mlflow Platform for Complete Machine Learning Lifecycle

Jules S. Damji
@2twitme

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Outline – Introduction to MLflow: Understanding MLflow Projects and Models- Part 2

- Review & Recap Part 1: MLflow Tracking
- MLFlow Component
  - MLflow Projects & Models
  - Concepts and Motivations
  - MLflow on Databricks Community Edition (DCE)
  - Explore MLflow UI
  - Tutorials
- Q & A

https://dbricks.co/mlflow-part-2
https://github.com/dmatrix/mlflow-workshop-project-expamle-1

Machine Learning Development is Complex

Traditional Software vs. Machine Learning

Traditional Software

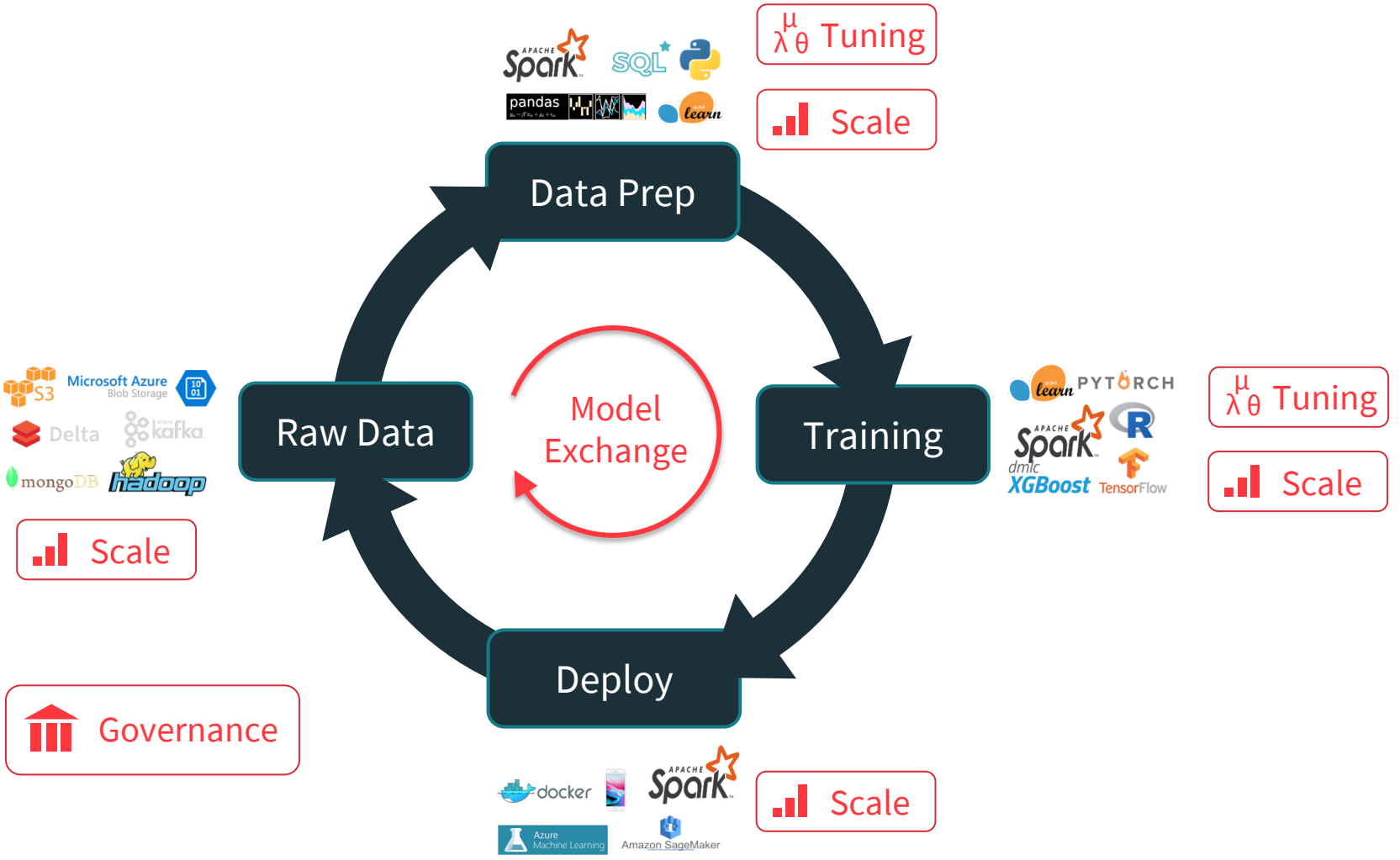
- Goal: Meet a functional specification
- Quality depends only on code
- Typically pick one software stack w/ fewer libraries and tools

Machine Learning

- Goal: Optimize metric(e.g., accuracy. Constantly experiment to improve it
- Quality depends on input data and tuning parameters

- Compare + combine many libraries, model

Machine Learning Lifecycle



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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 environments

new

mlflow

Model Registry

Store, annotate and manage models in a central repository

databricks.com/mlflow

mlflow.org

github.com/mlflow

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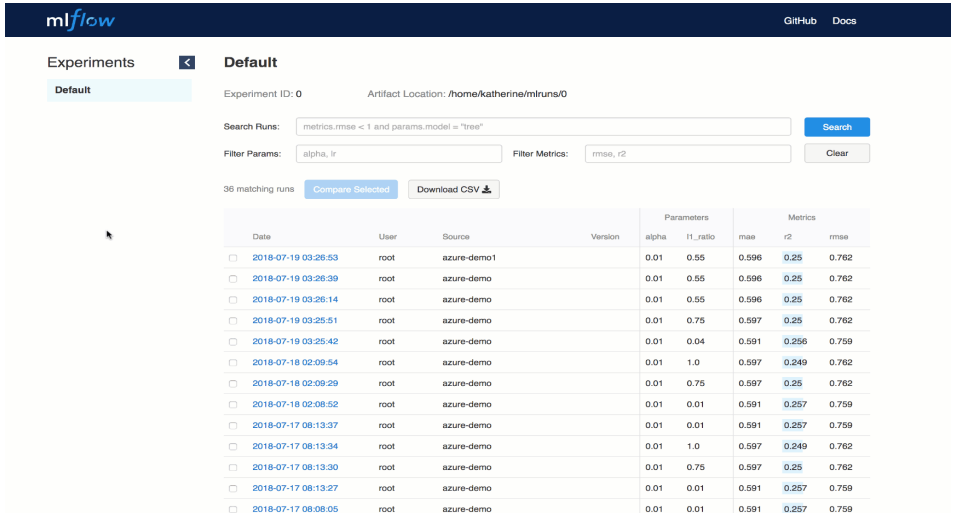
Model Development *with* MLflow is *Simple!*

```
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
```



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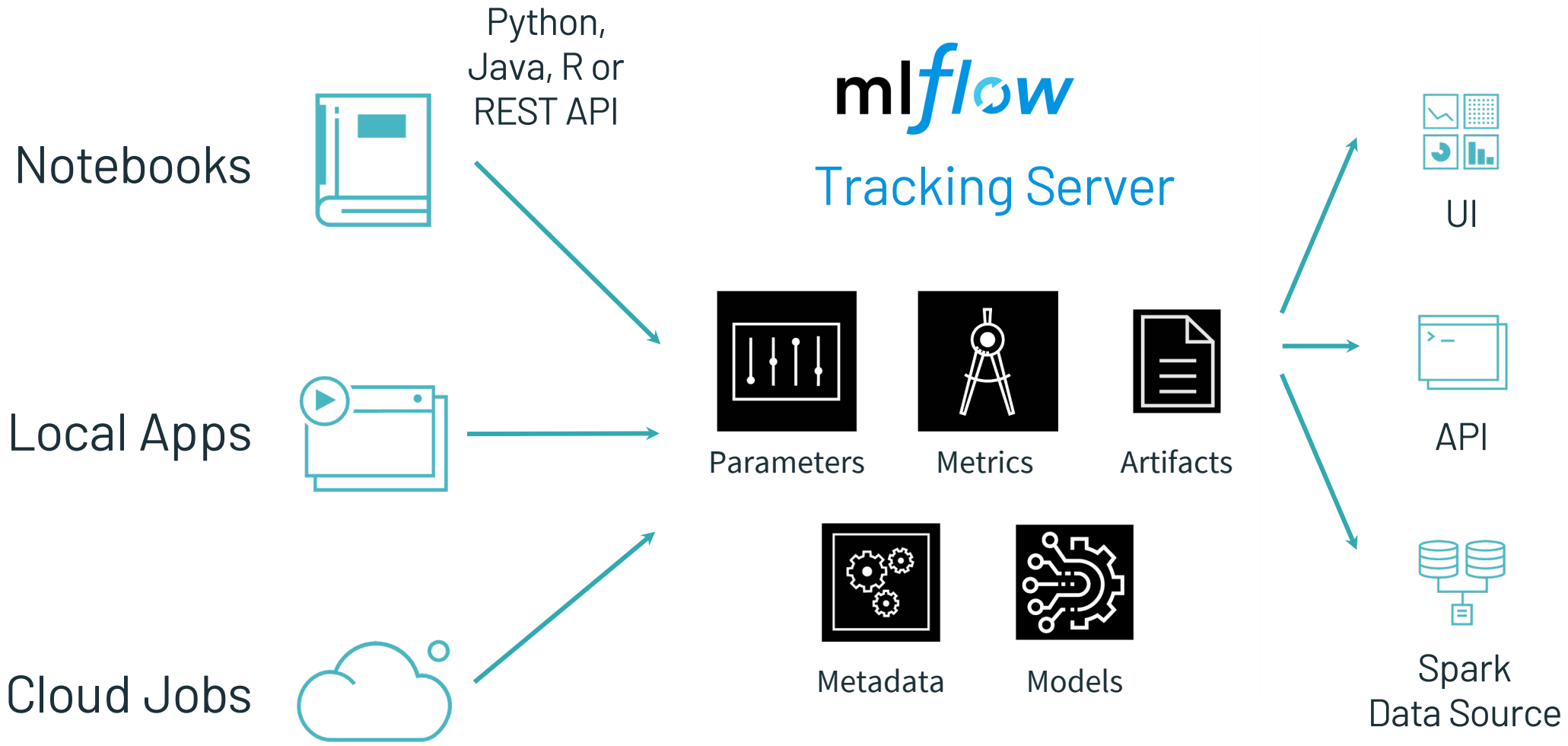
MLflow Tracking




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

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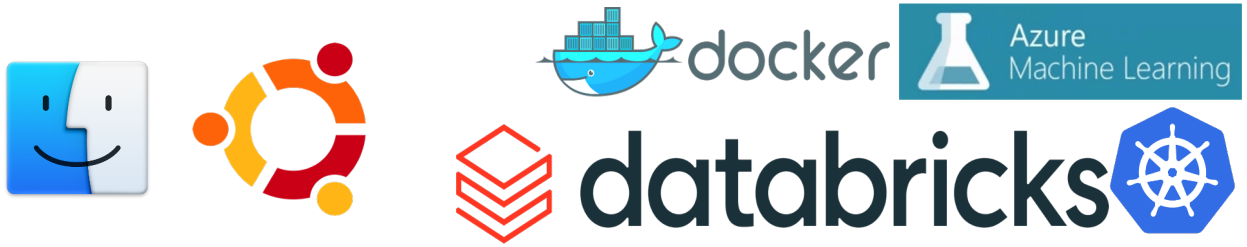
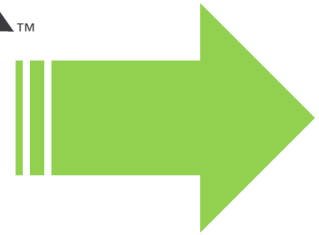
MLflow Projects Motivation

Diverse set of tools

Diverse set of environments





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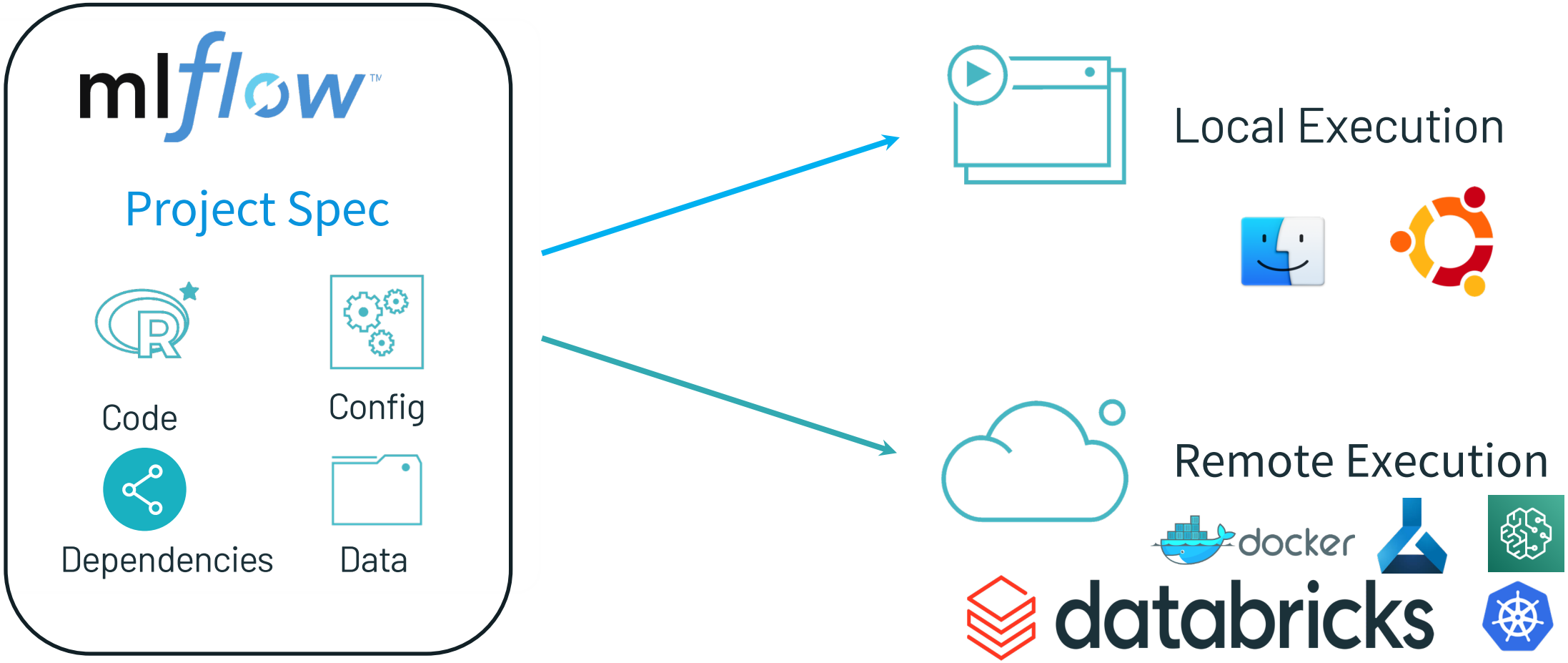
Projects

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

Challenge: ML results difficult to reproduce

MLflow Projects



1. Example MLflow Project File

```
my_projectject/
├── MLproject
│
│
│
│
│
│
├── conda.yaml
├── main.py
└── model.py
  …
```

```
conda_env: conda.yaml

entry_points:
  main:
    parameters:
      training_data: path
      lambda: {type: float, default: 0.1}
    command: python main.py {training_data} {lambda}
```

```
$ mlflow run git://<my_project>.git -P lambda=0.2

mlflow.run("git://<my_project>", parameters={..})

mlflow run . -e main -P lambda=0.2
```

2. Example Conda.yaml

```
my_project/
├── MLproject
│
│
│
│
│
│
├── conda.yaml
├── main.py
└── model.py

....
```

```
channels:
- defaults
dependencies:
- python=3.7.3
- scikit-learn=0.20.3
- pip:
  - mlflow
  - cloudpickle==0.8.0
name: mlflow-env
```

MLflow Projects

Packaging format for reproducible ML runs

- Any code folder or GitHub repository
- MLproject file with project configuration

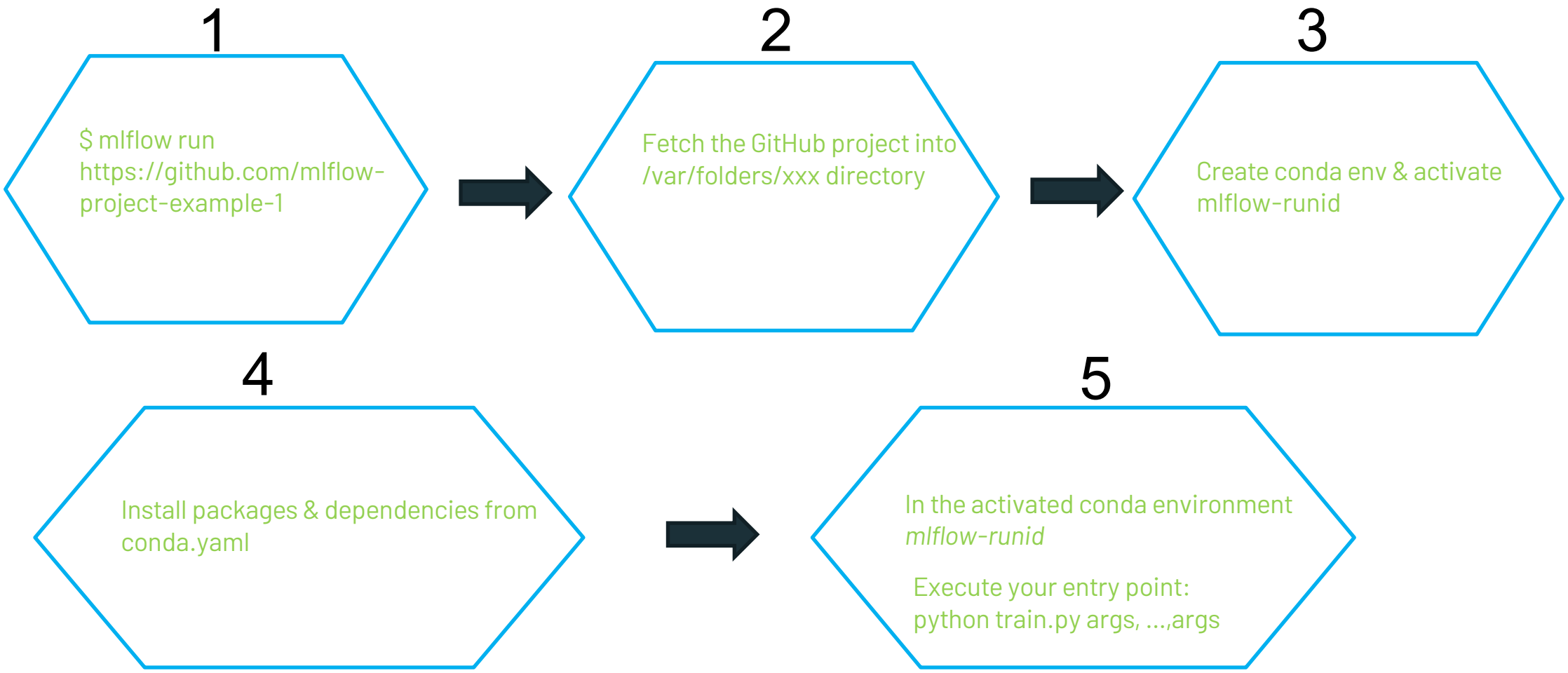
Defines dependencies for reproducibility

- Conda (+ R, Docker, ...) dependencies can be specified in MLproject
- Reproducible in (almost) any environment

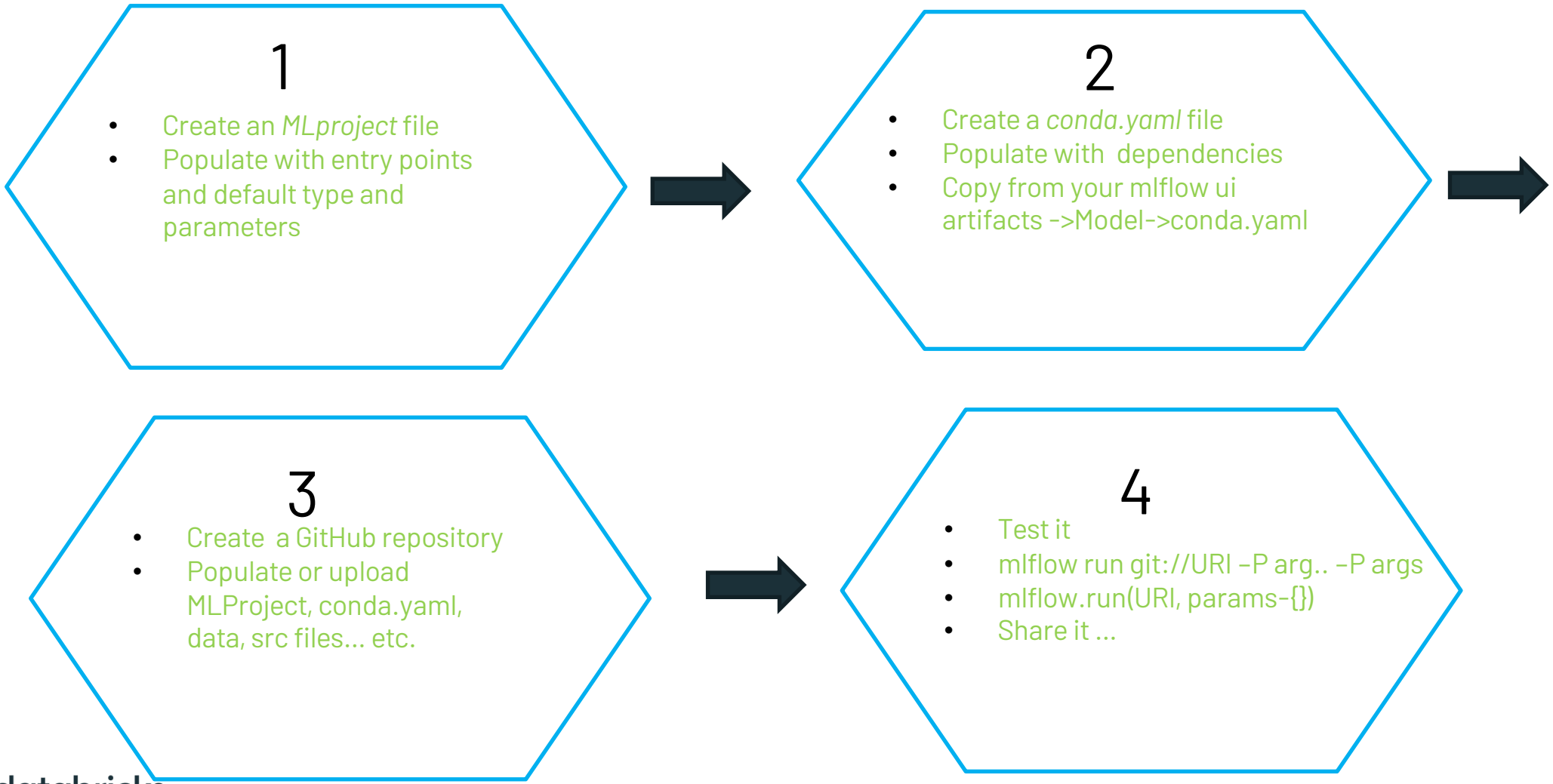
Execution API for running projects

- CLI / Python / R / Java
- Supports local and remote execution
  - mlflow run –help (CLI)
  - mlflow run https://github.com/dmatrix/jsd-mlflow-examples.git#keras/imdbclassifier (CLI)
  - mlflow.run (<project_uri>, parameters={}) or mlflow.projects.run((<project_uri>, parameters={}) (API)

Anatomy of MLflow Project Execution



How to build an MLflow Project



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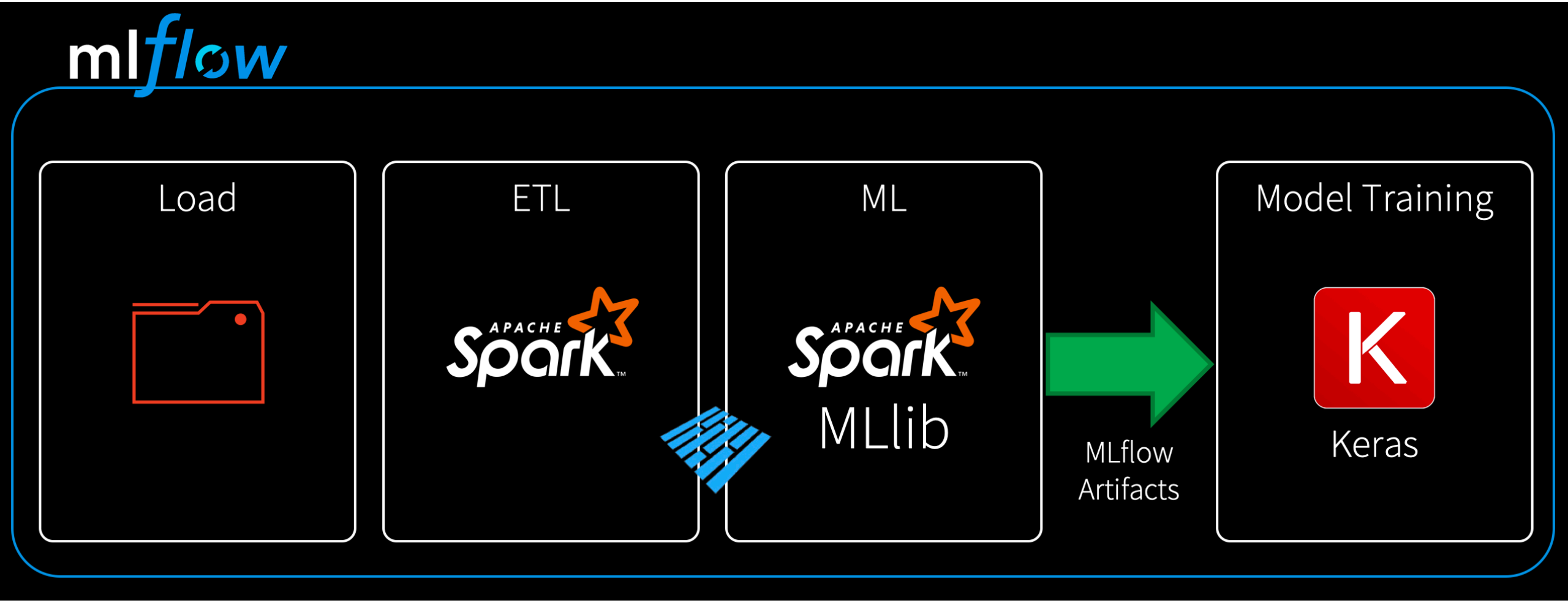
MLflow Project: Create Multi-Step Workflow



https://github.com/mlflow/mlflow/tree/master/examples/multistep_workflow

37 lines (30 sloc) | 1.17 KB

Raw | Blame | History

```yaml
name: multistep_example

conda_env: conda.yaml

entry_points:
  load_raw_data:
    command: "python load_raw_data.py"

  etl_data:
    parameters:
      ratings_csv: path
      max_row_limit: {type: int, default: 100000}
    command: "python etl_data.py --ratings-csv {ratings_csv} --max-row-limit {max_row_limit}"

  als:
    parameters:
      ratings_data: path
      max_iter: {type: int, default: 10}
      reg_param: {type: float, default: 0.1}
      rank: {type: int, default: 12}
    command: "python als.py --ratings-data {ratings_data} --max-iter {max_iter} --reg-param {reg_param} --rank {rank}"

  train_keras:
    parameters:
      ratings_data: path
      als_model_uri: string
      hidden_units: {type: int, default: 20}
    command: "python train_keras.py --ratings-data {ratings_data} --als-model-uri {als_model_uri} --hidden-units {hidden_units}

  main:
    parameters:
      als_max_iter: {type: int, default: 10}
      keras_hidden_units: {type: int, default: 20}
      max_row_limit: {type: int, default: 100000}
    command: "python main.py --als-max-iter {als_max_iter} --keras-hidden-units {keras_hidden_units}
                             --max-row-limit {max_row_limit}"

```

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MLflow Model Motivations

ML Frameworks

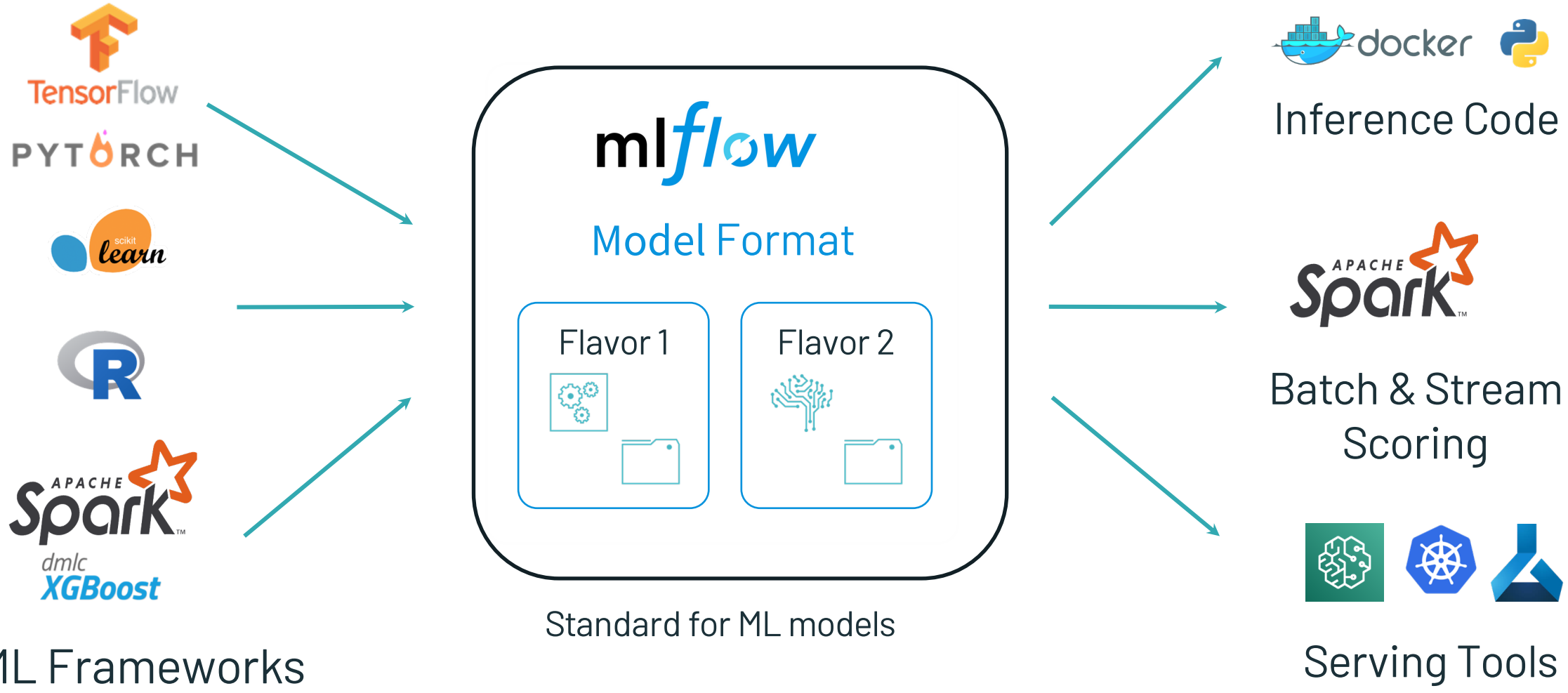
N x M
Combination of
Model support for
all Serving tools

Inference Code

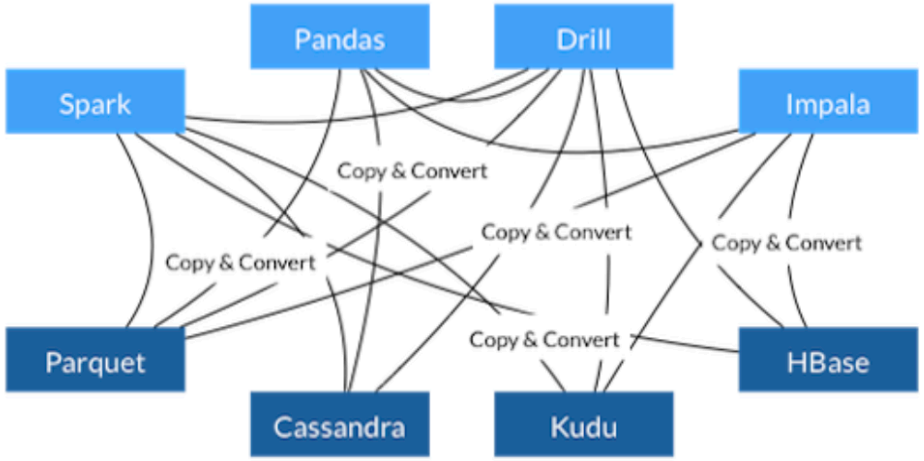
Batch & Stream Scoring

Serving Tools

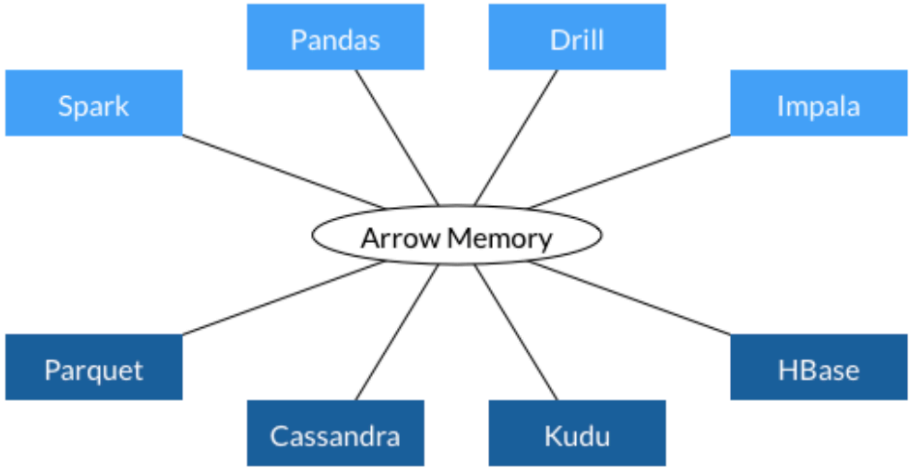
MLflow Models



Advantages of a Common Data Layer



- Each system has its own internal memory format
- 70-80% computation wasted on serialization and deserialization
- Similar functionality implemented in multiple projects



- All systems utilize the same memory format
- No overhead for cross-system communication
- Projects can share functionality (eg, Parquet-to-Arrow reader)

Example MLflow Model

```
mlflow.tensorflow.log_model(...)
```

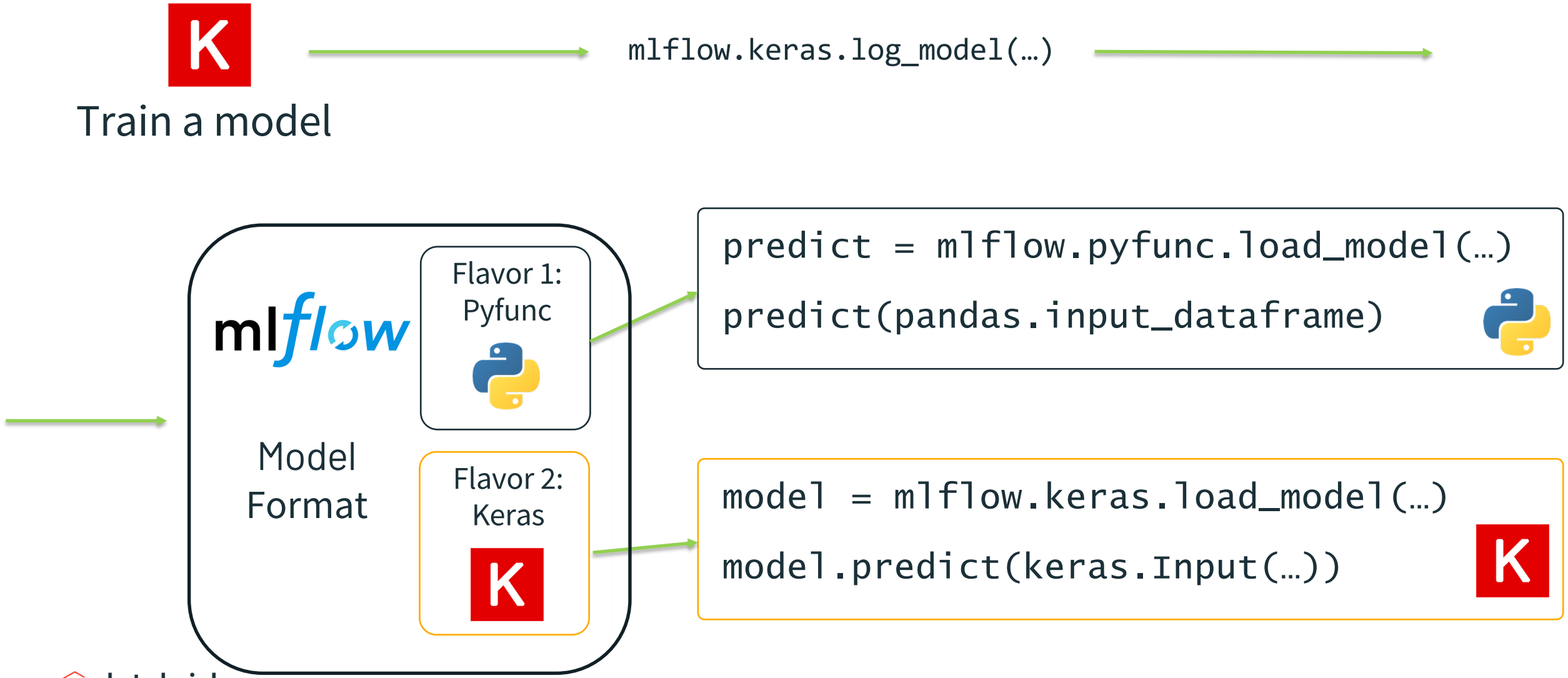
```
my_model/
├── MLmodel
└── estimator/
    ├── saved_model.pb
    └── variables/
        ...
```

```
run_id: 769915006efd4c4bbd662461
time_created: 2018-06-28T12:34
flavors:
  tensorflow:
    saved_model_dir: estimator
    signature_def_key: predict
  python_function:
    loader_module: mlflow.tensorflow
```

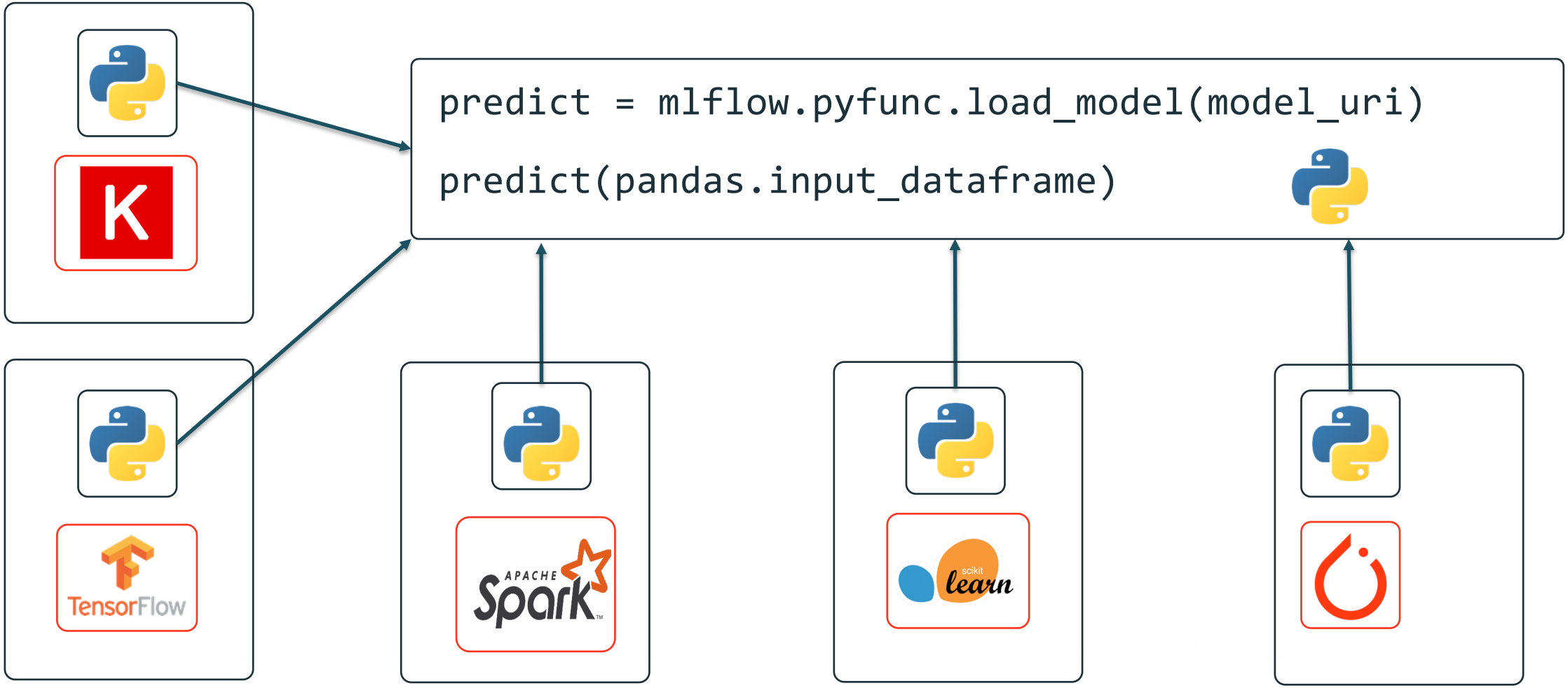
Usable by tools that understand TensorFlow model format

Usable by any tool that can run Python (Docker, Spark, etc!)

Model Keras Flavor Example



Model Flavors Example



MLflow Models

Packaging format for ML Models

- Any directory with MLmodel file

Defines dependencies for reproducibility

- Conda environment can be specified in MLmodel configuration

Model creation and loading utilities

- mlflow.<model_flavor>.save_model(...) or log_model(...)
- mlflow.<model_flavor>.load_model(...)

Deployment APIs

- CLI / Python / R / Java
- mlflow models [OPTIONS] COMMAND [ARGS]...
  - mlflow models serve [OPTIONS [ARGS] ....
  - mlflow models predict [OPTIONS [ARGS] ...

MLflow Project & Models Tutorials

Tutorials: https://github.com/dmatrix/mlflow-workshop-part-2

MLflow Project Keras Example:
https://github.com/dmatrix/mlflow-workshop-project-expamle-1

Learning More About MLflow

- pip install mlflow to get started
- Find docs & examples at mlflow.org
- Peruse code at MLflow Github
- Join the Slack channel
- More MLflow tutorials

Thank you! ☺

Q & A

jules@databricks.com
@2twitme
https://www.linkedin.com/in/dmatrix/