TensorFlow

Machine Learning over Real-Time Streaming Data with TensorFlow

Yong Tang, MobileIron

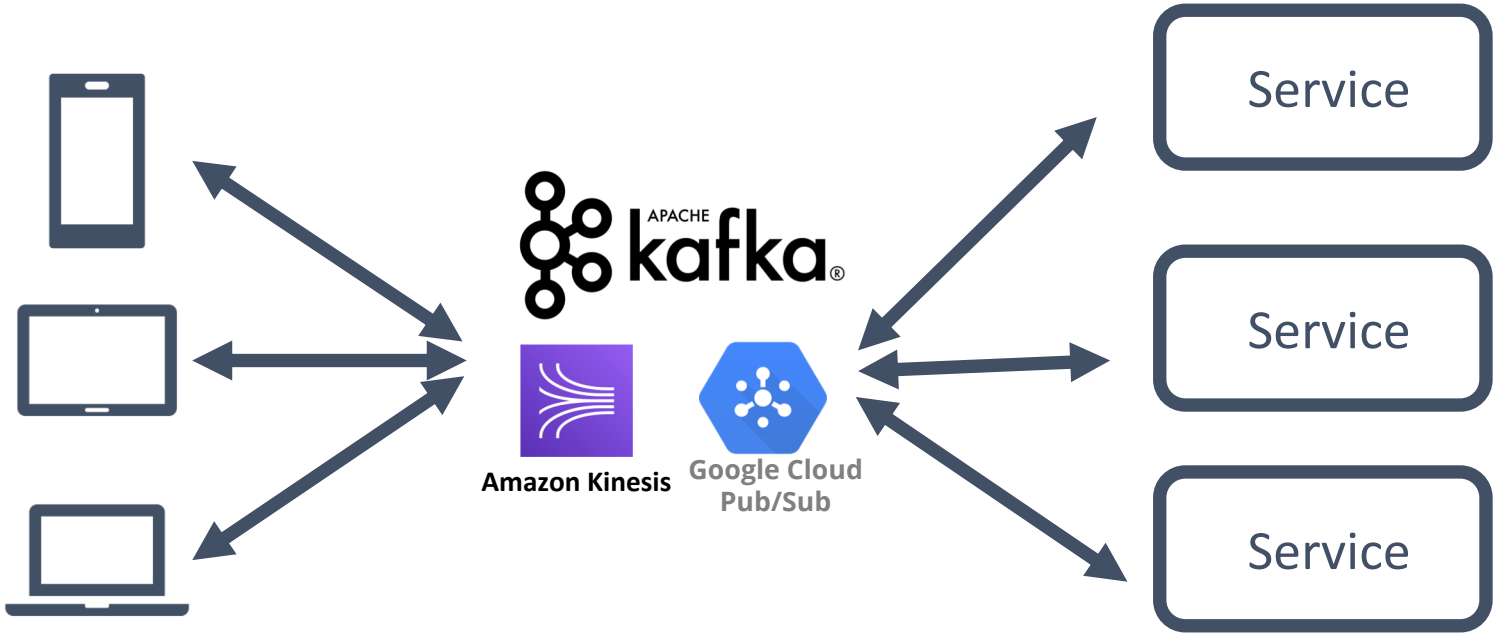
SIG IO Lead, TensorFlow

GitHub: yongtang

Streaming Data

- IoT sensors
- GPS positions
- Web transactions
- Social media updates

Event Driven Microservices



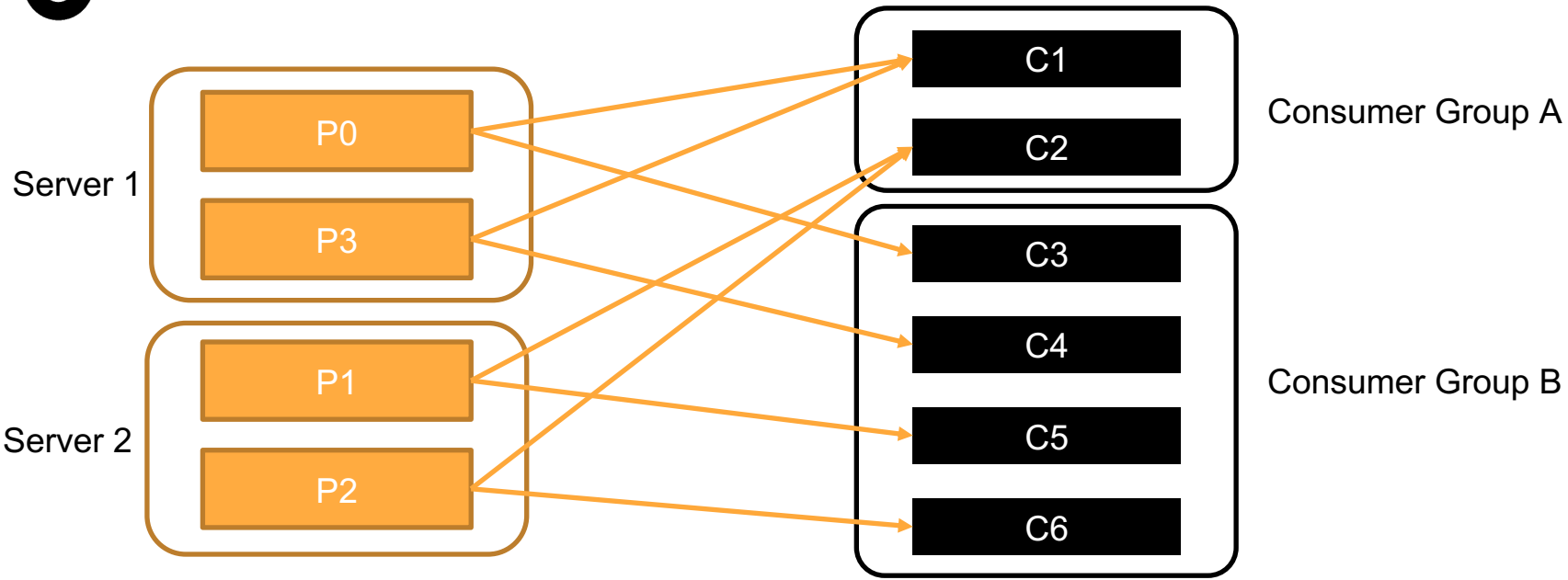
Distributed Streaming Framework

Structured Commit Log

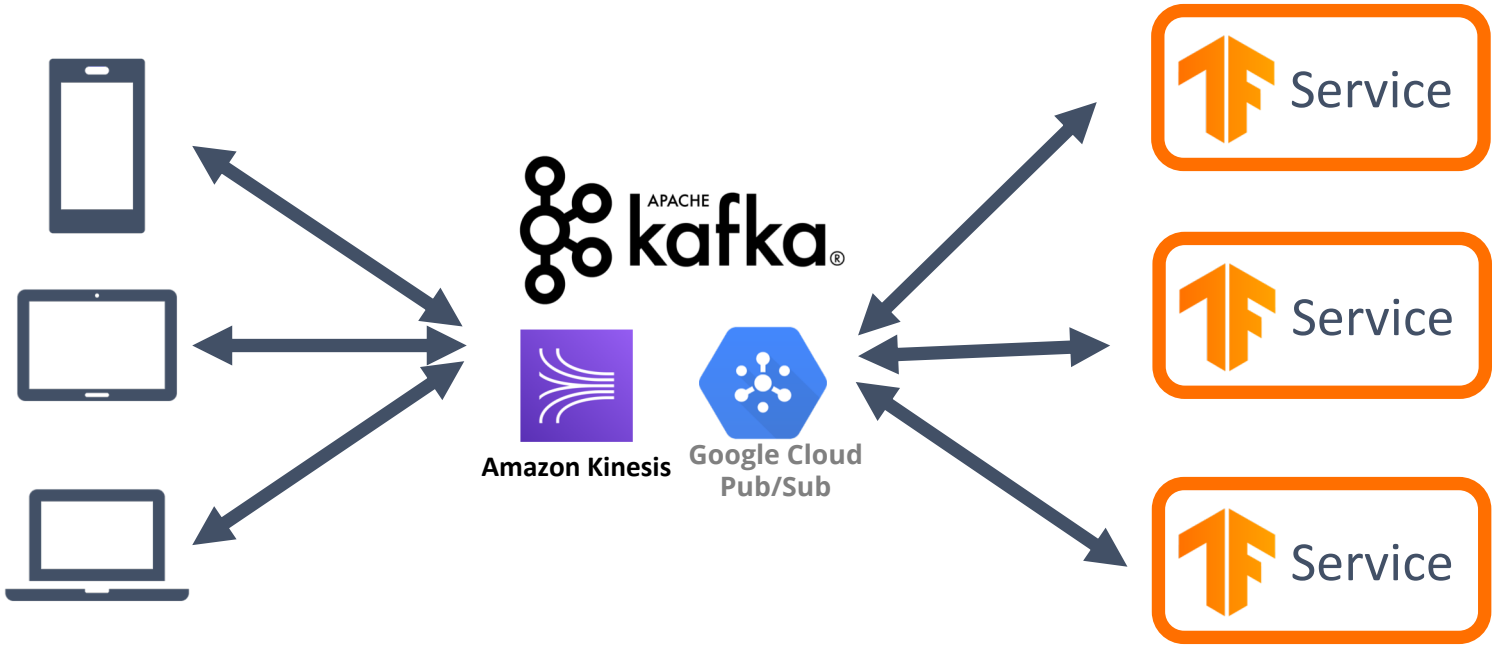
Partition and Offset Management

APACHE
kafka®
Partition 0
0 1 2 3 4 5 6 7 8 9 10 11 12
Partition 1
0 1 2 3 4 5 6 7 8 9
Partition 2
0 1 2 3 4 5 6 7 8 9 10 11 12
Writes
Old
New

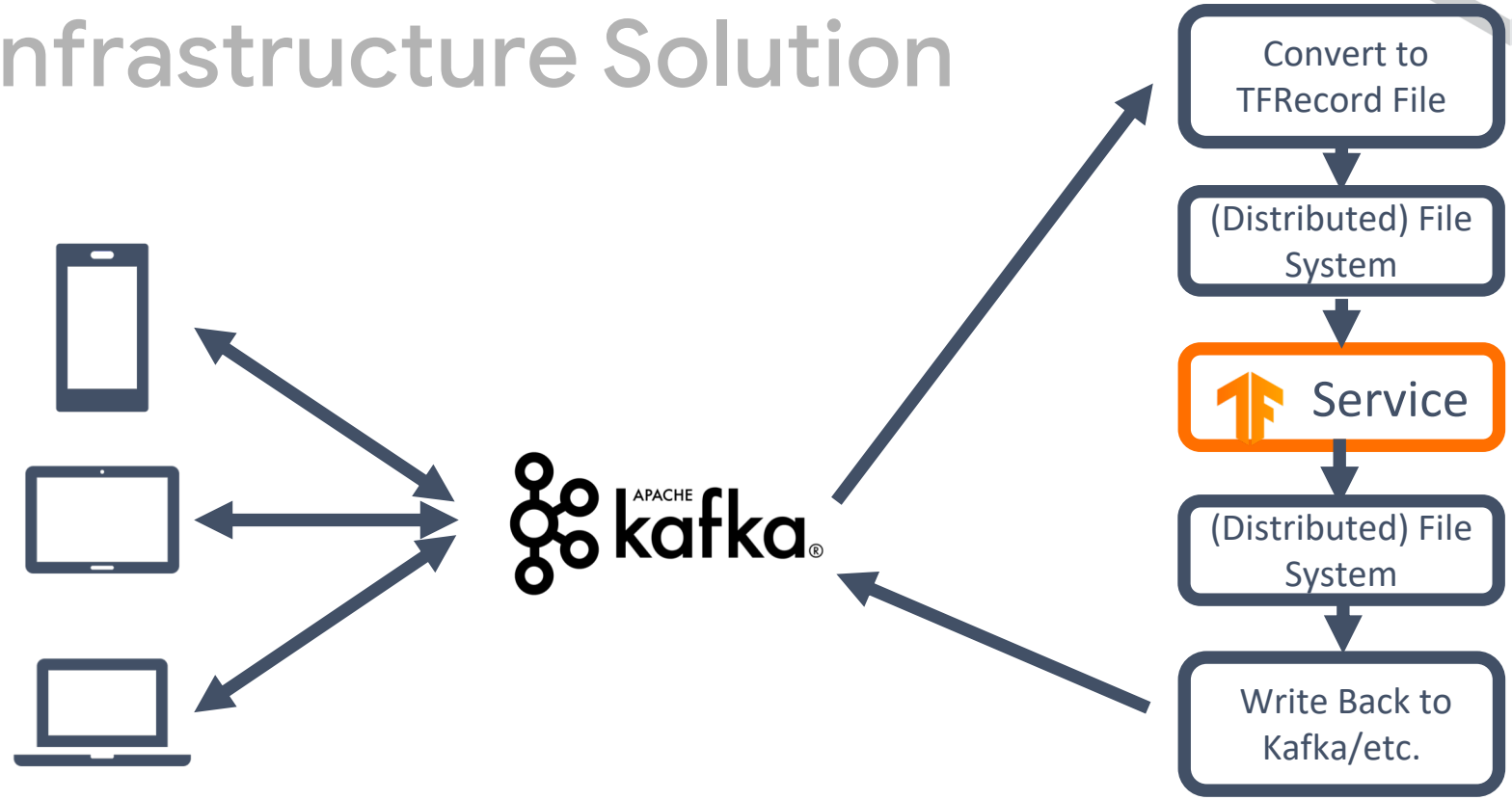
APACHE
kafka®


Server 1
P0
P3
Server 2
P1
P2
C1
C2
C3
C4
C5
C6
Consumer Group A
Consumer Group B

ML as Microservices



Infrastructure Solution



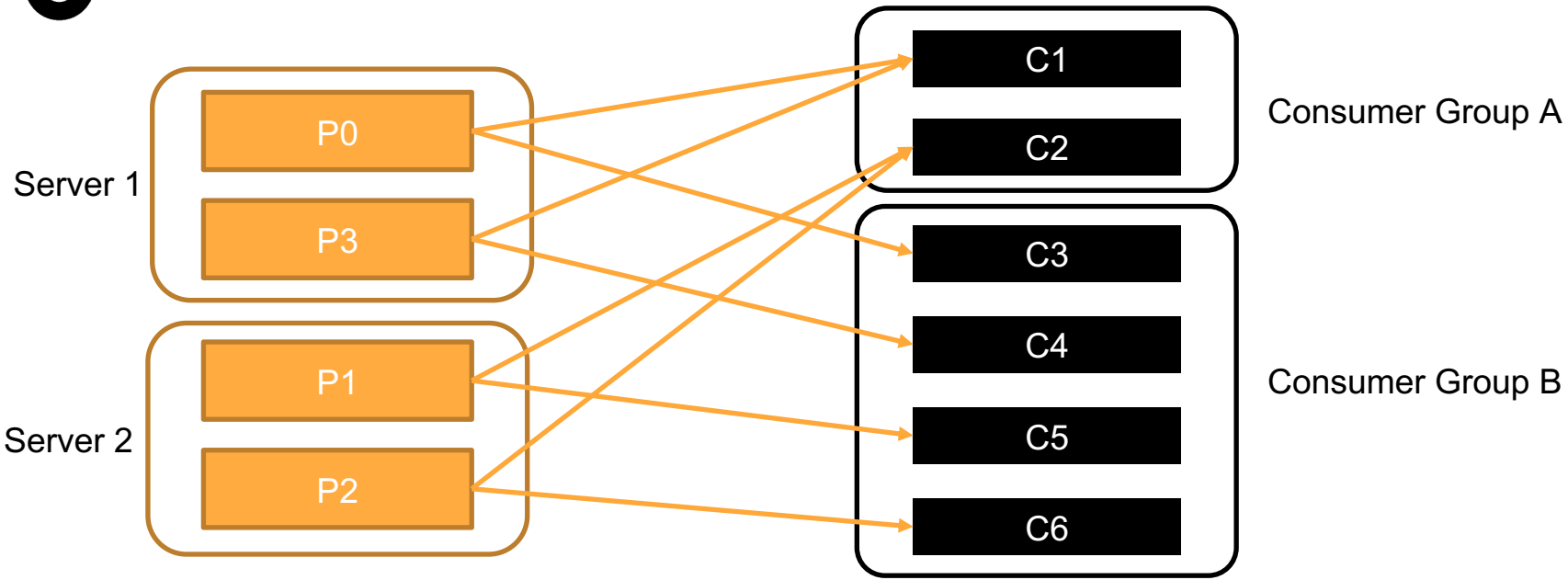
Solution

Distributed Persistent Storage

+

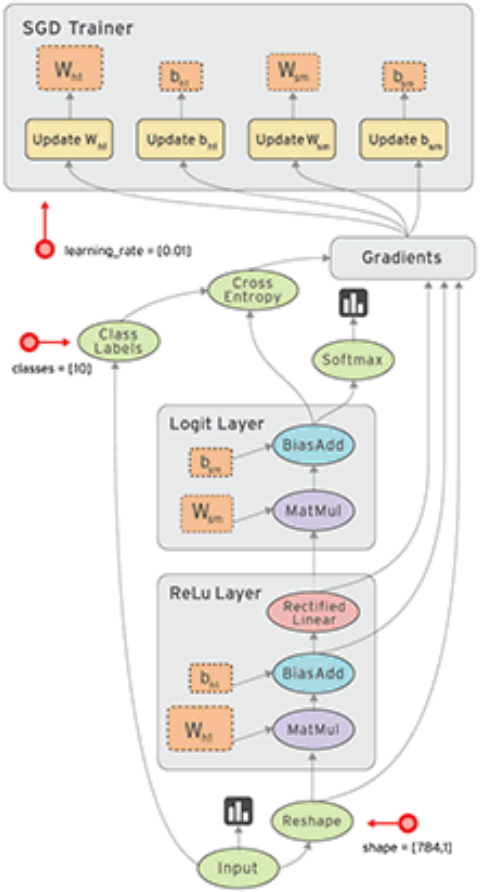
Distributed ML Data Pipeline

Distributed Persistent Storage



TensorFlow

Distributed ML Data Pipeline



Kafka Support in TensorFlow

Part of tf.contrib in TF 1.x

Part of tensorflow-io for TF 2.0:

KafkaDataset (for Read)

KafkaOutputSequence (for Write)

Kafka Support in TensorFlow

- Package: tensorflow-io 0.9.0
- Implemented in C++
- Dependency: tensorflow only
- Python and R bindings

Kafka Support in TensorFlow 2.0

$ pip install tensorflow-io

```
import tensorflow as tf
mnist = tf.keras.datasets.mnist

(x_train, y_train),(x_test, y_test) = mnist.load_data()
x_train, x_test = x_train / 255.0, x_test / 255.0

model = tf.keras.models.Sequential([
  tf.keras.layers.Flatten(input_shape=(28, 28)),
  tf.keras.layers.Dense(128, activation='relu'),
  tf.keras.layers.Dropout(0.2),
  tf.keras.layers.Dense(10, activation='softmax')
])

model.compile(optimizer='adam',
              loss='sparse_categorical_crossentropy',
              metrics=['accuracy'])

model.fit(x_train, y_train, epochs=5)

model.evaluate(x_test, y_test)
```

```
import tensorflow as tf

import tensorflow_io.kafka as kafka_io

def func_x(self, x):
  # Decode image to (28, 28)
  x = tf.io.decode_raw(x, out_type=tf.uint8)
  x = tf.reshape(x, [28, 28])
  # Convert to float32 for tf.keras
  x = tf.image.convert_image_dtype(x, tf.float32)
 return x

def func_y(self, y):
  # Decode label to (, )
  x = tf.io.decode_raw(x, out_type=tf.uint8)
  x = tf.reshape(x, [])
  return x

d_train_x = kafka_io.KafkaDataset(
       ['x_train:0'], group='x', eof=True).map(func_x)

d_train_y = kafka_io.KafkaDataset(
       ['y_train:0'], group='y', eof=True).map(func_y)
```

```
model = tf.keras.models.Sequential([
  tf.keras.layers.Flatten(input_shape=(28, 28)),
  tf.keras.layers.Dense(128, activation='relu'),
  tf.keras.layers.Dropout(0.2),
  tf.keras.layers.Dense(10, activation='softmax')
])

model.compile(optimizer='adam',
              loss='sparse_categorical_crossentropy',
              metrics=['accuracy'])
```

```
d_train = tf.data.Dataset.zip(
      (d_train_x, d_train_y)).batch(1)

model.fit(d_train, epochs=5)
```

```
# continue with inference and write

# build keras callback for Kafka producer
class OutputCallback(tf.keras.callbacks.Callback):

  def __init__(self, batch_size, topic, servers):
    self._sequence = kafka_io.KafkaOutputSequence(
        topic=topic, servers=servers)
    self._batch_size = batch_size

  def on_predict_batch_end(self, batch, logs=None):
    ...
    self._sequence.setitem(index, class_names)

# <= inference with callback for streaming output
model.predict(
      dataset,
      callbacks=[OutputCallback(32, 'topic', 'localhost')])
```

Demo


```
# setup zookeeper

docker run -d \
  --net=host \
  -e ZOOKEEPER_CLIENT_PORT=2181 \
  -e ZOOKEEPER_TICK_TIME=2000 \
  -e ZOOKEEPER_SYNC_LIMIT=2 \
  confluentinc/cp-zookeeper:5.3.1

# setup kafka

docker run -d \
  --net=host \
  -e KAFKA_ZOOKEEPER_CONNECT=localhost:2181 \
  -e KAFKA_ADVERTISED_LISTENERS=PLAINTEXT://localhost:9092 \
  -e KAFKA_BROKER_ID=2 \
  -e KAFKA_OFFSETS_TOPIC_REPLICATION_FACTOR=1 \
  confluentinc/cp-kafka:5.3.1
```

Demo

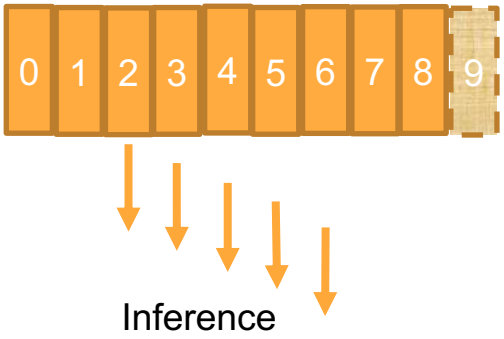

```
# push mnist data into kafka,
# not truly needed, for completeness only.

import numpy as np
import tensorflow as tf
import confluent_kafka as kafka

(x_train, y_train), (x_test, y_test) = tf.keras.datasets.mnist.load_data()
producer = kafka.Producer({'bootstrap.servers': 'localhost:9092'})

count = 0
for (x, y) in zip(x_train, y_train):
    producer.poll(0)
    producer.produce('x_train', x.tobytes())
    producer.produce('y_train', y.tobytes())
    count += 1
print("count(x, y): ", count)

producer.flush()
```

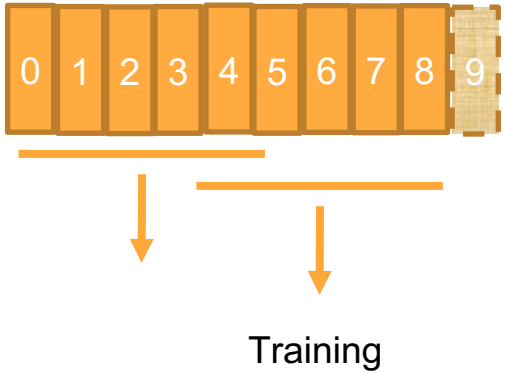
Demo

TensorFlow

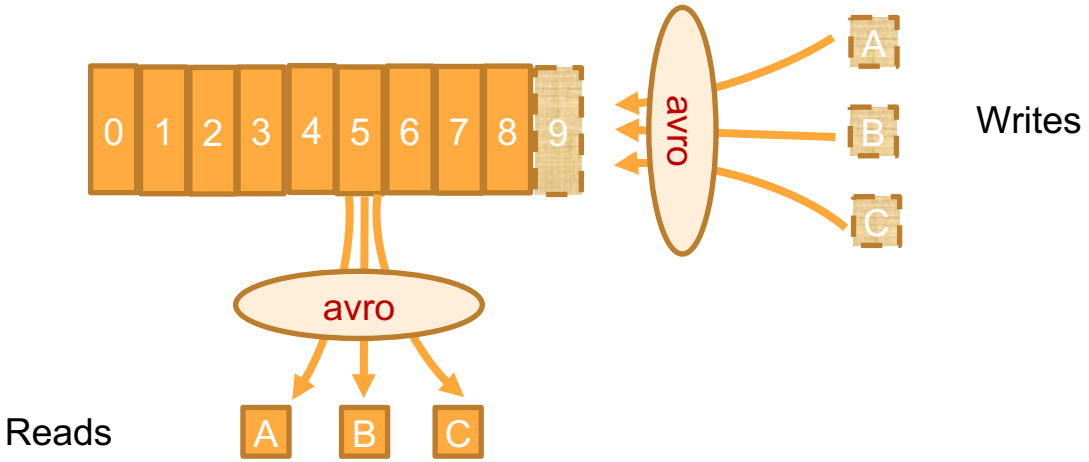
```
# push mnist data into kafka,
# not truly needed, for completeness only.

import numpy as np
import tensorflow as tf
import confluent_kafka as kafka

(x_train, y_train), (x_test, y_test) = tf.keras.datasets.mnist.load_data()
producer = kafka.Producer({'bootstrap.servers': 'localhost:9092'})

count = 0
for (x, y) in zip(x_train, y_train):
    producer.poll(0)
    producer.produce('x_train', x.tobytes())
    producer.produce('y_train', y.tobytes())
    count += 1
print("count(x, y): ", count)

producer.flush()
```

Inference vs Training

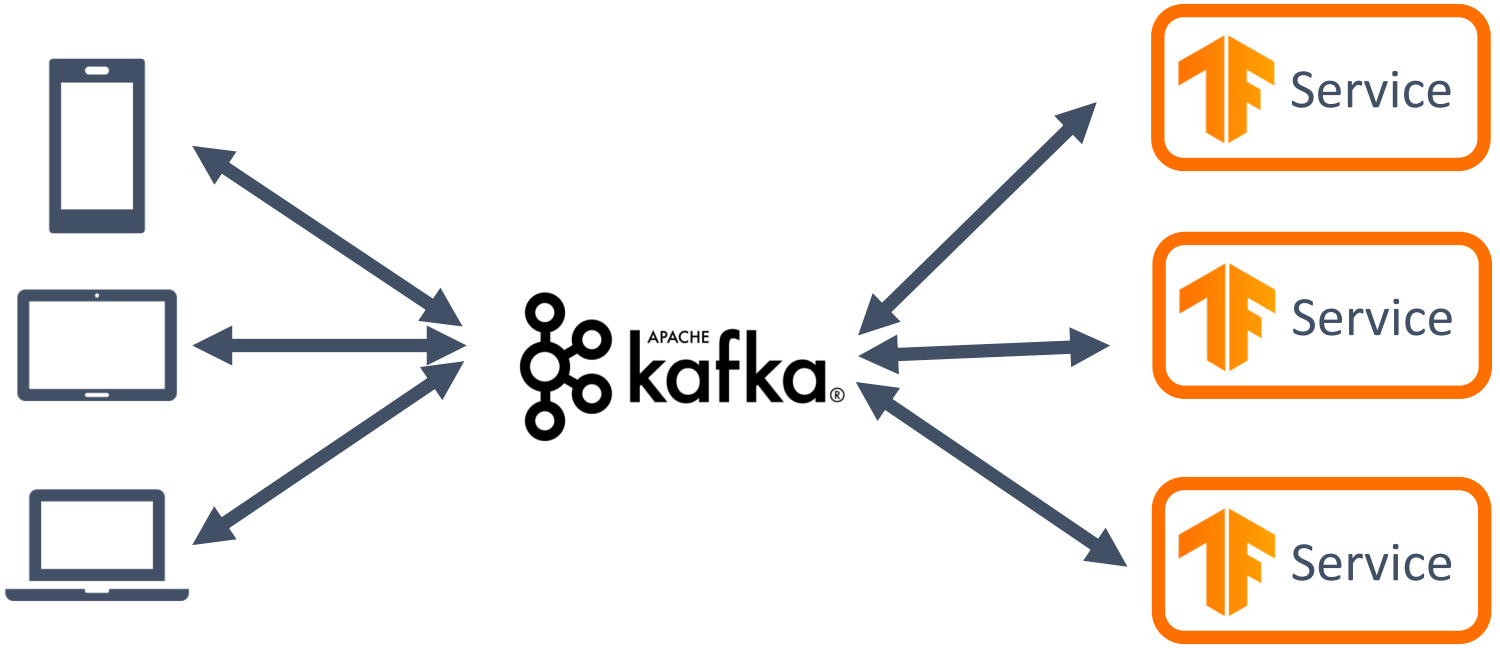




Schema with Avro



TensorFlow + Apache Kafka



TensorFlow + Apache Kafka

MQTT => Kafka => TensorFlow I/O => TensorFlow

SIG IO

TensorFlow

SIG IO

TensorFlow

Special Interest Group under TensorFlow

I/O, Data streaming, File formats

Apache Kafka, Apache Parquet/Arrow, Apache Ignite

Google Cloud BigQuery, Azure File Storage

WebP, TIFF, OpenEXR, HDR, FFmpeg

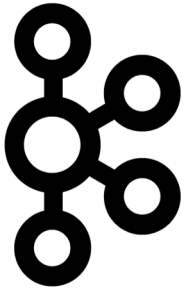
……

SIG IO

TensorFlow

https://github.com/tensorflow/io

TensorFlow



APACHE kafka®

TensorFlow

THANK YOU