Enhancements to CloudStack Kubernetes Service in 4.21.0 / 4.22.0

Major enhancements for production-grade container orchestration

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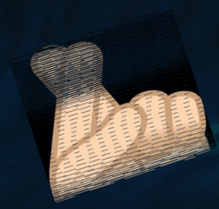
Agenda....

 About me...	 CKS & Evolution	 Enhanced Template Capabilities
 Flexible Service Offerings	 External etcd Architecture	 CNI Configuration
 External Node Integration	 CSI Driver support	  Demo!

About me....

Software Developer @ ShapeBlue

Pearl Dsilva

Apache CloudStack PMC / Committer

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CKS - CloudStack Kubernetes Service

A fully integrated service to deploy, manage, and scale Kubernetes clusters directly within Apache CloudStack.

One click Cluster deployment

Native CloudStack Integration - Uses CloudStack networks, storage and load balancers

Simplified lifecycle management - Upgrades, Scaling, and maintenance

Now.. customizable and flexible - Supports custom templates, CNIs, CSI driver

Extensible architecture - Enables use of external or bare-metal nodes

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Platform Evolution Timeline

CloudStack Kubernetes Service has evolved significantly with the 4.21.0 release, introducing enterprise-grade capabilities for demanding production workloads.

Pre-4.21.0

Limited template support, basic service offerings, coupled control plane architecture (*ACS 4.14.0*)

1

2

Release 4.21.0

Custom templates, flexible service offerings, unstacked etcd, CNI as first-class citizen

3

Version 4.22.0

Full CSI driver integration with snapshot capabilities for stateful workloads

One-Size-Fits-All Templates — A Limiting Factor for CKS Users

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Custom Template Support

Enhanced Capability

Deploy CKS clusters on custom templates of your choice, enabling standardized OS images, security hardening, and compliance with organizational policies.

- **Customizable configurations**
- **Rapid deployment**
- **Version Control**

Use Cases and Benefits

Enterprise compliance	Bake-in security agents, auditing tools
Air-gapped deployments	Include dependencies & images preloaded
Performance tuning	Custom kernel or container runtime settings
Multi-version testing	Templates for different use-cases

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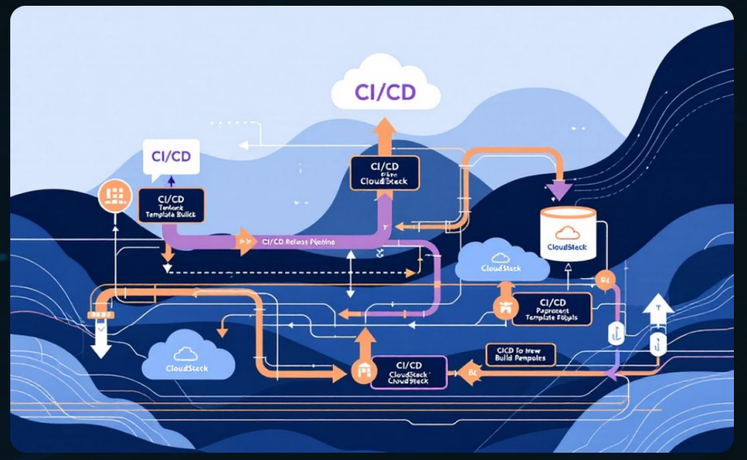
Template Architecture & Deployment

Cloud-init Integration

Templates must be cloud-init enabled and pre-configured with essential Kubernetes components for CKS manager bootstrapping, ensuring a ready-to-deploy environment.

Externalized Scripts

CKS deployment scripts are now externalized and fully modifiable on the Management Server (MS), offering greater control and flexibility.



CI/CD Pipeline Integration

Integrate CloudStack template builds directly into your release pipeline to continuously produce compliant and up-to-date Kubernetes images.

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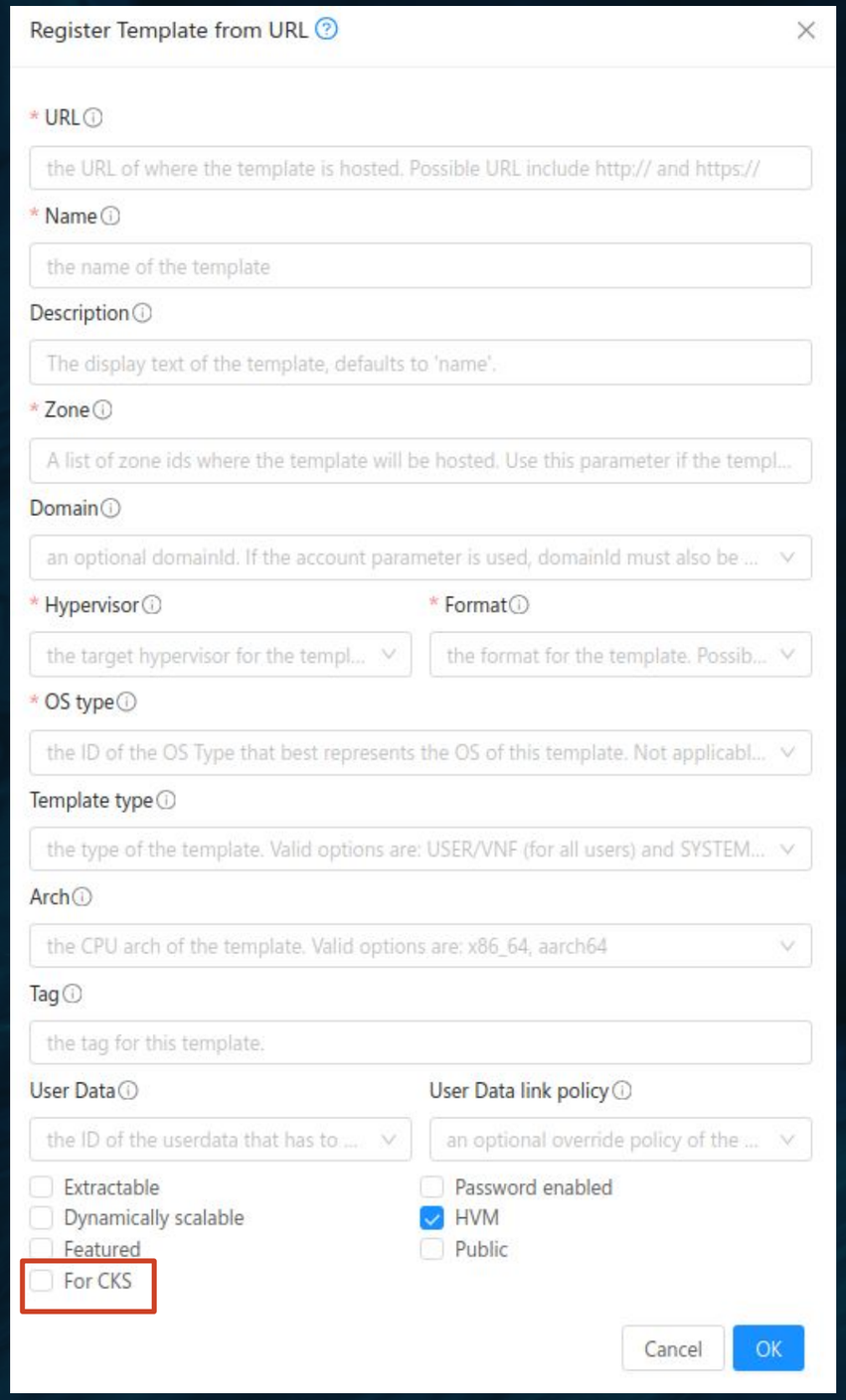

Pre-requisites for a custom template:

- Packages:
  - cloud-init
  - cloud-guest-utils
  - conntrack
  - apt-transport-https
  - ca-certificates
  - curl gnupg gnupg-agent software-properties-common gnupg
  - lsb-release python3-json-pointer python3-jsonschema
  - containerd.io
- A user named cloud needs to be created and added to the sudoers list
- Once VM is deployed, place MS SSH Public Key in the cloud users's *~/.ssh/authorised_keys* file

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One-Size-Fits-All Service Offering — A Limiting Factor for CKS Nodes

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Flexible Service Offerings

Optimize resource allocation across your Kubernetes infrastructure with granular control over compute profiles.

Control Plane Nodes

Dedicated service offerings for control nodes with higher CPU and memory for API server, scheduler, and controller manager workloads.

Worker Nodes

Customized compute profiles optimized for application pods, with flexible scaling options based on workload requirements.

etcd Nodes

Purpose-built service offerings for etcd nodes with low-latency storage and consistent IOPS for cluster state management.

Show advanced settings

Enable CloudStack CSI Driver

Service Offering for Control Nodes

Service Offering for Control Nodes

Template for Control Nodes

Template for Control Nodes

Service Offering for Worker Nodes

Service Offering for Worker Nodes

Template for Worker Nodes

Template for Worker Nodes

Etcd Nodes

(Optional) Number of Kubernetes cluster etcd nodes, default is 0.In case the numbe...

CNI Configuration

User Data	Account	Domain
No thanks	-	-

Scale Kubernetes Cluster

Please select desired Cluster configuration.

Compute Offering

CKSMinimum

Compute offering for Worker Nodes

the ID of the service offering for the virtual machines in the clust...

Compute offering for Control Nodes

the ID of the service offering for the virtual machines in the clust...

Enable auto scaling on this cluster

Cluster size (Worker nodes)

1

Cancel OK

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Embedded etcd — A Limiting Factor for Scalability and Reliability

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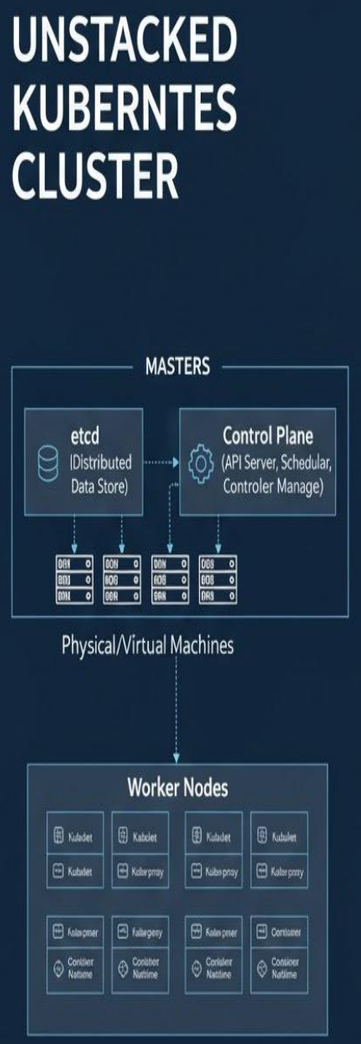
External etcd Architecture



Architecture Benefits

- Improved cluster resilience
- Independent scaling
- Enhanced security isolation
- Better performance tuning

The 4.21.0 release introduces unstacked etcd topology, separating the etcd cluster from control plane nodes.

- Reduces blast radius during failures
- Enables independent resource optimization
- Aligns with production best practices for high-availability Kubernetes deployments

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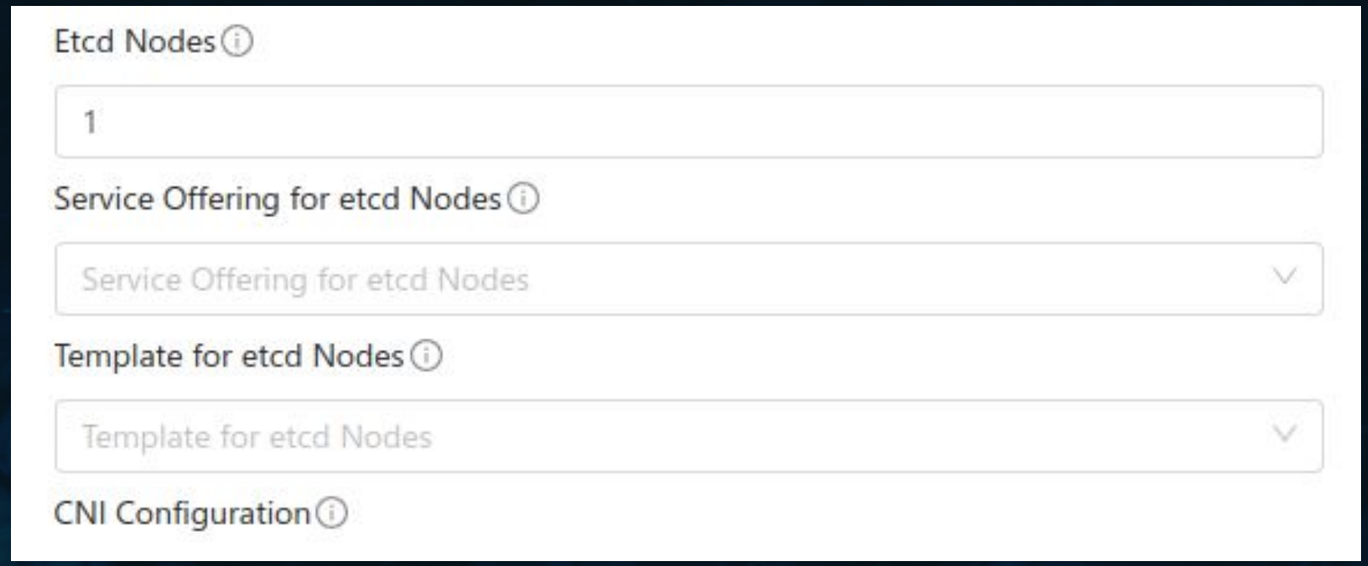
cloud.kubernetes.etcd.node.start.port- *Indicates the start port for etcd nodes SSH access port forwarding rules on the cluster public IP address. Default value =* ***50000***



CKS data iso needs to be built with the etcd binaries. Pre-built images are available at: ***https://download.cloudstack.org/cks/***
If you want a specific version of etcd, build the ISO using the ***create-kubernetes-binaries-iso.sh***

Static CNI Configuration — A Limiting Factor for Cluster Customization

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CNI Configuration as First-Class Citizen

Container Network Interface configuration now receives the same treatment as UserData, with powerful management capabilities built directly into CloudStack.

Register CNI Configs

Store multiple CNI configurations in CloudStack for reuse across clusters

Customize Settings

Modify network policies, IP addressing, and plugin parameters to match requirements

Link at Deployment

Attach the appropriate CNI configuration during cluster creation for consistent networking

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Register CNI Configuration

Please fill in the following data to register CNI Configuration as user data.

* Name

calico-as-number

CNI Configuration

```
    metadata:
      name: default
    spec:
      logSeverityScreen: Debug
      asNumber: {{ AS_NUMBER }}
    EOL
    cat << 'EOL' > /home/cloud/bgp-peer.yaml
    apiVersion: crd.projectcalico.org/v1
    kind: BGPPeer
    metadata:
      name: bgp-peer-1
    spec:
      peerIP: {{ ds.meta_data.peer_ip_address }}
      asNumber: {{ ds.meta_data.peer_as_number }}
    EOL
    EOF
  - chmod +x /home/cloud/create-configs.sh
  - /home/cloud/create-configs.sh
  - for i in {1..3}; do sudo /opt/bin/kubectl apply -f /home/cloud/
bgp-config.yaml && break || sleep 5; done
  - for i in {1..3}; do sudo /opt/bin/kubectl apply -f /home/cloud/
bgp-peer.yaml && break || sleep 5; done
```

Base64 encoded

CNI Configuration parameters

peer_ip_address × peer_as_number ×

/ CNI Configuration Refresh

Register CNI Configuration +

Search

Name	ID	Account	Domain
calico-as-number	c5ecfdb0-87d7-4899-b601-b9e5606ddb4f	admin	ROOT

Etcd Nodes

(Optional) Number of Kubernetes cluster etcd nodes, default is 0.In case the numbe...

CNI Configuration

	User Data	Account	Domain
○	No thanks	-	-
◉	calico-as-number	admin	ROOT

< 1 >

Key	Value
peer_ip_address	
peer_as_number	

Cancel OK

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Limited Node Extensibility — CKS Clusters Confined to CloudStack VMs

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External Node Integration

Hybrid Cluster Topology

Extend CKS clusters beyond CloudStack-managed infrastructure by adding external nodes from bare metal servers, edge locations..

This capability can pave way to:

- Multi-cloud Kubernetes deployments
- Edge computing integration
- Migration path from existing infrastructure
- Specialized hardware utilization (GPU)

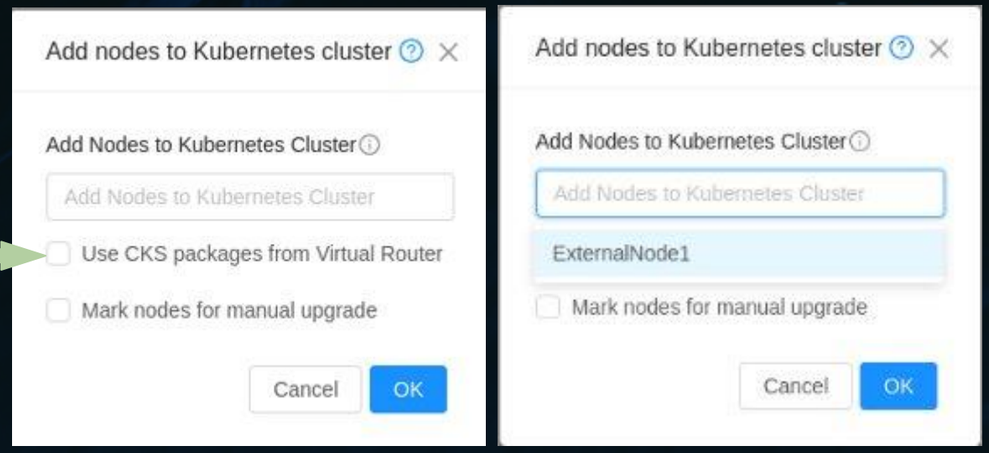
Import Process

Node Validation

Firewall & DNAT Configuration

Reboot node with Userdata

Attach ISO - Bootstrap node as worker node



- ***Legacy way*** - Attach CKS data iso to the cluster nodes
- ***mountcksisoonvr*** -
  - *Specifically added to support external baremetal nodes*
  - *ISO is mounted to the network's VR and served via HTTP to the nodes*

Requirements for Node Import

CKS Template Registered	Network Configuration	Cluster status
Template needs to be registered as a CKS template	Default NIC needs to be on the CKS cluster network	Node shouldn't already be part of the cluster

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CSI Driver Support: Game Changer

Production-Ready Stateful Workloads

Full Container Storage Interface (CSI) driver integration arriving in version 4.22.0 represents the most significant enhancement for running databases, message queues, and stateful applications on CKS and CAPC

https://github.com/cloudstack/cloudstack-csi-driver

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Project Evolution

Initial development & concept

Further development & refinement

Further development, community visibility for broader usage

CSI Benefits and Snapshot Capabilities

Dynamic Volume Provisioning

Automatically create and attach persistent volumes to pods on-demand, eliminating manual storage management overhead.

Storage Class Flexibility

Define multiple storage tiers with different performance characteristics, from high-IOPS NVMe for databases to cost-effective bulk storage.

Volume Snapshots

Create point-in-time snapshots of persistent volumes for backup, disaster recovery, and blue-green deployments without application downtime.

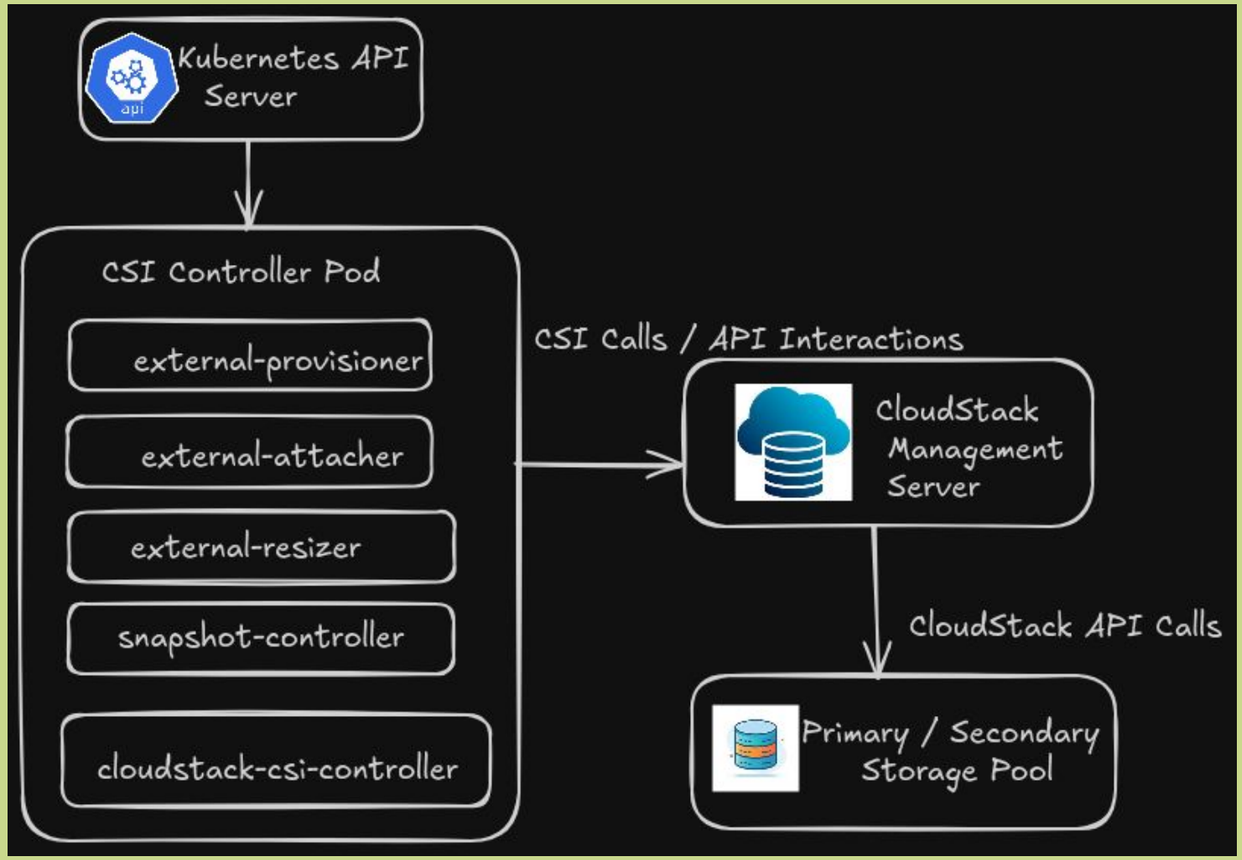
CKS & CAPC Support

Works well with both CKS and CAPC

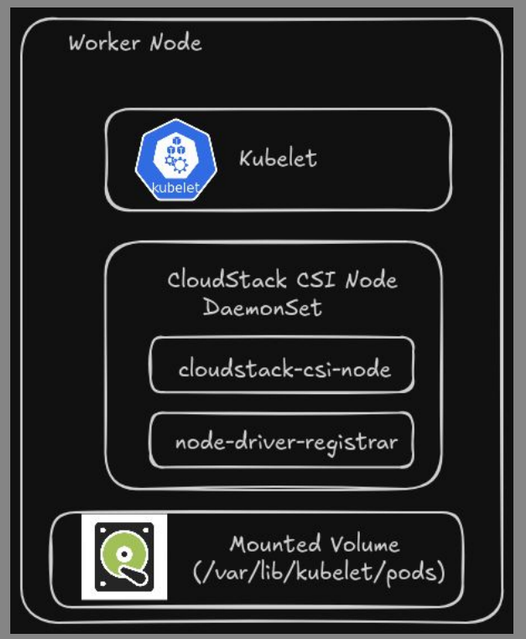
Domain & Project-level support

Works with KVM, XenServer/ XCP-ng/ VMware

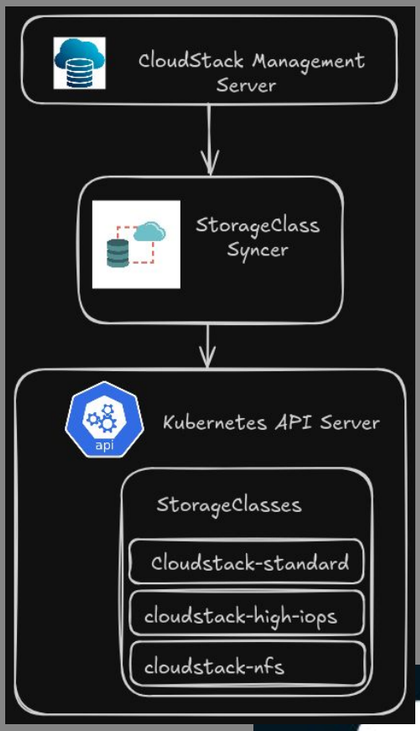
CSI Controller



Node Driver



Storage Class Syncer



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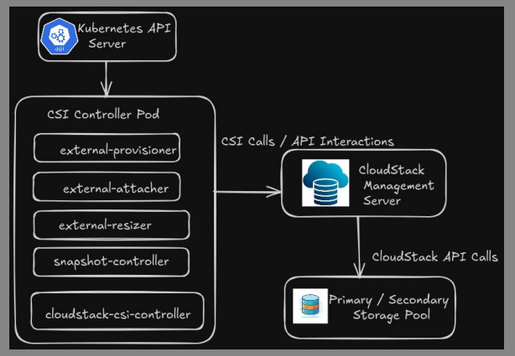
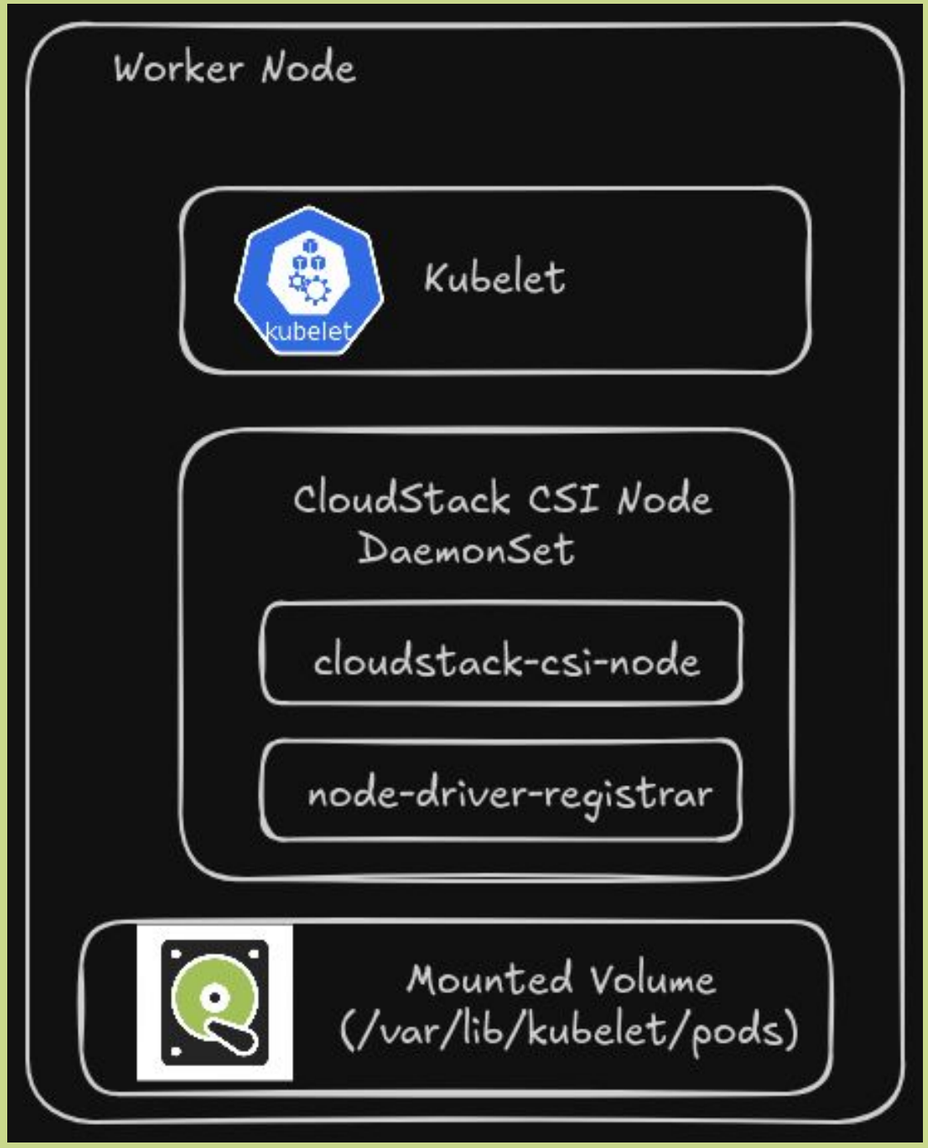
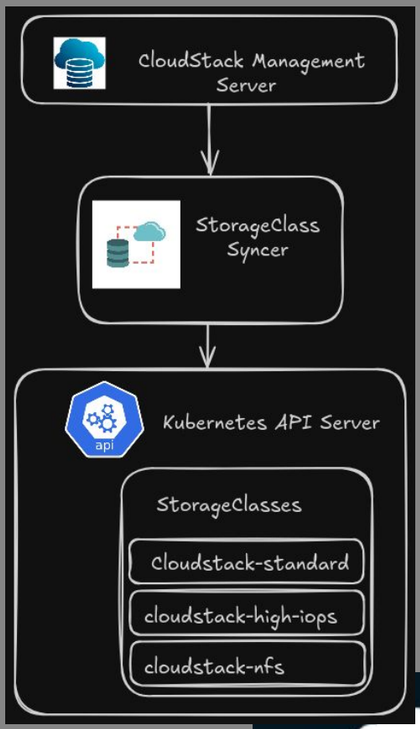
CSI Controller



Node Driver



Storage Class Syncer



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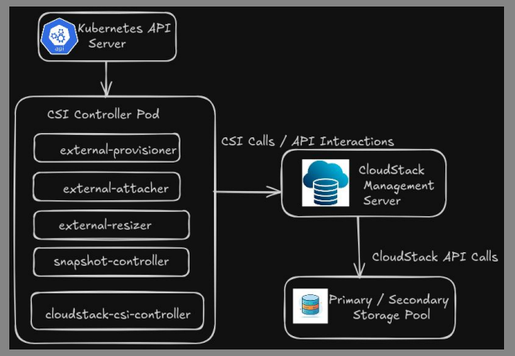
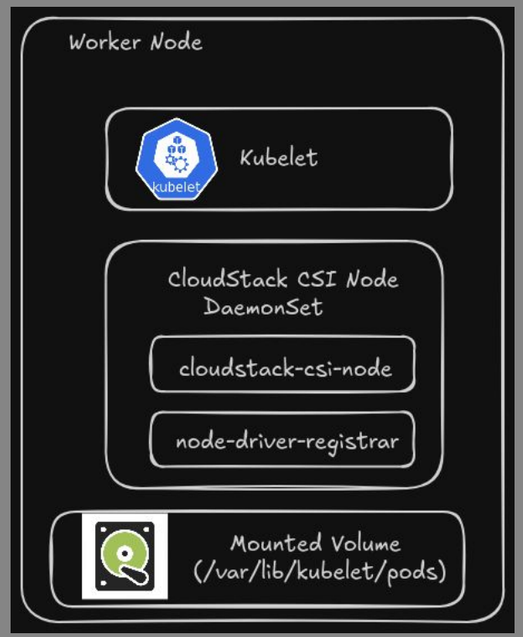
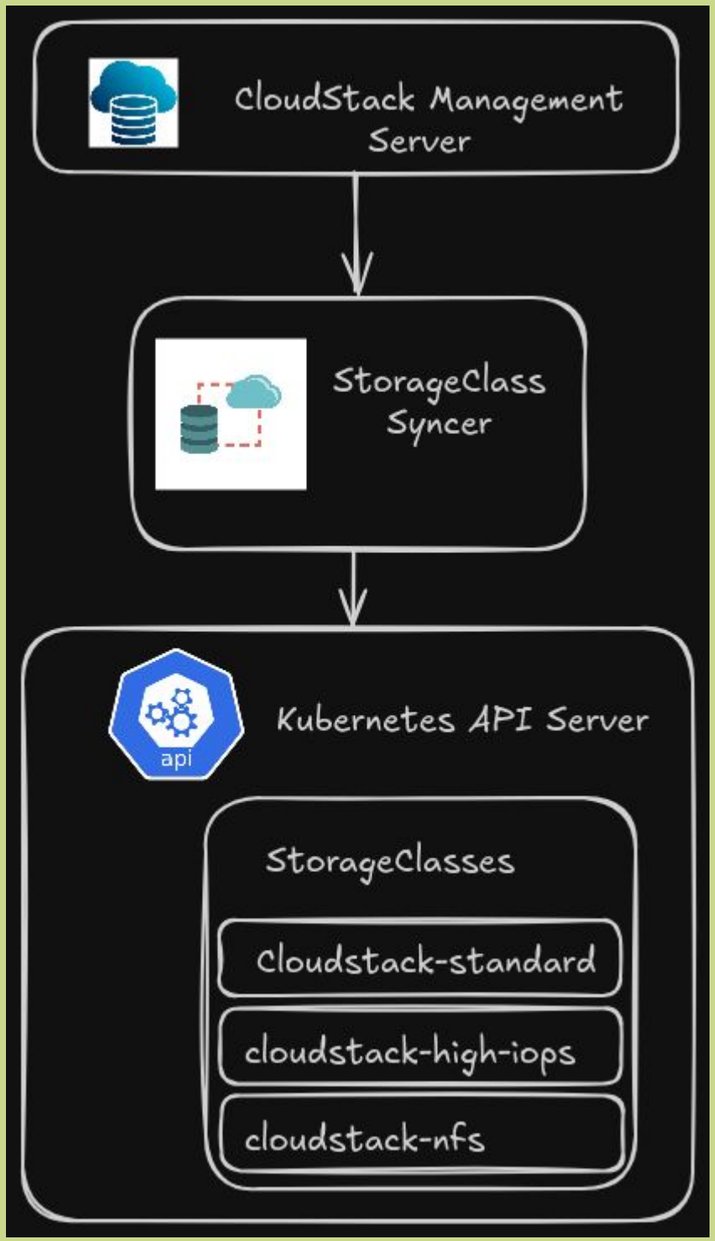
CSI Controller



Node Driver



Storage Class Syncer



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Kubernetes API Server

Receives storage requests from applications

CloudStack CSI Controller

Processes requests and communicates with CloudStack Management Server

CloudStack

Provisions and manages volumes in storage pools

CloudStack CSI Node Driver

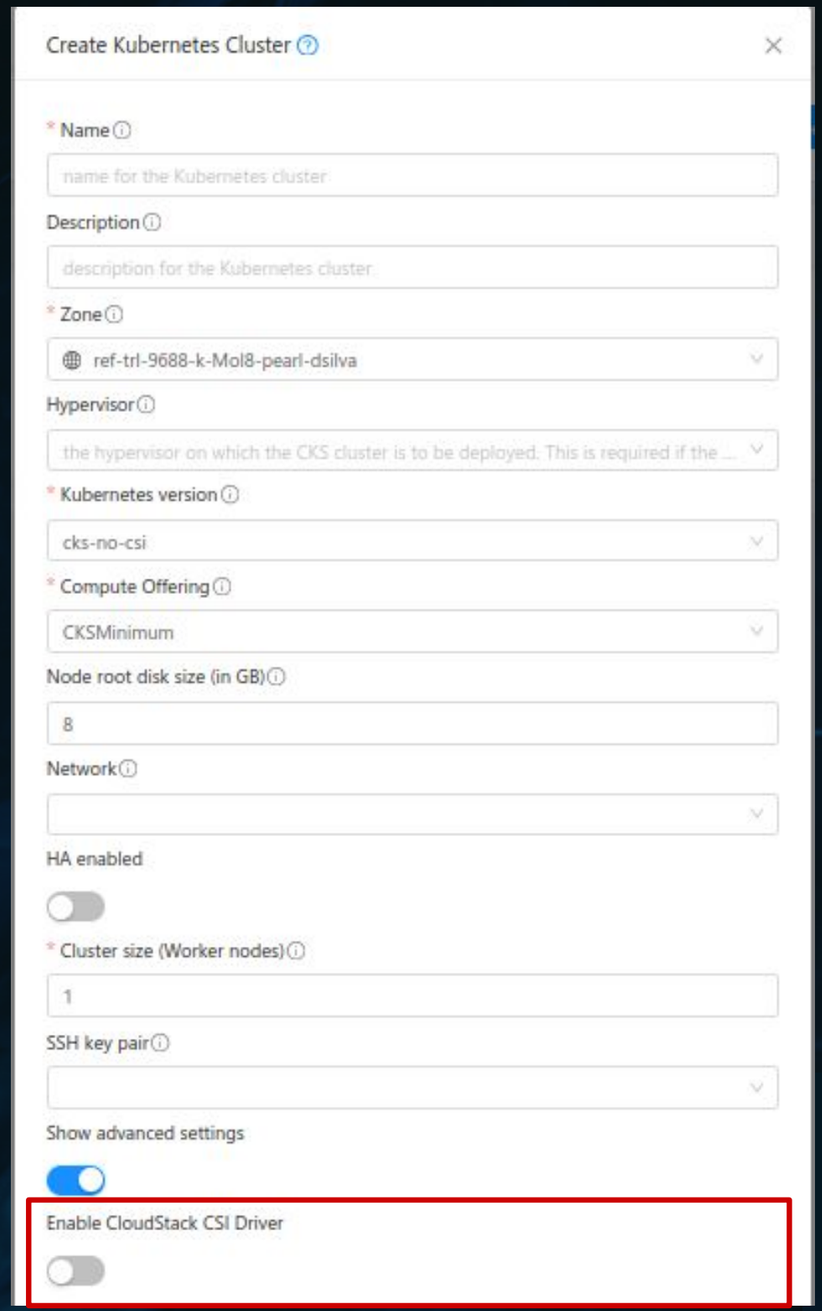
Handles Mounting and Unmounting Volumes locally on worker nodes

Application Pods

Volumes become available for use by application pods

Integrating CSI Driver with CKS

```
root@csi-control-19a161d316b:~# kubectl get po -A
NAMESPACE              NAME                                                READY   STATUS    RESTARTS   AGE
kube-system            calico-kube-controllers-7bfdc5b57c-d8s7n            1/1     Running   0          67s
kube-system            calico-node-8dzjs                                   1/1     Running   0          68s
kube-system            calico-node-lrff8                                   1/1     Running   0          67s
kube-system            cloud-controller-manager-857cd68cf5-bg7x8           1/1     Running   0          22s
kube-system            cloudstack-csi-controller-85f5b85cdb-dblrx          7/7     Running   0          14s
kube-system            cloudstack-csi-controller-85f5b85cdb-nshl2          7/7     Running   0          14s
kube-system            cloudstack-csi-node-fld6b                           3/3     Running   0          14s
kube-system            cloudstack-csi-node-w692f                           3/3     Running   0          14s
kube-system            coredns-674b8bbfcf-lqdsz                            1/1     Running   0          73s
kube-system            coredns-674b8bbfcf-pmfq2                            1/1     Running   0          73s
kube-system            etcd-csi-control-19a161d316b                        1/1     Running   0          76s
kube-system            kube-apiserver-csi-control-19a161d316b              1/1     Running   0          76s
kube-system            kube-controller-manager-csi-control-19a161d316b     1/1     Running   0          76s
kube-system            kube-proxy-s7ctn                                    1/1     Running   0          69s
kube-system            kube-proxy-z5p4q                                    1/1     Running   0          73s
kube-system            kube-scheduler-csi-control-19a161d316b              1/1     Running   0          76s
kubernetes-dashboard   dashboard-metrics-scraper-5bd45c9dd6-tt7vl          1/1     Running   0          63s
kubernetes-dashboard   kubernetes-dashboard-687457b9bd-sgn4w               1/1     Running   0          64s
```



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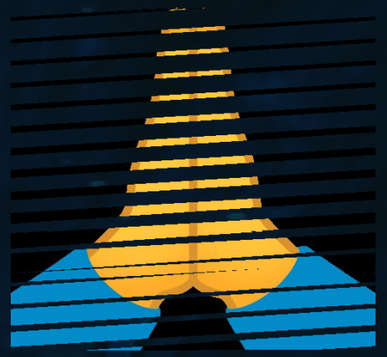
Demo

Questions?...

(or reach me @ pearl11594@apache.org)



Thank You!!

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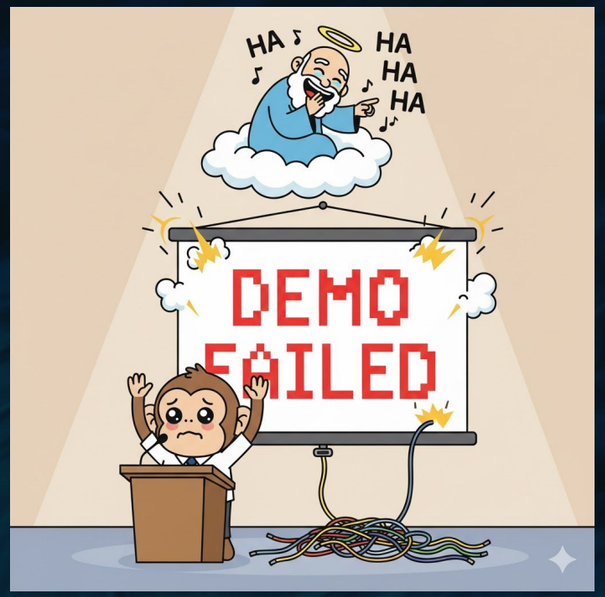
Demo Images...

Just in case



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```yaml
apiVersion: storage.k8s.io/v1
kind: StorageClass
metadata:
  name: cloudstack-standard
provisioner: csi.cloudstack.apache.org
reclaimPolicy: Delete
volumeBindingMode: WaitForFirstConsumer
allowVolumeExpansion: true
parameters:
  csi.cloudstack.apache.org/disk-offering-id: 9926dc7d-a991-43c1-96b2-34bd8d8cb02a
---
```

```yaml
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  name: mariadb-pv-claim
spec:
  accessModes:
    - ReadWriteOnce
  storageClassName: cloudstack-standard
  resources:
    requests:
      storage: 2Gi
```

```yaml
apiVersion: apps/v1
kind: Deployment
metadata:
  name: mariadb
spec:
  selector:
    matchLabels:
      app: mariadb
  strategy:
    type: Recreate
  template:
    metadata:
      labels:
        app: mariadb
    spec:
      containers:
      - image: mariadb:10.11
        name: mariadb
        env:
          - name: MYSQL_ROOT_PASSWORD
            value: wordpress
          - name: MYSQL_DATABASE
            value: wordpress
          - name: MYSQL_USER
            value: wpuser
          - name: MYSQL_PASSWORD
            value: wppass
        ports:
          - containerPort: 3306
            name: mariadb
        volumeMounts:
          - name: mariadb-storage
            mountPath: /var/lib/mysql
      volumes:
        - name: mariadb-storage
          persistentVolumeClaim:
            claimName: mariadb-pv-claim
---
```

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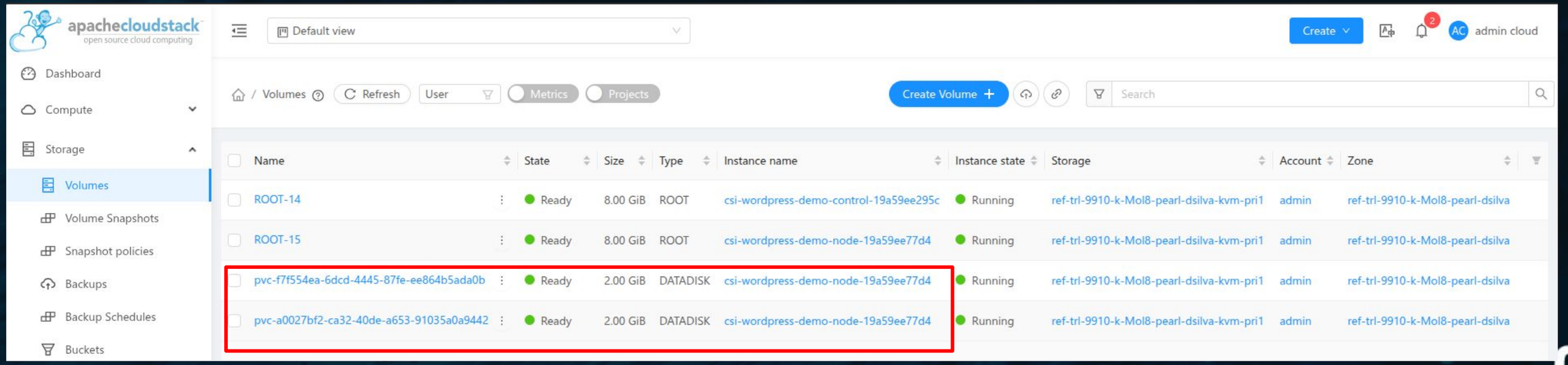
```
pdsilva@pdsilva-XPS-15-7590:~/ccc2025/wordpress-csi-demo$
pdsilva@pdsilva-XPS-15-7590:~/ccc2025/wordpress-csi-demo$ kubectl --kubeconfig kube.conf get sc
NAME                PROVISIONER                RECLAIMPOLICY   VOLUMEBINDINGMODE      ALLOWVOLUMEEXPANSION   AGE
cloudstack-standard   csi.cloudstack.apache.org   Delete          WaitForFirstConsumer   true                   9s
pdsilva@pdsilva-XPS-15-7590:~/ccc2025/wordpress-csi-demo$
pdsilva@pdsilva-XPS-15-7590:~/ccc2025/wordpress-csi-demo$
pdsilva@pdsilva-XPS-15-7590:~/ccc2025/wordpress-csi-demo$
pdsilva@pdsilva-XPS-15-7590:~/ccc2025/wordpress-csi-demo$ kubectl --kubeconfig kube.conf get pvc

NAME                STATUS   VOLUME                                     CAPACITY   ACCESS MODES   STORAGECLASS          VOLUMEATTRIBUTESCLASS   AGE
mariadb-pv-claim    Bound    pvc-f7f554ea-6dcd-4445-87fe-ee864b5ada0b   2Gi        RWO            cloudstack-standard   <unset>                 21s
wordpress-pv-claim   Bound    pvc-a0027bf2-ca32-40de-a653-91035a0a9442   2Gi        RWO            cloudstack-standard   <unset>                 21s
pdsilva@pdsilva-XPS-15-7590:~/ccc2025/wordpress-csi-demo$
pdsilva@pdsilva-XPS-15-7590:~/ccc2025/wordpress-csi-demo$
pdsilva@pdsilva-XPS-15-7590:~/ccc2025/wordpress-csi-demo$
pdsilva@pdsilva-XPS-15-7590:~/ccc2025/wordpress-csi-demo$
pdsilva@pdsilva-XPS-15-7590:~/ccc2025/wordpress-csi-demo$ kubectl --kubeconfig kube.conf get pv
NAME                                       CAPACITY   ACCESS MODES   RECLAIM POLICY   STATUS   CLAIM                       STORAGECLASS          VOLUMEATTRIBUTESCLASS   REASON   AGE
pvc-a0027bf2-ca32-40de-a653-91035a0a9442   2Gi        RWO            Delete           Bound    default/wordpress-pv-claim   cloudstack-standard   <unset>                          25s
pvc-f7f554ea-6dcd-4445-87fe-ee864b5ada0b   2Gi        RWO            Delete           Bound    default/mariadb-pv-claim     cloudstack-standard   <unset>                          26s
pdsilva@pdsilva-XPS-15-7590:~/ccc2025/wordpress-csi-demo$
```



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CSI Driver for CloudStack released!!!

Nov 14, 2025 — by admin in Uncategorized

Comments

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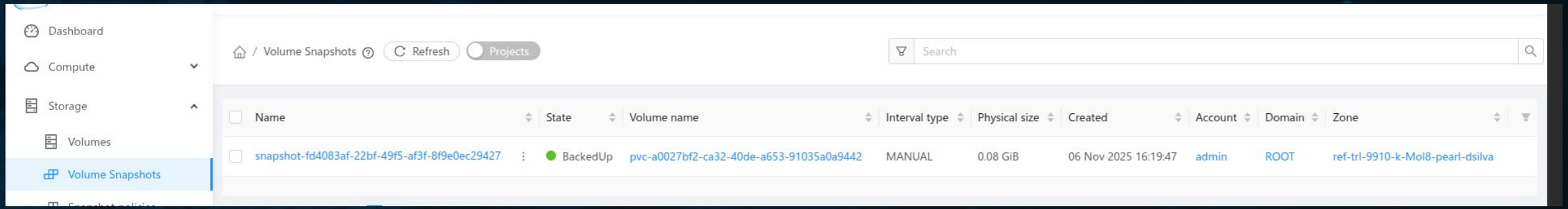
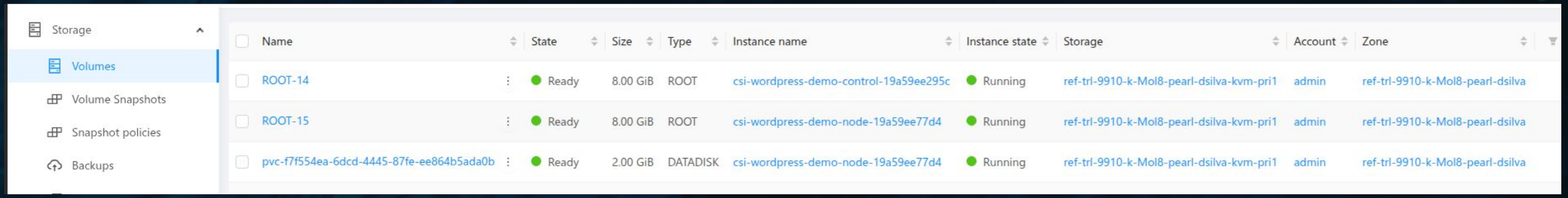
Comment *

```
pdsilva@pdsilva-XPS-15-7590:~/ccc2025/wordpress-csi-demo$
pdsilva@pdsilva-XPS-15-7590:~/ccc2025/wordpress-csi-demo$ cat snapshot.yaml
apiVersion: snapshot.storage.k8s.io/v1
kind: VolumeSnapshot
metadata:
  name: wordpress-snapshot
spec:
  volumeSnapshotClassName: cloudstack-snapshot
  source:
    persistentVolumeClaimName: wordpress-pv-claim
pdsilva@pdsilva-XPS-15-7590:~/ccc2025/wordpress-csi-demo$ kubectl --kubeconfig kube.conf apply -f snapshot.yaml
volumesnapshot.snapshot.storage.k8s.io/wordpress-snapshot created
pdsilva@pdsilva-XPS-15-7590:~/ccc2025/wordpress-csi-demo$
pdsilva@pdsilva-XPS-15-7590:~/ccc2025/wordpress-csi-demo$ kubectl --kubeconfig kube.conf get volumesnapshot
NAME                READYTOUSE   SOURCEPVC           SOURCESNAPSHOTCONTENT   RESTORESIZE   SNAPSHOTCLASS         SNAPSHOTCONTENT                                    CREATIONTIME   AGE
wordpress-snapshot  true         wordpress-pv-claim                          0             cloudstack-snapshot   snapcontent-fd4083af-22bf-49f5-af3f-8f9e0ec29427   11s            12s
pdsilva@pdsilva-XPS-15-7590:~/ccc2025/wordpress-csi-demo$
pdsilva@pdsilva-XPS-15-7590:~/ccc2025/wordpress-csi-demo$ kubectl --kubeconfig kube.conf get volumesnapshotcontent
NAME                                               READYTOUSE   RESTORESIZE   DELETIONPOLICY   DRIVER                       VOLUMESNAPSHOTCLASS   VOLUMESNAPSHOT      VOLUMESNAPSHOTNAMESPACE   AGE
snapcontent-fd4083af-22bf-49f5-af3f-8f9e0ec29427   true         0             Delete           csi.cloudstack.apache.org    cloudstack-snapshot   wordpress-snapshot  default                   16s
pdsilva@pdsilva-XPS-15-7590:~/ccc2025/wordpress-csi-demo$
```



cloud STACK COLLABORATION CONFERENCE

```
pdsilva@pdsilva-XPS-15-7590:~/ccc2025/wordpress-csi-demo$ kubectl --kubeconfig kube.conf delete deployments.apps
mariadb    wordpress
pdsilva@pdsilva-XPS-15-7590:~/ccc2025/wordpress-csi-demo$ kubectl --kubeconfig kube.conf delete deployments.apps
mariadb    wordpress
pdsilva@pdsilva-XPS-15-7590:~/ccc2025/wordpress-csi-demo$ kubectl --kubeconfig kube.conf delete deployments.apps
mariadb    wordpress
pdsilva@pdsilva-XPS-15-7590:~/ccc2025/wordpress-csi-demo$ kubectl --kubeconfig kube.conf delete deployments wordpress
deployment.apps "wordpress" deleted
pdsilva@pdsilva-XPS-15-7590:~/ccc2025/wordpress-csi-demo$ kubectl --kubeconfig kube.conf delete pvc wordpress-pv-claim
persistentvolumeclaim "wordpress-pv-claim" deleted
pdsilva@pdsilva-XPS-15-7590:~/ccc2025/wordpress-csi-demo$
```



```
pdsilva@pdsilva-XPS-15-7590:~/ccc2025/wordpress-csi-demo$ cat pvc-from-snapshot.yaml
apiVersion: v1
kind: PersistentVolumeClaim
metadata:
  name: wordpress-pv-claim-restore
spec:
  storageClassName: cloudstack-standard
  dataSource:
    name: wordpress-snapshot
    kind: VolumeSnapshot
    apiGroup: snapshot.storage.k8s.io
  accessModes:
    - ReadWriteOnce
  resources:
    requests:
      storage: 2Gi
pdsilva@pdsilva-XPS-15-7590:~/ccc2025/wordpress-csi-demo$ kubectl --kubeconfig kube.conf apply -f pvc-from-snapshot.yaml
persistentvolumeclaim/wordpress-pv-claim-restore created
pdsilva@pdsilva-XPS-15-7590:~/ccc2025/wordpress-csi-demo$
pdsilva@pdsilva-XPS-15-7590:~/ccc2025/wordpress-csi-demo$
pdsilva@pdsilva-XPS-15-7590:~/ccc2025/wordpress-csi-demo$ vi wordpress-csi-demo
pdsilva@pdsilva-XPS-15-7590:~/ccc2025/wordpress-csi-demo$ vi wordpress-csi-demo.yaml
pdsilva@pdsilva-XPS-15-7590:~/ccc2025/wordpress-csi-demo$ kubectl --kubeconfig kube.conf apply -f wordpress-csi-demo.yaml
storageclass.storage.k8s.io/cloudstack-standard unchanged
persistentvolumeclaim/mariadb-pv-claim unchanged
persistentvolumeclaim/wordpress-pv-claim created
deployment.apps/mariadb unchanged
service/mariadb unchanged
deployment.apps/wordpress created
service/wordpress unchanged
```

```
pdsilva@pdsilva-XPS-15-7590:~/ccc2025/wordpress-csi-demo$ kubectl --kubeconfig kube.conf get pvc
NAME                     STATUS    VOLUME                                     CAPACITY   ACCESS MODES   STORAGECLASS          VOLUMEATTRIBUTESCLASS   AGE
mariadb-pv-claim         Bound     pvc-f7f554ea-6dcd-4445-87fe-ee864b5ada0b   2Gi        RWO            cloudstack-standard   <unset>                 9m34s
wordpress-pv-claim       Pending                                              2Gi        RWO            cloudstack-standard   <unset>                 43s
wordpress-pv-claim-restore   Bound     pvc-81ad5d7a-31c9-4393-a81e-52b7b2bf7d49   2Gi        RWO            cloudstack-standard   <unset>                 89s
pdsilva@pdsilva-XPS-15-7590:~/ccc2025/wordpress-csi-demo$
```

Storage

- Volumes
- Volume Snapshots
- Snapshot policies
- Backups
- Backup Schedules

Name	State	Size	Type	Instance name	Instance state	Storage	Account	Zone
ROOT-14	Ready	8.00 GiB	ROOT	csi-wordpress-demo-control-19a59ee295c	Running	ref-trl-9910-k-Mol8-pearl-dsilva-kvm-pri1	admin	ref-trl-9910-k-Mol8-pearl-dsilva
ROOT-15	Ready	8.00 GiB	ROOT	csi-wordpress-demo-node-19a59ee77d4	Running	ref-trl-9910-k-Mol8-pearl-dsilva-kvm-pri1	admin	ref-trl-9910-k-Mol8-pearl-dsilva
pvc-f7f554ea-6dcd-4445-87fe-ee864b5ada0b	Ready	2.00 GiB	DATADISK	csi-wordpress-demo-node-19a59ee77d4	Running	ref-trl-9910-k-Mol8-pearl-dsilva-kvm-pri1	admin	ref-trl-9910-k-Mol8-pearl-dsilva
pvc-81ad5d7a-31c9-4393-a81e-52b7b2bf7d49	Ready	2.00 GiB	DATADISK	csi-wordpress-demo-node-19a59ee77d4	Running	ref-trl-9910-k-Mol8-pearl-dsilva-kvm-pri1	admin	ref-trl-9910-k-Mol8-pearl-dsilva