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U.S. DEPARTMENT OF ENERGY

Kubernetes/OKD at BNL

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pre-GDB on Kubernetes - June 7, 2022

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Kubernetes at BNL

- Have had a vanilla kubernetes cluster for SDCC staff use for a number of years
  - Primarily utilized for testing
  - Currently have a REANA testbed deployed on this cluster
    - Framework for reusable analysis
  - Can be utilized by SDCC administrator staff to deploy staff-controlled services which require k8s
  - 1 control plane node, and 5 workers
    - No HA setup as primarily utilized for testing

- Increasingly, users have been interested in deploying their own internal services at our facility
  - k8s is a natural mechanism to provide this functionality
  - However, opening vanilla k8s API access to untrusted users (multi-tenant) so they can deploy services posed a number of security issues in the default k8s configuration:
    - Allows containers to run as root
    - Users can mount arbitrary system paths into containers
    - Of particular concern in an environment like ours with shared network filesystems with UID-based auth (NFS, Lustre, etc.)

OKD at BNL

- Setting up secure multi-tenancy in a vanilla k8s cluster is difficult
  - Possible to work around issues through the setup of admissions controllers, RBAC, etc.
    - Not trivial and easily opens the door for administrator error
  - One of the reasons the large commercial k8s providers give tenants completely isolated/individual clusters on VMs

- Another issue is there is a fast pace of development in vanilla k8s
  - There are frequently major changes between “minor” releases
  - Important functionality sometimes stays “beta” for a long time, or is dropped

- Therefore, decided to adopt OKD for our k8s needs
  - The community release of Red Hat’s Openshift k8s platform
  - Secure out the box - suitable for multi-tenant use
    - Users are never root in containers by default
    - OKD/Openshift adopted at a number of other US national labs including FNAL and ORNL
  - Release model more consistent with an enterprise product than vanilla k8s
  - Simple integration with LDAP/OIDC identity providers
  - Provides users with a convenient easy to use management web interface (“Web Console”)
  - ***Will likely decommission our vanilla staff k8s cluster, once we port REANA to OKD***

okd

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OKD/Openshift Considerations

- Namespaces are referred to as “projects” in OKD/Openshift

- `oc`, rather than `kubectl` is the standard OKD/Openshift CLI tool
  - Essentially an extended kubectl binary - supports all kubectl commands/constructs
    - Client tarball actually ships with kubectl hardlink to oc
  - Adds additional functionality, such as managing OKD/Openshift projects, and logging into the system

- Helm3 can be used with Openshift/OKD
  - Extremely convenient for deploying services
    - Helm is the defacto package/deployment manager for k8s
    - Openshift Templates are far less commonly used
  - Some helm charts and containers will not work out of the box for regular/unprivileged users, and need to be modified for use with OKD/Openshift
    - Can’t define ClusterRole/ClusteRoleBinding objects
    - Can’t run as root in containers
      - Each project is assigned a unique ranges of UIDs that can be used
        - Allows multi-tenancy

OKD Clusters at BNL

- Two production OKD clusters brought online in 2022
  - **ATLAS cluster**
    - Primarily for Analysis Facility (AF) services that require k8s
      - ServiceX (latest release: 20220418-1418-stable)
      - REANA (porting in progress)
      - Note that our analysis facility JupyterHub deployment does not require k8s and uses a modified batchspawner plugin to utilize our existing large batch (HTCondor/SLURM) farms
        - REANA is also capable of leveraging batch resources
  - **sPHENIX cluster**
    - Primarily for Panda service, and conditions database (CDB) deployment
      - Panda developers have created numerous helm charts
    - Example of a developer/user-deployed service in OKD
      - Collaboration between two groups at BNL
        - SDCC managing the OKD software/hardware
        - CDB and Panda deployments maintained/managed by the NPPS (Nuclear Particle Physics Software) group at BNL, with SDCC support
- Separate clusters for now as the ATLAS AF services are currently in development

OKD Cluster Details

- Each cluster running OKD 4.10, and is provisioned with:
  - 7 Dell R640 Servers
    - 3 HA control plane nodes, 4 worker nodes
      - Running Fedora CoreOS (FCOS) 35 deployed via OKD Installer-Provisioned Infrastructure (IPI)
        - CRI-O used as container runtime
    - Specs:
      - 2x Xeon Silver 4210 CPU @ 2.20 GHz
      - 128 GB RAM
      - 4x 25 Gbps NICs
      - 3x 480 GB SSDs
  - NetApp A250 Storage Appliance
    - 14 x 1.92 TB NVME drives (~26 TB raw)
    - ONTAP NetApp OS allows dynamic PV provisioning via Trident

ATLAS OKD Cluster Hardware

OKD Cluster Details (Cont.)

- Node layout

```
# oc get nodes
NAME                          STATUS    ROLES     AGE   VERSION
control0.usatlas.bnl.gov      Ready     master    90d   v1.23.3+759c22b
control1.usatlas.bnl.gov      Ready     master    90d   v1.23.3+759c22b
control2.usatlas.bnl.gov      Ready     master    90d   v1.23.3+759c22b
node0.usatlas.bnl.gov         Ready     worker    14d   v1.23.3+759c22b
node1.usatlas.bnl.gov         Ready     worker    14d   v1.23.3+759c22b
node2.usatlas.bnl.gov         Ready     worker    15d   v1.23.3+759c22b
node3.usatlas.bnl.gov         Ready     worker    22d   v1.23.3+759c22b

# oc get clusterversion
NAME      VERSION                             AVAILABLE   PROGRESSING   SINCE   STATUS
version   4.10.0-0.okd-2022-03-07-131213      True        False         86d     4.10.0-0.okd-2022-03-07-131213
```

  - HAProxy running on VM for control plane API service redundancy

- Plan to add additional nodes and storage in the coming years, based on utilization
  - Likely more compute-farm-like nodes will be added for processing/workload oriented use cases like ServiceX/REANA

- May consider moving to fully/paid supported Red Hat Openshift product if clusters see wide adoption
  - Will depend on pricing

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OKD Cluster Details (Cont.)

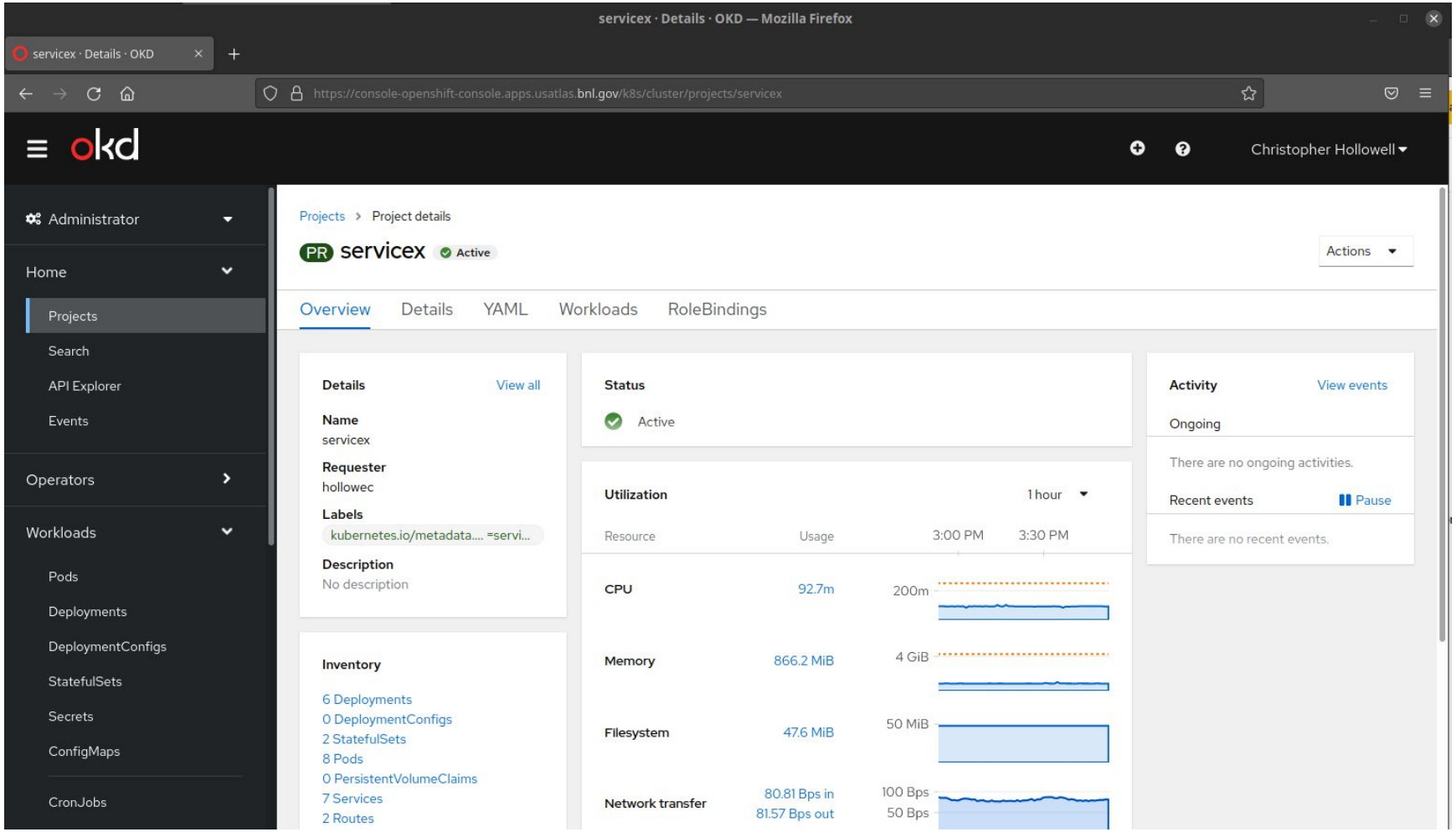
- Authentication tied to our Keycloak OIDC IDP
  - Users login to web console to obtain a token which can be used with the oc CLI:

    ```
    oc login --token=XYZ --server=https://api.usatlas.bnl.gov:6443
    ```
  - API server accessible internally at SDCC, so `oc` typically used from our various interactive nodes

- OKD web console only available internally, at least for now
  - Users/admins access from workstations onsite, or via VPN or SSH SOCKS proxy

- Users can setup Openshift/OKD routes to expose services internally
  - Facility-level firewalls prevent them from being accessed outside SDCC
  - Web services that needs to be opened to the world must go through a reverse proxy
    - Can be manually setup by SDCC administrator staff
    - Only available after approval/scanning, etc.

OKD Web Console



OKD Web Console - Project Screen

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OKD Web Console (Cont.)

Pods · OKD — Mozilla Firefox

Pods · OKD

https://console-openshift-console.apps.usatlas.bnl.gov/k8s/ns/servicex/pods

okd

Christopher Hollowell

Administrator

Home

Projects

Search

API Explorer

Events

Operators

Workloads

Pods

Deployments

DeploymentConfigs

StatefulSets

Secrets

ConfigMaps

CronJobs

Jobs

DaemonSets

Project: servicex

Pods

Create Pod

Filter | Name | Search by name...

Name	Status	Ready	Restarts	Owner	Memory	CPU	Created
servicex-code-gen-8f55cbf99-4dj6b	Running	1/1	0	servicex-code-gen-8f55cbf99	58.7 MiB	0.000 cores	May 19, 2022, 12:02 PM
servicex-did-finder-cernopendata-7bf84c89df-r7cng	Running	1/1	0	servicex-did-finder-cernopendata-7bf84c89df	19.6 MiB	0.000 cores	May 19, 2022, 12:02 PM
servicex-did-finder-rucio-676c4f866d-mkxsc	Running	1/1	0	servicex-did-finder-rucio-676c4f866d	24.5 MiB	0.000 cores	May 19, 2022, 12:21 PM
servicex-minio-66cdf7896-frdqr	Running	1/1	0	servicex-minio-66cdf7896	83.9 MiB	0.001 cores	May 18, 2022, 3:58 PM
servicex-postgresql-0	Running	1/1	0	servicex-postgresql	50.4 MiB	0.003 cores	May 19, 2022, 11:29 AM
servicex-rabbitmq-0	Running	1/1	0	servicex-rabbitmq	180.0 MiB	0.088 cores	May 18, 2022, 12:31 PM
servicex-servicex-app-858cdc48bf-wg6zs	Running	1/1	0	servicex-servicex-app-858cdc48bf	403.5 MiB	0.000 cores	May 19, 2022, 12:00 PM
servicex-x509-secrets-795559d88c-psprs	Running	1/1	0	servicex-x509-secrets-795559d88c	45.6 MiB	-	May 16, 2022, 2:15 PM

OKD Web Console - Project Pod Listing

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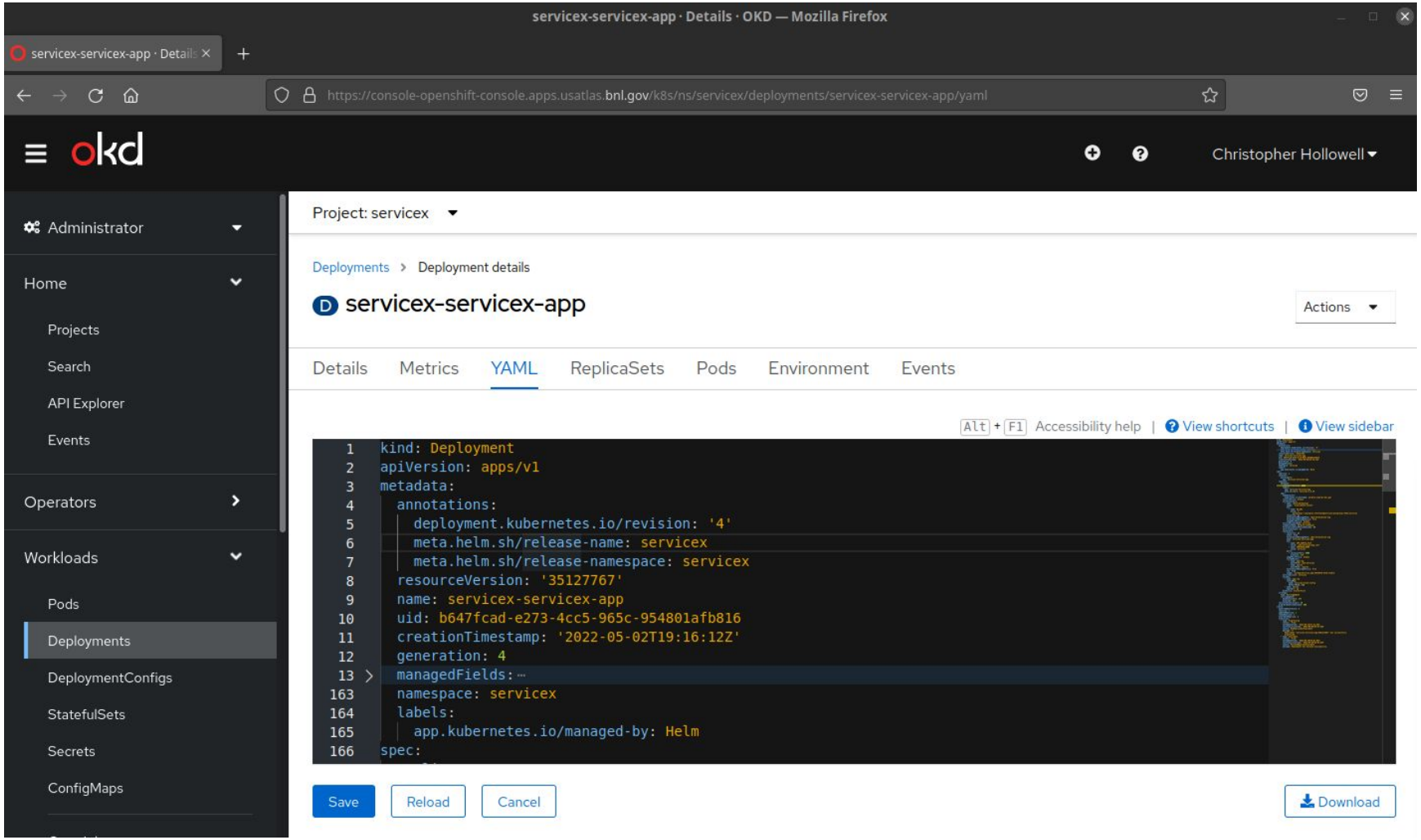
OKD Web Console (Cont.)



OKD Web Console - Editing Deployment YAML

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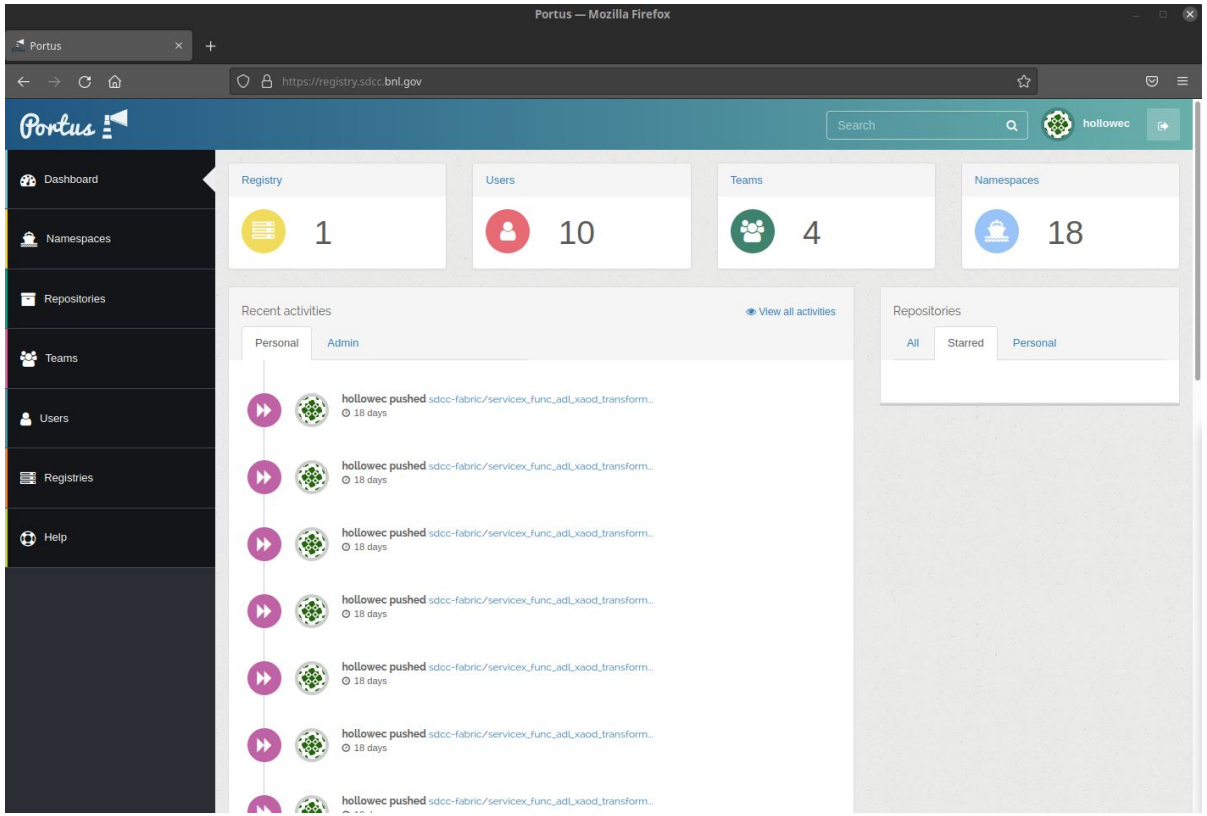
Local Docker Registry

- We provide users with local private Docker registry where they can store containers for use with OKD
  - Portus user interface
    - Can manage user teams, visibility of containers, etc.
  - Tied into SDCC's IPA for authorization
  - Also only currently accessible internally at BNL
    - Users utilize with local workstations onsite, VPN or ssh SOCKS proxy
  - Eliminates dependence on Dockerhub, or other external registries for critical services



Private Registry Portus Web Interface

Conclusions

- Deployed two production OKD Clusters at BNL/SDCC
  - For ATLAS and sPHENIX
  - Various services including ServiceX and the sPHENIX CDB already running on the clusters
  - May merge the clusters later as ATLAS AF services become production-ready

- Unlike vanilla k8s, OKD/Openshift provides a secure default configuration that is suitable for multi-tenant use
  - Users are never root in containers by default

- Deployed a local/private Docker container registry service for our users
  - Can be utilized with OKD
  - Eliminates dependence on external registries for important services

- Plan to add additional hardware to our OKD clusters as utilization increases