Barcelona Supercomputing Center
Centro Nacional de Supercomputación

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Scanflow

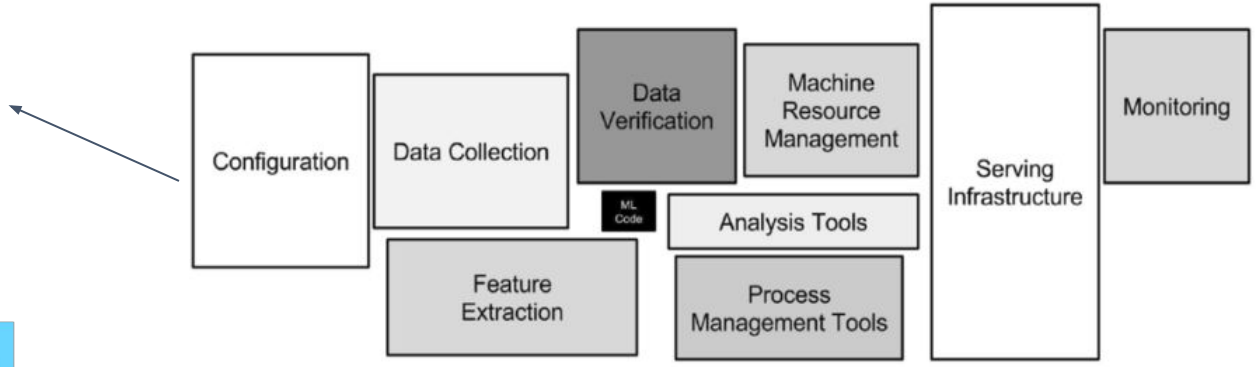
A containerized graph framework for debugging ML workflows

Lenovo-BSC collaboration

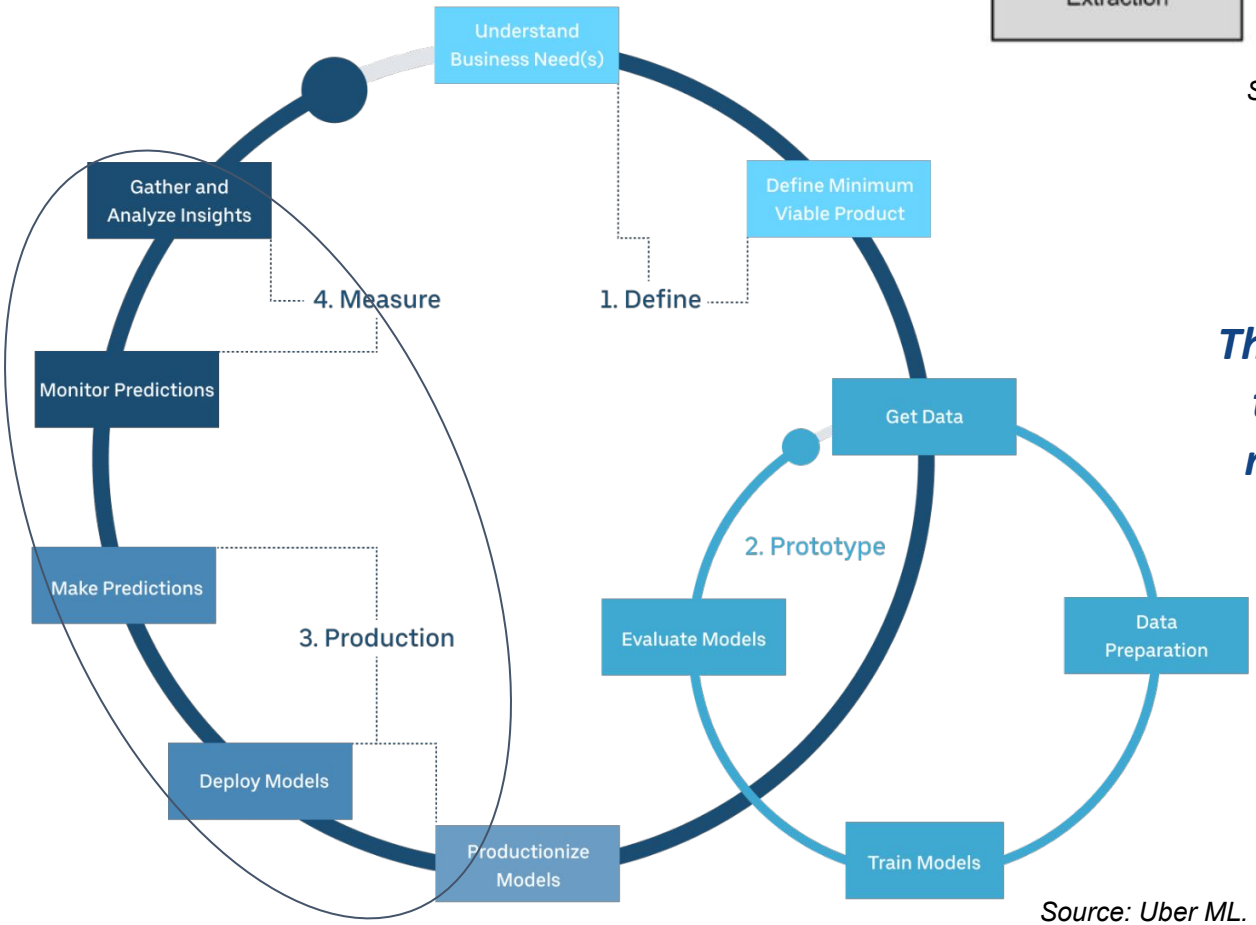
January 2020

Applied Machine Learning: Workflow

Deployment: The ML code is a small part of the complete pipeline. More steps are needed to get it working on production.



Source: Sculley D., Holt. G.



Source: Uber ML.

The modeling phase is not the end of a workflow, more steps are needed.

Applied Machine Learning: Issues

- **Moving** a complete workflow from development **platform** to another new platform can break things, e.g, operating system, libraries, dependencies, etc.
- Controlling a **myriad** of **pipelines** manually might be hard.
- Some steps in a workflow need **different** amount and type of **computational resources**, e.g, RAM, Storage, CPU, GPU.
- The complete workflow might **scale** from a single **node** to a **cluster**.
- The dataset distribution might change (**model decay**). It is called **distribution drift**. An anomaly detector might help this.
- Some **feature levels** and balance of classes might **change** (**categories**, e.g, before {red, blue}, after {red, blue, black}. Classes, e.g, before {30% men, 70%women}. after {60% men, 40%women}).

- On the other hand, issues regarding robustness on ML models, such as social discrimination (**bias** in **classification**), security vulnerabilities (**adversarial attacks**), lack of **explainability** (black box networks) [?], and more, can make a model vulnerable.

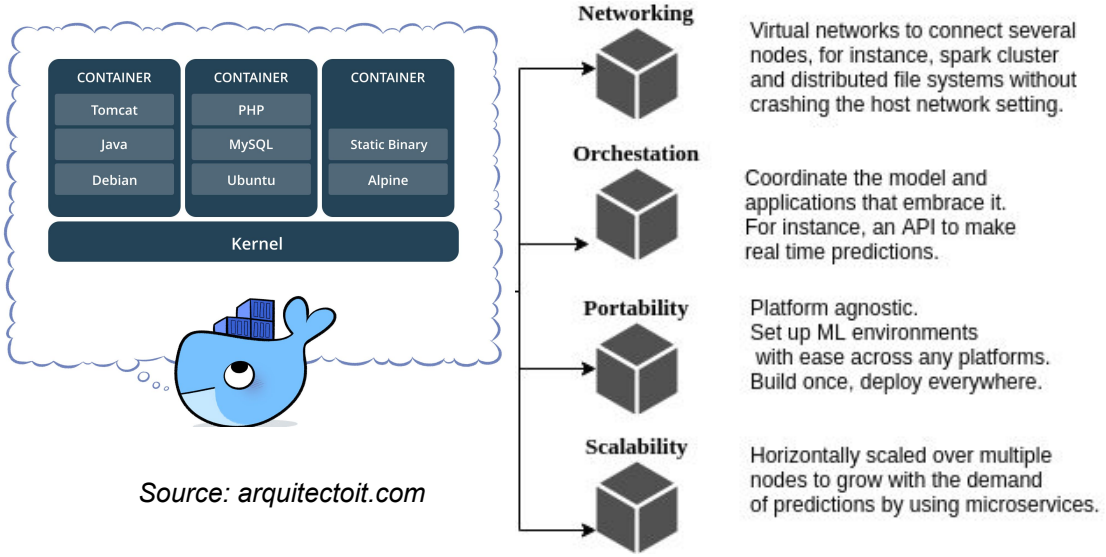
In production, many unexpected situations might arise such as drift distributions, unformatted data, etc.

Data scientists require tools for ease of deployment, tracking and reproducing experiments.

We need Interactive Machine Learning tools that can consider human agent in the process

Applied Machine Learning: Recipes

Docker: Isolate environments, portability, scalability, affinity, etc.

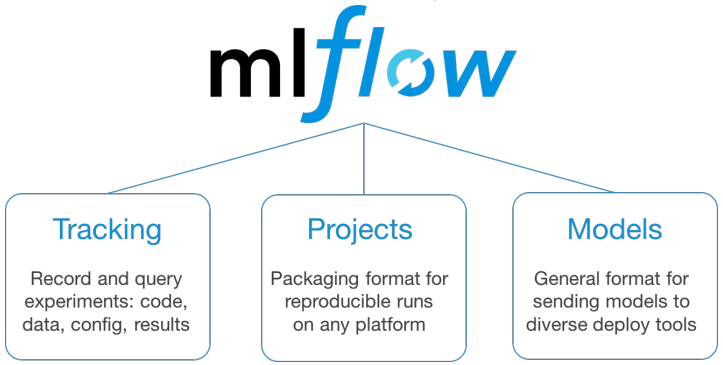


Source: arquitectoit.com

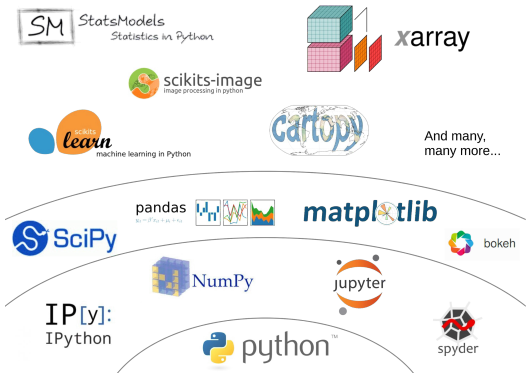
***Scanflow* is a high-level library that is built on top of these tools to manage and supervise workflows efficiently.**

Python: Fast prototyping and expressiveness. Robust AI ecosystem.

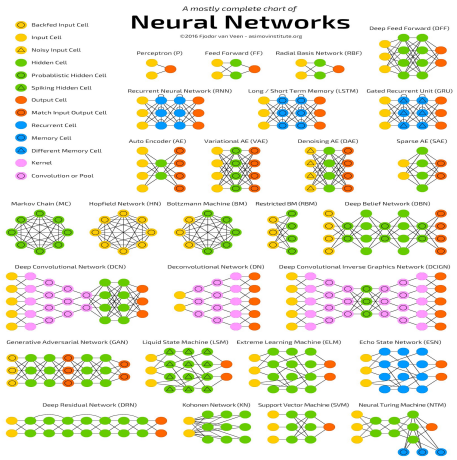
MLflow: Track metrics, organize projects, model versioning and serialization, etc.



Source: mlflow.org

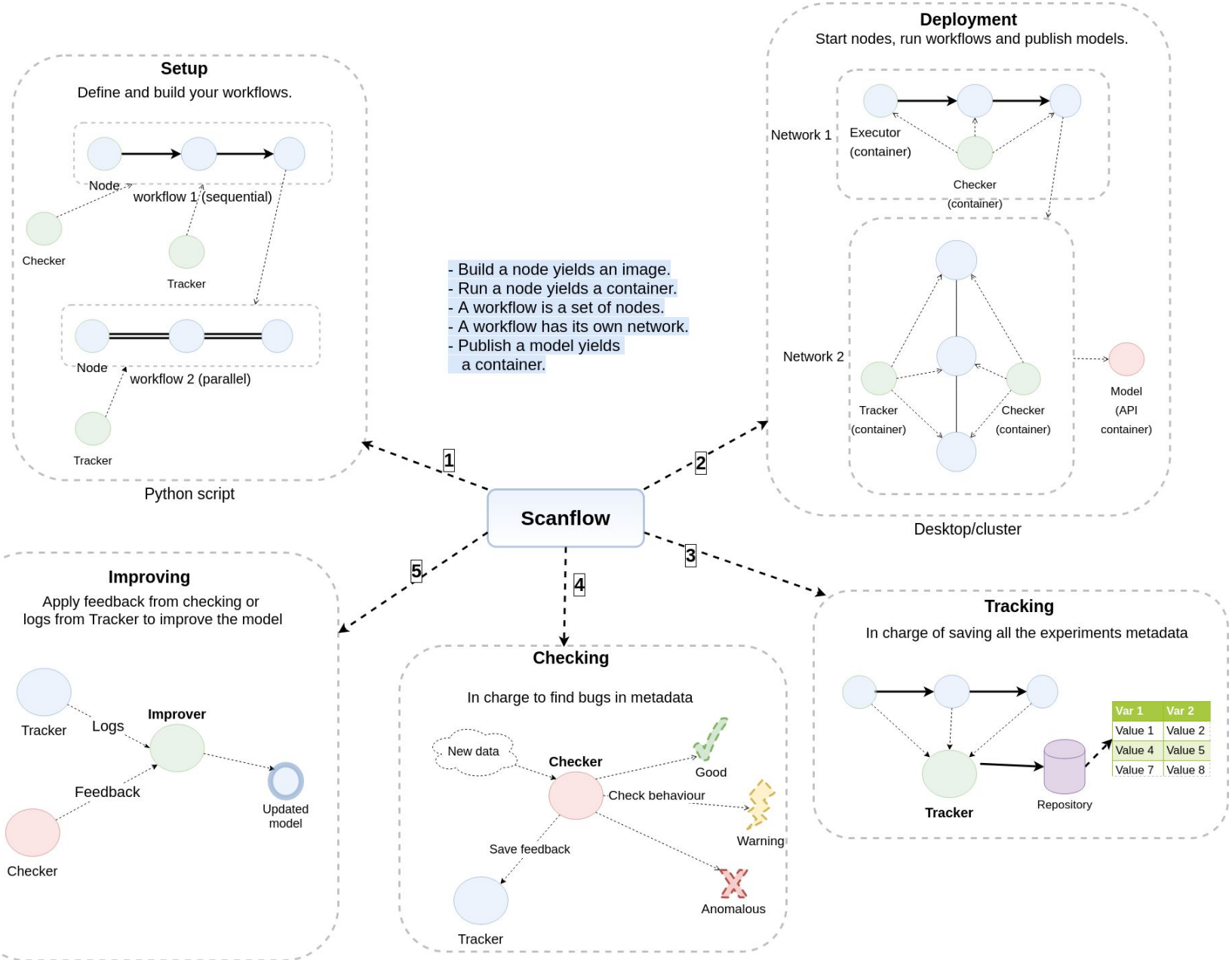


Source: leblancfg.com

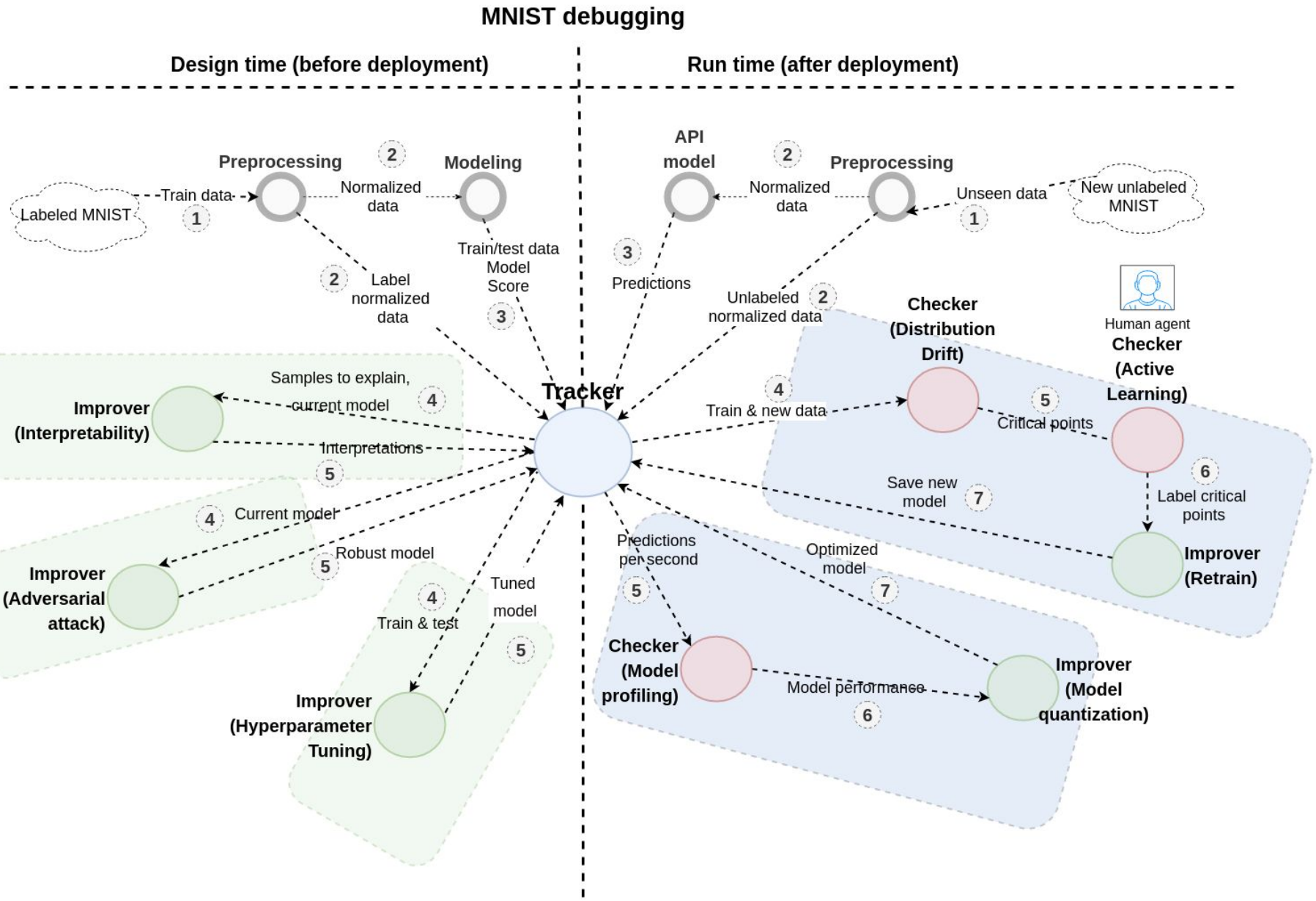


Source: fjodor van veen - asimovinstitute.org

Scanflow: High-level overview

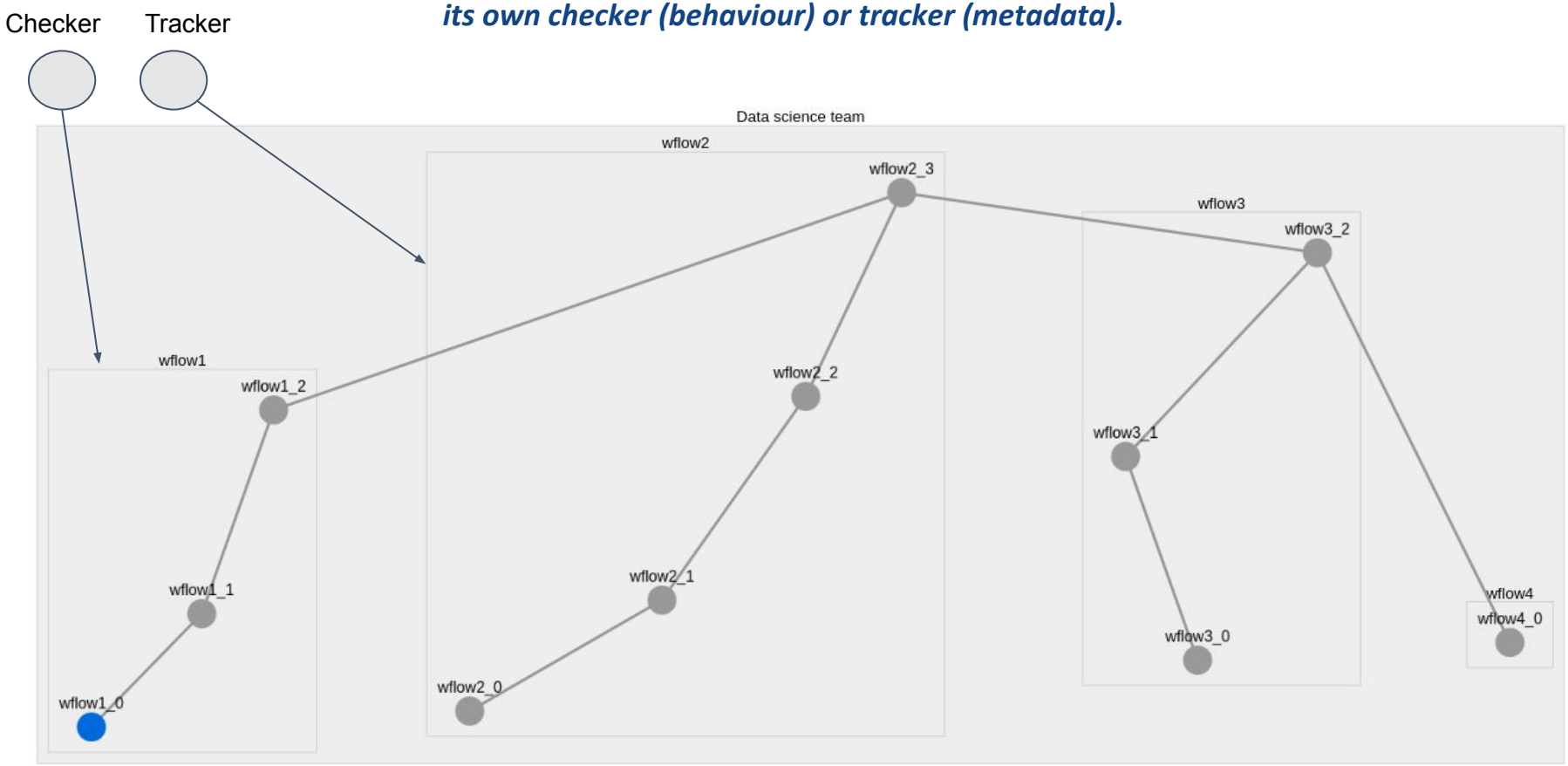


Scanflow: Use Case



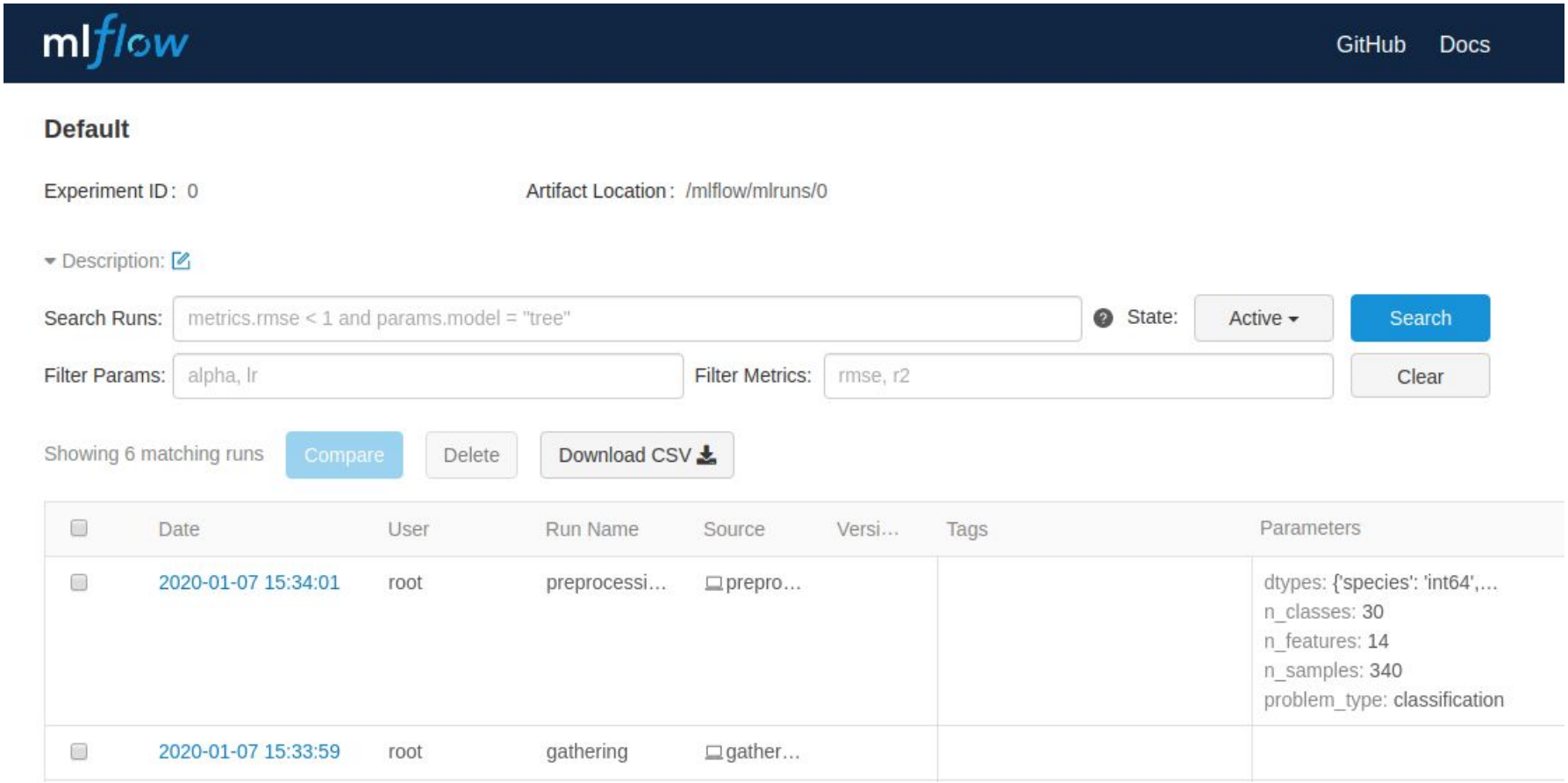
Setup and deployment

Design nested and parallel workflows: ***Each node is a computation function, e.g. preprocessing or modeling. They can be executed following the user ordering design. Besides, each node is a docker container (environment) inside a workflow (rectangle in the following picture). Finally, each workflow has its own checker (behaviour) or tracker (metadata).***



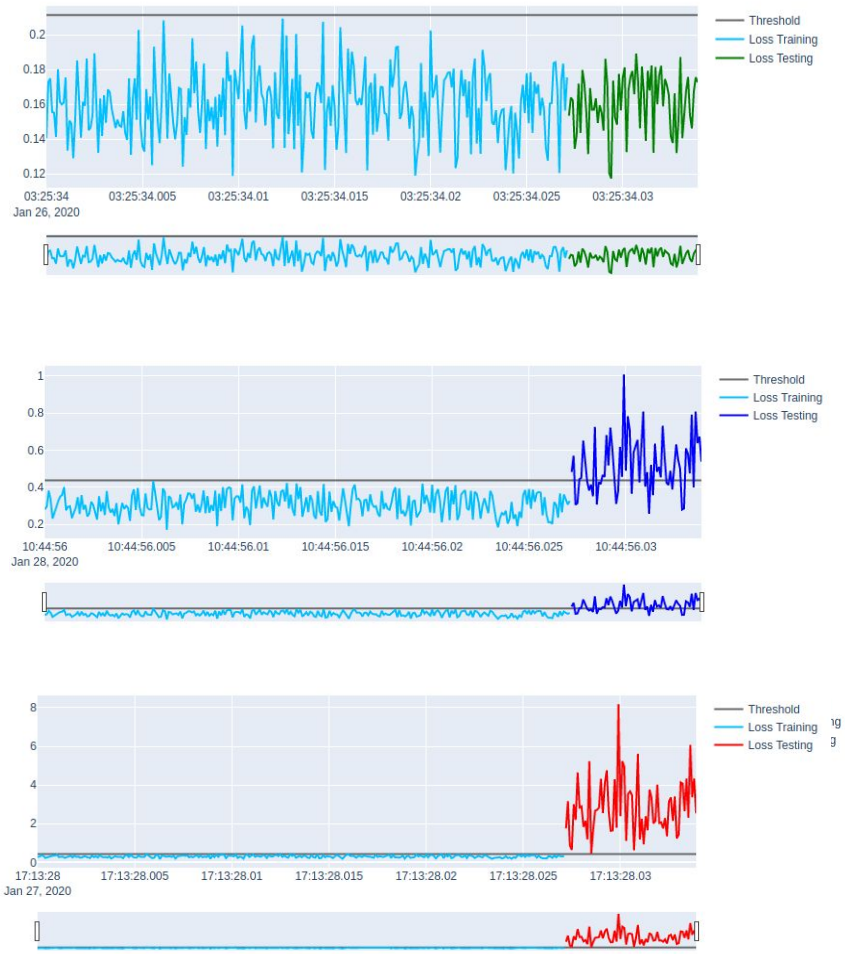
Tracking: Save any workflow metadata for future analysis

This module logs intermediate results belonging to a workflow such as, settings, metrics, statistics, scores, etc.



Checking: supervise workflow's behaviour in production

Early drift distribution detector (built-in function)



Custom plugins can be added to check the behaviour of any workflow: for sanity, integrity, anomaly, interpretability, etc.

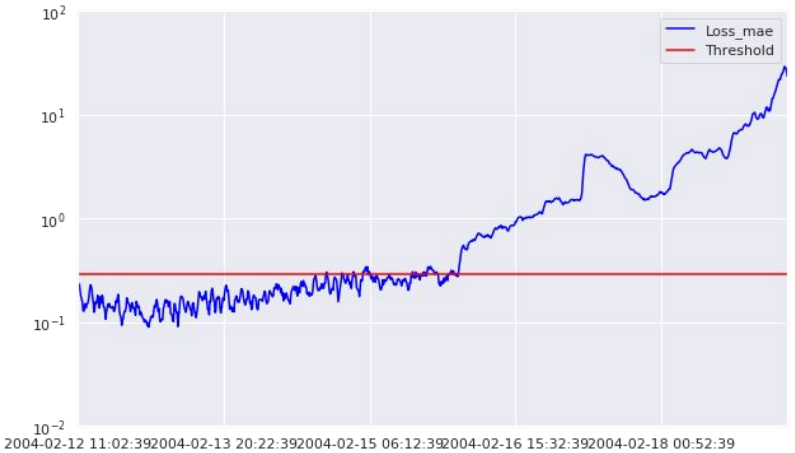
Any plugin is supposed to be run in real time

Early drift distribution detector: architecture

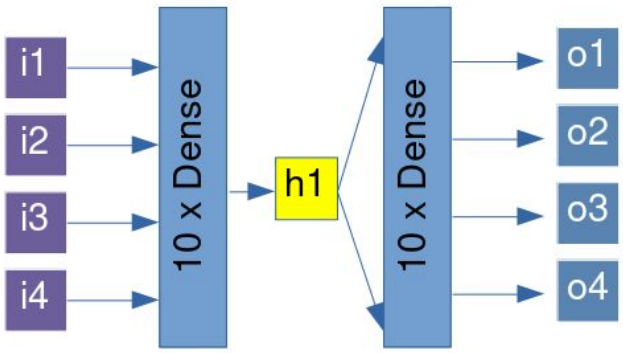
Reconstruction error is calculated to measure how different is a new distribution from the original one

Input

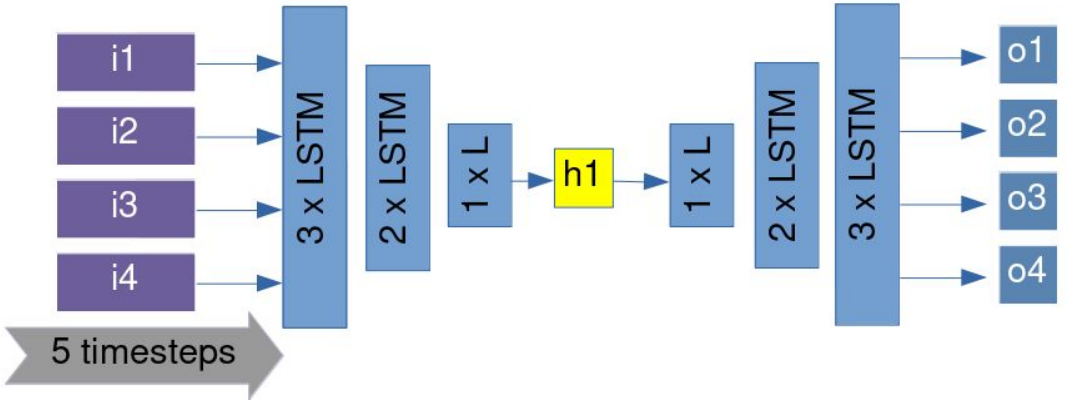
Output



Naive Autoencoder

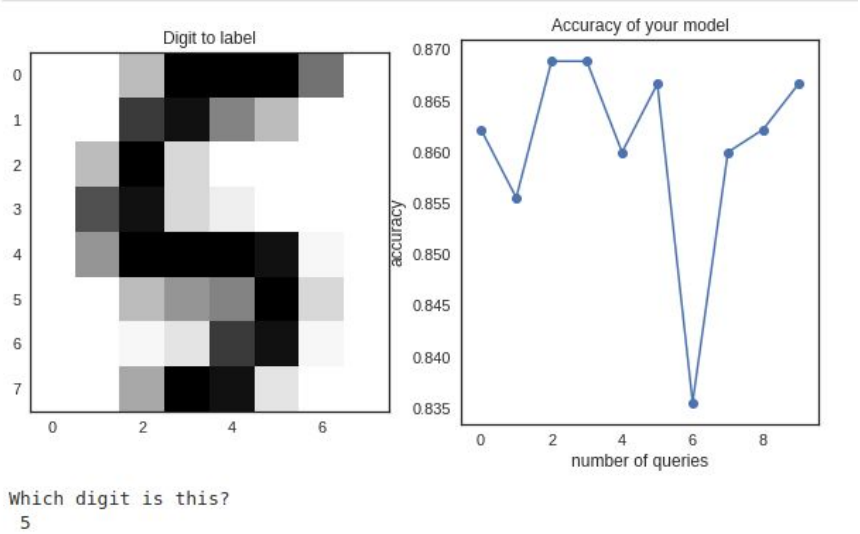


LSTM Autoencoder



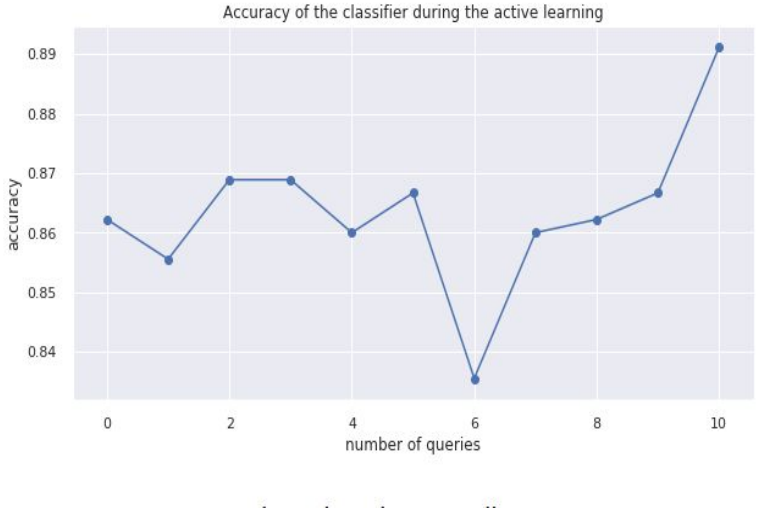
Checker: Active Learning

Example using the MNIST dataset



Label just the set of samples that are more informative

2

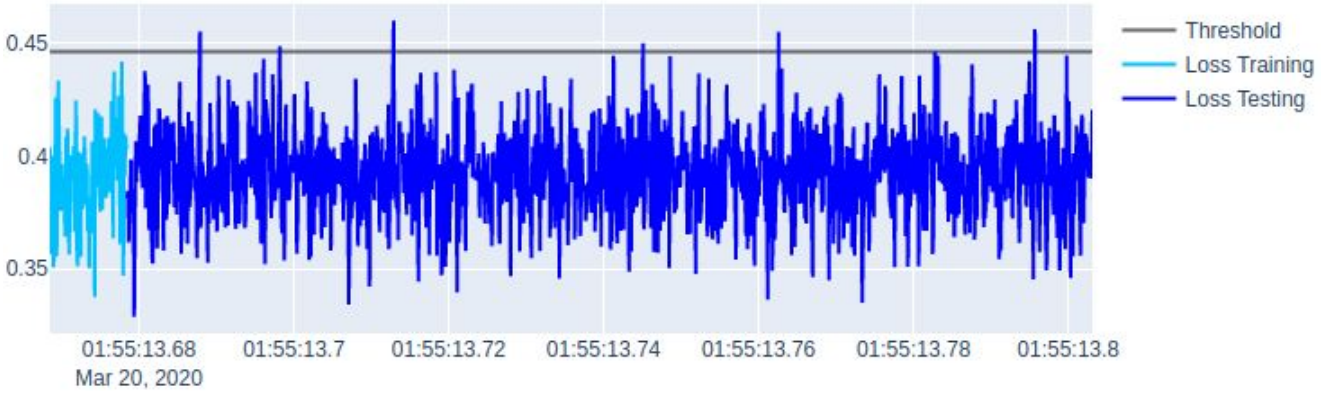


After labeling, the model has filled out gaps in the feature space, therefore, it's improved.

3

1

The points above the threshold (gray line) are the critical points that bring more information.



Improver: Now the model has been updated

Current model: A model built with only pedestrian scenario as input. Other scenarios will be anomalous.

Normal Clip

Pedestrians

Abnormal Clip

A car

Abnormal Clip

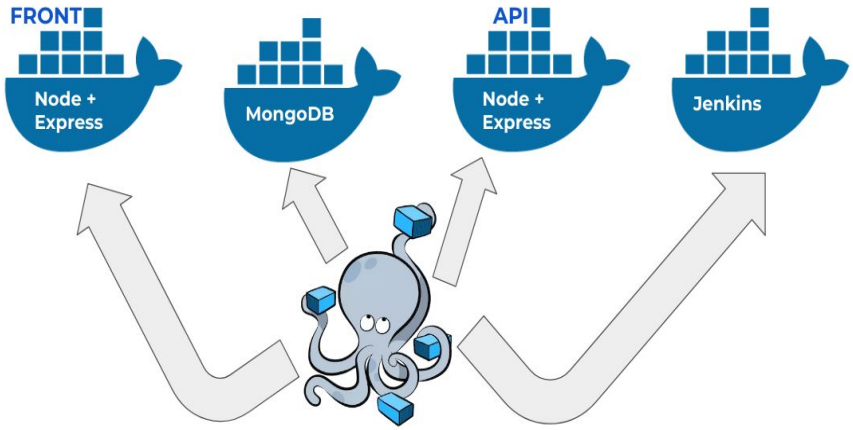
A bike

<u>Before labeling</u>. A bike is detected as anomalous.

<u>After labeling.</u> A bike is detected now as normal.

Deployment integration: Docker compose

Docker compose behaviour



Source: medium.com

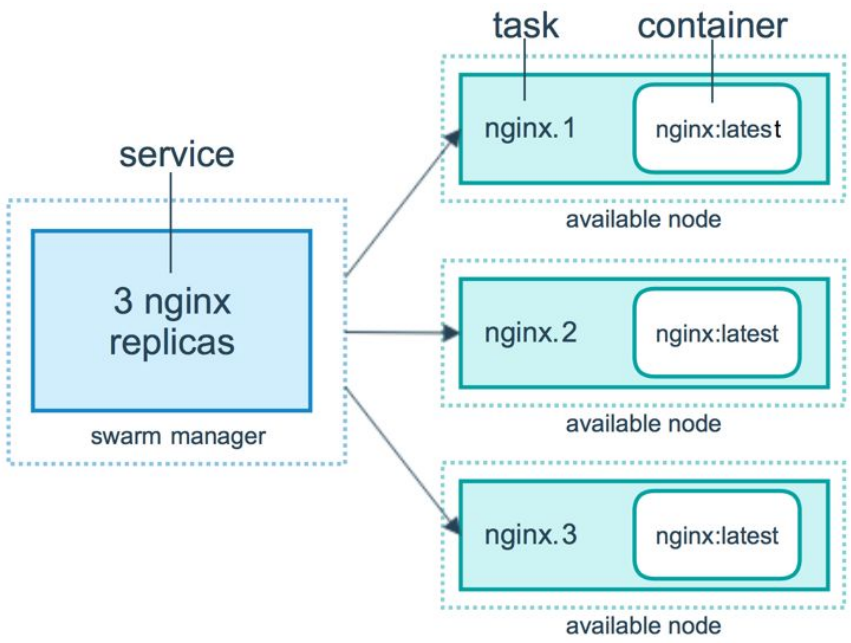
Once finished defining the workflows, they can be saved as a docker-compose file

docker-compose.yml

```
version: '3'
services:
  get_new_data:
    image: get_new_data
    container_name: get_new_data-20200126033621
    networks:
    - network-workflow3
    depends_on:
    - tracker-workflow3
    environment:
      MLFLOW_TRACKING_URI: http://tracker-workflow3:8003
    volumes:
    - /home/guess/Desktop/autodeploy/examples/demo2/data-
eng/:/app
    - /home/guess/Desktop/autodeploy/examples/demo2/data-
eng/ad-stuff/ad-tracker/tracker-workflow3:/mlflow
    tty: 'true'
  preprocessing_new_data:
    image: preprocessing_new_data
    container_name: preprocessing_new_data-20200126033621
    networks:
    - network-workflow3
    depends_on:
    - tracker-workflow3
    environment:
      MLFLOW_TRACKING_URI: http://tracker-workflow3:8003
    volumes:
    - /home/guess/Desktop/autodeploy/examples/demo2/data-
eng/:/app
    - /home/guess/Desktop/autodeploy/examples/demo2/data-
eng/ad-stuff/ad-tracker/tracker-workflow3:/mlflow
    tty: 'true'
  tracker-workflow3:
    image: tracker-workflow3
    container_name: tracker-workflow3-20200126033621
    networks:
    - network-workflow3
    volumes:
    - /home/guess/Desktop/autodeploy/examples/demo2/data-
eng/ad-stuff/ad-tracker/tracker-workflow3:/mlflow
    ports:
    - 8008:8003
networks:
  network_workflow3: null
```

Deployment integration: Docker Swarm

Docker Swarm behaviour



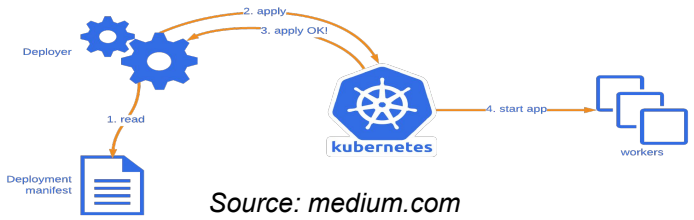
Scanflow provides a docker-stack file to deploy a swarm cluster to schedule the workflows.

Source: filepicker.io

Docker Swarm console

```
[xgbravo@nxt2027 compose_repo]$ docker service ls
ID                  NAME                                MODE                REPLICAS            IMAGE                                PORTS
5r1l6yx27pfk        my_swarm_gathering                  replicated          1/1                 gathering:latest
xke5uf9aqdh4        my_swarm_modeling                   replicated          1/1                 modeling:latest
ro9haibzt9ma        my_swarm_preprocessing              replicated          1/1                 preprocessing:latest
pvdud6whi4pg        my_swarm_tracker_workflow1          replicated          1/1                 tracker_workflow1:latest             *:8006->8001/tcp
alnxiq8y3tfs        my_swarm_tracker_workflow1_scale    replicated          0/5                 my_swarm:latest
2dh4zpwu48od        my_swarm_tracker_workflow1_scale2   replicated          0/5                 my_swarm_tracker_workflow1:latest
ilzhcp546xft        my_swarm_tracker_workflow1_scale3   replicated          5/5                 tracker_workflow1:latest
ygwulqaah8a8        my_swarm_tracker_workflow2          replicated          1/1                 tracker_workflow2:latest             *:8007->8002/tcp
```

Deployment integration: Kubernetes



Source: medium.com

Scanflow provides a kube.config file to deploy a kubernetes cluster to schedule the workflows.

Kubernetes dashboard

kubernetes

Search

Discovery and Load Balancing > Services

Cluster

Cluster Roles

Namespaces

Nodes

Persistent Volumes

Storage Classes

Namespace

default

Overview

Workloads

Cron Jobs

Daemon Sets

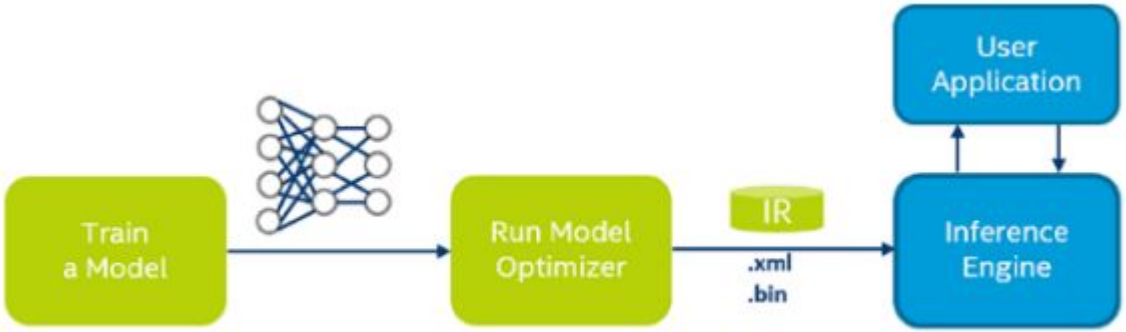
Deployments

Services

Name	Namespace	Labels	Cluster IP	Internal Endpoints	External Endpoints	Age
tracker-workflow1	default	io.kompose.service: tracker-workflow1	10.152.183.	tracker-workflow1:8 TCP tracker-workflow1:0 TCP	-	8 minutes
tracker-workflow2	default	io.kompose.service: tracker-workflow2	10.152.183.	tracker-workflow2:8 TCP tracker-workflow2:0 TCP	-	8 minutes
kubernetes	default	component: apiserver provider: kubernetes	10.152.183.	kubernetes: TCP kubernetes:I TCP	-	2 hours

1 – 3 of 3

Deployment integration: Intel OpenVINO



Intel tries to accelerate the model inference by lowering numerical precision training and inference

-However, adapting current working nodes and workflows to these optimizer nodes is not direct.

- Our proposal is to develop interfaces that facilitate this integration.

Proposal

TODO

- Transitional interfaces between states (e.g, the arrows in: model -> optimized_model -> inference), in order to make it simpler.

3. Transitional interfaces for [inference - Checking] and [inference - Interact] modules.

Benefits:

1. Standarization of communication between nodes, therefore, converting a model without much effort.

2. Flexibility to choose which workflow to run: a workflow that best fit a certain platform, such as desktop, car, raspberry pi, etc. For instance:

```
if device is typeA:
  run workflow A,
elif (device is typeB):
  run workflow B1 or run workflow B2
else
  run workflow C1 then run workflow C2 then workflow C3
```

3. Depending on traffic, switch models. For example:

```
if inference_time is critical:
  pick model A,
elif (accuracy is critical)
  pick model B
else pick model  C
```

Comparison ML workflow tools

	MLflow	Scanflow	Kubeflow/Airflow
Usability	Medium	**High**	Low
Built-in scheduling	No	No	Yes
Dynamic execution	No	**Yes**	Yes
Experiment tracking	Yes	Yes	Yes
Model versioning	Yes	Yes	Yes
Model checking	No	**Yes**	No
Orchestration-agnostic	Yes	**Yes**	No

Most appropriate tools for:

- Pre-deployment (steps required for getting a model): MLflow, Scanflow.
- Deployment (put a model into production): MLflow, Scanflow, Kubeflow/Airflow.
- Post-Deployment (check the model's health): Scanflow.
- Ease of use: Scanflow > MLflow > Kubeflow/Airflow.

Scanflow's main goals are usability, integration for deployment and real-time checking

Is it relevant?. AI predictions for 2020.

Creator of pytorch: … " place more value on AI model performance beyond accuracy. "

Celeste Kidd, psychologist at the University of California, Berkeley: … " increased awareness of the real-life implications of tech tools … "

Jeff Dean, Google AI chief: … " he wants to see less of an emphasis on slight state-of-the-art advances in favor of creating more robust models. "

Anima, Anandkumar, NVIDIA: … " self-supervision, and self-training methods of training models, which are the kinds of models that can improve through self-training with unlabeled data. "

Dario gil, IBM: …" focus on metrics beyond accuracy to consider the value of models deployed in production. Shifting the field toward building trusted systems instead of prioritizing accuracy above all else will be a central pillar to the continued adoption of AI. "

Keywords: **robust models, interpretable models, trusted models**.

Source: https://venturebeat.com/2020/01/02/top-minds-in-machine-learning-predict-where-ai-is-going-in-2020/

Current status

- Creation of nested workflows where each node can be an executor, tracker or checker. DONE
- Isolation of each workflow using docker, it comprises auto-creation of networks, volumes, docker files, images, containers and registries. DONE
- Tested integration with docker-compose.
- Ongoing development on swarm and kubernetes integration.
- Deploy ML models into services for prediction.
- Tracking module for saving any metadata. DONE
- Checking module (for now, drift distribution plugin) for post-deployment. DONE
- **Developing Interact module**.

Future work

- Interaction module: it will in charge of the interaction between the model and the human with the aim of make the former better. **Human-in-the-loop intelligent systems.**
- Lightweight integration with additional third-party tools.
- Enhance interface module for checking.
- Dashboard for checking module.
- Improve compatibility with docker-compose, swarm, kubernetes.
- Test more use cases.
- Start formalizing scanflow for writing a paper.
- Start writing documentation.
- Set up scanflow as a python package.
- Improve drift distribution checker.
- Add option for wipe out any metadata (tracking and checking).
- Add a new plugin for integrity checking.
- Add option to compress all the settings needed to transfer an application.
- Add interface to write on databases.
- Add option to plot nested workflows in jupyter notebooks.