Sign up for a Google Cloud Platform free trial (https://cloud.google.com) to follow along or try at home.

https://goo.gl/nqsCo5 (this deck)

End-to-end machine learning on structured data

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Google Cloud

2017-10-12
World Summit AI,
Amsterdam

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Agenda

Machine Learning on Google Cloud

Explore the data

Create the dataset

Build the model

Operationalize model

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The most common ML models at Google are models that operate on structured data

Type of network	# of network layers	# of weights	% of deployed models
MLP0	5	20M	61%
MLP1	4	5M	
LSTM0	58	52M	29%
LSTM1	56	34M	
CNN0	16	8M	5%
CNN1	89	100M	

https://cloud.google.com/blog/big-data/2017/05/an-in-depth-look-at-googles-first-tensor-processing-unit-tpu

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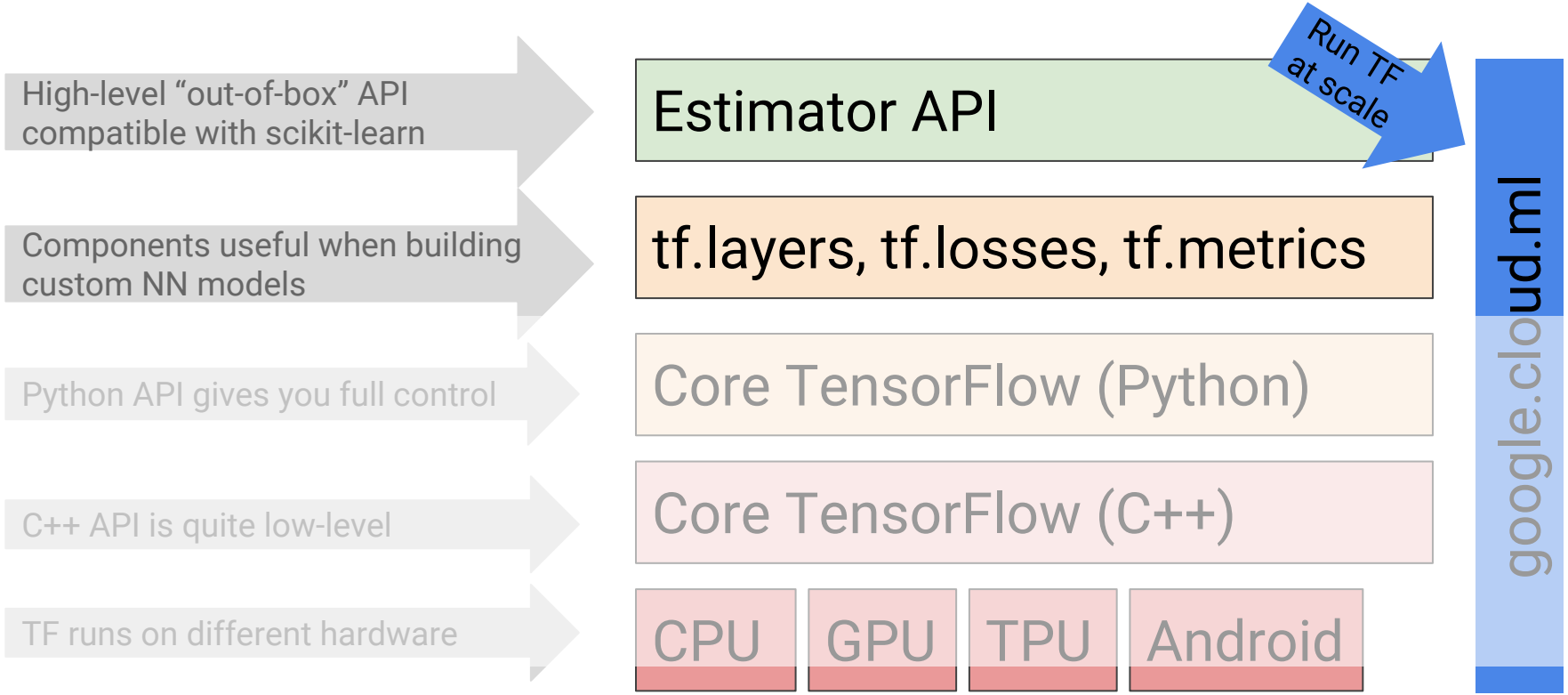
We will use distributed TensorFlow on Cloud ML Engine



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Many Machine Learning frameworks can handle toy problems

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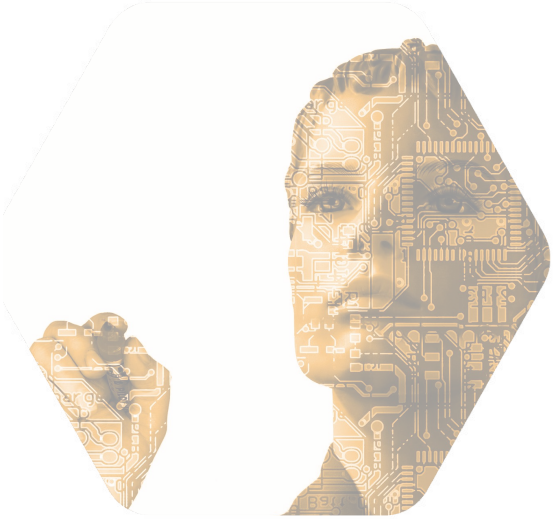
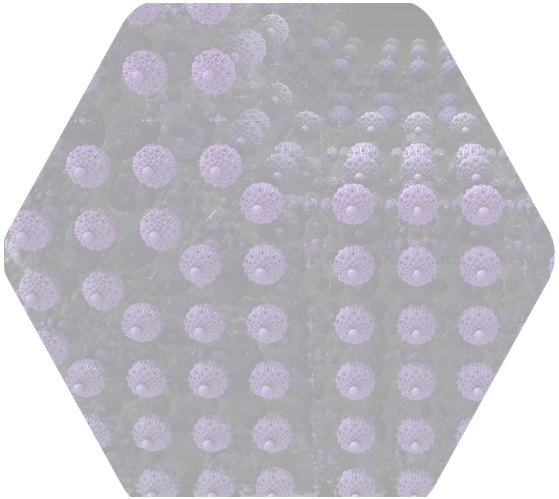
To build effective ML, you need:

Big Data



Feature Engineering



Model Architectures

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As your data size increases, batching and distribution become important

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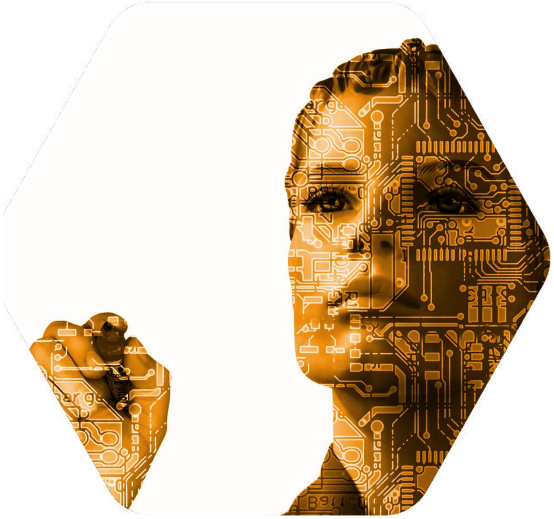
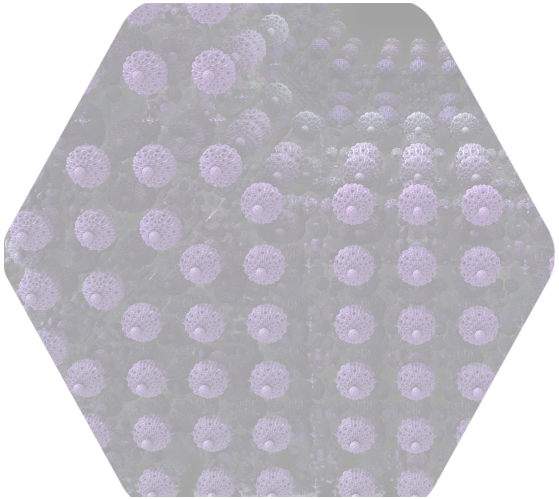
To build effective ML, you need:

Big Data



Feature Engineering



Model Architectures

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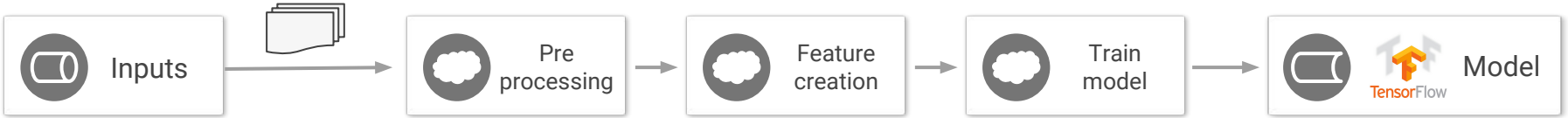
Input necessary transformations



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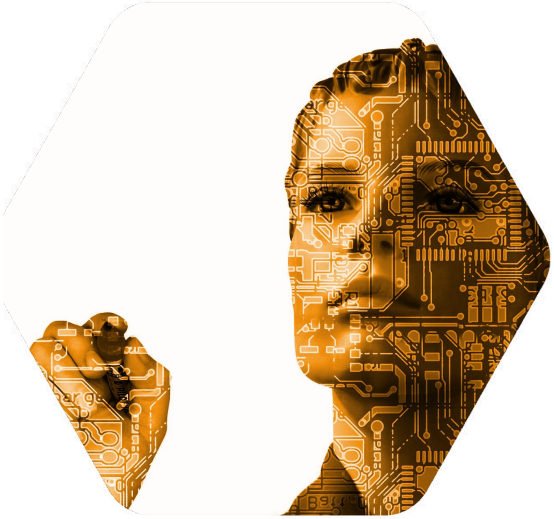
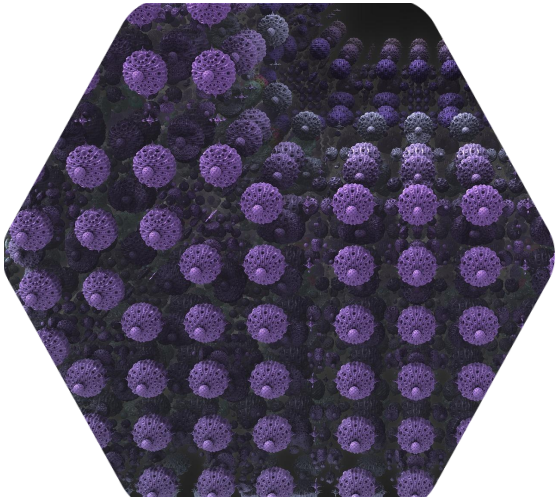
To build effective ML, you need:

Big Data



Feature Engineering



Model Architectures

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What else does a ML framework need to provide?

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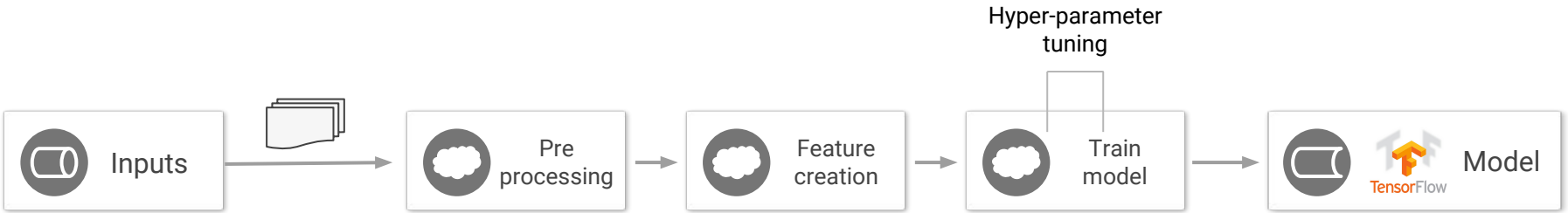
Hyperparameter tuning might be nice



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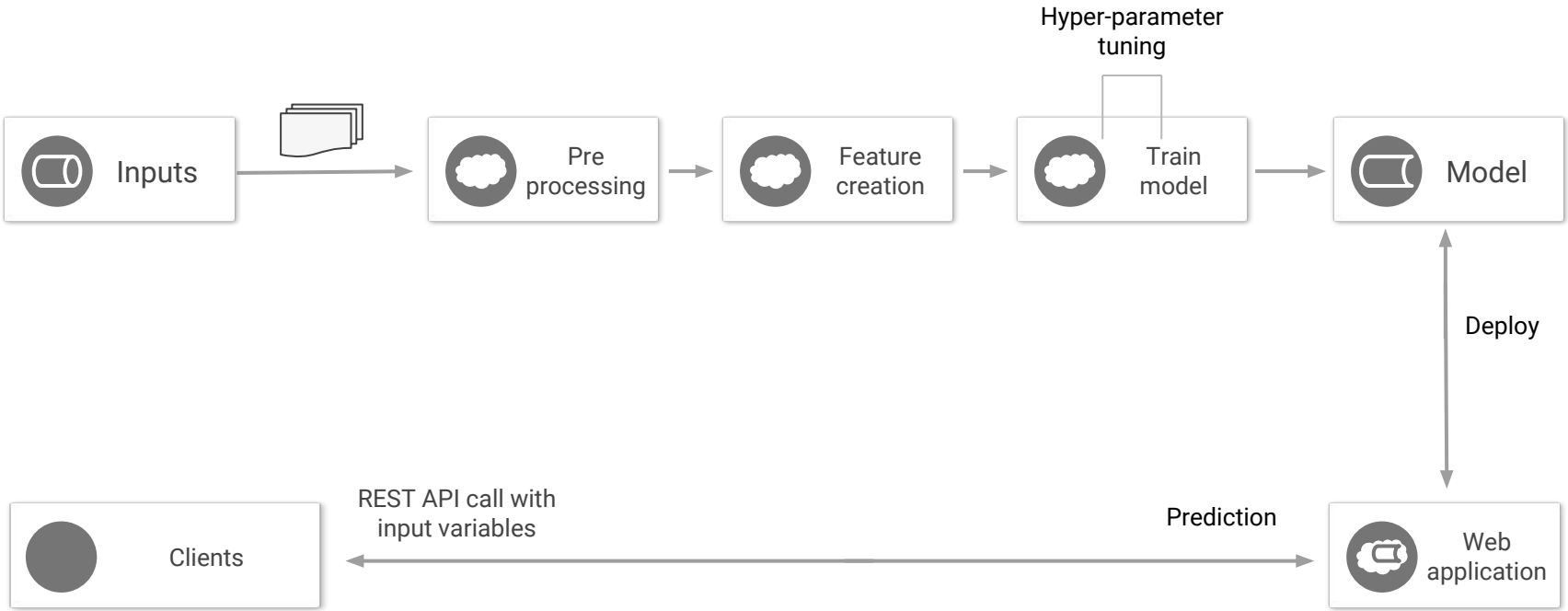
Need to autoscale prediction code



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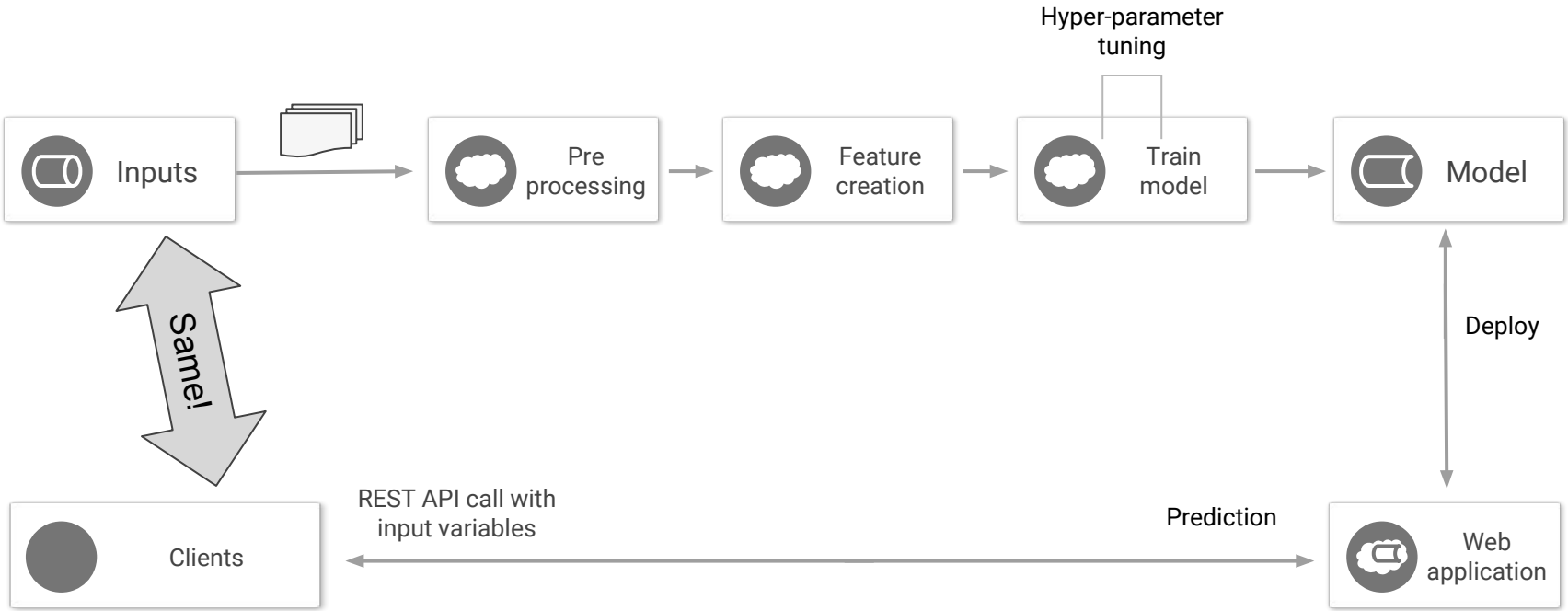
Who does the preprocessing?



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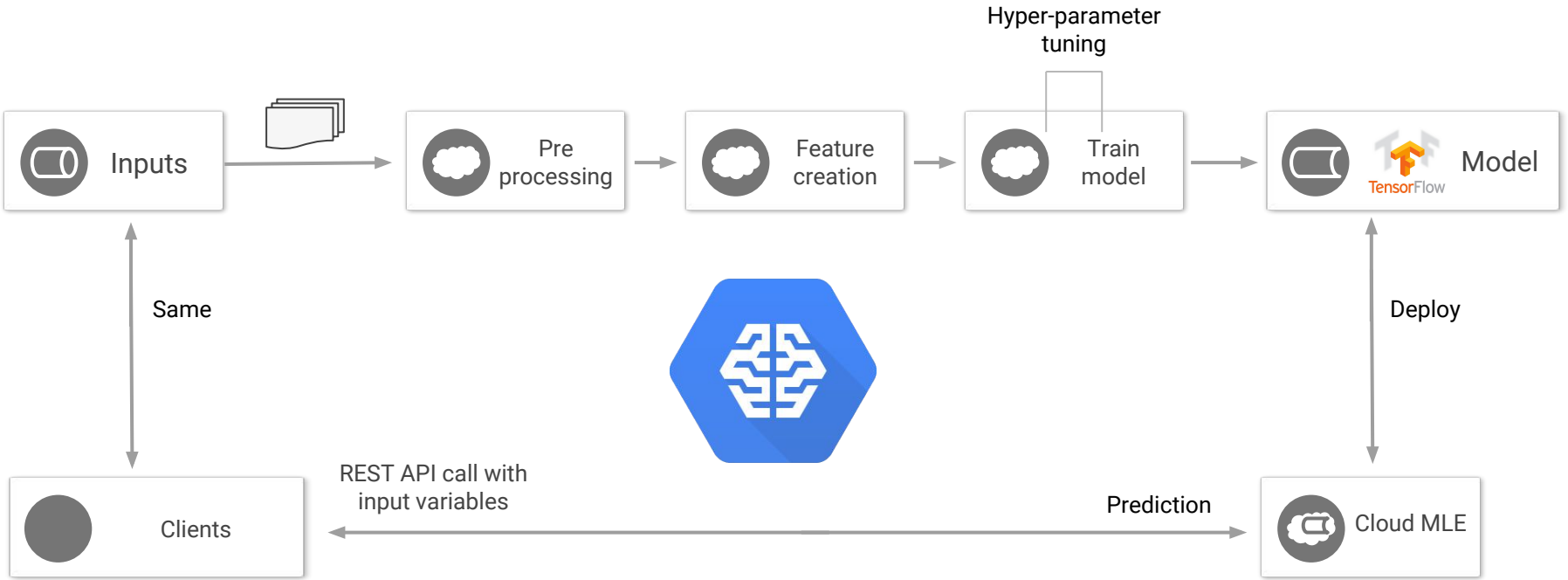
Cloud Machine Learning—repeatable, scalable, tuned



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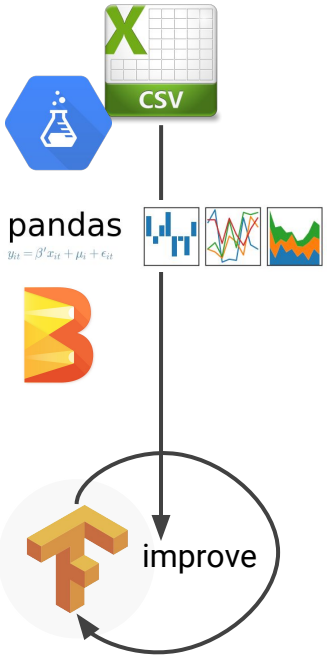
In Datalab, start locally on sampled dataset



Google Cloud Datalab tfclassic (unsaved changes)

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2b. Working with low-level TensorFlow

This notebook is Lab2b of CPB 102, Google's course on Machine Learning using Cloud ML.

In this notebook, we will work with relatively low-level TensorFlow functions to implement a linear regression model. We will use this notebook to demonstrate early stopping -- a technique whereby training is stopped once the error on the validation dataset starts to increase.

```
import datalab.bigquery as bq
import tensorflow as tf
import pandas as pd
import numpy as np
import shutil
```

Code to read data and compute error is the same as Lab2a.

```
def read_dataset(filename):
  return pd.read_csv(filename, header=None, names=['pickuplon','pickuplat','dropofflon','dropofflat','passengers','fare_amount'])

df_train = read_dataset('../lab1a/taxi-train.csv')
df_valid = read_dataset('../lab1a/taxi-valid.csv')
df_test = read_dataset('../lab1a/taxi-test.csv')
df_train[:5]
```

```
FEATURE_COLS = np.arange(0,5)
TARGET_COL   = 'fare_amount'
```

```
def compute_rmse(actual, predicted):
  return np.sqrt(np.mean((actual-predicted)**2))

def print_rmse(model):
  print "Train RMSE = {0}".format(compute_rmse(df_train[TARGET_COL], model.predict(df_train.iloc[:,FEATURE_COLS].values)))
  print "Valid RMSE = {0}".format(compute_rmse(df_valid[TARGET_COL], model.predict(df_valid.iloc[:,FEATURE_COLS].values)))
```

Linear Regression

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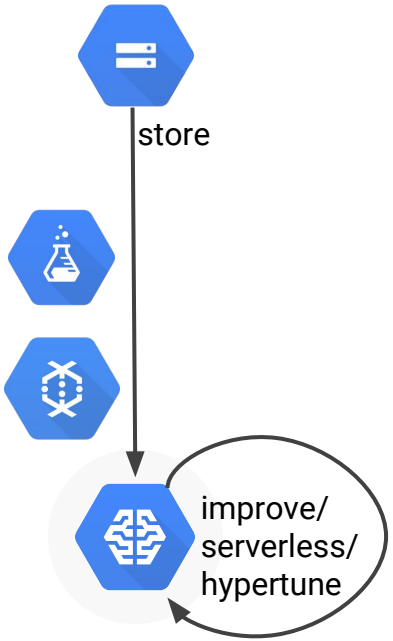
Then, scale it out to GCP using serverless technology



Google Cloud Datalab cloudml (autosaved)

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Training on cloud

In order to train on the cloud, we have to copy the model and data to our bucket on Google Cloud Storage (GCS).

```
%bash
rm -rf taxifare.tar.gz taxi_trained
tar cvfz taxifare.tar.gz taxifare
gsutil cp taxifare.tar.gz gs://$BUCKET/taxifare/source/taxifare.tar.gz
gsutil cp ../labla/*.csv  gs://$BUCKET/taxifare/input/
gsutil -m rm -r -f gs://$BUCKET/taxifare/taxi_preproc
gsutil -m rm -r -f gs://$BUCKET/taxifare/taxi_trained
```

Running...

When you run your preprocessor, you have to change the input and output to be on GCS.

Using DirectPipelineRunner runs Dataflow locally, but the inputs & outputs are on the cloud. Using BlockingDataflowPipelineRunner will use Cloud Dataflow (and take much longer because of the overhead involved for such a small dataset). To see the status of your BlockingDataflowPipelineRunner job, visit https://console.cloud.google.com/dataflow

```
# imports
import apache_beam as beam
import google.cloud.ml as ml
import google.cloud.ml.dataflow.io.tfrecordio as tfrecordio
import google.cloud.ml.io as io
import os

# Change as needed
#RUNNER = 'DirectPipelineRunner'  #
RUNNER = 'BlockingDataflowPipelineRunner'

# defines
feature_set = TaxifareFeatures()
OUTPUT_DIR = 'gs://{0}/taxifare/taxi_preproc'.format(BUCKET)
```

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Agenda

Machine Learning on Google Cloud

Explore the data

Create the dataset

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Goal: predict weight of a newborn

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An open dataset of births is available in BigQuery

Births recorded in the 50 states of the USA from 1969 to 2008

Table ID	bigquery-public-data:samples.natality
Table Size	21.9 GB
Long Term Storage Size	21.9 GB
Number of Rows	137,826,763

https://bigquery.cloud.google.com/table/bigquery-public-data:samples.natality

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The data set includes details about the pregnancy

Date of birth	**year**	INTEGER	NULLABLE	Four-digit year of the birth. Example: 1975.
	month	INTEGER	NULLABLE	Month index of the date of birth, where 1=January.
	day	INTEGER	NULLABLE	Day of birth, starting from 1.
	wday	INTEGER	NULLABLE	Day of the week, where 1 is Sunday and 7 is Saturday.
Location of birth (US state)	**state**	STRING	NULLABLE	The two character postal code for the state. Entries after 2004 do not include this value.
Baby's birth weight (lbs)	**weight_pounds**	FLOAT	NULLABLE	Weight of the child, in pounds.
Mother's age at birth	**mother_age**	INTEGER	NULLABLE	Reported age of the mother when giving birth.
Duration of pregnancy	**gestation_weeks**	INTEGER	NULLABLE	The number of weeks of the pregnancy.
Mother's use of cigarette or alcohol	**cigarette_use**	BOOLEAN	NULLABLE	True if the mother smoked cigarettes. Available starting 2003.
	alcohol_use	BOOLEAN	NULLABLE	True if the mother used alcohol. Available starting 1989.
Mother's weight gain (lbs)	**weight_gain_pounds**	INTEGER	NULLABLE	Number of pounds gained by the mother during pregnancy.

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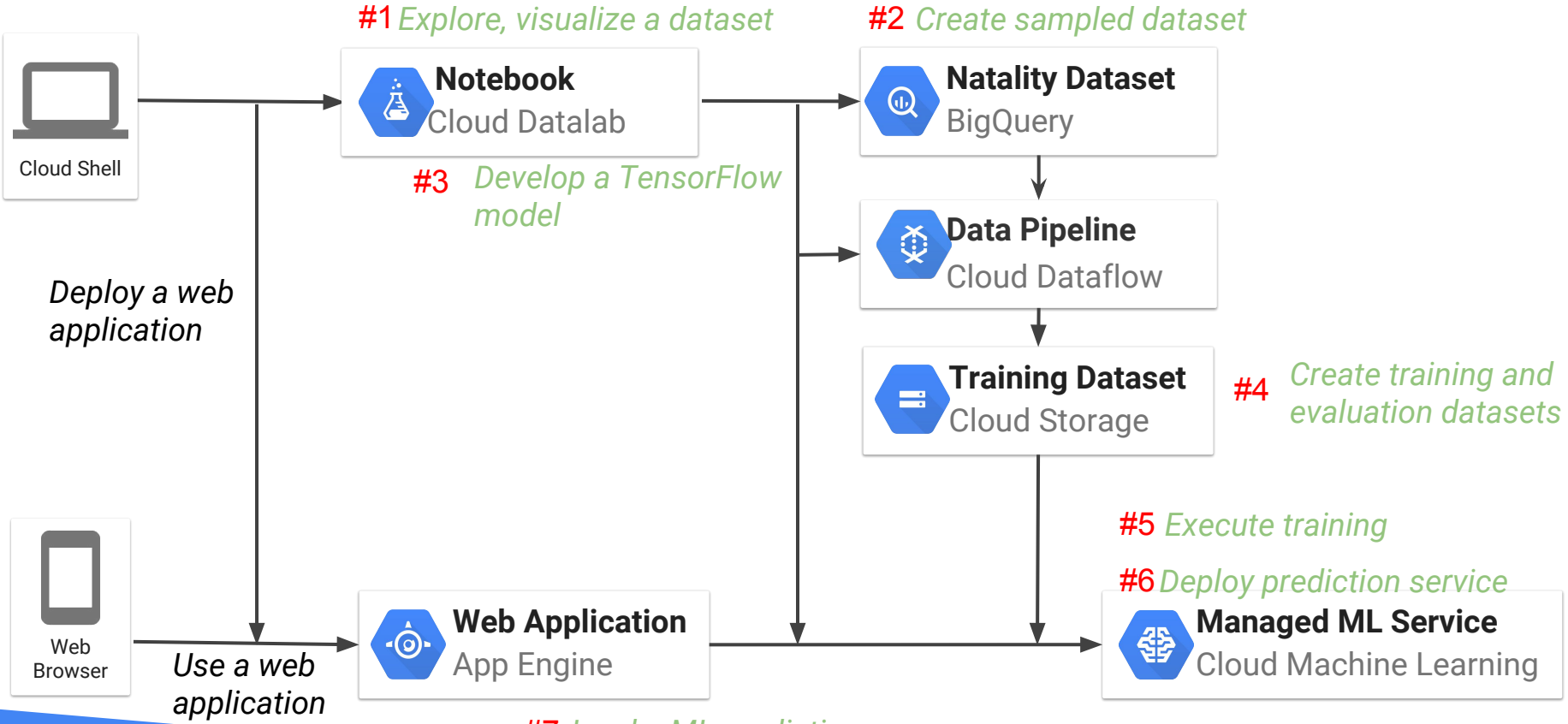
The end-to-end machine learning set of labs



= Lab Exercises

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https://goo.gl/nqsCo5 (this deck)

codelabs.developers.google.com/cloud-quest-scientific-data

github.com/GoogleCloudPlatform/training-data-analyst/blob/master/blogs/babyweight/

Lab #1: Exploring a BigQuery dataset to find features to use in model

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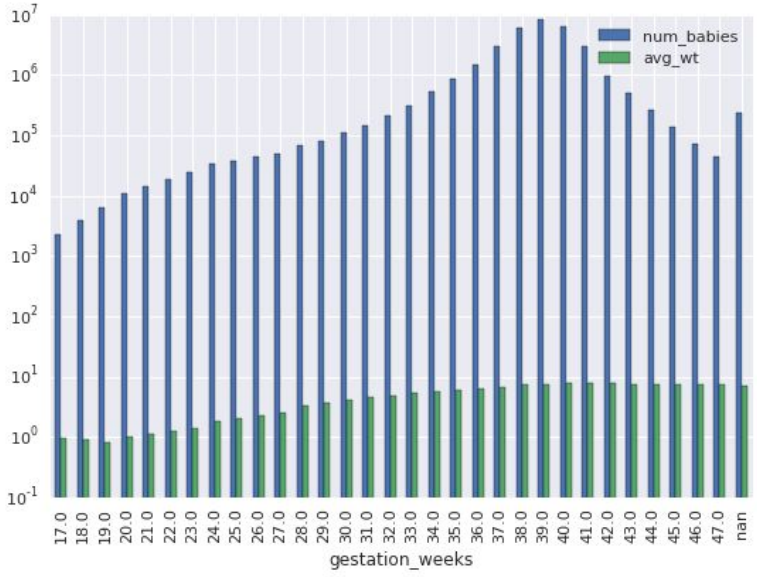
Lab #1: Exploring a BigQuery dataset to find features to use in model

BigQuery: `publicdata.samples.natality`



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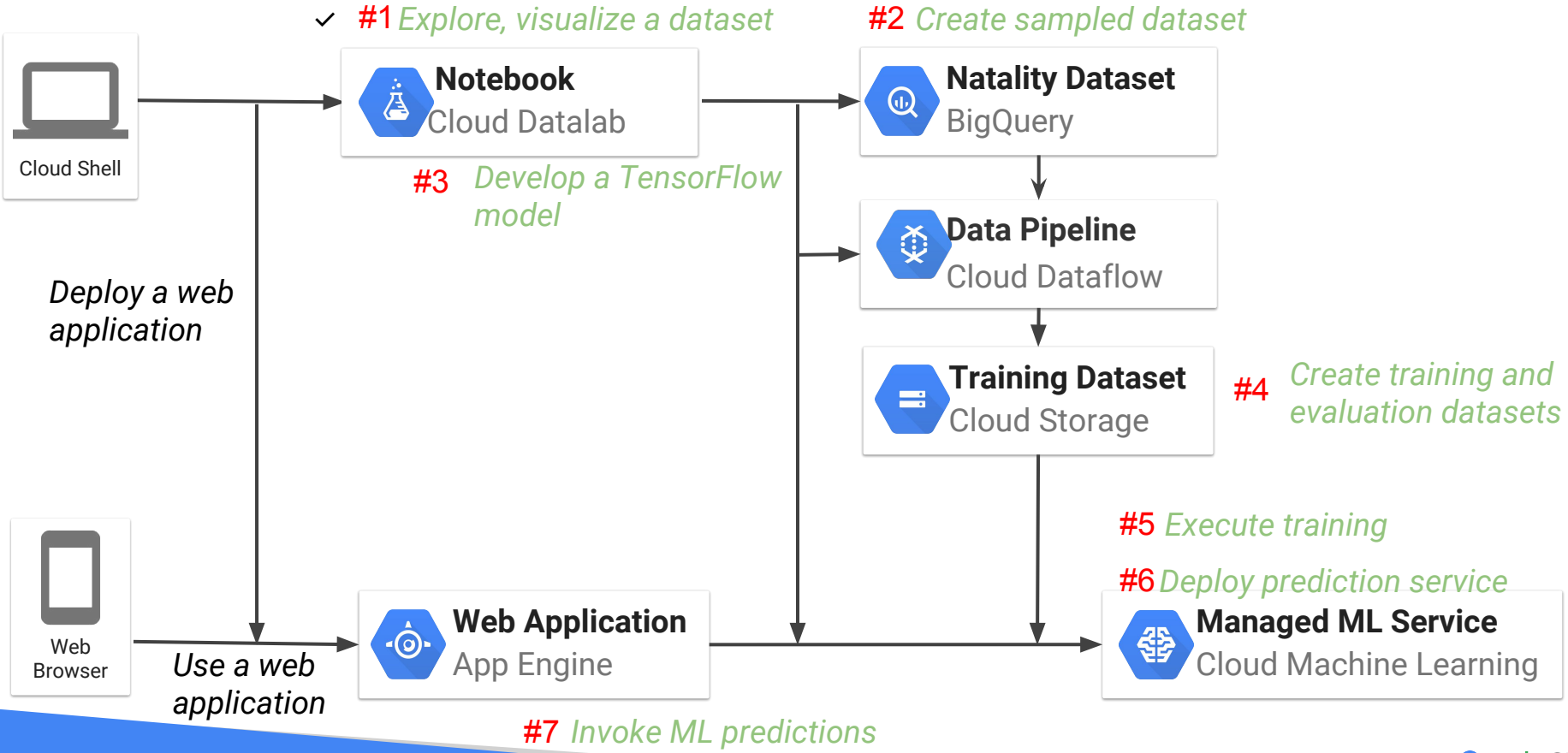
Google Cloud

The End-to-End process



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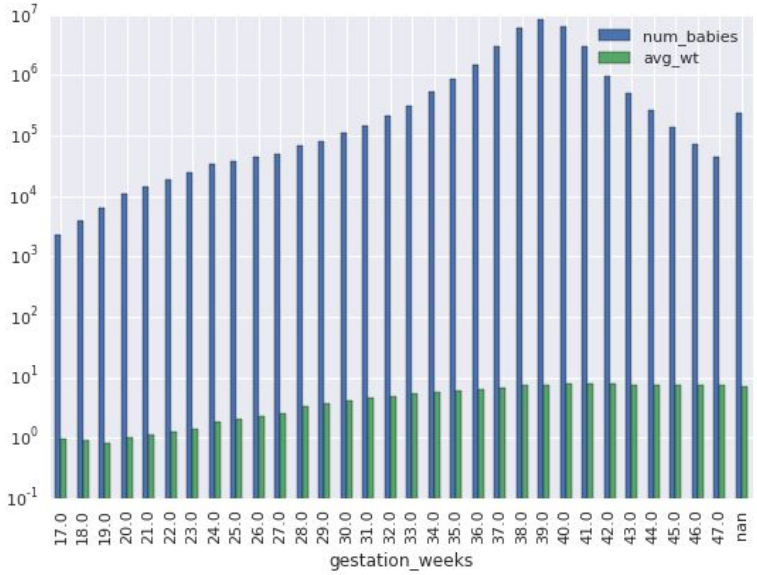
Debrief

What features did you use? Why?



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Google Cloud

Is it fair practice to use mother's race as a feature?

How would we check whether the use/non-use of mother's race amplifies injustice?

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Agenda

- Machine Learning on Google Cloud
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Building a ML model involves:

Create the dataset

Build the model

Operationalize the model

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codelabs.developers.google.com/cloud-quest-scientific-data

github.com/GoogleCloudPlatform/training-data-analyst/blob/master/blogs/babyweight/

Lab #2: Creating a sampled dataset

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Lab #2: Creating a sampled dataset

1. Sample the full BigQuery, creating a smaller dataset so that you can use it for model development and local training

2. Make sure that this smaller dataset is representative of the full dataset.

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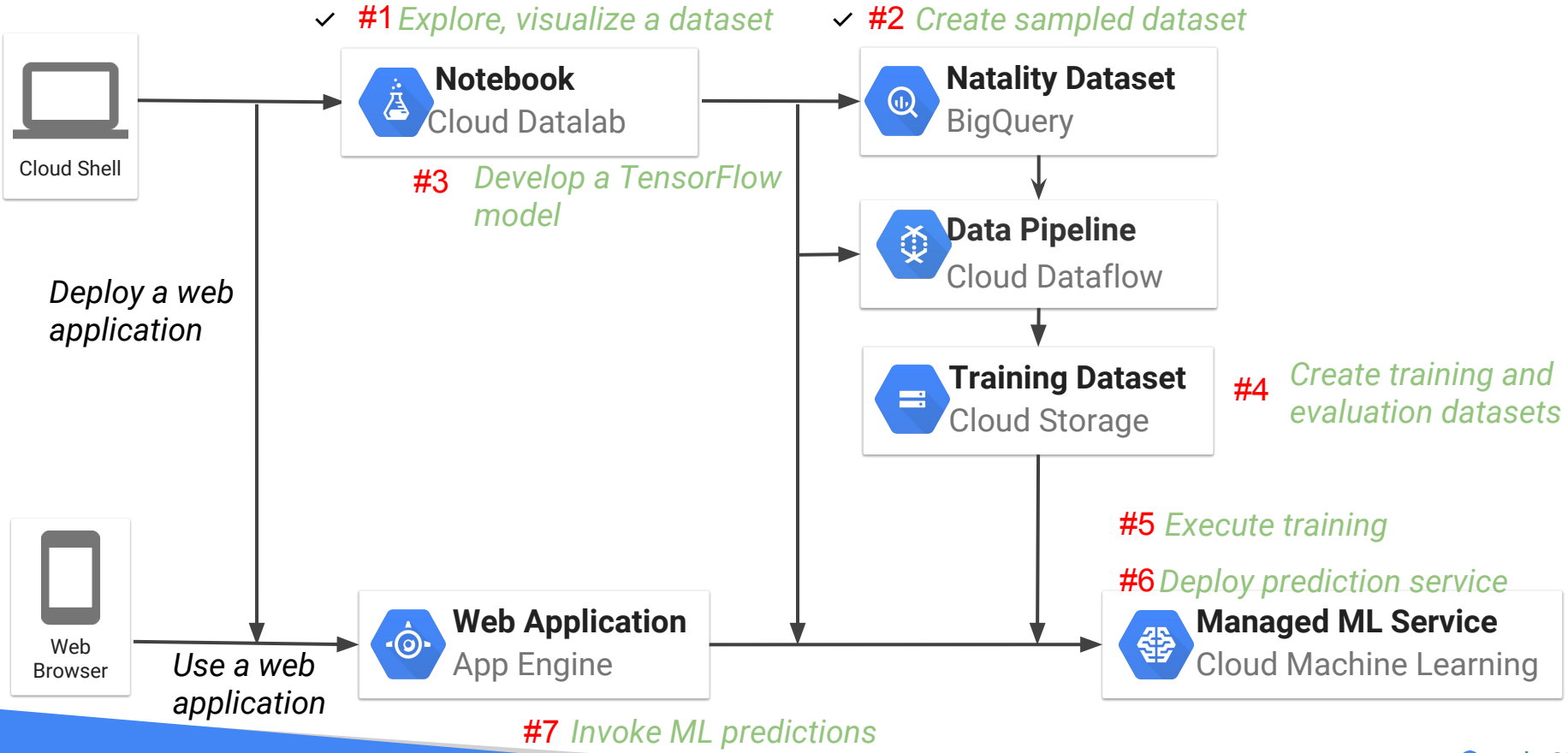
The End-to-End process



= Lab Exercises

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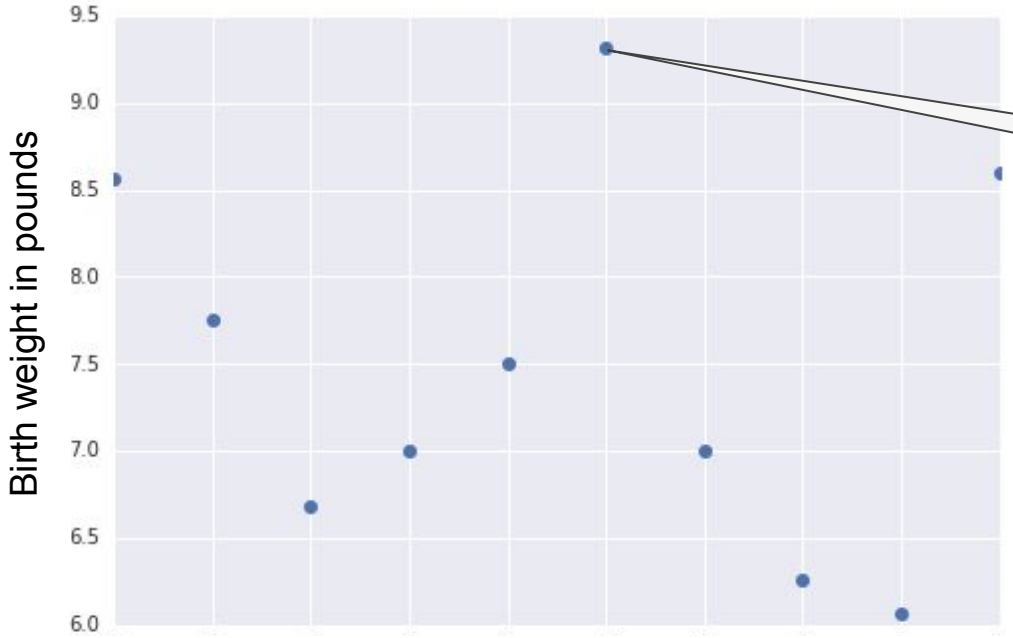
Debrief: The simplest option is to sample rows randomly



- Each data point is a birth record from the natality dataset

weight	year	mother_age	gestation_weeks	cigarette_use	alcohol_use
6.03	2004	29	39	false	false

- Random sampling eliminates potential biases due to order of the training examples but ...

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But what about triplets?

3 rows with essentially the same data!

How can we make this data unique?

How can we solve this?

Use FARM_FINGERPRINT so that you get a repeatable, nonoverlapping sample.

Export train.csv and eval.csv (2 files)

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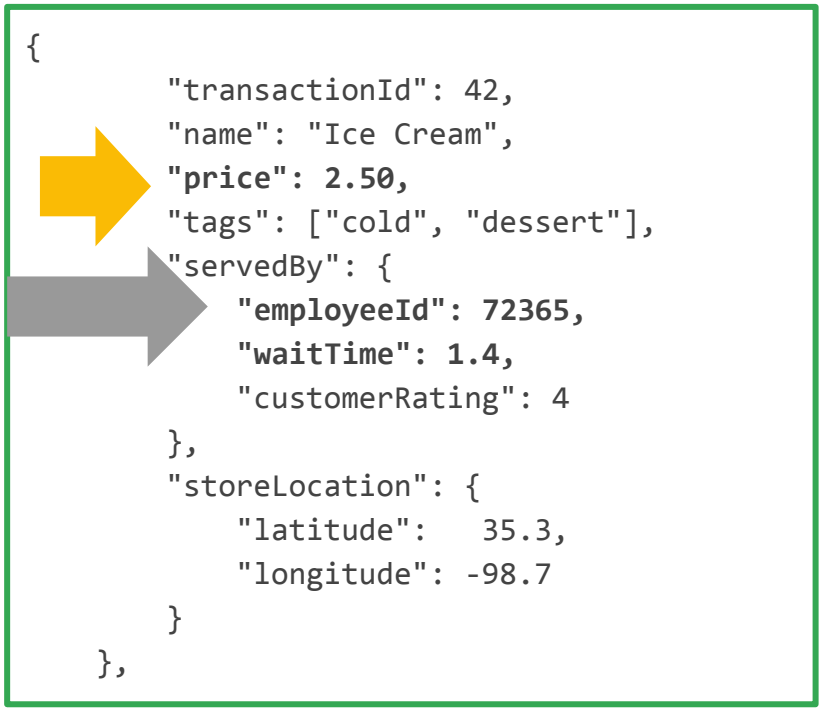
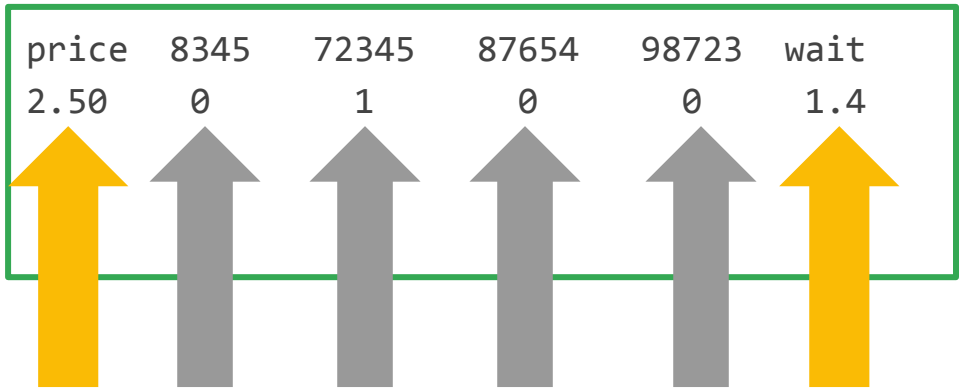
Two types of features: Dense & sparse





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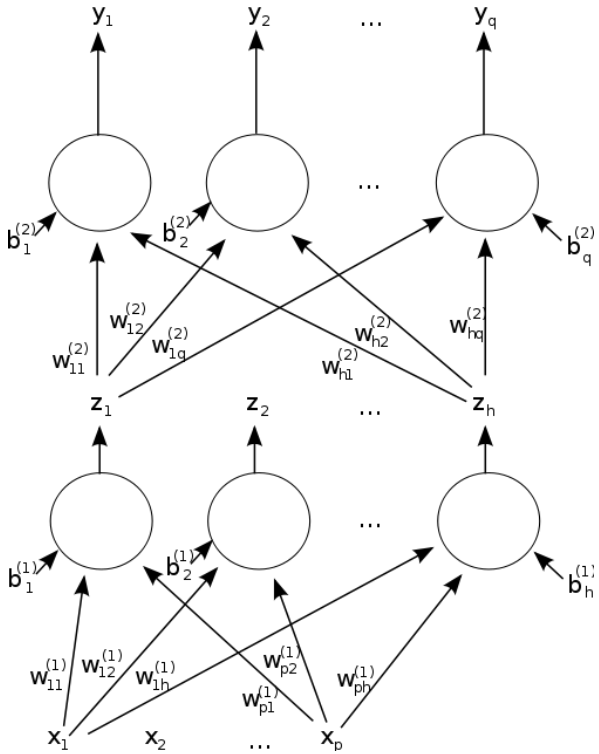
DNNs good for dense, highly correlated

pixel_values ()



1024^2 input nodes

10 hidden nodes -> 10 image features

https://commons.wikimedia.org/wiki/File:Two_layer_ann.svg

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Linear for sparse, independent features

One hot encoding

```
[ 0.  1.  0.  0.  0.  0.  0.  0.  0.  0.]
[ 0.  0.  0.  0.  0.  0.  0.  1.  0.  0.]
[ 0.  0.  0.  0.  0.  0.  0.  0.  0.  1.]
[ 0.  1.  0.  0.  0.  0.  0.  0.  0.  0.]
[ 0.  0.  0.  0.  0.  0.  0.  1.  0.  0.]
[ 0.  0.  0.  1.  0.  0.  0.  0.  0.  0.]
[ 0.  0.  0.  0.  0.  0.  1.  0.  0.  0.]
[ 0.  1.  0.  0.  0.  0.  0.  0.  0.  0.]
[ 0.  0.  0.  0.  1.  0.  0.  0.  0.  0.]
[ 0.  1.  0.  0.  0.  0.  0.  0.  0.  0.]
```

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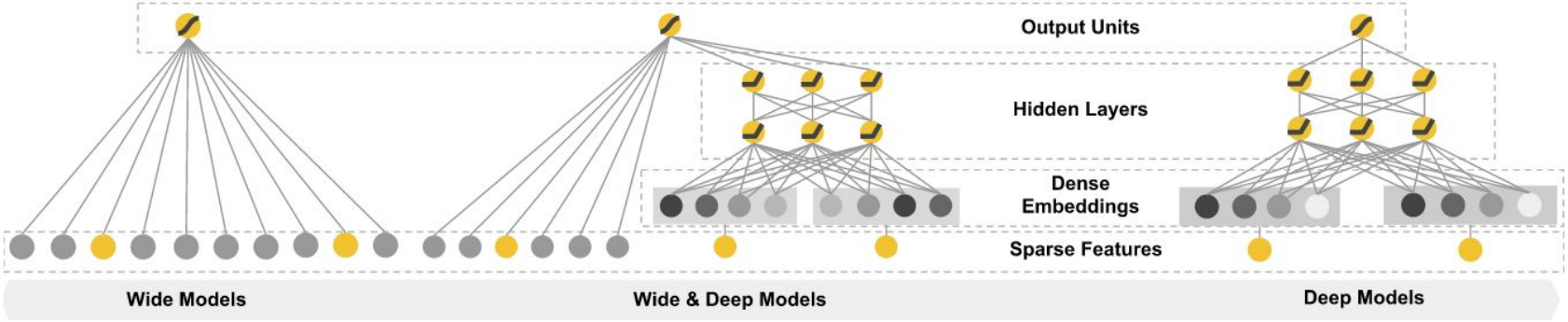
Wide-and-deep models let you handle both



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Wide & Deep

memorization
relevance

generalization
diversity

Wide-and-deep network in Estimator API

```
model = tf.contrib.learn.DNNLinearCombinedClassifier(
    model_dir=...,
    linear_feature_columns=wide_columns,
    dnn_feature_columns=deep_columns,
    dnn_hidden_units=[100, 50])
```

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codelabs.developers.google.com/cloud-quest-scientific-data

github.com/GoogleCloudPlatform/training-data-analyst/blob/master/blogs/babyweight/

Lab #3: Create Tensorflow model

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Lab #3: Create Tensorflow model

In this lab, you use the high-level Estimator API for wide-and-deep model

1. Determine your wide columns and deep columns

2. Determine if you need any embeddings

3. Feel free to iterate and add further preprocessing of features

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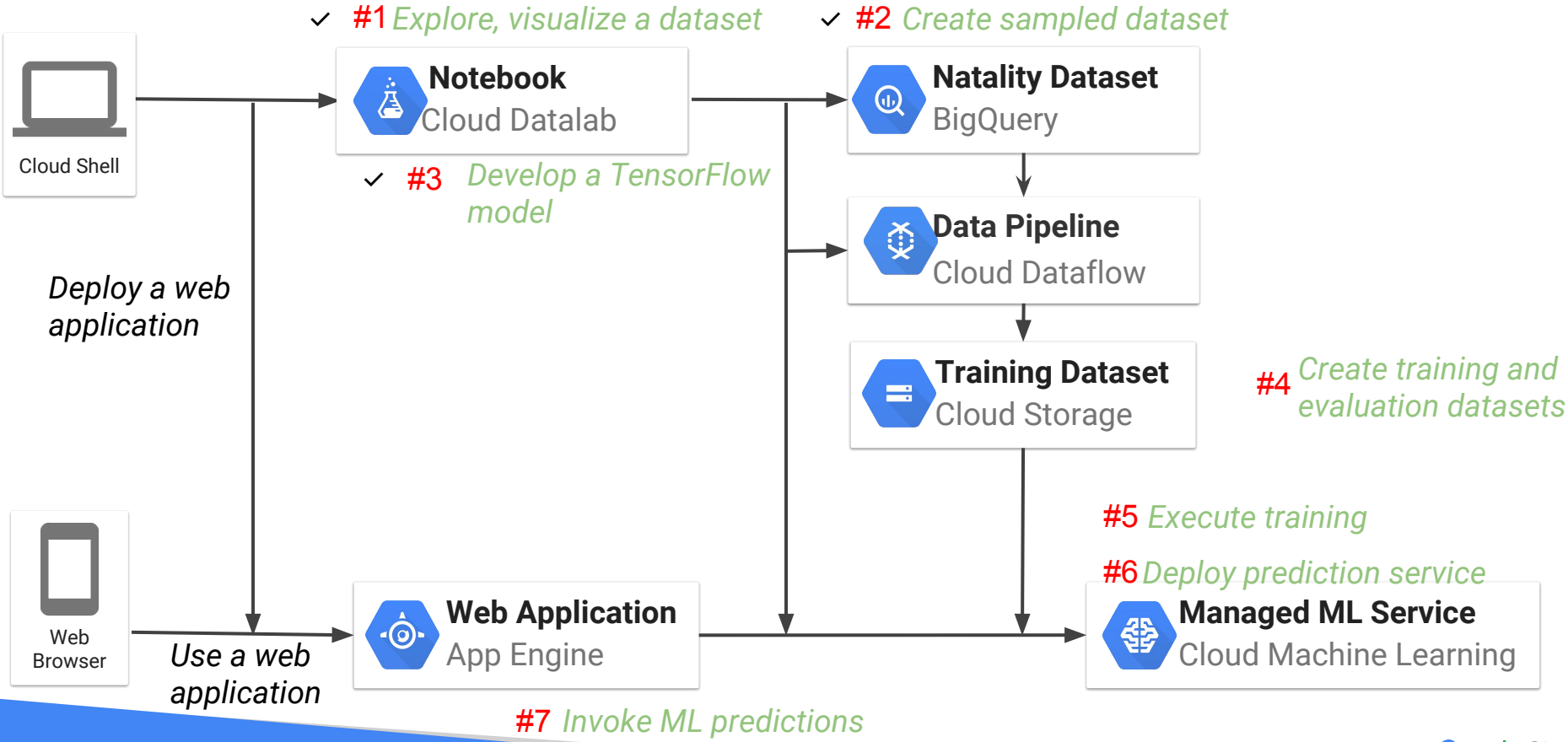
The End-to-End process



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Agenda

Machine Learning on Google Cloud

Explore the data

Create the dataset

Build the model

Operationalize model

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Lab #4: Preprocess using Dataflow

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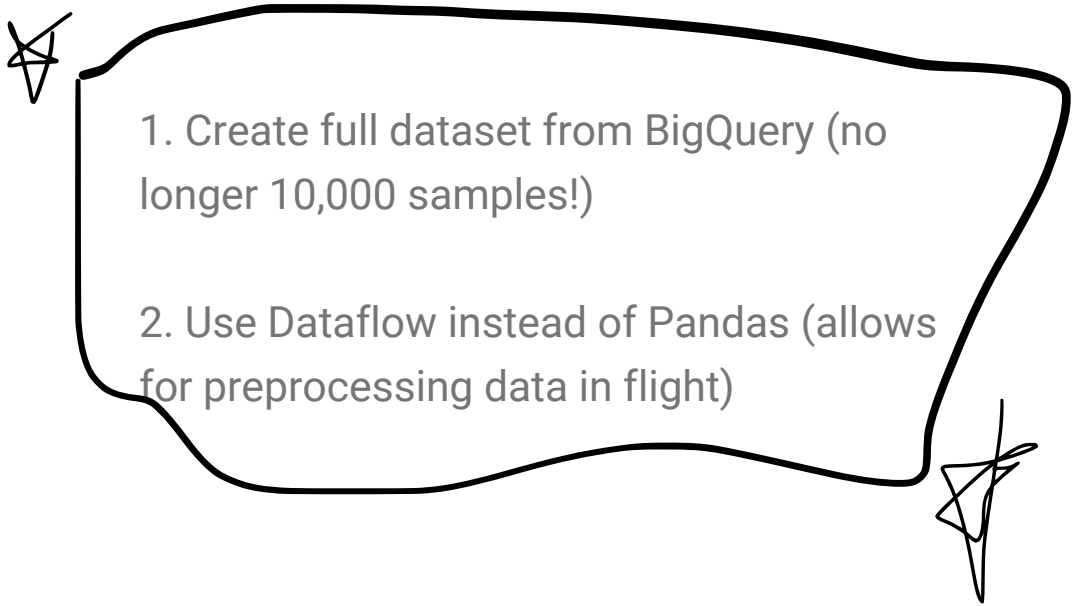
Lab #4: Preprocess using Dataflow

While Pandas is fine for experimenting, for operationalization of your workflow, it is better to do preprocessing in Apache Beam (Dataflow)



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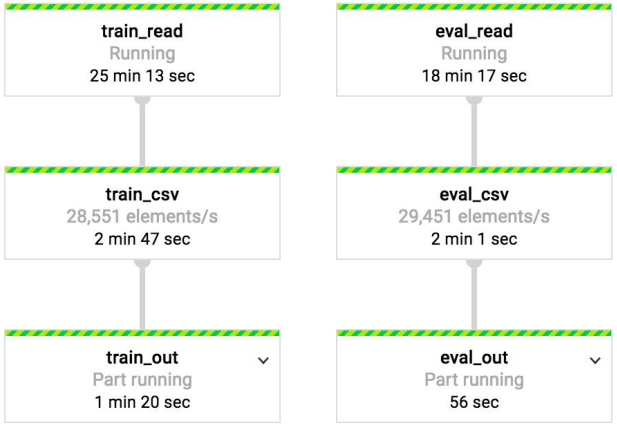
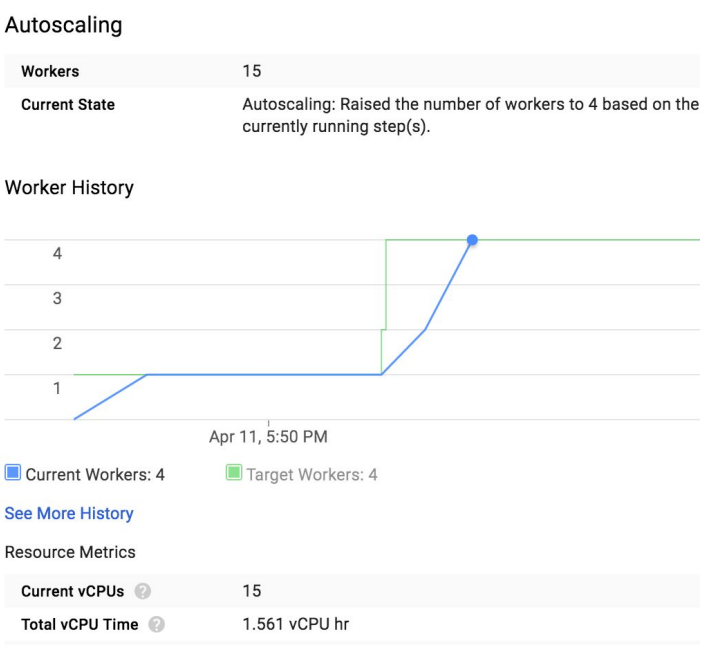
Split full dataset into train/eval and do preprocessing

BigQuery -> Dataflow -> CSV





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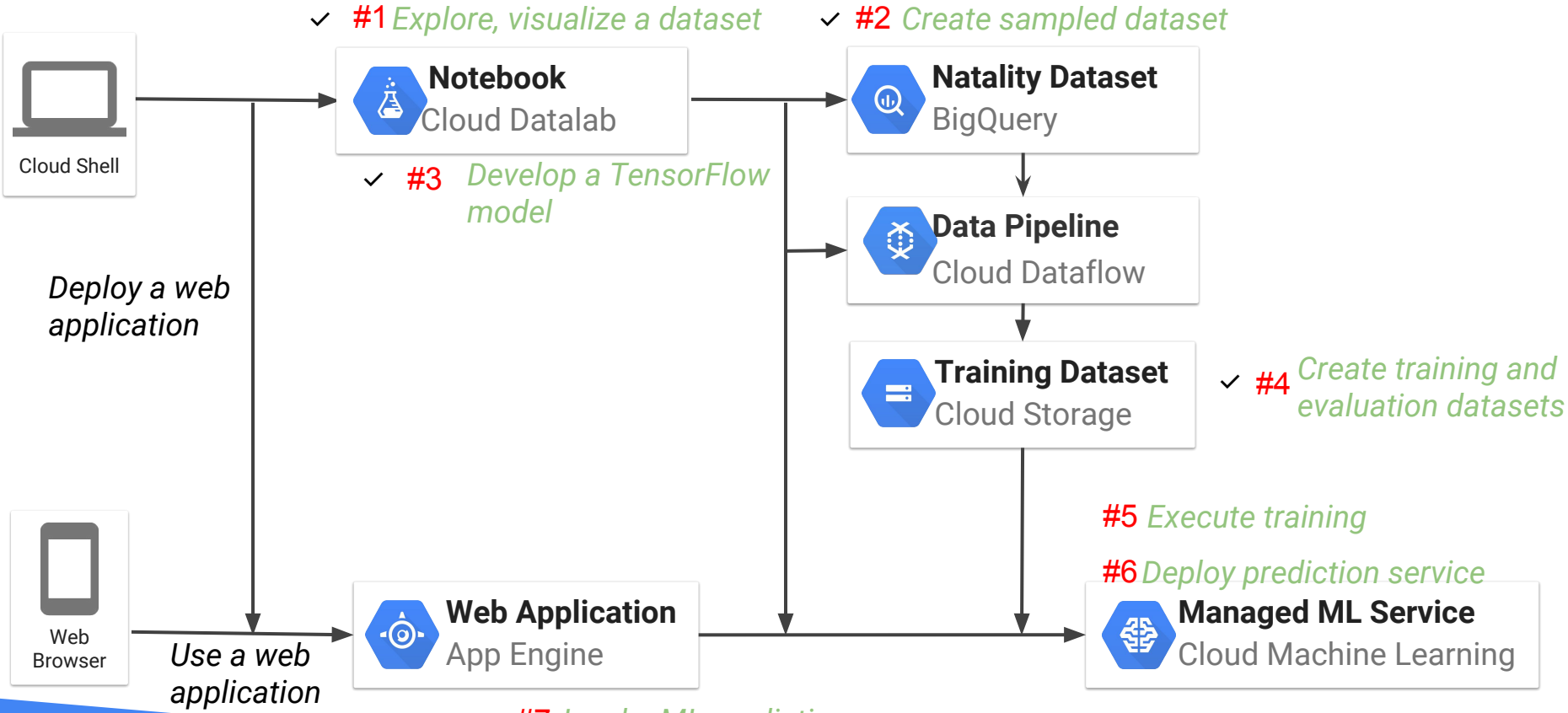
The End-to-End process



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Lab #5: Train on Cloud ML Engine

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Lab #5: Train on Cloud ML Engine

This lab illustrates distributed training and hyperparameter tuning on Cloud ML Engine

1. change batchsize if necessary
2. use train_steps instead of num_epochs

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Train on Cloud ML Engine

Submit training job on full dataset, monitor using TensorBoard

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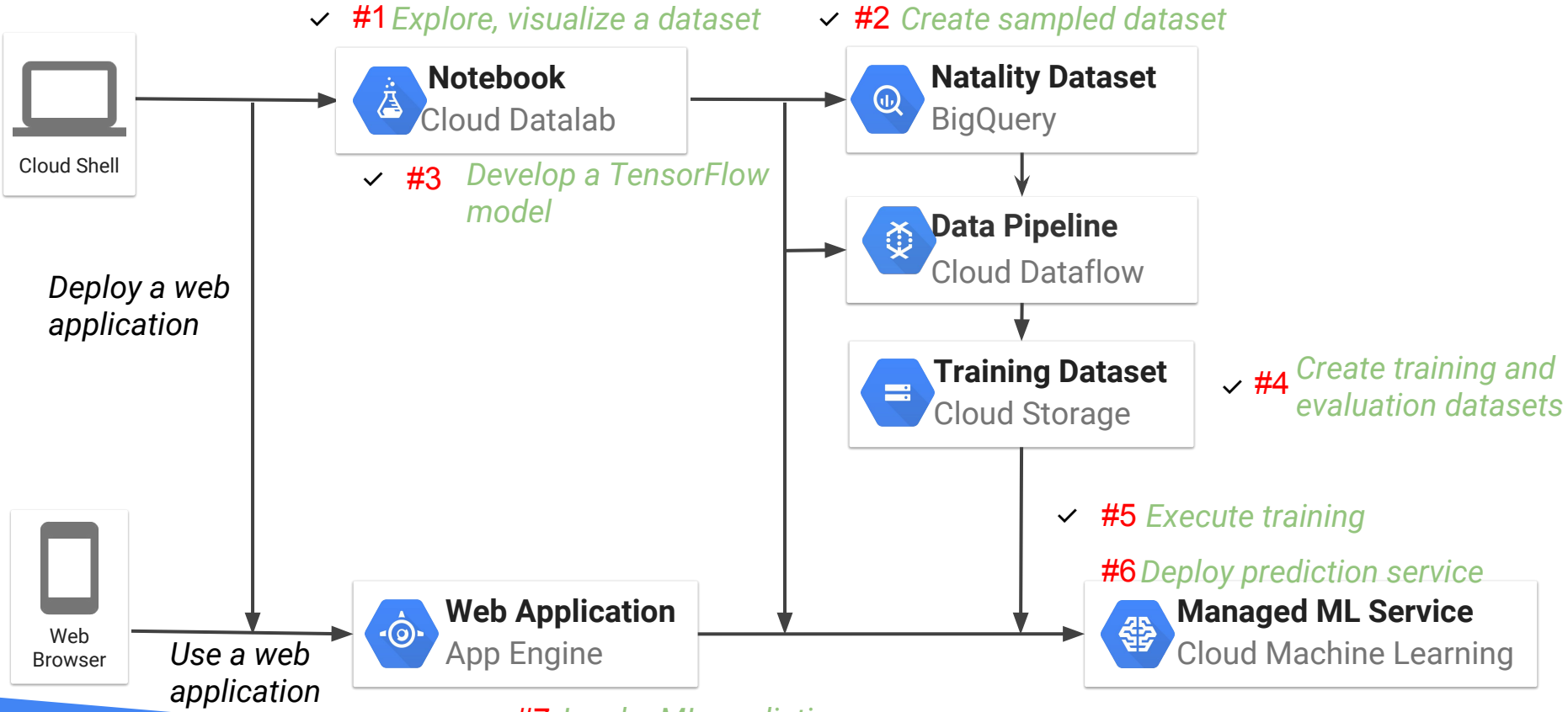
The End-to-End process



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Lab #6: Deploy and predict

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Lab #6: Deploy and predict

In this lab, you will:

1. Deploy trained model to Cloud ML Engine

2. Send JSON request to model to get predictions

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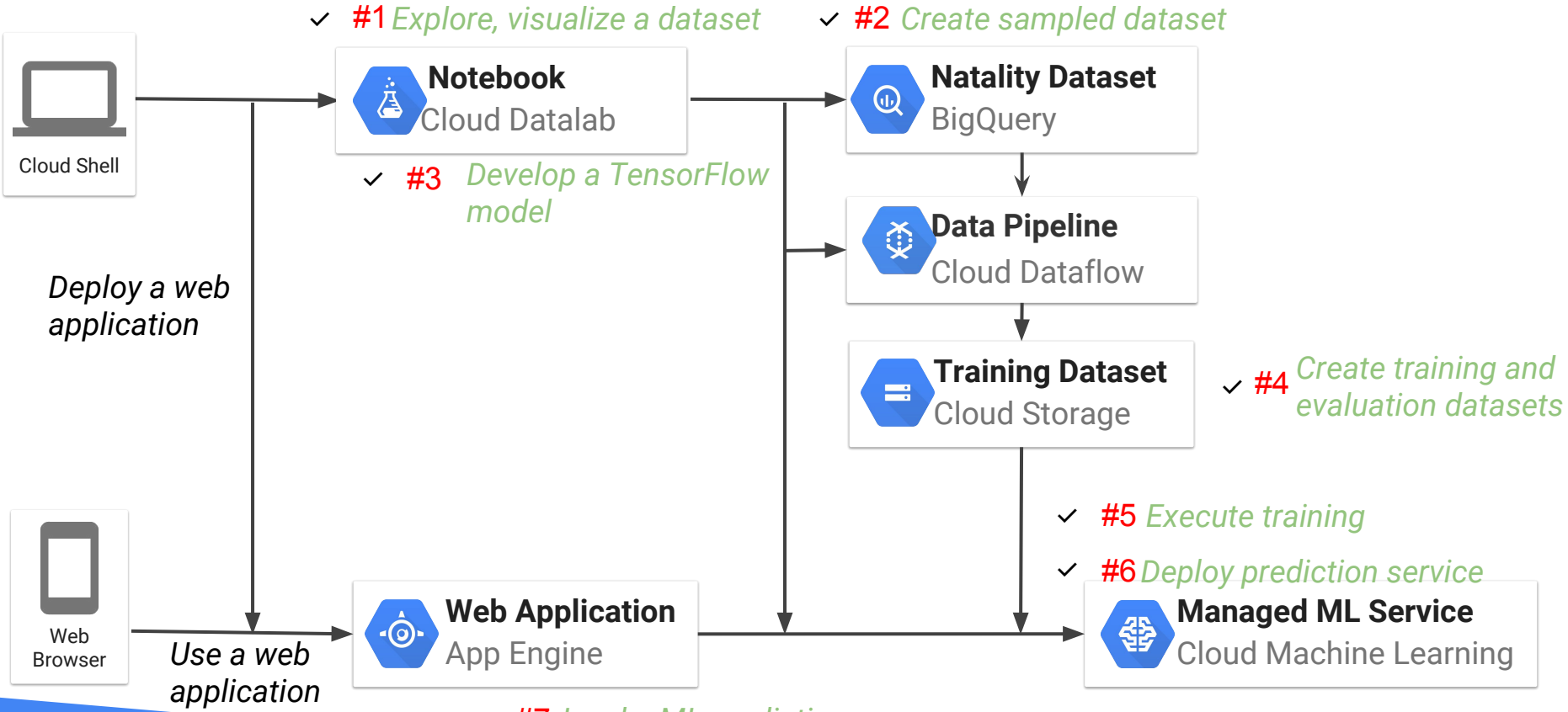
The End-to-End process



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github.com/GoogleCloudPlatform/training-data-analyst/blob/master/blogs/babyweight/

Lab #7: Build an AppEngine app to serve ML predictions

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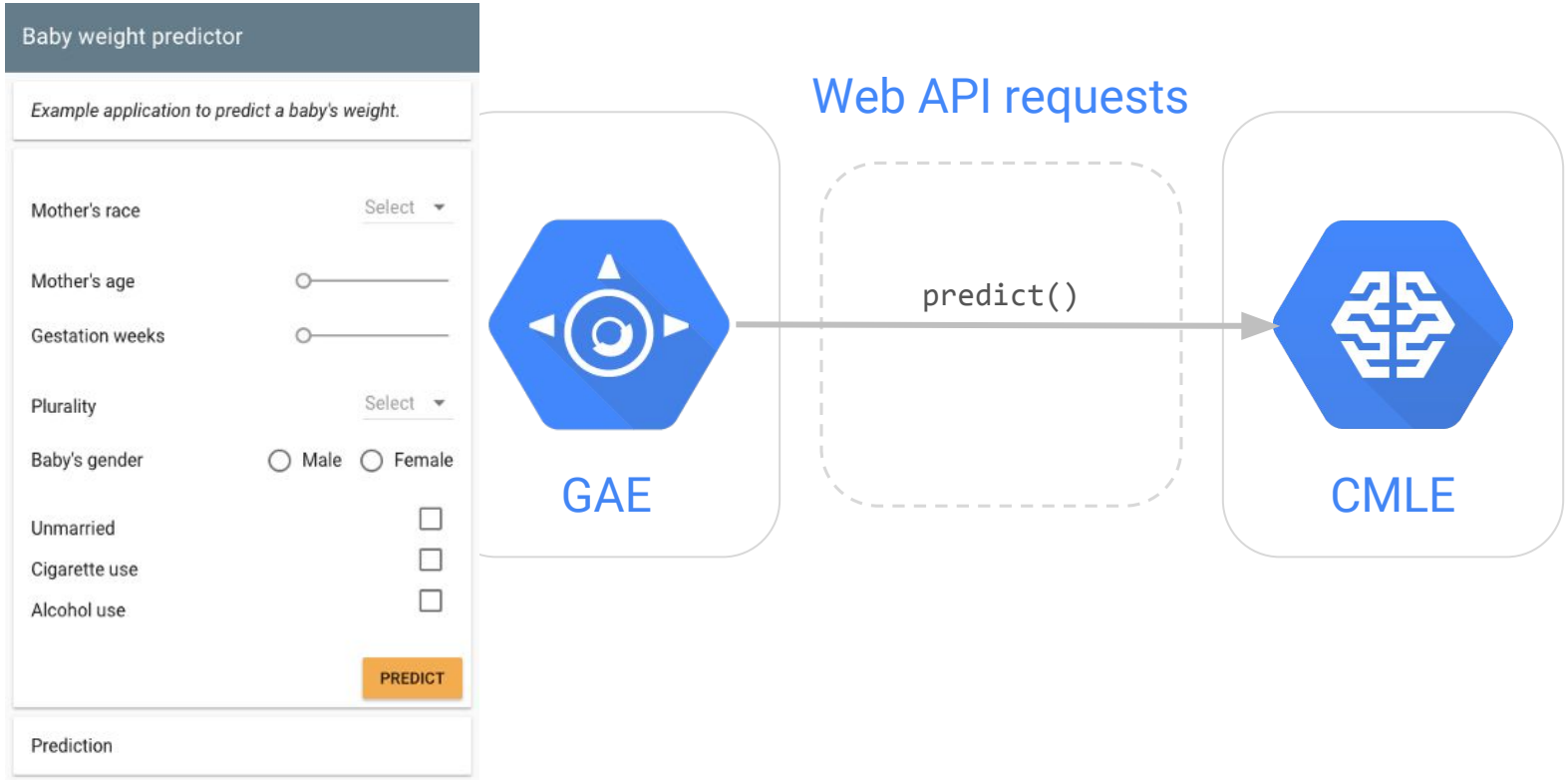
In this lab, we will use AppEngine to invoke ML predictions



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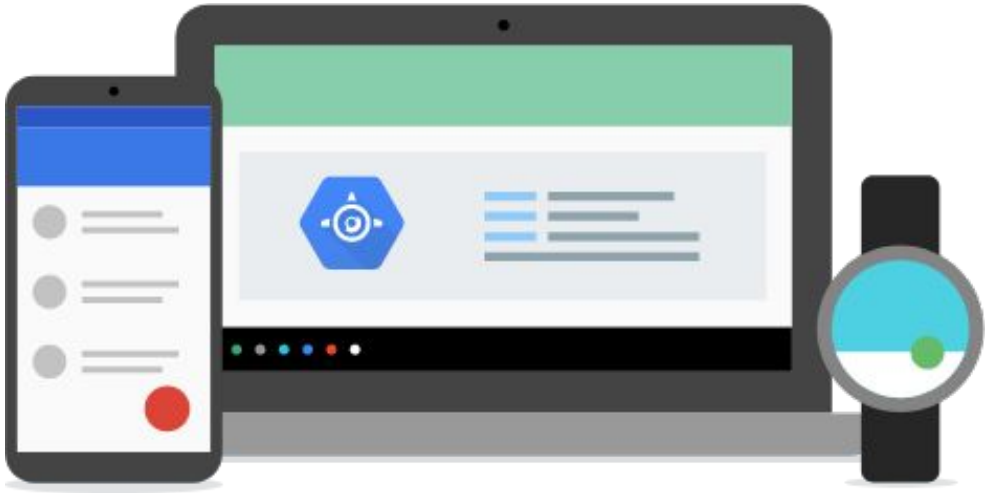
Google App Engine is a fully-managed service for building web backends

Supports Java, Node.js, Ruby, C#, Go, Python, and PHP



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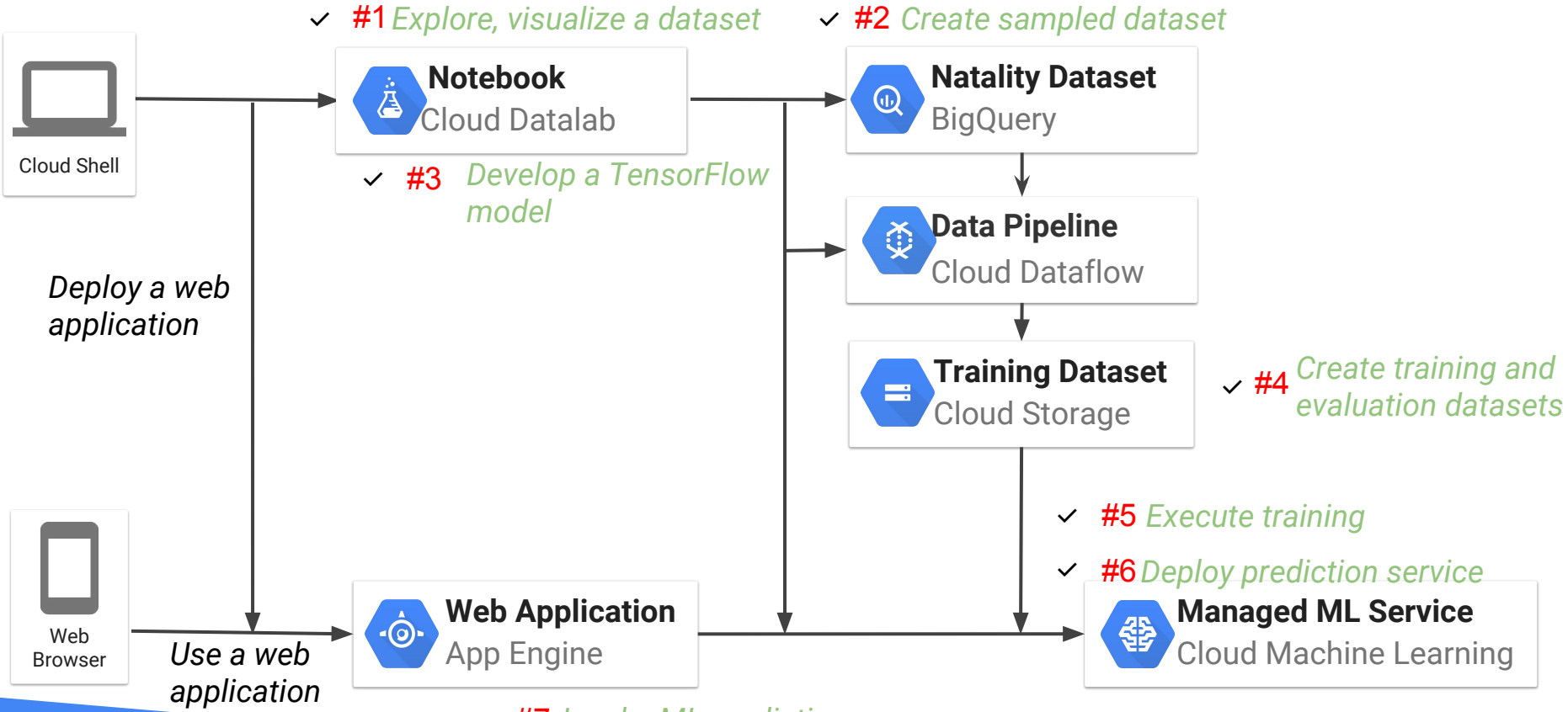
Summary: An end-to-end process to operationalize ML models



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To learn more about TensorFlow on Google Cloud

Hands-on Tensorflow (next session)

goo.gl/nqsCo5

Serverless Machine Learning with TensorFlow bootcamp in Amsterdam

Thursday, October 19 (9:00 – 17:00) at GoDataDriven, Wibautstraat 202
www.godatafest.com/google

Serverless Machine Learning with TensorFlow on Coursera

https://www.coursera.org/learn/serverless-machine-learning-gcp/

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