Multitenancy in Kubernetes:

Better walls make better tenants

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Wednesday, June 17, 2020
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Goal of this session

Understand Google's opinionated **best practices** for enterprise multitenancy on Kubernetes, including when and how to apply them.

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Topics

1. Why use multitenancy?
2. What are the principles of multitenancy?
3. How do I implement multitenancy?
4. Advanced topics
5. Conclusion

Why use multitenancy?

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What companies care about

Cost

Velocity

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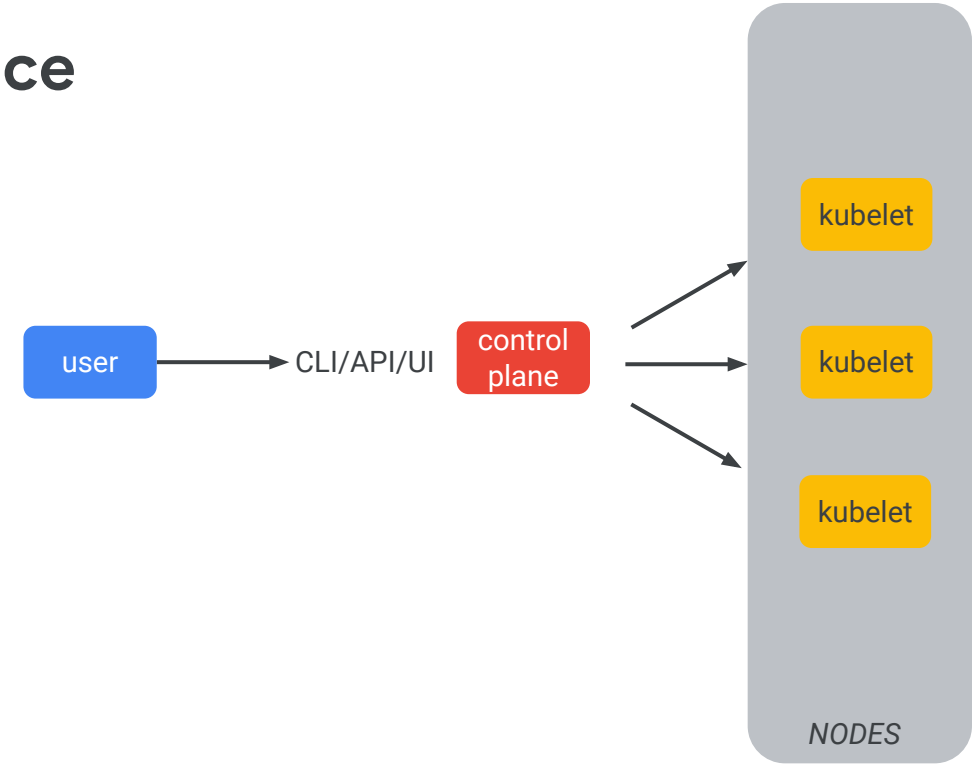
Kubernetes at a glance



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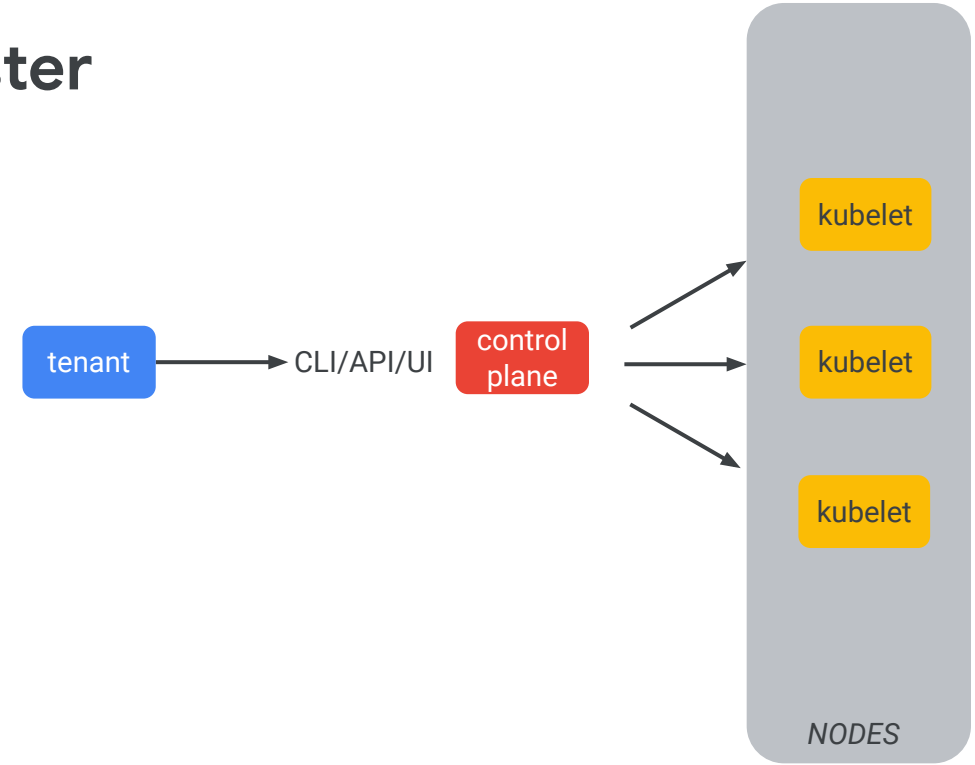
One tenant, one cluster



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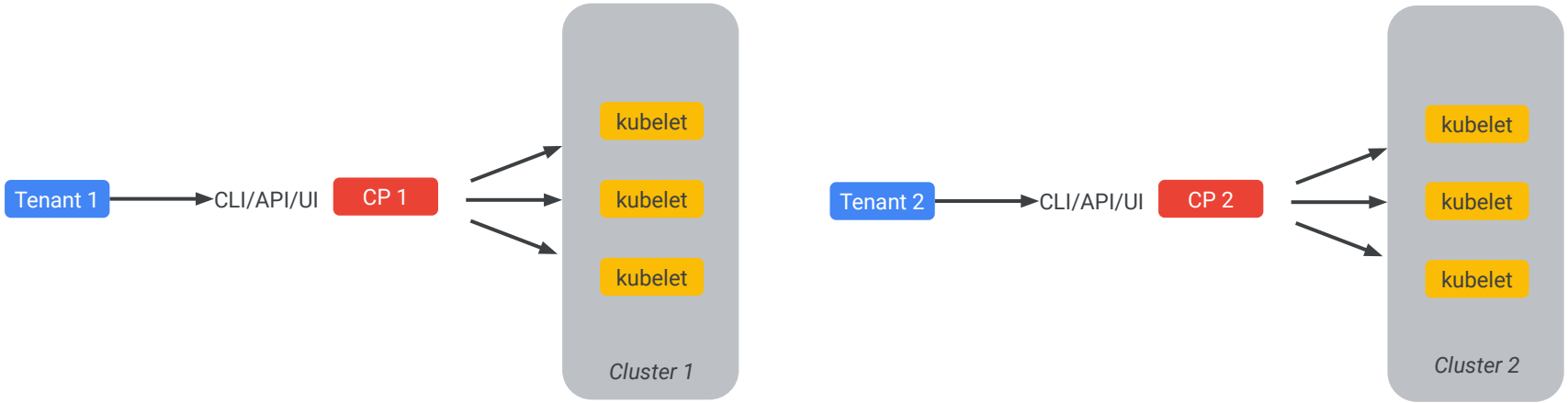
Multiple tenants, multiple clusters



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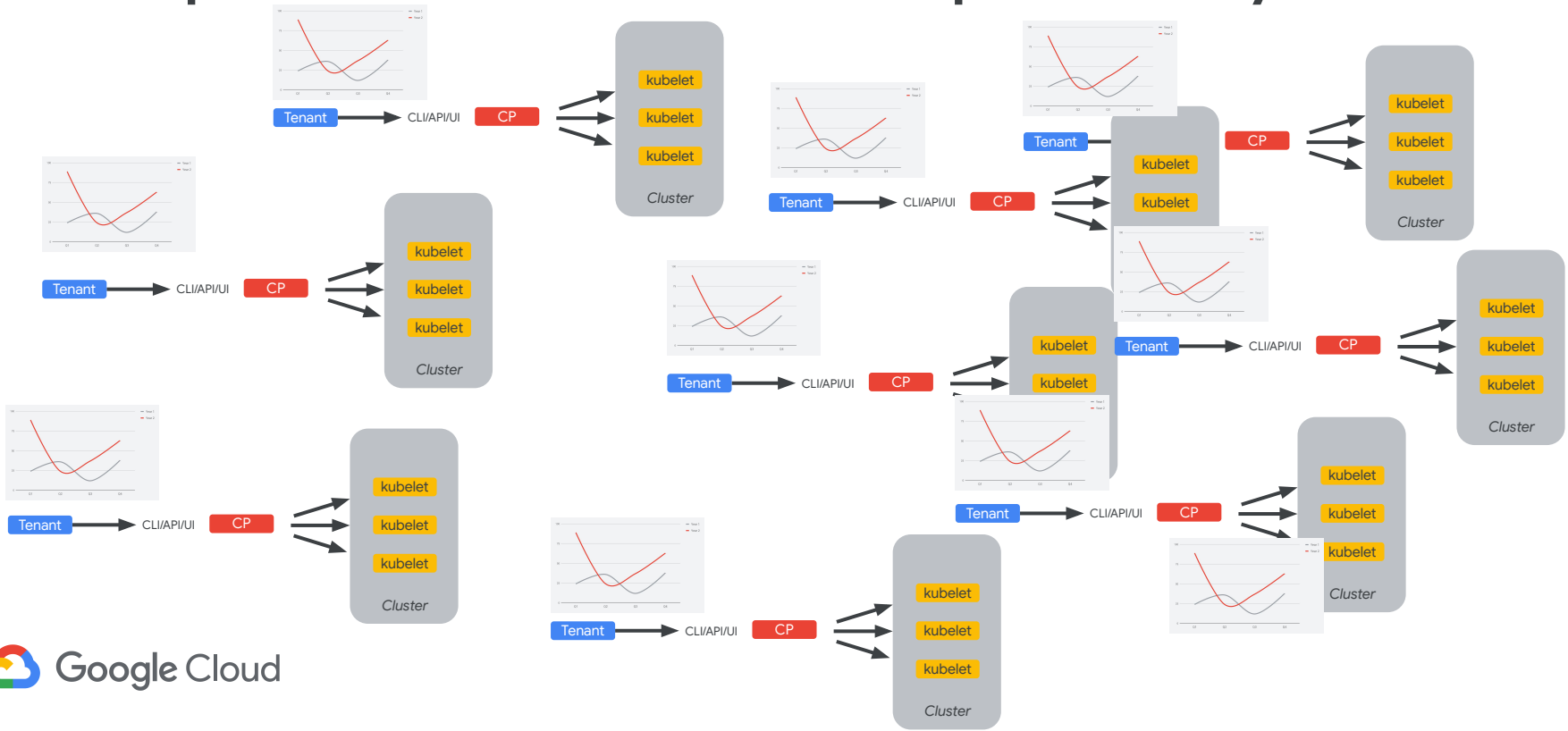
Kubesprawl: how does this scale operationally?



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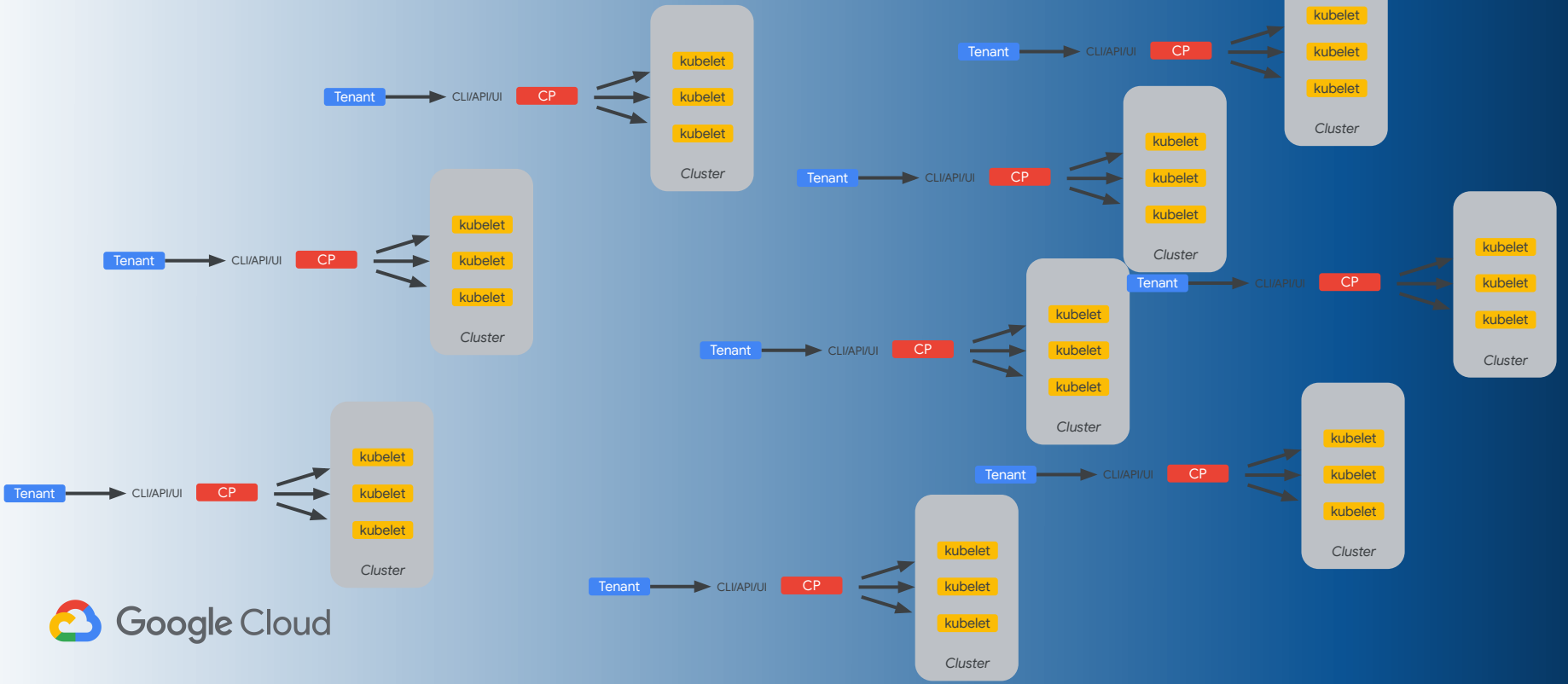
Kubesprawl: how does this scale financially?



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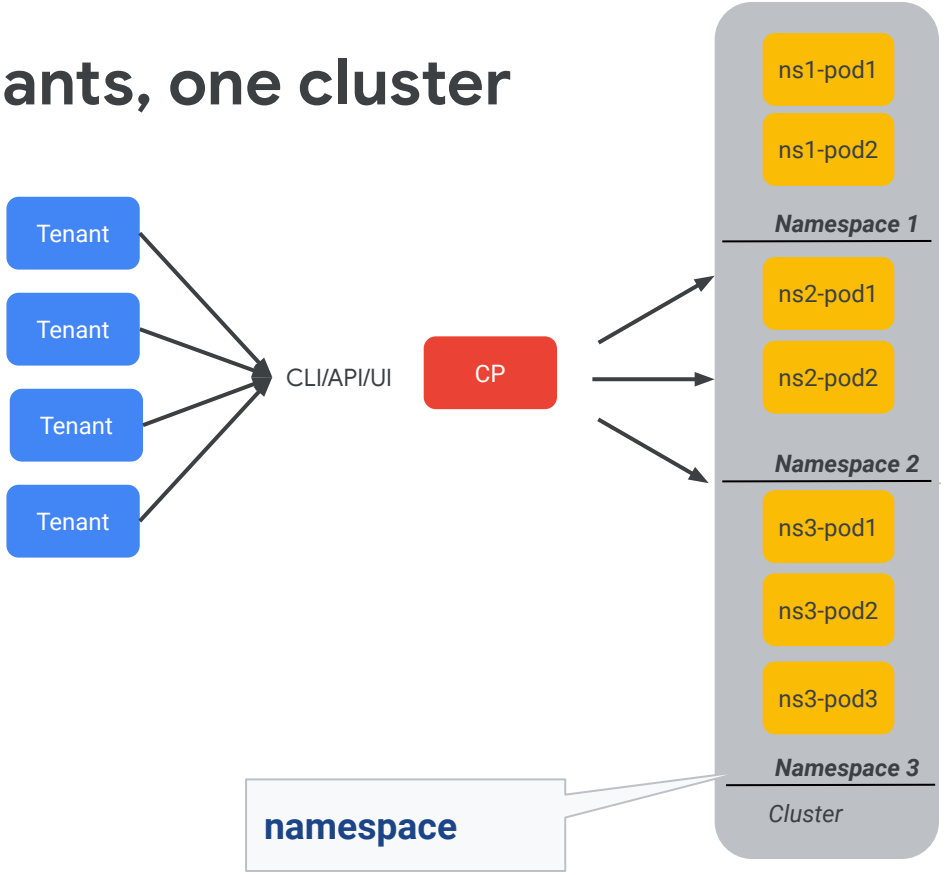
Alternative: many tenants, one cluster



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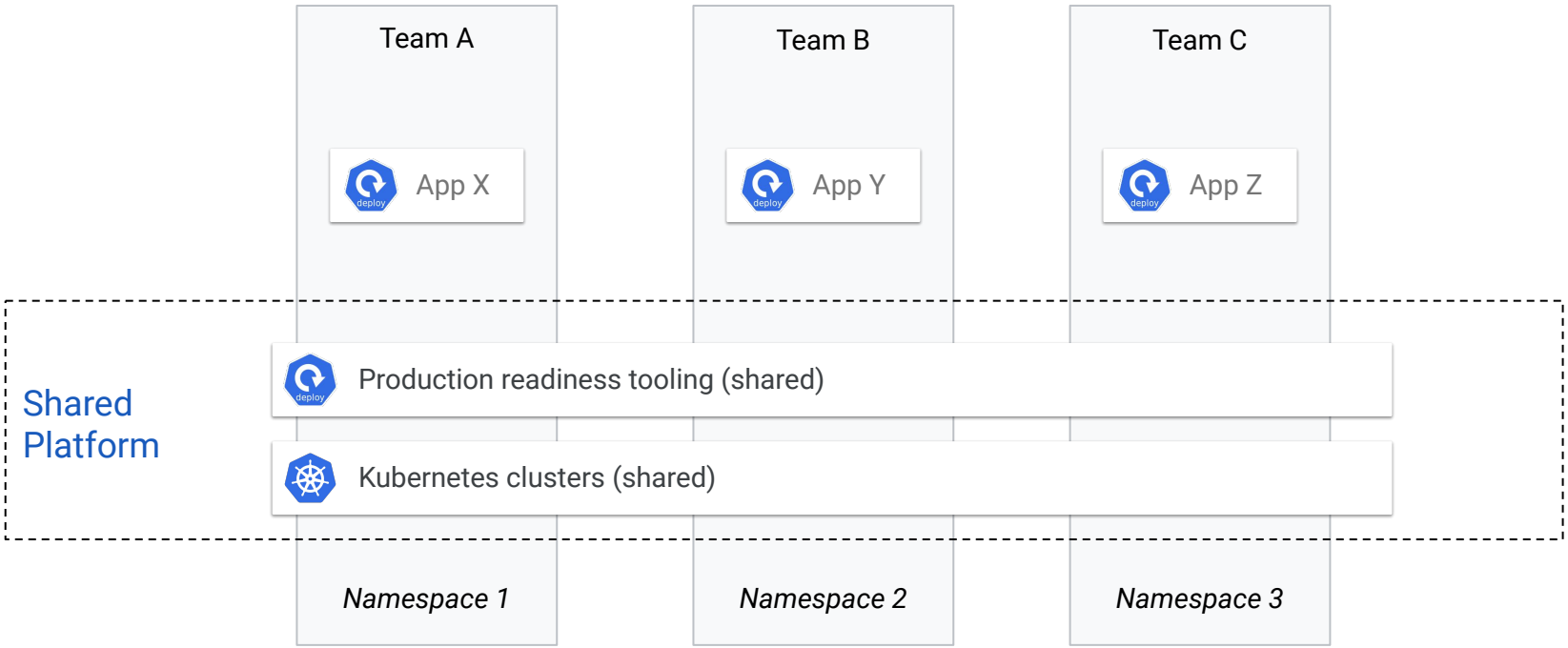
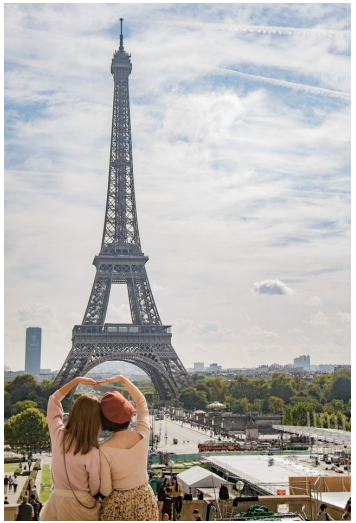
Multitenancy reduces overhead and cost



When *should* you use multiple clusters?

Regionalization



Blast radius

Scalability

Cluster snowflakes

… mainly CRDs, webhooks, or cluster-scoped operators

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See also: "The myth of the monocluster"

What are the principles of multitenancy?

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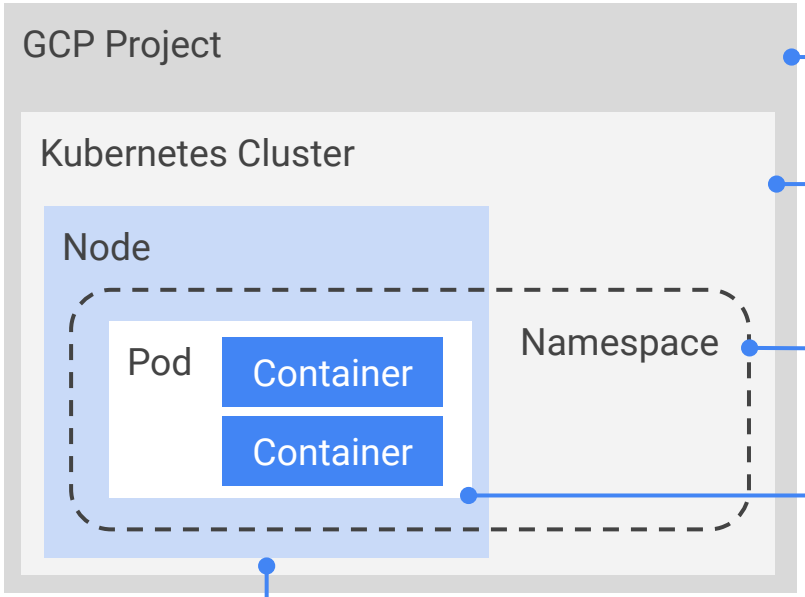
Overview of isolation in Kubernetes



Project: top level isolation

Cluster: strongest isolation within the same project

Namespace: allows control plane isolation within the same cluster (no workload isolation)

Pod: localhost “isolation”

Node: good resource (not security!) isolation

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What does “multitenancy in Kubernetes” mean?

Provide isolation and
fair resource sharing between
multiple users and their workloads
within a single cluster

Best Practices

1. Understand your needs. Not everyone needs everything all at once! Think about cost, overhead, and risk tolerance.
2. Understand the pros/cons of various approaches and technologies to solve your most critical problems.
3. Deploy your solutions, and keep them up-to-date, and iterate to achieve more benefits.

How do I implement multitenancy?

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Namespaces

Namespaces are the primary unit of tenancy in Kubernetes.

By themselves, they don't do much except organize other objects - but almost all policies support namespaces by default.

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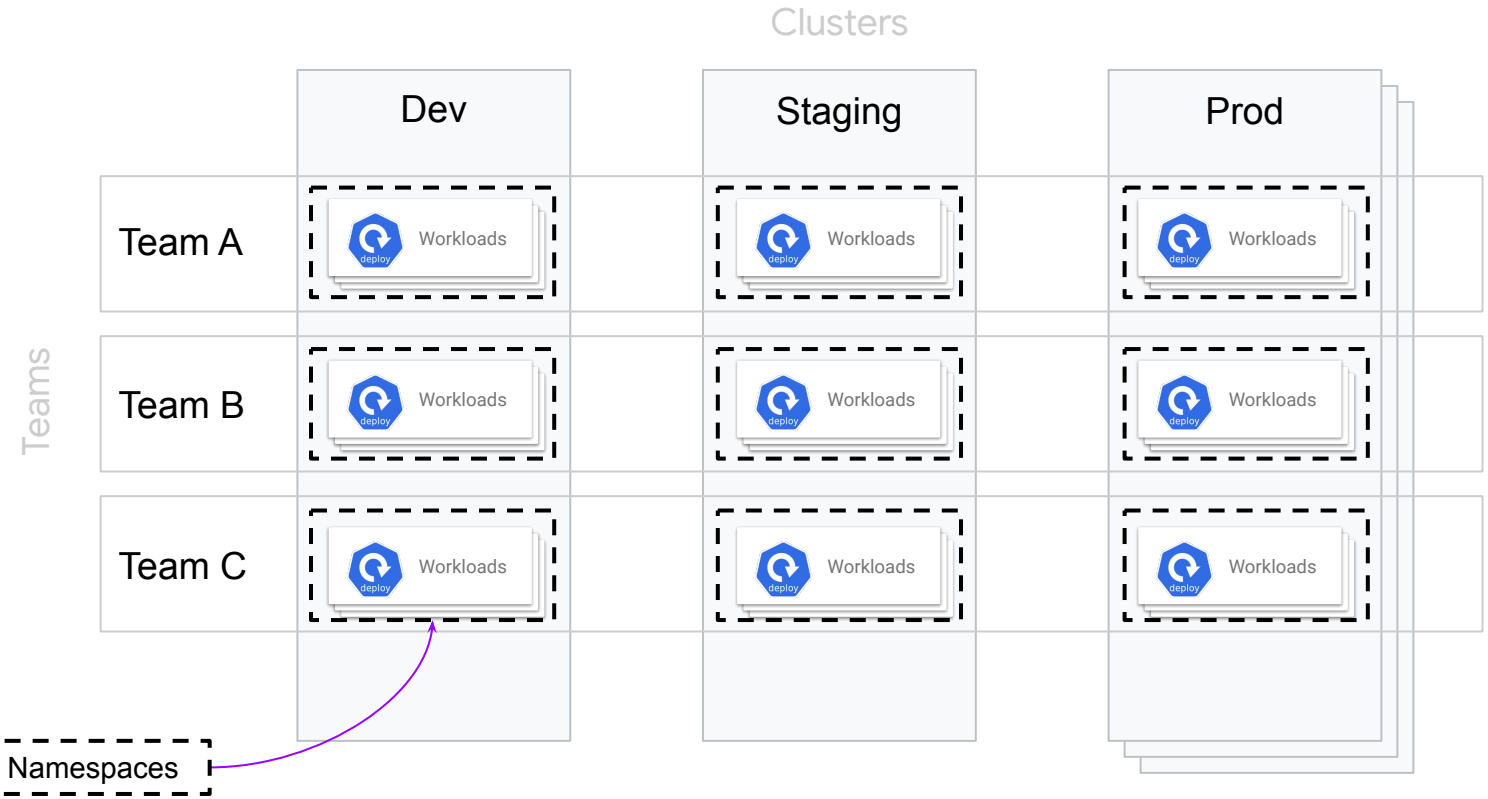
Multitenancy across clusters



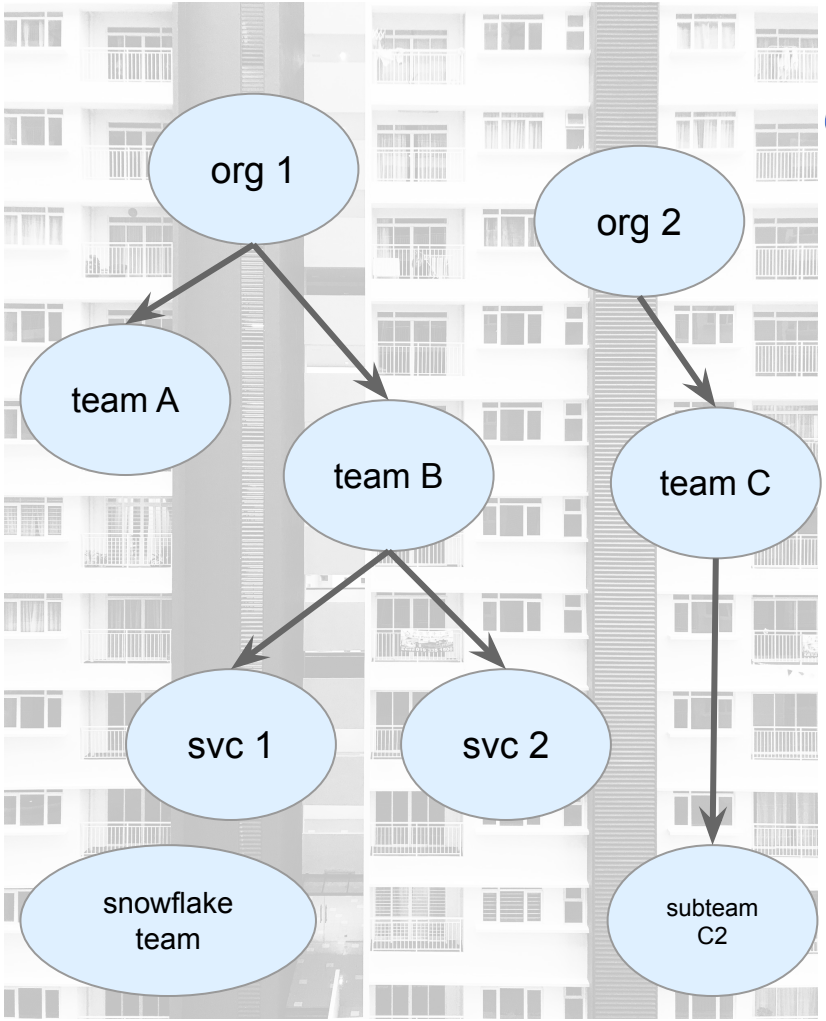
Properties of namespaces

- Require cluster-level permissions to create
- Fully independent policies
- Must be labeled manually to use in policy application (e.g. in Network Policies)
- Included in Kubernetes natively

Hierarchical namespaces

Traditional Kubernetes namespaces are flat, with no relation between them. Hierarchical namespaces express *ownership,* allow for admin delegation and cascading policies.

Hierarchical Namespaces are provided by the [Hierarchical Namespace Controller (HNC)](), a project of wg-multitenancy.



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Properties of hierarchical namespaces

- Can use namespace-level “subnamespace” permission to create
- Inherit policies from ancestors
- Can be selected individually or as subtrees
- Provided via the OSS Hierarchical Namespace Controller (HNC), or as a part of GKE’s Config Sync (available later in June 2020).

Applying multitenancy

1. Access Control
2. Resource Sharing
3. Runtime Isolation
4. Insights

Applying multitenancy

Access control

Tenancy is about *ownership*, and ownership is about control. Job #1 is ensuring that tenants can't control each others' resources.

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Authentication and authorization

Control Plane (apiserver)

Resources

Pluggable Auth
(GKE IAM)

RBAC

Cloud IAM Policies

{Cluster}Role
{Cluster}RoleBinding

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Role-Based Access Control (RBAC)

RBAC controls access to namespaces in Kubernetes. They're used for:

- Giving **humans** access to Kubernetes resources
  - On GKE, can use Google Groups to give groups of people identical access
- Giving **non-Kubernetes service accounts** access to the Kubernetes API
  - Example: GCP Service Accounts; also work with Google Groups
- Giving access to **pods** calling Kubernetes APIs (with Kubernetes Service Accounts)

Key RBAC concepts:

ClusterRole	A set of cluster-wide permissions. Some useful defaults are preset (e.g. "admin")
Role	Like a ClusterRole, but limited to a single namespace
ClusterRoleBinding	Give a role to one or more *subjects* (humans, SAs, etc) across the whole cluster.
RoleBinding	Give a role *within* a single namespace. You can also use ClusterRoles (e.g. "admin") to grant predefined permissions, but limited to that one namespace

GKE Workload Identity

Let Google **manage and rotate the credentials** that are used by your Kubernetes workloads to access GCP services.

- Workloads attaching a Kubernetes SA automatically authenticate as a separate GCP SA when accessing GCP API
- Allows the Oauth scopes and service accounts attached to node pools to follow least privilege

Replaces these workarounds:

- Using node (VM) identity for the pod
- Removes the need for exporting user managed service account keys and embedding them in kubernetes native secrets

Applying multitenancy

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Resource sharing

Many elements of the cluster are still shared, especially nodes and the apiserver itself. Make sure your tenants can share them fairly.

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Resource Sharing

- **Resource Quotas:** no one *namespace* can exceed resource usage. Also used to control dangerous objects (ingress, external services).
- **Limit Range:** no one *pod* can exceed resource usage
- **Pod Affinity/Anti-affinity:** keep pods scheduled together/apart
- **Pod Priority:** pick a winner when there isn't enough to go around

Applying multitenancy

Access Control

Resource Sharing

Runtime Isolation

Insights

1 2 3 4

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Runtime isolation

Vulnerabilities and attacks are a reality, and containers aren’t a security boundary. Consider adding runtime isolation to stop anything getting out of your containers.

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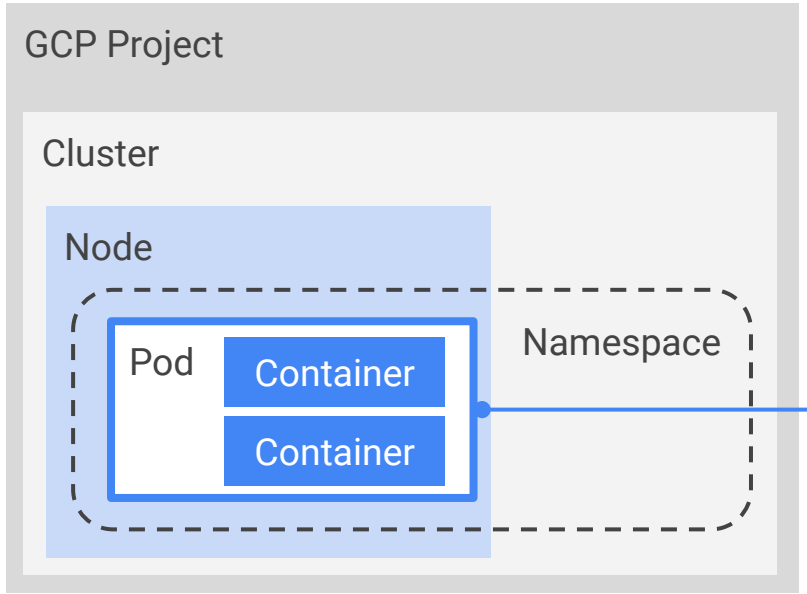
Runtime boundaries in Kubernetes



Pod: a unit of scheduling and deploying workloads (no secure isolation by default)

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Runtime isolation: overview

- **Pod Security Context:** restrict a pod's workload (eg non-root).
- **Pod Security Policy:** enforce that pods *must* declare an appropriate context. **Hard to enable on a working cluster;** consider alternatives like OPA Gatekeeper or Anthos Policy Controller.
- **Network Policy:** forbid pods from talking to each other if they have no good reason to.
- **Runtime Class:** run pods in sandboxes like gVisor or Kata Containers.

Runtime isolation: GKE Sandbox

GKE's built-in Runtime Class protects your pods.

Adds a security boundary to containers in GKE based on **gVisor**.

Defense-in-depth security principles **without application changes**, new architecture models, or added complexity.

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Applying multitenancy

Access Control

Resource Sharing

Runtime Isolation

Insights

1 2 3 4

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Insights

Tenants need to be able to observe themselves, and you need to be able to observe (and charge!) your tenants.

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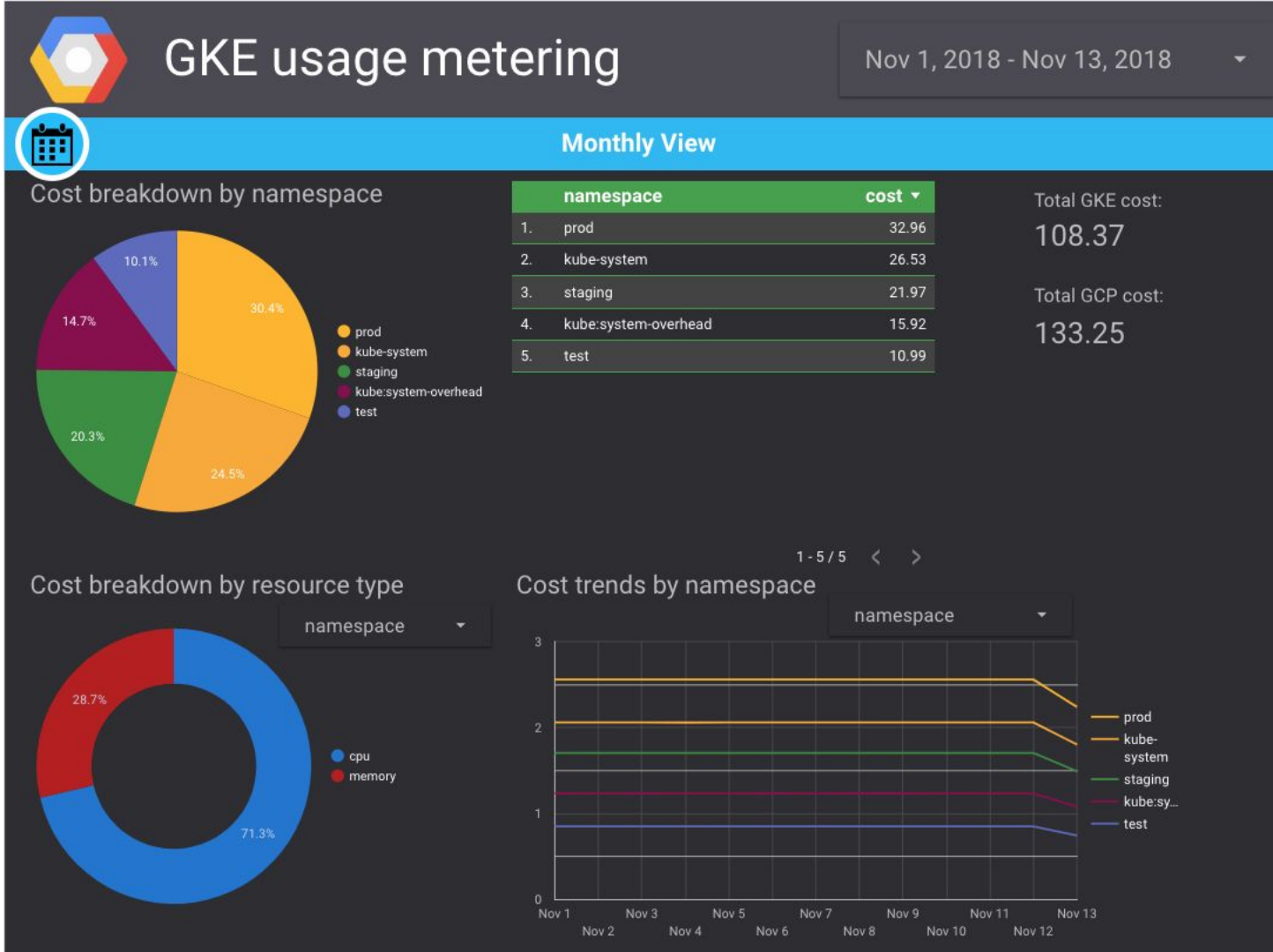
GKE Usage Metering

- View workloads’ resource usage in BigQuery, broken down by namespace and labels
    - Memory, CPU, GPU, PD, network, etc.
- Join usage data with GCP Billing Export data to compute resource costs per tenant

GKE Usage Metering



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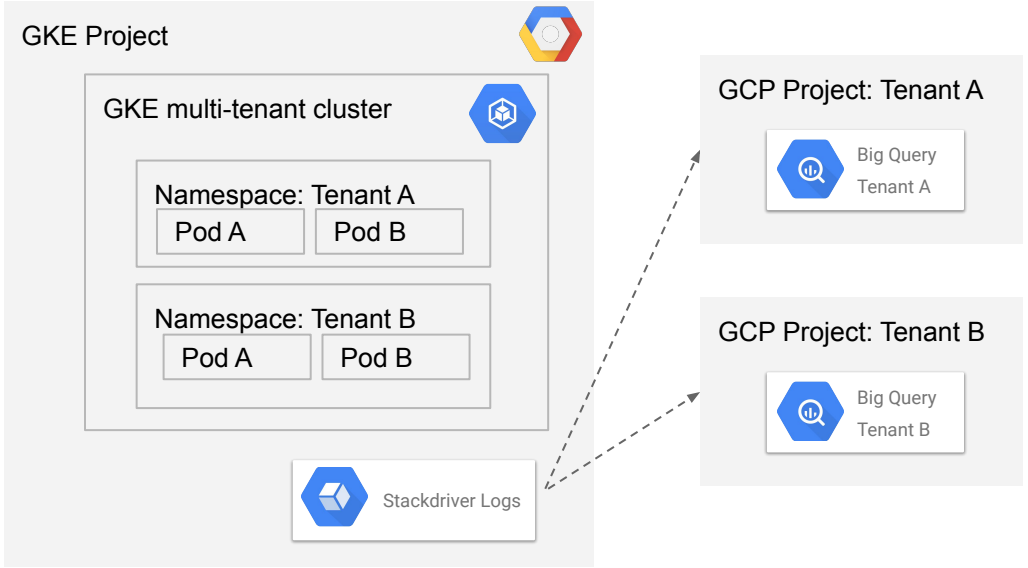
Multitenant logging

Logs often refer to sensitive data, so consider controlling access to them carefully.

- Create a tenant project with a BigQuery dataset for each team.
- Use Log Routing to **filter logs by namespace** and send them to the correct BigQuery dataset.



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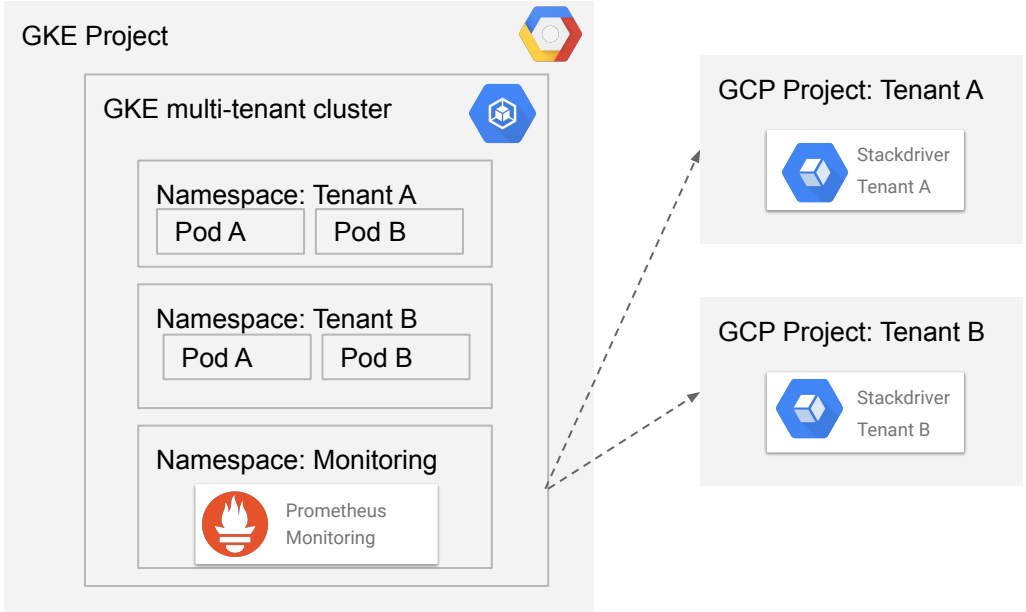
Multitenant monitoring

Metrics are often less sensitive than logs, but you can still control access by tenant if you like.

- Create a tenant project per team.
- As part of the onboarding process, create a **Prometheus / Stackdriver adapter** with a **per namespace config**
- Send each tenant's metrics to the correct project.



Advanced topics

04

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Policy deployment

Be careful about storing your source-of-truth on your cluster.

- Check your policies (e.g. RBAC, Network Policy) into Git as YAML files.
- Have your cluster admin apply them based on Git, or use a CD tool like **GKE Config Sync** or **Anthos Config Management**.
- Test out changes on a canary cluster first, even in prod!
- Separate your policies from your workloads.
  - Possible exception: DaemonSets

Policy enforcement and auditing

Use OPA Gatekeeper (or Anthos Policy Controller) to define and apply custom policies.

- Define rules in Rego (Python-like rule language)
- Apply them across your clusters
- Audit violations
- Useful alternative to Pod Security Policies

Further exploration

Hard multitenancy is loosely defined as the condition where tenants are mutually hostile, not relatively co-operative.

- **Virtual Clusters:** an wg-multitenancy project to give each tenant its own control plane while sharing a data plane. Must be combined with sandboxing.
- **SaaS multitenancy:** many different instances of the same application for different **consumers**. Generally requires sandboxing and control plane automation.

Your needs will be very specific to your threat model!

Conclusion

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Best Practices

1. Understand your needs. Not everyone needs everything all at once! Think about cost, overhead, and risk tolerance.
2. Understand the pros/cons of various approaches and technologies to solve your most critical problems.
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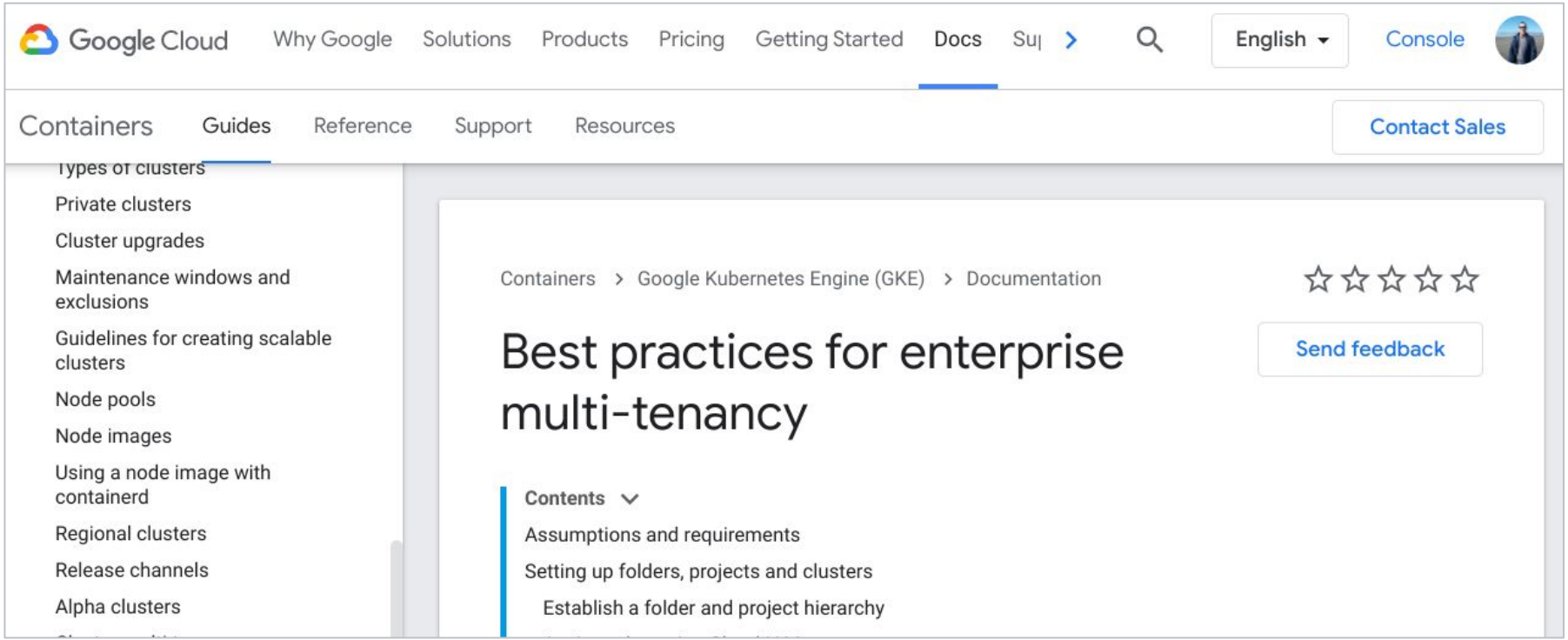
Learning more...



[Available from the GCP docs website]

Learning more...

Kubecon San Diego had some great presentations on building multitenancy systems on Kubernetes. My favourites include:

- Walls within walls: what if your attacker knows parkour?
- Kubernetes at Cruise: two years of multitenancy
- Plus two sessions from the multitenancy working group (wg-multitenancy)

Some other interesting links to follow include:

- The Multitenancy Working Group
- Mercari's experience with multitenant Istio

Multitenancy reduces overhead and cost