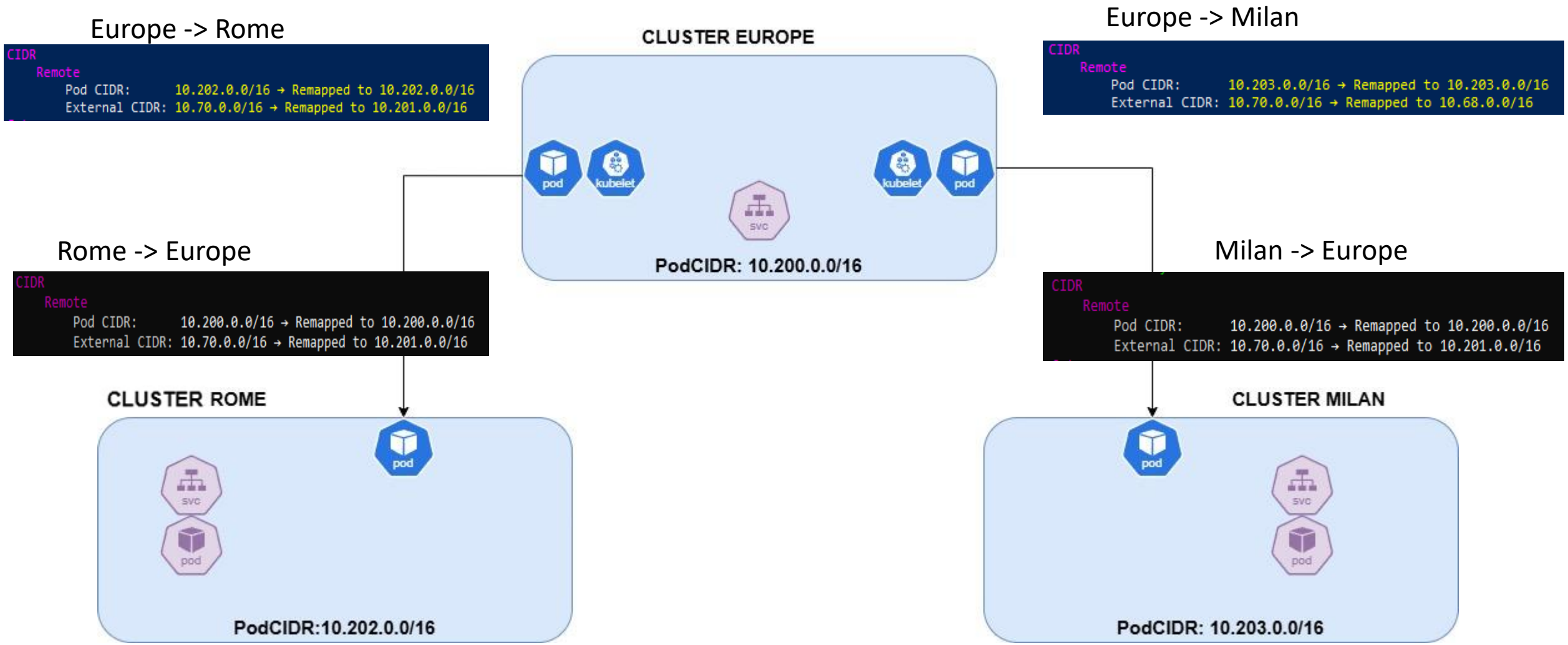
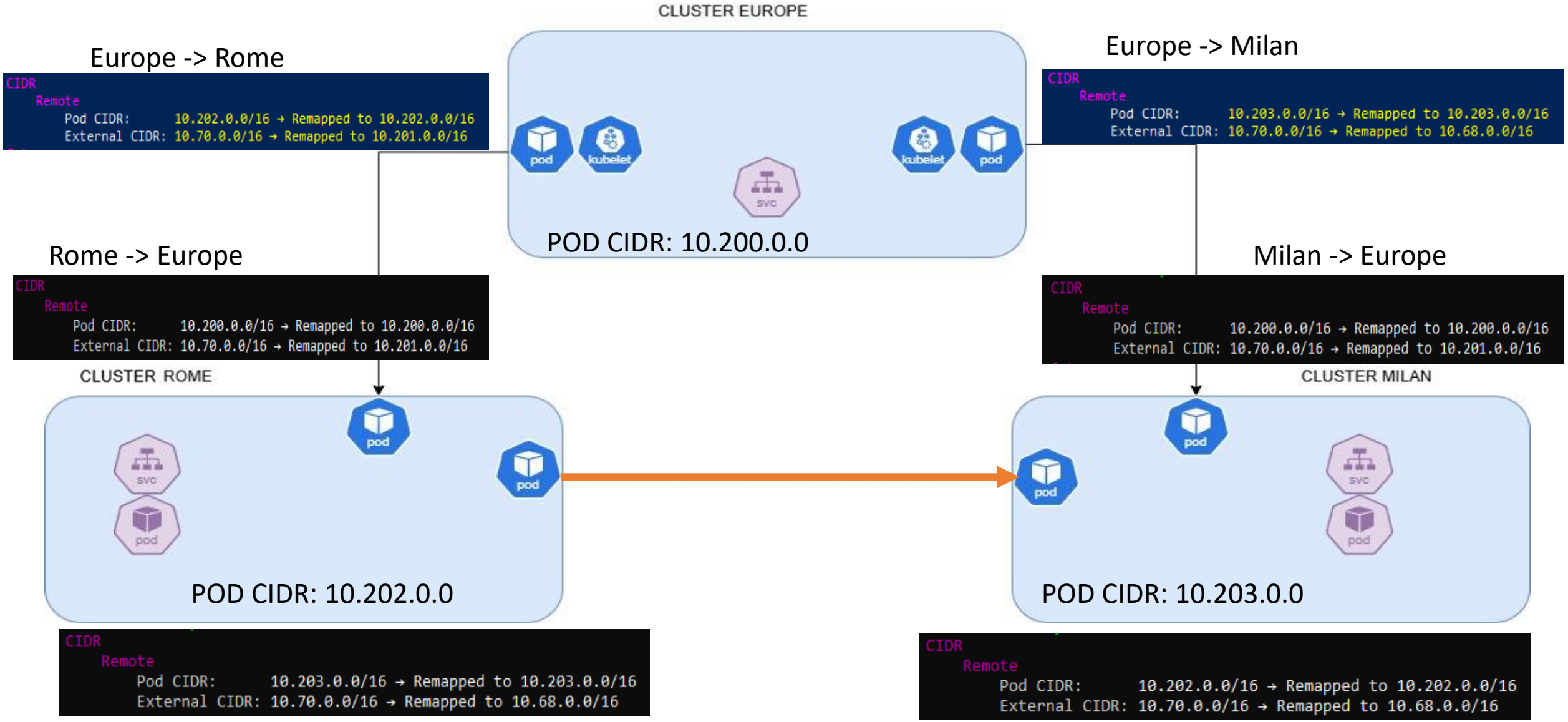
Centralized Management of Liqo Network Creation

Example Topology



The liqoctl network connect command

- This command is used in a liqo system to establish a network between two clusters
- In the previous topology we could use this command to create a direct communication between the two leaf clusters
- For example: liqoctl network connect –kubeconfig cluster-rome –remote-kubeconfig cluster-milan will create a network between cluster-rome and cluster-milan


CLUSTER EUROPE
Europe -> Rome
CIDR
Remote
Pod CIDR: 10.202.0.0/16 → Remapped to 10.202.0.0/16
External CIDR: 10.70.0.0/16 → Remapped to 10.201.0.0/16
Europe -> Milan
CIDR
Remote
Pod CIDR: 10.203.0.0/16 → Remapped to 10.203.0.0/16
External CIDR: 10.70.0.0/16 → Remapped to 10.68.0.0/16
pod
kubelet
svc
POD CIDR: 10.200.0.0
Rome -> Europe
CIDR
Remote
Pod CIDR: 10.200.0.0/16 → Remapped to 10.200.0.0/16
External CIDR: 10.70.0.0/16 → Remapped to 10.201.0.0/16
Milan -> Europe
CIDR
Remote
Pod CIDR: 10.200.0.0/16 → Remapped to 10.200.0.0/16
External CIDR: 10.70.0.0/16 → Remapped to 10.201.0.0/16
CLUSTER ROME
CLUSTER MILAN
POD CIDR: 10.202.0.0
POD CIDR: 10.203.0.0
CIDR
Remote
Pod CIDR: 10.203.0.0/16 → Remapped to 10.203.0.0/16
External CIDR: 10.70.0.0/16 → Remapped to 10.68.0.0/16
CIDR
Remote
Pod CIDR: 10.202.0.0/16 → Remapped to 10.202.0.0/16
External CIDR: 10.70.0.0/16 → Remapped to 10.68.0.0/16
Rome -> Milan
Milan -> Rome

Drawbacks of this approach

- The main cluster is not aware of the direct connections
- The command should be executed in one of the leaf clusters
- The shortcut connection management is decentralized

Proposed Solution

Introducing a centralized mechanism for managing network connections between virtual nodes in a multi-cluster Liqo environment. While this feature does not directly modify routing, it serves as a **first step** toward optimizing leaf-to-leaf cluster communication by making the main cluster aware of existing shortcut connections. This awareness will later enable further optimizations in IP propagation and routing decisions.

Motivation

Currently, inter-cluster communication in Liqo primarily follows paths dictated by the main cluster, even when more efficient direct routes could be available between leaf clusters. However, the main cluster lacks a structured way to **manage and track direct remote clusters connections**. By introducing a centralized mechanism, we can:

- Provide the main cluster with **visibility** into established shortcut connections.
- Enable future enhancements that will optimize **routing and IP propagation**.
- Maintain consistency in network management without immediate route modifications.

Proposed Solution Implementation

We propose adding a **new liqoctl command** to facilitate the creation and management of **direct connections** between remote clusters in the Liqo network. This command will:

1. Allow an administrator to specify **two remote clusters** that should be connected.
2. Generate a **Custom Resource (CR)** containing all relevant connection metadata, such as:
    1. **Kubeconfig** for authentication between clusters.
    2. **CIDR and remapped CIDR** to maintain network structure.
    3. Additional connection-related metadata.
3. Trigger an **operator** responsible for establishing or removing the connection between the selected remote clusters based on the CR lifecycle.

Next Steps & Future Use Cases

This proposal lays the groundwork for a future feature that will enhance IP propagation and routing decisions based on the presence of the new CR. Specifically:

- **Conditional IP Propagation**: The **IPAM (IP Address Management) and virtual-kubelet** already handle IP allocation and service propagation across clusters. However, with this new CR, the system can determine whether a **direct IP** can be propagated instead of the default **indirect one** that routes through the main cluster.
- **Dynamic Routing Optimization**: Once the main cluster is aware of a direct connection between virtual nodes, future enhancements can allow routing mechanisms to **prefer shortcut connections** over indirect paths, improving network efficiency.