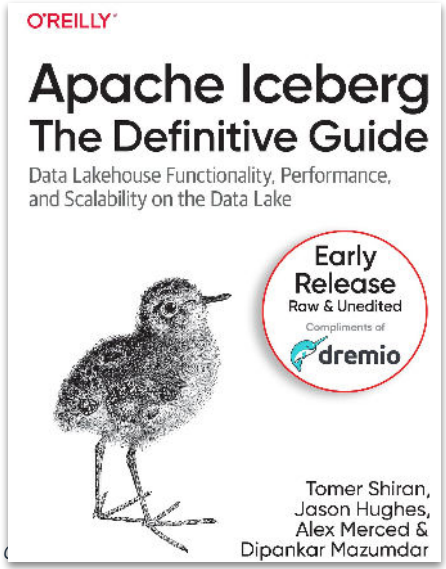
Data as Code with Dremio Arctic

ML experimentation & reproducibility on Lakehouse

About Me

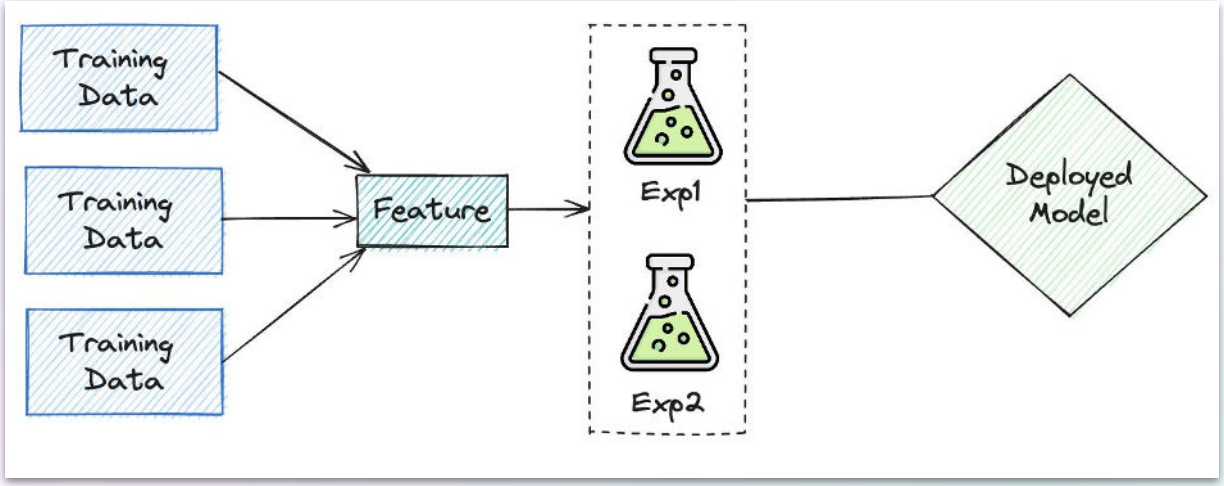
- **Current:** Developer Advocate @Dremio
- **Open source:** Apache Iceberg, Arrow, Project Nessie
- **Past:** BI, Machine Learning, Data architecture



Agenda

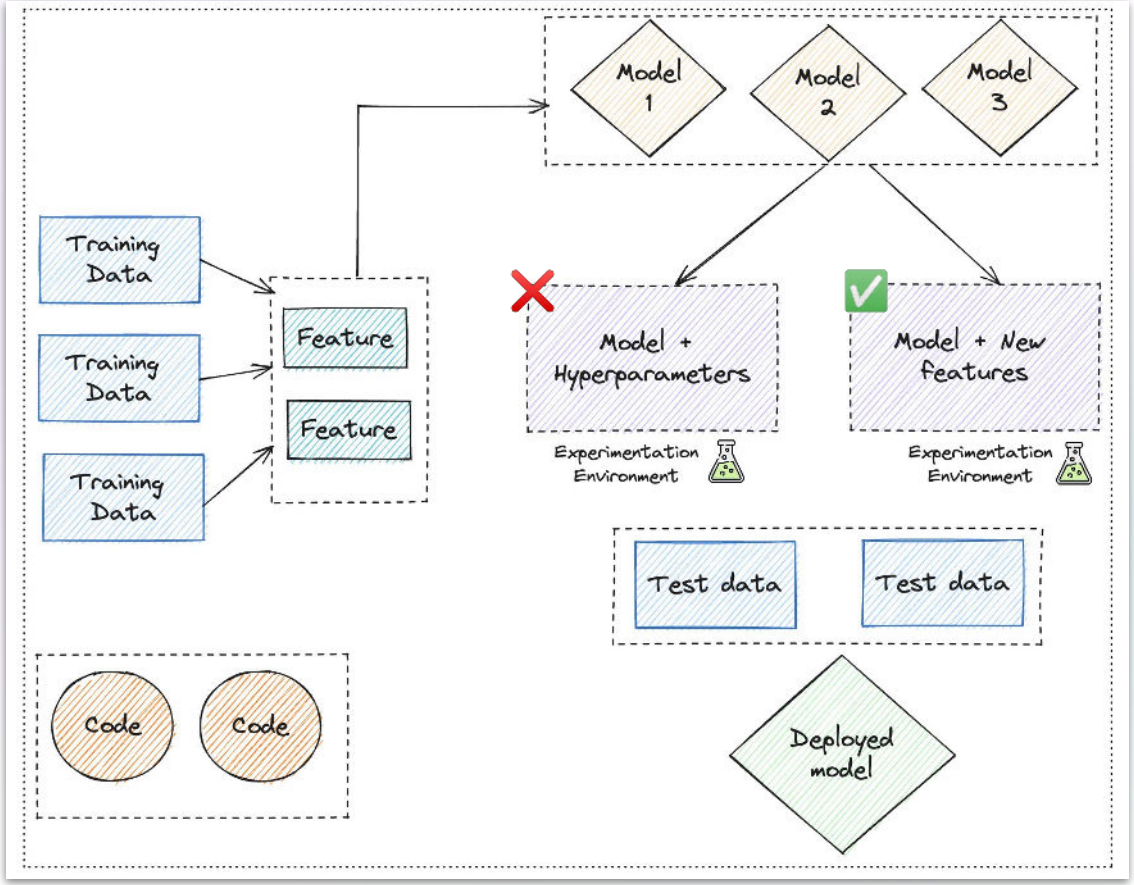
1. ML Experimentation & Reproducibility
2. Dremio Arctic: data-as-code
3. Creating Branches for ML experiments
4. Using Tags for ML reproducibility
5. Advantages of using data-as-code

Software Eng Vs MLE



Unlike Software Engineering, Machine Learning is more of an **empirical** procedure to **test** a hypothesis

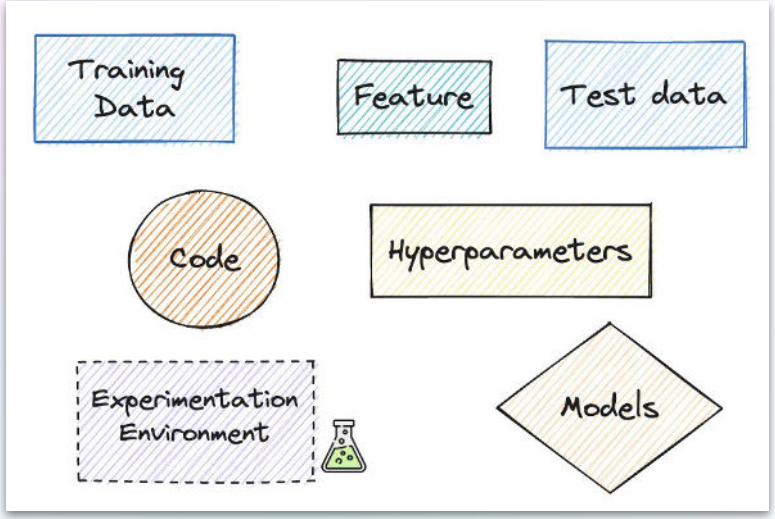
Experiments in Machine Learning



Problems

Too many variables:

- Models
- Different segments of train & test sets
- Hyperparameters of the model
- Different Features
- Environment
- Code to train/test models



Problems

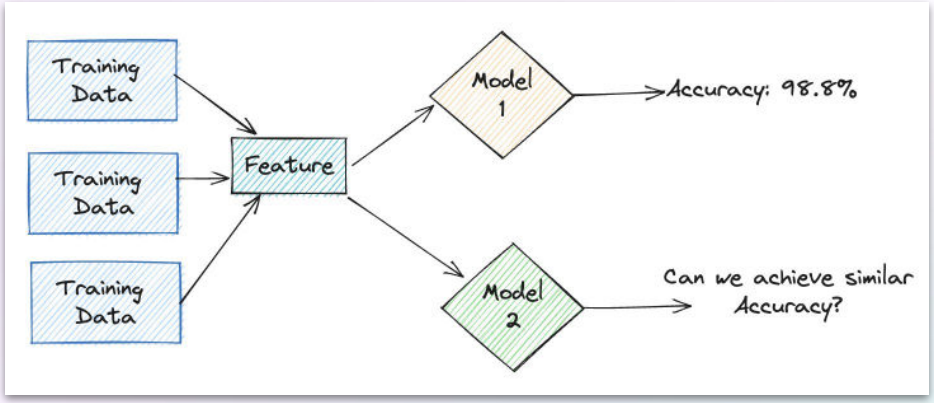
EXPERIMENTATION

"We developed a highly accurate model after a series of experiments, but have a tough time figuring out what resulted in that accuracy as we used different datasets with varying features in different environments"

Solution

Provide flexibility by tracking:
Data and **Model** artifacts

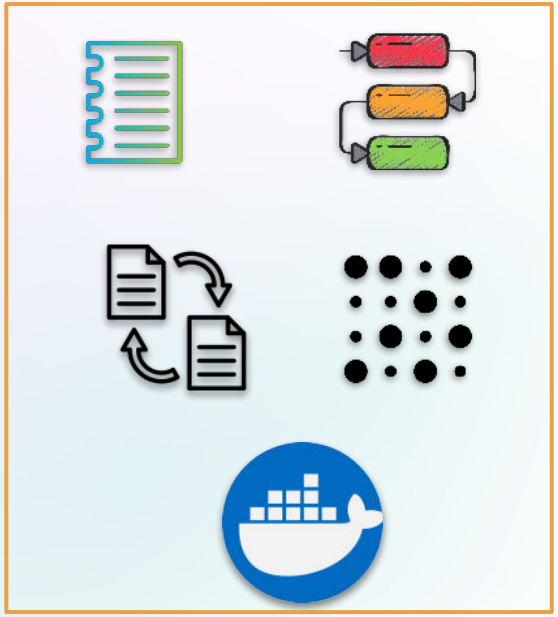
Machine Learning Reproducibility



- Recreate & achieve consistent results as the original model across different setups
- Involves same training dataset, code, environment
- Important for ML research, building reliable ML systems in industry

Problems

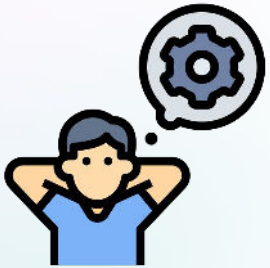
- Lack of documentation when building models
- Dependency Management - versions, frameworks
- Dataset changes - newly inserted records, etc.
- Randomness
- Environment - Hardware, Platform differences



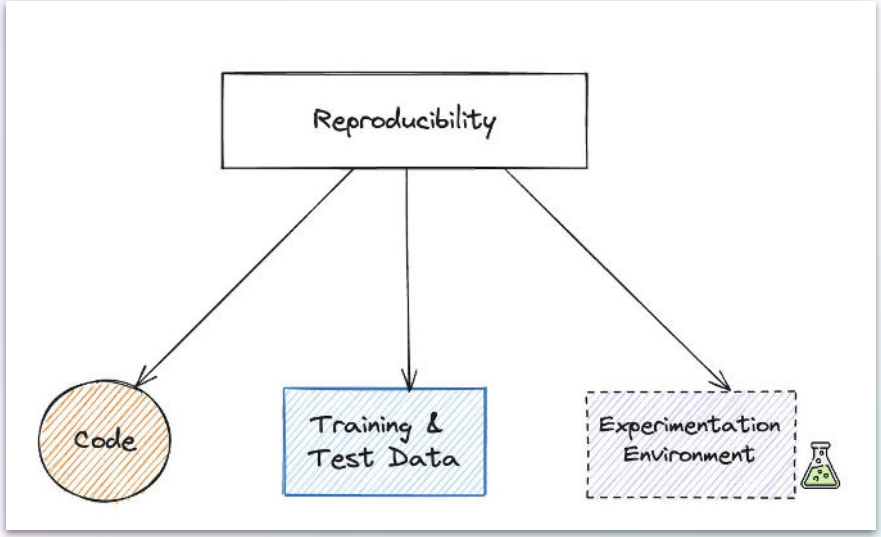
Problems

REPRODUCIBILITY

"We are trying to achieve similar precision & accuracy using the same model & code released by our ML Research team on a similar dataset. We can't seem to replicate"



Solution



To reproduce we need to track Code, Data and Environment

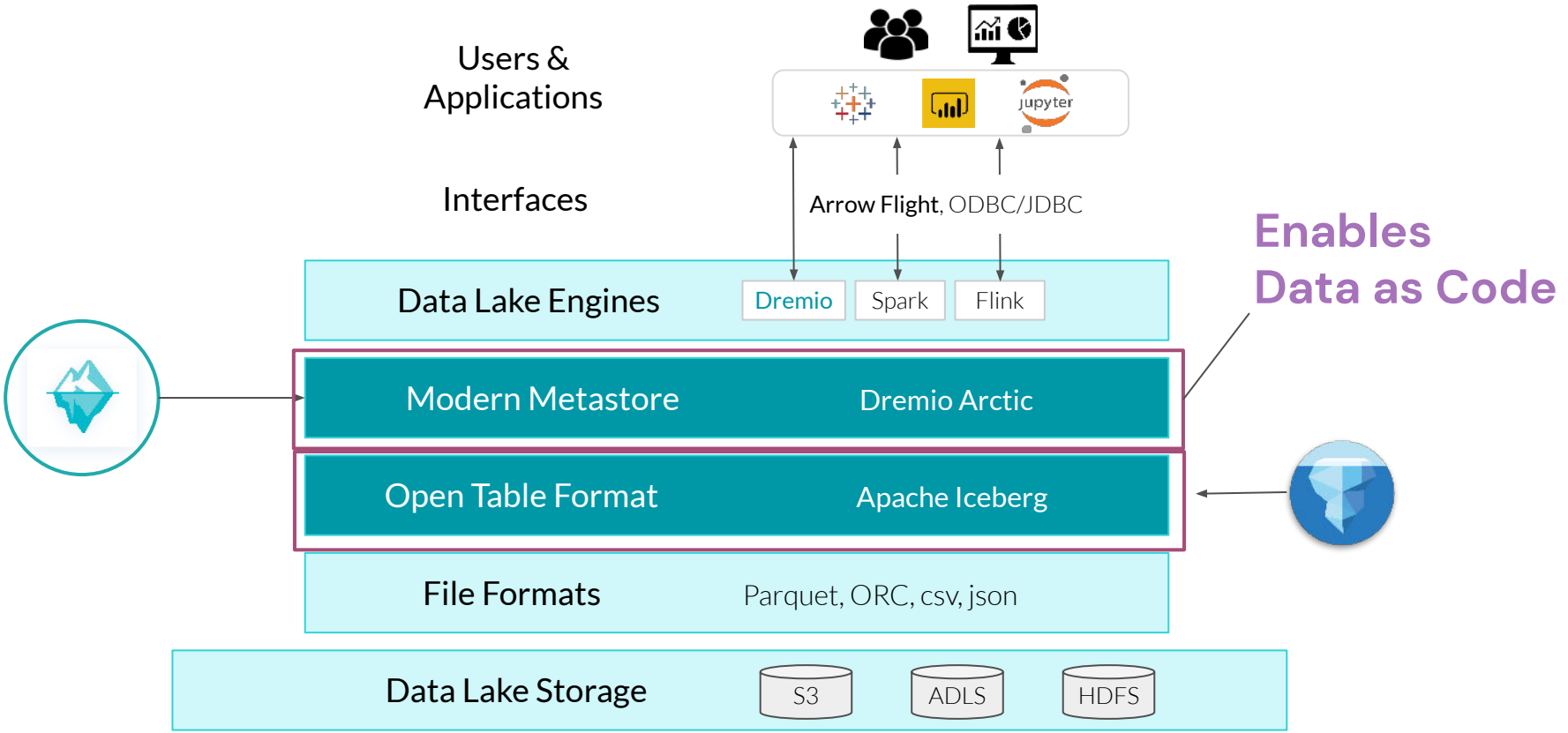
Our focus will be on Data

Code →

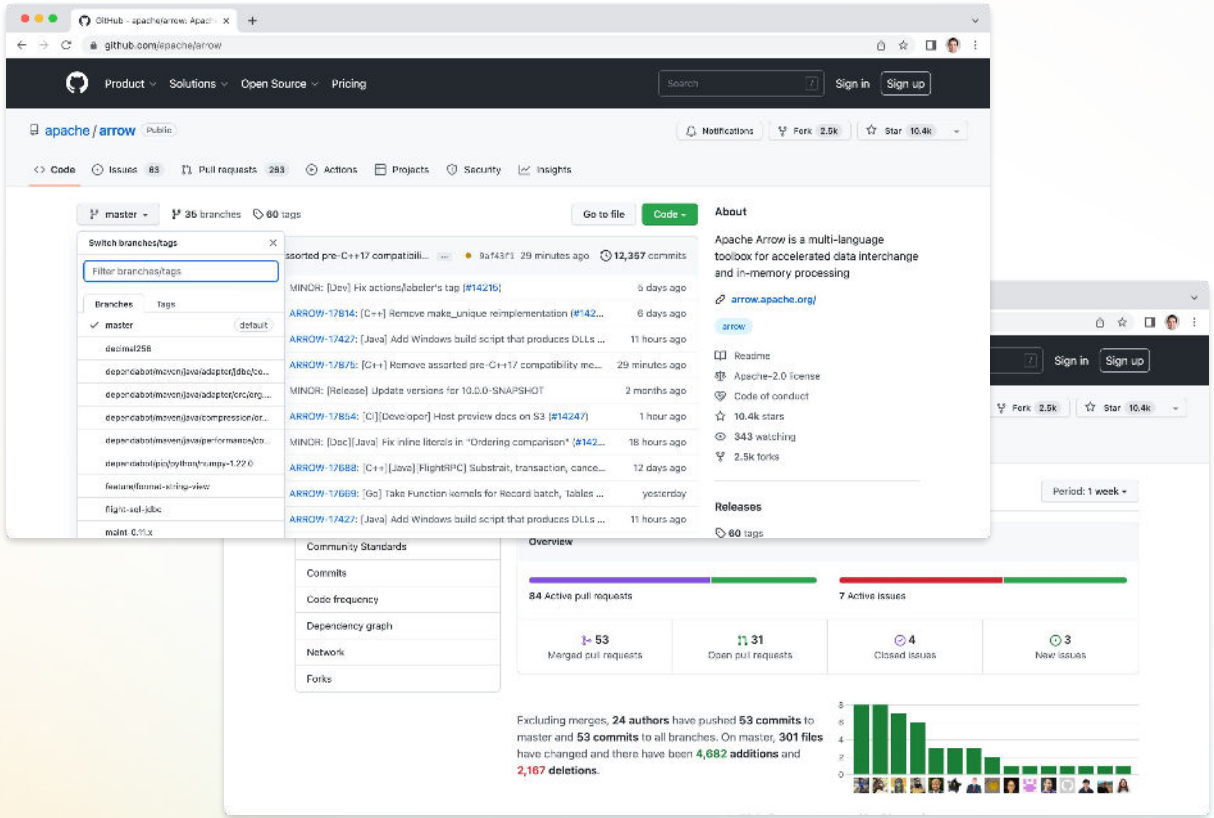
Model Artifacts →

Data →

How do we support these in a Data Lakehouse?



GitHub in Software Engineering



- ✓ Code storage
- ✓ Atomic changes
- ✓ Documentation
- ✓ Access old versions
- ✓ Recover from mistakes
- ✓ Trace history
- ✓ Isolated development
- ✓ CI/CD
- ✓ Collaboration

Don’t we already do that in software development though?

Data teams gain the same capabilities that took application development market by storm...

1. Consistency
2. Isolation
3. Experimentation
4. Pre-prod verification

... through the same functionality GitHub enabled for developers

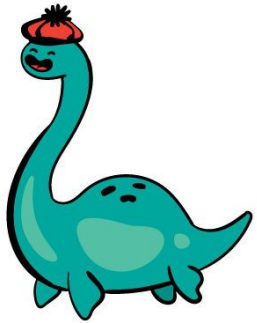
- **Commits** - Atomic transactions affecting multiple tables/views at once
- **Branches** - Free to create (virtual) copies of entire data lake for development, verification or experimentation
- **Tags** - Immutable reference used to permanently record a specific state of the Data Lake
- **Merges** - Migrate changes from development, ETL or experimentation from one branch to another.

Nessie: A Git-like Experience

Data Branching

- Multi-table consistency/transactions
- Experimentation (isolated dev/test)
- Pre-prod verification (stage->prod)

```
CREATE BRANCH etl
[Kafka] Data Ingestion
[Spark] Transformation 1
[Spark] Transformation 2
[Dremio] Reflection Refresh 1
[Dremio] Reflection Refresh 2
USE BRANCH main
MERGE BRANCH etl
```

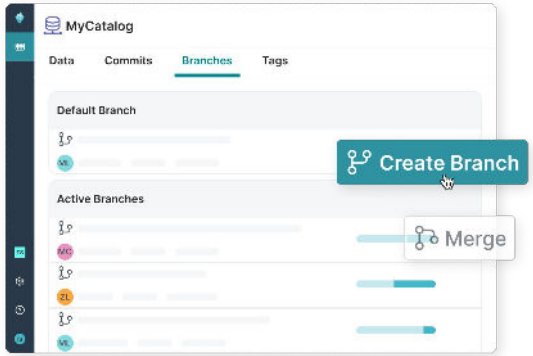


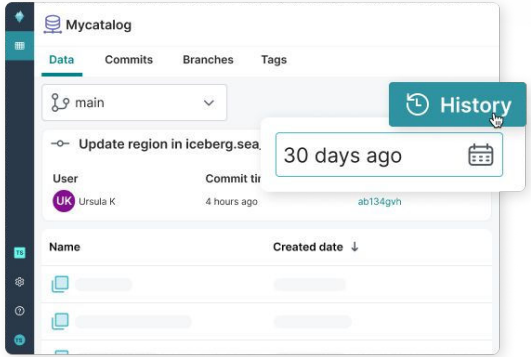
Data Version Control

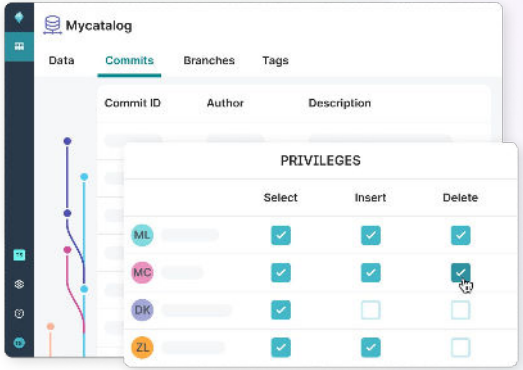
- Reproducibility
- Compliance
- Historical comparisons

```
USE BRANCH 'main'
SELECT * FROM t1 // main implicit
SELECT * FROM t1@etl
SELECT * FROM t1 AT '2020-10-26'
SELECT * FROM t1@etl AT '2020-10-26'
```

Dremio Arctic enables Data as Code (DaC)







ISOLATION

- Experiment with data without impacting other users
- Ingest, transform and test data before exposing it to other users in an atomic merge

VERSION CONTROL

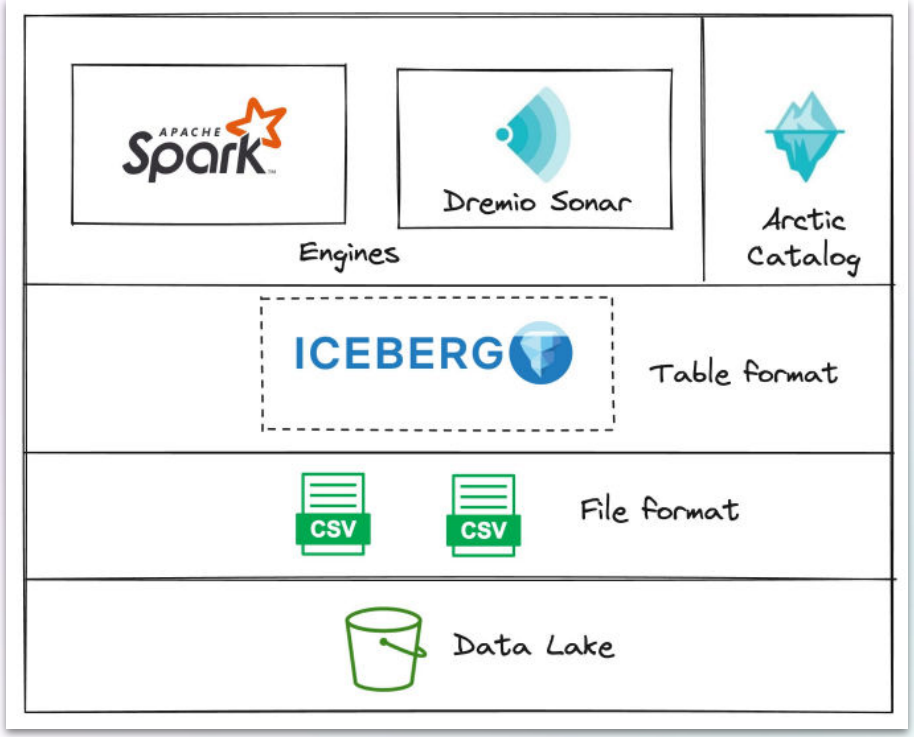
- Reproduce models and dashboards from historical data based on time or tags
- Recover from any mistake by instantly undoing accidental data or metadata changes

GOVERNANCE

- All changes to the data and metadata are tracked: who accessed what data and when
- Fine-grained privileges to control access to the data at the table, column and row level

Live Tour & Demo!

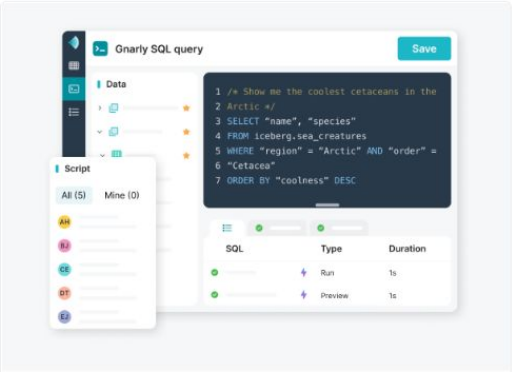
Setup for Demo



Lakehouse Architecture for
ML Experiments & Reproducibility

Sign-up for Dremio Cloud

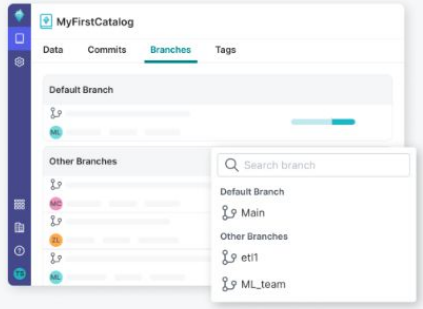
Services



Sonar

A lakehouse query engine that allows analysts to explore data with sub-second query response times. Learn more.

Add Sonar Project



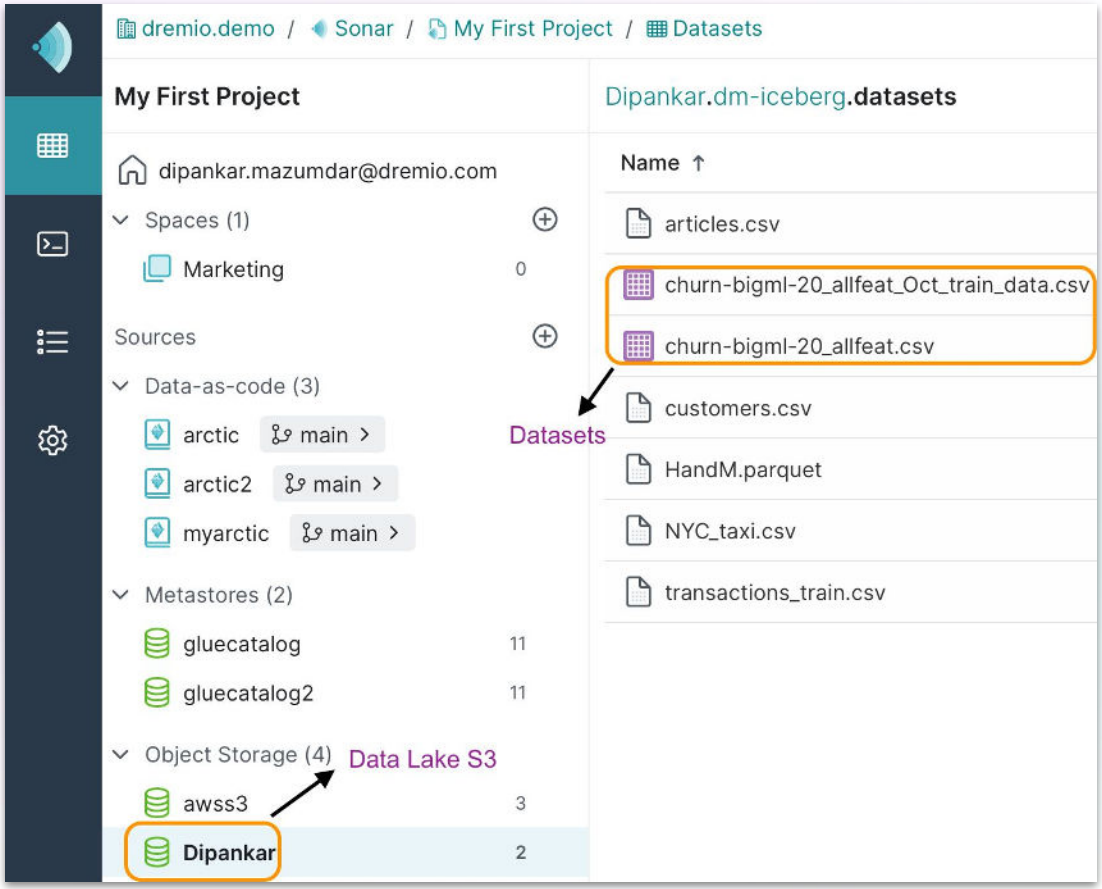
Arctic (Preview)

A catalog for Iceberg tables that enables data to be managed like code with Git-like capabilities. Learn more.

Add Arctic Catalog

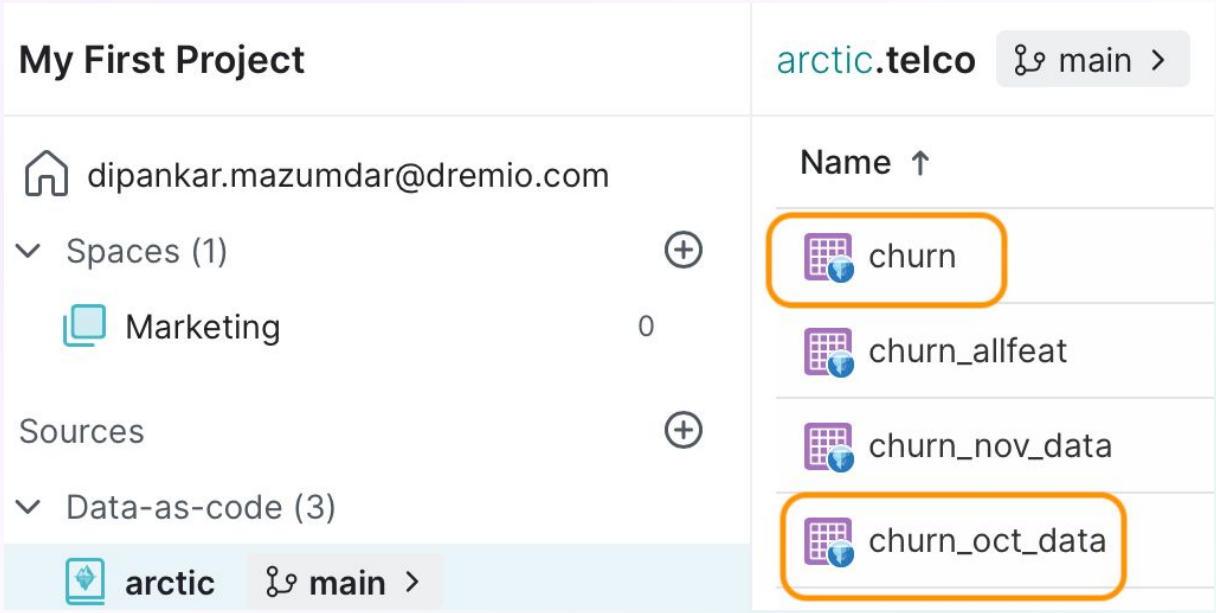
dremio

Connect to Data Lake



dremio

Create Iceberg tables using Dremio



Spark + Arctic + Iceberg Setup

```
conf.set(
    "spark.jars.packages",
    f"org.apache.iceberg:iceberg-spark-runtime-3.3_2.12:1.2.0,org.projectnessie:nessie-spark-extensions-3.3_2.12:0.54.0,software.amazon.awssdk:bundle:2.17.178,software.amazon.awssdk:url-connection-client:2.17.178",
)

# create catalog named arctic as an iceberg catalog
conf.set("spark.sql.catalog.arctic", "org.apache.iceberg.spark.SparkCatalog")

# tell the catalog that its a Nessie catalog
conf.set("spark.sql.catalog.arctic.catalog-impl", "org.apache.iceberg.nessie.NessieCatalog")

# set the location for the catalog to store data. Spark writes to this directory
conf.set("spark.sql.catalog.arctic.warehouse", "s3://myrepo")
```

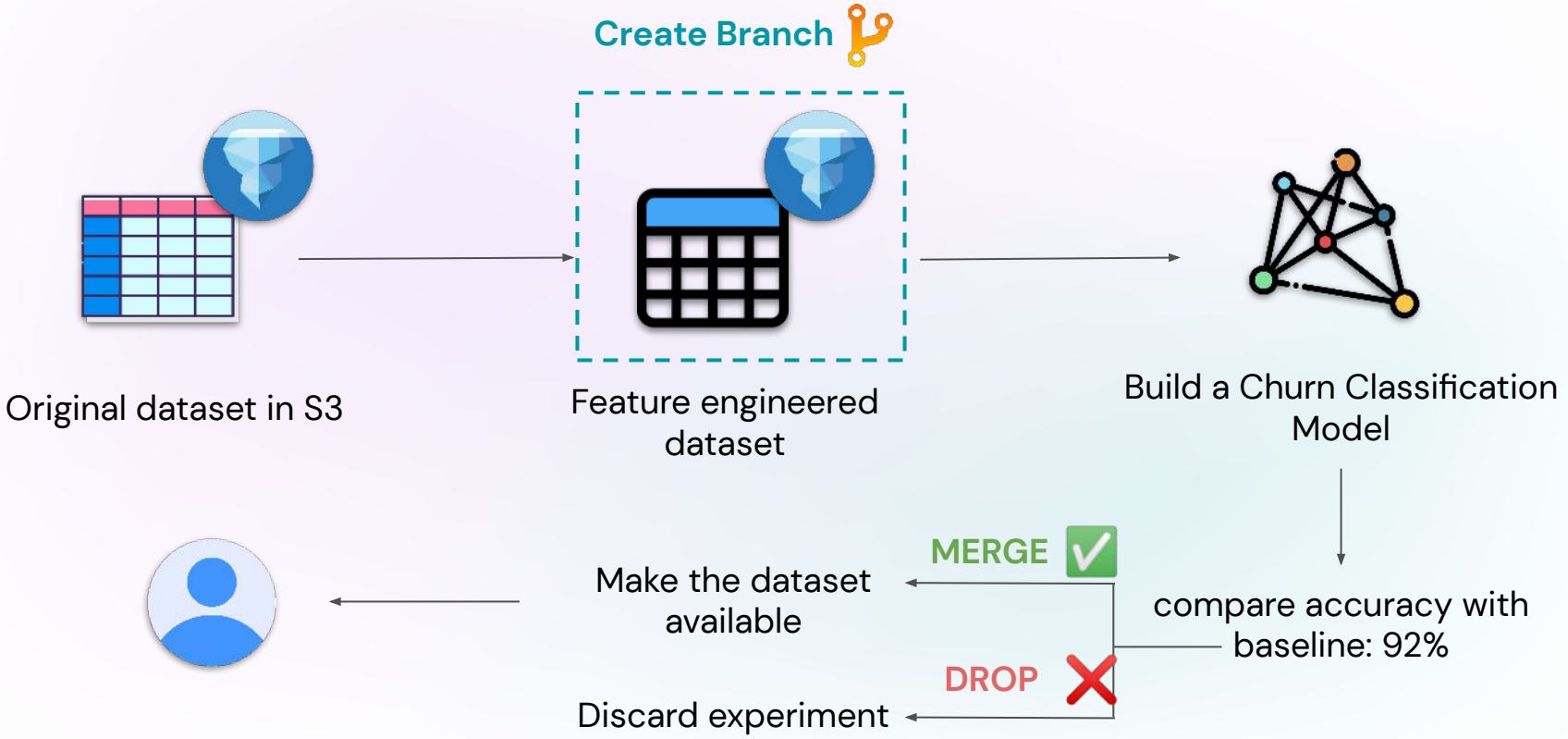
Spark + Arctic + Iceberg Setup

```
# set the location of the Nessie/Arctic server.
conf.set("spark.sql.catalog.arctic.uri", "https://nessie.dremio.cloud/v1/repositories/xyz")

# Authentication mechanism. Here, we use AWS with BEARER
conf.set("spark.sql.catalog.arctic.authentication.type", "BEARER")
conf.set("spark.sql.catalog.arctic.authentication.token", token)

# enable the extensions for both Nessie and Iceberg
conf.set(
    "spark.sql.extensions",
"org.apache.iceberg.spark.extensions.IcebergSparkSessionExtensions,org.projectnessie.spark.extensio
ns.NessieSparkSessionExtensions",
)
```

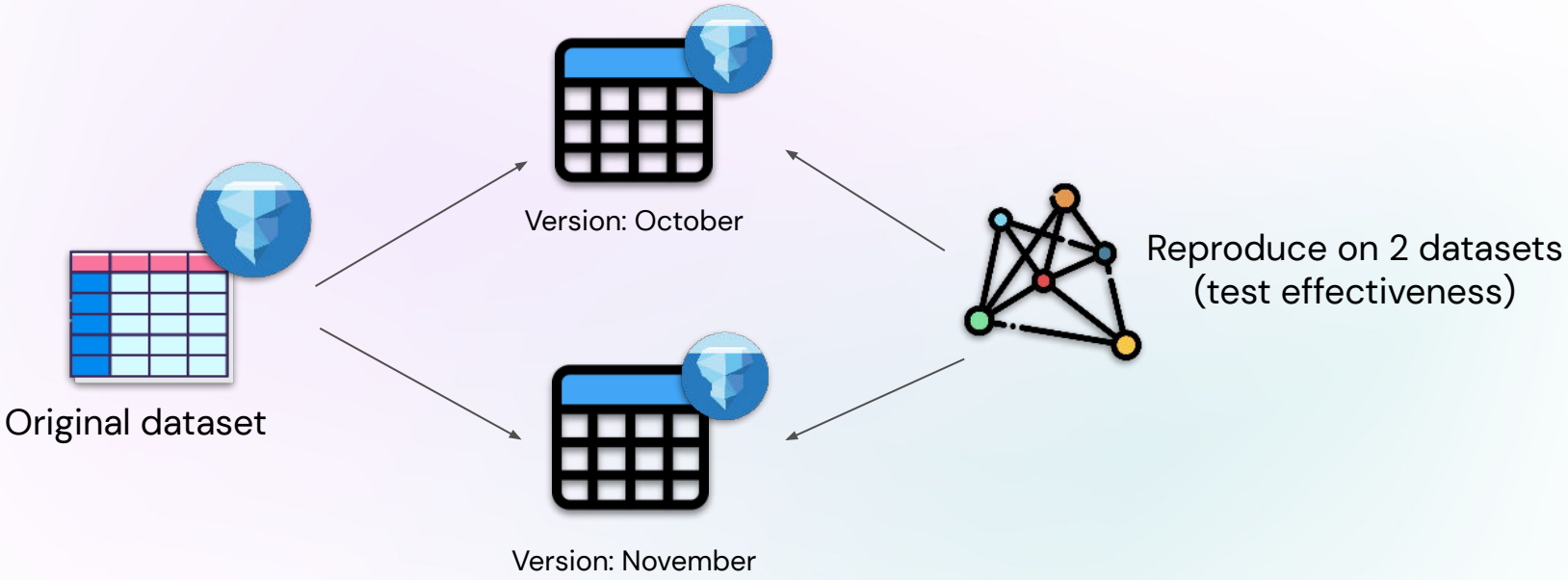
Use Case 1: ML Experimentation



Values Gained

- Greater flexibility in experimentation with the **isolated** branches feature
- Ability to work with data without needing extra **copies** for each and every experiment.
- Establish the viability of the dataset to ensure the data is **good** enough for the model

Use Case 2: ML Reproducibility



Values Gained

- Understand the **effectiveness** of our model for further deployment in other environments.
- Arctic provides an easy way to create **tagged** datasets & keep track of data **versions**

Thank you!