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Kafka Introduction

Kafka messaging

What is Kafka?

- Distributed Streaming Platform
  - Publish and Subscribe to streams of records
  - Fault tolerant storage
  - Process records as they occur

Kafka Usage

- Build real-time streaming data pipe-lines
  - Enable in-memory microservices (actors, Akka, Vert.x, Qbit)
- Build real-time streaming applications that react to streams
  - Real-time data analytics
  - Transform, react, aggregate, join real-time data flows

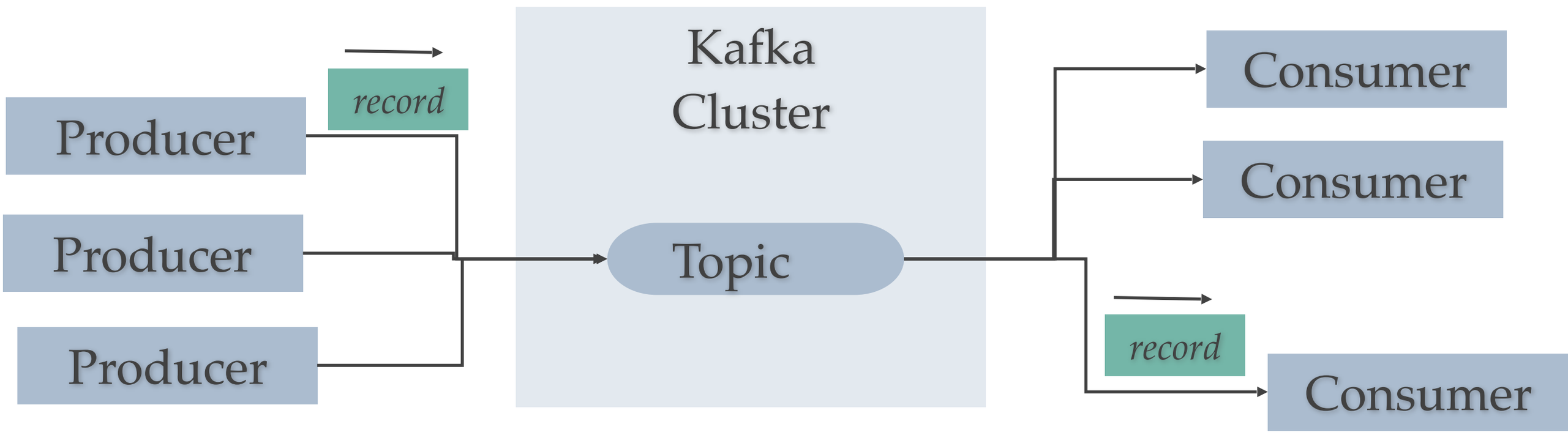
Kafka Use Cases

- Metrics / KPIs gathering
  - Aggregate statistics from many sources
- Even Sourcing
  - Used with microservices (in-memory) and actor systems
- Commit Log
  - External commit log for distributed systems. Replicated data between nodes, re-sync for nodes to restore state
- Real-time data analytics, Stream Processing, Log Aggregation, Messaging, Click-stream tracking, Audit trail, etc.

Who uses Kafka?

- ***LinkedIn***: Activity data and operational metrics
- ***Twitter***: Uses it as part of Storm – stream processing infrastructure
- ***Square***: Kafka as bus to move all system events to various Square data centers (logs, custom events, metrics, an so on). Outputs to Splunk, Graphite, Esper-like alerting systems
- Spotify, Uber, Tumbler, Goldman Sachs, PayPal, Box, Cisco, CloudFlare, DataDog, LucidWorks, MailChimp, NetFlix, etc.

Kafka: Topics, Producers, and Consumers



Kafka Fundamentals

- ***Records*** have a ***key***, ***value*** and ***timestamp***
- ***Topic*** a stream of records (“/orders”, “/user-signups”), feed name
  - ***Log*** topic storage on disk
  - ***Partition*** / Segments (parts of Topic Log)

- ***Producer*** API to produce a streams or records
- ***Consumer*** API to consume a stream of records
- ***Broker***: Cluster of Kafka servers running in cluster form broker. Consists on many processes on many servers
- ***ZooKeeper***: Does coordination of broker and consumers. Consistent file system for configuration information and leadership election

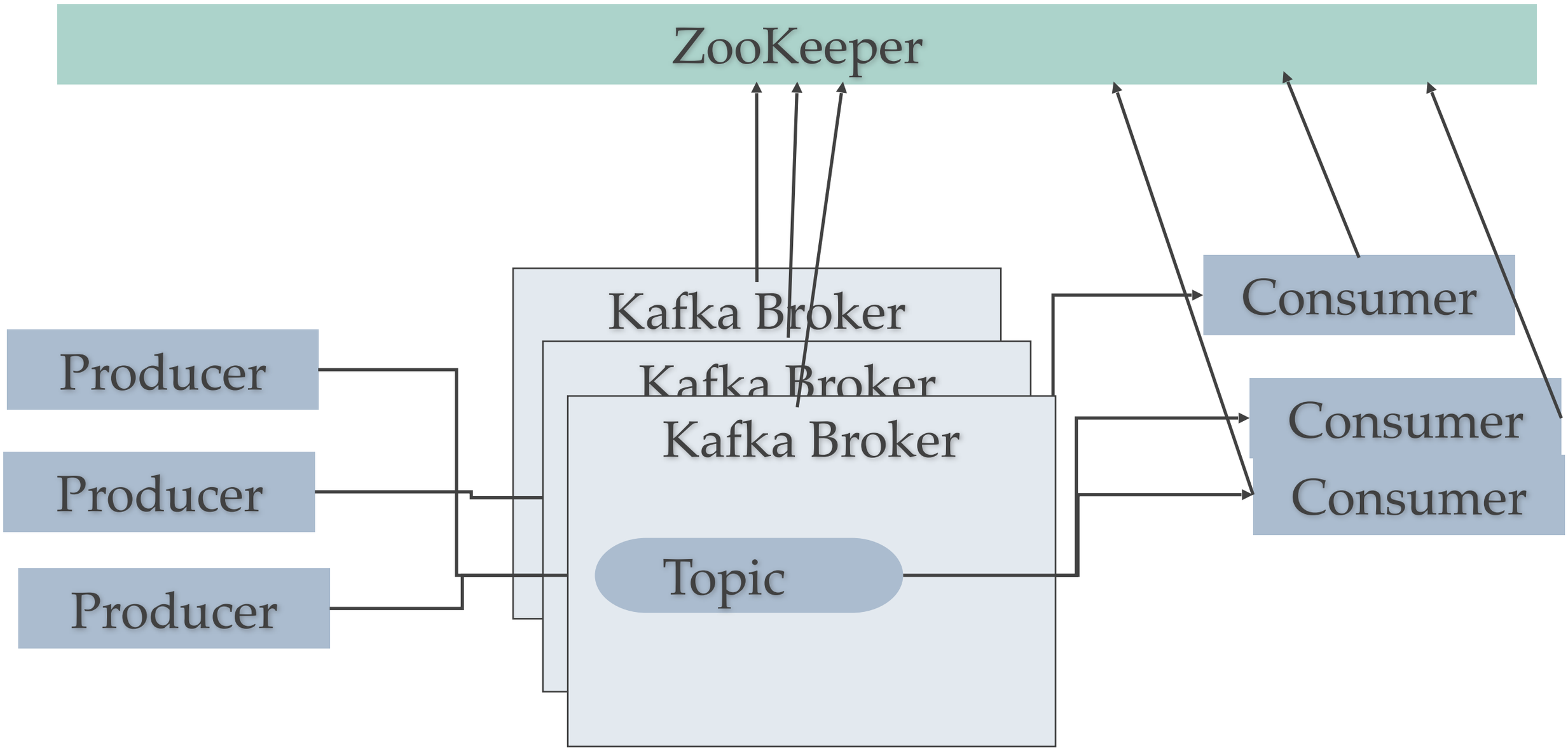
Kafka Performance details

- ***Topic*** is like a feed name *"/**shopping-cart-done**"*, *"/**user-signups**"*, which Producers write to and Consumers read from
- ***Topic*** associated with a log which is data structure on disk
- ***Producer***(s) append ***Records*** at end of Topic log
- Whilst many ***Consumers*** read from Kafka at their own cadence
  - Each Consumer (Consumer Group) tracks offset from where they left off reading
- How can Kafka scale if multiple producers and consumers read/write to the same Kafka Topic log?
  - Sequential writes to filesystem are ***fast*** (700 MB or more a second)
  - Kafka scales writes and reads by ***sharding*** Topic logs into ***Partitions*** (parts of a Topic log)
  - Topics logs can be split into multiple Partitions ***different machines/different disks***
  - Multiple Producers can write to different Partitions of the same Topic
  - Multiple Consumers Groups can read from different partitions efficiently
- ***Partitions*** can be distributed on different machines in a cluster
  - high performance with horizontal scalability and failover

Kafka Fundamentals 2

- ***Kafka*** uses ***ZooKeeper*** to form ***Kafka Brokers*** into a cluster
- Each ***node*** in Kafka cluster is called a ***Kafka Broker***
- ***Partitions*** can be ***replicated*** across ***multiple nodes*** for failover
- One node/partition's replicas is chosen as ***leader***
- Leader handles all reads and writes of Records for partition
- Writes to partition are ***replicated*** to ***followers*** (node/partition pair)
- An ***follower*** that is ***in-sync*** is called an ***ISR (in-sync replica)***
- If a partition leader fails, one ISR is chosen as new leader

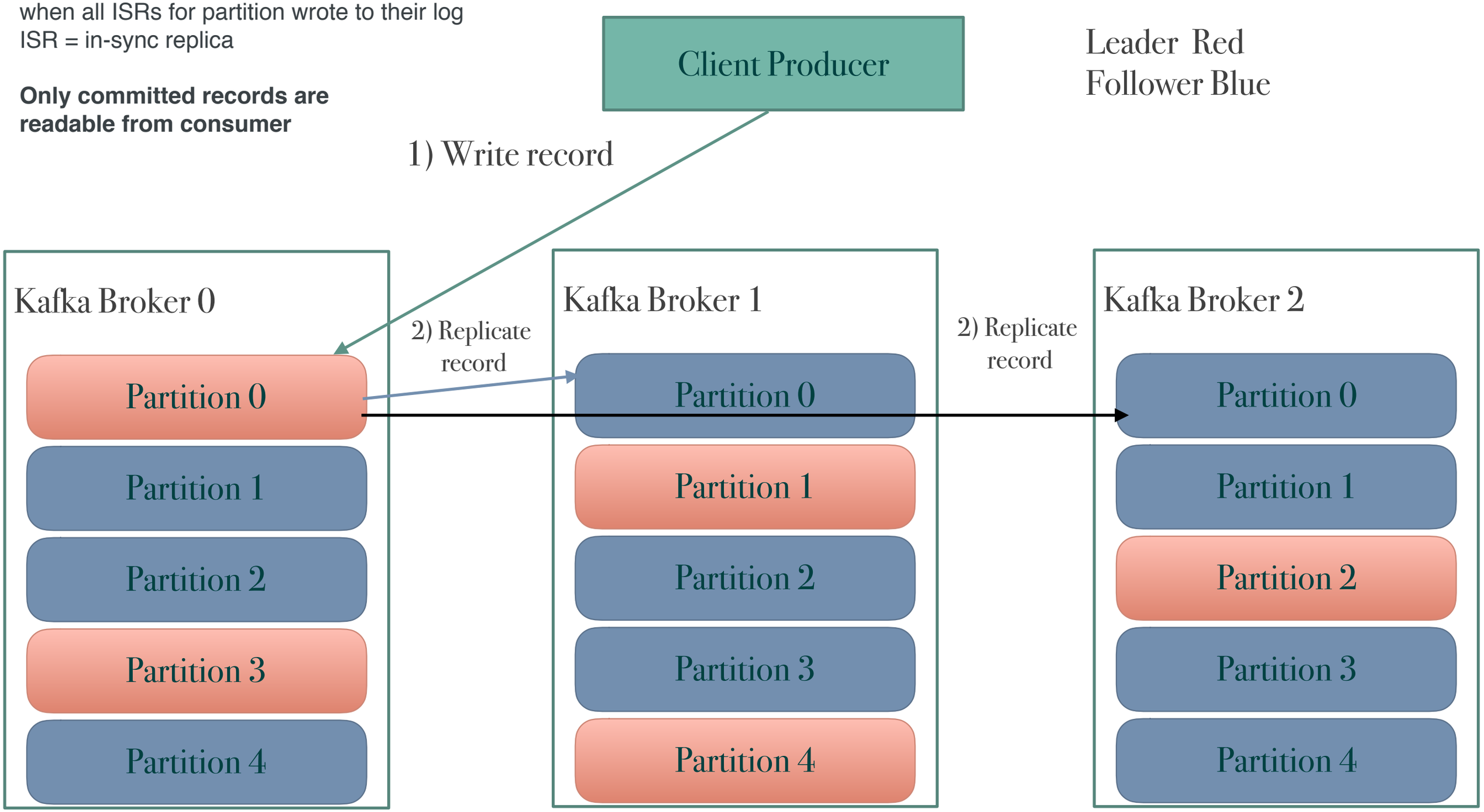
ZooKeeper does coordination for Kafka Consumer and Kafka Cluster



Replication of Kafka Partitions 0

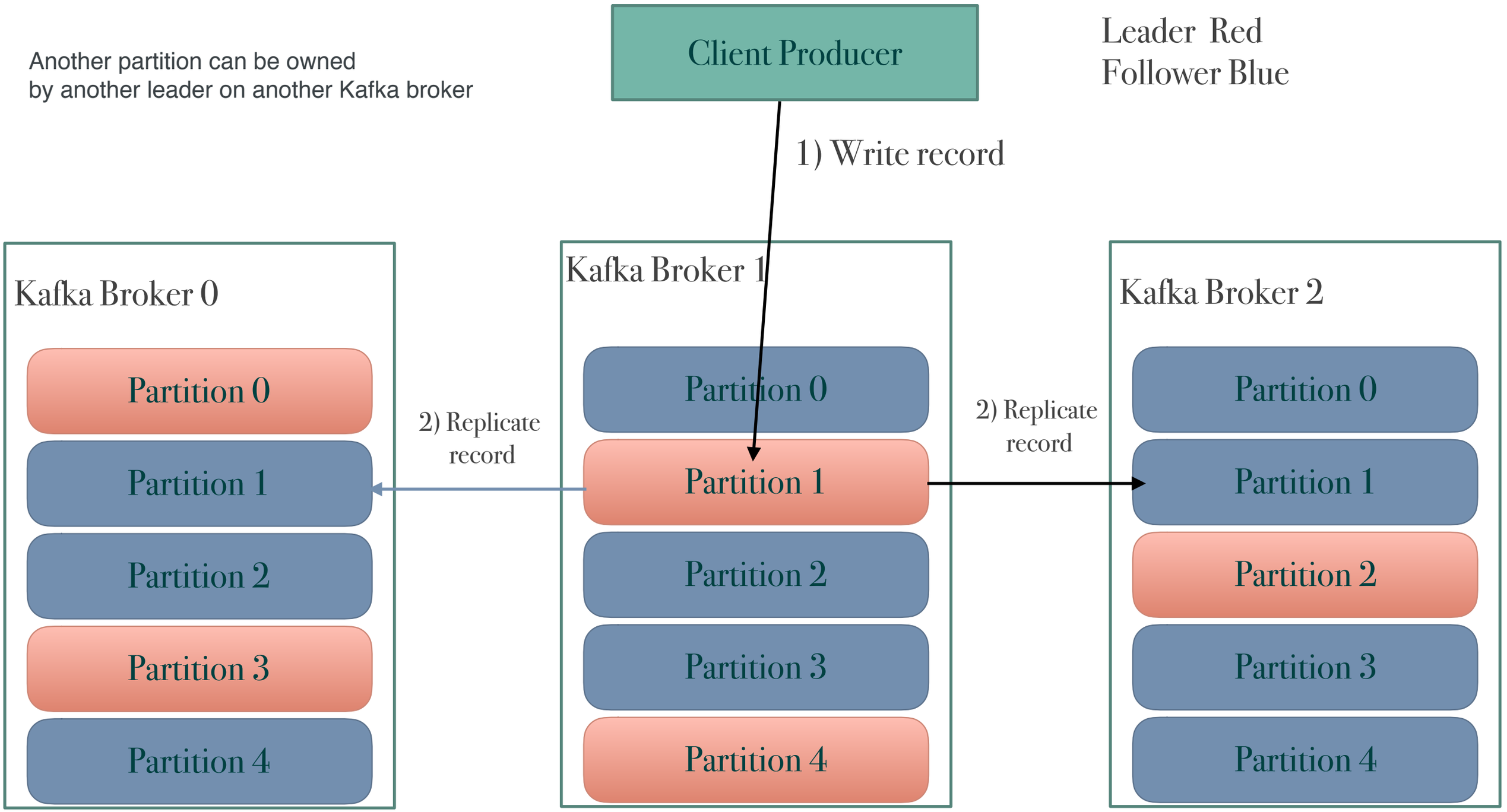
Record is considered "committed"
when all ISRs for partition wrote to their log
ISR = in-sync replica

Only committed records are readable from consumer



Replication of Kafka Partitions 1

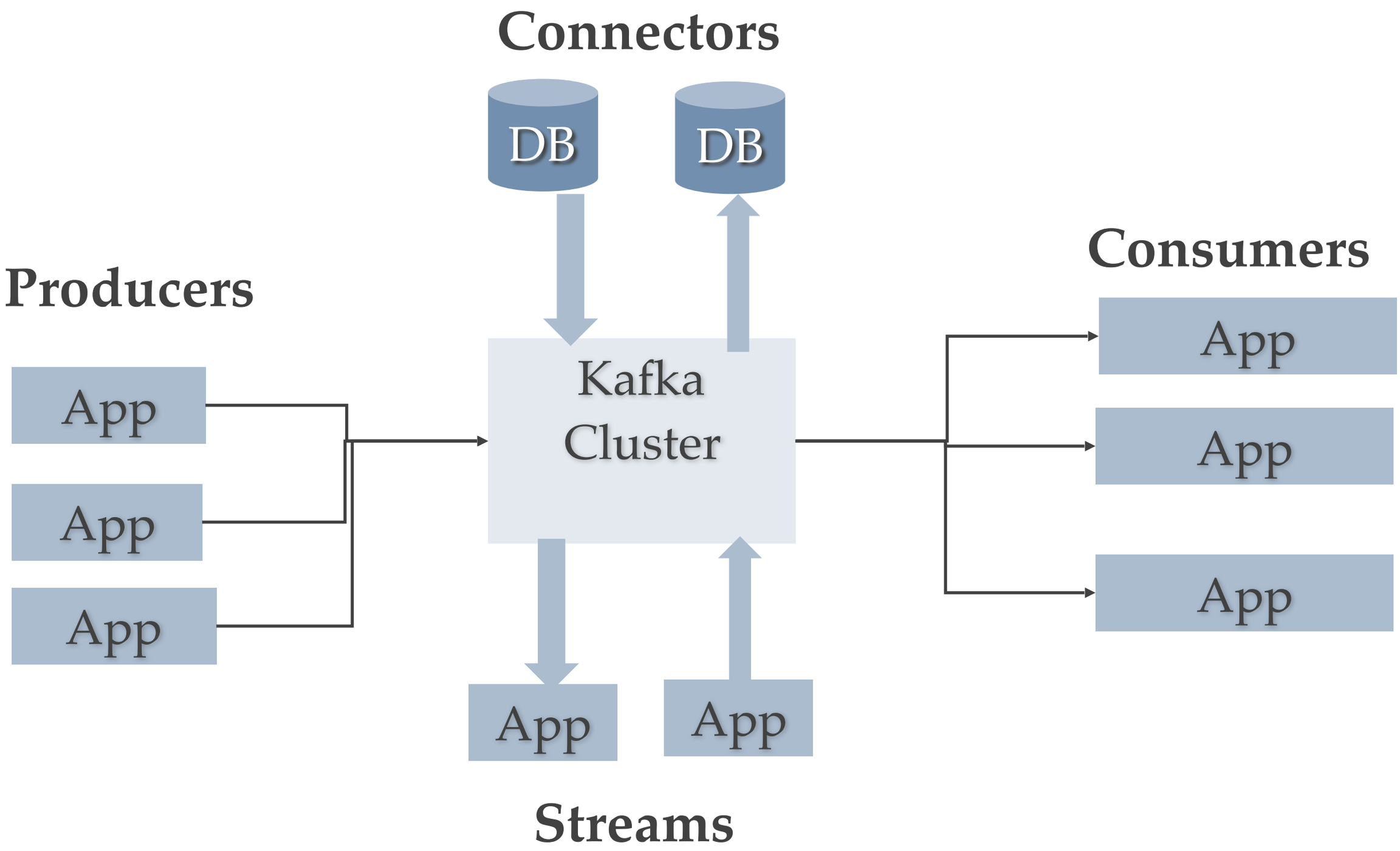
Another partition can be owned
by another leader on another Kafka broker



Kafka Extensions

- ***Streams*** API to transform, aggregate, process records from a stream and produce derivative streams
- ***Connector*** API reusable producers and consumers (e.g., stream of changes from DynamoDB)

Kafka Connectors and Streams



Kafka Polyglot clients / Wire protocol

- Kafka communication from clients and servers wire protocol over TCP protocol
- Protocol versioned
- Maintains backwards compatibility
- Many languages supported

Topics and Logs

- ***Topic*** is a stream of records
- ***Topics*** stored in log
- ***Log*** broken up into ***partitions*** and ***segments***

- ***Topic*** is a category or stream name
- Topics are pub/sub
  - Can have zero or many consumer groups (subscribers)
- ***Topics*** are broken up into partitions for speed and size

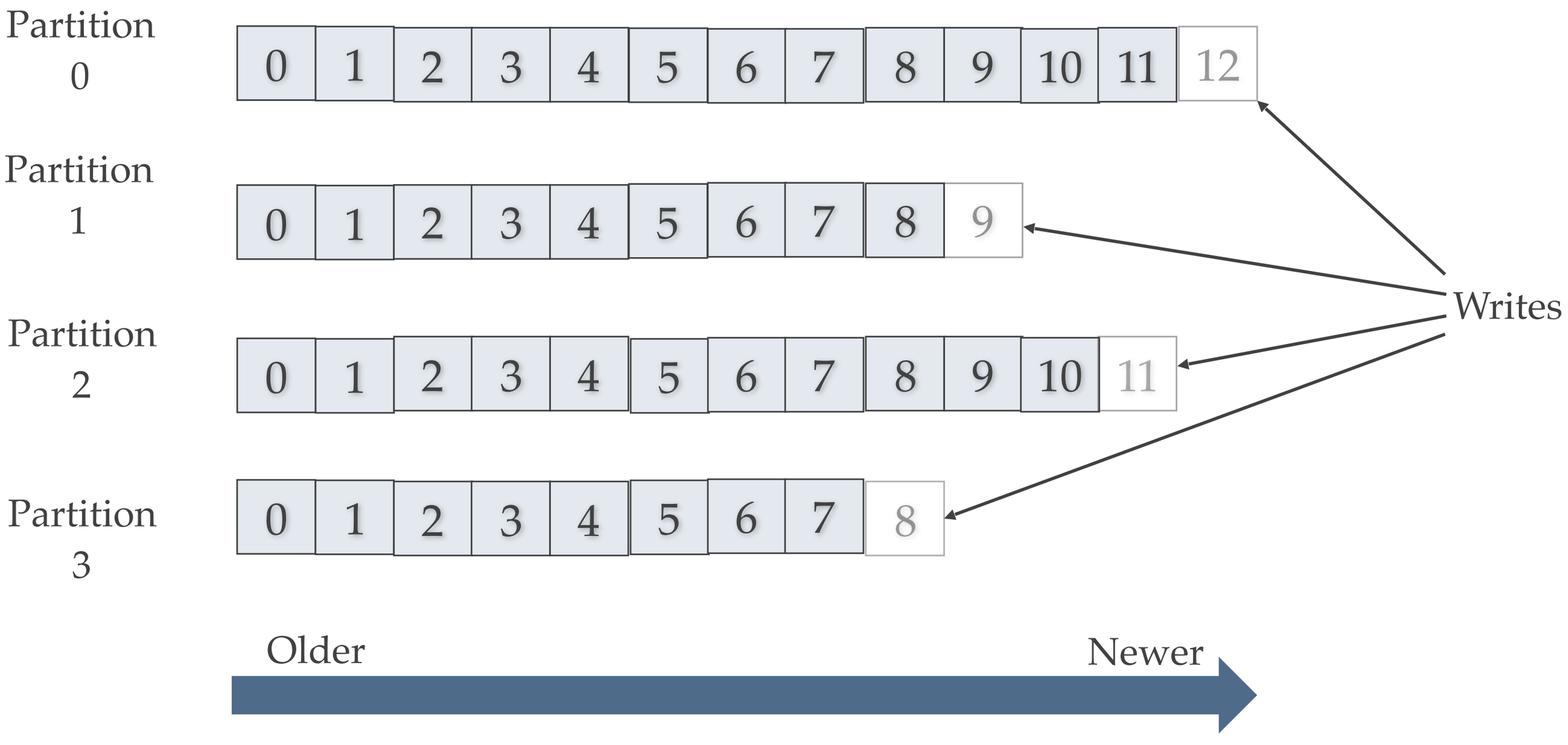
Topic Partitions

- ***Topics*** are broken up into ***partitions***
- ***Partitions*** are decided usually by key of record
  - Key of record determines which partition
- ***Partitions*** are used to scale Kafka across many servers
  - Record sent to correct partition by key
- ***Partitions*** are used to facilitate parallel consumers
  - Records are consumed in parallel up to the number of partitions

Partition Log

- ***Order*** is maintained only in a single ***partition***
  - ***Partition*** is ordered, immutable sequence of records that is continually appended to—a structured commit ***log***
- Producers write at their own cadence so order of Records cannot be guaranteed across partitions
- Producers pick the partition such that Record/messages goes to a given same partition based on the data
  - Example have all the events of a certain 'employeeId' go to same partition
  - If order within a partition is not needed, a 'Round Robin' partition strategy can be used so Records are evenly distributed across partitions.
- ***Records*** in partitions are assigned ***sequential id*** number called the *offset*
- ***Offset*** identifies each record within the partition
- ***Topic Partitions*** allow Kafka log to scale beyond a size that will fit on a single server
  - Topic partition must fit on servers that host it, but topic can span many partitions hosted by many servers
- Topic Partitions are unit of ***parallelism*** - each consumer in a consumer group can work on one partition at a time

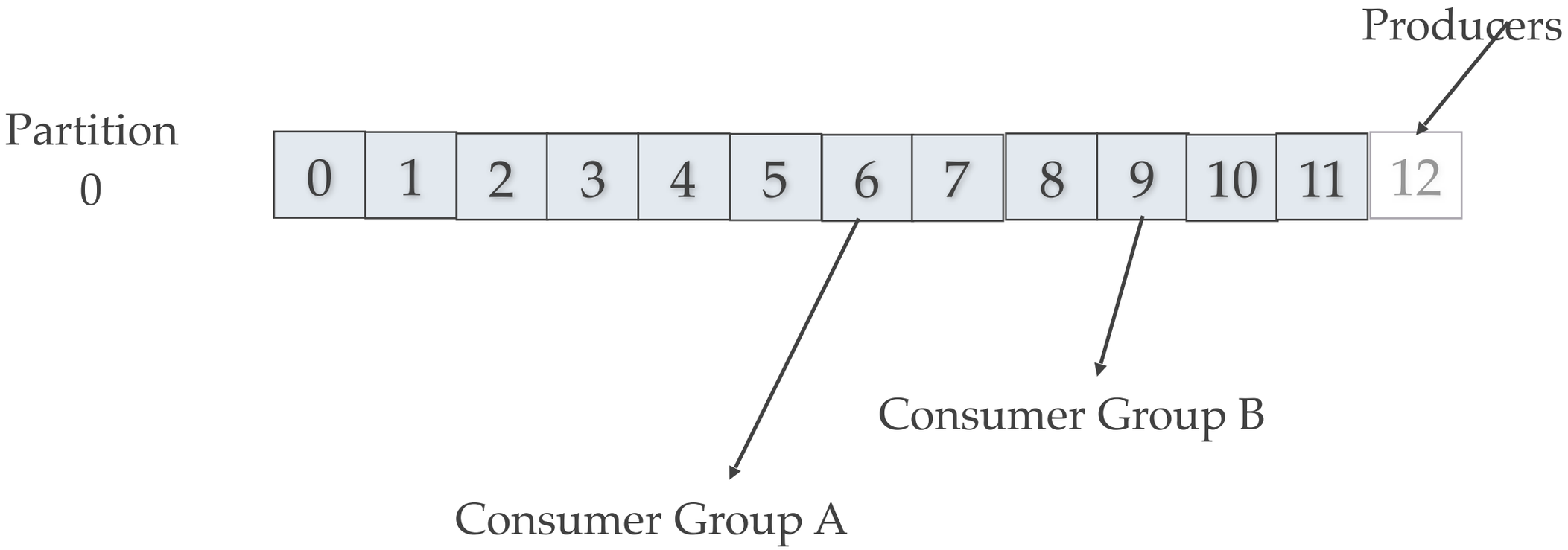
Kafka Topic Partitions Layout



Kafka Record retention

- Kafka cluster retains all published records
  - Time based – configurable retention period
  - Size based
  - Compaction
- Retention policy of three days or two weeks or a month
- It is available for consumption until discarded by time, size or compaction
- Consumption speed not impacted by size

Kafka Consumers / Producers



Consumers remember offset where they left off.

Consumers groups each have their own offset.

Kafka Partition Distribution

- Each partition has ***leader server*** and zero or more ***follower servers***
  - ***Leader*** handles all read and write requests for partition
  - ***Followers*** replicate leader, and take over if leader dies
    - Used for parallel consumer handling within a group
- Partitions of log are distributed over the servers in the Kafka cluster with each server handling data and requests for a share of partitions
- Each partition can be replicated across a configurable number of Kafka servers
  - Used for fault tolerance

Kafka Producers

- ***Producers*** send records to topics
- ***Producer*** picks which partition to send record to per topic
  - Can be done in a ***round-robin***
  - Can be based on priority
  - Typically based on ***key*** of ***record***
  - Kafka ***default partitioner*** for Java uses hash of keys to choose partitions, or a round-robin strategy if no key
- Important: *Producer picks partition*

Kafka Consumer Groups

- Consumers are grouped into a ***Consumer Group***
  - ***Consumer group*** has a unique id
  - Each ***consumer group*** is a subscriber
  - Each ***consumer group*** maintains its own offset
  - Multiple subscribers = multiple consumer groups
- ***A Record*** is delivered to one ***Consumer*** in a ***Consumer Group***
- Each consumer in consumer groups takes records and only one consumer in group gets same record
- Consumers in Consumer Group ***load balance record consumption***

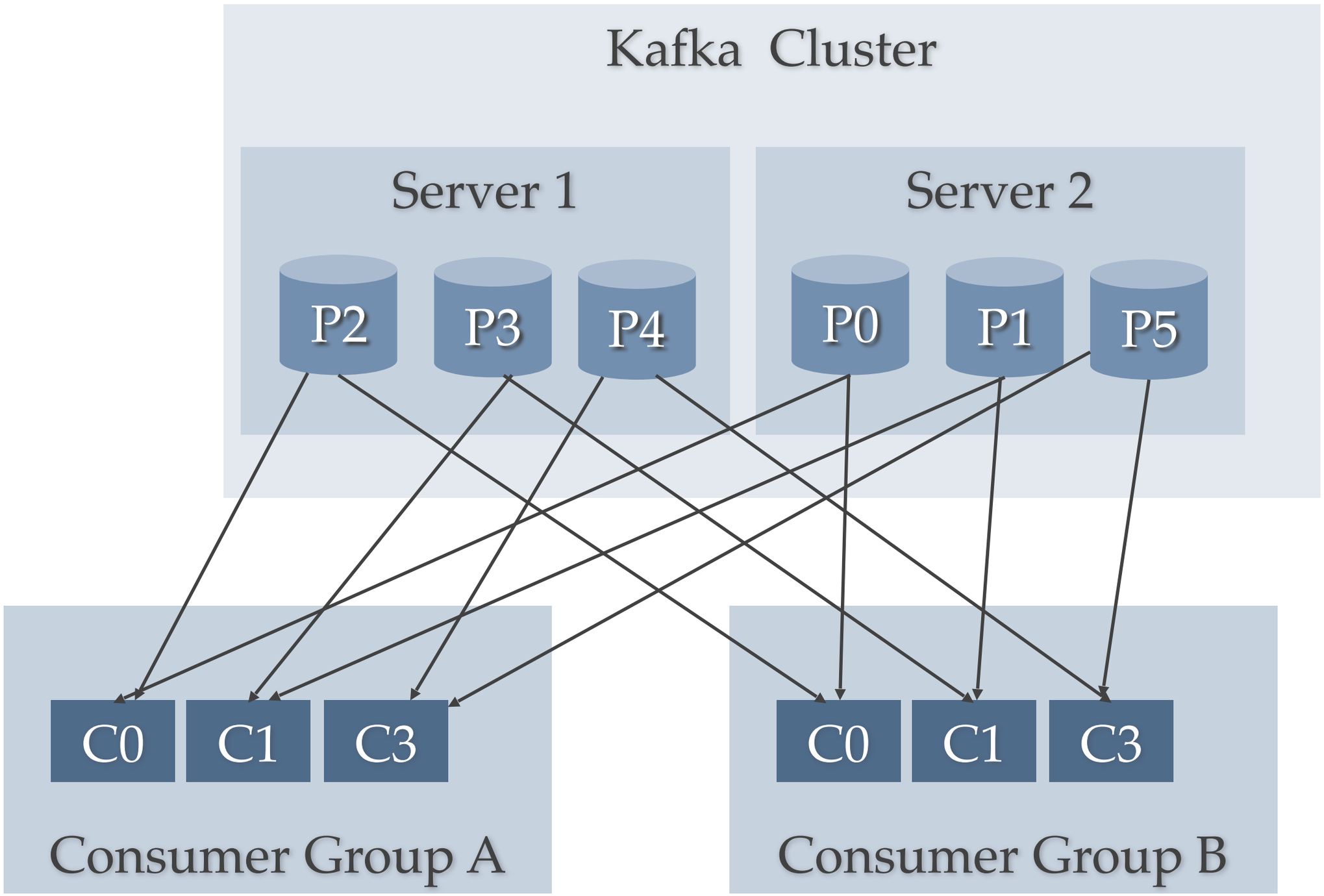
Kafka Consumer Groups 2

- How does Kafka divide up topic so multiple Consumers in a consumer group can process a topic?
- Kafka makes you group consumers into consumers group with a group id
- Consumer with same id belong in same Consumer Group
- One ***Kafka broker*** becomes ***group coordinator*** for Consumer Group
  - assigns partitions when new members arrive (older clients would talk direct to ZooKeeper now broker does coordination)
  - or reassign partitions when group members leave or topic changes (config / meta-data change
- When ***Consumer group*** is created, offset set according to reset policy of topic

Kafka Consumer Group 3

- If ***Consumer*** fails before sending commit offset XXX to Kafka broker,
  - different ***Consumer*** can continue from the last committed offset
  - some Kafka records could be reprocessed (***at least once behavior***)
- ***"Log end offset"*** is offset of last record written to log partition and where ***Producers*** write to next
- ***"High watermark"*** is offset of last record that was successfully replicated to all partitions followers
- ***Consumer*** only reads up to the "high watermark". ***Consumer can't read un-replicated data***
- Only a single ***Consumer*** from the same ***Consumer Group*** can access a single ***Partition***
- If ***Consumer Group*** count ***exceeds*** Partition count:
  - Extra Consumers remain idle; can be used for failover
- If more Partitions than Consumer Group instances,
  - Some Consumers will read from more than one partition

2 server Kafka cluster hosting 4 partitions (P0-P5)



Kafka Consumer Consumption

- Kafka ***Consumer*** consumption divides partitions over consumer instances
  - Each Consumer is exclusive consumer of a "fair share" of partitions
  - Consumer membership in group is handled by the Kafka protocol dynamically
    - If new Consumers join Consumer group they get share of partitions
    - If Consumer dies, its partitions are split among remaining live Consumers in group
- Order is only guaranteed within a single partition
- Since ***records*** are typically stored ***by key into a partition*** then order per partition is sufficient for most use cases

Kafka vs JMS Messaging

- It is a bit like both Queues and Topics in JMS
- Kafka is a queue system per consumer in consumer group so load balancing like JMS queue
- Kafka is a topic/pub/sub by offering Consumer Groups which act like subscriptions
  - Broadcast to multiple consumer groups
- By design Kafka is better suited for scale due to partition topic log
- Also by moving location in log to client/consumer side of equation instead of the broker, less tracking required by Broker
- Handles parallel consumers better

Kafka scalable message storage

- Kafka acts as a good storage system for records/messages
- Records written to Kafka topics are persisted to disk and replicated to other servers for fault-tolerance
- Kafka Producers can wait on acknowledgement
  - Write not complete until fully replicated
- Kafka disk structures scales well
  - Writing in large streaming batches is fast
- Clients/Consumers control read position (offset)
  - Kafka acts like high-speed file system for commit log storage, replication

Kafka Stream Processing

- Kafka for Stream Processing
  - Kafka enable ***real-time*** processing of streams.
- Kafka supports stream processor
  - Stream processor takes continual streams of records from input topics, performs some processing, transformation, aggregation on input, and produces one or more output streams
- A video player app might take in input streams of videos watched and videos paused, and output a stream of user preferences and gear new video recommendations based on recent user activity or aggregate activity of many users to see what new videos are hot
- Kafka Stream API solves hard problems with out of order records, aggregating across multiple streams, joining data from multiple streams, allowing for stateful computations, and more
- Stream API builds on core Kafka primitives and has a life of its own

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Using Kafka Single Node

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Run Kafka

- Run ZooKeeper
- Run Kafka Server / Broker
- Create Kafka Topic
- Run producer
- Run consumer

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Run ZooKeeper

run-zookeeper.sh

```
#!/usr/bin/env bash
cd ~/kafka-training

kafka/bin/zookeeper-server-start.sh kafka/config/zookeeper.properties &
```

```
rick@Richards-MacBook-Pro-2.local:~/kafka-training
$ ./run-zookeeper.sh
rick@Richards-MacBook-Pro-2.local:~/kafka-training
$ [2017-04-14 17:45:53,408] INFO Accepted socket connection from /0:0:0:0:0:0:0:1:56952 (org.apache.zookeeper.server.NIOServer
CnxnFactory)
[2017-04-14 17:45:53,415] INFO Client attempting to establish new session at /0:0:0:0:0:0:0:1:56952 (org.apache.zookeeper.serv
er.ZooKeeperServer)
[2017-04-14 17:45:53,417] INFO Established session 0x15b6ec06f690014 with negotiated timeout 6000 for client /0:0:0:0:0:0:0:1:
56952 (org.apache.zookeeper.server.ZooKeeperServer)
[2017-04-14 17:45:57,612] INFO Reading configuration from: kafka/config/zookeeper.properties (org.apache.zookeeper.server.quor
um.QuorumPeerConfig)
```

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Run Kafka Server

run-kafka.sh

```
#!/usr/bin/env bash
cd ~/kafka-training

kafka/bin/kafka-server-start.sh kafka/config/server.properties
```

```
rick@Richards-MacBook-Pro-2.local:~/kafka-training
$ kafka/bin/kafka-server-start.sh kafka/config/server.properties
[2017-04-14 17:49:09,709] INFO KafkaConfig values:
        advertised.host.name = null
        advertised.listeners = null
        advertised.port = null
        authorizer.class.name =
        auto.create.topics.enable = true
        auto.leader.rebalance.enable = true
        background.threads = 10
        broker.id = 0
```

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Create Kafka Topic

create-topic.sh

```
#!/usr/bin/env bash

cd ~/kafka-training

# Create a topic
kafka/bin/kafka-topics.sh --create --zookeeper localhost:2181 \
--replication-factor 1 --partitions 1 --topic my-topic

# List existing topics
kafka/bin/kafka-topics.sh --list --zookeeper localhost:2181
```

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Kafka Producer

start-producer-console.sh

```
#!/usr/bin/env bash
cd ~/kafka-training

kafka/bin/kafka-console-producer.sh --broker-list \
localhost:9092 --topic my-topic
```

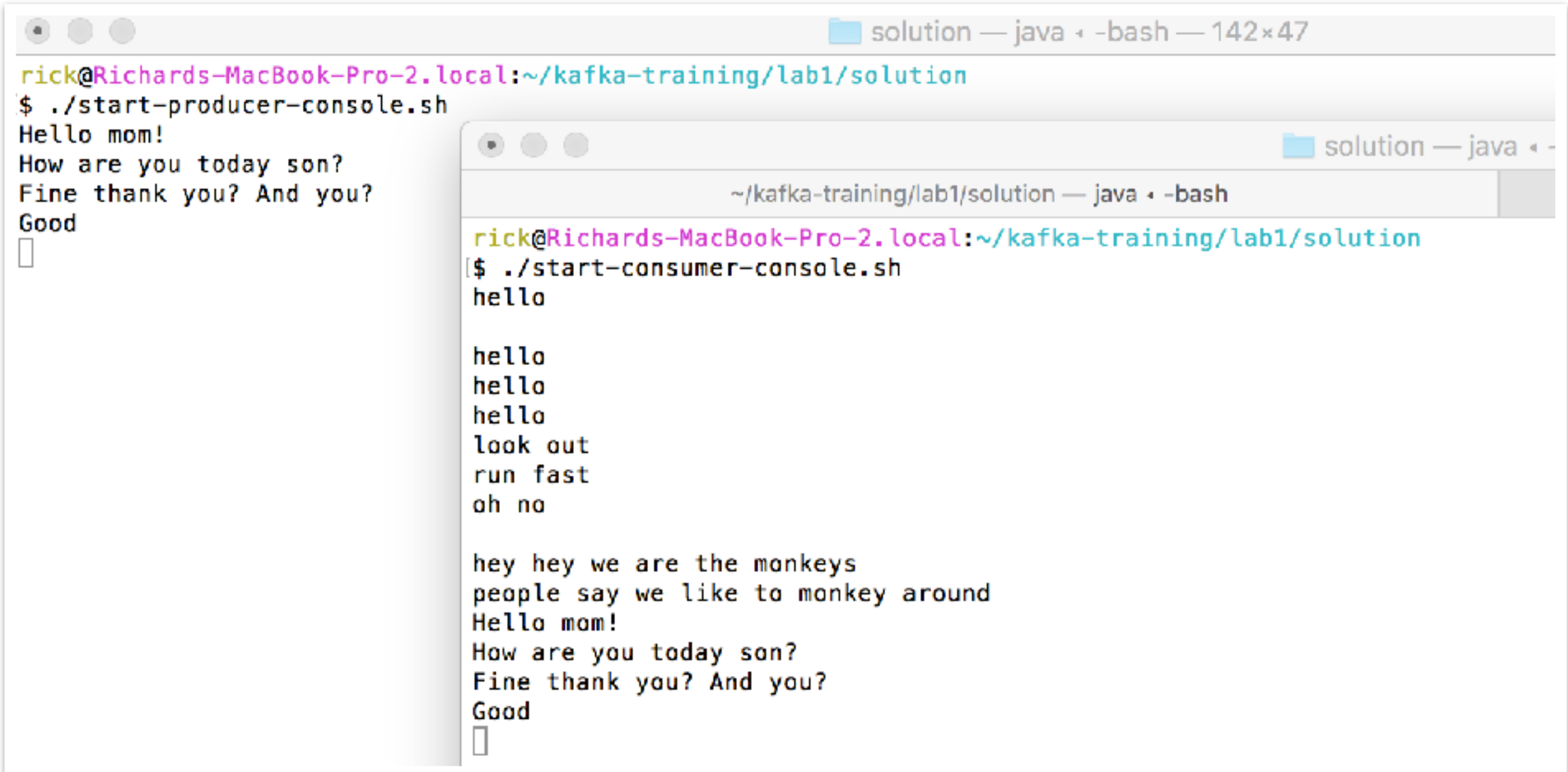
Kafka Consumer

start-consumer-console.sh

```
#!/usr/bin/env bash
cd ~/kafka-training

kafka/bin/kafka-console-consumer.sh --bootstrap-server localhost:9092 \
--topic my-topic --from-beginning
```

Running Kafka Producer and Consumer



Use Kafka to send and receive messages

Lab 1-A Use Kafka

Use single server version of Kafka

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Using Kafka Cluster

Running many nodes

- Modify properties files
  - Change port
  - Change Kafka log location
- Start up many Kafka server instances
- Create Replicated Topic

Leave everything from before running

run-zookeeper.sh

```
#!/usr/bin/env bash
cd ~/kafka-training

kafka/bin/zookeeper-server-start.sh kafka/config/zookeeper.properties &

```

run-kafka.sh

```
#!/usr/bin/env bash
cd ~/kafka-training

kafka/bin/kafka-server-start.sh kafka/config/server.properties

```

Create two new server.properties files

- Copy existing ***server.properties*** to ***server-1.properties, server-2.properties***
- Change ***server-1.properties*** to use ***port 9093, broker id 1,*** and ***log.dirs " /tmp/kafka-logs-1"***
- Change ***server-2.properties*** to use ***port 9094, broker id 2,*** and ***log.dirs " /tmp/kafka-logs-2"***

server-x.properties

server-1.properties

```
broker.id=1
port=9093
log.dirs=/tmp/kafka-logs-1
```

server-2.properties

```
broker.id=2
port=9094
log.dirs=/tmp/kafka-logs-2
```

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Start second and third servers

start-2nd-server.sh × start-3rd-server.sh ×

```
1  #!/usr/bin/env bash
2  CONFIG=`pwd`/config
3  cd ~/kafka-training
4  kafka/bin/kafka-server-start.sh $CONFIG/server-1.properties
```

start-2nd-server.sh × start-3rd-server.sh ×

```
1  #!/usr/bin/env bash
2  CONFIG=`pwd`/config
3  cd ~/kafka-training
4  kafka/bin/kafka-server-start.sh "$CONFIG/server-2.properties"
```

Create Kafka replicated topic **my-failsafe-topic**

create-replicated-topic.sh

```
#!/usr/bin/env bash

cd ~/kafka-training

kafka/bin/kafka-topics.sh --create --zookeeper localhost:2181 \
--replication-factor 3 --partitions 1 --topic my-failsafe-topic

kafka/bin/kafka-topics.sh --list --zookeeper localhost:2181
```

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Start Kafka consumer and producer

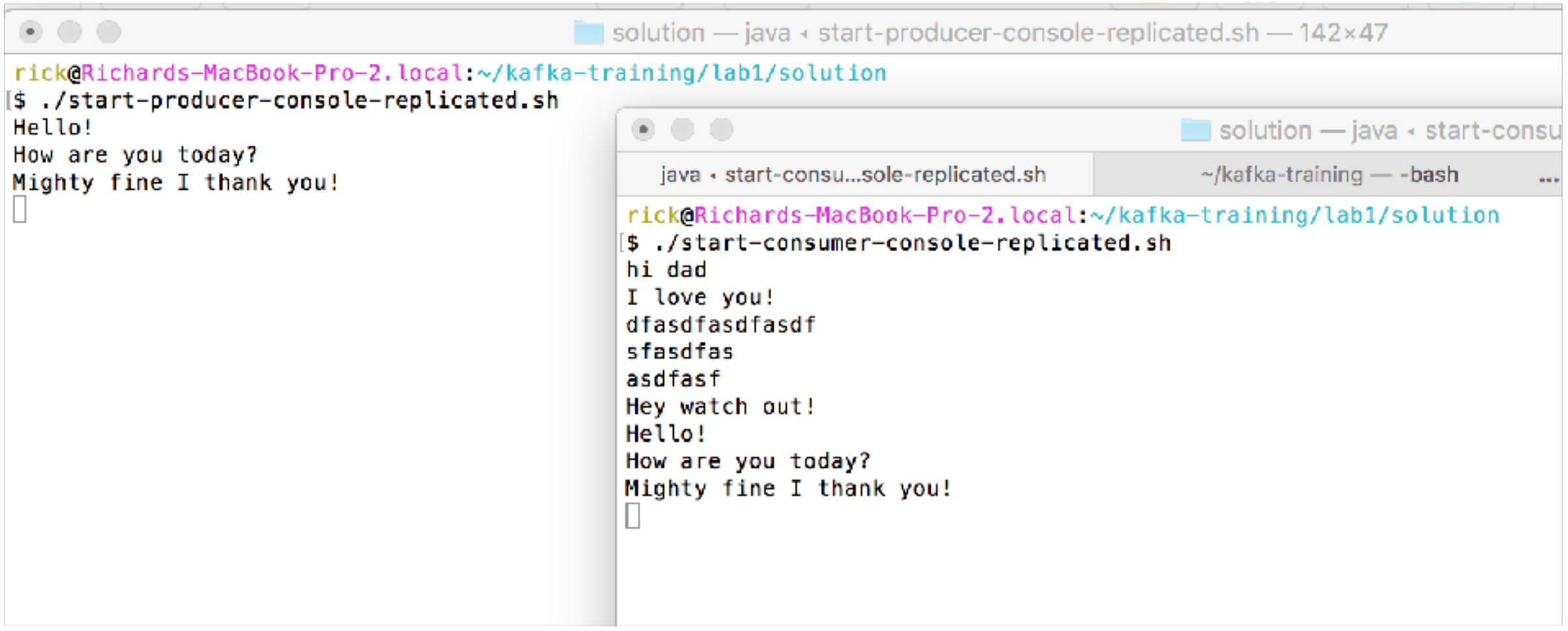
start-producer-console-replicated.sh × | start-consumer-console-replicated.sh ×

```
1  #!/usr/bin/env bash
2  cd ~/kafka-training
3
4  kafka/bin/kafka-console-producer.sh \
5  --broker-list localhost:9092,localhost:9093 \
6  --topic my-failsafe-topic
```

start-producer-console-replicated.sh × | start-consumer-console-replicated.sh ×

```
1  #!/usr/bin/env bash
2  cd ~/kafka-training
3
4  kafka/bin/kafka-console-consumer.sh --bootstrap-server \
5  localhost:9092 --topic my-failsafe-topic --from-beginning
```

Kafka consumer and producer running



Use Kafka Describe Topic

```
$ kafka/bin/kafka-topics.sh --describe --zookeeper localhost:2181 --topic my-failsafe-topic
Topic:my-failsafe-topic PartitionCount:1        ReplicationFactor:3     Configs:
        Topic: my-failsafe-topic        Partition: 0    Leader: 0       Replicas: 0,2,1 Isr: 0,1,2
rick@Richards-MacBook-Pro-2.local:~/kafka-training
```

There is only one partition

The leader is broker 0

There are three in-sync replicas (ISR)

Test Failover by killing 1st server

```
$ ps aux | grep "server.properties" | tr -s " " | cut -d " " -f2 | head -n 1
24822
rick@Richards-MacBook-Pro-2.local:~/kafka-training
$ kill 24822
```

Use Kafka topic describe to see that a new leader was elected!

```
$ kafka/bin/kafka-topics.sh --describe --zookeeper localhost:2181 --topic my-failsafe-topic
Topic:my-failsafe-topic PartitionCount:1        ReplicationFactor:3     Configs:
        Topic: my-failsafe-topic        Partition: 0    Leader: 2       Replicas: 0,2,1 Isr: 1,2
rick@Richards-MacBook-Pro-2.local:~/kafka-training
```

NEW LEADER IS 2!

Use Kafka to send and receive messages

Lab 2-A Use Kafka

Use a Kafka Cluster to replicate a Kafka topic log

Kafka Consumer and Producers

Working with producers and consumers
Step by step first example

Objectives Create Producer and Consumer example

- Create simple example that creates a ***Kafka Consumer*** and a ***Kafka Producer***
- Create a new replicated ***Kafka topic***
- ***Create Producer*** that uses topic to send records
- ***Send records*** with ***Kafka Producer***
- ***Create Consumer*** that uses topic to receive messages
- ***Process messages*** from Kafka with ***Consumer***

Create Replicated Kafka Topic

create-topic.sh

```
#!/usr/bin/env bash
cd ~/kafka-training
kafka/bin/kafka-topics.sh --create --zookeeper localhost:2181 \
--replication-factor 3 --partitions 1 --topic my-example-topic
kafka/bin/kafka-topics.sh --list --zookeeper localhost:2181
```

```
$ ./create-topic.sh
Created topic "my-example-topic".
EXAMPLE_TOPIC
__consumer_offsets
kafkatopic
my-example-topic
my-failsafe-topic
my-topic
```

Build script

kafka-training

```
group 'cloudurable-kafka'
version '1.0-SNAPSHOT'

apply plugin: 'java'

sourceCompatibility = 1.8

repositories {
    mavenCentral()
}

dependencies {
    testCompile group: 'junit', name: 'junit', version: '4.11'
    compile group: 'org.apache.kafka', name: 'kafka-clients', version: '0.10.2.0'
}
```

Create Kafka Producer to send records

- Specify bootstrap servers
- Specify client.id
- Specify Record Key serializer
- Specify Record Value serializer

Common Kafka imports and constants

```
package com.cloudurable.kafka;
import org.apache.kafka.clients.consumer.*;
import org.apache.kafka.clients.consumer.Consumer;
import org.apache.kafka.clients.producer.*;
import org.apache.kafka.common.serialization.*;

import java.util.Collections;
import java.util.Properties;
import java.util.concurrent.CountDownLatch;
import java.util.concurrent.TimeUnit;

public class KafkaExample {

    private final static String TOPIC = "my-example-topic";
    private final static String BOOTSTRAP_SERVERS =
            "localhost:9092,localhost:9093,localhost:9094";
```

Create Kafka Producer to send records

```
private static Producer<Long, String> createProducer() {
    Properties props = new Properties();
    props.put(ProducerConfig.BOOTSTRAP_SERVERS_CONFIG, BOOTSTRAP_SERVERS);
    props.put(ProducerConfig.CLIENT_ID_CONFIG, "KafkaExampleProducer");
    props.put(ProducerConfig.KEY_SERIALIZER_CLASS_CONFIG, LongSerializer.class.getName());
    props.put(ProducerConfig.VALUE_SERIALIZER_CLASS_CONFIG, StringSerializer.class.getName());
    return new KafkaProducer<>(props);
}
```

Send sync records with Kafka Producer

```
static void runProducer(final int sendMessageCount) throws Exception {
    final Producer<Long, String> producer = createProducer();
    long time = System.currentTimeMillis();

    try {
        for (long index = time; index < time + sendMessageCount; index++) {
            final ProducerRecord<Long, String> record =
                    new ProducerRecord<>(TOPIC, index, value: "Hello Mom " + index);

            RecordMetadata metadata = producer.send(record).get();

            long elapsedTime = System.currentTimeMillis() - time;
            System.out.printf("sent record(key=%s value=%s) " +
                            "meta(partition=%d, offset=%d) time=%d\n",
                            record.key(), record.value(), metadata.partition(),
                    metadata.offset(), elapsedTime);

        }
    }finally {
        producer.flush();
        producer.close();
```

The response **RecordMetadata** has 'partition' where record was written and the 'offset' of the record.

Send async records with Kafka Producer

```
static void runProducer(final int sendMessageCount) throws InterruptedException {
    final Producer<Long, String> producer = createProducer();
    long time = System.currentTimeMillis();
    final CountDownLatch countDownLatch = new CountDownLatch(sendMessageCount);

    try {
        for (long index = time; index < time + sendMessageCount; index++) {
            final ProducerRecord<Long, String> record =
                    new ProducerRecord<>(TOPIC, index, value: "Hello Mom " + index);
            producer.send(record, (metadata, exception) -> {
                long elapsedTime = System.currentTimeMillis() - time;
                if (metadata != null) {
                    System.out.printf("sent record(key=%s value=%s) " +
                                    "meta(partition=%d, offset=%d) time=%d\n",
                            record.key(), record.value(), metadata.partition(),
                            metadata.offset(), elapsedTime);
                } else {
                    exception.printStackTrace();
                }
                countDownLatch.countDown();
            });
        }
        countDownLatch.await( timeout: 25, TimeUnit.SECONDS);
    }finally {
        producer.flush();
        producer.close();
```

Create Consumer using Topic to Receive Records

- Specify bootstrap servers
- Specify client.id
- Specify Record Key deserializer
- Specify Record Value deserializer
- Specify Consumer Group
- Subscribe to Topic

Create Consumer using Topic to Receive Records

```
private static Consumer<Long, String> createConsumer() {
    Properties props = new Properties();
    props.put(ConsumerConfig.BOOTSTRAP_SERVERS_CONFIG, BOOTSTRAP_SERVERS);
    props.put(ConsumerConfig.GROUP_ID_CONFIG, "KafkaExampleConsumer");
    props.put(ConsumerConfig.KEY_DESERIALIZER_CLASS_CONFIG,
            LongDeserializer.class.getName());
    props.put(ConsumerConfig.VALUE_DESERIALIZER_CLASS_CONFIG,
            StringDeserializer.class.getName());
    Consumer<Long, String> consumer = new KafkaConsumer<>(props);
    consumer.subscribe(Collections.singletonList(TOPIC));
    return consumer;
}
```

Process messages from Kafka with Consumer

KafkaExample.java

KafkaExample › runConsumer()

```
76      static void runConsumer() throws InterruptedException {
77          Consumer<Long, String> consumer = createConsumer();
78
79          while (true) {
80              final ConsumerRecords<Long, String> consumerRecords = consumer.poll( timeout: 100);
81
82              if (consumerRecords.count()==0) {
83                  break;
84              }
85
86              consumerRecords.forEach(record -> {
87                  System.out.println("Got Record: (" + record.key() + ", " + record.value()
88                          + ") at offset " + record.offset());
89              });
90              consumer.commitAsync();
91          }
92          consumer.close();
93          System.out.println("DONE");
94      }
95
```

Consumer poll

- poll() method returns fetched records based on current partition offset
- Blocking method waiting for specified time if no records available
- When/If records available, method returns straight away
- Control the maximum records returned by the poll() with `props.put(ConsumerConfig.MAX_POLL_RECORDS_CONFIG, 100);`
- poll() is not meant to be called from multiple threads

Running both Consumer and Producer

```
public static void main(String... args) throws InterruptedException {
    runProducer( sendMessageCount: 5);
    runConsumer();
}
```

```
Run  KafkaExample
/Library/Java/JavaVirtualMachines/jdk1.8.0_66.jdk/Contents/Home/bin/java ...
SLF4J: Failed to load class "org.slf4j.impl.StaticLoggerBinder".
SLF4J: Defaulting to no-operation (NOP) logger implementation
SLF4J: See http://www.slf4j.org/codes.html#StaticLoggerBinder for further details.
sent record(key=1492463982402 value=Hello Mom 1492463982402) meta(partition=0, offset=380) time=139
sent record(key=1492463982403 value=Hello Mom 1492463982403) meta(partition=0, offset=381) time=141
sent record(key=1492463982404 value=Hello Mom 1492463982404) meta(partition=0, offset=382) time=141
sent record(key=1492463982405 value=Hello Mom 1492463982405) meta(partition=0, offset=383) time=141
sent record(key=1492463982406 value=Hello Mom 1492463982406) meta(partition=0, offset=384) time=141
Got Record: (1492463982402, Hello Mom 1492463982402) at offset 380
Got Record: (1492463982403, Hello Mom 1492463982403) at offset 381
Got Record: (1492463982404, Hello Mom 1492463982404) at offset 382
Got Record: (1492463982405, Hello Mom 1492463982405) at offset 383
Got Record: (1492463982406, Hello Mom 1492463982406) at offset 384
DONE
```

Java Kafka simple example recap

- Created simple example that creates a ***Kafka Consumer*** and a ***Kafka Producer***
- Created a new replicated ***Kafka topic***
- ***Created Producer*** that uses topic to send records
- ***Send records*** with ***Kafka Producer***
- ***Created Consumer*** that uses topic to receive messages
- ***Processed records*** from Kafka with ***Consumer***

TM

Kafka design

Design discussion of Kafka

Kafka Design Motivation

- Kafka unified platform for handling real-time data feeds/streams
- High-throughput supports high volume event streams like log aggregation
- Must support real-time analytics
  - real-time processing of streams to create new, derived streams
    - inspired partitioning and consumer model
- Handle large data backlogs - periodic data loads from offline systems
- Low-latency delivery to handle traditional messaging use-cases
- Scale writes and reads via partitioned, distributed, commit logs
- Fault-tolerance for machine failures
- Kafka design is more like database transaction log than a traditional messaging system

Persistence: Embrace filesystem

- Kafka relies heavily on filesystem for storing and caching messages/records
- Disk performance of hard drives performance of sequential writes is fast
  - JBOD configuration with six 7200rpm SATA RAID-5 array is about 600MB/sec
  - Sequential reads and writes are predictable, and are heavily optimized by operating systems
  - Sequential disk access can be faster than random memory access and SSD
- Operating systems use available of main memory for disk caching
- JVM GC overhead is high for caching objects whilst OS file caches are almost free
- Filesystem and relying on page-cache is preferable to maintaining an in-memory cache in the JVM
- By relying on the OS page cache Kafka greatly simplifies code for cache coherence
- Since Kafka disk usage tends to do sequential reads the read-ahead cache of the OS pre-populating its page-cache

Cassandra, Netty, and Varnish use similar techniques.
The above is explained well in the Kafka Documentation.
And there is a more entertaining explanation at the Varnish site.

Long sequential disk access

- Like Cassandra, LevelDB, RocksDB, and others Kafka uses a form of log structured storage and compaction instead of an on-disk mutable BTree
- Kafka uses tombstones instead of deleting records right away
- Since disks these days have somewhat unlimited space and are very fast, Kafka can provide features not usually found in a messaging system like holding on to old messages for a really long time
  - This flexibility allows for interesting application of Kafka

Kafka compression

- Kafka provides ***End-to-end Batch Compression***
- Bottleneck is not always CPU or disk but often network bandwidth
  - especially in cloud and virtualized environments
  - especially when talking datacenter to datacenter or WAN
- Instead of compressing records one at a time…
- Kafka enable efficient compression of a whole batch or a whole message set or message batch
- Message batch can be compressed and sent to Kafka broker/server in one go
- Message batch will be written in compressed form in log partition
  - don't get decompressed until they consumer
- GZIP, Snappy and LZ4 compression protocols supported

Read more at Kafka documents on end to end compression.

Kafka Producer Load Balancing

- Producer sends records directly to Kafka broker partition leader
- Producer asks Kafka broker for metadata about which Kafka broker has which topic partitions leaders - thus no routing layer needed
- Producer client controls which partition it publishes messages to
- Partitioning can be done by key, round-robin or using a custom semantic partitioner

Kafka Producer Record Batching

- Kafka producers support record batching
- Batching is good for efficient compression and network IO throughput
- Batching can be configured by size of records in bytes in batch
- Batches can be auto-flushed based on time
- See code example on the next slide
- Batching allows accumulation of more bytes to send, which equate to few larger I/O operations on Kafka Brokers and increase compression efficiency
- Buffering is configurable and lets you make a tradeoff between additional latency for better throughput
  - Or in the case of an heavily used system, it could be both better average throughput and

QBit a microservice library uses message batching in an identical fashion as Kafka to send messages over WebSocket between nodes and from client to QBit server.

More producer settings for performance

KafkaExample.java

```
KafkaExample
21      private static Producer<Long, String> createProducer() {
22          Properties props = new Properties();
23          props.put(ProducerConfig.BOOTSTRAP_SERVERS_CONFIG, BOOTSTRAP_SERVERS);
24          props.put(ProducerConfig.CLIENT_ID_CONFIG, "KafkaExampleProducer");
25          props.put(ProducerConfig.KEY_SERIALIZER_CLASS_CONFIG, LongSerializer.class.getName());
26          props.put(ProducerConfig.VALUE_SERIALIZER_CLASS_CONFIG, StringSerializer.class.getName(
27
28          //The batch.size in bytes of record size, 0 disables batching
29          props.put(ProducerConfig.BATCH_SIZE_CONFIG, 32768);
30
31          //Linger how much to wait for other records before sending the batch over the network.
32          props.put(ProducerConfig.LINGER_MS_CONFIG, 20);
33
34          // The total bytes of memory the producer can use to buffer records waiting to be sent
35          // to the Kafka broker. If records are sent faster than broker can handle than
36          // the producer blocks. Used for compression and in-flight records.
37          props.put(ProducerConfig.BUFFER_MEMORY_CONFIG, 67_108_864);
38
39          //Control how much time Producer blocks before throwing BufferExhaustedException.
40          props.put(ProducerConfig.MAX_BLOCK_MS_CONFIG, 1000);
```

For higher throughput, Kafka Producer allows buffering based on time and size.
Multiple records can be sent as a batches with fewer network requests.
Speeds up throughput drastically.