

# Beyond MLOps

## Building AI Systems with Metaflow

Ville Tuulos  
Outerbounds

Run ETL with  
dbt

Generate ads with  
stable diffusion



2014

## Sectionals

Filter By:

## Color



## Material

Cotton (27)

Cotton/Poly  
Blend (27)

Leather (4)

Linen Blend (31)

Other/Synthetic (9)

Performance Faux  
Suede (35)

Microfiber (37)

[See More](#)

## Price Range

\$1000 - \$1500 (3)

\$1500 - \$2000 (24)

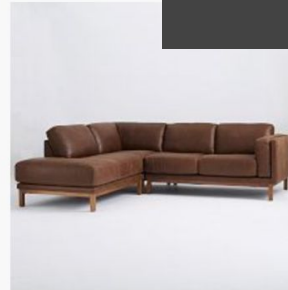
\$2000 - \$3000 (37)

Bliss Down-Filled 2-Piece  
Chaise Sectional  
New Colors

\$2,398 - \$2,998

**SPECIAL \$2,038 - \$2,598**Dekalb Premium Leather 2-  
Piece Chaise Sectional  
New

\$4,298

**SPECIAL \$3,653**Dekalb Premium Leather 3-  
Piece Chaise Sectional  
New

\$5,497

**SPECIAL \$4,672**Henry 3-Piece Sectional -  
LeatherHenry 3-Piece L-Shaped  
Sectional - LeatherYork 2-Piece Leather Chaise  
Sectional

## Sectionals

Quick ship: 1-5 weeks

Configuration ▾

Fabric ▾

Seating capacity ▾

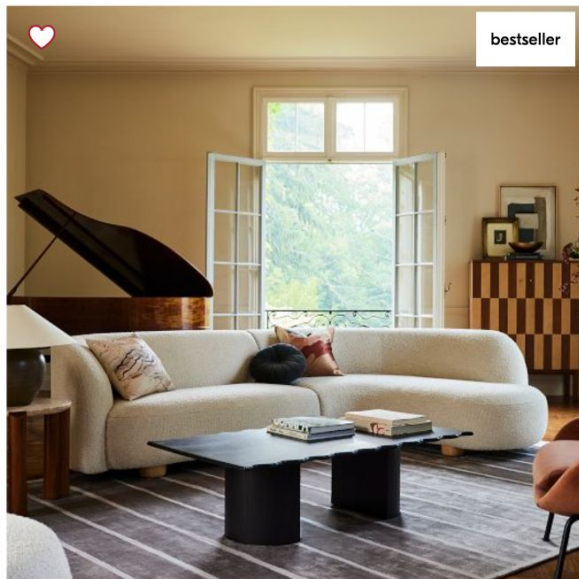
Seat firmness ▾

Color ▾

Features ▾

 All filters

# 2023

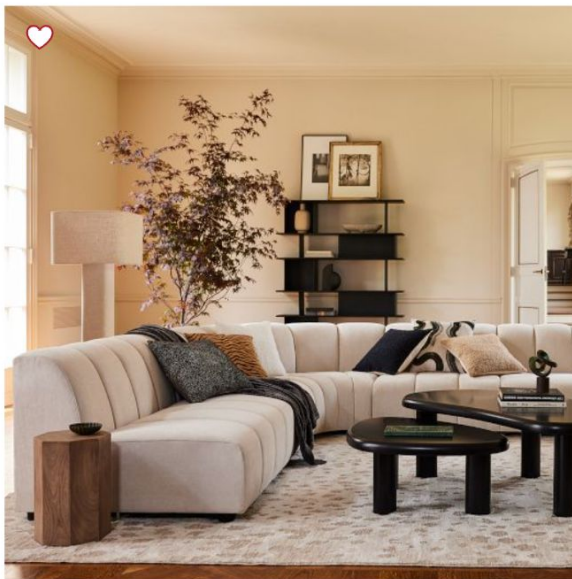


 + 31 more

Laurent 2-Piece Wedge Chaise Sectional (111.5")

Contract Grade

\$2,399 — \$2,999



 + 125 more

Avalon Channeled 3-Piece L-Shaped Sectional (87"—122")

\$2,597 — \$4,897

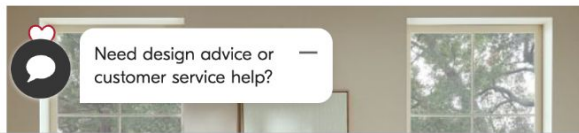


 + 48 more

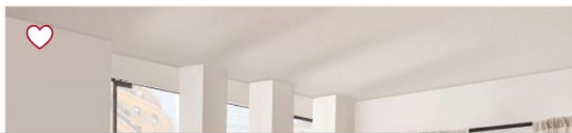
Harmony Modular Motion Reclining 3-Piece Chaise Sectional (125")

New

\$3,646 — \$4,996

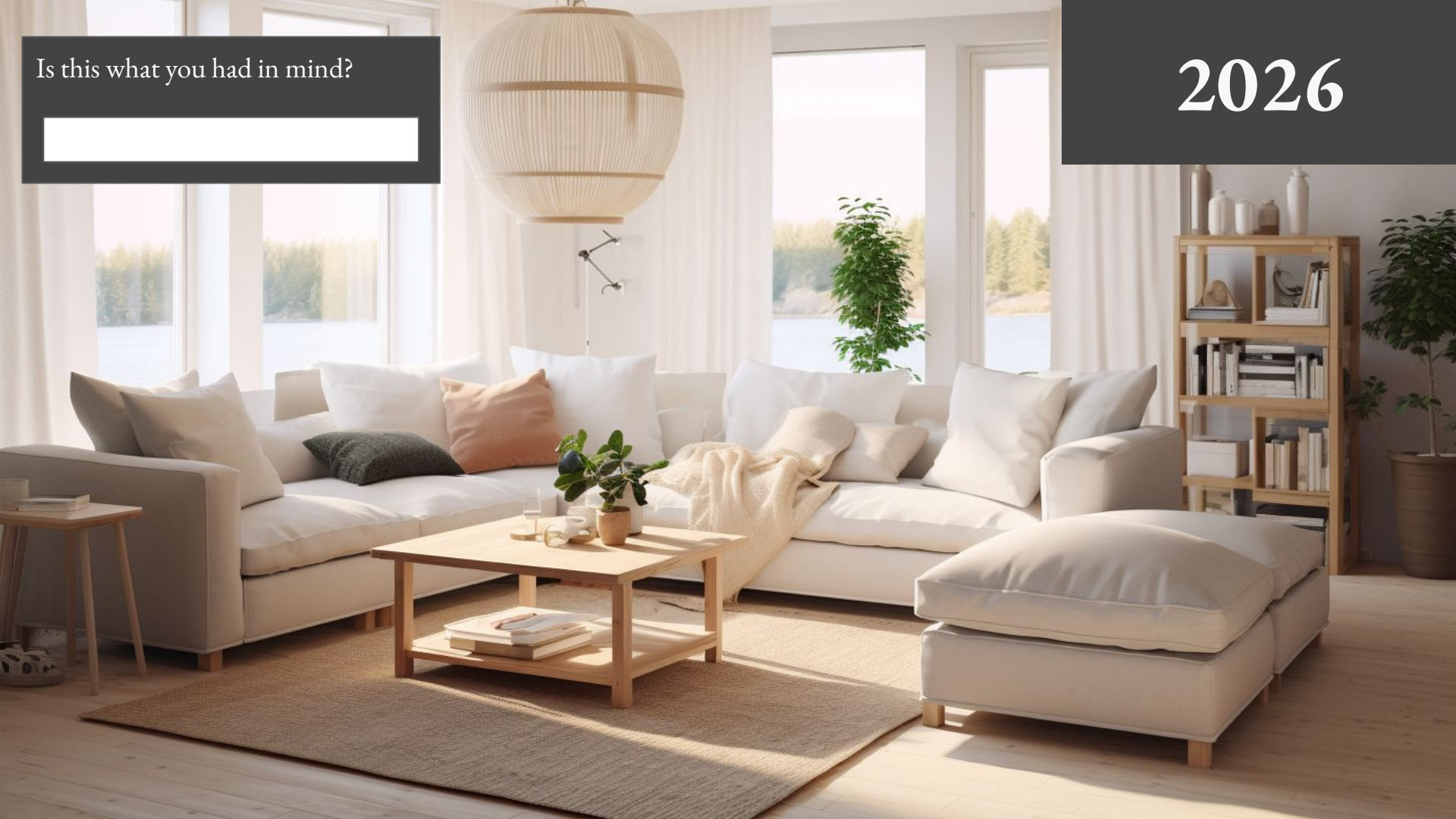


Need design advice or customer service help?



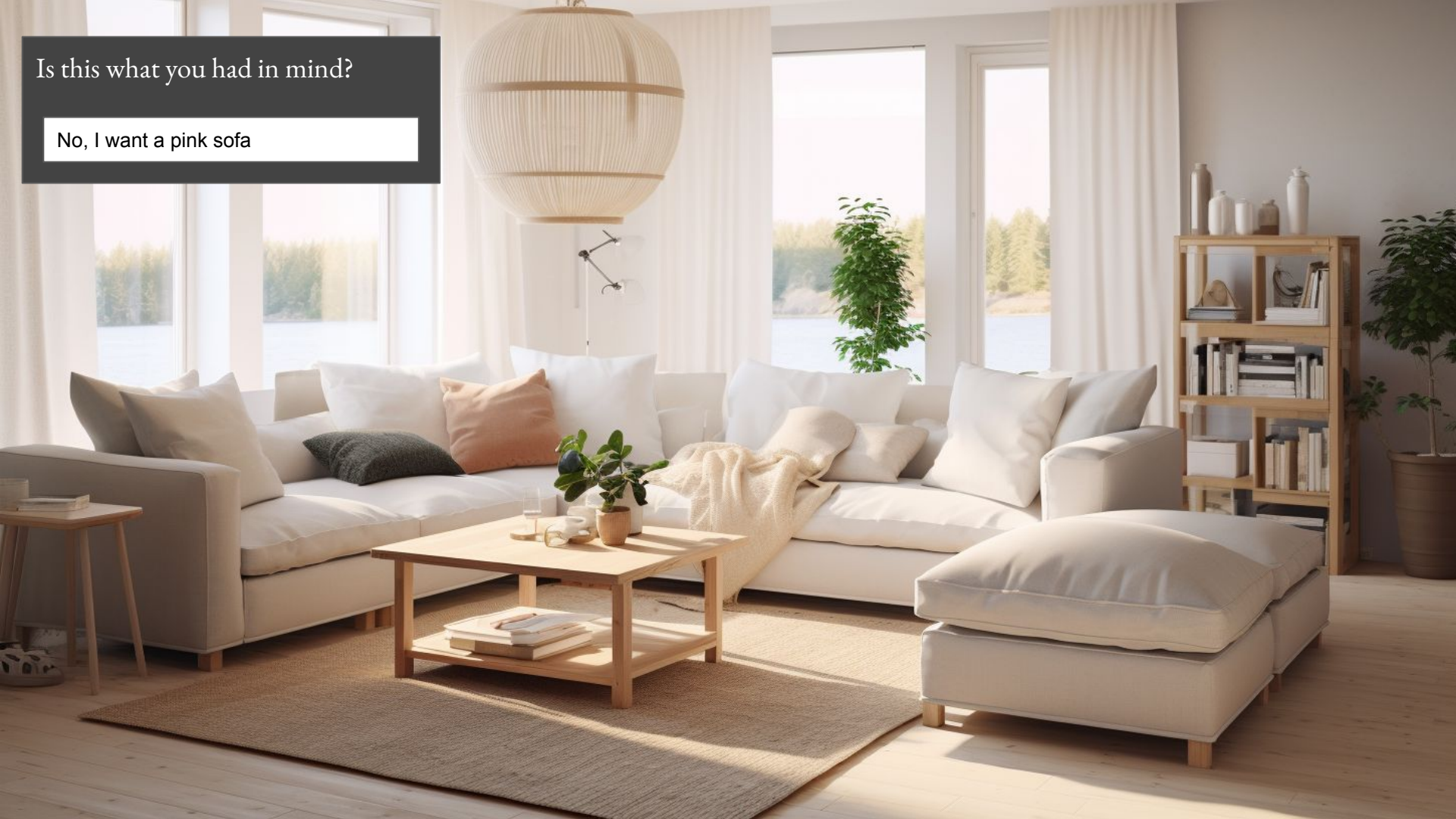
Is this what you had in mind?

2026



Is this what you had in mind?

No, I want a pink sofa



Is this what you had in mind?

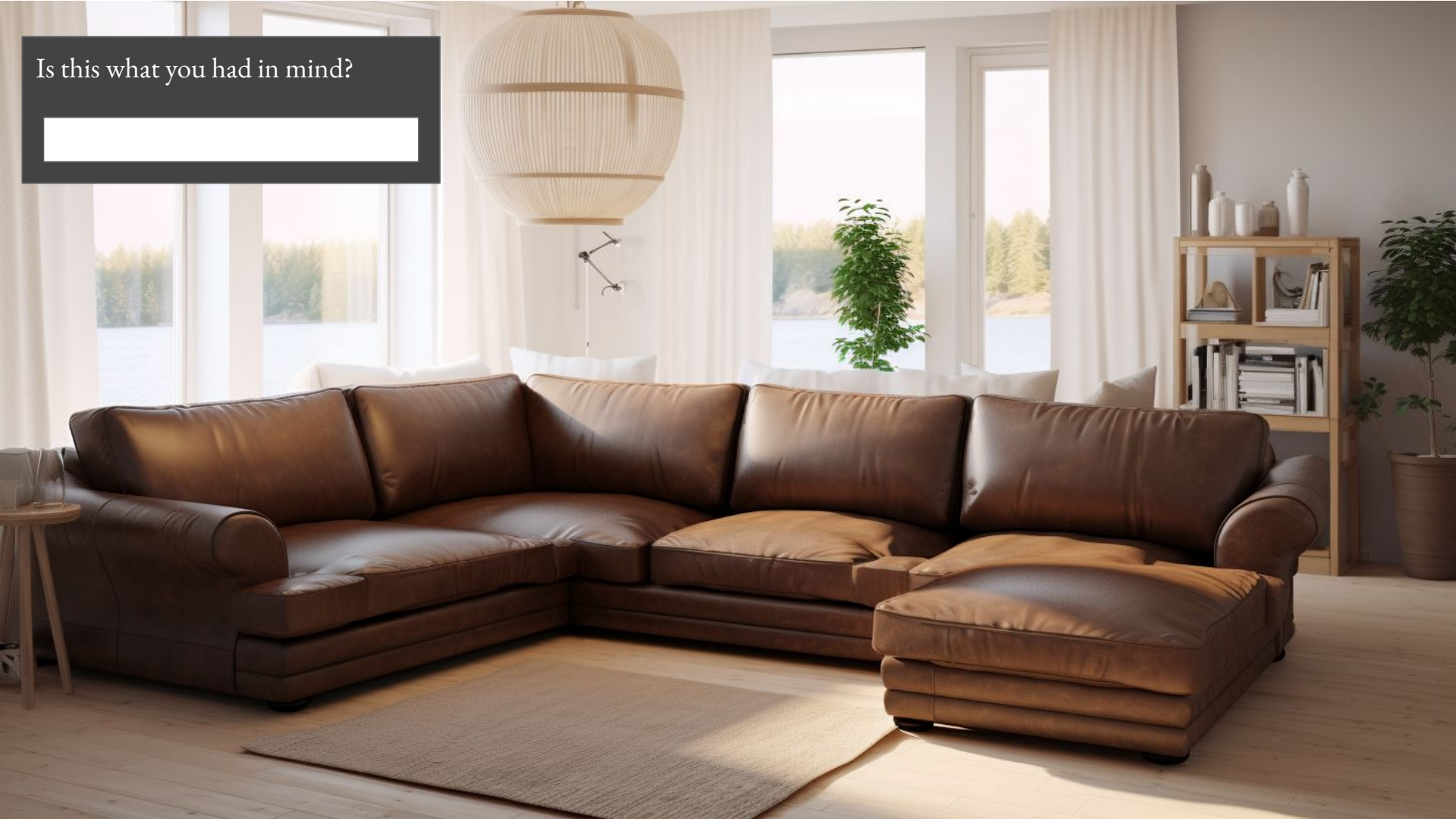


Is this what you had in mind?

Let's try leather



Is this what you had in mind?





Is this what you had in mind?



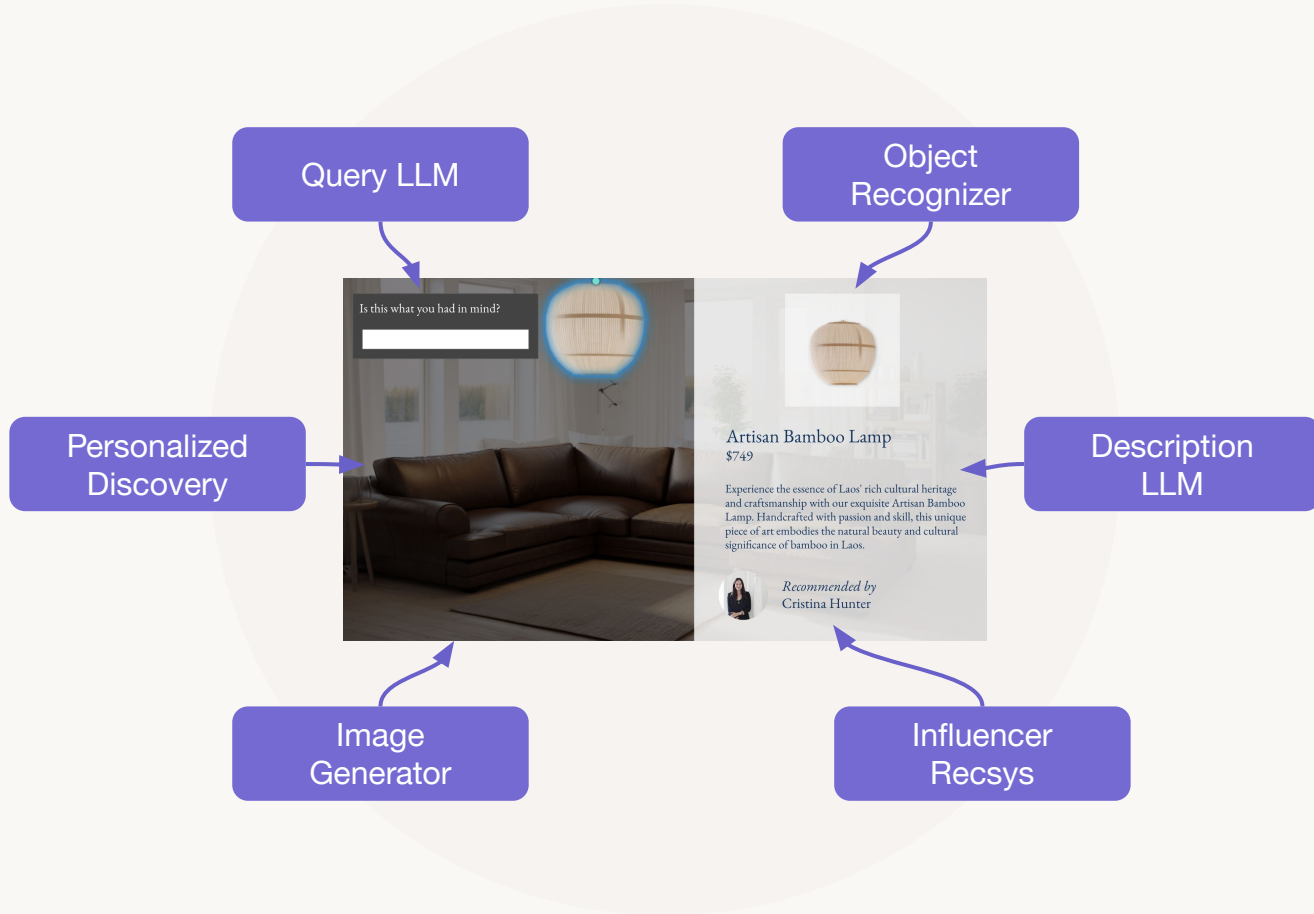
## Artisan Bamboo Lamp

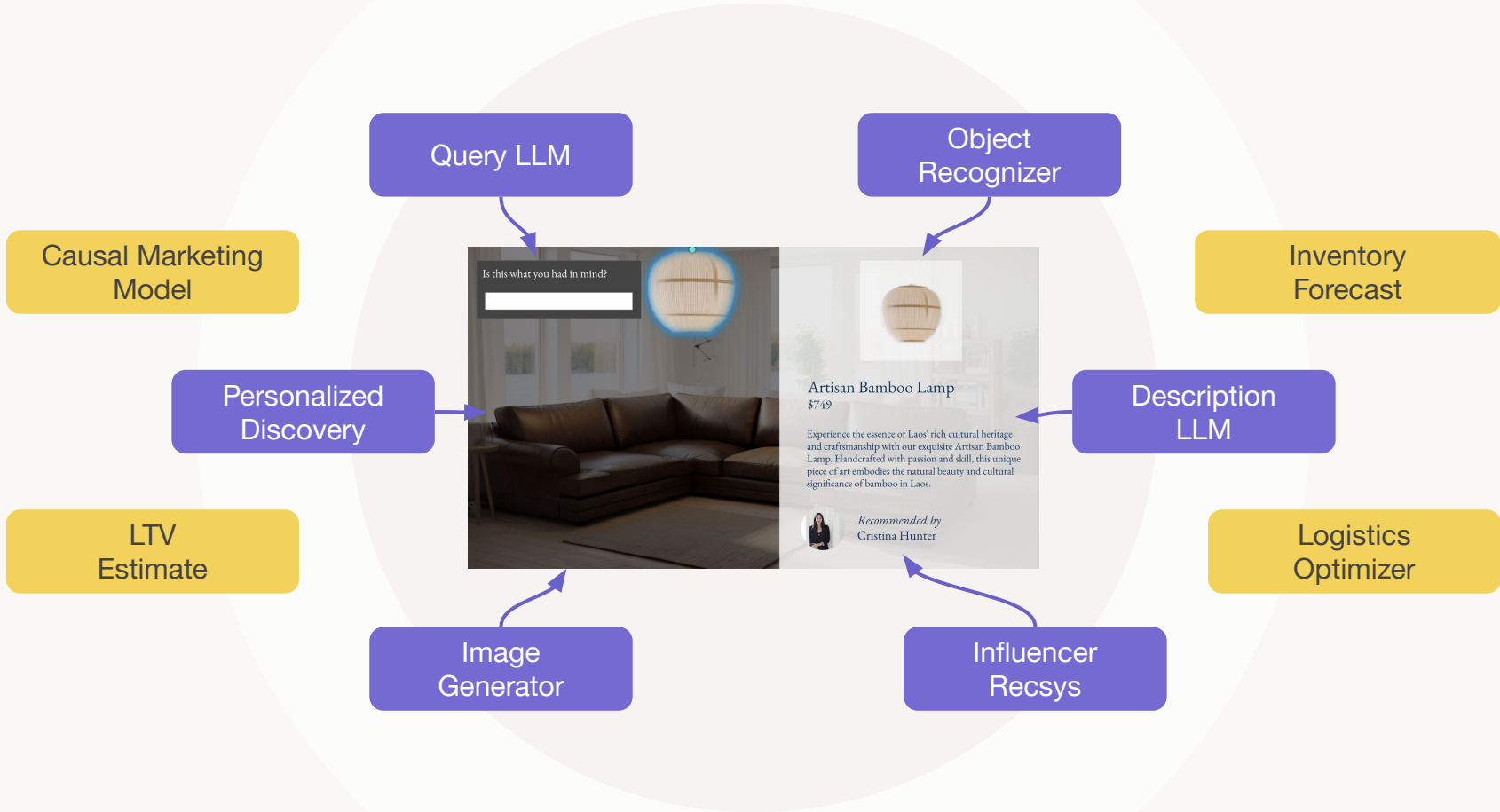
\$749

Experience the essence of Laos' rich cultural heritage and craftsmanship with our exquisite Artisan Bamboo Lamp. Handcrafted with passion and skill, this unique piece of art embodies the natural beauty and cultural significance of bamboo in Laos.



*Recommended by*  
Cristina Hunter





Query LLM

Object Recognizer

Causal Marketing Model

Inventory Forecast

Personalized Discovery

Description LLM

LTV Estimate

Logistics Optimizer

Image Generator

Influencer Recsys

Is this what you had in mind?

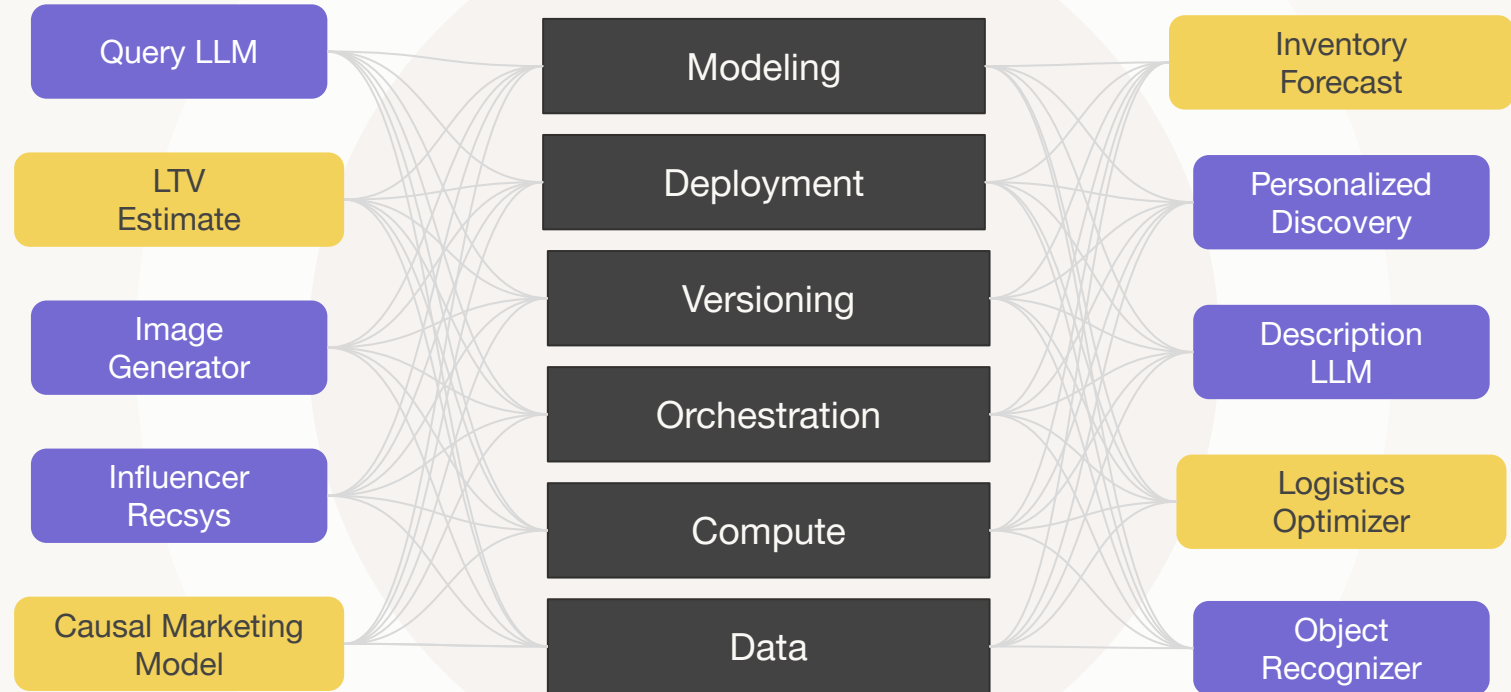
Artisan Bamboo Lamp

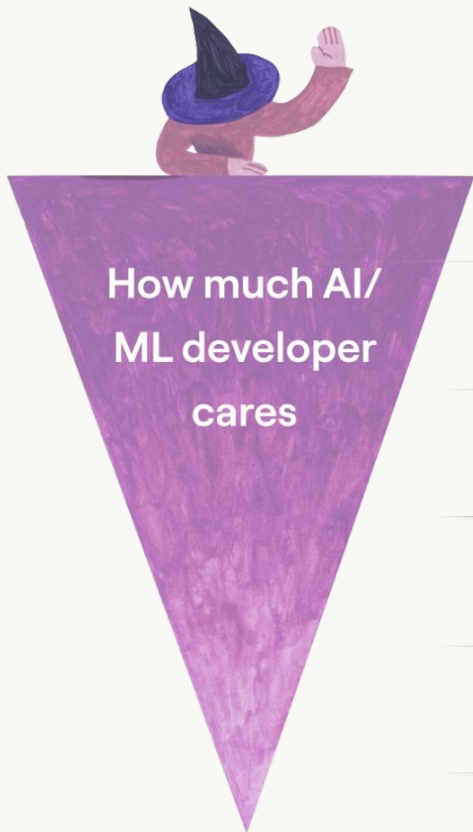
\$749

Experience the essence of Laos' rich cultural heritage and craftsmanship with our exquisite Artisan Bamboo Lamp. Handcrafted with passion and skill, this unique piece of art embodies the natural beauty and cultural significance of bamboo in Laos.



Recommended by  
Cristina Hunter





```
from metaflow import FlowSpec, step, conda_base,
                    kubernetes, schedule
```

```
@conda_base(libraries={'scikit-learn': '1.1.2'})
@trigger(event='data_updated')
class HelloFlow(FlowSpec):
    @step
    def start(self):
        self.x = 1
        self.next(self.end)

    @kubernetes(memory=64000)
    @step
    def end(self):
        self.x += 1
        print("Hello world! The value of x is", self.x)

if __name__ == '__main__':
    HelloFlow()
```



Modeling

Deployment

Versioning

Orchestration

Compute

Data

# Trusted by the world's most demanding AI & ML teams



HAGERTY

NETFLIX

prime video



SIEMENS

DELL

flexport.

Sainsbury's

zipline



INTUITIVE  
SURGICAL

Medtronic

MERCK

notable



BCG

/thoughtworks

Goldman  
Sachs

J.P.Morgan

ramp

TRADE REPUBLIC



attentive

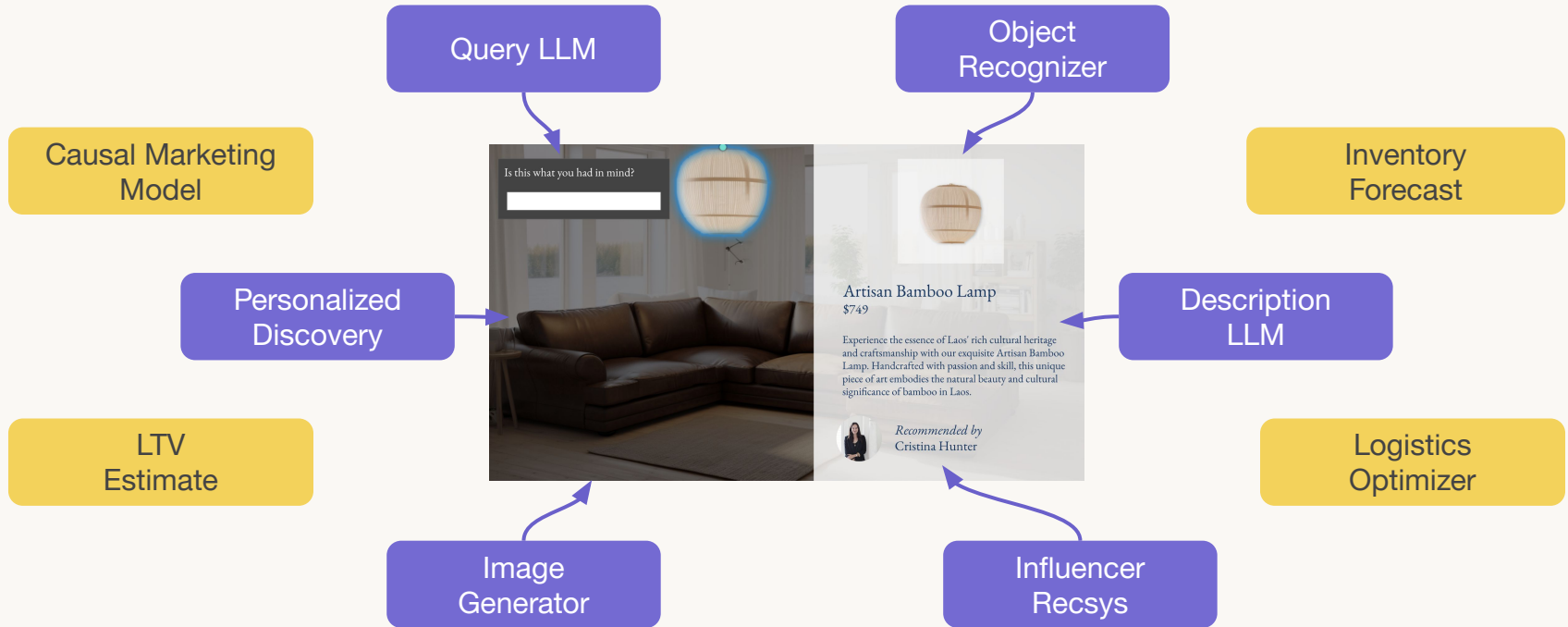
ADEPT

AUTODESK



inte

# Let's dissect an ML/AI-driven company of 2026





# Let's dissect an ML/AI-driven company of 2026

## LLMs

Query LLM

Description  
LLM

# Let's dissect an ML/AI-driven company of 2026 (so much more than just LLMs)

## LLMs

Query LLM

Description LLM

## Multimodal

Image Generator

Object Recognizer

## Hybrid Models

Personalized Discovery

Influencer Recsys

## Advanced Data & ML

Causal Marketing Model

Logistics Optimizer

LTV Estimate

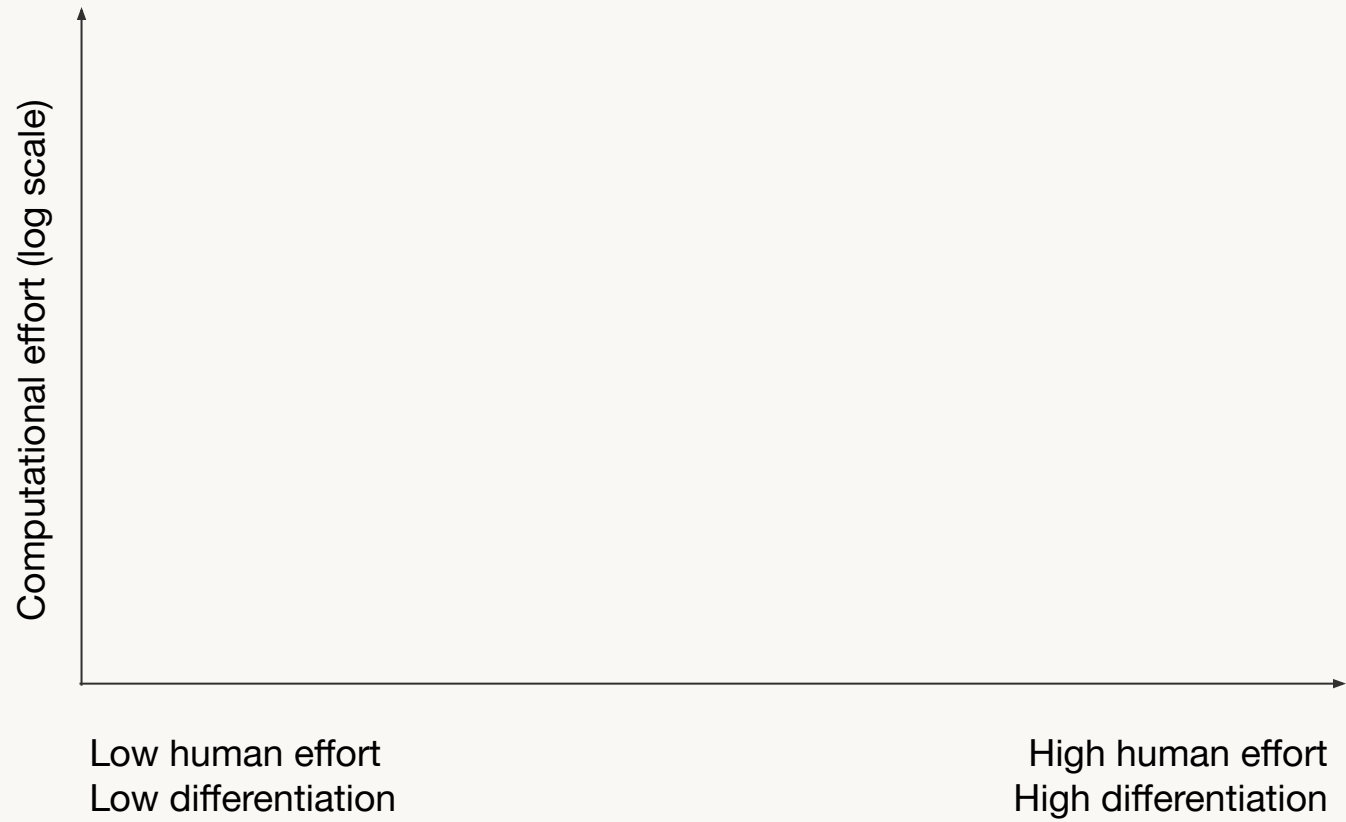
Inventory Forecast

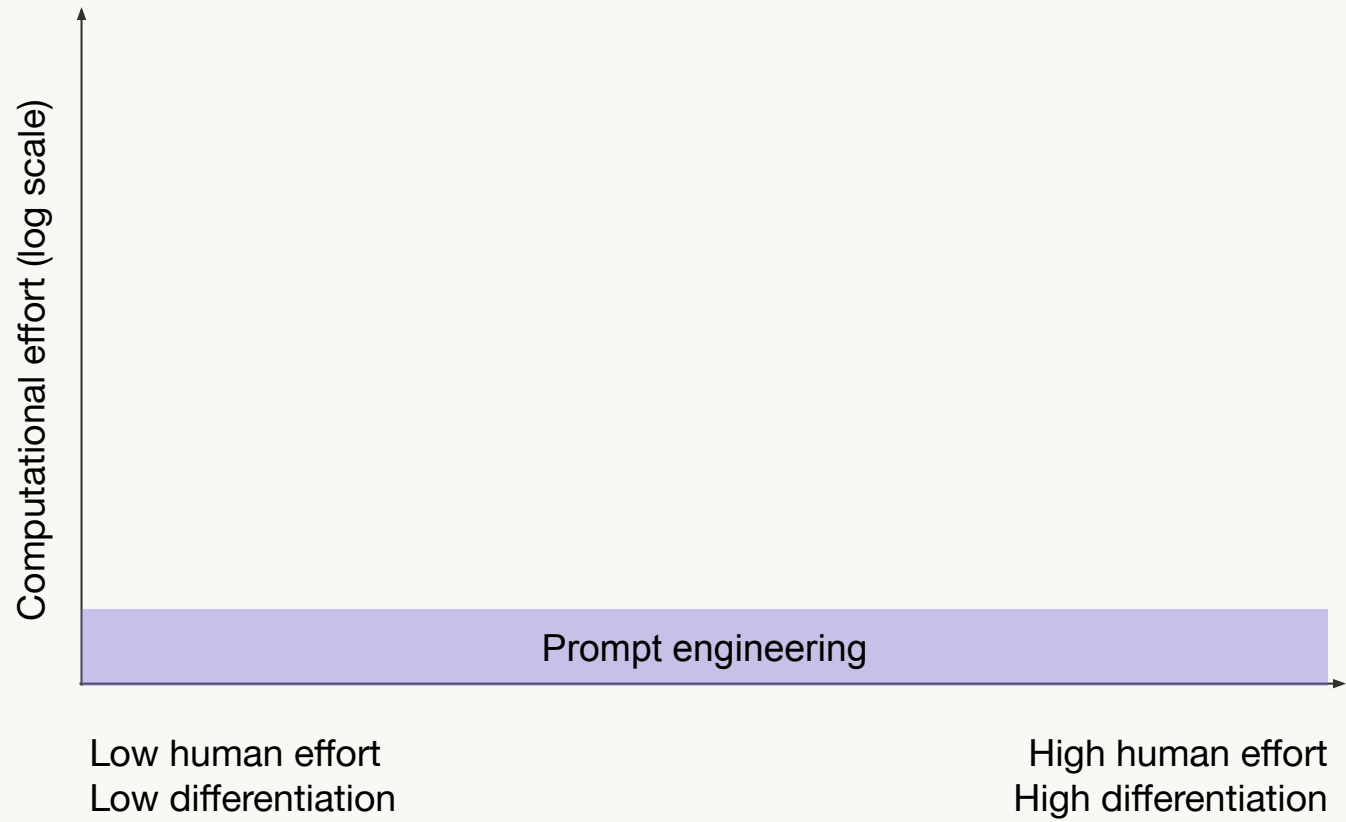
## LLMs

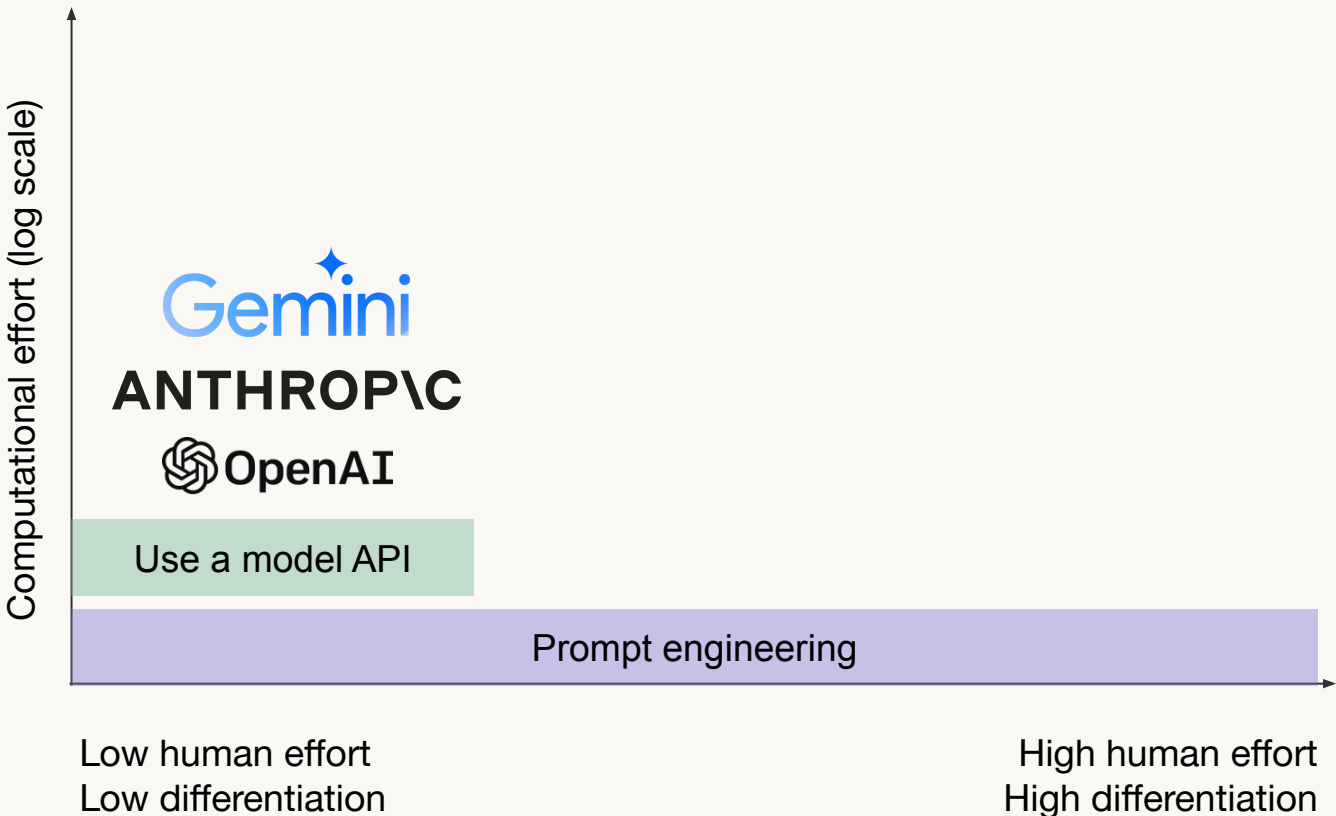
Query LLM

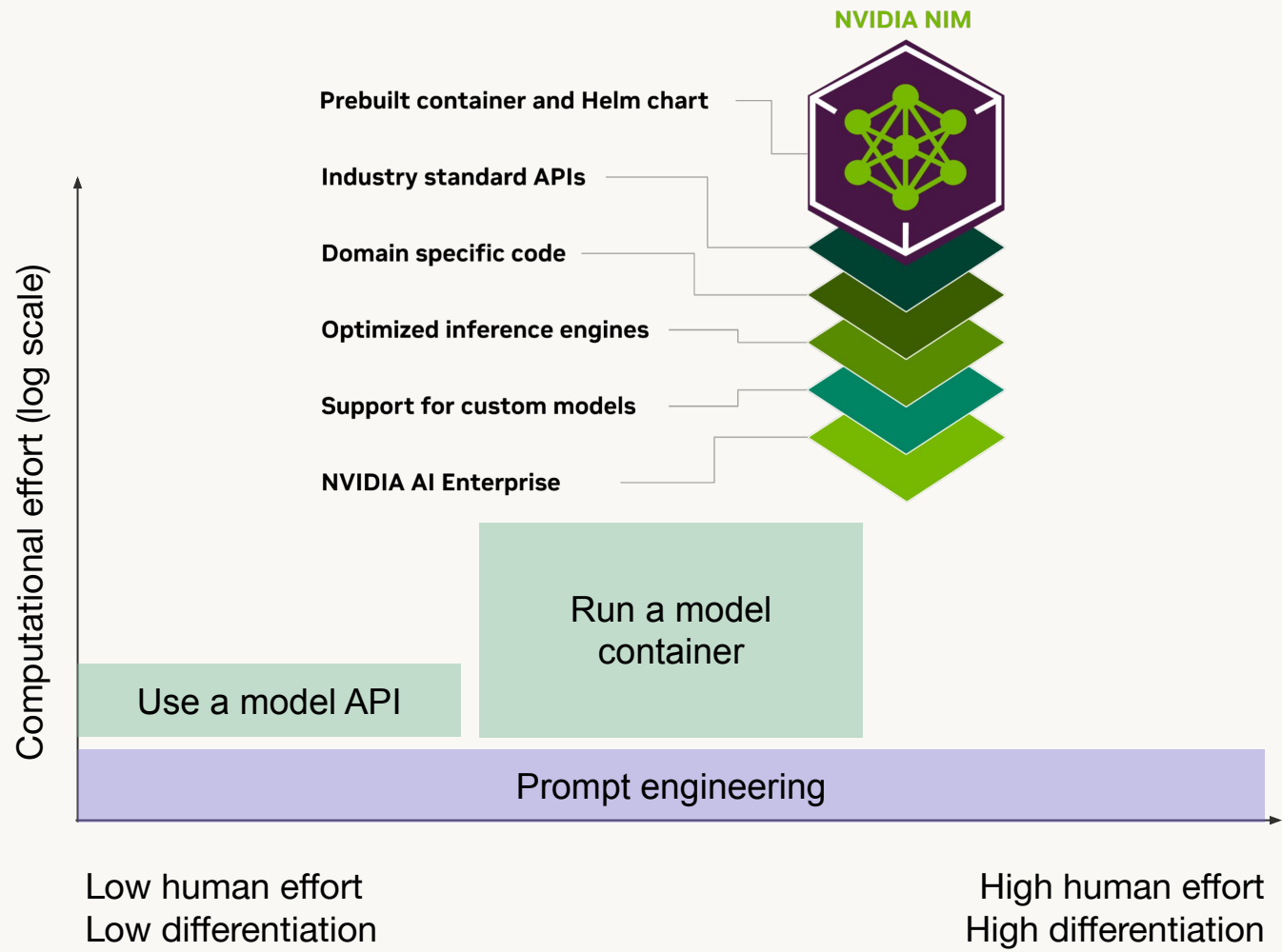
Description  
LLM

# LLMs

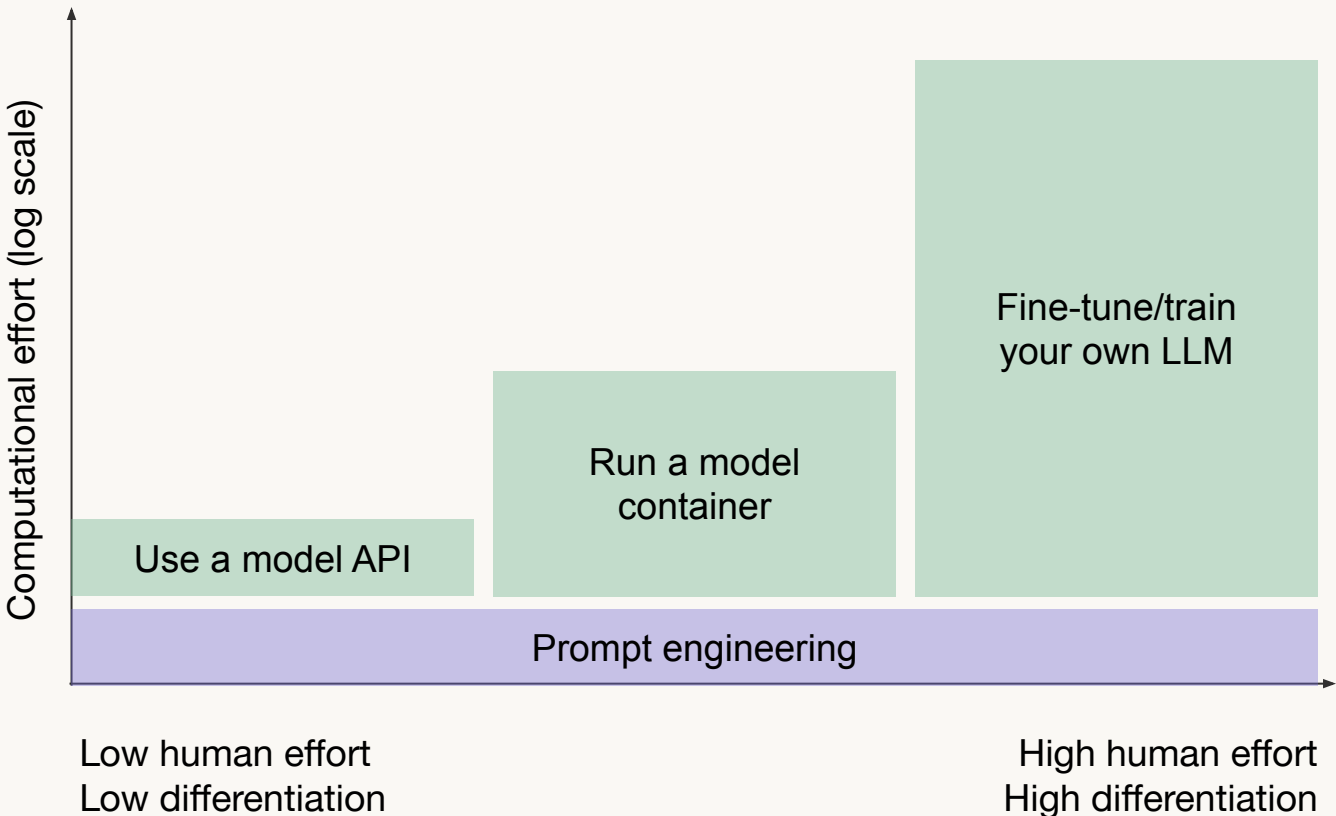




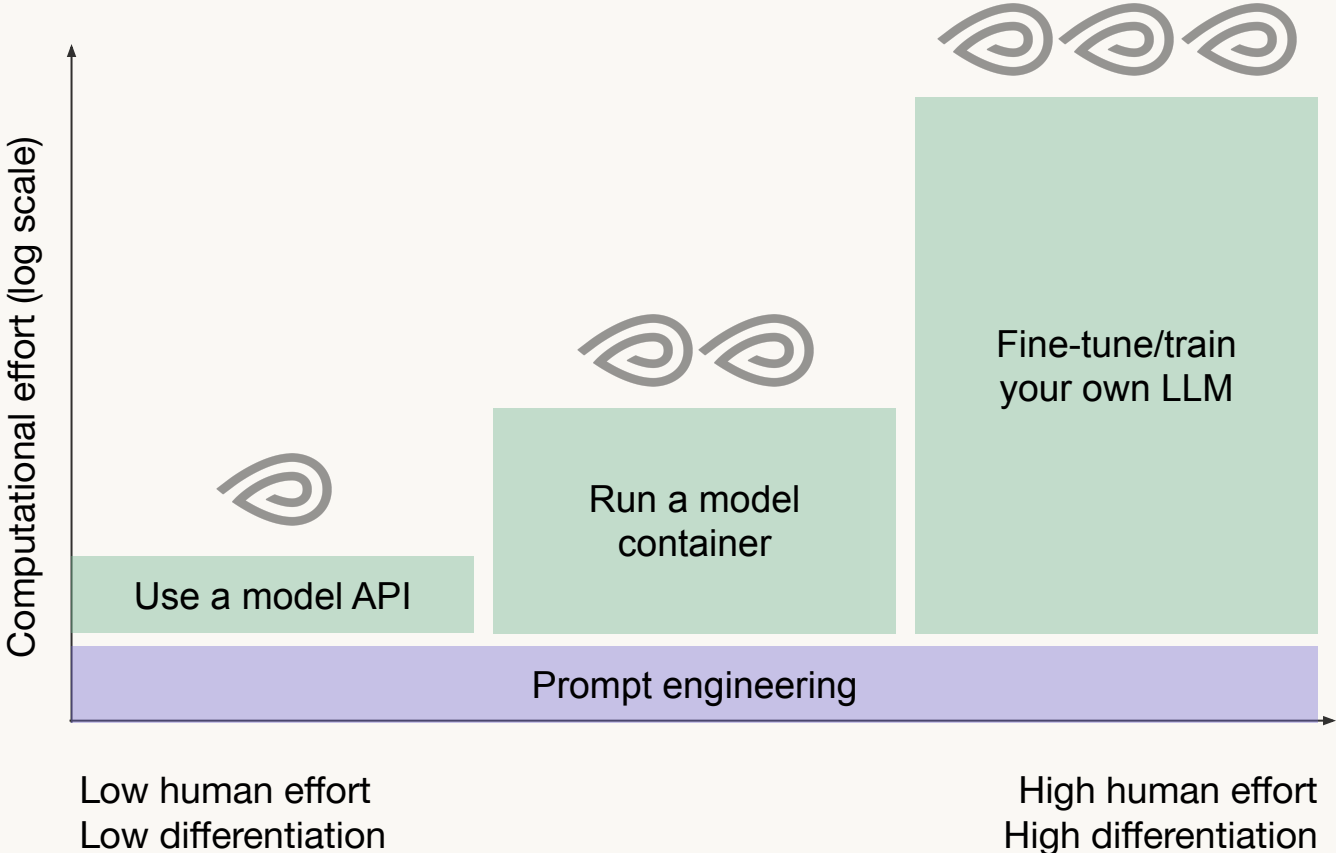




# LLMs







# Top challenges



Modeling

Deployment

Versioning

Orchestration

Compute

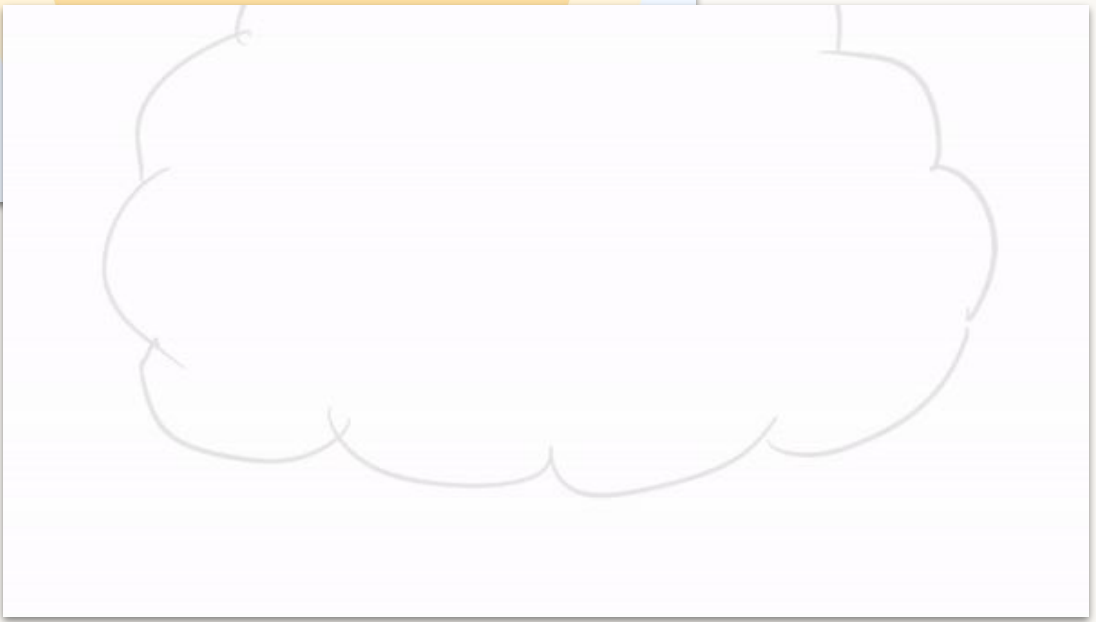
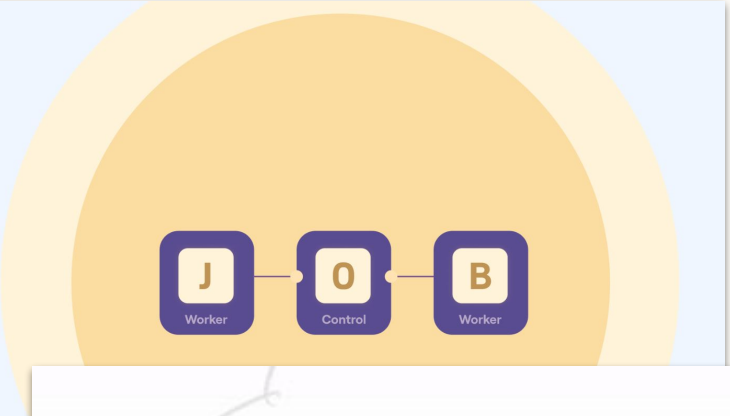
Data

# LLMs

Fine-tune  
your own

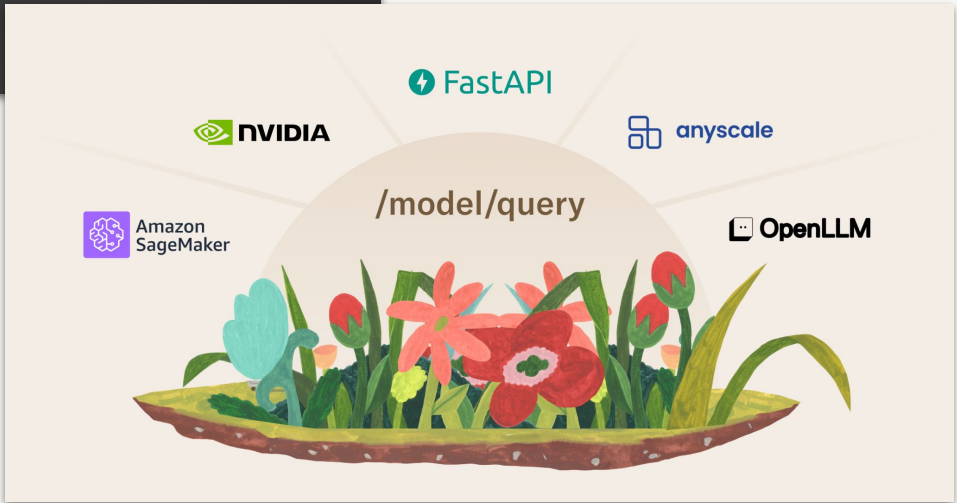
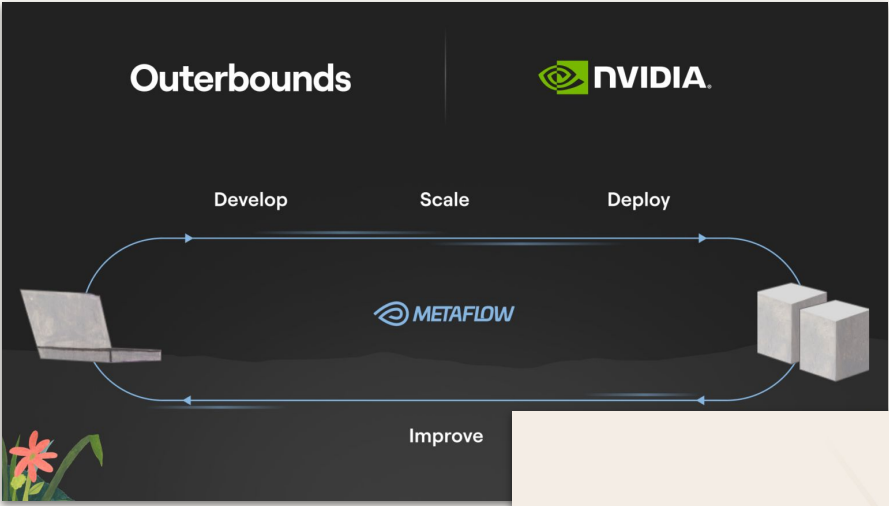
## Metaflow

- @metaflow\_ray
- @deepspeed
- @tensorflow
- @torchrun
- @mpi



# LLMs

Fine-tune  
your own

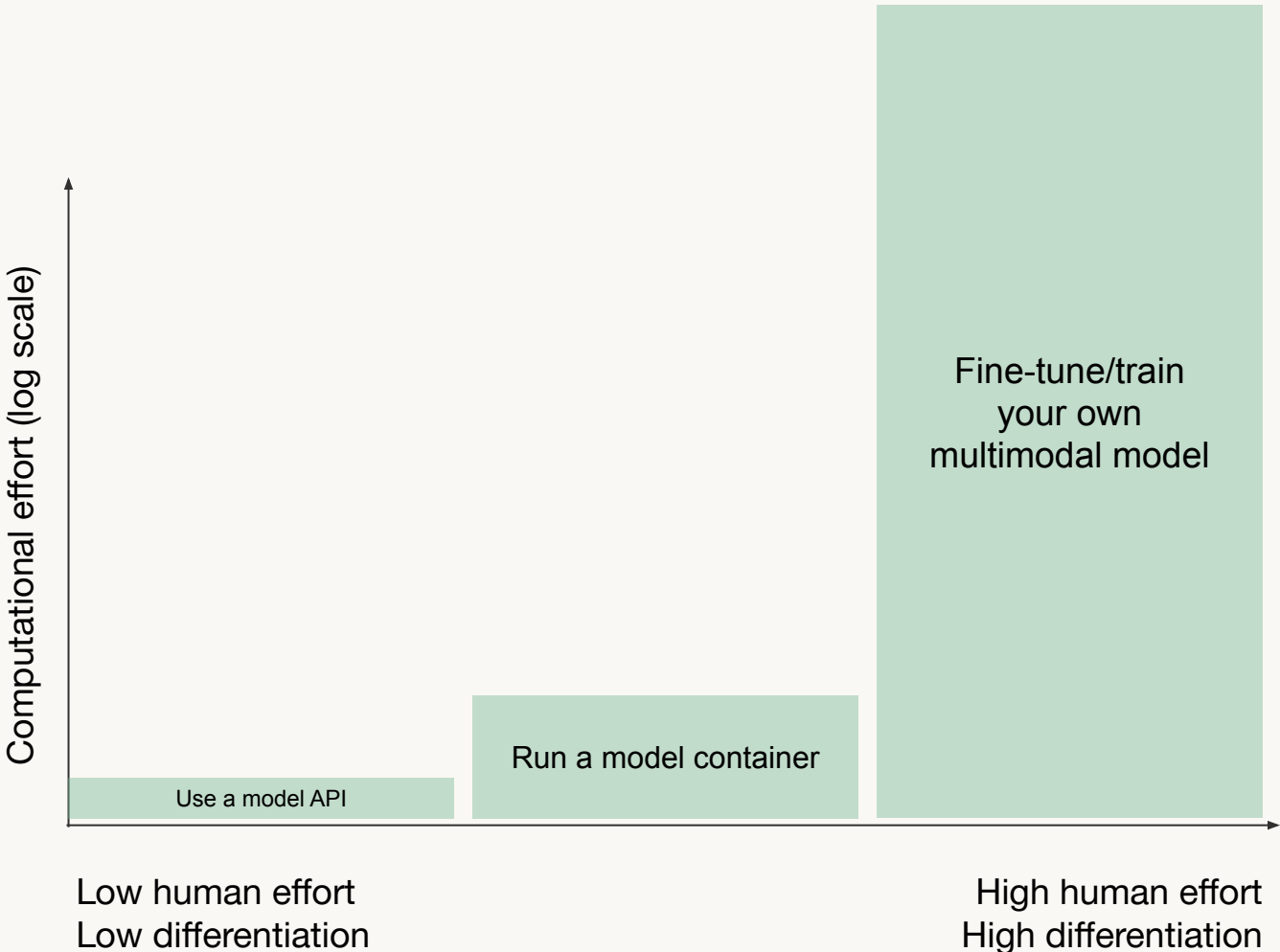


**Multimodal**

Image  
Generator

Object  
Recognizer

Multi modal



## Top challenges



Modeling

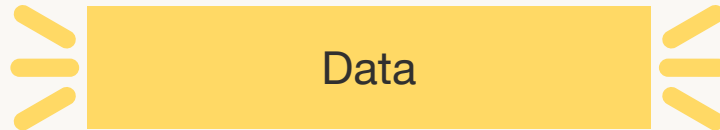
Deployment

Versioning

Orchestration

Compute

Data

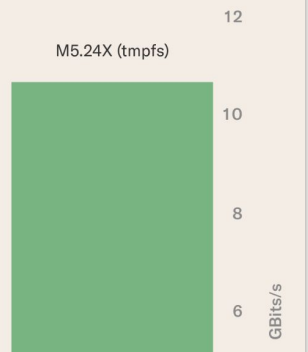


Multi modal

Train your own

# Fast Data

Loading tables from S3 at lightning speed with `pyarrow` and `metaflow.s3`





## Hybrid models

Personalized  
Discovery

Influencer  
Recsys

# Typical traditional ML workflow

Structured data

Age	Attrition	BusinessTravel	DailyRate	Department	DistanceFromHome
41	Yes	Travel_Rarely	1102	Sales	1
49	No	Travel_Frequently	279	Research & Development	8
37	Yes	Travel_Rarely	1373	Research & Development	2
33	No	Travel_Frequently	1392	Research & Development	3
27	No	Travel_Rarely	591	Research & Development	2
32	No	Travel_Frequently	1005	Research & Development	2
59	No	Travel_Rarely	1324	Research & Development	3
30	No	Travel_Rarely	1358	Research & Development	24
38	No	Travel_Frequently	216	Research & Development	23
36	No	Travel_Rarely	1299	Research & Development	27
35	No	Travel_Rarely	809	Research & Development	16
29	No	Travel_Rarely	153	Research & Development	15

Feature matrix

```
matrix([[ '1.0', '1.0', '1.0', '1.0', '0.0', '1.0', '0.0', '1.0', '1.0',  
         '1.0', '1.0', '1.0', '0.0', '1.0', '1.0', '1.0', '1.0', '1.0',  
         '0.0', '0.0', '0.0', '0.0', '0.0', '0.0', '0.0', '0.0', '1.0',  
         '1.0', '1.0', '0.0', '1.0' ],  
        [ '1.0', '1.0', '1.0', '1.0', '1.0', '0.0', '0.0', '1.0', '0.0',  
         '0.0', '1.0', '1.0', '1.0', '0.0', '1.0', '1.0', '1.0', '1.0',  
         '0.0', '0.0', '0.0', '0.0', '0.0', '0.0', '1.0', '0.0', '1.0',  
         '1.0', '1.0', '0.0', '1.0' ]])
```

Train a model

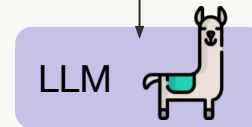
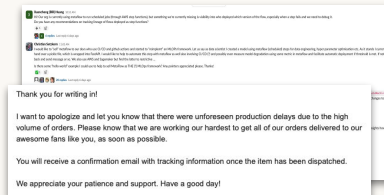
# XGBoost

## Hybrid structured + unstructured ML workflow

Structured data

Age	Attrition	BusinessTravel	DailyRate	Department	DistanceFromHome
41	Yes	Travel_Rarely	1102	Sales	1
49	No	Travel_Frequently	279	Research & Development	8
37	Yes	Travel_Rarely	1373	Research & Development	2
33	No	Travel_Frequently	1392	Research & Development	3
27	No	Travel_Rarely	591	Research & Development	2
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59	No	Travel_Rarely	1324	Research & Development	3
50	No	Travel_Rarely	1358	Research & Development	24
38	No	Travel_Frequently	216	Research & Development	23
36	No	Travel_Rarely	1209	Research & Development	27
35	No	Travel_Rarely	809	Research & Development	16
29	No	Travel_Rarely	153	Research & Development	15

Unstructured data



Feature matrix

```
matrix([[1.0, '1.0', '1.0', '1.0', '0.0', '1.0', '0.0', '1.0', '1.0',
         '1.0', '1.0', '1.0', '0.0', '1.0', '1.0', '1.0', '1.0', '1.0',
         '0.0', '0.0', '0.0', '0.0', '0.0', '0.0', '0.0', '0.0', '1.0',
         '1.0', '1.0', '0.0', '1.0'],
        [1.0, '1.0', '1.0', '1.0', '1.0', '0.0', '0.0', '0.0', '1.0', '0.0',
         '0.0', '1.0', '1.0', '1.0', '1.0', '1.0', '1.0', '1.0', '1.0',
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         '0.0', '0.0', '0.0', '0.0', '0.0', '0.0', '1.0', '0.0', '1.0',
         '1.0', '1.0', '0.0', '1.0']])
```

Embeddings

```
matrix([[1.0, '1.0', '1.0', '1.0', '0.0', '1.0', '0.0', '1.0', '1.0',
         '1.0', '1.0', '1.0', '0.0', '1.0', '1.0', '1.0', '1.0', '1.0',
         '0.0', '0.0', '0.0', '0.0', '0.0', '0.0', '0.0', '0.0', '1.0',
         '1.0', '1.0', '0.0', '1.0'],
        [1.0, '1.0', '1.0', '1.0', '1.0', '0.0', '0.0', '0.0', '1.0', '0.0',
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         '0.0', '0.0', '0.0', '0.0', '0.0', '0.0', '1.0', '1.0', '1.0',
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         '1.0', '1.0', '0.0', '1.0']])
```

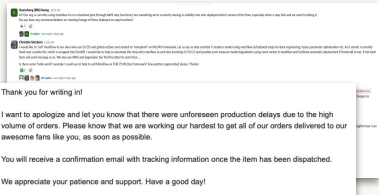
Train a model

# Hybrid models

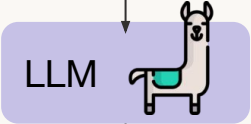
## Personalized Discovery

Structured data  
Past purchases  
Browsing history  
Demographic data

Age	Attrition	BusinessTravel	DailyRate	Department	DistanceFromHome
41	Yes	Travel_Rarely	1102	Sales	1
49	No	Travel_Frequently	279	Research & Development	8
37	Yes	Travel_Rarely	1373	Research & Development	2
33	No	Travel_Frequently	1392	Research & Development	3
27	No	Travel_Rarely	591	Research & Development	2
32	No	Travel_Frequently	1005	Research & Development	2
59	No	Travel_Rarely	1324	Research & Development	3
56	No	Travel_Rarely	1358	Research & Development	24
38	No	Travel_Frequently	216	Research & Development	23
36	No	Travel_Rarely	1209	Research & Development	27
35	No	Travel_Rarely	809	Research & Development	16
29	No	Travel_Rarely	153	Research & Development	15



Unstructured data  
Social media activity  
Product data  
Reviews



Feature matrix

```
matrix([[1.0, 1.0, 1.0, 1.0, 0.0, 1.0, 0.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 0.0, 0.0, 0.0, 0.0, 0.0, 1.0], [1.0, 1.0, 1.0, 1.0, 0.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 0.0, 0.0, 0.0, 0.0, 1.0], [0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0], [1.0, 1.0, 0.0, 1.0], [1.0, 1.0, 1.0, 1.0, 1.0, 0.0, 0.0, 0.0, 1.0, 0.0], [1.0, 1.0, 1.0, 1.0, 1.0, 0.0, 1.0, 1.0, 1.0, 1.0], [0.0, 1.0, 1.0, 1.0, 1.0, 0.0, 1.0, 1.0, 1.0, 1.0], [0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 1.0, 0.0, 1.0], [1.0, 1.0, 0.0, 1.0]]]
```

Embeddings

```
matrix([[1.0, 1.0, 1.0, 1.0, 0.0, 1.0, 0.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 0.0, 0.0, 0.0, 0.0, 0.0, 1.0], [1.0, 1.0, 1.0, 1.0, 0.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 0.0, 0.0, 0.0, 0.0, 1.0], [0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0], [1.0, 1.0, 1.0, 1.0, 1.0, 0.0, 0.0, 1.0, 0.0], [1.0, 1.0, 1.0, 1.0, 1.0, 0.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 0.0, 0.0, 0.0, 0.0, 1.0], [0.0, 1.0, 1.0, 1.0, 1.0, 0.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 1.0, 0.0, 0.0, 0.0, 0.0, 1.0], [0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 0.0, 1.0, 0.0, 1.0], [1.0, 1.0, 0.0, 1.0]]]
```

Train a model

# XGBoost



## Top challenges



Modeling

Deployment

Versioning

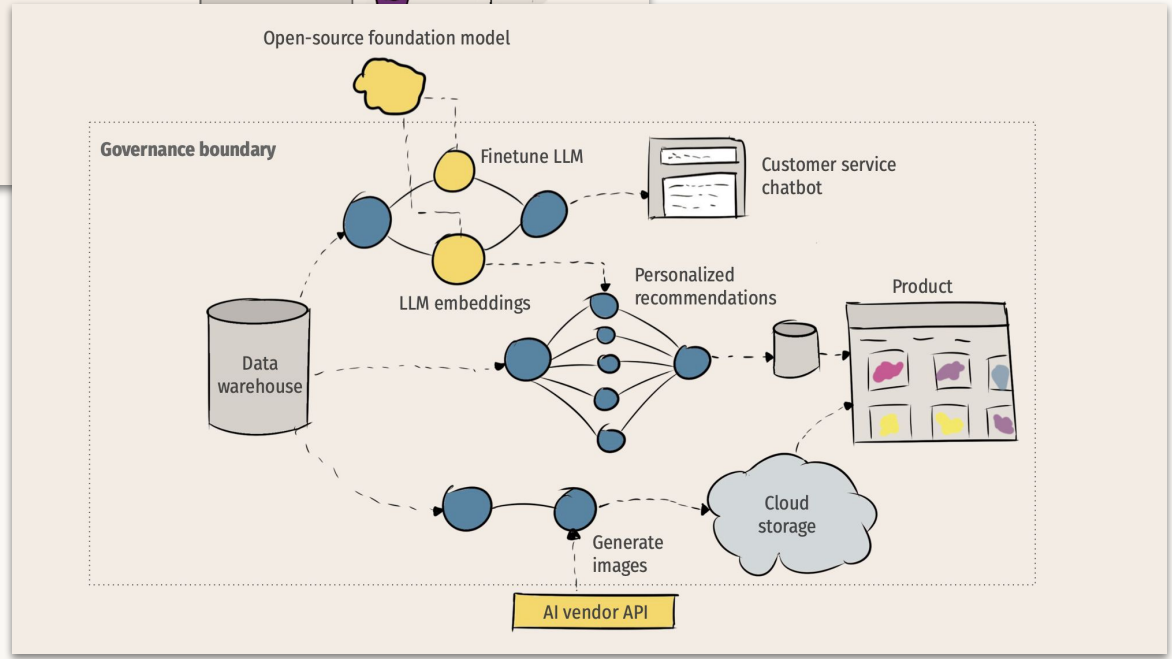
Orchestration

Compute

Data

# Hybrid models

The future of  
**ML Stack for  
Large Language  
Models**



**Advanced Data & ML**

Causal Marketing Model	Logistics Optimizer
LTV Estimate	Inventory Forecast



The world is getting increasingly sophisticated behind the scenes! 🤖



Building the World's Leading  
Verification Platform for Soil-Based  
Carbon Removal with Metaflow and  
AWS Step Functions

*METAFLOW*



Building a Modern Power Company  
using Data Science and Metaflow:  
Equilibrium Energy

*METAFLOW*



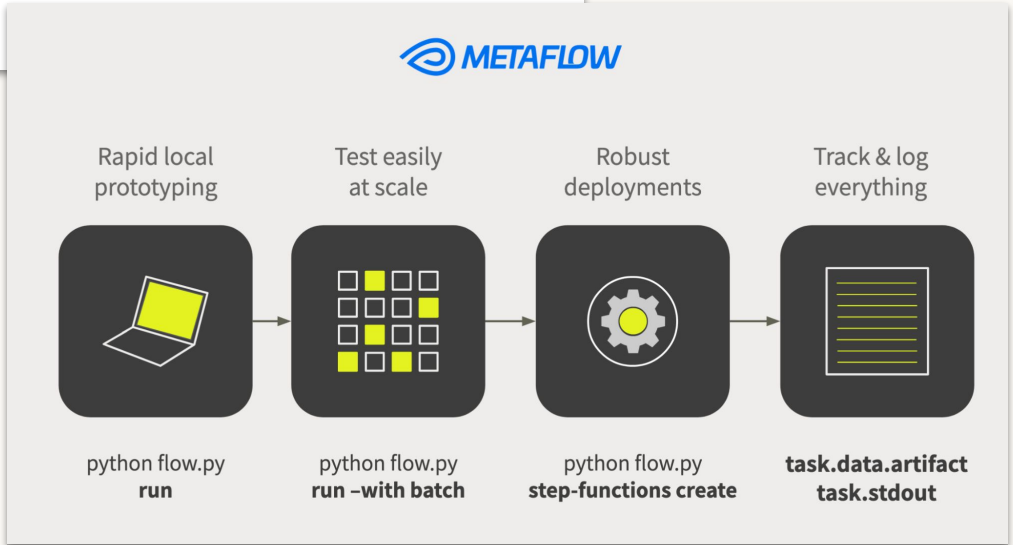
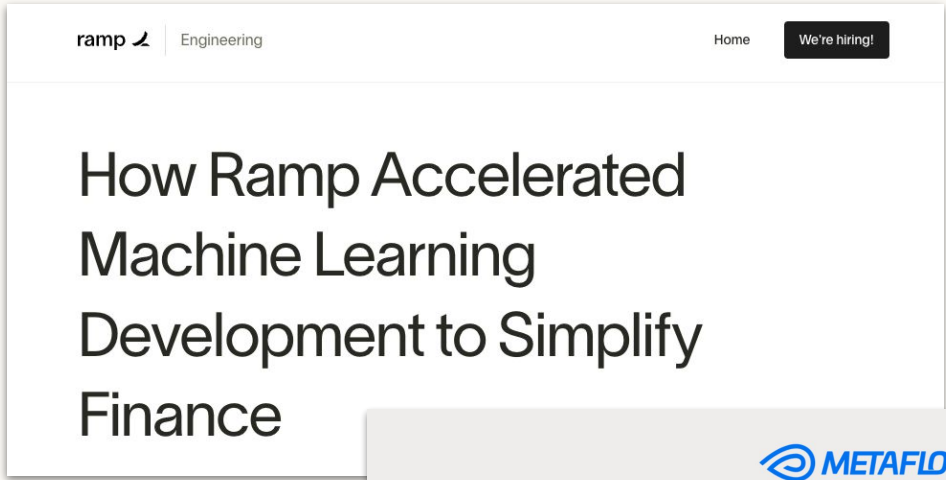
Revolutionizing Healthcare Machine  
Learning with Metaflow at Prolaio

*METAFLOW*



Telematics with Metaflow: How  
Nirvana Insurance Built a Large-Scale  
Risk Estimation Platform

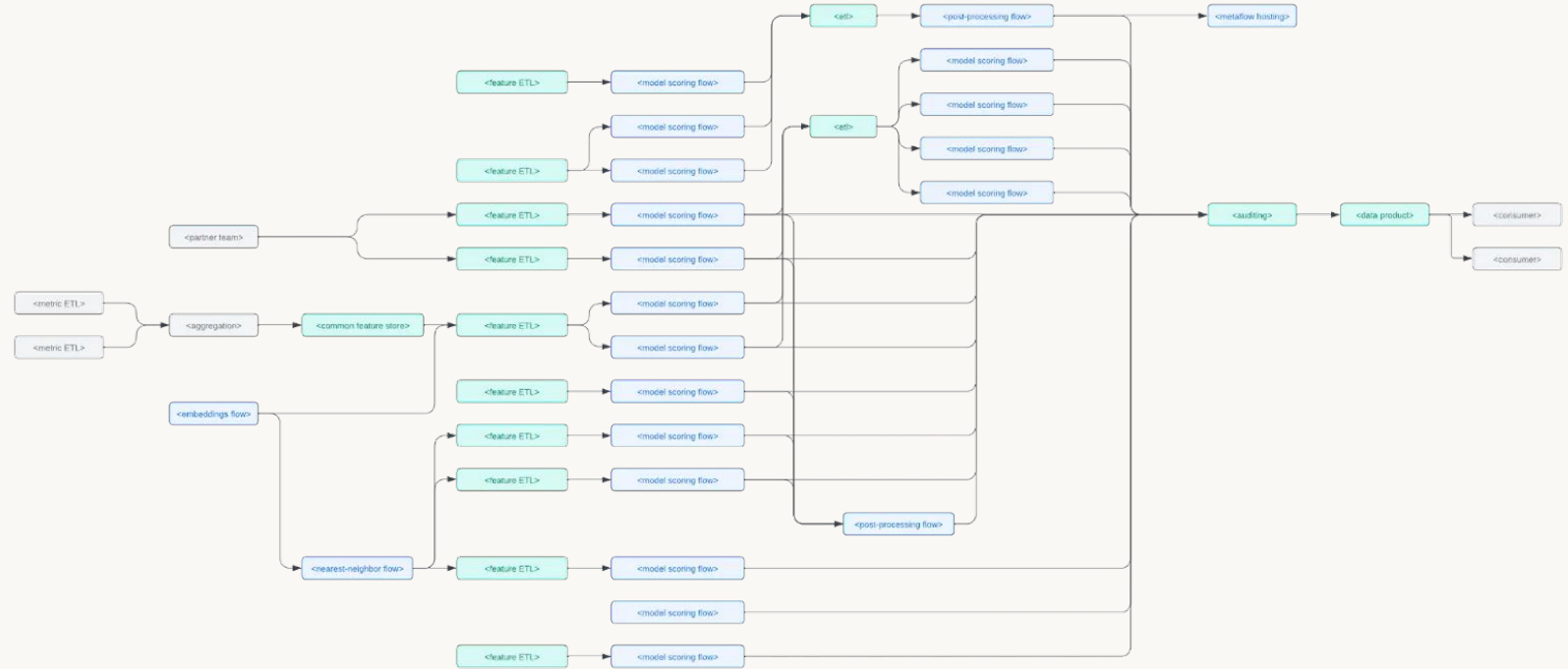
*METAFLOW*



## Supporting Diverse ML Systems at Netflix



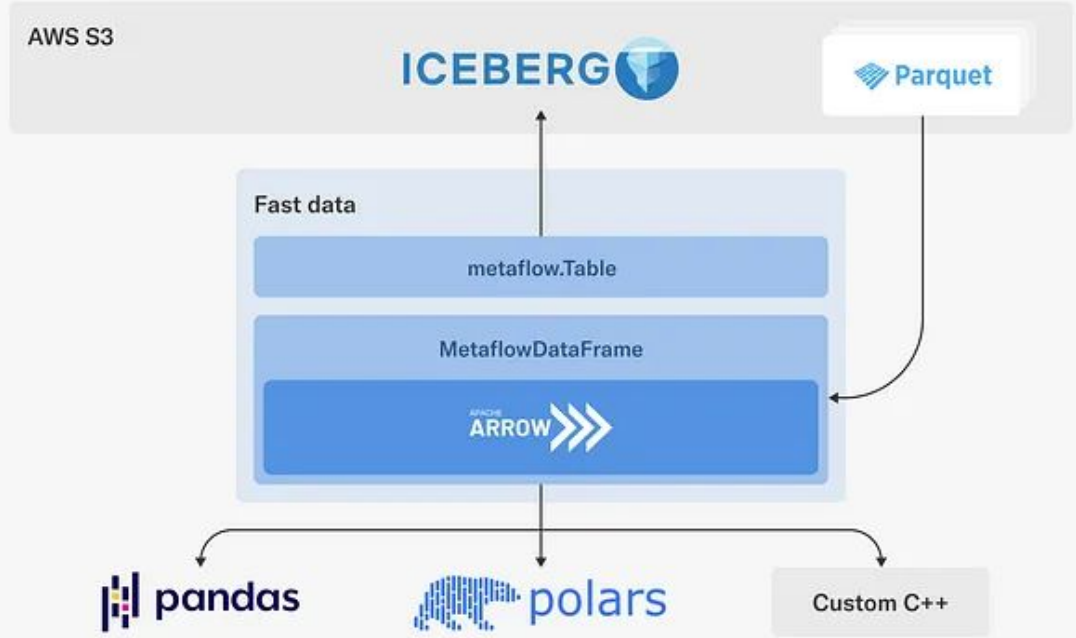
Netflix Technology Blog · Follow  
Published in Netflix TechBlog · 12 min read · Mar 7, 2024



## Supporting Diverse ML Systems at Netflix

Netflix Technology Blog · Follow  
Published in Netflix TechBlog · 12 min read · Mar 7, 2024

The unbundled data stack





Modeling

Deployment

Versioning

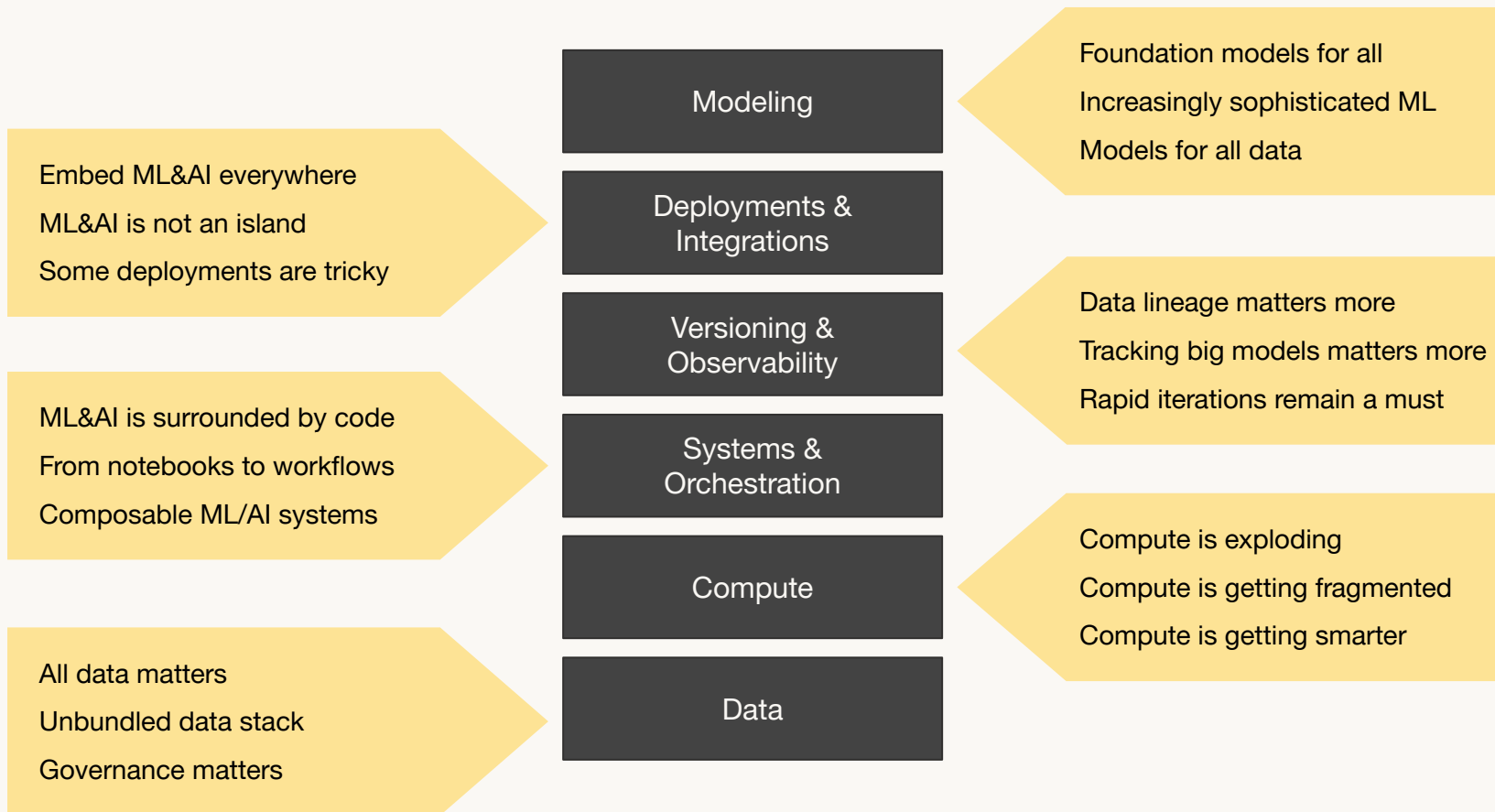
Orchestration

Compute

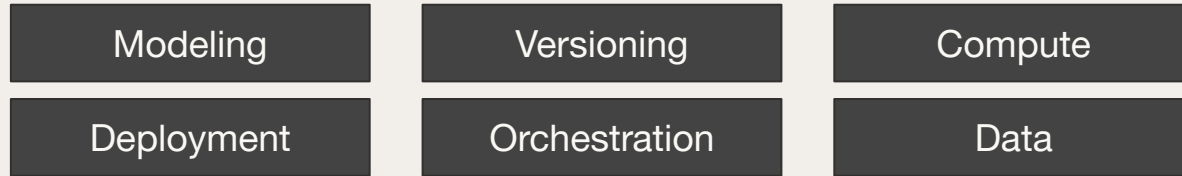
Data

## Summary

# Towards the ML/AI-powered future



Build delightfully human-centric AI-powered experiences 🥰



on top of a robust foundation 💪



# Thank you!

See you at the Metaflow community Slack!

<http://slack.outerbounds.co>



Run ETL with  
dbt

Generate ads with  
Google Ads

