



TECH TALK:

# Kubernetes for Researchers

Friday, February 5th, 2021  
10:30 AM US EDT

**Rajib Ghosh**

Global Senior Solutions Architect  
Oracle for Research

## TECH TALK HOUSEKEEPING

- Today's webinar is being recorded. We will share the link to the recording with you via email after the event. The recording will also be made available to the Oracle for Research community.
- We invite your comments and questions, both about the tech topic being discussed and about the series more generally. Questions may be submitted using the Q&A box on your screen or you may ask questions directly using your microphone. When not asking a question, please mute your microphone.
- Questions may be asked during the presentation and we will also have a Q & A time at the end of the presentation when you can ask questions directly and engage in discussion.
- At Oracle for Research, we believe that research and innovation happen best when a diverse and thoughtful community is free to engage in respectful, compassionate, and open dialog. To that end, when asking a question or providing feedback, we ask that all participants be respectful, collaborative, and constructive.

# Agenda

## Recap and Asks from researchers

- ❑ Q & A – Cloud bursting to OCI
- ❑ Container orchestration for research
- ❑ Cloud bursting to Oracle cloud Kubernetes Infrastructure

## Kubernetes

- ❑ Kubernetes and orchestration overview
- ❑ Kubernetes for research use cases
- ❑ Cloud bursting scenarios with Kubernetes
- ❑ Oracle cloud Kubernetes Options (OKE vs IaaS)
- ❑ Networking infrastructure for Kubernetes cloud bursting
- ❑ Container scaling and instance scaling options
- ❑ Deploying with OCI-CLI
- ❑ Running containers on GPU nodes
- ❑ Singularity with Kubernetes – peek overview

## Demos

- ❑ Oracle Kubernetes Engine – overview and key elements
- ❑ Oracle for research Kubernetes image
- ❑ Networking infrastructure for k8s builds
- ❑ Singularity demo

# Kubernetes overview

## Kubernetes – Benefits and Features

- ❑ Portable, scalable and open-source platform for managing container workloads and services
- ❑ Donated by Google to the open source community in 2014
- ❑ Managed by [Cloud native computing foundation \(CNCF\)](#) and [kubernetes.io](#)
- ❑ Key Features
  - ❑ Provides automation for running service containers across multiple machines/VMs
  - ❑ Flexible automatic load balancing and scaling on demand
  - ❑ Automatic self-monitoring of containers
  - ❑ Automatic resource management and utilization
  - ❑ Horizontal scaling
  - ❑ Running deployments and rollbacks
  - ❑ Run anywhere (on-premise, laptop, cloud or hybrid)
  - ❑ Storage orchestration
  - ❑ Support for multiple container runtimes – docker, rkt
- ❑ CNCF provides software conformance for [certified kubernetes offerings](#) by different vendors
- ❑ Oracle is a CNCF conformed Kubernetes vendor
- ❑ Oracle provides container engine (OKE) as a platform service

## Kubernetes Key elements

- ❑ Standard specifications
  - ❑ Container Runtime interface CRI
    - ❑ Supports Docker, containerd, CRI-O, [open container initiative \(OCI\)](#)
  - ❑ [Container Networking Interface \(CNI\)](#)
    - ❑ Flannel, calico, Weave Net, Canal , romana etc..

# Use cases for Research

## Cloud bursting

- ❖ Researcher requires cloud GPU/CPU resources at peak load times
- ❖ Requires cloud nodes to scale containers/nodes from on-premise master Kubernetes controller
- ❖ May need separate Kubernetes clusters in on-premise and oracle cloud for different purpose
- ❖ Researcher may need to migrate from GPU enabled IaaS k8s to OKE
- ❖ Automatically scale up/down cloud containers and OCI instances

## Containers with GPU

- ❖ Researcher needs separation of software versions (CPU/GPU accelerated) on same environment
- ❖ Requires performance evaluation on CPU / GPU clusters
- ❖ Remove CUDA / NVIDIA driver incompatibilities
- ❖ Scale laptop GPU to cloud GPU environments

## HPC containers With singularity

- ❖ Container platform for HPC developed at Lawrence Berkeley National Lab maintained by syslabs.io
- ❖ Researcher needs GPUs, RDMA networks, parallel filesystems and MPI for HPC computation
- ❖ Researcher needs a containerized solution that works and scales easily with HPC
- ❖ Researcher needs easy and seamless shell-based execution between host and container environment
- ❖ Researcher need an image that can work flexibly in any Kubernetes based orchestration environment

## Machine learning workflows

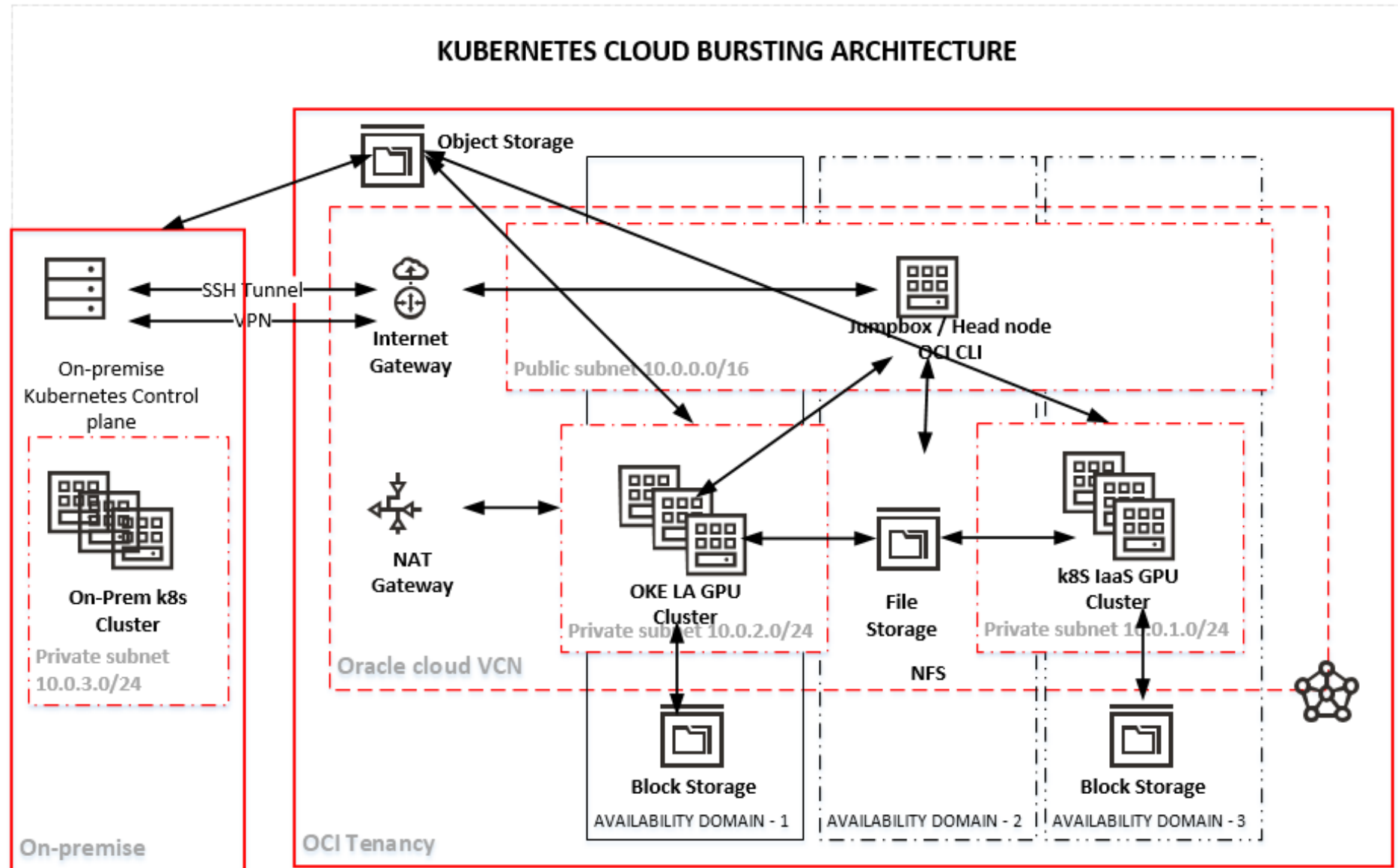
- ❖ Researchers need iterative model trainings in a defined pipeline workflow
- ❖ Researcher needs to scale on CPU/GPU clusters on pipeline steps
- ❖ Researcher need the ability to stop/change pipeline workflows
- ❖ Researcher may need to swap containers/tools/data for model trainings

## Kubernetes sandbox

- ❖ Researcher need a common image that can act as head node / bastion / client node to Kubernetes



# Cloud bursting with Kubernetes



# Cloud bursting with Kubernetes

## Deployment Architectures

- ❖ Separate k8s clusters in on-premise and Oracle cloud
  - ❖ No scaling across clusters between on-premise and cloud
  - ❖ Manual cloud bursting based on separate project workloads
  - ❖ Consistent performance (GPU shapes in on-premise / cloud are consistent)
  - ❖ Separate k8s masters on on-premise and cloud
  - ❖ Data do not traverse across clusters
- ❖ OKE and IaaS k8s clusters – managed by a single head node
  - ❖ Public facing head node with OCI-CLI and k8s client (kubectl) installed
  - ❖ OKE and IaaS k8s clusters accessible through same head node
  - ❖ Deployable through OCI-CLI
  - ❖ OKE and k8s IaaS in separate private subnets
  - ❖ Easy migration to OKE once it is GPU enabled
- ❖ On-premise and Oracle cloud hybrid k8s cluster
  - ❖ K8s Master resides on-premise
  - ❖ Nodes auto or manually scaled to Oracle cloud
  - ❖ OCI instance scaling manages node scaling
  - ❖ Suitable for workloads that need bursting to higher GPU power
  - ❖ Can be managed with a cluster management tool (I,e slateci)
  - ❖ Requires VPN setup between on-premise and Oracle cloud

# Singularity containers

Oracle for Research Singularity image	<ul style="list-style-type: none"><li>❖ Download URL: <a href="https://github.com/OracleForResearch/Research-Image-Sandbox">github.com/OracleForResearch/Research-Image-Sandbox</a></li><li>❖ Locate the singularity image link (Ubuntu or OL7)</li><li>❖ Import the URL in your tenancy as a custom image</li><li>❖ Build single or multiple OCI compute instances with the image</li><li>❖ Import your container images from pre-built registry</li></ul>
Features	<ul style="list-style-type: none"><li>❖ Heavily used and popular in the university / research HPC computing</li><li>❖ Quickstart and easy command interface</li><li>❖ Easy integration with HPC MPI interface (OpenMPI / MPICH)</li><li>❖ Secure containers with self-sign capability</li><li>❖ Open source code and easy to build</li><li>❖ Secure – support non-root installs</li><li>❖ Remote build in the cloud</li><li>❖ Kubernetes compatible (<a href="#">singularity-CRI</a>)</li></ul>
Usage and commands	<ul style="list-style-type: none"><li>❖ <i>Checking the install version - <code>singularity --version</code></i></li><li>❖ <i>Pulling from the container library - <code>singularity pull library://sylabsed/linux/alpine</code></i></li><li>❖ <i>Pulling from docker - <code>singularity pull docker://godlovedc/lolcow</code></i></li><li>❖ <i>Run scripts - <code>singularity run lolcow_latest.sif</code></i></li><li>❖ <i>Build images - <code>sudo singularity build --sandbox ubuntu/ library://Ubuntu</code></i></li><li>❖ <i>Mounting a file - <code>singularity exec --bind /data:/mnt lolcow_latest.sif cat /mnt/cow_advice.txt</code></i></li><li>❖ <i>Use the file USAGE.md in <code>~/singularity</code> under <code>opc/ubuntu</code> user for a quick start on the singularity commands</i></li></ul>
Oracle Cloud & Kubernetes	<ul style="list-style-type: none"><li>❖ Spin up Oracle Kubernetes engine (OKE) or IaaS based Kubernetes using research k8s gateway</li><li>❖ Implement singularity-CRI with OKE or IaaS based Kubernetes installation</li><li>❖ Scale your HPC workloads on singularity containers</li></ul>

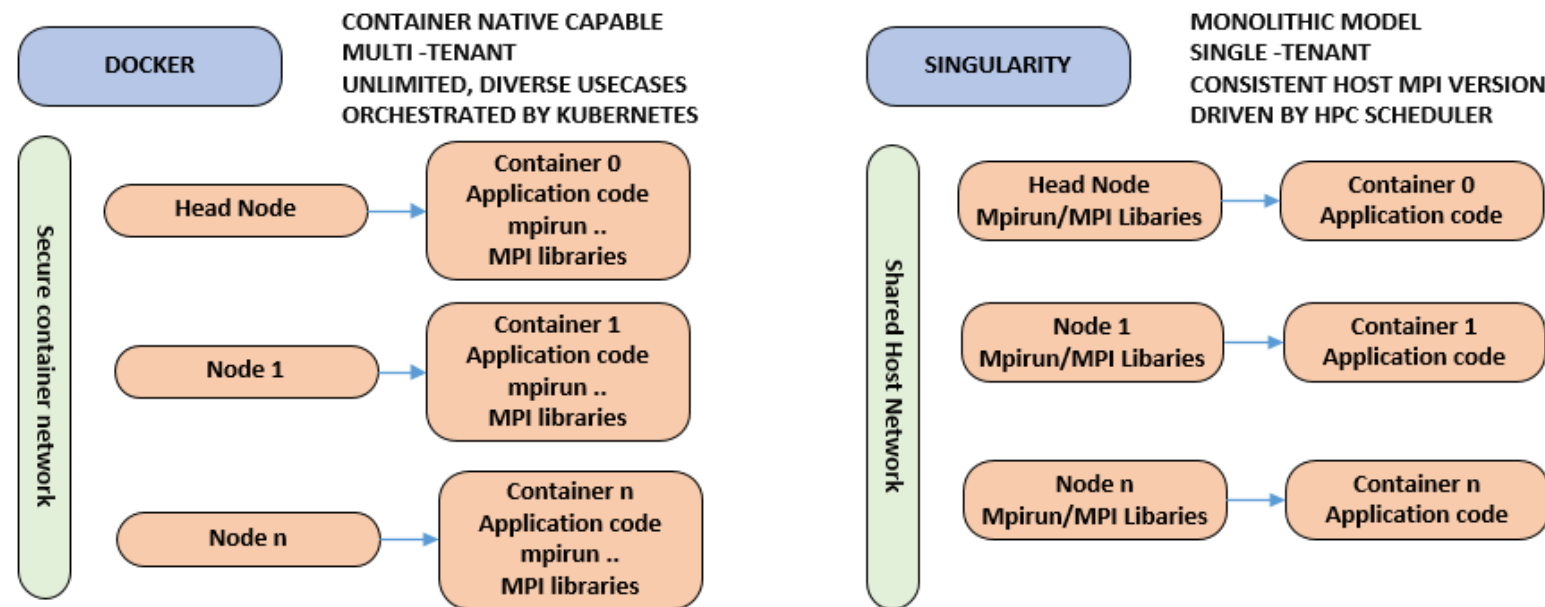


# Singularity with Kubernetes

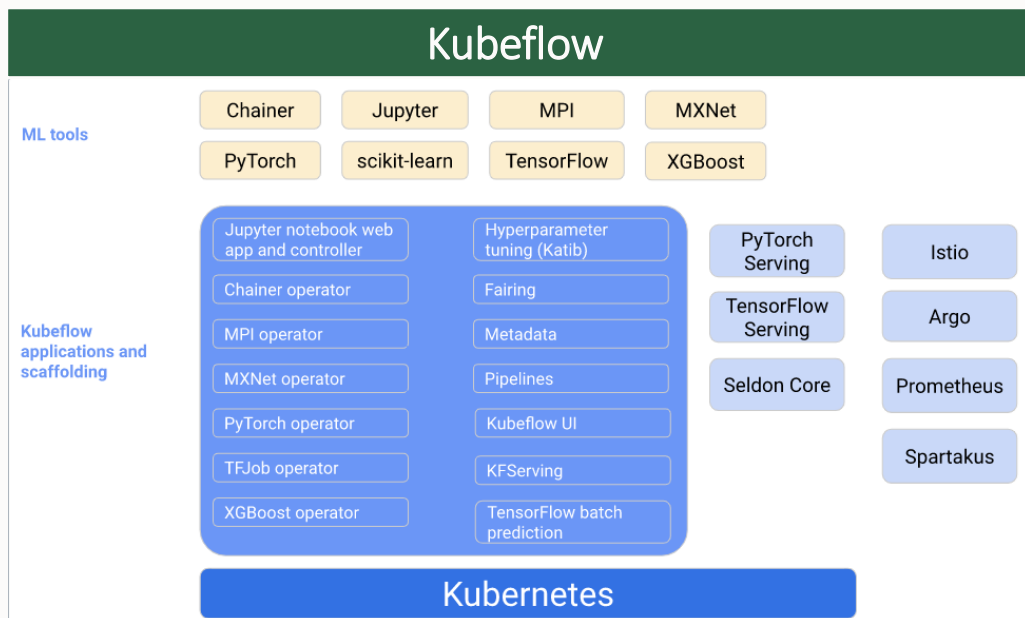
## Docker vs Singularity (on HPC)

- ❖ Docker containers run in full isolation
- ❖ Secure container network fabric
- ❖ Containers host application + mpi libraries within it
- ❖ Fatter images
- ❖ Container native capable
- ❖ Pre-CRI integration with docker/k8s removed from k8s v1.7+
- ❖ HPC with docker containers difficult because it requires mounting host storage to containers

- ❖ Singularity runs interchangeably between host and container
- ❖ Singularity uses host network capabilities
- ❖ Singularity uses application only – uses host mpi libraries /nvidia adapters
- ❖ Thinner images
- ❖ Monolithic but parallelizes
- ❖ Kubernetes integration with open standard CRI-O
- ❖ MPI seamlessly works with singularity



# ML workflow with Kubernetes (Kubeflow)



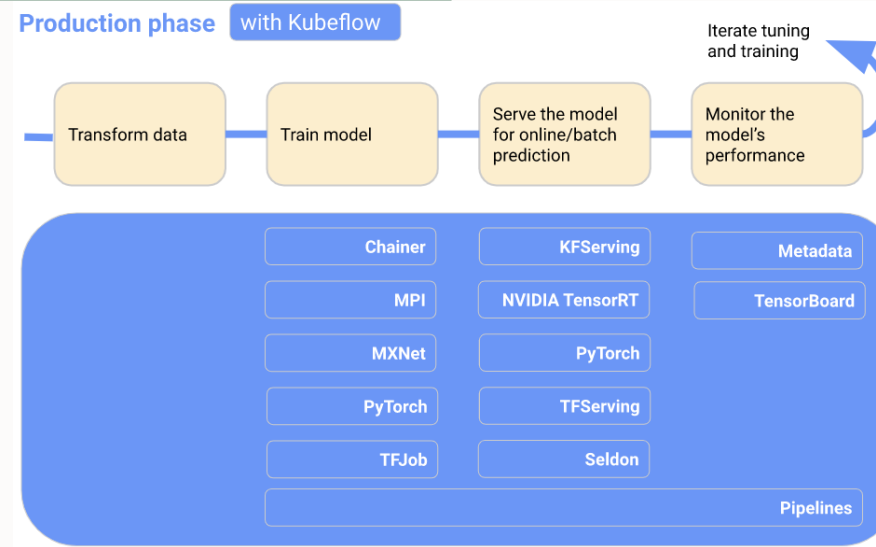
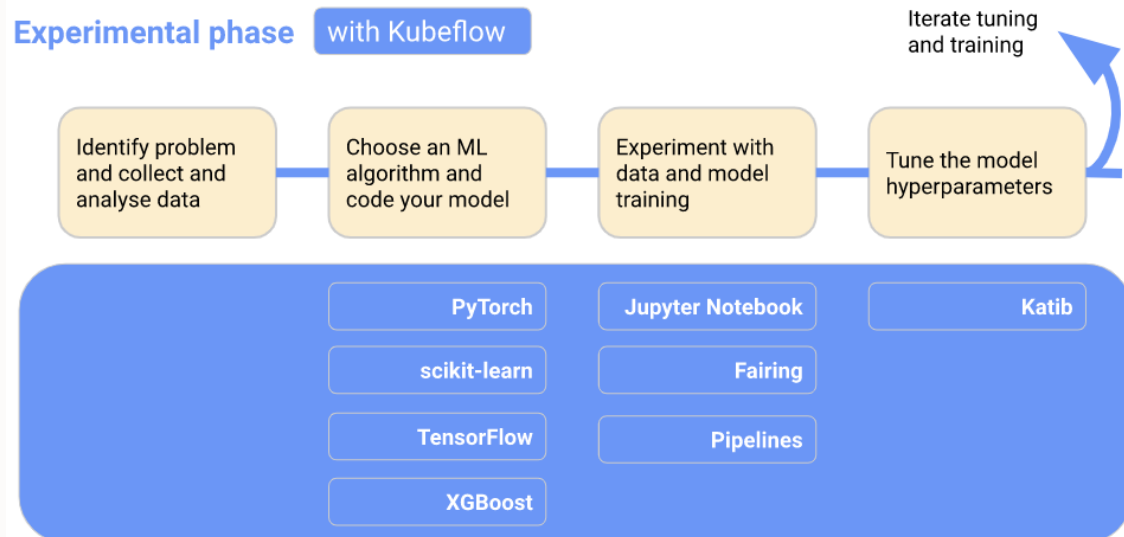
## Kubeflow

- ❖ Scalable machine learning pipelines over Kubernetes
- ❖ Specify any ML tools required in the pipeline
- ❖ Scale containers / pods with Kubernetes at workflow steps
- ❖ Scale from laptop, other clouds, on-premise to Oracle Cloud
- ❖ *Deploy existing IaaS k8s Cluster or OKE (testing/in progress)*

## Kubeflow use-cases for research

- ❖ Deploy and manage complex ML at scale
- ❖ Rapid experimentation to build high quality ML models
- ❖ End to end on-prem and multi-cloud
- ❖ Use built-in hyperparameter tuning (Katib)
- ❖ Create reproducible workflows for consistency

## Workflow phases and components





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## Questions, Answers & Discussion



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**Questions? Comments? Feedback?**

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*Next Tech Talk: Feb 26<sup>th</sup> 2021*

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