Kubernetes Cluster Federation: How To Write A Federated Controller

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Overview

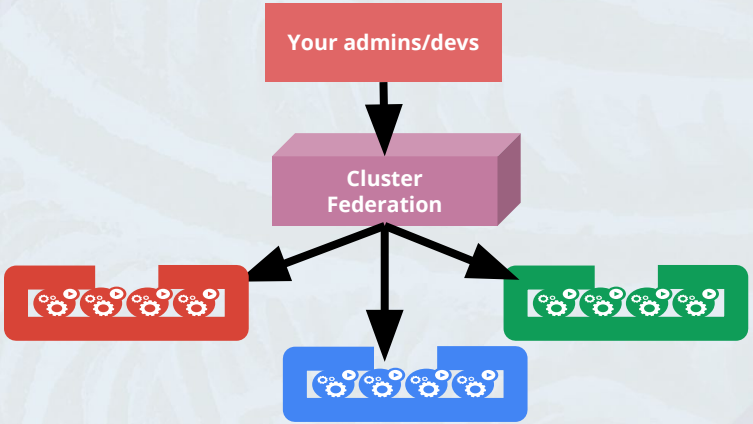
Cluster federation makes it easy to manage multiple clusters.

Why multiple clusters?

- Serving users from clusters closest to them
- High availability
- Scalability
- Avoiding vendor lock-in

Why federation?

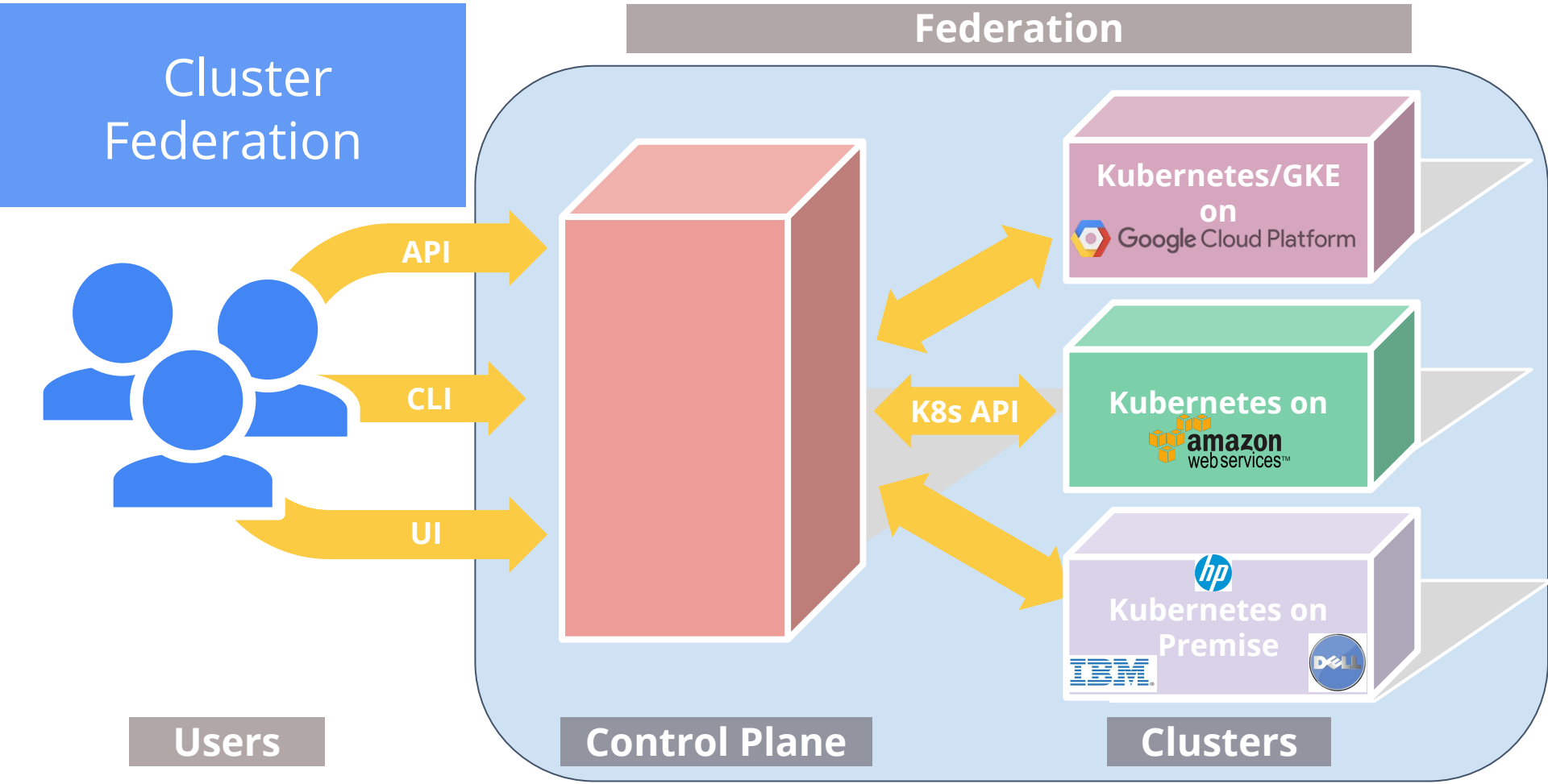
- Keep your app synced across clusters
- Configure network resources (services, ingress) to route traffic across clusters
- Single place to apply policies



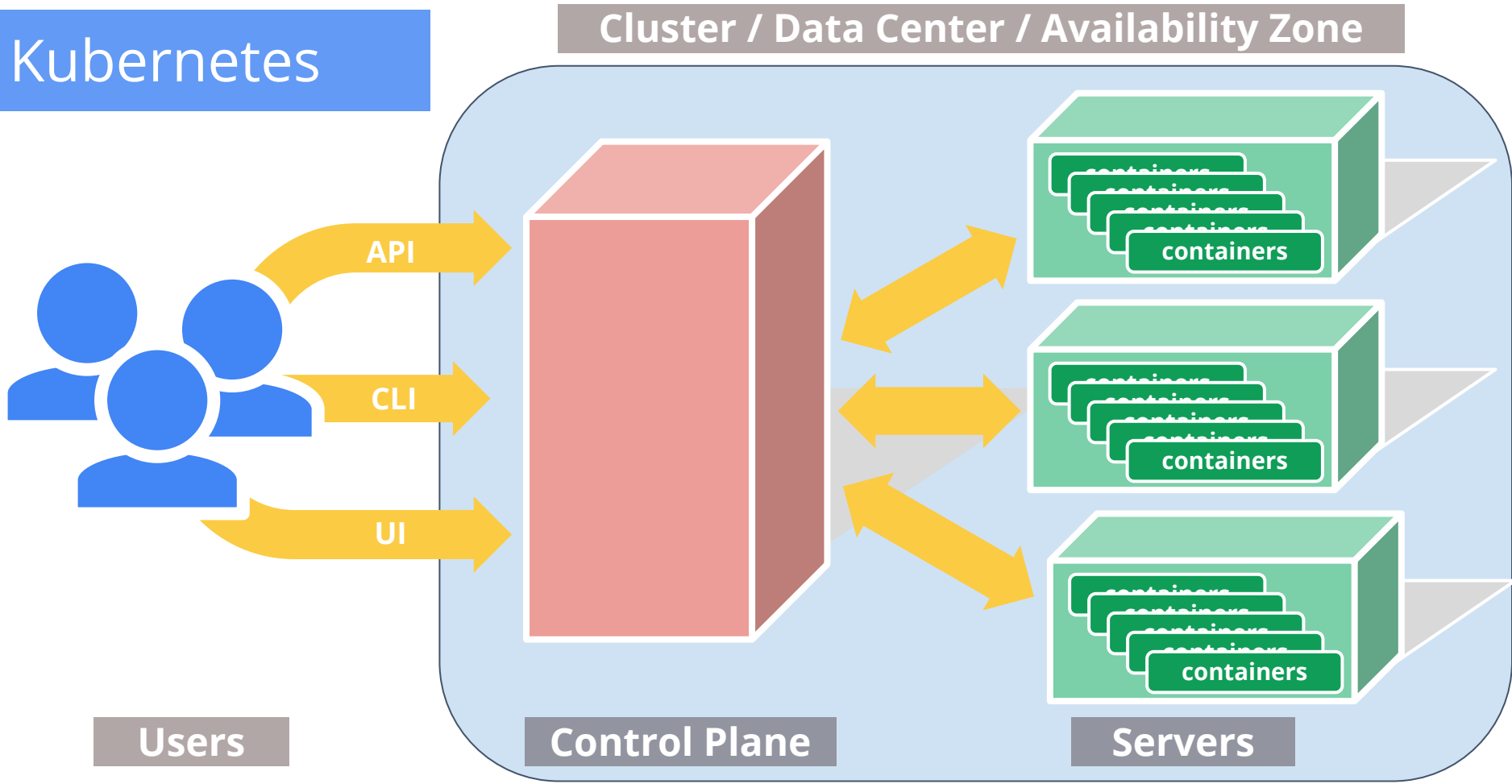
How it works

- Join clusters
- Create deployments, configmaps - spreads them across clusters and keeps them in sync
- Create services, ingress - configures them to route traffic across clusters
- 100% API compatibility with kubernetes

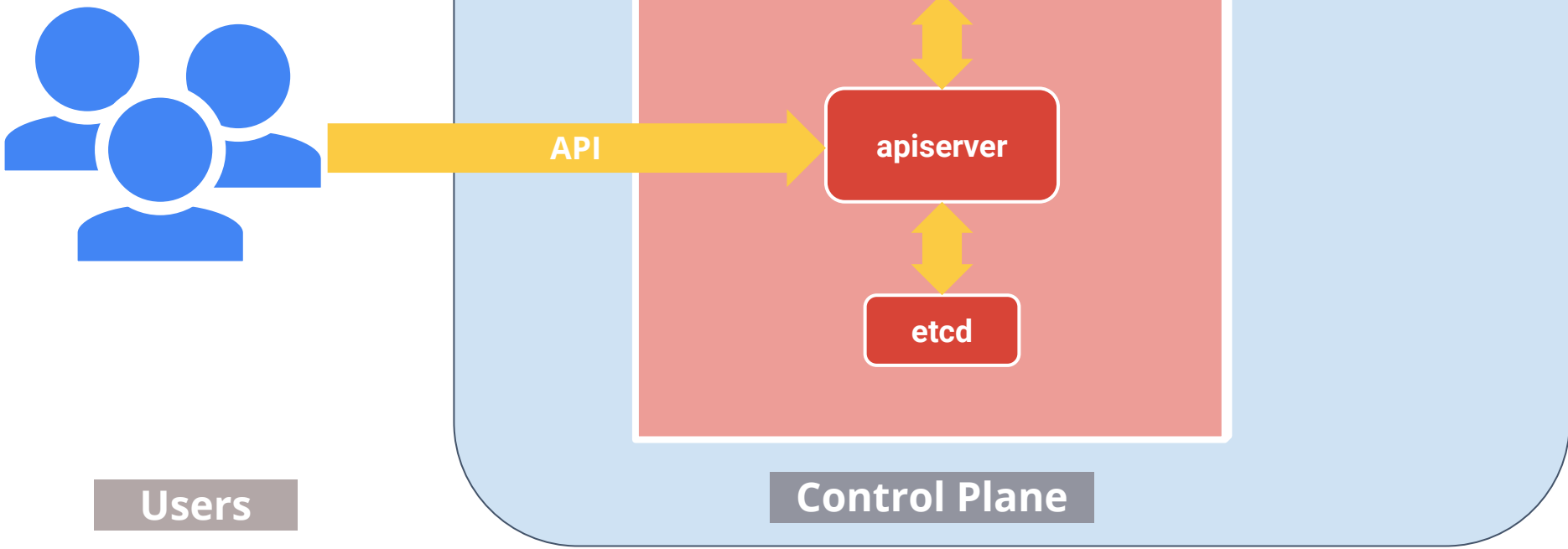
Architecture


Cluster Federation
Federation
API
CLI
UI
K8s API
Kubernetes/GKE on Google Cloud Platform
Kubernetes on amazon web services
Kubernetes on Premise
IBM
DELL
Users
Control Plane
Clusters

Kubernetes


Cluster / Data Center / Availability Zone
API
CLI
UI
containers
containers
containers
Users
Control Plane
Servers

Kubernetes


Cluster
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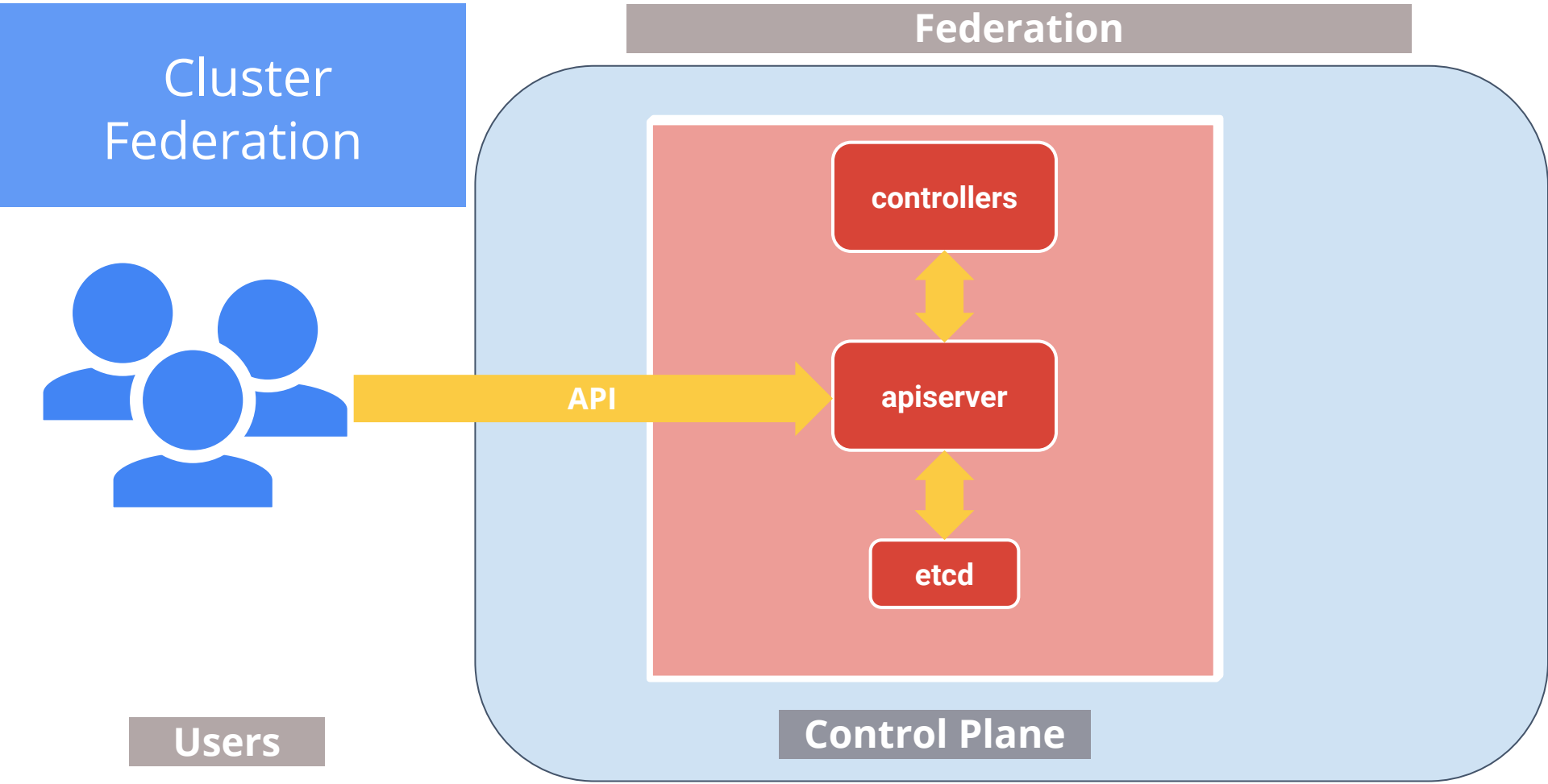
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Federation Controllers

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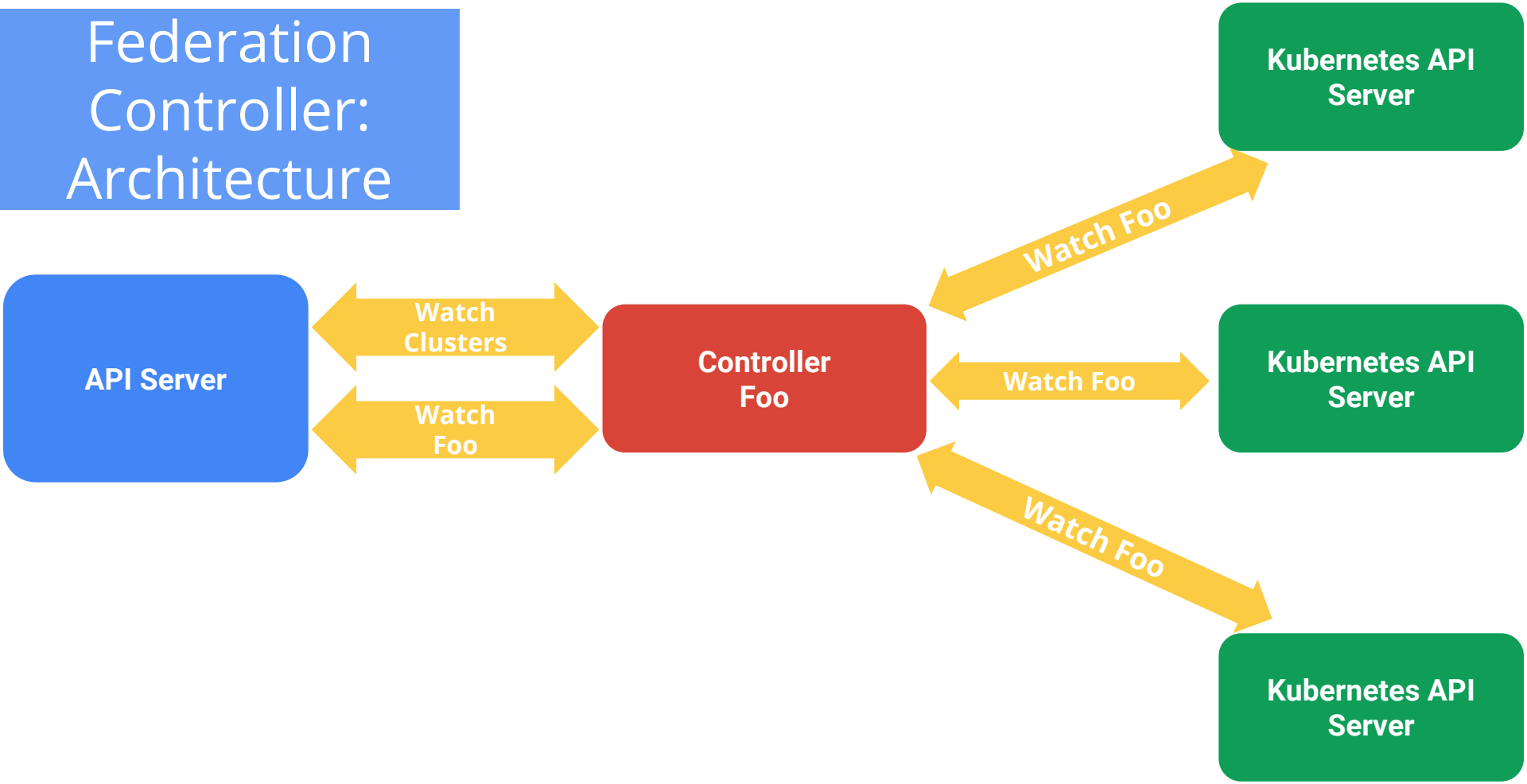
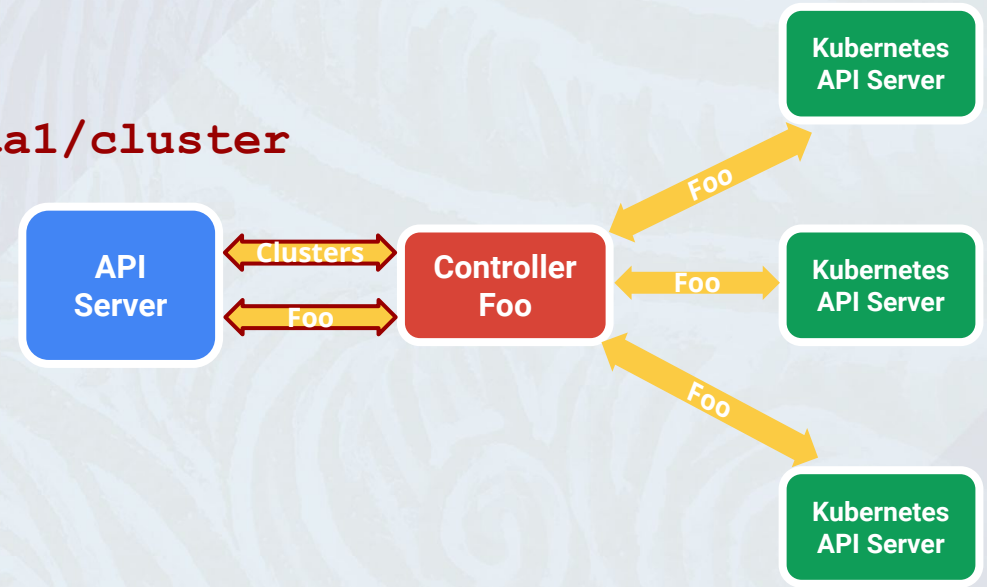
- Augment existing functionality
  - Extend available controllers
- Customize behavior
  - Replace existing controllers with custom implementations

Federation Controller: Architecture



Federation Controller: Architecture

- Watches Federation API Server
  - Clusters - `federation/v1beta1/cluster`
  - API Resources - `v1/foo`



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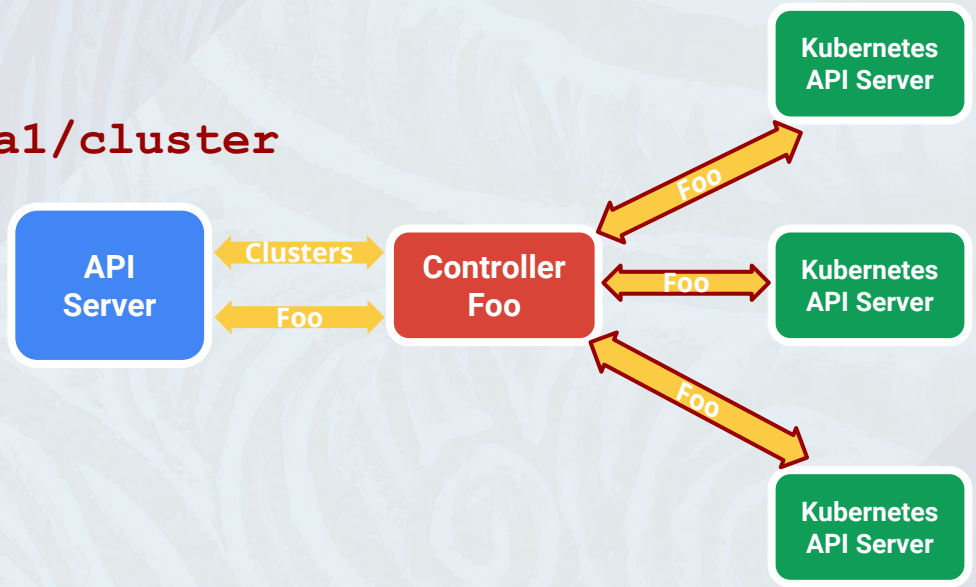

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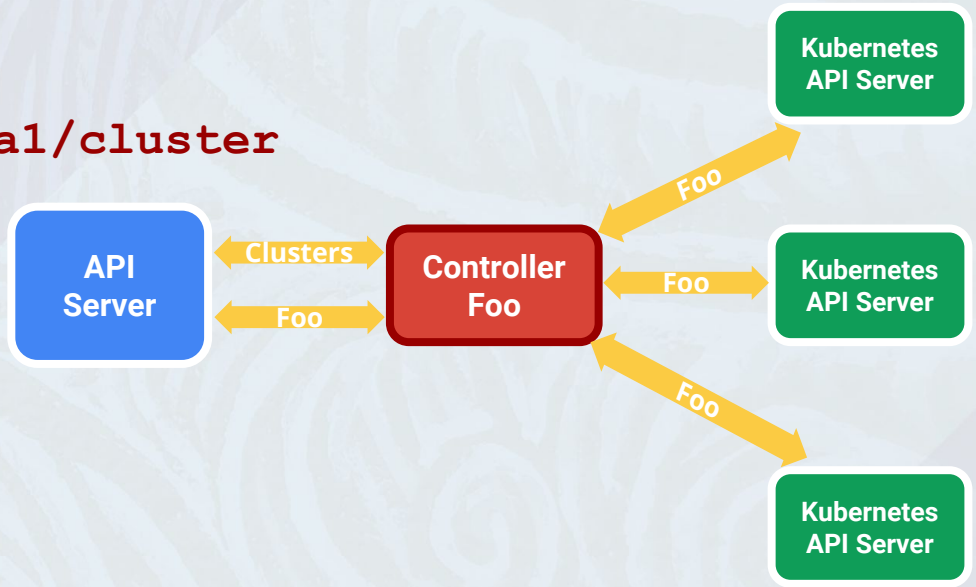
  - Compare and update



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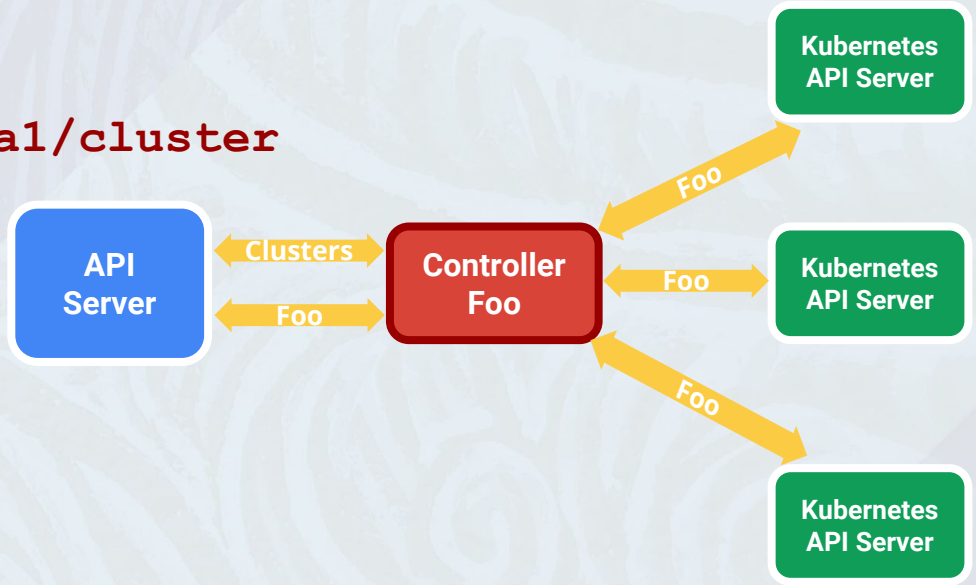
- Handles cascading deletion



Federation Controller: Implementation

- Informer to watch Federation API Resource - **v1/foo**

```
// Start informer on federated API servers on foos that should be federated.
foocontroller.fooInformerStore, foocontroller.fooInformerController = cache.NewInformer(
      &cache.ListWatch{
            ListFunc: func(options metav1.ListOptions) (pkgruntime.Object, error) {
                  return client.Core().Foos(metav1.NamespaceAll).List(options)
            },
            WatchFunc: func(options metav1.ListOptions) (watch.Interface, error) {
                  return client.Core().Foos(metav1.NamespaceAll).Watch(options)
            },
      },
      &apiv1.Foo{},
      controller.NoResyncPeriodFunc(),
      util.NewTriggerOnAllChanges(func(obj pkgruntime.Object) {
            foocontroller.deliverFooObj(obj, 0, false)
      }),
)
```

- Federated Informer to watch
  - Kubernetes API Resource in all clusters - **v1/foo**
  - Kubernetes clusters - **federation/v1beta1/cluster**

```
// Federated informer on foos in members of federation.
foocontroller.fooFederatedInformer = util.NewFederatedInformer(
        client,
        func(cluster *federationapi.Cluster, targetClient kubeclientset.Interface) (cache.Store, cache.Controller) {
                return cache.NewInformer(
                        &cache.ListWatch{
                                ...
                        },
                        &apiv1.Foo{},
                        controller.NoResyncPeriodFunc(),
                        // Trigger reconciliation whenever something in federated cluster is changed. In most cases it
                        // would be just confirmation that some foo operation succeeded.
                        util.NewTriggerOnAllChanges(
                                func(obj pkgruntime.Object) {
                                        foocontroller.deliverFooObj(obj, foocontroller.fooReviewDelay, false)
                                },
                        ))
        },
        &util.ClusterLifecycleHandlerFuncs{
                ClusterAvailable: func(cluster *federationapi.Cluster) {
                        // When new cluster becomes available process all the foos again.
                        foocontroller.clusterDeliverer.DeliverAt(allClustersKey, nil, time.Now().Add(foocontroller.clusterAvailableDelay))
                },
        },
)
```

- DeletionHelper to set up cascading deletion

```
foocontroller.deletionHelper = deletionhelper.NewDeletionHelper(
      foocontroller.hasFinalizerFunc,
      foocontroller.removeFinalizerFunc,
      foocontroller.addFinalizerFunc,
      // objNameFunc
      func(obj pkgruntime.Object) string {
            foo := obj.(*apiv1.Foo)
            return foo.Name
      },
      foocontroller.updateTimeout,
      foocontroller.eventRecorder,
      foocontroller.fooFederatedInformer,
      foocontroller.federatedUpdater,
)
```

- Connecting the dots...

```
func (foocontroller *FooController) Run(stopChan <-chan struct{}) {
	go foocontroller.fooInformerController.Run(stopChan)
	foocontroller.fooFederatedInformer.Start()
	go func() {
		<-stopChan
		foocontroller.fooFederatedInformer.Stop()
	}()
	foocontroller.fooDeliverer.StartWithHandler(func(item *util.DelayingDelivererItem) {
		foo := item.Value.(*types.NamespacedName)
		foocontroller.reconcileFoo(*foo)
	})
	foocontroller.clusterDeliverer.StartWithHandler(func(_ *util.DelayingDelivererItem) {
		foocontroller.reconcileFoosOnClusterChange()
	})
	util.StartBackoffGC(foocontroller.fooBackoff, stopChan)
}
```

- Reconcile on federation membership change

```
// The function triggers reconciliation of all federated foos.
func (foocontroller *FooController) reconcileFoosOnClusterChange() {
      if !foocontroller.isSynced() {
            glog.V(4).Infof("Foo controller not synced")
            foocontroller.clusterDeliverer.DeliverAt(allClustersKey, nil,
time.Now().Add(foocontroller.clusterAvailableDelay))
      }
      for _, obj := range foocontroller.fooInformerStore.List() {
            foo := obj.(*apiv1.Foo)
            foocontroller.deliverFoo(types.NamespacedName{Namespace: foo.Namespace, Name: foo.Name},
                  foocontroller.smallDelay, false)
      }
}
```

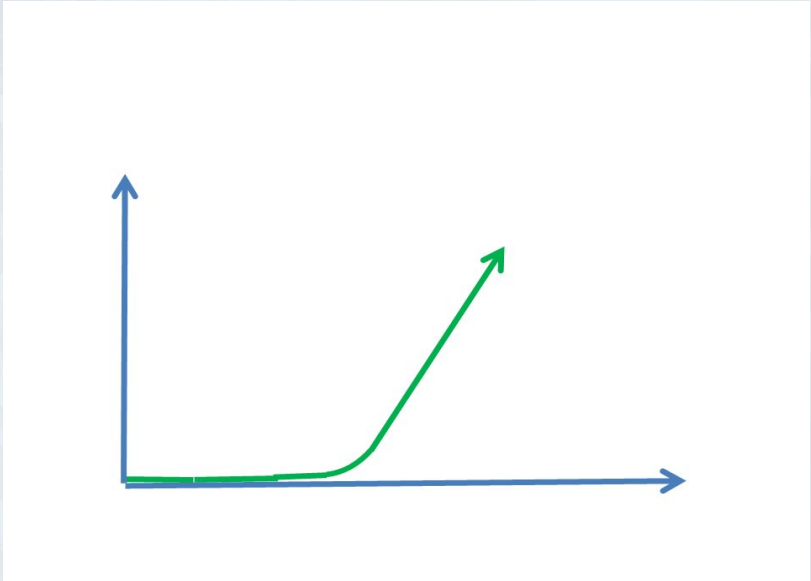
- Reconcile on any change

```
func (foocontroller *FooController) reconcileFoo(nsFoo types.NamespacedName) {
	...
	for _, cluster := range clusters {
		if !found {
			operations = append(operations, util.FederatedOperation{
				Type:        util.OperationTypeAdd,
				Obj:         desiredFoo,
				ClusterName: cluster.Name,
			})
		} else {
			// Update existing foo, if needed.
			if !util.FooEquivalent(desiredFoo, clusterFoo) {
				operations = append(operations, util.FederatedOperation{
					Type:        util.OperationTypeUpdate,
					Obj:         desiredFoo,
					ClusterName: cluster.Name,
				})
			}
		}
	}
	...
	err = foocontroller.federatedUpdater.UpdateWithOnError(operations, foocontroller.updateTimeout,
		func(op util.FederatedOperation, operror error) {...})
	...
```

Demo

We're moving fast...

- **Q3 2016 - Some killer features:**
  - Federated **Ingress**,
  - **ReplicaSets**,
  - **Namespaces**,
  - **Secrets**,
  - **Events**
- **Q4 2016 - Easier installation, expanded API:**
  - Federated **Deployments**,
  - **Daemonsets**,
  - **ConfigMaps**
  - `kubefed` **"alpha"**
- **Q1 2017 - Stabilization and paying debt:**
  - `kubefed` **"beta"**



The Future... 2017 and beyond

- **Policy-based Resource Placement (and...)**
  - Federation overlays policy over application requirements
- **Improved Identity and Access Management**
  - Especially integration with external IAM providers, across multiple cloud providers
- **Stateful Apps and Federated Persistent Storage**
  - Cross-cluster data replication, snapshot+restore, etc...
- **Hybrid Cloud Federated Ingress**
  - Smart cross-cloud L7 load balancing
- **Private Federated Services**
  - Private IP's and DNS
- **GUI/Visualization**, etc, etc...

This is a community effort! Feel free to join.

- **SIG Federation**
  - kubernetes-sig-federation@groups.google.com
  - groups.google.com/kubernetes-sig-federation
- **Working Group**
  - tinyurl.com/ubernetes-wg-notes
- **Us:**
  - Nikhil
    - nikhiljindal@google.com
    - nikhiljindal@github
  - Madhu
    - madhusudancs@google.com
    - madhusudancs@github

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Thank you!