A surreal image of a man in a graduation cap and suit, holding a small plant, with a large blue 'A' logo on the right.

# Déployer une stack MLOps sous Azure : *gagnez progressivement en maturité !*

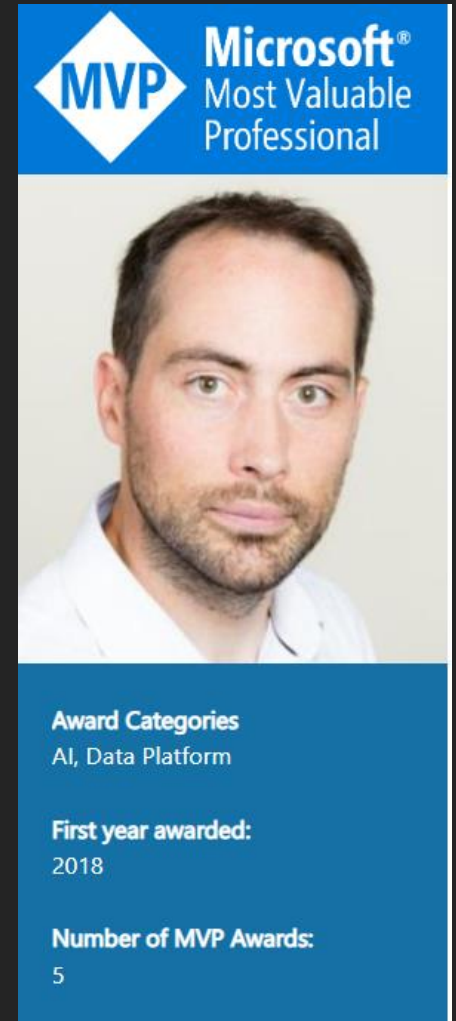
Meetup Data Cloud Paris  
Mercredi 12 octobre 2022

# Speaker : Paul PETON

- Tech Lead Intelligence Artificielle
- Data Platform & AI MVP since 2018
- Co-animateur du podcast



- [GitHub.com/methodidacte/meetups](https://github.com/methodidacte/meetups)







# Agenda

- MLOps dans une coquille de noix
- Les niveaux de maturité du MLOps
- Une stack MLOps sur Azure
  - Par où commencer ?
  - L'architecture sous-jacente
  - Distinguer les familles de composants
  - Piocher dans la « boîte à outils »
  - Utiliser plusieurs environnements

Déployer une stack MLOps sous Azure :  
*gagnez progressivement en maturité*

*people dealing with process on a platform (DALL.E)*

# MLOps dans une coquille de noix

---

- Pourquoi industrialiser ?
  - Pour **diminuer les coûts** (d'opérations manuelles, d'erreurs...)
  - Pour **augmenter la qualité** (par des opérations testées et automatisées)
  - Pour **réduire le temps de mise en production** (*time to market*)
- MLOps = ML + DevOps, mais pas que
  - **Framework complet** : design + model development + operations
  - Des niveaux de **maturité**
  - Une **stack** construite à partir d'un **tooling** vaste et mouvant
  - Sites de référence :
    - <https://ml-ops.org/>
    - <https://mlops-guide.github.io/>
- Une **complexité forte** liée à la nature de l'apprentissage automatique
  - Notion de **reproductibilité**
  - Notions de **dérive** (*drift*)







78:18

PAR

1

1

BEN

DIRECT

RMC  
SPORT 1

TOP COACH

Il n'y a pas de certitude dans  
dans le MLOps.

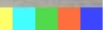
# Les points de tension à résoudre

---

- La **collaboration** entre les Data Scientists
- Le temps passé et les efforts pour **déployer** les modèles
- La non **performance** des modèles lors de l'inférence
- La **gouvernance** des modèles et des données d'entraînement

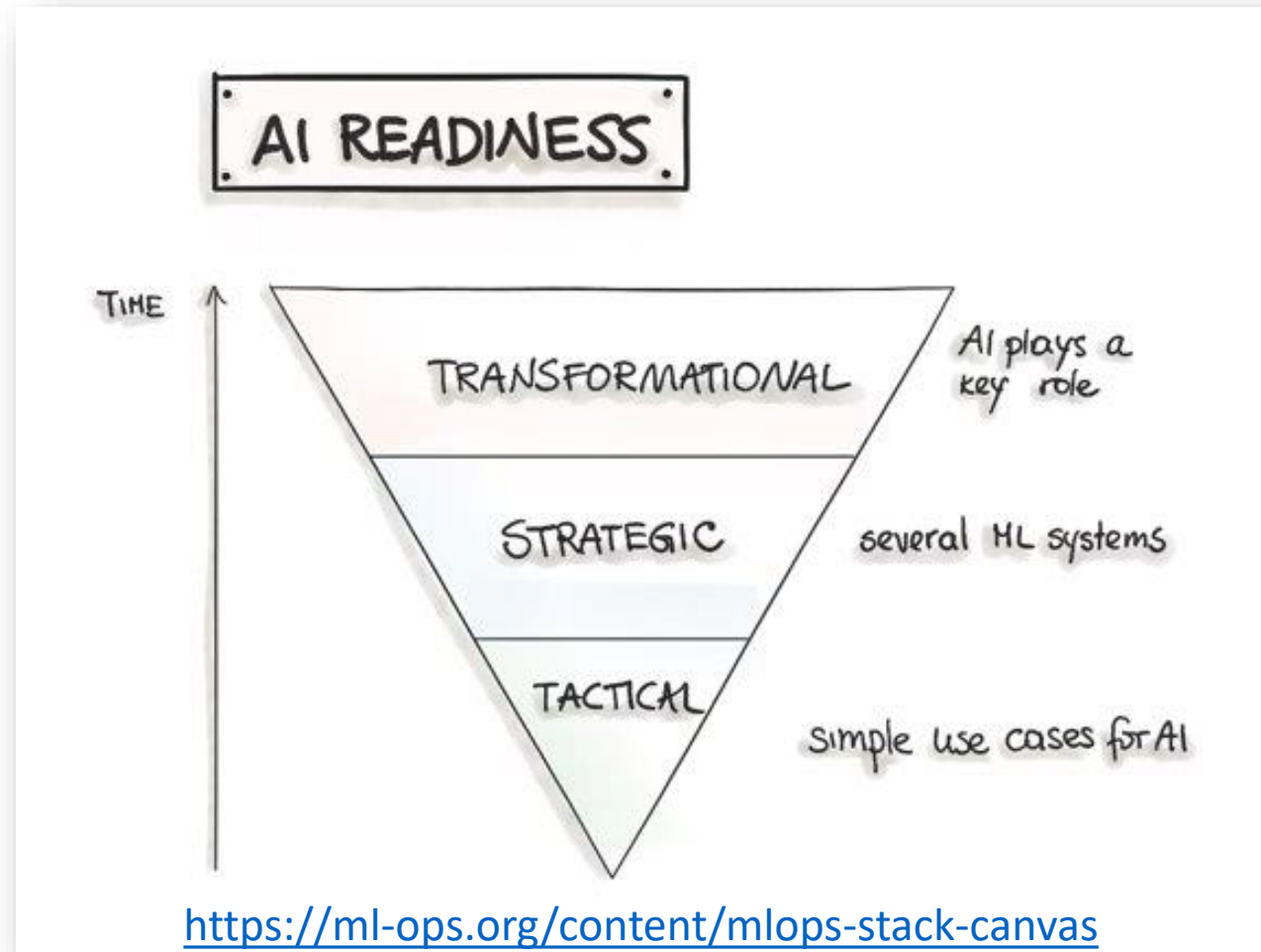


*tensions to be resolved*



# What is your AI readiness ?

---





# Tracking

Maturité – niveau 0

- Suivre les **performances** des entraînements
- Assurer le **linéage** “code – data – model”





# Tracking et versioning des modèles avec mlflow™

The screenshot displays the Databricks MLflow interface for tracking and versioning models. The left sidebar contains navigation options: Workspace, Repos, Recents, Search, Data, Compute, Workflows, Experiments (selected), Feature Store, Models, Partner Connect, Help, Settings, and user information (dbxsalondata, paul.peton@live.fr).

The main panel shows the experiment page for `/Users/paul.peton@live.fr/mlflow/MLflow quickstart part 1: training and logging`. The experiment ID is `3524505339477402`. The description is `Description Edit`. The interface includes buttons for `Refresh`, `Compare`, `Delete`, `Download CSV`, and a `Start Time` dropdown set to `All time`. A search bar contains the query `metrics.rmse < 1 and params.model = "tree"`. The results show 4 matching runs.

	Start Time	Duration	Run Name	User	Source	Version	Models	Metrics
<input type="checkbox"/>	6 months ago	11.2s	-	paul.peton...	MLflow ...	-	sklearn	mae: 51.05
<input type="checkbox"/>	6 months ago	9.7s	-	paul.peton...	MLflow ...	-	sklearn	mae: 56.74
<input type="checkbox"/>	6 months ago	10.2s	-	paul.peton...	MLflow ...	-	sklearn	mae: 53.76
<input type="checkbox"/>	6 months ago	14.7s	-	paul.peton...	MLflow ...	-	sklearn	mae: 60.09

A `Load more` button is located below the table.

The right sidebar shows the `Metrics (3)` section with a table:

Name	Value
mae	51.05
r2	0.395
rmse	63.25

Below the metrics, there are sections for `Tags` and `Artifacts`. The `Artifacts` section shows a `model` folder containing `MLmodel`, `conda.yaml`, `model.pkl`, `requirements.txt`, and `ElasticNet-paths.png`. The `MLmodel` artifact is selected, showing its full path and size (394B). The `Full Path` is `dbfs:/databricks/mlflow-tracking/3524505339477402/`. The `artifact_path` is `model`. The `databricks_runtime` is `10.2.x-cpu-ml-scala2.12`. The `flavors` section lists the `python_function` environment, loader module, model path, python version, and sklearn version. The `run_id` is `b39eef6044fc4f669e16d1148f503011` and the `utc_time_created` is `'2022-02-17 16:15:29.595400'`.

A close-up, slightly blurred photograph of industrial machinery, likely a steam engine or boiler. Dark, metallic pipes and valves are visible, with some steam or smoke rising from the equipment. The lighting is warm and focused on the central part of the machinery.

# Automation

Maturité – niveau 1

- CI : **packager** les livrables
- CD : **déployer** le code et les modèles



# CI : tests automatisés et packaging du code

MyMLOps

Overview

Boards

Repos

Pipelines

Pipelines

Environments

Releases

Library

Task groups

Deployment groups

Test Plans

Artifacts

#20221004.16 • version 0.1.3

citibike\_pkg

This run is being retained as one of 3 recent runs by main (Branch).

Run new

Summary

Triggered by Paul PETON

Repository and version

citibike\_pkg

main 57d72325

Stages

Jobs

Test Stage

Build Stage

%pip install --index-url=https://methodidacte.pkgs.visualstudio.com/MyMLOps/\_packaging/citibike\_feed/pypi/simple/ citibike-pkg==0.1.2

Show result

Cmd 7

from citibike\_pkg import \_\_version\_\_

print(f"Package version: {\_\_version\_\_}")

Package version: 0.1.2

Command took 0.02 seconds -- by paul.peton@live.fr at 03/10/2022 22:49:24 on dev-dbx-cluster

Cmd 8

from citibike\_pkg.citibike\_prep import read\_csv

Command took 0.04 seconds -- by paul.peton@live.fr at 03/10/2022 22:49:10 on dev-dbx-cluster

# CD : déploiement de modèle par CLI

Azure DevOps methodidacte / MyMLOps / Pipelines / MyMLOps / 20221006.5

Search

MyMLOps

Overview

Boards

Repos

Pipelines

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Artifacts

Jobs in run #20221006.5

MyMLOps

Jobs

Job	Duration
Initialize job	<1s
Checkout MyMLOps@...	3s
az upgrade	7s
az ml install	26s
az configure	2s
az deploy	8m 42s
Post-job: Checkout M...	<1s
Finalize Job	<1s
Report build status	<1s

az deploy

```
34 /usr/bin/az cloud set -n AzureCloud
35 /usr/bin/az login --service-principal -u *** --password=*** --tenant [REDACTED] --allow-no-subscriptions
36 [
37   {
38     "cloudName": "AzureCloud",
39     "homeTenantId": "[REDACTED]",
40     "id": "[REDACTED]",
41     "isDefault": true,
42     "managedByTenants": [
43       {
44         "tenantId": "[REDACTED]"
45       }
46     ],
47     "name": "Microsoft Azure Sponsorship",
48     "state": "Enabled",
49     "tenantId": "[REDACTED]",
50     "user": {
51       "name": "****",
52       "type": "servicePrincipal"
53     }
54   }
55 ]
56 /usr/bin/az account set --subscription [REDACTED]
57 /usr/bin/bash /home/vsts/work/_temp/azureclitaskscript1665082764736.sh
58 Check: endpoint [REDACTED]moe-mlflow-cli-endpoint exists
59 Creating/updating online deployment sklearn-deployment .....
60 /usr/bin/az account clear
61 Finishing: az deploy
```

View raw log

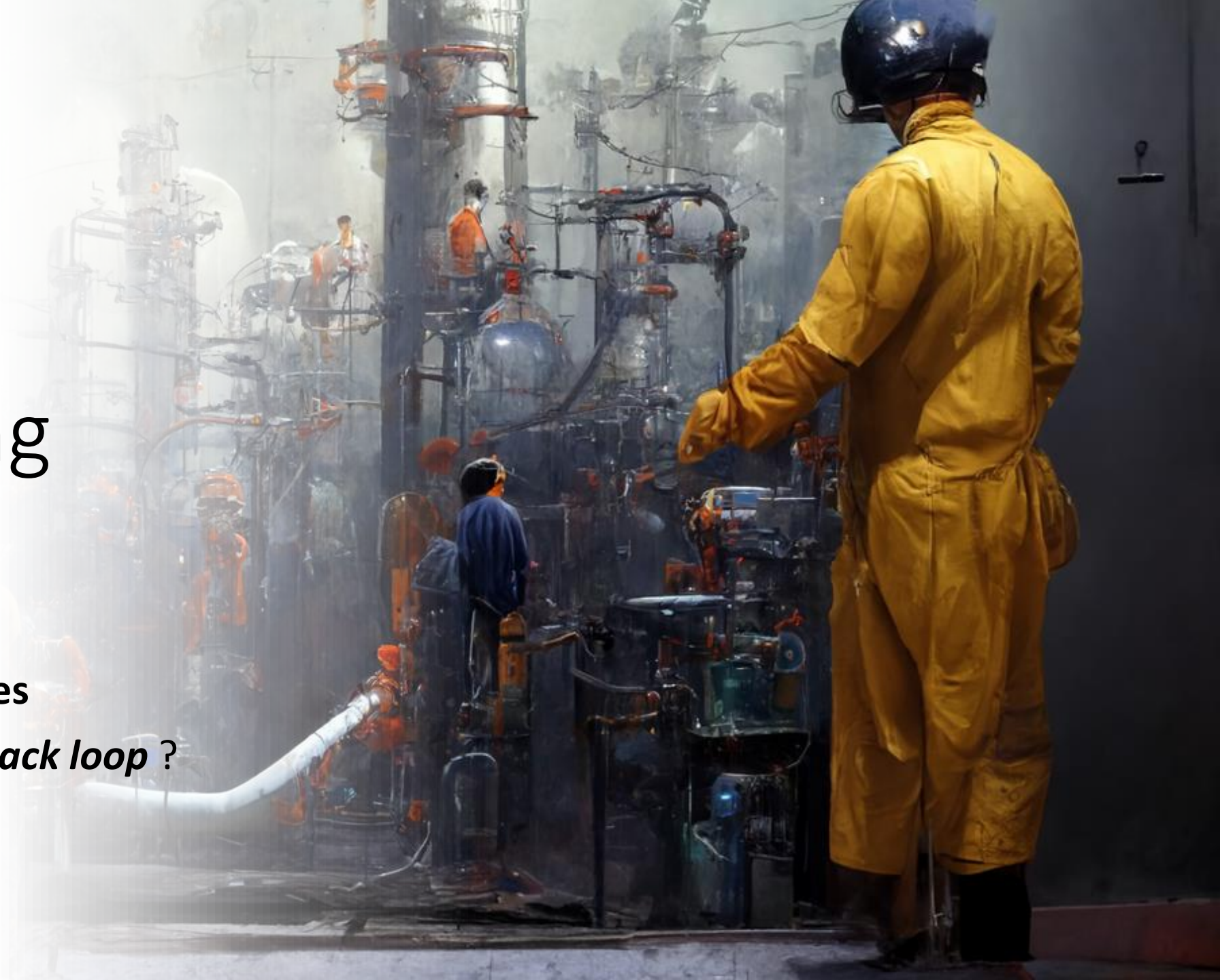
```
12 steps:
13 - task: AzureCLI@2
14   displayName: 'az upgrade'
15   inputs:
16     azureSubscription: [REDACTED]
17     scriptType: 'bash'
18     scriptLocation: 'inlineScript'
19     inlineScript: 'az upgrade'
20 - task: AzureCLI@2
21   displayName: 'az ml install'
22   inputs:
23     azureSubscription: [REDACTED]
24     scriptType: 'bash'
25     scriptLocation: 'inlineScript'
26     inlineScript: |
27       az extension remove -n azure-cli-ml
28       az extension remove -n ml
29       az extension add -n ml -y
30 - task: AzureCLI@2
31   displayName: 'az configure'
32   inputs:
33     azureSubscription: [REDACTED]
34     scriptType: 'bash'
35     scriptLocation: 'inlineScript'
36     inlineScript: |
37       az account set --subscription [REDACTED]
38       az configure --defaults workspace=amldev group=rg-dbx-dev
39 - task: AzureCLI@2
40   displayName: 'az deploy'
41   inputs:
42     azureSubscription: [REDACTED]
43     scriptType: 'bash'
44     scriptLocation: 'inlineScript'
45     inlineScript: |
46       az ml online-deployment update --name sklearn-deployment --endpoint diabetes-moe-mlflow-cli-endpoint -f moe/sklearn-deployment.yaml
```



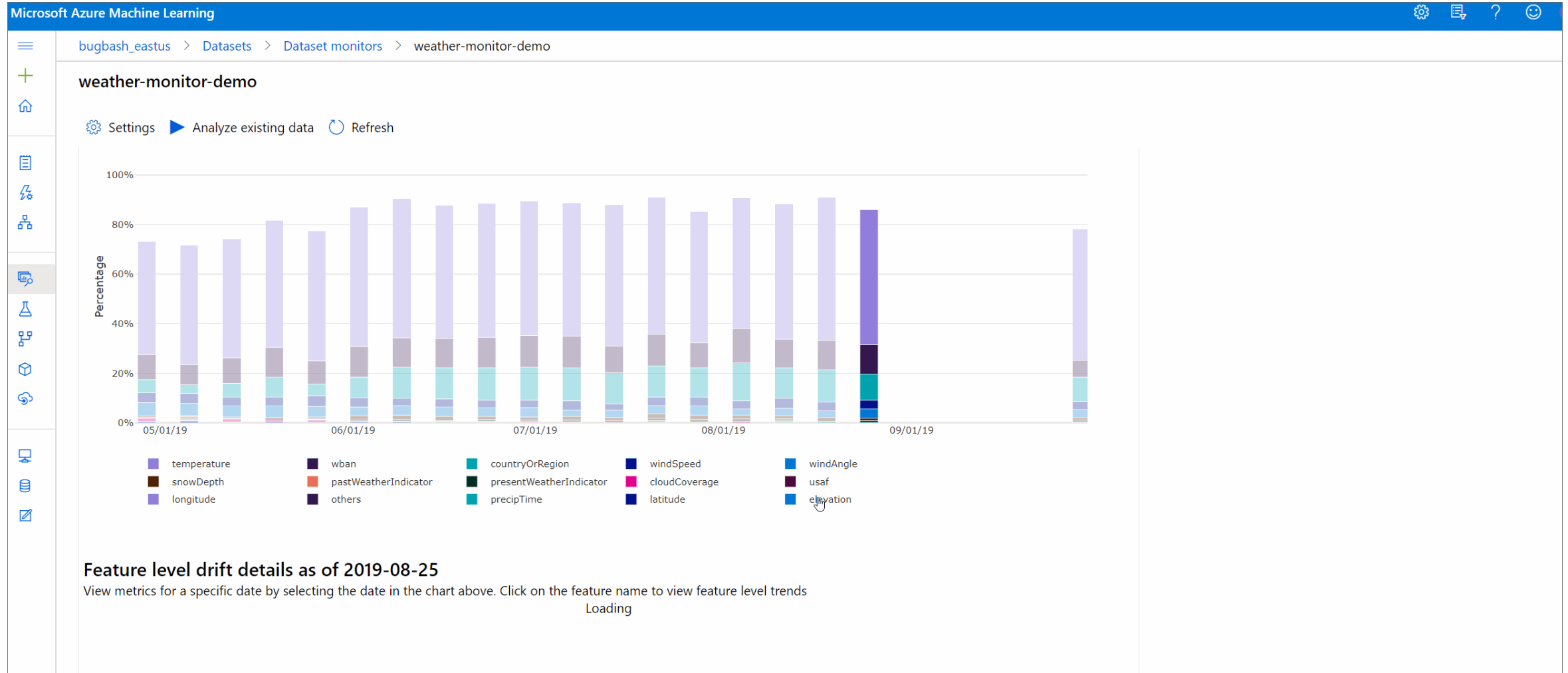
# Monitoring

Maturité – niveau 2

- Détecter les **dérives**
- Ajouter une ***feedback loop*** ?



# Drift detection avec Azure Machine Learning







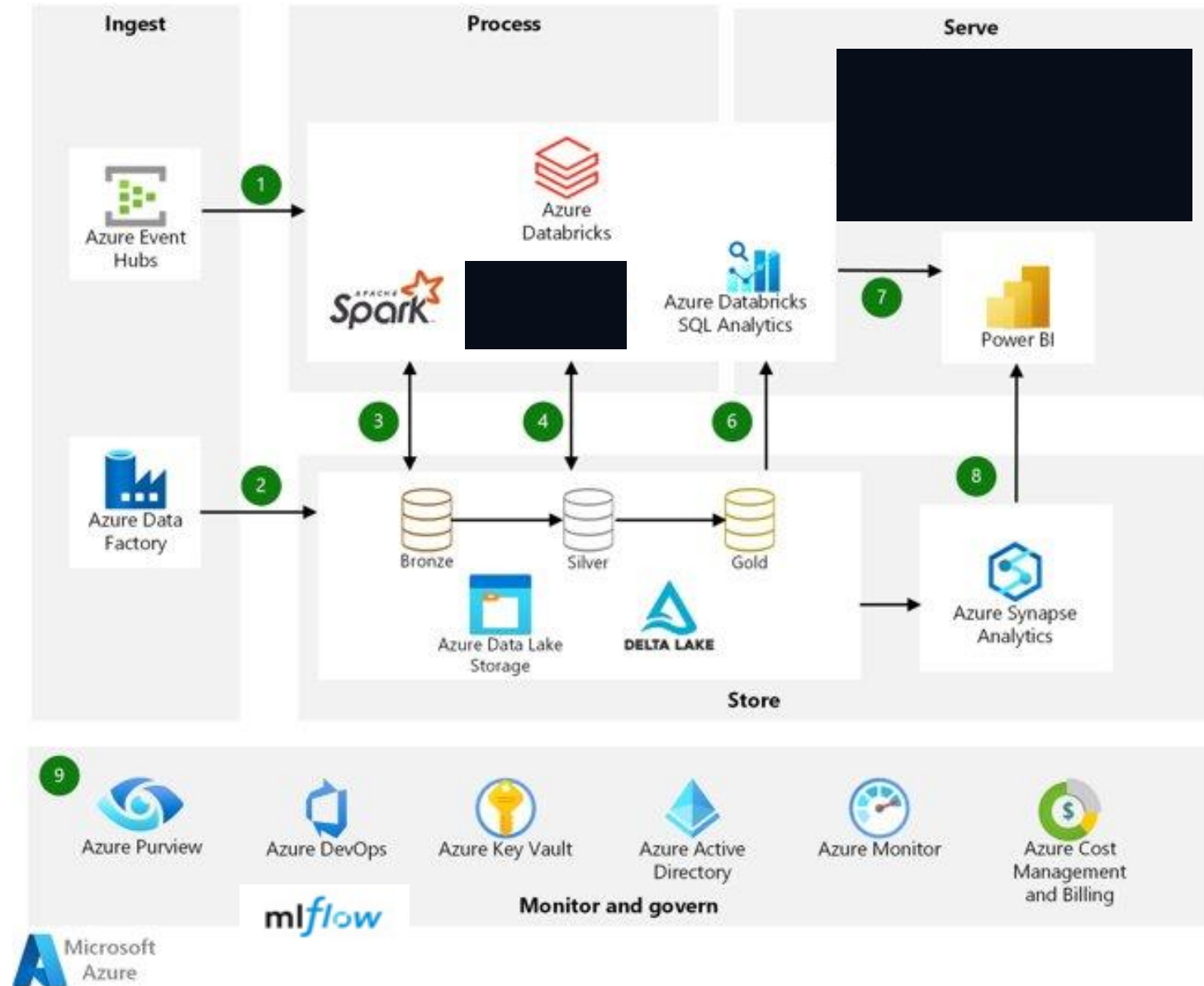
# Stack MLOps dans Azure

---

Un exemple parmi tant d'autres

# L'architecture sous-jacente : le *lake house*

- ... sauf si vous êtes déjà passé au *Data Mesh* !
- Un lac de données qui **centralise** tout, découpé en couches :
  - Brute
  - Raffinée
  - Valeur métier
- Des outils transverses
  - Dont les **registres**





# Lire des papiers de recherche ?

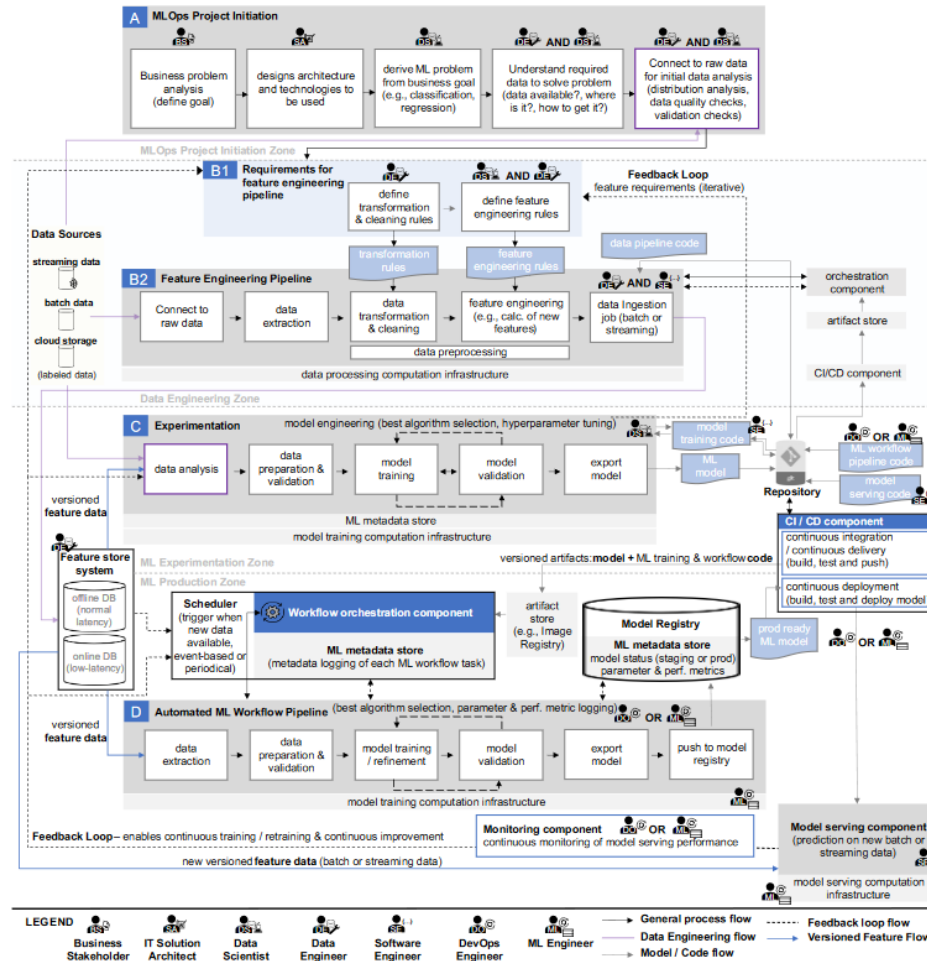
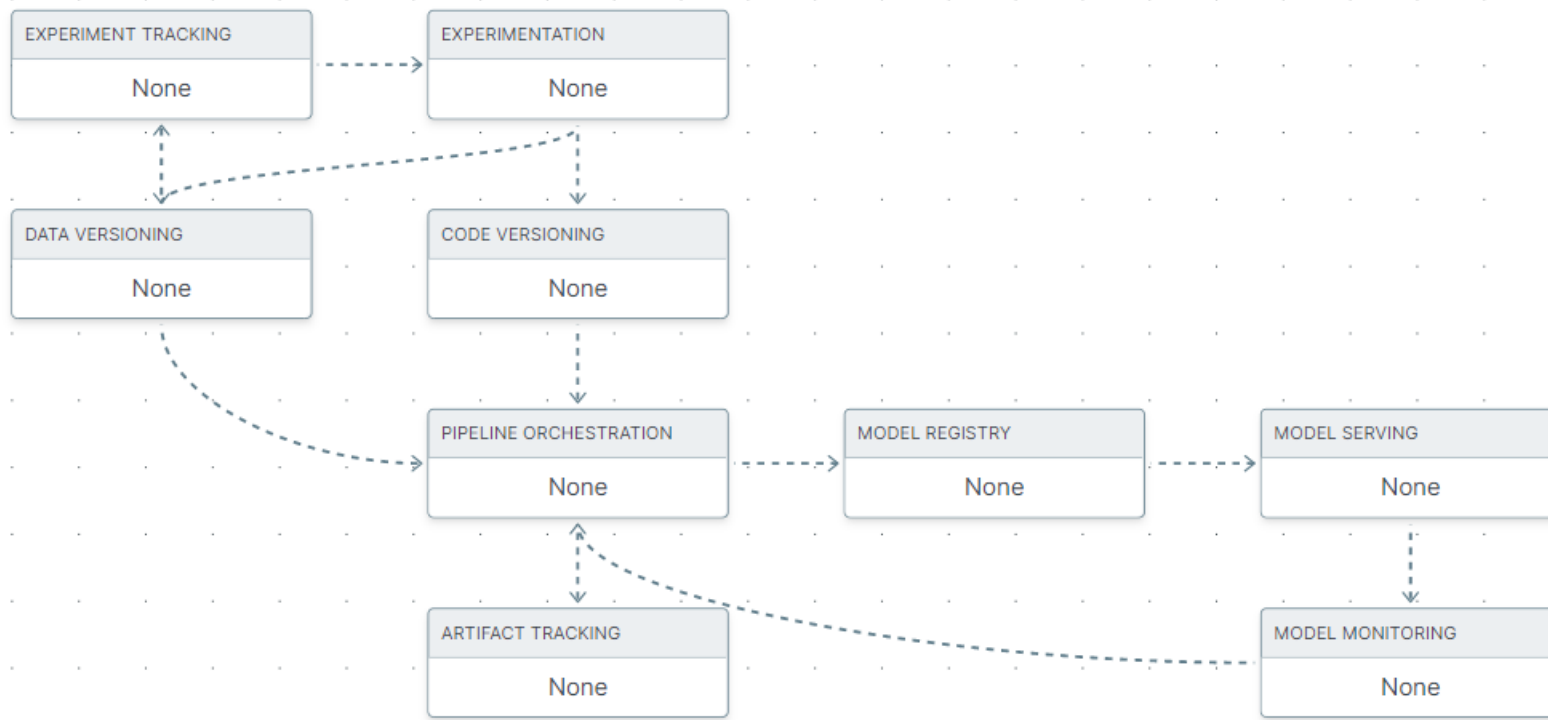


Figure 4. End-to-end MLOps architecture and workflow with functional components and roles

# Build your open-source MLOps stack ?

*Explore tools and components of the MLOps stack. Select any tool to find more about it. Add it to build your own stack.*

<https://mymlops.com/>



# Les trois pipelines (de code) du Machine Learning

## Data Engineering Pipelines

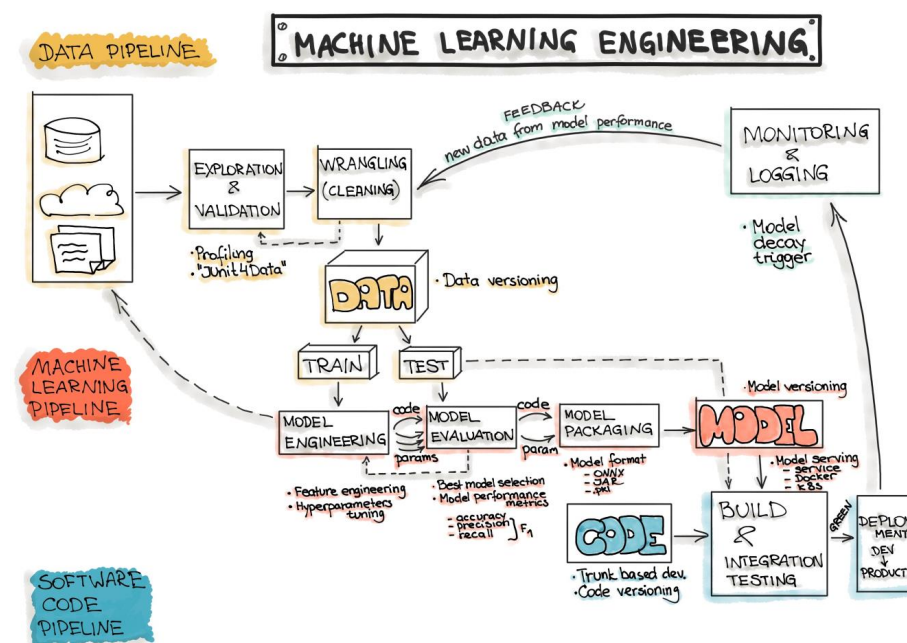
Data Ingestion  
Exploration and Validation  
Data Wrangling  
Data Splitting

## ML Pipelines / workflows

Model Training  
Model Evaluation  
Model Testing  
Model Packaging

## Model Serving

Batch  
On-demand (microservices, REST API)





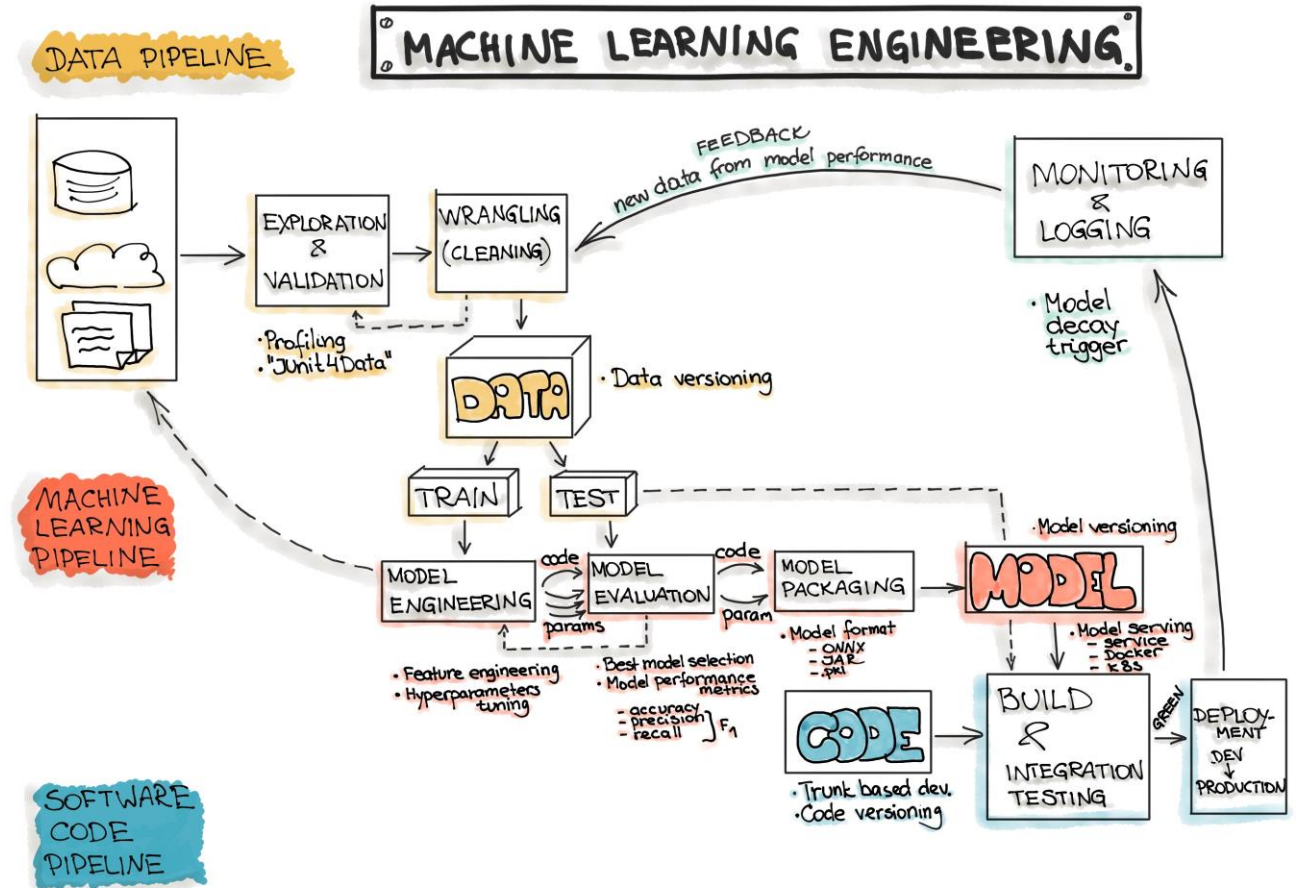
# Distinguer les familles de composants

Code

Registry

Pipeline

Monitoring



# Distinguer les familles de composants

- Pipeline

Code

- Data preparation

- Code versionné dans un Repository Git

- Model training

- Artefact de modèle déposé dans un Model Registry

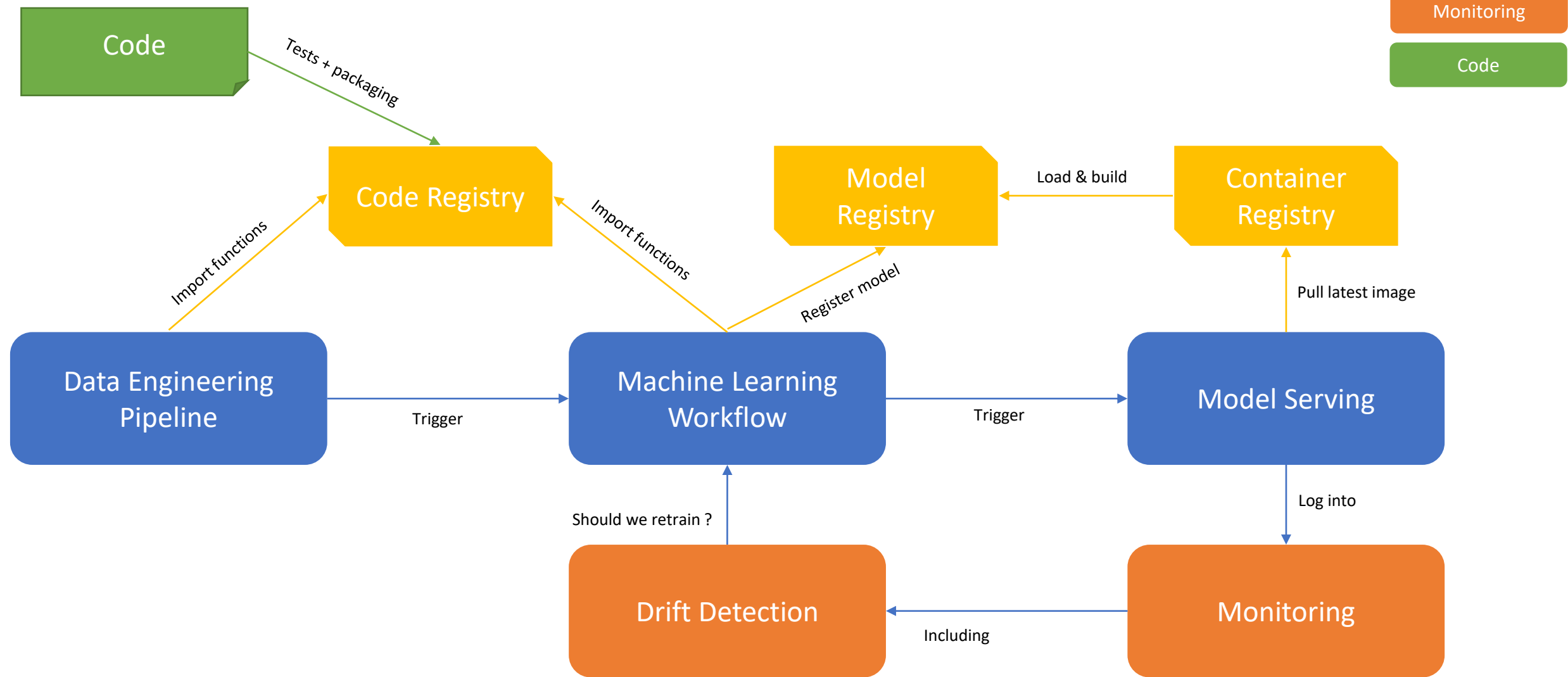
- Model serving

- Image (Docker) déposée dans un Container Registry


- Monitoring

- Inclut la détection de la dérive

# Our version of MLOps Stack template

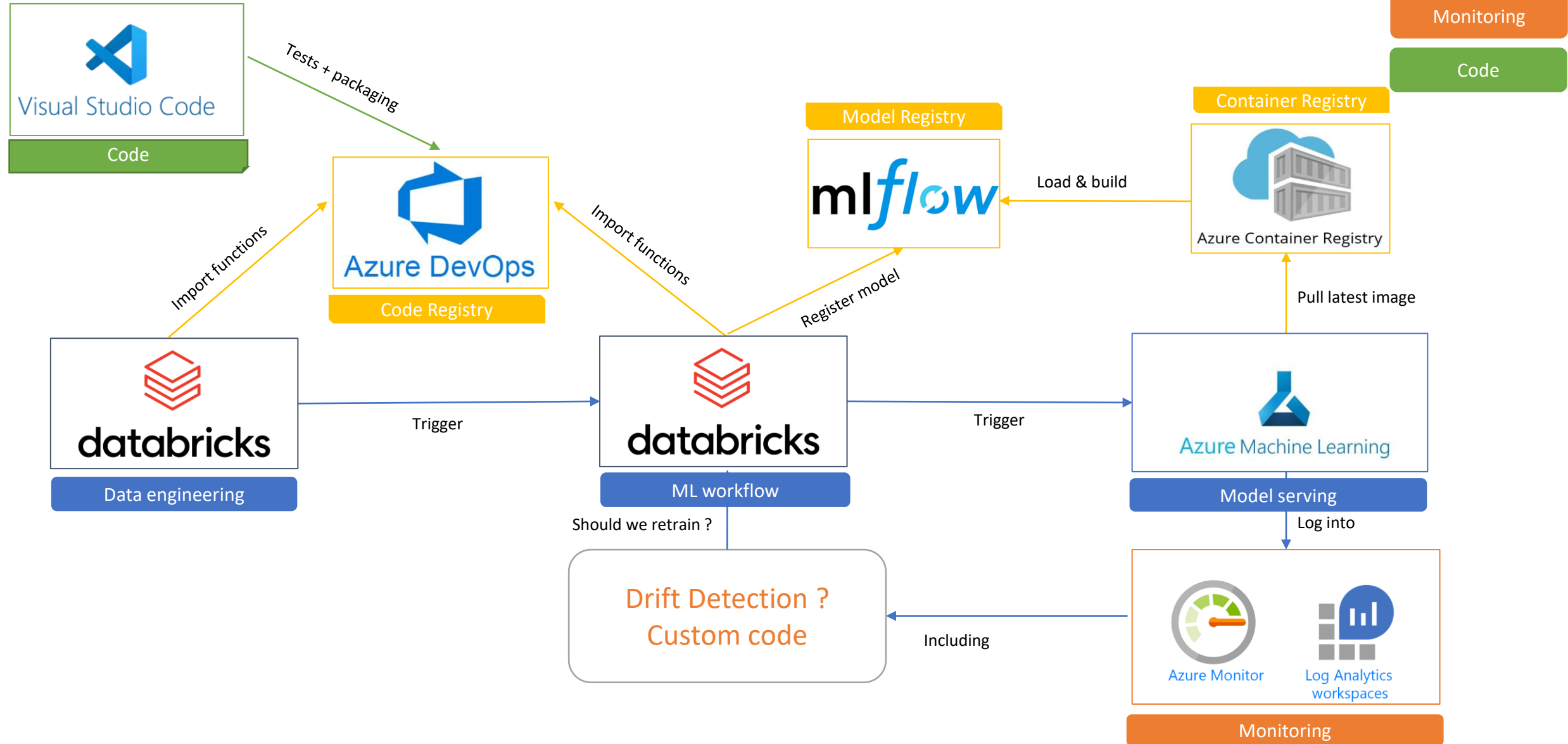




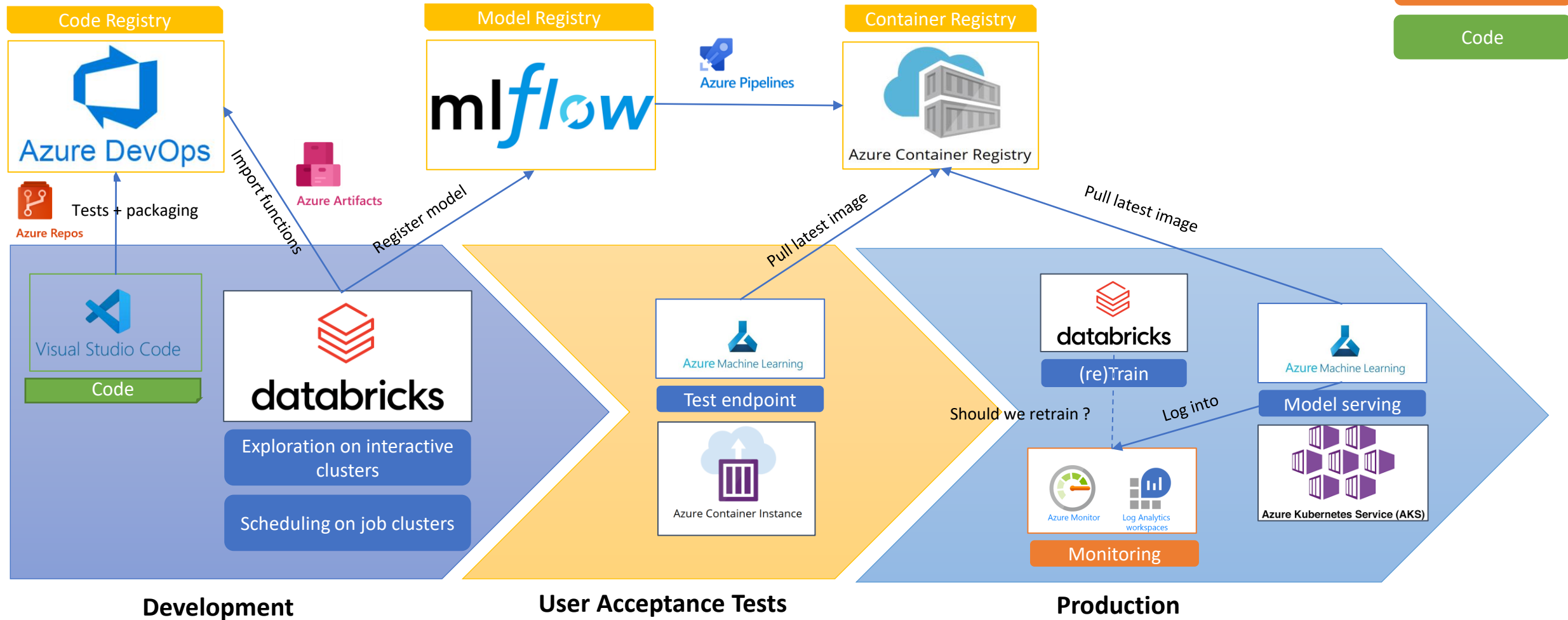


*a data factory surrounded by five-  
legged unicorns*

# Our MLOps Stack on Microsoft Azure



# In a multiple environments context





*Oh, que je préfère,  
à un mouton à cinq pattes,  
les doigts de la main*



*A five-legged unicorn and a giant hand with human fingers  
comicbook style by J.M.W. Turner*