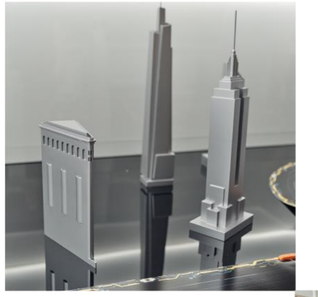
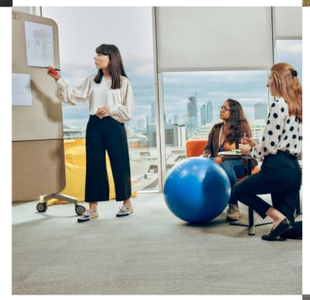
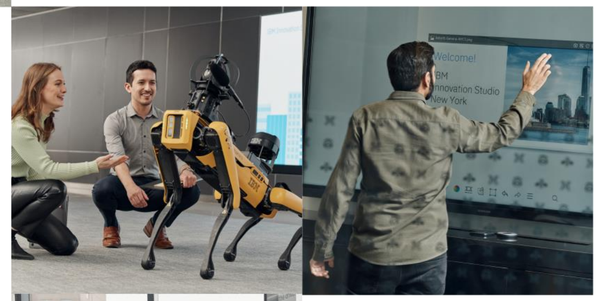
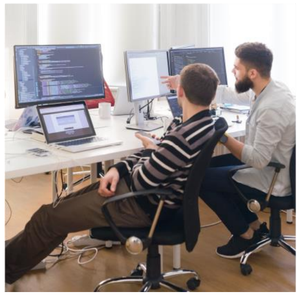
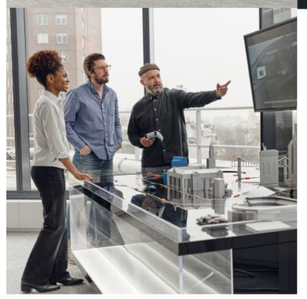
IBM **TechXchange**

Open Source Data Science and MLOps in **watsonx.ai**



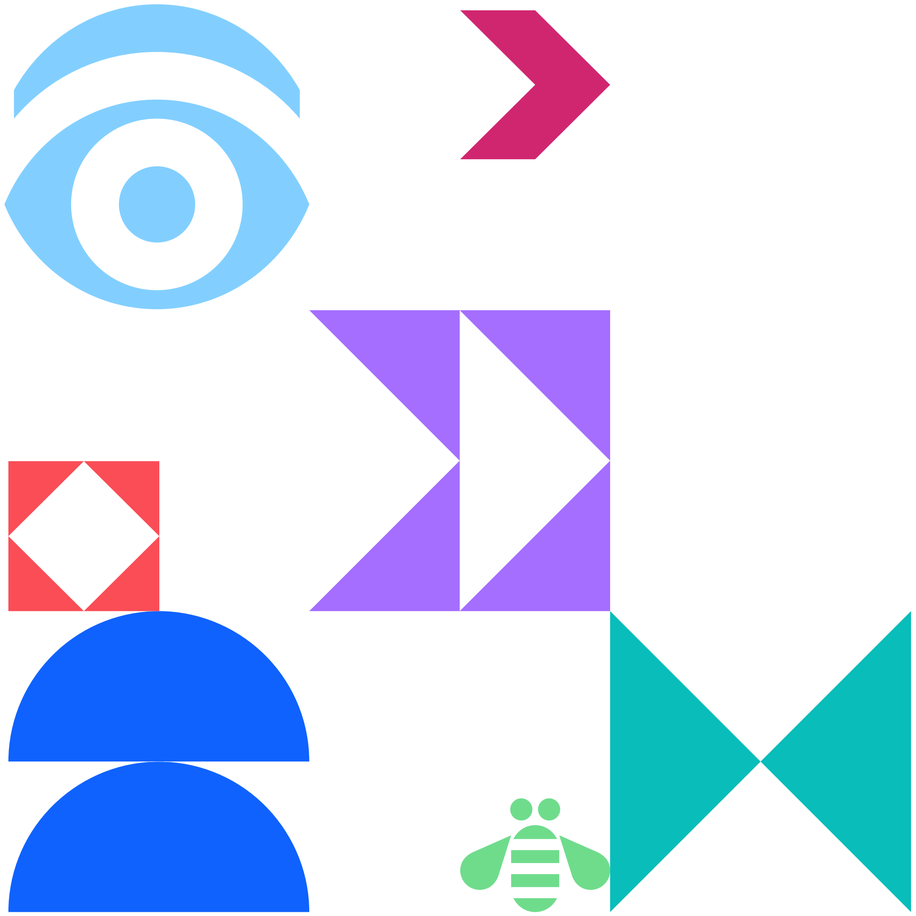



Ryan Kather – Public Market
IBM, Principal AI Engineer – IBM Data, AI, Automation
Session Code: 2494

October 23, 2024
Mandalay Bay, Las Vegas

IBM

Agenda



01 Simpler Times

02 *Ops

03 watsonx.ai

04 - Secure Coding

05 - Resources

06 - Environments

Simpler Times

Data Science is now a team sport.

Data and ML landscapes have evolved.

Factors to Account

- Repeatability
- Accountability
- Transparency
- Explainability
- Risk Exposure
- Robustness
- Performance

+BP4DS

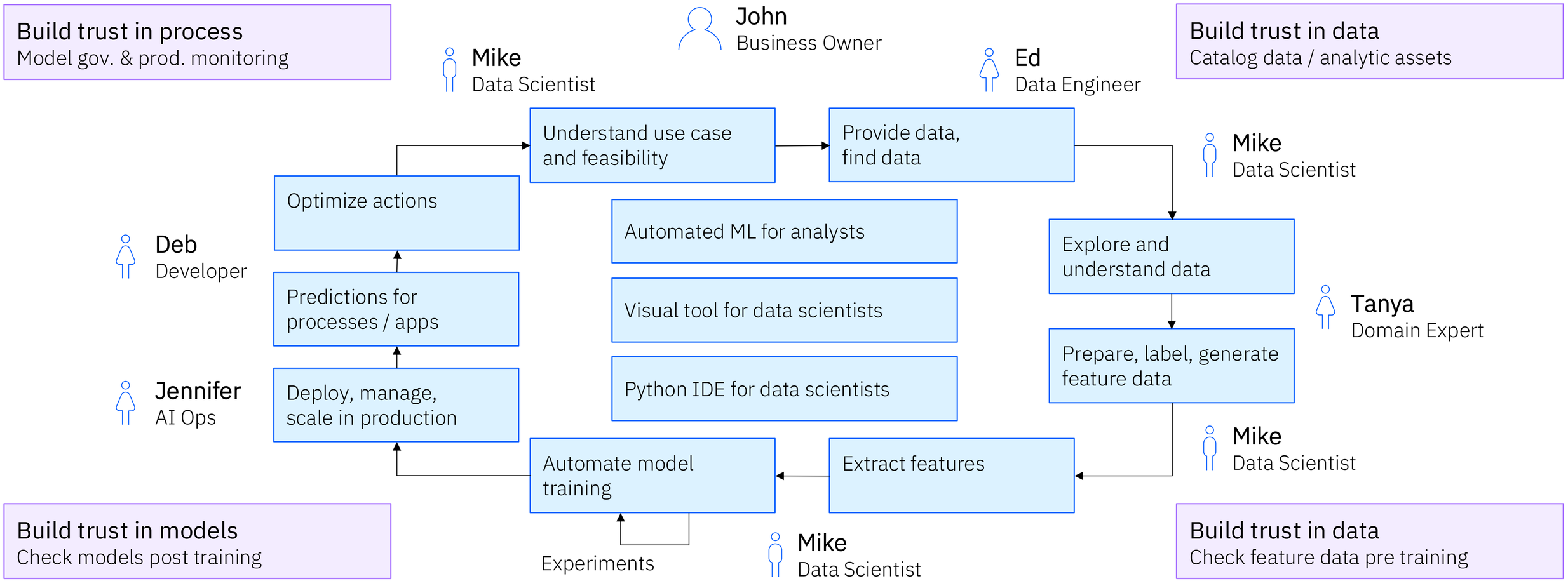
1. Understand Business Context
2. Prioritize Data Cleaning
3. Conduct Exploratory Data Analysis
4. Validate Models Properly
5. Communicate Results Clearly

-- GPT4

1. Start with a Clear Problem Statement
2. Use Version Control
3. Use Reproducible Methods
4. Use Appropriate Visualizations
5. Continuously Learn and Improve

-- Llama2

DS Process
CRISP-DM NIST Methodology



What is MLOps?

MLOps, also known as Machine Learning Operations, is a set of practices that aim to streamline and automate the process of taking machine learning (ML) models from development to production. It involves collaboration between data scientists, engineers, and operations teams to ensure the smooth deployment, monitoring, and maintenance of ML models in a production environment.

*Ops All the Things

Relationship to DevOps

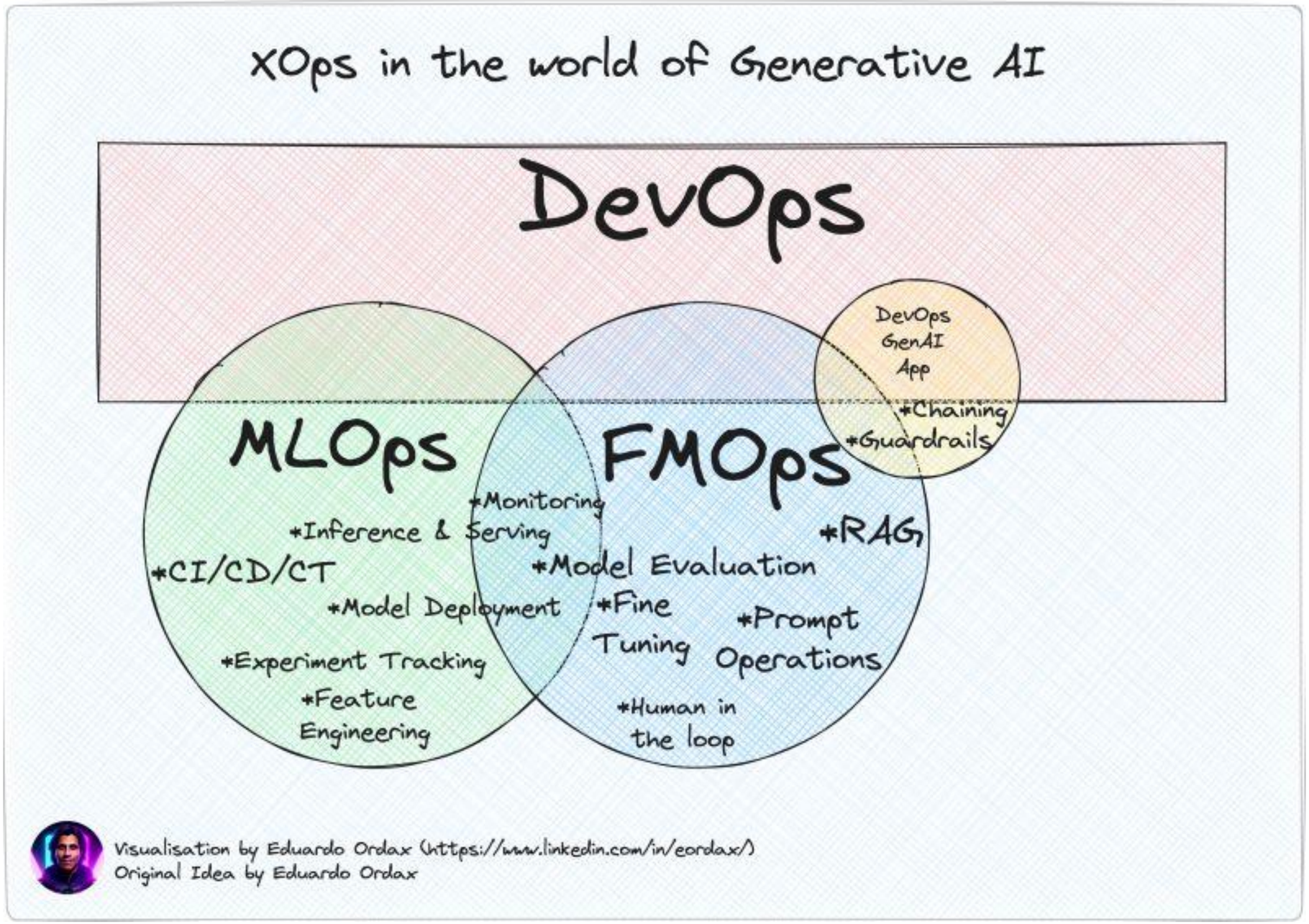
DevOps focuses on bridging the gap between software development and operations teams, while MLOps does the same for machine learning development and operations teams. Both practices aim to:

- Improve collaboration and communication between teams
- Automate processes to increase efficiency and reduce errors
- Ensure smooth deployment and monitoring of systems/models
- Foster a culture of continuous improvement and learning

AI Ops

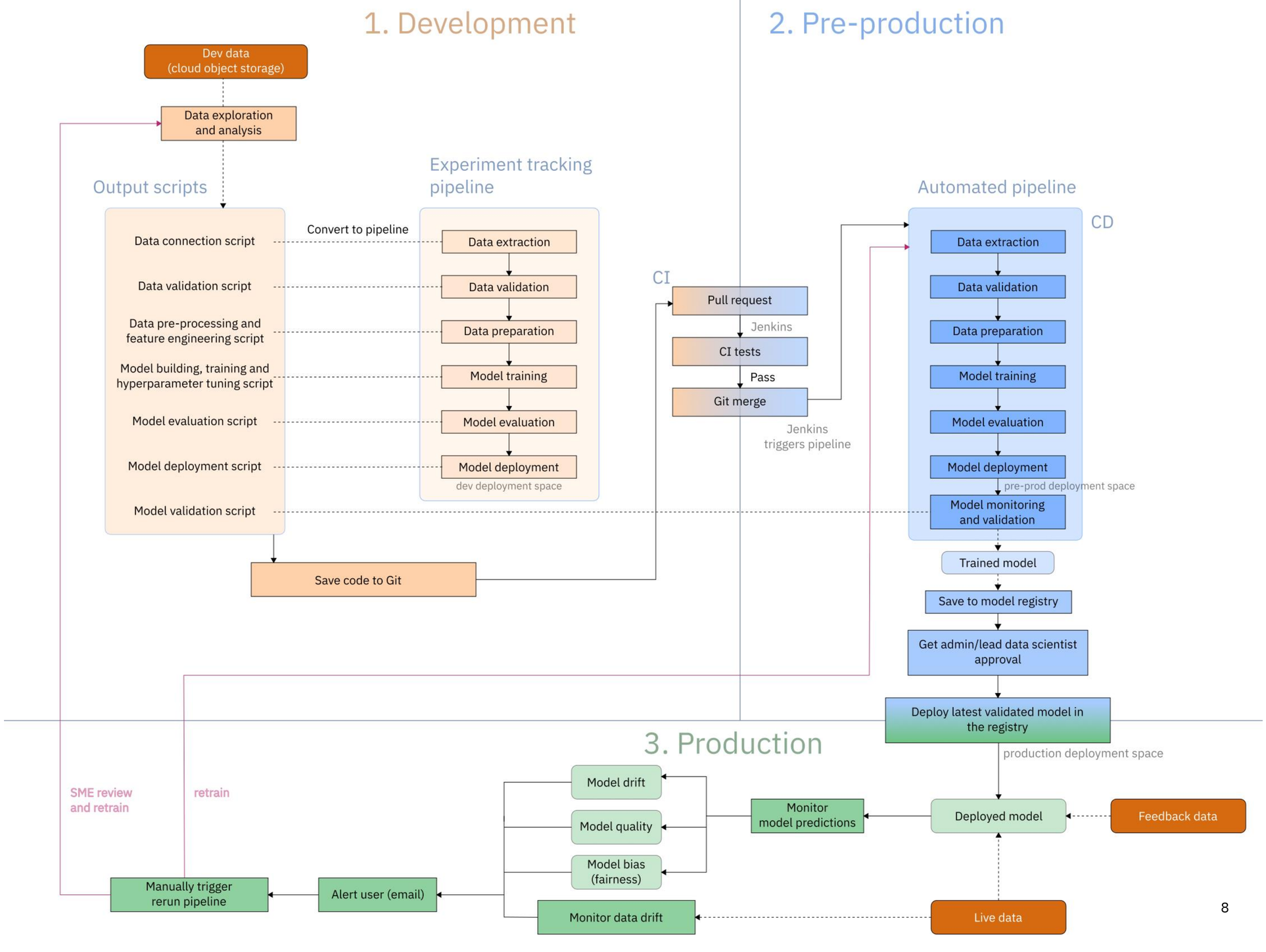
Common alignment on Core Tenants:

- LLMOps and MLOps aim to streamline the deployment, monitoring, and maintenance of machine learning models in production environments.
- Involve collaboration between data scientists, engineers, and operations teams.
- Focus on ensuring model performance, scalability, and reliability.



MLOps

Modern Watson Studio MLOps Workflow from Dev to Prod with CI-CD

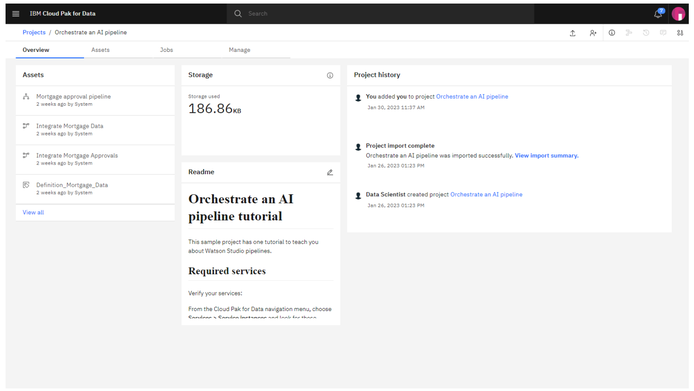


watsonx.ai

Where does IBM’s platform fit?

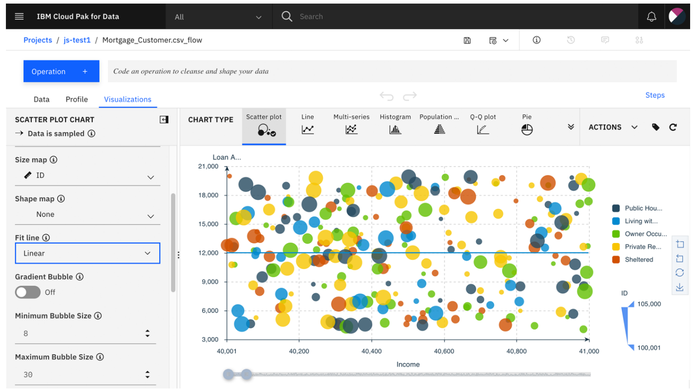
Development Environments

Flexible microservices based development architecture with customization support.



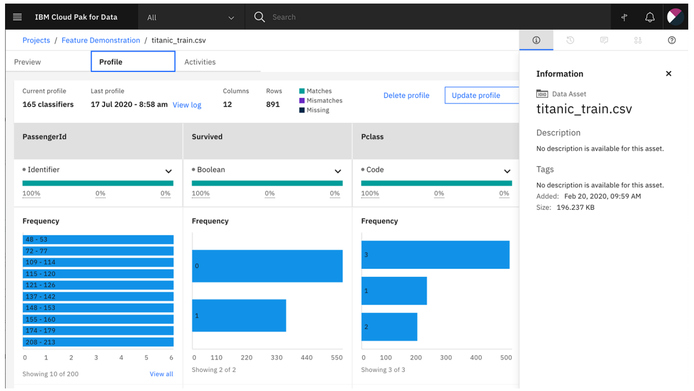
Production Hosting

Secure, auditable, and production hosting for analytic assets and modeling products.

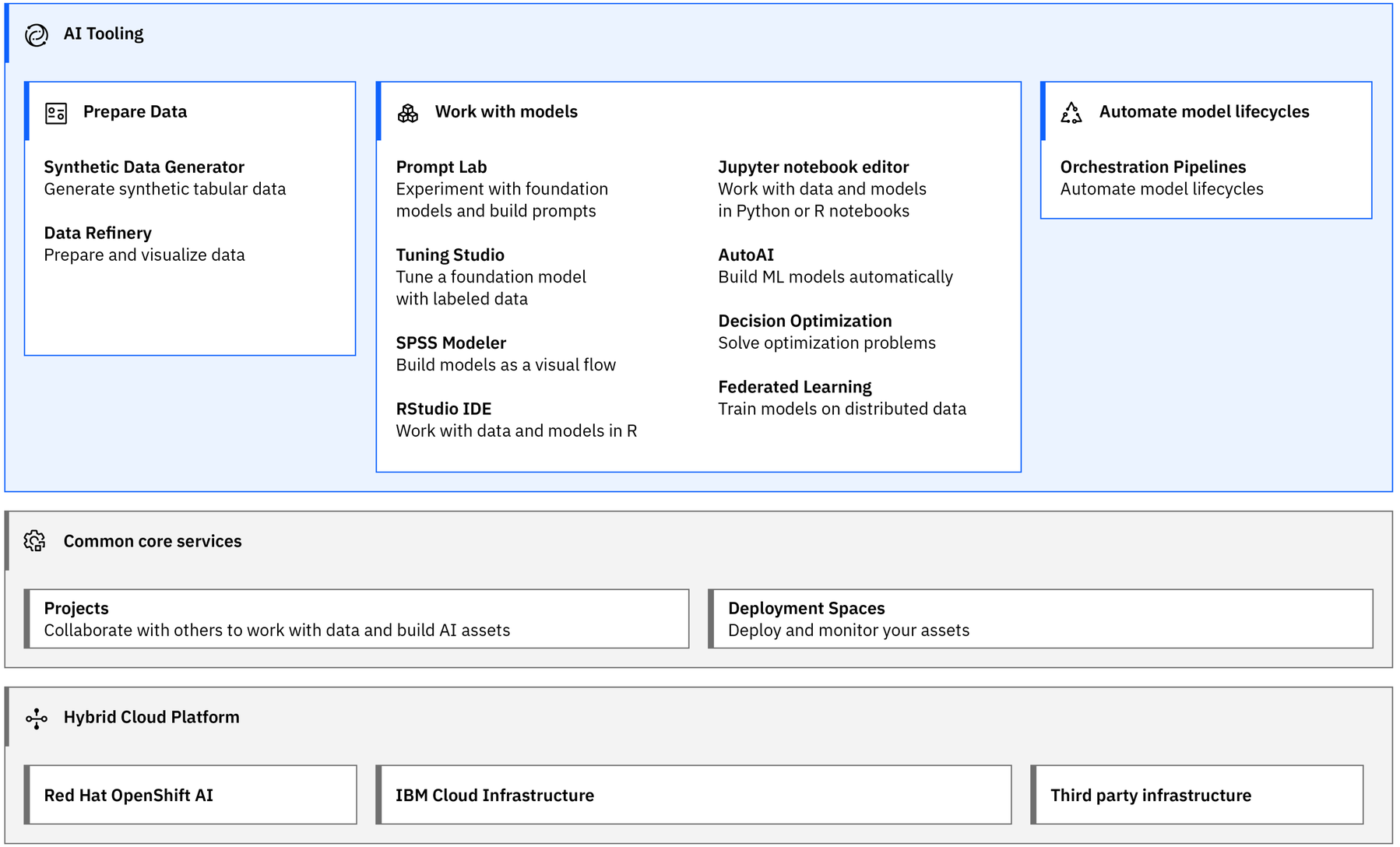


Data Handling

Abstracted data layer for governed, traceable, and collaborative data integration.



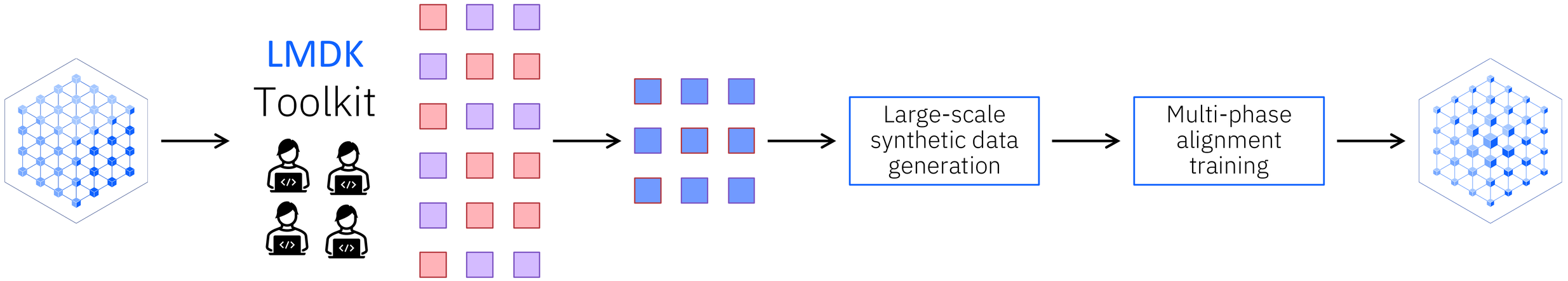
IBM watsonx.ai architecture



Common core services

- Collaborative projects
- Deployment spaces
- Jobs
- Notifications
- Common connectivity
- Access and Authentication
- Resource management
- Central asset management system

InstructLab Workflow for Model Training



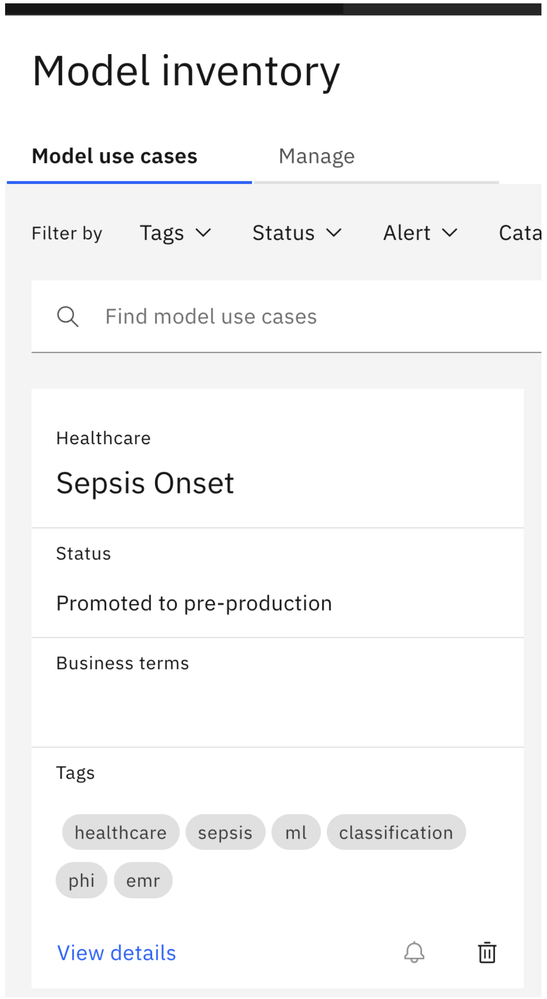
Base model version N

Developers use LMDK to develop, test, and submit skills as pull requests.

Pull requests are reviewed for quality and a subset is chosen for this round

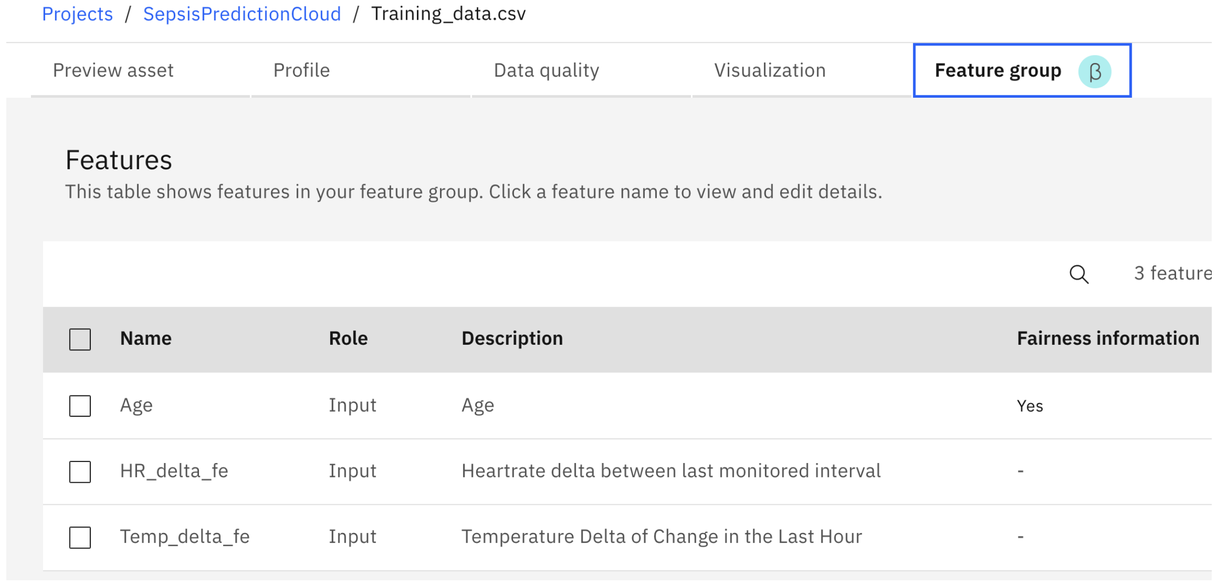
Back-end pipeline executes the steps in the LAB technique to “merge” skills and update the model.

Base model version N+1



Model Registry

- Use Case Details
- Associated Assets
- Approval Workflow
- Model Metadata
  - Training
  - Algorithm
  - Schema



Feature Store / Catalog / EDA

- Engineered Features for Data
- Repeatablity / Understanding
- Metadata Enrichment
- Lineage

MLOps

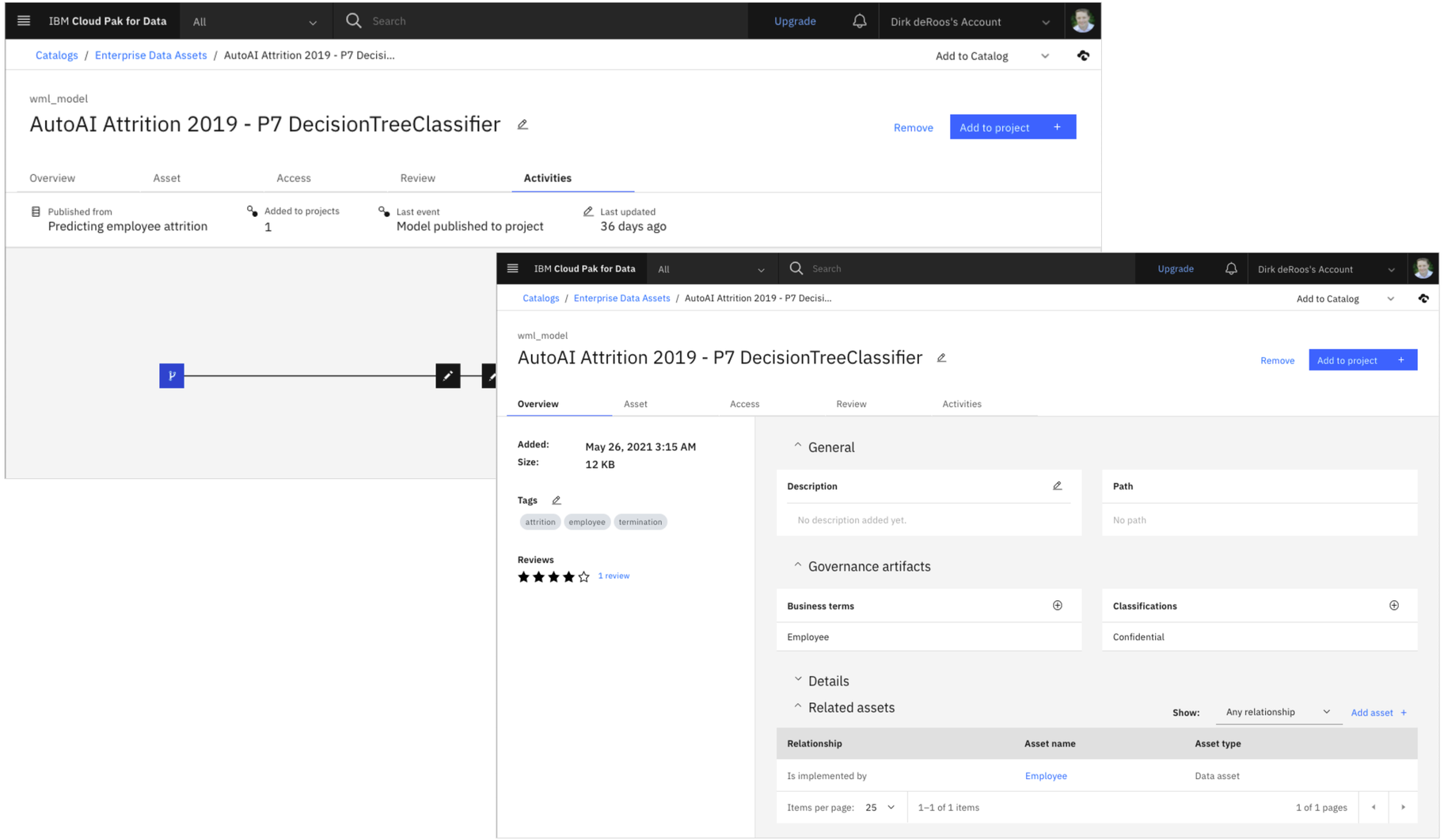
DataOps

Facts and lineage

Promote models to a catalog
- Add metadata – tags, reviews, classifications, business terms, description
- Fully searchable and governed

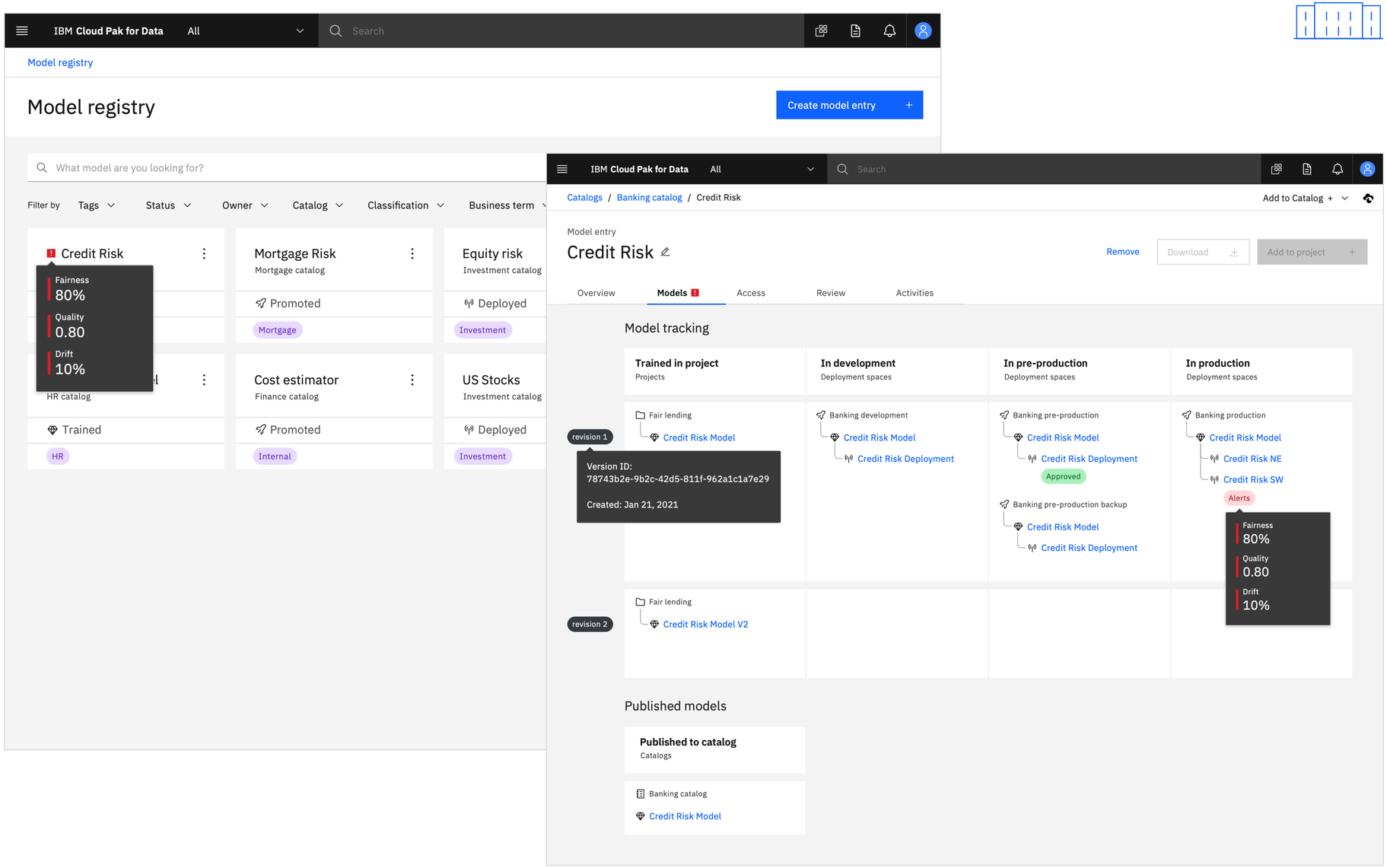
Lineage
- Track consumption and version changes
- Identify related datasets

Model governance in the knowledge catalog



Model registry and lifecycle tracking

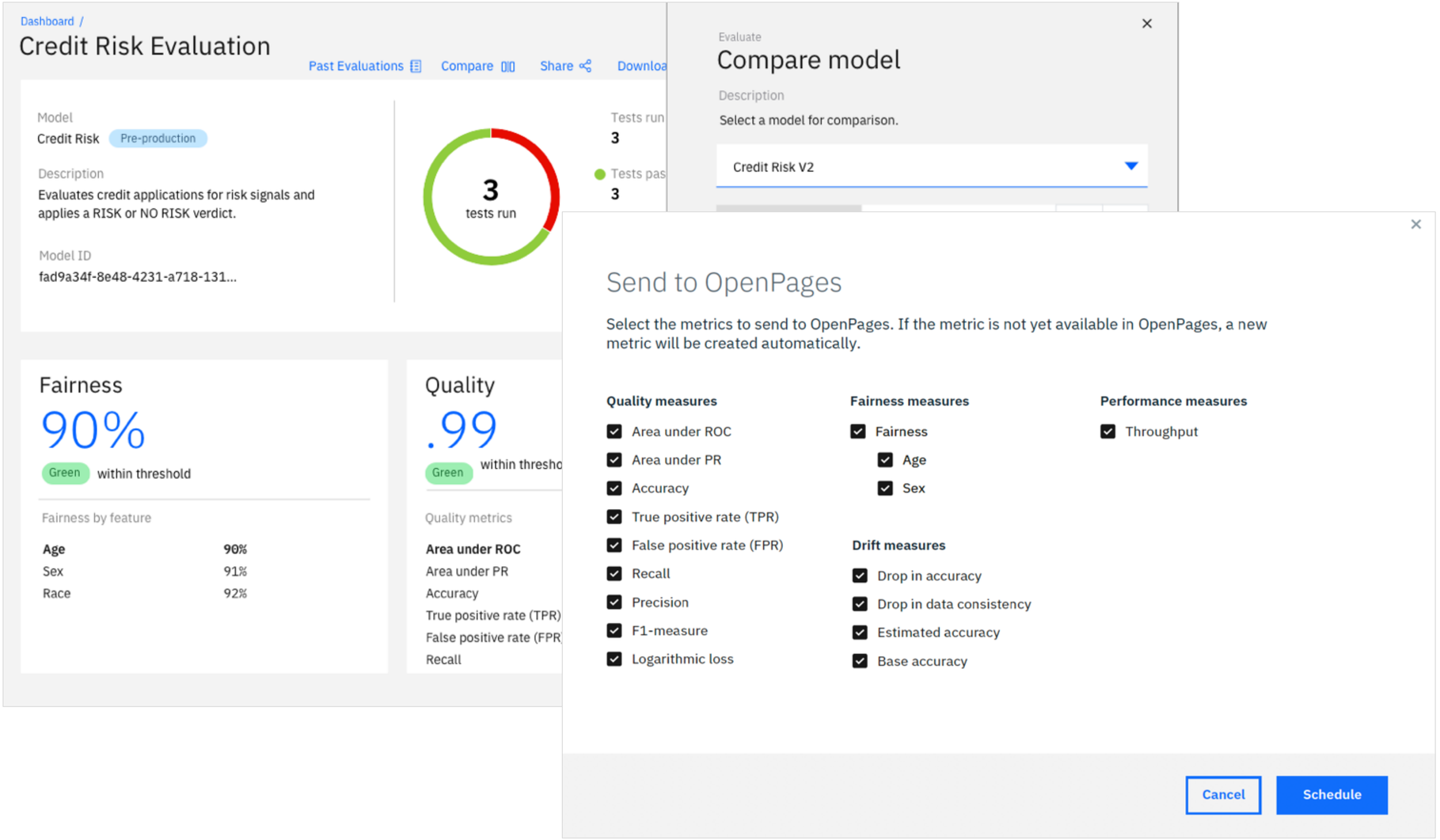
- Entry point for keeping track of model attributes and status
- Track deployments, versions, and status



Model validation

Deployment monitoring
- Validate pre-production models
- Compare models performance
- Continual gathering of quality and trust metrics

Model Risk Governance
- Integrates with Watson Studio model monitoring metrics
- Store, manage, and monitor model metrics
- Calculate risk scores and impact for models

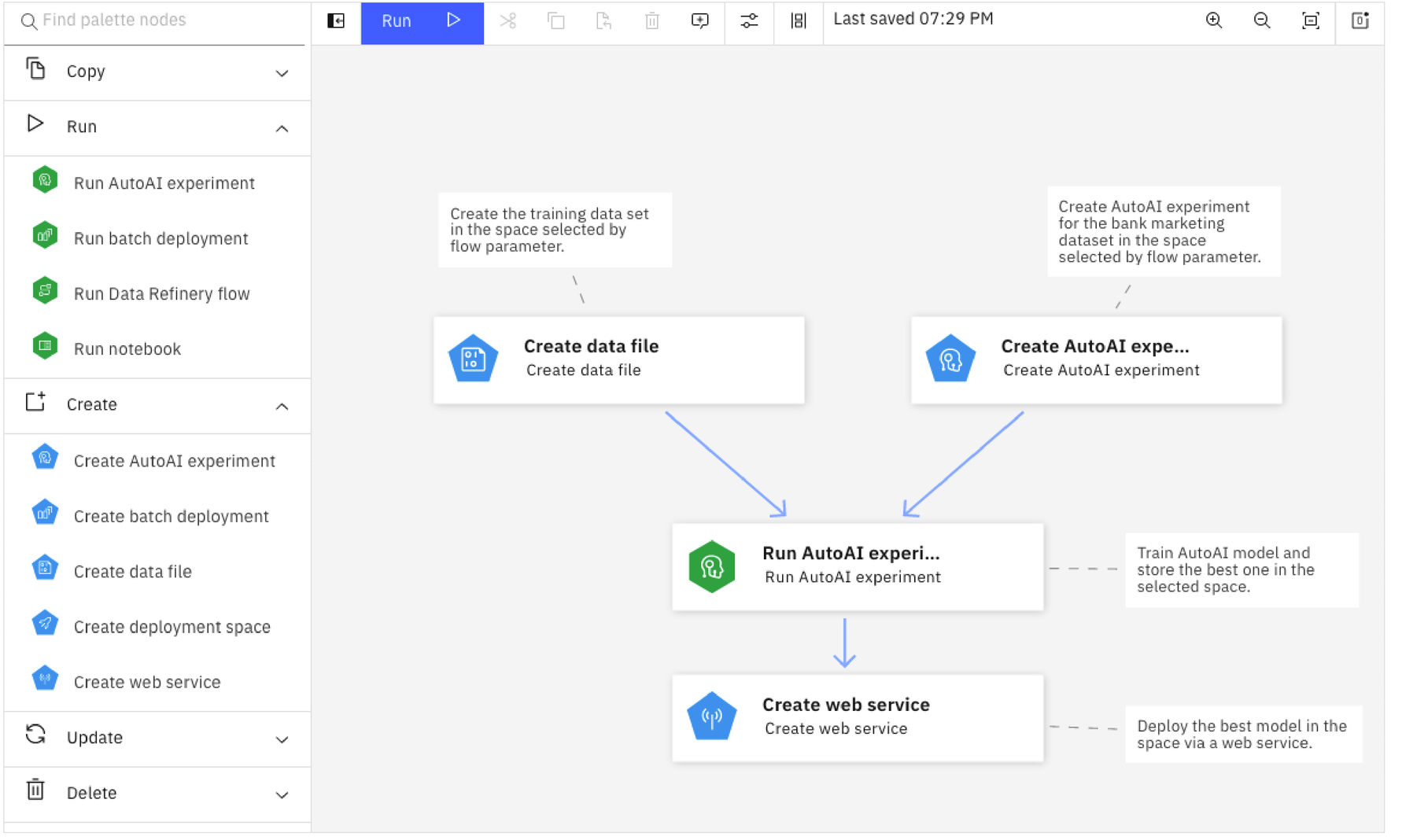


Orchestrate AI modeling

Automated pipeline interface
- Combine tasks from different tools
  - Notebooks
  - Data refinery
  - Model creation
  - Model deployments

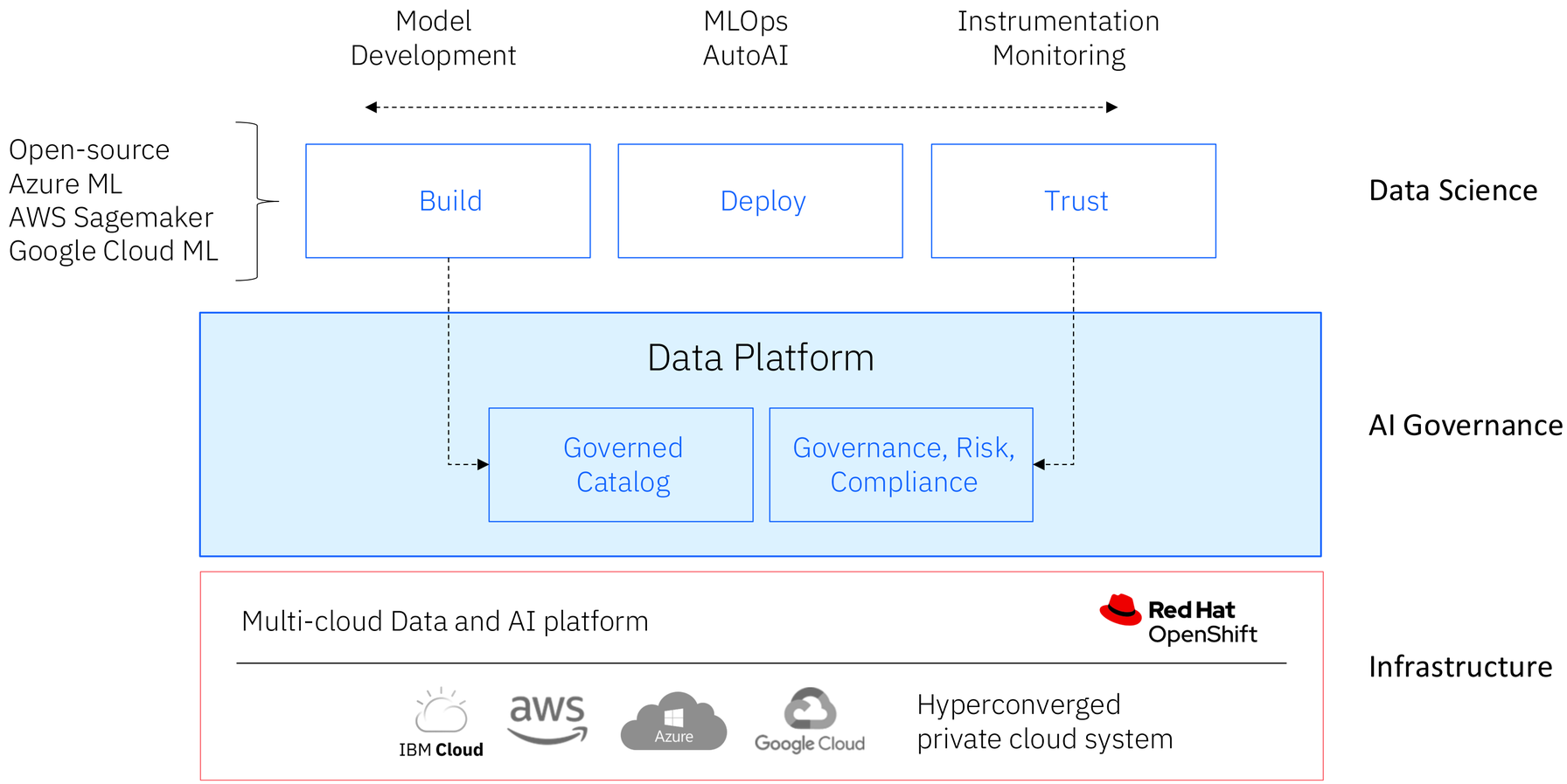
- Automate model training with new data sets

- Automatically deploy better challenger models



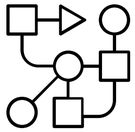
MLOps and Trustworthy AI platform

Modular components running on any technology stack



watsonx.ai Usage Best Practices

Decide early if you are going to use Git or internal collaboration



Automate with Jobs, Pipelines, and Deployment Spaces

Define Projects by Use Case and Identify Stakeholders and Required Data

Define Roles for Participants, with an emphasis on Project Owner

Secure Coding (Collaboration)

Collaborating with Sensitive Credentials – 4 Methods (Non Exhaustive)

– Insecure Example

```
import types
import pandas as pd
from botocore.client import Config
import ibm_boto3
def __iter__(self): return 0
# @hidden_cell
# The following code accesses a file in your IBM Cloud Object Storage. It includes
# You might want to remove those credentials before you share the notebook.
client_01da3b8d07aa40ca85ec5cee0637167f = ibm_boto3.client(service_name='s3',
    ibm_api_key_id='KEYID-EXAMPLE',
    ibm_auth_endpoint="https://iam.cloud.ibm.com/oidc/token",
    config=Config(signature_version='oauth'),
    endpoint_url='https://s3-api.us-geo.objectstorage.service.networklayer.com')
body = client_01da3b8d07aa40ca85ec5cee0637167f.get_object(Bucket='cloudproject-don
# add missing __iter__ method, so pandas accepts body as file-like object
if not hasattr(body, "__iter__"): body.__iter__ = types.MethodType( __iter__, body
df = pd.read_csv(body)
df.head()
```

1 Secrets

Preferred Method:

https://www.ibm.com/docs/en/cloud-paks/cp-data/4.7.x?topic=2-managing-secrets-vaults

2 Dotenv

Load environment variables from .env file(untested) (https://pypi.org/project/python-dotenv/)

3 File

Import credentials from a resident file. **Add to .gitignore.**

4 Getpass

Interactively prompt for user input.

Disrupts automated flows.

(https://docs.python.org/3/library/getpass.html)

Overview of secrets and vaults

A *secret* contains sensitive data

A *vault* is a secure place to store and manage secrets.

The information in the secret is stored in a secure and encrypted environment that conforms to your organization's policies.

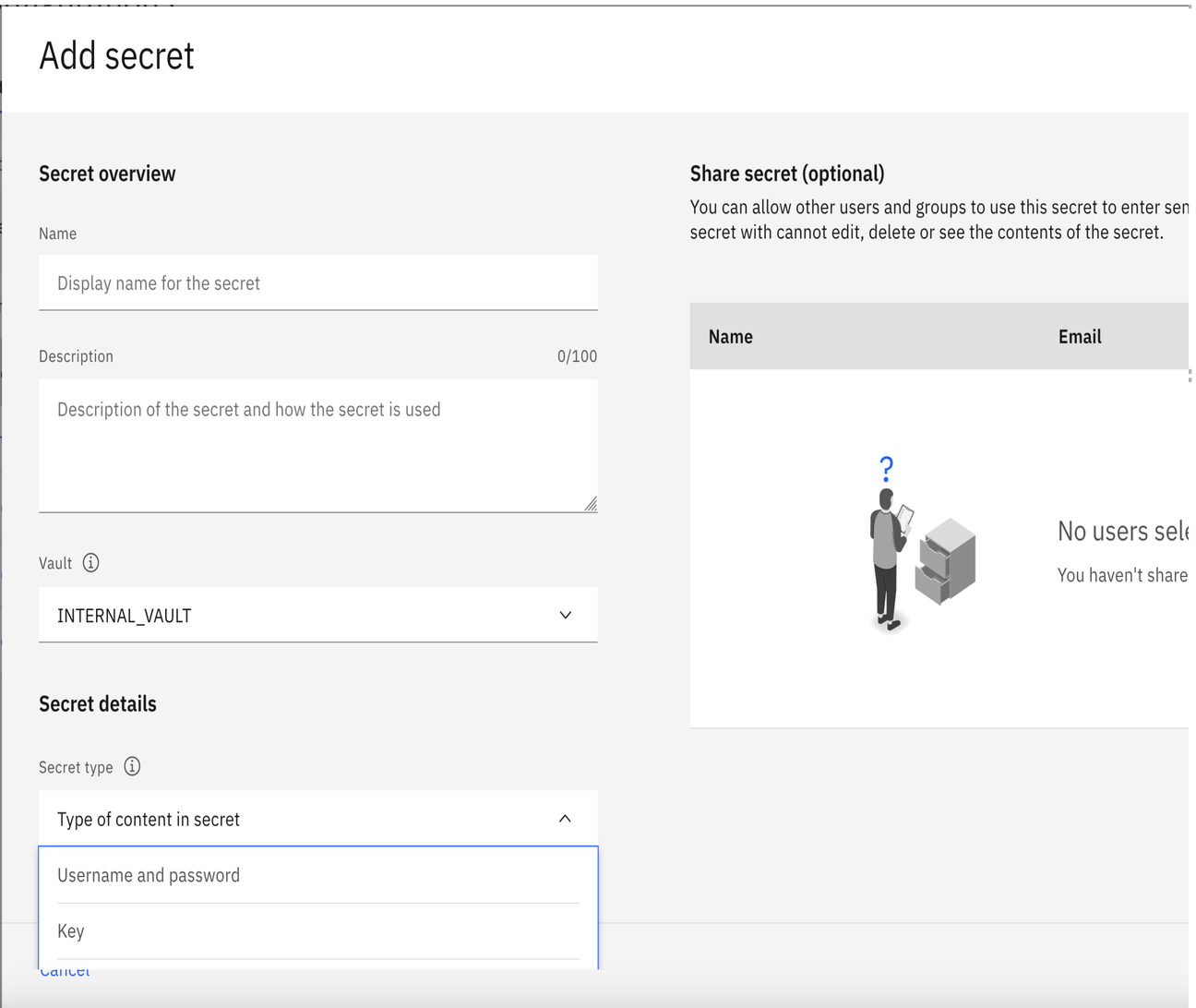
The services and connections that use the secret do not have direct access to the information in the secret.

The information in the secret can be updated once. The change is automatically picked up by all services or connections that use the secret.

Cloud Pak for Data includes an internal vault. If you have a supported enterprise-grade vault, you can also connect to external vaults.

Secrets (API and GUI)

*Not Available on aaS




```
secret = {
    'secret_name':'example_ibm_api_key',
    'description':'IBM Cloud API Key',
    'secret':{'apikey':'INSERT YOUR KEY HERE'},
    'type':'credentials',
    'vault_name':'internal'}
```

Create Vault Secret

Store a secret in the vault so we can retrieve later for IBM Cloud API Key

```
# @hidden_cell

import os
import json
import requests
from requests.packages.urllib3.exceptions import InsecureRequestWarning

requests.packages.urllib3.disable_warnings(InsecureRequestWarning)

url = "https://cpd-cpd-instance.apps.cpd47pub2.tec.ihost.com/zen-data/v1/secrets"
token = os.environ.get('USER_ACCESS_TOKEN')

headers = {
    'Authorization': 'Bearer {}'.format(token),
    'Content-Type': 'application/json',
}

payload = json.dumps(secret)
response = requests.post(
    url,
    headers=headers,
    data=payload,
```

File – Import and Reference

External File

Parse an external file hidden from Github

```
import secrets
api_key = secrets.api_key
```

- Does not Prevent Access from Project Members

- Extra Method Required for CPDaaS

Jupyter Notebook Script File Reference

Unlike Jupyterlab with Git, Jupyter Notebooks local data directories are ephemeral and destroyed after
directory here;

Jupyter Notebook Workding Directory (Deleted on Environment Shutdown)

```
!pwd
```

```
/home/wsuser/work
```

As a result, script files you place in that folder will disappear when the environment is shut down. Our docu
in the project data assets.
I would rather just improt the script from the data assets folder directly. You can browse the data as
environments.

Project Data Assets

```
!ls /project_data/data_asset/
```

```
__pycache__  script.py
```

You cannot simply reference a script above the working directory though without it being included in the p
Let's use the **sys** library to append the data assets directory to the path and then import our script.

Add Project Data to the Search Path for Python

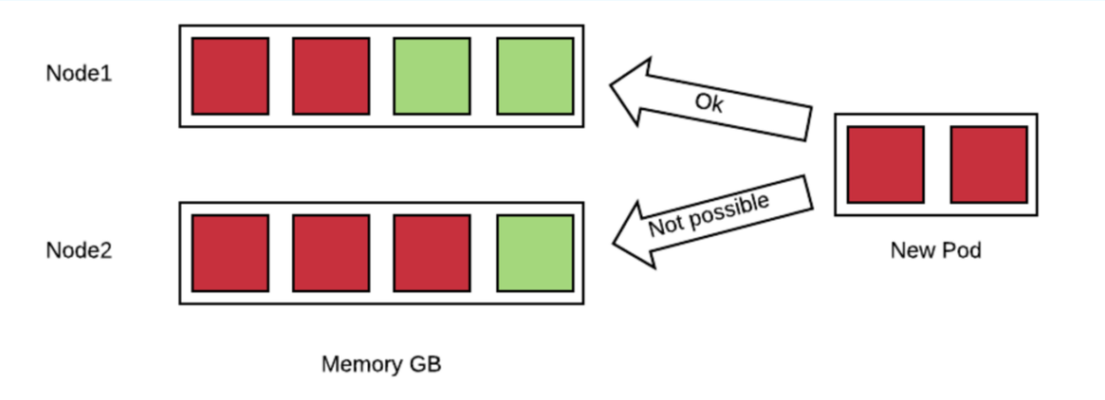
```
import sys
sys.path.append('/project_data/data_asset/')
```

* Add to .gitignore

Resources (Capacity Management)

Levels of Resource Considerations (Non-Exhaustive)

– Openshift Scheduler



1 Monitoring

Resource overhead understanding. https://www.ibm.com/docs/en/cloud-paks/cp-data/4.7.x?topic=2-best-practices-monitoring

2 Code

Memory management, Frameworks, Code Optimization

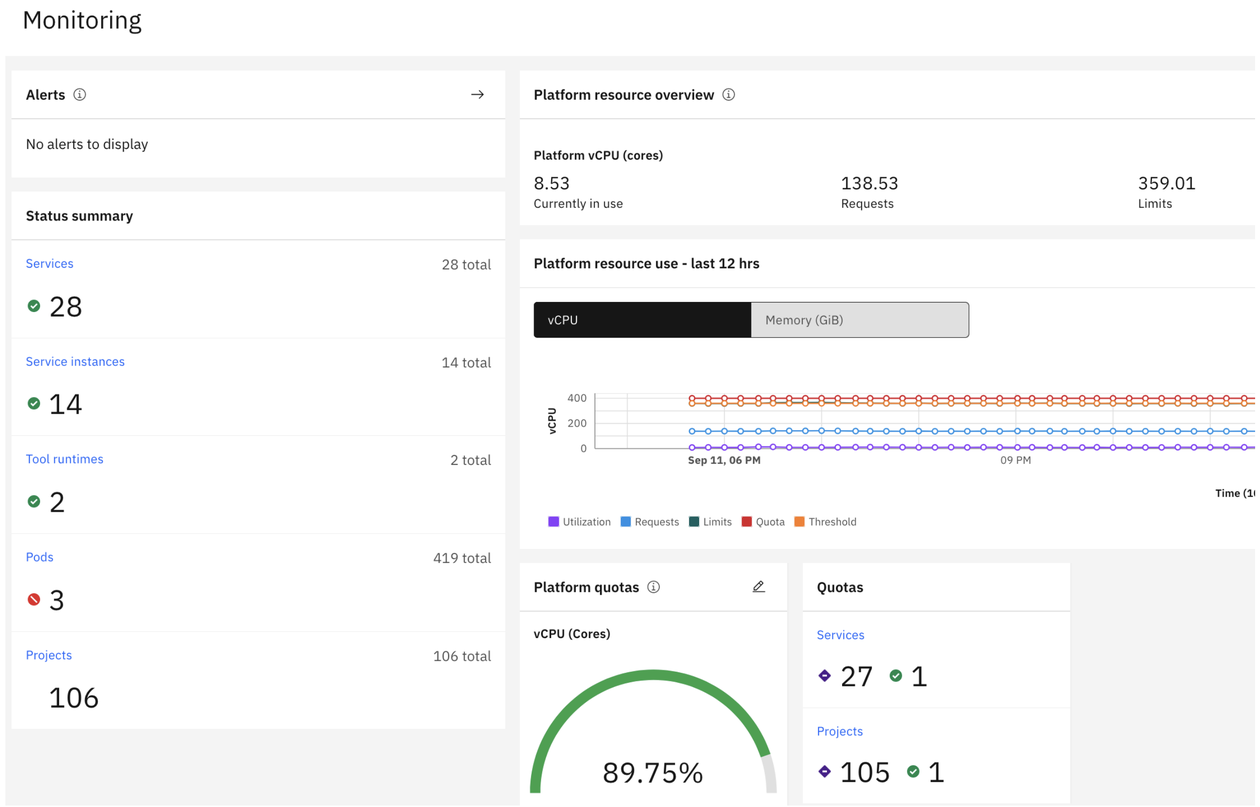
3 Load

Competing workloads, user volumes, active projects

4 Data

Volume of data, type of data, operations required.

Overview of Monitoring and Controls



Cluster Capacity Reporting native to CP4D. CPDaaS Usage Monitoring for CuH with workload runtime reporting. OpenShift monitors and Prometheus Integration

Resource Quota Support:

Per Namespace, Per Service, Per Project. Per User Threshold

Autoscaling services using the Horizontal Pod Autoscaler (HPA). Changes the resource allocation of services by increasing or decreasing the number of pods in response to CPU or memory consumption.

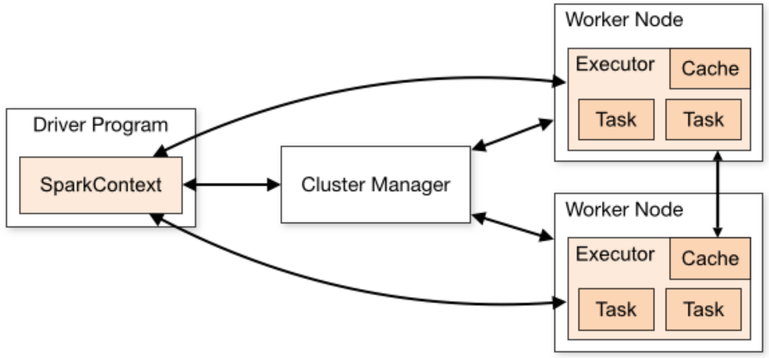
Cluster Scaling support with Machinesets, Cloud Providers instrumented autoscalers with Teraform

WMLA GPU management Options

MIG (Multiple GPU Instances)

Code – Optimization, Framework Considerations

Spark:



– Arrow with Inferred Schema

```
import itc_utils.flight_service as itcfs

readClient = itcfs.get_flight_client()

RDK_COS_WL_data_request = {
    'connection_name': """RDK-COS-WL""",
    'interaction_properties': {
        #'row_limit': 5000,
        'file_name': 'labels.csv',
        'infer_schema': 'true',
        'infer_as_varchar': 'false'
    }
}

flightInfo = itcfs.get_flight_info(readClient, nb_data_request=RDK_COS_WL_data_request)

data_df_1 = itcfs.read_pandas_and_concat(readClient, flightInfo, timeout=240)
data_df_1.head(10)
```

Apache Arrow reduces the time to serialize data in memory, and it can also reduce the footprint and time to read/process DataFrames https://arrow.apache.org/

Memory Management:

Garbage Collection, functions, data structures (Pandas, R Dataframe), interim sets, and sampling

Alternate frameworks:

Spark, larger than memory datasets. Distributed compute with executors. Other options.

Memory Monitoring in Jupyter. Dead Kernel, pod logs (administration/ monitoring)

Load – Managing with MLOps, Understanding Limits/Requests

Details YAML

```
64                'f:requests.memory': {}
65    spec:
66      hard:
67        limits.cpu: '4'
68        limits.memory: 4Gi
69        requests.cpu: '1'
70        requests.memory: 2Gi
71    status:
```

```
Resource   Requests         Limits
--------   --------         ------
cpu        3861m (96%)      3240m (81%)
memory     14396Mi (91%)    17302Mi (109%)
--
Resource   Requests         Limits
--------   --------         ------
cpu        3746m (93%)      190m (4%)
memory     12336Mi (78%)    13274Mi (84%)
--
Resource   Requests         Limits
--------   --------         ------
cpu        3362m (84%)      1720m (43%)
memory     12518Mi (79%)    13728Mi (87%)
```

Limits and Requests:

Limits are a hard reservation for pod resources, requests are an overcommit up to. Environment Definitions.

Dev/QA/UAT/Prod Acceptance asset movement. Git, CI-CD, APIs and SDK

https://github.com/IBM/cpdctl

Multiple Workloads:

Namespace isolation, quota assignment and other solution stacks.

Environment Sizing specific to need. Destroy and recreate within bounds.

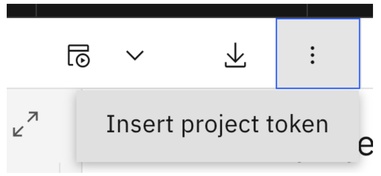
APIs and SDK

Related but Different Purposes

Programmatically interface with projects, data, and assets within project spaces. *Project Lib Deprecated

Samples Repo: https://github.com/IBMDataScience/sample-notebooks/blob/master/CloudPakForData/notebooks/4.0/IPYNB/Working%20with%20ibm-watson-studio-lib%20in%20CPD.ipynb

Documentation: https://www.ibm.com/docs/en/cloud-paks/cp-data/5.0.x?topic=lib-watson-studio-python




```
# @hidden_cell
# The project token is an authorization token that is used to access proje
from project_lib import Project
project = Project(project_id='FFFFFFFF-027c-4e8a-94c7-f0c7a6e39301', proje
pc = project.project_context

from ibm_watson_studio_lib import access_project_or_space
wslib = access_project_or_space({'token':'p-FFFFFFFFFFFF198813818918'})
```

Programmatically instantiate models, package metadata, manage deployments, and deployment spaces.

Samples Repo: https://github.com/IBM/watson-machine-learning-samples

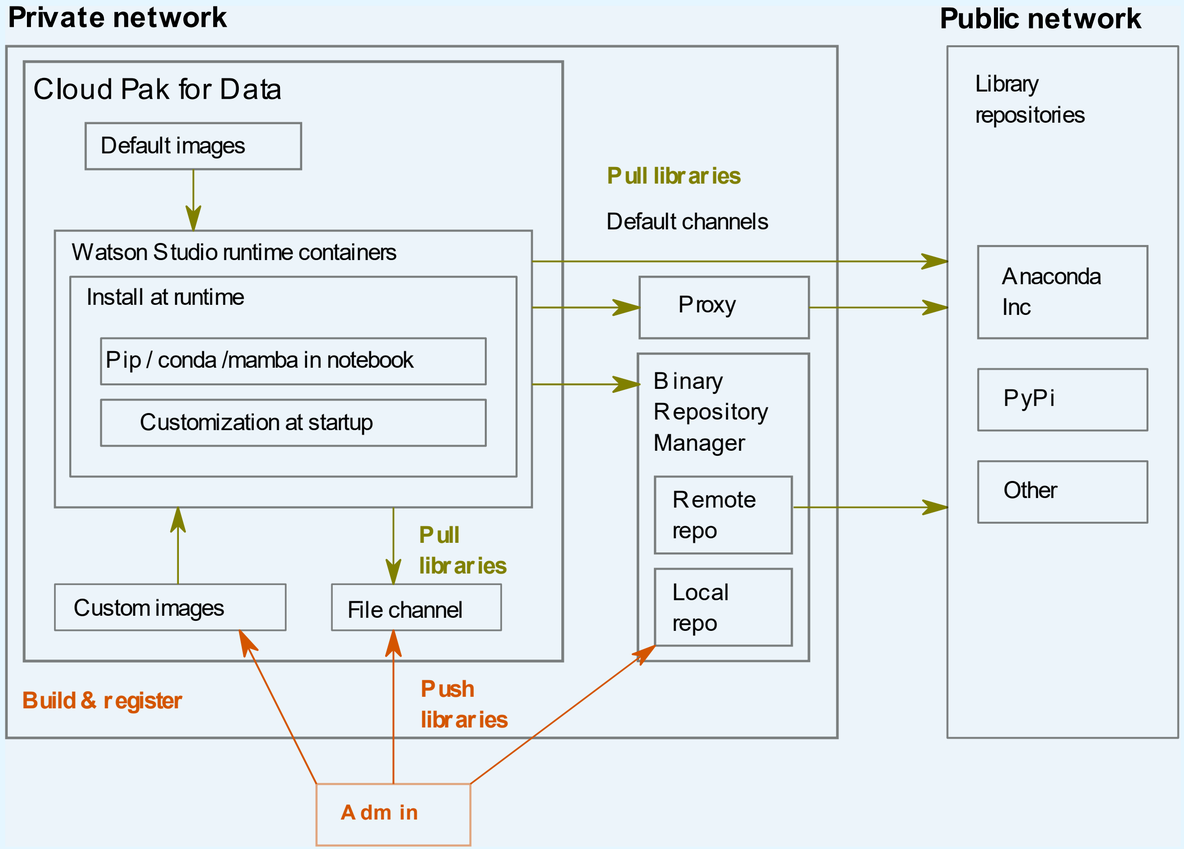
Documentation: https://ibm.github.io/watson-machine-learning-sdk/

– Persist Data without Exposing in UI: `wslib.storage.save_data()` `wslib.upload_file()` `wslib.save_data()`

Environments (container management)

Environment Tuning & Customization

– Image Customization



1 Libraries

Installing required libraries from the internet or trusted repositories

2 Preload

Environment template customizations and channel specifications

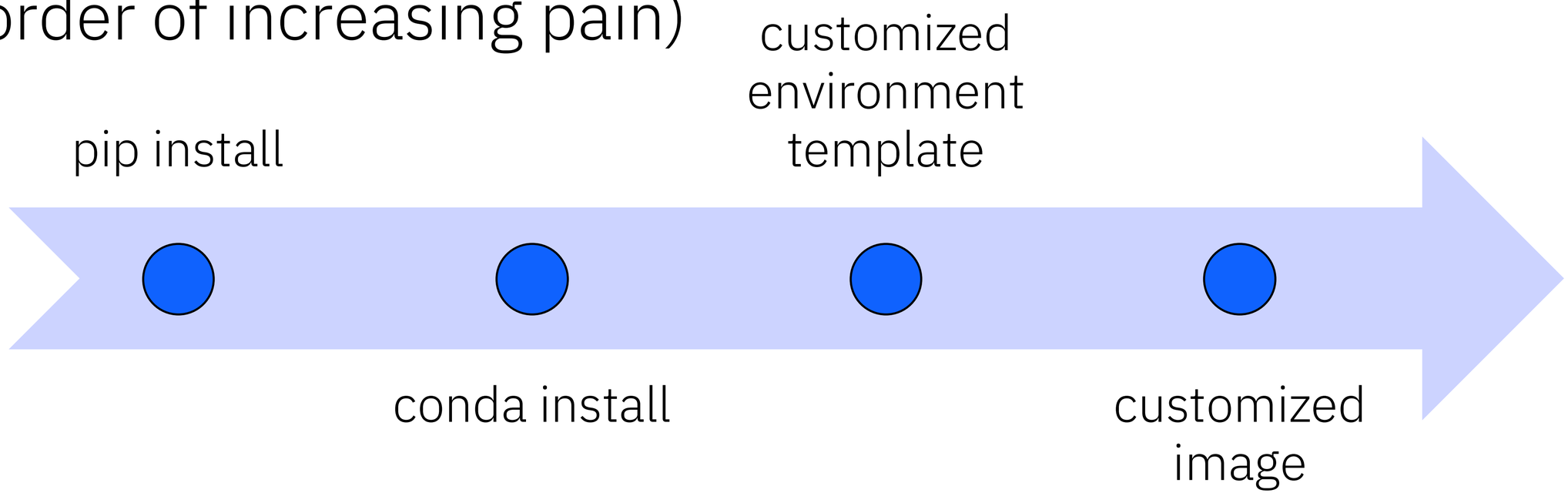
3 Images

Custom built images for specific functionality and use case

4 Labels

Restrict pods to nodes by requirement. Say GPU, extra memory?

Library Management
(in order of increasing pain)



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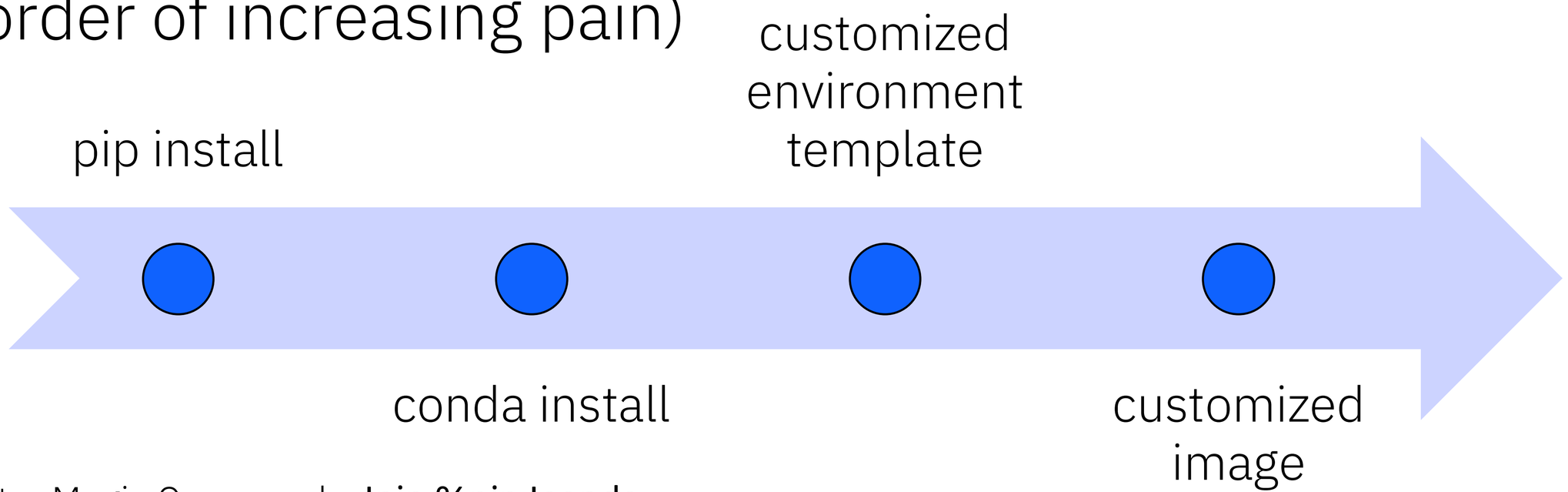


Jupyter Magic Commands: **!pip %pip !conda**

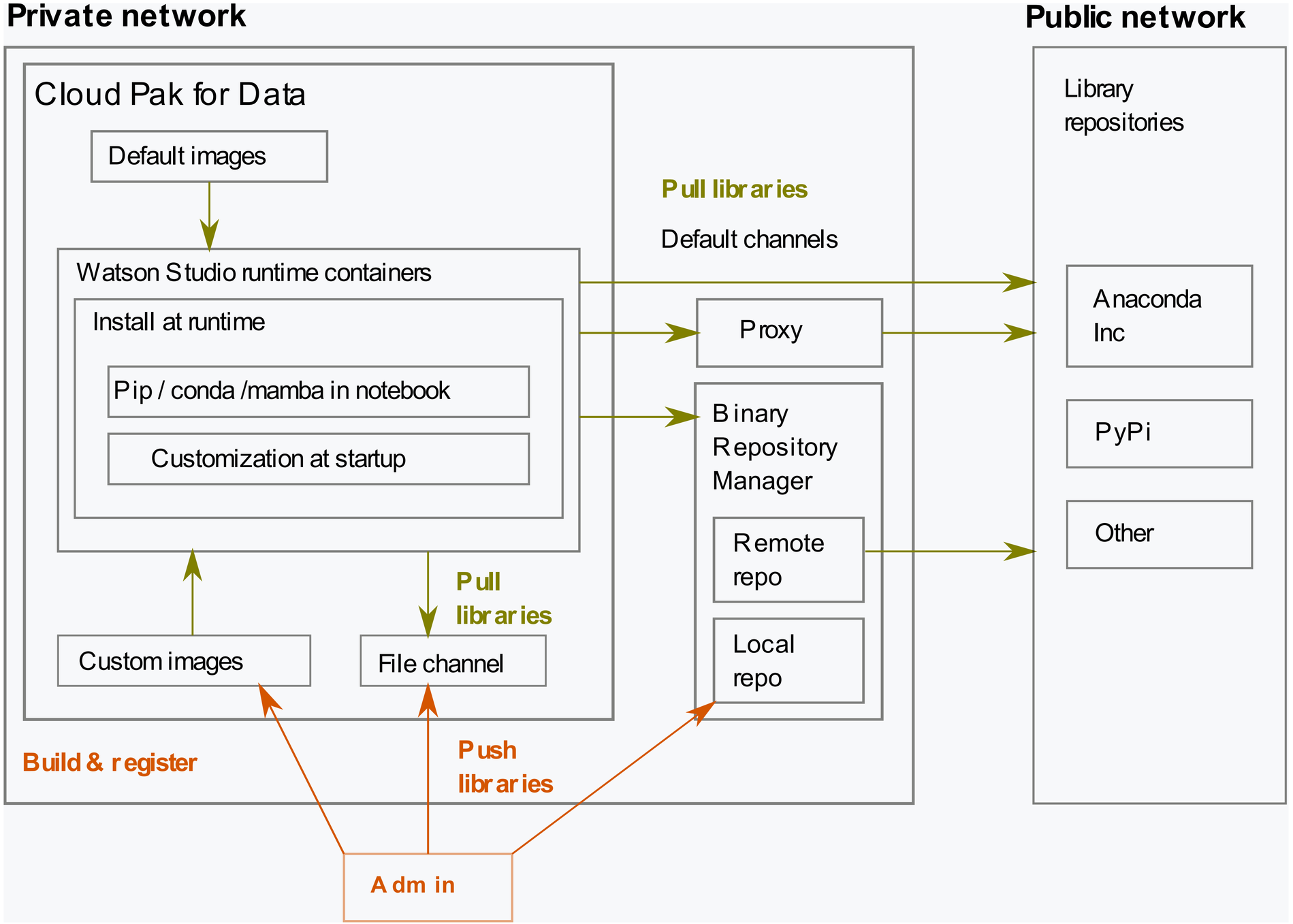
pip and conda install when you want to quickly add a few libraries in the running environment
conda solver is much longer and memory intensive

Environment templates execute per container initialization (watch that start time)

Custom images for more invasive libraries (especially system library requirements) and LARGE frameworks

Custom Images

- Admin Required*
- Download Configuration File
- Download the Image
- Build Image
- Register the Image
- Push the Image
- Update Configuration



Process Outline

1. Pull Instance Configuration from Data API
2. Fetch Available Image Runtimes
3. Pull Specific Runtime Configuration
4. In runtime configuration find image id from registry:
   such as; wslocal-runtime-py310main@sha256:491c86cb5604a1fe0e11d1…
5. Login to Registry and Pull Image ID
6. Edit Dockerfile with Customizations
7. Build updated image
8. Push image to registry
9. Update configuration file with updated image id
10. Push configuration file to cluster.

https://www.ibm.com/docs/en/cloud-paks/cp-data/4.7.x?topic=environments-building-custom-images

Dockerfile Best Practices

1.Run an image build that installs the packages you require.

2.From the build log output , collect a list of all packages and versions that were installed.

3.Add comments to the install commands without package versions. These comments will be useful when packages need to be updated.

4.Add new install commands with the full list of packages and their versions.

5.Rebuild the image.

```
FROM ${base_image_tag}

# ============
# root section
# ============
USER root:root

COPY install-as-root.sh /tmp/install/
RUN umask 022 \
 && bash /tmp/install/install-as-root.sh \
 && /opt/ibm/build/bin/microdnf-clean.sh \
 && rm -rf /tmp/install
# The microdnf-clean.sh script also grants required permissions.

# ----------------------------------------
# Change display name of the Jupyter kernel
# ----------------------------------------
# Changing the display name of the kernel allows for distinguishing different
# custom images from the default runtime images when editing a notebook.
# It is good practice, but not strictly required.

RUN sed -i -e '/display_name/{s/",/ with modifications",/}' \
   /opt/ibm/run/kernels/*/kernel.json

# ============
# user section
# ============
USER wsbuild:wsbuild

COPY --chown=wsbuild install-as-user.sh /tmp/install/
RUN umask 002 \
 && bash /tmp/install/install-as-user.sh \
 && /opt/ibm/build/bin/fix-conda-permissions.sh \
 && conda run -n $DSX_KERNEL_CONDENV pip cache purge \
 && conda clean --tarballs \
 && rm -rf /tmp/install

# ====
# conda
# ====
USER nobody:wsbuild
```

Labels and Pod Customizations

RSI (Resource Specification Injection): Customize Specifications of Pods

- Labels
- Environment Variables
- Annotations
- Node Affinity
- Init Containers or Sidecar Containers
- Custom Resource Requests

– OCP Authentication

```
cpd-cli manage login-to-ocp \
--username=${OCP_USERNAME} \
--password=${OCP_PASSWORD} \
--server=${OCP_URL}
```

– Install RSI (public registry)

```
cpd-cli manage install-rsi \
--cpd_instance_ns=${PROJECT_CPD_INST_OPERANDS}
```

https://www.ibm.com/docs/en/cloud-paks/cp-data/4.7.x?topic=2-customizing-pod-specifications-rsi

Additional Cool Features

VSCode Extension:

Must be enabled by admin on the cluster. Develop in VSCode and remotely execute in CP4D.

SSH over secure websocket tunnel. Uses cluster configured auth.

https://www.ibm.com/docs/en/cloud-paks/cp-data/4.7.x?topic=scripts-visual-studio-code

Storage Volumes:

Access NFS and CIFS Shares. Access permissions operates oddly, however. Ownership for CIFS derived from user account creating, NFS from openshift UIDs

Killer use case is, local storage volumes. Use a common shared storage space for cross project data (Library concept).

https://www.ibm.com/docs/en/cloud-paks/cp-data/4.7.x?topic=2-managing-storage-volumes

Watson Pipelines:

Instrument flows and interactions from assets. Derive a data product, validate quality, use to train model, compare to existing model, promote challenger to production.

Can work across project and deployment spaces.

https://www.ibm.com/docs/en/cloud-paks/cp-data/4.7.x?topic=assets-watson-pipelines

Q&A

Next Steps

Try watsonx.ai in IBM Cloud

Join us for hands-on labs at
IBM TechXChange conference

Fuel Your AI
at the ultimate
IBM learning event

IBM TechXchange Conference
October 21-24, 2024
Mandalay Bay – Las Vegas

Thank You

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https://github.com/krondor/techxchange2023-ws-bp

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