

# Machine Learning Operations (MLOps)

Ankit Pal (Monk)

# AI Research Engineer @ Saama AI Lab

- I work in Graph Learning and NLP field
- I am interested in
  - Representation Learning on Graphs
  - Privacy preserved Federated learning in Healthcare
  - Large Language Models(LLMs)
  - Biomedical signal processing

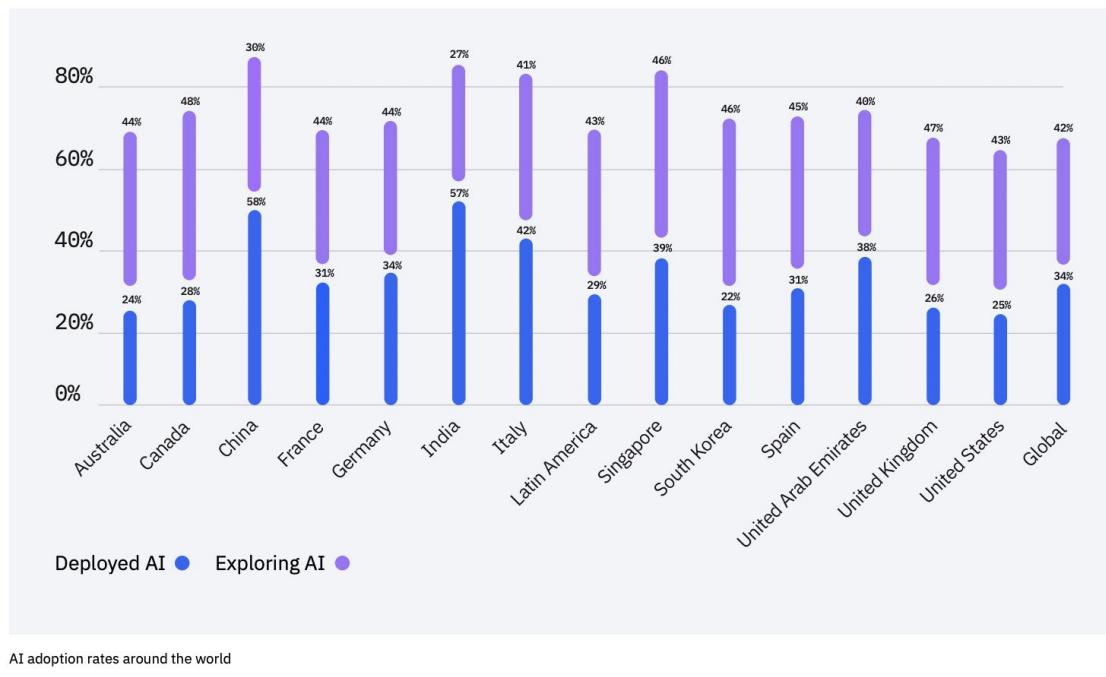
I also do :D

Cool Research | Trekking | Judo | Boxing | Skiing



What is MLOps  
and  
WHY should you care?

# Evaluation of AI



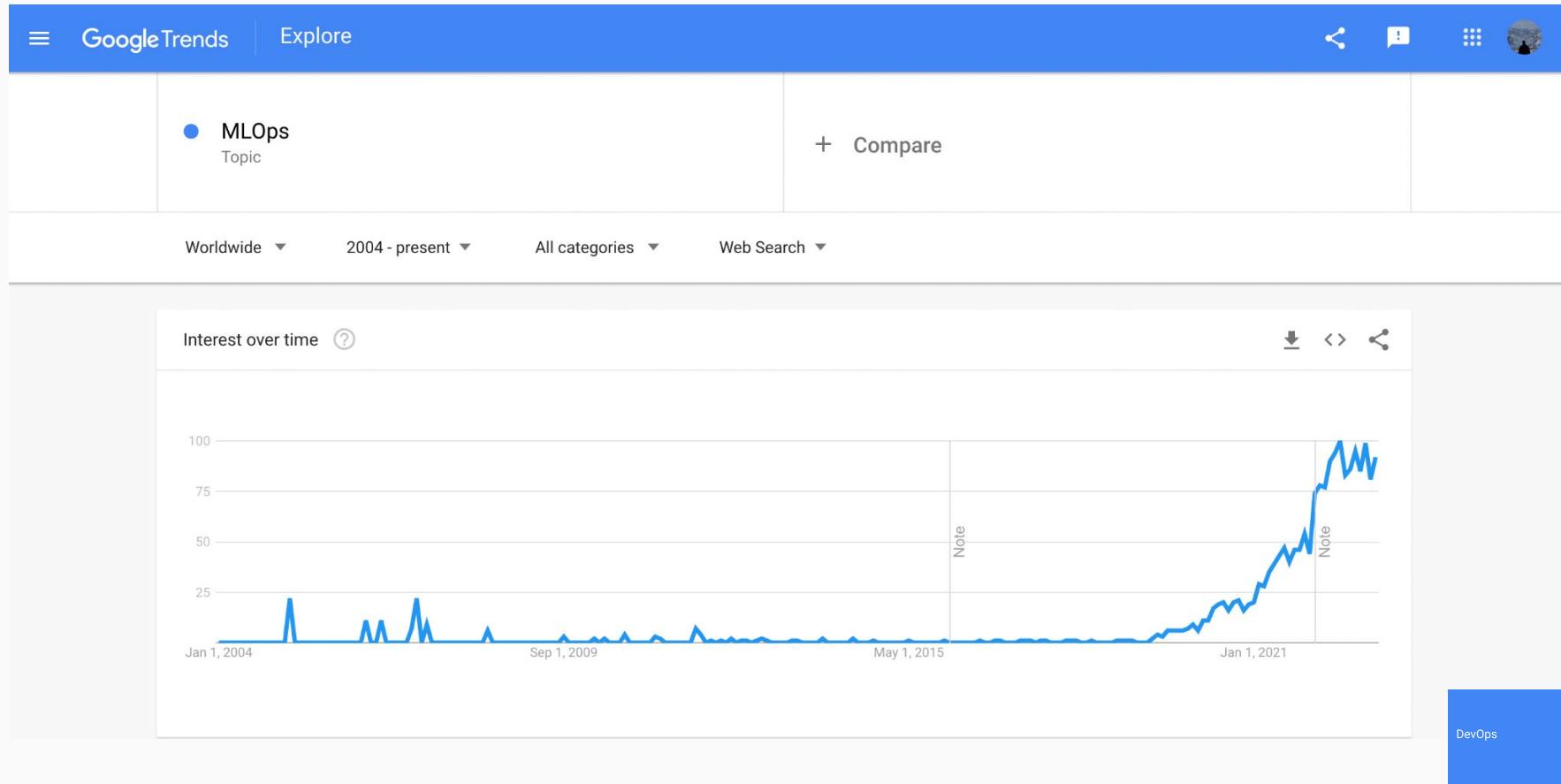
13%

Compared with 2021, organizations are more likely to have adopted AI in 2022.

IBM Global AI Adoption Index 2022



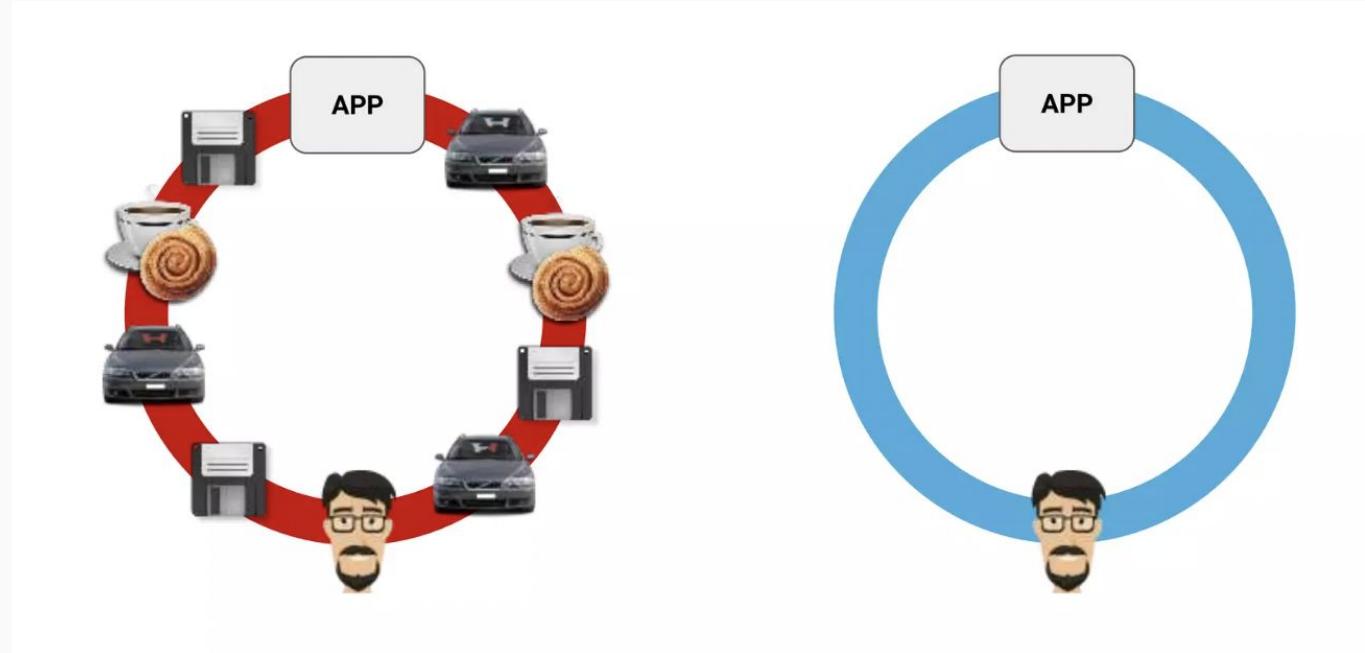
# MLOps



# DevOps

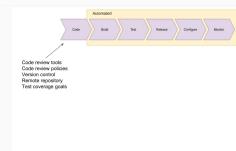


# DevOps

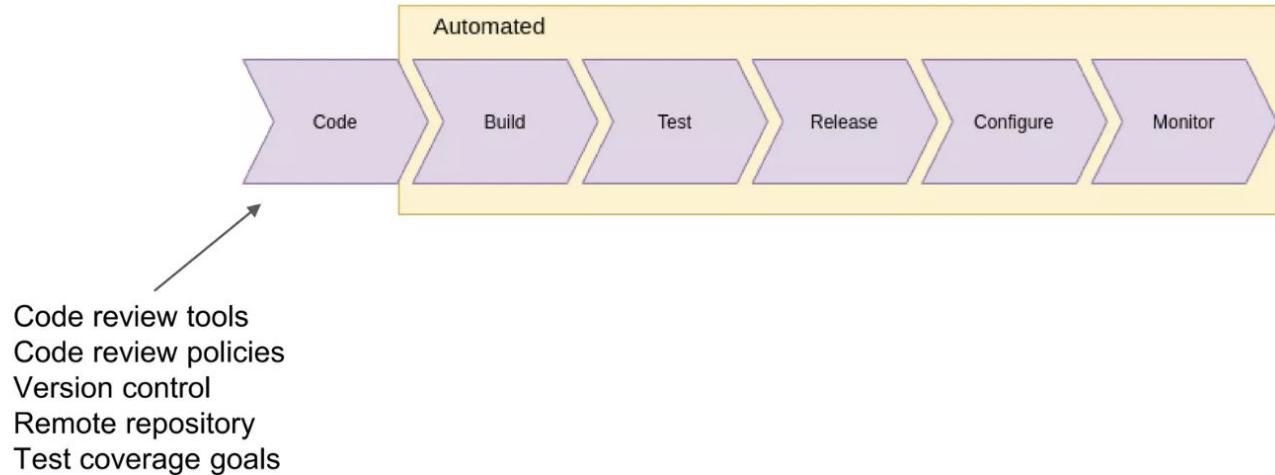


**DevOps '95**

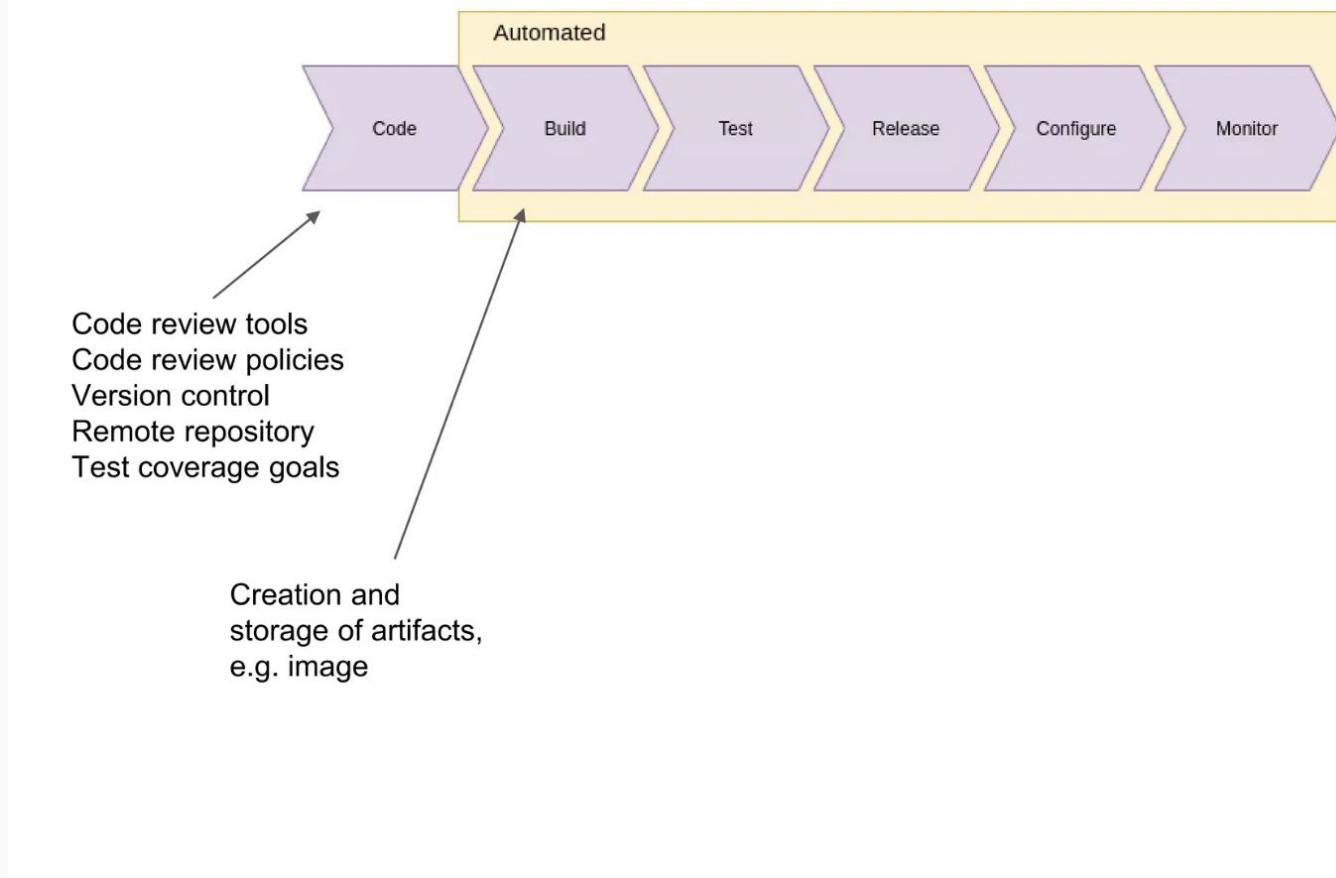
**DevOps '23**



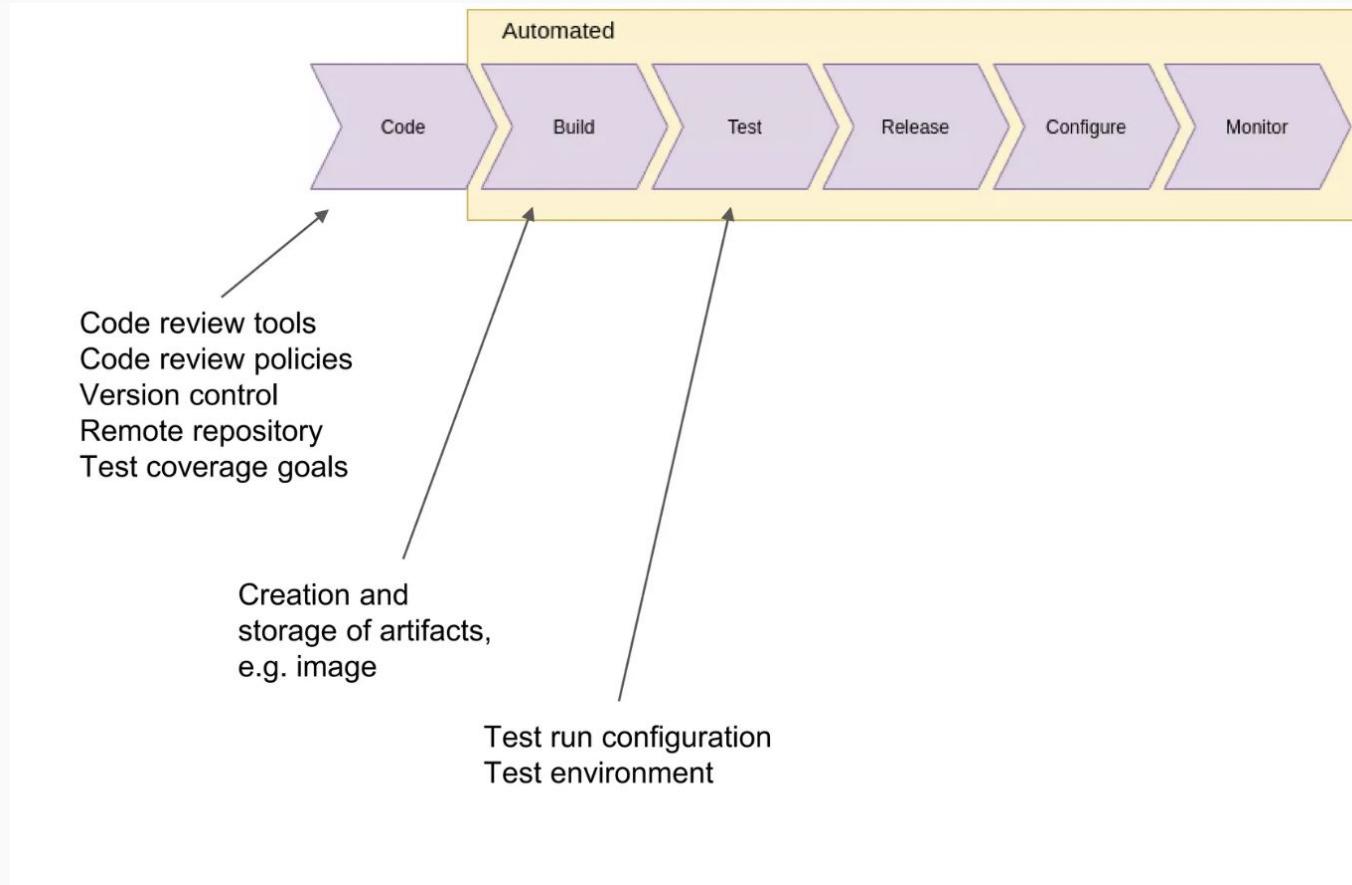
# DevOps



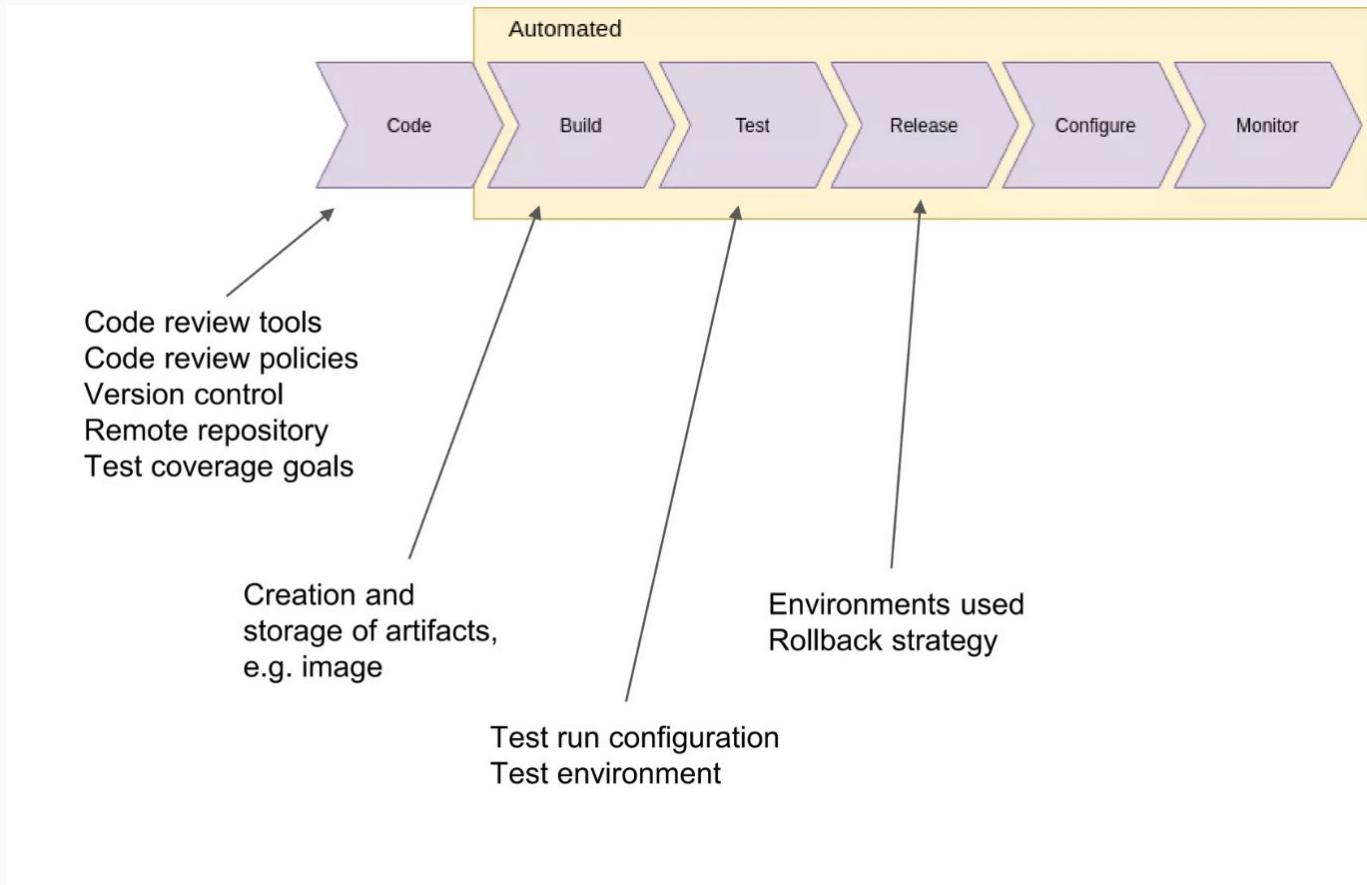
# DevOps



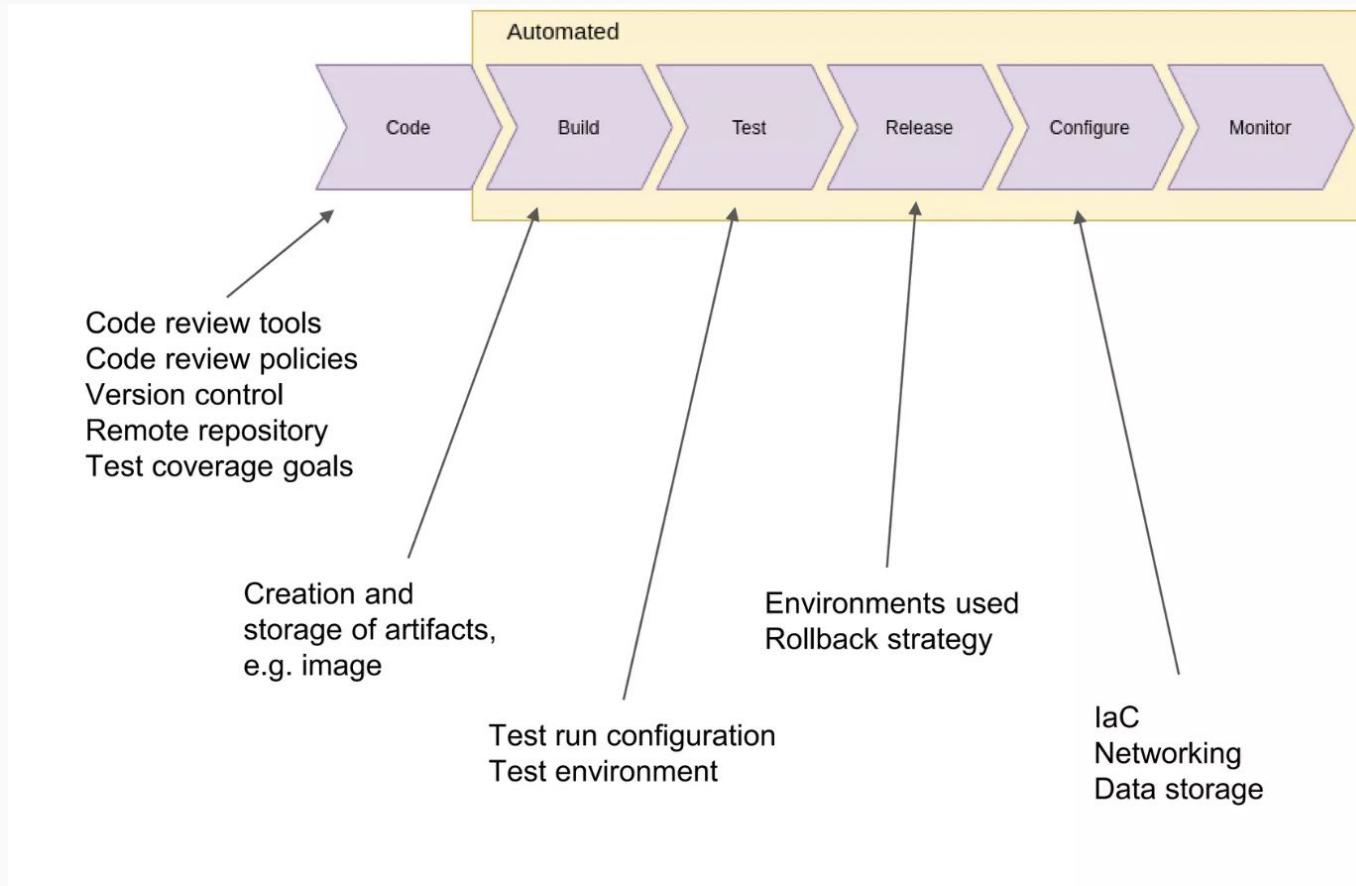
# DevOps

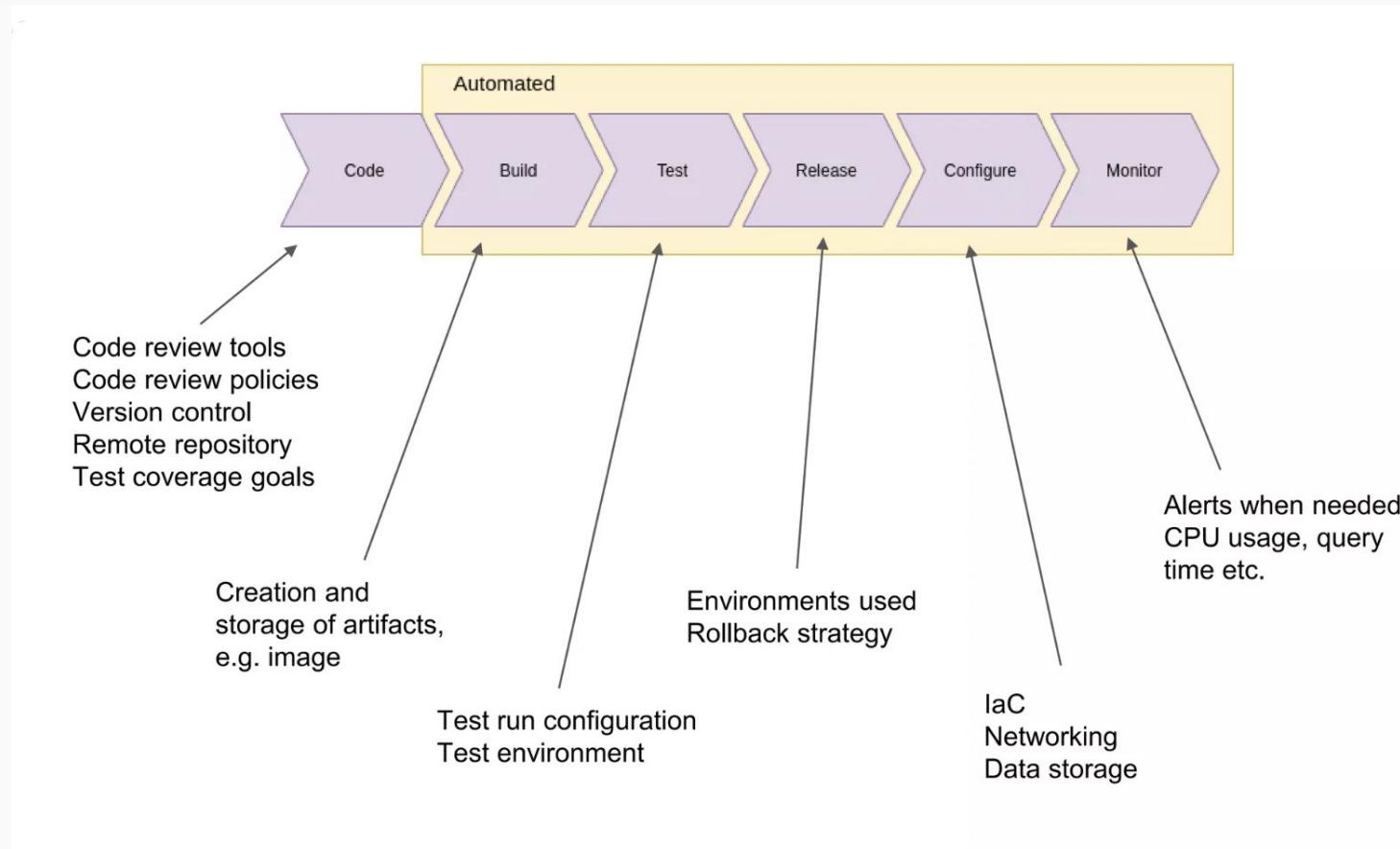


# DevOps



# DevOps





- Agile software development
  - Iterations, planning, retrospectives
  - Methodologies (Scrum, Kanban)
- Continuous Integration
- Continuous Delivery
- Monitoring, alerting

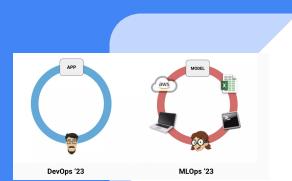


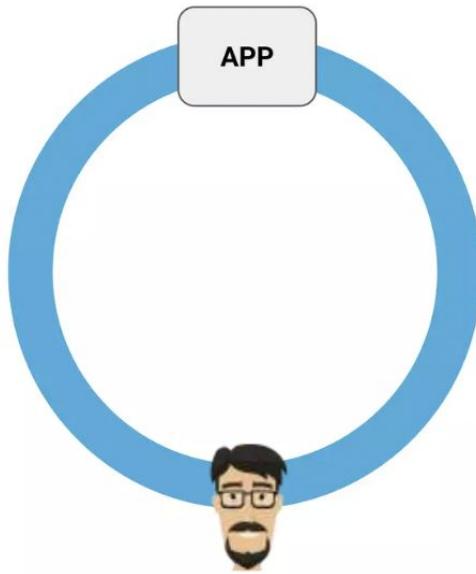
## DevOps

- Agile software development
  - Iterations, planning, retrospectives
  - Multidisciplinary teams
- Continuous Integration
- Continuous Delivery
- Monitoring, alerting

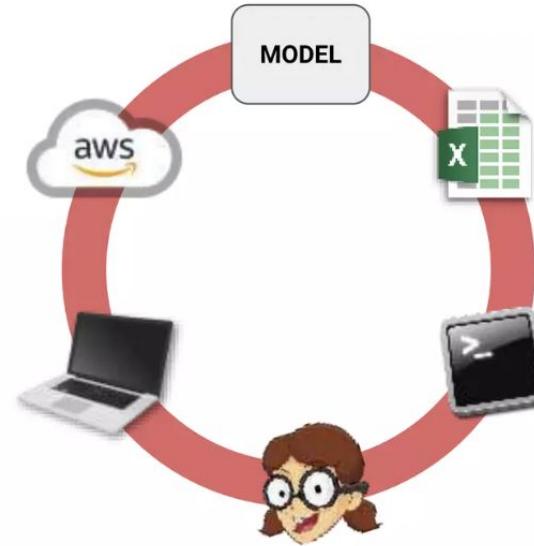


# MLOps





**DevOps '23**



**MLOps '23**

# ML-Pipeline

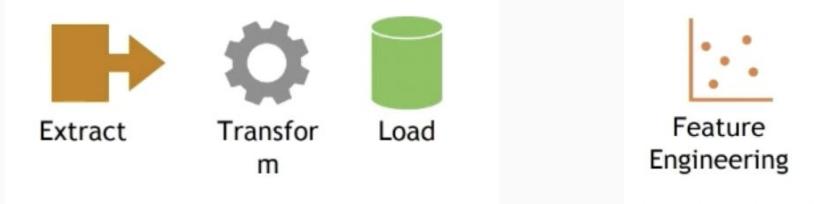
## Data

## Data

Data Engineer

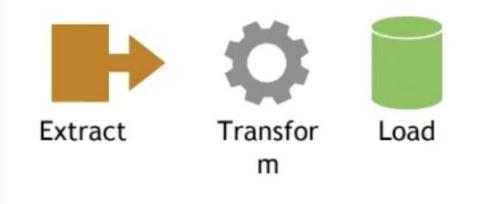
## Data

Data Engineer

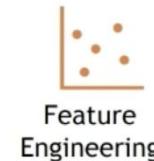


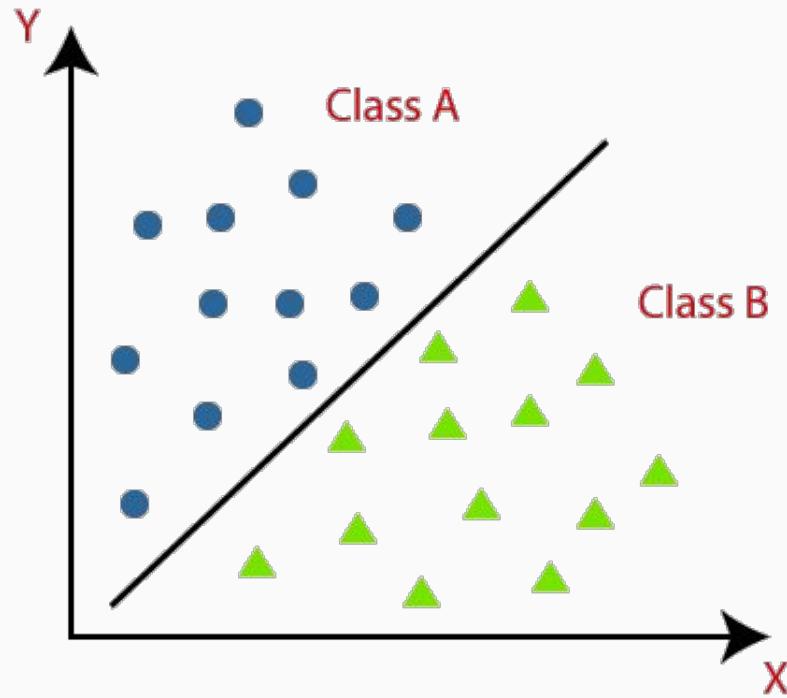
## Data

Data Engineer

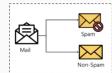


## Model

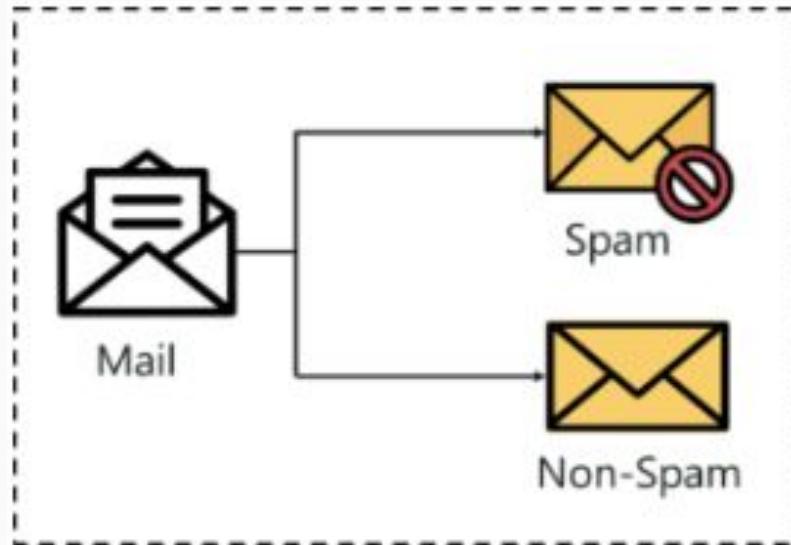




## What is a ML Model?



What is a ML Model?



## What is a ML Model?

## Data

Data Engineer



## Model

Data Scientist



## Data

Data Engineer



Extract



Transform



Load

## Model

Data Scientist



Feature  
Engineering



Build  
Model



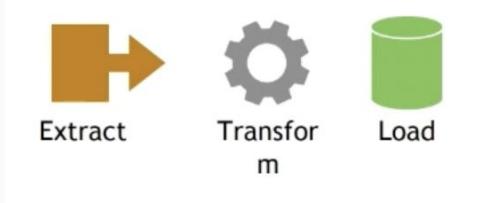
Train  
Model



Optimize  
Model

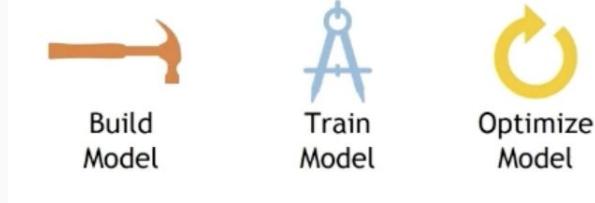
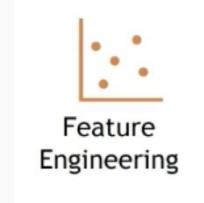
## Data

Data Engineer



## Model

Data Scientist



Model Accuracy : 95%

We think building model is everything.



**After getting good accuracy on test-set - Job Done?**

# The Million Dollar Question



## How Do we Put the Model in Production, Anna?

## Problem



ginablaber  
@ginablaber

Follow



The story of enterprise Machine Learning: “It took me 3 weeks to develop the model. It’s been >11 months, and it’s still not deployed.”  
@DineshNirmalIBM #StrataData #strataconf

10:19 AM - 7 Mar 2018

7 Retweets 19 Likes



7



19

Why?



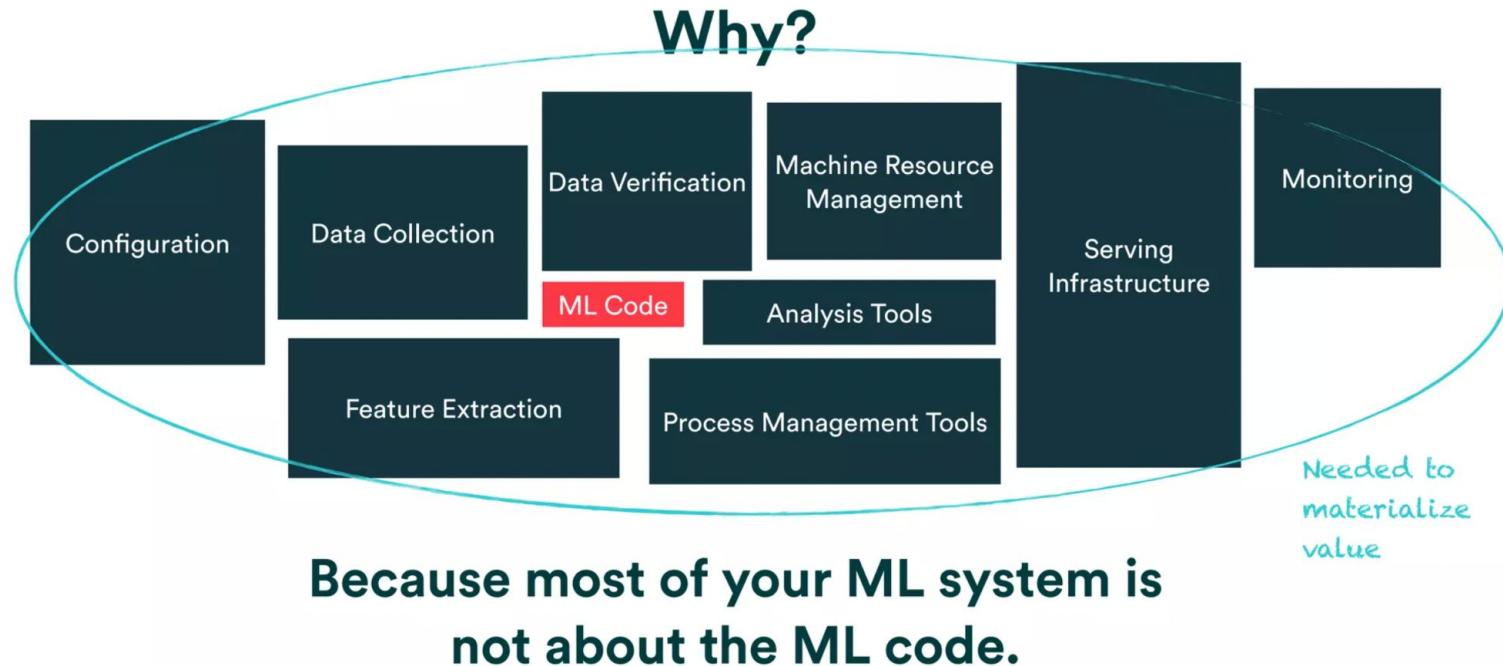
## Problem

# Why?



Needed to  
prove value

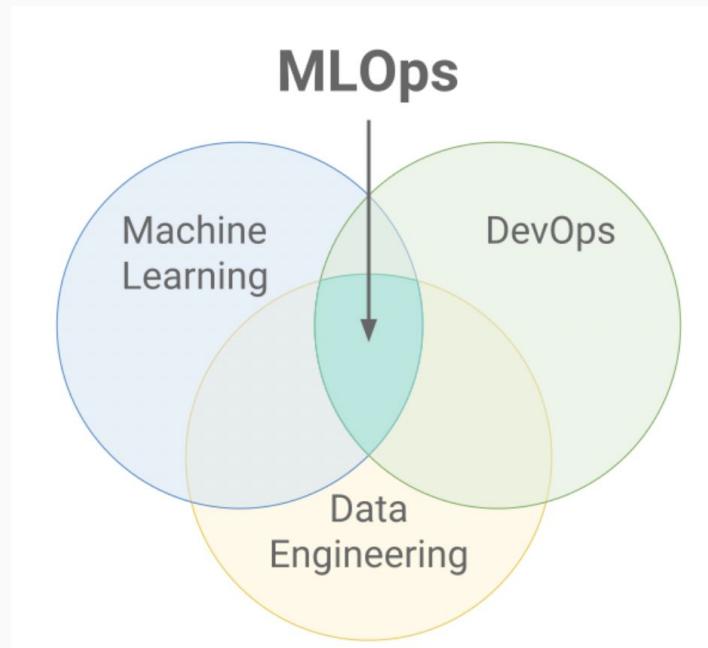
# Problem



The goal of MLOps is to **reduce technical friction** to get the model from an idea into production in the shortest possible time with as little risk as possible.



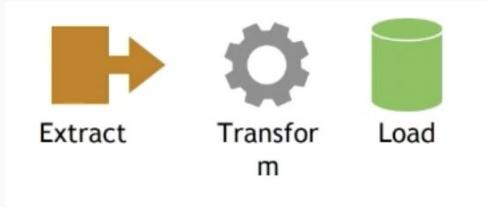
## MLOps is DevOps for Machine Learning Models



# ML-Pipeline

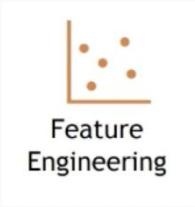
## Data

Data Engineer



## Model

Data Scientist



Machine Learning Engineer



# ML-Pipeline

## Data

Data Engineer



## Model

Data Scientist



Machine Learning Engineer

Dev Engineer



# ML-Pipeline

## Data

Data Engineer



## Model

Data Scientist



Machine Learning Engineer

Dev Engineer

Ops Engineer

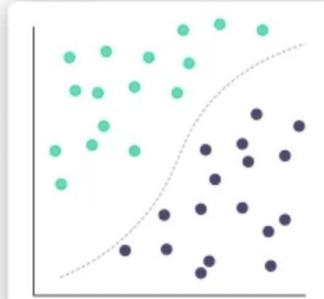


\* Data Drifts  
\* Model Issues

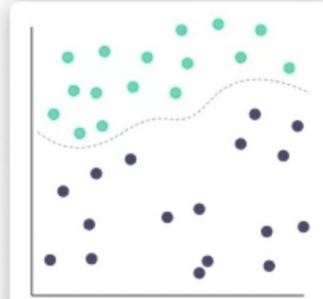
- **Data Drifts**
- **Model issues**

# What is Data drift?

Original Data

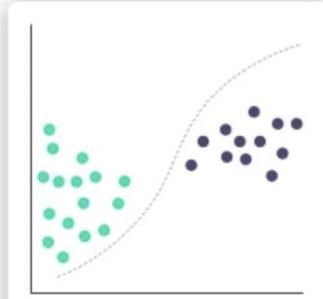


Real concept drift



$p(y|X)$  changes

Virtual drift



$p(X)$  changes, but not  $p(y|X)$

What is Data drift?



# What is Data drift?

cat



cat



dog



dog



Fig. 4.7.1 Training data for distinguishing cats and dogs.

At test time we are asked to classify the images in Fig. 4.7.2.

cat



cat



dog



dog



Dataset Monitors

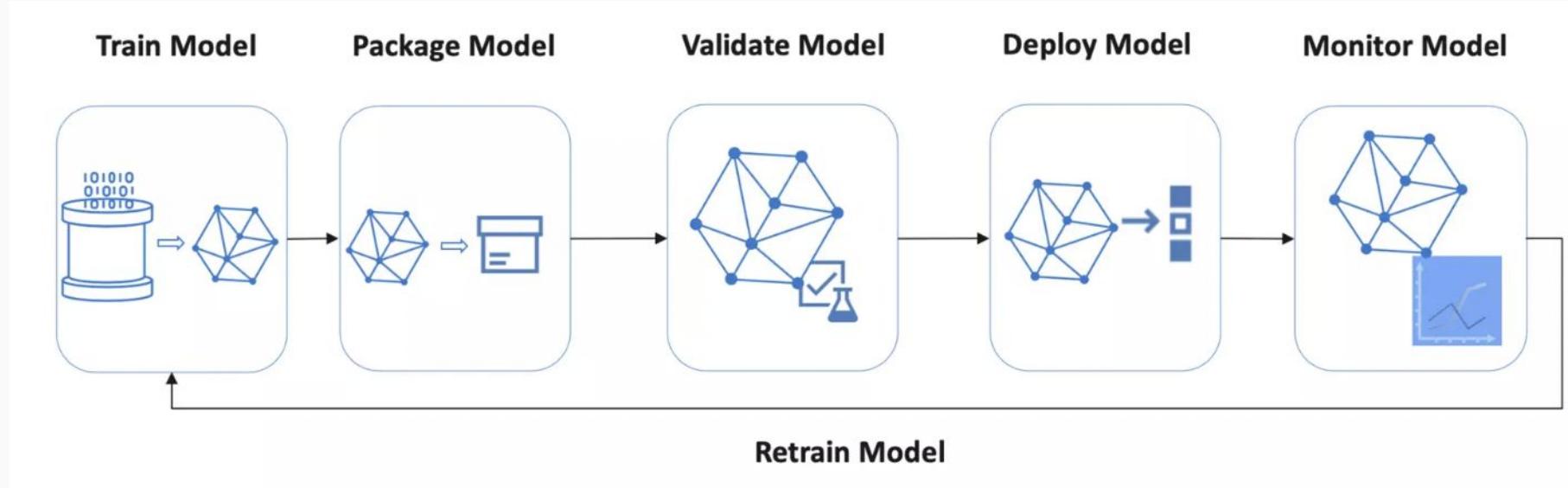
Fig. 4.7.2 Test data for distinguishing cats and dogs.

- Detect an event by data drift on new data in a dataset.
- Detect anomalies in a dataset.
- Profile new data over time.

# Dataset Monitors

- Detect and alert to data drift on new data in a dataset.
- Analyze historical data for drift.
- Profile new data over time.

- **Data Drifts** → Monitor Data
- **Model issues**



## Model Pipeline

### **Model versioning**

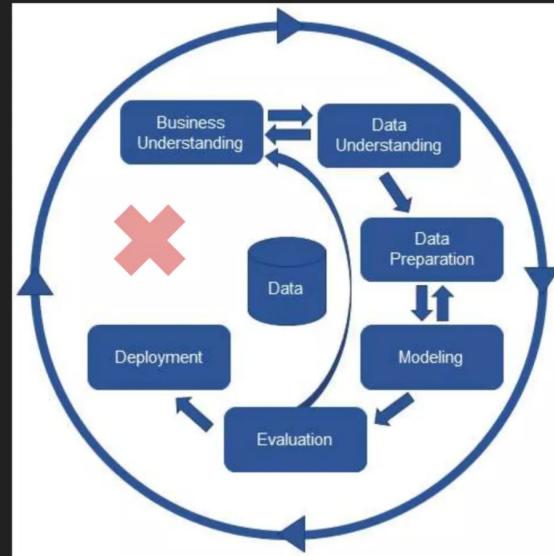
- Frequently Update Models
- Test New Models
- Safely Rolling Out ML Models To Production

- **Data Drifts** → Monitor Data
- **Model issues** -> Update Models on new data



## Monitoring!

- **Mostly problems can be:**
  - **Data Monitoring (Inputs):**
    - Data Drift
    - Input Distribution
    - Data Checks
    - ...
  - **Prediction Monitoring (Outputs)**
    - Prediction Distribution
    - Model Performance
    - ...
  - **Operations issues**
    - System Performance
    - Uptime
    - Response time



## Machine Learning Lifecycle

Traditional software

Version control of code  
Managing the application  
Tests  
Deployment  
CI/CD pipeline

## Traditional software

- Version control of code
- Monitoring the application
- Tests
- Deployment
- CI/CD pipeline

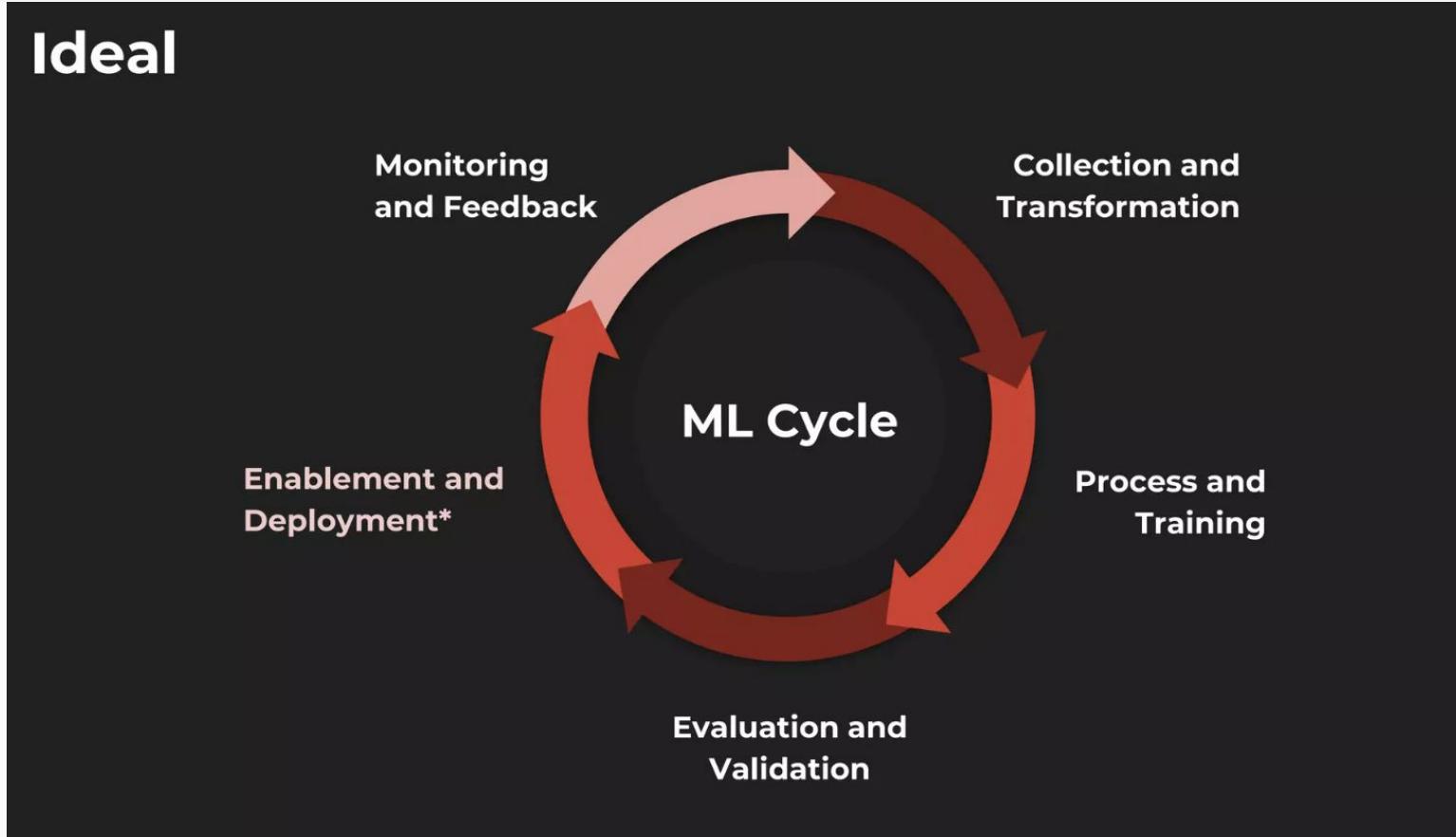
# Software with ML elements

Version control of code  
Monitoring the application  
Tests  
Deployment  
CI/CD pipeline

Monitoring your data  
Versioning data  
Cyclical dependencies  
Data validation  
Model quality evaluation

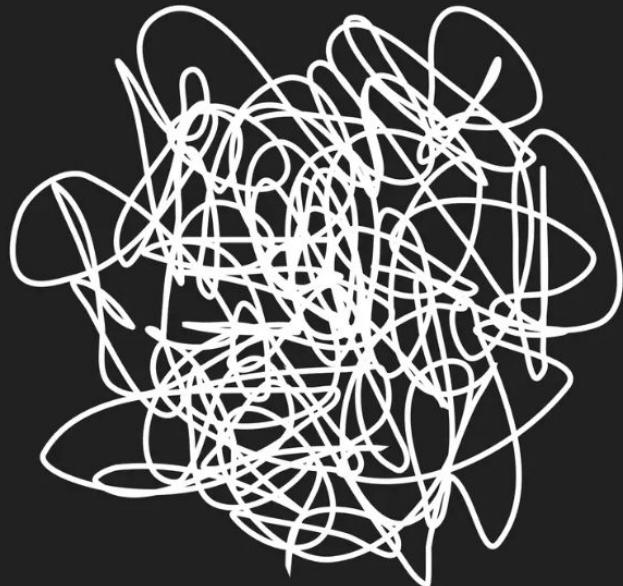


# Ideal ML-Lifecycle



IRL

# IRL (In Real Life...)



## Available tools

mlflow

DVC

$\Sigma$   
SIGOPT



Pachyderm

comet



Kubeflow



# mlflow

## Tracking

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

## Projects

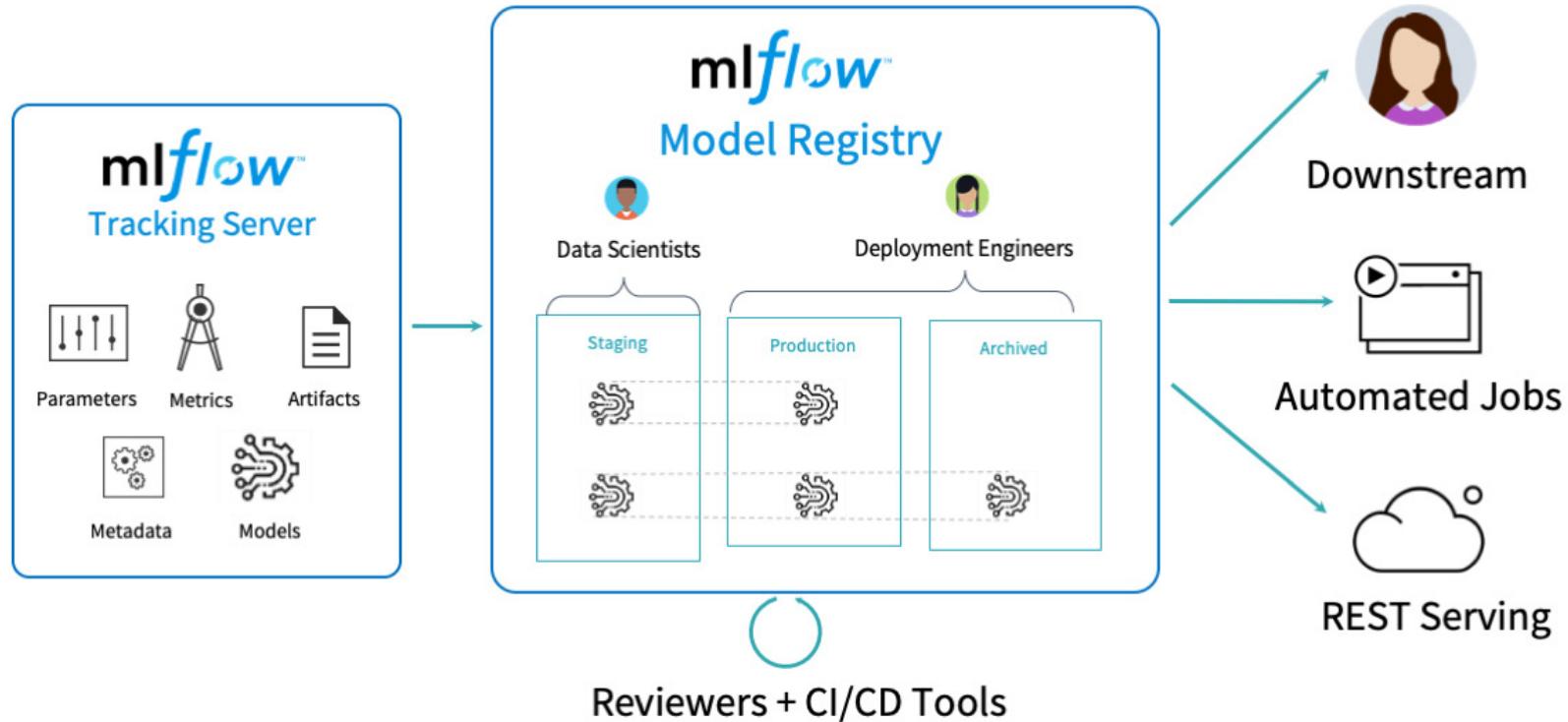
Packaging format for reproducible runs on any platform

## Models

General format for sending models to diverse deplo



# Available tools



### Wrap-UP

- Building the ML Model is **NOT EVERYTHING**
- MLOps is **applying DevOps principles and practices** to Machine Learning models.
- Deploying the model is not end of the story
- Generate alerts, **monitoring, Updating and tracking data drifts**, model drifts, and code issues are critical to a successful working ML Application
- **MLflow, Kubeflow** etc, are a few of the best MLOps frameworks in the market.

# Thank you for your attention!

