SPDK-CSI: Bring SPDK to Kubernetes

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Agenda

- SPDK Briefs
- Container Storage Interface (CSI)
  - CSI Internals
  - Kubernetes CSI development
- SPDK-CSI Implementation
- SPDK-CSI Community

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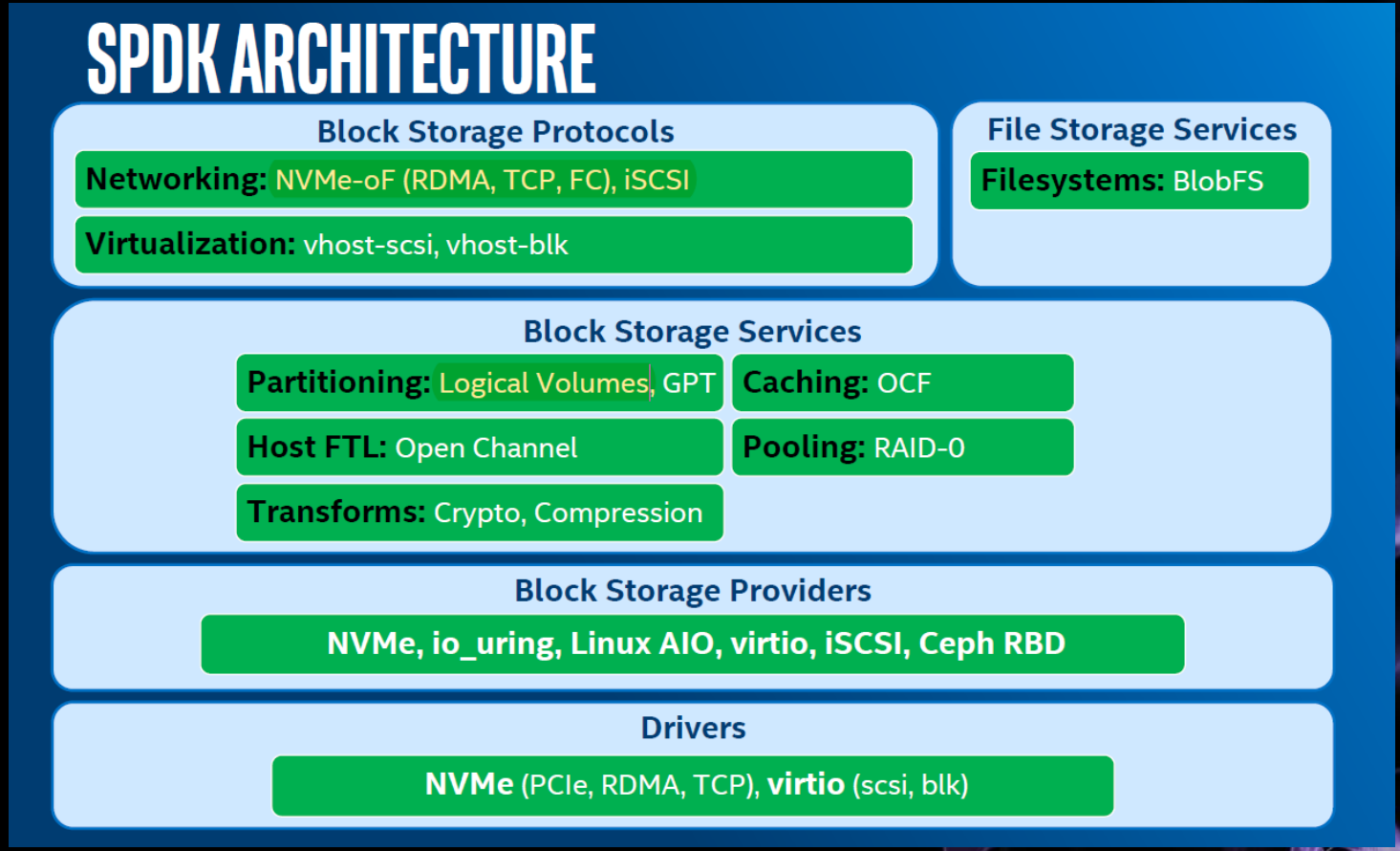
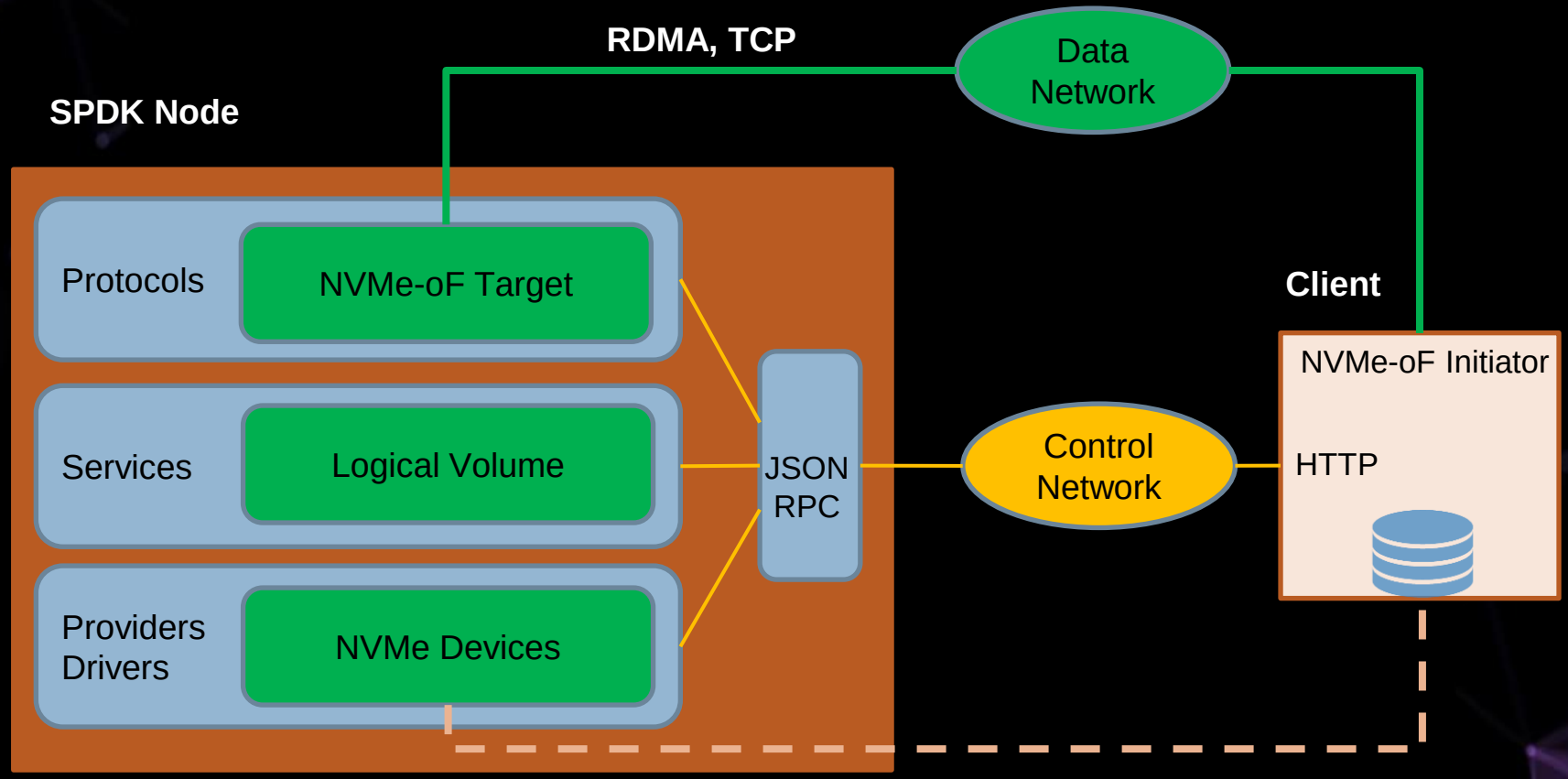
SPDK

What is SPDK

- Quoted from https://spdk.io/
  - The Storage Performance Development Kit (SPDK) provides a set of tools and libraries for writing *high performance, scalable, user-mode* storage applications.
- Key techniques
  - Interact with hardware directly in user space
  - Polling data readiness instead of interrupt
  - No locks in I/O path



SPDK Network Storage



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Container Storage Interface (CSI)

What is CSI

- Kubernetes volume driver: a brief history
  - In-Tree: storage driver coupled in Kubernetes code base.
    - Deprecated, legacy code will be removed.
  - FlexVolume: exec based API for volume plugins.
    - Hard to deploy and manage dependency.
  - Container Storage Interface (CSI)
    - Addresses pains of In-Tree and FlexVolume.
    - Standardizes storage system integration with Kubernetes.
    - Kubernetes CSI Drivers List

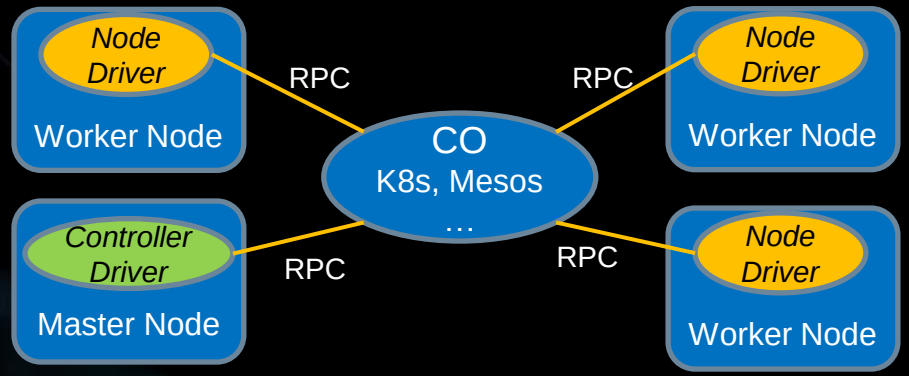
What is CSI – An Example

To use Ceph RBD (block device) in a K8s pod		
No.	**Steps**	**Run command at**
	App starts	
1	Create RBD volume in Ceph cluster through Ceph API	Any host can access Ceph cluster
2	Mount RBD to host and container directory	Host where the pod runs
	App stops	
3	Unmount RBD directory	Host where the app runs
4	Delete RBD volume in Ceph cluster through Ceph API	Any host can access Ceph cluster

How CSI automates the procedure	
What we need	**In CSI Term**
[Step 1, 4] A storage driver to handle Ceph API and create/delete RBD on demand. It can run on any host which has access to Ceph cluster control plane.	Controller Driver
[Step 2, 3] A storage driver to (un)mount Ceph RBD volumes. It must run on all hosts where pods may be scheduled.	Node Driver
A protocol to define messages between K8s master and the plugins, so they can cooperate to finish the job.	RPC

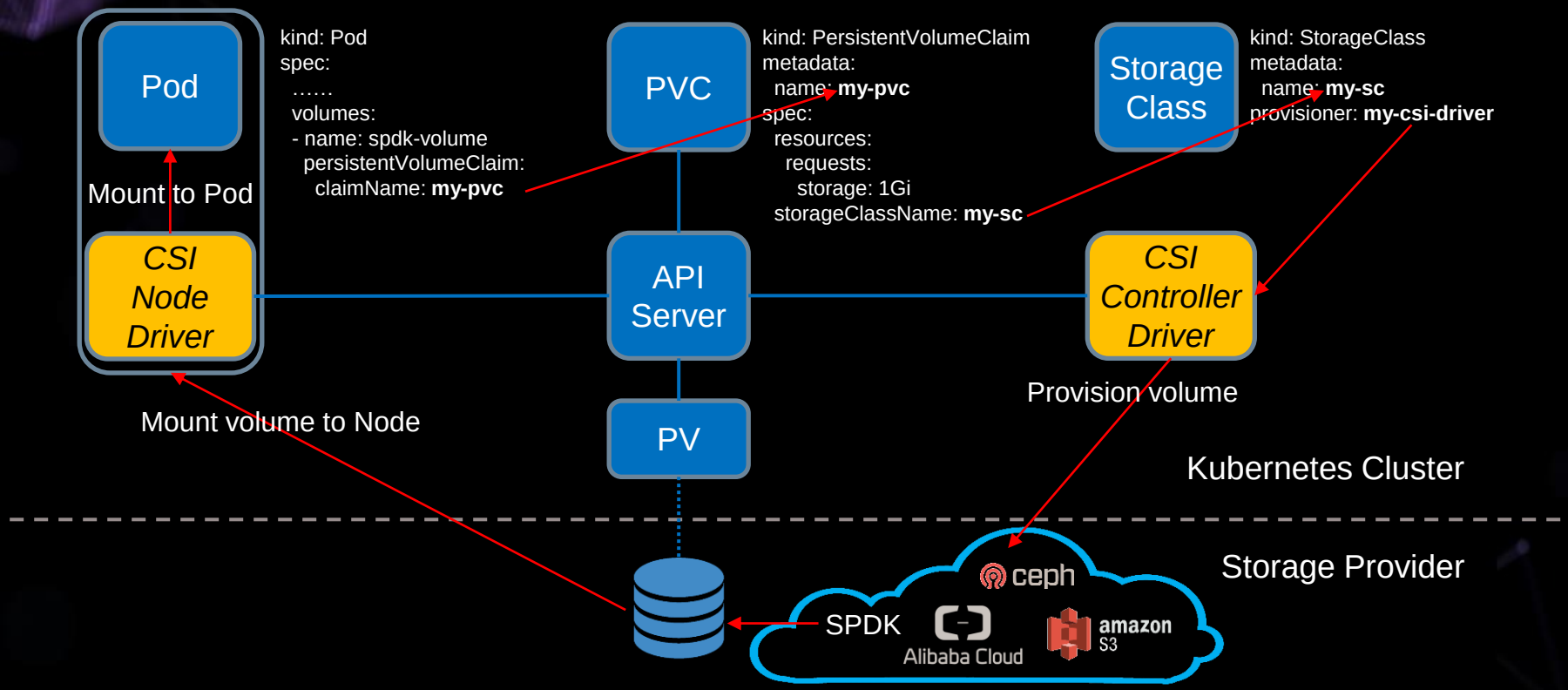
CSI Drivers and RPCs

- Controller Driver
  - Talk to Service Provider (SP) to create/delete volumes
- Node Driver
  - Mount/unmount remote volumes to local host



RPC	Explains
CO → Controller Driver	
CreateVolume	Create a volume with specific parameters in storage provider
DeleteVolume	Revert creating
ControllerPublishVolume	Expose the volume to be accessible from worker node
ControllerUnpublishVolume	Revert publishing
CO → Node Driver	
NodeStageVolume	Import remote volume and mount to worker node host
NodeUnstageVolume	Revert staging
NodePublishVolume	Bind mount host staging directory to container internal directory
NodeUnpublishVolume	Revert publishing

Dynamic Volume Provisioning with CSI

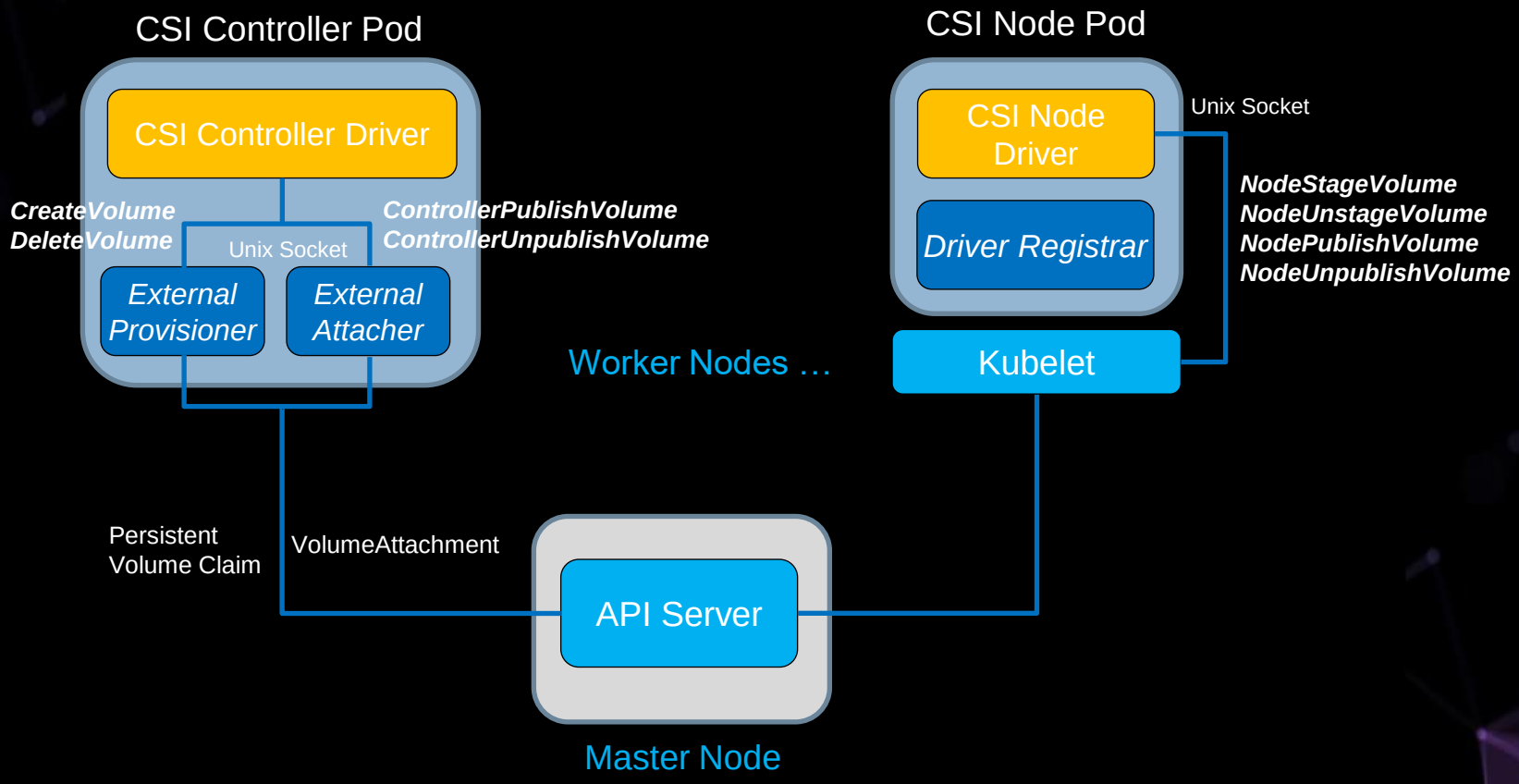


Kubernetes CSI Support

- Wrap Controller and Node driver in a single binary. Select functionality per command line.
- Deploy Controller driver as Deployment or StatefulSet
- Deploy Node driver as DaemonSet
  - Exactly one instance on each worker node
- Leverage CSI Sidecar containers to reduce boilerplate code

Sidecar	Purpose
External Provisioner	Watches for PersistentVolumeClaim objects and triggers [Create|Delete]Volume operations
External Attacher	Watches for VolumeAttachment objects and triggers Controller[Publish|Unpublish]Volume operations
Node Driver Registrar	Registers the CSI driver with Kubelet to receive Node[Stage|Unstage|Publish|Unpublish]Volume operations
……	……

Kubernetes CSI Support



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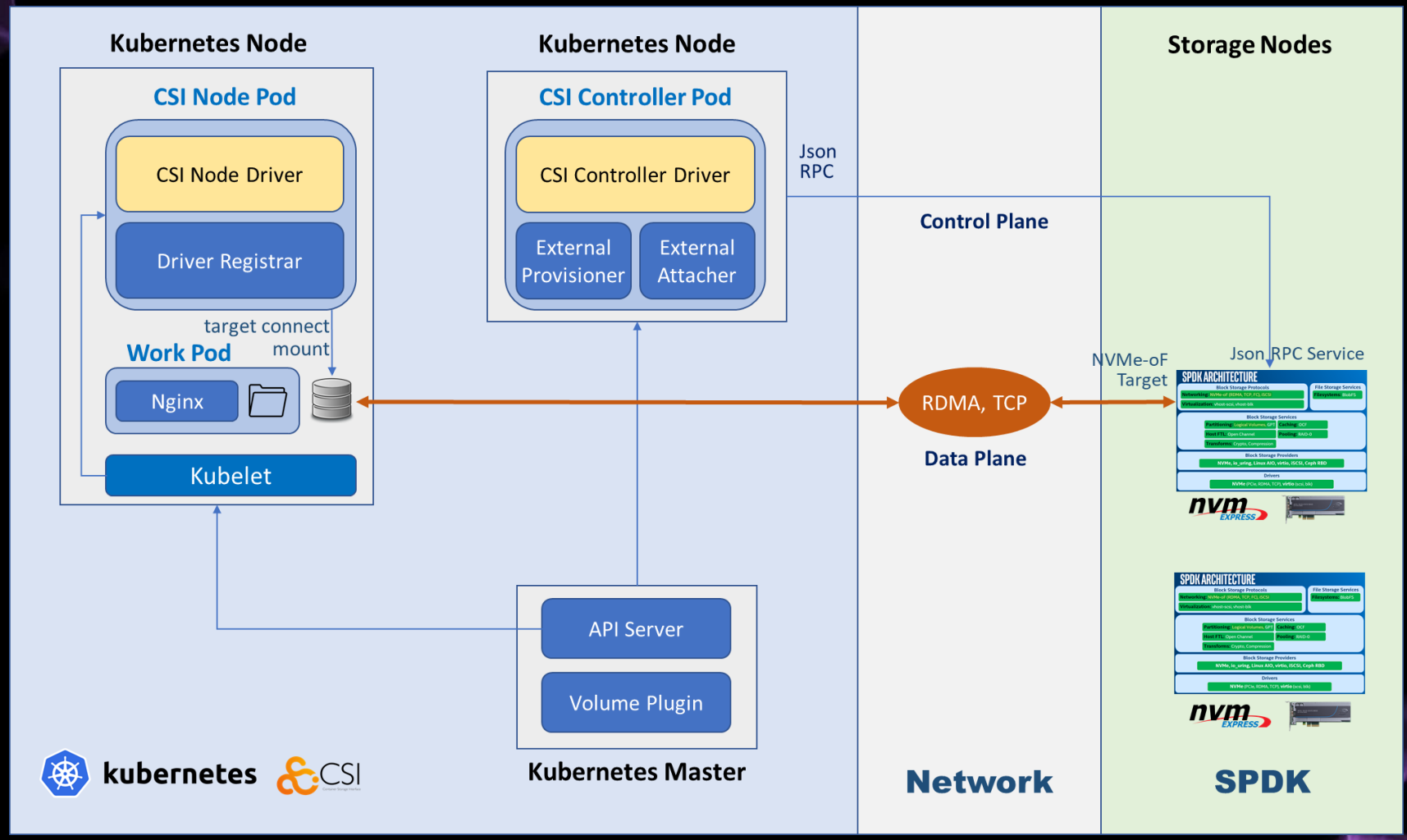
SPDK-CSI Implementation

Overview


Kubernetes Node
CSI Node Pod
CSI Node Driver
Driver Registrar
target connect
mount
Work Pod
Nginx
Kubelet
Kubernetes Node
CSI Controller Pod
CSI Controller Driver
External Provisioner
External Attacher
Json RPC
Control Plane
RDMA, TCP
Data Plane
NVMe-oF Target
Json RPC Service
Storage Nodes
SPDK ARCHITECTURE
API Server
Volume Plugin
Kubernetes Master
kubernetes
CSI
Network
SPDK

Controller Driver

Controller configures SPDK network target through JSON-RPC

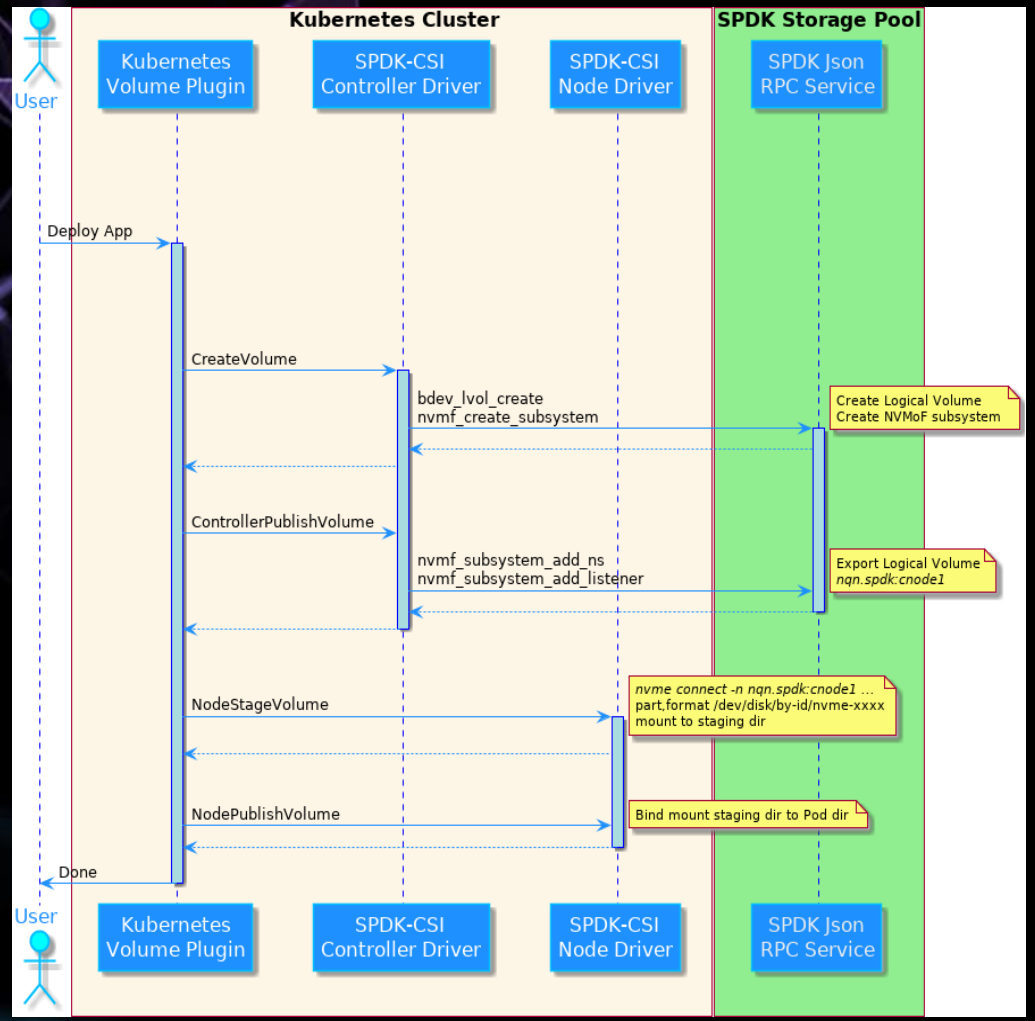
CSI RPC	SPDK JSON-RPC (NVMf)	SPDK JSON-RPC (iSCSI)
CreateVolume	bdev_lvol_create	bdev_lvol_create
DeleteVolume	bdev_lvol_delete	bdev_lvol_delete
ControllerPublishVolume	nvmf_subsystem_add_ns nvmf_subsystem_add_listener	iscsi_create_portal_group iscsi_create_initiator_group iscsi_create_target_node
ControllerUnpublishVolume	nvmf_subsystem_remove_ns	iscsi_delete_target_node

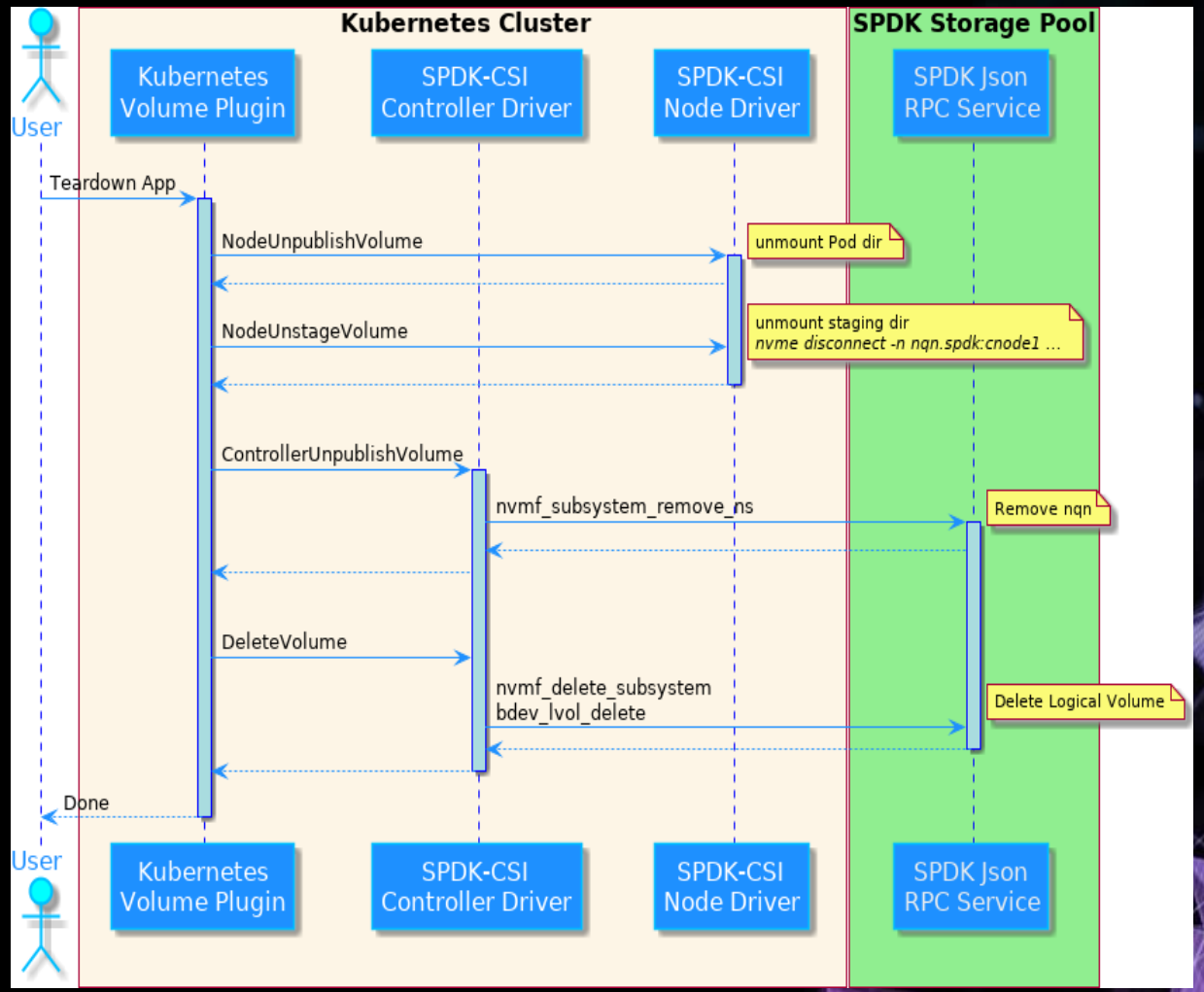
Node Driver

- Node connects to SPDK target and mounts remote volume
- "*nqn, ip, port, diskid, iqn*" are passed in from Controller Driver

CSI Message	Node (NVMf)	Node (iSCSI)
StageVolume	nvme connect -n *nqn* -a *ip* -s *port* ... mount /dev/disk/by-id/*diskid* stagePath	iscsiadm -p *ip*:*port* -m discovery ... iscsiadm -T *iqn* -p *ip*:*port* --login ... mount /dev/disk/by-id/*diskid* stagePath
UnstageVolume	nvme disconnect -n *nqn* umount stagePath	iscsiadm -T *iqn* -p *ip*:*port* --logout ... umount stagePath
PublishVolume	mount -o bind stagePath podPath	mount -o bind stagePath podPath
UnpublishVolume	umount podPath	umount podPath

Sequence Diagram





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Community

Contributions Welcome

- Code review at SPDK Gerrit
  - *git clone https://review.spdk.io/spdk/spdk-csi*
  - Github mirror: https://github.com/spdk/spdk-csi
- Development Guidelines
  - https://spdk.io/development/
- Trello Board
  - https://trello.com/b/nBujJzya/kubernetes-integration
- Slack Channnel
  - https://spdk-team.slack.com/messages/containers

References

- Container Storage Interface (CSI) Spec
  - https://github.com/container-storage-interface/spec/
- Kubernetes CSI Documentation
  - https://kubernetes-csi.github.io/docs/
- SPDK JSON-RPC
  - https://spdk.io/doc/jsonrpc.html
- SPDK-CSI Design Document
  - https://tinyurl.com/spdkcsi-design-doc

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Thank you