


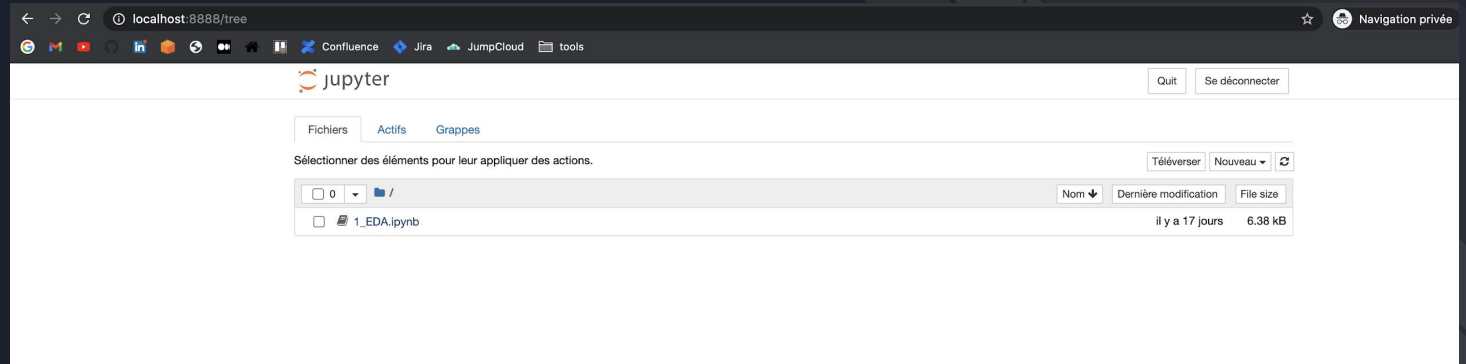
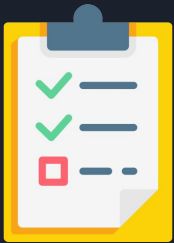
**Better track your
ML experiments
with**

mlflow™

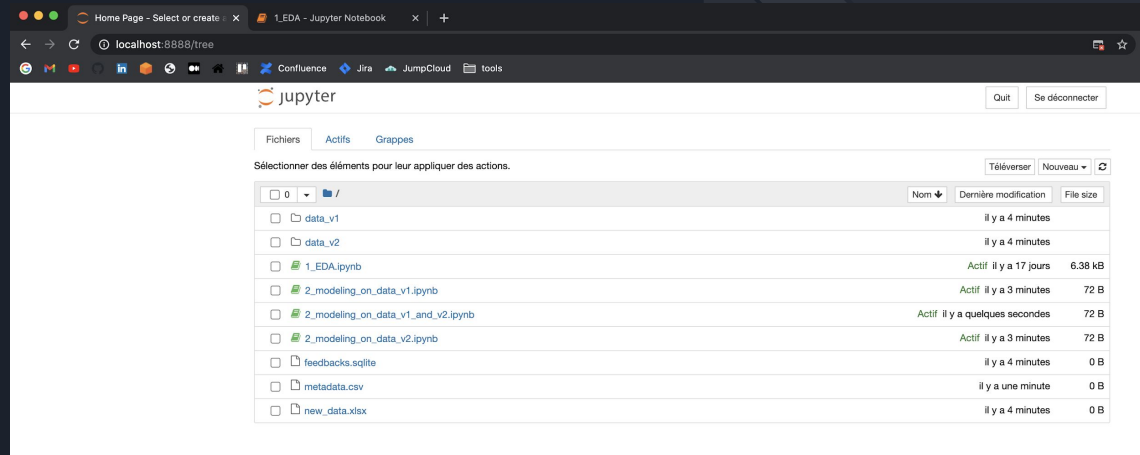


Here's a situation that you
may be familiar with

Week 1 - your start a project



Week 2 - You get more data...



Week 3 - Another data scientist joins the team



Home Page - Select or create x 1_EDA - Jupyter Notebook x +

localhost:8888/tree

Confluence Jira JumpCloud tools

jupyter Quit Se déconnecter

Fichiers Actifs Grappes

Sélectionner des éléments pour leur appliquer des actions. Téléverser Nouveau ↕

<input type="checkbox"/>	0 ▾	📁 /	Nom ↓	Dernière modification	File size
<input type="checkbox"/>		📁 data_v1		Il y a 13 minutes	
<input type="checkbox"/>		📁 data_v2		Il y a 13 minutes	
<input type="checkbox"/>		📄 1_EDA.ipynb		Actif il y a 17 jours	6.38 kB
<input type="checkbox"/>		📄 1_EDA_Alice.ipynb		il y a une minute	6.38 kB
<input type="checkbox"/>		📄 2_modeling_on_data_v1.ipynb		Actif il y a 12 minutes	72 B
<input type="checkbox"/>		📄 2_modeling_on_data_v1_Alice.ipynb		il y a une minute	72 B
<input type="checkbox"/>		📄 2_modeling_on_data_v1_and_v2.ipynb		Actif il y a 9 minutes	72 B
<input type="checkbox"/>		📄 2_modeling_on_data_v1_and_v2_Alice.ipynb		il y a une minute	72 B
<input type="checkbox"/>		📄 2_modeling_on_data_v2.ipynb		Actif il y a 12 minutes	72 B
<input type="checkbox"/>		📄 2_modeling_on_data_v2_Alice.ipynb		il y a une minute	72 B
<input type="checkbox"/>		📄 feedbacks.sqlite		il y a 13 minutes	0 B
<input type="checkbox"/>		📄 metadata.csv		il y a 10 minutes	0 B
<input type="checkbox"/>		📄 new_data.xlsx		Il y a 13 minutes	0 B

Week 4 - You start having some results



Fichiers Actifs Grappes

Sélectionner des éléments pour leur appliquer des actions.

☐ 0 ▾

/ exports


<input type="checkbox"/>	..
<input type="checkbox"/>	model_v11_alice_best.pkl
<input type="checkbox"/>	model_v1_alice_all_data.pkl
<input type="checkbox"/>	model_v1_bob.pkl
<input type="checkbox"/>	model_v1_bob_auc_0-Copy1.76.pkl
<input type="checkbox"/>	model_v1_bob_auc_0.76.pkl
<input type="checkbox"/>	model_v2_bob.pkl
<input type="checkbox"/>	model_v3_alice.pkl

Week 5 - your manager comes in



- ❑ How does the best model score?
- ❑ On which data has it been trained?
- ❑ What are the different experiments each data scientist undertook?
- ❑ Is it possible to deploy the model to the business teams to try it out?





Track your ML
experiments
with

mlflow™



mi*flow*™



What is MLflow?

*“MLflow is an open source platform to manage the **ML lifecycle**, including **experimentation**, **reproducibility**, **deployment**, and a **central model registry**. MLflow currently offers four components”*

MLflow Tracking

Record and query experiments: code, data, config, and results

[Read more](#)

MLflow Projects

Package data science code in a format to reproduce runs on any platform

[Read more](#)

MLflow Models

Deploy machine learning models in diverse serving environments

[Read more](#)

Model Registry

Store, annotate, discover, and manage models in a central repository

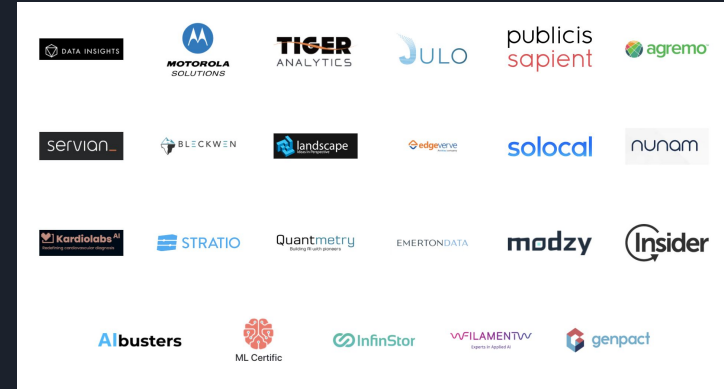
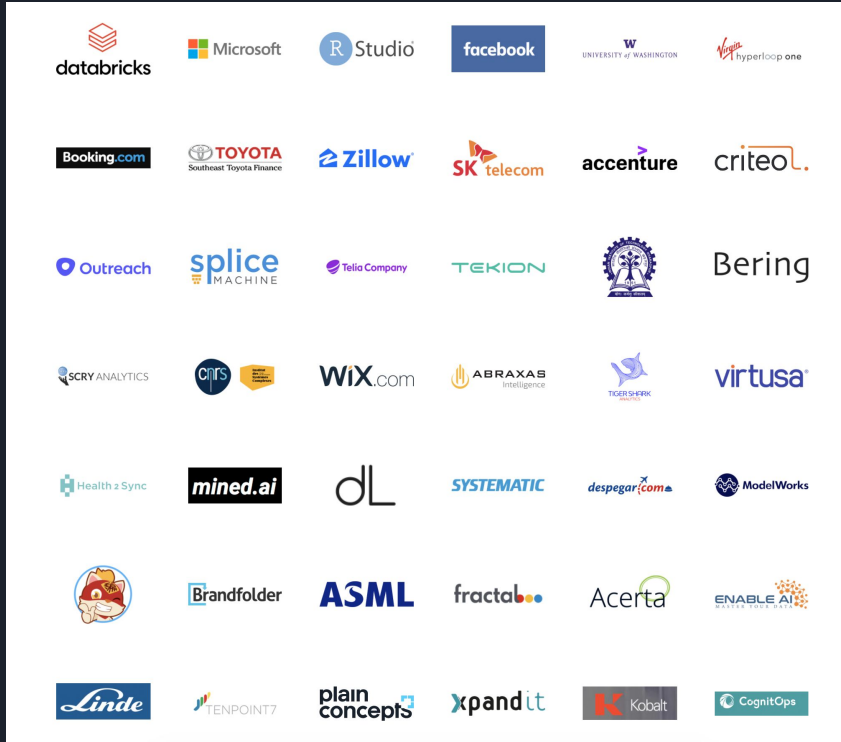
[Read more](#)

Integrated to a large set of libraries, frameworks and cloud providers

Integrations with:



And used by many companies...



Some **alternative** to MLflow



TensorFlow Extended



Michelangelo

Jeremy Hermann, Machine Learning Platform © Uber

Uber



TensorBoard



neptune.ai

The lifecycle of an ML project

Development

Exploratory data analysis
Feature engineering and model training
Evaluation, validation and versioning

Deployment

Reproducibility and dependency management
Scalability
Batch vs real time



Operations

Monitoring et alerting
Debugging
Feedbacks
Resource managements

Delivery

Dashboards
User interfaces
APIs
Notifications & recommendations



MLflow enforces MLOPs principles

MLOPs = Machine Learning + DEV + OPs

- DEV: packaging, déploiement, testing, release
- OPS: Config, monitoring

A set of principles to unify development and operations

Enforces automation and monitoring at every stage (integration, testing, release, ...)

Speeds up time to production

Allows to detect bugs and errors early



MLflow Tracking



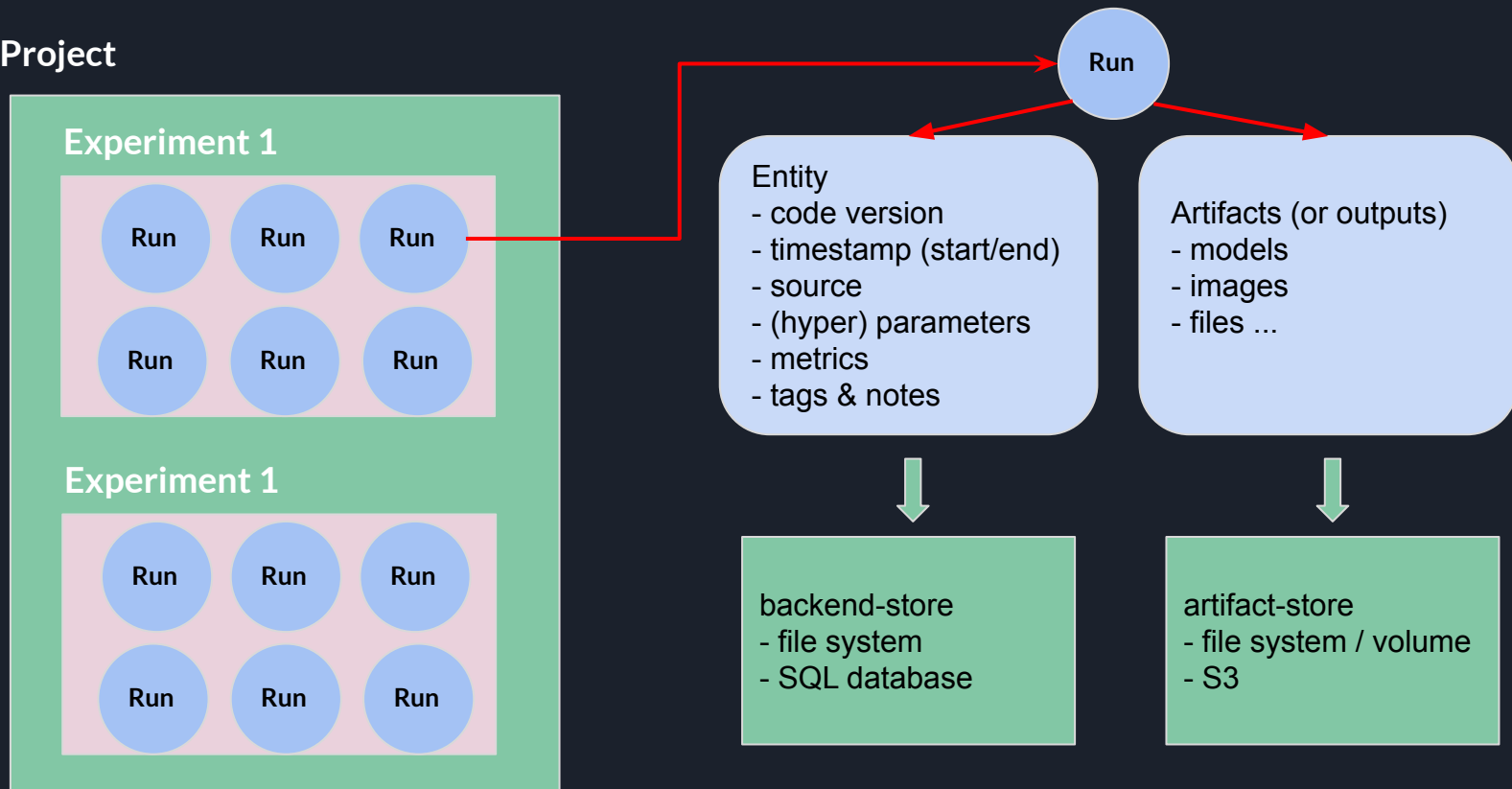


What does MLflow track?

- ❑ **parameters:** `n_estimators`, `max_depth`, `epochs`, `kernel_size`, `dropout`, `batch_size`?
- ❑ **metrics:** AUC, MAE, MSE; F1 score, accuracy, R-squared (r^2)
- ❑ **data:** what version of the data has the model been trained on?
- ❑ **artifacts:**
 - ❑ **models:** binary outputs (think pickle files)
 - ❑ **other outputs** (images, csv, text, html, etc.)
- ❑ **source:** which script/notebook was responsible of this run?
- ❑ **tags and comments:** individual or team annotations

Some terminology: runs et experiments

Project





```
pip install mlflow
```



```
import mlflow

# set tracking URI i.e. where MLflow saves runs
# the format : "file://" + absolute path

mlflow.set_tracking_uri("file:///Users/ahmed.besbes/projects/mlflow/mlruns")

# create an experiment
experiment_id = mlflow.create_experiment("training experiment")
```



```
with mlflow.start_run(experiment_id=experiment_id):
```

```
    model = RandomForestClassifier(
        n_estimators=n_estimators,
        max_depth=max_depth,
        max_features=max_features,
        n_jobs=3,
    )
```

```
    model.fit(x_train, y_train)
    y_pred = model.predict(x_test)
```

```
    accuracy = accuracy_score(y_test, y_pred)
    precision = precision_score(y_test, y_pred)
    recall = recall_score(y_test, y_pred)
    f1 = f1_score(y_test, y_pred)
    auc = roc_auc_score(y_test, y_pred)
```

```
mlflow.log_param("n_estimators", n_estimators)
mlflow.log_param("max_depth", max_depth)
mlflow.log_param("max_features", max_features)
```

hyperparameters logging

```
mlflow.log_metric("accuracy", accuracy)
mlflow.log_metric("precision", precision)
mlflow.log_metric("recall", recall)
mlflow.log_metric("f1", f1)
mlflow.log_metric("auc", auc)
```

metric logging

```
mlflow.sklearn.log_model(model, "model")
```

model logging

localhost:5000/#/experiments/1/s?orderByKey=tags.%60mlflow.source.git.commit%60

mlflow Experiments Models GitHub Docs

Experiments + <

Search Experiments

Default

training experiment

training experiment

Track machine learning training runs in an experiment. [Learn more](#)

Experiment ID: 1 Artifact Location: file:///Users/ahmed.besbes/projects/mlflow/mlruns/1

Notes

None

run

Search Runs: metrics.rmse < 1 and params.model = "tree" and tags.mlflow.source.type = "LOCAL"

Showing 100 matching runs Compare Delete Download CSV

Filter Search Clear

Columns

							Parameters			Metrics >		
	Start Time	Run Name	User	Source	Version	Models	max_depth	max_features	n_estimators	accuracy	auc	f1
	2021-03-05 17:38:55	-	ahmed.bes...	train.py	0bbaa7	-	21	None	275	0.785	0.691	0.538
	2021-03-05 17:38:54	-	ahmed.bes...	train.py	0bbaa7	sklearn	21	sqrt	275	0.787	0.688	0.535
	2021-03-05 17:38:53	-	ahmed.bes...	train.py	0bbaa7	sklearn	19	log2	275	0.788	0.693	0.542
	2021-03-05 17:38:50	-	ahmed.bes...	train.py	0bbaa7	sklearn	19	None	275	0.785	0.694	0.543
	2021-03-05 17:38:48	-	ahmed.bes...	train.py	0bbaa7	sklearn	19	sqrt	275	0.788	0.692	0.54
	2021-03-05 17:38:47	-	ahmed.bes...	train.py	0bbaa7	sklearn	17	log2	275	0.79	0.696	0.547
	2021-03-05 17:38:44	-	ahmed.bes...	train.py	0bbaa7	sklearn	17	None	275	0.786	0.699	0.55
	2021-03-05 17:38:43	-	ahmed.bes...	train.py	0bbaa7	sklearn	17	sqrt	275	0.789	0.697	0.548
	2021-03-05 17:38:41	-	ahmed.bes...	train.py	0bbaa7	sklearn	15	log2	275	0.791	0.702	0.555
	2021-03-05 17:38:39	-	ahmed.bes...	train.py	0bbaa7	sklearn	15	None	275	0.788	0.704	0.559
	2021-03-05 17:38:38	-	ahmed.bes...	train.py	0bbaa7	sklearn	15	sqrt	275	0.793	0.704	0.56
	2021-03-05 17:38:37	-	ahmed.bes...	train.py	0bbaa7	sklearn	13	log2	275	0.793	0.712	0.57

mlflow

ExperimentsModels

GitHub

training experiment > Run 2622ec9357dc4bb29104a41e0337e1d4

Date: 2021-03-05 17:38:54

User: ahmed.besbes

Source: train.py

Duration: 1.4s

Git Commit: 0bbaa7a1f9af0f402865b336d737884d0c03f889

Status: FINISHED

Notes

None

Parameters

Name	Value
max_depth	21
max_features	sqrt
n_estimators	275

Metrics

Name	Value
accuracy	0.787
auc	0.688
f1	0.535
precision	0.588
recall	0.491

▼ Tags

Name	Value	Actions
------	-------	---------

No tags found.

Add Tag

<input type="text" value="Name"/>	<input type="text" value="Value"/>	<input type="button" value="Add"/>
-----------------------------------	------------------------------------	------------------------------------

▼ Artifacts

▼ model

- MLmodel
- conda.yaml
- model.pkl

Full Path: s3://mlflow-artifact-store-demo/1/70c1791605c448f89f01df584597e9b5/artifacts/model

Size: 0B

[Register Model](#)

MLflow Model

The code snippets below demonstrate how to make predictions using the logged model. You can also [register it to the model registry](#).

Model schema

Input and output schema for your model. [Learn more](#)

Name	Type
No Schema.	

Make Predictions

Predict on a Spark DataFrame:

```
import mlflow
logged_model = 's3://mlflow-artifact-store-demo/1/70c1791605c448f89f01df584597e9b5/artifacts/model'

# Load model as a Spark UDF.
loaded_model = mlflow.pyfunc.spark_udf(logged_model)

# Predict on a Spark DataFrame.
df.withColumn(loaded_model, 'my_predictions')
```

Predict on a Pandas DataFrame:

```
import mlflow
logged_model = 's3://mlflow-artifact-store-demo/1/70c1791605c448f89f01df584597e9b5/artifacts/model'
```

Auto logging - Keras

```
import mlflow
import mlflow.keras
# Build, compile, enable autologging, and train your model
keras_model = ...
keras_model.compile(optimizer="rmsprop", loss="mse", metrics=["accuracy"])
# autolog your metrics, parameters, and model
mlflow.keras.autolog()
results = keras_model.fit(
    x_train, y_train, epochs=20, batch_size=128, validation_data=(x_val, y_val))
```

Enables (or disables) and configures autologging from Keras to MLflow. Autologging captures the following information:

Metrics and Parameters

- Training loss; validation loss; user-specified metrics
- Metrics associated with the **EarlyStopping** callbacks: **stopped_epoch**, **restored_epoch**, **restore_best_weight**, **last_epoch**, etc
- **fit()** or **fit_generator()** parameters; optimizer name; learning rate; epsilon
- **fit()** or **fit_generator()** parameters associated with **EarlyStopping**: **min_delta**, **patience**, **baseline**, **restore_best_weights**, etc

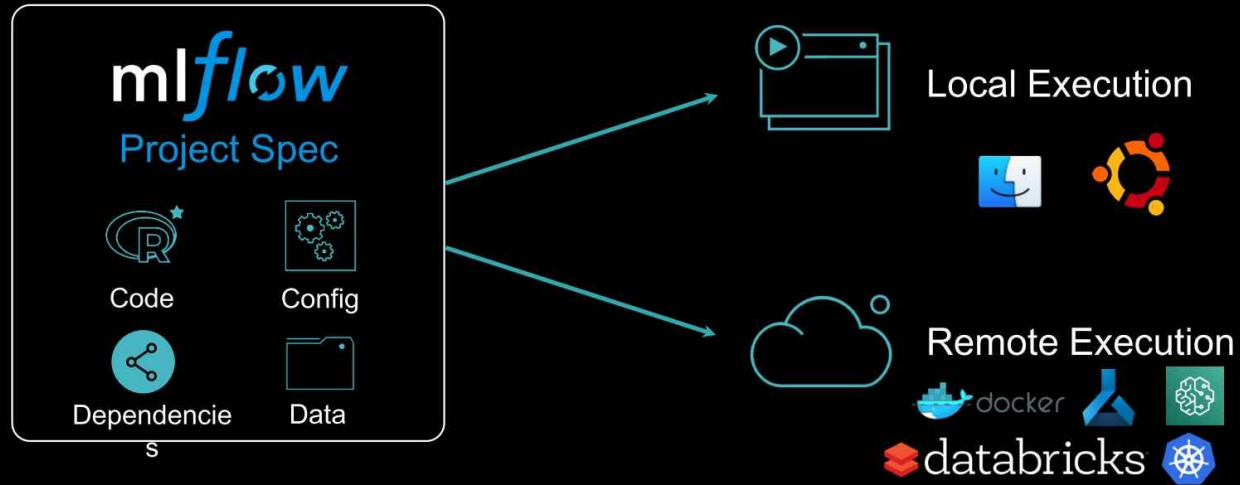
DEMO



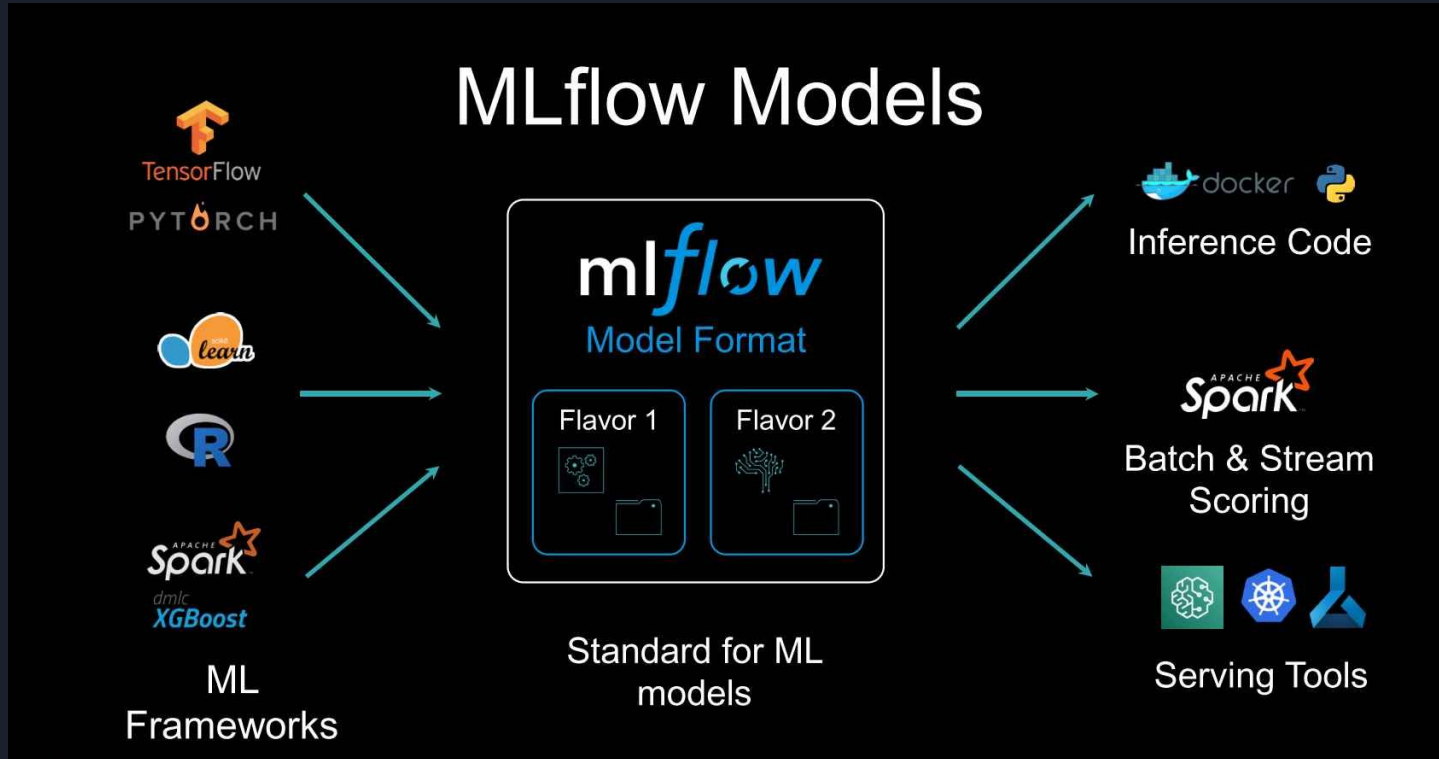
code @ : <https://github.com/ahmedbesbes/mlflow>

MLflow Projects

MLflow Projects



MLflow Models





Ressources

- <https://kaskada.com/insights/a-guide-to-mlops-for-data-scientists-part-1>
- <https://medium.com/swlh/hyperparameter-tuning-with-mlflow-tracking-b67ec4de18c9>
- <https://www.mlflow.org/docs/latest/tutorials-and-examples/tutorial.html>

Questions ?

