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Kubernetes Backup Legitimized: CSI Changed Block Tracking has Arrived

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Xing Yang (VMware by Broadcom)

Agenda

- Motivation and History
- Architecture and Implementation
- Demonstration: CSI CBT Workflow
- Resources and How to Get Involved
- Questions and Answers

Motivation

Changed Block Tracking (CBT) radically improves backup and restore efficiency by identifying the changed blocks between two **`VolumeSnapshot`** objects:

- Reduces the RPO (Recovery Point Objective) and RTO (Return to Operation) metrics for backup and recovery
  - CBT enables the potential for no block change!
    = huge resource savings for storage, network, and CPU
    compared to the current situation: another full **`VolumeSnapshot`**
- Lacking CBT has impaired Kubernetes adoption when compared to traditional storage and required proprietary storage drivers

KEP-3314 provides a standard interface for Kubernetes Data Protection by introducing CBT to CSI and Kubernetes

History

- May 2022: Data Protection Working Group (DPWG) start
  - CBT design = KEP-3314
  - Three major redesigns: incorporated suggestions from SIG Architecture, SIG Auth, API reviewers, CSI reviewers, storage and backup vendors, and community members
    - Addressed security concerns
    - Avoided overloading API server
- June 2024: KEP approved
  - Available as alpha feature in CSI spec 1.11.0
- Today:
  - Implementation and e2e testing complete; targeting alpha in Kubernetes 1.33

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Architecture and Implementation

SnapshotMetadata CSI Specification

Storage providers should implement a new CSI service and RPCs in their CSI drivers to support CBT:

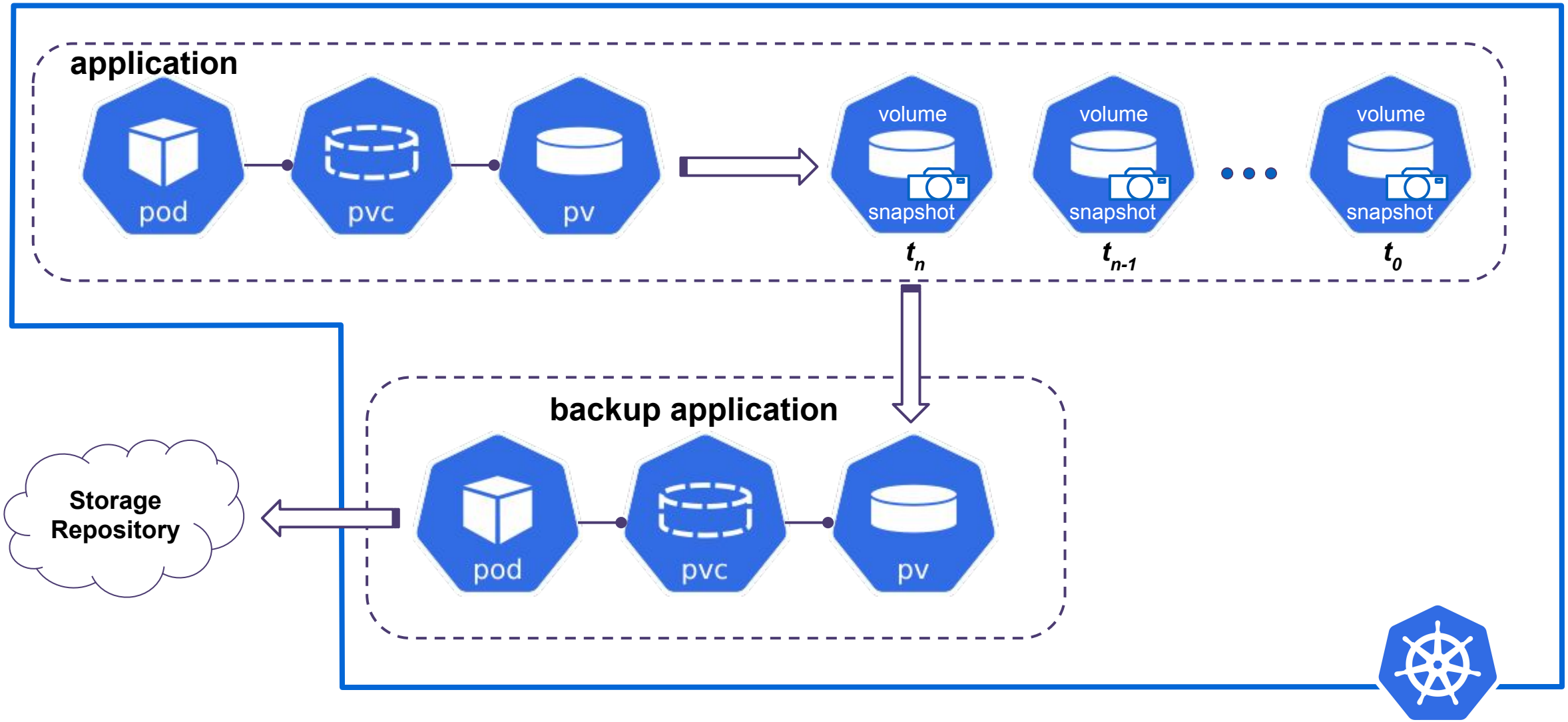
- New SnapshotMetadata Service
  - SNAPSHOT_METADATA_SERVICE Plugin Capability
  - Two new CSI RPCs
    - GetMetadataAllocated
    - GetMetadataDelta
- Supports block volume only

SnapshotMetadata in Kubernetes

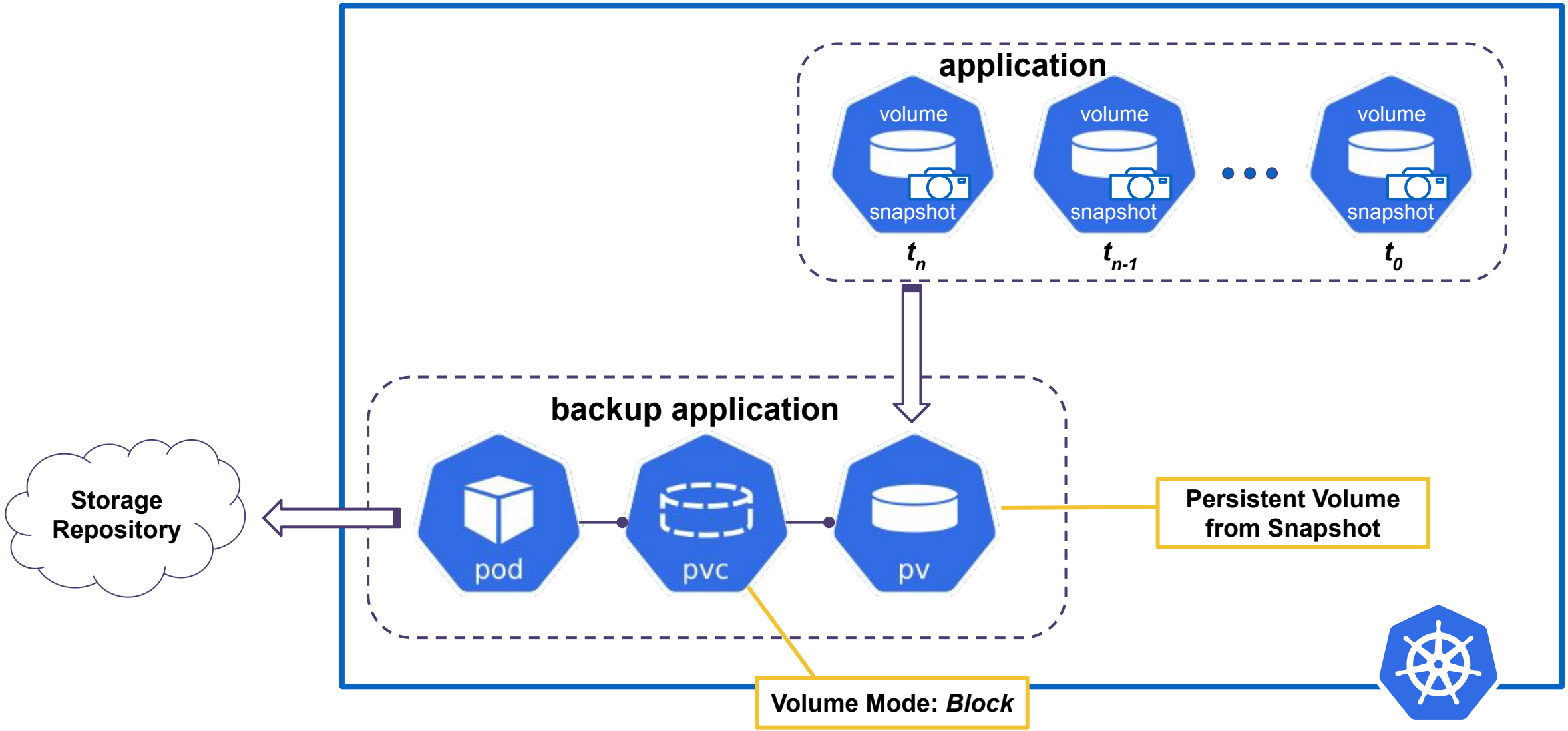
Backup software should adopt these APIs to support CBT:

- New SnapshotMetadataService CRD
- Two Kubernetes SnapshotMetadata gRPC RPCs
  - Very similar to CSI SnapshotMetadata Service gRPC PRCs
    - GetMetadataAllocated
    - GetMetadataDelta
  - Consumes CBT via gRPC
- The `SnapshotMetadata` sidecar container

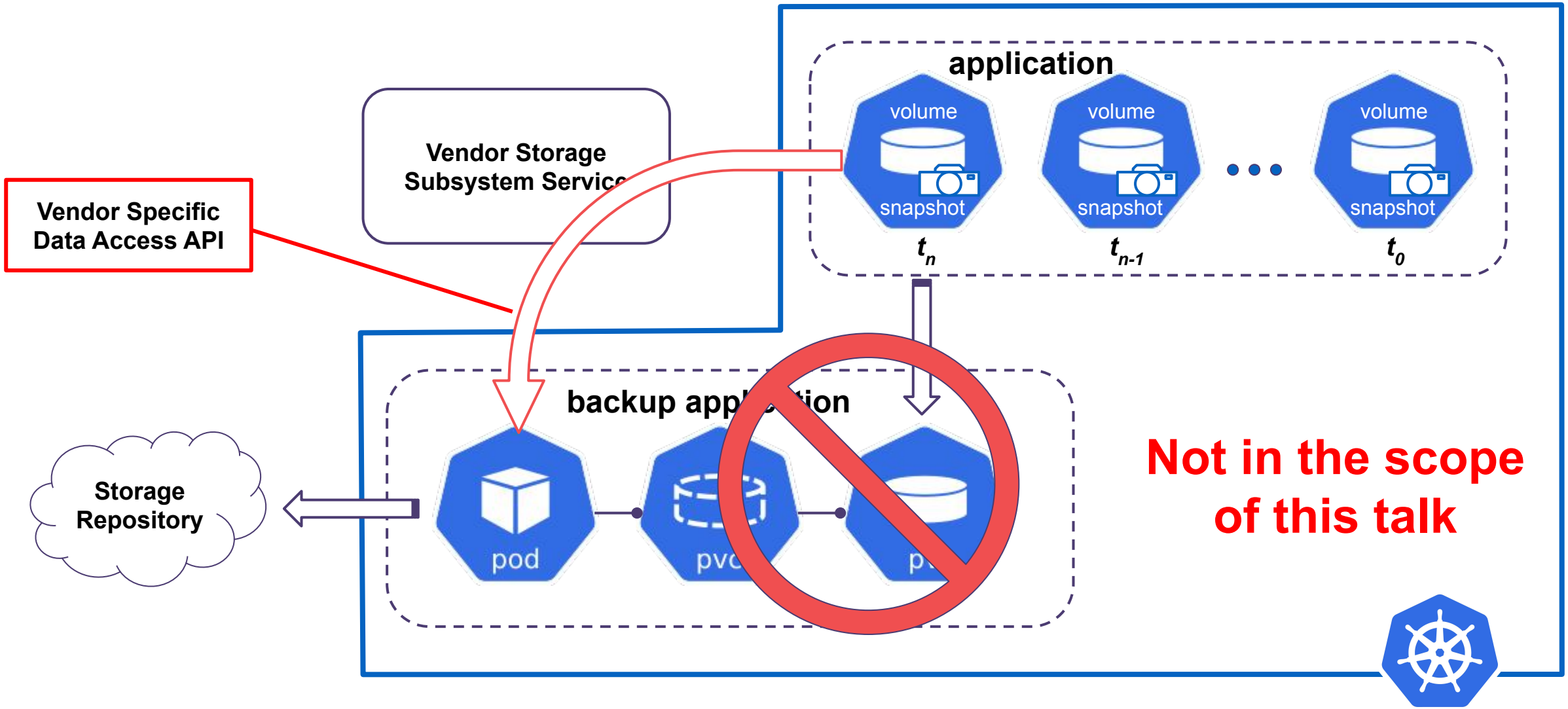
Backup approach with volume snapshots



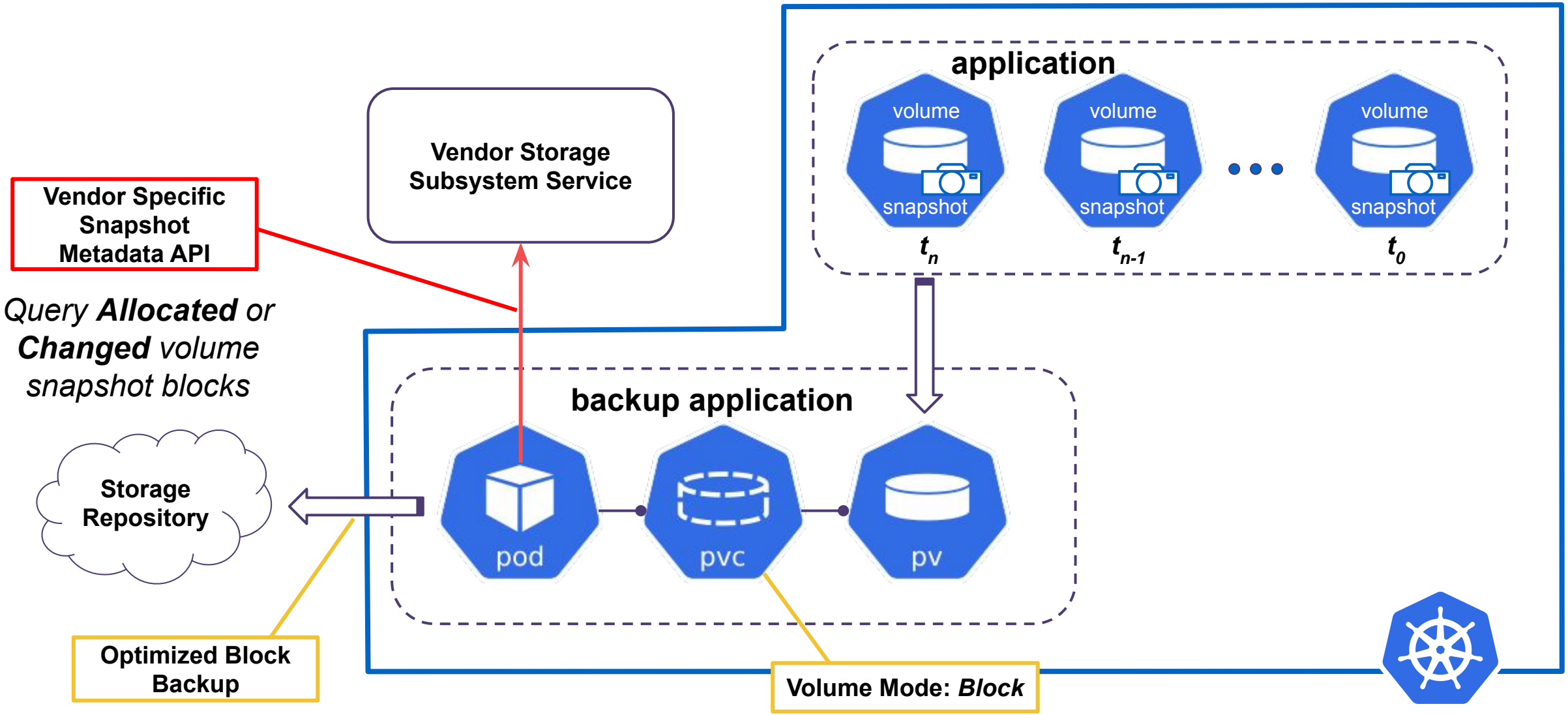
Block mode backups



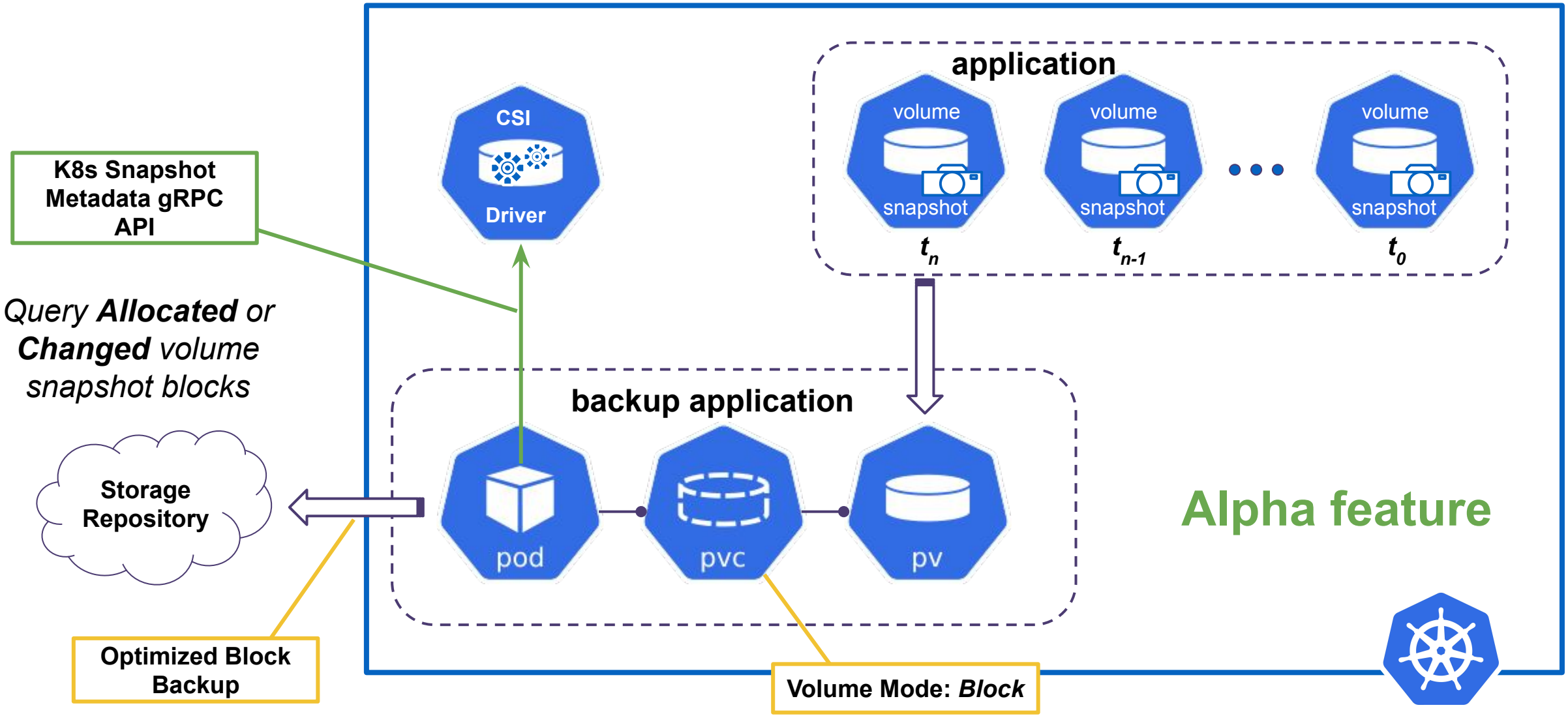
Block mode data access optimization using vendor-specific APIs



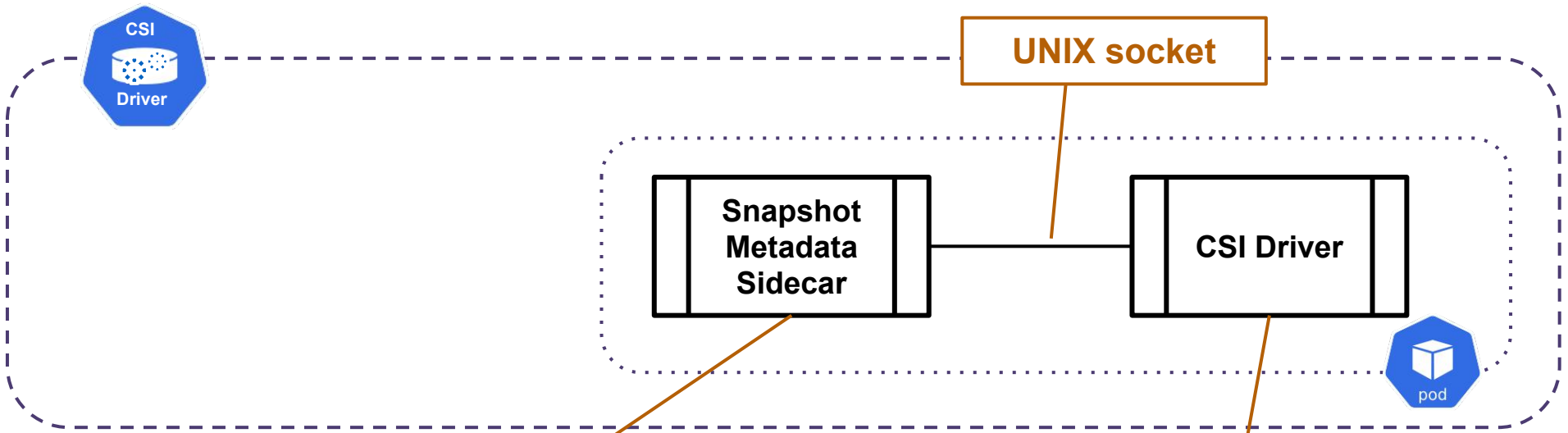
Block mode snapshot metadata optimization using vendor-specific APIs



Block mode snapshot metadata optimization using the new K8s API



CSI driver deployment



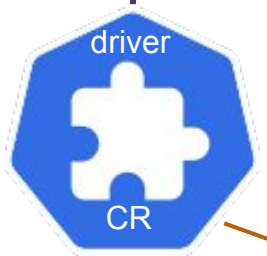
The SnapshotMetadata sidecar implements a K8s SnapshotMetadata gRPC service and proxies calls to the CSI SnapshotMetadata gRPC service.

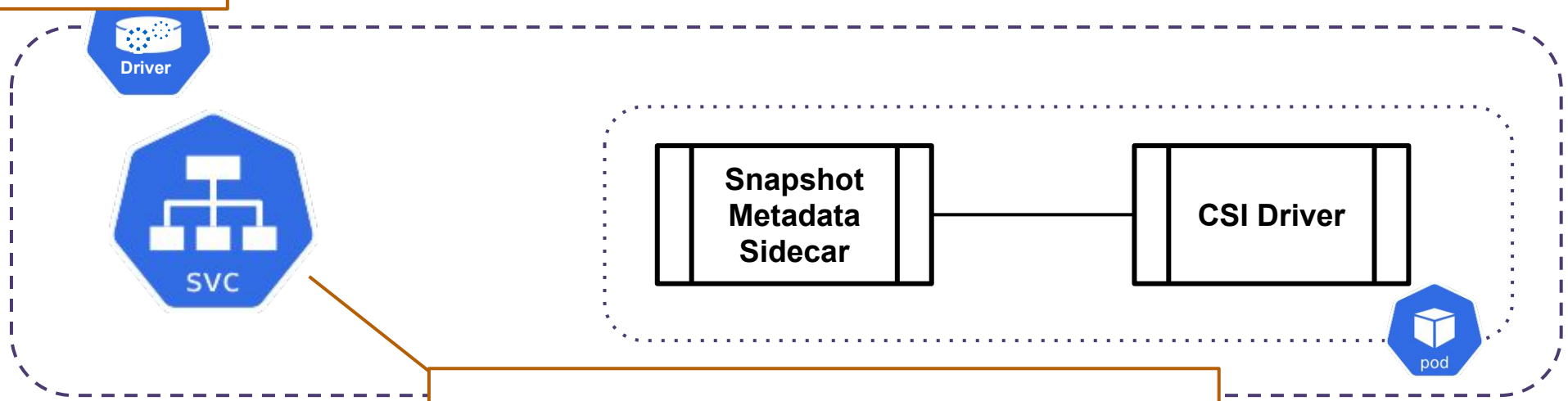
K8s authentication and RBAC based authorization supported.

The CSI driver implements the CSI SnapshotMetadata gRPC service

Feature discovery via CSI driver supplied CR

The `SnapshotMetadata` CRD must be installed if it doesn't exist

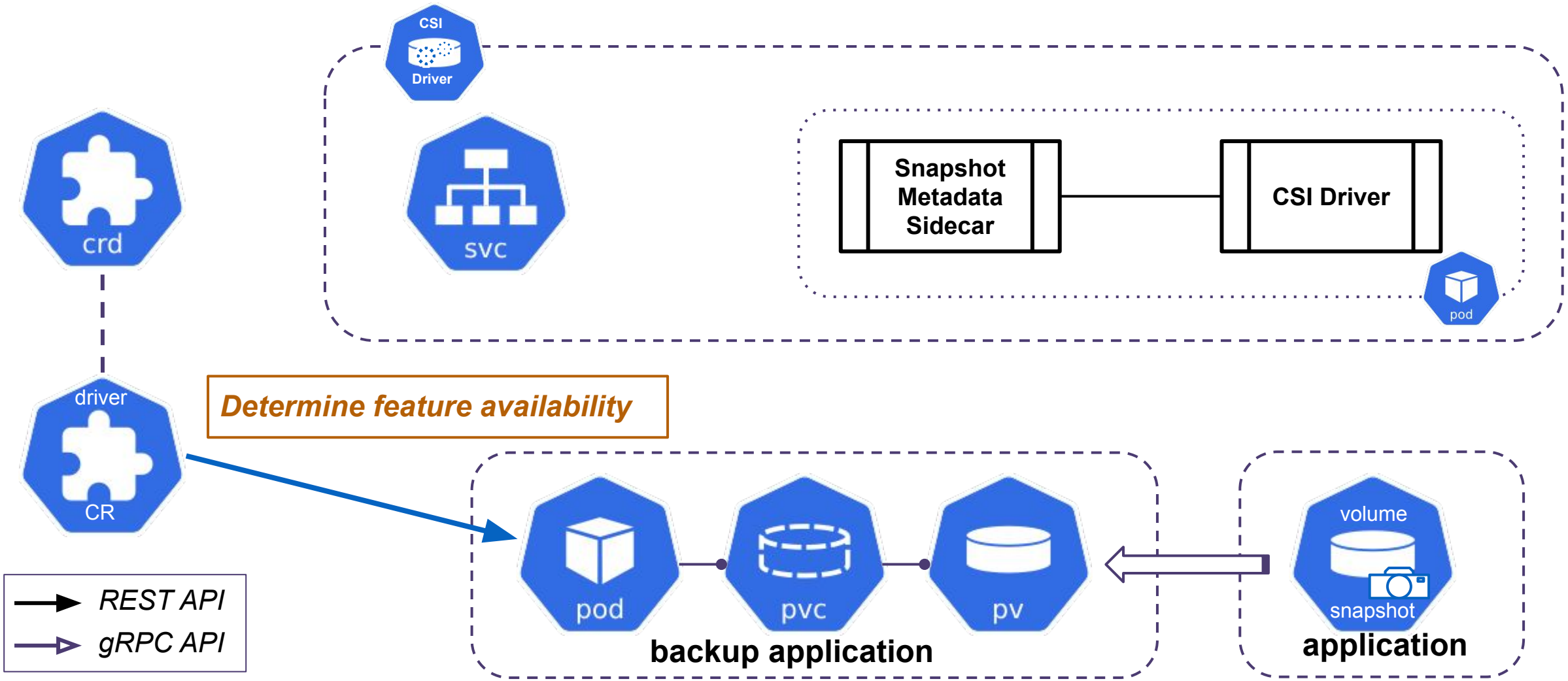




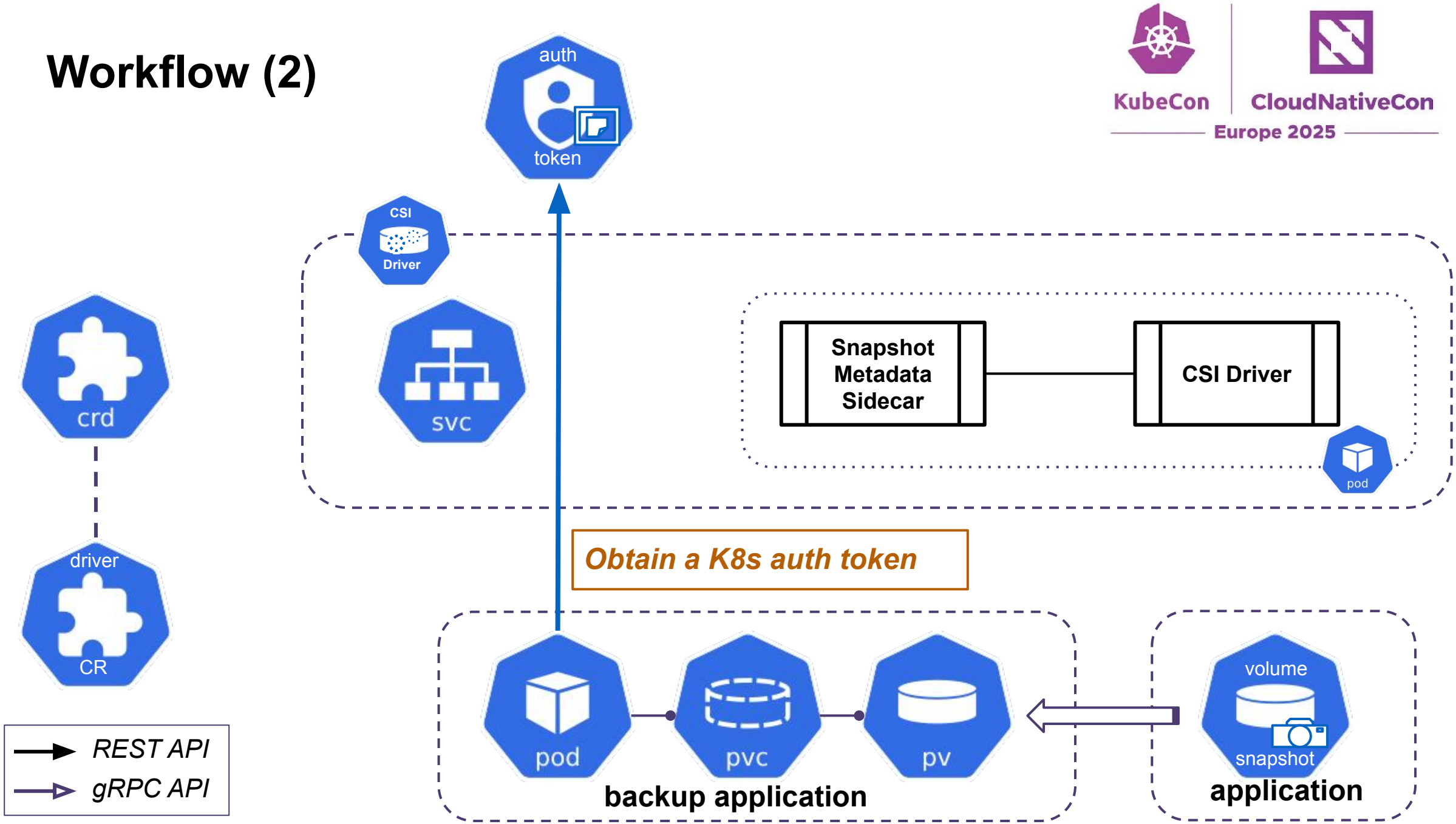
A Service object defines the K8s `SnapshotMetadata` gRPC service endpoint

CR named for the CSI driver;
it contains the K8s `SnapshotMetadata` gRPC service endpoint, CA cert and security token audience string

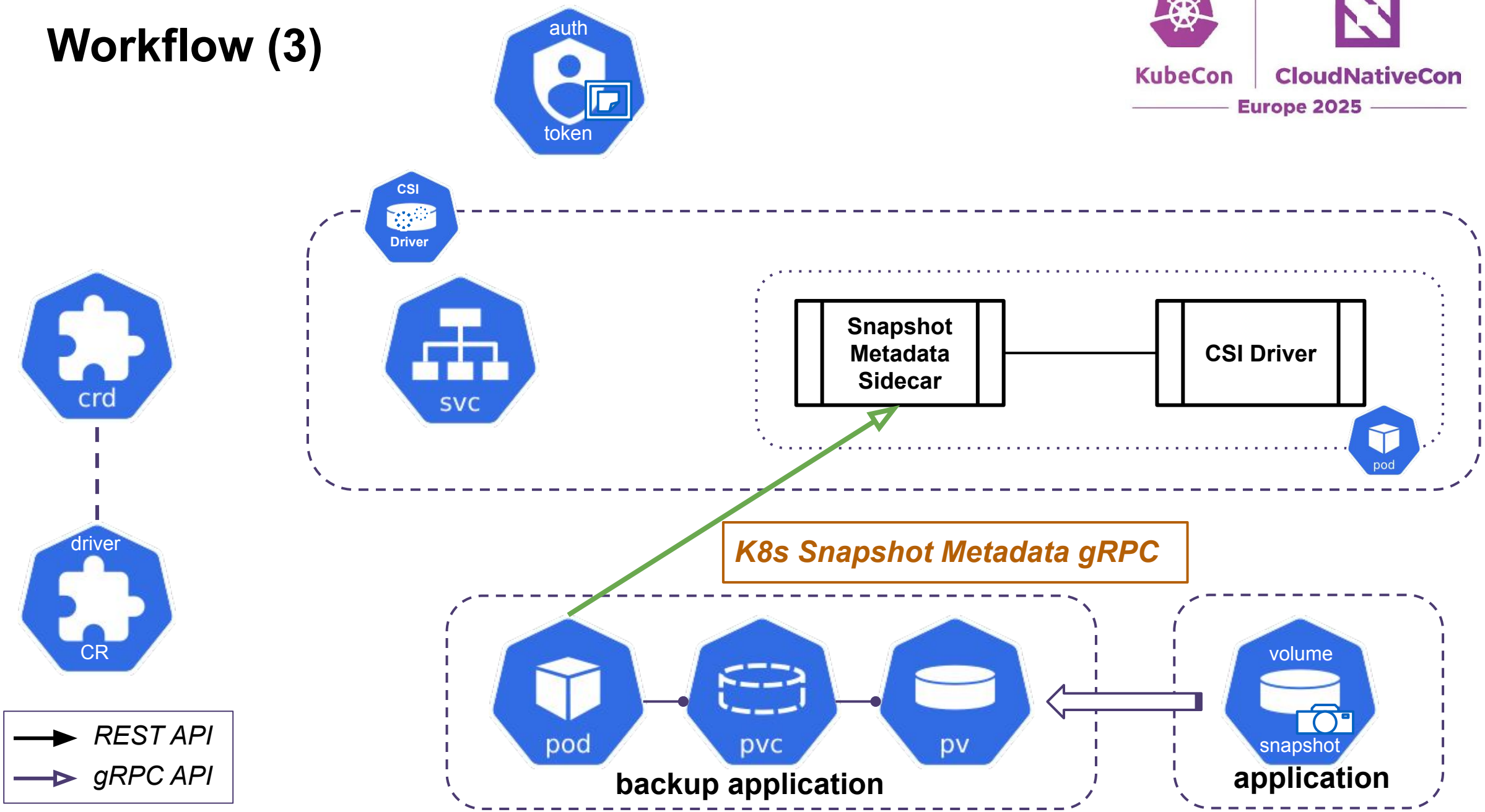
Workflow (1)


CSI
Driver
svc
crd
Snapshot
Metadata
Sidecar
CSI Driver
pod
driver
CR
Determine feature availability
pod
pvc
pv
backup application
volume
snapshot
application
REST API
gRPC API

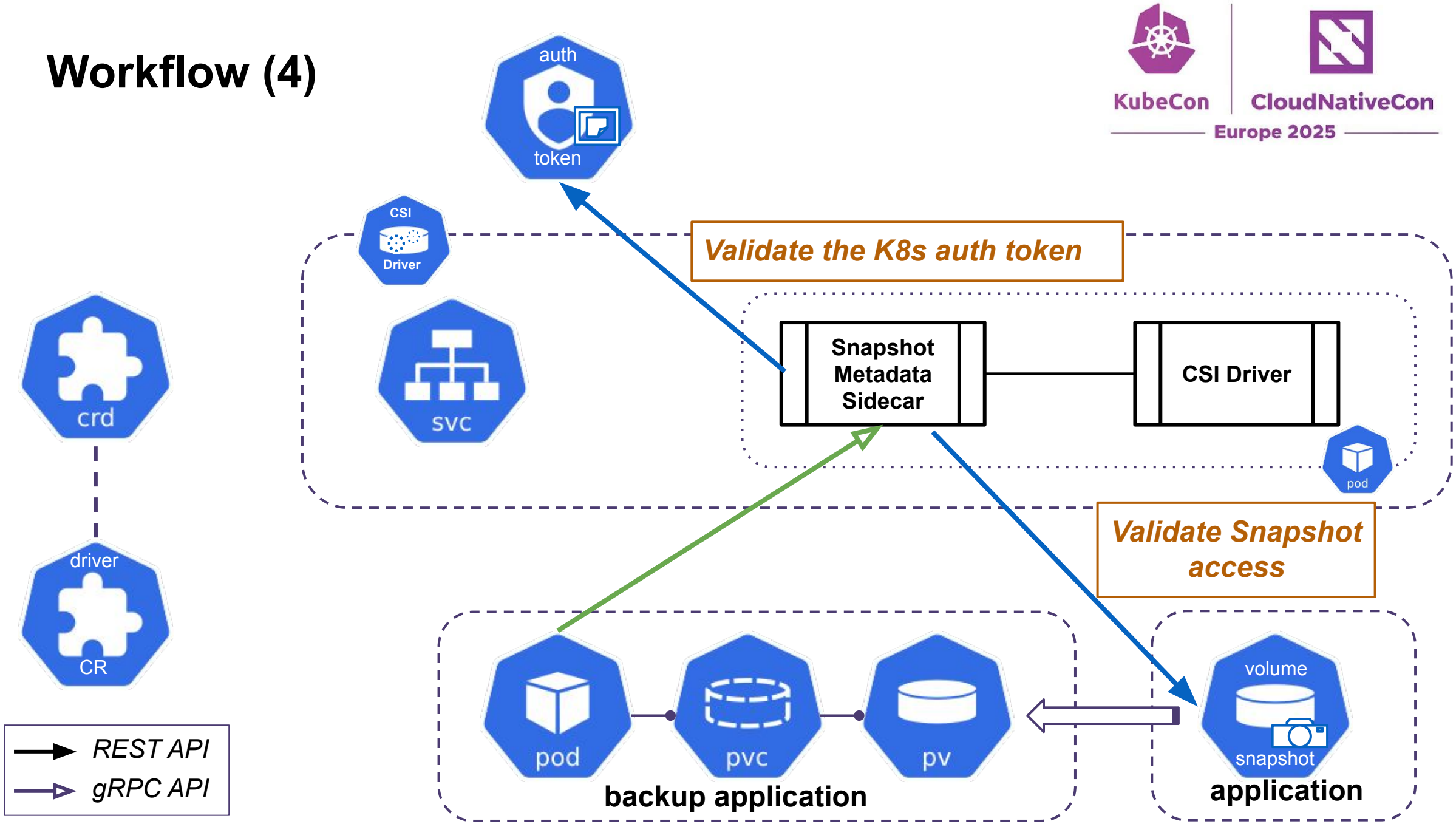
Workflow (2)


auth
token
CSI
Driver
svc
crd
driver
CR
Snapshot
Metadata
Sidecar
CSI Driver
pod
Obtain a K8s auth token
pod
pvc
pv
backup application
volume
snapshot
application
REST API
gRPC API

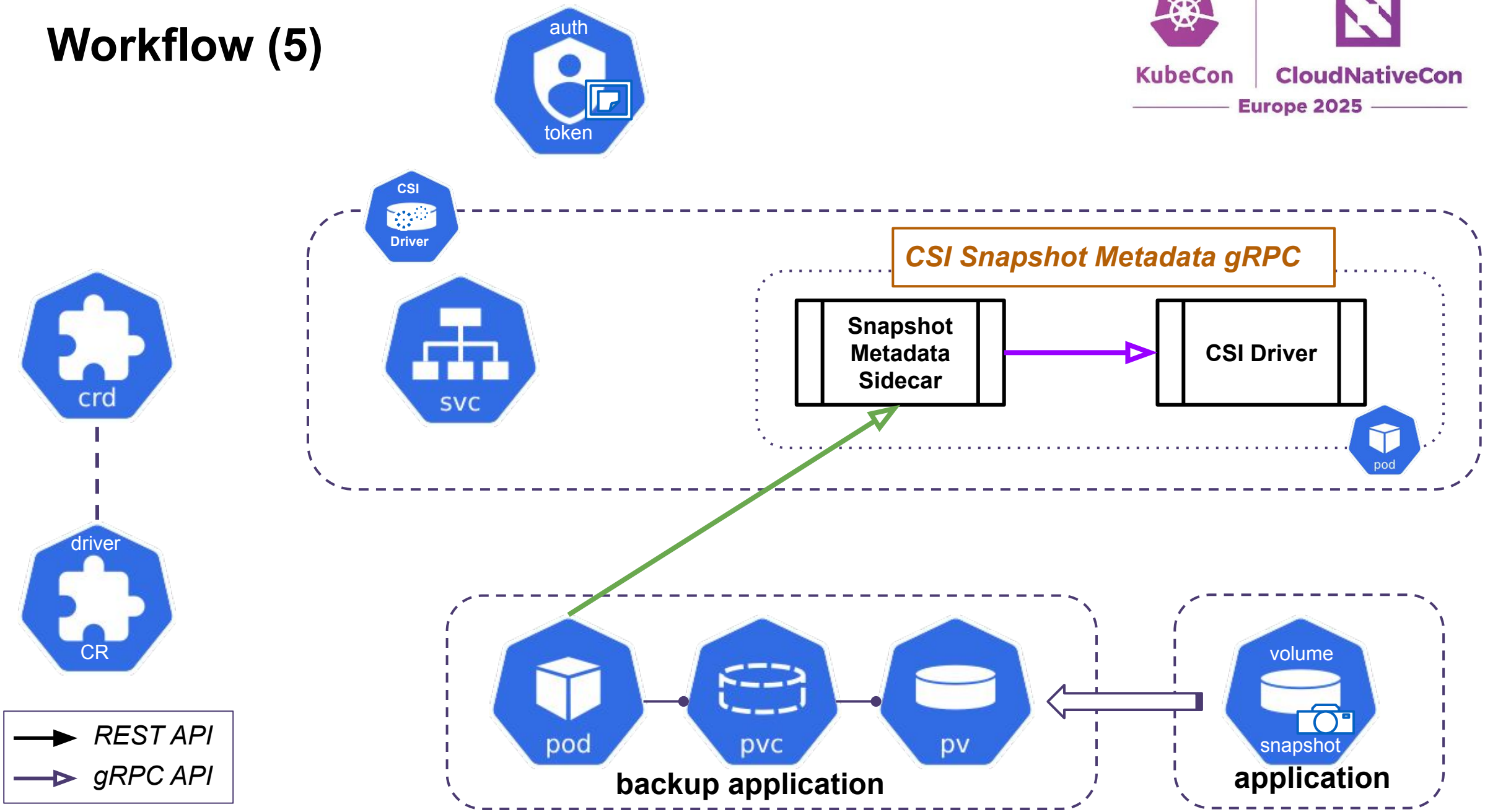
Workflow (3)


auth
token
CSI
Driver
svc
crd
driver
CR
Snapshot
Metadata
Sidecar
CSI Driver
pod
K8s Snapshot Metadata gRPC
pod
pvc
pv
backup application
volume
snapshot
application
REST API
gRPC API

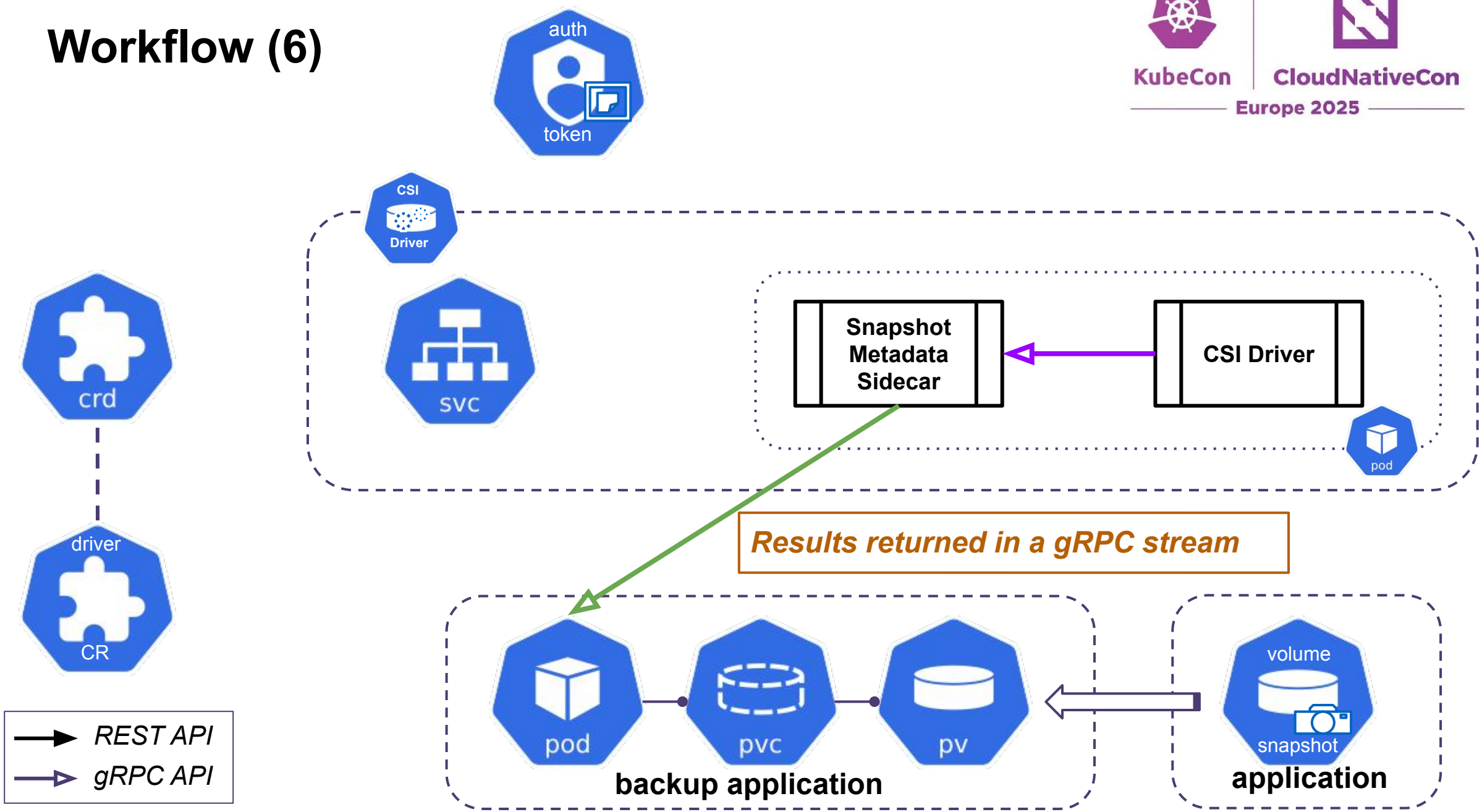
Workflow (4)


auth
token
CSI
Driver
svc
crd
driver
CR
Validate the K8s auth token
Snapshot
Metadata
Sidecar
CSI Driver
pod
Validate Snapshot
access
pod
pvc
pv
backup application
volume
snapshot
application
REST API
gRPC API

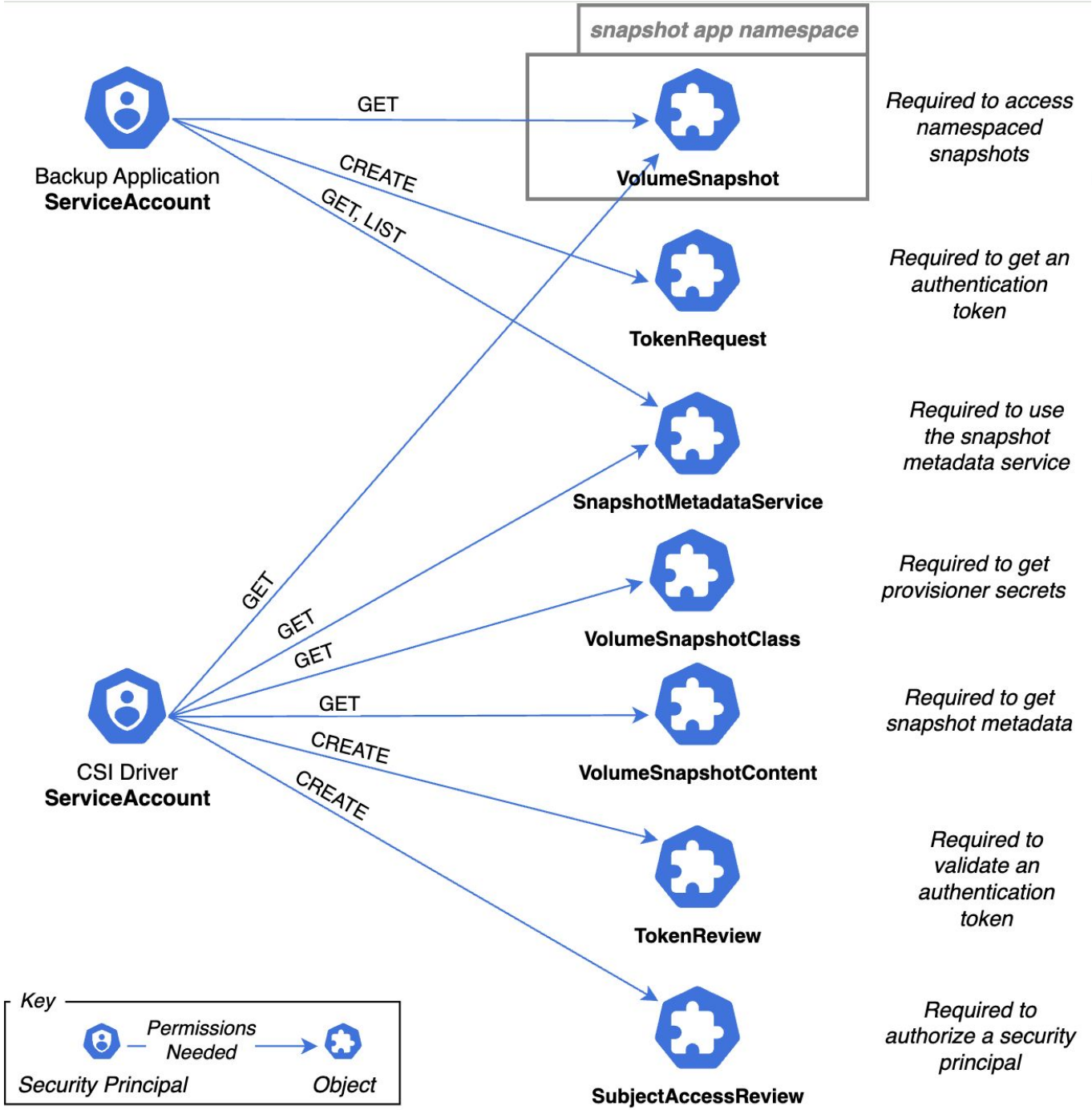
Workflow (5)


auth
token
CSI
Driver
svc
crd
driver
CR
CSI Snapshot Metadata gRPC
Snapshot Metadata Sidecar
CSI Driver
pod
pod
pvc
pv
backup application
volume
snapshot
application
REST API
gRPC API

Workflow (6)


auth
token
CSI
Driver
svc
crd
driver
CR
Snapshot
Metadata
Sidecar
CSI Driver
pod
Results returned in a gRPC stream
pod
pvc
pv
backup application
volume
snapshot
application
REST API
gRPC API

RBAC policy



Supporting resources

The kubernetes-csi/external-snapshot-metadata repository contains:

- gRPC protobuf specification, stubs and mocks for the K8s **`SnapshotMetadata`** API
- The **`SnapshotMetadata`** sidecar container
- The **`SnapshotMetadata`** CRD
- A Go iterator package that performs all the steps required to fetch snapshot metadata from the CSI driver
- Additional resources to support CSI driver development

Kubernetes CSI Developer Documentation

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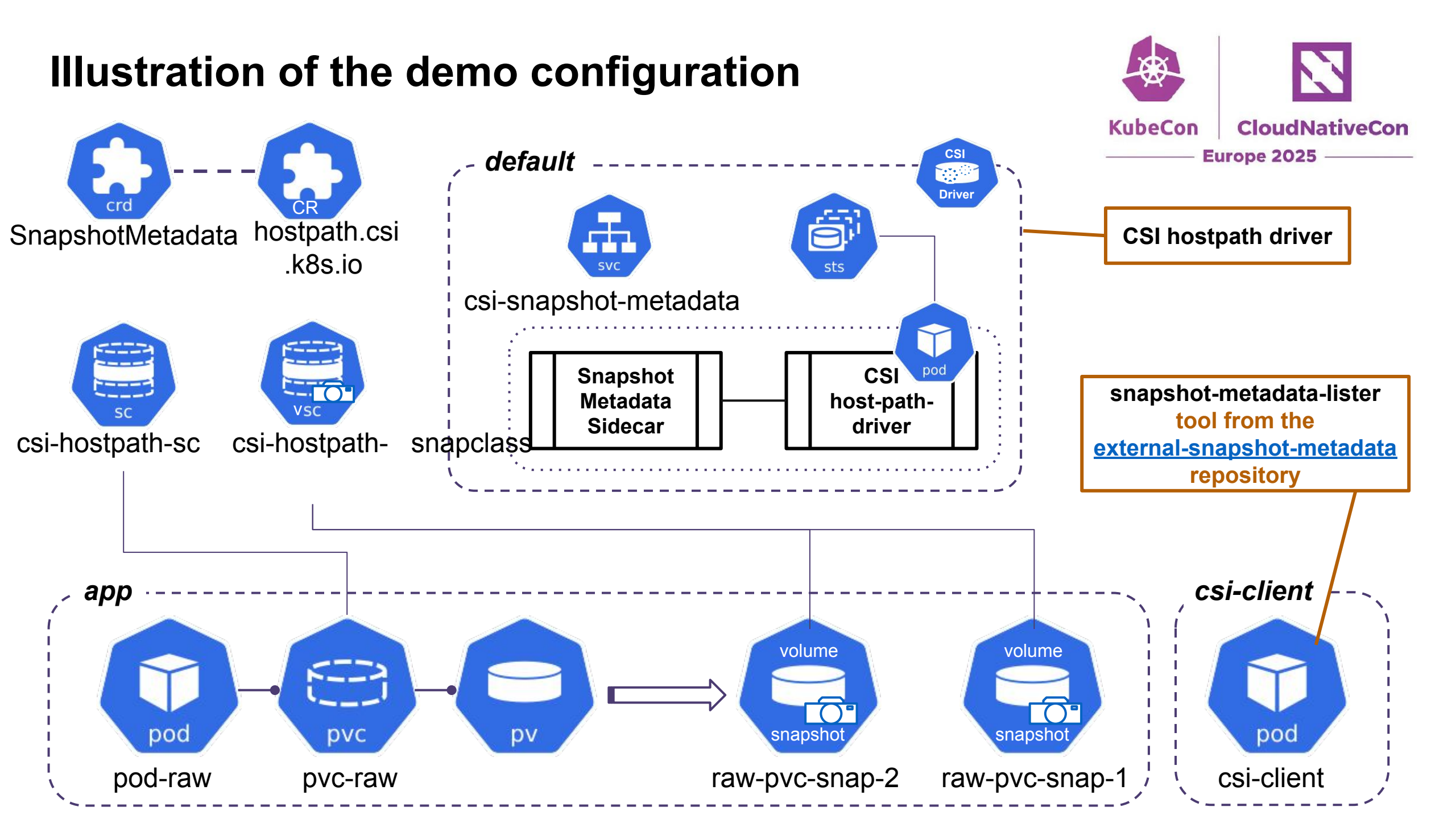
Demonstration

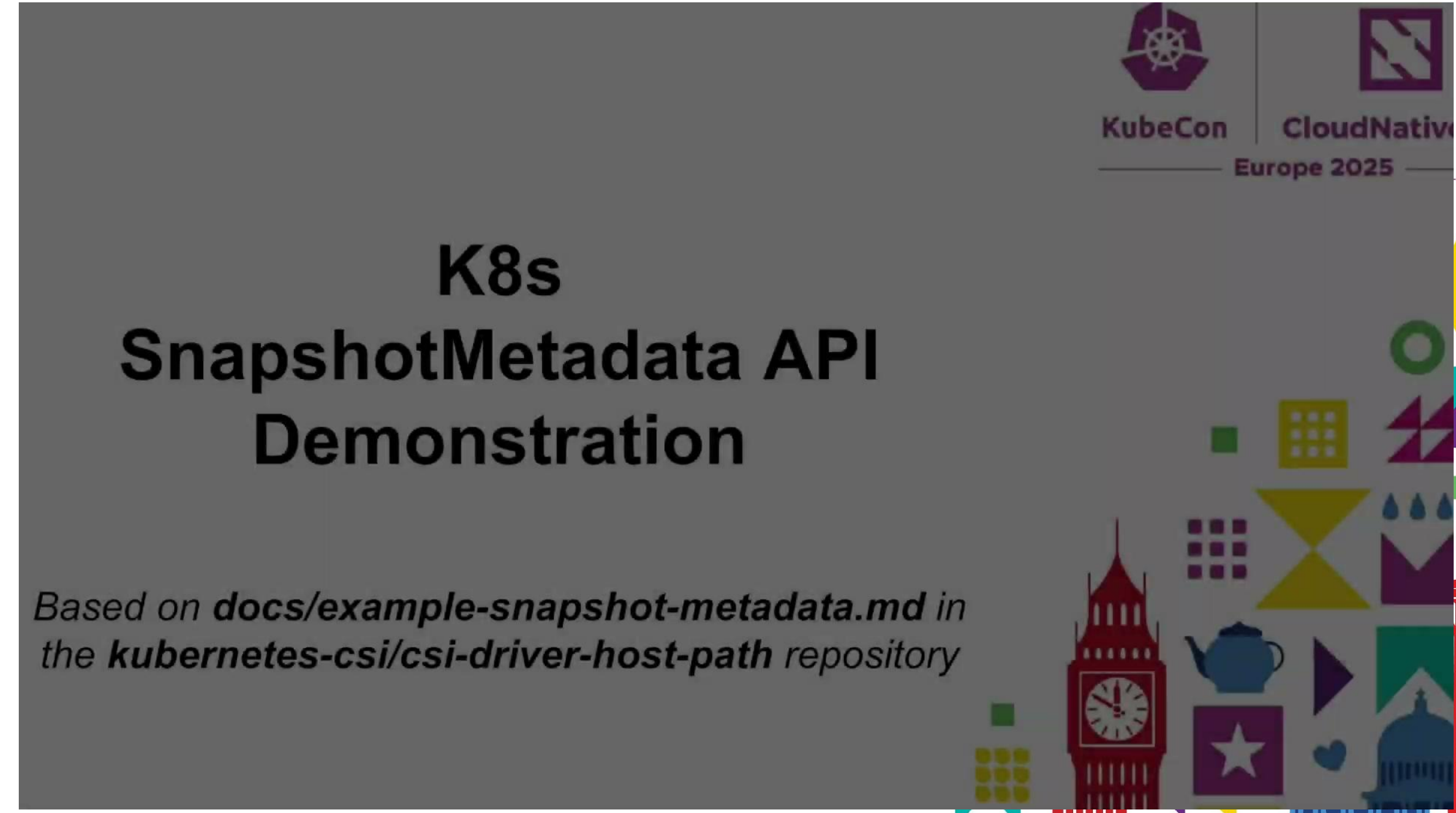
Demonstration: CSI CBT Workflow

Based on the example cited in kubernetes-csi/csi-driver-host-path/docs/example-snapshot-metadata.md

- Uses the CSI hostpath driver (a testing tool) configured with the snapshot metadata sidecar
- Creates an application with a Block mode PVC and makes 2 snapshots
- Uses the **snapshot-metadata-lister** tool from the kubernetes-csi/external-snapshot-metadata repository to examine
  - Allocated blocks
  - Changed blocks

Illustration of the demo configuration

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K8s
SnapshotMetadata API
Demonstration
Based on docs/example-snapshot-metadata.md in
the kubernetes-csi/csi-driver-host-path repository

Resources

Specification and Documentation:

- CBT KEP-3314
  - KEP 3314 Design Slides and Diagrams
- Kubernetes CSI Developer Documentation
  - Snapshot Metadata Service CSI spec: v1alpha
  - external-snapshot-metadata Code Repo

Overviews and Talks: (to share with influencers)

- Cloud Native Rejekts 2023 talk: “Revolutionizing Data Backup in Kubernetes: Unlocking the Power of Change Block Tracking With CSI”
  - abstract and video (30 minutes)
- https://thenewstack.io/kubernetes-advances-cloud-native-data-protection-share-feedback/
- DPWG: Data Protection Workflows white paper

Calls to Action

We need your help with adoption and improvements to get to beta!

- **For storage vendors and projects:**
  - Implement CSI CBT in your CSI driver
- **For backup vendors and projects:**
  - Add CSI CBT support to your backup and recovery software operations
- **For the Kubernetes community:**
  - Spread the word to promote CBT
  - Ask your storage and backup providers to add CBT support to their roadmap to improve your data protection!

How to Get Involved

Join the Data Protection Working Group: get in touch, we are here to help!

https://github.com/kubernetes/community/tree/master/wg-data-protection

- Bi-weekly meeting on Wednesdays at 9am Pacific Time
  - Meeting Minutes and Agenda document
  - Meeting recordings on YouTube: @Kubernetes-Storage
- Mailing list: https://groups.google.com/a/kubernetes.io/g/wg-data-protection
- Kubernetes Slack channel: #wg-data-protection

Questions and Answers

Q&A

(Ask who is adopting CSI-CBT!)

Thank You

Kubernetes Slack: #wg-data-protection