Course 2: Production ML Systems

Module 3: Designing Adaptable ML Systems

Lesson Title: **Introduction**

Presenter: Max Lotstein

Format: Talking Head

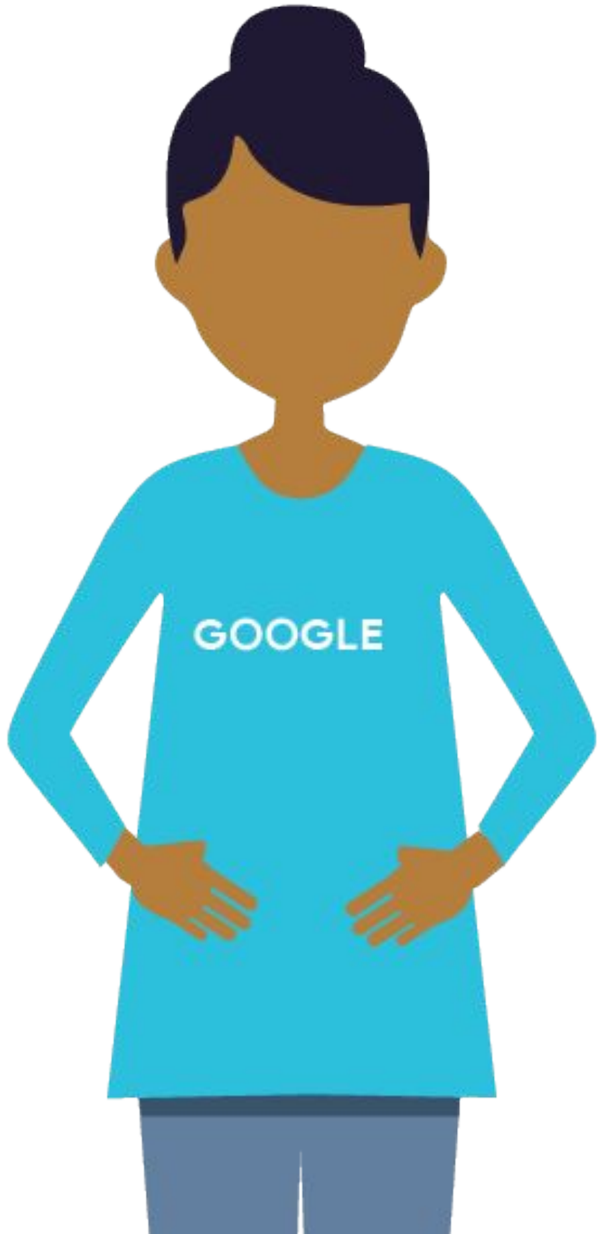
Video Name: T-PSML-O_3_l1_introduction

Google Cloud

Designing Adaptable ML Systems

Advanced Machine Learning on GCP

Max Lotstein



Learn how to...

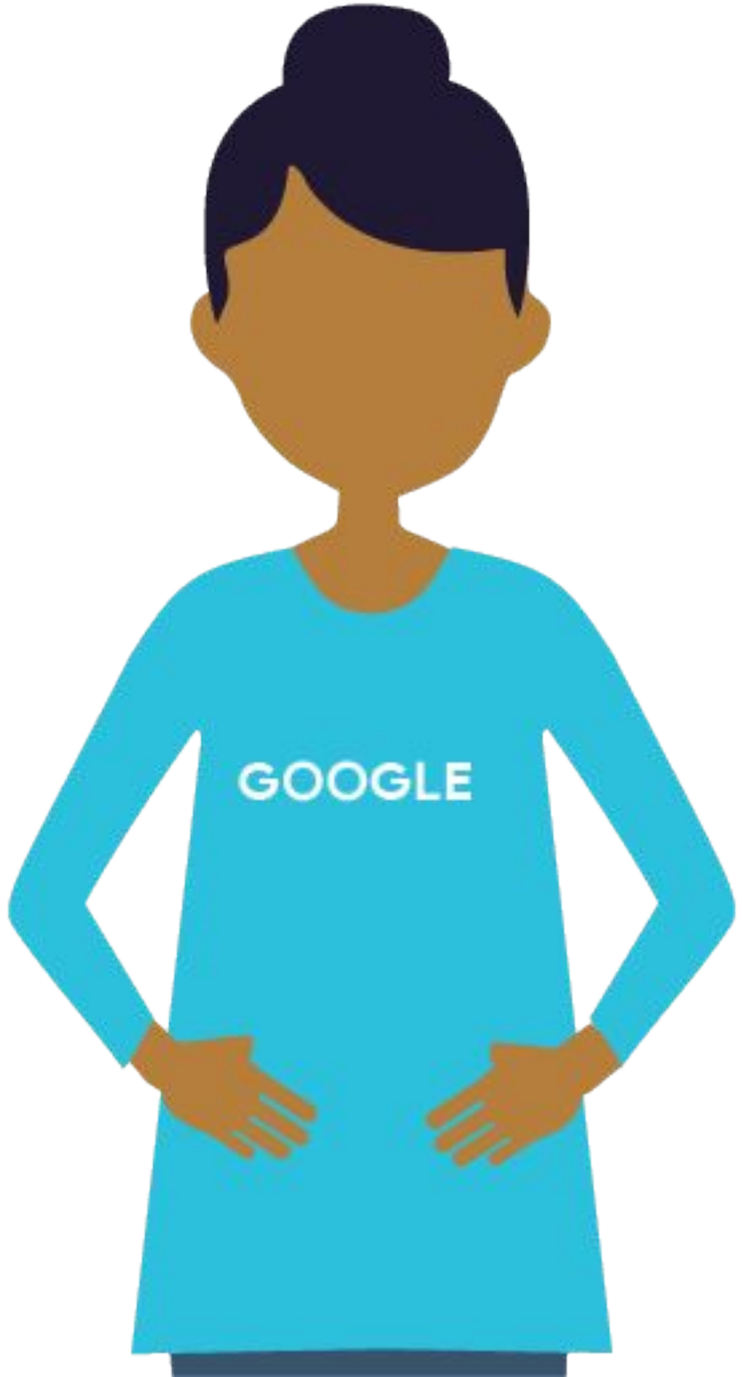
Recognize various data dependencies

Make cost-conscious engineering decisions

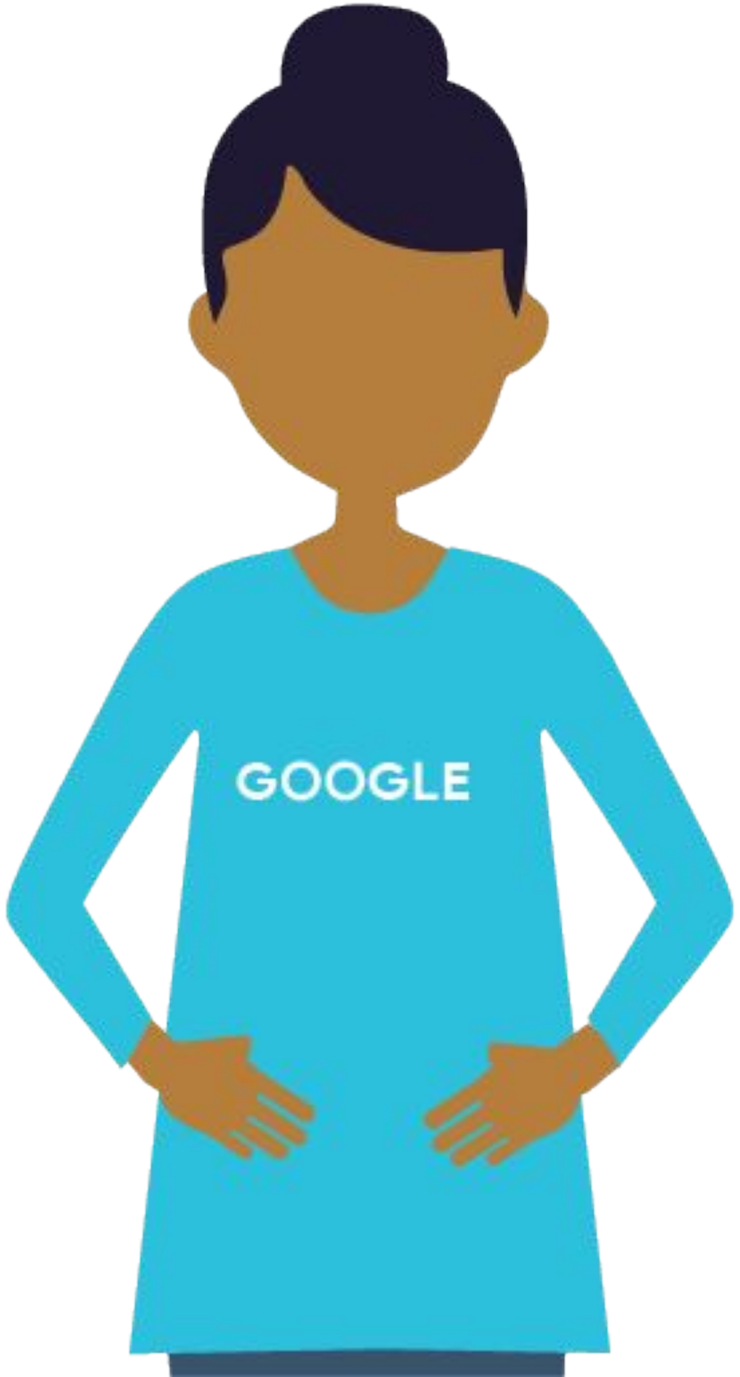
Mitigate model pollution

Implement a pipeline that is immune to one type of dependency

Debug the causes of observed model behavior



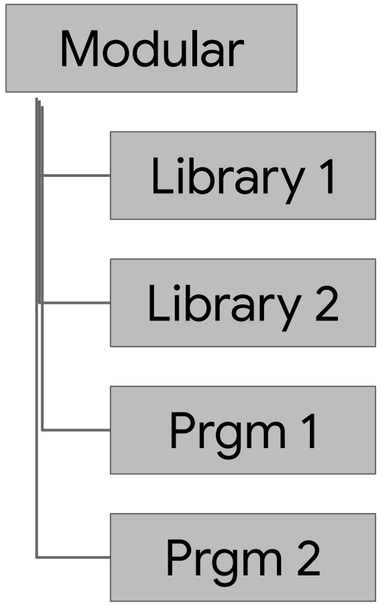
Few Programs are Islands

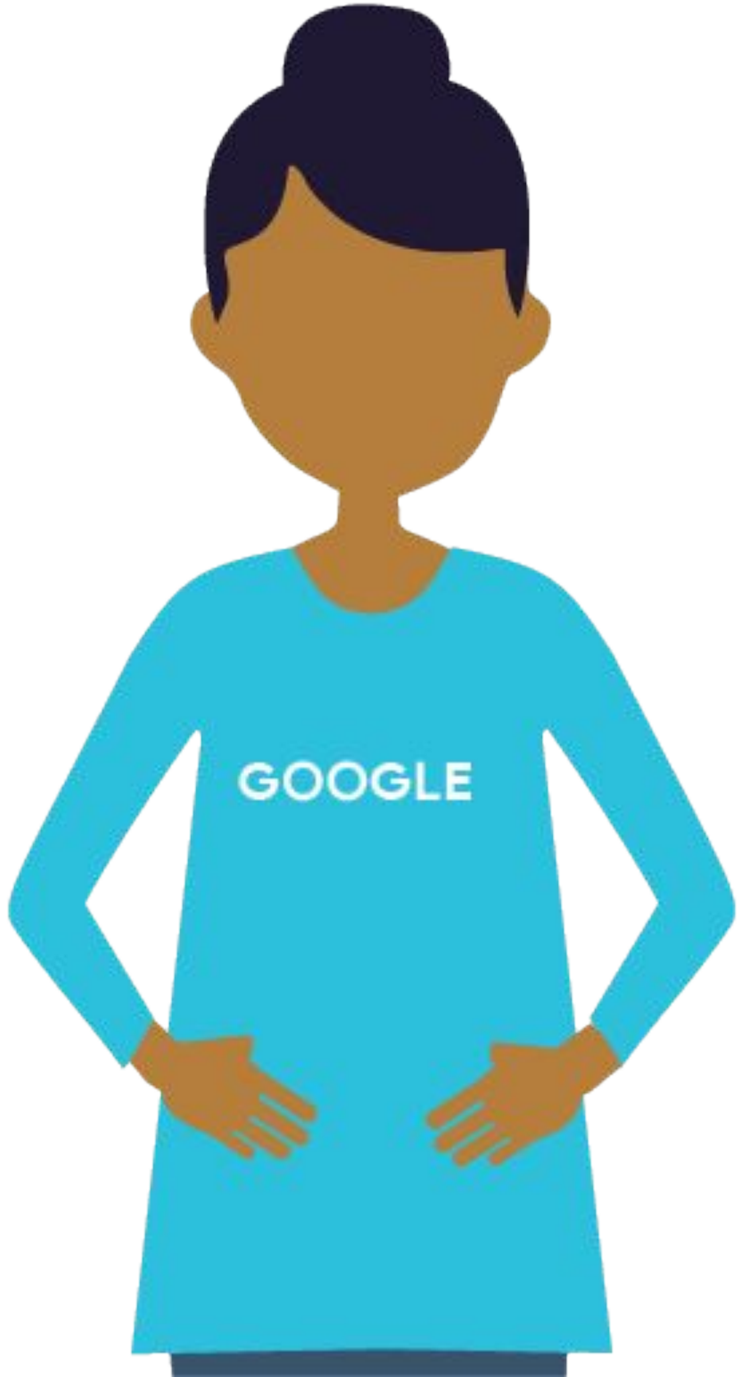


Few Programs are Islands

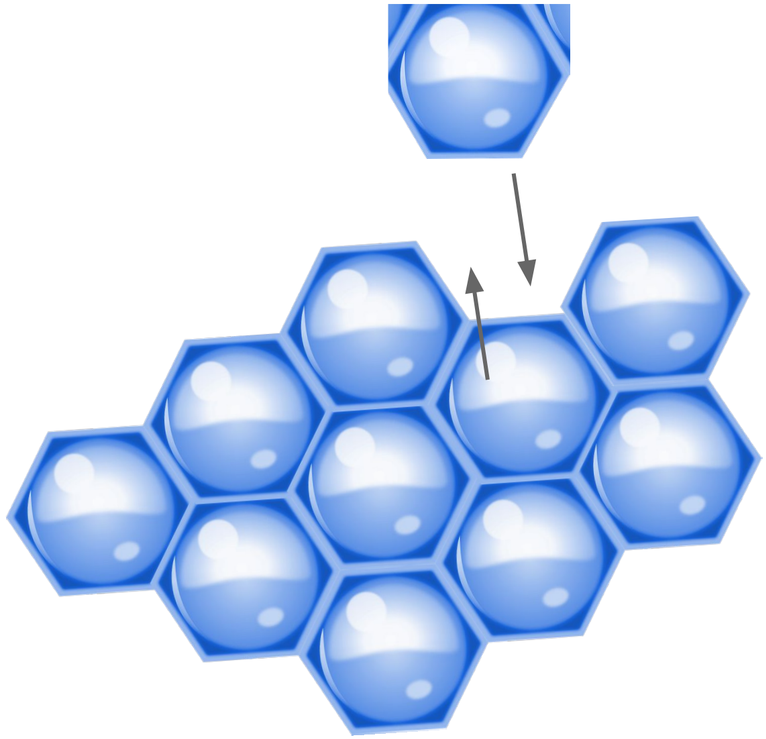
Monolithic Program

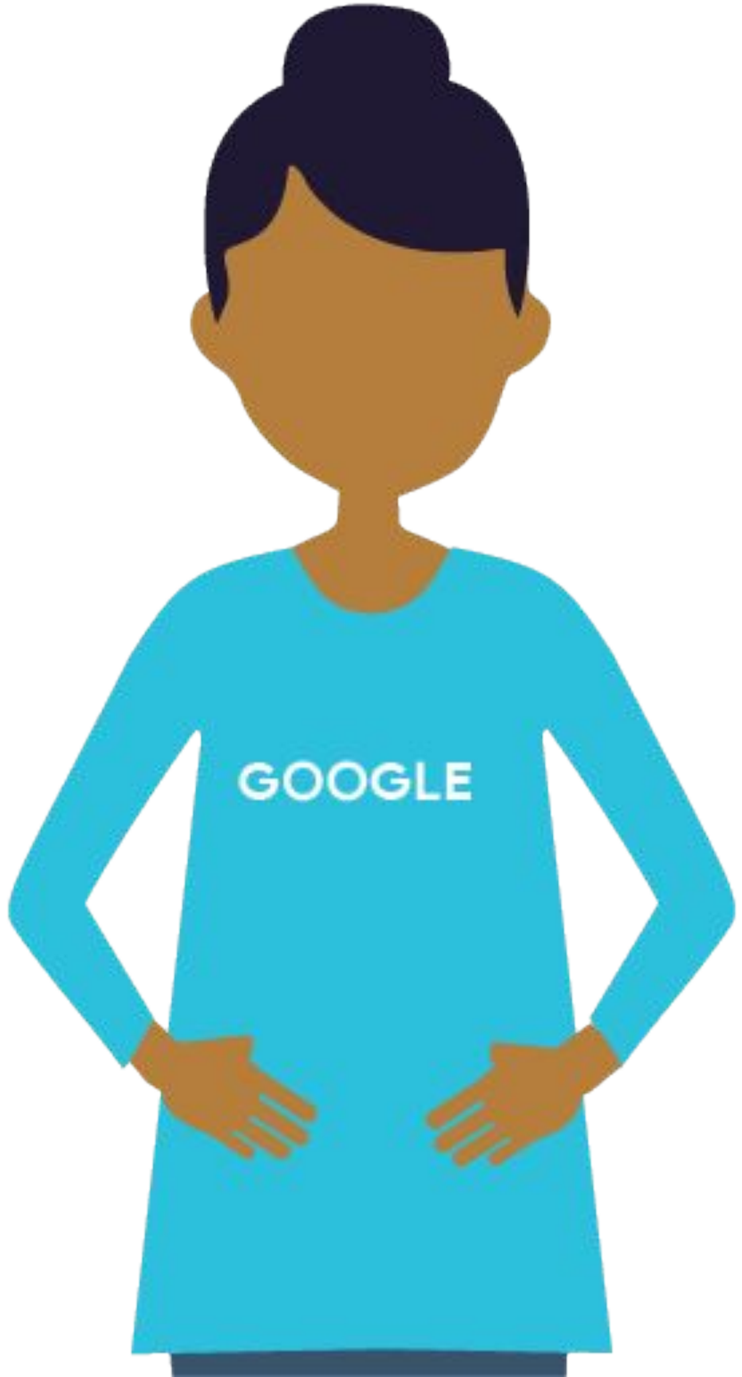
vs



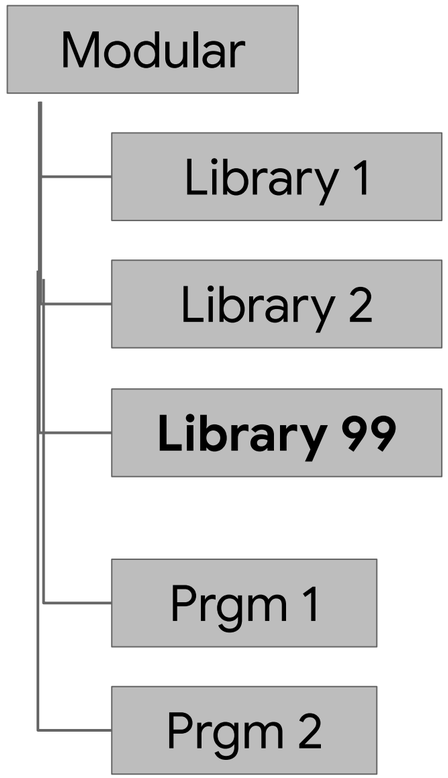


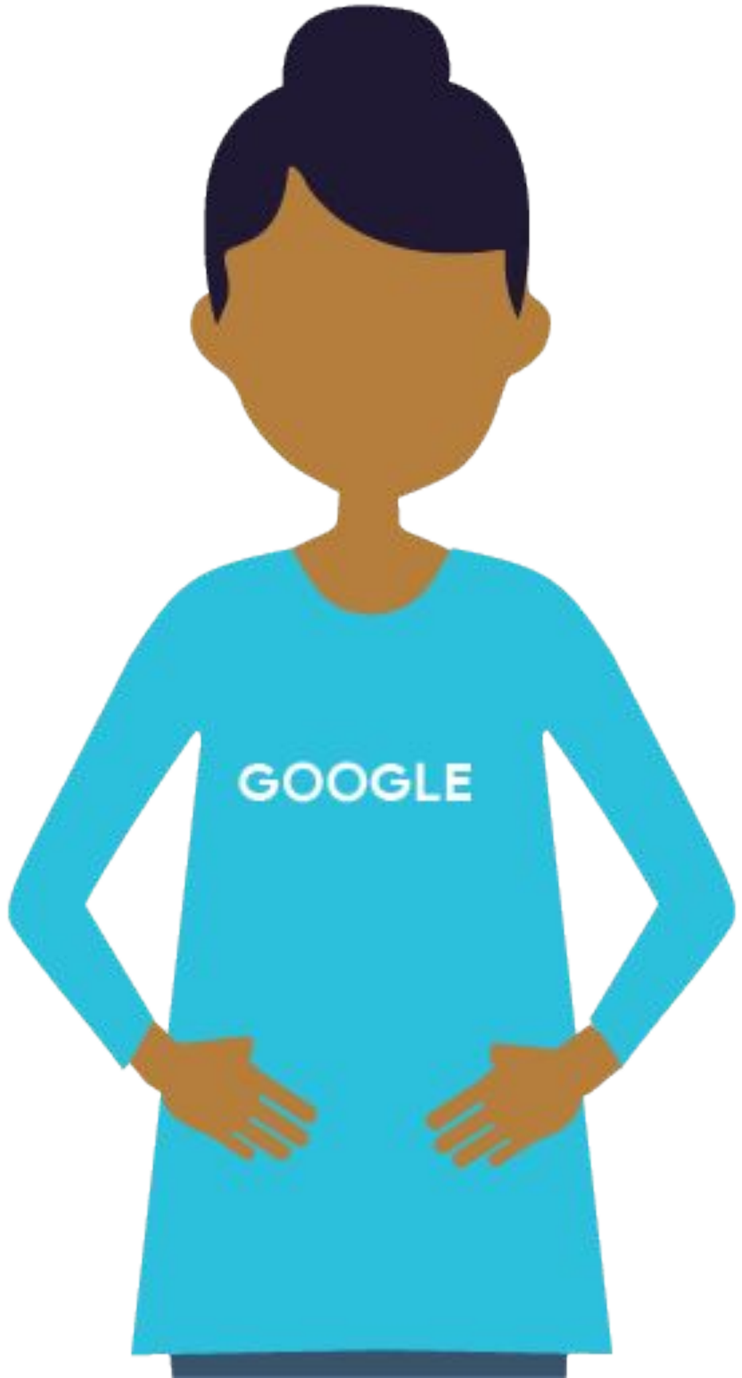
Modular Is More Maintainable



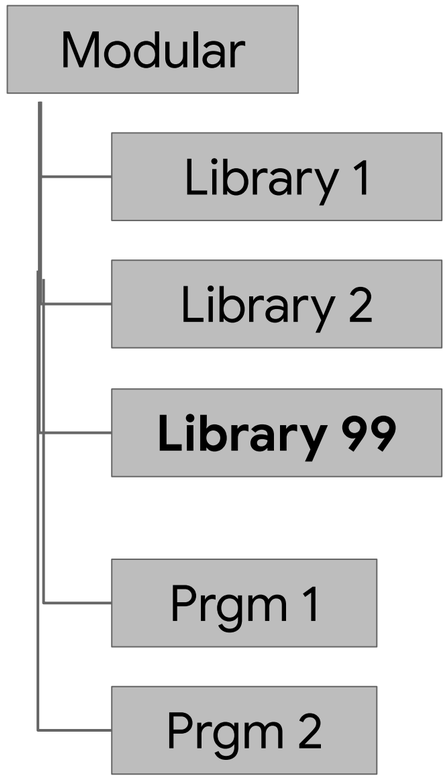


Dependency Management Is Manageable



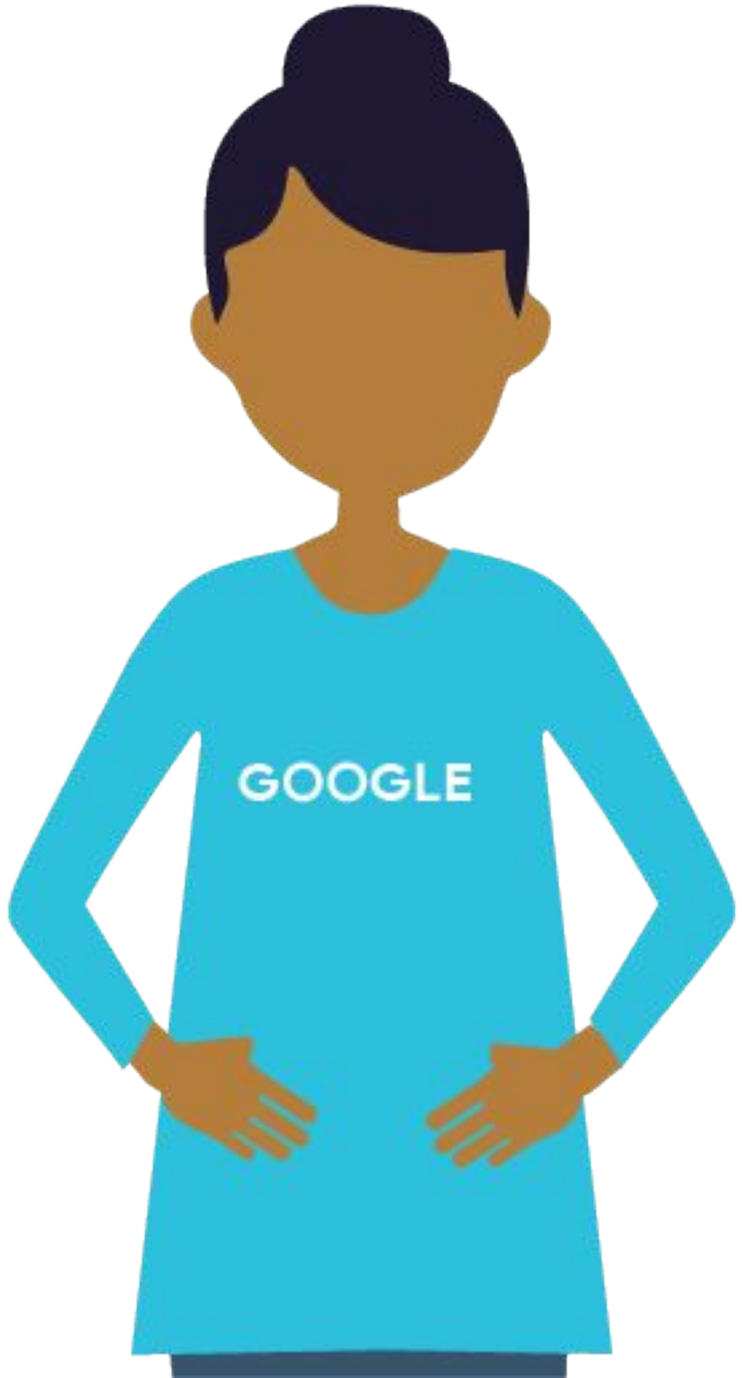


Dependency Management Is Manageable



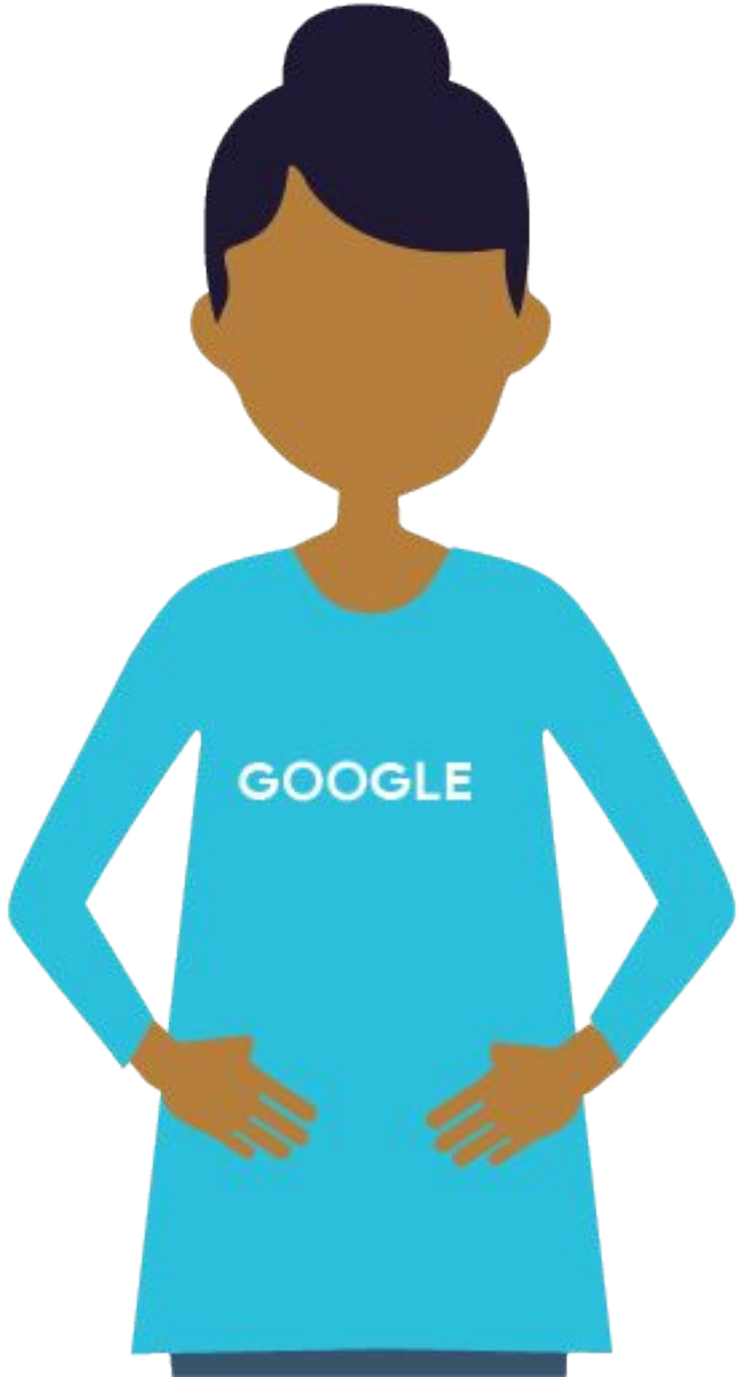
Maven™

PIP



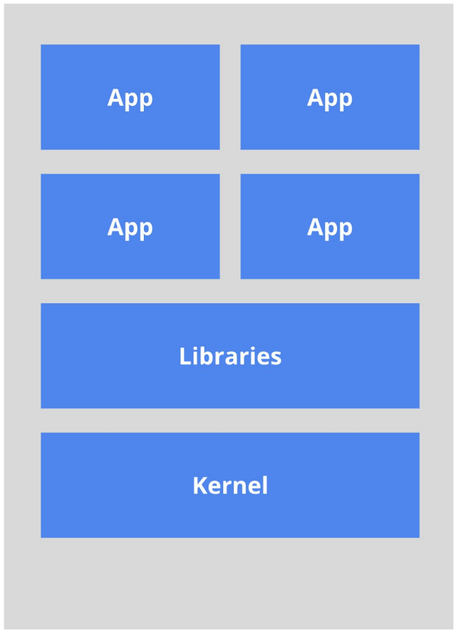
Explicit Dependencies Make Life Easier

```
1. <project xmlns="http://maven.apache.org/POM/4.
2.   xsi:schemaLocation="http://maven.apache.org/
3.   <modelVersion>4.0.0</modelVersion>
4.
5.   <groupId>com.mycompany.app</groupId>
6.   <artifactId>my-app</artifactId>
7.   <version>1.0-SNAPSHOT</version>
8.   <packaging>jar</packaging>
9.
10.  <name>Maven Quick Start Archetype</name>
11.  <url>http://maven.apache.org</url>
12.
13.  <dependencies>
14.    <dependency>
15.      <groupId>junit</groupId>
16.      <artifactId>junit</artifactId>
17.      <version>4.8.2</version>
18.      <scope>test</scope>
19.    </dependency>
20.  </dependencies>
21. </project>
```



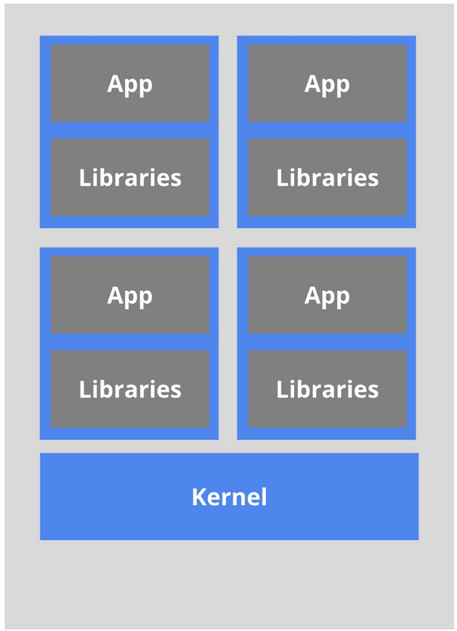
Containers eliminate infrastructure dependencies

The old way: Applications on host

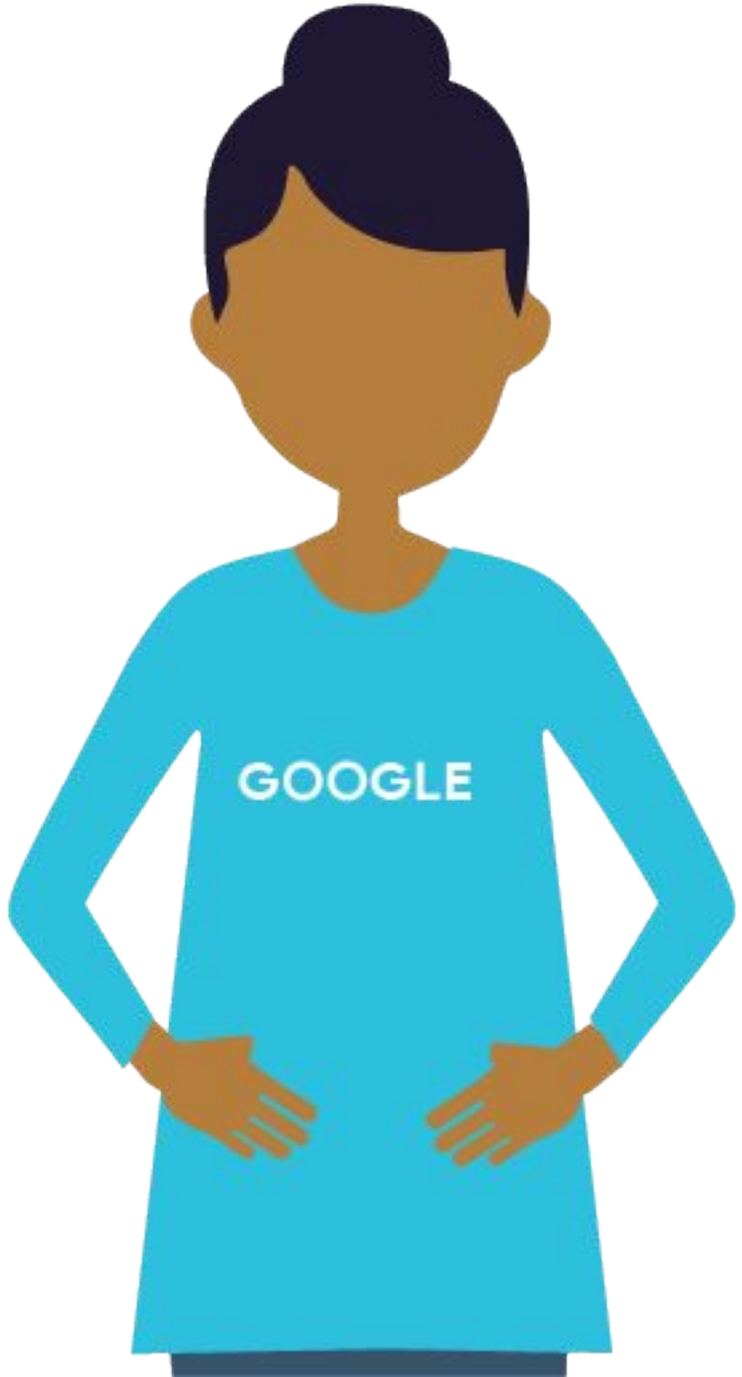


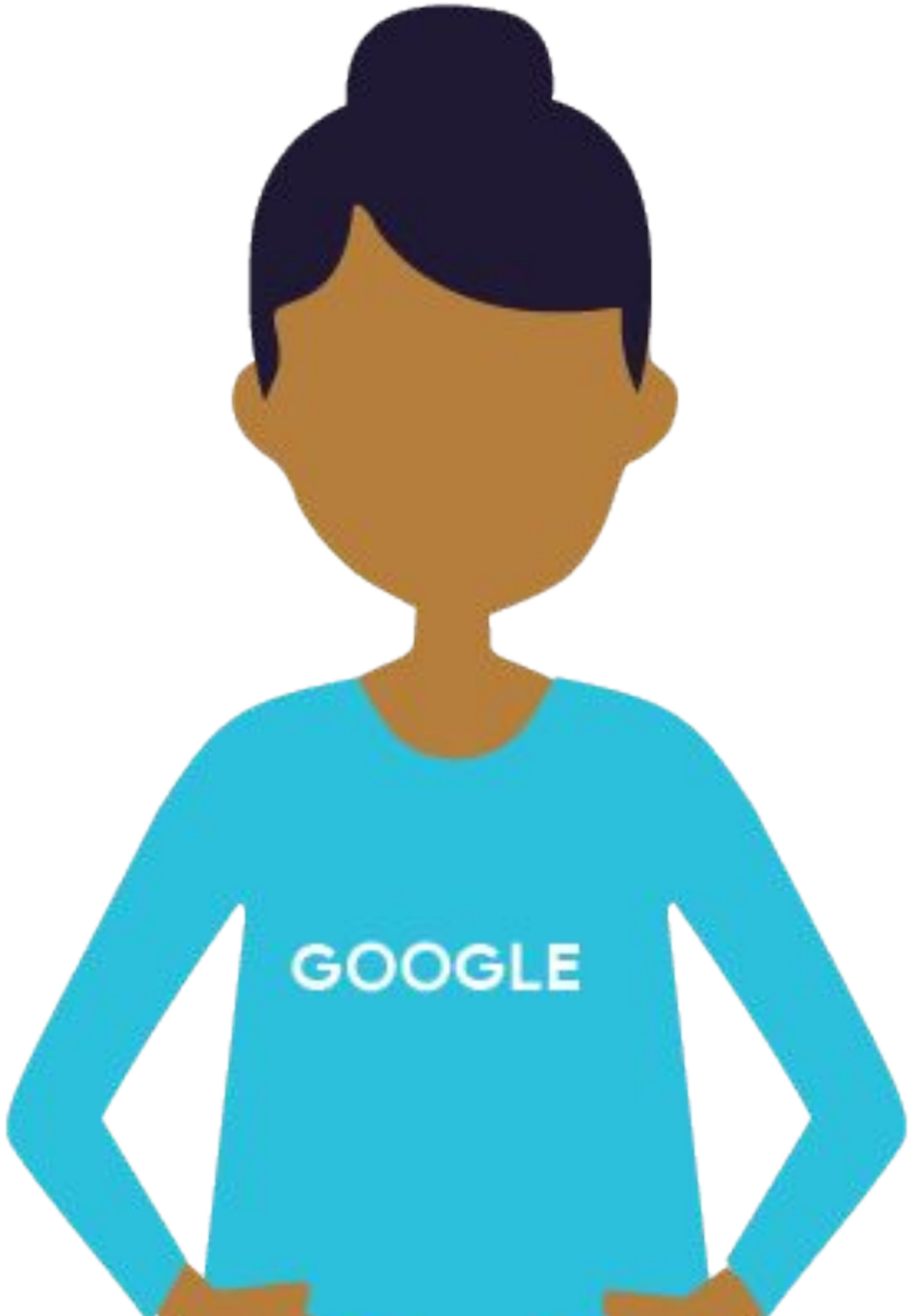
Heavyweight, non-portable
Relies on OS package manager

The new way: Deploy containers

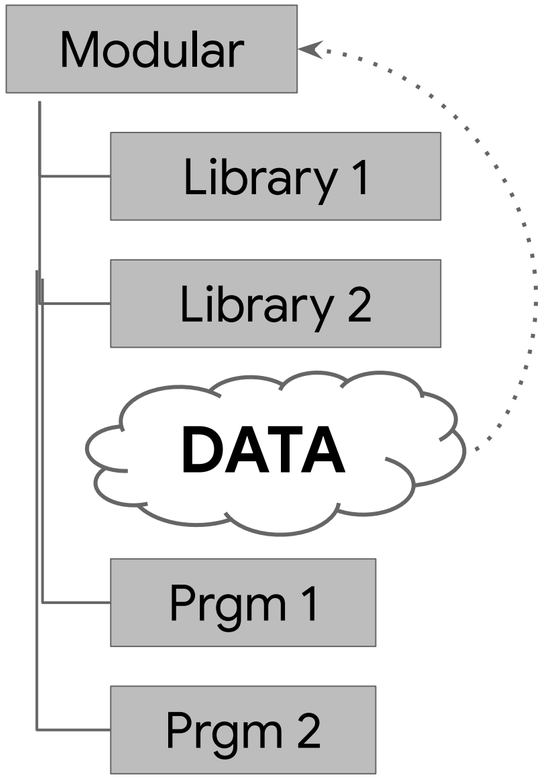


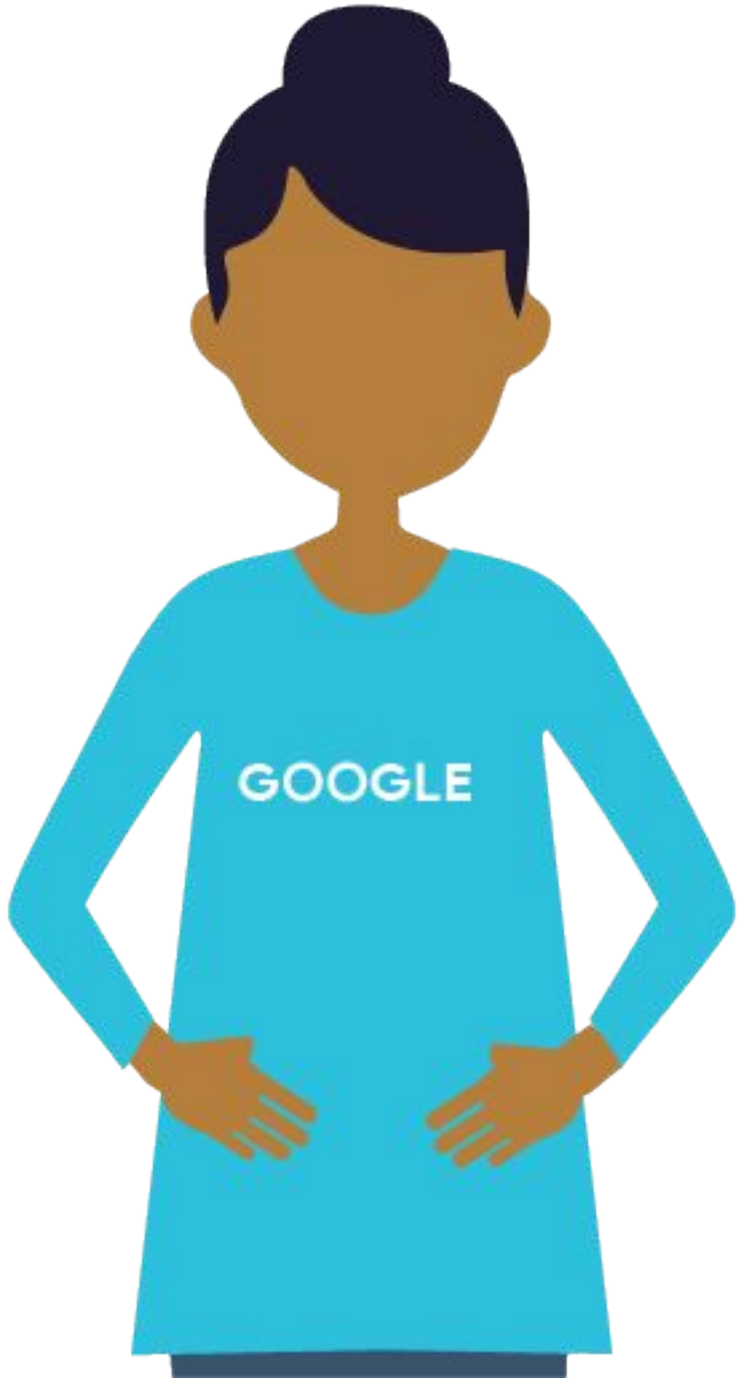
Small and fast, portable
Uses OS-level virtualization




GOOGLE

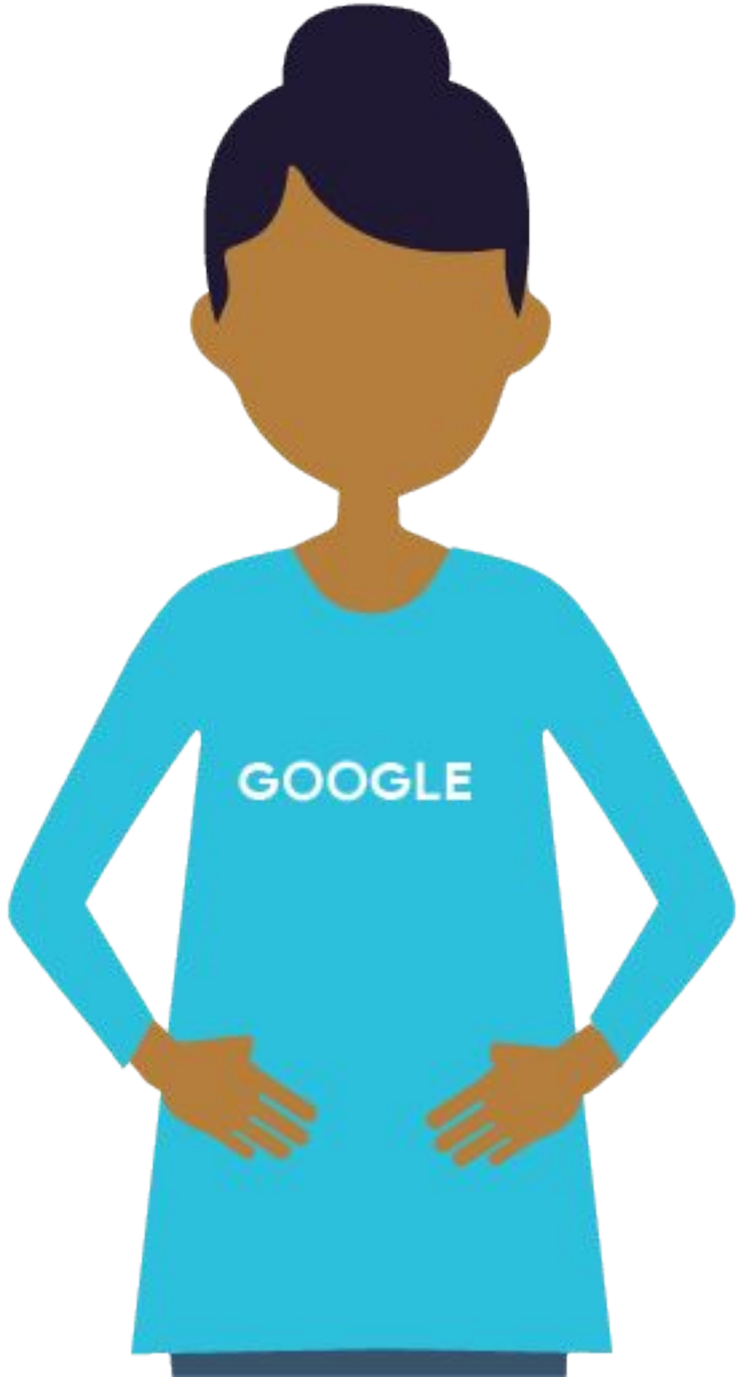
Data: the Dependency Outside the Codebase





Mismanaged Dependencies are Costly

- X Losses in prediction quality
- X Decreases to system stability
- X Decreases in team productivity



Course 2: Production ML Systems

Module 3: Designing Adaptable ML Systems

Lesson Title: **Adapting to Data**

Presenter: Max Lotstein

Format: Talking Head

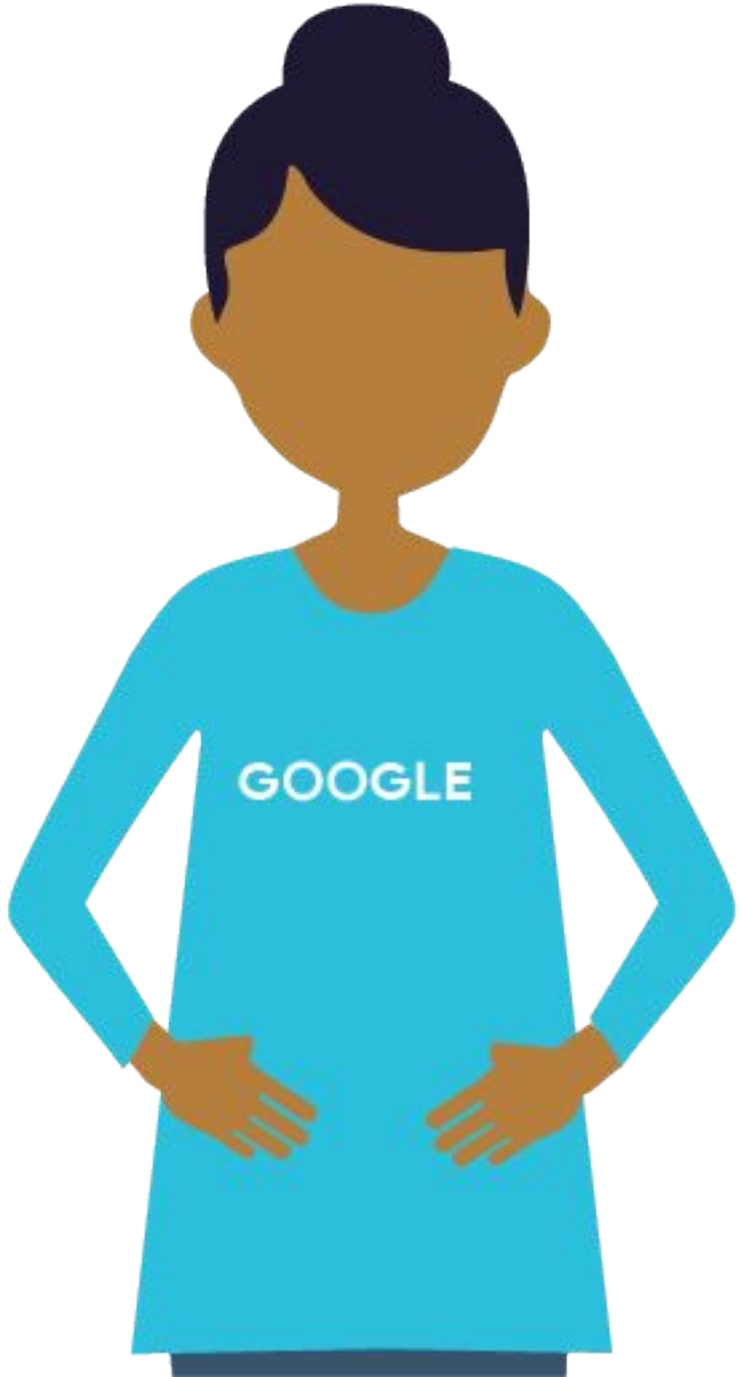
Video Name: T-PSML-O_3_l3_adapting_to_data

Agenda

Adapting to Data

Mitigating Training-Serving Skew Through Design

Debugging a Production Model

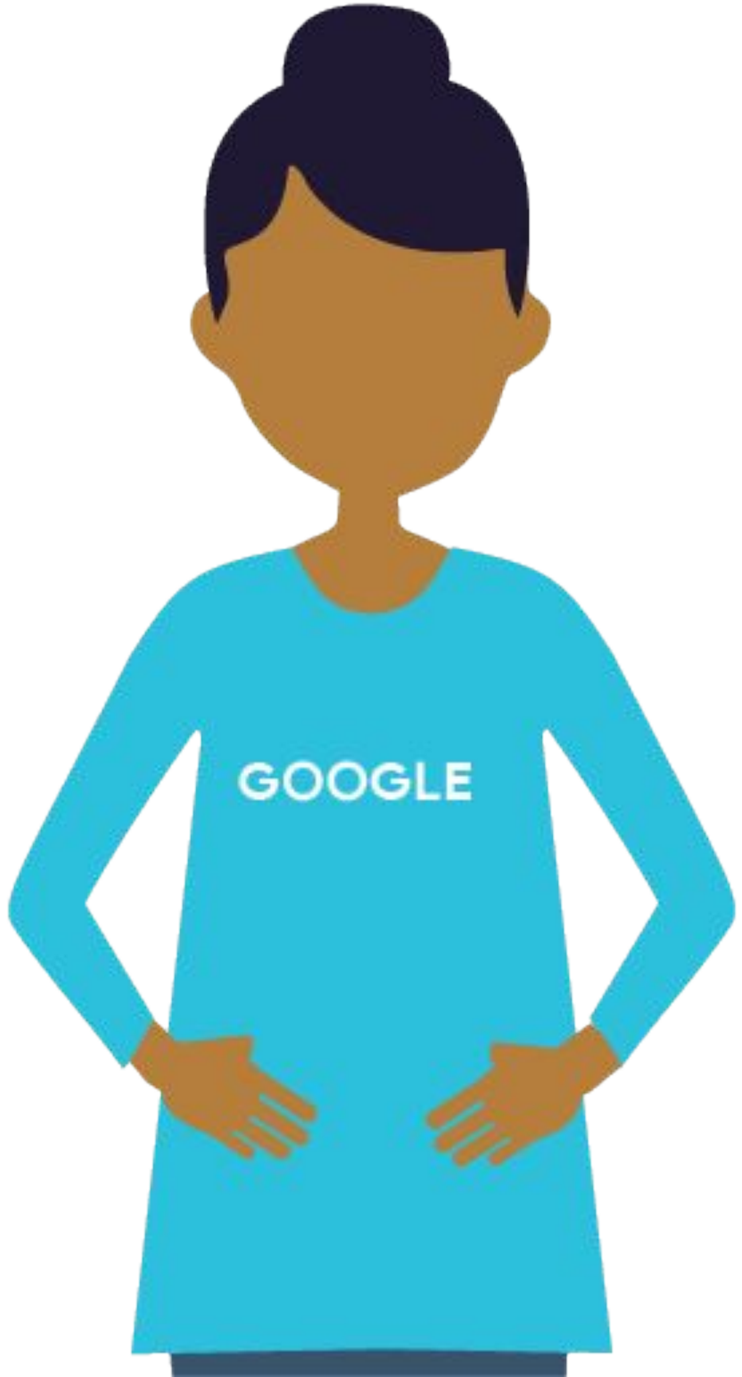


Agenda

Adapting to Data

Mitigating Training-Serving Skew Through Design

Debugging a Production Model

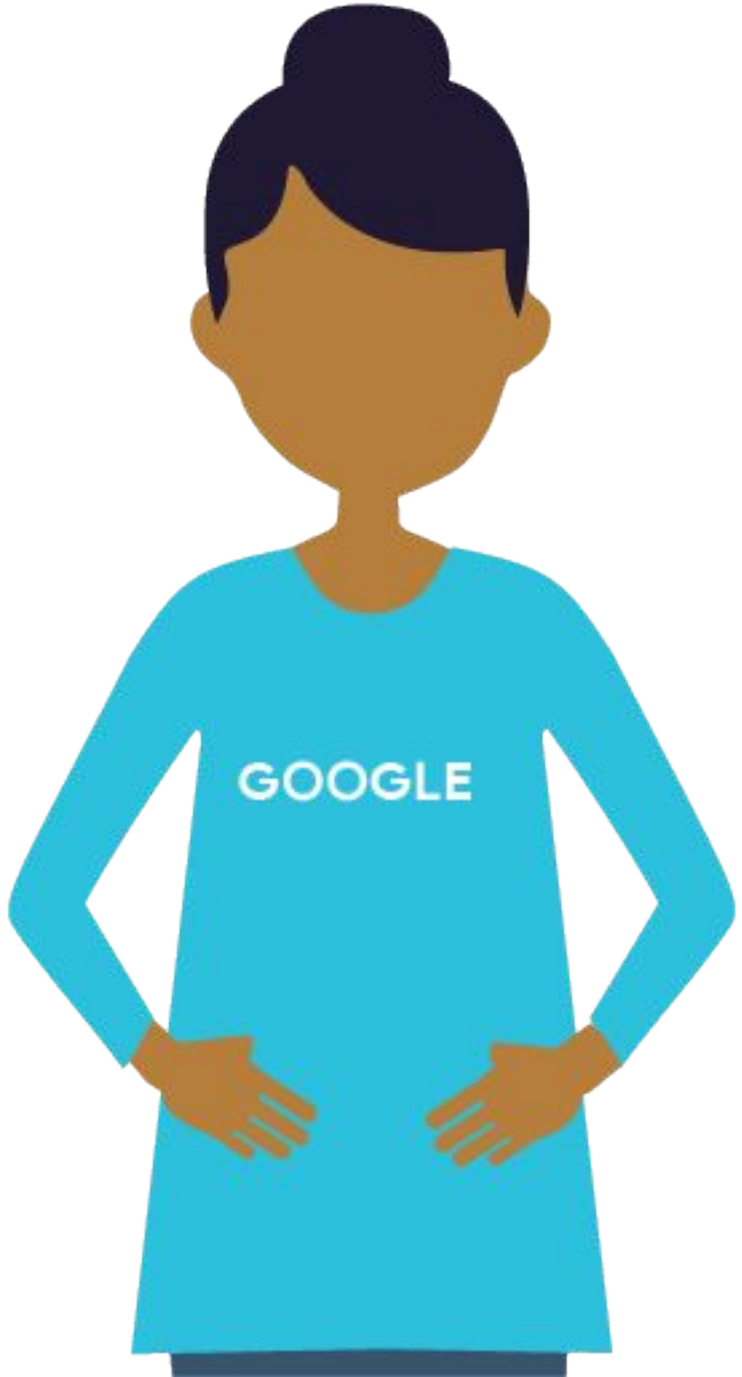


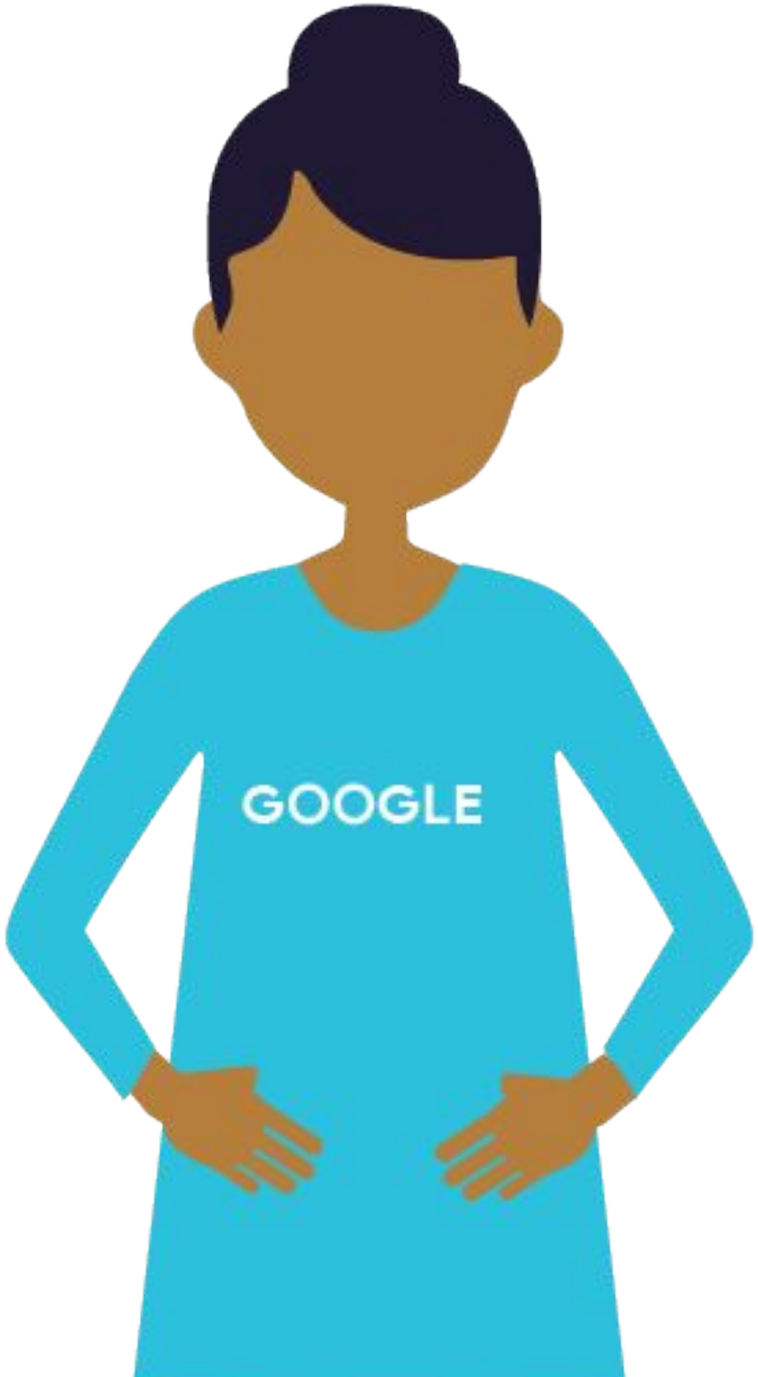
Agenda

Adapting to Data

Mitigating Training-Serving Skew Through Design

Debugging a Production Model



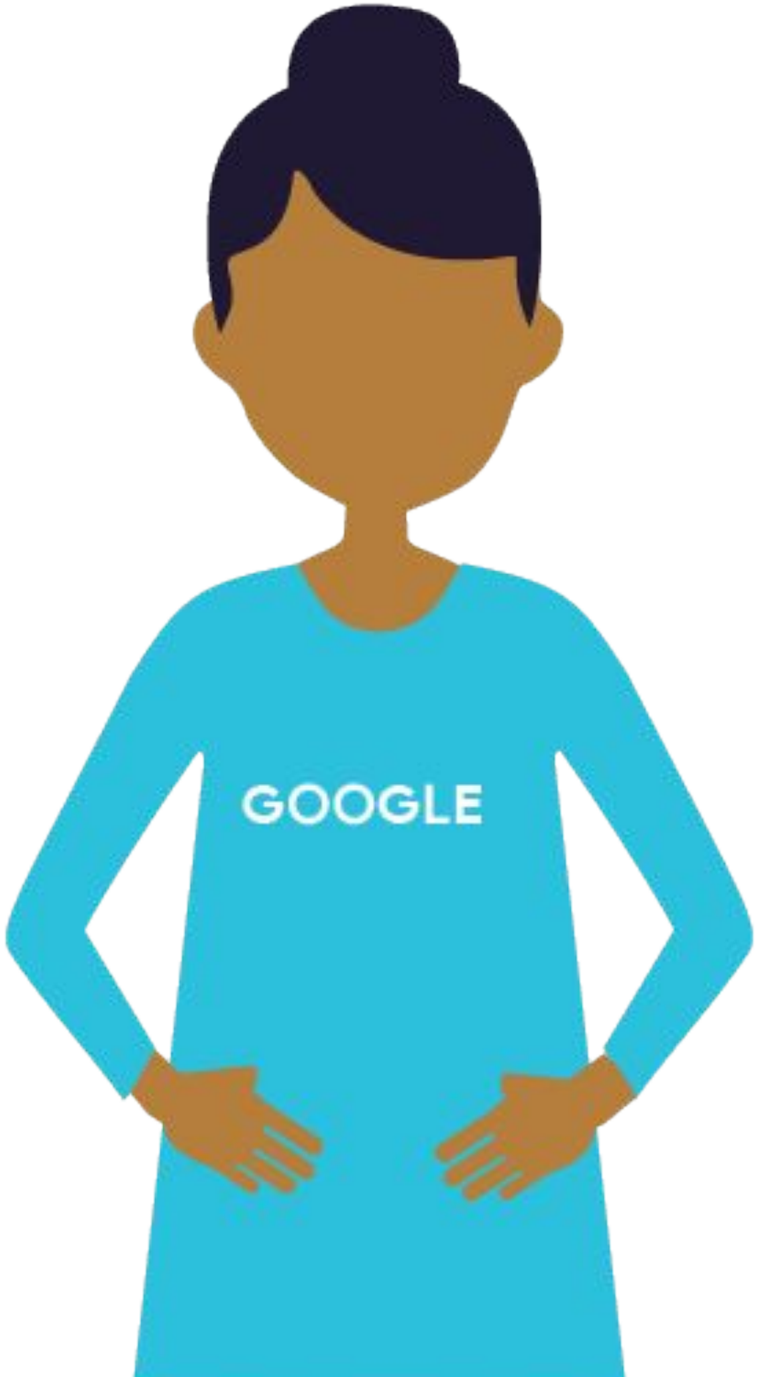


Agenda

Adapting to Data

Mitigating Training-Serving Skew Through Design

Debugging a Production Model

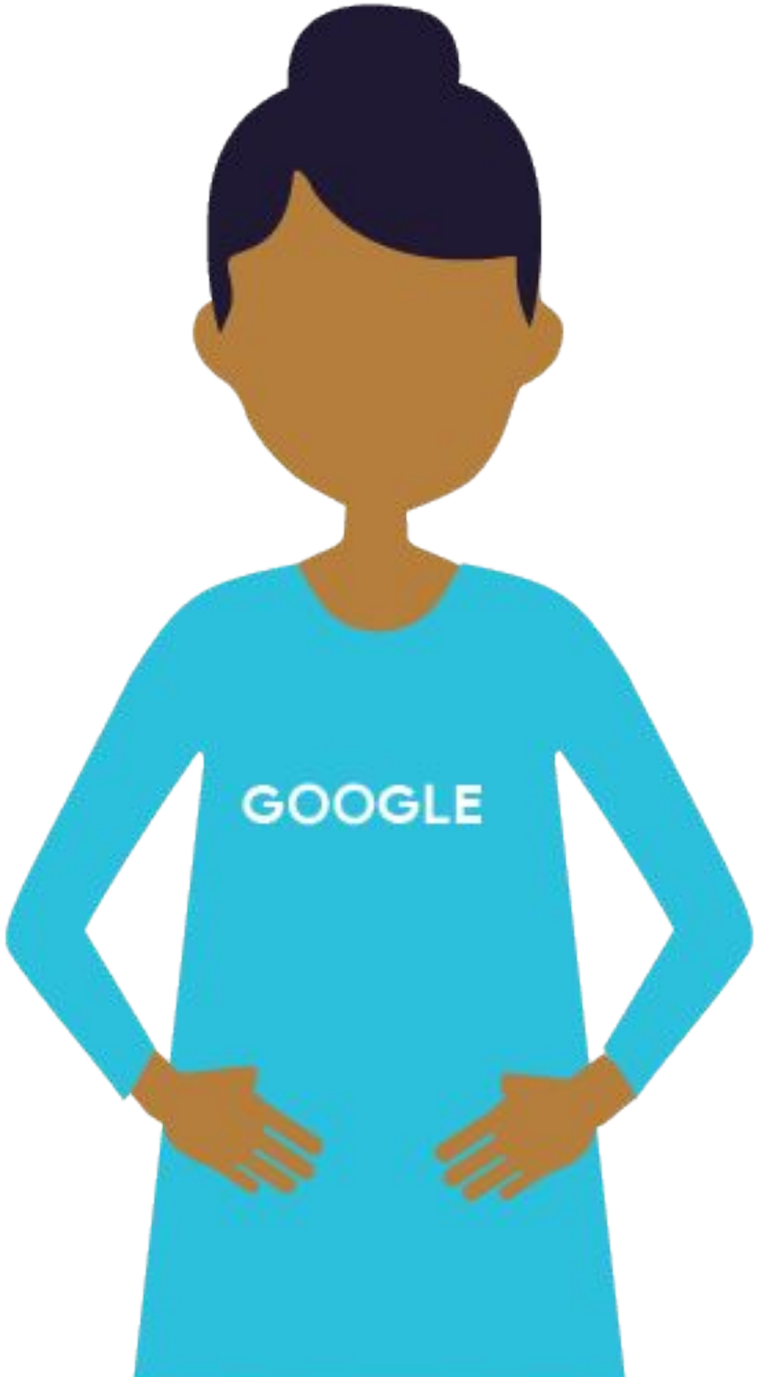


Agenda

Adapting to Data

Mitigating Training-Serving Skew Through Design

Debugging a Production Model

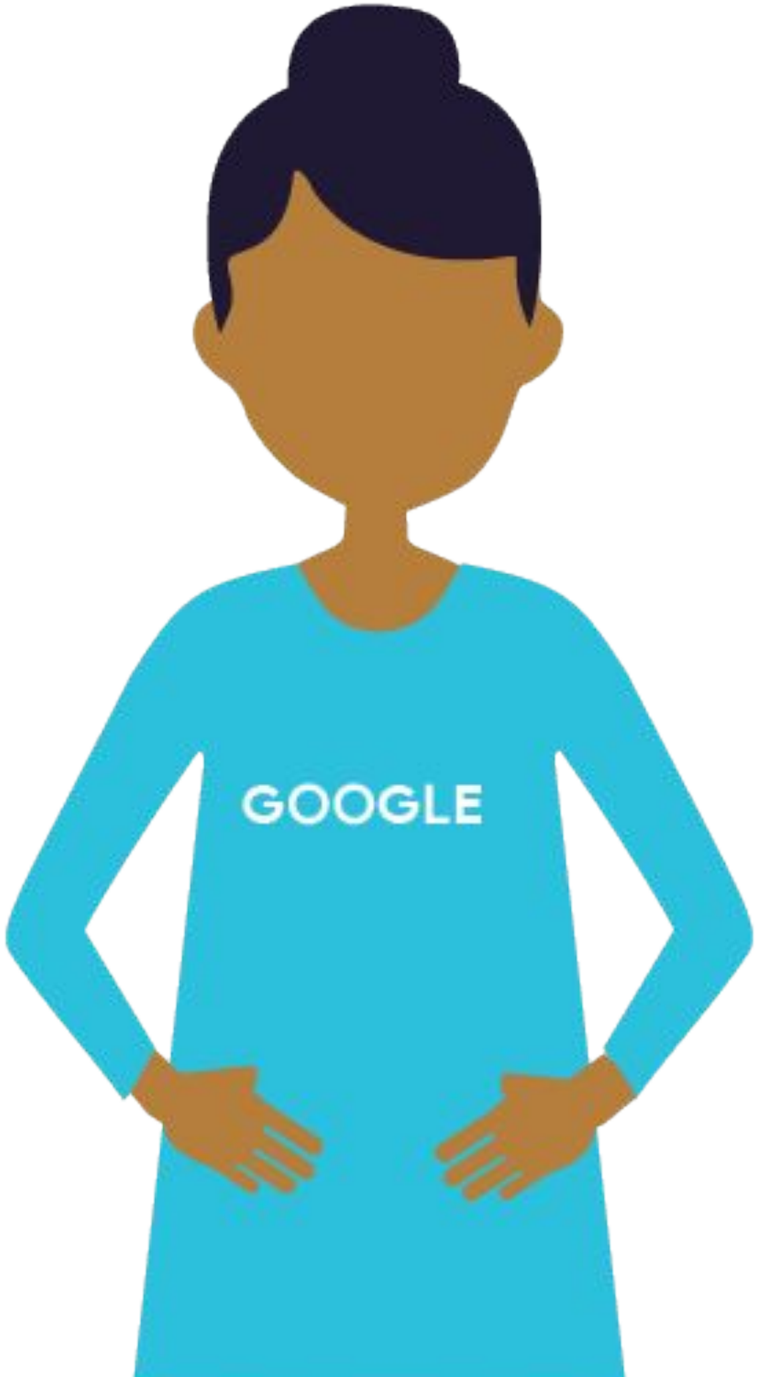


Agenda

Adapting to Data

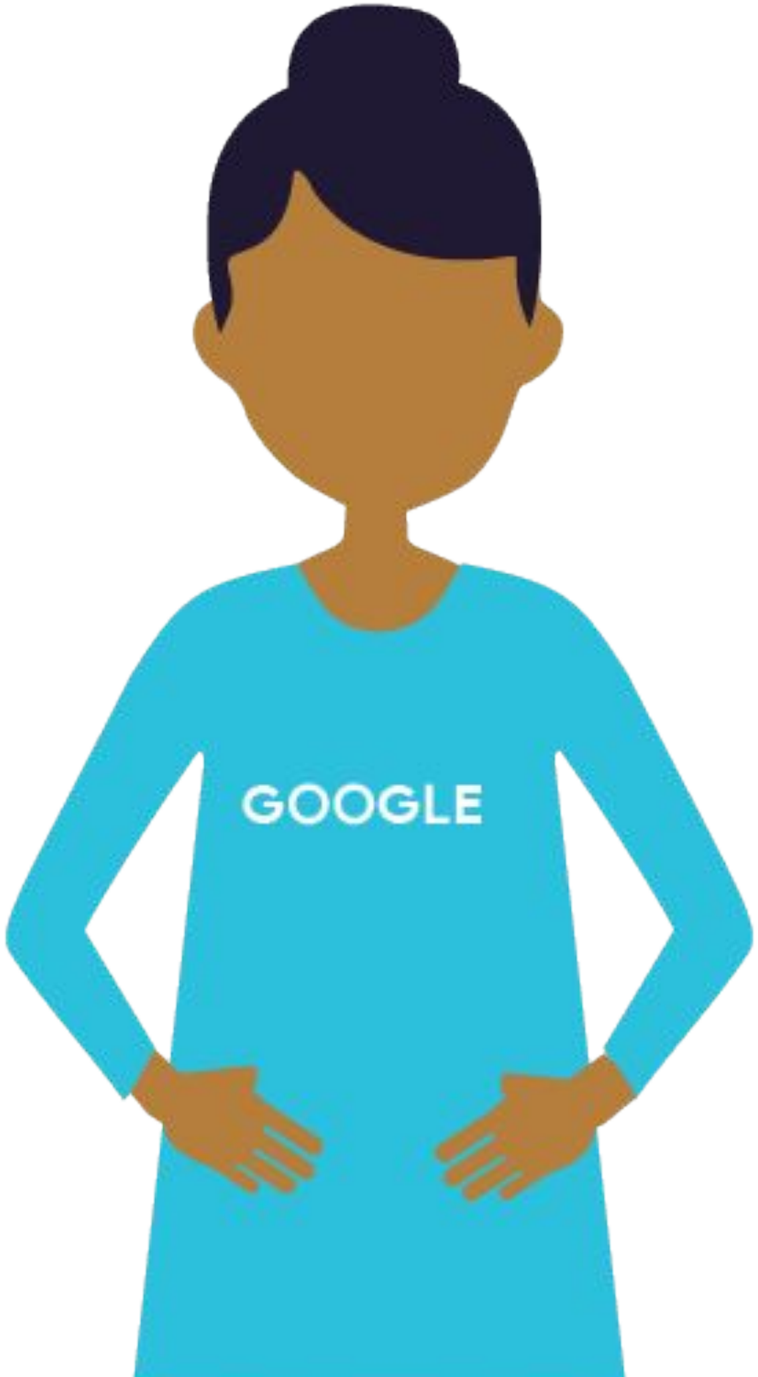
Mitigating Training-Serving Skew Through Design

Debugging a Production Model



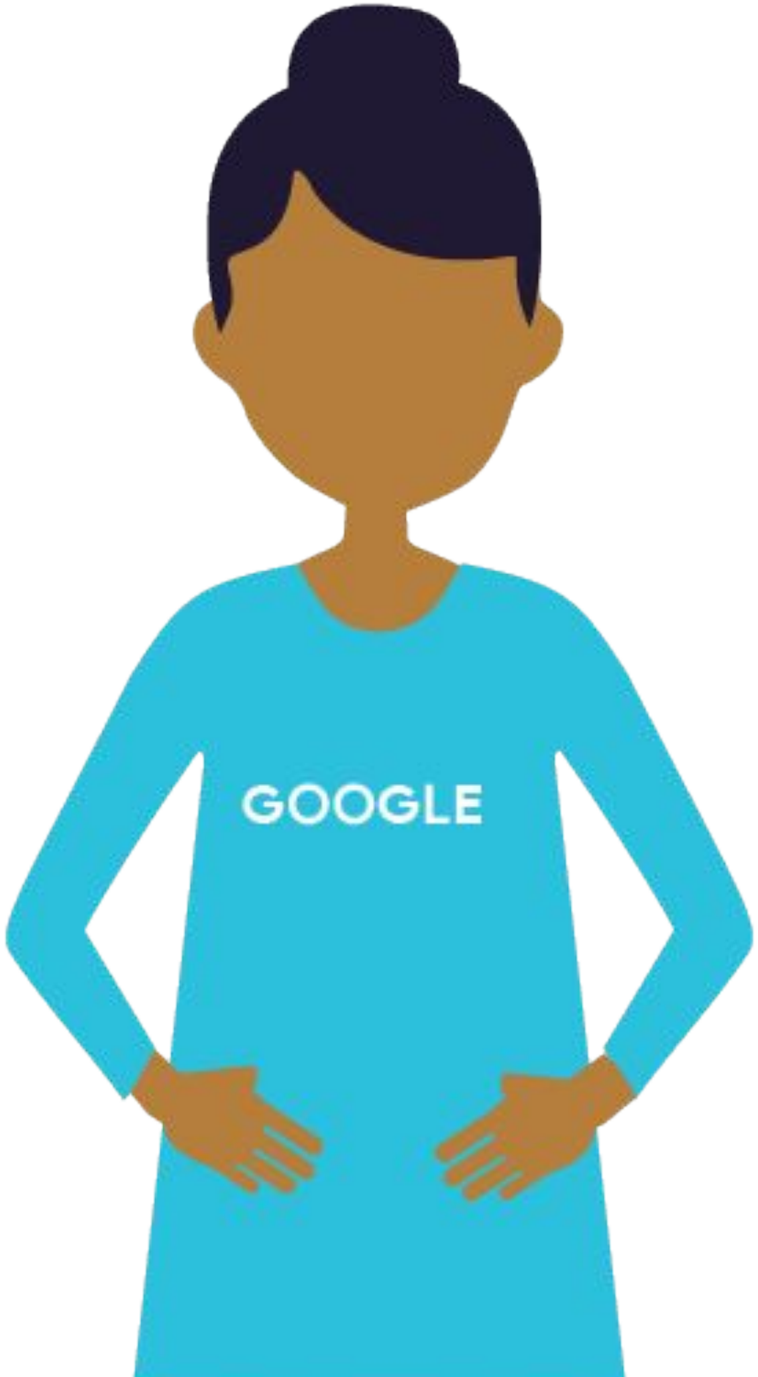
Which of these is least likely to change?

1. An upstream model
2. A data source maintained by another team
3. The relationship between features and labels
4. The distribution of inputs

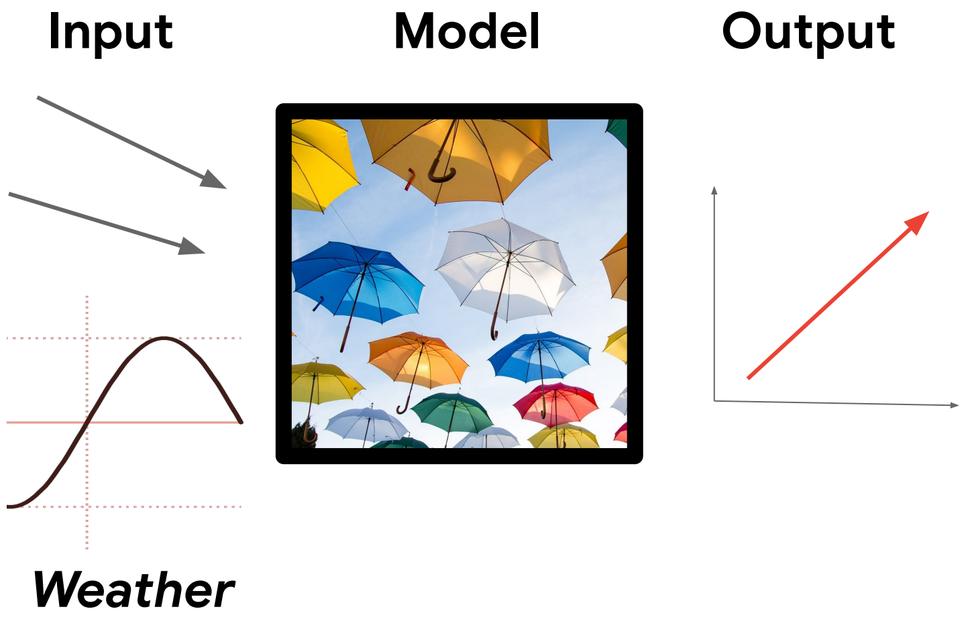


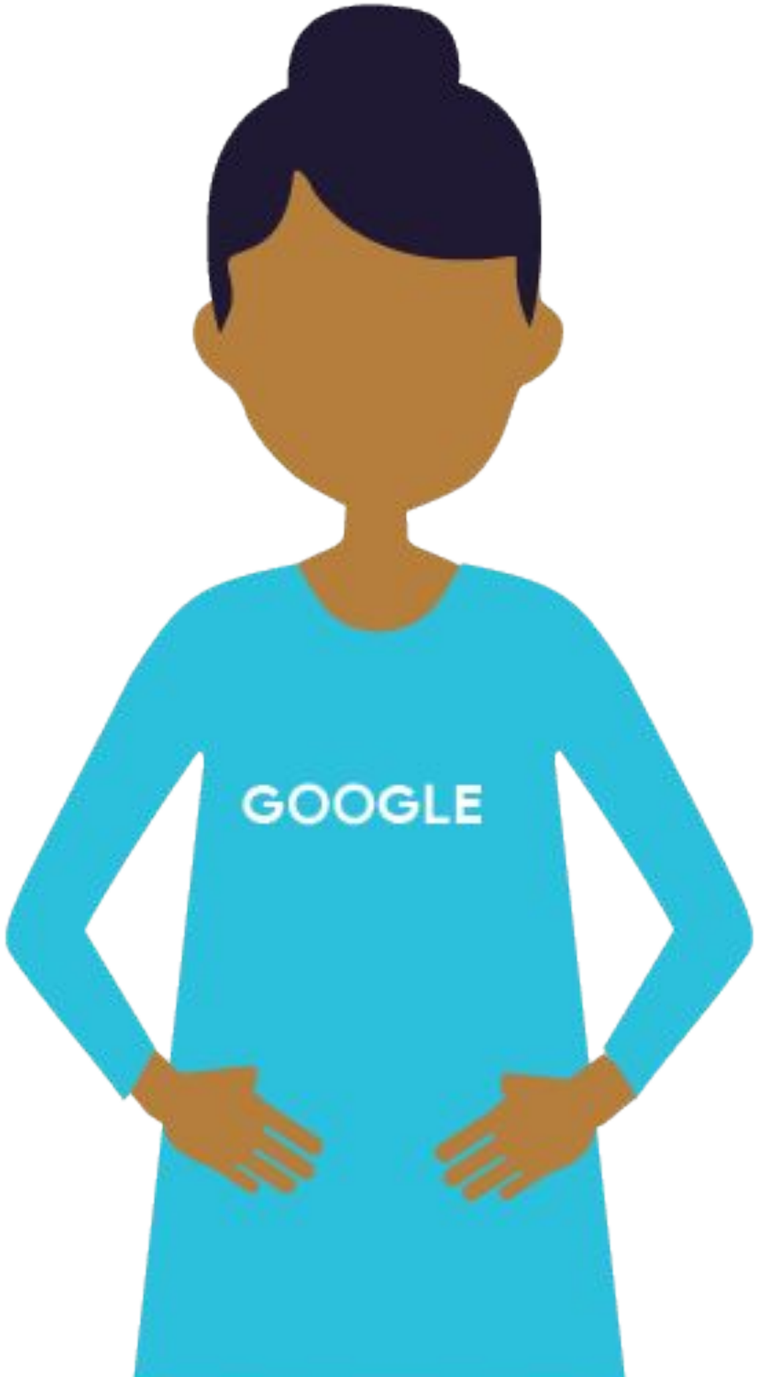
Which of these is least likely to change?

1. **An upstream model**
2. **A data source maintained by another team**
3. **The relationship between features and labels**
4. **The distribution of inputs**



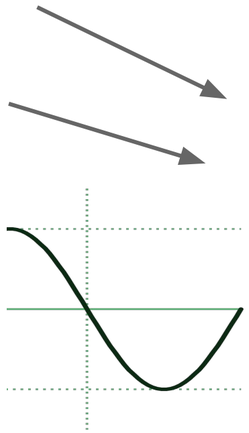
Decoupled upstream data producers



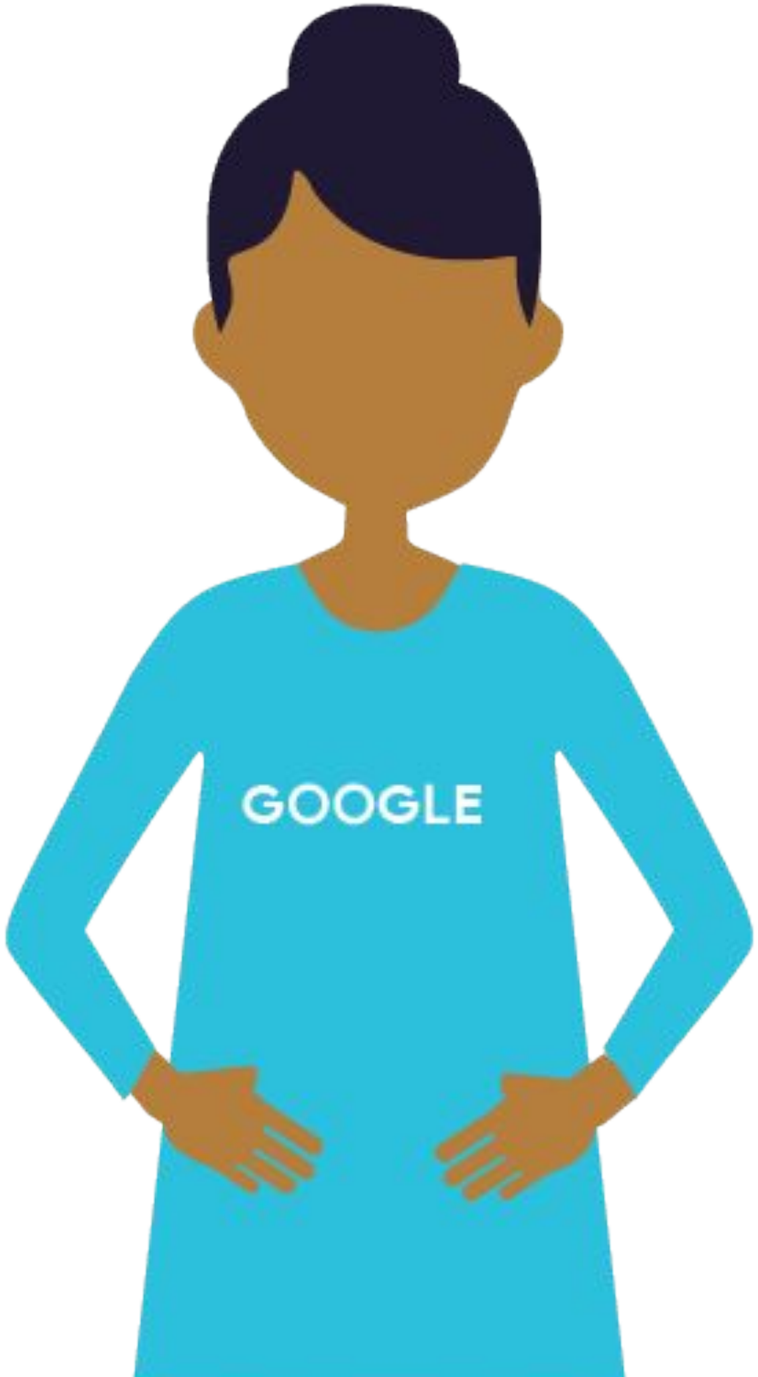


Decoupled upstream data producers

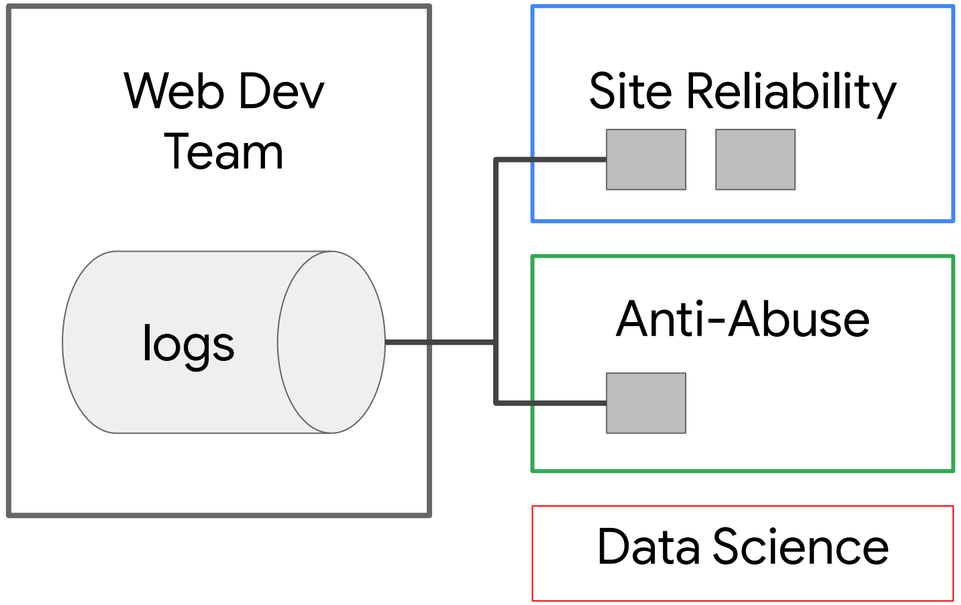
Input **Model** **Output**

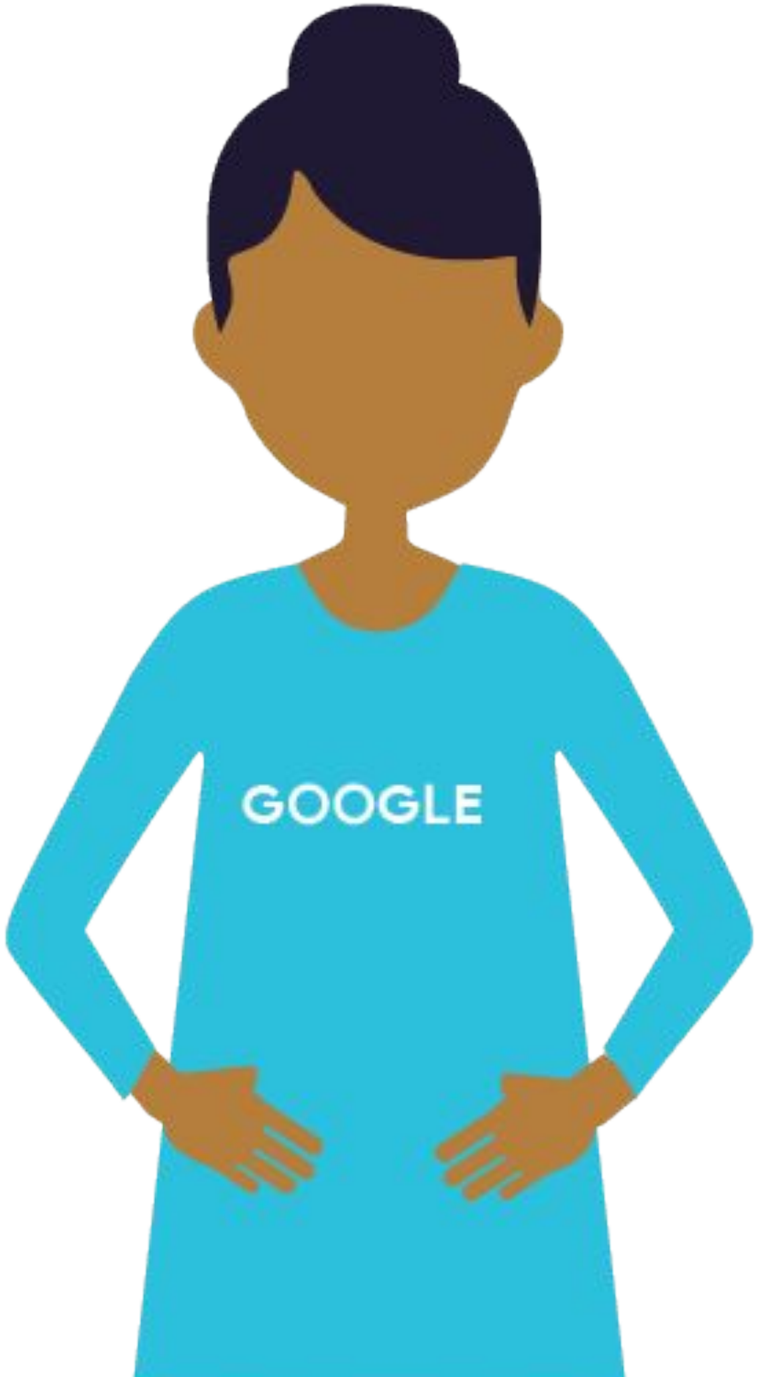


Weather

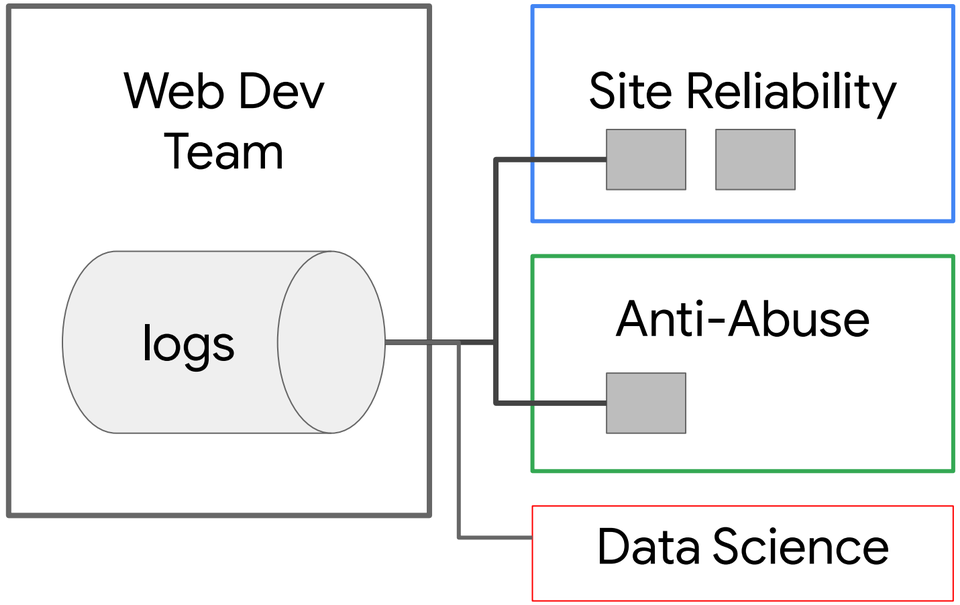


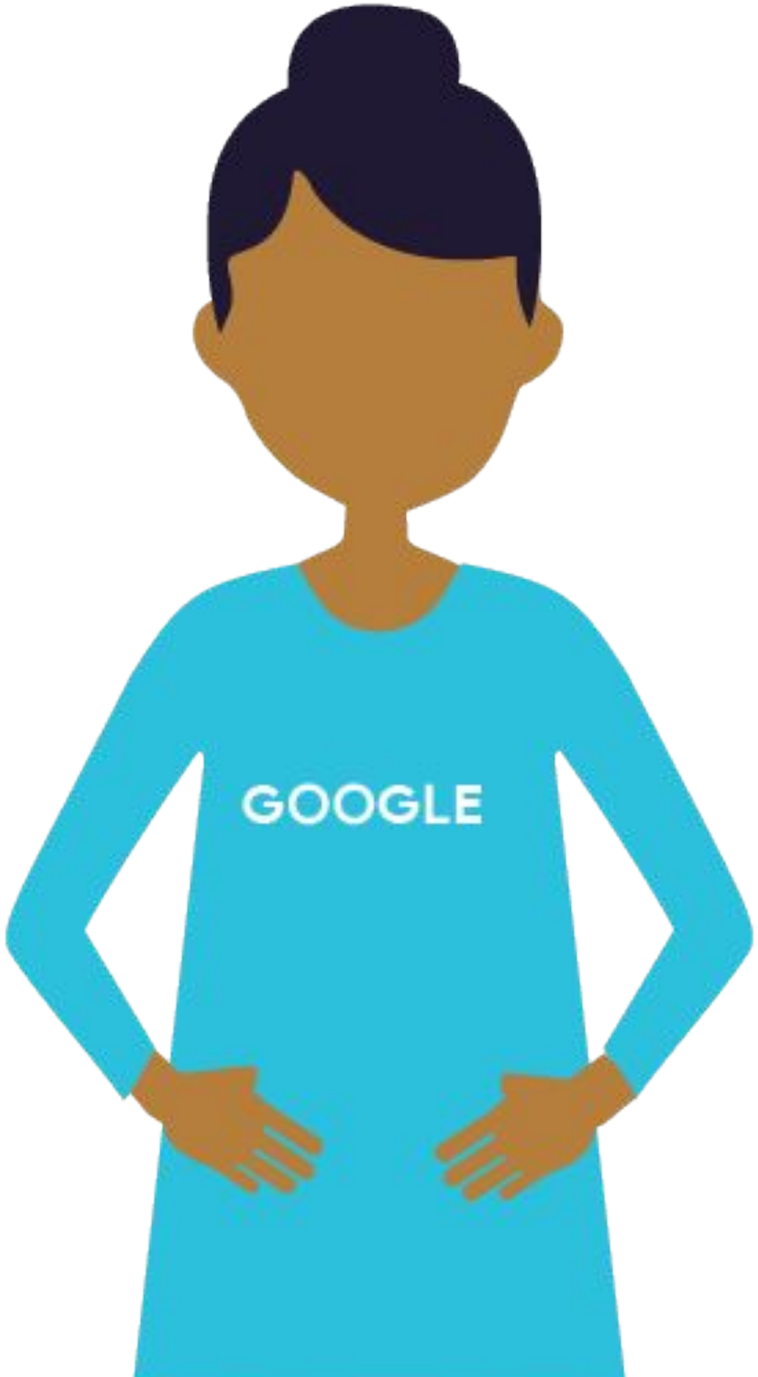
Decoupled upstream data producers





Decoupled upstream data producers





Decoupled upstream data producers

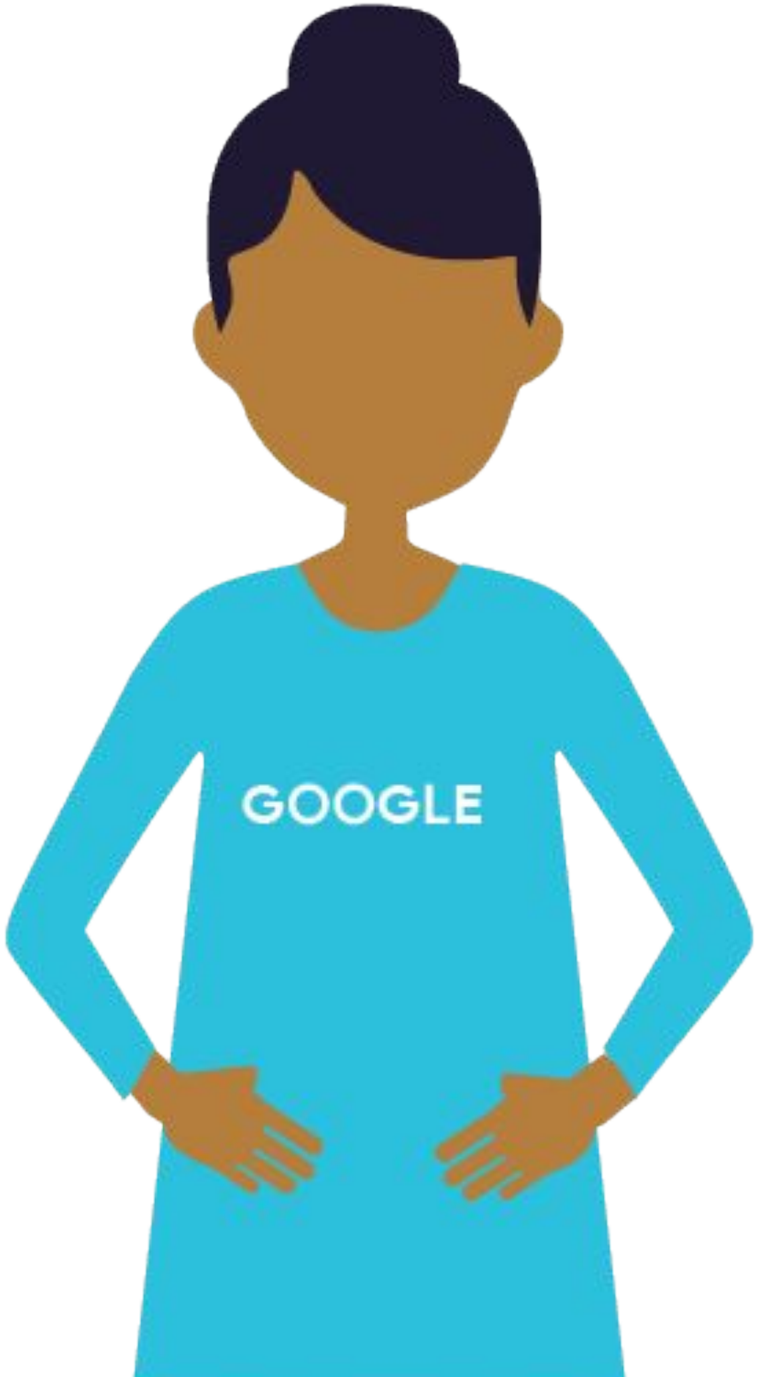
Web Dev Team

logs

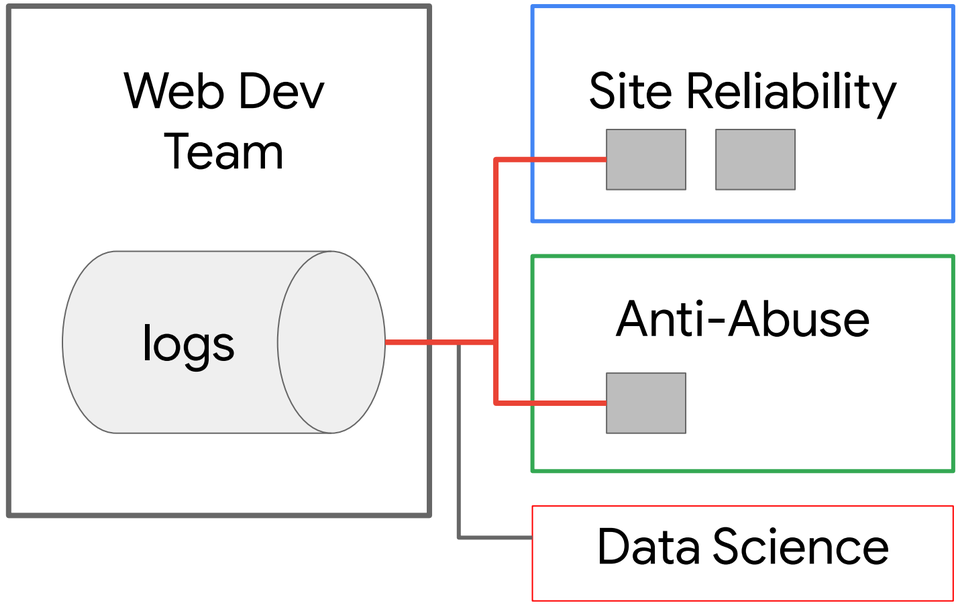
Site Reliability

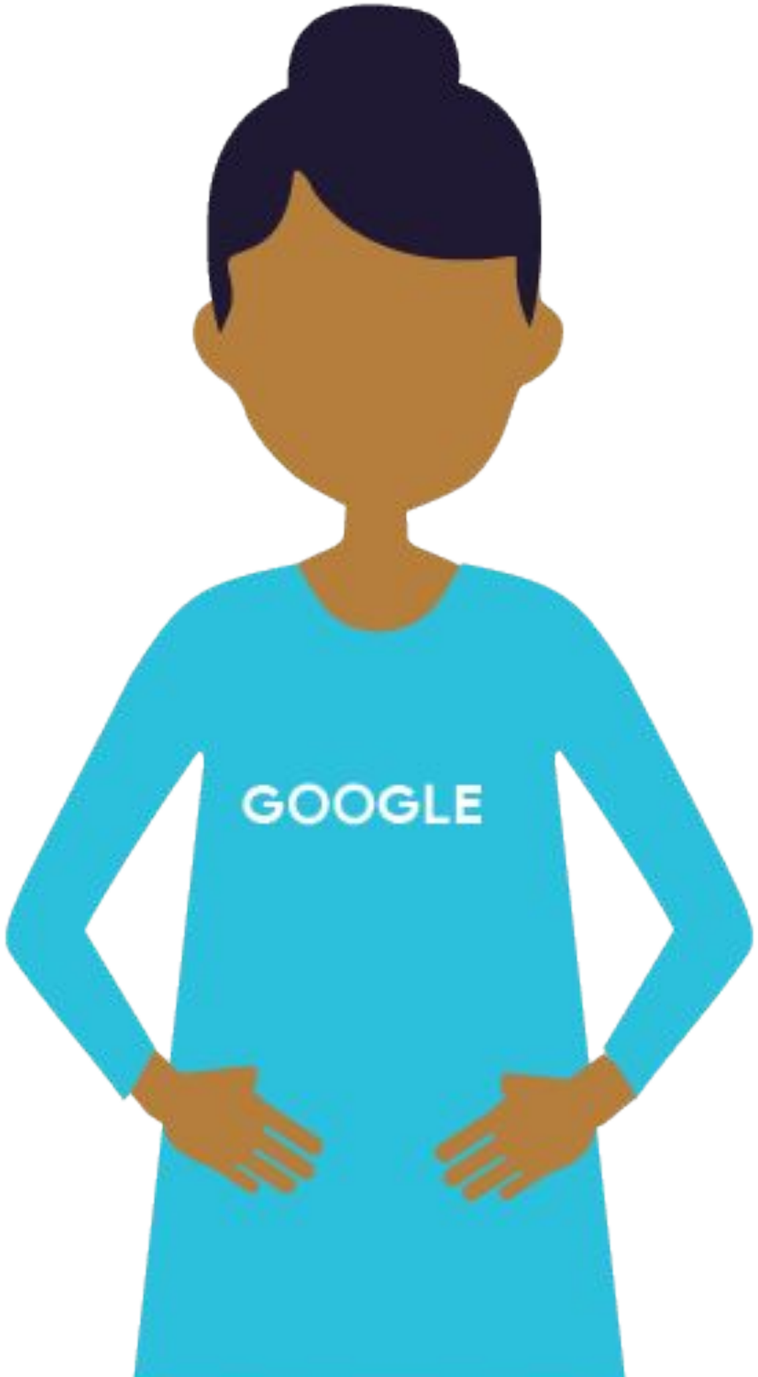
Anti-Abuse

Data Science

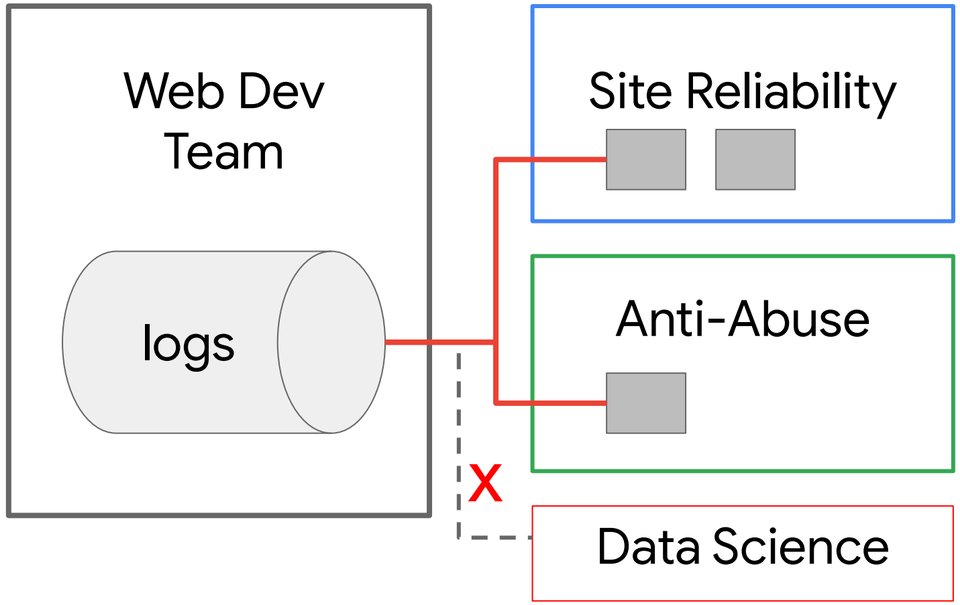


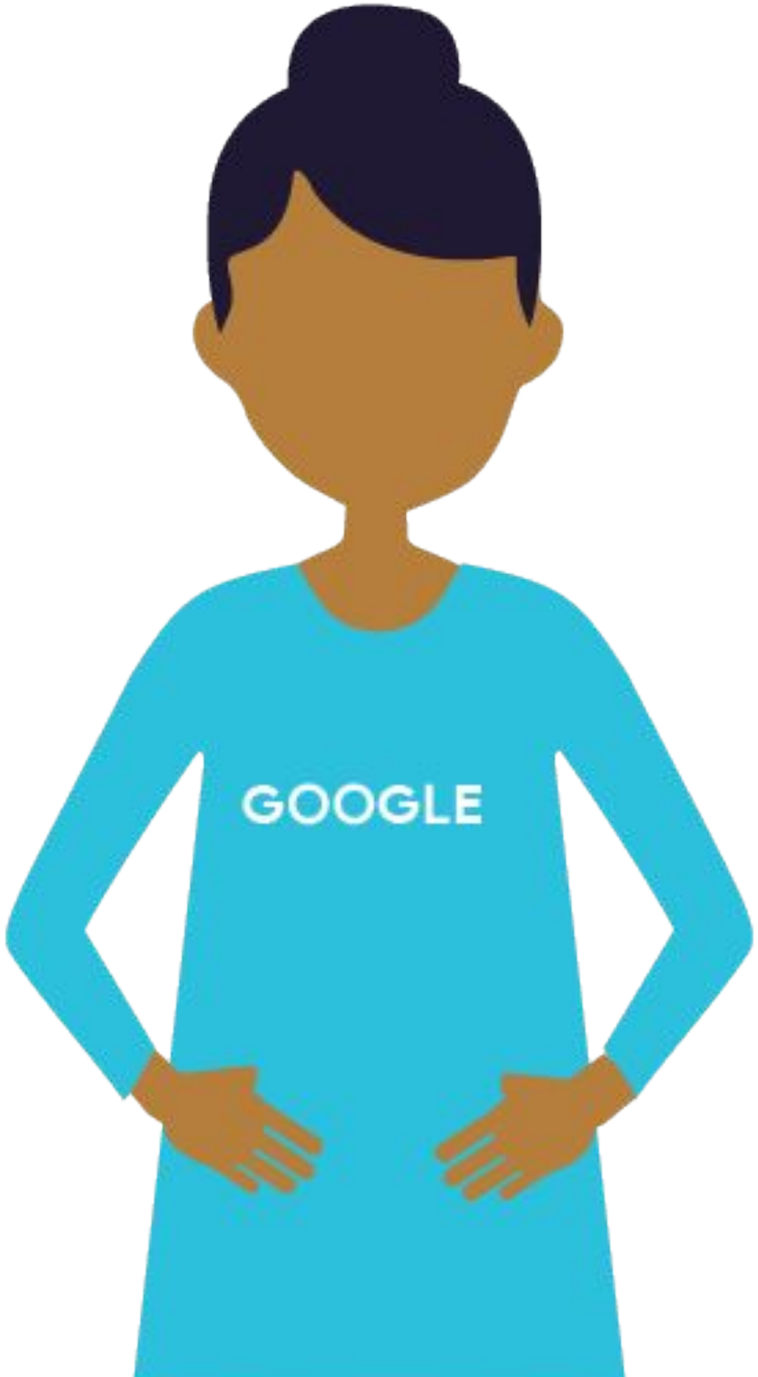
Decoupled upstream data producers



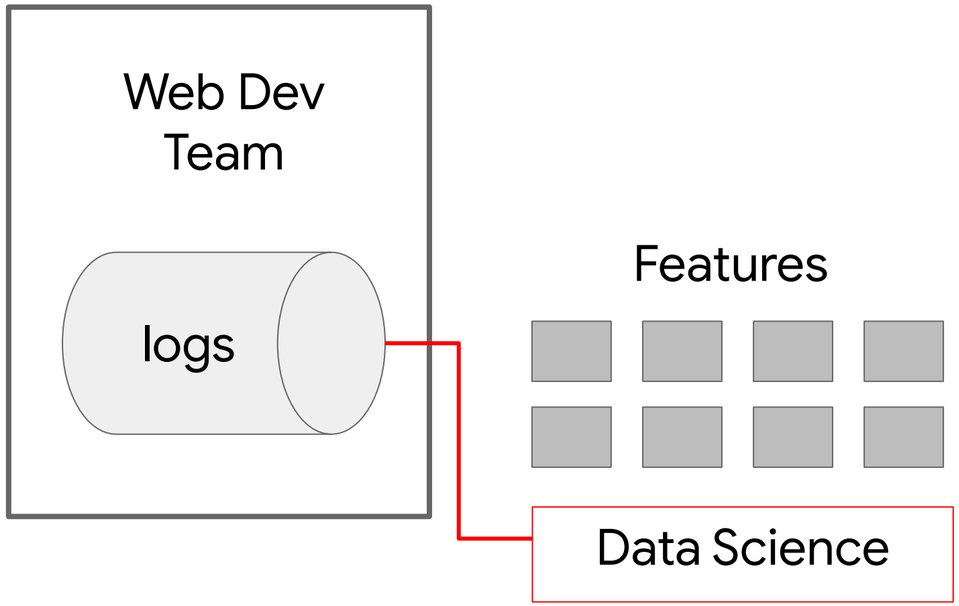


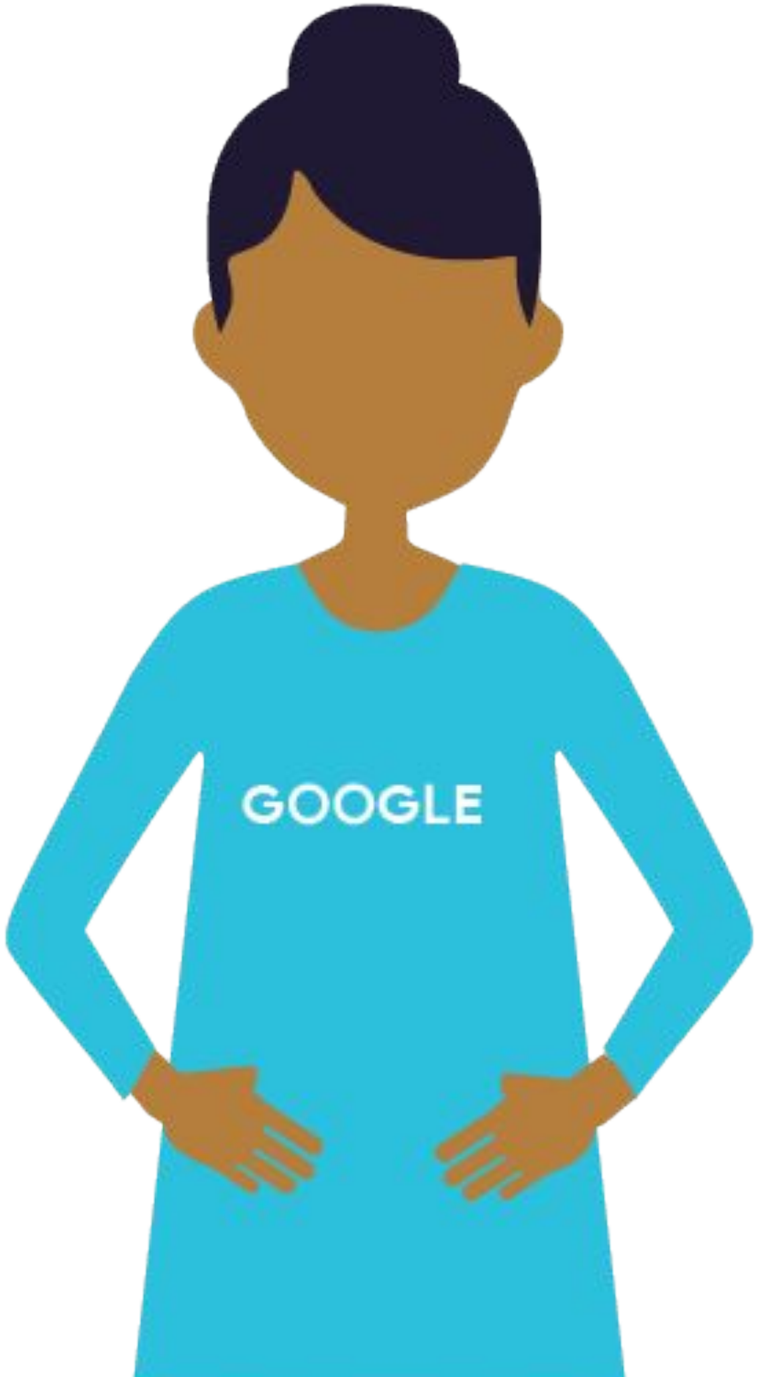
Decoupled upstream data producers



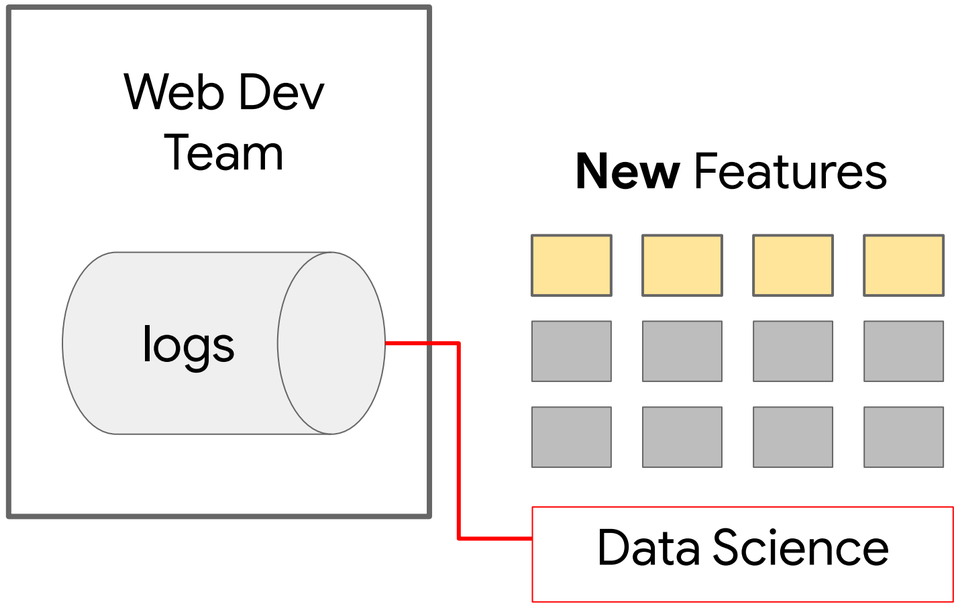


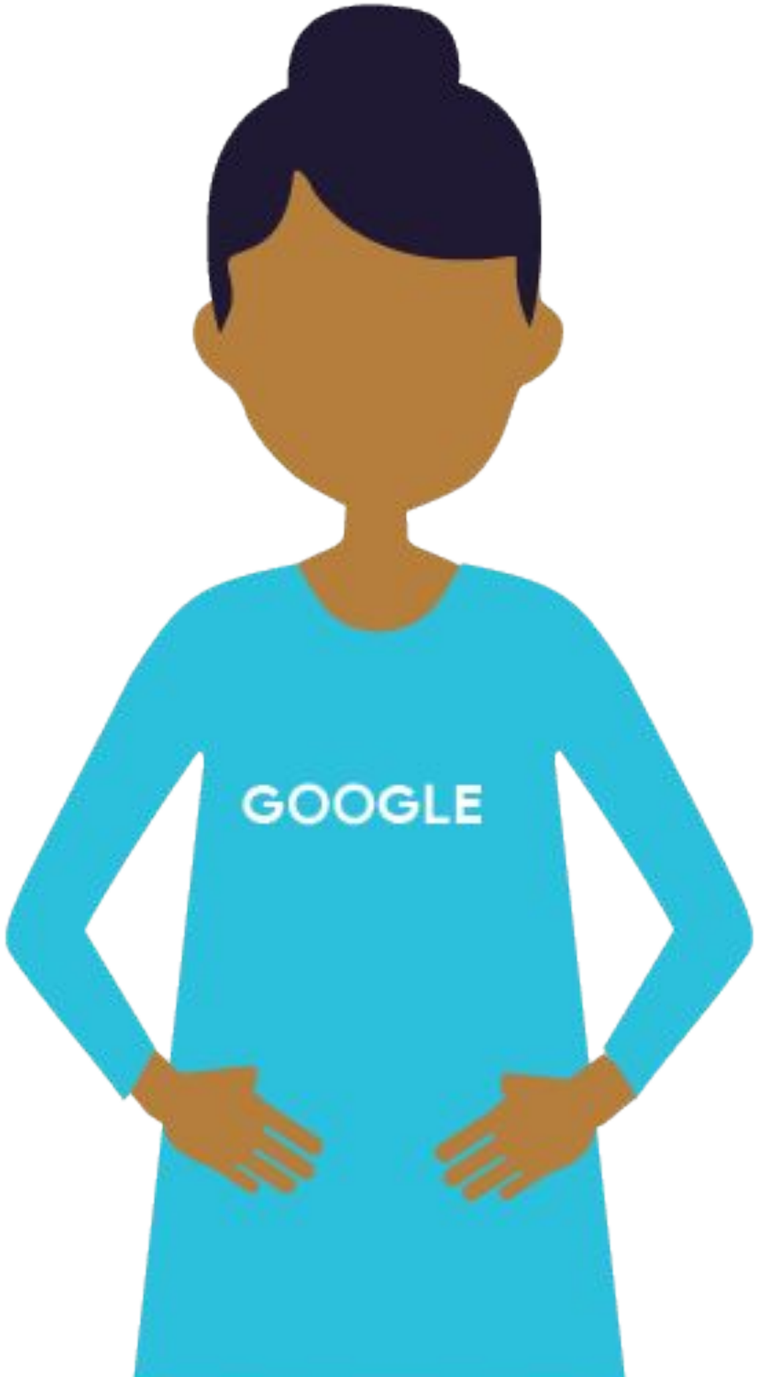
Underutilized data dependencies



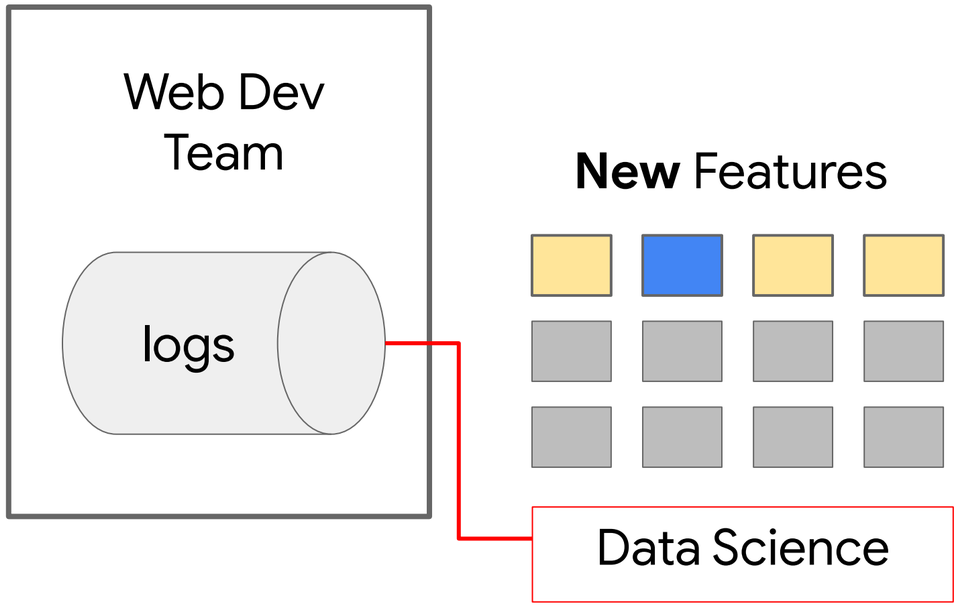


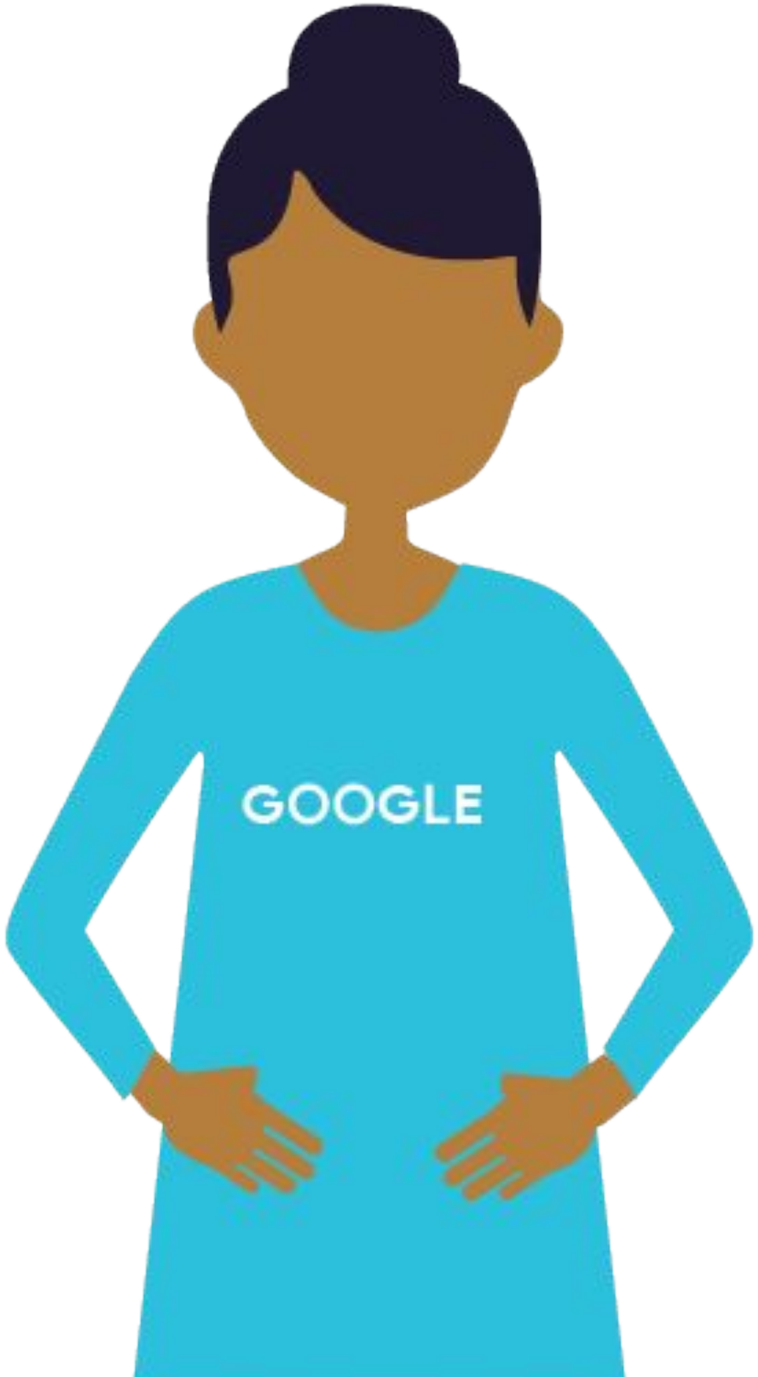
Underutilized data dependencies



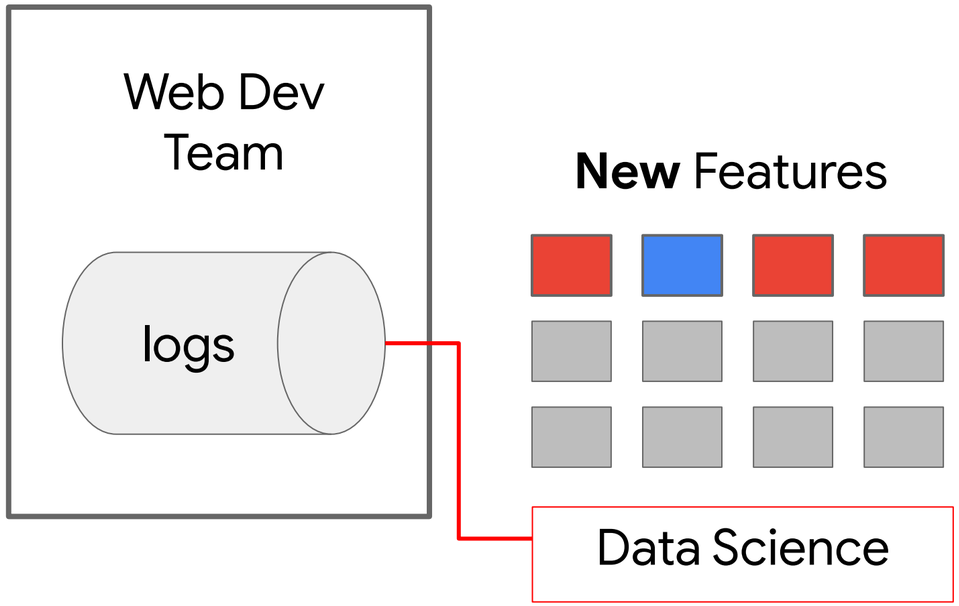


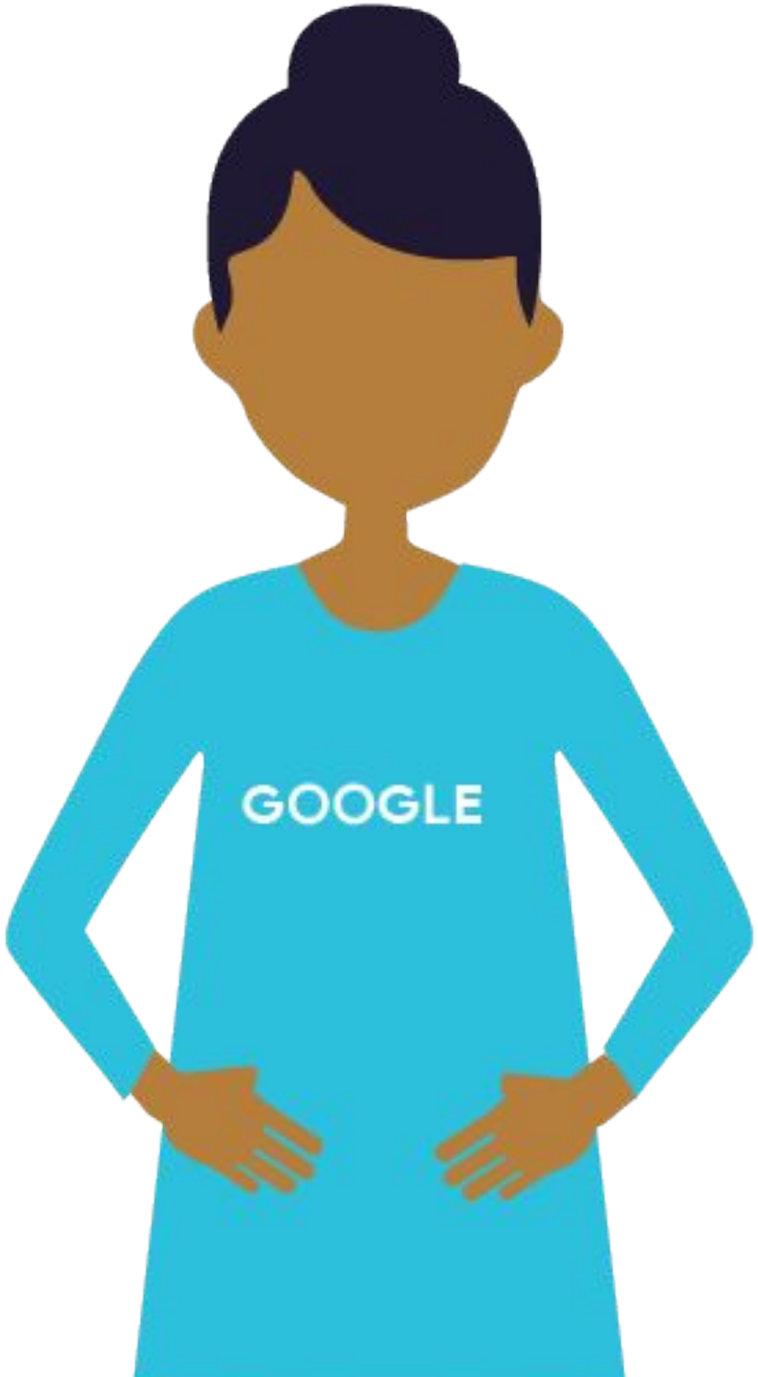
Underutilized data dependencies





Underutilized data dependencies





Underutilized data dependencies

Web Dev Team

logs

Rigorously assess all features

New Features

Data Science

Course 2: Production ML Systems

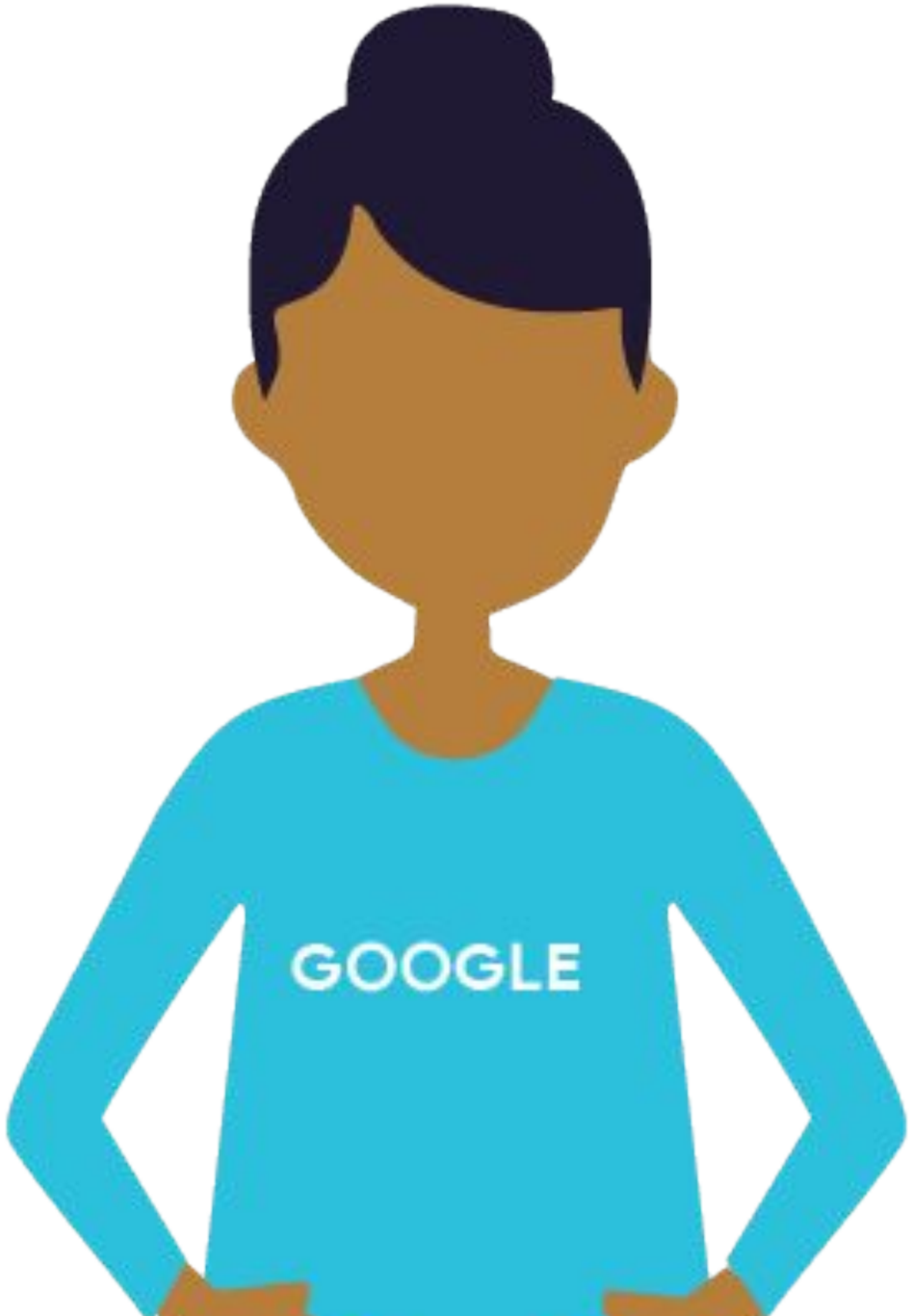
Module 3: Designing Adaptable ML Systems

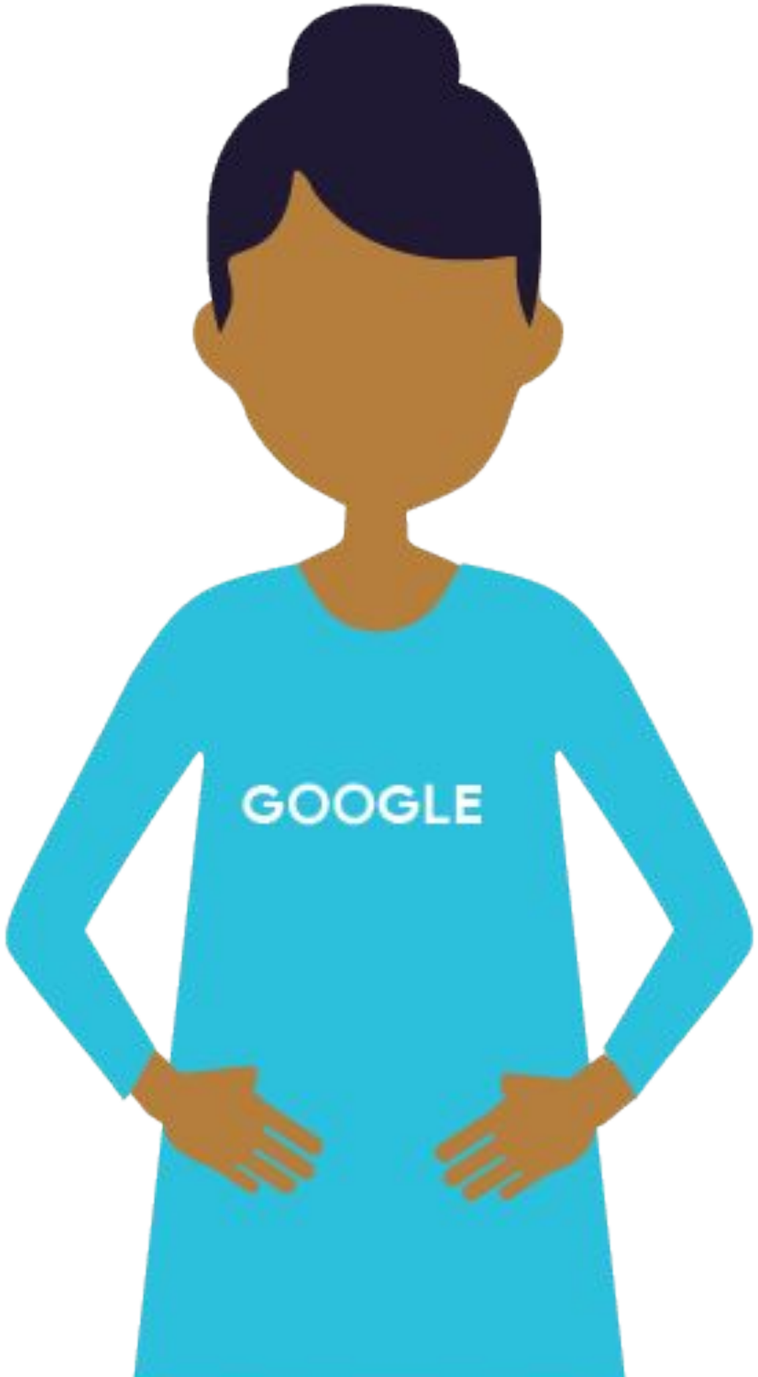
Lesson Title: **Adapting to Data: Changing Distributions**

Presenter: Max Lotstein

Format: Talking Head

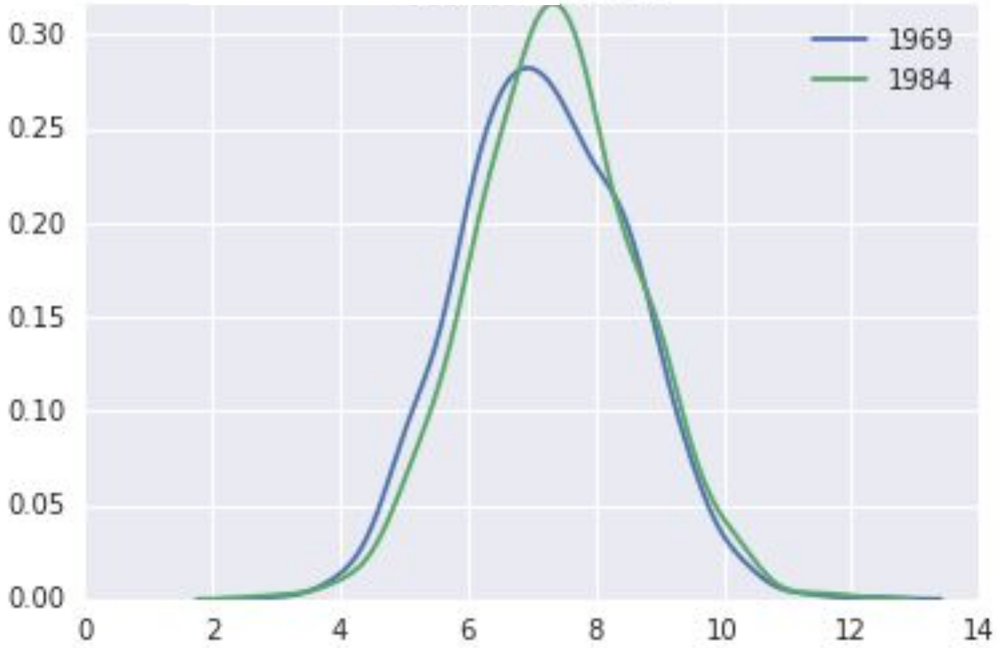
Video Name:
T-PSML-O_3_l4_adapting_to_data:_changing_distributions

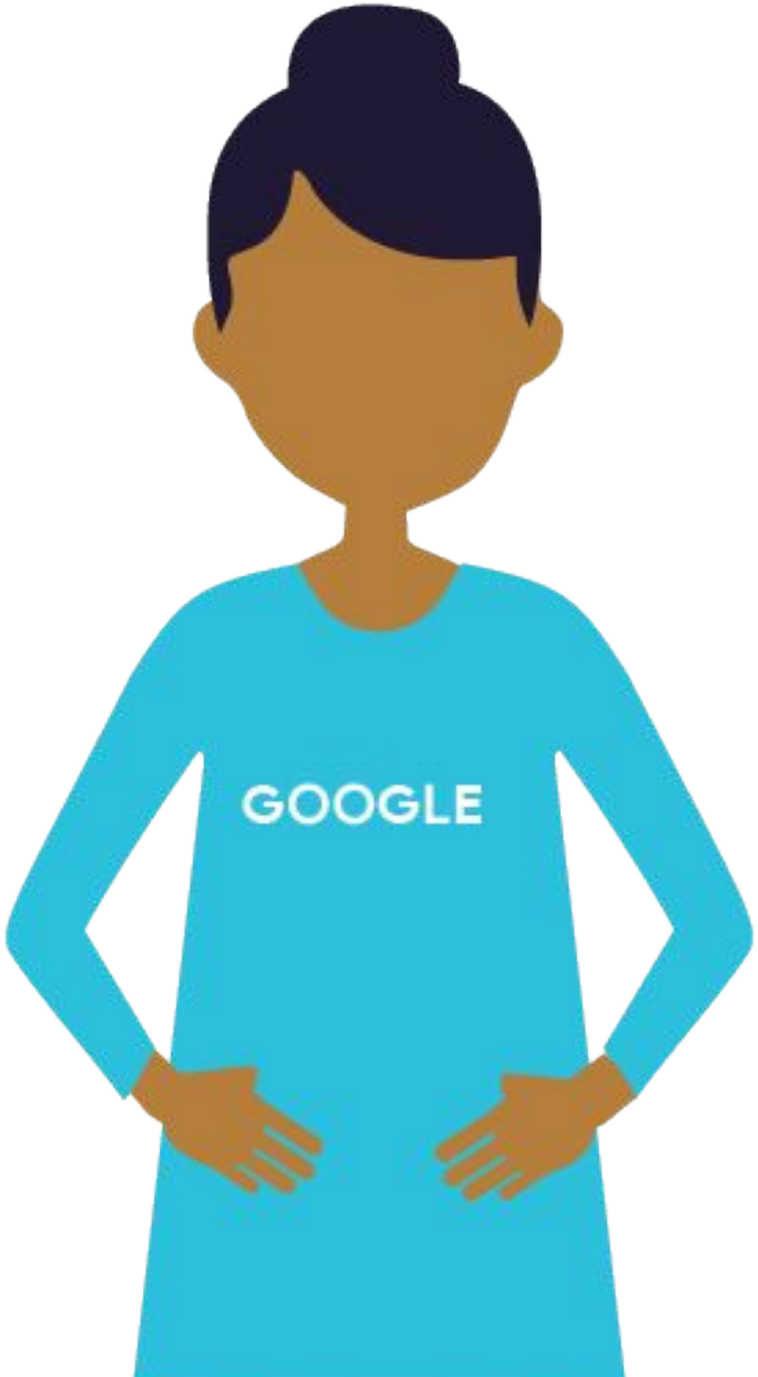

GOOGLE



Distributions change

Baby weight in 1969 and 1984



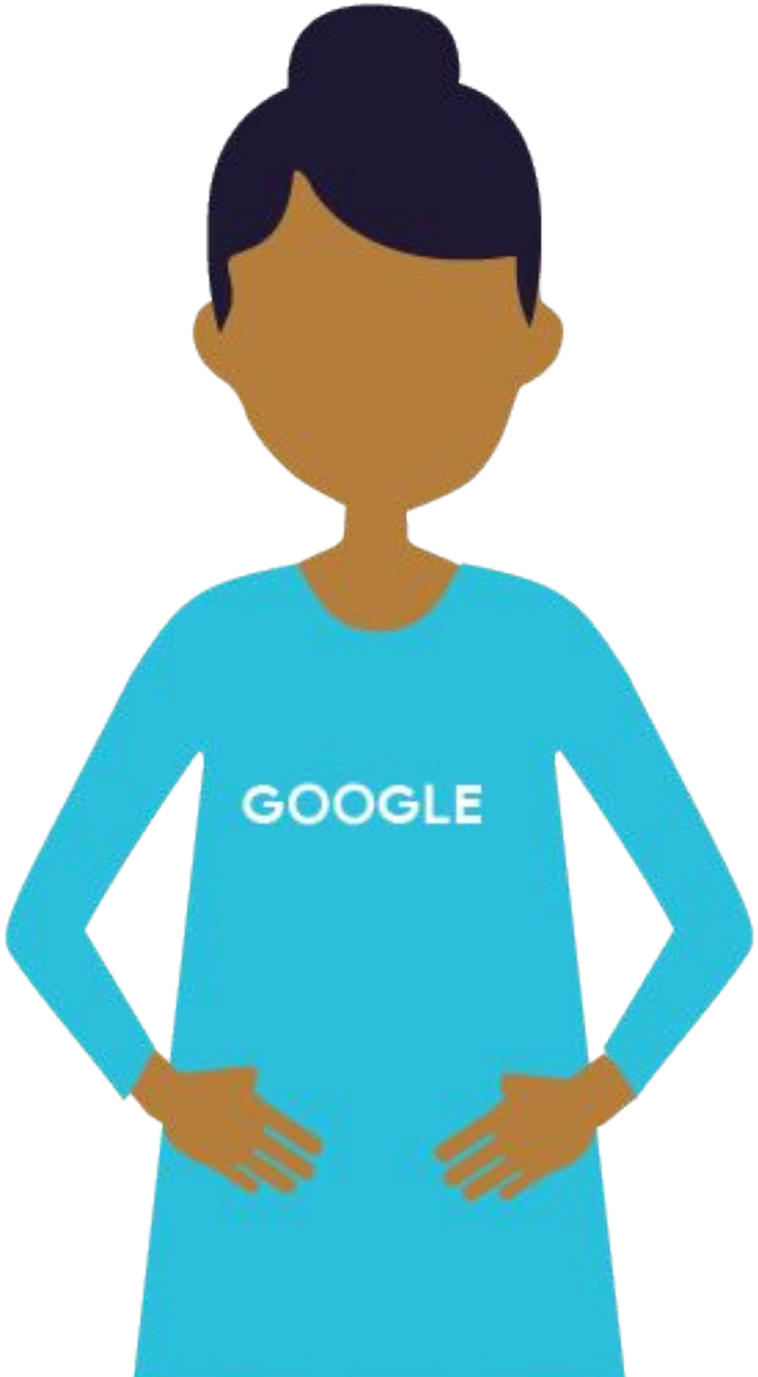


Distributions change

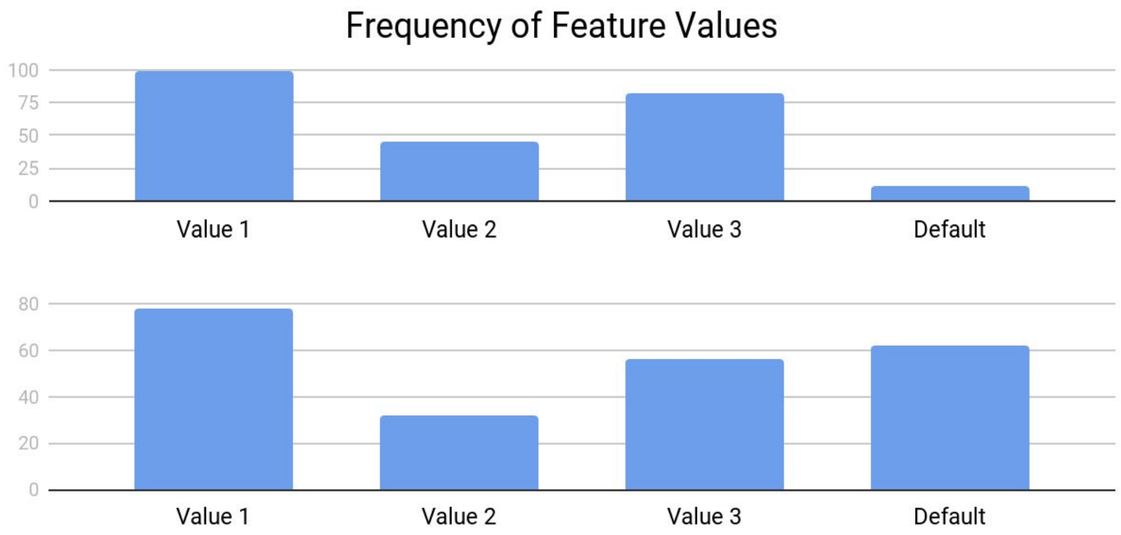
Zip Codes

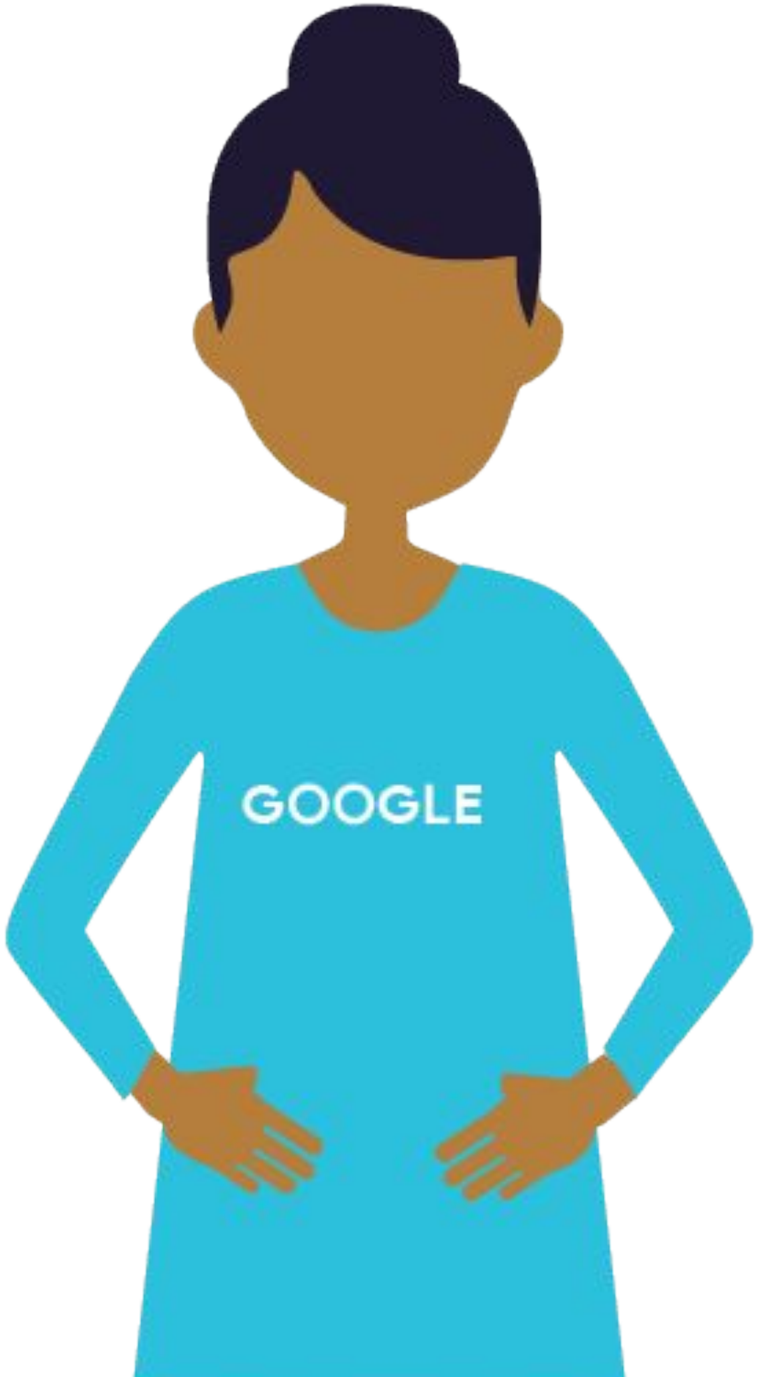
99501
87506
63141
04032
...

$$\{element1, element2, element3, ...\}$$

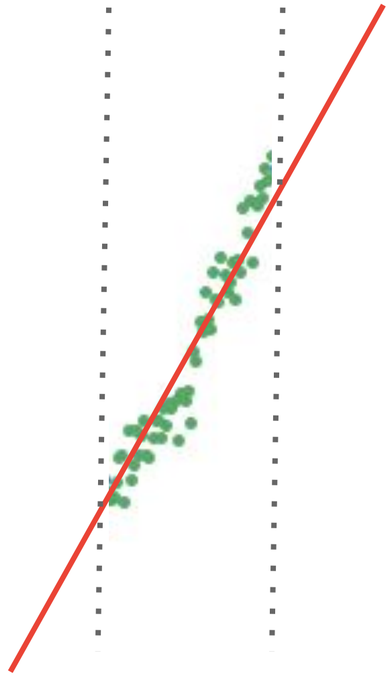


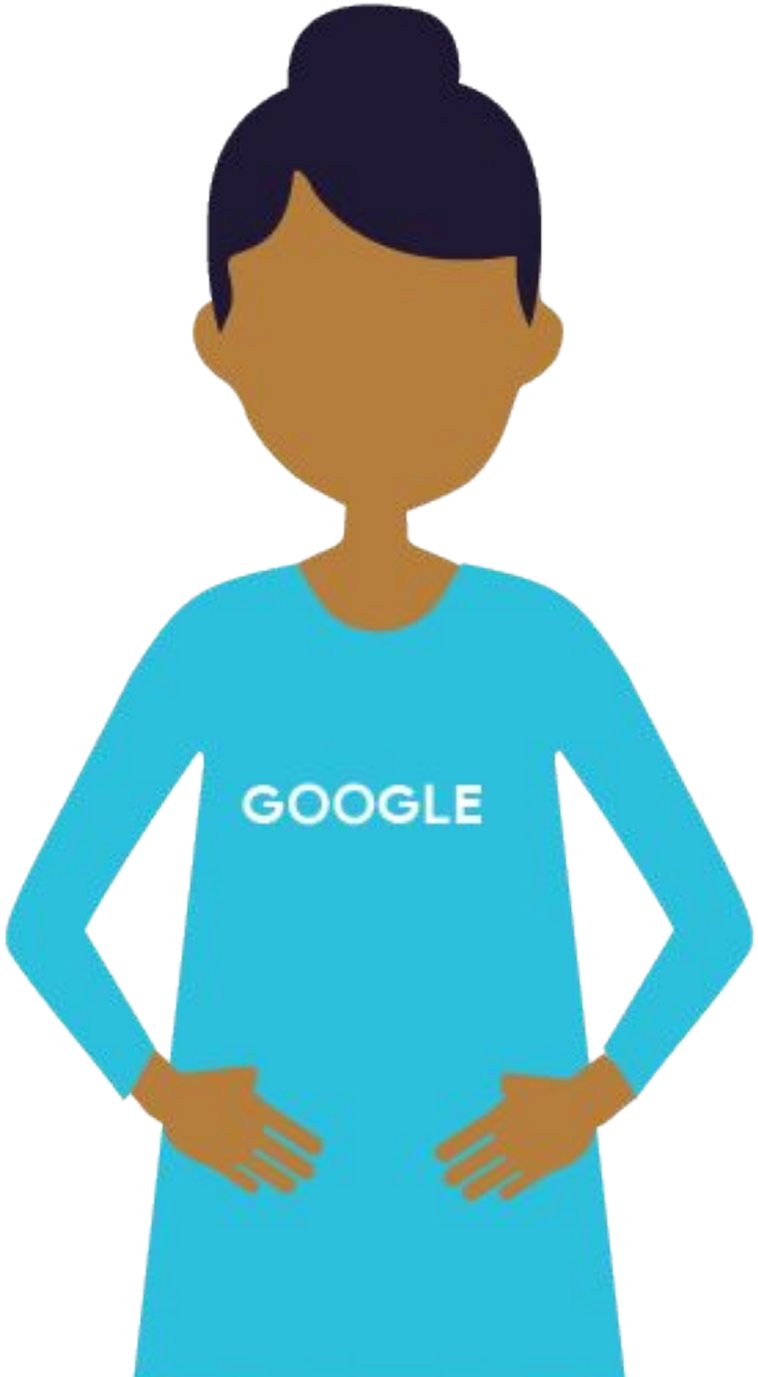
Distributions change



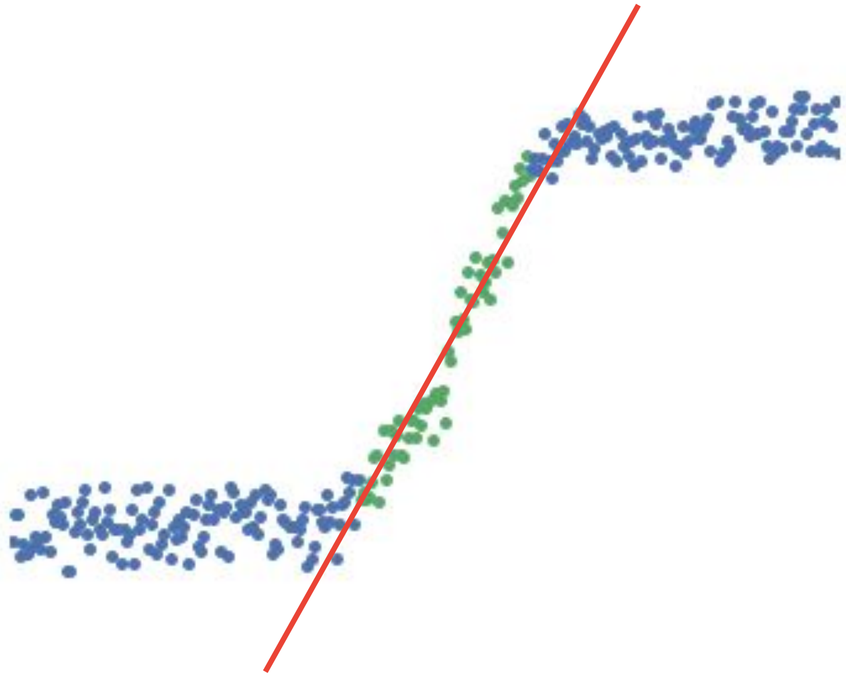


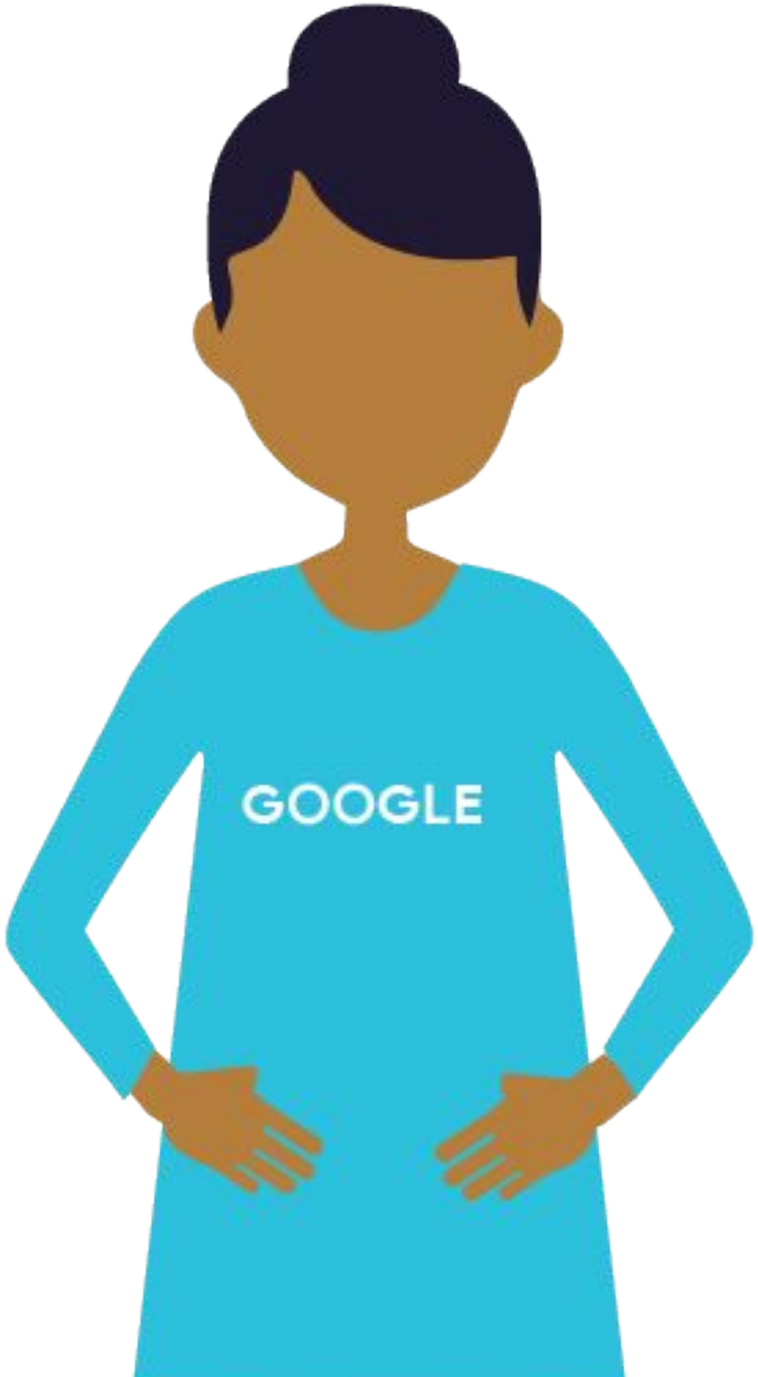
Distributions change





Distributions change





Distributions change

- Monitor descriptive statistics for your inputs and outputs
- Monitor your residuals as a function of your inputs
- Use custom weights in your loss function to emphasize data recency
- Use dynamic training architecture and regularly retrain your model

Course 2: Production ML Systems

Module 3: Designing Adaptable ML Systems

Lesson Title: **Adapting to Data: Lab**

Presenter: Max Lotstein

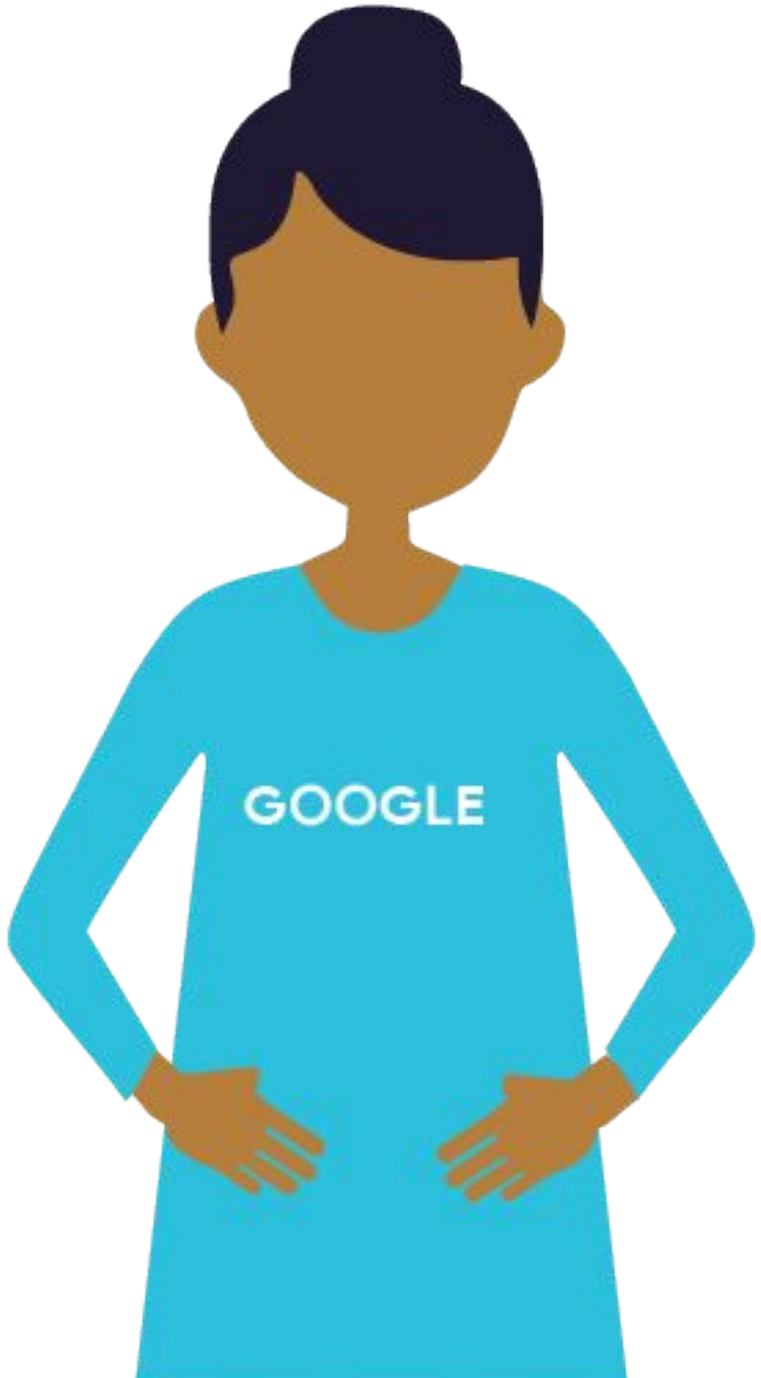
Format: Talking Head

Video Name: T-PSML-O_3_l5_adapting_to_data:_lab_intro

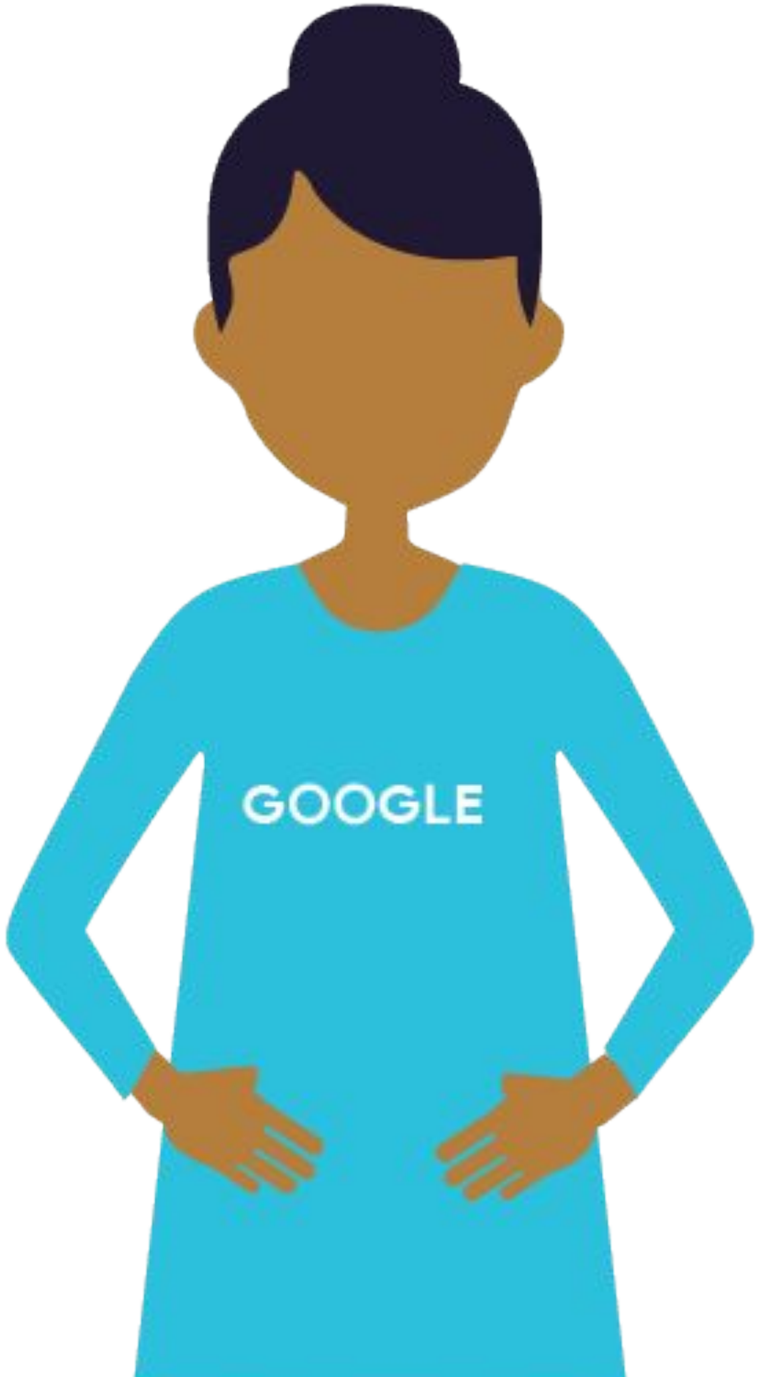
Lab

Making Good ML Engineering Investments

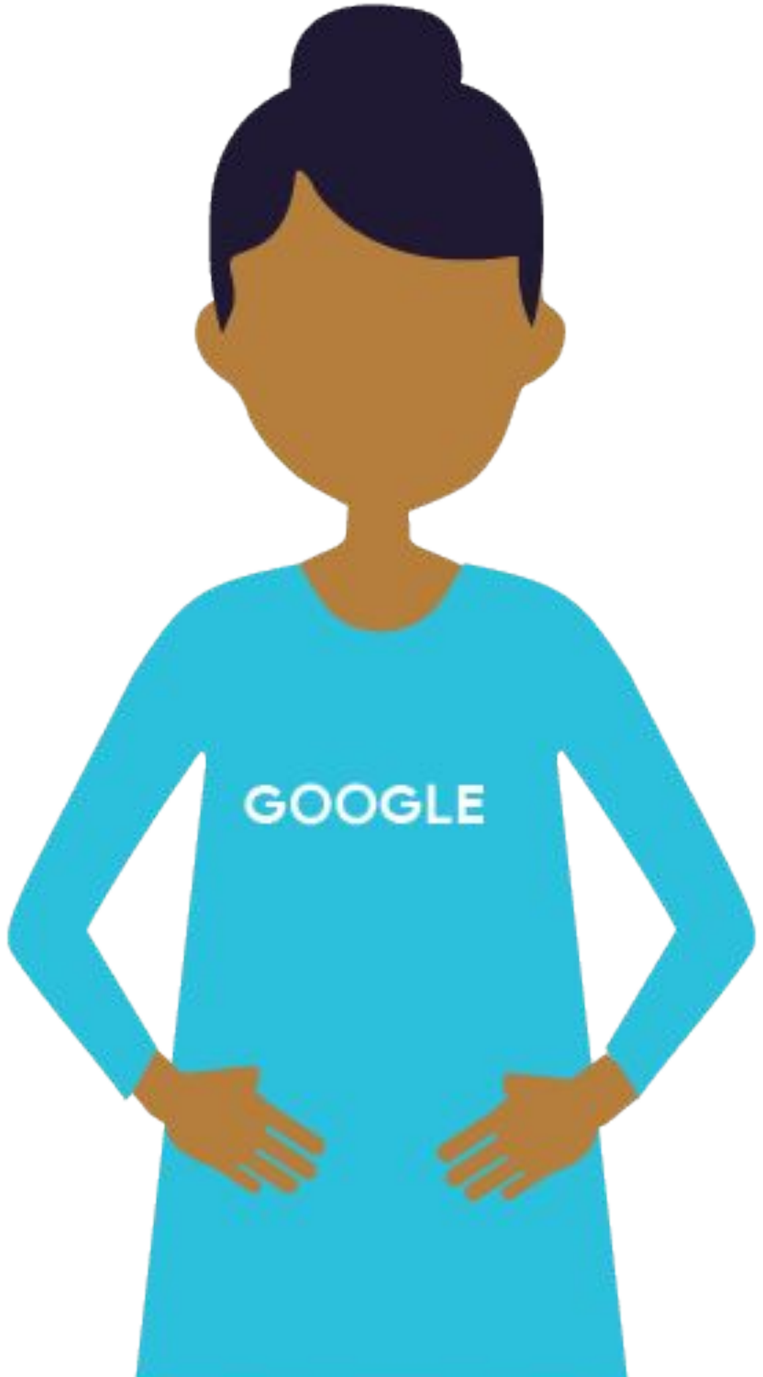
Max Lotstein



Scenario 1: Code Sprint



Scenario 2: A Gift Horse



Course 2: Production ML Systems

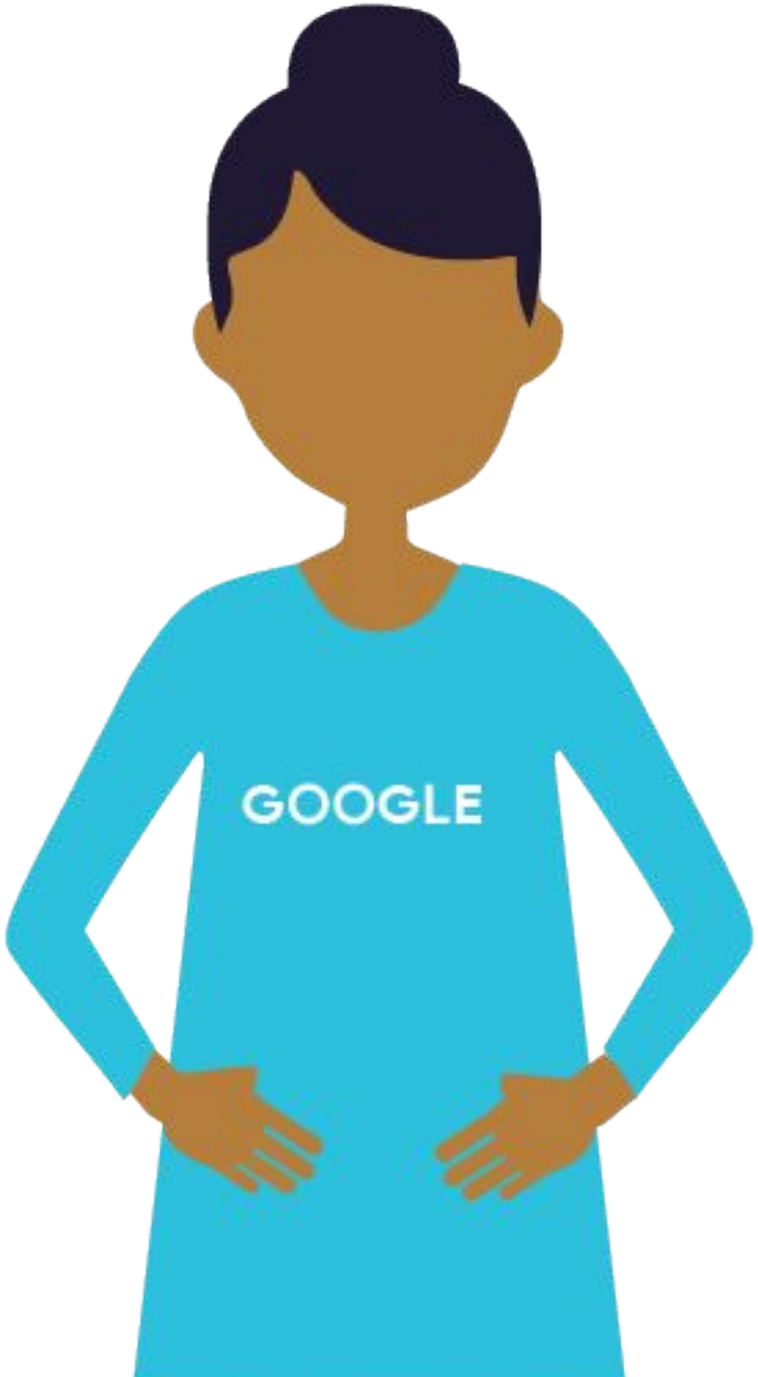
Module 3: Designing Adaptable ML Systems

Lesson Title: **Adapting to Data: Right and Wrong Decisions**

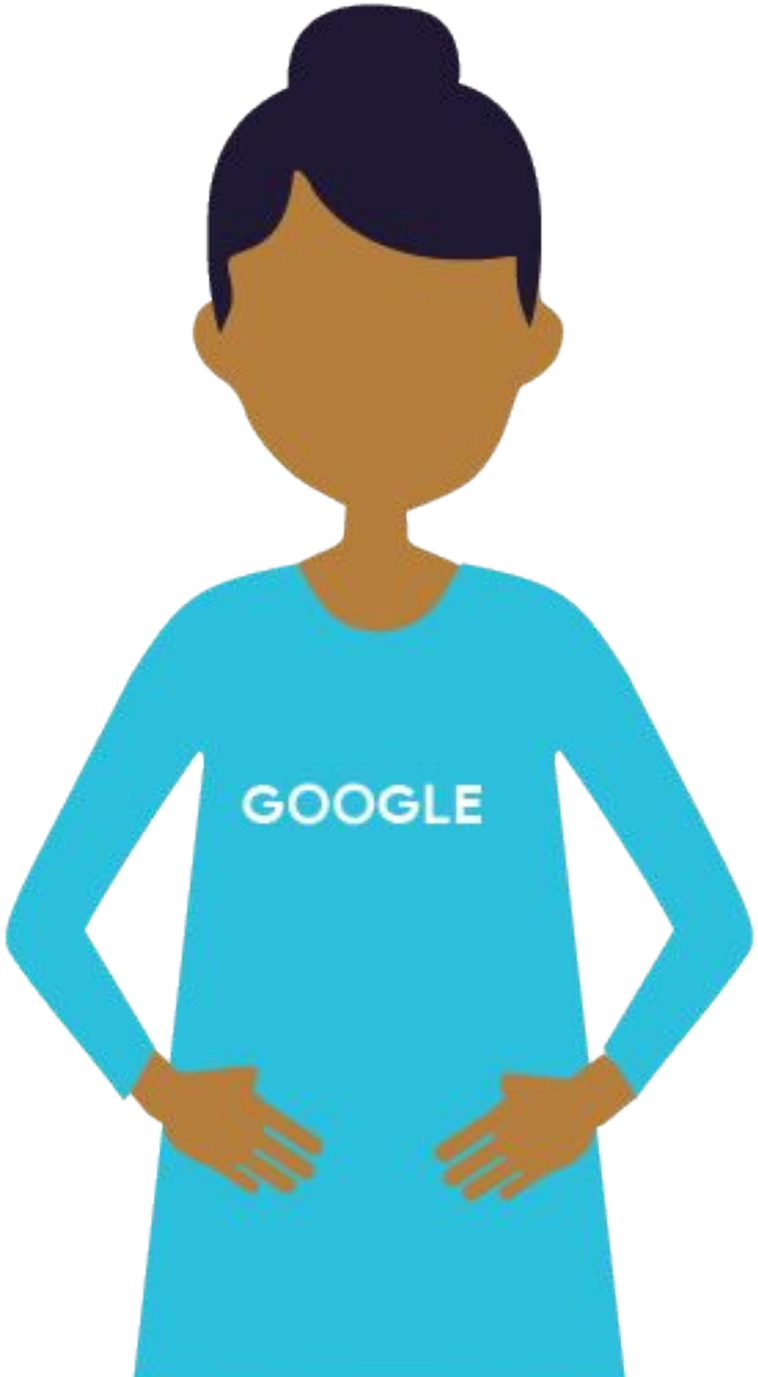
Presenter: Max Lotstein

Format: Talking Head

Video Name:
T-PSML-O_3_l7_adapting_to_data:_right_and_wrong_decisions

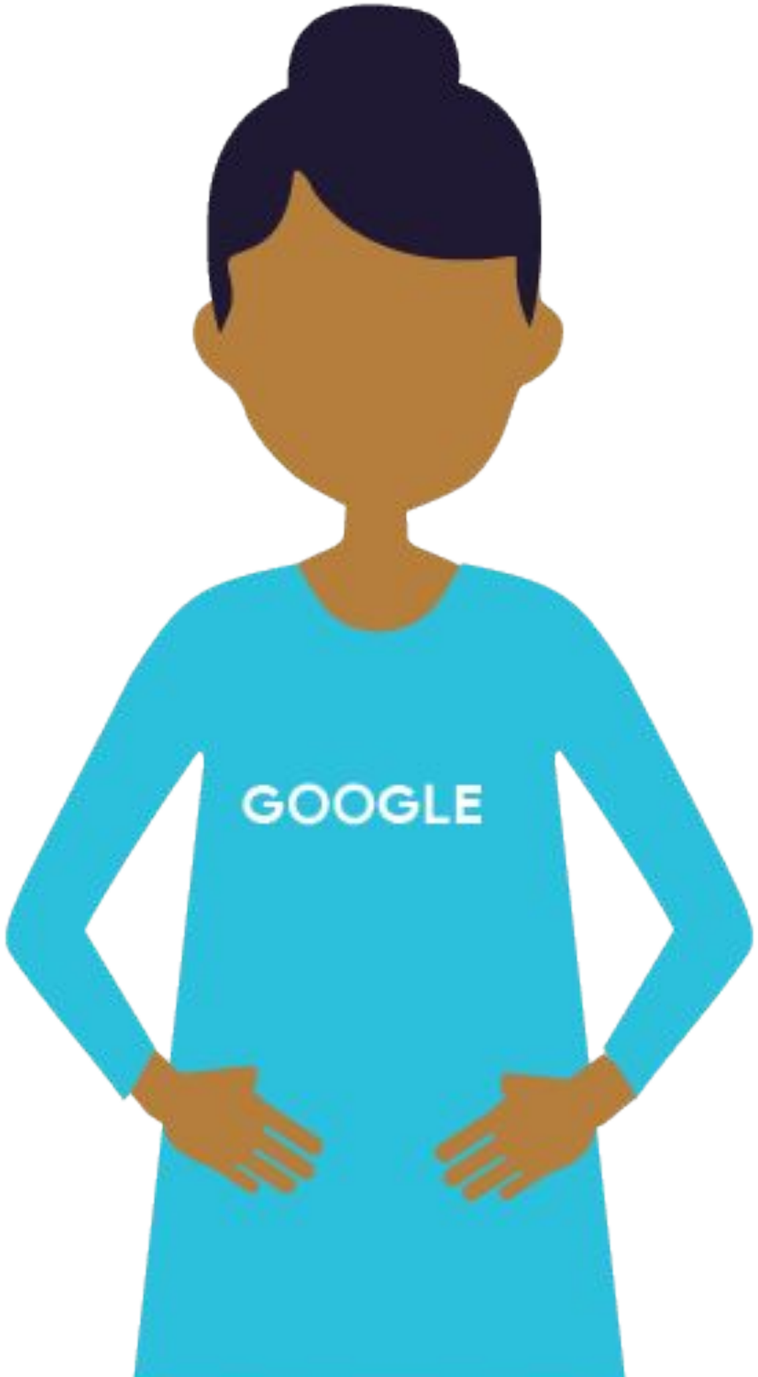


Right and Wrong Data Decisions



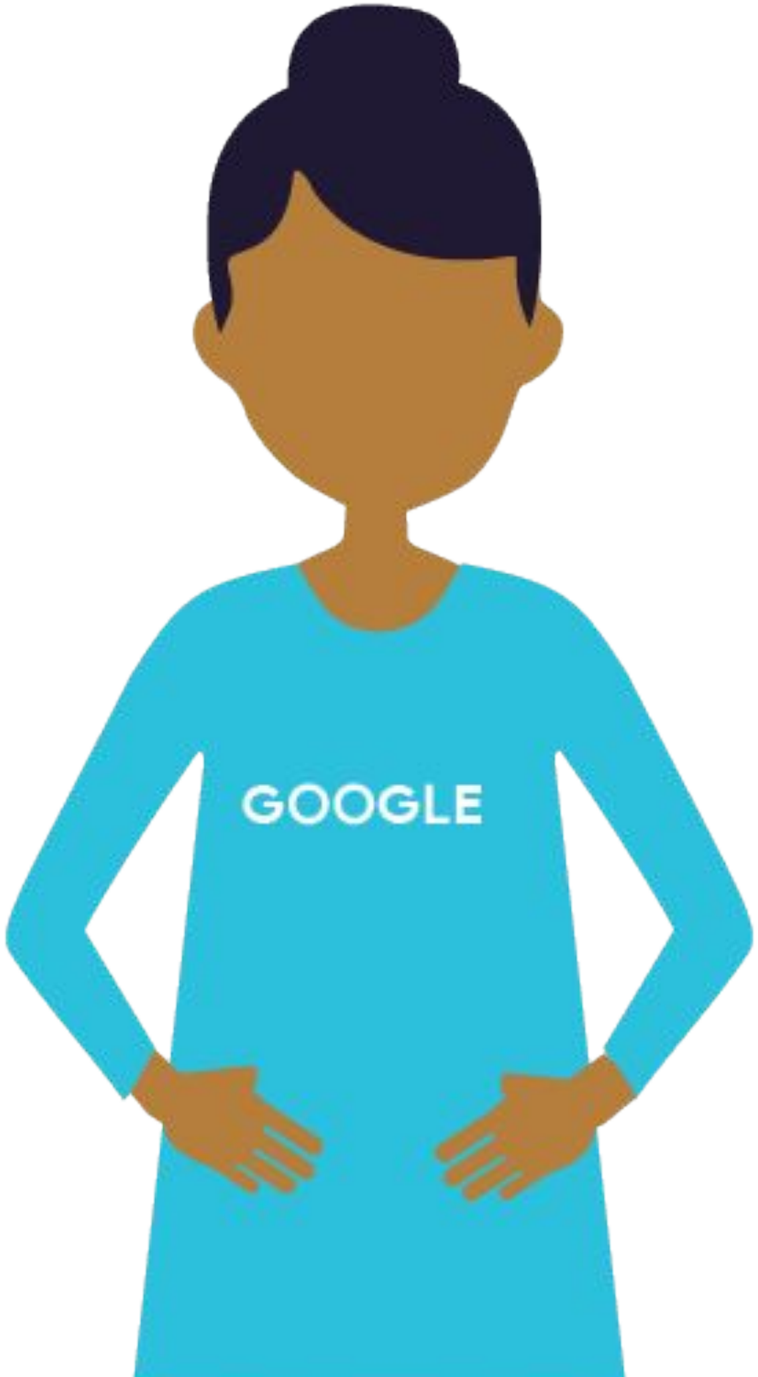
Right and Wrong Data Decisions

- patient age
- gender
- prior medical conditions
- hospital name
- vital signs
- test results

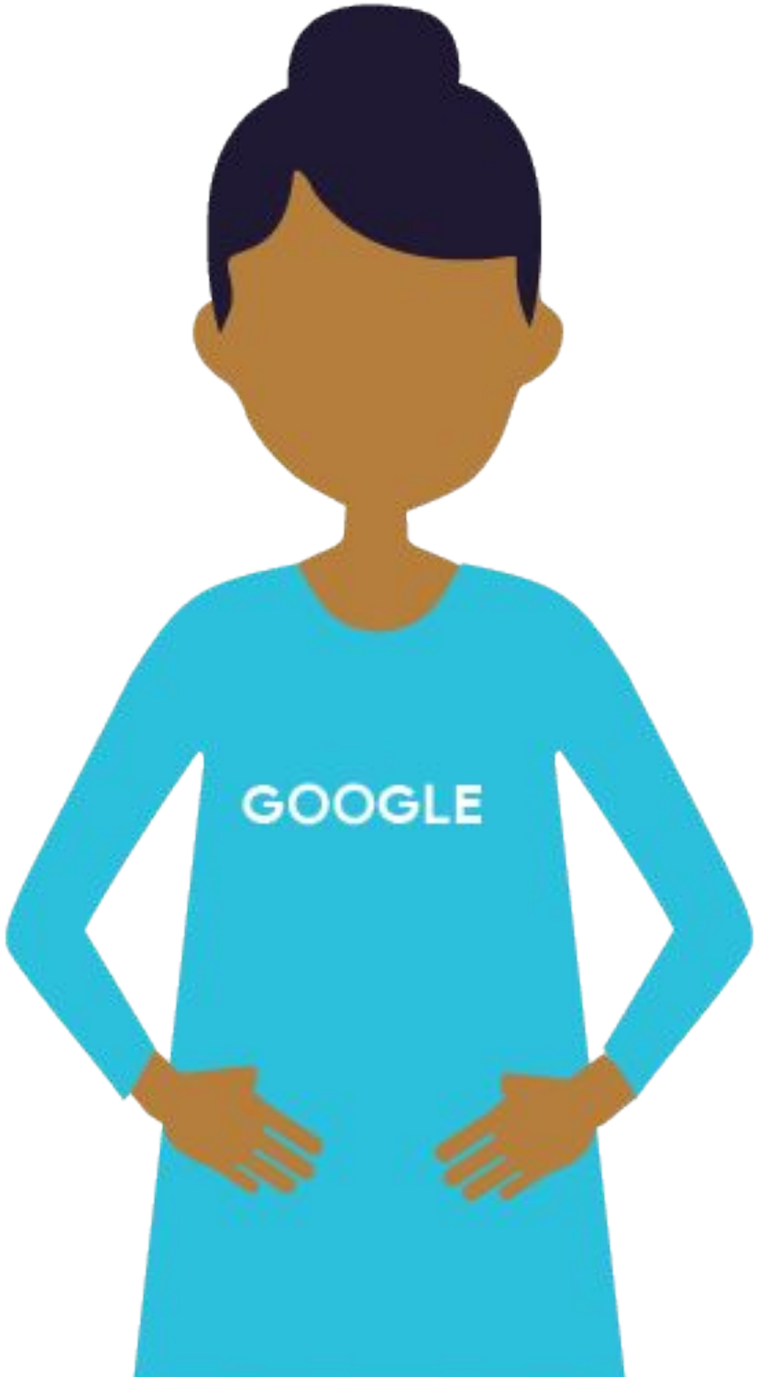


Data Leakage

https://upload.wikimedia.org/wikipedia/commons/5/5f/Beth_Israel_Deaconess_Medical_Center_East_Campus.jpg



Predict political affiliation from metaphors

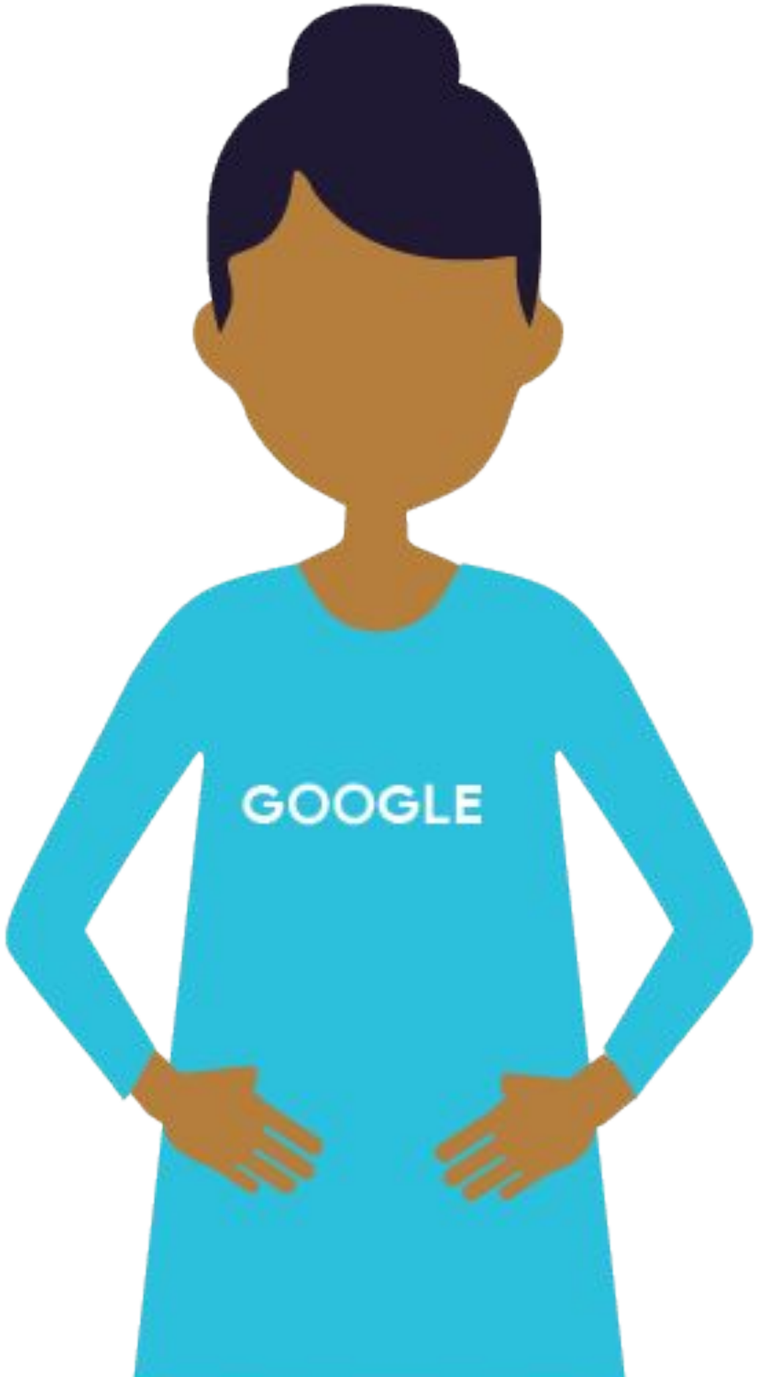


Predict political affiliation from metaphors

Google

the mind is a

the mind is a **battlefield**
the mind is a **walled garden**
the mind is a **muscle**
the mind is a **powerful tool**
the mind is a **powerful force**
the mind is a **powerful**
the mind is a **prison**
the mind is a **great servant**
the mind is a **soft boiled potato**
the mind is a **beautiful servant**



Predict political affiliation from metaphors

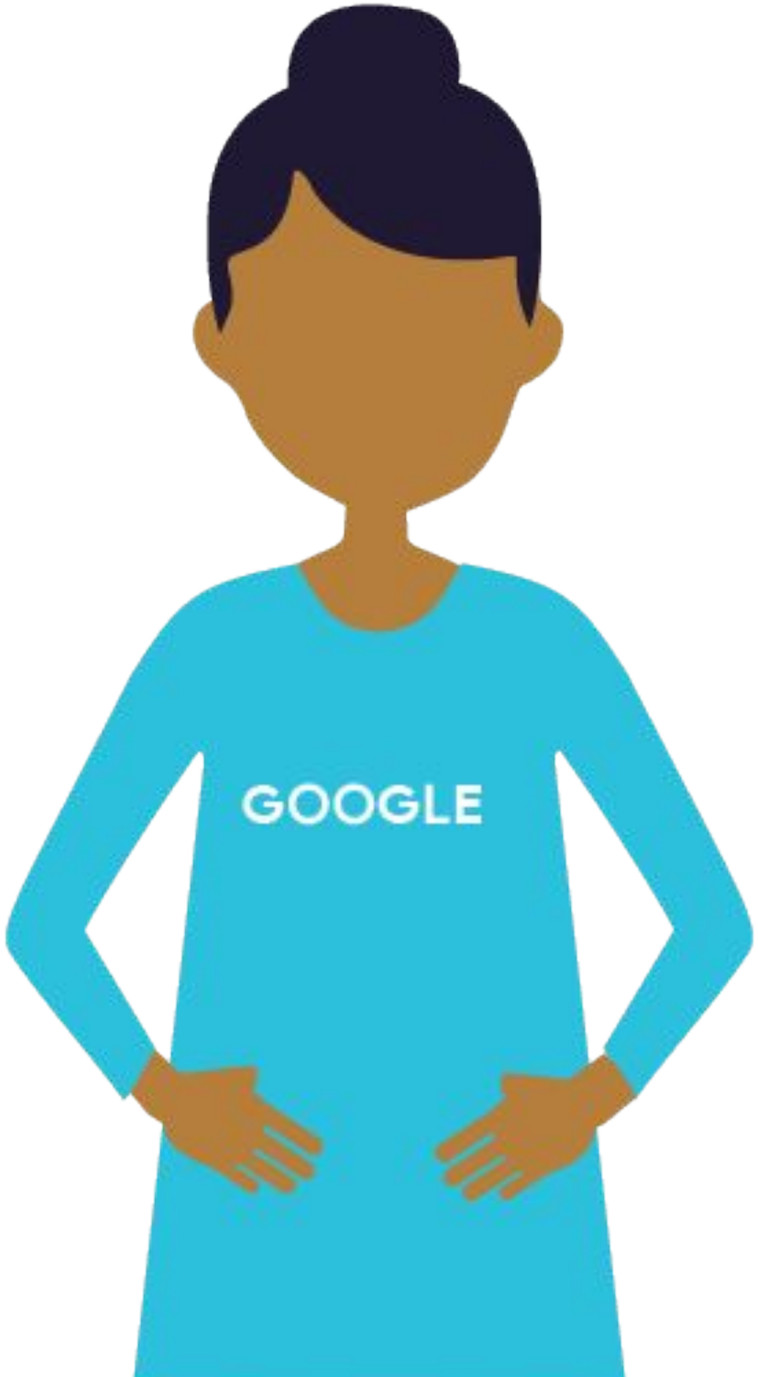
Google

the mind is a

the mind is a **battlefield**
the mind is a **walled garden**
the mind is a **muscle**

the mind is a **powerful tool**
the mind is a **powerful force**
the mind is a **powerful**

the mind is a **prison**
the mind is a **great servant**
the mind is a **soft boiled potato**
the mind is a **beautiful servant**



Training Set

Swift | Blake | Defoe

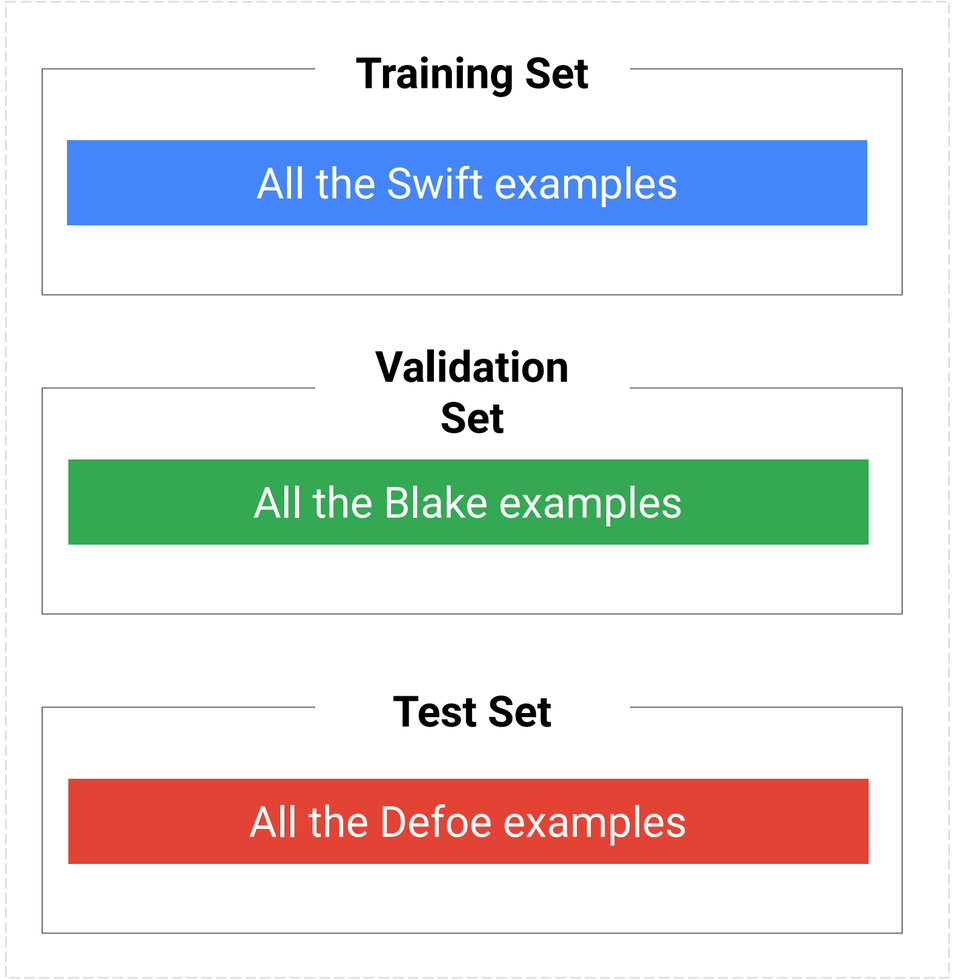
Validation Set

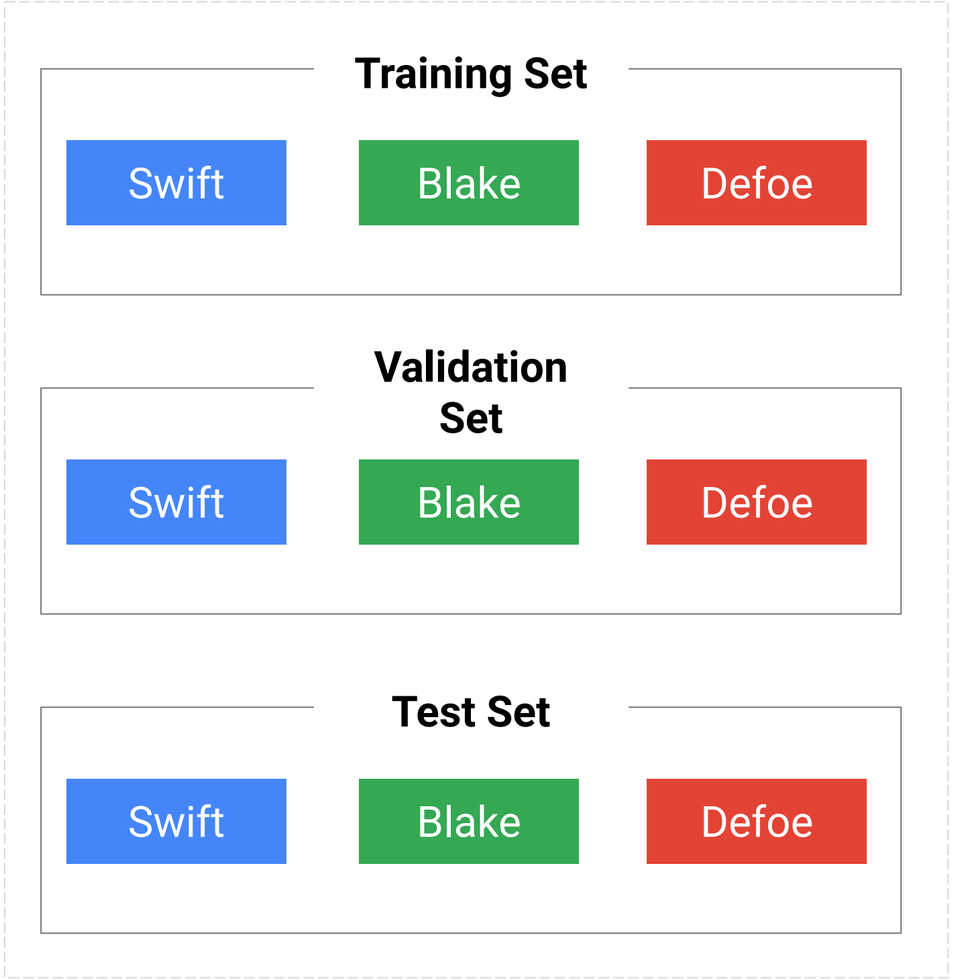
Swift | Blake | Defoe

Test Set

Swift | Blake | Defoe

Solution: Cross-contamination; you have to split by author





Course 2: Production ML Systems

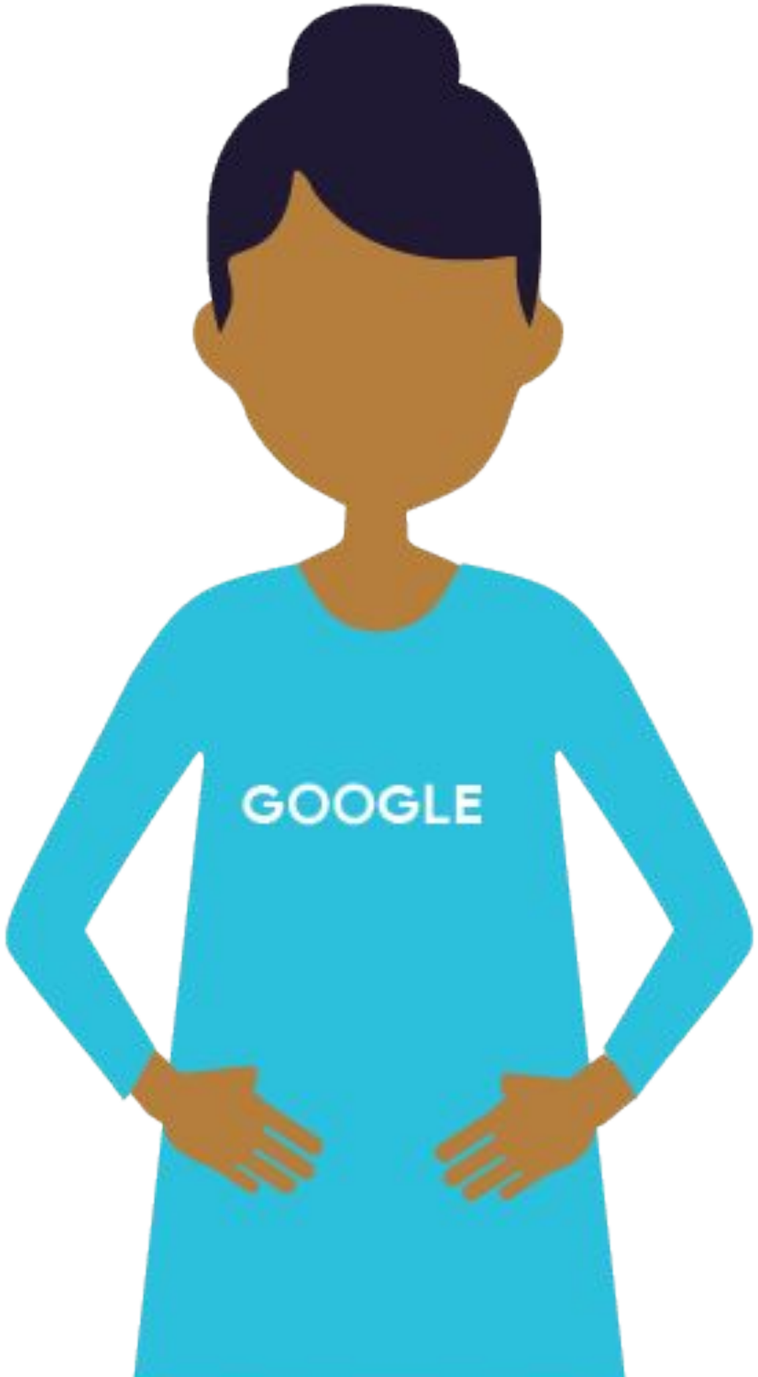
Module 3: Designing Adaptable ML Systems

Lesson Title: **Adapting to Data: System Failure**

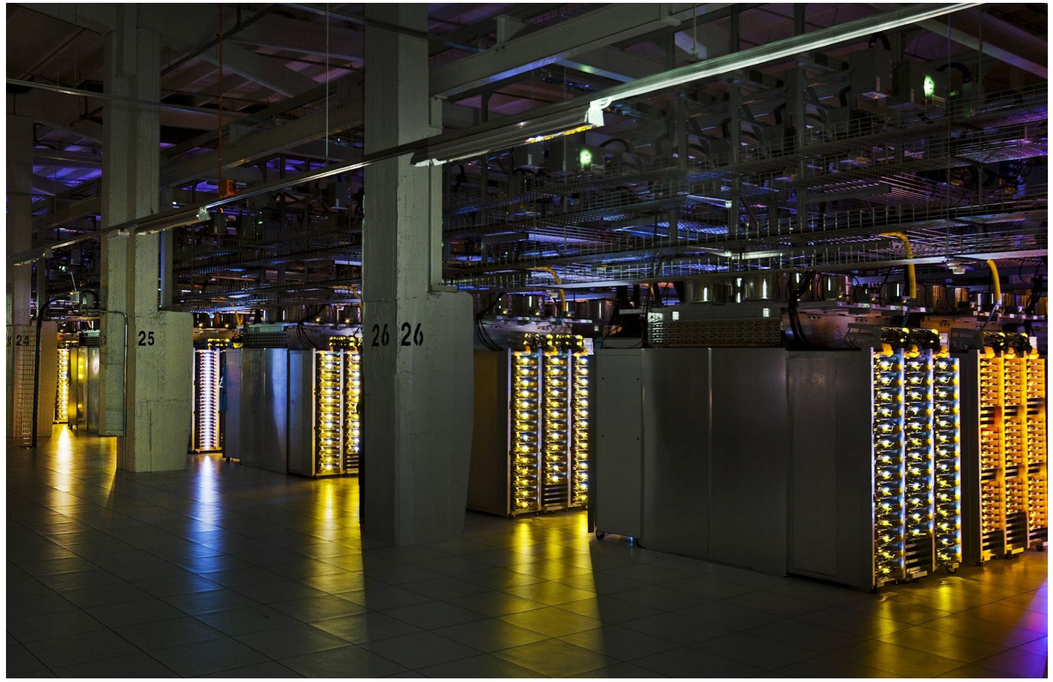
Presenter: Max Lotstein

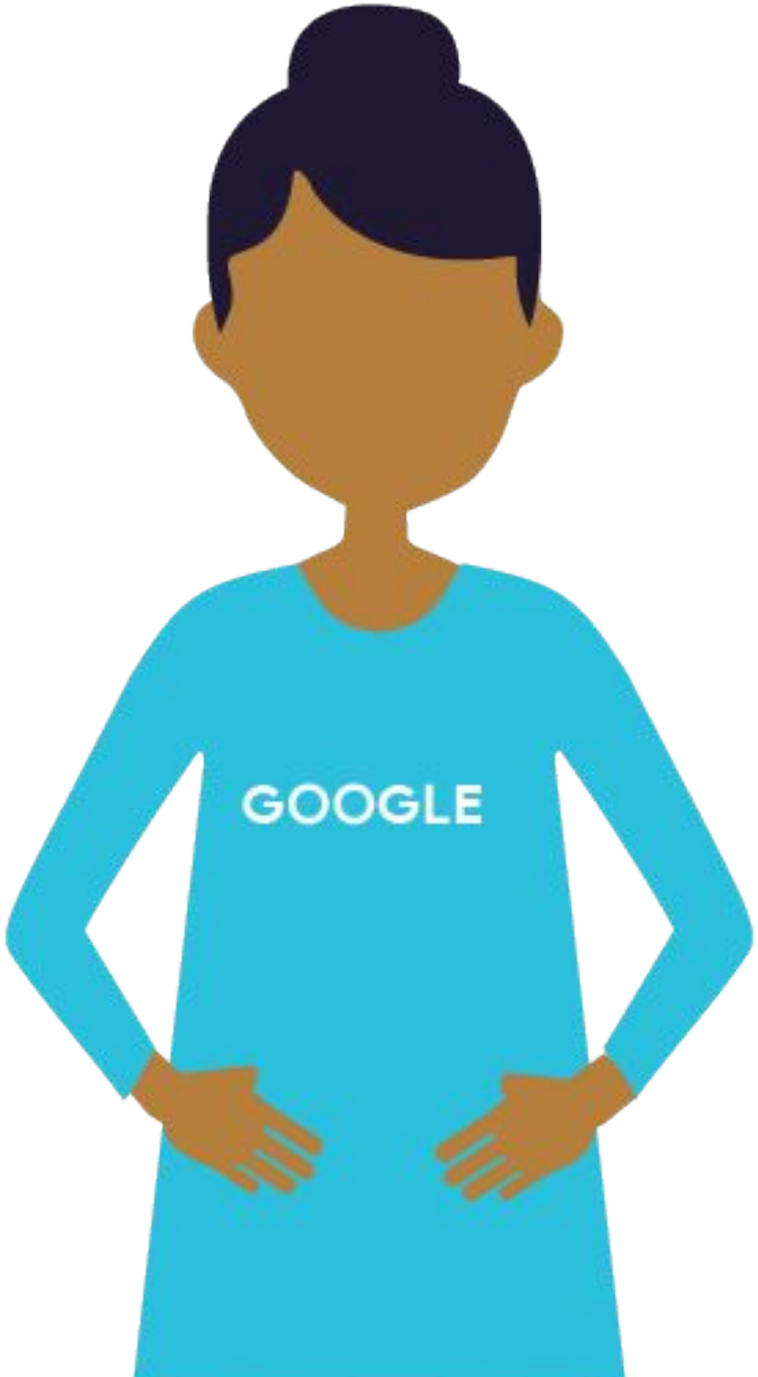
Format: Talking Head

Video Name: T-PSML-O_3_l8_adapting_to_data:_system_failure

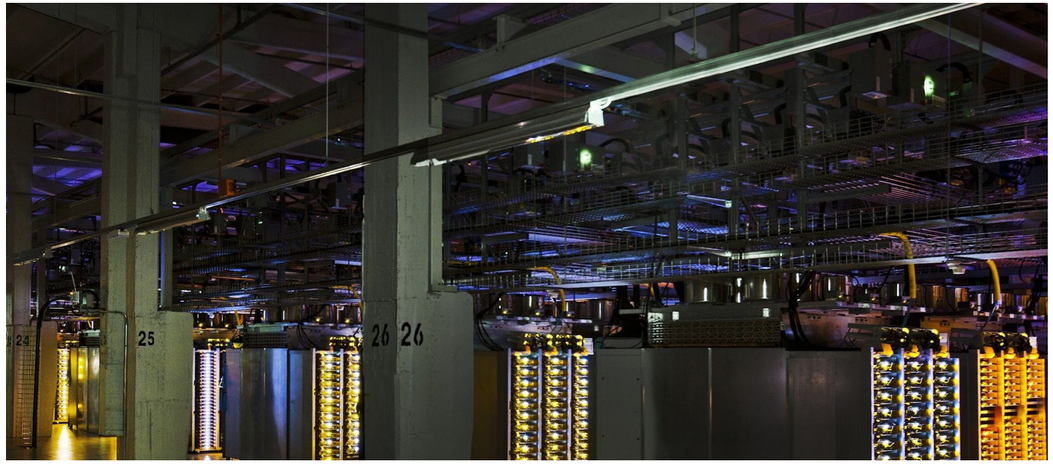


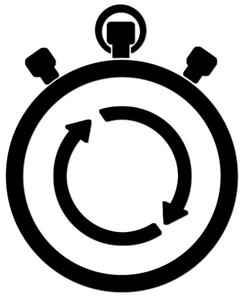
Systems Fail



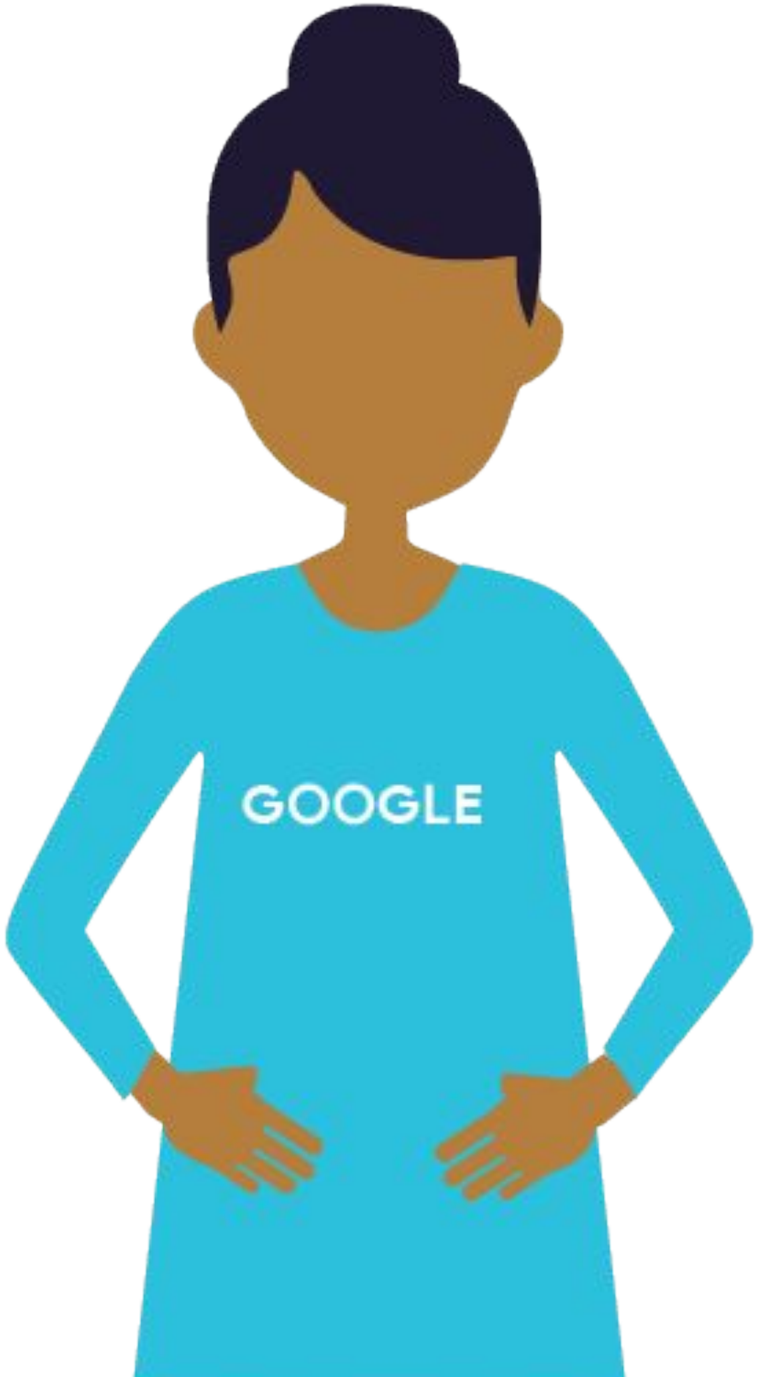


Systems Fail

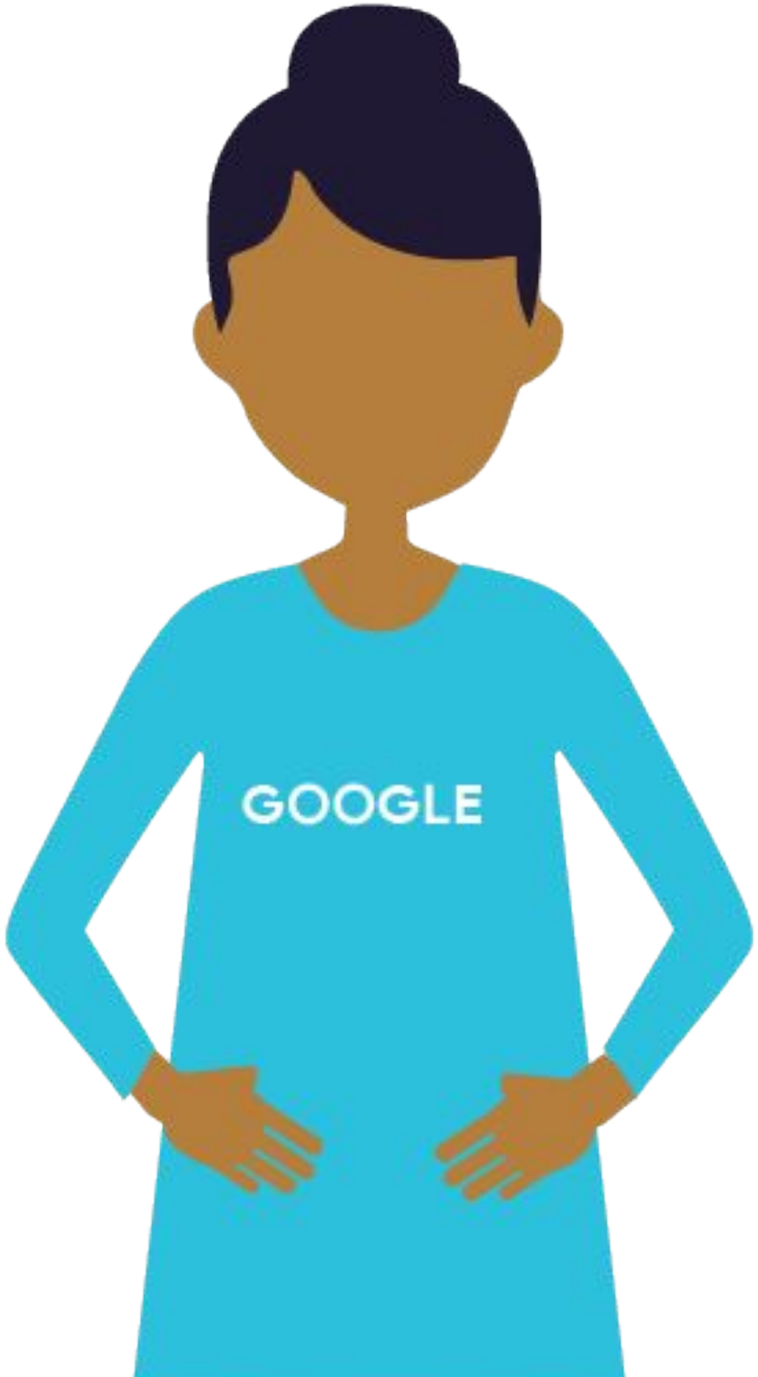




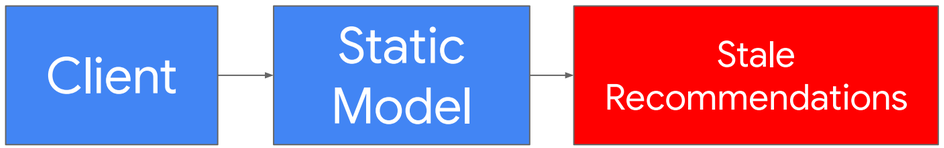
Rollback Initiated
Version 1.0.1
Three Months old

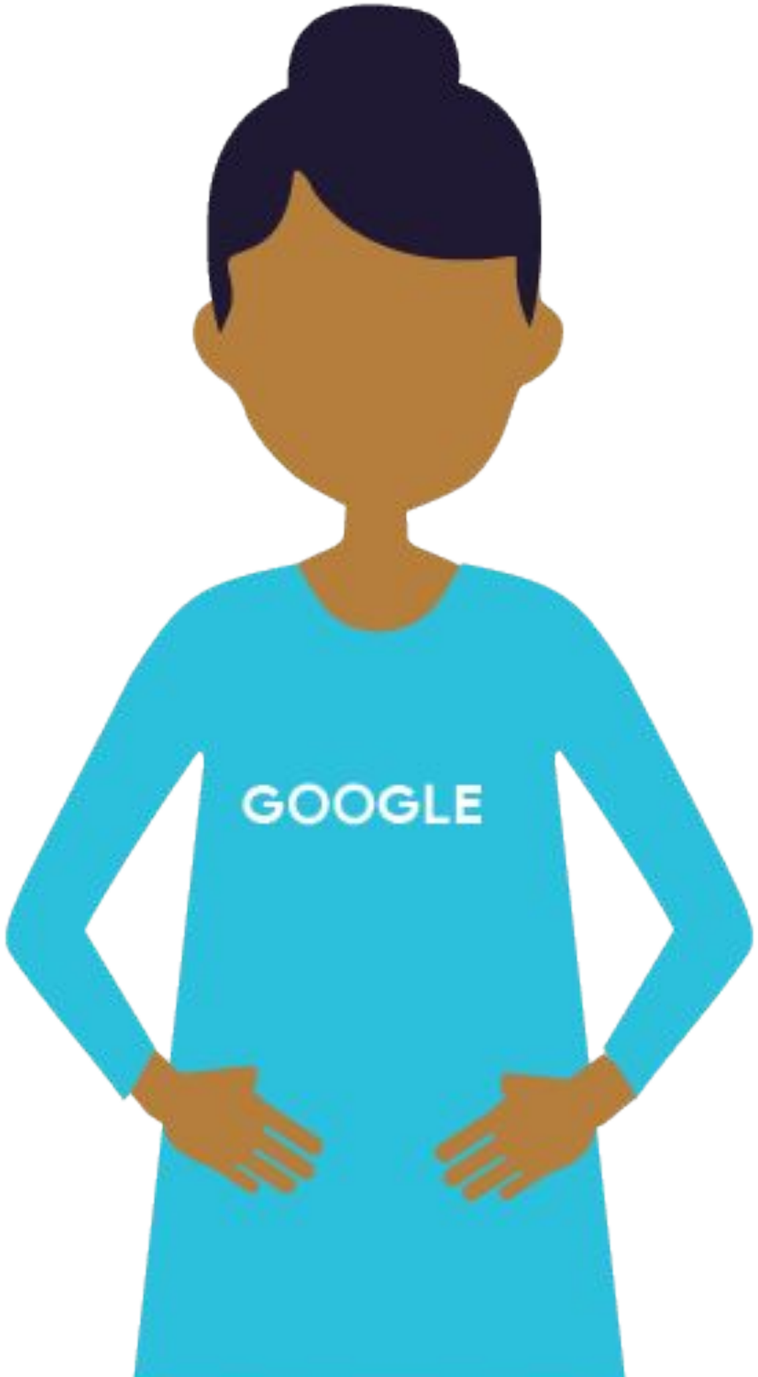


Feedback Loops

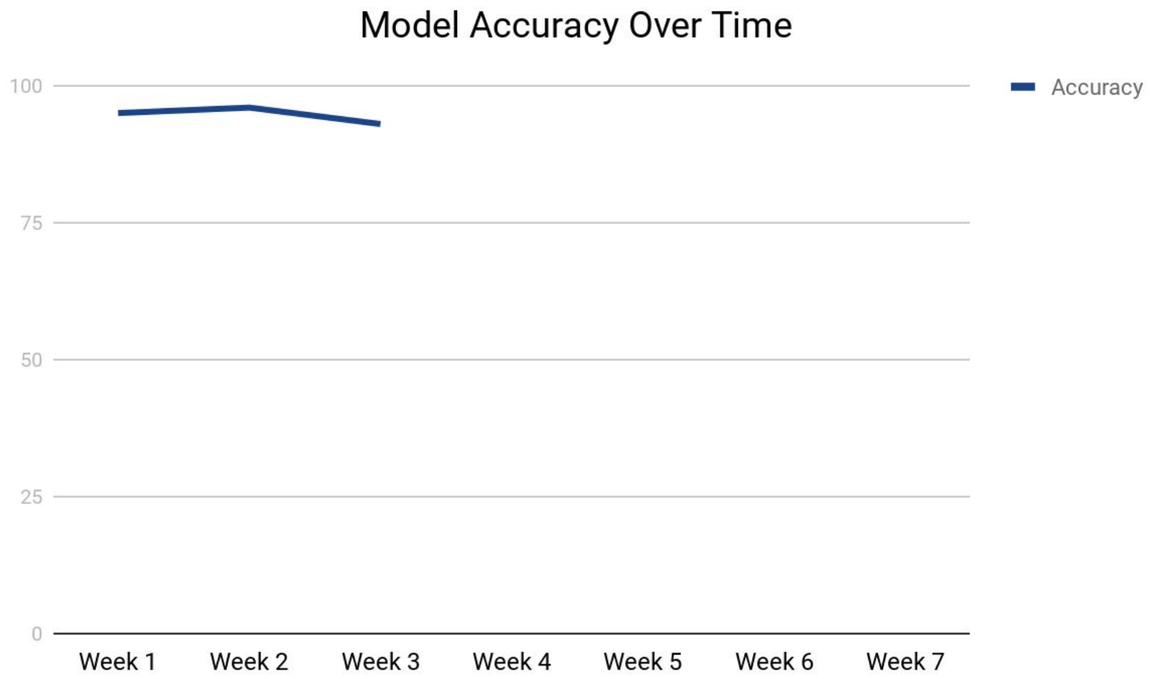


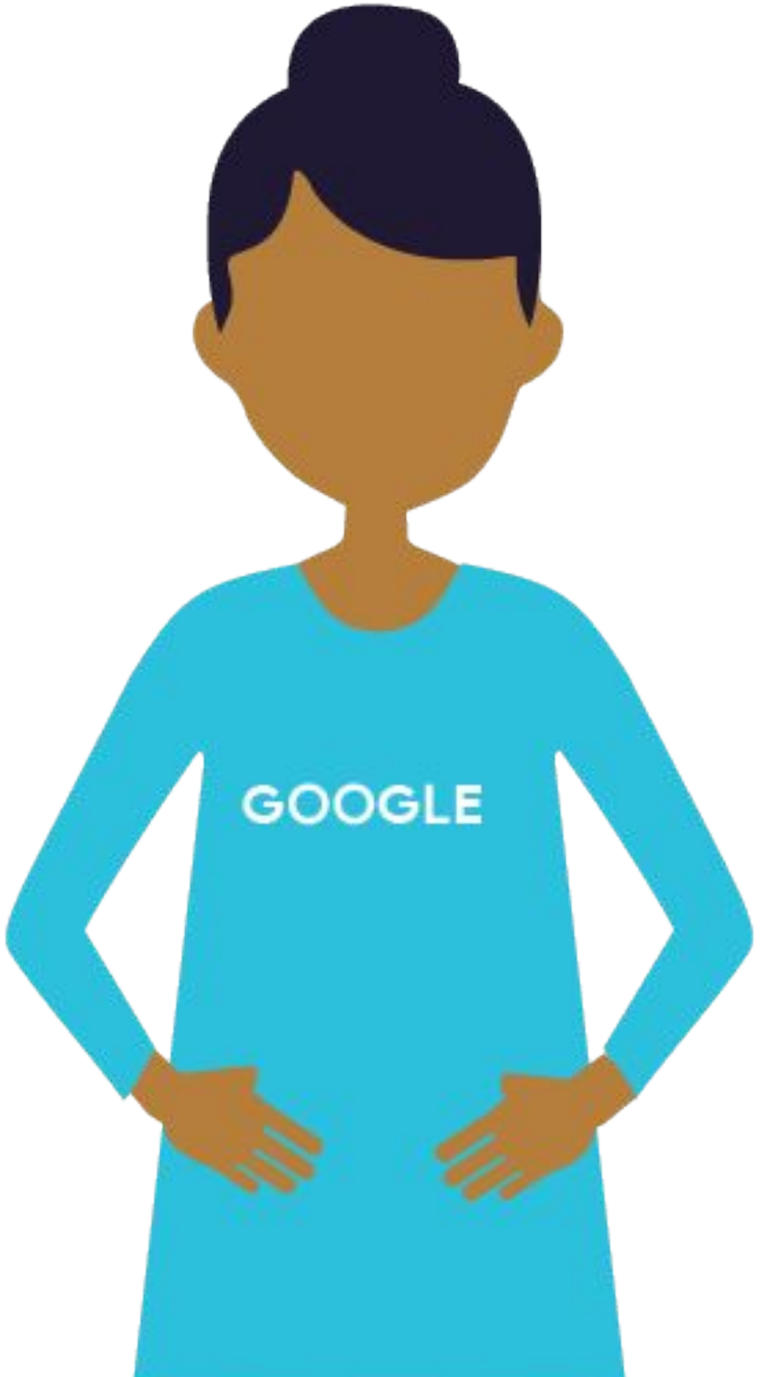
Feedback Loops



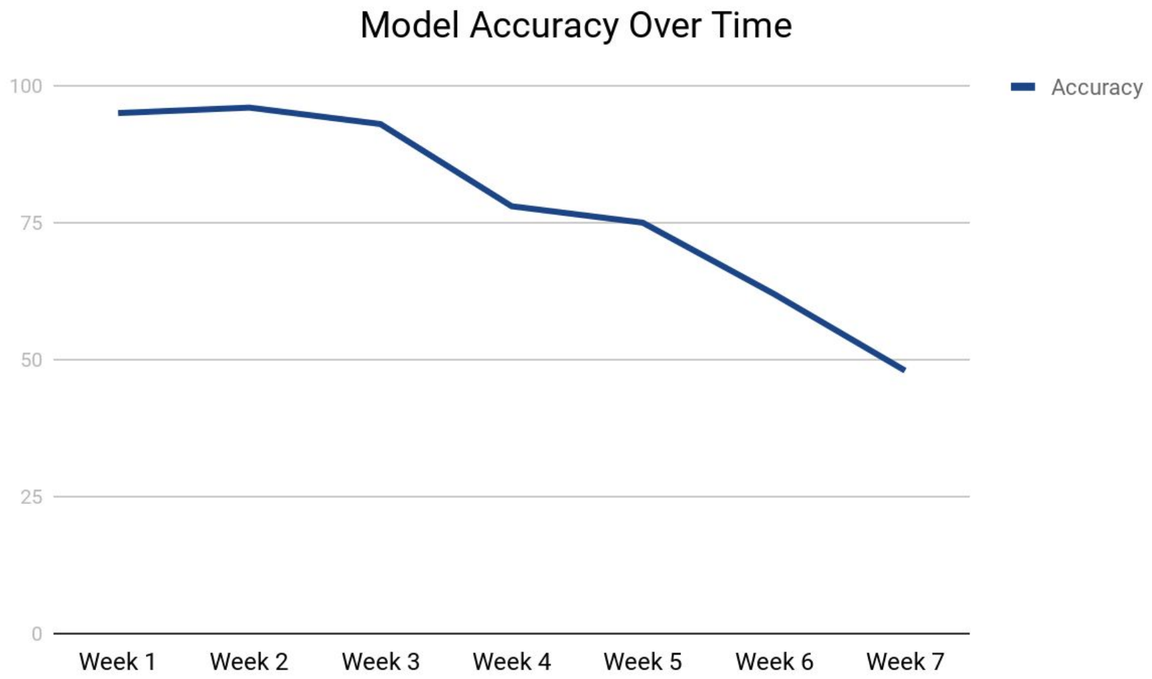


Feedback Loops





Feedback Loops



Course 2: Production ML Systems

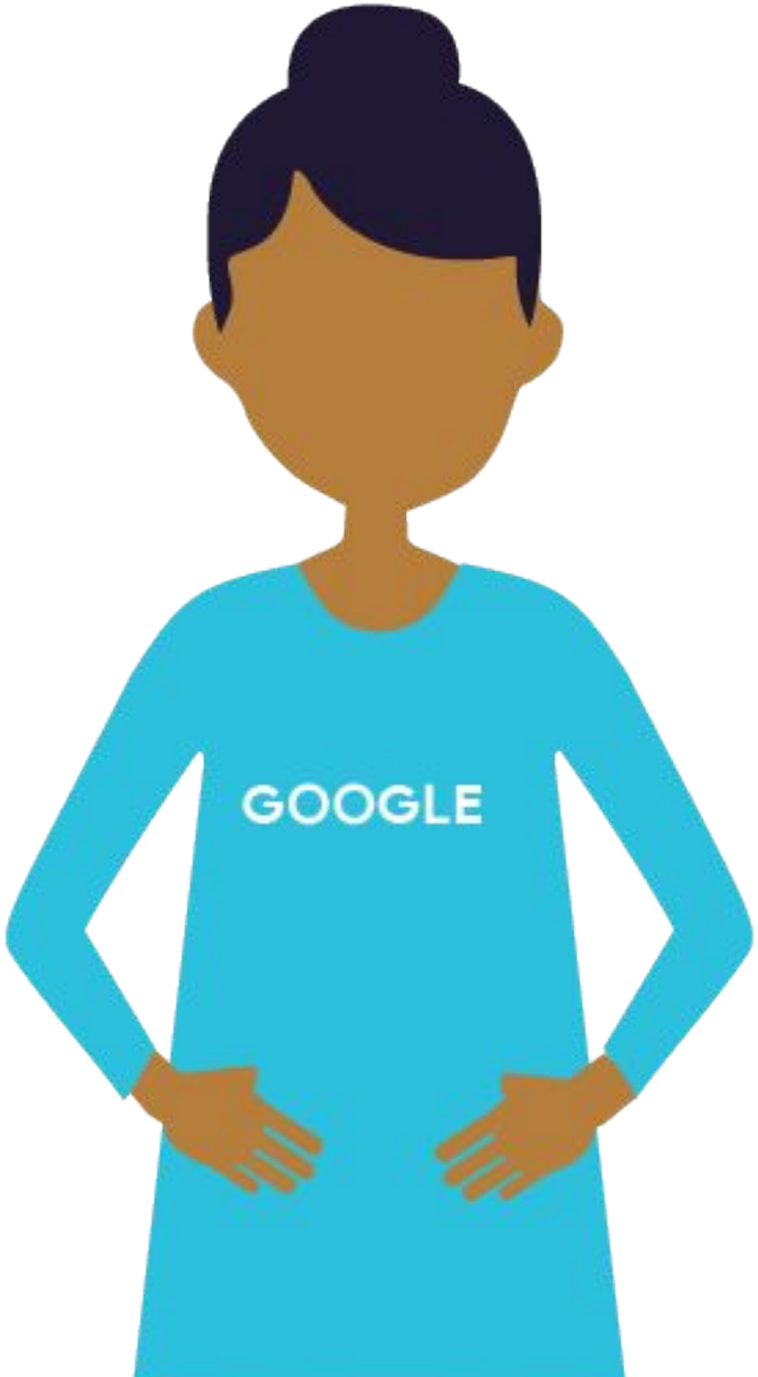
Module 3: Designing Adaptable ML Systems

Lesson Title: **Adapting to Data: Summary**

Presenter: Max Lotstein

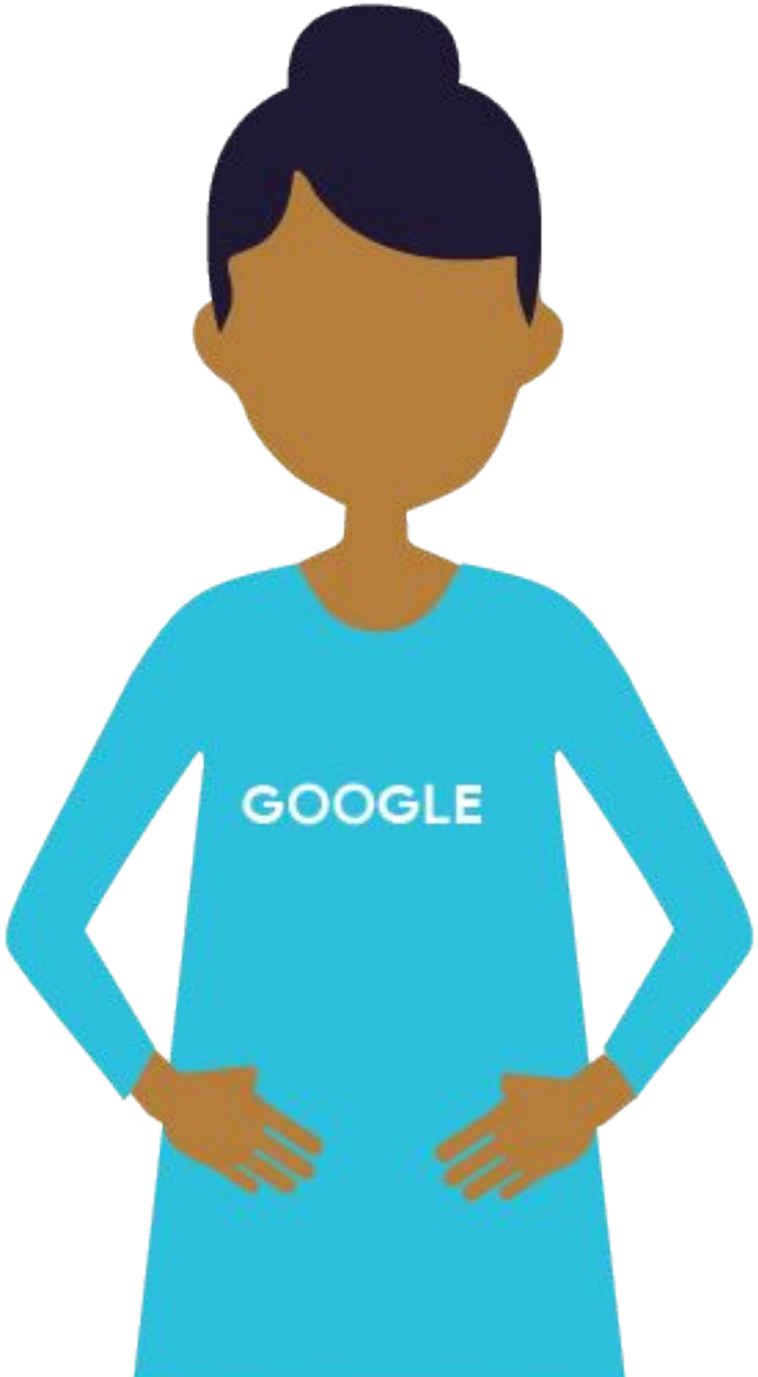
Format: Talking Head

Video Name: T-PSML-O_3_l9_adapting_to_data:_summary



Adapting to Data

- Assess all data sources and features based on both cost and benefit before including into the model
- Communicate with upstream data producers to make your needs known
- Replicate critical data sources
- Monitor descriptive statistics for your inputs and outputs



Adapting to Data

- Monitor your residuals as a function of your inputs
- Use custom weights in your loss function to emphasize data recency
- Use dynamic training architecture and regularly retrain your model
- You get what you optimize for

Course 2: Production ML Systems

Module 3: Designing Adaptable ML Systems

Lesson Title: **Mitigating Training-Serving Skew Through Design**

Presenter: Max Lotstein

Format: Talking Head

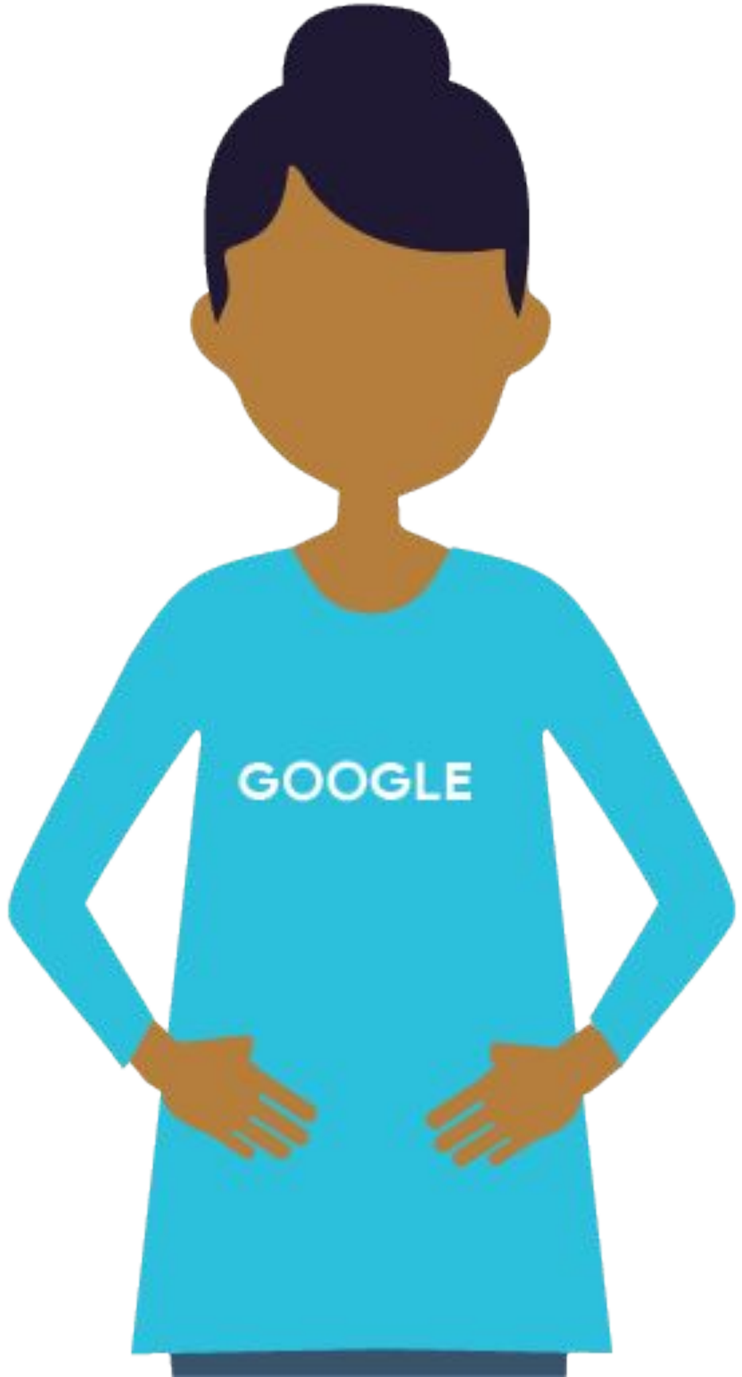
Video Name: T-PSML-O_3_l10_mitigating_training-serving_skew_through_design

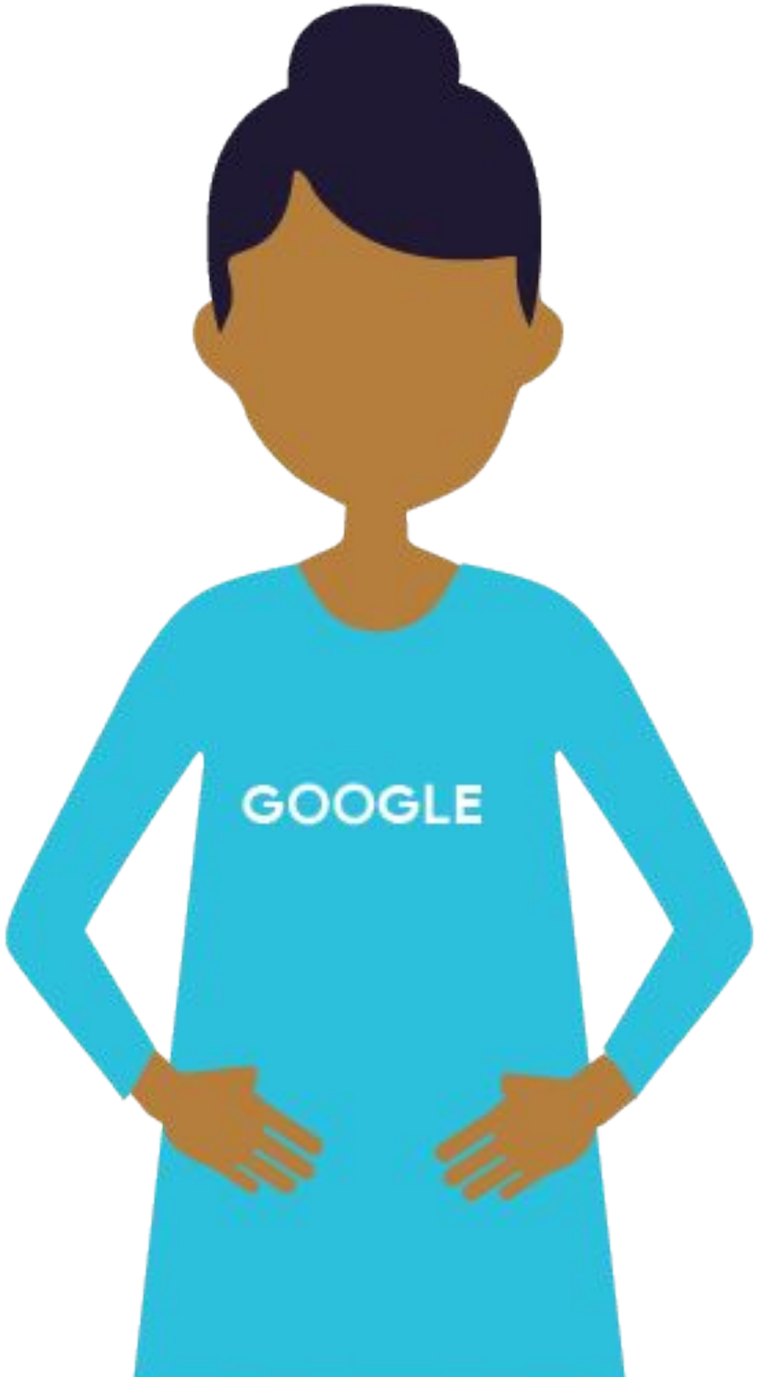
Agenda

Adapting to Data

Mitigating Training-Serving Skew Through Design

Debugging a Production Model



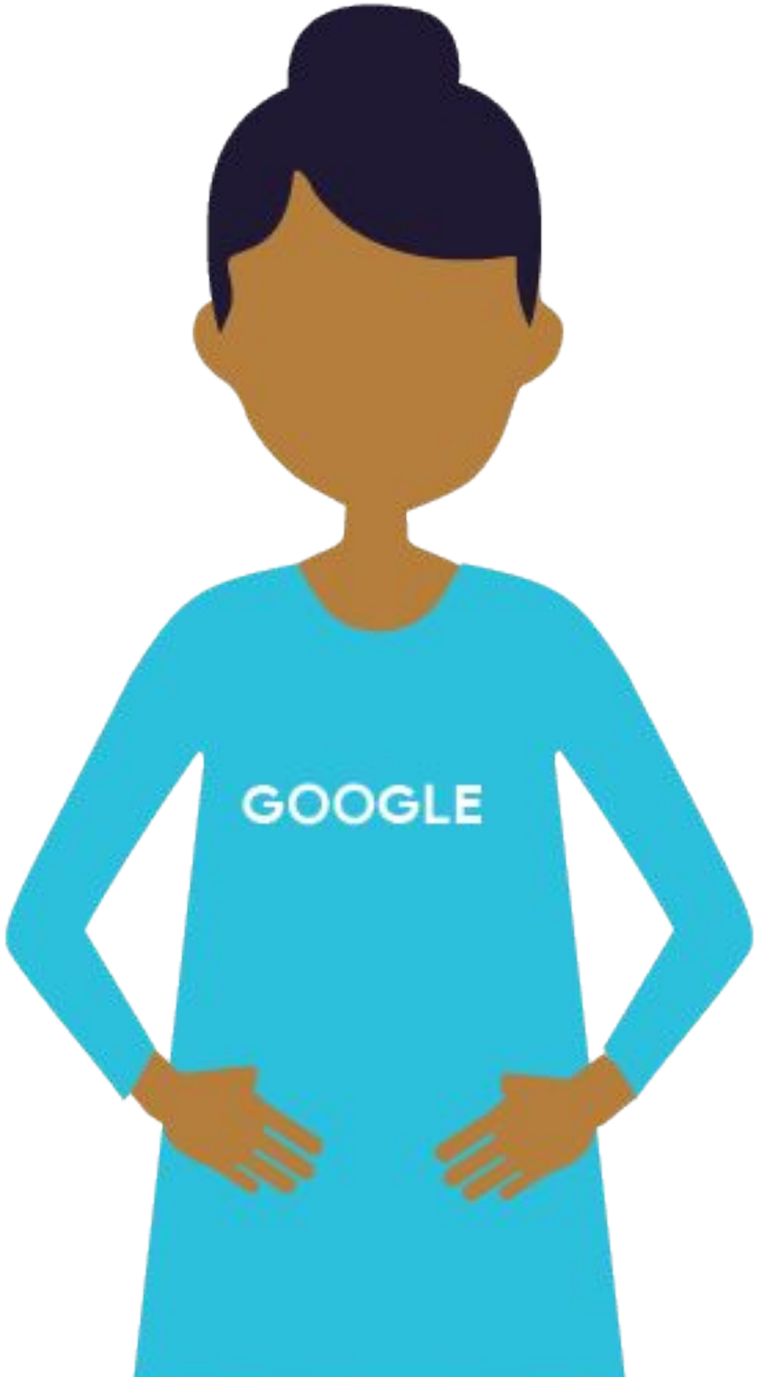


Agenda

Adapting to Data

Mitigating Training-Serving Skew Through Design

Debugging a Production Model

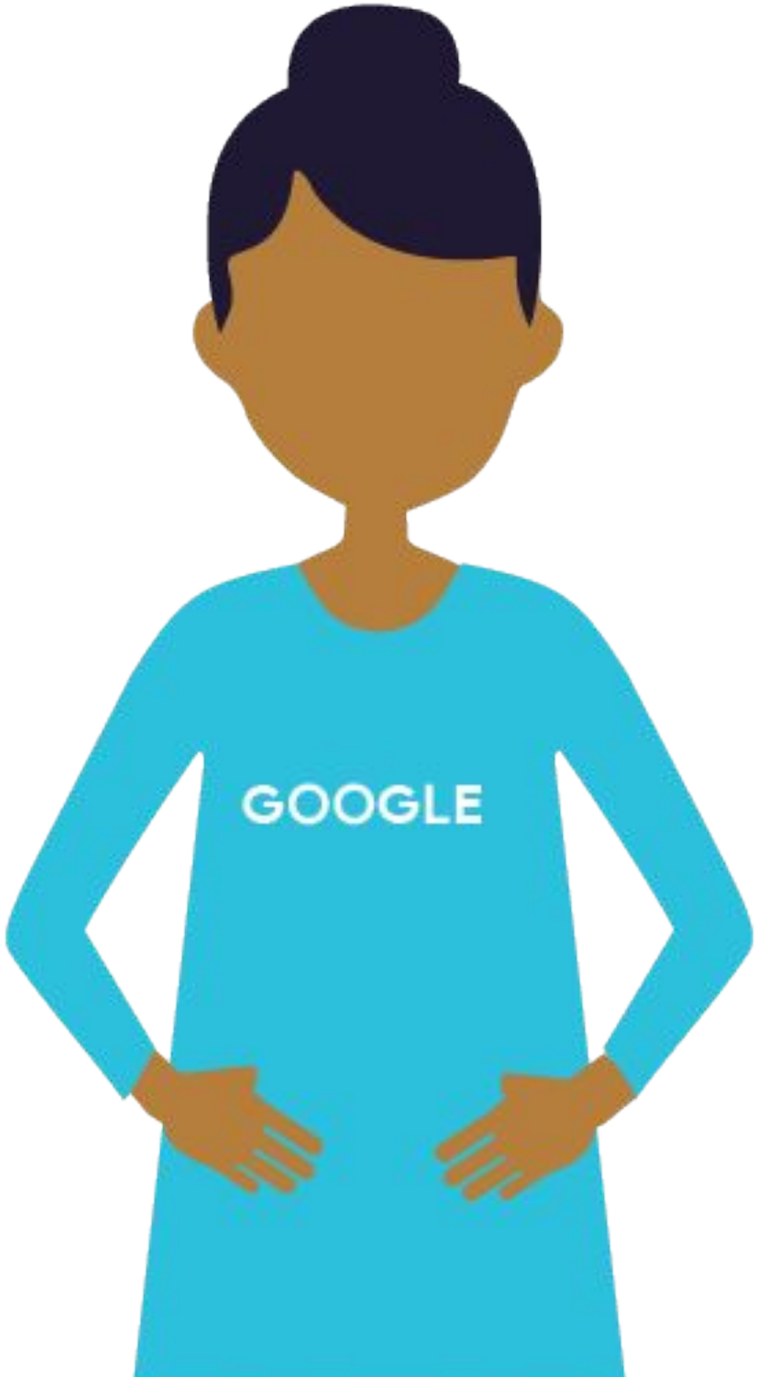


Training/Serving Skew

1. A discrepancy between how you handle data in the training and serving pipelines

2. A change in the data between when you train and when you serve.

3. A feedback loop between your model and your algorithm.



How Code Can Create Training/Serving Skew

- Different library versions that are functionally equivalent but optimized differently
- Different library versions that are not functionally equivalent
- Re-implemented functions

Course 2: Production ML Systems

Module 3: Designing Adaptable ML Systems

Lesson Title: **Lab Intro: Serving ML Predictions in batch and real-time**

Presenter: Max Lotstein

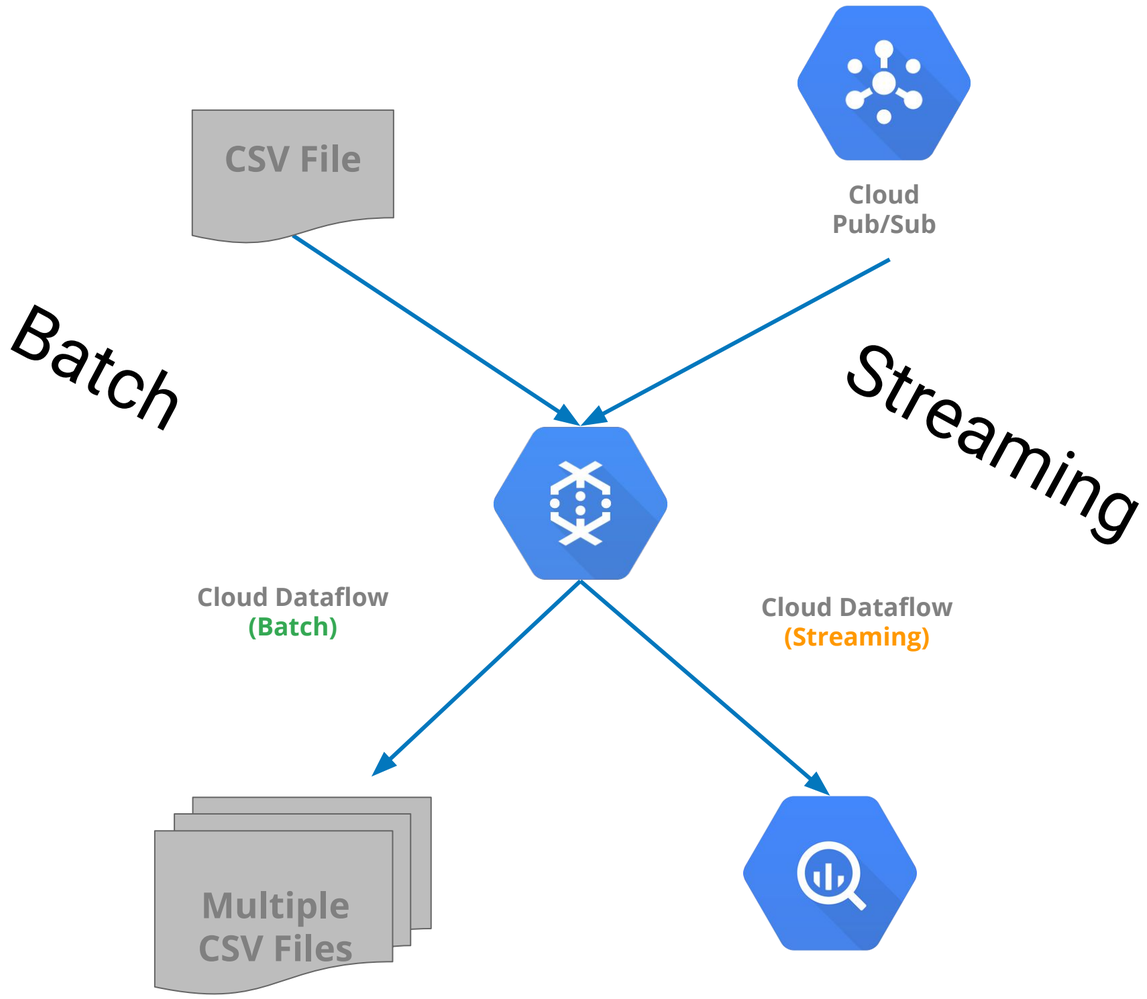
Format: Talking Head

Video Name: T-PSML-O_3_l11_lab_intro:_serving_ml_predictions_in_batch_and_real-time

Lab

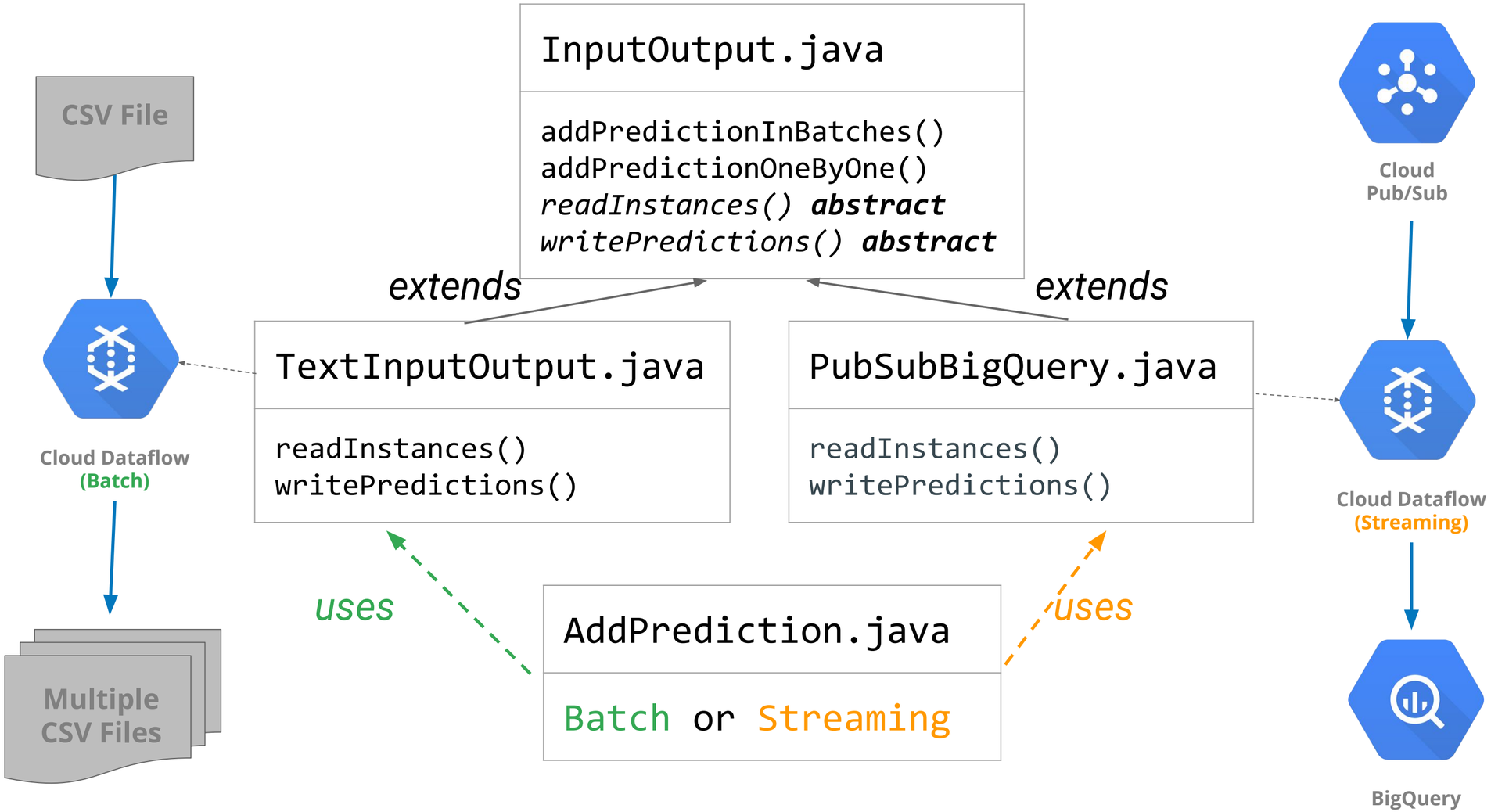
Serving ML Predictions in batch and real-time

Max Lotstein


CSV File
Cloud
Pub/Sub
Batch
Streaming
Cloud Dataflow
(Batch)
Cloud Dataflow
(Streaming)
Multiple
CSV Files


GOOGLE

Lab: Serving ML Predictions in batch and real-time



Course 2: Production ML Systems

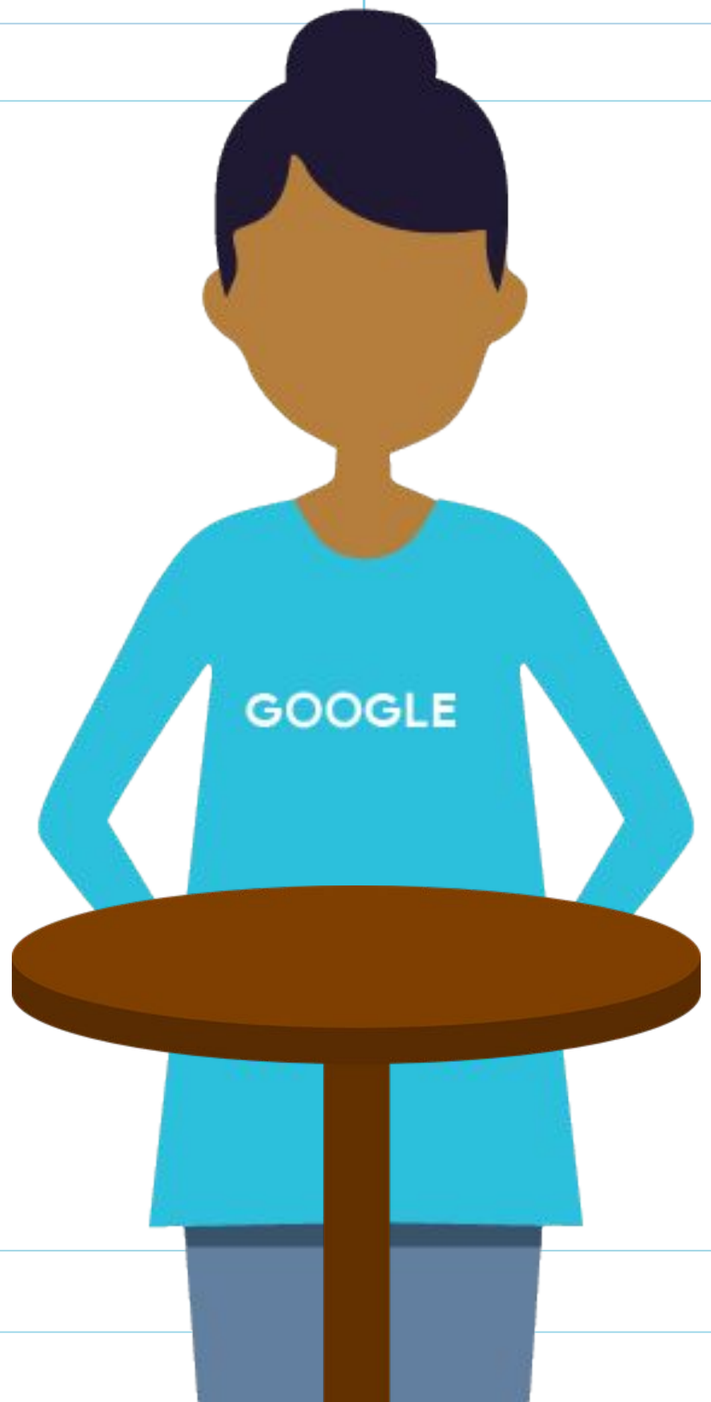
Module 3: Designing Adaptable ML Systems

Lesson Title: **Lab Solution: Serving ML Predictions in batch and real-time**

Presenter: Max Lotstein

Format: Talking Head

Video Name: T-PSML-O_3_l12_lab_solution:_serving_ml_predictions_in_batch_and_real-time



Title Safe >

< Action Safe

Course 2: Production ML Systems

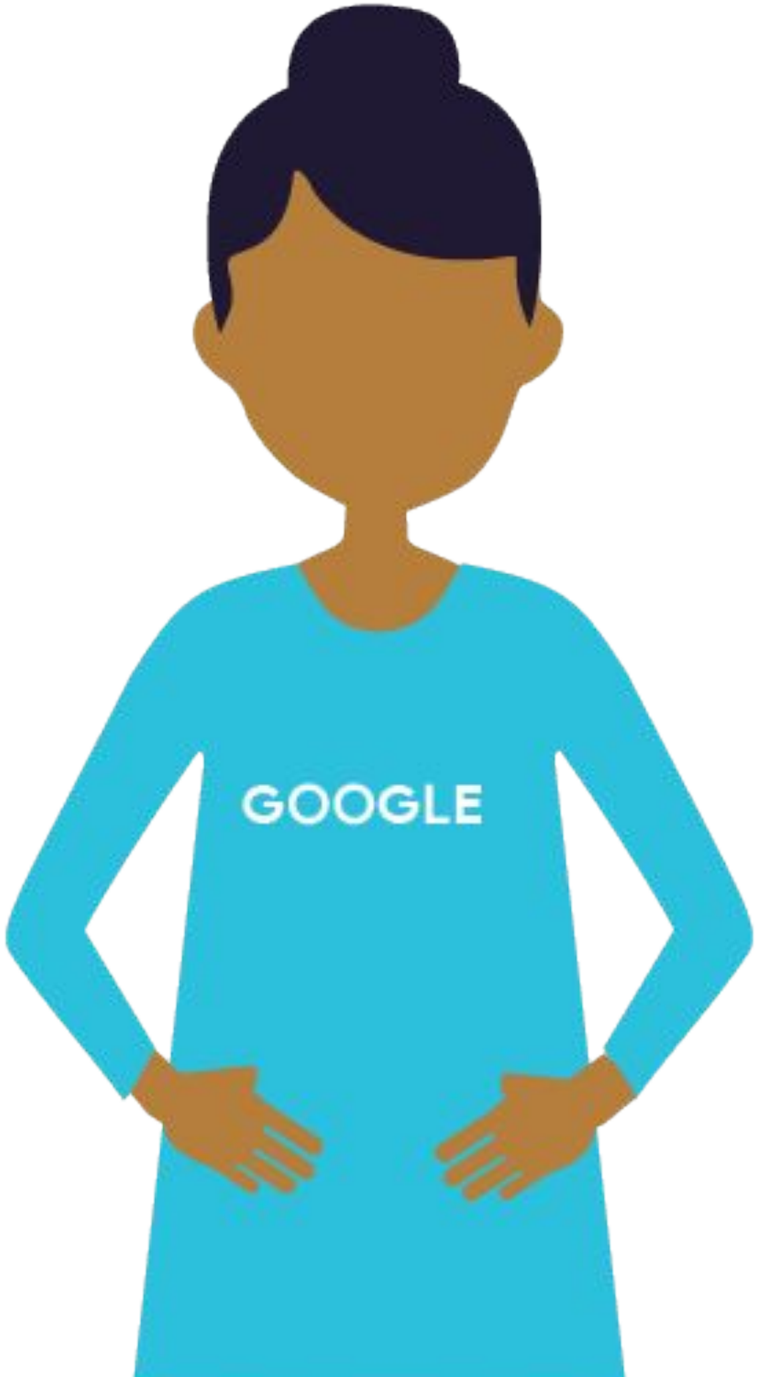
Module 3: Designing Adaptable ML Systems

Lesson Title: **Debugging a Production Model**

Presenter: Max Lotstein

Format: Talking Head

Video Name: T-PSML-O_3_l13_debugging_a_production_model



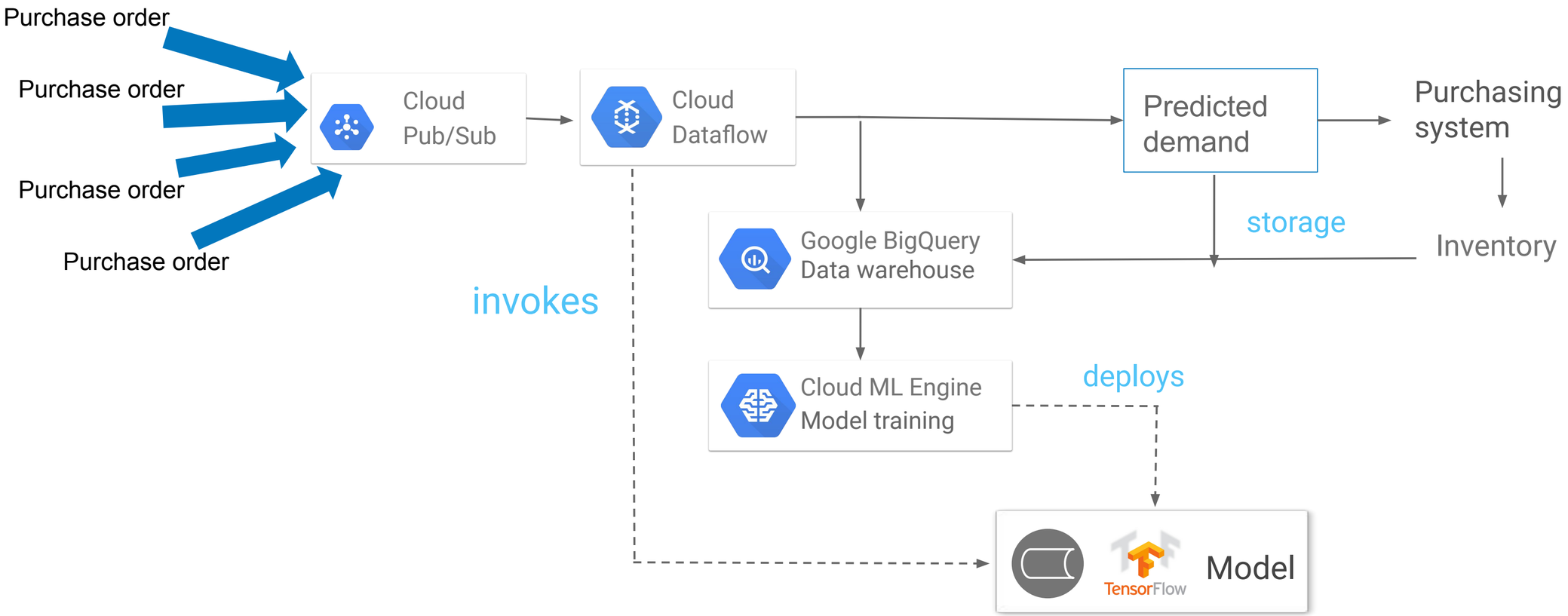
Agenda

Adapting to Data

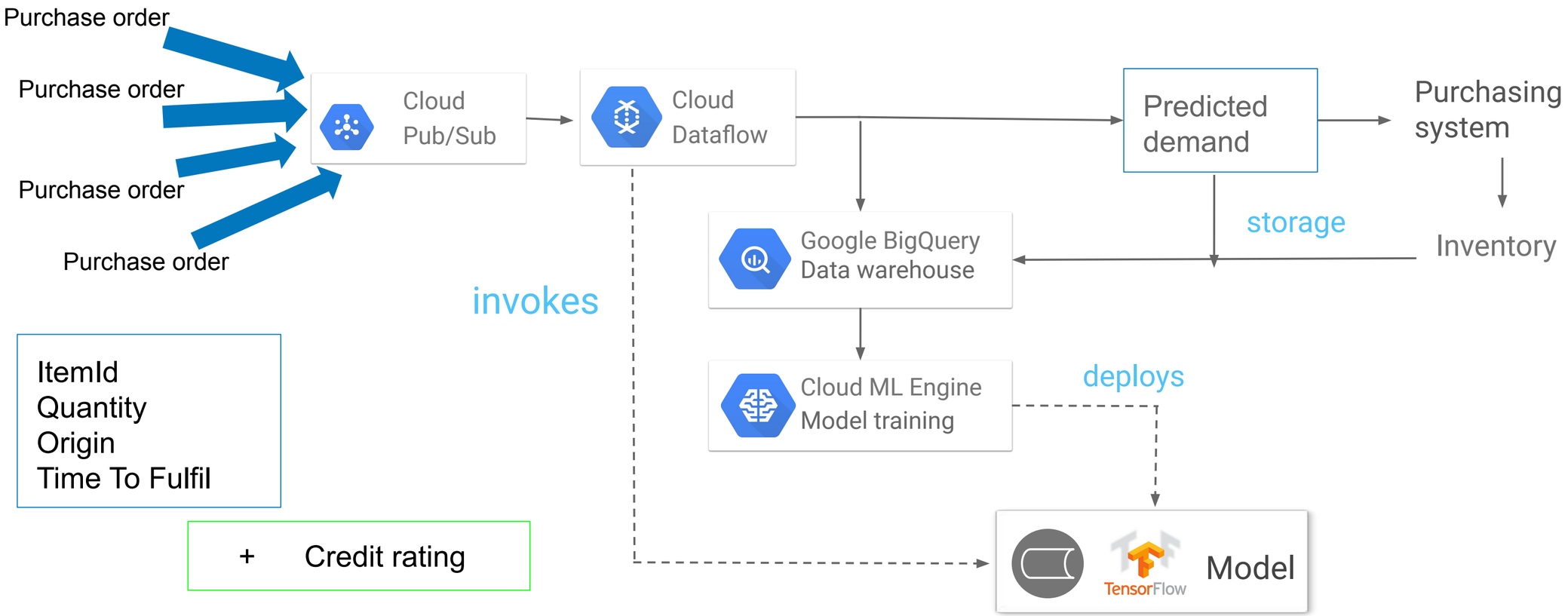
Mitigating Training-Serving Skew Through Design

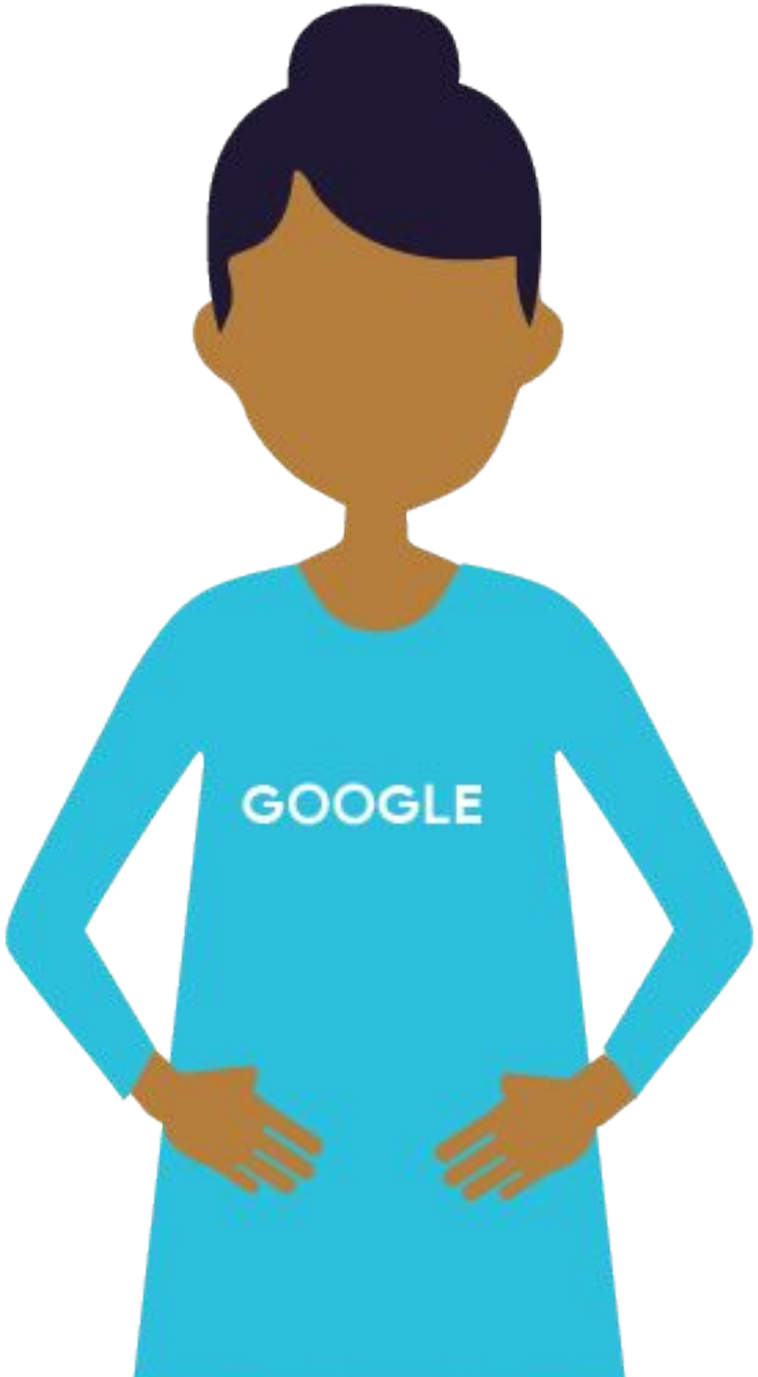
Debugging a Production Model

Predicting Widget Demand

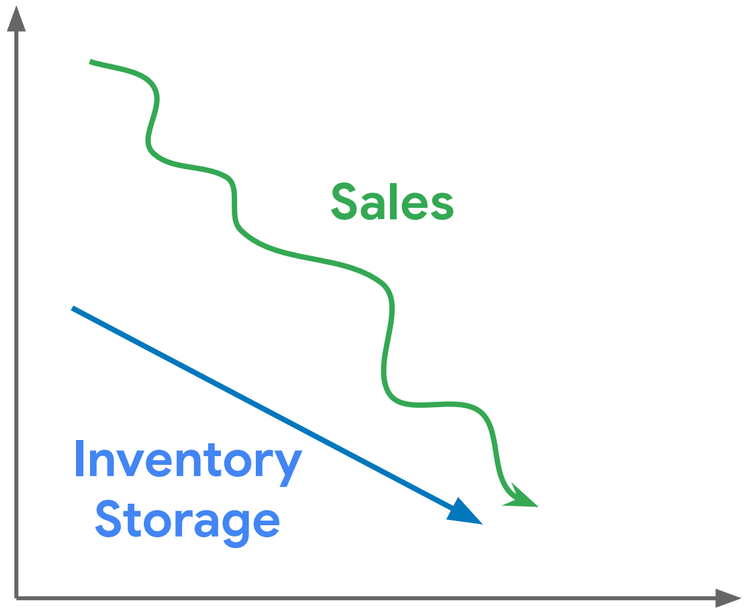


Along comes a new feature

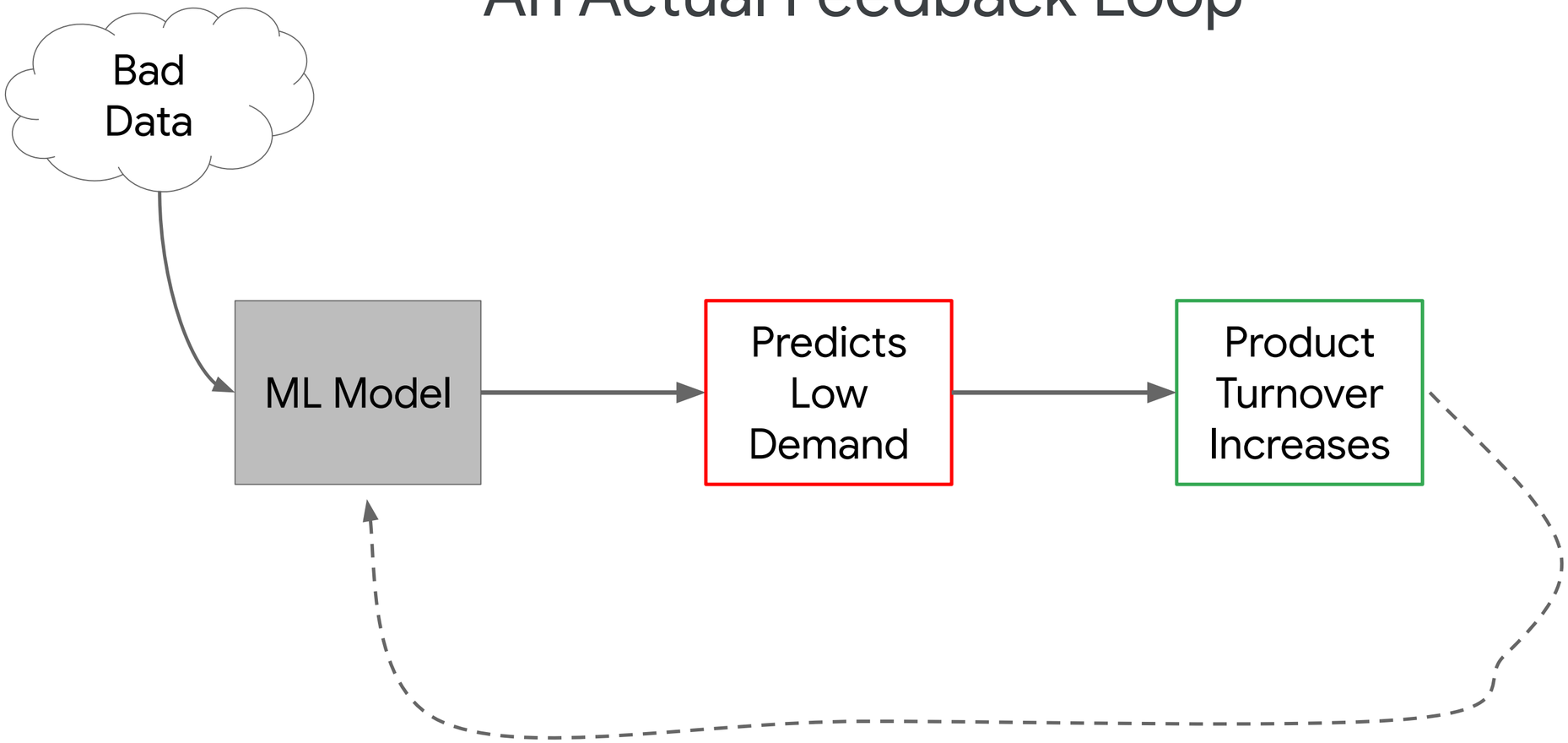


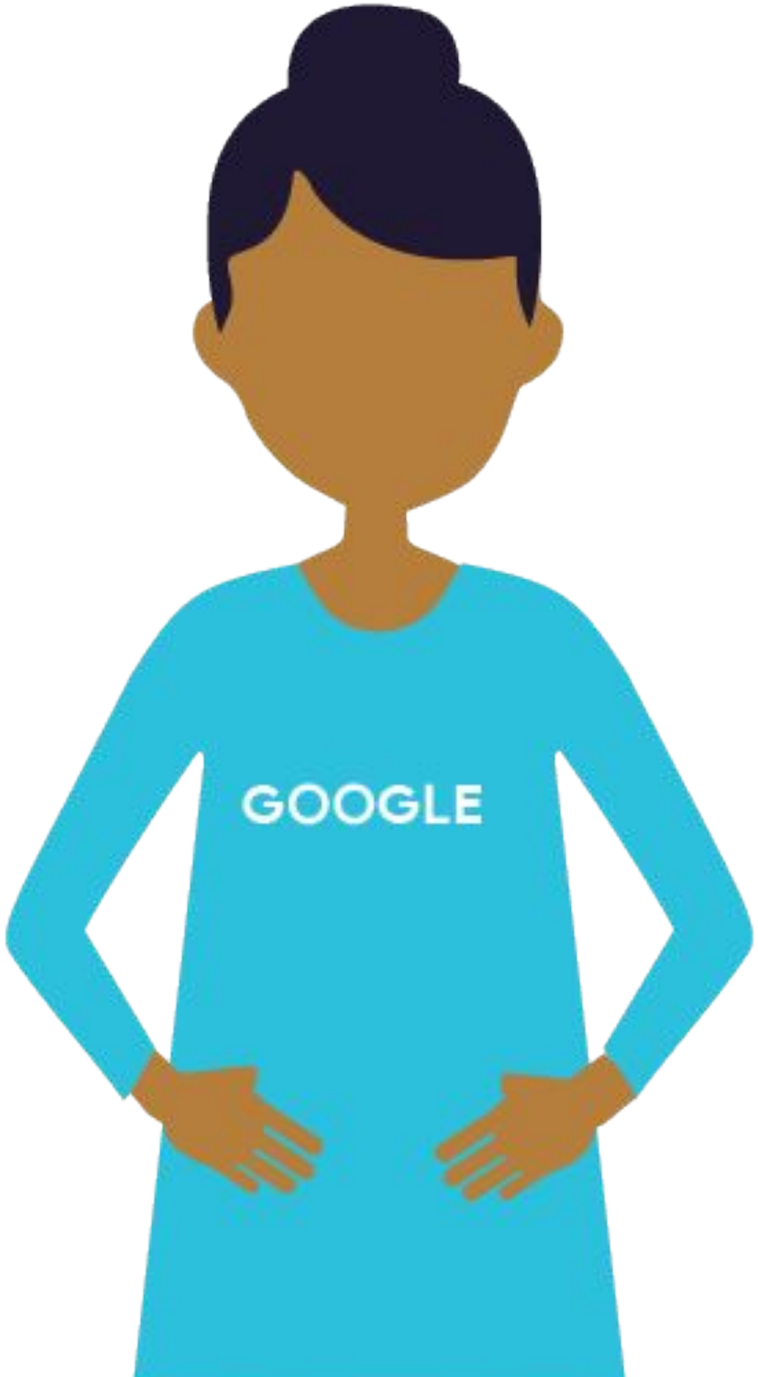


Business Catastrophe 1

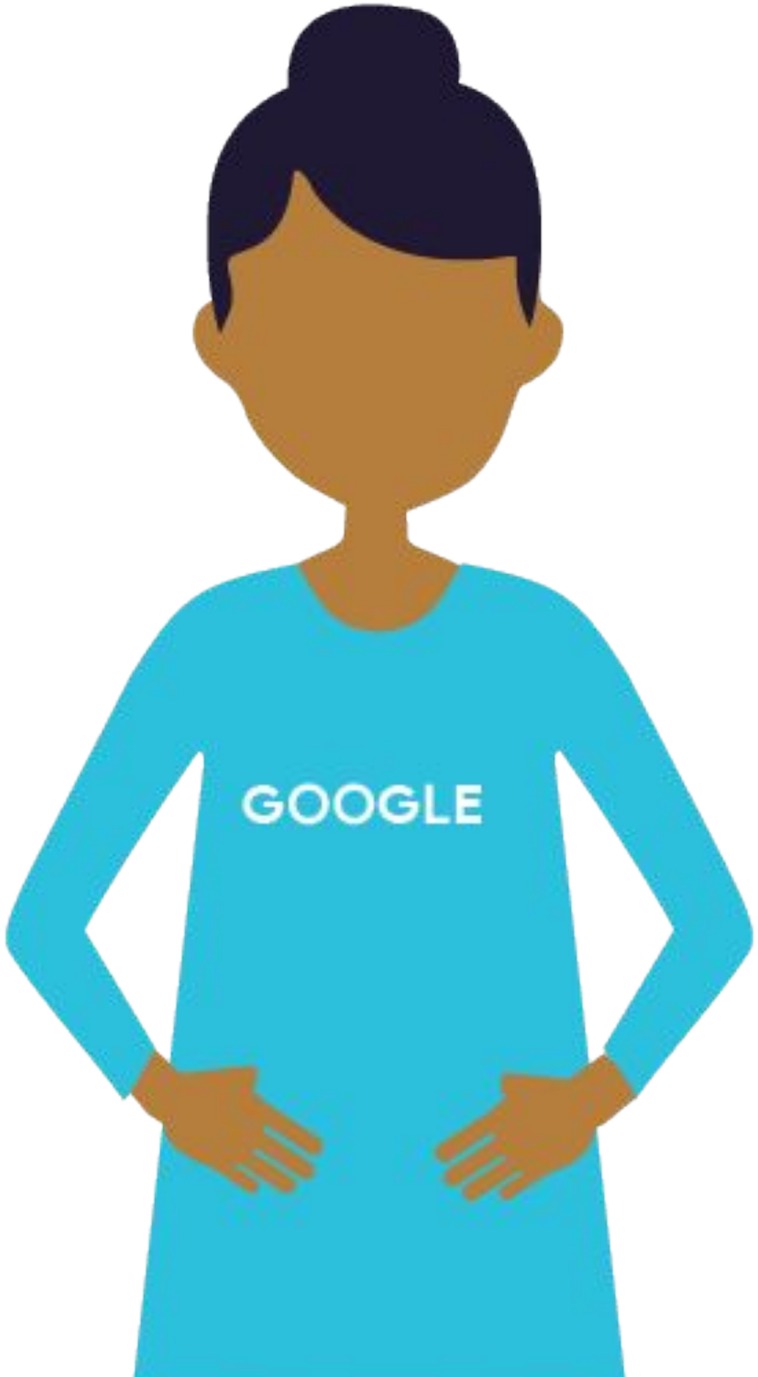


An Actual Feedback Loop

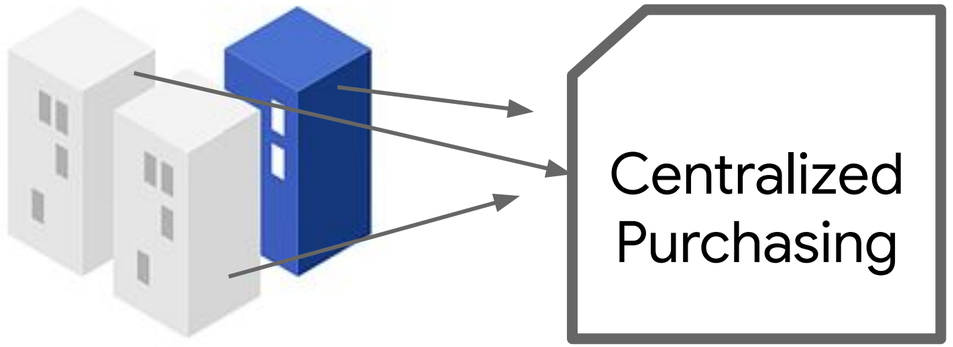


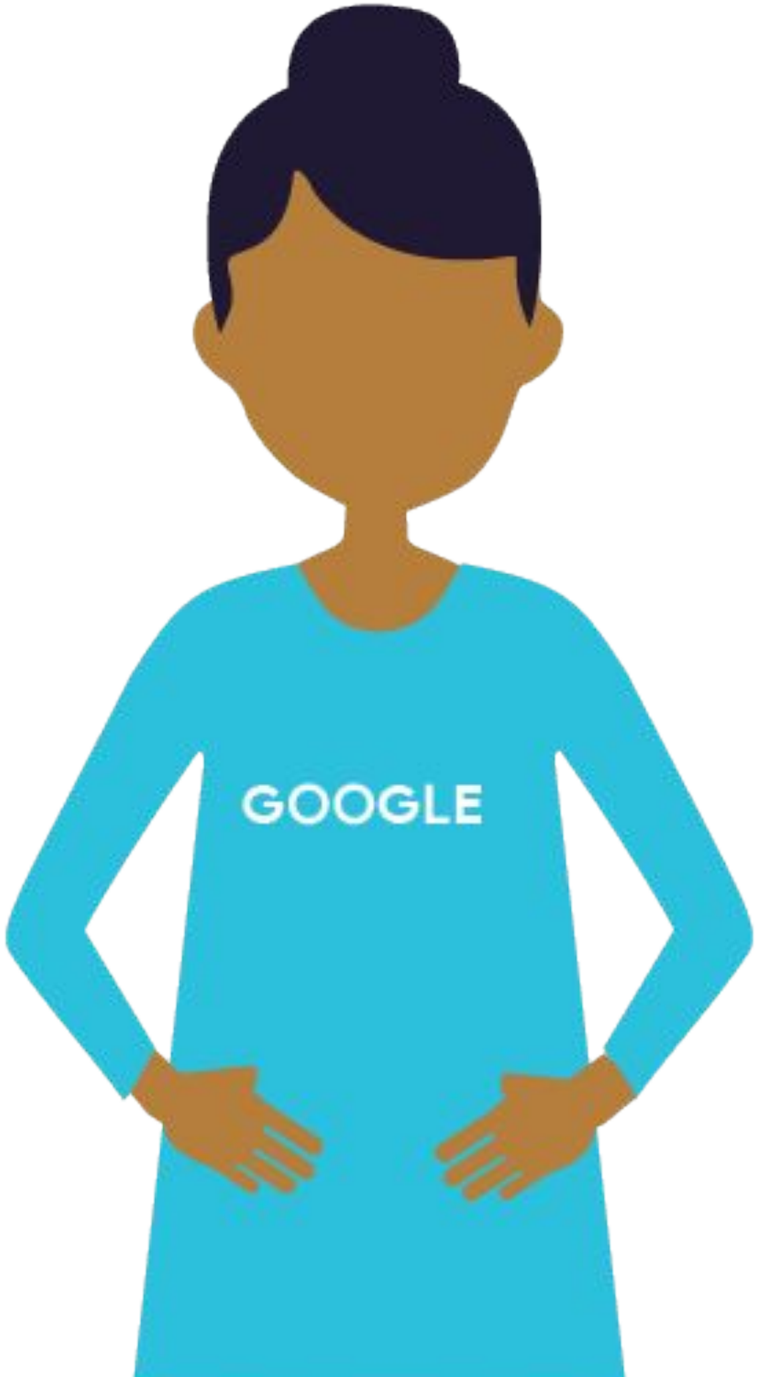


Business Catastrophe 2

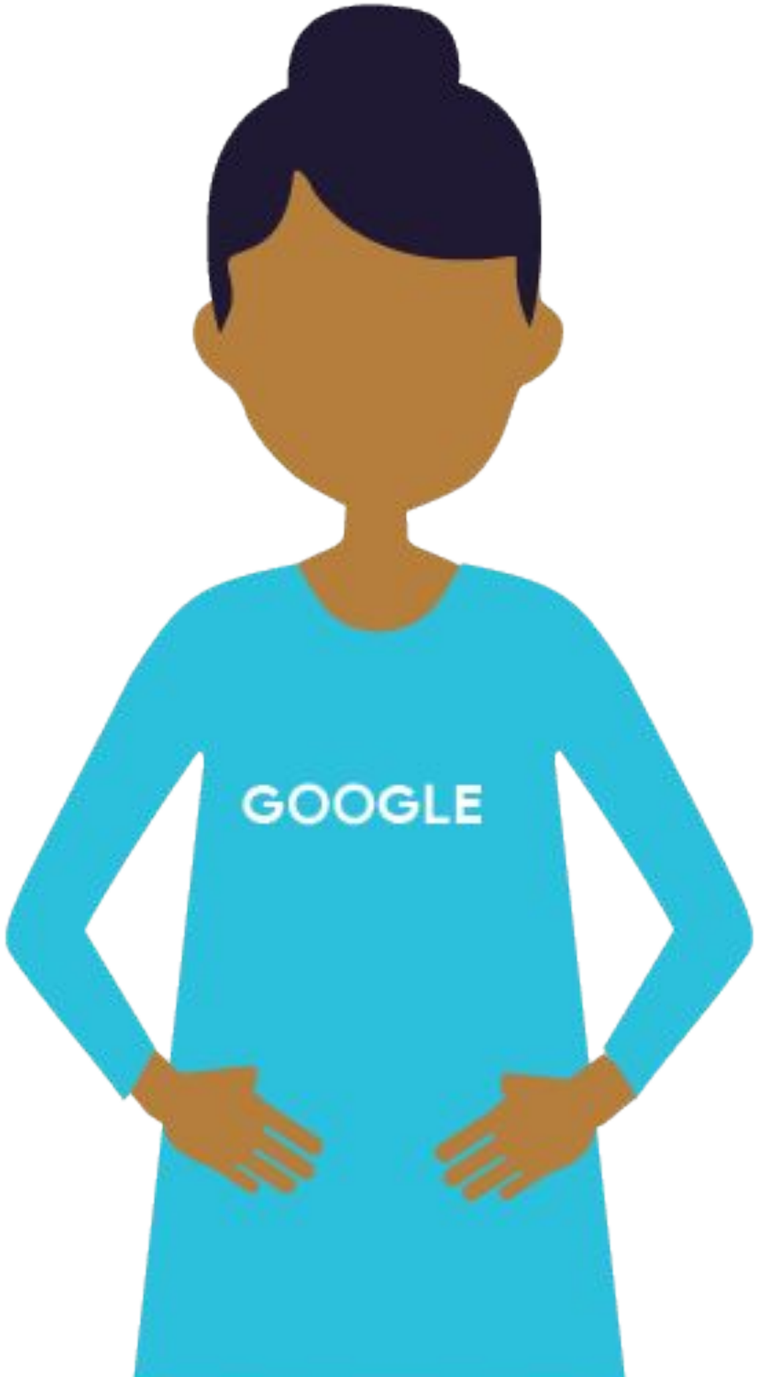


Business Catastrophe 2





Business Catastrophe 3



Business Catastrophe 3

Course 2: Production ML Systems

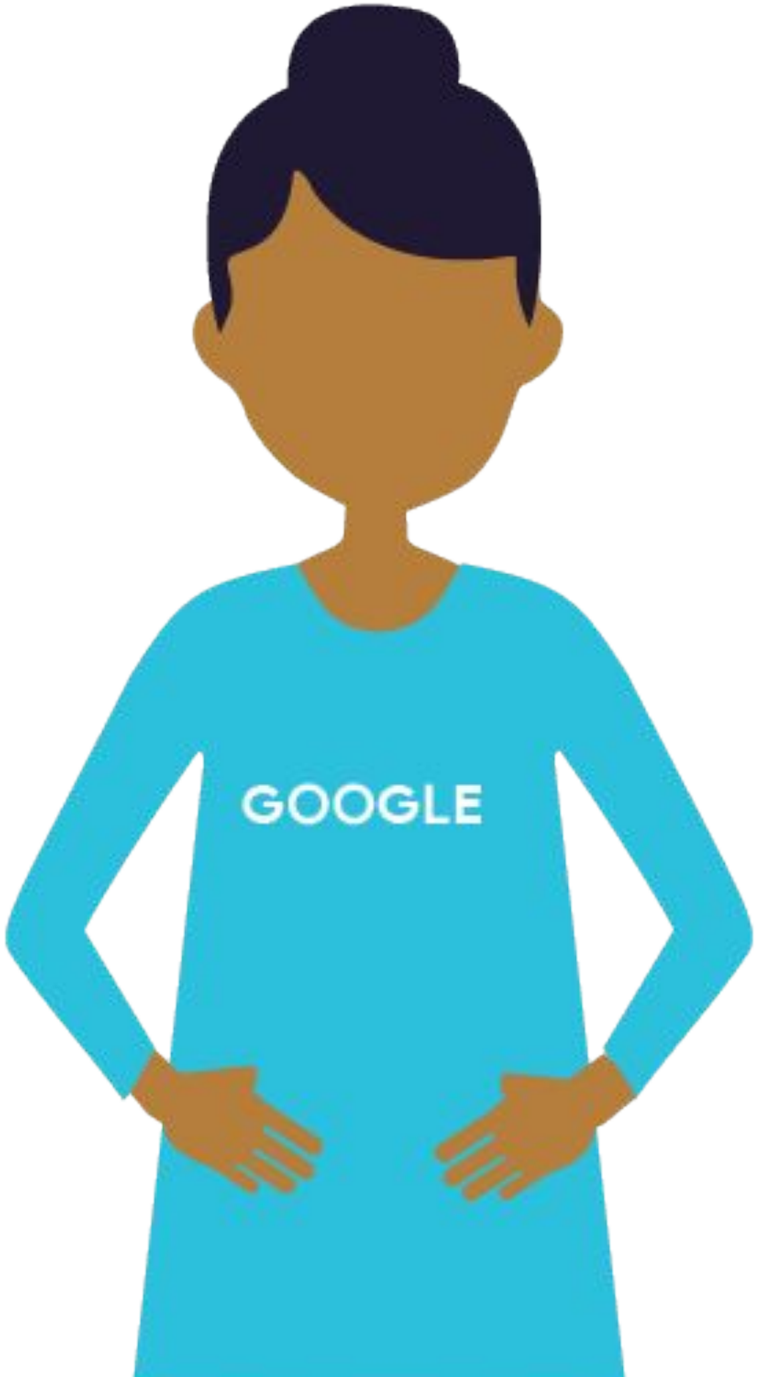
Module 3: Designing Adaptable ML Systems

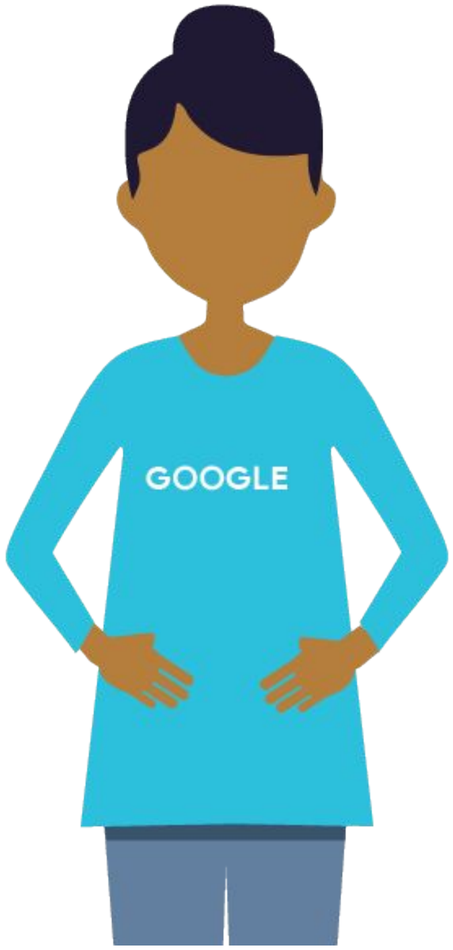
Lesson Title: **Module Summary**

Presenter: Max Lotstein

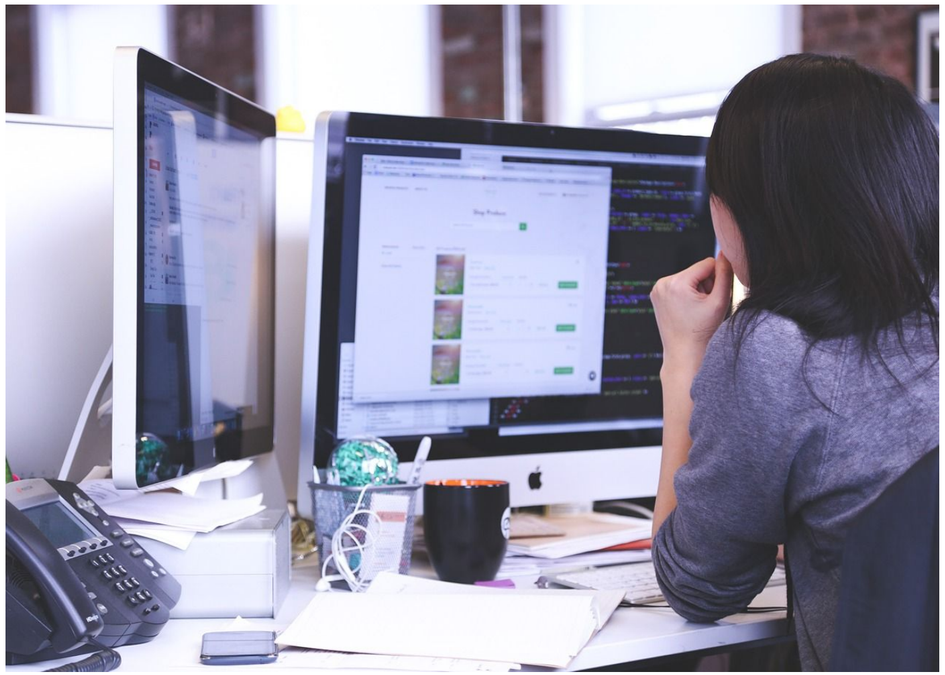
Format: Talking Head

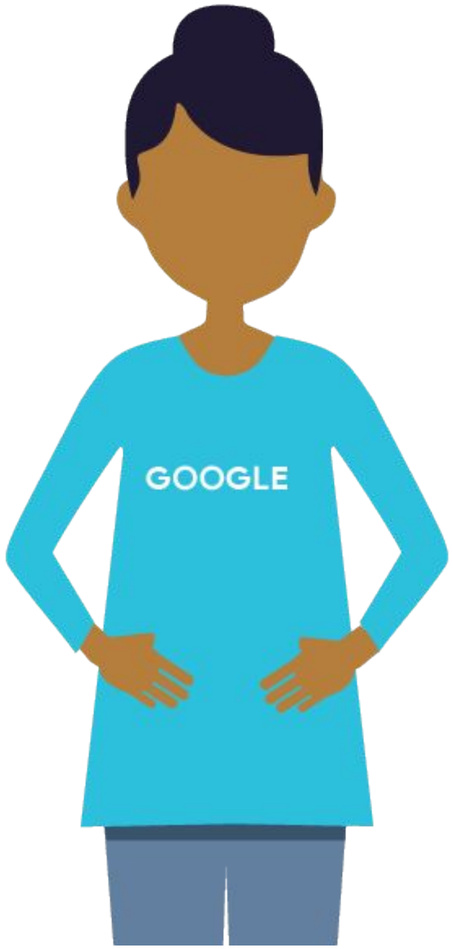
Video Name: T-PSML-O_3_l14_module_summary


GOOGLE

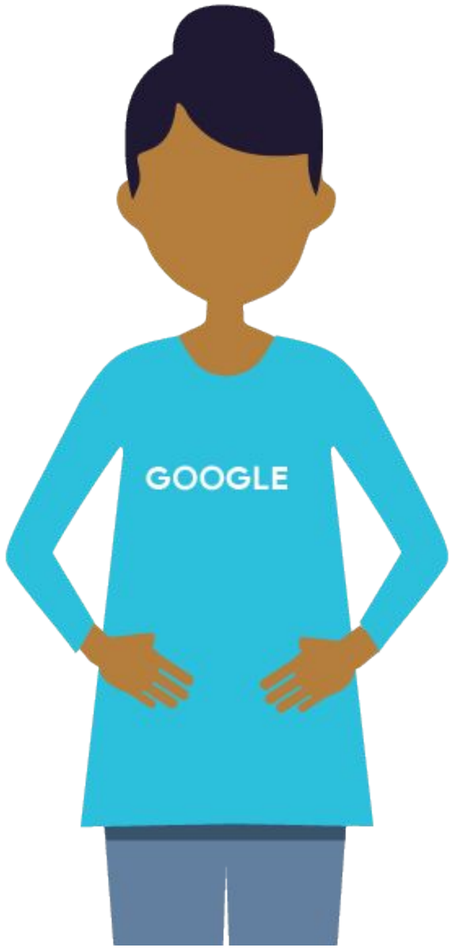


Keep humans in the loop





Prioritize maintainability



Get ready to roll back