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CloudNativeCon
Europe 2025
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Europe 2025

Extending Kubernetes Resource Model (KRM) Beyond Kubernetes workloads

Mangirdas Judeikis & Nabarun Pal

Introduction

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`@theonlynabarun`

Agenda

Part 1: What is Kubernetes Resource Model (KRM) and why it got such success.

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Part 2: We will explore how we, kcp maintainers, push for the next KRM evolution level.

Part 3: For the audience, we will show how to create custom APIs without using CRDs but still using Kubernetes API machinery or kcp.

Why are APIs hard?

Imagine managing a complex hybrid cloud environment with dozens of different APIs

https://github.com/Azure/azure-rest-api-specs https://github.com/googleapis https://github.com/aws/aws-sdk-go-v2

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- Consistency

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- Ecosystem

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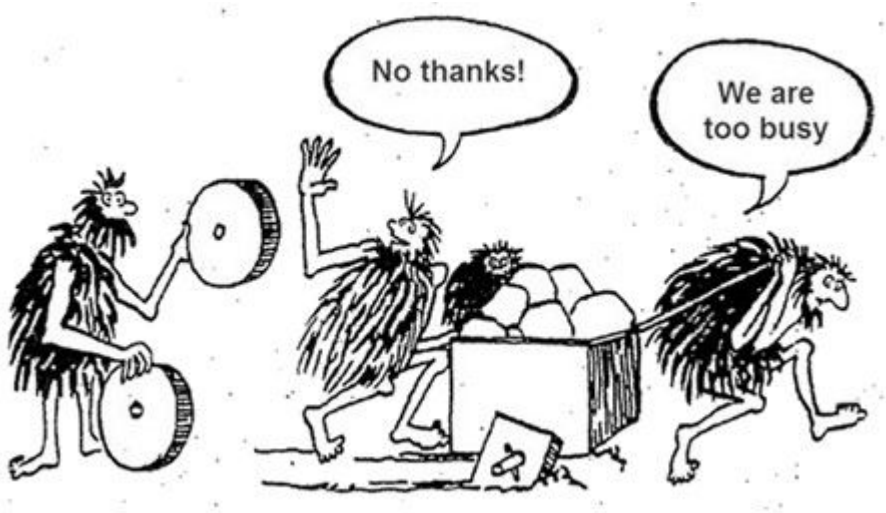
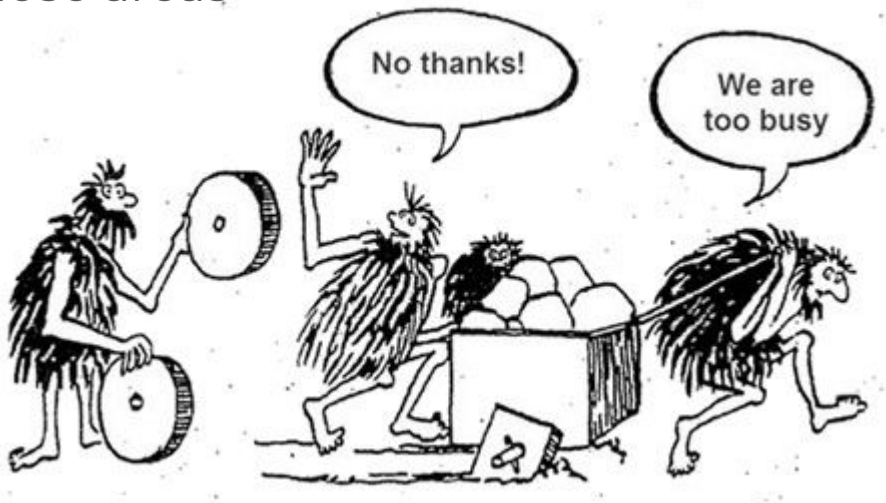


Why are APIs hard?

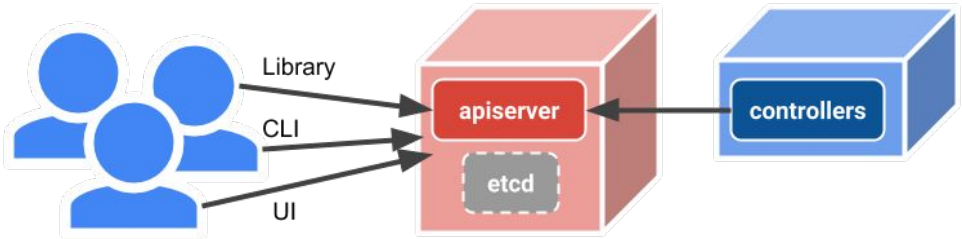
NIH - “Not Invented Here” syndrome. We like ***re-inventing!***

- Know your area of business
- Know where is your value proposition
- Stop inventing things outside those areas
- Adoption & mental model



But the question is **should we re-invent?**

Kubernetes Resource Model (KRM)



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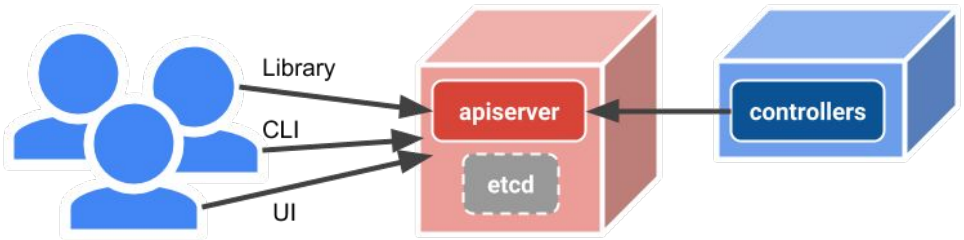
Kubernetes Resource Model (KRM)

Basically kubernetes API.



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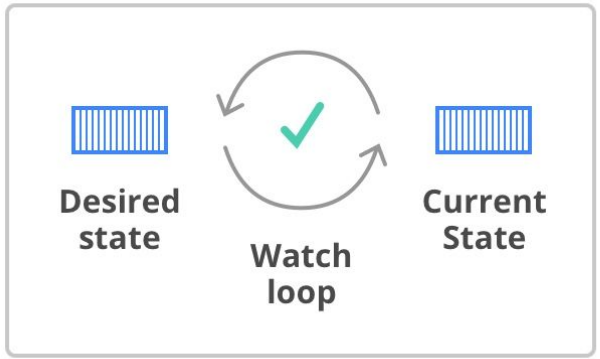
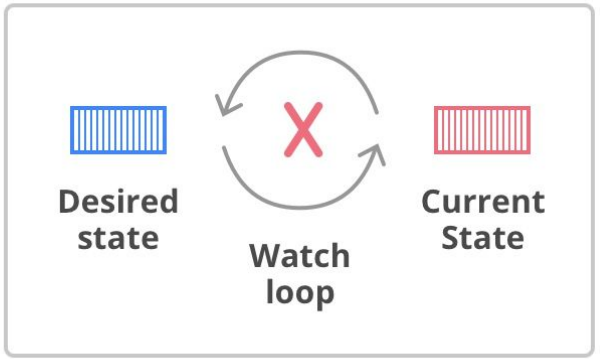
Declarativeness

Declarative models rely on preconfigured capabilities in the language **without explicit case-by-case instructions on what steps to take to accomplish a particular task**





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Structural Consistency


```
apiVersion: shop.k8s.io/v1
kind: Pizza
metadata:
 name: hawaiian
 namespace: default
spec:
 ingredients:
  - pineapples
  - mushrooms
 status:
   phase: baking
   conditions:
    - lastTransitionTime: "2025-01-16T15:41:43Z"
      status: "True"
      type: OrderAccepted
```

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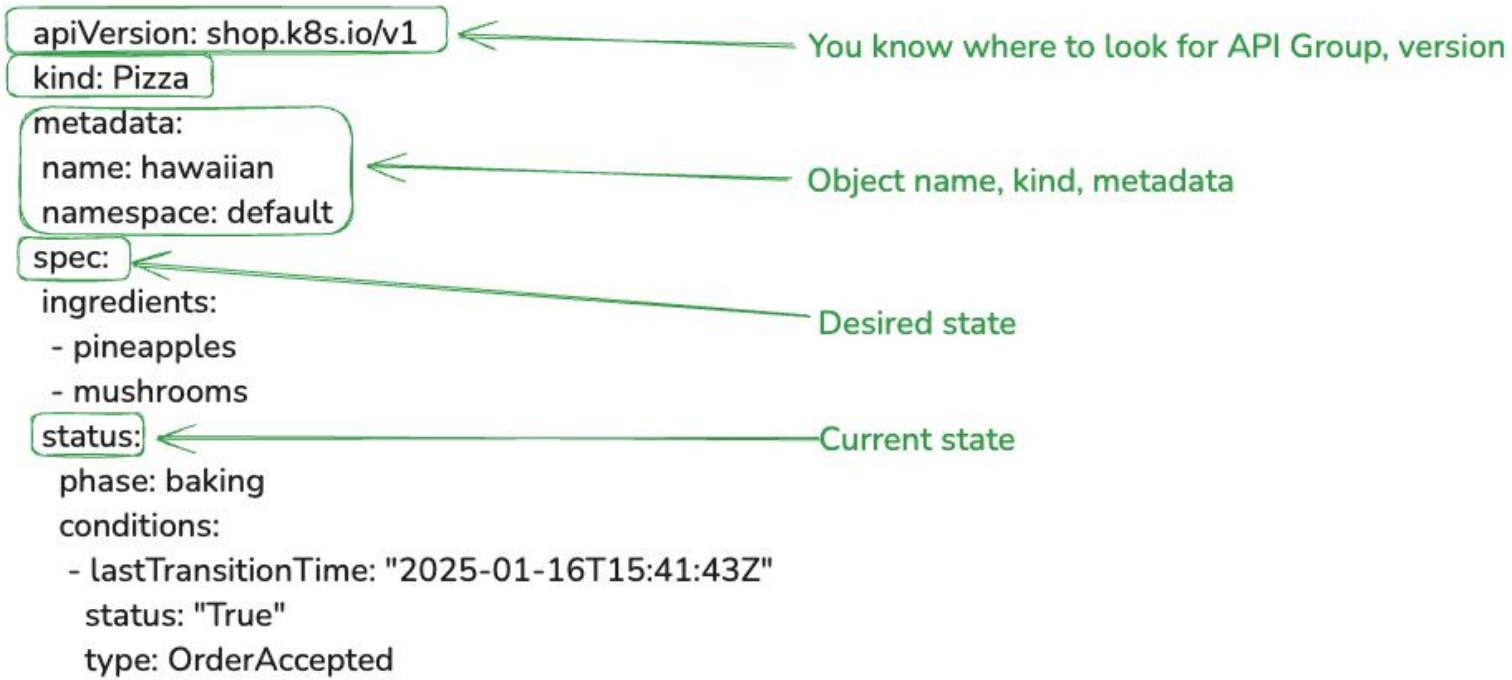

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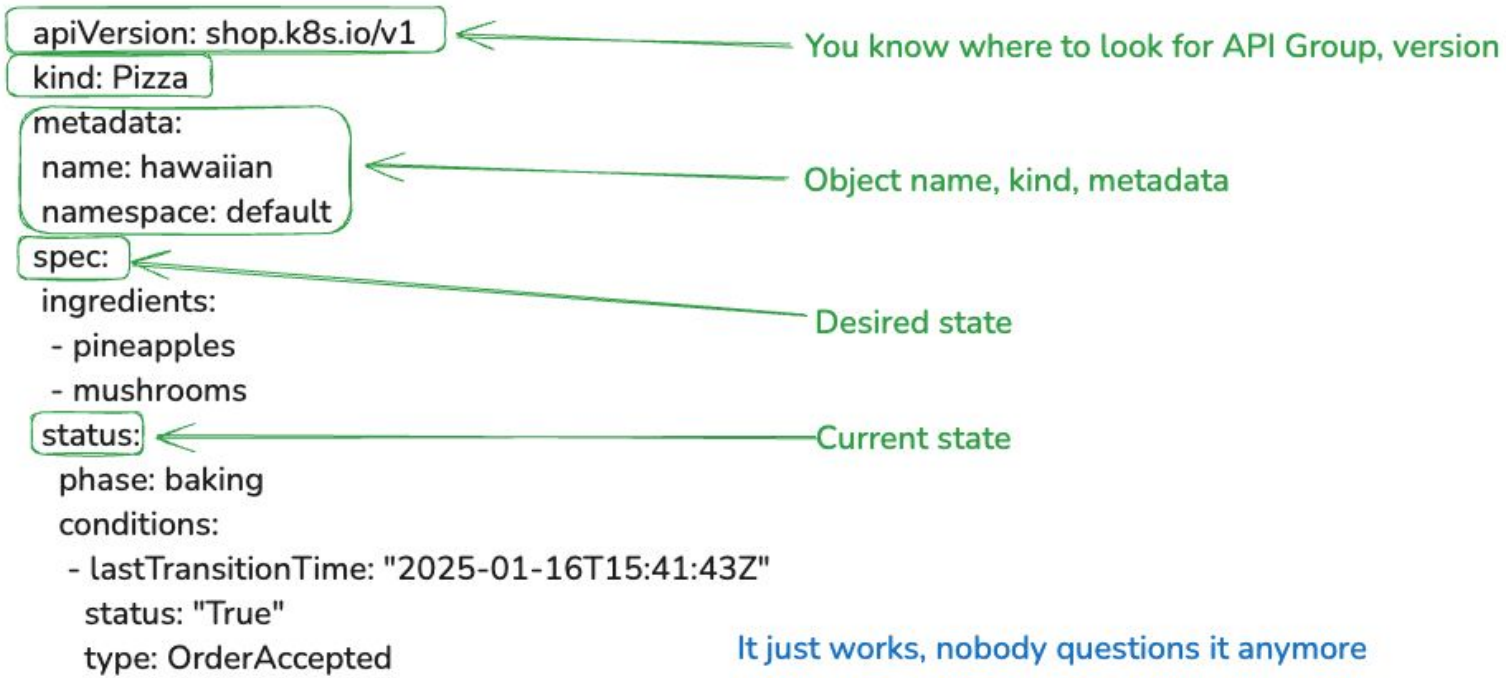

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Reconciliation Loop


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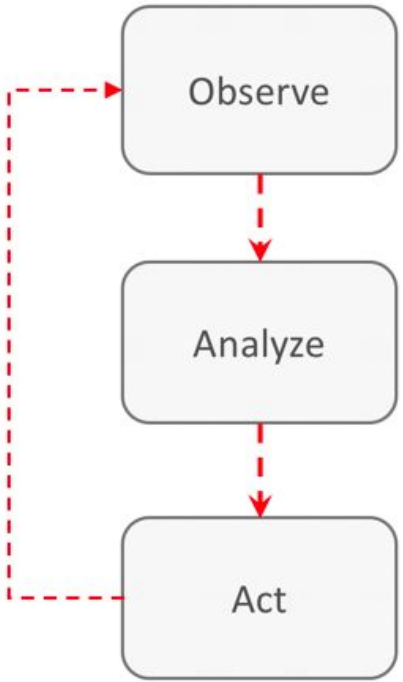

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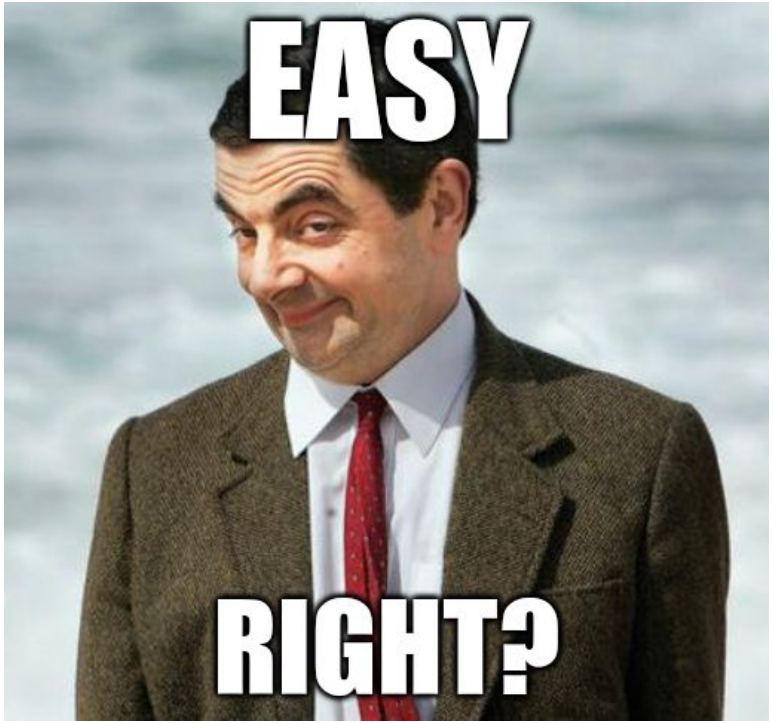
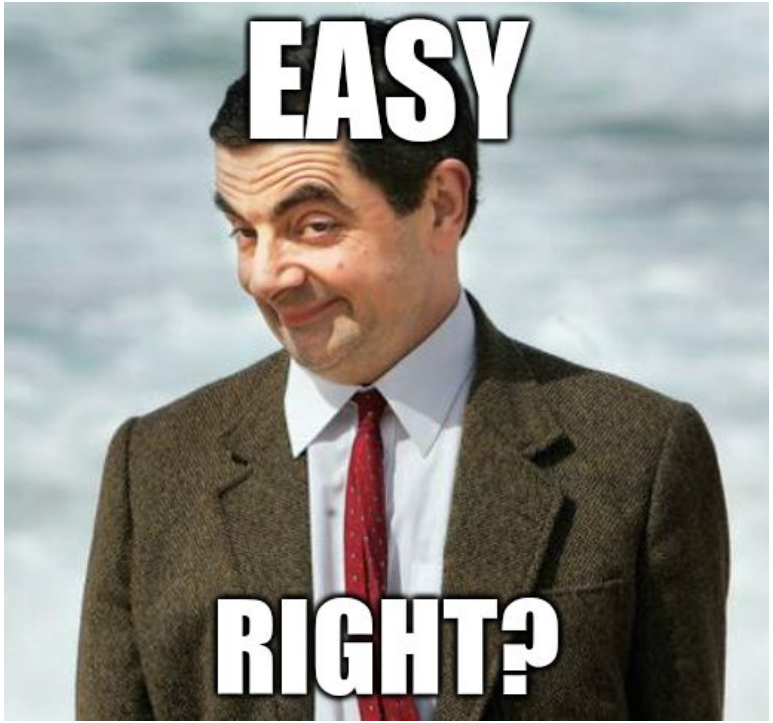
Easy Right?



Easy Right?

Having strict standard does not mean you can’t do stupid things!



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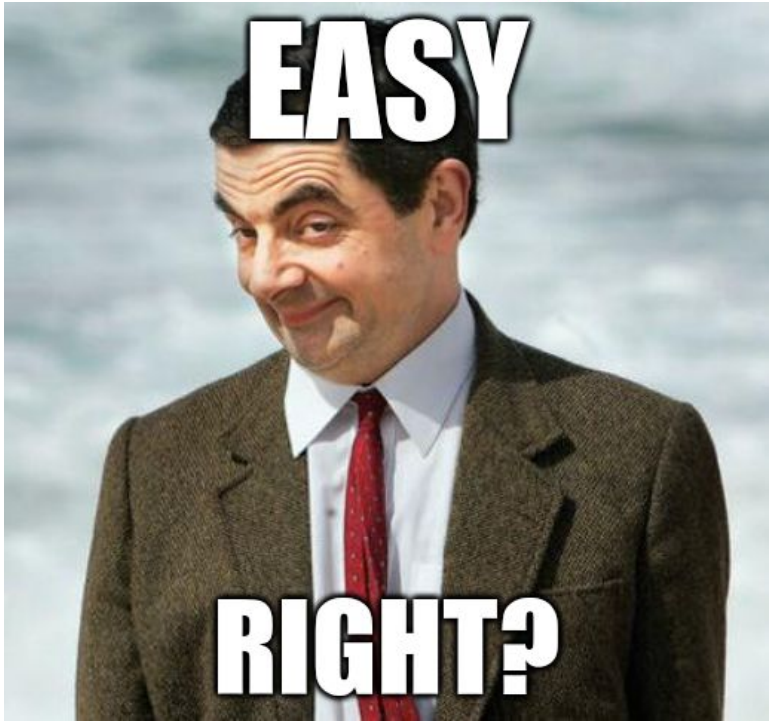
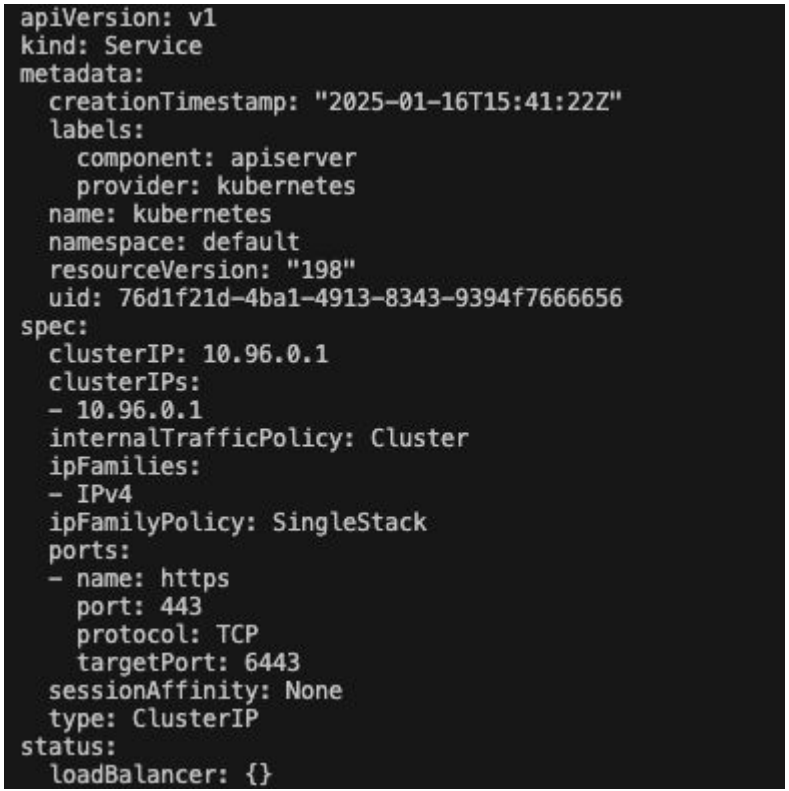


“Two things are infinite: the universe and human stupidity; and I'm not sure about the universe.”

— **Albert Einstein**

Few Things to Avoid

Mixing Business Logic into the CRD's Design



```yaml
apiVersion: v1
kind: Service
metadata:
  creationTimestamp: "2025-01-16T15:41:22Z"
  labels:
    component: apiserver
    provider: kubernetes
  name: kubernetes
  namespace: default
  resourceVersion: "198"
  uid: 76d1f21d-4ba1-4913-8343-9394f7666656
spec:
  clusterIP: 10.96.0.1
  clusterIPs:
  - 10.96.0.1
  internalTrafficPolicy: Cluster
  ipFamilies:
  - IPv4
  ipFamilyPolicy: SingleStack
  ports:
  - name: https
    port: 443
    protocol: TCP
    targetPort: 6443
  sessionAffinity: None
  type: ClusterIP
status:
  loadBalancer: {}
```

Spec vs. Status Misuse

Mixing Business Logic into the CRD's Design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Spec vs. Status Misuse

Embedding **too much logic or assumptions directly** into the CRD's spec instead of relegating dynamic state information to the status field.

Mixing Business Logic into the CRD's Design


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metadata:
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Spec vs. Status Misuse

Not clearly separating the desired state (spec) from the observed state (status).

Ignoring Established API Conventions and Best Practices


```yaml
apiVersion: apiextensions.k8s.io/v1
kind: CustomResourceDefinition
metadata:
  name: dbconnections.mycompany.io
spec:
  group: mycompany.io
  versions:
    - name: v1
      served: true
      storage: true
  scope: Namespaced
  names:
    plural: dbconnection        # ❌ Bad: singular instead of plural
    singular: dbconnection
    kind: Dbconnection          # ❌ Bad: inconsistent capitalization and lack of clarity
    shortNames:
      - dbc
```

https://github.com/kubernetes/community/blob/master/contributors/devel/sig-architecture/api-conventions.md

Ignoring Established API Conventions and Best Practices


```
apiVersion: apiextensions.k8s.io/v1
kind: CustomResourceDefinition
metadata:
  name: sheep.mycompany.io
spec:
  group: mycompany.io
  versions:
    - name: v1
      served: true
      storage: true
  scope: Namespaced
  names:
    plural: sheep      # ❌ Both singular and plural are "sheep" (flocks is wrong too)
    singular: sheep    # ❌ Ambiguity: no clear distinction between one item and many
    kind: Sheep
    shortNames:
      - shp
```

https://github.com/kubernetes/community/blob/master/contributors/devel/sig-architecture/api-conventions.md

Insufficient Schema Validation and Lack of Structural Schema

- Not defining a comprehensive OpenAPI v3 schema for your CRD
- Omitting validations for required fields, value ranges, or types

```
// +kubebuilder:validation:XValidation:rule="has(self.__namespace__) || has(self.name)",message="at least one field must be set"
type ResourceSelector struct {
        // name of an object within a claimed group/resource.
        // It matches the metadata.name field of the underlying object.
        // If namespace is unset, all objects matching that name will be claimed.
        //
        // +optional
        // +kubebuilder:validation:Pattern="^([a-z0-9][-a-z0-9_.]*)?[a-z0-9]$"
        // +kubebuilder:validation:MaxLength=253
        // +kubebuilder:validation:MinLength=1
        Name string `json:"name,omitempty"`

        // namespace containing the named object. Matches metadata.namespace field.
        // If "name" is unset, all objects from the namespace are being claimed.
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        Namespace string `json:"namespace,omitempty"`
```

You have a hammer in your tool-box, stop using a fork to nail these things!

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Improper Versioning and Lack of Conversion Strategy

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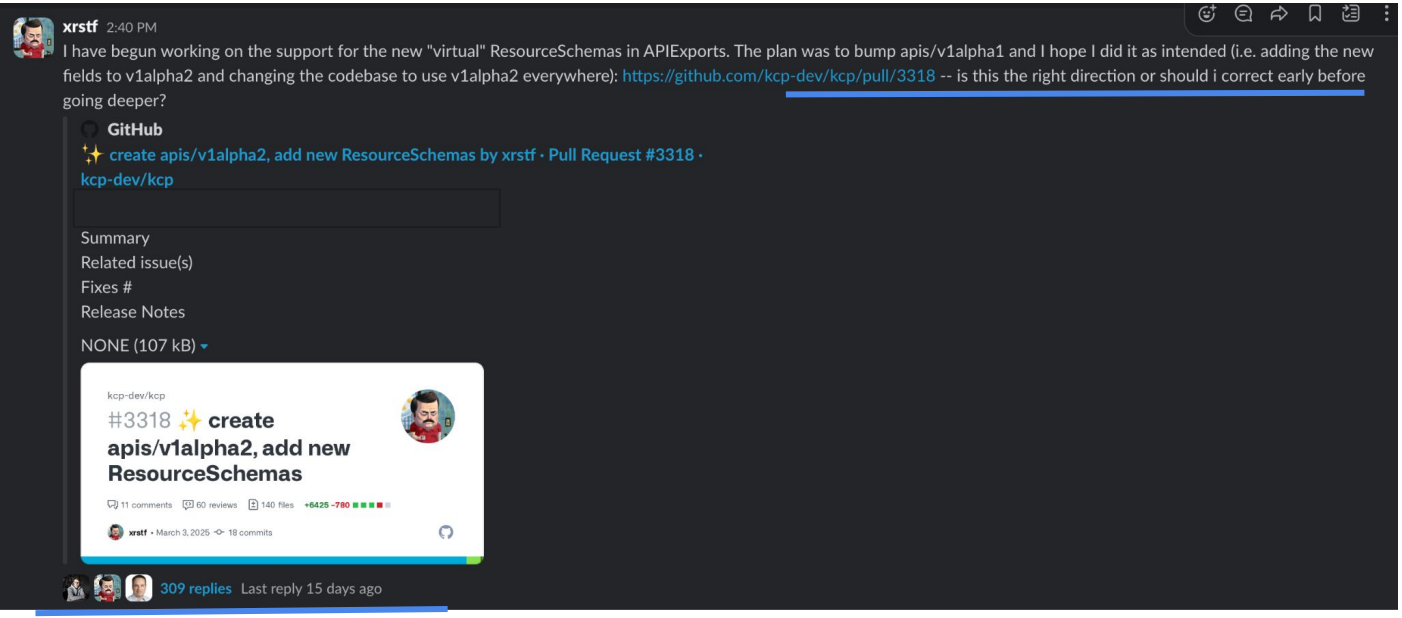
CRD versioning is hard! Spend some time creating best strategy for your use case, maybe even before you need it!



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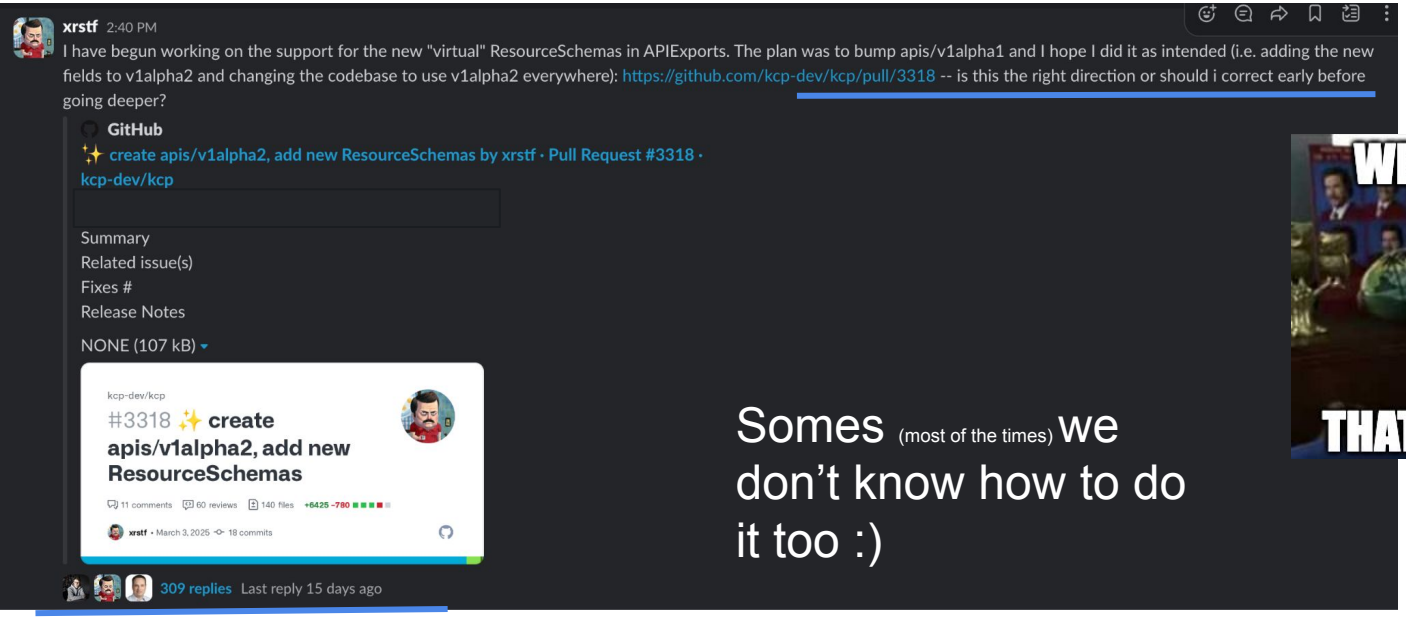

Somes (most of the times) we don't know how to do it too :)

Neglecting Controller Design and Operational Considerations


```
reconcilers := []reconciler{
        &metaDataReconciler{},
        &finazilerReconciler{},
        &deletionReconciler{
            getLogicalCluster: func(ctx context.Context, cluster logicalcluster.Path) {}
            deleteLogicalCluster: func(ctx context.Context, cluster logicalcluster.Path) {}
            ...
        },
        &schedulingReconciler{
            ...
        },
        &phaseReconciler{
            ....
        },
    }
```

Each of these implementes reconcile()

- Easy to test
- No mocking needed
- Easy to read

Neglecting Controller Design and Operational Considerations


```
var errs []error
    requeue := false
    for _, r := range reconcilers {
        var err error
        var status reconcileStatus
        status, err = r.reconcile(ctx, ws)
        if err != nil {
            errs = append(errs, err)
        }
        if status == reconcileStatusStopAndRequeue {
            requeue = true
            break
        }
    }

    return requeue, utilserrors.NewAggregate(errs)
```

One for next slide :)

- Easy to test
- No mocking needed
- Easy to read

Neglecting Controller Design and Operational Considerations


```
const (
    reconcileStatusStopAndRequeue reconcileStatus = iota
    reconcileStatusStop
    reconcileStatusContinue
)
```

- Small steps leads small decisions
  - Should I StopAndRequeue? Example: Add reconciler if not exists
  - Should I Stop? Example: Object is in terminal state - not much we can do.
  - Continue? Example: Reconciler computed desired replicas, next reconciler step will apply it (bad, example I know...)

Neglecting Controller Design and Operational Considerations


```
// If the object being reconciled changed as a result, update it.
oldResource := &workspaceResource{ObjectMeta: old.ObjectMeta, Spec: &old.Spec, Status: &old.Status}
newResource := &workspaceResource{ObjectMeta: workspace.ObjectMeta, Spec: &workspace.Spec, Status: &workspace.Statu
if err := c.commit(ctx, oldResource, newResource); err != nil {
        errs = append(errs, err)
```

Use existing patterns

- Committer
- Controller-runtime
- Kubebuilder
- client-go
- utilerrors "k8s.io/apimachinery/pkg/util/errors"
- utilruntime "k8s.io/apimachinery/pkg/util/runtime"
- ...

How this is better than what we have now?

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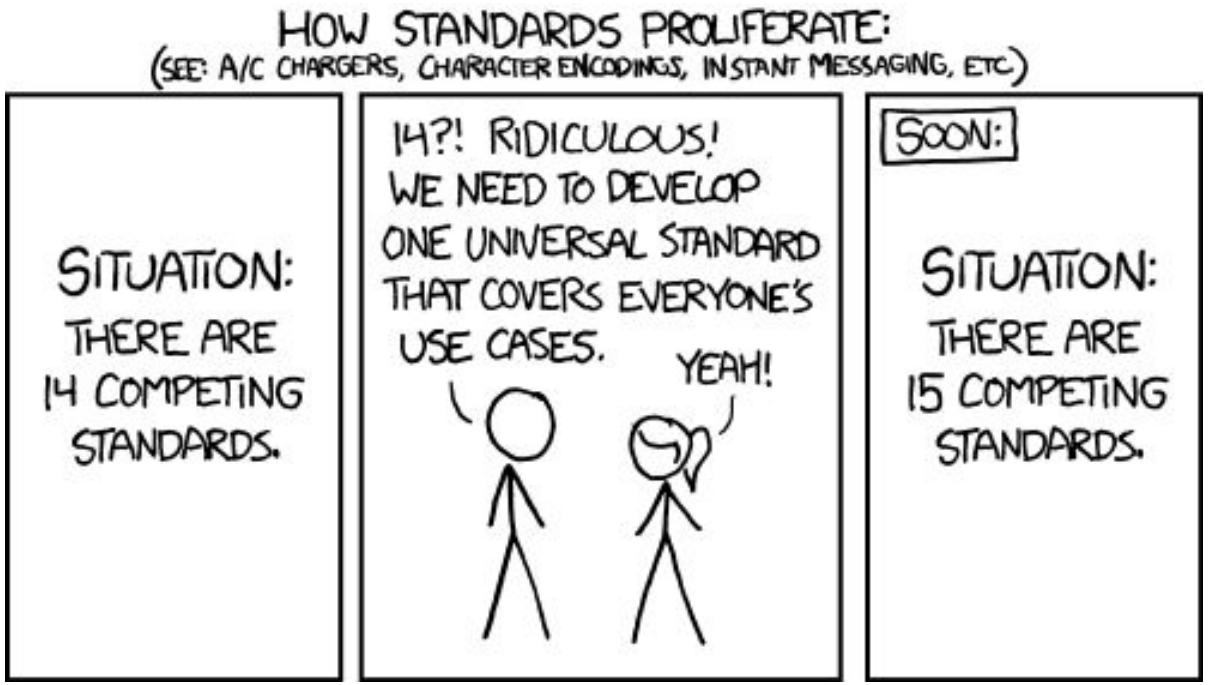

How this is better than what we have now?

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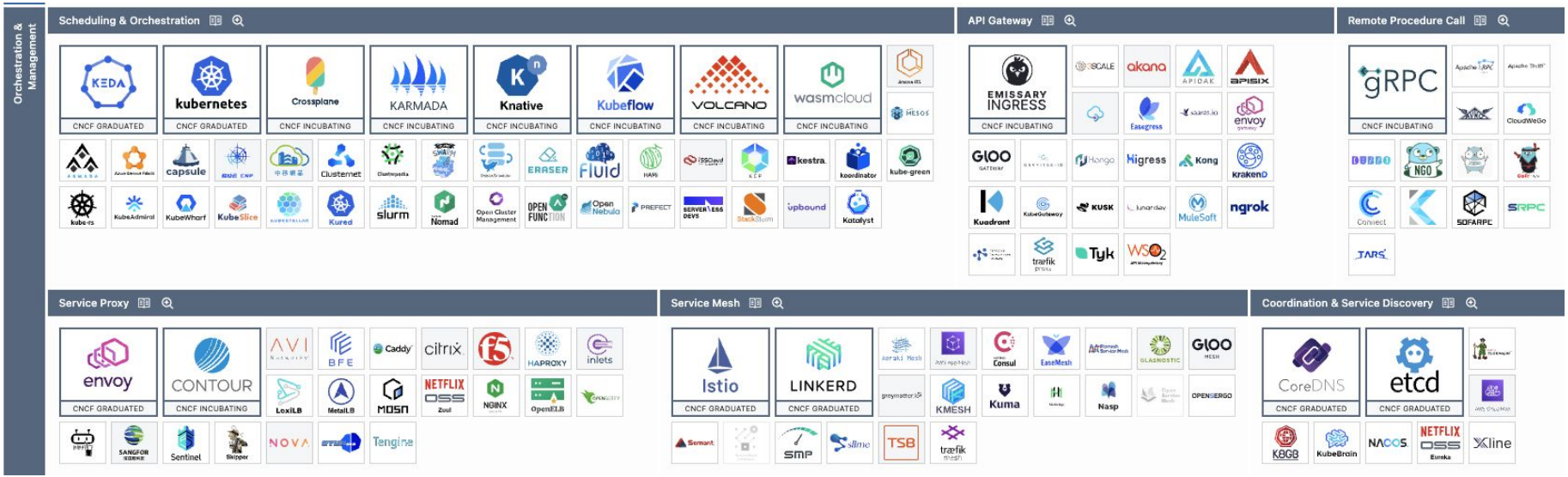
It’s a standard you gonna use either way, you like it or not :)



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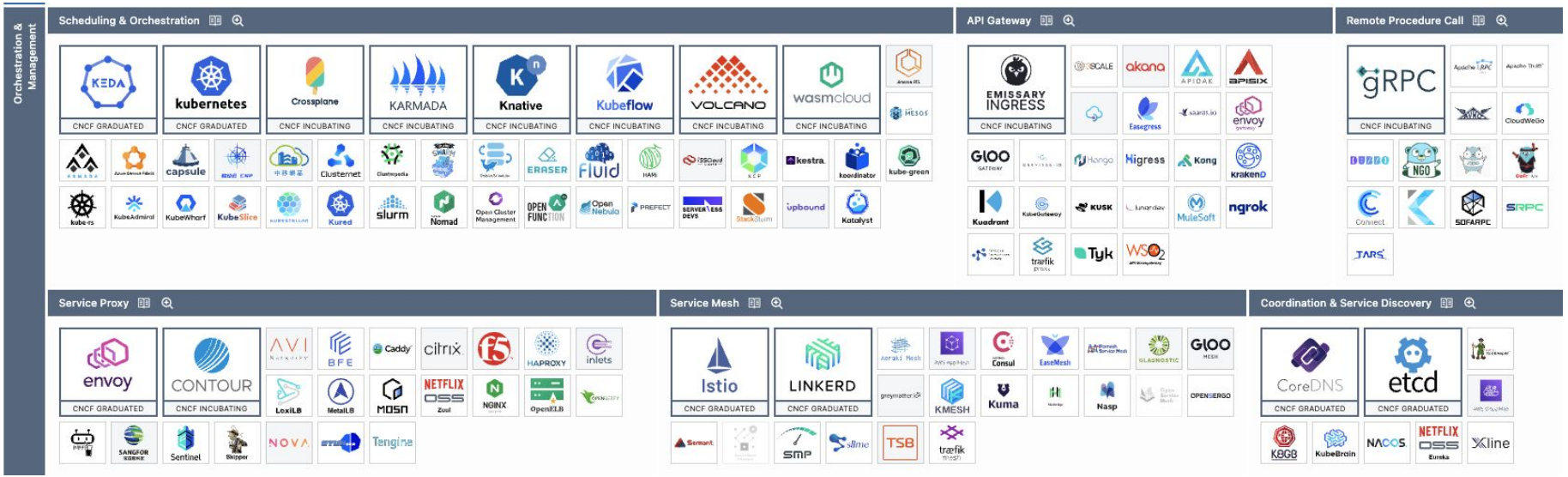
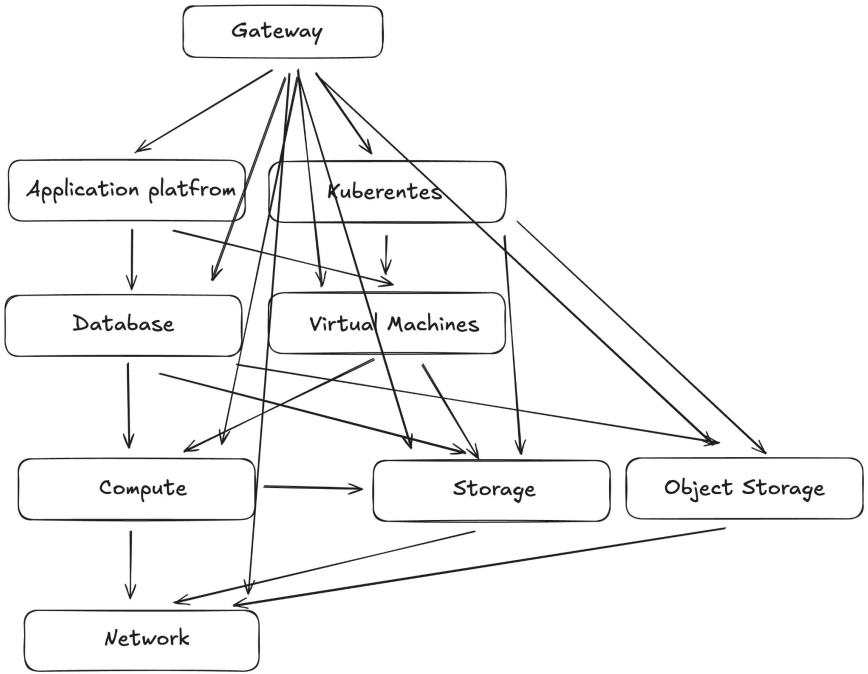
So why not stick with it?



Part 2: How kcp makes it easier

Take a look as “multi-team microservice architecture”



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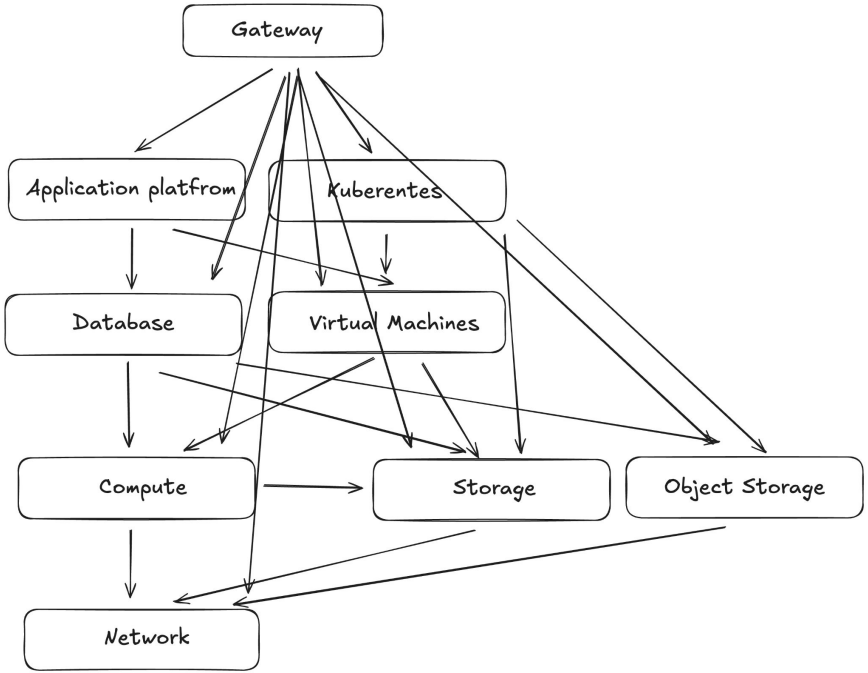

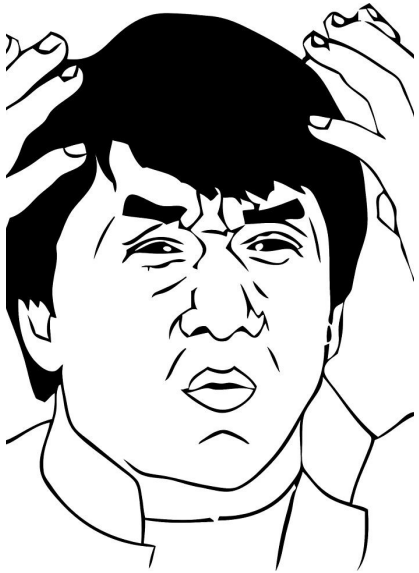

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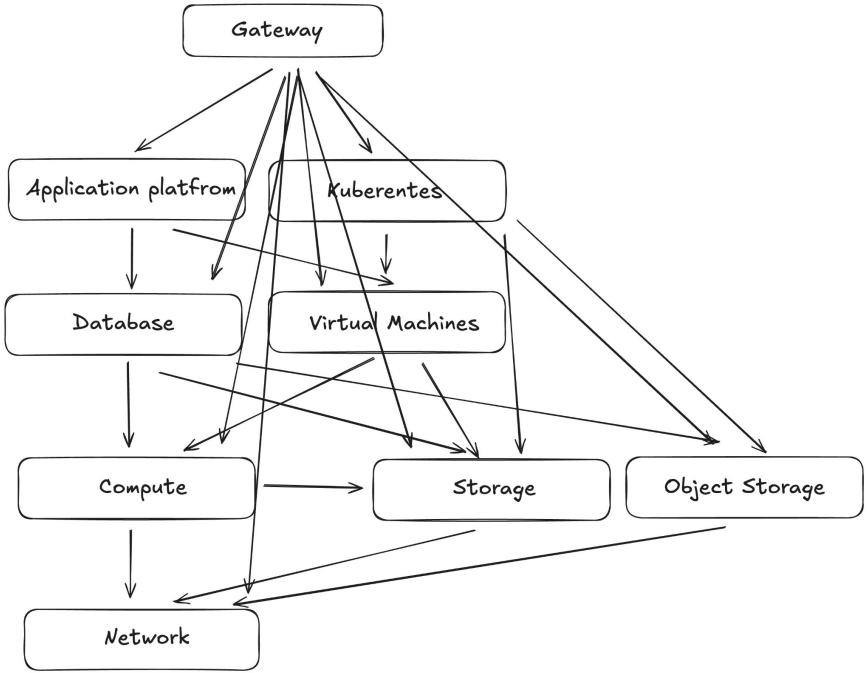

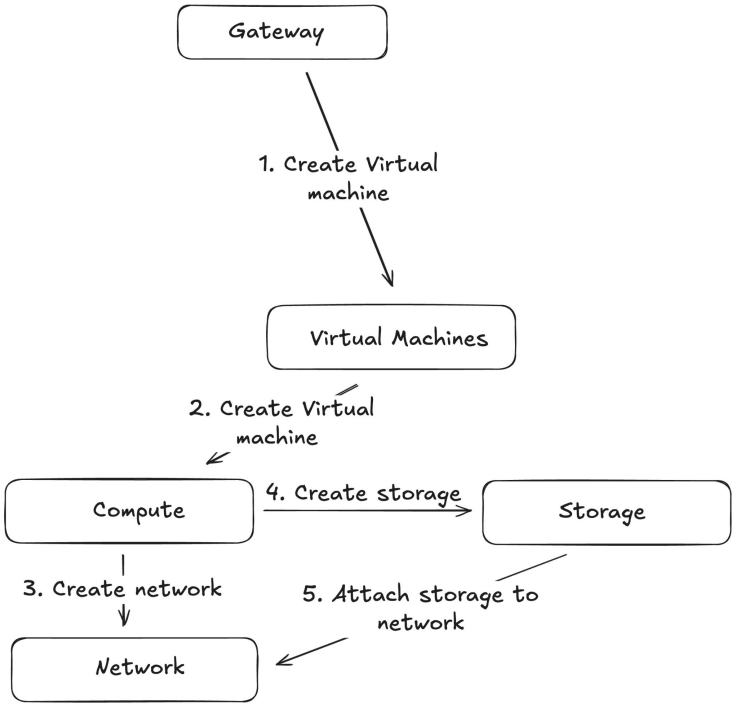

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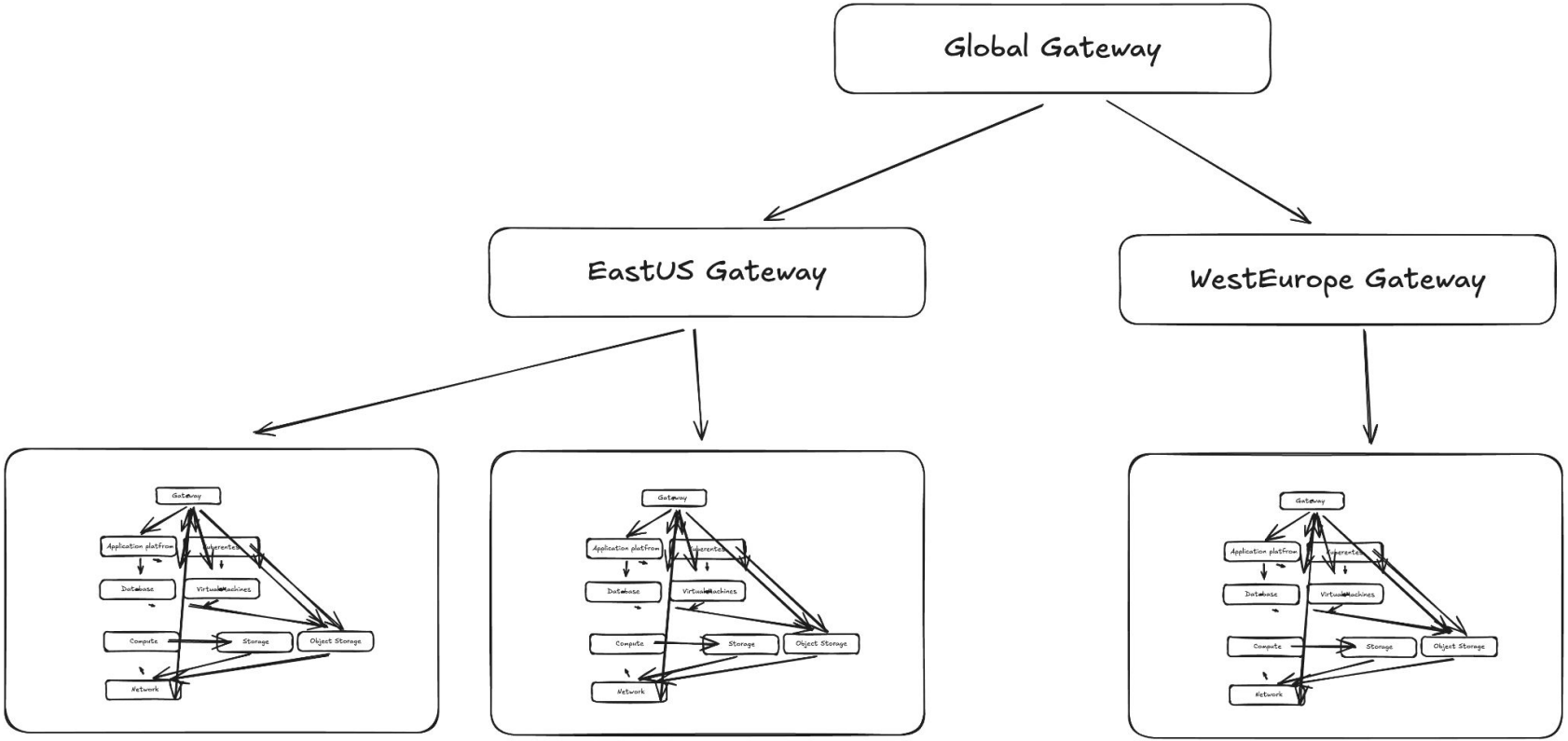
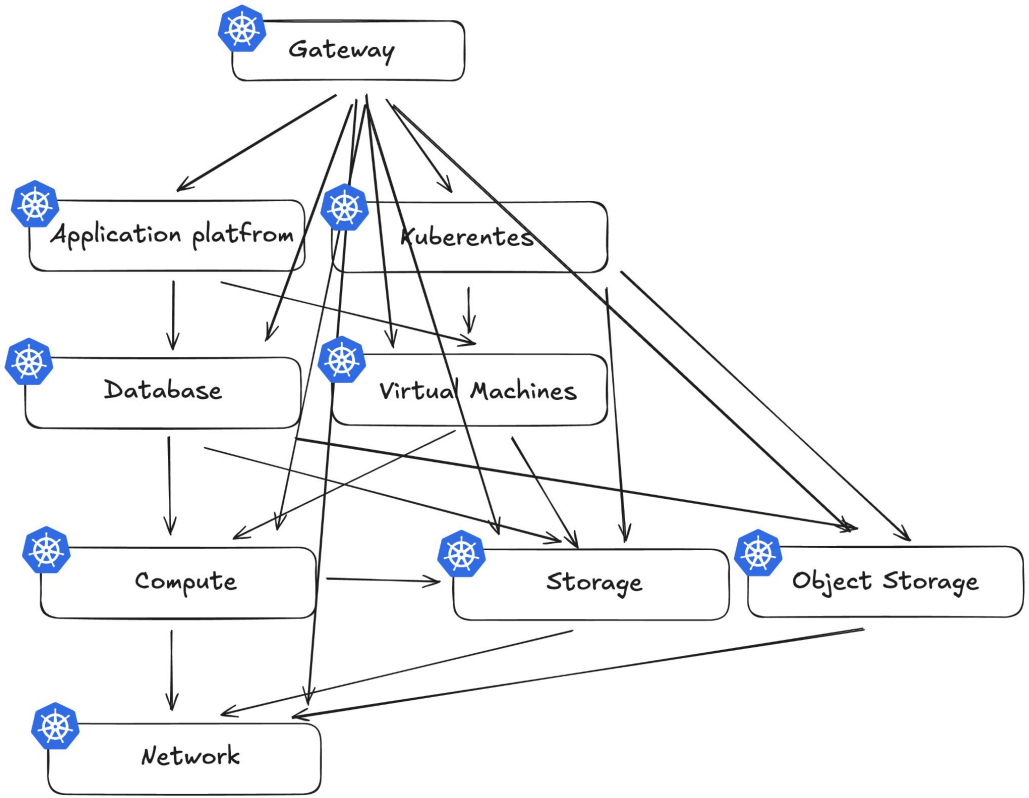


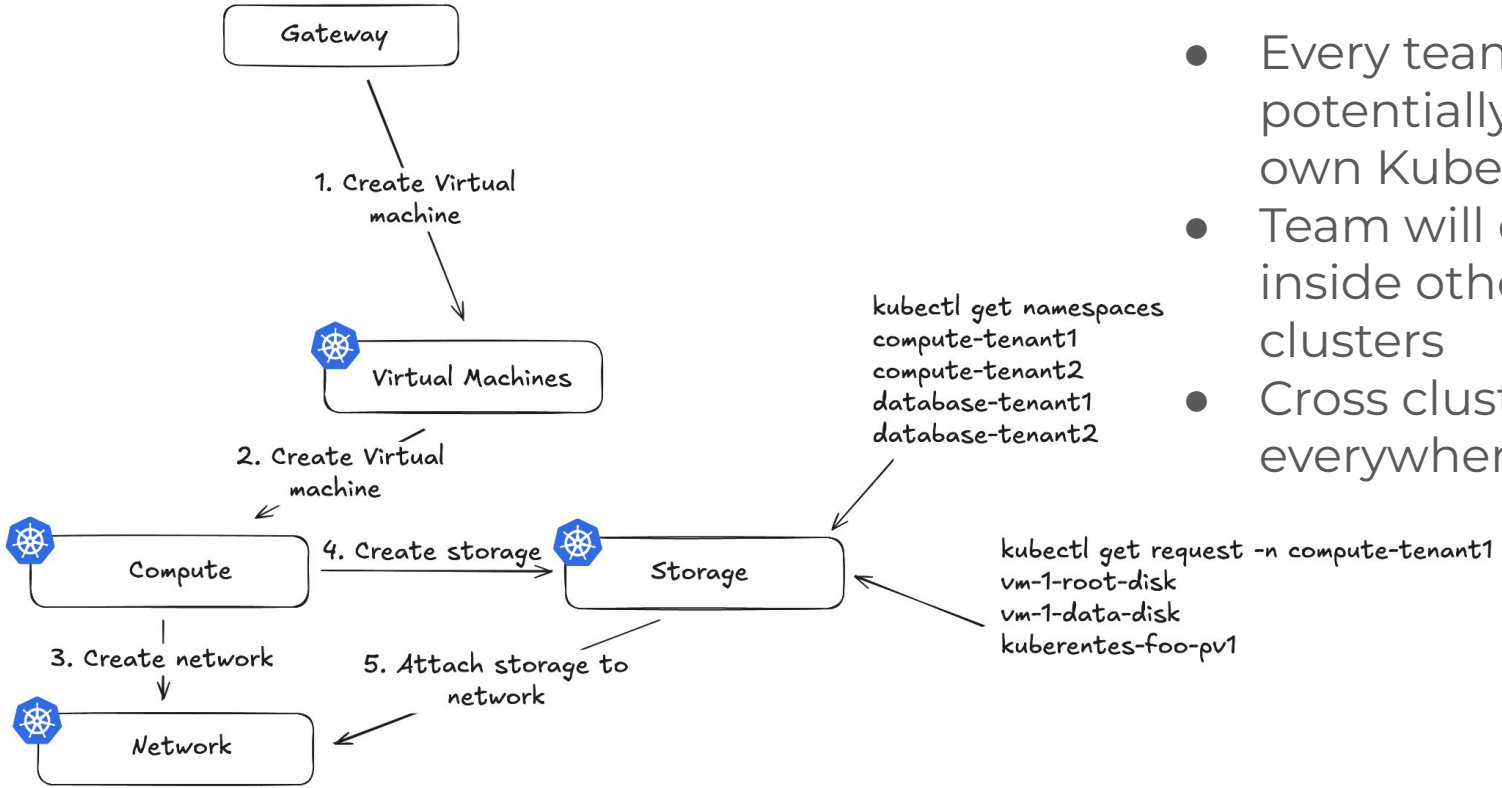
Try doing this in Kubernetes?



- Every team will potentially have their own Kubernetes cluster
- Team will create CR's inside other teams clusters
- Cross cluster reconcilers everywhere!

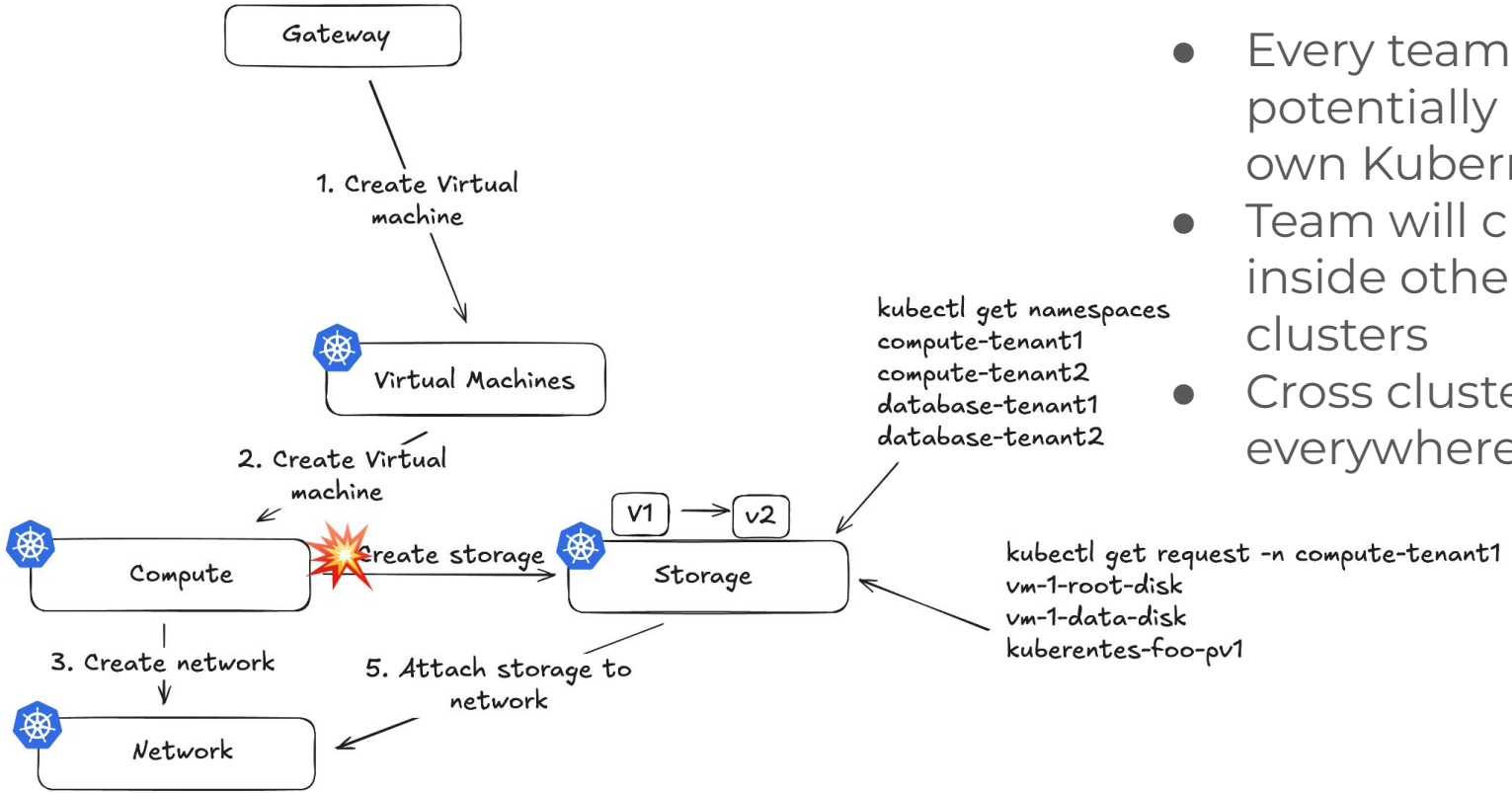
- **Why this is bad?**

Try doing this in Kubernetes?



- Every team will potentially have their own Kubernetes cluster
- Team will create CR's inside other teams clusters
- Cross cluster reconcilers everywhere!

Try doing this in Kubernetes?



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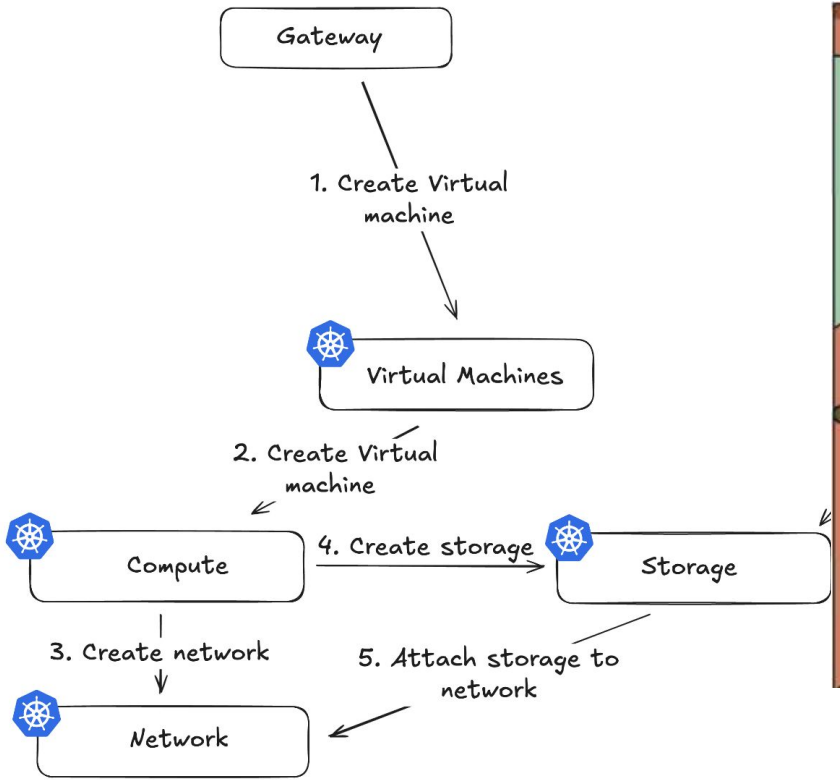
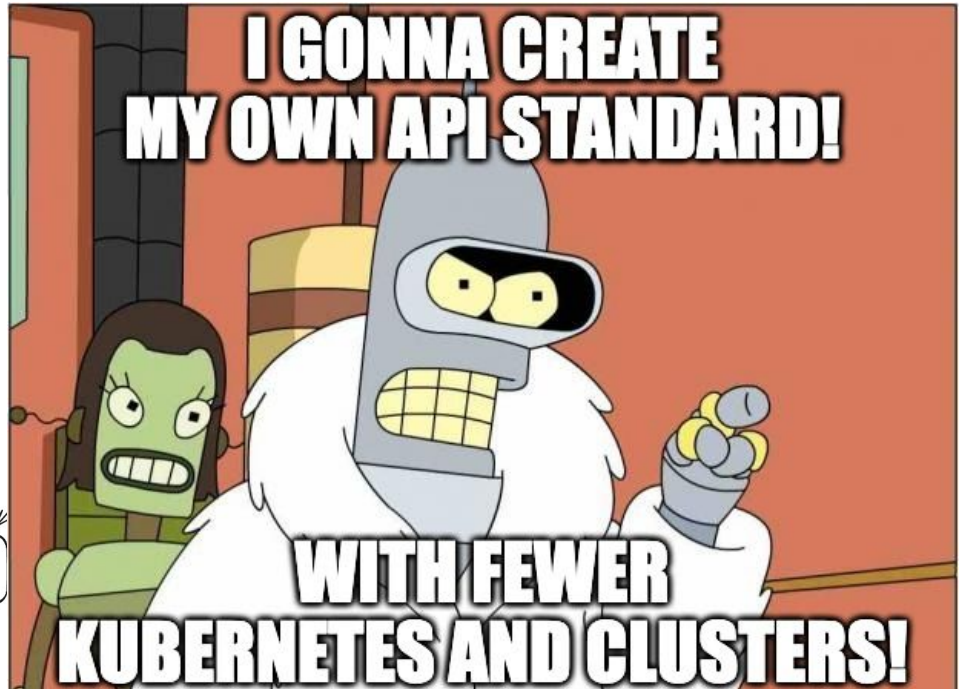




Many clusters problem

While API standard (KRM) is amazing, its vessel (🚢) is not (or is it?)!

- First: We are forces to do fragmentation to keep tenancy & isolation!
- Second: API management frameworks are not well adopted

Alternatives?

vClusters:

- Required pod(s) per tenant. You save on “cluster count”, but all other challenges still there.
- API management is not addressed.
- (Many clusters problem)^2.

Alternatives?

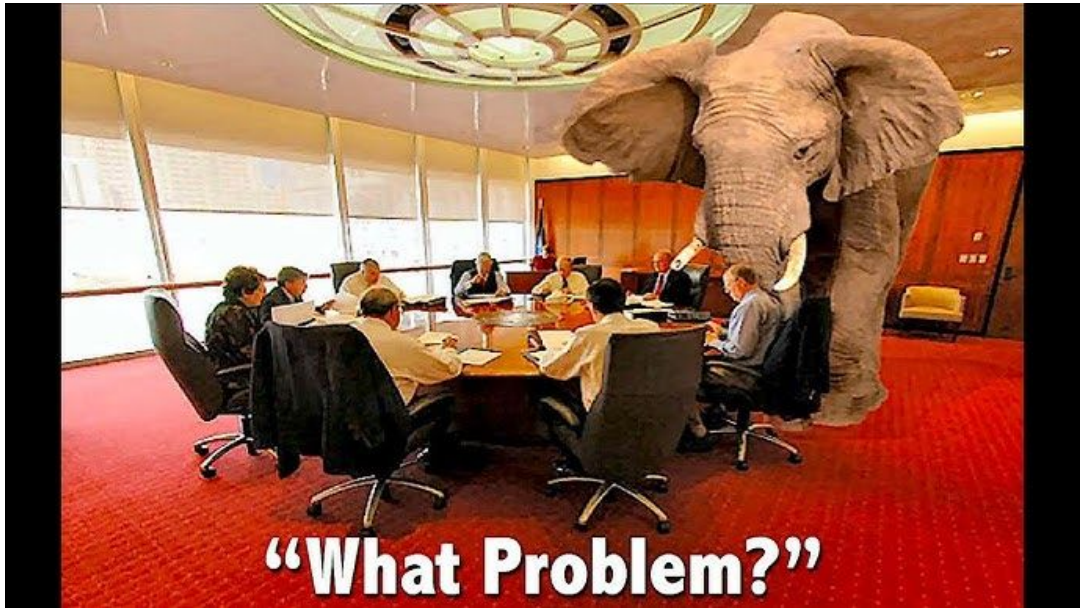
Generic control plane:

- Required pod per tenant. You save on “cluster count”, but all other challenges still there.
- API management is not addressed.
- (Many clusters problem)^3.
- You save on resources (a bit).

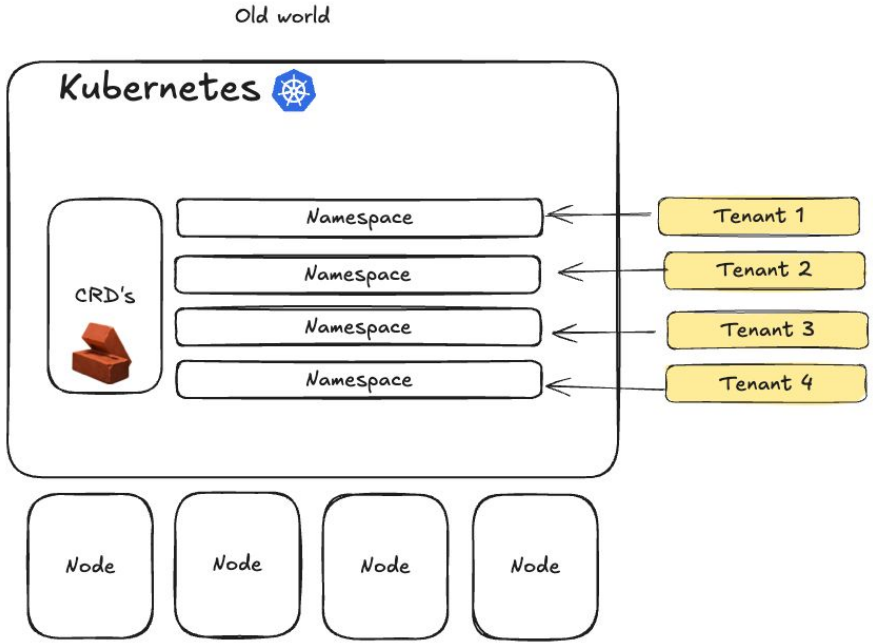
https://github.com/kcp-dev/generic-controlplane

Alternatives?

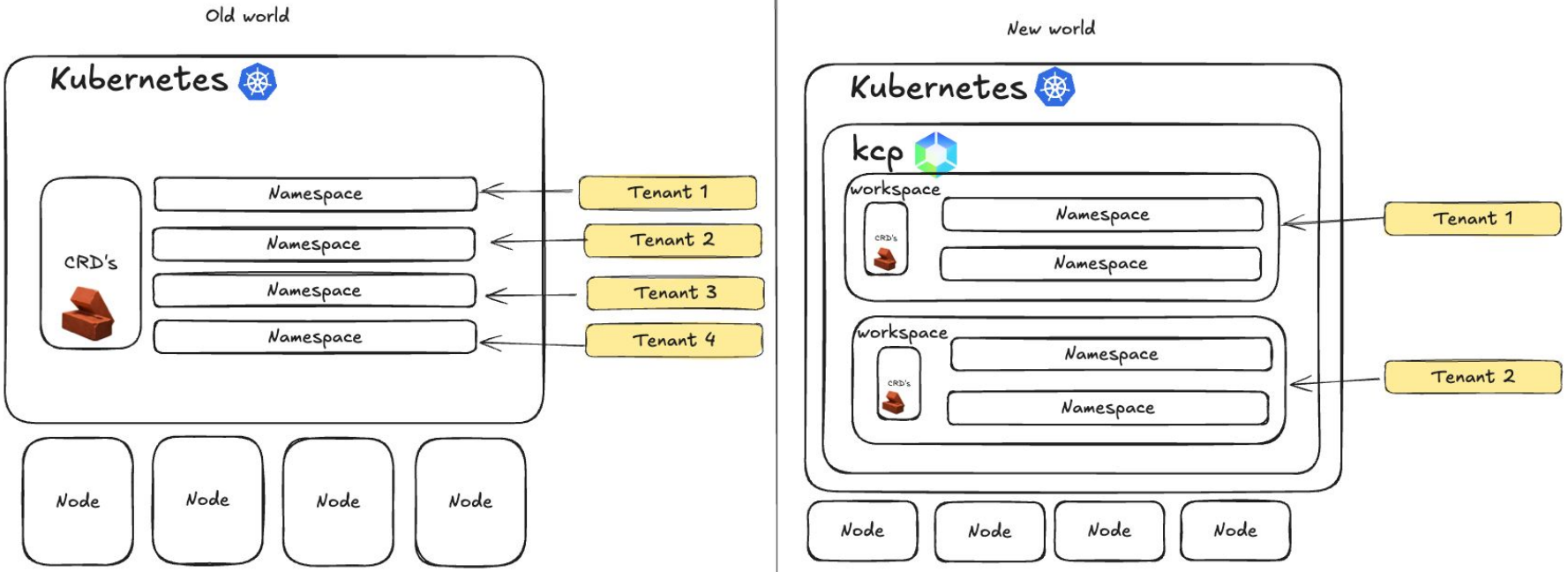
- Strong multi-tenancy
- API management!



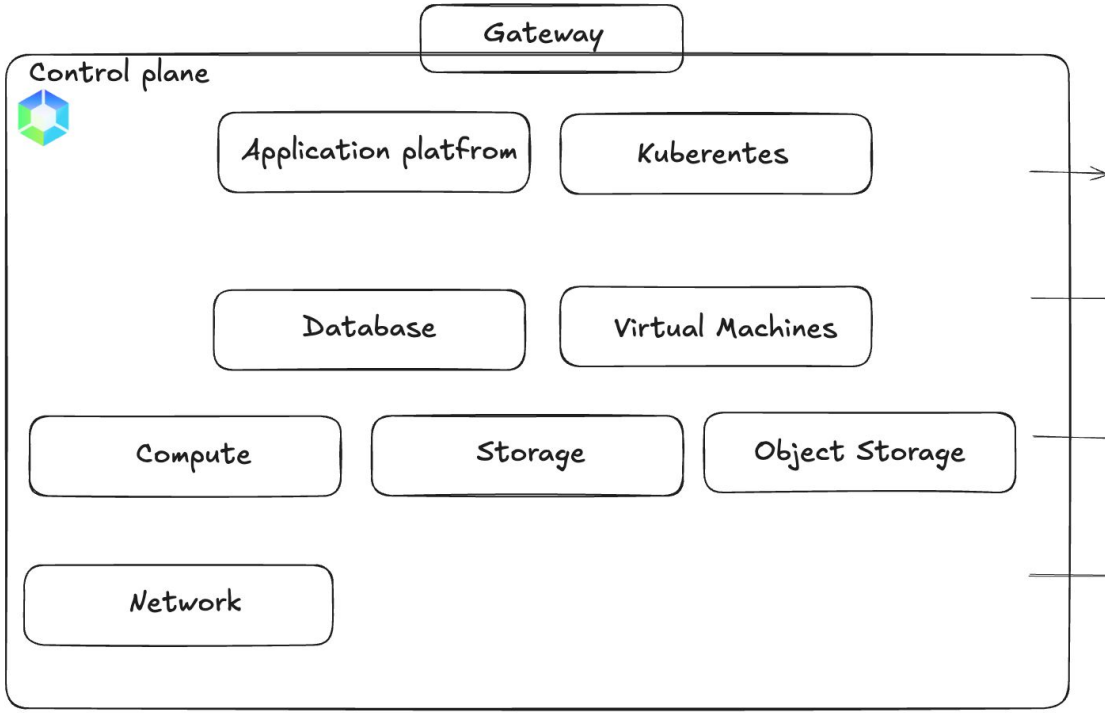
kcp - Kubernetes-like control plane



kcp - Kubernetes-like control plane



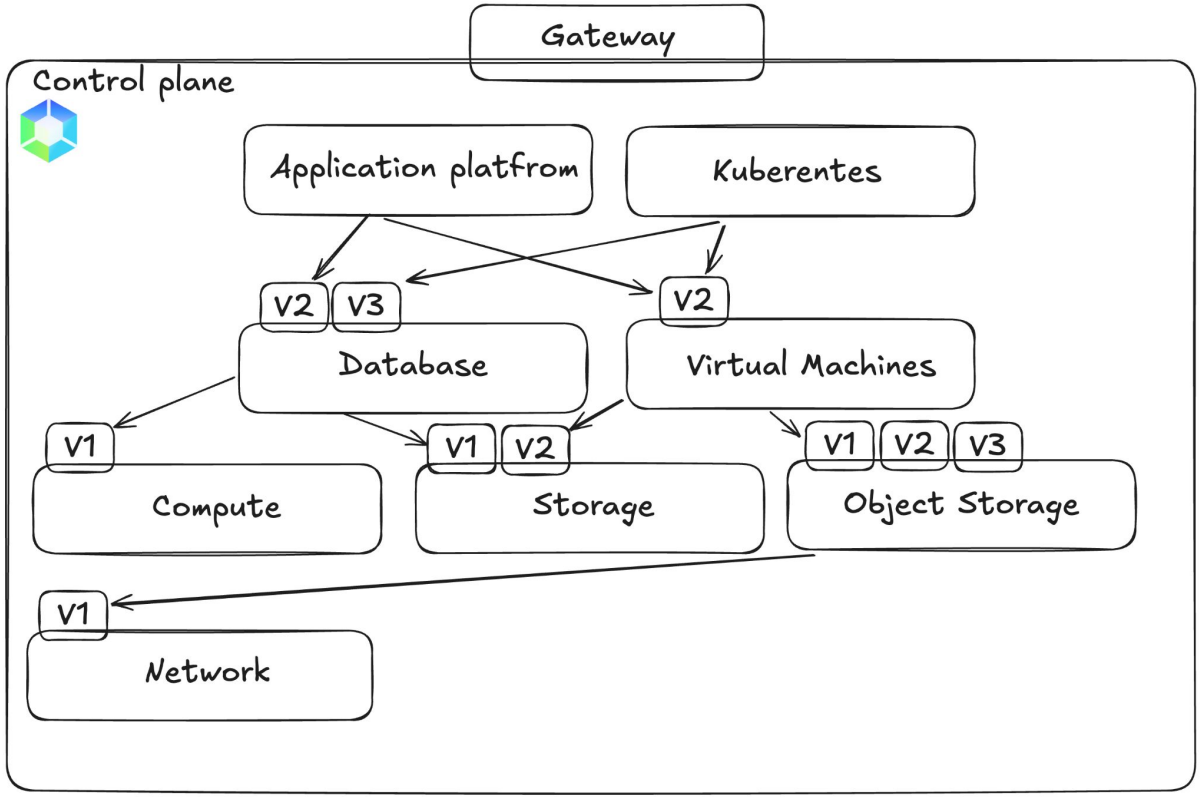
Control Plane



We want shared control plane

We offload API surface, not the logic.

Control Plane

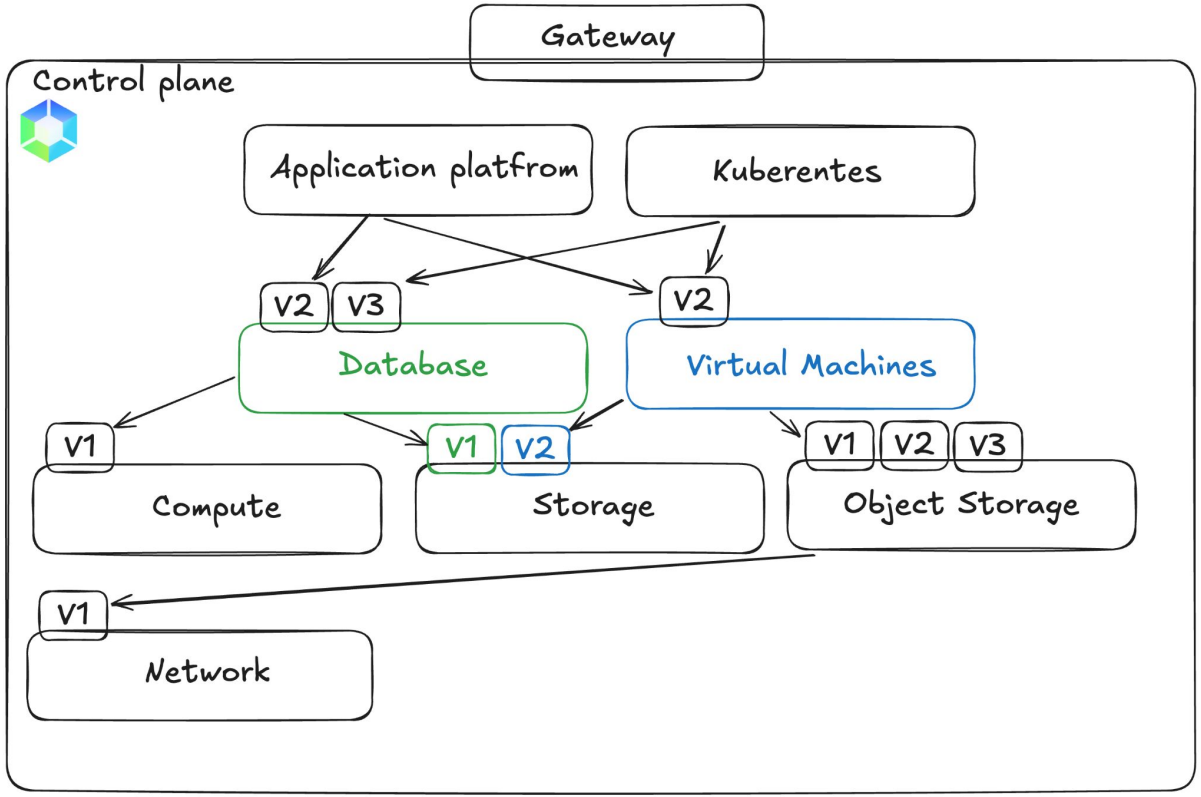


We want shared control plane

Strong multi-tenancy

Less fragmentation

Control Plane



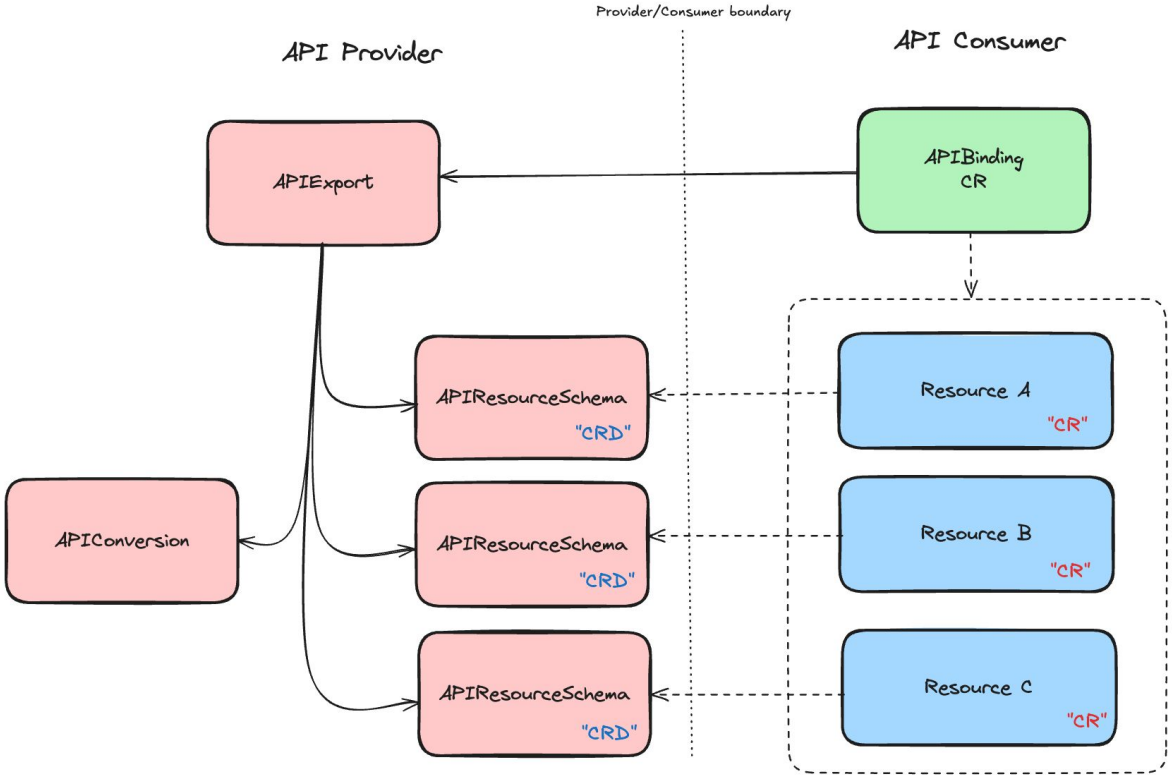
We want shared control plane

Strong multi-tenancy

Less fragmentation

Ability to support multiple version and clients

How? We make KRM management **easier**



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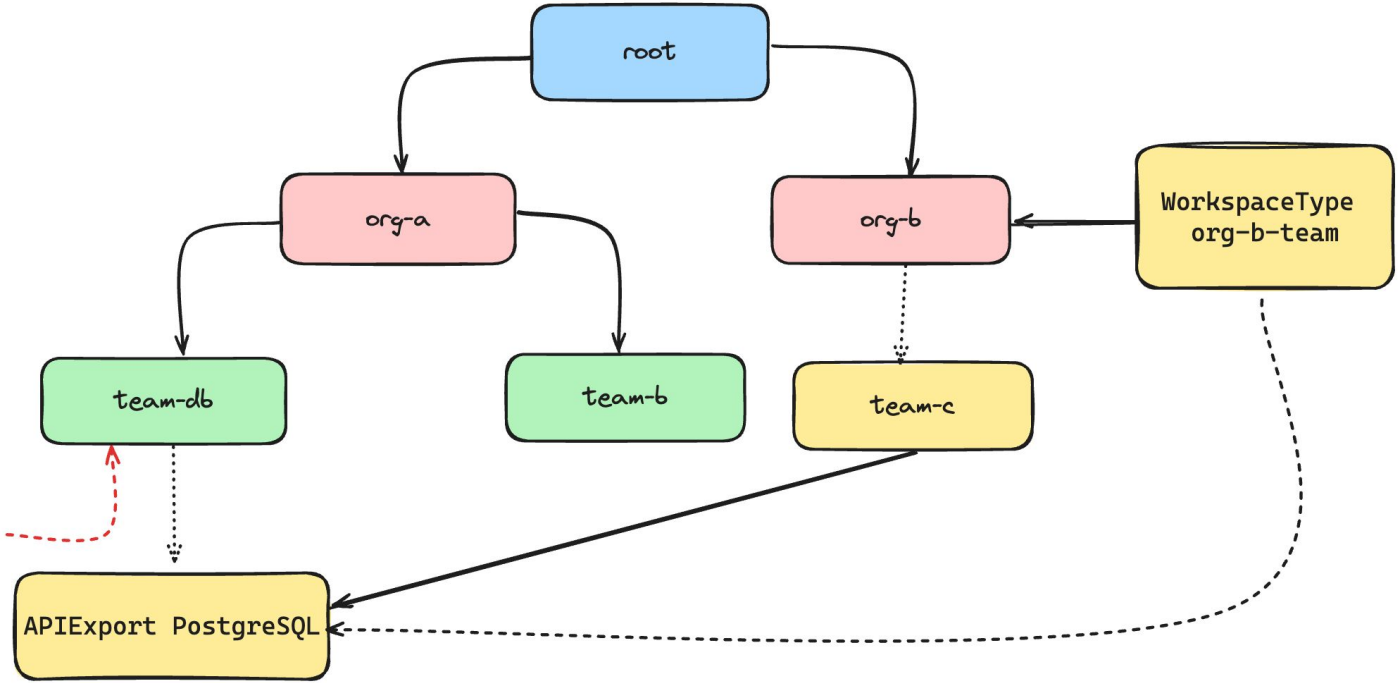

How? We make KRM management **easier**

KubeCon CloudNativeCon Europe 2025

```
› k ws tree
.
└── root
    ├── applications
    │   ├── application-platfrom-x
    │   └── managed-kubernetes
    ├── compute
    │   └── virtual-machines
    ├── networks
    │   └── core
    └── storage
        ├── databases
        └── object-storage
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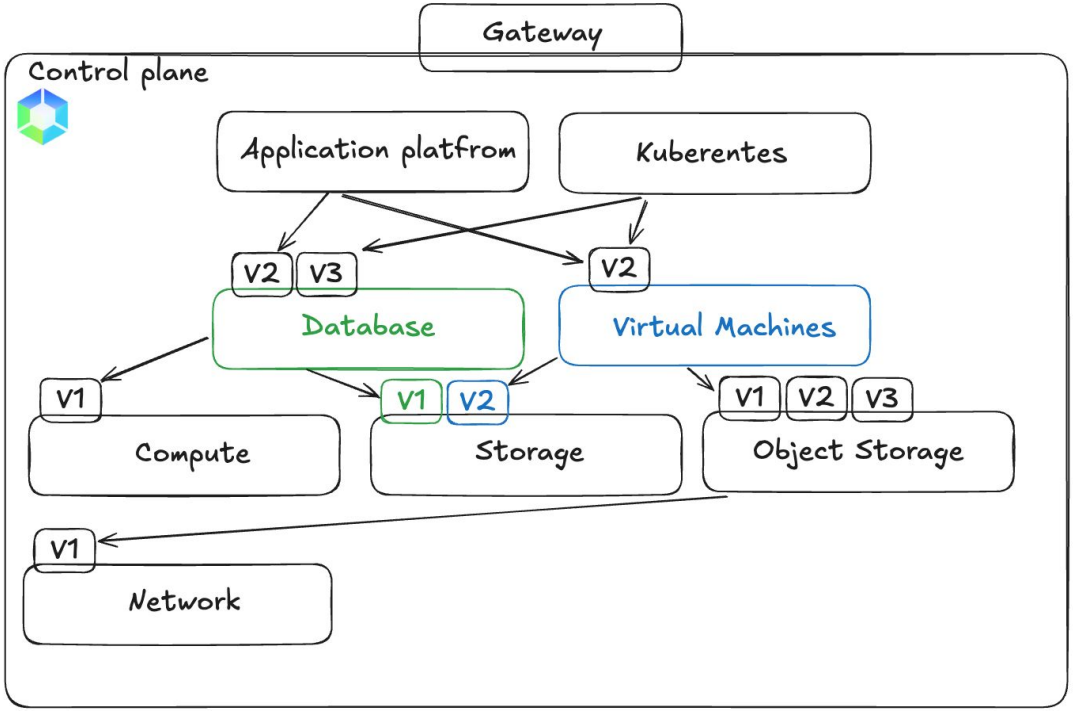
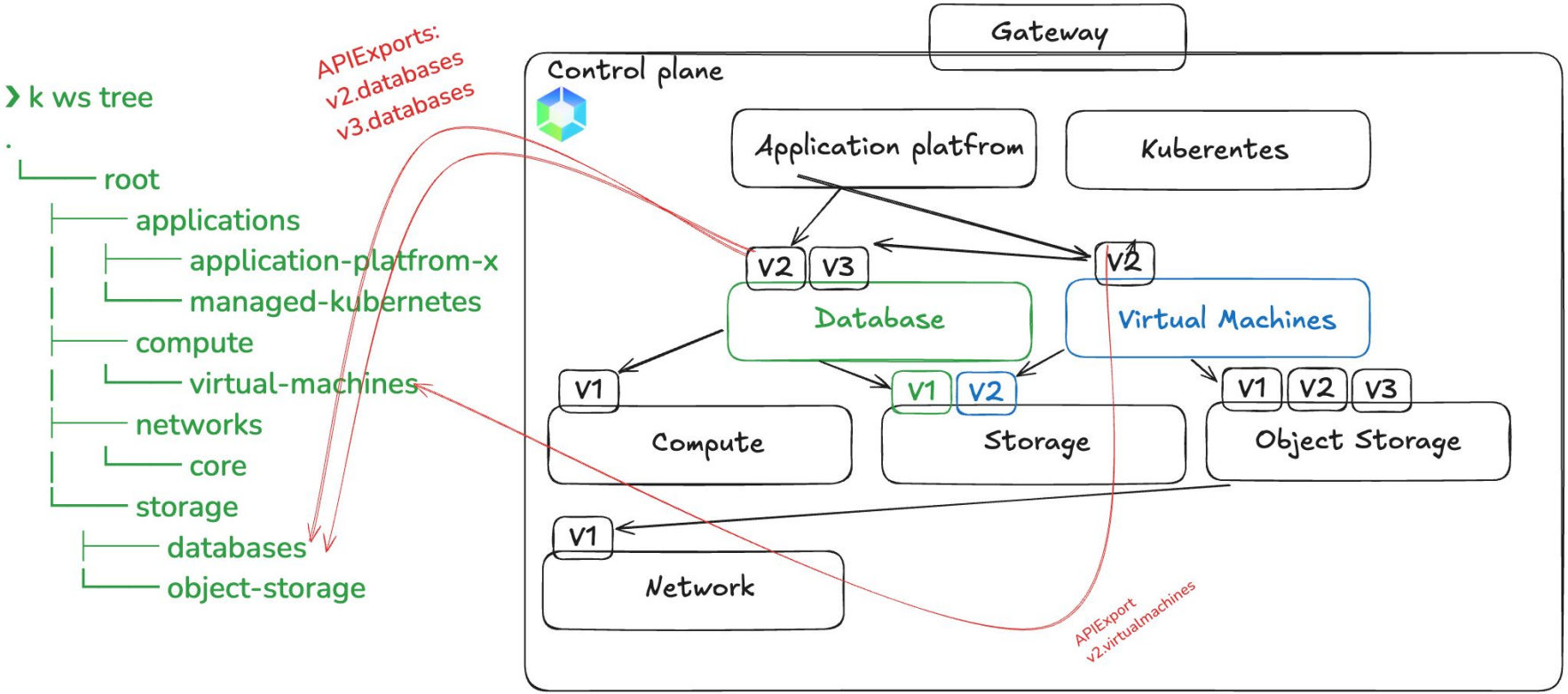


How? We make KRM management **easier**

KubeCon CloudNativeCon Europe 2025



How? We make KRM management **easier**

KubeCon CloudNativeCon Europe 2025

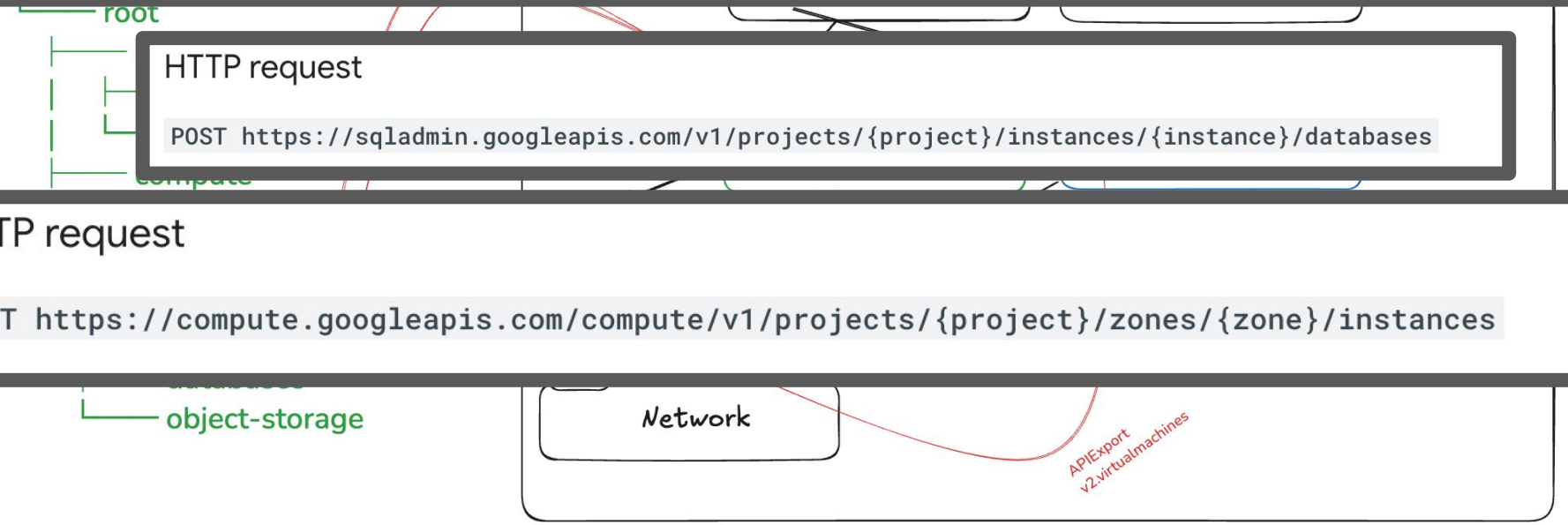
create	POST /v1beta1/{parent=projects/*/locations/*}/clusters Creates a cluster, consisting of the specified number and type of Google Compute Engine instances.

HTTP request

```
POST https://sqladmin.googleapis.com/v1/projects/{project}/instances/{instance}/databases
```

HTTP request

```
POST https://compute.googleapis.com/compute/v1/projects/{project}/zones/{zone}/instances
```



How? We make KRM management **easier**

KubeCon | CloudNativeCon Europe 2025

Single platform to manage **multiple** Kubernetes **resources**, **APIs** and **tenants** by shifting **API** surface out of Kubernetes clusters

Part 3: Demo

KubeCon | CloudNativeCon Europe 2025

Database as a service (DBaaS) - lift and shift

https://github.com/kcp-dev/contrib/tree/main/20250401-kubecon-london/workshop

More sessions on KCP

KubeCon CloudNativeCon Europe 2025

Wednesday, April 2

11:15 BST

Tutorial: Exploring Multi-Tenant Kubernetes APIs and Controllers With Kcp - Robert Vasek, Clyso GmbH; Nabarun Pal, Independent; Varsha Narsing, Red Hat; Marko Mudrinic, Kubermatic GmbH; Mangirdas Judeikis, Cast AI

Thursday, April 3

11:00 BST

Extending Kubernetes Resource Model (KRM) Beyond Kubernetes Workloads - Mangirdas Judeikis, Cast AI & Nabarun Pal, Independent (Description: kcp)

15:00 BST

Dynamic Multi-Cluster Controllers With Controller-runtime - Marvin Beckers, Kubermatic & Stefan Schimanski, Upbound (Description: kcp)

You are here!

Questions?

Talk to us - look for logo!

Find us at #kcp-dev kubernetes slack
Personas: @mjudeikis, @palnabarun

github.com/kcp-dev/kcp

@kcp @mangirdas @theonlynabarun

Feedback 👉