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Cooperative Scheduling for Stateful Systems

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LinkedIn

Intro



Michael Youssef
Staff Engineer

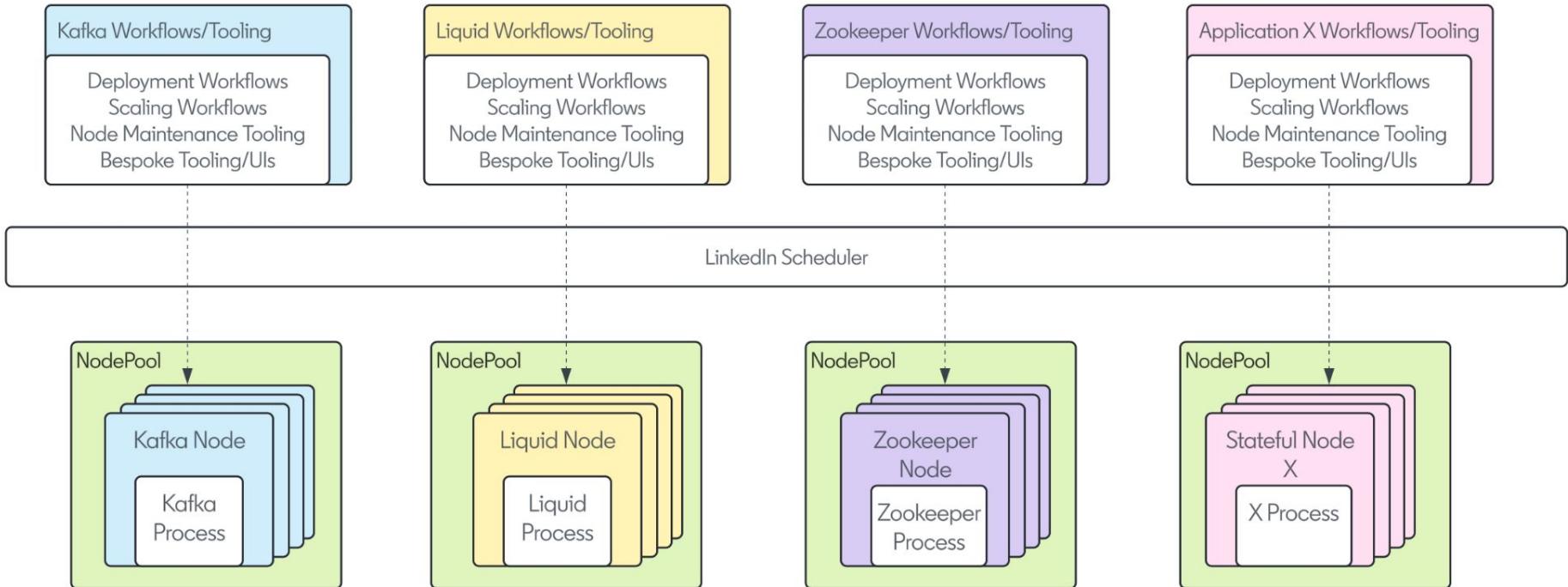


Zantong Shang
Software Engineer

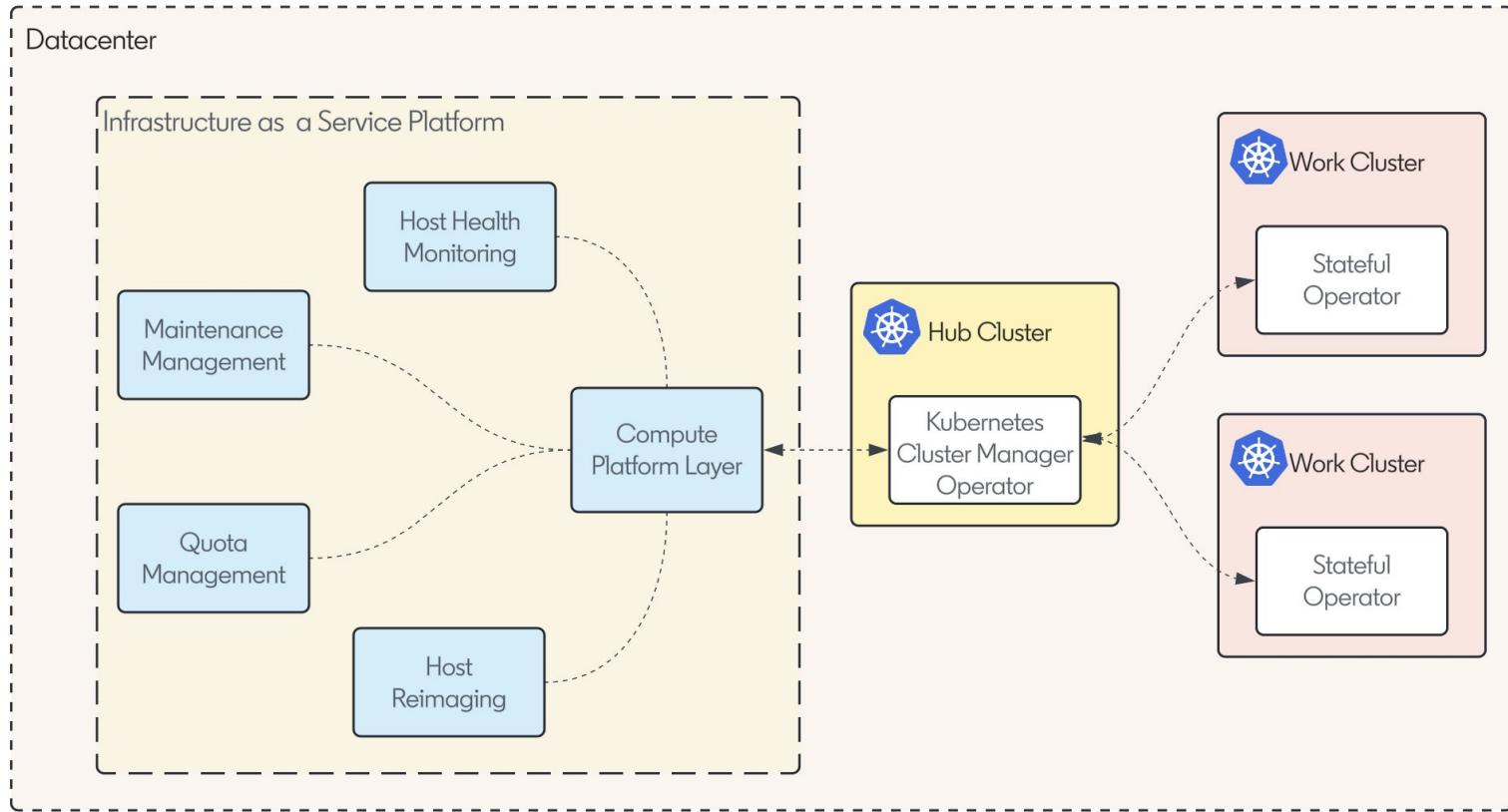
Agenda

1. Where we started
2. Cooperation with Application Cluster Managers
3. Operator breakdown
4. Host lifecycle maintenance
5. Lessons Learned
6. Acknowledgements
7. Q&A

Stateful Systems on Legacy Compute Infra

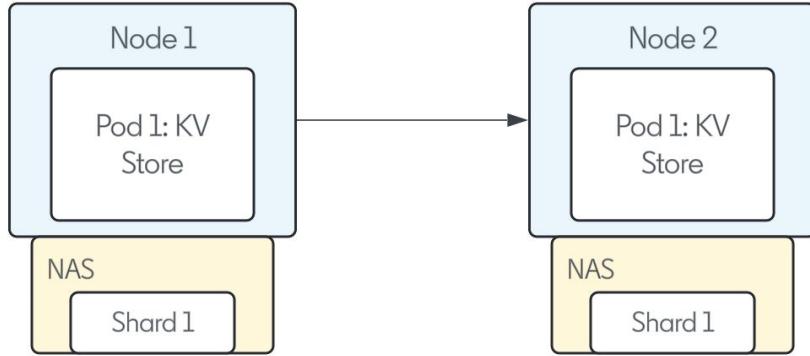


Next Generation Compute

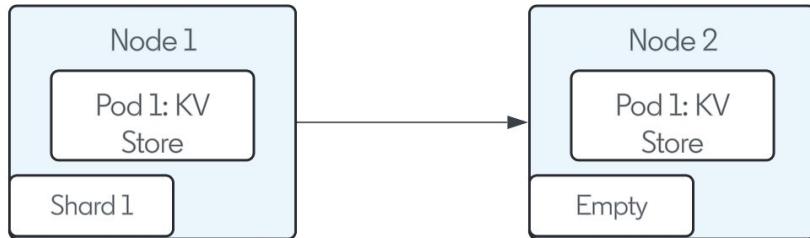


Problems with Running Stateful Workloads

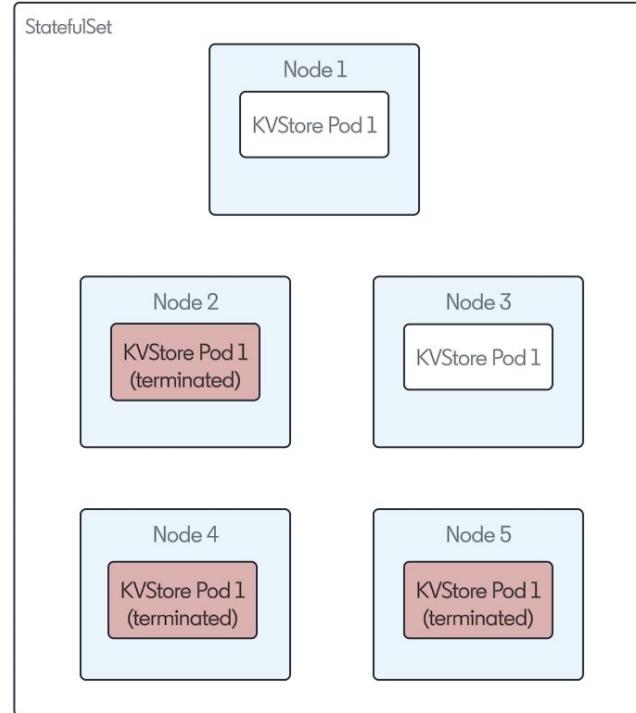
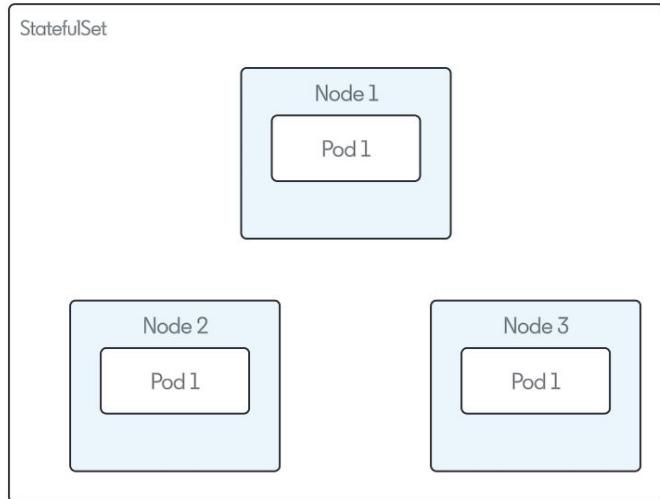
Seamless Node Loss



Data Loss



Problems with Running Stateful Workloads



Why StatefulSet Doesn't Cut It

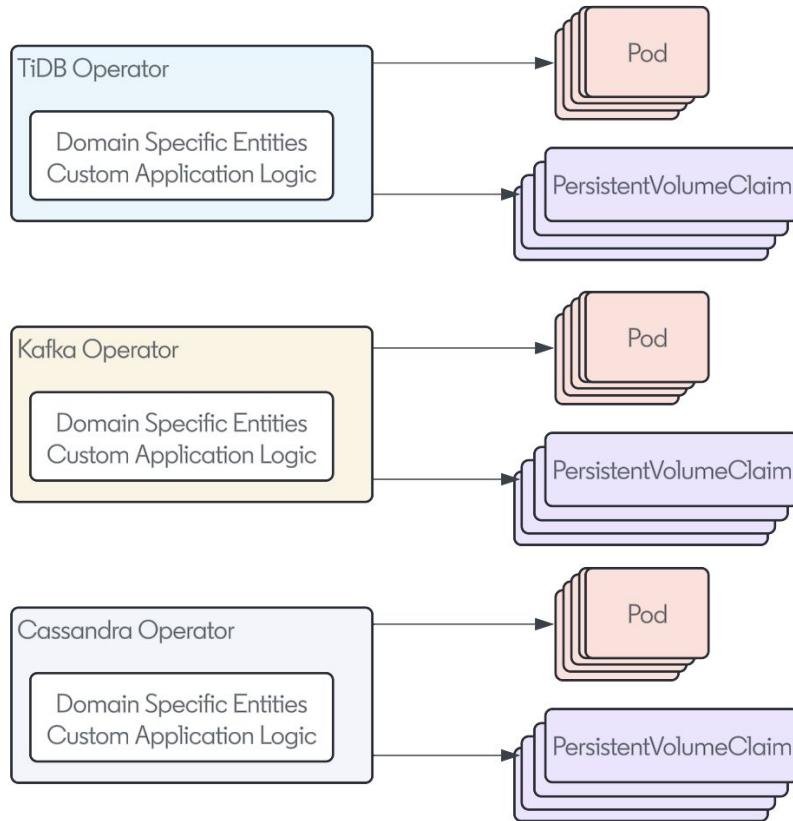
StatefulSet is great for certain use cases, but not ours at LinkedIn.

StatefulSet currently:

1. Lacks shard awareness/application safety
2. Is not host lifecycle aware
3. Cannot run n canaries within a single StatefulSet
4. Many other issues

We needed something to bridge this gap.

Should Everyone Get an Operator?



- Fine grain control of application lifecycle
- CRDs/Entities accurately describe intent with names relevant to the domain
- Come with drawbacks

Goals



Unified User
Experience

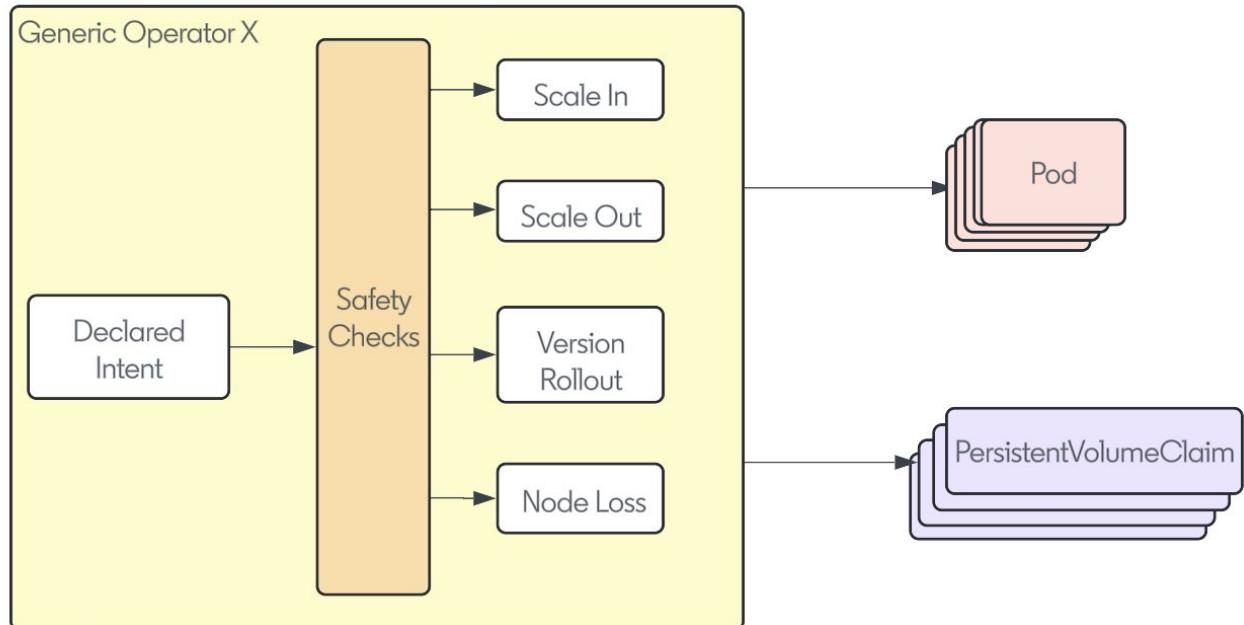


Unified Host
Lifecycle
Maintenance

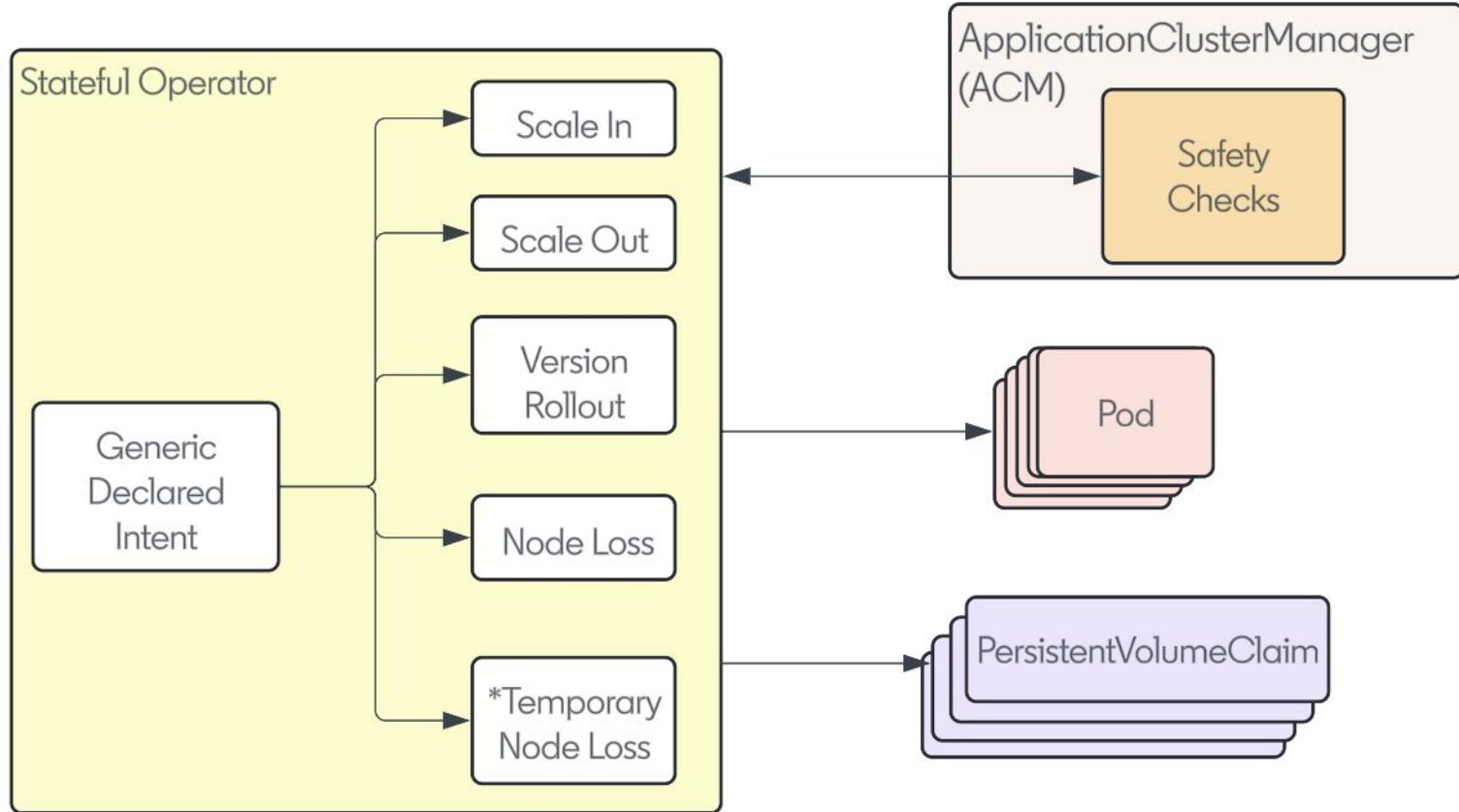


Abstract
Kubernetes

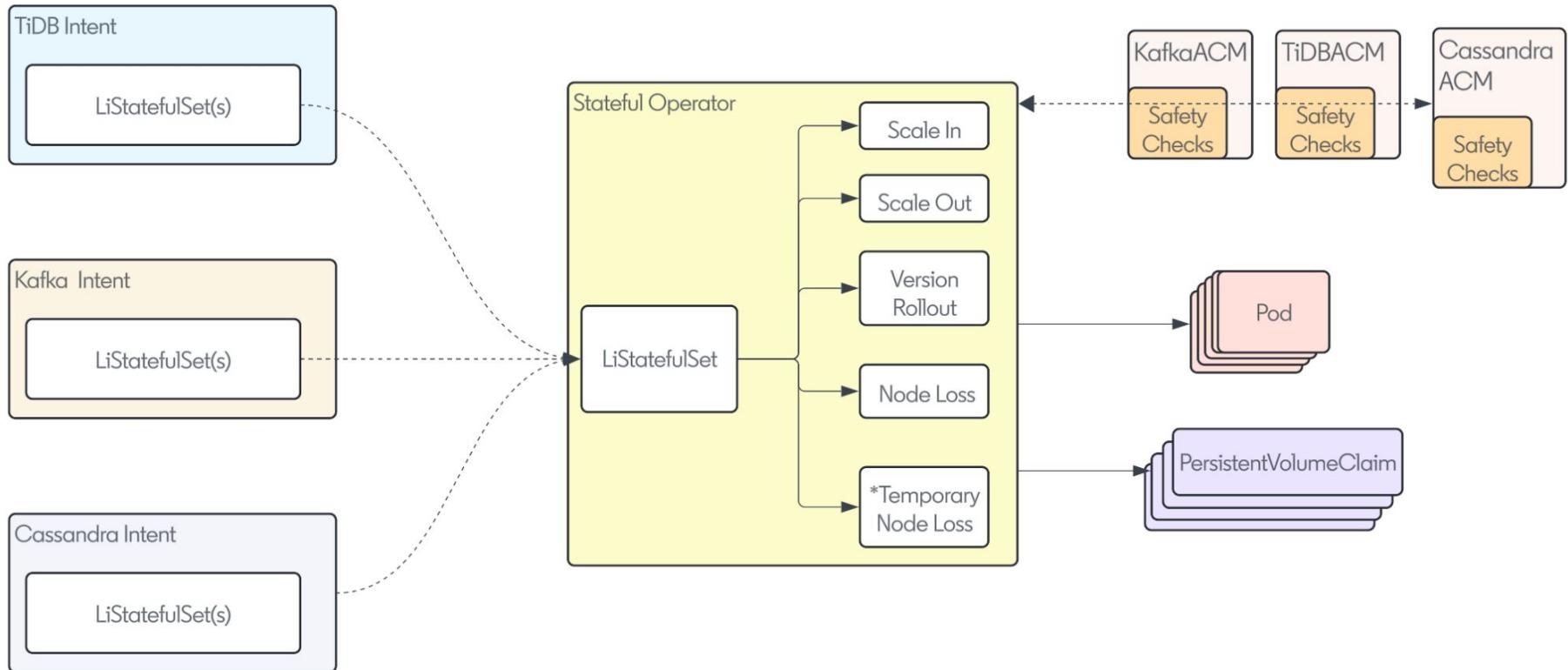
Abstracting a Stateful Operator



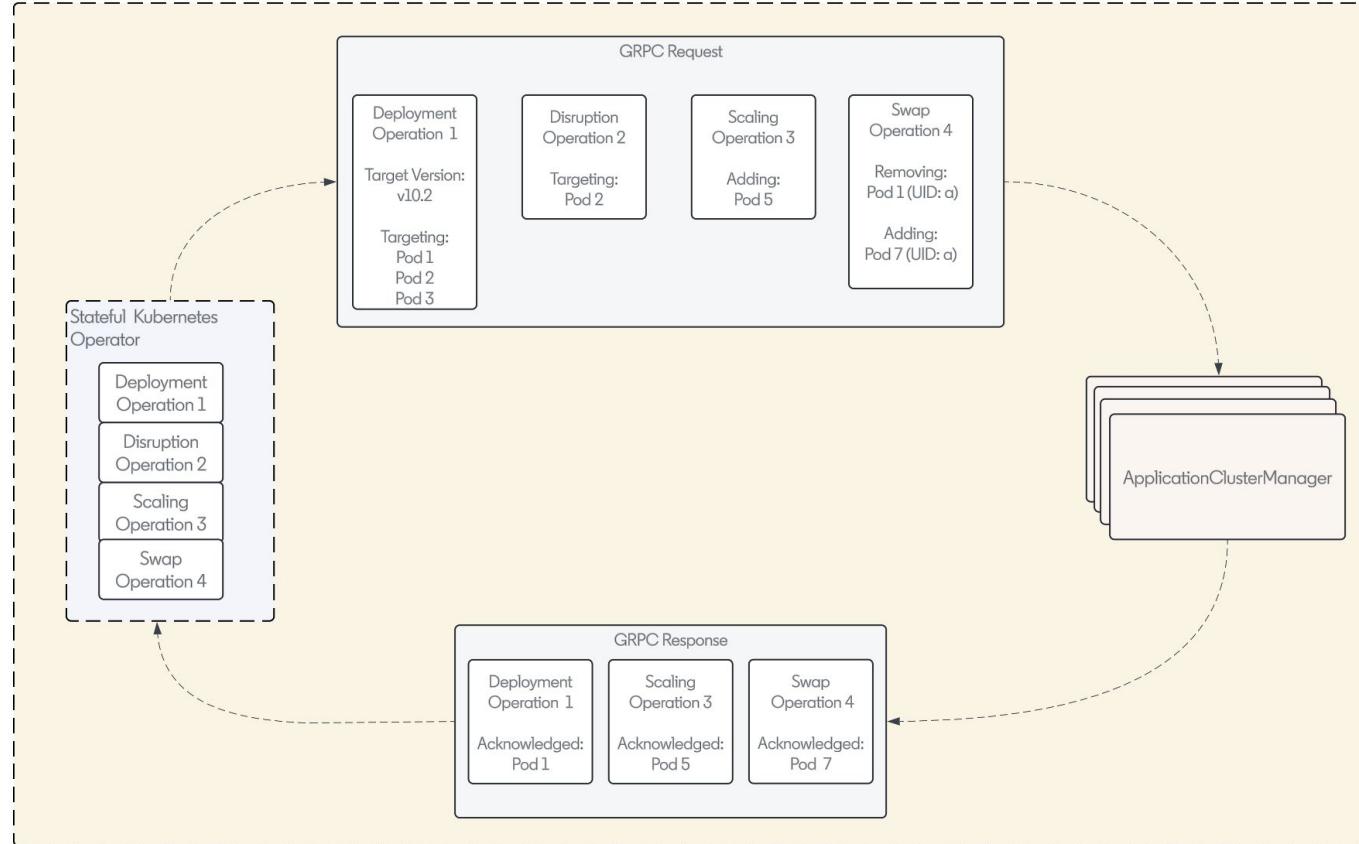
Making it pluggable



High Level Picture: Operator with ACMS

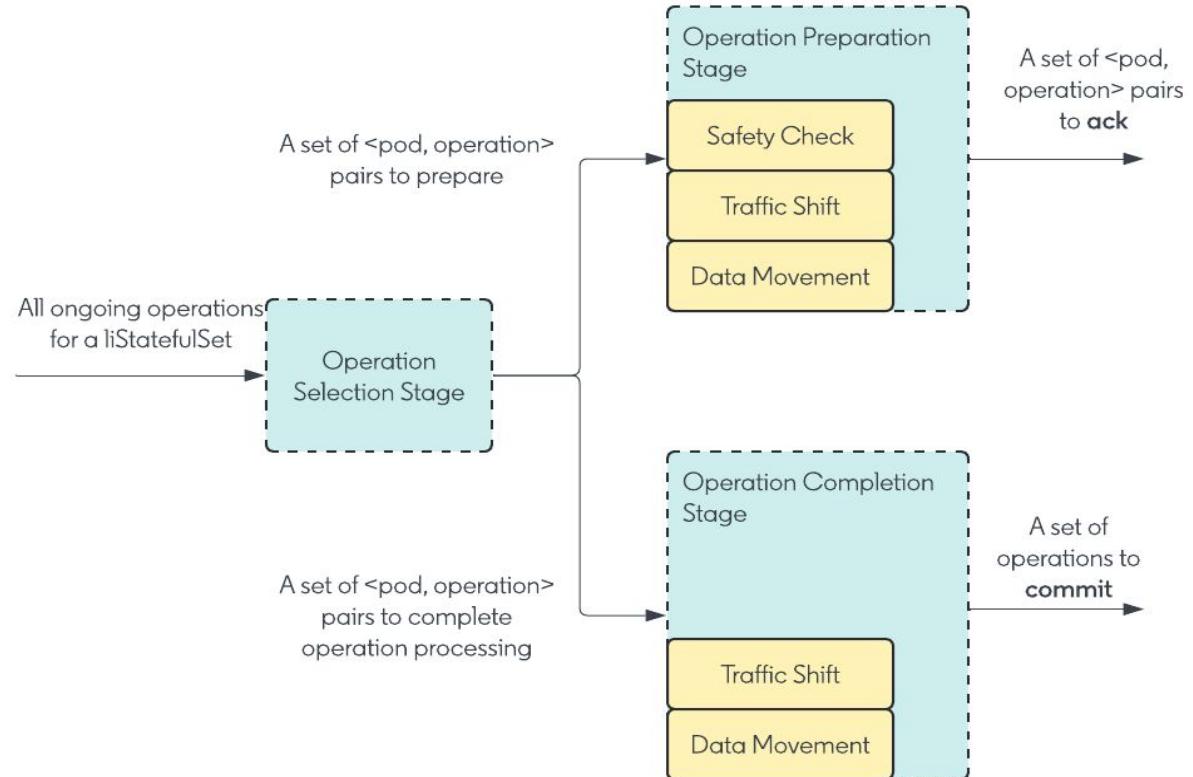


What is an Application Cluster Manager?



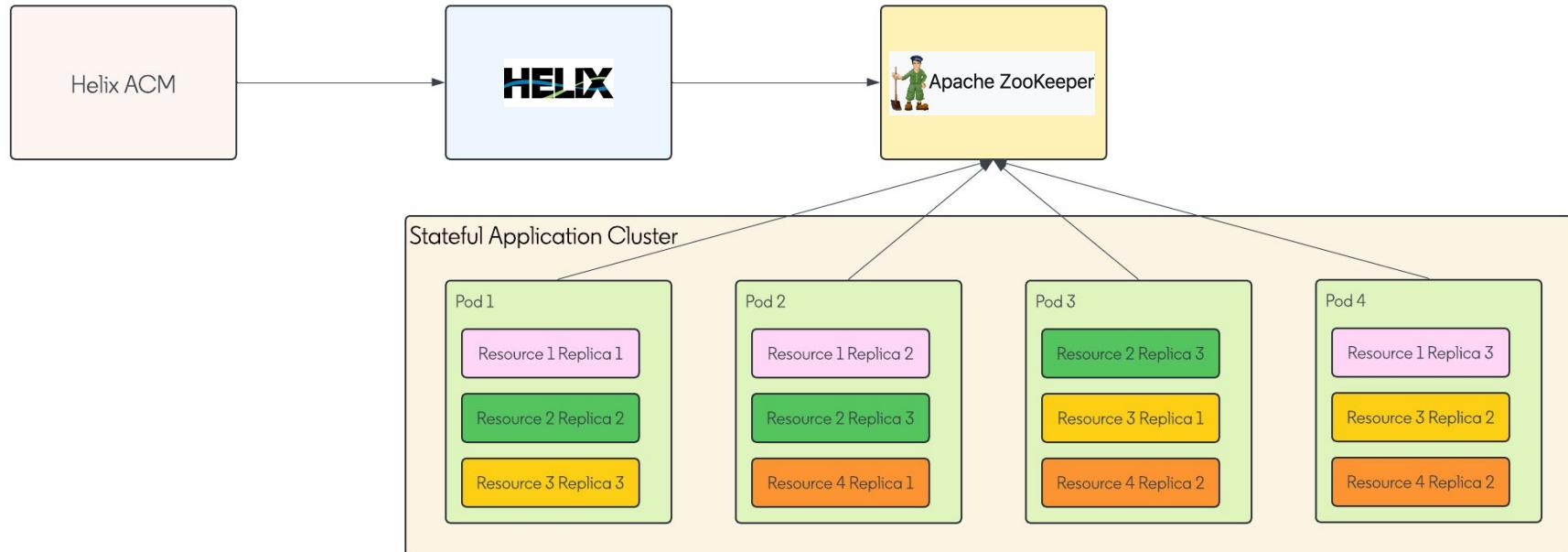
ACM/Application Cluster Manager Framework

- Modular operation processing stages
- Hiding common logics like GRPC request/response, state persistence

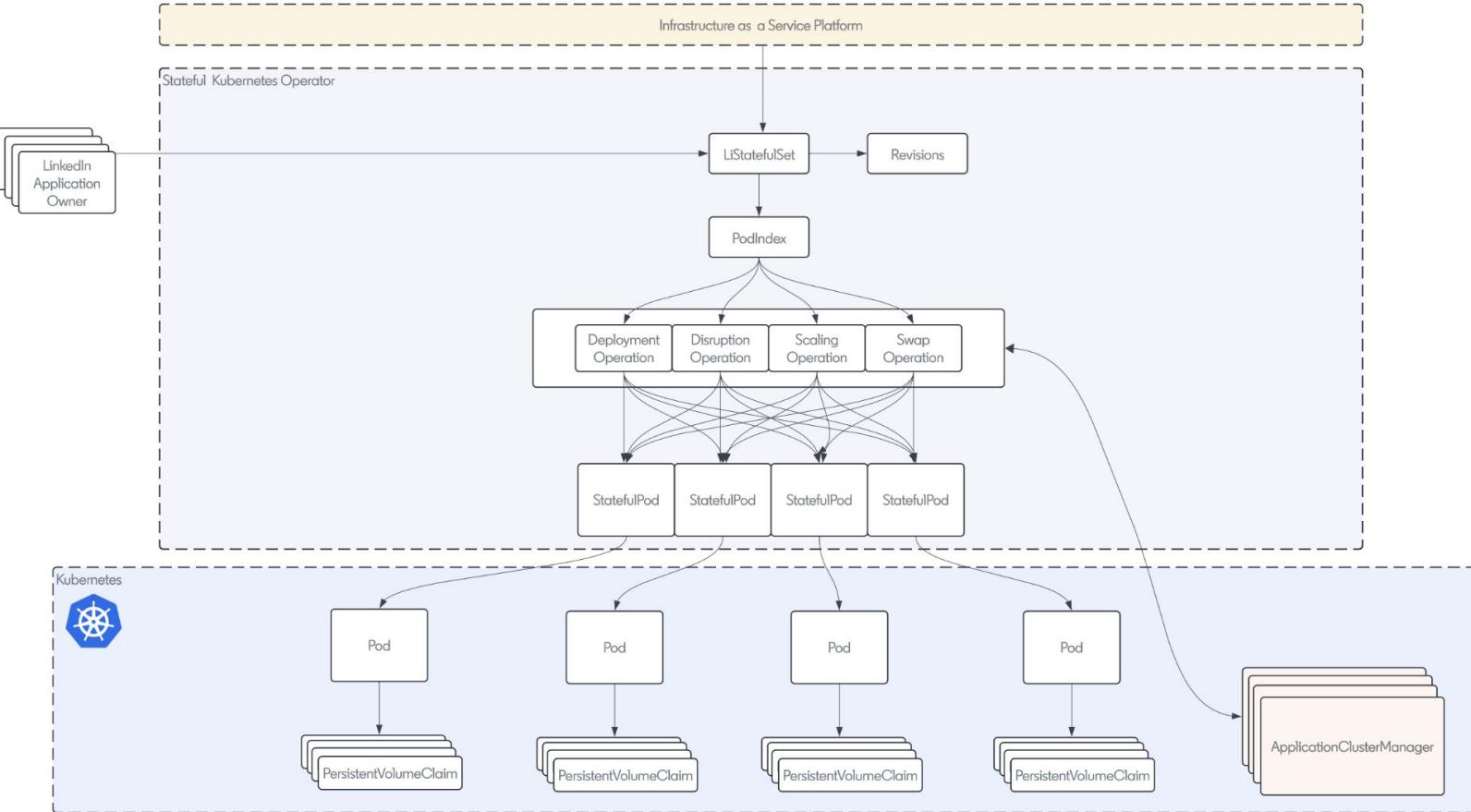


One ACM implementation - Helix ACM

- Helix: An open source project, used by many stateful applications at LinkedIn to manage instances and resources
- Helix ACM understands and is able to orchestrate operations for a Helix-based stateful system



Stateful Operator: Bird's Eye View



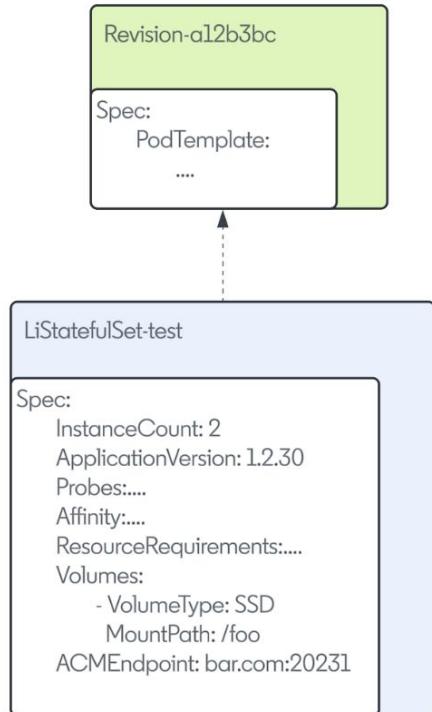
Example Flow

1. User Declares Intent

```
LiStatefulSet-test
Spec:
  InstanceCount: 2
  ApplicationVersion: 1.2.30
  Probes:.....
  Affinity:.....
  ResourceRequirements:.....
  Volumes:
    - VolumeType: SSD
      MountPath: /foo
  ACMEEndpoint: bar.com:20231
```

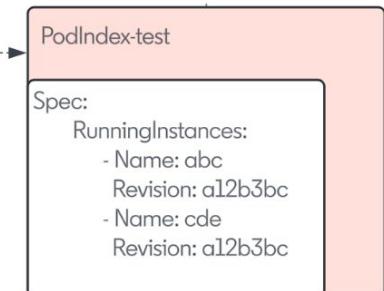
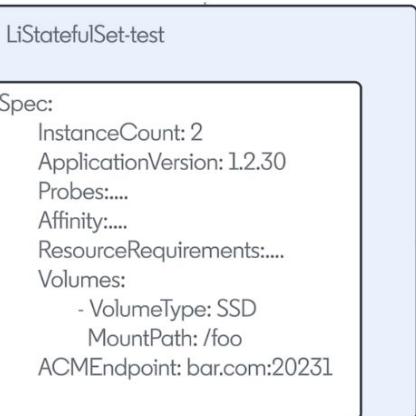
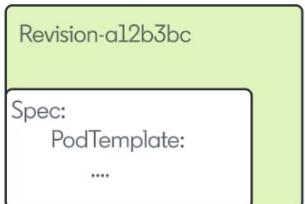
Example Flow

2. Generate an immutable PodTemplate representing the eventual pod payload



Example Flow

2. Generate an immutable PodTemplate representing the eventual pod payload



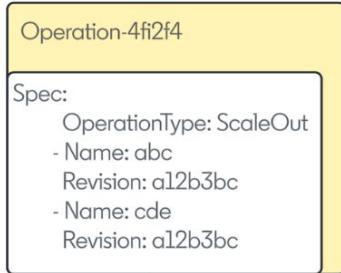
3. Stage the intent and pre-generate pod state

Example Flow

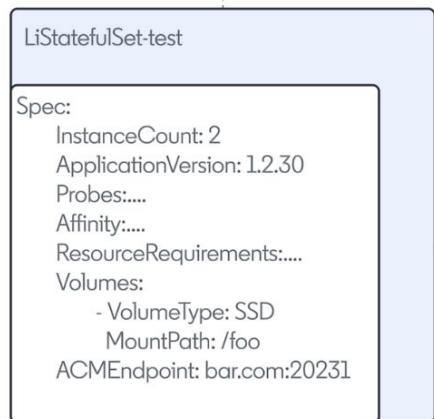
2. Generate an immutable PodTemplate representing the eventual pod payload



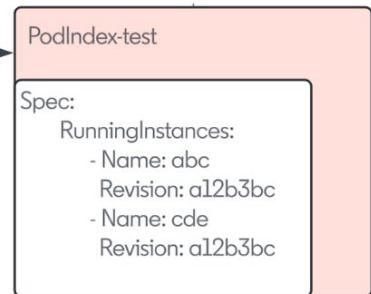
4. Generate an Operation, whose state machine will eventually act on the intent



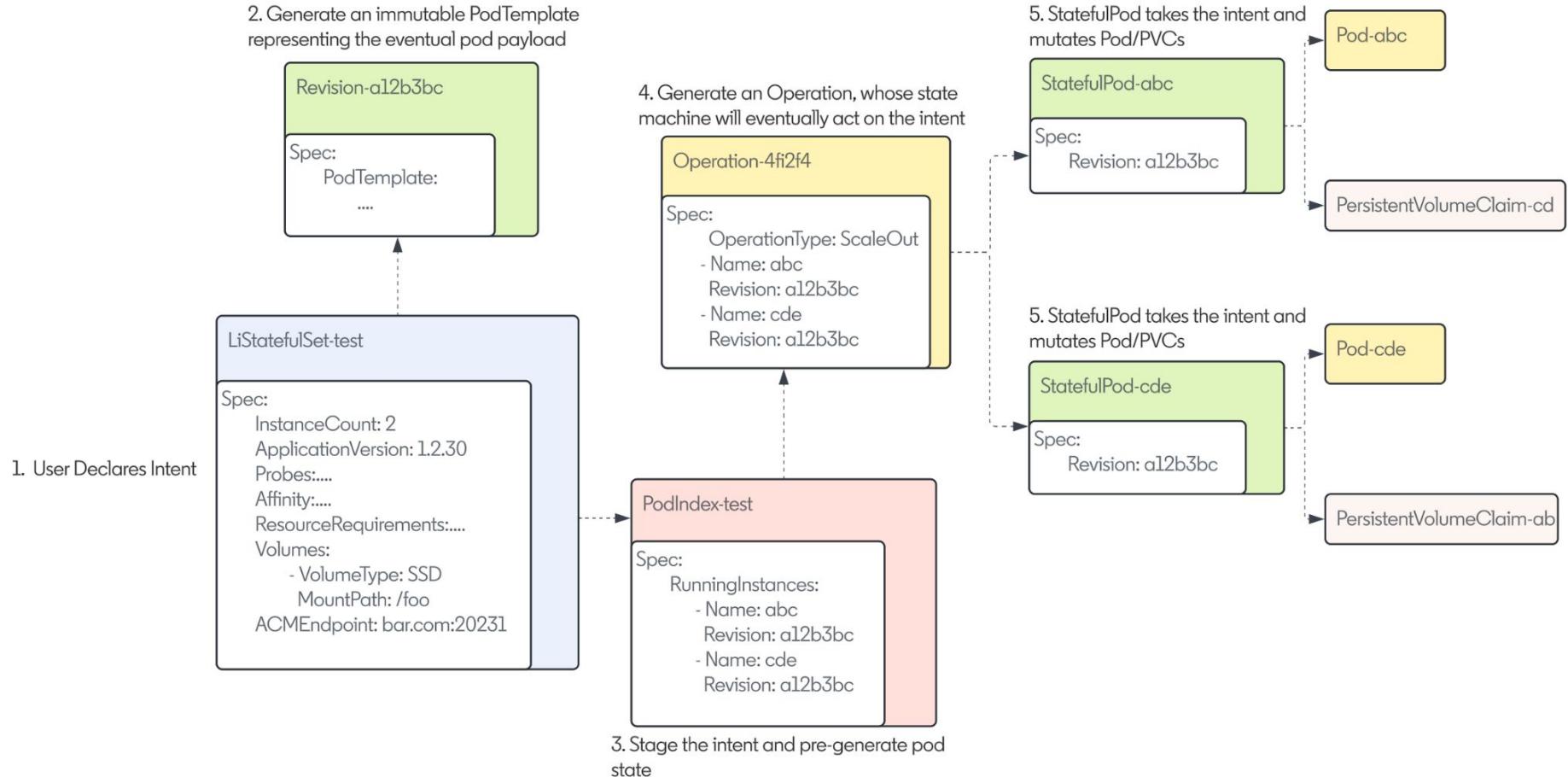
1. User Declares Intent



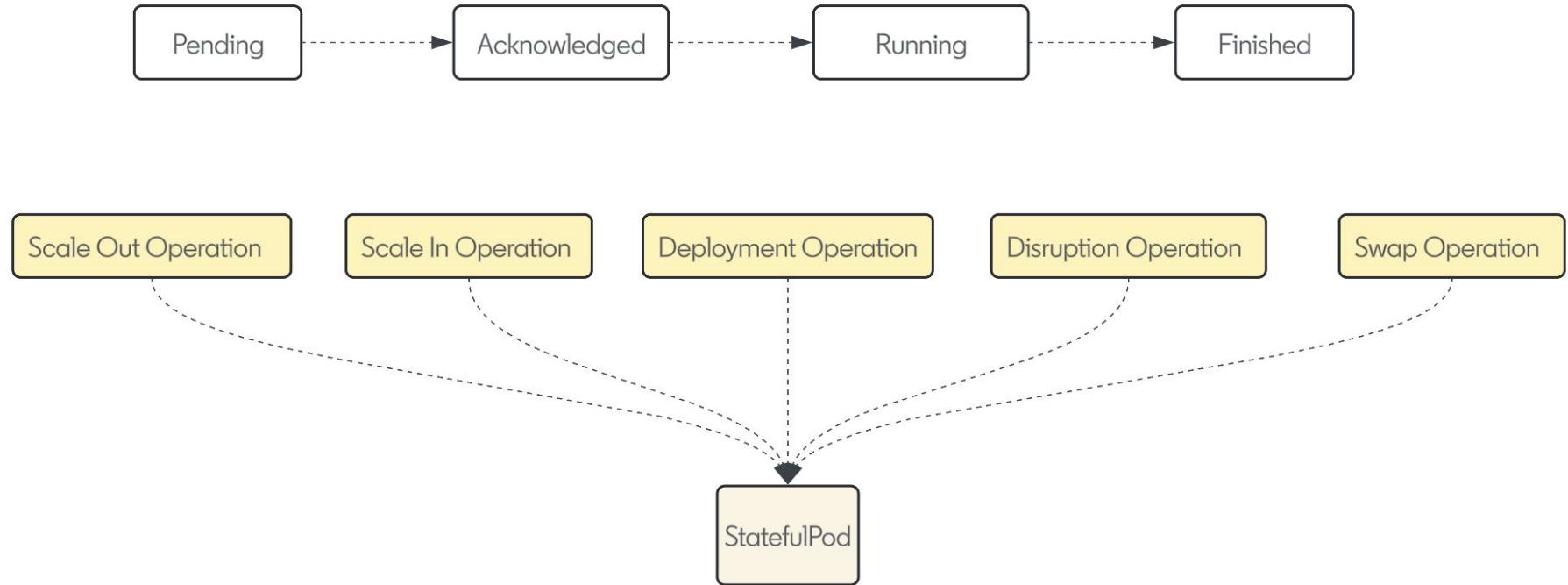
3. Stage the intent and pre-generate pod state



Example Flow



Operation Lifecycle





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Coordinating Host Lifecycle Maintenance

Types of Maintenance

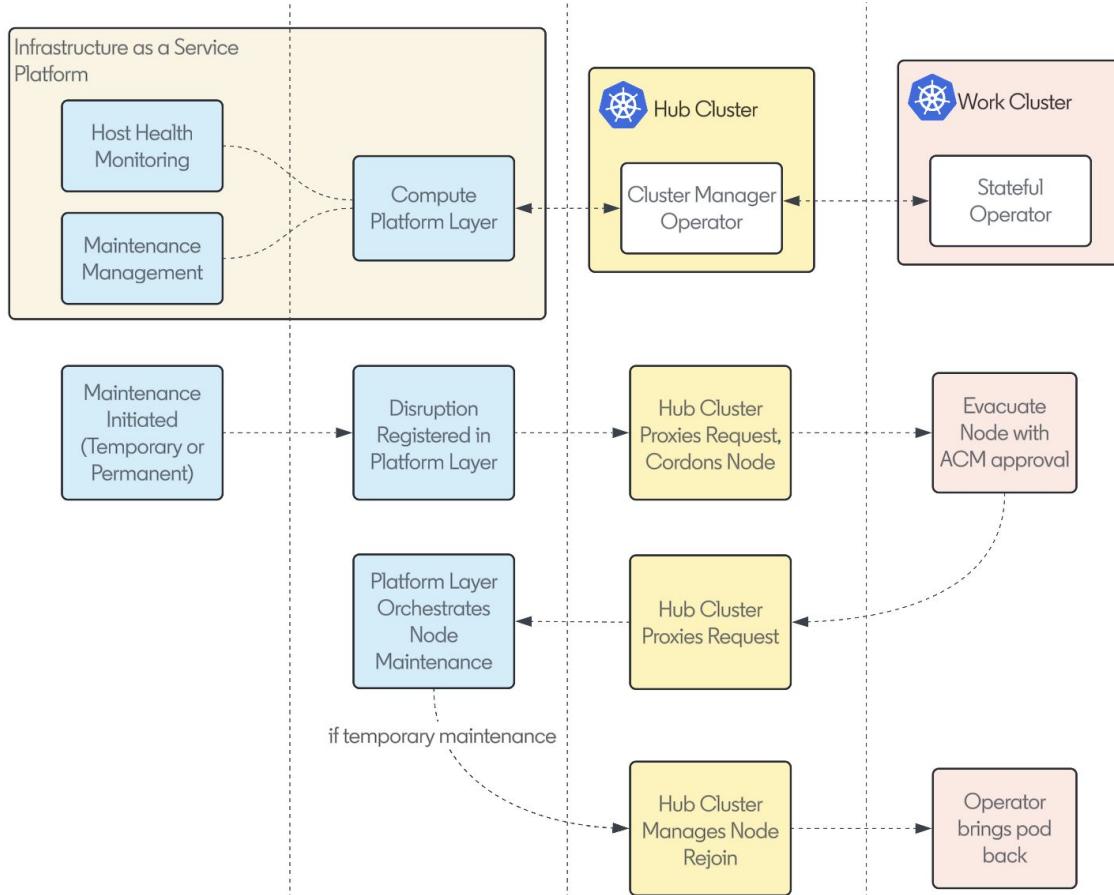
Temporary Node Loss

- Top of Rack Switch Upgrade
- OS Upgrade
- Firmware Upgrade
- Kubelet Upgrade

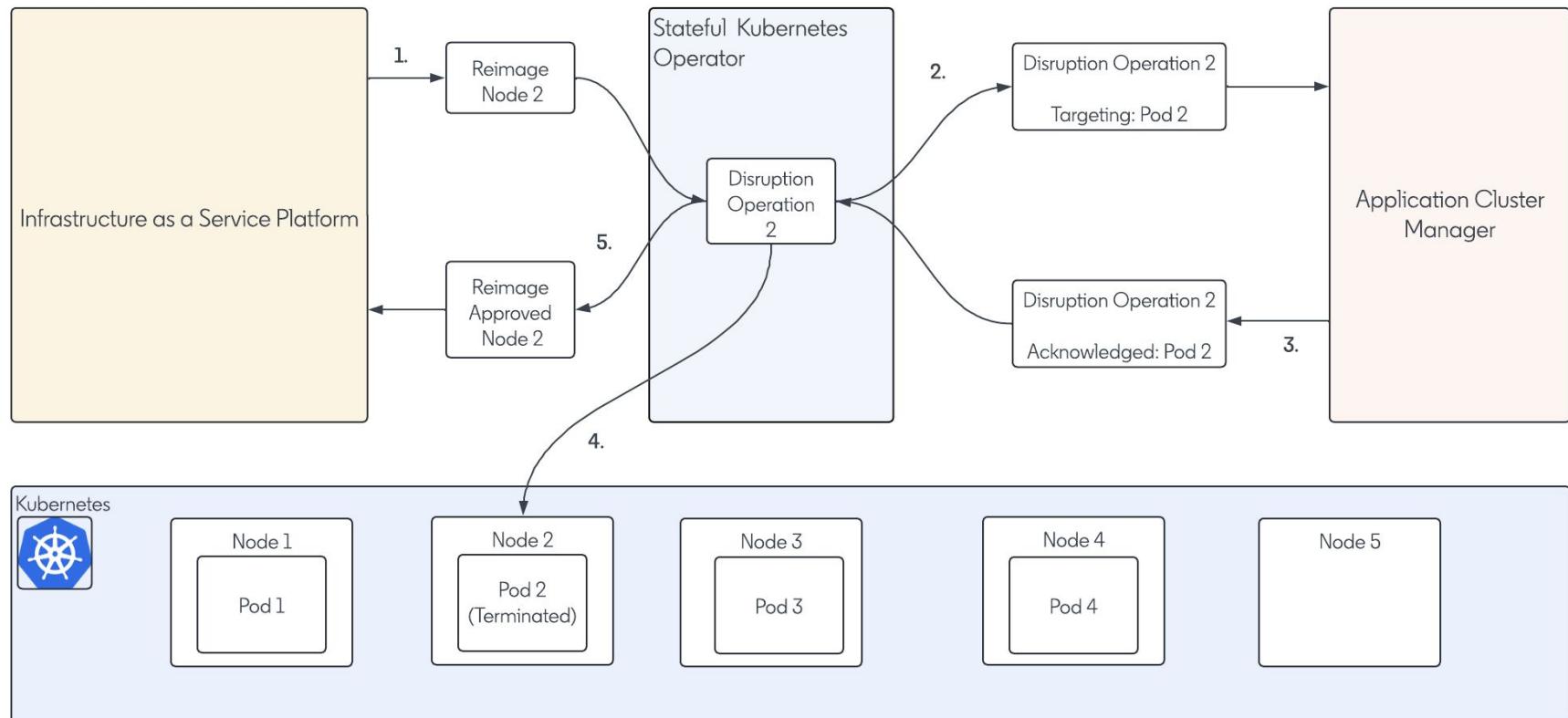
Permanent Node Loss

- Planned Decommission
- Chronic Host Health Issues

Maintenance: IaaS initiated

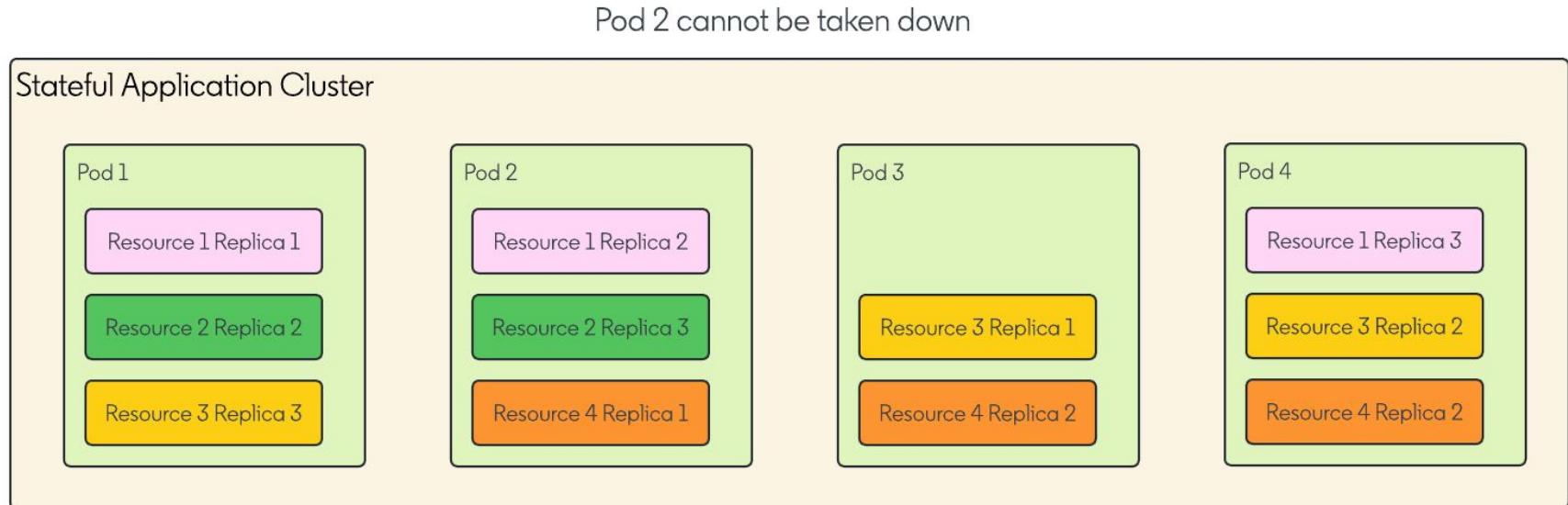


Temporary Node Loss - Before Operation



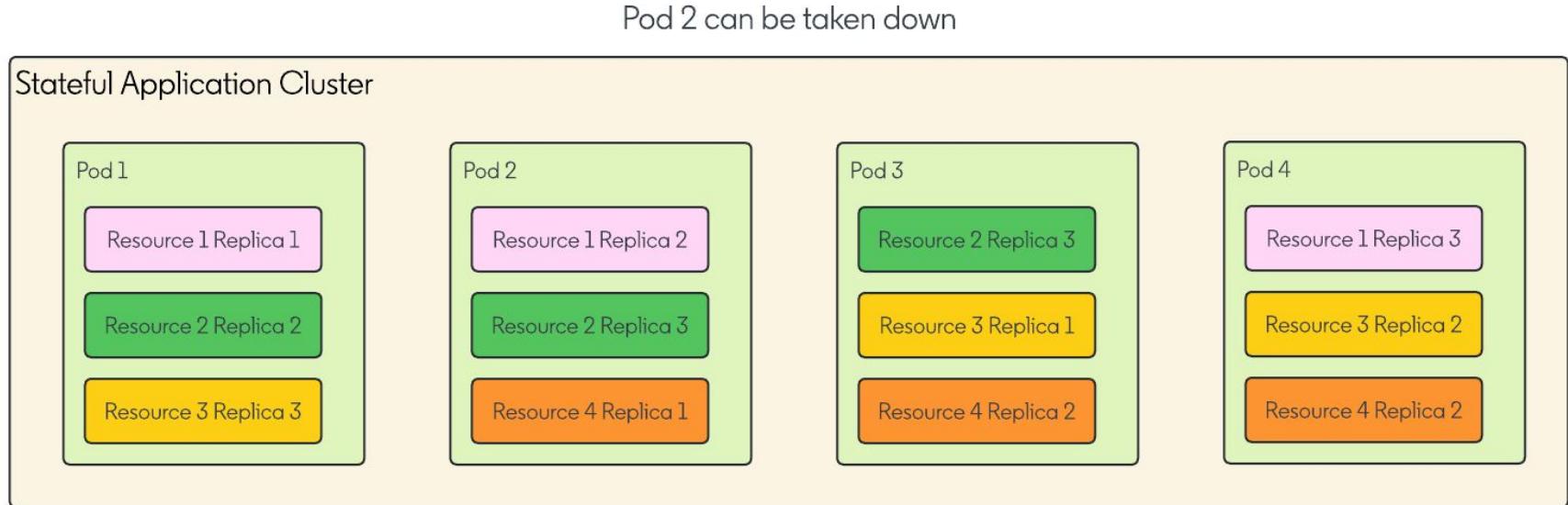
Temporary Node Loss - ACM Preparation

- Safety check: taking down pods does not cause under-replicated resources.



Temporary Node Loss - ACM Preparation

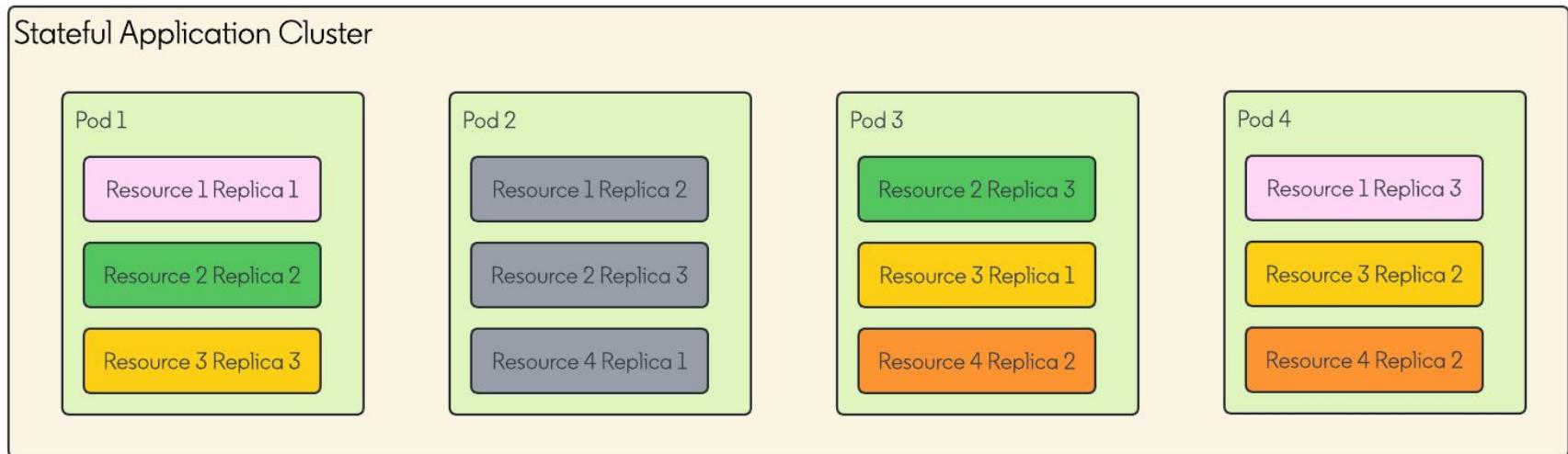
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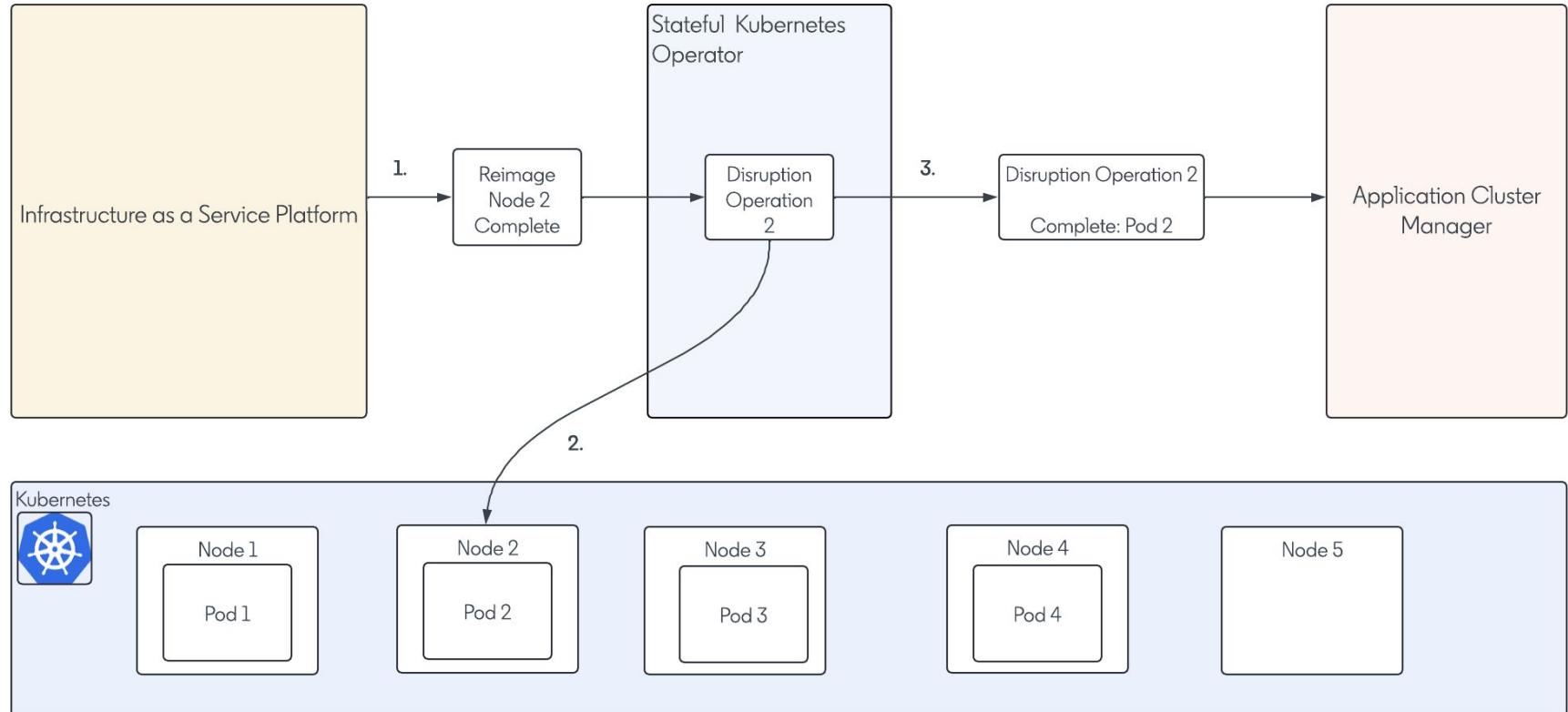
Temporary Node Loss - ACM Preparation

- Traffic is shifted out but data is kept.

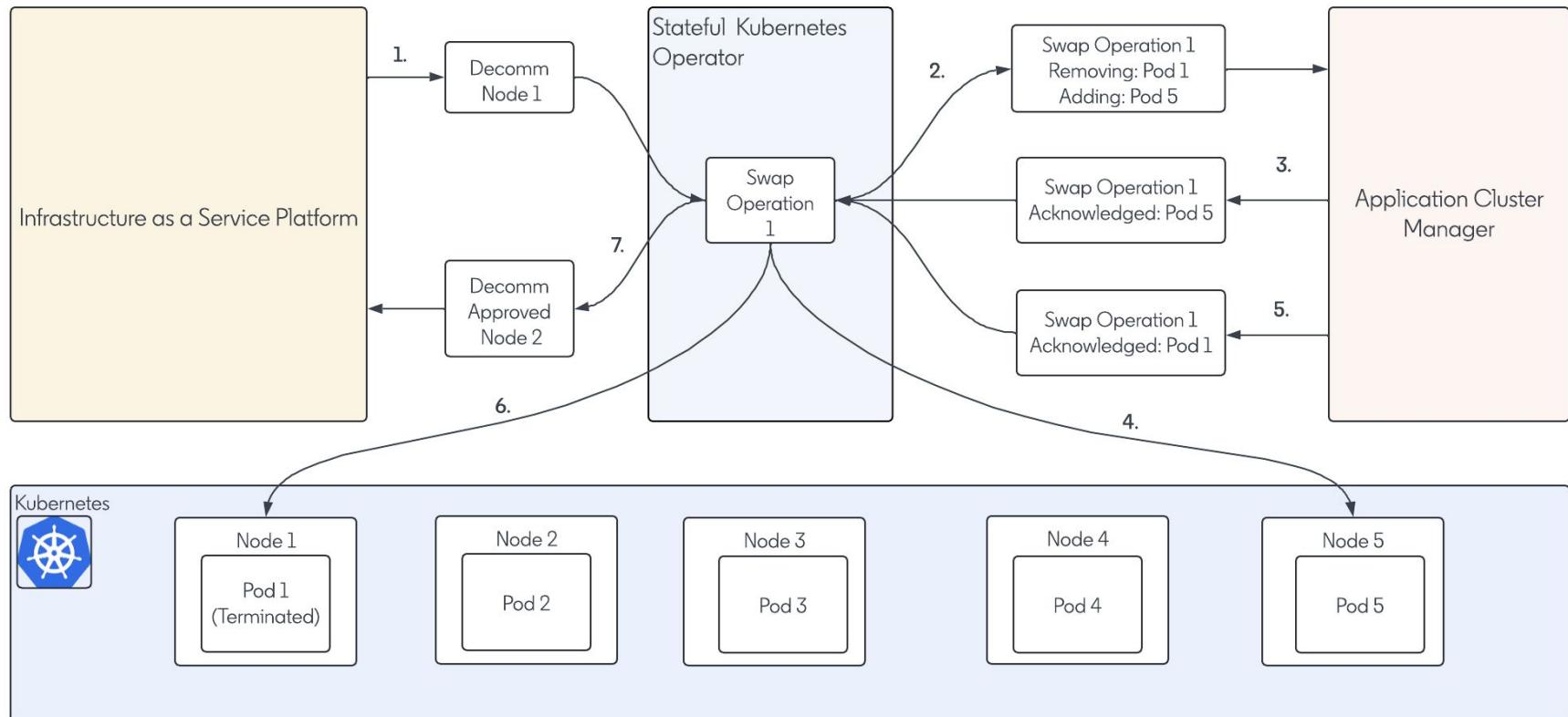
Traffic is shifted out of Pod 2



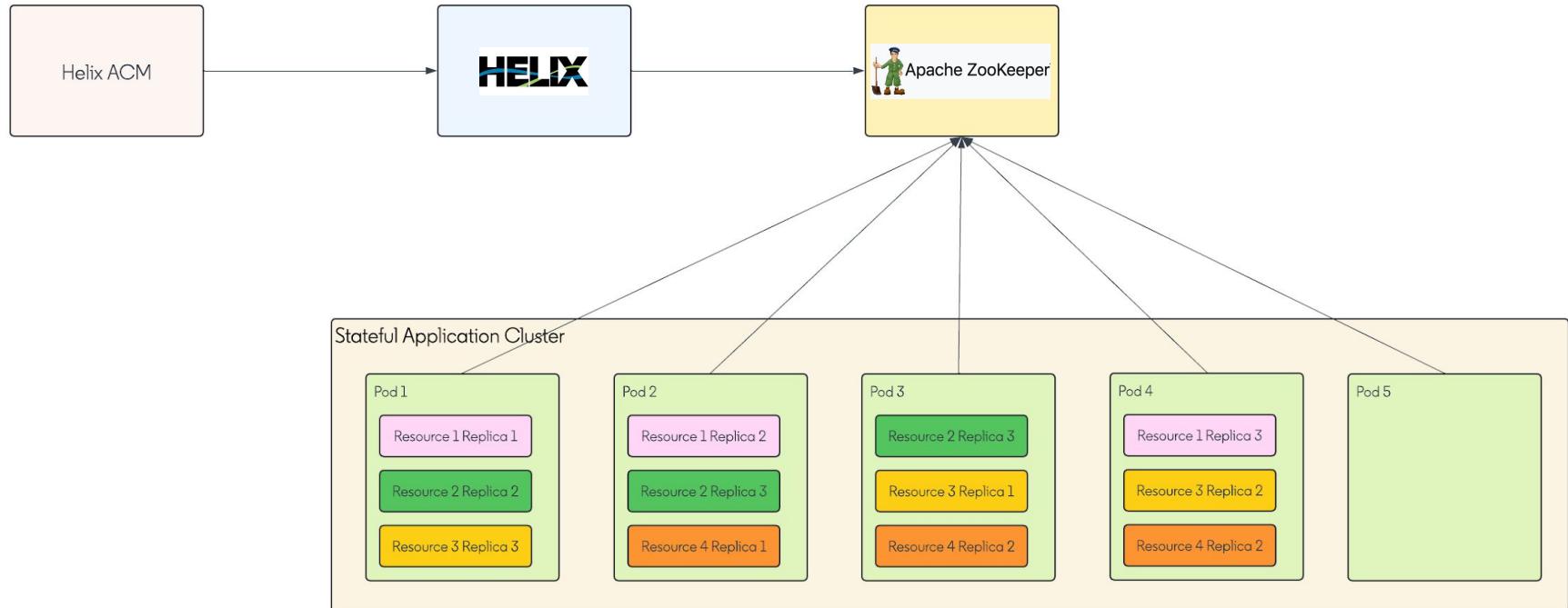
Temporary Node Loss Completion



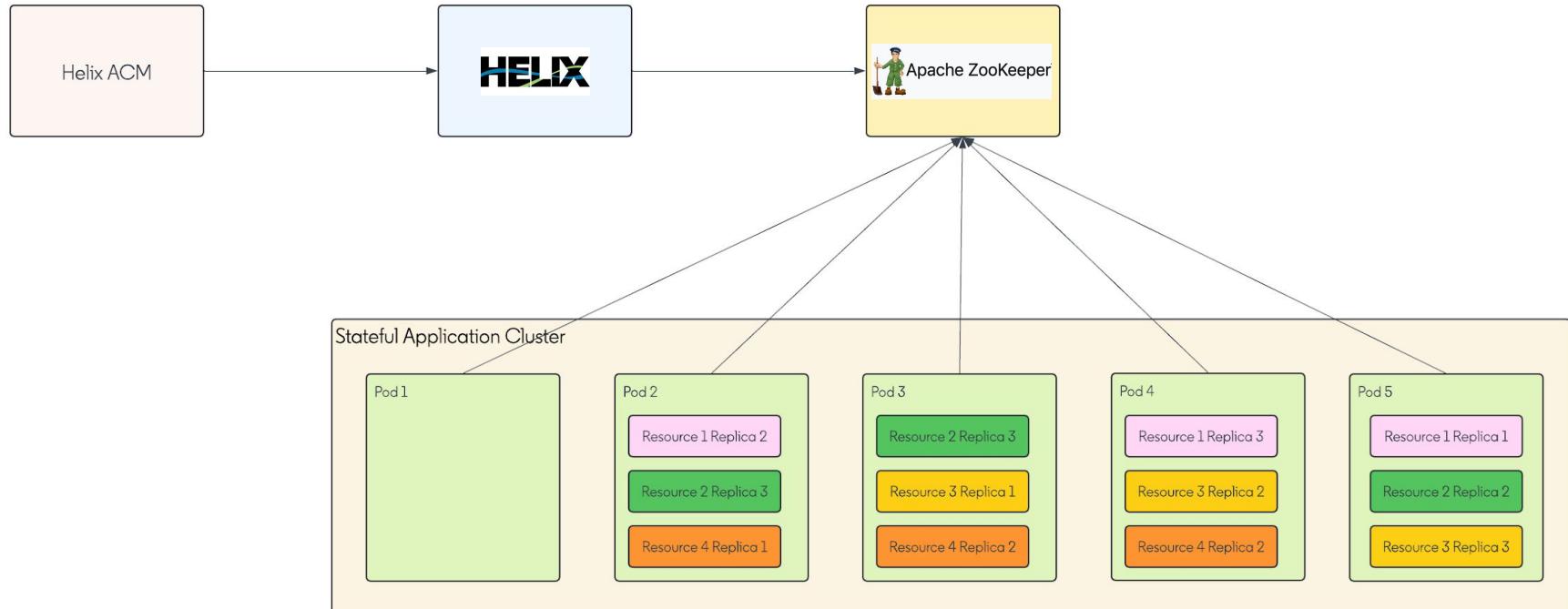
Permanent Node Loss - Overview



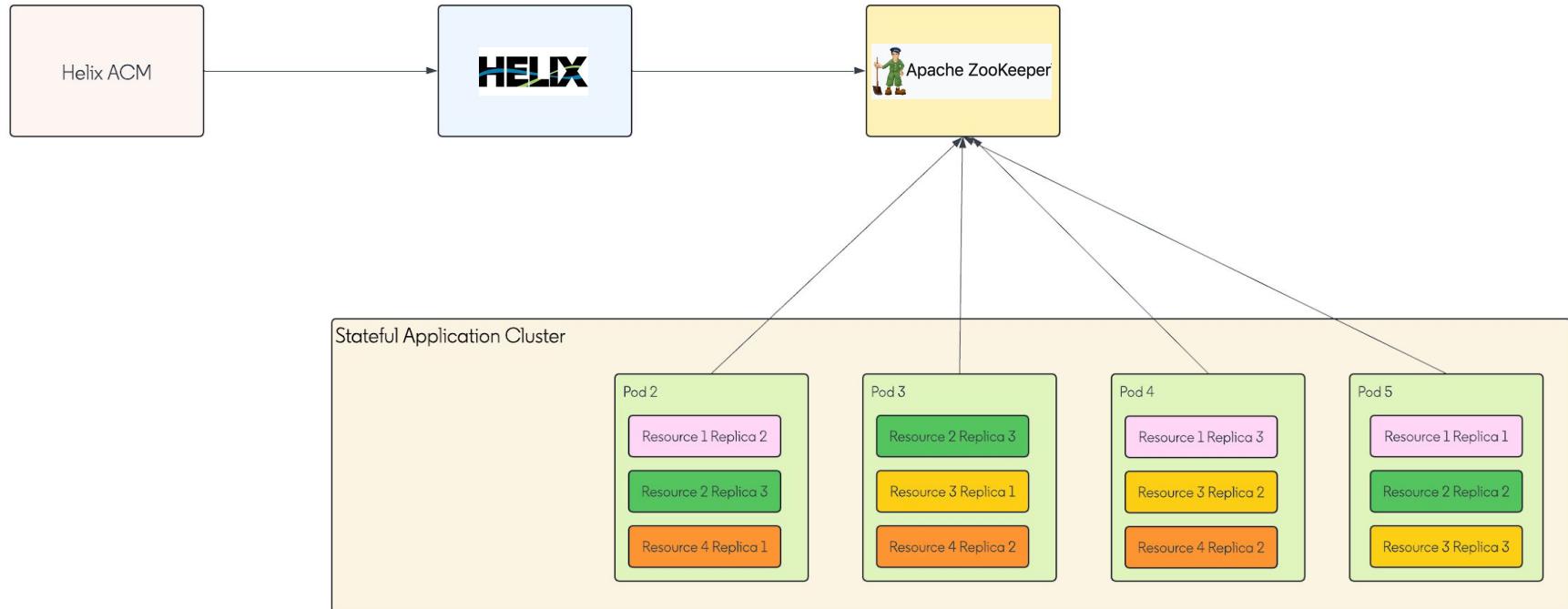
Permanent Node Loss - ACM Preparation



Permanent Node Loss - ACM Preparation



Permanent Node Loss - ACM Preparation



Recap



Unified User Experience



Unified Host Lifecycle Maintenance



Abstract Kubernetes

Single entity to describe the shape of any stateful cluster

Application Cluster Managers provide simple hooks into supporting host maintenance

Application Cluster Managers give applications full flexibility without having to write an operator or understand Kubernetes

Lessons Learned



Kubernetes provides incredible value to build solutions like ours



Operators are an ongoing challenge



Hard balance creating a unified solution for all



Minimize number of ACMs



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Acknowledgements



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Q&A

Questions? Connect with us!



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[Zhantong Shang](#)
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