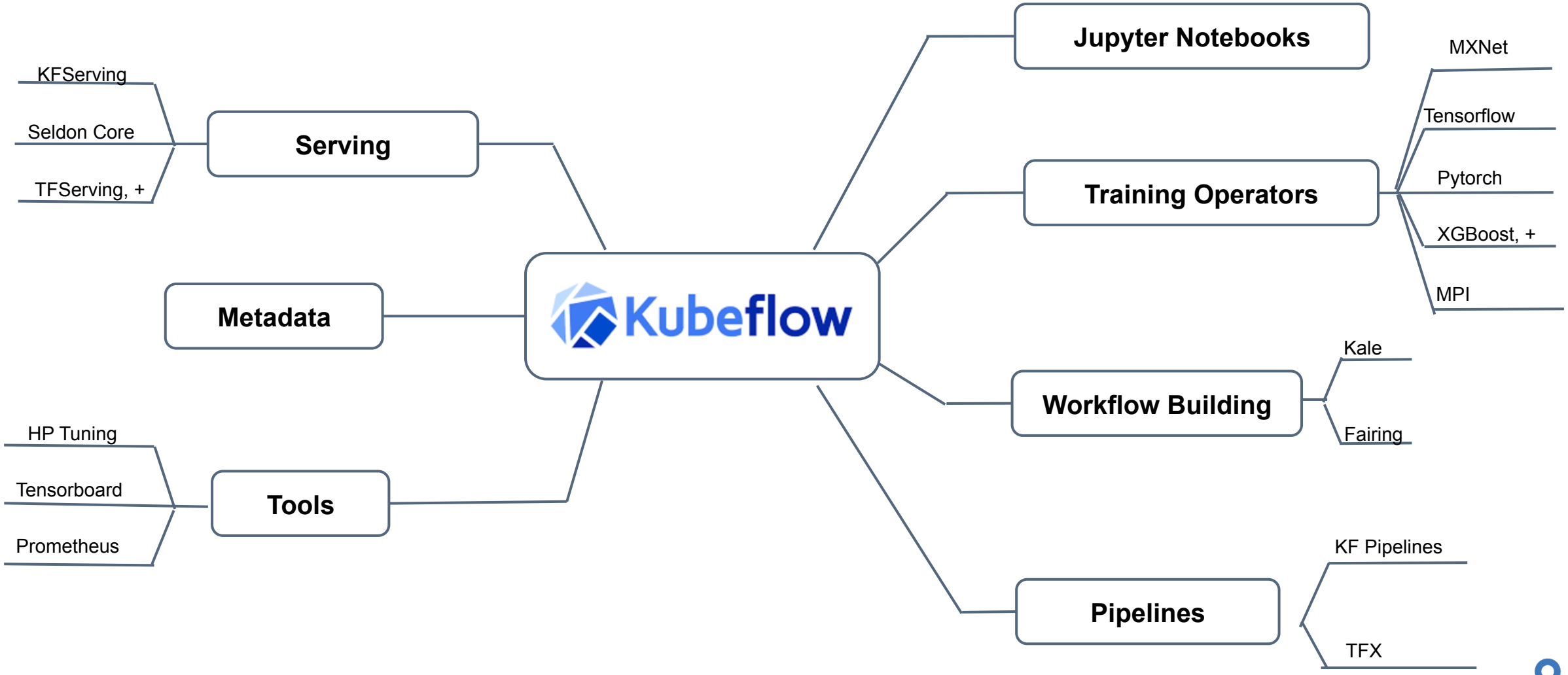
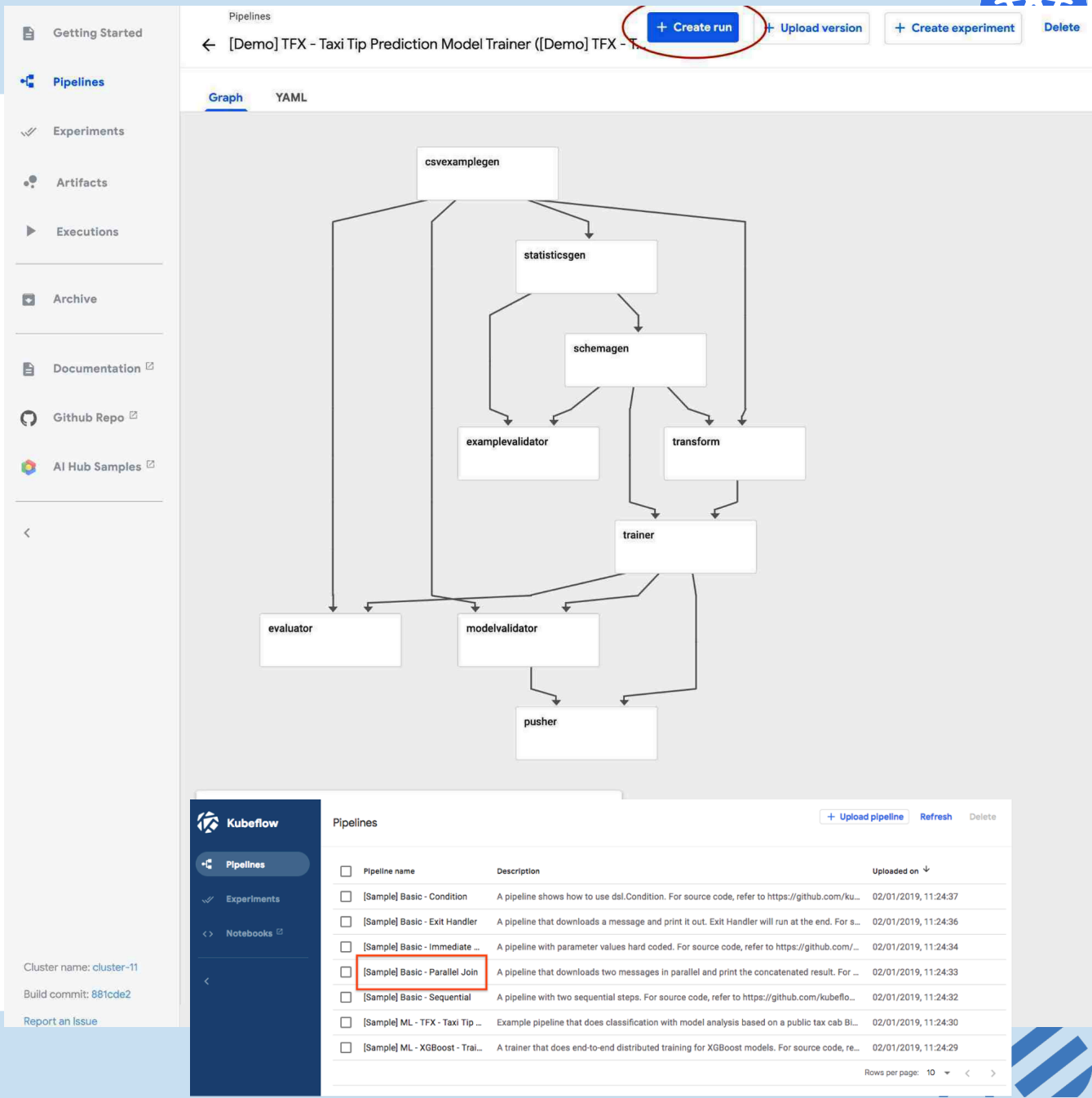
Kubeflow Pipelines and Tekton

Animesh Singh, Christian Kadner, Tommy Li

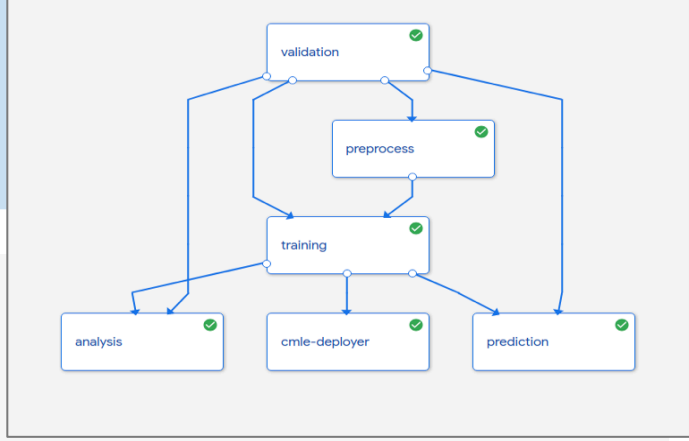


Kubeflow Pipelines

- Containerized implementations of ML Tasks
  - Pre-built components: Just provide params or code snippets (e.g. training code)
  - Create your own components from code or libraries
  - Use any runtime, framework, data types
  - Attach k8s objects - volumes, secrets
- Specification of the sequence of steps
  - Specified via Python DSL
  - Inferred from data dependencies on input/output
- Input Parameters
  - A “Run” = Pipeline invoked w/ specific parameters
  - Can be cloned with different parameters
- Schedules
  - Invoke a single run or create a recurring scheduled pipeline



Define Pipeline with Python SDK

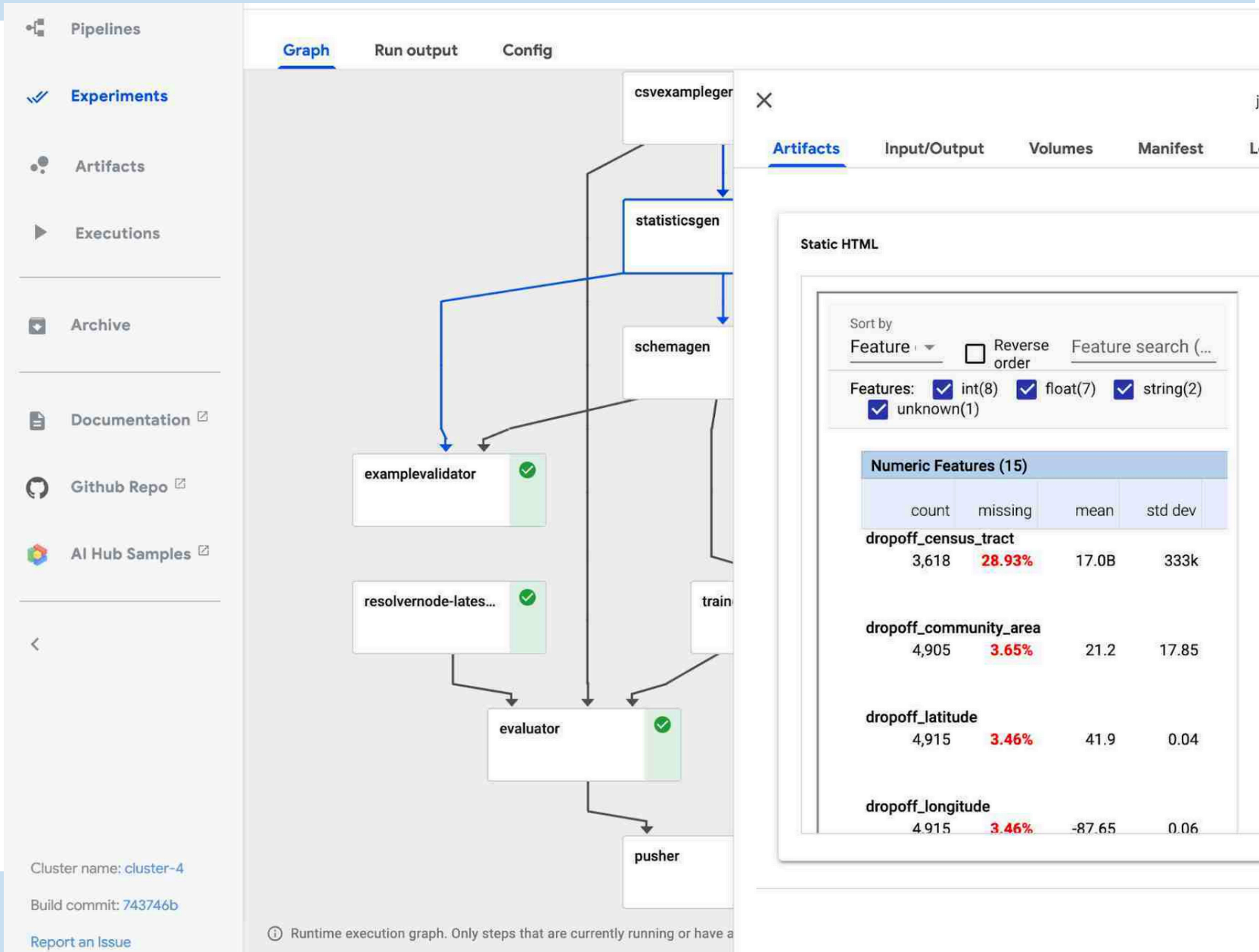



```
@dsl.pipeline(name='Taxi Cab Classification Pipeline Example’)
def taxi_cab_classification(
    output_dir,
    project,
    Train_data      = 'gs://bucket/train.csv',
    Evaluation_data = 'gs://bucket/eval.csv',
    Target          = 'tips',
    Learning_rate   = 0.1, hidden_layer_size = '100,50’, steps=3000):

        tfdv                = TfdvOp(train_data, evaluation_data, project, output_dir)
        preprocess          = PreprocessOp(train_data, evaluation_data, tfdv.output[“schema”], project, output_dir)
        training  = DnnTrainerOp(preprocess.output, tfdv.schema, learning_rate, hidden_layer_size, steps,
                                 target, output_dir)
        tfma                = TfmaOp(training.output, evaluation_data, tfdv.schema, project, output_dir)
        deploy    = TfServingDeployerOp(training.output)
```

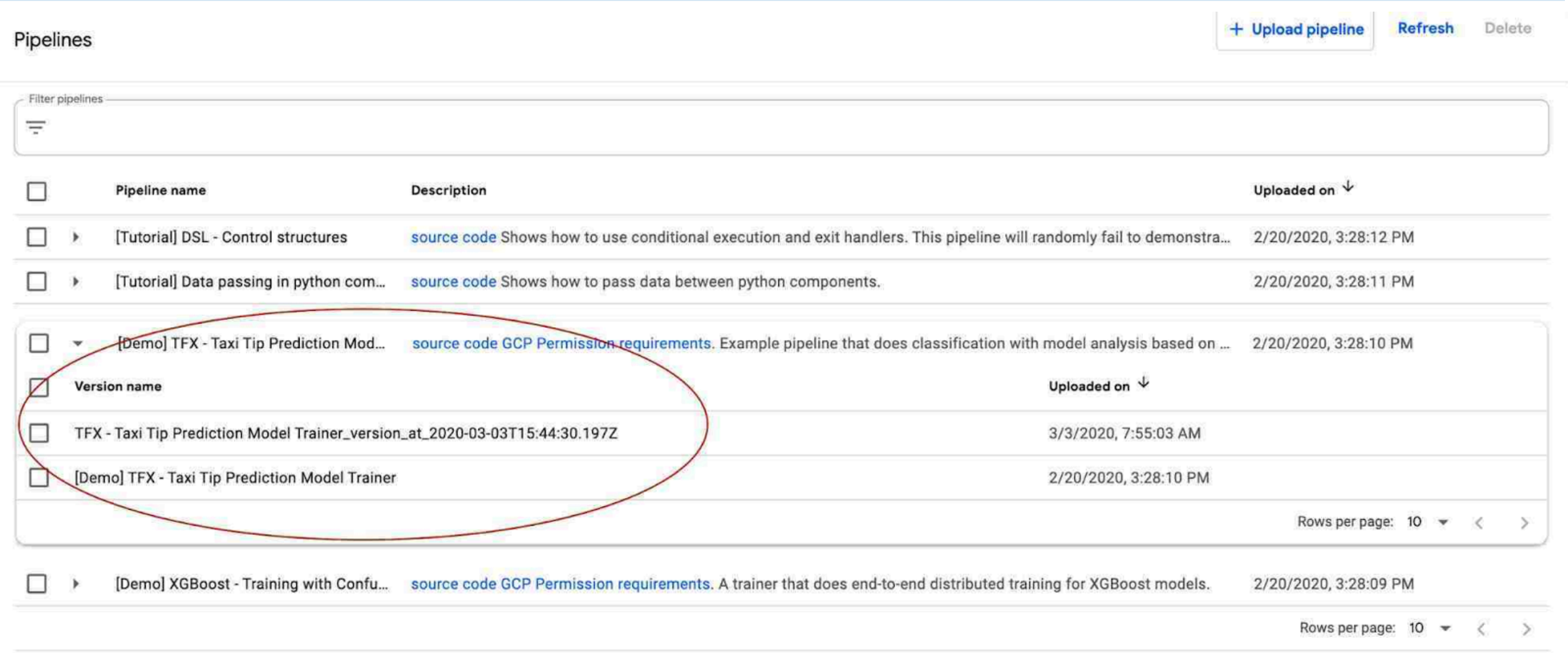
Compile and Submit Pipeline Run

```
dsl.compile(taxi_cab_classification,  'tfx.tar.gz')
run = client.run_pipeline(
      'tfx_run', 'tfx.tar.gz', params={'output': ‘gs://dpa22’, 'project': ‘my-project-33’})
```

Visualize the state of various components

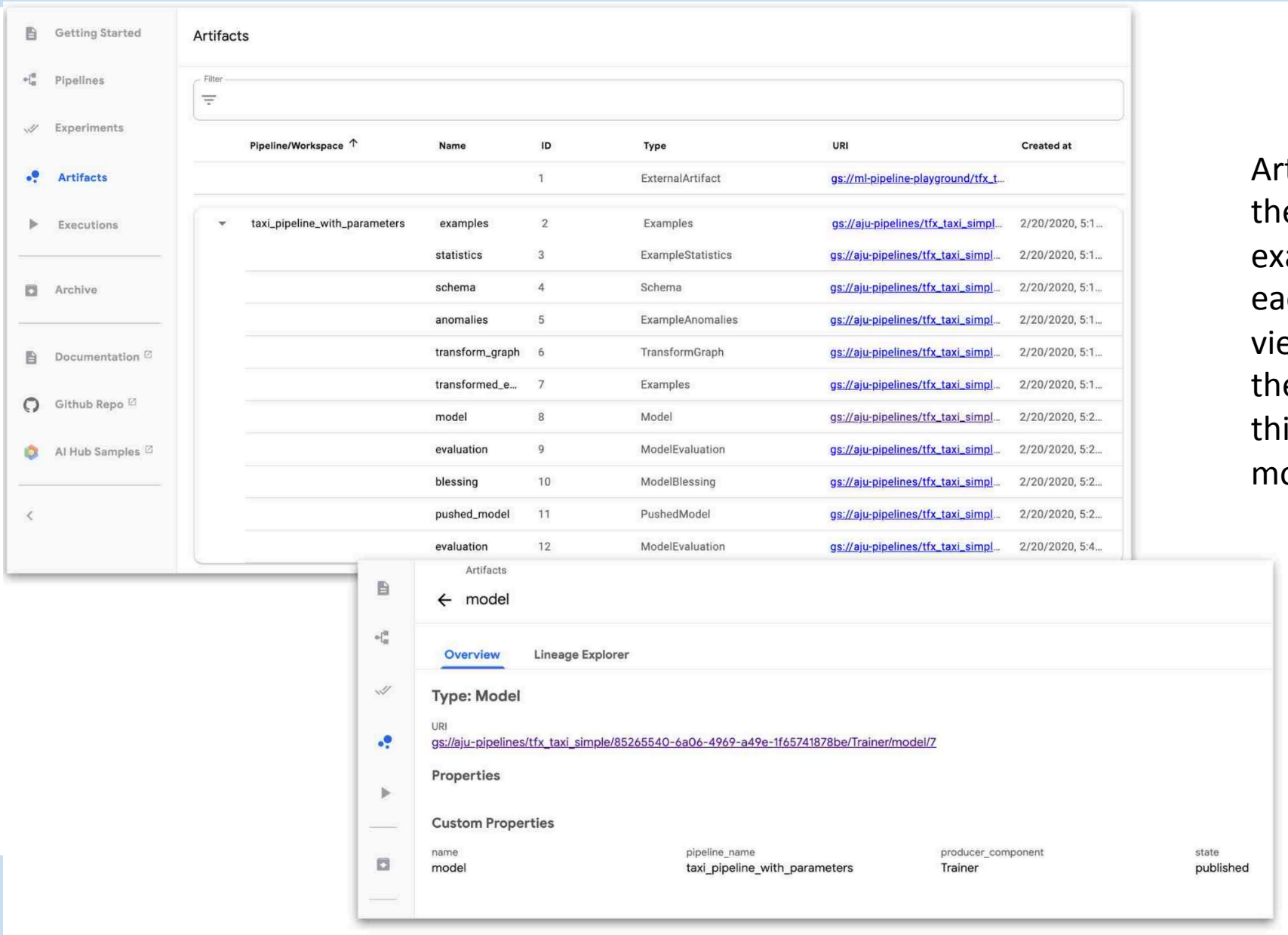


Pipelines versioning



Pipelines lets you group and manage multiple versions of a pipeline.

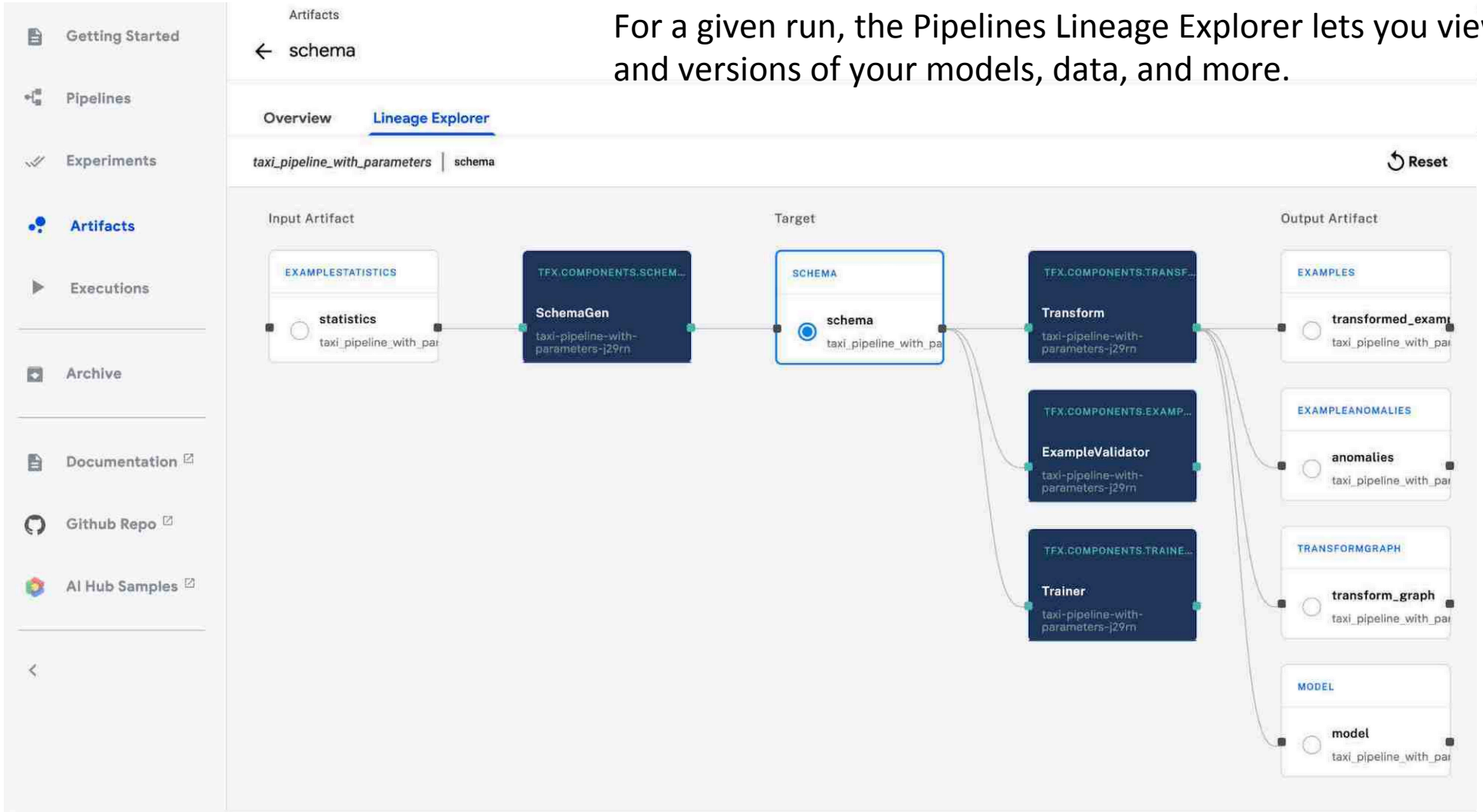
Artifact Tracking



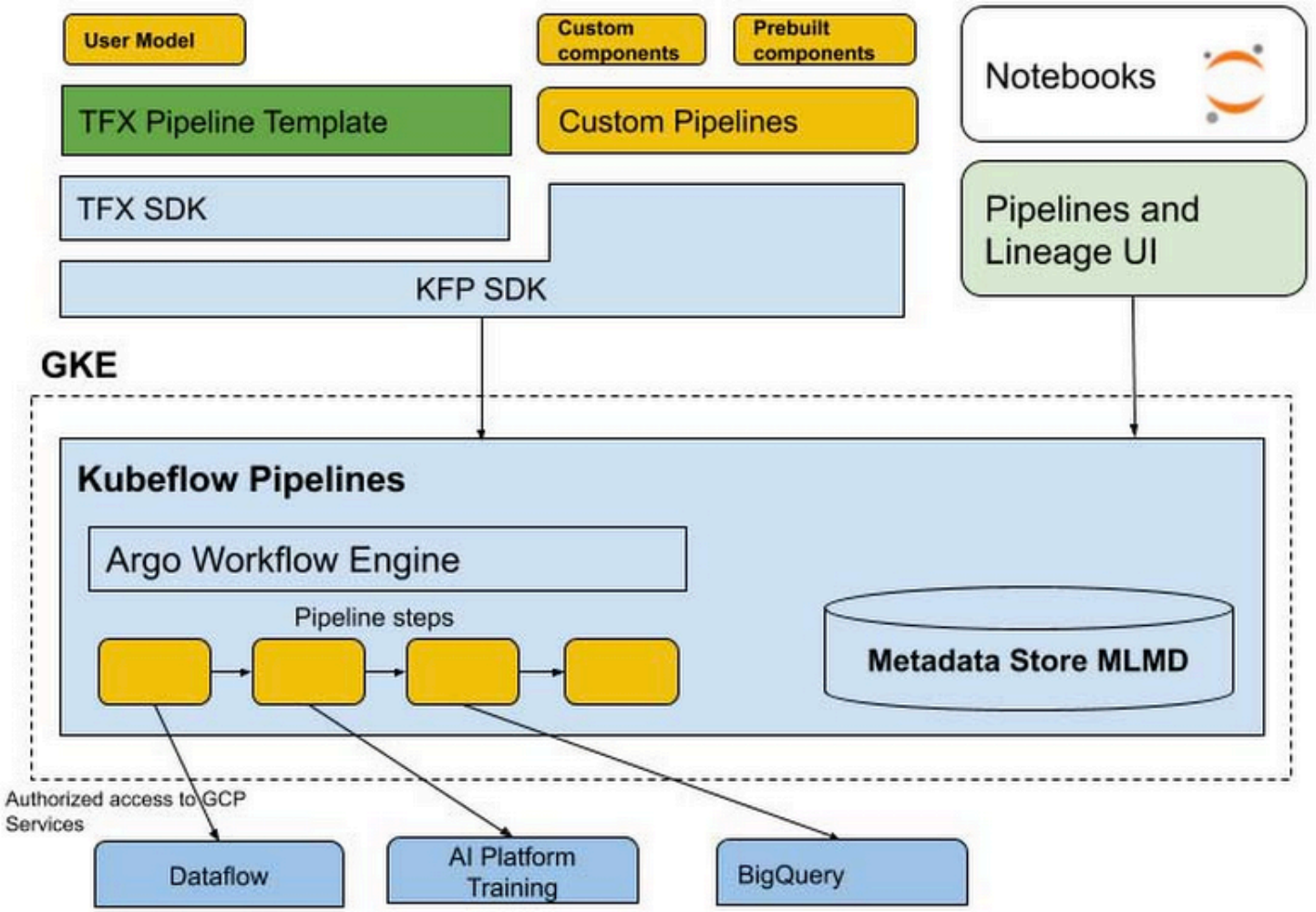
Artifacts for a run of the “TFX Taxi Trip” example pipeline. For each artifact, you can view details and get the artifact URL—in this case, for the model.

Lineage Tracking

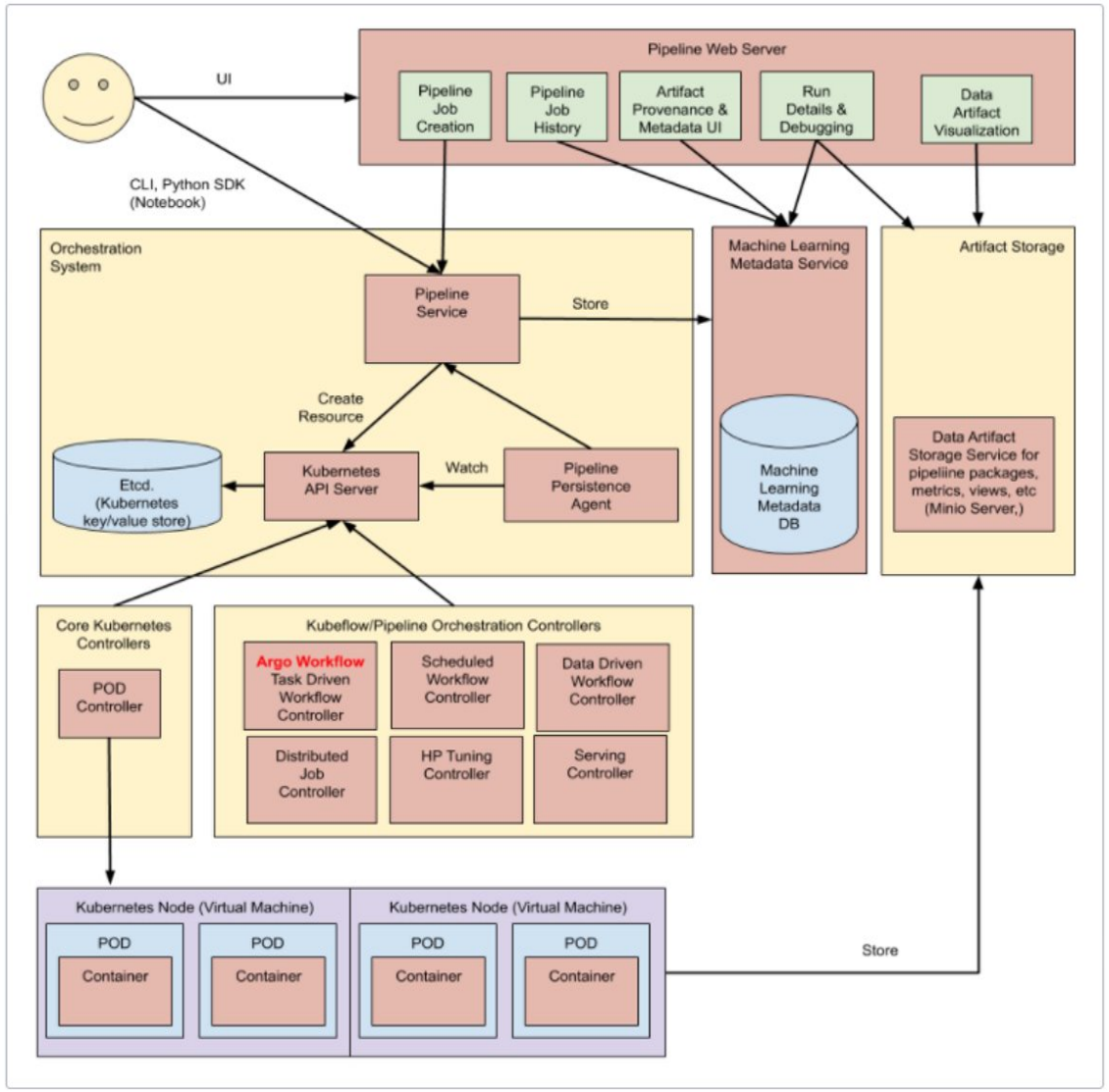
For a given run, the Pipelines Lineage Explorer lets you view the history and versions of your models, data, and more.



Kubeflow Pipeline Architecture

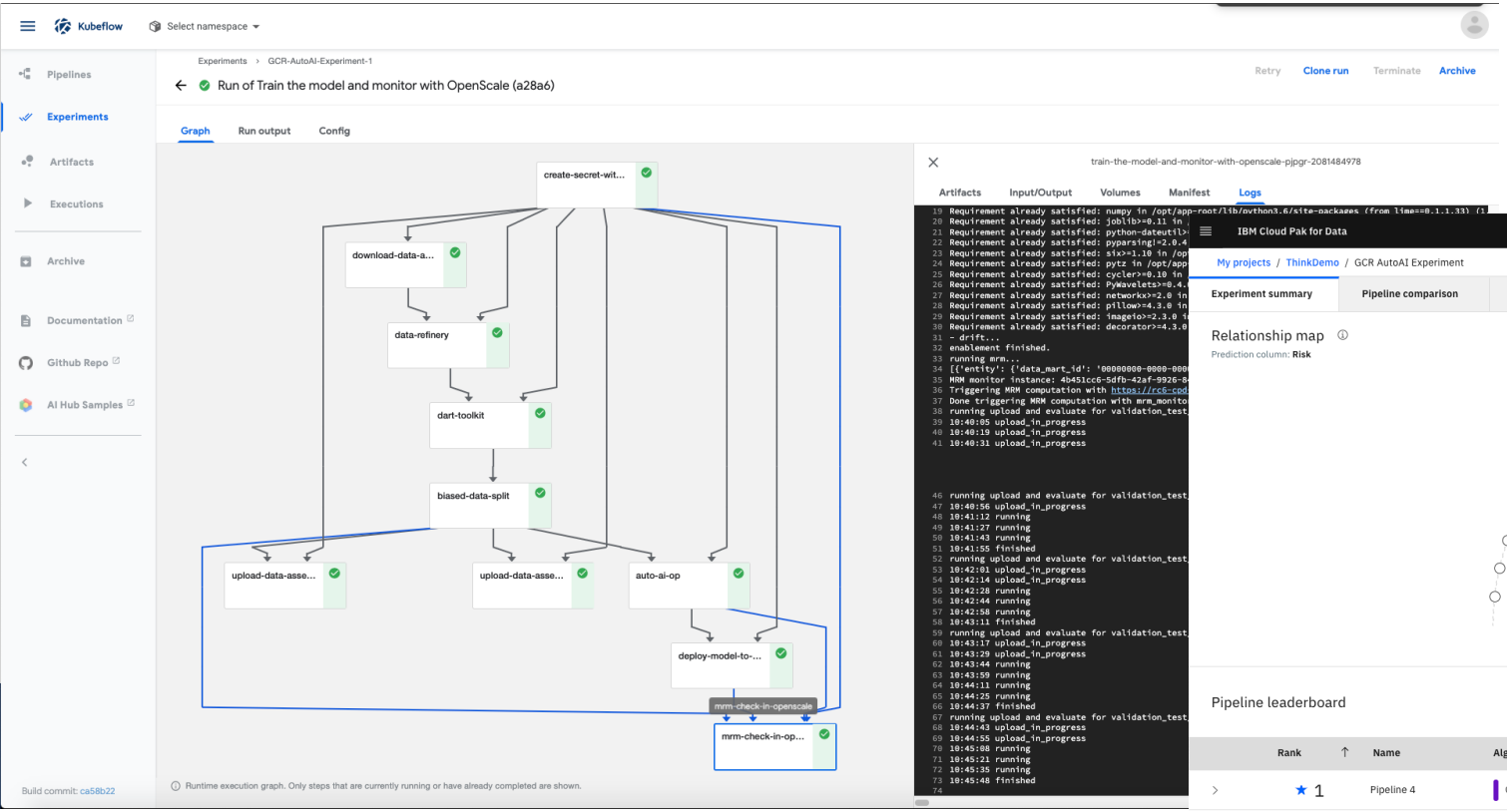


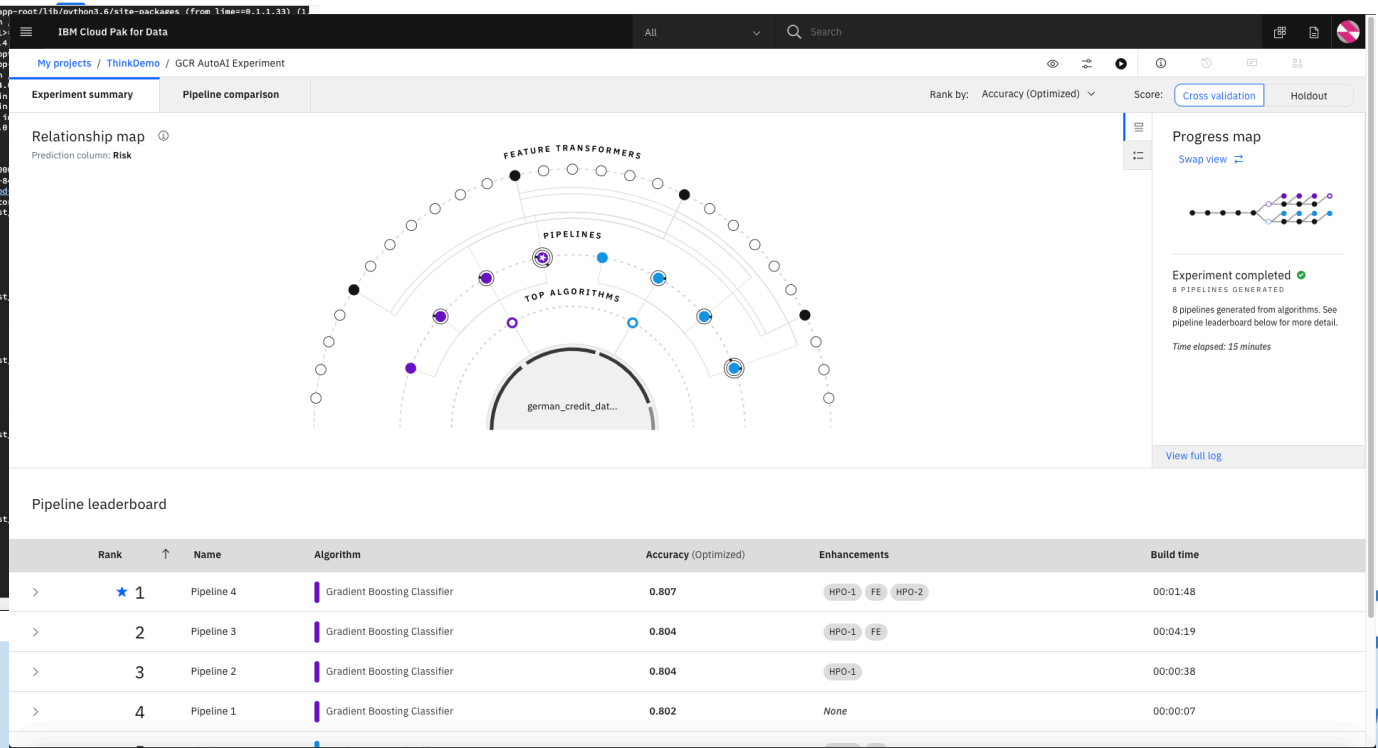
Kubeflow Pipeline Architecture



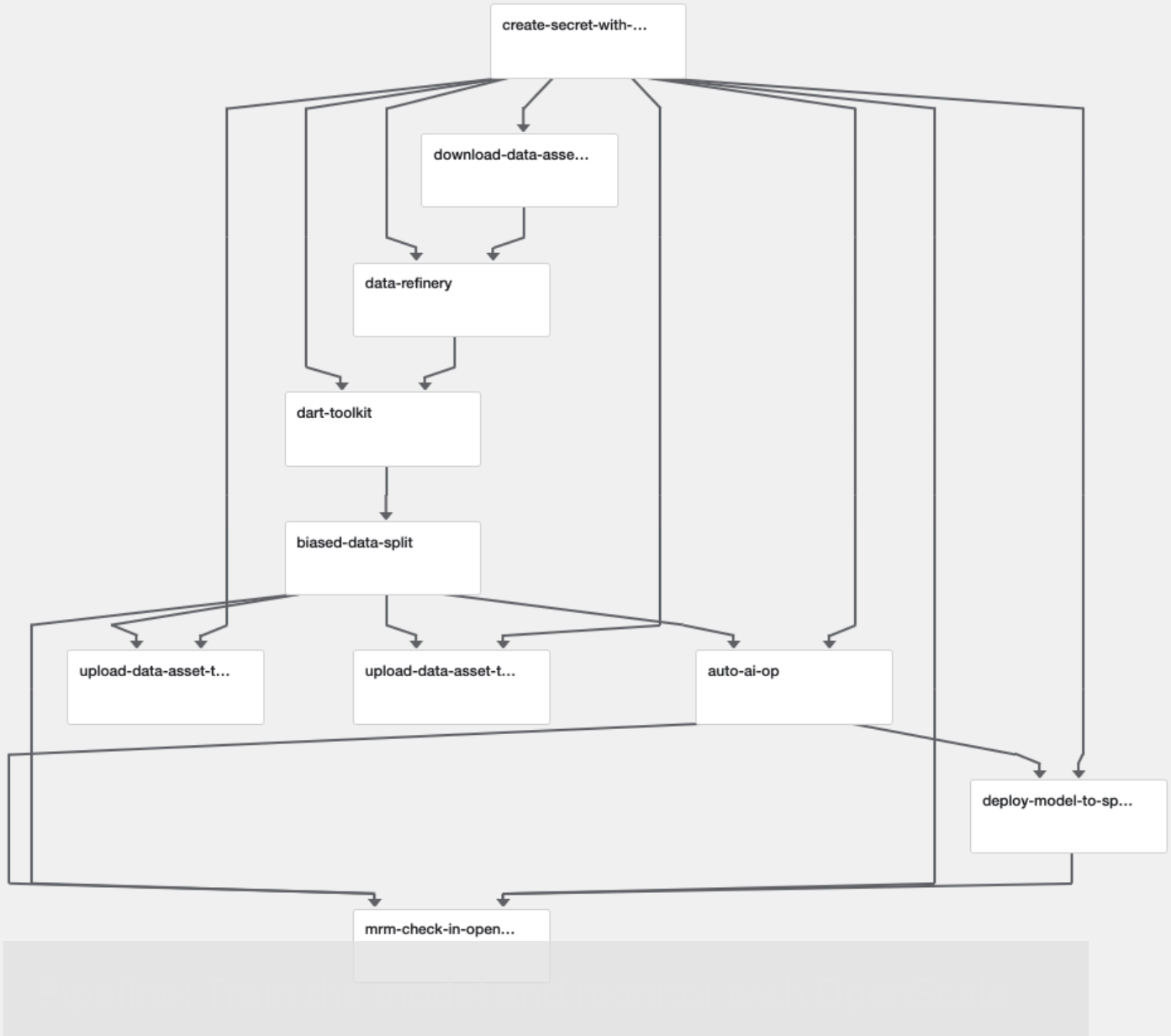
Goals

- Demonstrate that Watson can be used for end-end AI lifecycledata prep/model training/model risk validation/model deployment/monitoring/updating models
- Demonstrate that the full lifecycle can be operated programmatically, and have **Tekton** as a backend instead of Argo





Graph Source



Show summary Static pipeline graph

Run details

Pipeline *
Train the model and monitor with OpenScale Choose

Pipeline Version *
Train the model and monitor with OpenScale Choose

Run name *
Run of Train the model and monitor with OpenScale (a28a6)

Description (optional)

This run will be associated with the following experiment

Experiment *
GCR-AutoAI-Experiment-1 Choose

Run Type

(•) One-off ( ) Recurring

Run parameters

Specify parameters required by the pipeline

github_token
6fd86cff0394892e772cd84d43a9e2d7546b1576

ai_config_url
https://raw.github.ibm.com/AI-Lifecycle-Poland/kubeflow-pipelines-credentials/master/config_cpd

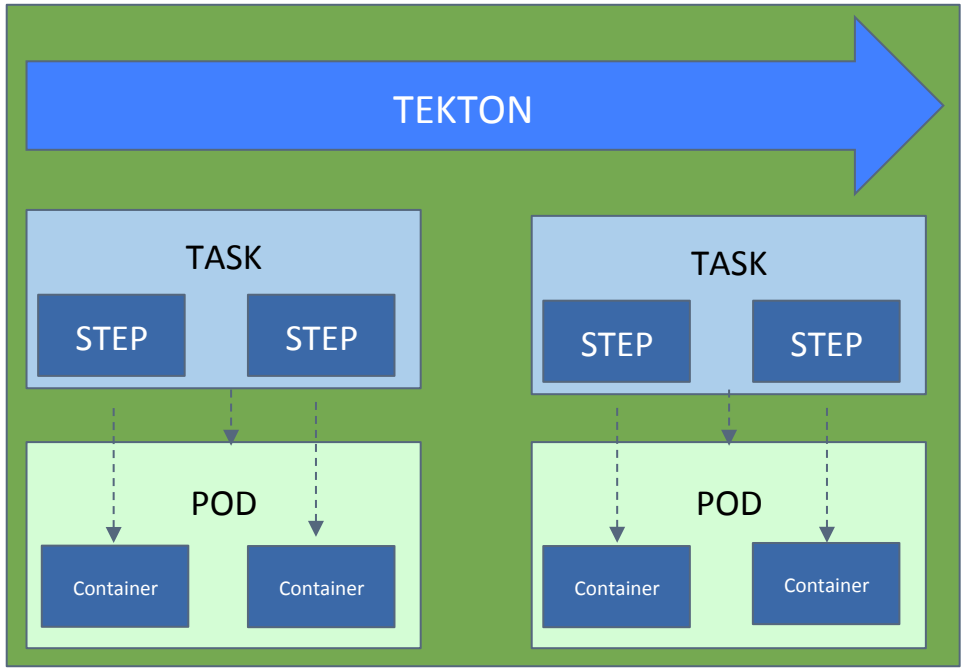
catalog_name
DataCatalog

asset_id
2737bafc-3f78-4e2d-850a-e7f352b3d6b8

pre_production_space_uid
1dd2aaec-781a-4712-a7ff-ae1862cf7a84

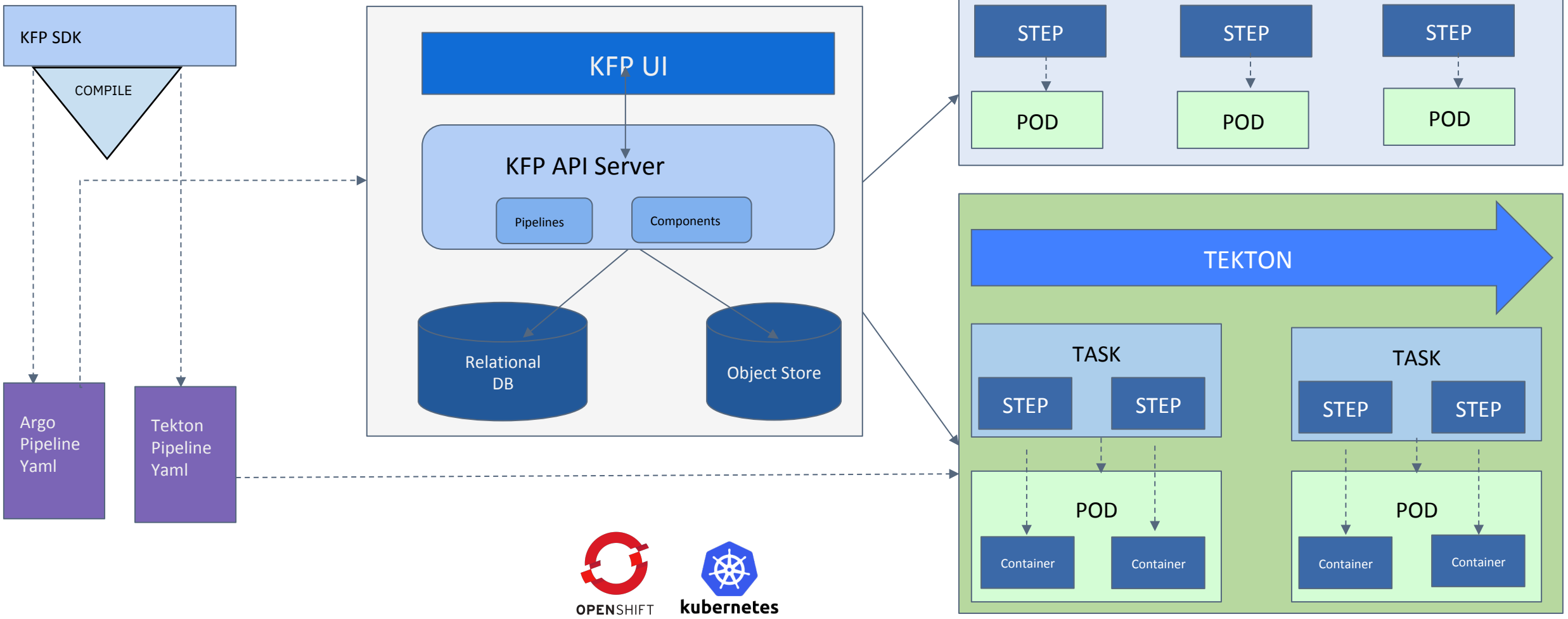
Tekton

- The Tekton Pipelines project provides Kubernetes-style resources for declaring CI/CD-style pipelines.
- Tekton introduces several new CRDs including Task, Pipeline, TaskRun, and PipelineRun.
- A PipelineRun represents a single running instance of a Pipeline and is responsible for creating a Pod for each of its Tasks and as many containers within each Pod as it has Steps.



- A **PipelineResource** defines an object that is an input (such as a git repository) or an output (such as a docker image) of the pipeline.
- A **PipelineRun** defines an execution of a pipeline. It references the Pipeline to run and the PipelineResources to use as inputs and outputs.
- A **Pipeline** defines the set of Tasks that compose a pipeline.
- A **Task** defines a set of build Steps such as compiling code, running tests, and building and deploying images.

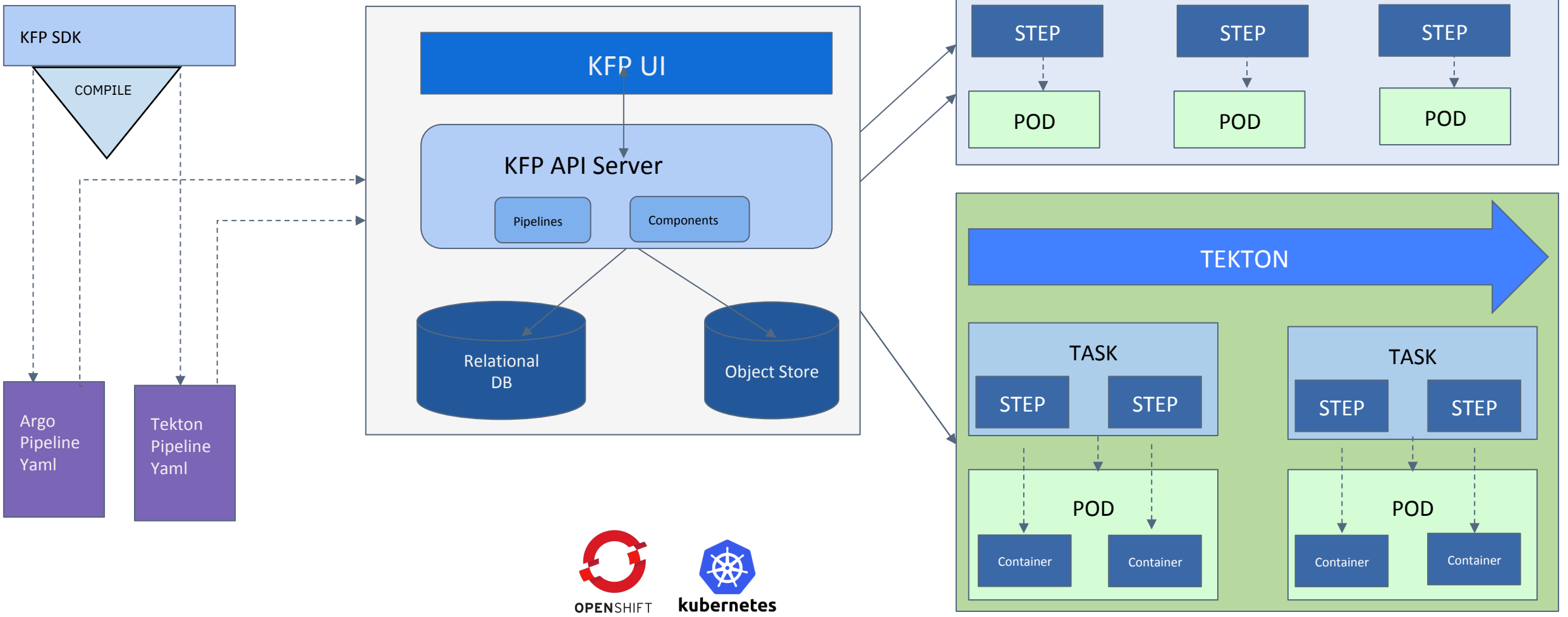
KFP – Tekton Phase One



Pluggable Components

Spark | Watson Studio | WML | Open Scale | Kubeflow Training | Seldon | AIF360 | ART | KATIB | KFSERVING | ...

KFP – Tekton Phase Two



Pluggable Components

Spark | Watson Studio | WML | Open Scale | Kubeflow Training | Seldon | AIF360 | ART | KATIB | KFSERVING | ...

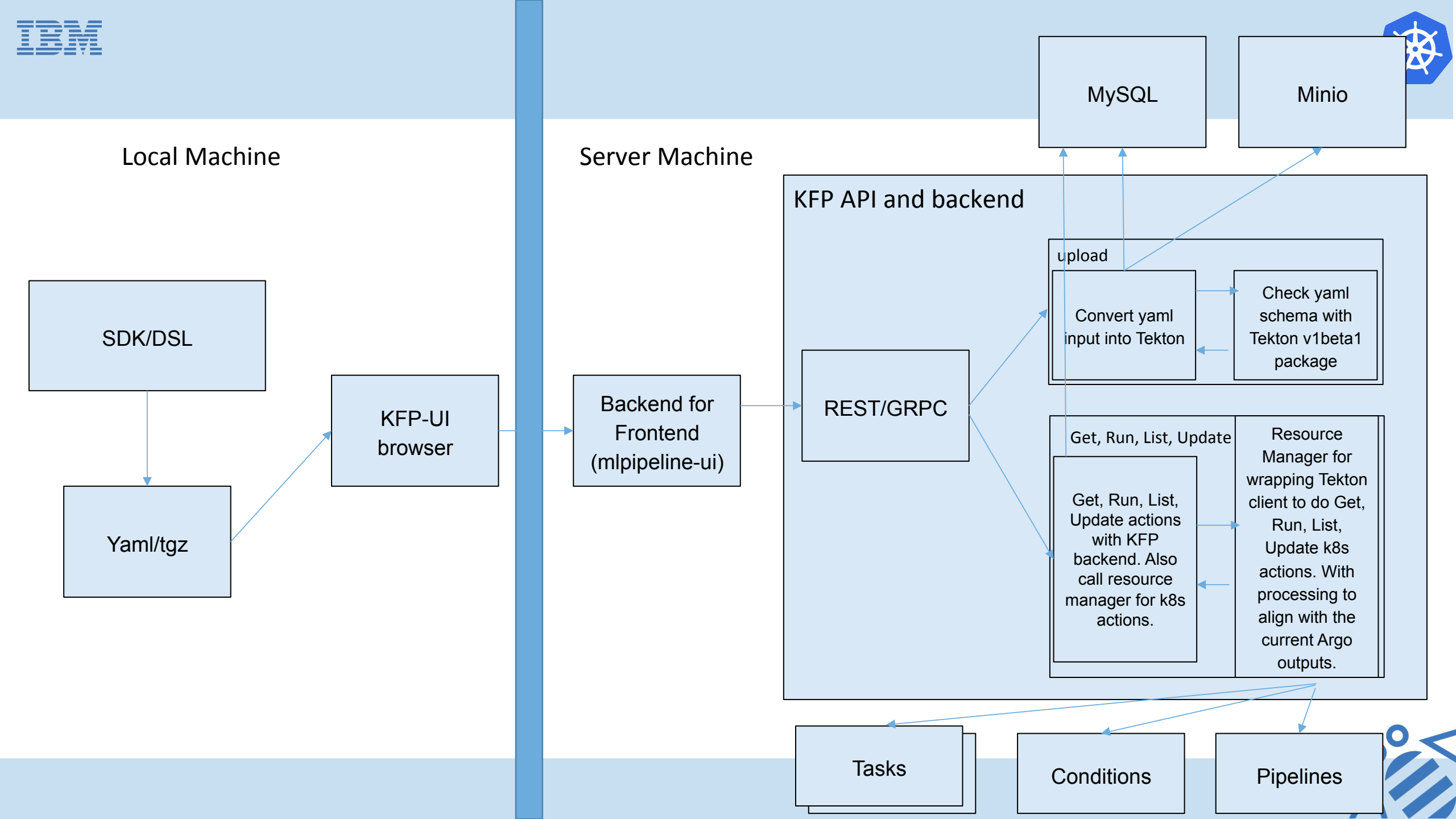
DSL features implemented

- Pipeline DSL features with native Tekton implementation
  - pod_annotations and pod_labels
  - Retries
  - Volumes
  - Timeout for Tasks and Pipelines
  - RunAfter
  - Input Parameters
  - ContainerOp
  - Affinity, Node Selector, and Tolerations
- Pipeline DSL features with custom Tekton implementation
  - Features with same behavior as Argo
    - InitContainers
    - Conditions
    - ResourceOp, VolumeOp, and VolumeSnapshotOp
    - Output Parameters
    - Input Artifacts
    - Output Artifacts
  - Features with limitations
    - ParallelFor - Tracking issue
    - Variable Substitutions - Tracking issue
    - ImagePullSecrets - Tracking issue
  - Features with different behavior than Argo
    - Sidecars - Tracking issue
- Pipeline features that are unavailable on Tekton
  - Exit Handler - Tracking PR

Pipeline samples we are running

- MNIST End to End example with Kubeflow components
- Hyperparameter tuning using Katib
- Trusted AI Pipeline with AI Fairness 360 and Adversarial Robustness 360 components
- Training and Serving Models with Watson Machine Learning
- Lightweight python components example
- The flip-coin pipeline
- Nested pipeline example

https://github.com/kubeflow/kfp-tekton/blob/master/samples/README.md


Local Machine
Server Machine
SDK/DSL
Yaml/tgz
KFP-UI browser
Backend for Frontend (mlpipeline-ui)
MySQL
Minio
KFP API and backend
REST/GRPC
upload
Convert yaml input into Tekton
Check yaml schema with Tekton v1beta1 package
Get, Run, List, Update
Get, Run, List, Update actions with KFP backend. Also call resource manager for k8s actions.
Resource Manager for wrapping Tekton client to do Get, Run, List, Update k8s actions. With processing to align with the current Argo outputs.
Tasks
Conditions
Pipelines

In [12]:
```
kfp.Client(host="169.62.93.163").run_pipeline(experiment_id="74f7f363-96f8-487e-8632-4980b0971c7a",
                                              job_name="sample-job",
                                              pipeline_id="e684bc9e-cb30-4a3e-88f7-5c768202e6b7")
```

Run link here

Out[12]:
```
{'created_at': datetime.datetime(2020, 5, 22, 0, 7, 46, tzinfo=tzutc()),
 'description': None,
 'error': None,
 'finished_at': datetime.datetime(1970, 1, 1, 0, 0, tzinfo=tzutc()),
 'id': '752ed34b-4ade-4654-b7d7-829618edd530',
 'metrics': None,
 'name': 'sample-job',
 'pipeline_spec': {'parameters': None,
                   'pipeline_id': 'e684bc9e-cb30-4a3e-88f7-5c768202e6b7',
                   'pipeline_manifest': None,
                   'pipeline_name': 'tekton-parameters',
                   'workflow_manifest': '{"kind":"PipelineRun","apiVersion":"tekton.dev/v1beta1","metadata":{"nam
e":"pipelinerun-with-taskspec-to-echo-message","creationTimestamp":null},"spec":{"pipelineSpec":{"tasks":[{"name":"ec
ho-message","taskSpec":{"params":[{"name":"MESSAGE","type":"string","default":"Hello '
                                  'World!"}],"steps":[{"name":"echo","image":"ubuntu","resources":{},"scrip
```

Experiments

+ Create run | + Create experiment | Compare runs | Clone run | Archive | Refresh

All experiments | All runs

Filter experiments

Experiment name	Description	Last 5 runs
Default	All runs created without specifying an experiment will be grouped here.	

Run name	Status	Duration	Pipeline Version	Recurring Run	Start time
sample-job	?	-	tekton-parameters	-	5/21/2020, 5:07:46 PM

Pipelines

watson-ml-pipeline (watson-ml-pipeline)

+ Create run | + Upload version | + Create experiment | Delete

Graph | YAML

Summary

Hide

ID
c377cb85-0120-443c-972f-04ae642d452a
Version
watson-ml-pipeline
Version source
Uploaded on
5/26/2020, 4:42:19 PM
Description

deploy-model-watson-machine-learning

Input parameters

model_name	
scoring_payload	
store-model-watson-machine-learning-model_uid	

Output parameters

scoring-endpoint	/tmp/outputs/scoring_endpoint/data
model-uid	/tmp/outputs/model_uid/data

Arguments

```
-u
/app/wml-deploy.py
--model-uid
$(inputs.params.store-model-watson-machine-learning-model_uid)
--model-name
$(inputs.params.model_name)
--scoring-payload
$(inputs.params.scoring_payload)
--deployment-name
--output-scoring-endpoint-path
$(results.scoring-endpoint.path)
--output-model-uid-path
$(results.model-uid.path)
```

Command

```
python
```

Image

```
docker.io/aipipeline/wml-deploy:latest
```

Volume Mounts

Pipelines

watson-ml-pipeline (watson-ml-pipeline)

+ Create run | + Upload version | + Create experiment | Delete

Graph | YAML

```yaml
apiVersion: tekton.dev/v1beta1
kind: PipelineRun
metadata:
  name: kfp-on-wml-training-run
spec:
  params:
  - name: GITHUB_TOKEN
    value: ''
  - name: CONFIG_FILE_URL
    value: https://raw.githubusercontent.com/user/repository/branch/creds.ini
  - name: train_code
    value: tf-model.zip
  - name: execution_command
    value: '''python3 convolutional_network.py --trainImagesFile ${DATA_DIR}/train-images-idx3-ubyte.gz
      --trainLabelsFile ${DATA_DIR}/train-labels-idx1-ubyte.gz --testImagesFile ${DATA_DIR}/t10k-images-idx3-ubyte.gz
      --testLabelsFile ${DATA_DIR}/t10k-labels-idx1-ubyte.gz --learningRate 0.001
      --trainingIters 20000'''
  - name: framework
    value: tensorflow
  - name: framework_version
    value: '1.15'
  - name: runtime
    value: python
  - name: runtime_version
    value: '3.6'
  - name: run_definition
    value: wml-tensorflow-definition
  - name: run_name
    value: wml-tensorflow-run
  - name: model_name
    value: wml-tensorflow-mnist
  - name: scoring_payload
    value: tf-mnist-test-payload.json
  - name: compute_name
    value: k80
  - name: compute_nodes
    value: '1'
  pipelineSpec:
    params:
    - default: ''
      name: GITHUB_TOKEN
    - default: https://raw.githubusercontent.com/user/repository/branch/creds.ini
      name: CONFIG_FILE_URL
    - default: tf-model.zip
      name: train_code
    - default: '''python3 convolutional_network.py --trainImagesFile ${DATA_DIR}/train-images-idx3-ubyte.gz
        --trainLabelsFile ${DATA_DIR}/train-labels-idx1-ubyte.gz --testImagesFile ${DATA_DIR}/t10k-images-idx3-ubyte.gz
        --testLabelsFile ${DATA_DIR}/t10k-labels-idx1-ubyte.gz --learningRate 0.001
        --trainingIters 20000'''
      name: execution_command
    - default: tensorflow
```

Pipelines

Experiments

Artifacts

Executions

Archive

Documentation

Github Repo

AI Hub Samples

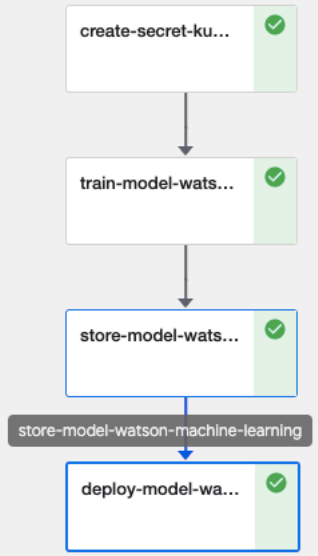
Build commit: unknown

Report an Issue

Run of watson-ml-pipeline (444a2)

Retry | Clone run | Terminate | Archive

Graph | Run output | Config

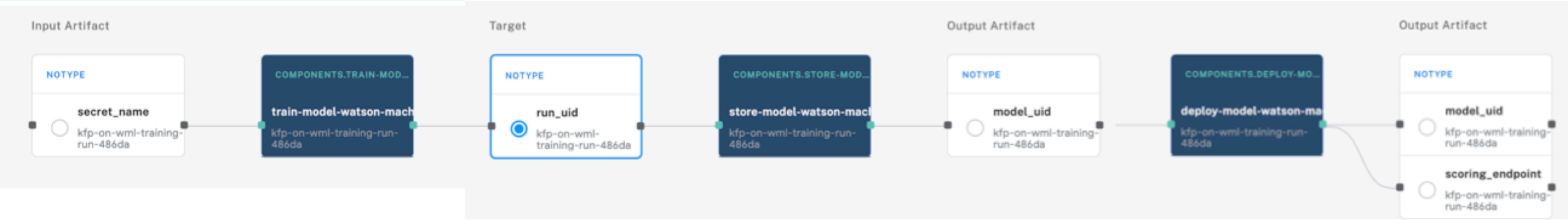


Runtime execution graph. Only steps that are currently running or have already comp

kfp-on-wml-training-run-c2934-deploy-model-watson-machine-8v52x

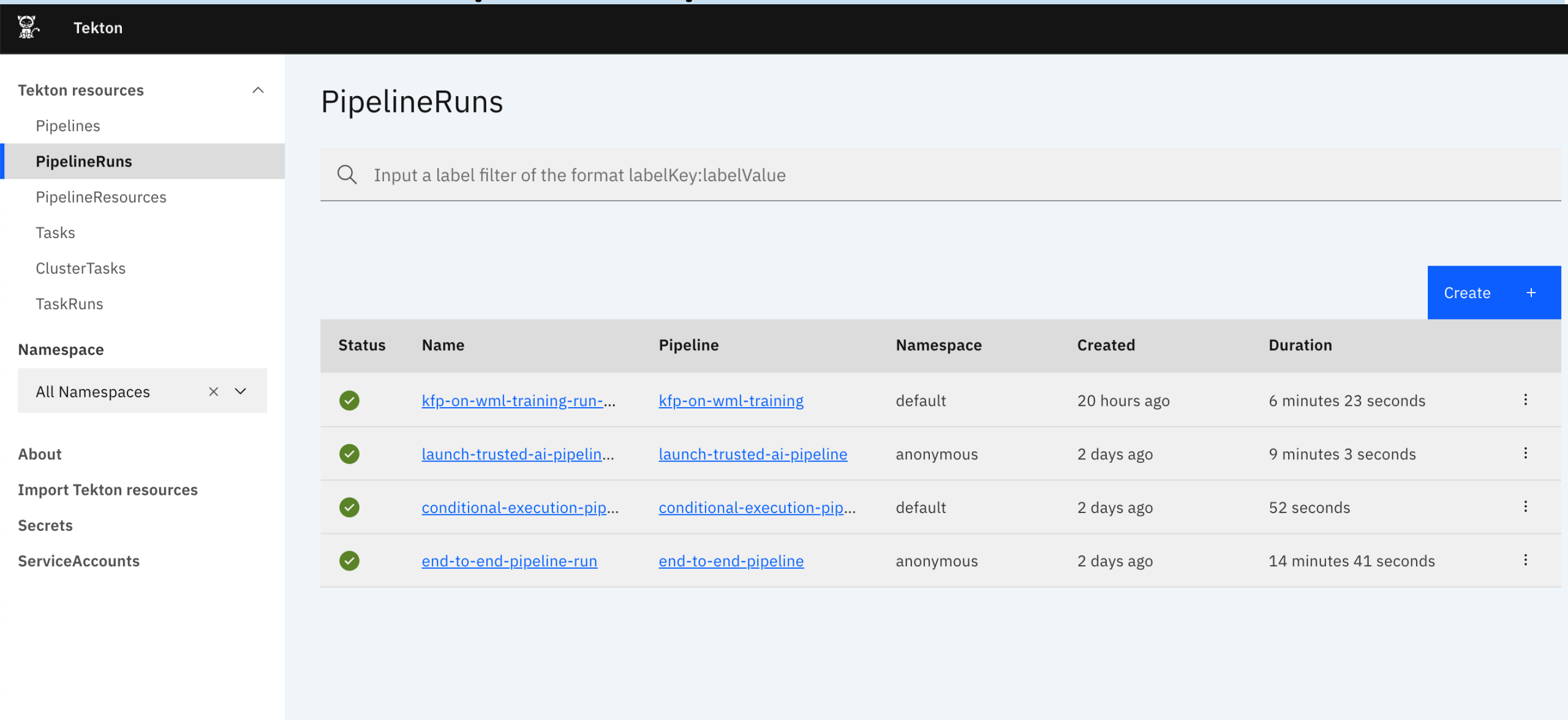
Artifacts | Input/Output | ML Metadata | Volumes | Manifest | Logs | Pod | Events

```
--------------------------------------  --------------------  -----  ------------------------  -------------
GUID                                    NAME                  STATE  CREATED                   ARTIFACT_TYPE
702d4b5c-075c-4114-b119-96a23a674e35    wml-tensorflow-mnist  ready  2020-03-19T20:42:52.406Z  model
4f635147-da34-4f38-ac39-18116288c6cd    wml-tensorflow-mnist  ready  2020-03-19T19:56:39.104Z  model
8381bf0c-776a-4c21-af1f-2c7a21334ee1    wml-tensorflow-mnist  ready  2020-03-19T19:55:44.681Z  model
8bb3f49c-2b2a-4e2d-88cd-045e139e78c6    wml-tensorflow-mnist  ready  2020-03-19T19:39:52.485Z  model
2e854faf-b091-49f3-858d-0f1d996cbda3    wml-tensorflow-mnist  ready  2020-03-19T01:25:13.537Z  model
--------------------------------------  --------------------  -----  ------------------------  -------------


################################################################################

Synchronous deployment creation for uid: 'bb170958-a27b-4001-b5d3-6fda6d4265a9' started

################################################################################


initializing
ready


-----------------------------------------------------------------------------------------------
Successfully finished deployment creation, deployment_uid='170be98d-1135-4ff9-b8e4-a9833fc7f524'
-----------------------------------------------------------------------------------------------


deployment_uid:  170be98d-1135-4ff9-b8e4-a9833fc7f524
Scoring result:
{'predictions': [{'values': [5, 4]}]}

```



kfp-on-wml-training-run-486da	secret_name	11	NoType	minio://mlpipeline/artifacts/kfp…	6/14/2020, 7:…
	run_uid	12	NoType	minio://mlpipeline/artifacts/kfp…	6/14/2020, 7:1…
	training_uid	13	NoType	minio://mlpipeline/artifacts/kfp…	6/14/2020, 7:1…
	model_uid	14	NoType	minio://mlpipeline/artifacts/kfp…	6/14/2020, 7:1…
	model_uid	15	NoType	minio://mlpipeline/artifacts/kfp…	6/14/2020, 7:2…
	scoring_endp…	16	NoType	minio://mlpipeline/artifacts/kfp…	6/14/2020, 7:2…

Compiled Pipelines on Tekton



Running Pipelines on Tekton

Tekton

Tekton resources

- Pipelines
- **PipelineRuns**
- PipelineResources
- Tasks
- ClusterTasks
- TaskRuns

Namespace

default

About

Import Tekton resources

Secrets

ServiceAccounts

kfp-on-wml-training-run-p7n6f 20 hours ago

Rerun

Succeeded Tasks Completed: 4, Skipped: 0

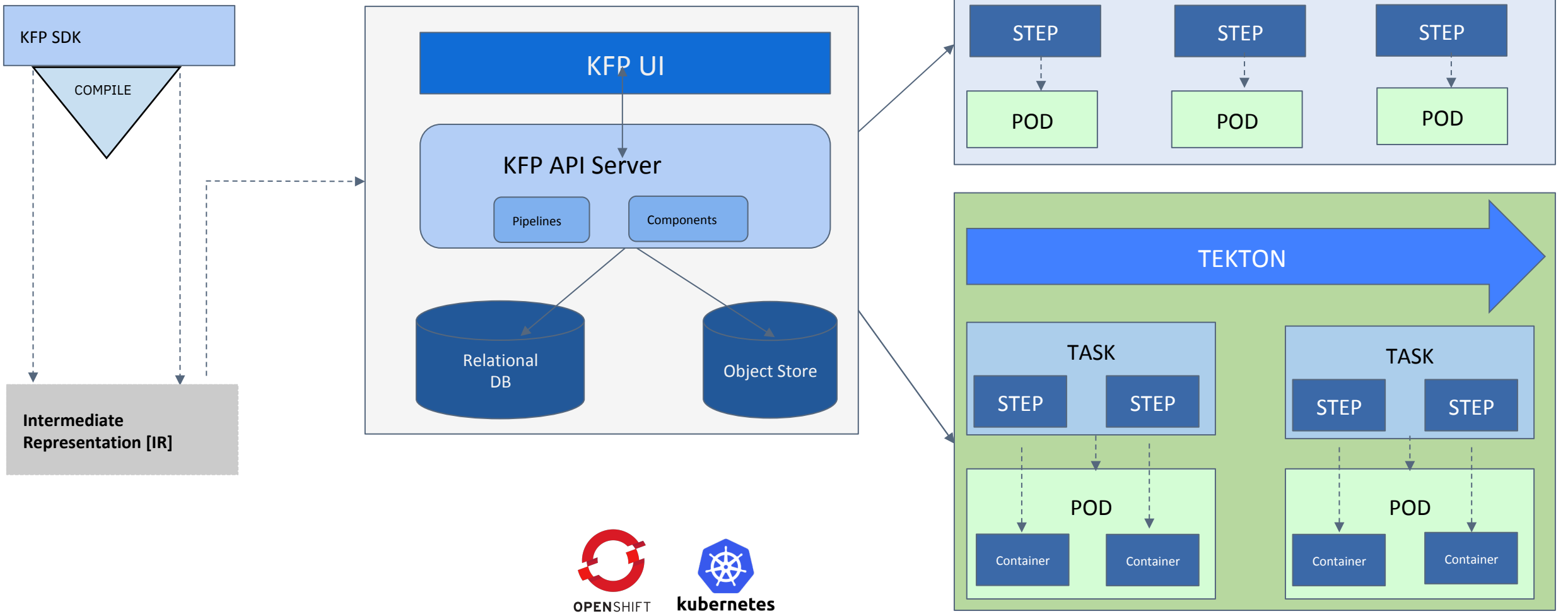
- create-secret-kubernete...
- train-model-watson-mac...
  - train-mode... Completed
- store-model-watson-ma...
- deploy-model-watson-m...

train-model-watson-machine-learning Completed

Logs | Status | Details

```
training_id {'metadata': {'created_at': '2020-05-07T23:57:46.868Z', 'guid': 'b200eef4-3dde-4b4e-a521-fe751735932c' ,
get status {'state': 'running'}

##################################################################################

Log monitor started for training run: b200eef4-3dde-4b4e-a521-fe751735932c

##################################################################################



-----------------
Log monitor done.
-----------------



##################################################################################

Metric monitor started for training run: b200eef4-3dde-4b4e-a521-fe751735932c
```

Future: KFP – Tekton Phase Three



Pluggable Components

Spark | Watson Studio | WML | Open Scale | Kubeflow Training | Seldon | AIF360 | ART | KATIB | KFSERVING | ...

Useful Links

Main Open Source Github Repository:
https://github.com/kubeflow/kfp-tekton

IBM internal Slack channels
#kfp-tekton
#kubeflow

The Kubeflow external Slack workspace is
kubeflow.slack.com

To join, click here
https://join.slack.com/t/kubeflow/shared_invite/zt-cpr020z4-PfcAue_2nw67~iIDy7maAQ