Internals of Docking Storage with Kubernetes Workloads

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Agenda

- Background
- What’s CSI
- CSI vs FlexVolume
- How CSI works
- FlexVolume Driver Part
- CSI Driver Part

Background

1. Kubernetes has supported a long list of volume types such as:

   • awsElasticBlockStore

   • fc(fibre channel)

   • scaleIO

   • list to be continued…

   Those are so-called `In-tree` volume plugins.

2. Even k8s has do a lot for you, but sometimes you still need to write a new one.

   In this case, FlexVolume and CSI can help you well ☺ which is also the focus of our today's topic: Out-of-Tree volume plugin interface.

Background

1. In-tree Volume Plugins
   - Those are linked, compiled, built and shipped with the core k8s binaries
   - Development is tightly coupled and dependent on k8s releases
   - Bugs in volume plugin can crash critical k8s components, instead of just the plugin
   - Will not be accepted since k8s 1.8
2. Out-of-Tree Volume Plugins (customized plugins by storage providers)
   - FlexVolume driver
   - CSI driver (*)

What's CSI

- Container Storage Interface (CSI) is a standardized mechanism for Container Orchestration Systems (COs), including Kubernetes, to expose arbitrary storage systems to containerized workloads. Storage Provider (SP) develops once and this works across a number of COs.
- The goal of CSI is to become the primary volume plugin system for k8s in the future.
- k8s 1.9 release has already included the alpha feature of CSI implementation, then beta in Kubernetes v1.10
- The CSI spec can be found at:

  https://github.com/container-storage-interface/spec/blob/master/spec.md

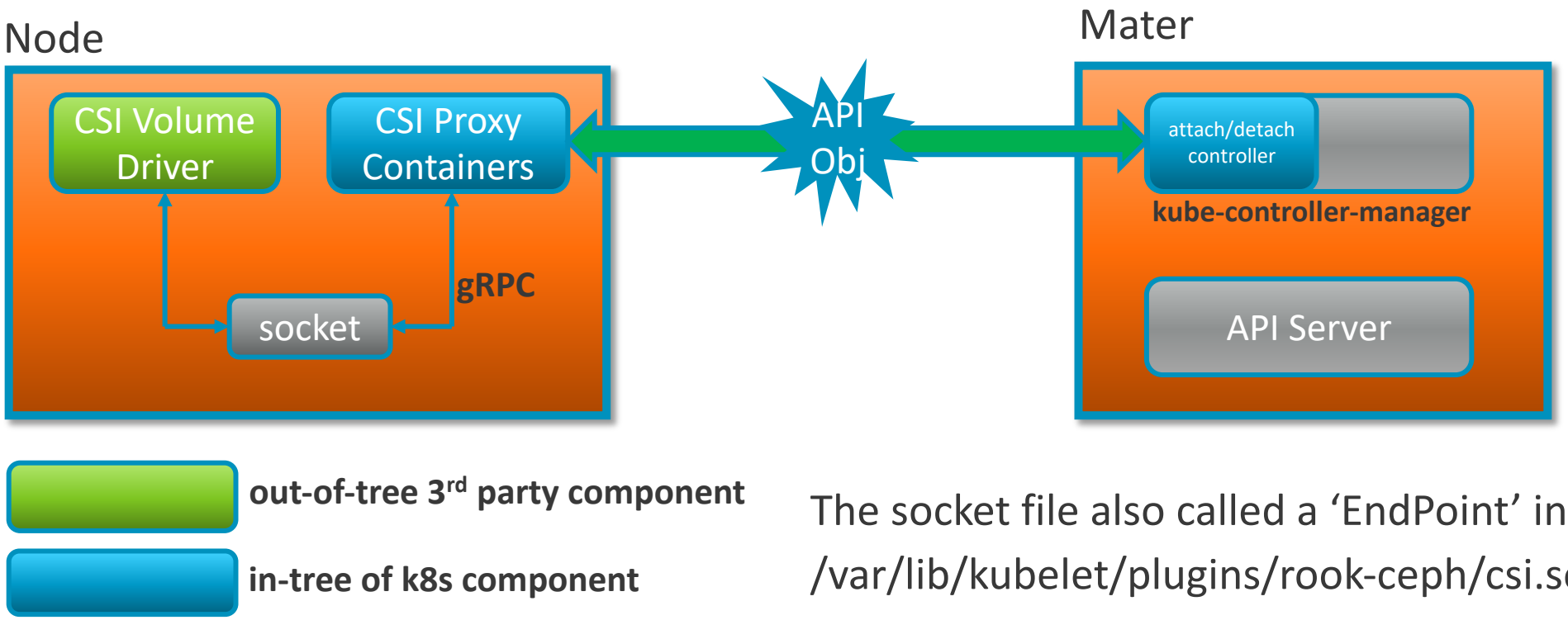
CSI vs FlexVolume

Two Out-of-Tree Volume Plugin mechanisms in K8s – FlexVolume and CSI

1. FlexVolume plugin framework:
   - Makes the 3rd party storage providers' plugin as "Out-of-Tree" (same as CSI does)
   - exec based API for external volume plugins
   - Needs to access the root filesystem of node and master machines when deploying
   - Doesn't address the pain point of dependencies.
2. CSI overcomes the limitations of FlexVolume listed above. CSI is the preferred solution, for now CSI and FlexVolume can co-exist.

How CSI works

- A new in-tree CSI Volume plugin(K8s) + out-of-tree CSI Volume driver (3rd party)
- Communication channel via a Unix Domain Socket(UDS) created by 3rd Volume Driver



The socket file also called a 'EndPoint' in form of like:
/var/lib/kubelet/plugins/rook-ceph/csi.sock

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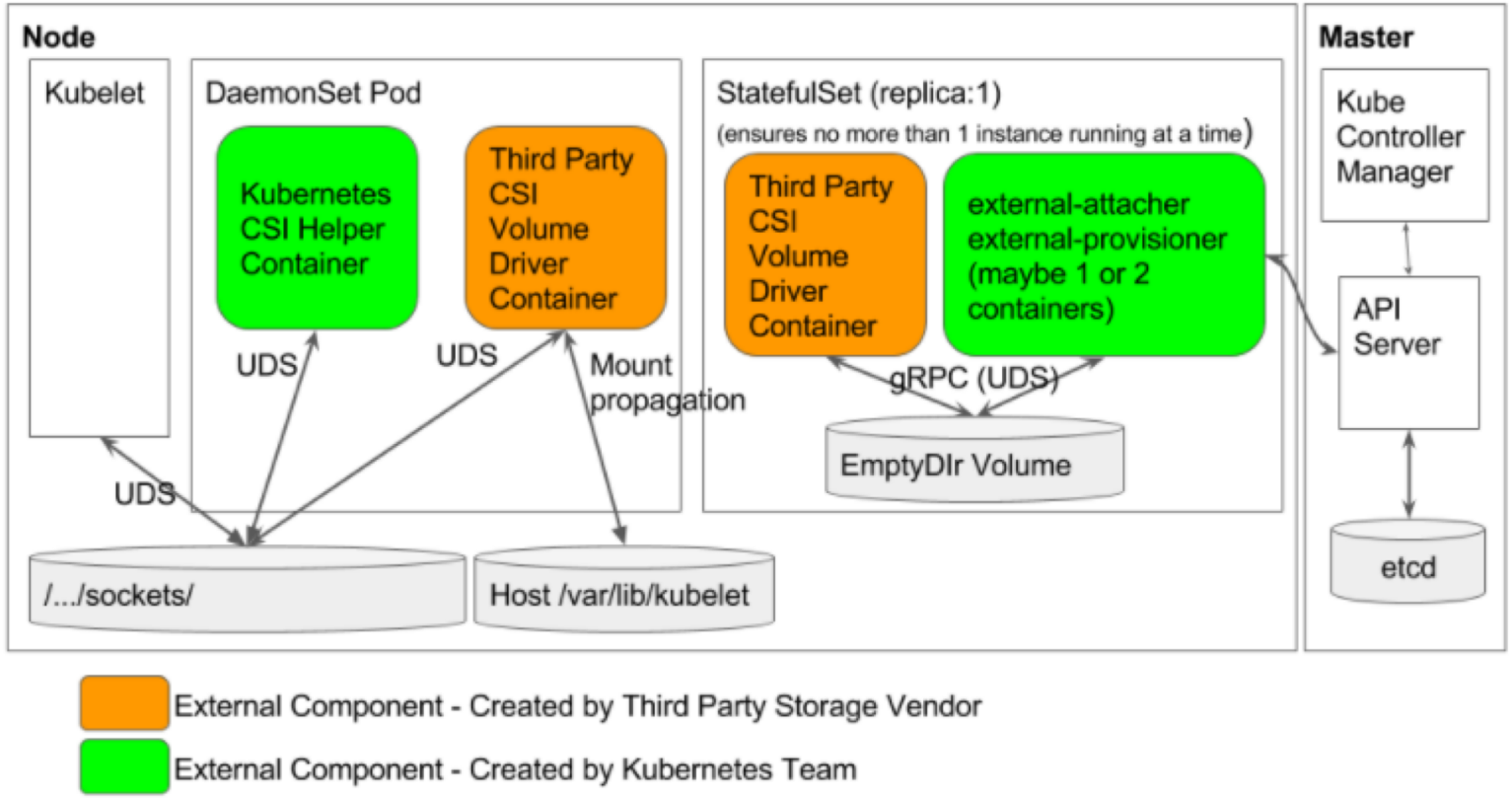
How CSI works

Recommended Mechanism for Deploying CSI Drivers on k8s



https://github.com/kubernetes/community/blob/master/contributors/design-proposals/storage/container-storage-interface.md

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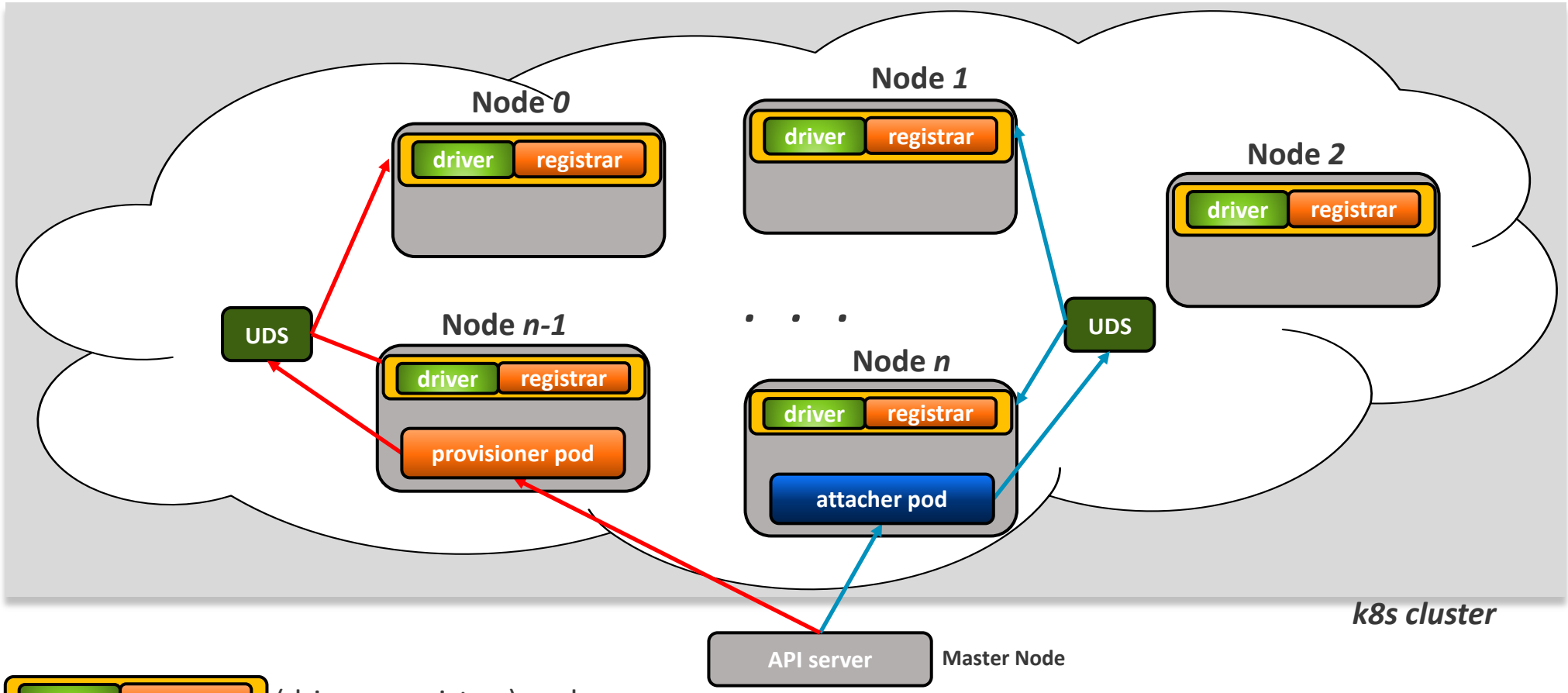
A CSI deployment in real world



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FlexVolume Driver Part (Take Rook as an example)

FlexVolume Driver -- rookflex

- `rookflex` exists in form of a binary file and has been deployed into volume-plugin-dir by Rook Agent on each node.
- `rookflex` implements ‘mount’ and ‘umount’ methods required by FlexVolume Spec
- For a specific YAML file of a workload, the storage related part looks like:

Storage Provisioning

```
---
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
   name: rook-ceph-block
provisioner: ceph.rook.io/block
parameters:
  pool: replicapool
```

```
---
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  name: wp-pv-claim
  labels:
    app: wordpress
spec:
  storageClassName: rook-ceph-block
  accessModes:
  - ReadWriteOnce
  resources:
    requests:
      storage: 20Gi
---
```

Storage Consuming

```
    spec:
      containers:
      - image: wordpress:4.6.1-apache
        name: wordpress
        env:
        - name: WORDPRESS_DB_HOST
          value: wordpress-mysql
        - name: WORDPRESS_DB_PASSWORD
          value: changeme
        ports:
        - containerPort: 80
          name: wordpress
        volumeMounts:
        - name: wordpress-persistent-storage
          mountPath: /var/www/html
      volumes:
      - name: wordpress-persistent-storage
        persistentVolumeClaim:
          claimName: wp-pv-claim
```


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A practical FlexVolume driver -- rookflex

- When that workload pod is scheduled to one node and begin to run, the kubelet will interacts with the driver to mount the volume into the `mountPath` specified by the YAML. To do so, kubelet needs to:

  1. Lookup the right FlexVolume driver.

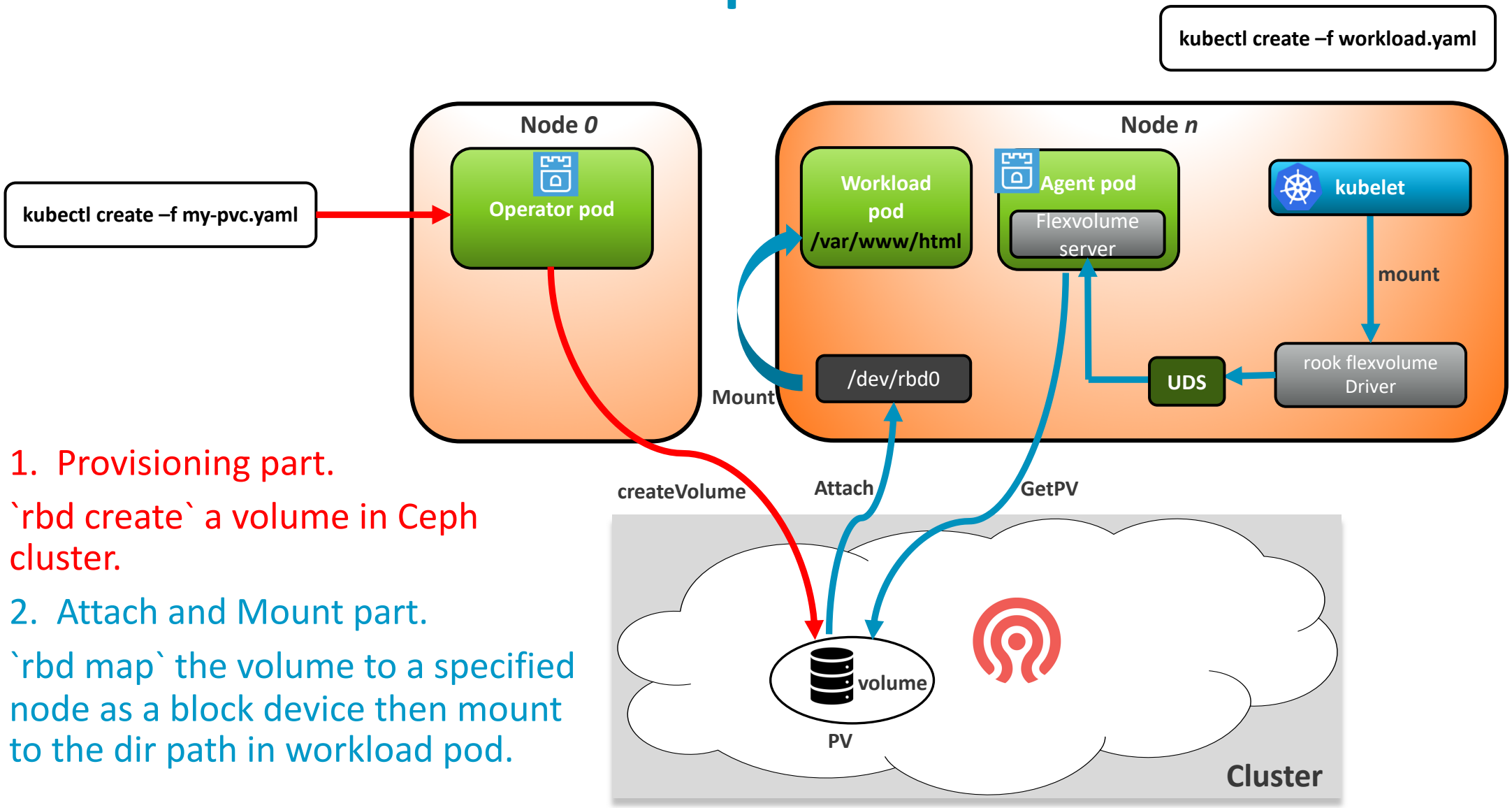
     The look up flow is: PVC name → StorageClass → provisioner name: ceph.rook.io/block → Flex volume vendor name: "ceph.rook.io“ → figure out the driver folder and driver name: rookflex

  2. Call `mount` method of rookflex like: `$(volume-plugin-dir)/rookflex mount`

  3. The above `mount` will call the corresponding function in Rook Agent via UDS.

  4. Local Rook Agent will attach the volume into its node(a ‘rbd map’ operation).

Flexvolume-based volume operations



1. Provisioning part.

`rbd create` a volume in Ceph cluster.

2. Attach and Mount part.

`rbd map` the volume to a specified node as a block device then mount to the dir path in workload pod.

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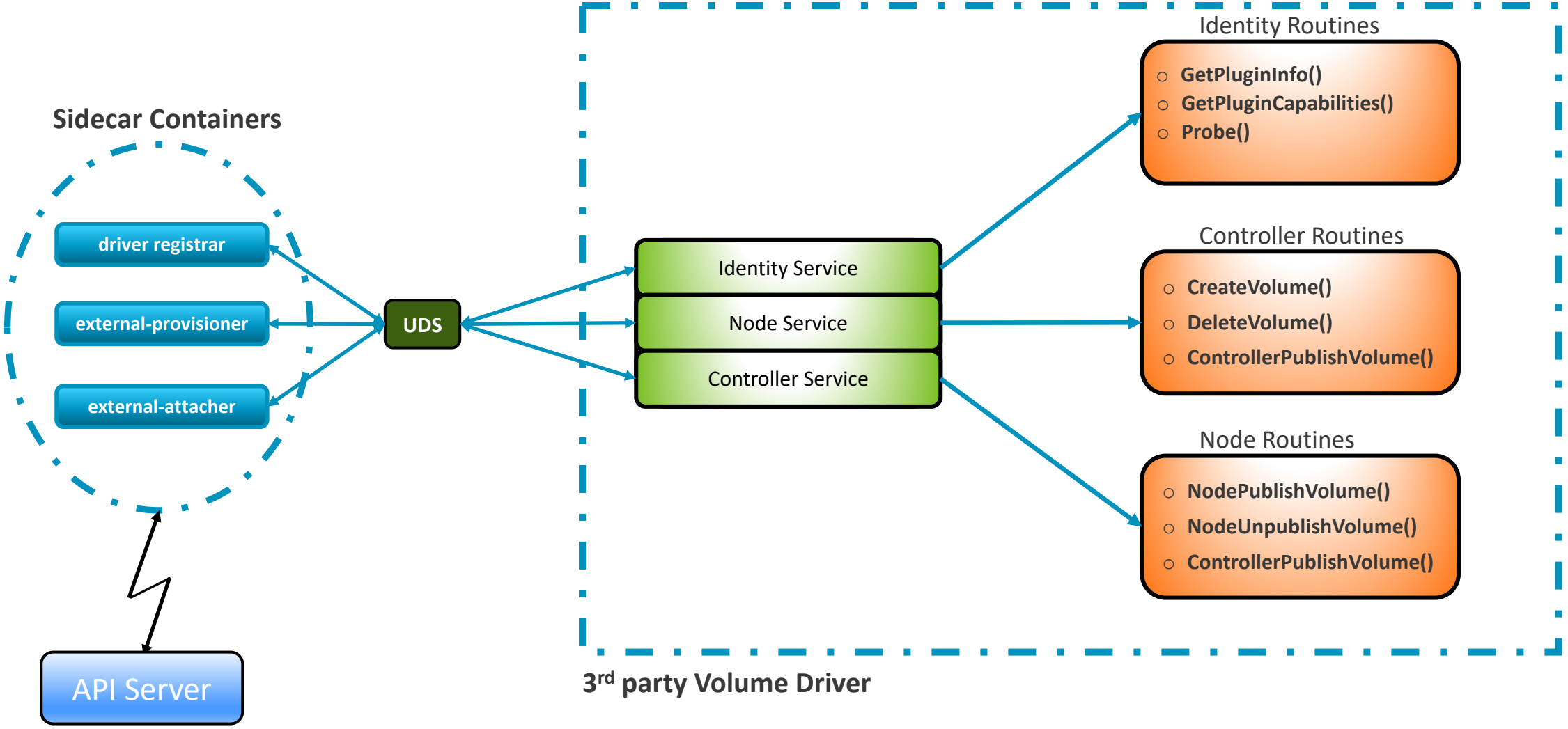
CSI Volume Driver Part

CSI: Zoom into the volume driver



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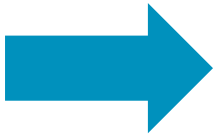
CSI: external-provisioner

1. A cluster admin creates a ***StorageClass*** pointing to the CSI driver's external-provisioner.
2. A user creates a ***PersistantVolumeClaim*** referring to the new ***StorageClasss***.
3. The persistent volume controller realizes that dynamic provisioning is needed.
4. The external-provisioner for the CSI driver sees the ***PersistentVolumeClaim*** so it stats dynamic volume provisioning:
   - It deferences the ***StorageClass*** to collect the opaque parameters to use for provisioning.
   - It calls CreateVolume() against the CSI driver container with parameters from the ***StorageClass*** and ***PersistentVolumeClaim*** objects.
5. Once the volume is successfully created, the external-provisioner creates a ***PersistentVolume*** object to represent the newly create volume and binds it to the ***PersistentVolumeClaim***.

CSI: external-attacher

```
43        spec:
44          containers:
45          - image: wordpress:4.6.1-apache
46            name: wordpress
47            env:
48            - name: WORDPRESS_DB_HOST
49              value: wordpress-mysql
50            - name: WORDPRESS_DB_PASSWORD
51              value: changeme
52            ports:
53            - containerPort: 80
54              name: wordpress
55            volumeMounts:
56            - name: wordpress-persistent-storage
57              mountPath: /var/www/html
58          volumes:
59          - name: wordpress-persistent-storage
60            persistentVolumeClaim:
61              claimName: wp-pv-claim
```



Kubernetes attach/detach controller

type ***VolumeAttachment*** {

…

// The name of the volume driver MUST handle this request. This name must be the same as StorageCloass.Provisioner

Attacher string

…

// The name of the PV to attache

PersistentVolumeName string

// k8s node name that the volume should be attached to

NodeName string

…

}

1. k8s attach/detach controller sees that a pod referencing a CSI volume plugin is scheduled to a node → call in-tree volume plugin's attach()
2. The in-tree volume plugin creates a new ***VolumeAttachment*** object in the k8s API
3. The external-attacher sees the ***VolumeAttachment*** object and triggers a ***ControllerPublish*** again the CSI volume driver to fulfil it.

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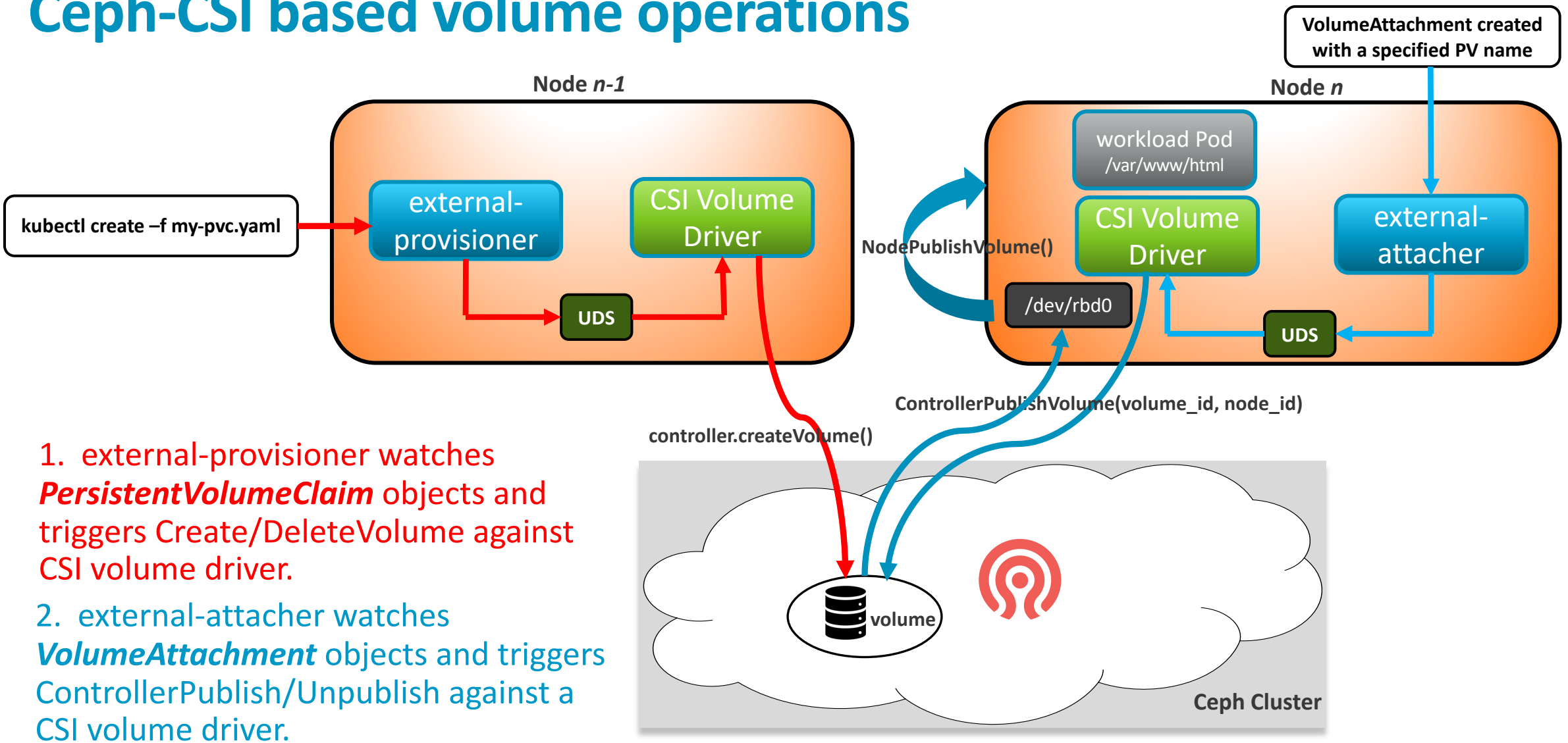
Ceph-CSI based volume operations



1. external-provisioner watches ***PersistentVolumeClaim*** objects and triggers Create/DeleteVolume against CSI volume driver.
2. external-attacher watches ***VolumeAttachment*** objects and triggers ControllerPublish/Unpublish against a CSI volume driver.

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Thank You!
Danke!
Merci!
谢谢!
ありがとう!
Gracias!
Kiitos!