mlflow Platform for Complete Machine Learning Lifecycle

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San Francisco| April 29, 2020: Part 1 of 4 Series

$ whoami

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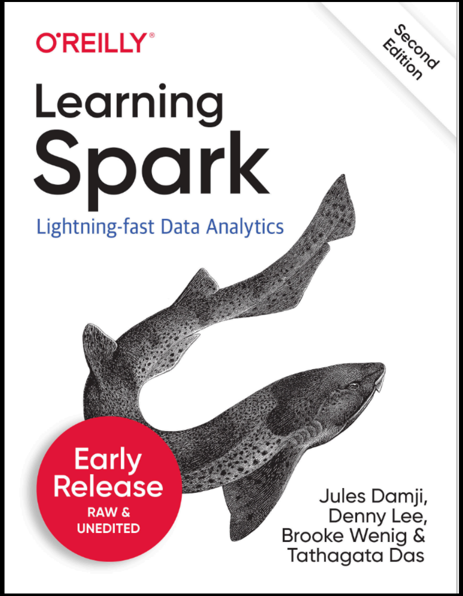
O'REILLY
Second Edition
Learning Spark
Lightning-fast Data Analytics
Early Release
RAW & UNEDITED
Jules Damji, Denny Lee, Brooke Wenig & Tathagata Das

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VISION

Accelerate innovation by unifying data science, engineering and business to solve data problems

SOLUTION

Unified Data Analytics Platform

WHO WE ARE

- Original creators of Apache Spark, Delta Lake, mlflow, Koalas
- 2000+ global companies use our platform across big data & machine learning lifecycle

Outline – Part 1

- Overview of ML development challenges
- Concepts and Motivations
- How MLflow tackles these
- MLflow Components
  - MLflow Tracking
  - Build and Track metrics, params, runs
  - User MLflow UI to compare runs
- Q & A

Machine Learning Development is Complex

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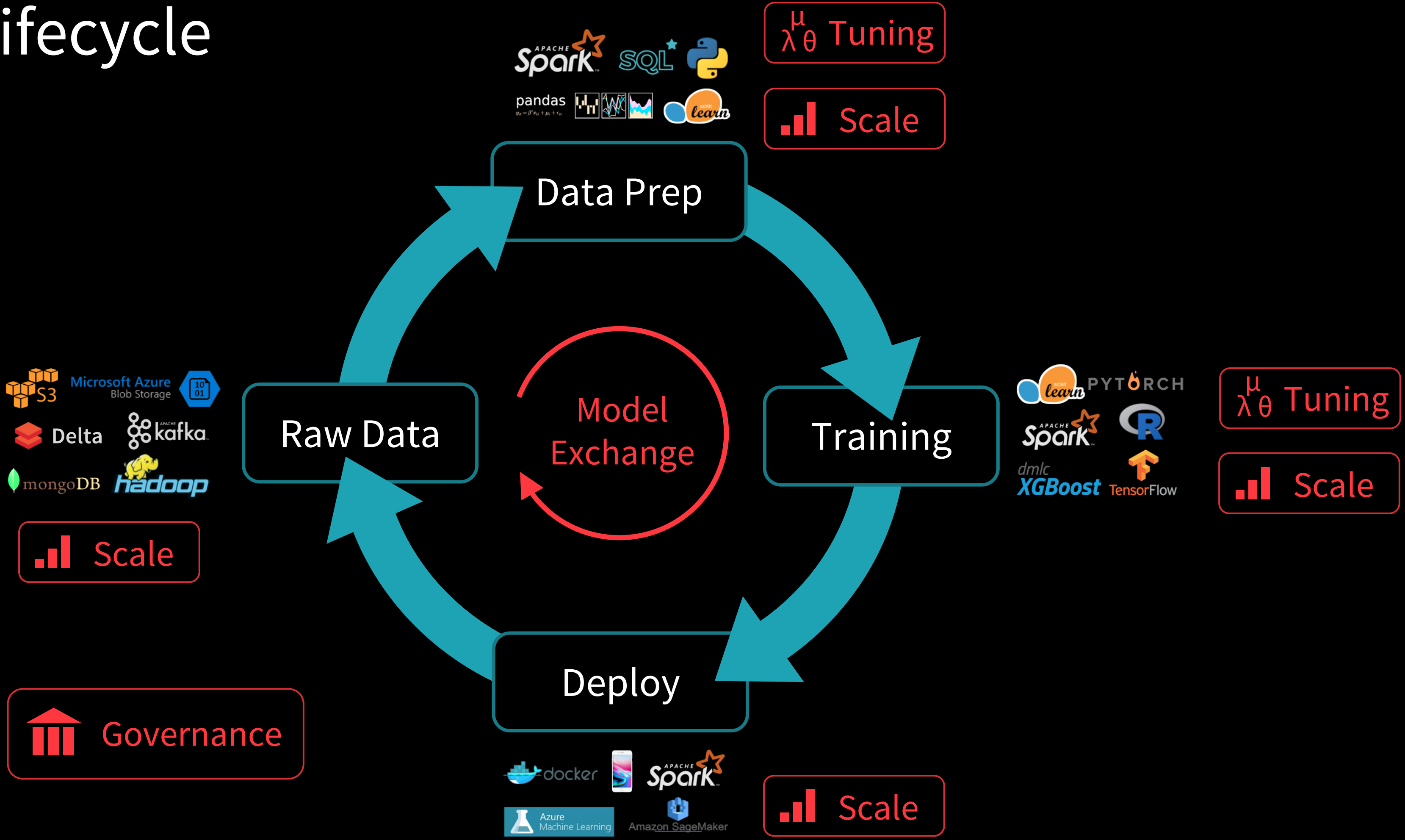
Traditional Software	Machine Learning
Goal: Meet a functional specification	Goal: Optimize a metric (e.g., accuracy) Constantly experiment to improve it
Quality depends only on code	Quality depends on input data and tuning parameters
Typically pick one software stack	Compare + combine many libraries, models & algorithms for the same task

ML Lifecycle



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Custom ML Platforms

Some Big Data Companies

- + **Standardize the data prep / training / deploy loop: if you work with the platform, you get these!**
- – **Limited to a few algorithms or frameworks**
- – **Tied to one company's infrastructure**
- – **Out of luck if you left the company….**

Can we provide similar benefits in an open manner?

Introducing mlflow

Open machine learning platform

- Works with popular ML library & language
- Runs the same way anywhere (e.g., any cloud or locally)
- Designed to be useful for 1 or 1000+ person orgs
- *Simple. Modular.Easy-to-use.*
- *Offers positive developer experience to get started!*

MLflow Design Philosophy

“API-first”

- Submit runs, log models, metrics, etc. from popular library & language
- Abstract “model” lambda function that MLflow can then deploy in many places (Docker, Azure ML, Spark UDF)
- Open interface allows easy integration from the community

Key enabler: built around Programmatic APIs, REST APIs & CLI

Modular design

- Allow different components individually (e.g., use MLflow’s project format but not its deployment tools)
- Not monolithic
- But Distinctive and Selective

Key enabler: distinct components (Tracking/Projects/Models/Registry)

MLflow Components

mlflow
Tracking

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

mlflow
Projects

Package data science code in a format that enables reproducible runs on any platform

mlflow
Models

Deploy machine learning models in diverse serving environments

new

mlflow
Model Registry

Store, annotate and manage models in a central repository

databricks.com/mlflow

mlflow.org

github.com/mlflow

twitter.com/MLflow

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Key Concepts in MLflow Tracking

Parameters: key-value inputs to your code

Metrics: numeric values (can update over time)

Tags and Notes: information about a run

Artifacts: files, data, and models

Source: what code ran?

Version: what of the code?

Model Development without MLflow

```
data   = load_text(file)
ngrams = extract_ngrams(data, N=n)
model  = train_model(ngrams,
             learning_rate=lr)
score  = compute_accuracy(model)

print("For n=%d, lr=%f: accuracy=%f"
      % (n, lr, score))

pickle.dump(model, open("model.pkl"))
```

```
For n=2, lr=0.1: accuracy=0.71
For n=2, lr=0.2: accuracy=0.79
For n=2, lr=0.5: accuracy=0.83
For n=2, lr=0.9: accuracy=0.79
For n=3, lr=0.1: accuracy=0.83
For n=3, lr=0.2: accuracy=0.82
For n=4, lr=0.5: accuracy=0.75
...
```

What version of my code was this result from?

MLflow Tracking API: *Simple & Pythonic!*

mlflow
Tracking

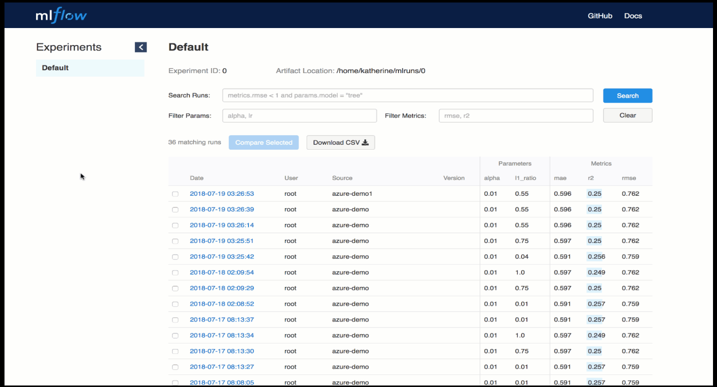
Record and query experiments: code, configs, results, …etc

```
import mlflow
import mflow.tensorflow

# log model’s tuning parameters
with mlflow.start_run() as run:
  mlflow.log_param("layers", layers)
  mlflow.log_param("alpha", alpha)

  # log metrics and model
  mlflow.log_metric("mse", model.mse())
  mlflow.log_artifact("plot", model.plot(test_df))
  mlflow.tensorflow.log_model(model)
```

Model Development *with* MLflow is *Simple!*

```
data   = load_text(file)
ngrams = extract_ngrams(data, N=n)
model  = train_model(ngrams,
             learning_rate=lr)
score  = compute_accuracy(model)
with mlflow.start_run() as run:
  mlflow.log_param("data_file", file)
  mlflow.log_param("n", n)
  mlflow.log_param("learn_rate", lr)
  mlflow.log_metric("score", score)
  mlflow.sklearn.log_model(model)
```

```
$ mlflow ui
```



Default

Experiment ID: 0 Artifact Location: /home/katherine/mlruns/0

Search Runs: metrics.rmse < 1 and params.model = "tree"

Filter Params: alpha, lr Filter Metrics: rmse, r2

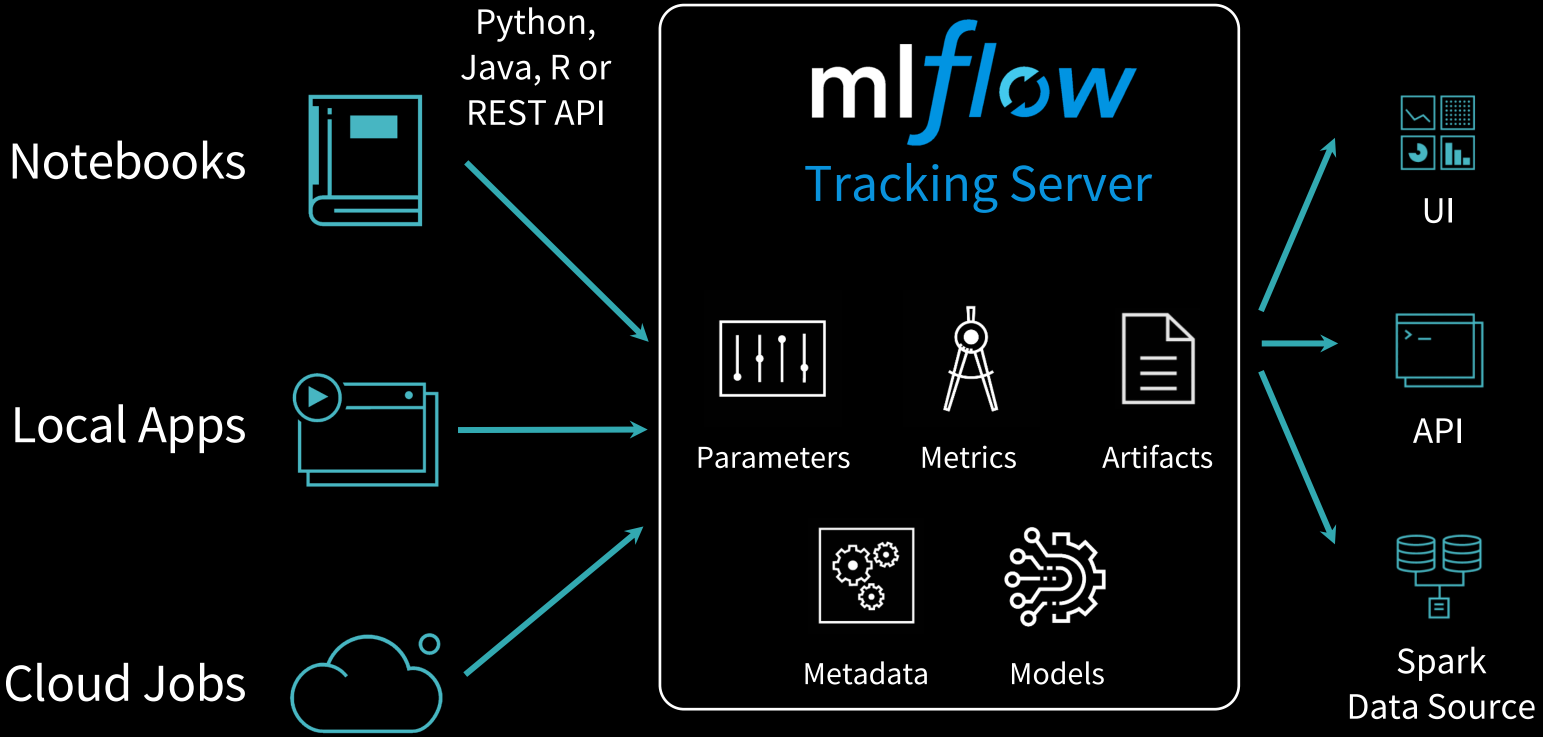
36 matching runs

				Parameters		Metrics		
Date	User	Source	Version	alpha	l1_ratio	mae	r2	rmse
2018-07-19 03:26:53	root	azure-demo1		0.01	0.55	0.596	0.25	0.762
2018-07-19 03:26:39	root	azure-demo		0.01	0.55	0.596	0.25	0.762
2018-07-19 03:26:14	root	azure-demo		0.01	0.55	0.596	0.25	0.762
2018-07-19 03:25:51	root	azure-demo		0.01	0.75	0.597	0.25	0.762
2018-07-19 03:25:42	root	azure-demo		0.01	0.04	0.591	0.256	0.759
2018-07-18 02:09:54	root	azure-demo		0.01	1.0	0.597	0.249	0.762
2018-07-18 02:09:29	root	azure-demo		0.01	0.75	0.597	0.25	0.762
2018-07-18 02:08:52	root	azure-demo		0.01	0.01	0.591	0.257	0.759
2018-07-17 08:13:37	root	azure-demo		0.01	0.01	0.591	0.257	0.759
2018-07-17 08:13:34	root	azure-demo		0.01	1.0	0.597	0.249	0.762
2018-07-17 08:13:30	root	azure-demo		0.01	0.75	0.597	0.25	0.762
2018-07-17 08:13:27	root	azure-demo		0.01	0.01	0.591	0.257	0.759
2018-07-17 08:08:05	root	azure-demo		0.01	0.01	0.591	0.257	0.759

Track parameters, metrics, output files & code version

Search using UI or API

MLflow Tracking



```
$ export MLFLOW_TRACKING_URI <URI>
mlflow.set_tracking_uri(URI)
```

MLflow Tracking Backend Stores

1. **Entity (Metadata) Store**
   - FileStore (local filesystem)
   - SQLStore (via SQLAlchemy)
     - PostgreSQL, MySQL, SQLlite

2. **Artifact Store**
   - S3 backed store
   - Azure Blob storage
   - Google Cloud storage
   - DBFS artifact repo

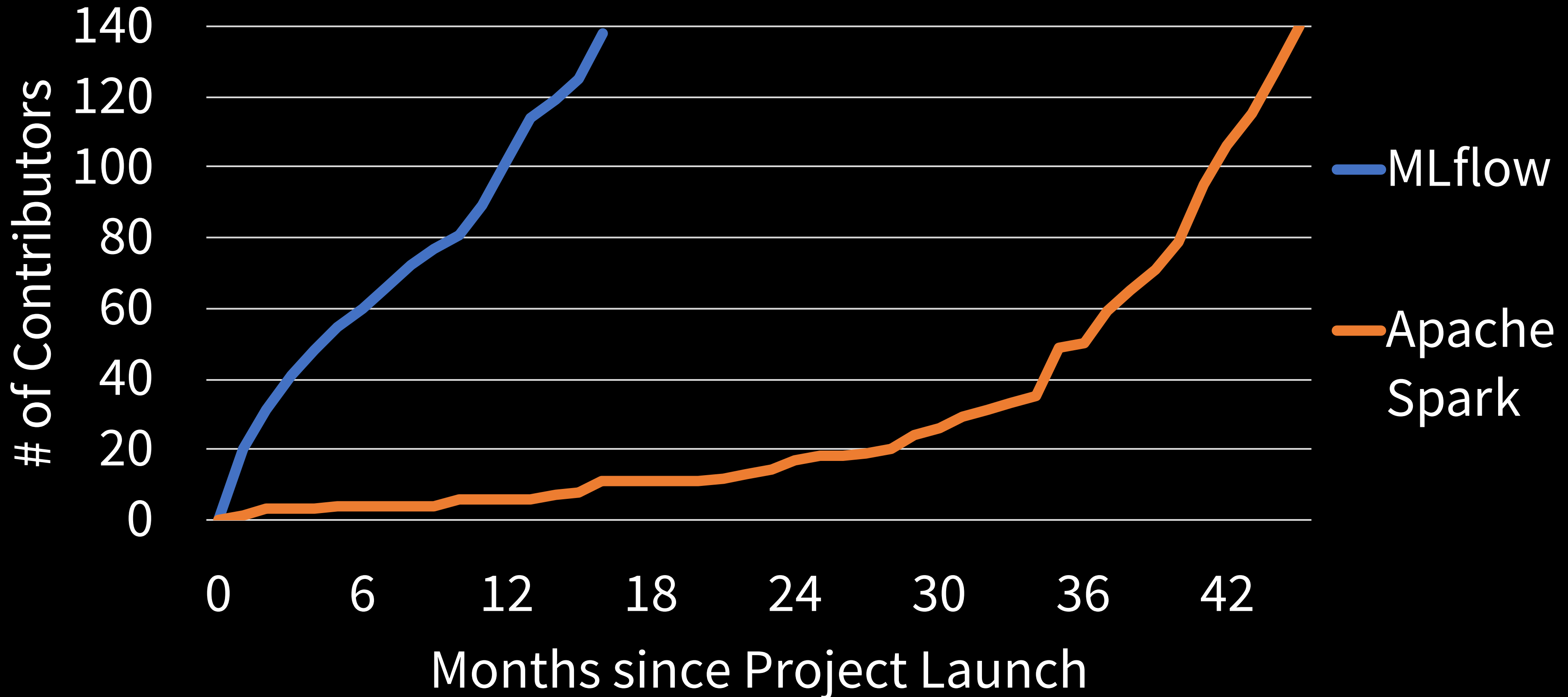
What Did We Talk About? mlflow

Modular Components greatly simplify the ML lifecycle

- Open machine learning platform
- Available APIs: Python, Java & R (Soon Scala)
- *Simple. Modular.Easy-to-use.*
- *Offers positive developer experience to get started!*

Project Contributors over Time

Today at 191 contributors



Learning More About MLflow

- pip install mlflow to get started
- Find docs & examples at mlflow.org
- https://github.com/mlflow/mlflow
- tinyurl.com/mlflow-slac
- dbricks.co/mlflow-tutorials

MLflow Tracking Tutorials

https://github.com/dmatrix/mlflow-workshop-part-1

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Thank you! ☺

Q & A

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