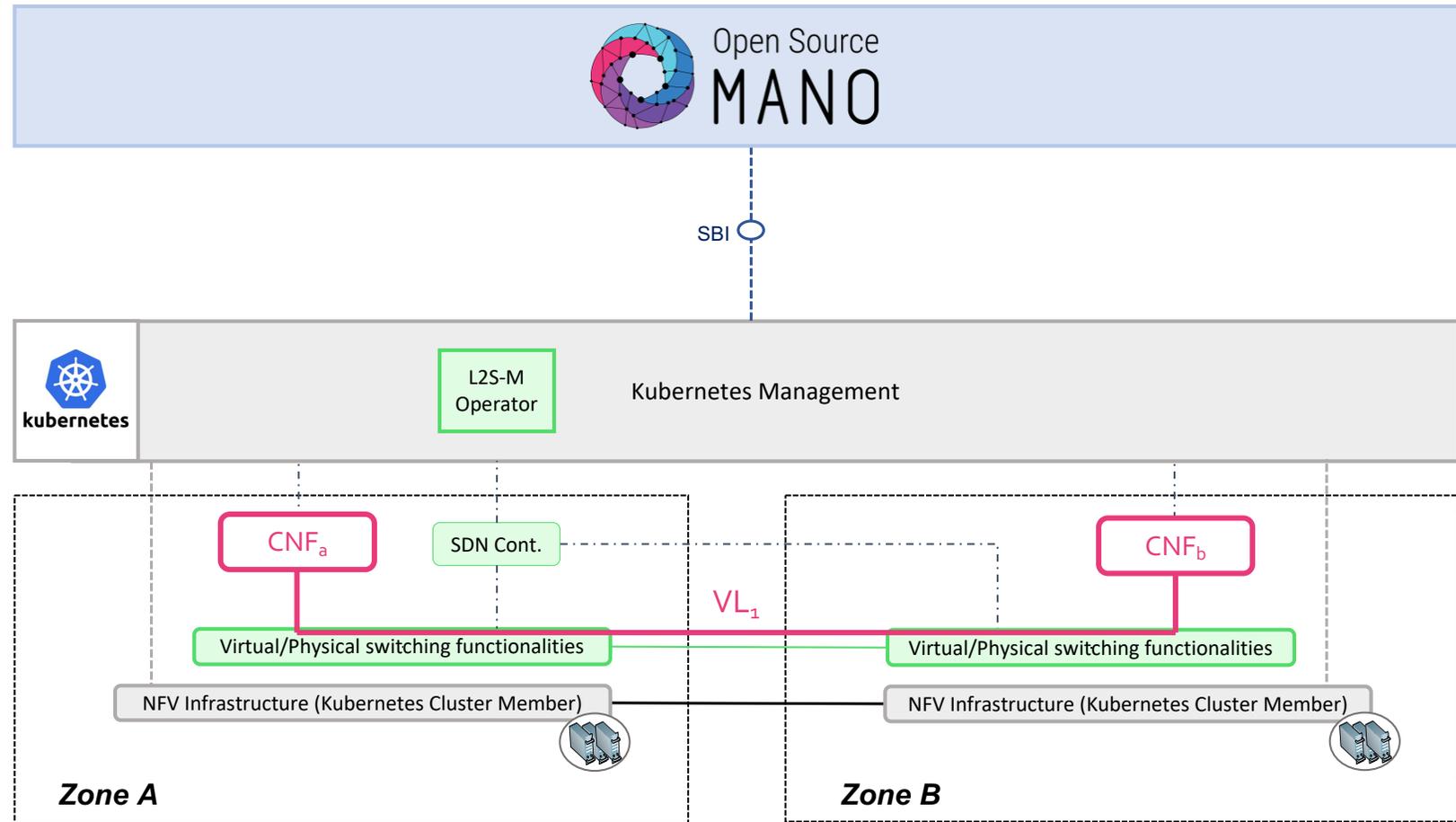
Operational Flow Summary

- New steps that OSM should perform (New).

- Modifications to existing OSM procedures (Delta).

- OSM does not intervene in these steps (None).
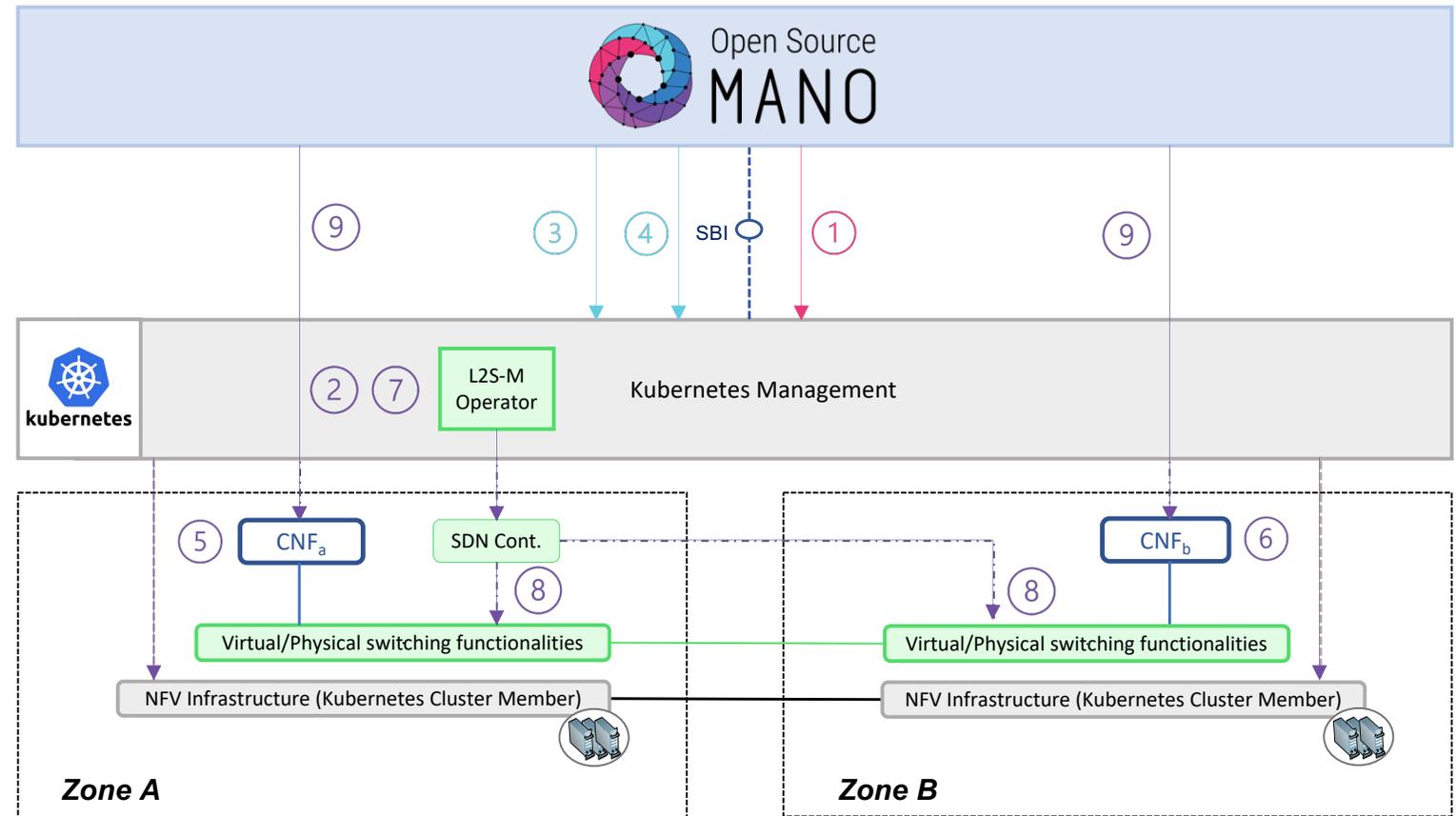
- New
- Delta
- None

Operational Flow Summary

1. OSM asks VL creation

2. L2S-M operator creates VL in the cluster

3. 4. OSM asks the deployment of CNFs

5. 6. K8s & L2S-M instantiates CNFs in VL

7. L2S-M send informs to the SDN Controller

8. The SDN controller configures rules in the switches

9. OSM configures the CNFs (Juju charms)
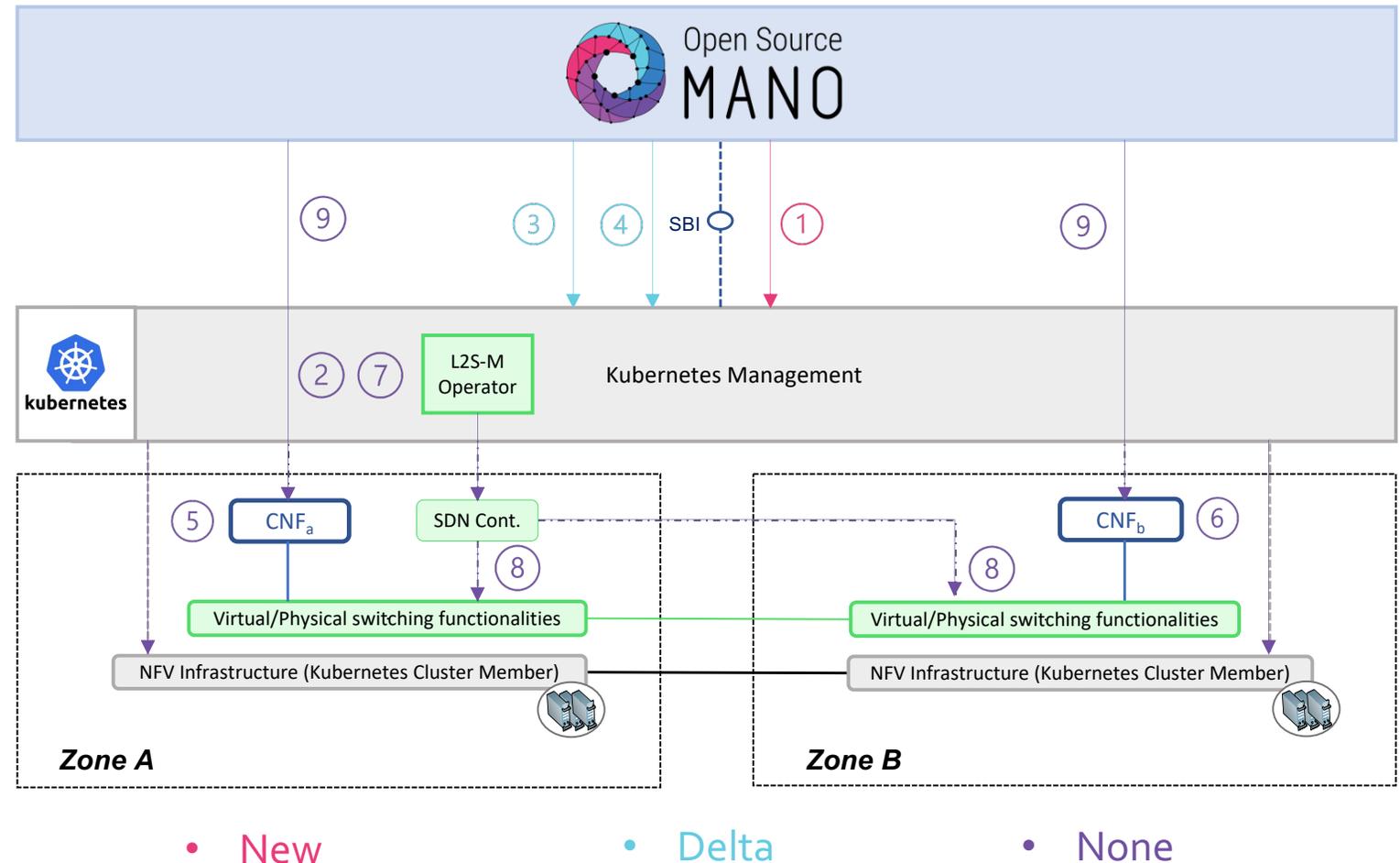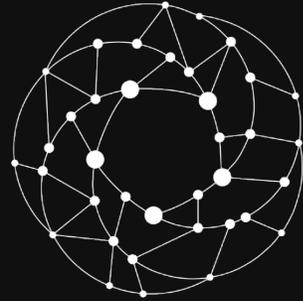
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Thank you so much for your attention!

Any questions?

ETSI