Kafka Topics, Partitions, Consumers

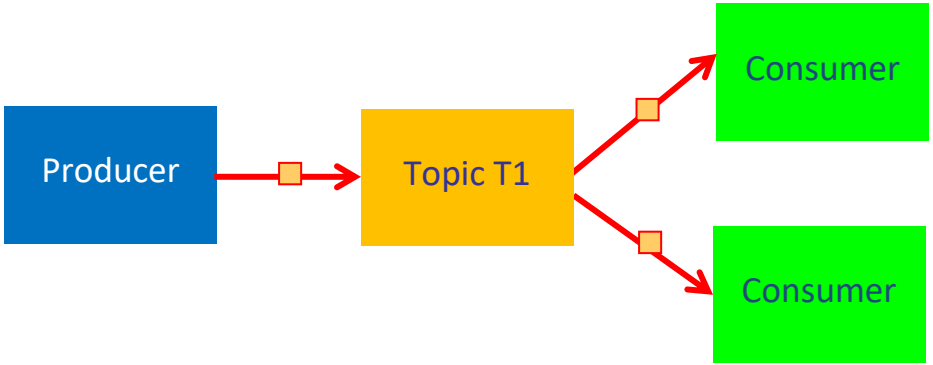
1. Topics and partitions
2. Partitions and replication
3. Consumers
4. Kafka commands

1. Topics and Partitions

- Recap of topics
- Topics are partitioned
- How partitioning works
- Defining a custom partitioner
- Partitioning strategies

Recap of Topics

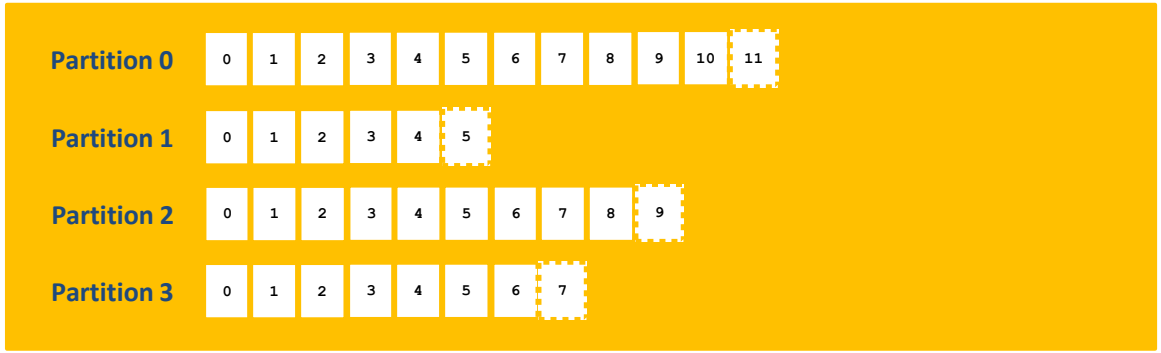
- A topic is a logical sequential collection of messages
  - A producer process publishes messages to a topic
  - Consumer processes pull messages from a topic



- Note:
  - The docs refers to messages as *records*, so we will too ☺

Topics are Partitioned

- In Kafka, each topic is partitioned
  - You specify the number of partitions when you create the topic



- Records are ordered within each partition
  - Writes to each partition are sequential
- Each record in a partition is assigned a sequential id
  - This is called the *offset*, identifies each record in a partition

How Partitioning Works

- When a producer sends a record, the record is a key/value pair
  - The key (optional) is a partition specifier
  - The value is the actual record data

- If Kafka receives a record that doesn't have a key:
  - Kafka use a round-robin partition strategy

- If Kafka receives a record that does have a key:
  - Kafka uses a default partitioner to choose the partition…
  - The default partitioner hashes the key…
  - Kafka uses the hash to determine the partition

Defining a Custom Partitioner

- You can also define a custom partitioner
  - A custom partitioner performs semantic processing on a key
  - E.g. if a key is a country, we can map it to a partition per continent
- You can implement a custom partitioner as a Java class
  - Kafka will pass records to the custom partitioner
  - The custom partitioner has access to a record's key/value
  - The custom partitioner decides the partition for the record
- We'll show how to do all this later

Partitioning Strategies

- Each partition is consumed by a designated consumer
  - We'll describe how this works shortly

- Random partitioning is recommended
  - When the producer sends a record, specify a random key
  - So records will be evenly distributed across partitions
  - So consumers will have an even distribution of work to do

- Aggregated partitioning is another possibility
  - Scenario: In an online retailer app, each customer has an ID
  - The producer can use the customer ID as a record key
  - All records for the same customer will go in the same partition, and will therefore be processed by the same consumer
  - This enables the consumer to aggregate data per customer

2. Partitions and Replication

- Overview
- Leader vs. follower brokers
- Additional technical info

Overview

- Replication is a critical ingredient in production systems
  - Data must be replicated, to avoid a single point of failure

- In Kafka, replication works at the partition level
  - The default replication factor is 3
  - i.e. each partition is stored on 3 separate brokers

Leader vs. Follower Brokers

- For each partition:
  - 1 broker is designated as the *leader* broker
  - The other brokers (e.g. 2 others) are designated as *followers*

- All reads/writes go to the leader broker
  - The follower brokers just fulfil a backup role

- E.g. when a producer publishes a record, it goes to the leader
  - The leader appends the record to its log and increments the offset
  - The leader propagates the record to the follower brokers
  - Acknowledgments are issued, to indicate successful delivery

Additional Technical Info

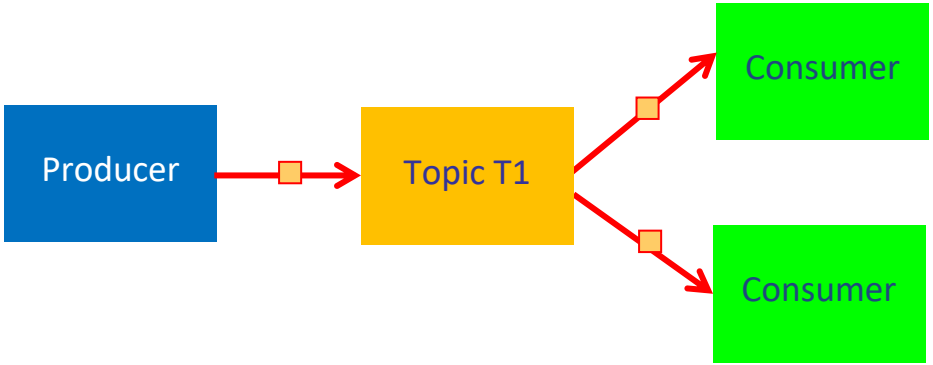
- How does a producer know which broker is the leader for a particular partition?
  - The producer contacts the cluster to determine partition leaders
- How does Kafka distribute leadership?
  - Fairly, i.e. each broker is a leader for a fair share of partitions
- What happens when a leader broker goes down?
  - Kafka promotes one of the followers to become the leader
- Where is data actually stored?
  - Each partition is stored as a separate directory on the file system
  - There are 2 files - the data (*.log file) and an index (*.index file)

3. Consumers

- Recap of consumers
- Consumer groups
- Consumers and partitions
- Best practices

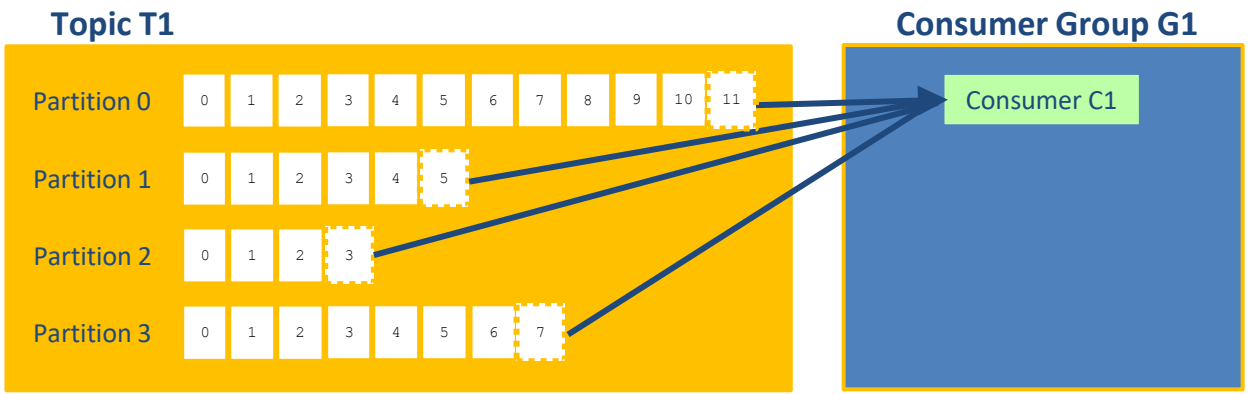
Recap of Consumers

- A consumer is a process that subscribes to a topic and reads records from that topic



Consumer Groups

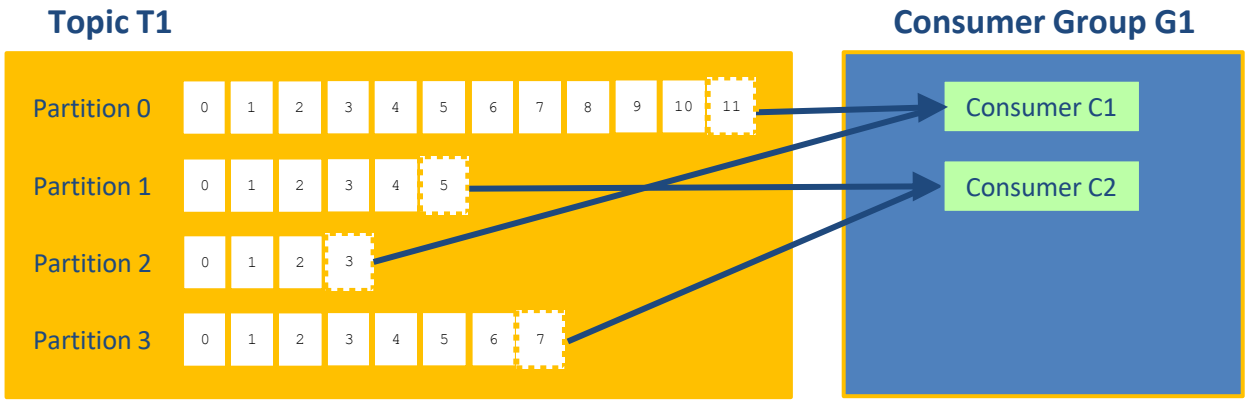
- Kafka consumers are all part of a <u>consumer group</u>
  - A consumer group can have multiple consumers



- Consider the scenario above:
  - Topic T1 has 4 partitions
  - Consumer group G1 has one consumer C1
  - If C1 subscribes to T1, it gets all records from all 4 partitions in T1

Consumers and Partitions (1 of 3)

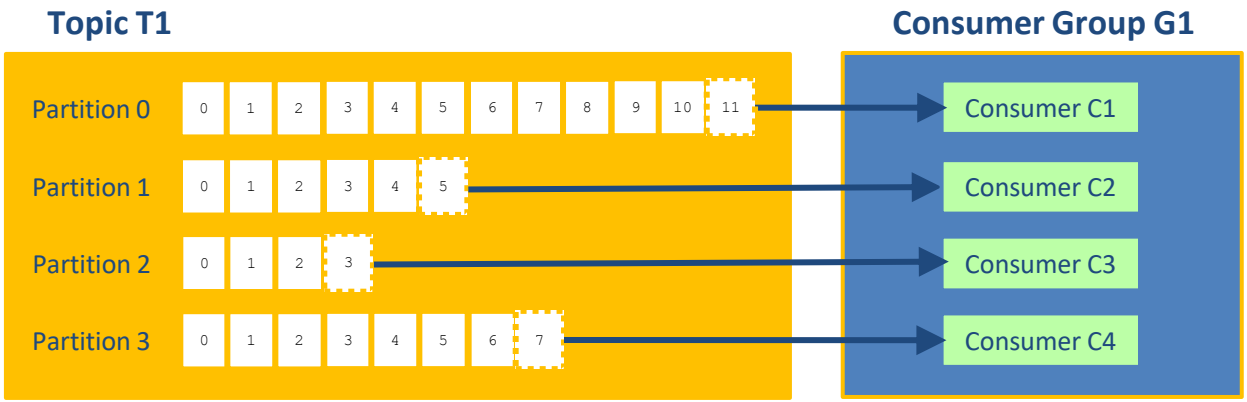
- If there are multiple consumers in a group…
  - Each consumer in the group will handle specific partition(s)
  - All records in a particular partition go to the same consumer



- Consider the scenario above:
  - Consumer group G1 has fewer consumers than there are partitions
  - Kafka will share the partitions evenly amongst the consumers

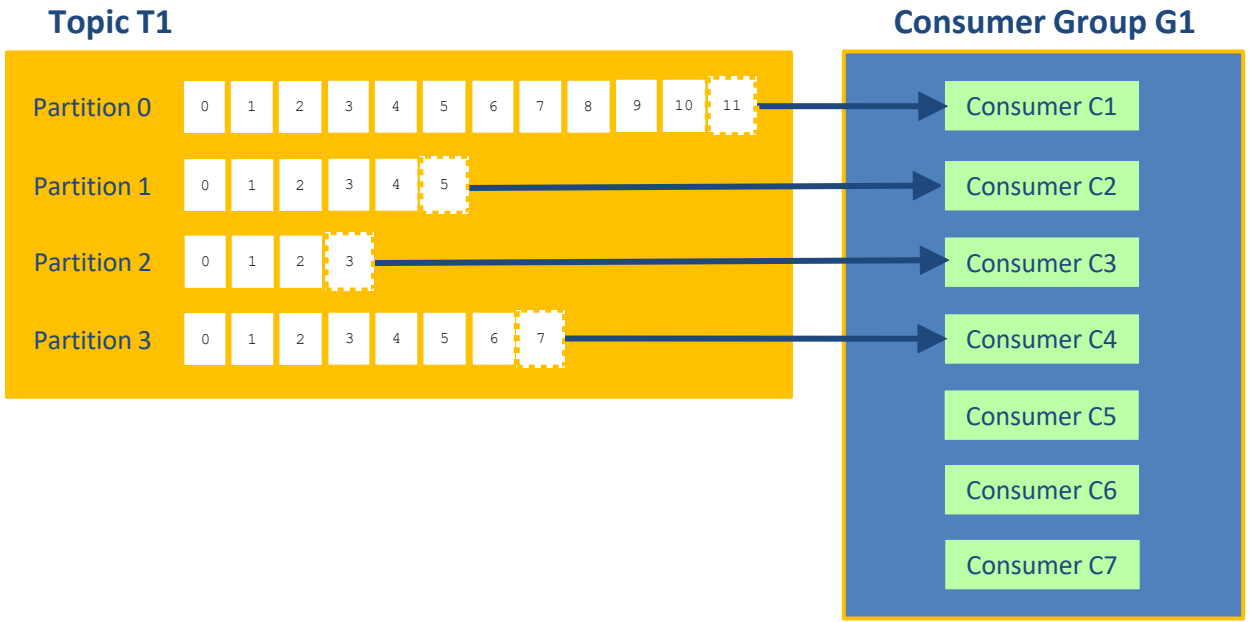
Consumers and Partitions (2 of 3)

- If there are the same number of consumers in a group as there are partitions in the topic…
  - Each consumer in the group will handle a specific partition



Consumers and Partitions (3 of 3)

- If there are more consumers in a group than there are partitions in the topic…
  - Surplus consumers are idle - they never receive any records



Best Practices

- The primary way to improve data consumption is to add more consumers to a consumer group
  - Consumers might be doing time-intensive work
  - A single consumer can’t keep up with the rate of data as it arrives
  - Having multiple consumers helps achieve parallelization

- This is a good reason to create topics with lot of partitions
  - The more partitions, the more dedicated consumers you can have
  - You can scale up the number of consumers, based on the load

- Note:
  - Kafka rebalances partitions when a new consumer joins a group
  - Consumers are reassigned a new bunch of partitions to handle

4. Kafka Commands

- Overview
- Creating a topic
- Describing topics
- Deleting a topic
- Publishing records to a topic
- Consuming records from a topic

Overview

- Kafka provides various utilities you can run from a shell or Windows command prompt
  - Create / delete topics
  - Describe topics
  - Publish records to a topic
  - Consume records from a topic
  - Etc.

- To run these commands, open a shell / command window and go to the following directory
  - In Linux/OSX: Kafka `bin` directory
  - In Windows: Kafka `bin/windows` directory

Creating a Topic (1 of 2)

- To create a topic (e.g. in a Windows command prompt):

```
kafka-topics --create ^
             --bootstrap-server localhost:9092 ^
             --replication-factor 1 ^
             --partitions 1 ^
             --topic my-topic-a
```

- Note about `kafka-topics` options:
  - `bootstrap-server` can be any node in the cluster
  - `replication-factor` default is 1 (in production, 3 is good)
  - `partitions` default is 1 (in production, specify a suitable value)

- Aside: Line continuations characters for different shells:
  - ^ Windows command prompt
  - \ Linux or macOS shell window
  - ` Windows PowerShell window

Creating a Topic (2 of 2)

- To change the number of partitions in a topic:

```
kafka-topics --alter ^
             --bootstrap-server localhost:9092 ^
             --partitions 3 ^
             --topic my-topic-a
```

- To create a topic with multiple partitions in the first place:

```
kafka-topics --create ^
             --bootstrap-server localhost:9092 ^
             --replication-factor 1 ^
             --partitions 5 ^
             --topic my-topic-b
```

Describing Topics

- To describe topics:

```
kafka-topics --bootstrap-server localhost:9092 --describe
```

C:\Windows\System32\cmd.exe

```
C:\Apps\kafka_2.12-2.4.1\bin\windows>kafka-topics --bootstrap-server localhost:9092 --describe
Topic: my-topic-a       PartitionCount: 3       ReplicationFactor: 1    Configs: segment.bytes=1073741824
        Topic: my-topic-a       Partition: 0    Leader: 0       Replicas: 0     Isr: 0
        Topic: my-topic-a       Partition: 1    Leader: 0       Replicas: 0     Isr: 0
        Topic: my-topic-a       Partition: 2    Leader: 0       Replicas: 0     Isr: 0
Topic: my-topic-b       PartitionCount: 5       ReplicationFactor: 1    Configs: segment.bytes=1073741824
        Topic: my-topic-b       Partition: 0    Leader: 0       Replicas: 0     Isr: 0
        Topic: my-topic-b       Partition: 1    Leader: 0       Replicas: 0     Isr: 0
        Topic: my-topic-b       Partition: 2    Leader: 0       Replicas: 0     Isr: 0
        Topic: my-topic-b       Partition: 3    Leader: 0       Replicas: 0     Isr: 0
        Topic: my-topic-b       Partition: 4    Leader: 0       Replicas: 0     Isr: 0

C:\Apps\kafka_2.12-2.4.1\bin\windows>
```

Isr means
"in-sync replicas"

Deleting a Topic

- To delete a topic (and all its partitions):

```
kafka-topics --delete ^
             --bootstrap-server localhost:9092 ^
             --topic my-topic-b
```

- NOTE: This might cause an exception, based on file system permissions!

Publishing Records to a Topic (1 of 2)

- To publish records from the console to a topic:

```
kafka-console-producer --broker-list localhost:9092 ^
                       --topic my-topic-a
```

C:\Windows\System32\cmd.exe

```
C:\Apps\kafka_2.12-2.4.1\bin\windows>kafka-console-producer --broker-list localhost:9092 ^
More?                       --topic my-topic-a
>this is a record
>this is another record
>Terminate batch job (Y/N)? y

C:\Apps\kafka_2.12-2.4.1\bin\windows>
```

- In this example, we've just specified record <u>values</u>
  - We haven't specified record <u>keys</u>
  - So Kafka will round-robin the records to partitions

Publishing Records to a Topic (2 of 2)

- To publish a record (key + value) to a topic:

```
kafka-console-producer --broker-list localhost:9092 ^
                       --topic my-topic-a ^
                       --property "parse.key=true" ^
                       --property "key.separator=:"
```

C:\Windows\System32\cmd.exe

```
C:\Apps\kafka_2.12-2.4.1\bin\windows>kafka-console-producer --broker-list localhost:9092 ^
More?                        --topic my-topic-a ^
More?                        --property "parse.key=true" ^
More?                        --property "key.separator=:"
>key1:This is a value with key1
>key2:This is a different value with key2
>Terminate batch job (Y/N)? y

C:\Apps\kafka_2.12-2.4.1\bin\windows>
```

Consuming Records from a Topic (1 of 2)

- To consume records from a topic to the console:

```
kafka-console-consumer ^
   --bootstrap-server localhost:9092 ^
   --topic my-topic-a ^
   --from-beginning ^
   --property print.key=true ^
   --property print.value=true ^
   --key-deserializer "org.apache.kafka.common.serialization.StringDeserializer" ^
   --value-deserializer "org.apache.kafka.common.serialization.StringDeserializer"
```

C:\Windows\system32\cmd.exe

```
C:\Apps\kafka_2.12-2.4.1\bin\windows>kafka-console-consumer ^
More?    --bootstrap-server localhost:9092 ^
More?    --topic my-topic-a ^
More?    --from-beginning ^
More?    --property print.key=true ^
More?    --property print.value=true ^
More?    --key-deserializer "org.apache.kafka.common.serialization.StringDeserializer" ^
More?    --value-deserializer "org.apache.kafka.common.serialization.StringDeserializer"
null    this is a record
null    this is another record
key1    This is a value with key1
key2    This is a different value with key2
Processed a total of 4 messages
Terminate batch job (Y/N)? y

C:\Apps\kafka_2.12-2.4.1\bin\windows>
```

Consuming Records from a Topic (2 of 2)

- A consumer is in control over which records it consumes, e.g. `kafka-console-consumer` has these options:
  - `--from-beginning` – get all records from beginning
  - `--offset` – get records from offset for a partition
  - `--max-messages` – max number of records, then exit

- Example:

```
kafka-console-consumer ^
   --bootstrap-server localhost:9092 ^
   --topic my-topic-a ^
   --partition 2 ^
   --offset 1 ^
   --max-messages 2 ^
   --property print.key=true ^
   --property print.value=true ^
   --key-deserializer "org.apache.kafka.common.serialization.StringDeserializer" ^
   --value-deserializer "org.apache.kafka.common.serialization.StringDeserializer"
```

Summary

- Topics and partitions
- Partitions and replication
- Consumers
- Kafka commands