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Datahack

Datahack Meetup

Dataset Versioning and Feature Stores for Machine Learning

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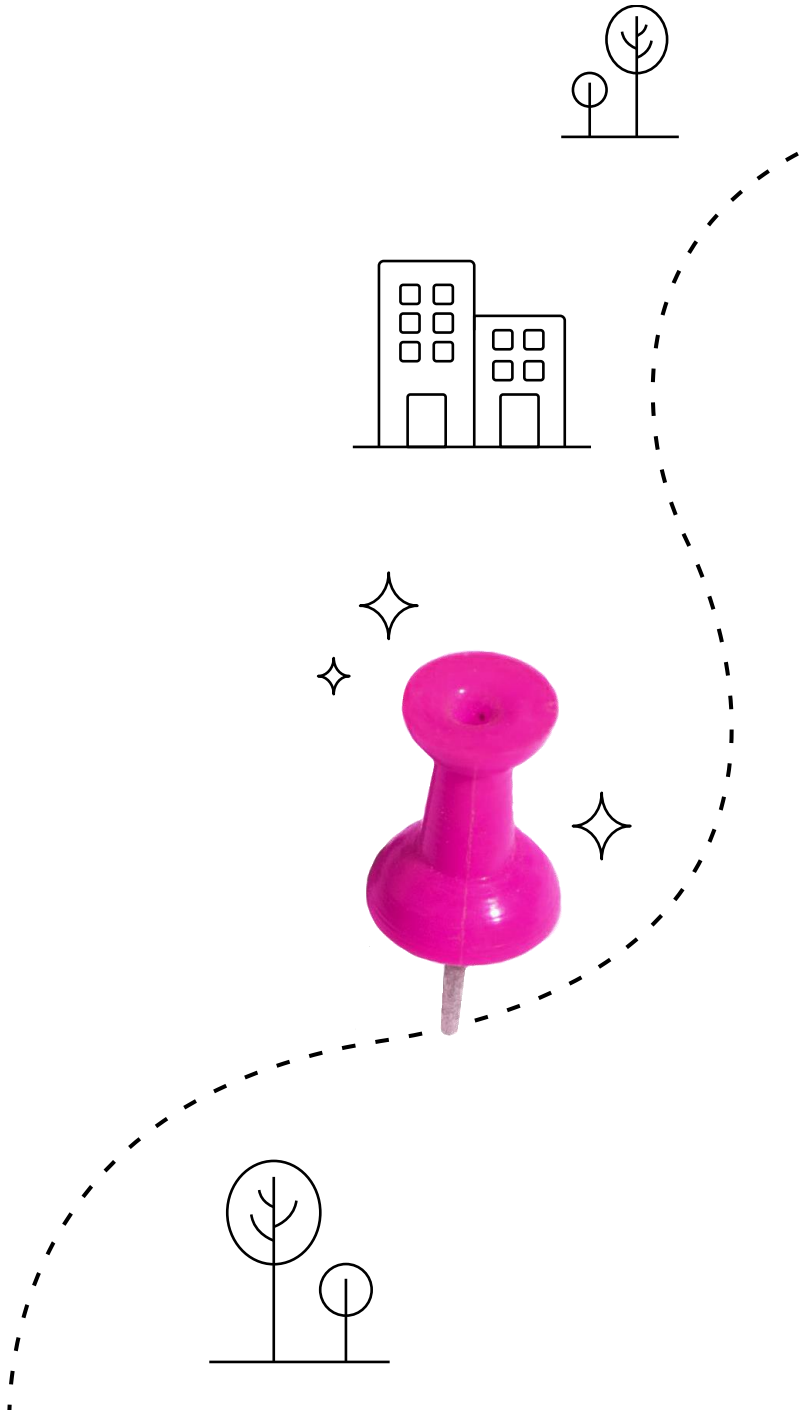
Agenda

1. Motivation
2. Data Versioning Approaches
    1. Git (LFS)
    2. Object Storage (Amazon S3)
    3. Data Version Control (DVC)
3. Feature Stores
4. SageMaker Feature Store Demo



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Motivation

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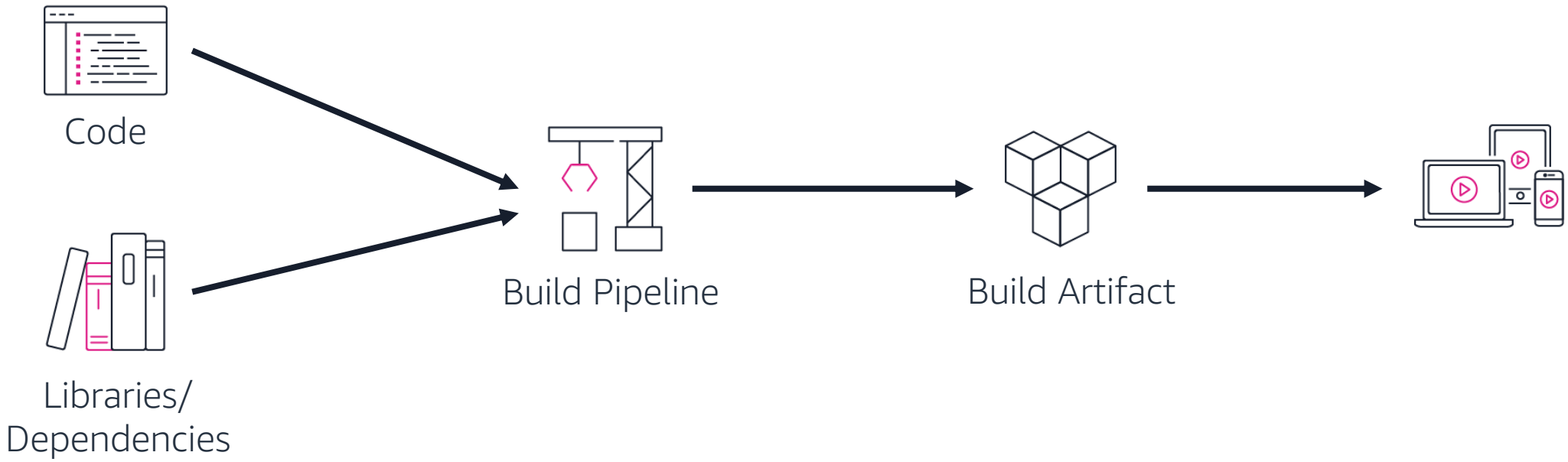
Excursion: SW Development – Build Pipelines



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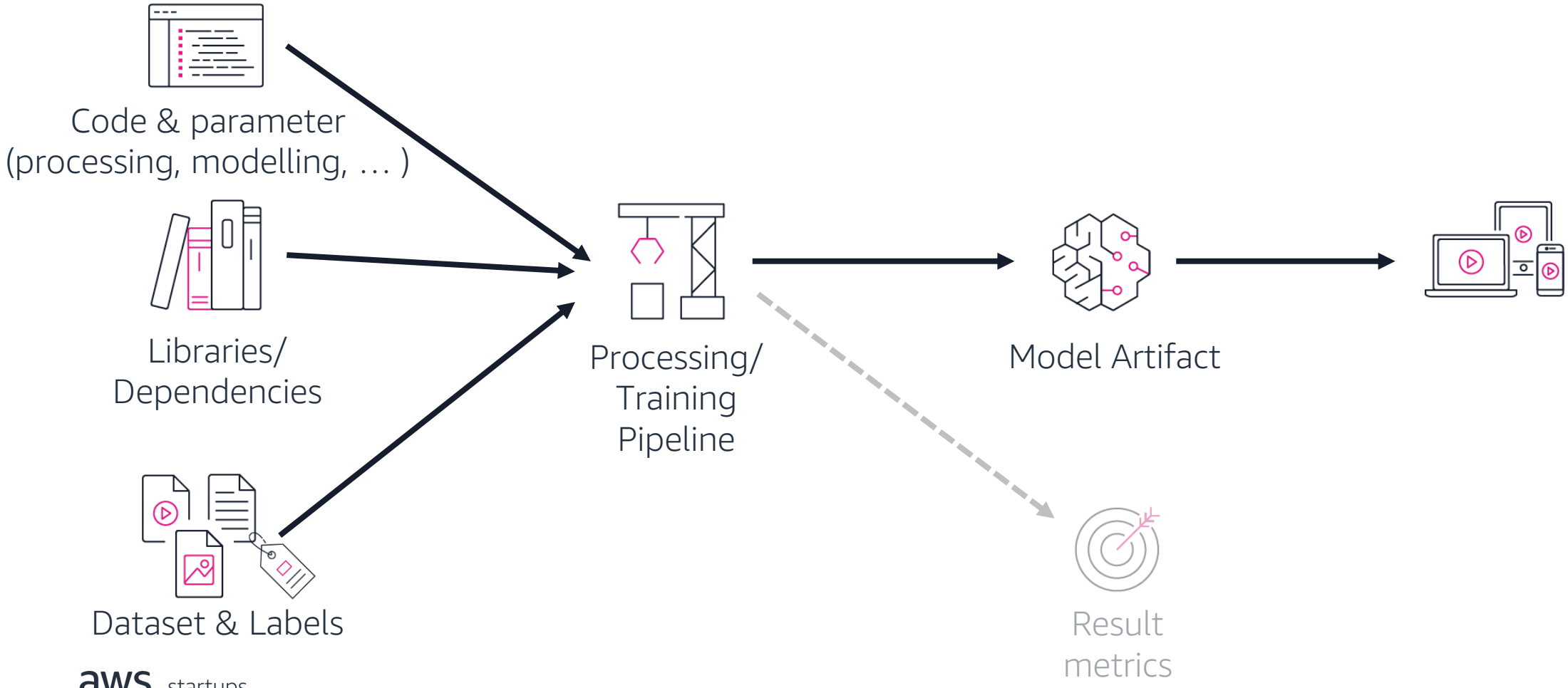
Reproducible Pipelines: What about Data Science?



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Why bother about it?

- Best practice data quality management
    - Garbage in, garbage out
- Reproducible training and retraining
- Reuse and share preprocessed datasets
- Impossible to debug data errors
- Testing: i.e. integration tests for your full ML pipeline
- Explainability (debugging predictions)
- Auditing, regulatory and ethical AI requirements
- …

85% AI projects deliver erroneous outcomes due to bias in Data, algorithms or teams managing it.

92% Of AI practitioners reported **Data cascading** effects are prevalent in their AI/ML projects.

Sources:: https://www.gartner.com/en/newsroom/press-releases/2018-02-13-gartner-says-nearly-half-of-cios-are-planning-to-deploy-artificial-intelligence and https://storage.googleapis.com/pub-tools-public-publication-data/pdf/0d556e45afc54afeb2eb6b51a9bc1827b9961ff4.pdf

What is the cost to your business of making wrong or suboptimal predictions?
(Caused by training on the wrong data)

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Data Versioning Approaches

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git
&
Git Large File Storage

Git LFS : Why not use Git?

- Git
  - Great for text files, i.e. code, that Git can handle as DAG
  - Bad for binary files, images, videos etc.
    - Especially for larger files or changing files
      (GitHub file size limit 100MB)
  - Huge repos, slow cloning, branch switching etc…

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- Git LFS (large file storage)
  - An open source git extension for versioning large files
  - Little change to git workflows
  - Small repos and faster cloning and fetching
  - Data storage on remote git LFS server
  - File size limitations (2GB GitHub free, 5GB GitHub Enterprise)

Git Large File Storage

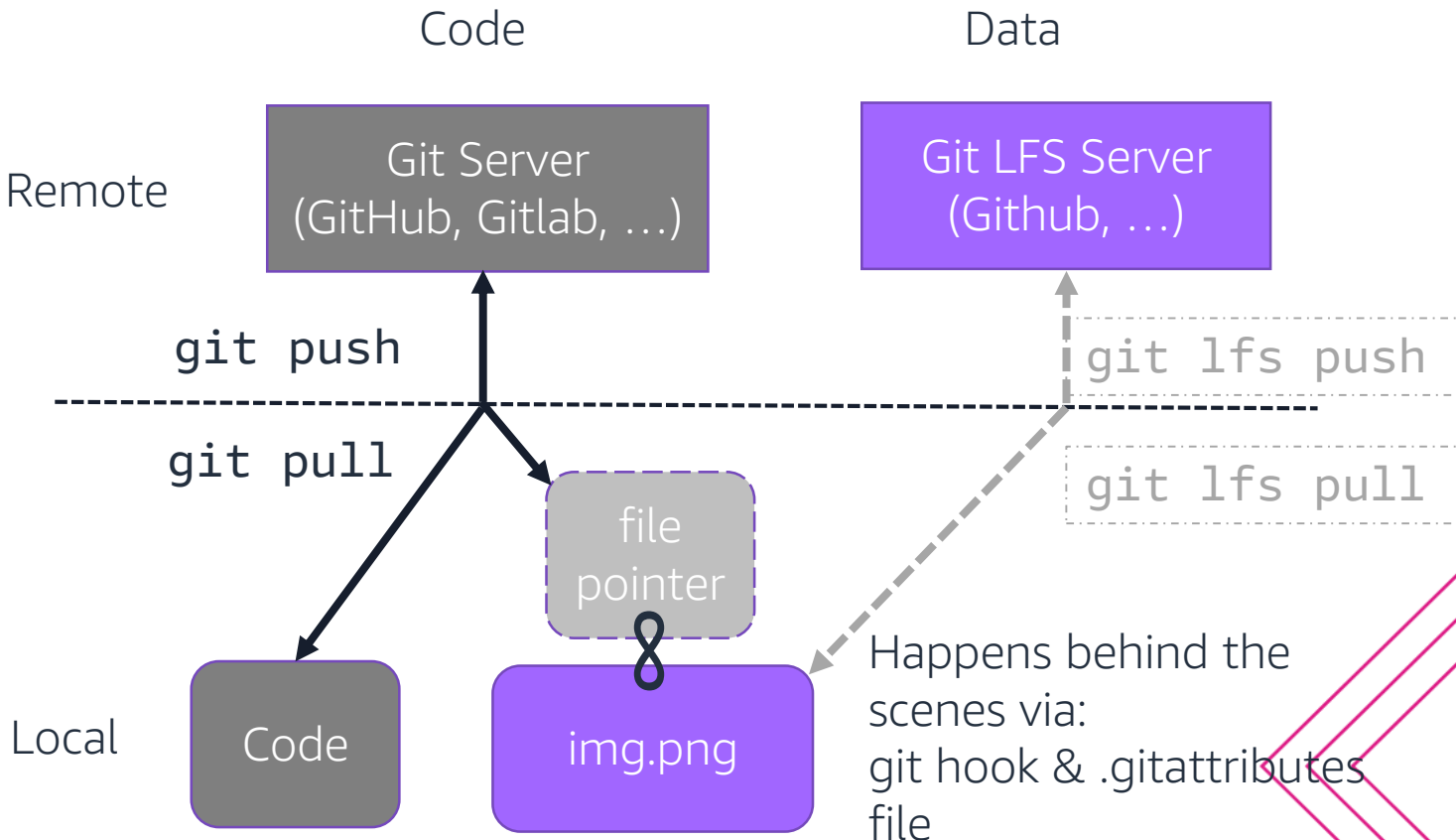
Git LFS: Quick Overview

```
$ git lfs install

$ git lfs track “*.png”

$ git add path-to-file/img.png

$ git commit -m “add image”
$ git push
…
$ git pull
```



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Git LFS: Interacting with the files

- Git (lfs) pull
- Just like local files, e.g. git updates pointer to actual files

Git LFS: A few Downsides

- Requires Git LFS Server (GitHub, Gitlab, Atlassian, self-hosted)
- Max file size implementations ~2GB
- No direct storage integrations (Amazon S3, Snowflake, Azure, GCP etc)
- Data transfer…
- Not great for sharing datasets across projects

Cloud Object Storage

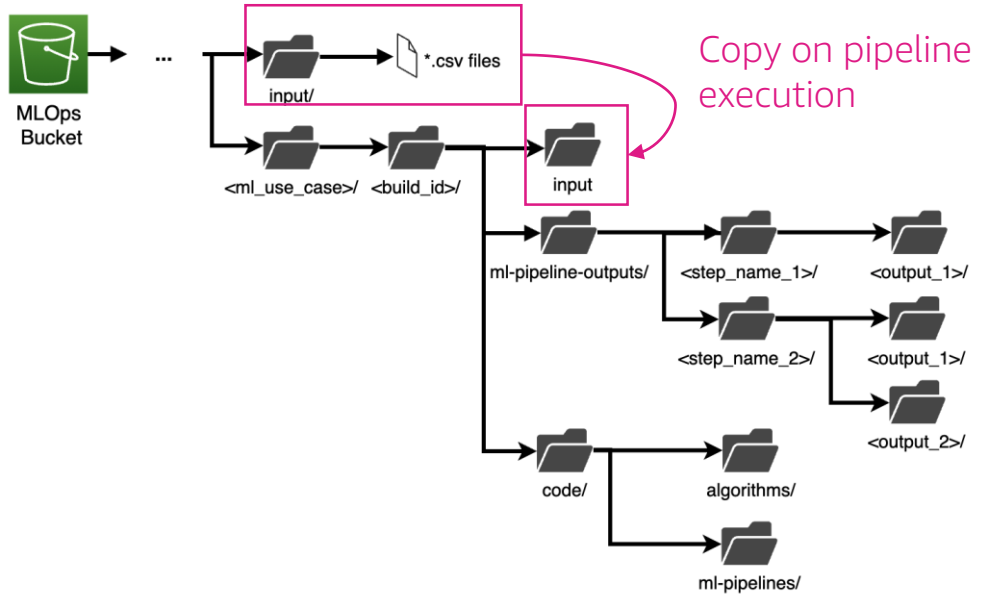
Amazon S3

Object storage (S3) with immutable files

Option 1) Manifest files

```
{"source-ref": "S3 bucket location 1"}
{"source-ref": "S3 bucket location 2"}
                  ...
{"source-ref": "S3 bucket location n"}
```

Option 2) Copy datasets



- Caveats:
  - Relies on data immutability
  - Manifest files require code or a system that will load the listed files
  - Copying creates data duplication, i.e. not suited for large/changing data sets

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Object storage (S3): Interacting with your files

- Download before training/processing
  - Fully replicated
  - Sharded/split
- Options to pipe on-the-fly
- High-performance/Caching options FSx for Lustre

- See also AWS blog: Choose the best data source for your Amazon SageMaker training job

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DVC: Data Version Control

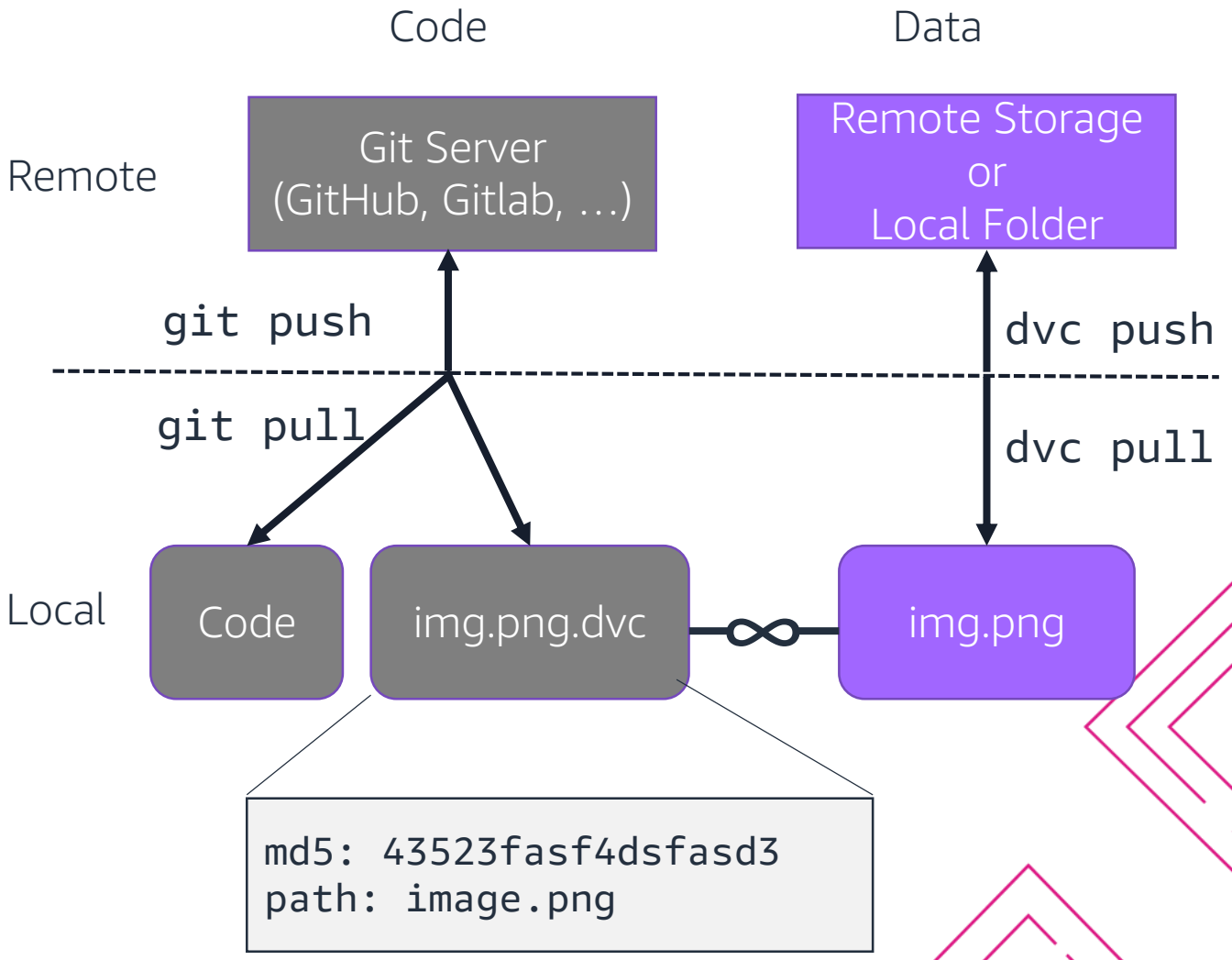
- “Open-source Version Control System for Machine Learning Projects”
- Closely adopting git style syntax
- Track Datasets (but also ML Workflows and Projects)
- Many storage backend options (Amazon S3, Azure, GCP, SSH, local)

- Versions control features beyond dataset tracking:
  - Model artifacts
  - Data pipelines
  - Metrics and Parameters

DVC Quick Overview

```
$ dvc init
$ dvc remote add -d myrepo s3://mybucket

$ dvc add image.png
$ git commit -m “data: add image”
$ dvc push
…
$ git checkout <>
$ dvc pull
```



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DVC: Interacting with your files

- Within your Git/DVC project:
  - `dvc pull` + local processing

- Outside the original project
  - `dvc get` (download only)
  - `dvc import` (download + tracking)
  - Python API: `dvc.api.open` or `dvc.api.read`

```python
import dvc.api

with dvc.api.open(
    "get-started/data.xml",
    repo="https://github.com/iterative/dataset-registry")
    as fd:
        # fd.read()
```

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DVC Demo

```
$ git init
$ dvc init
$ git status
$ git commit -m ‘initial’
### for local: $ dvc remote add -d dvc-remote /tmp/dvc-store
$ dvc remote -d s3-dataset s3://dvc-demo-datahack/demodata/
$ git commit ./dvc/config -m “configure dvc”
<Copy a file >
$ dvc add file/folder
$ git commit .gitignore data.dvc
$ git tag -a ‘v1’ -m “raw data set”
$ dvc push
…
```

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...and there are more (selected)

Pachyderm automates and scales the machine learning lifecycle while guaranteeing reproducibility including: Data Driven Automation, Petabyte Scalability, End-to-End Reproducibility

The lakeFS open source project for data lakes allows data versioning, rollback, debugging, testing in isolation, and more – all in one.

Delta Lake is an open-source storage framework that enables building a Lakehouse architecture with compute engines including Spark, PrestoDB, Flink, Trino, and Hive and APIs for Scala, Java, Rust, Ruby, and Python..

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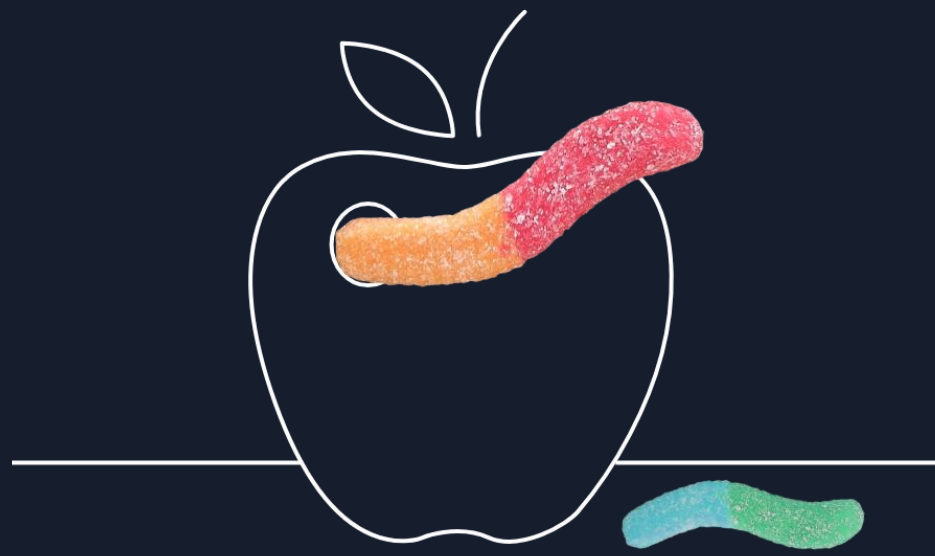
Feature Stores



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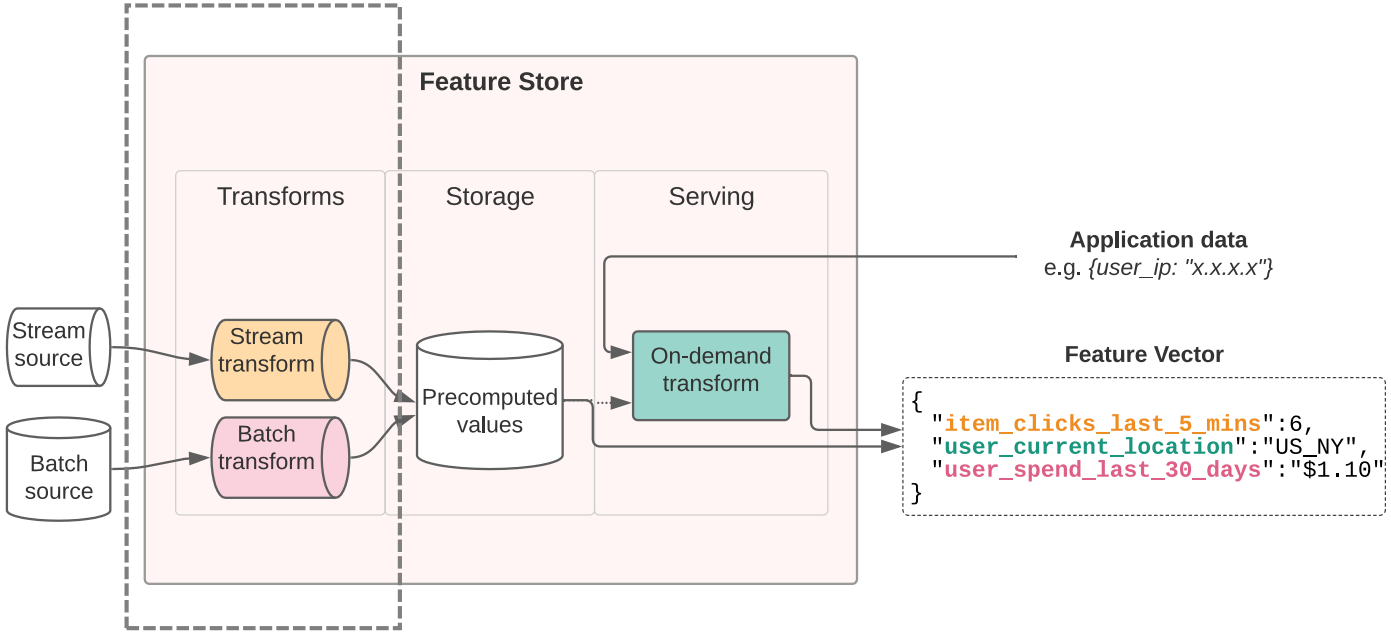
What is an Feature Store?

A central repository to ingest, store and serve features for machine learning

A "**feature**" refers to the entire column in the dataset

Transaction_id	in_foreign_country	size_compared_to_avg_transaction	fraud?
7485	False	0.8x	False
46854	True	21.2x	True
3521	True	1.1x	False

A "**feature value**" refers to a single value of a feature column



Transforms are not always part of the feature store itself

source: https://feast.dev/blog/what-is-a-feature-store/

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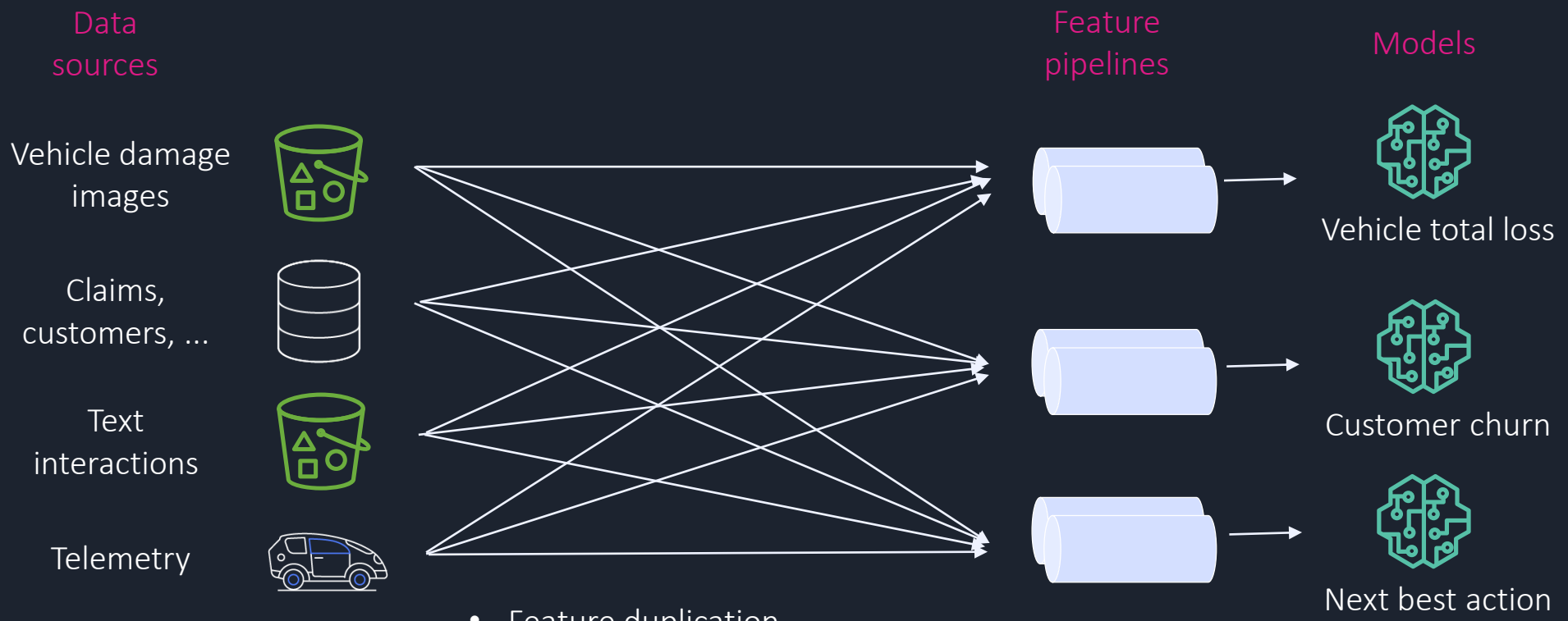
What is a feature store trying to solve?

Standalone feature engineering for each new model



- Feature duplication
- Slow time to market
- Inaccurate predictions

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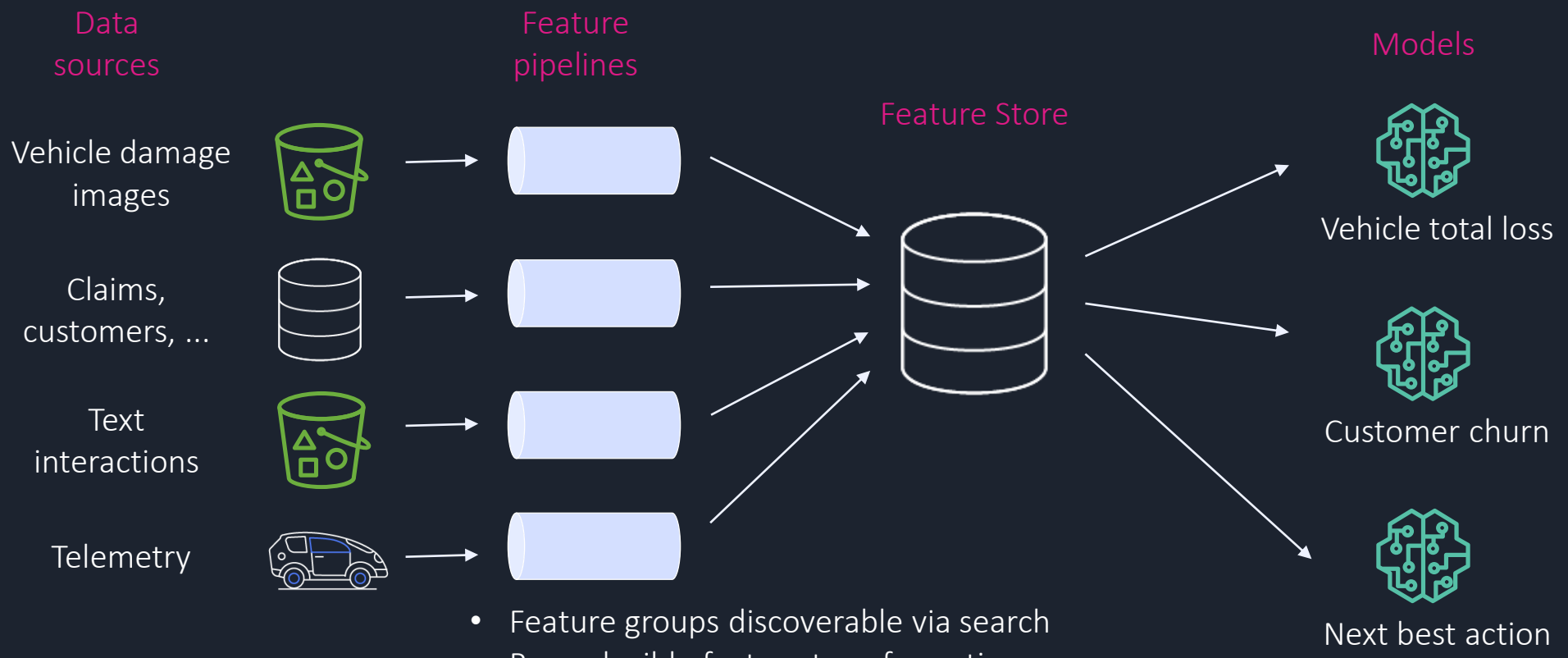
With A Feature Store...

Build features once, reuse them across teams and models



- Feature groups discoverable via search
- Reproducible feature transformations
- Extract accurate training datasets
- Low latency lookups for inference
- Consistent features for training and inference

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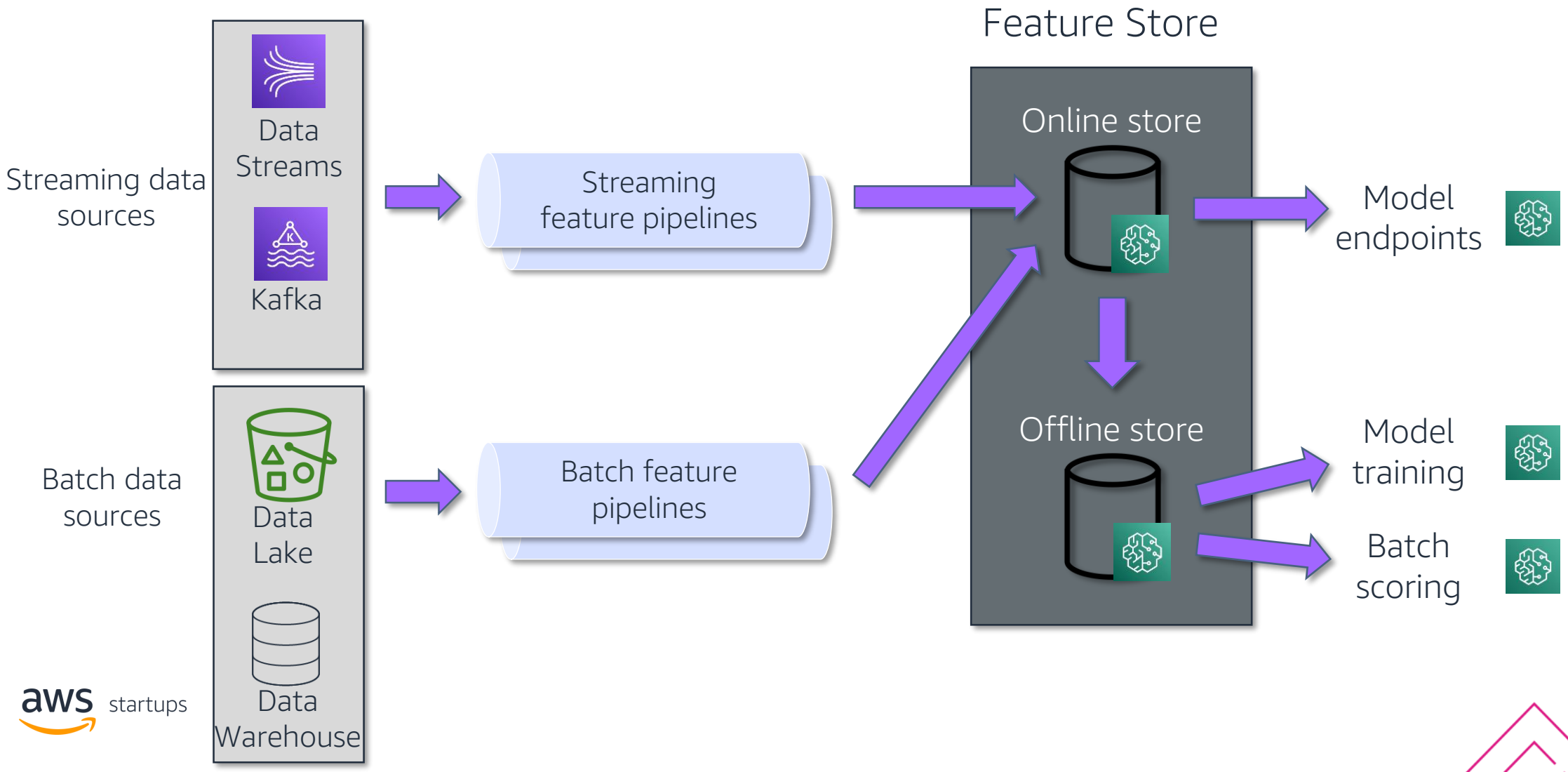
Why Feature Stores?

- Feature Engineering
    - Standardize your features across teams
    - Enable feature sharing, discovery, and reuse
    - Security and governance of features
- Training:
    - Dataset versioning: point-in-time dataset retrieval via query (no data leakage)
    - Reproducibility for training datasets
    - Combining multiple features into training data
- Serving:
    - System for low latency serving of latest features matching an ID
    - Data or feature consistency across training and serving

Feature Store in Context



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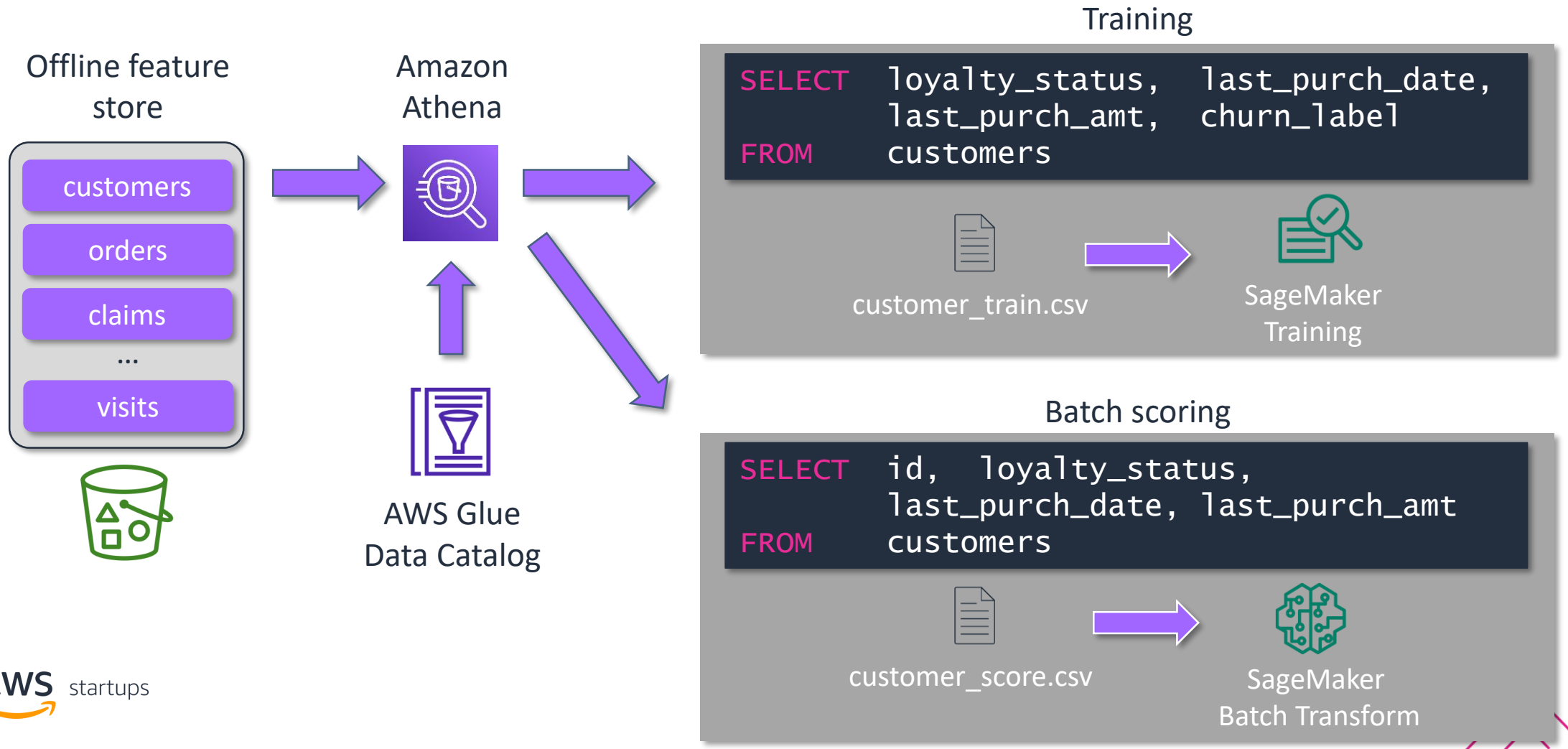
Reproducible Training Datasets: Query the Feature Store



Query features interactively, or with Python SDK

Amazon SageMaker

Athena console

Python SDK

```
s = f'SELECT COUNT(*) FROM "{fg.athena_query().table_name}" ' + \
        'WHERE fl_date = \'2020-03-31\''
q = feature_group.athena_query()
q.run(s, output_location=output_location)
q.wait()
df = q.as_dataframe()
```

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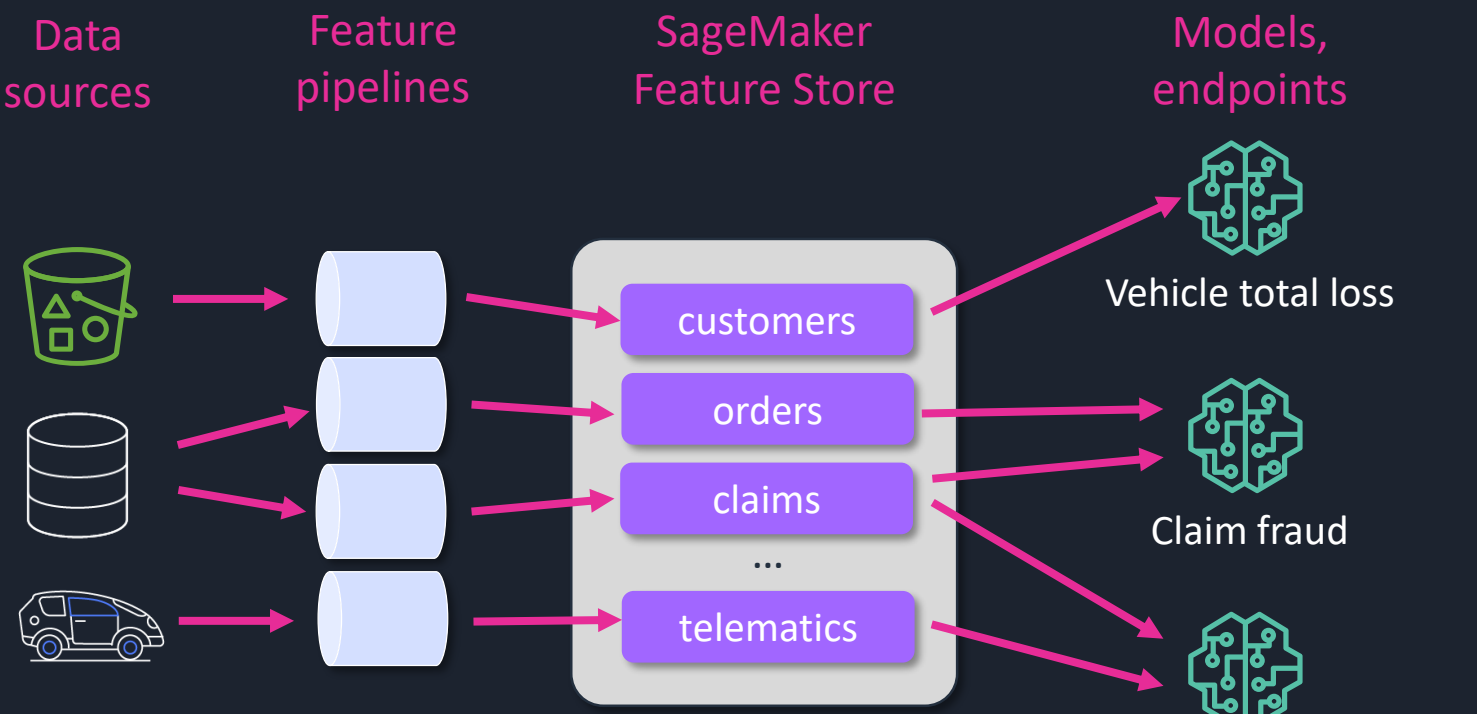
ML lineage from data to model



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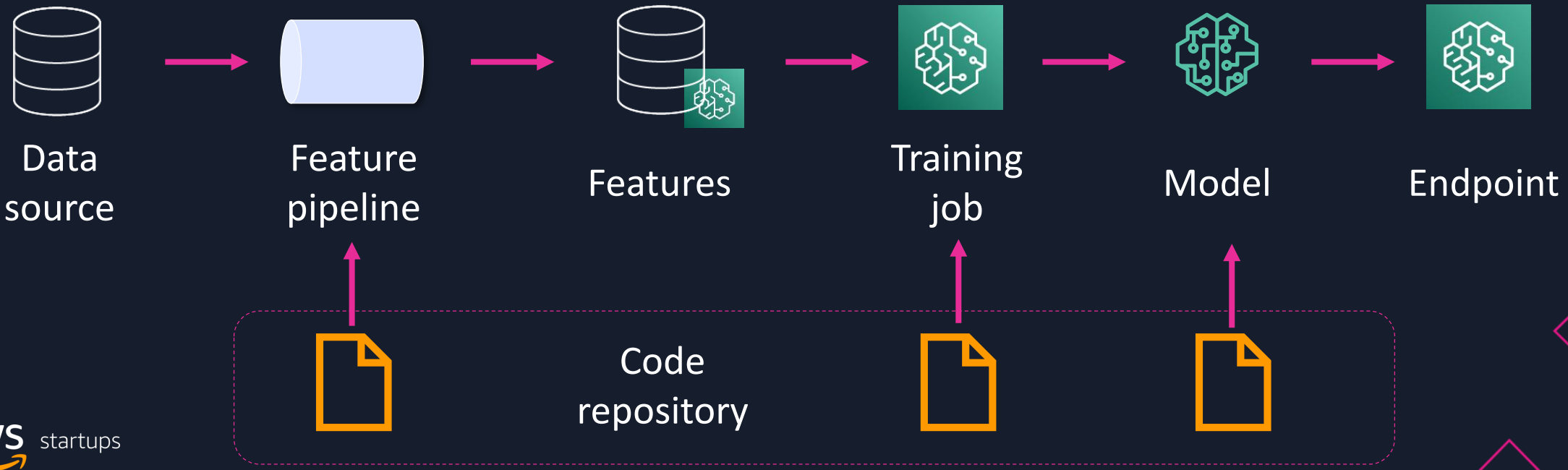
ML lineage

Feature management

- What's the impact of a feature change?
- Do existing features cover my use case?
- …

Auditing and troubleshooting

- What features do these predictions count on?
- How were the features built?
- …



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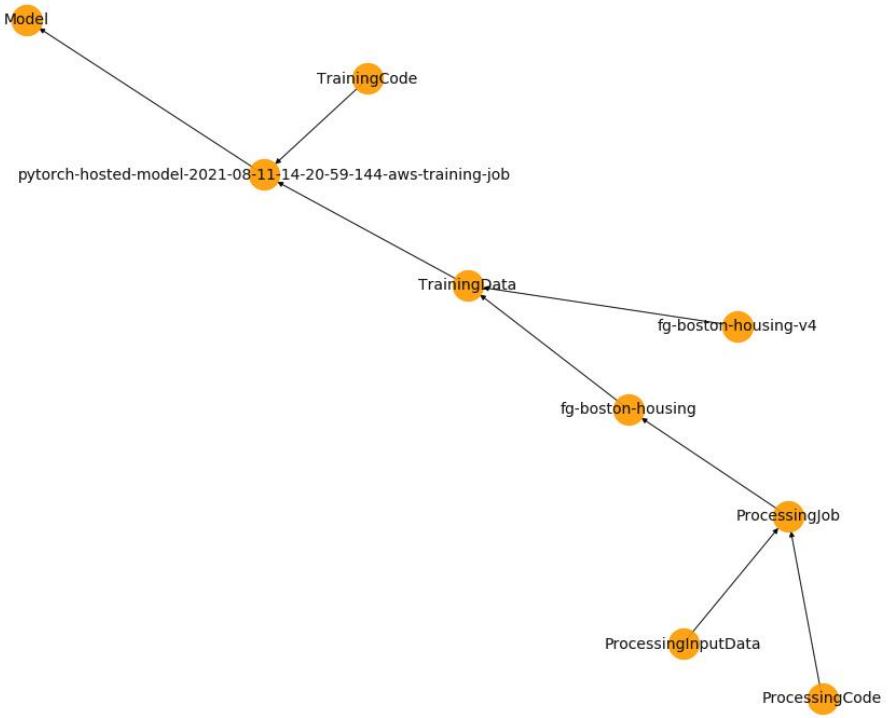
Track Lineage from Query to model as DAG

```
ml_lineage = MLLineageTracking(sagemaker_session)

lineage = ml_lineage.create_ml_lineage(estimator,
        model_name=model_name,
        query=query,
        sagemaker_processing_job_description=
             preprocessing_job_description
        )

ml_lineage.graph()
```



Feature Store Landscape

A few selected popular feature stores…but there many more

Amazon SageMaker

Tecton

FEAST

Google Vertex AI

HOPSWORKS

Databricks

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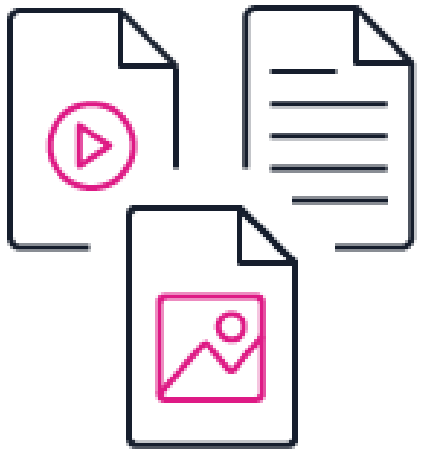
To get an overview check out https://www.featurestore.org/

What about other data, i.e. unstructured data?

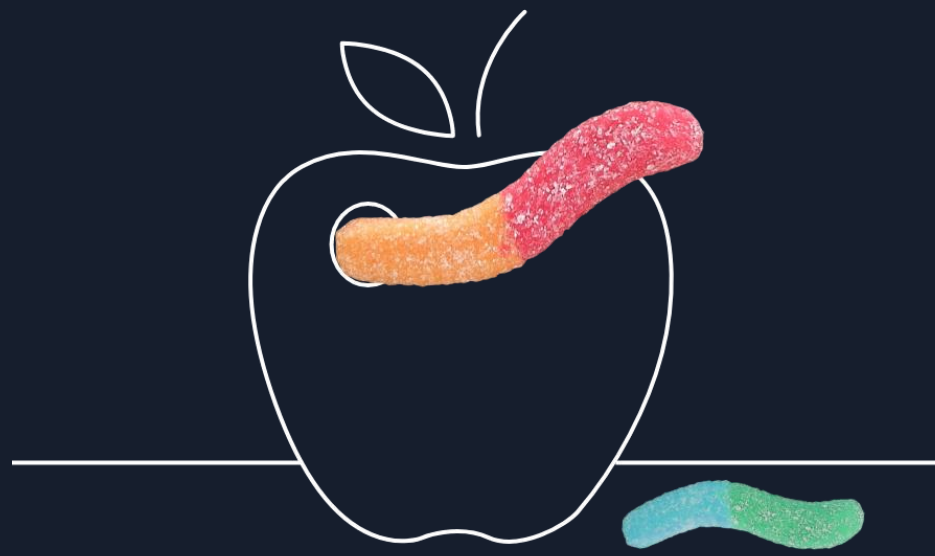
- Most feature stores focus on structured, e.g. tabular, data



- Options to include unstructured data (images, videos, …):
  - Limited support for blobs or text documents as strings
  - Convert arrays to strings, e.g. images
  - Feature with path to files stored on object storage
  - Convert unstructured data into structured, e.g. an image into a classification
  - Limited support for embeddings

SageMaker Feature Store

A quick demo



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SageMaker Feature Store – 10min Demo

https://www.youtube.com/watch?v=kgI0Rwn41S0&t=458s **(from 7:42 until 18:10)**

Q&A

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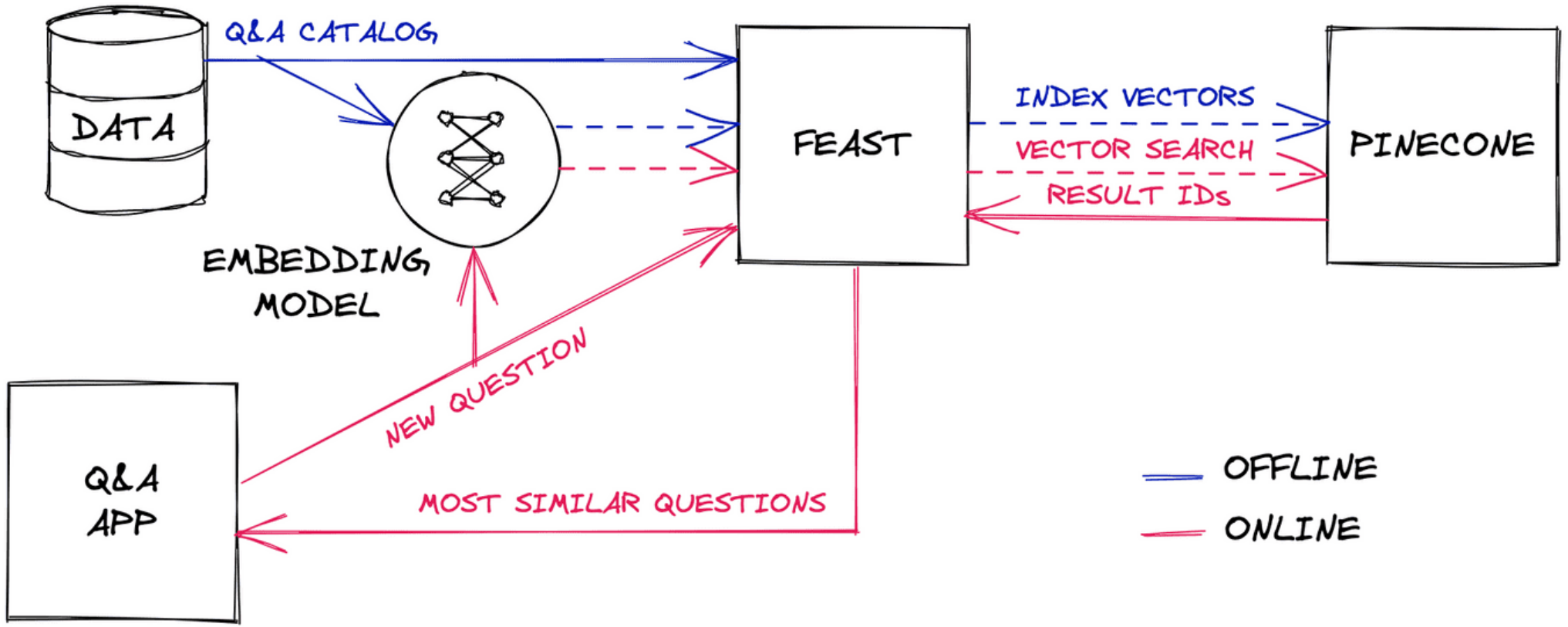
Thank you

Feature Store + Vector DB for embeddings + KNN



https://www.pinecone.io/docs/examples/feast-feature-store/