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#KubeCon #CloudNativeCon

Improving Submariner in Support of Privacy-preserving Federated Statistics Research on Kubernetes

Stephen Kitt, Red Hat

Julien D., Lausanne University Hospital





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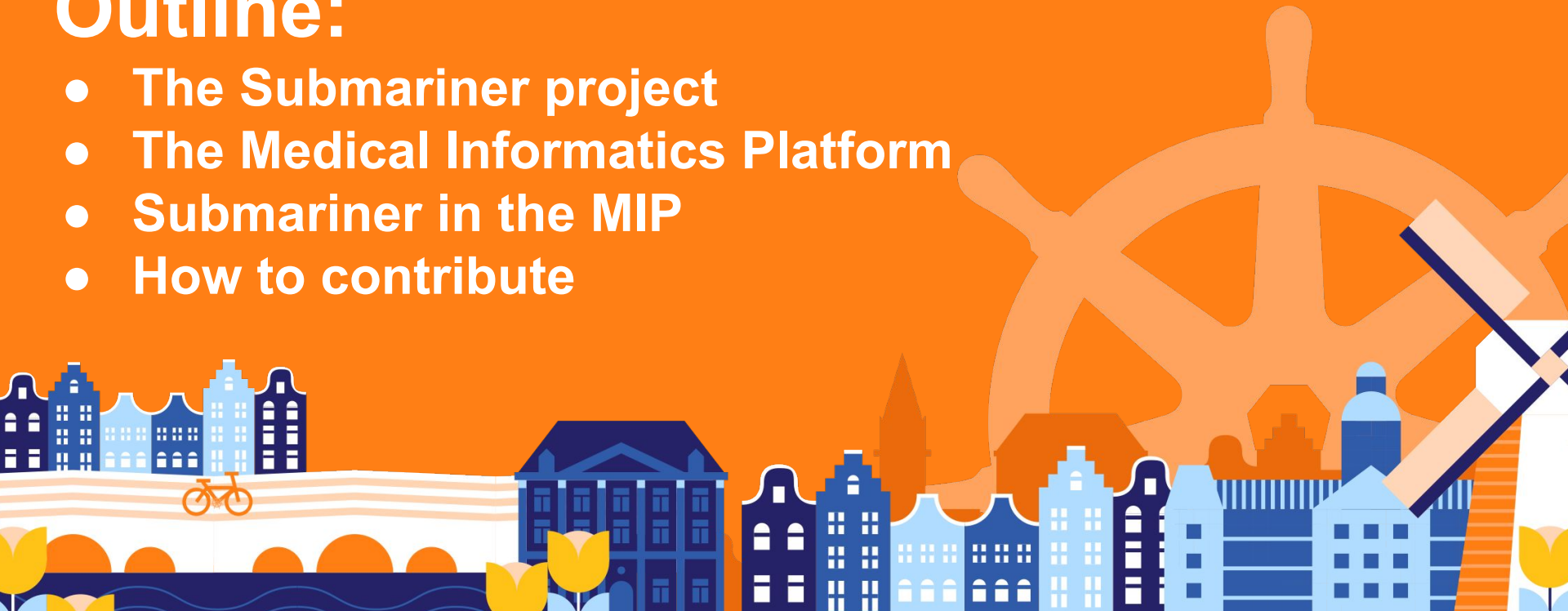


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Outline:

- The Submariner project
- The Medical Informatics Platform
- Submariner in the MIP
- How to contribute





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Q: Why are you here?

What would you like to achieve?



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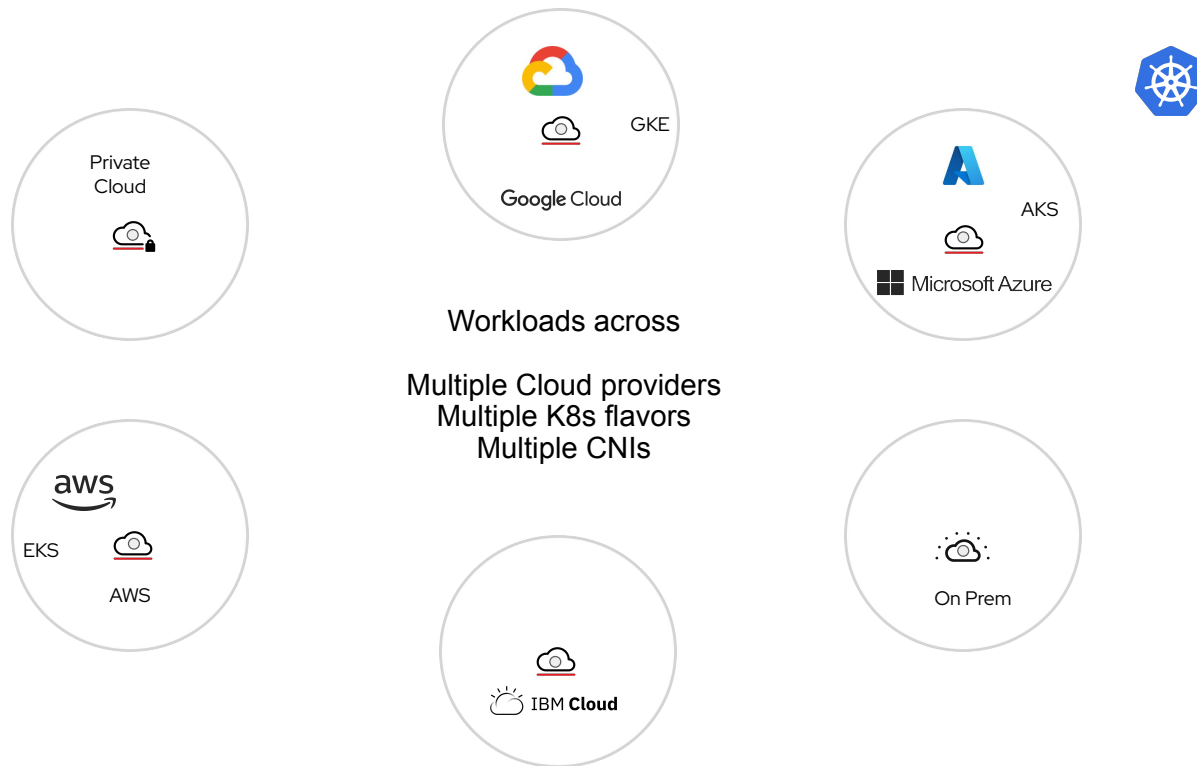
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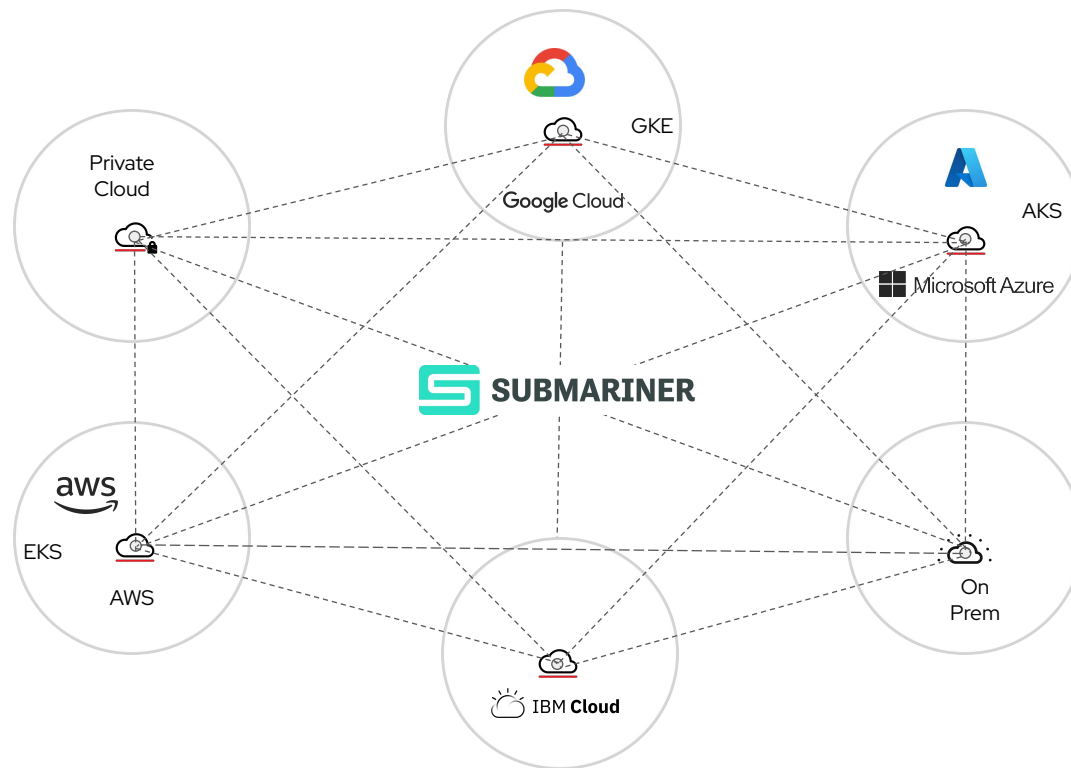
The Submariner project



The Submariner project



The Submariner project



Submariner features



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- Cross-cluster connectivity
 - Pod-to-pod
 - Pod-to-service
- Support for different tunnels
 - IPSec
 - VxLAN
 - WireGuard
- MCS-API-compatible service discovery
- Support for clusters with overlapping CIDRs

Submariner projects

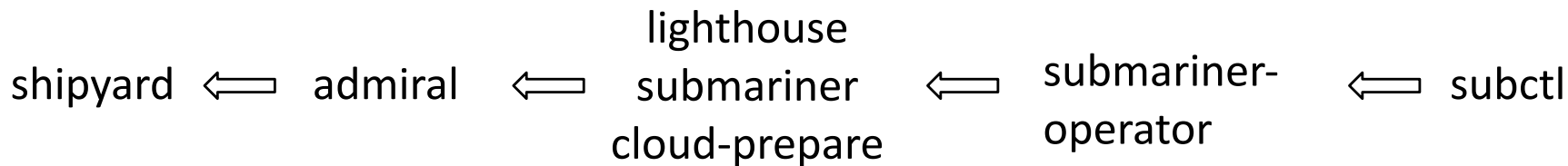


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<https://github.com/submariner-io>

Submariner projects



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- enhancements
- releases
- submariner-charts
- submariner-website
- (coastguard)



<https://github.com/submariner-io>

Submariner components



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- Multi-cluster synchronization (admiral)
 - Instantiated in relevant components
- Cross-cluster connectivity (cable drivers in submariner)
- Routing (route agent in submariner)
- Service discovery (CoreDNS plugin in lighthouse)

Multi-cluster synchronization (broker)

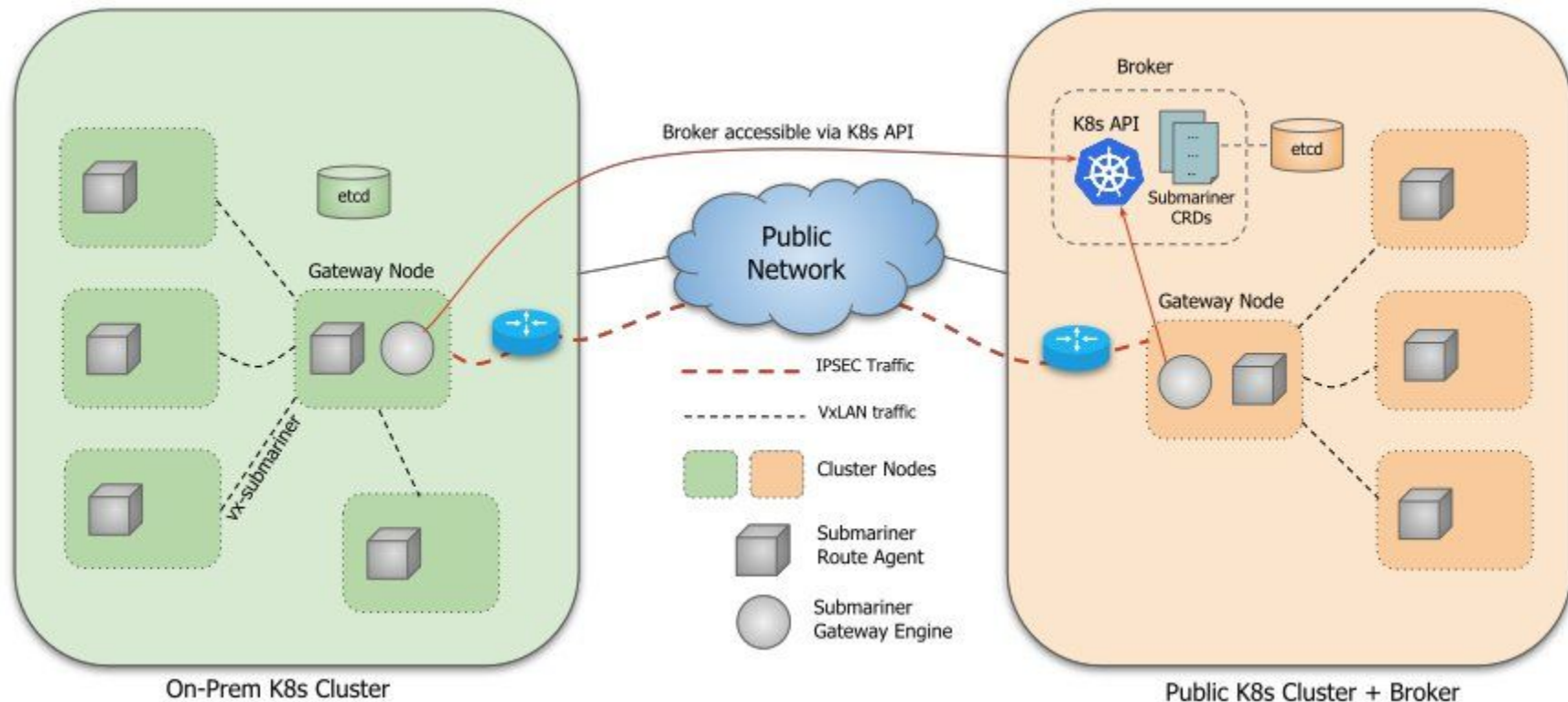


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Cross-cluster connectivity, routing

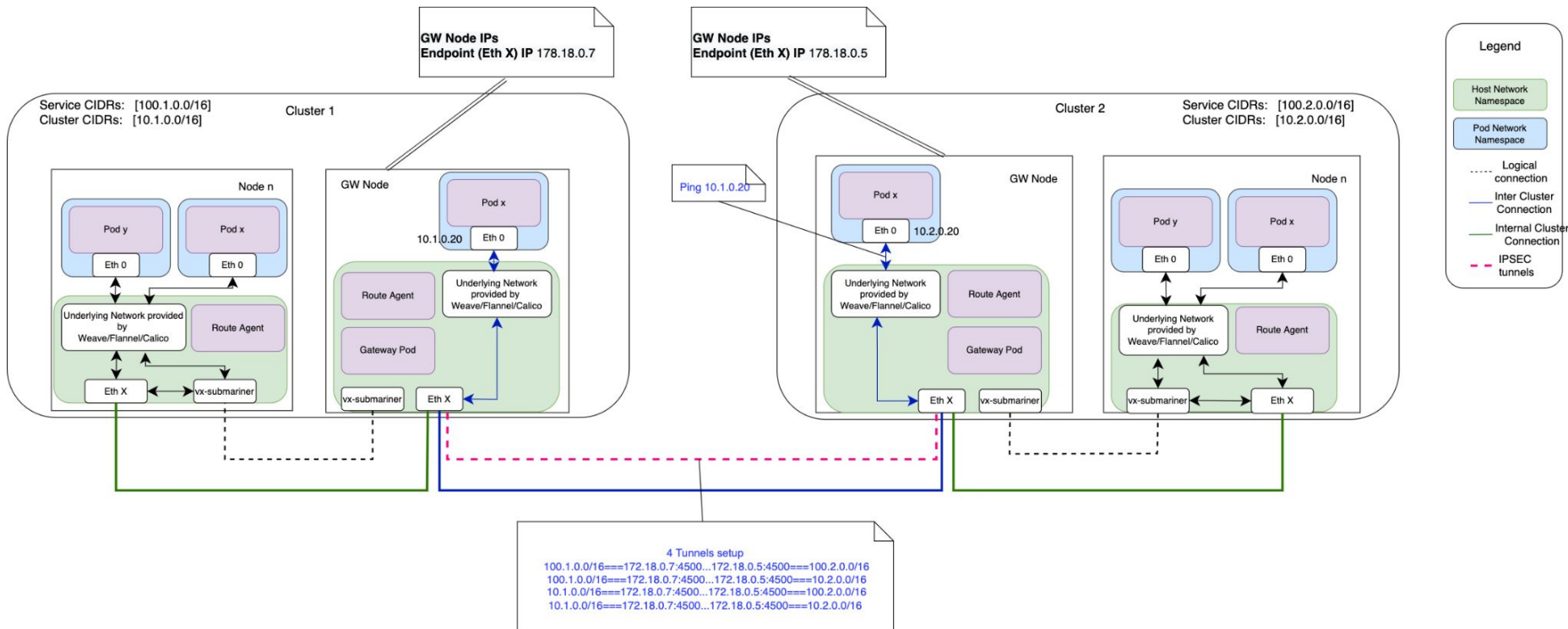


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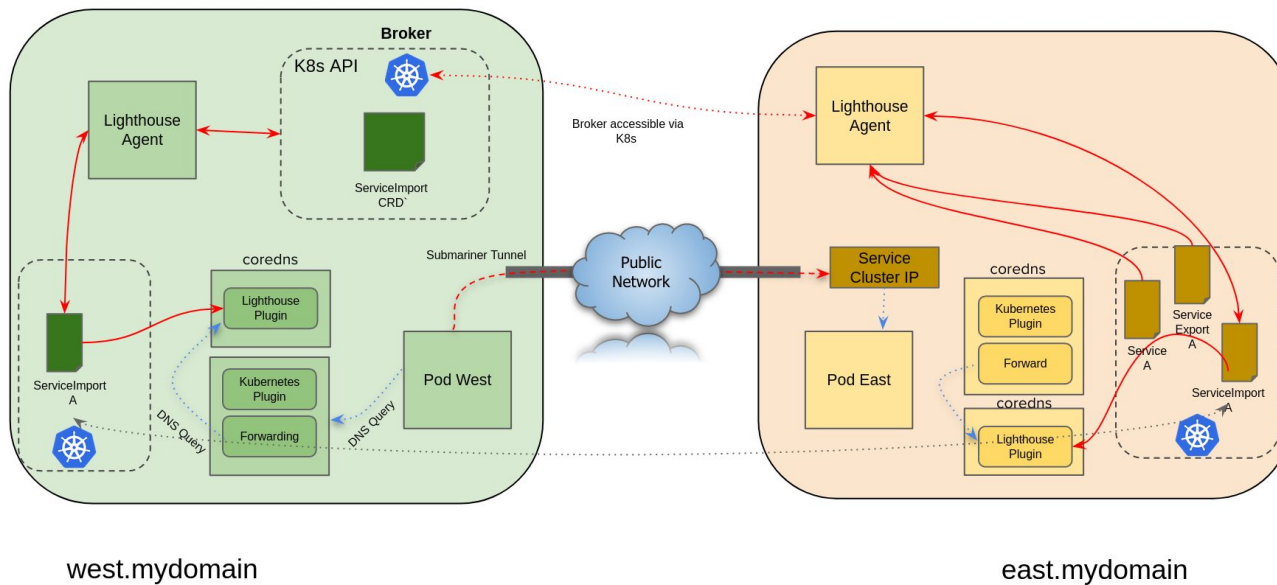


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Service discovery





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The Medical Informatics Platform (MIP)



What is the MIP - Federated data analysis



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EXPERIMENT STUDIO

[← Back to dashboard](#)

STUDIO

[Datasets & Variables](#)

ANALYSIS

[Descriptive statistics](#)

[Algorithm](#)

PATHOLOGY

Dementia

DATASETS

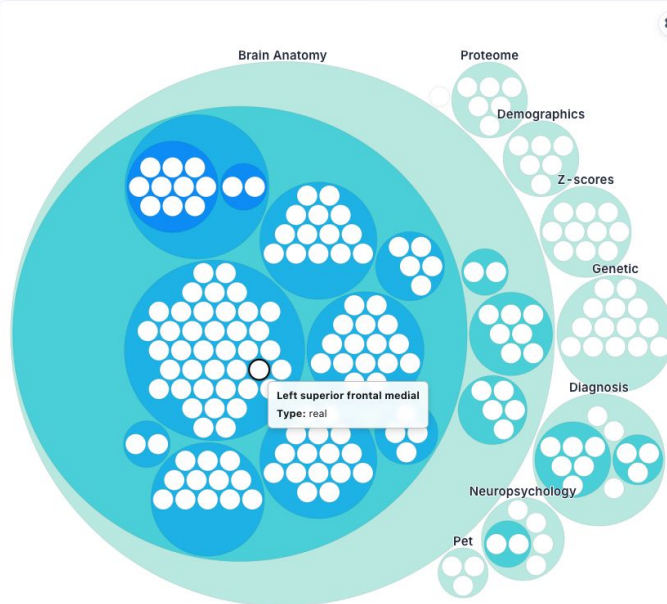
Datasets

3

Search variables or groups

Variables

All Types



Parameters

+ Variables 0

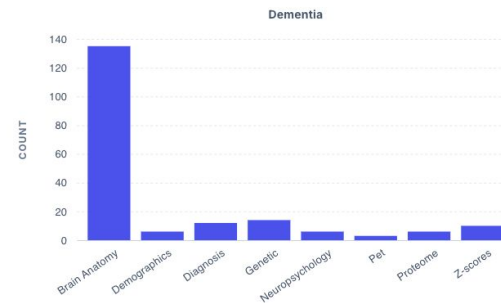
+ Covariates 0

+ Filters 0

Group Information

PATH [Dementia](#)

NUMBER OF GROUPS IN Dementia 8



What is the MIP - Federated data analysis



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- Medical Informatics Platform
 - Developed in ATHENA RC and CHUV
 - Part of EBRAINS (EU-funded digital research infrastructure)
- Federated data analysis system
 - Advanced statistical analysis on distributed data
 - Privacy preserving processing (no information < 10 data points)
- “Nodes” / hospitals join a federation for research
 - Distributed data governance
 - Collaboration independent of data-sharing



Overall architecture



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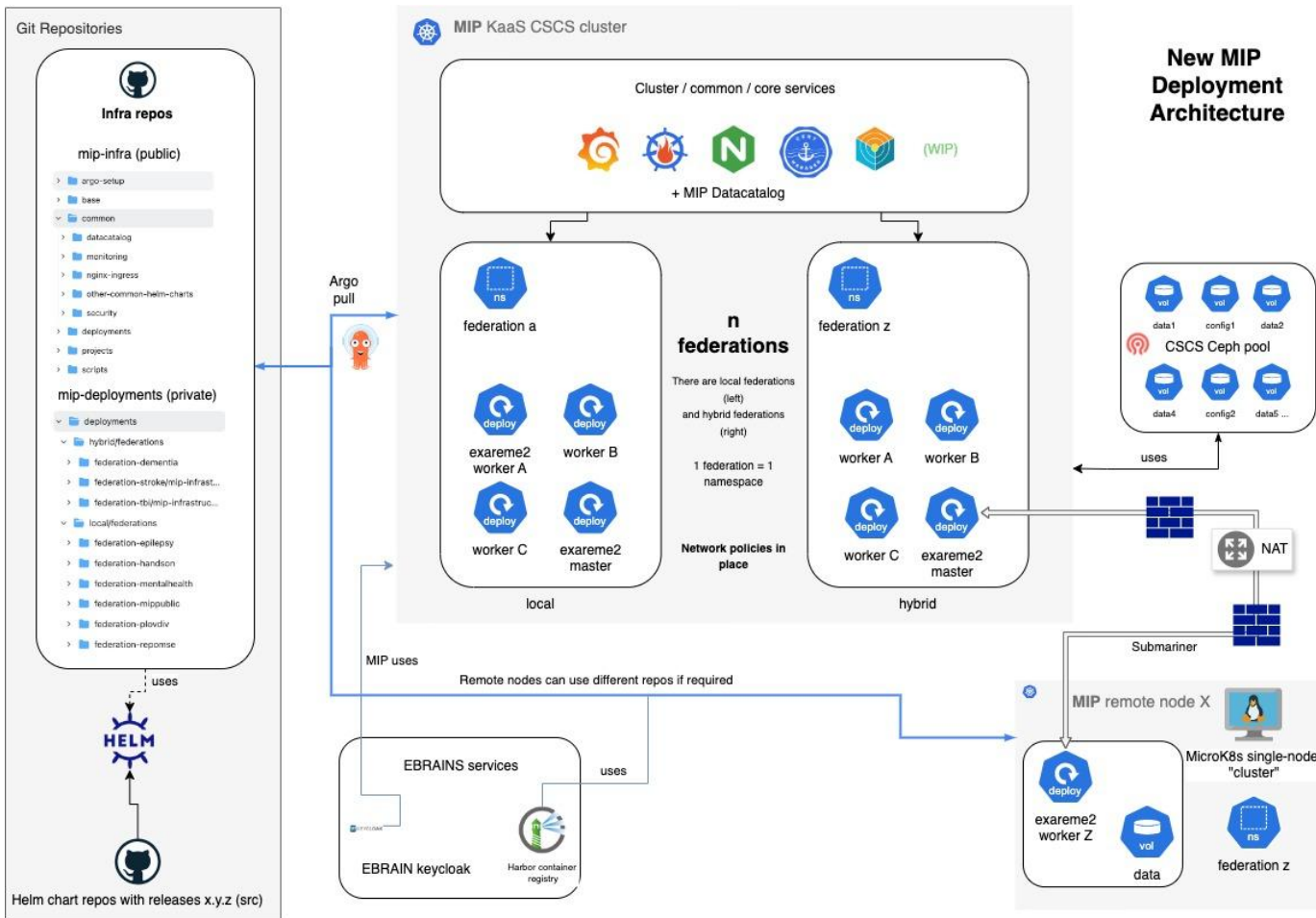


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- IaC - <https://github.com/Medical-Informatics-Platform/mip-infra> (QR)
 - Argo-based deployment
 - Deploy Argo on KaaS → RBACs → Argo projects → Argo “infra” → rest automated
- Overall cluster architecture
 - Core / common services (Kubernetes essentials + security + monitoring)
 - N federations deployed from a set of manifests from a private repository
- Cross-cluster connectivity through Submariner
 - Used to connect remote “nodes” aka 1 node clusters on a hardened Linux VM
 - Relies on a “subpart” of Submariner and on its strong resilience
 - Calico + Libreswan as the cable driver - long term goal is to use Cilium





A federation in the MIP - Argo POC



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Applications / [deployments-local-mippublic](#)

[DETAILS](#) [DIFF](#) [SYNC](#) [SYNC STATUS](#) [HISTORY AND ROLLBACK](#) [DELETE](#) [REFRESH](#)

APP HEALTH

Healthy

SYNC STATUS

Synced to [main \(f8c8c06\)](#)

Auto sync is enabled.

Author: [Julien D <150942337+jdaln@users.noreply.github.com>](#) -

Comment: [Version 0.9.0 \(#2\)](#)

LAST SYNC

Sync OK to [7e7baac](#)

Succeeded 7 days ago (Mon Aug 11 2025 09:28:11 GMT+0200)

Author: [github-actions\[bot\] <github-actions\[bot\]@users.noreply.github.com>](#) -

Comment: [style: auto-fix YAML linting issues](#)

SYNC WINDOWS

SyncWindow

100%



deployments-local-mippublic



10 days



federation-mippublic-exareme2



application

10 days



federation-mippublic-mip-stack



application

10 days

A federation in the MIP - Argo POV

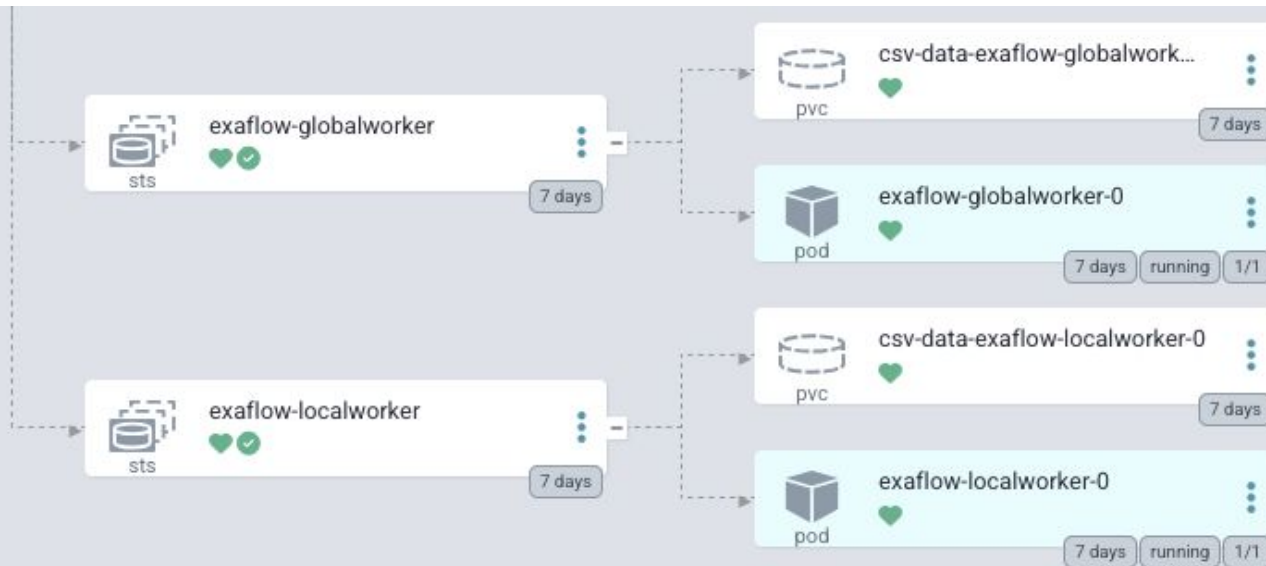


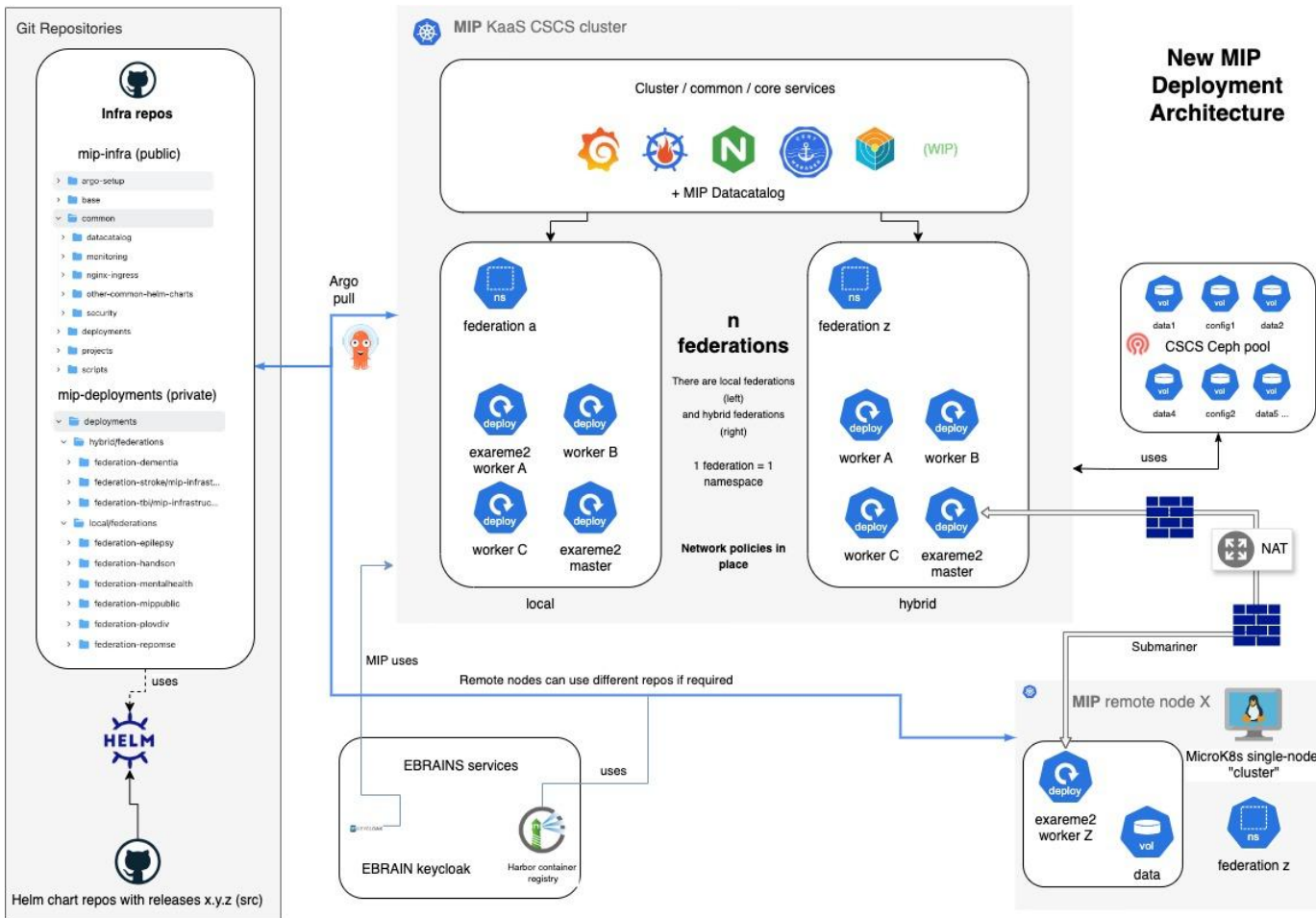
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Submariner in the MIP



What we needed



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- 2-way connection through any network barrier that
 - is secure
 - and fault tolerant
- Scalable solution
 - a few nodes to start
 - but it will become larger
- Minimal exposure of the main cluster to the remote nodes (some kind of a service mesh)



What we considered or tried - 1/2



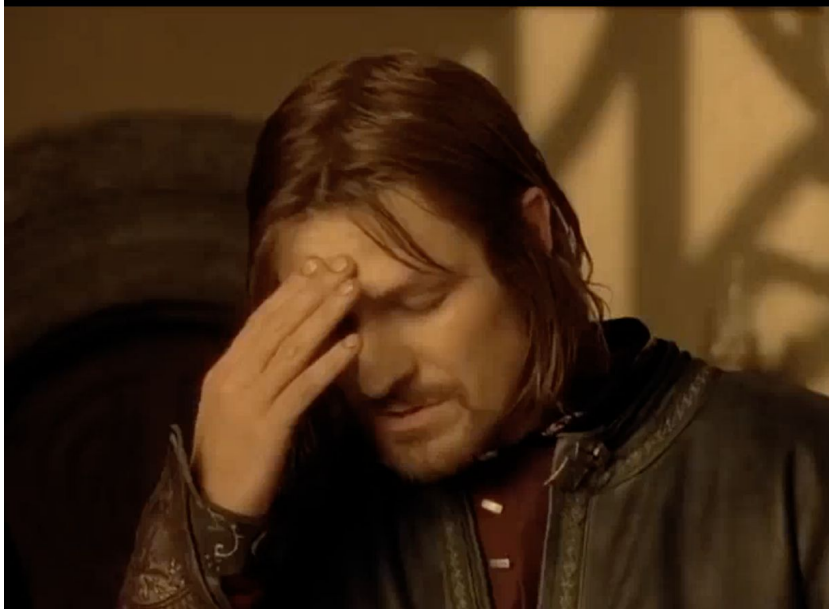
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ONE DOES NOT SIMPLY



CONNECT REMOTE NODES

- Cilium Mesh + Wireguard
 - Keywords match...
 - However not Mesh over wireguard!
- k0s
 - Connects full Kubernetes to one another over any network
 - Hard to segment workloads
 - Might cause issues with our KaaS provider
- Submariner
 - Fits it all
 - But does not work fully with Cilium!

What we considered or tried 2/2



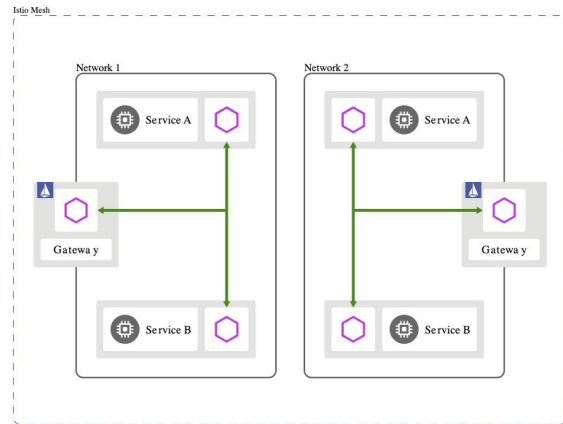
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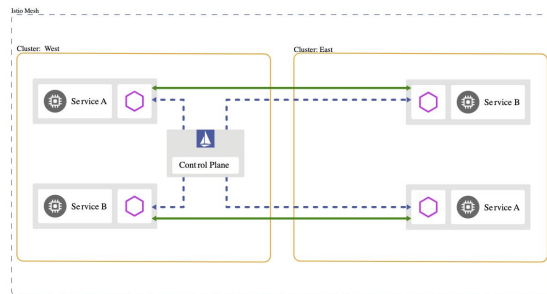
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- Karmada
 - Uses Submariner
 - → same issue with Cilium
- Tailscale
 - Not really meant for that in 2024-2025
- Istio service mesh
 - ... almost!
 - Multi-network: each cluster exposes east-west gateway that must be reachable from the other cluster



A service mesh with multiple networks



A service mesh with a primary and a remote cluster

source: solo.io /
istio project

Sorry Cilium - bye for now



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- Move to Calico
 - Calico must run with the Calico API (all peers & broker) for auto provisioning
 - <https://github.com/Medical-Informatics-Platform/mip-infra/tree/main/deployments/hybrid/federations/federation-Z/remote-node>
Federation-Z remote node deployment example (QR)



```
~ > kubectl get clusters.submariner.io,endpoints.submariner.io -n submariner-k8s-broker
```

NAME	AGE
cluster.submariner.io/mip-tds-fqdn	7d21h
cluster.submariner.io/node2	7d21h
cluster.submariner.io/node3	5d23h

NAME	AGE
endpoint.submariner.io/mip-tds-fqdn-submariner-cable-mip-tds-fqdn-148-187-27-131	7d21h
endpoint.submariner.io/node2-submariner-cable-node2-194-182-160-141	7d21h
endpoint.submariner.io/node3-submariner-cable-node3-10-86-204-132	5d23h

```
~ > subctl show all
Cluster "mip-tds-fqdn"
✓ Detecting broker(s)
```

NAMESPACE	NAME	COMPONENTS	GLOBALNET	GLOBALNET CIDR	DEFAULT GLOBALNET
submariner-k8s-broker	submariner-broker	service-discovery, connectivity	no	242.0.0.0/8	65536

```
✓ Showing Connections
```

GATEWAY	CLUSTER	REMOTE IP	NAT	CABLE DRIVER	SUBNETS	STATUS
testing-cilium-remotenode-2	node3	148.187.149.178	yes	libreswan	10.152.185.0/24, 10.3.0.0/16	connected
submariner-remote-node-testing	node2	194.182.160.141	no	libreswan	10.152.184.0/24, 10.2.0.0/16	connected
vm-proxmox-test	node6	144.2.116.162	yes	libreswan	10.152.189.0/24, 10.7.0.0/16	connected

Sorry Cilium - bye for now



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```
ju4777 -- kubecti -n test run tmp-shell --rm -it --image quay.io/submariner/nettest -- -- kubecti -- kubecti -n test run tmp-sh...
<style>
html { color-scheme: light dark; }
body { width: 35em; margin: 0 auto;
font-family: Tahoma, Verdana, Arial, sans-serif; }
</style>
</head>
<body>
<h1>Welcome to nginx!</h1>
<p>If you see this page, the nginx web server is successfully installed and
working. Further configuration is required.</p>

<p>For online documentation and support please refer to
<a href="http://nginx.org/">nginx.org</a>.<br/>
Commercial support is available at
<a href="http://nginx.com/">nginx.com</a>.</p>

<p><em>Thank you for using nginx.</em></p>
</body>
</html>
bash-5.0# curl nginx9.test.svc.clusterset.local:8080
<!DOCTYPE html>
<html>
<head>
<title>Welcome to nginx!</title>
<style>
html { color-scheme: light dark; }
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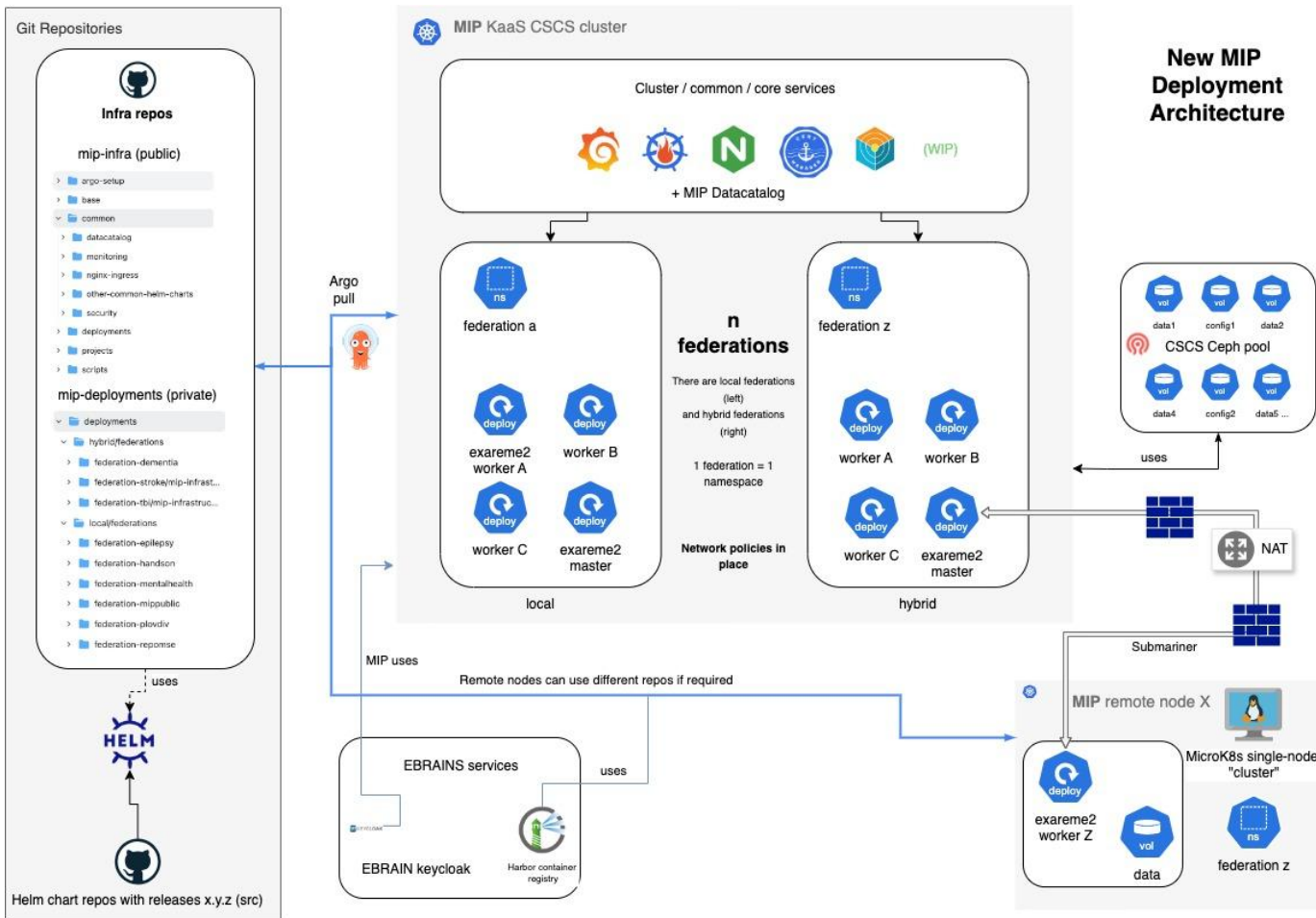
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<p><em>Thank you for using nginx.</em></p>
</body>
</html>
bash-5.0#
```

```
Downloads -- ubuntu@testing-cilium-remotenode-2: -- ssh - ssh ubuntu@10.86.204.132 -- 88x44
nginx5 ClusterSetIP 5d23h
nginx9 ClusterSetIP 50s
ubuntu@testing-cilium-remotenode-2:~$ subctl show connections
Cluster "microk8s-cluster"
  ✓ Showing Connections
GATEWAY CLUSTER REMOTE IP NAT CABLE DRIVER SU
BNETS STATUS RTT avg.
submariner-remote-node-testing node2 194.182.160.141 yes libreswan 10
.152.184.0/24, 10.2.0.0/16 connected 5.492823ms
mip-tds-worker-lc4mp-762nv mip-tds-fqdn 148.187.27.131 yes libreswan 10
.43.0.0/16, 10.42.0.0/16 connected 1.042367ms
vm-proxmox-test node6 144.2.116.162 yes libreswan 10
.152.189.0/24, 10.7.0.0/16 connecting 0s
ubuntu@testing-cilium-remotenode-2:~$ kubecti -n test run tmp-shell --rm -it --image quay
.io/submariner/nettest -- /bin/bash
If you don't see a command prompt, try pressing enter.
bash-5.0# curl nginx.test.svc.clusterset.local:8080
<!DOCTYPE html>
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<head>
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<p><em>Thank you for using nginx.</em></p>
</body>
</html>
bash-5.0# curl nginx9.test.svc.clusterset.local:8080
curl: (6) Could not resolve host: nginx9.test.svc.clusterset.local
bash-5.0#
```



Coping with Cilium + Submariner



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- Experiments in 2024 - 2025 → Remember **we have only one non FW/NATed cluster**
 - Sometimes clusters would display connected
 - However, cross cluster traffic would not work
 - 2 trials brought some success
 - `"enable-ipv4-masquerade":"false"` on one side would allow 1-way traffic
 - Our KaaS provider could not have it set to false on their side
 - We could not find a way to get the traffic flowing the other way
 - → Real solution: make Submariner work with eBPF?
 - Loadbalancer mode
 - `subctl join --load-balancer --clustercidr "10.42.0.0/16" broker-info.subm`
 - Communication would work from public cluster → node but not the reverse way
- <https://github.com/submariner-io/submariner/issues/3168> open for contributions

Submariner broker/peer models misused

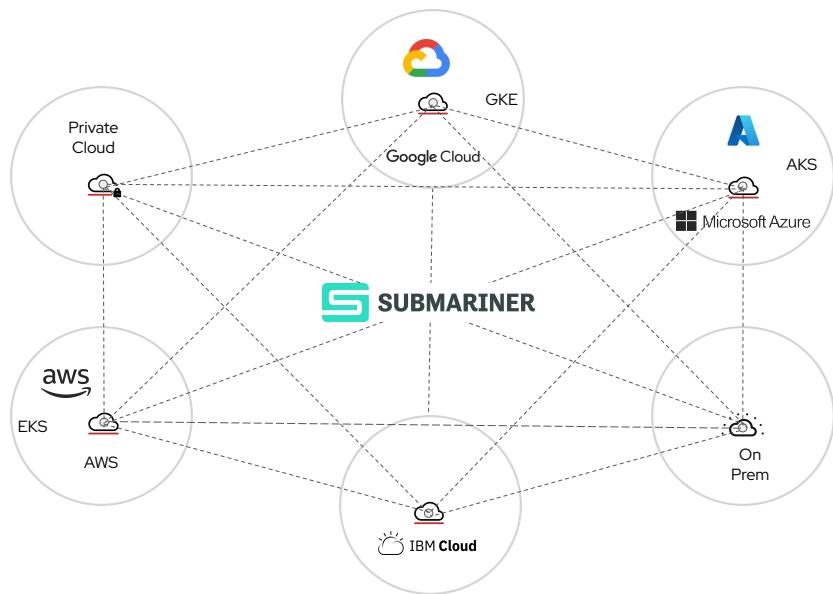


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- Federation rather than peering
 - We have a main cluster
 - And remote nodes communicating
- Remote nodes do not communicate
 - This is by design in our case
- ... but Submariner is not designed for that!
 - ... however, it works :)
 - The logs fill up
 - Solution: add a switch to the connecting of the peers so they don't retry or don't connect in the first place?

Integration of the Helm chart with Argo



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- Submariner in the common directory has:
 - Broker
 - Operator
- Broker
 - Needed to have both secrets and PSK to the operator → would not work in argo
 - missing hooks → now patched, secrets can be set before
- Operator
 - Uses these secrets for remote node communication and encryption

- ▼ submariner
 - ▼ broker
 - copy-secret-hook.yaml
 - kustomization.yaml
 - values.yaml
 - ▼ operator
 - gateway-loadbalancer-ip.yaml
 - kustomization.yaml
 - values.yaml
 - ▼ patches
 - gateway-loadbalancer-ip.yaml
 - README.md
 - kustomization.yaml
 - submariner.yaml
 - values-public-cluster.yaml

Integration of the Helm chart with Argo



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apiVersion: kustomize.config.k8s.io/v1beta1

kind: Kustomization

helmCharts:

- name: submariner-operator

repo: <https://raw.githubusercontent.com/submariner-io/submariner-charts/gh-pages/charts>

version: 0.21.0

releaseName: submariner-operator

namespace: submariner-operator

valuesFile: values.yaml

includeCRDs: true

resources: [gateway-loadbalancer-ip.yaml]

patches:

kustomization.yaml

values.yaml

submariner:

clusterId: mip-tds-fqdn

Network configuration - From deployed cluster

clusterCidr: 10.42.0.0/16 # Pod network CIDR

serviceCidr: '' # Not specified (empty in deployed config)

Globalnet disabled (CIDRs don't overlap)

globalCidr: ''

Clusterset IP configuration for service discovery

clustersetIpCidr: 243.0.0.0/20

clustersetIpEnabled: false

NAT traversal enabled for remote clusters behind NAT

natEnabled: true

LoadBalancer service type for gateway

loadBalancerEnabled: true

Cable driver - From deployed config

cableDriver: libreswan



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How to contribute



Do you use Submariner?



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- Please let us know!
- Open an issue on <https://github.com/submariner-io/submariner/issues/new>

Do you struggle with Submariner?



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- Please let us know!
- Open an issue on <https://github.com/submariner-io/submariner/issues/new>

Do you want to learn more about Submariner?



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<https://submariner.io>

Do you want to chat with the developers?



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- Join them in the weekly development call
- Mondays at 3pm CET



<https://meet.google.com/grf-vgsh-ubv>

Do you want to explore Submariner?



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- Clone any of the development repositories
- Deploy a test environment
 - make deploy
- Use the resulting KUBECONFIG
- To clean up,
 - make clean-clusters

Do you want to improve Submariner?



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- Clone the relevant repository and open a pull-request!
- Before submitting, please check your work:
 - make build
 - make golangci-lint
 - make unit
 - make e2e



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<https://sched.co/2EF7I>