TEKCRUX

We ReDefine IT

kafka

Module 2: Kafka Producer

Objectives

After completing of this module, you should be able to:

- ✓ Configure Producers
- ✓ Construct Kafka Producer
- ✓ Send Messages to Kafka
- ✓ Synchronous and Asynchronous messages
- ✓ Serialize Messages using Avro
- ✓ Create and handle Partitions

Let’s see how to configure
Single-Node Multi-broker Kafka Cluster

Objectives

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Multi-Broker Cluster Setup

For *setting up multiple brokers* on a *single node*, separate *server property files* are required for *each broker*. Each property file will *define different values* for the following properties: *broker.id, listeners, log.dir*

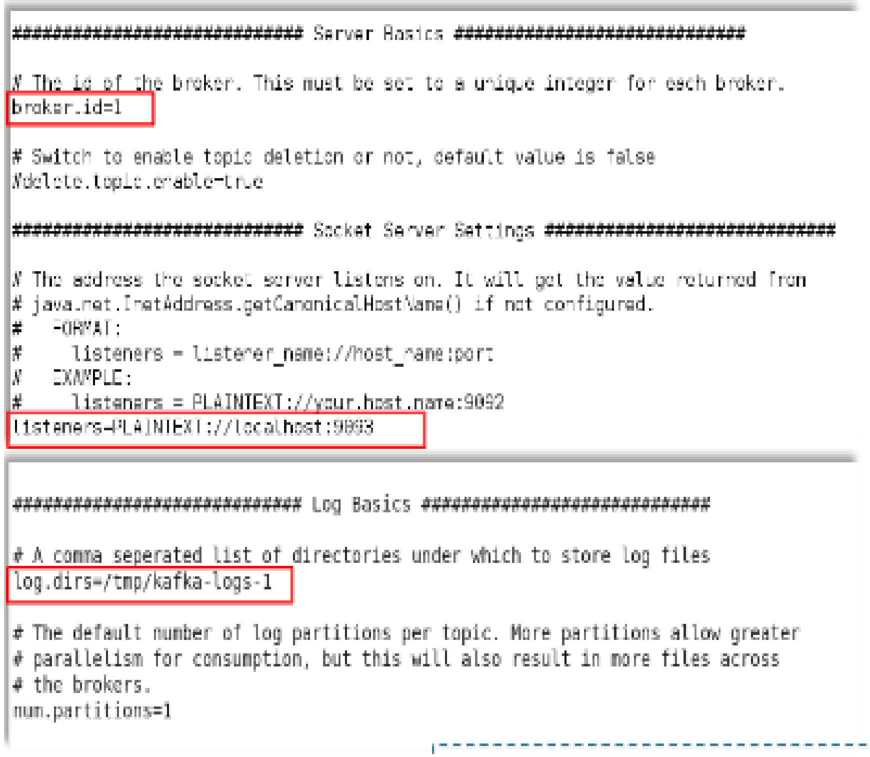
Steps:

- Go to Kafka directory
- Open ***config*** folder
- Make two separate server property files in config folder
- Make changes in the files created as shown on next slide

Change in Server Property Files

server-1.properties

server-2.properties



```
############################# Server Basics #############################

# The id of the broker. This must be set to a unique integer for each broker.
broker.id=1

# Switch to enable topic deletion or not, default value is false
#delete.topic.enable=true

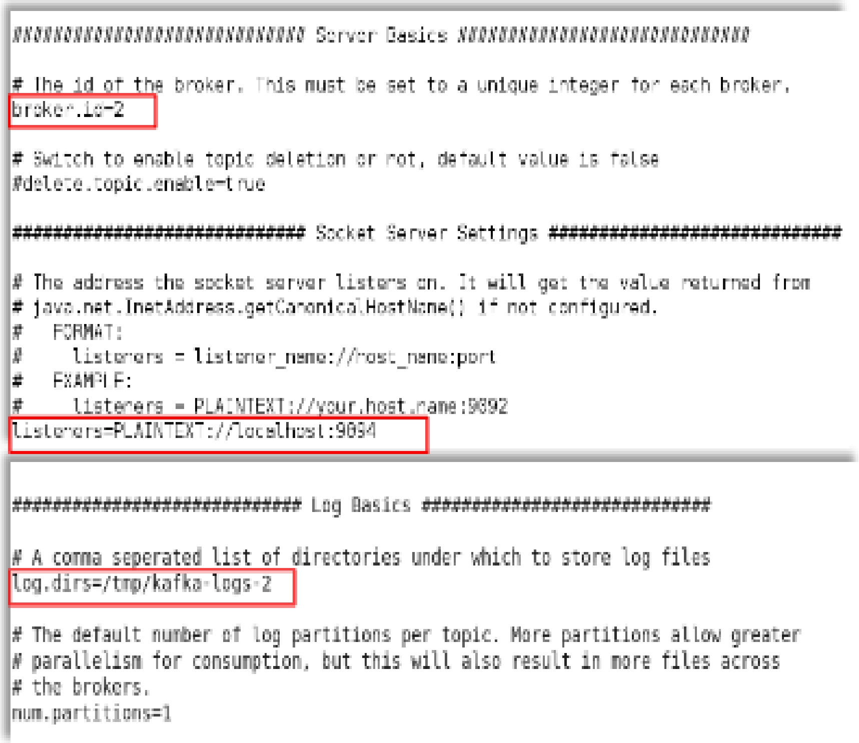
############################# Socket Server Settings #############################

# The address the socket server listens on. It will get the value returned from
# java.net.InetAddress.getCanonicalHostName() if not configured.
#   FORMAT:
#     listeners = listener_name://host_name:port
#   EXAMPLE:
#     listeners = PLAINTEXT://your.host.name:9092
listeners=PLAINTEXT://localhost:9093
```

```
############################# Log Basics #############################

# A comma seperated list of directories under which to store log files
log.dirs=/tmp/kafka-logs-1

# The default number of log partitions per topic. More partitions allow greater
# parallelism for consumption, but this will also result in more files across
# the brokers.
num.partitions=1
```



```
############################# Server Basics #############################

# The id of the broker. This must be set to a unique integer for each broker.
broker.id=2

# Switch to enable topic deletion or not, default value is false
#delete.topic.enable=true

############################# Socket Server Settings #############################

# The address the socket server listens on. It will get the value returned from
# java.net.InetAddress.getCanonicalHostName() if not configured.
#   FORMAT:
#     listeners = listener_name://host_name:port
#   EXAMPLE:
#     listeners = PLAINTEXT://your.host.name:9092
listeners=PLAINTEXT://localhost:9094
```

```
############################# Log Basics #############################

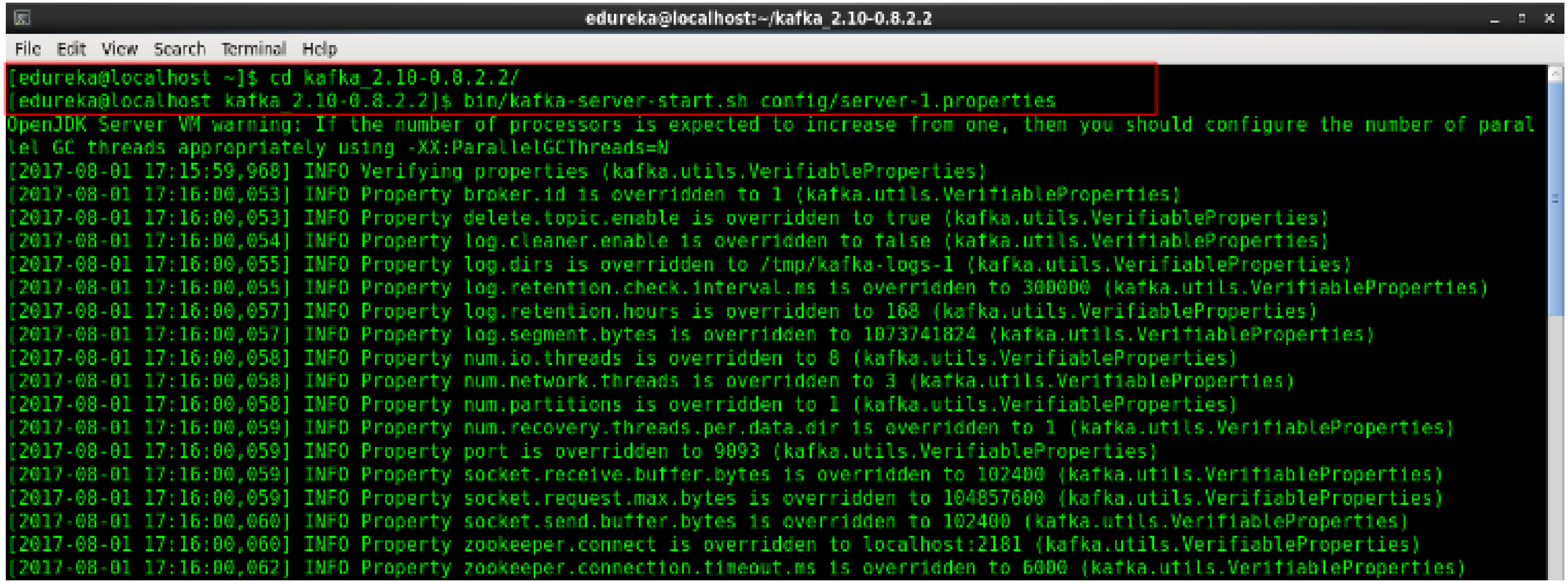
# A comma seperated list of directories under which to store log files
log.dirs=/tmp/kafka-logs-2

# The default number of log partitions per topic. More partitions allow greater
# parallelism for consumption, but this will also result in more files across
# the brokers.
num.partitions=1
```

Now we start each new broker in a separate console window

Running Broker 1

Command: `bin/kafka-server-start.sh config/server-1.properties`

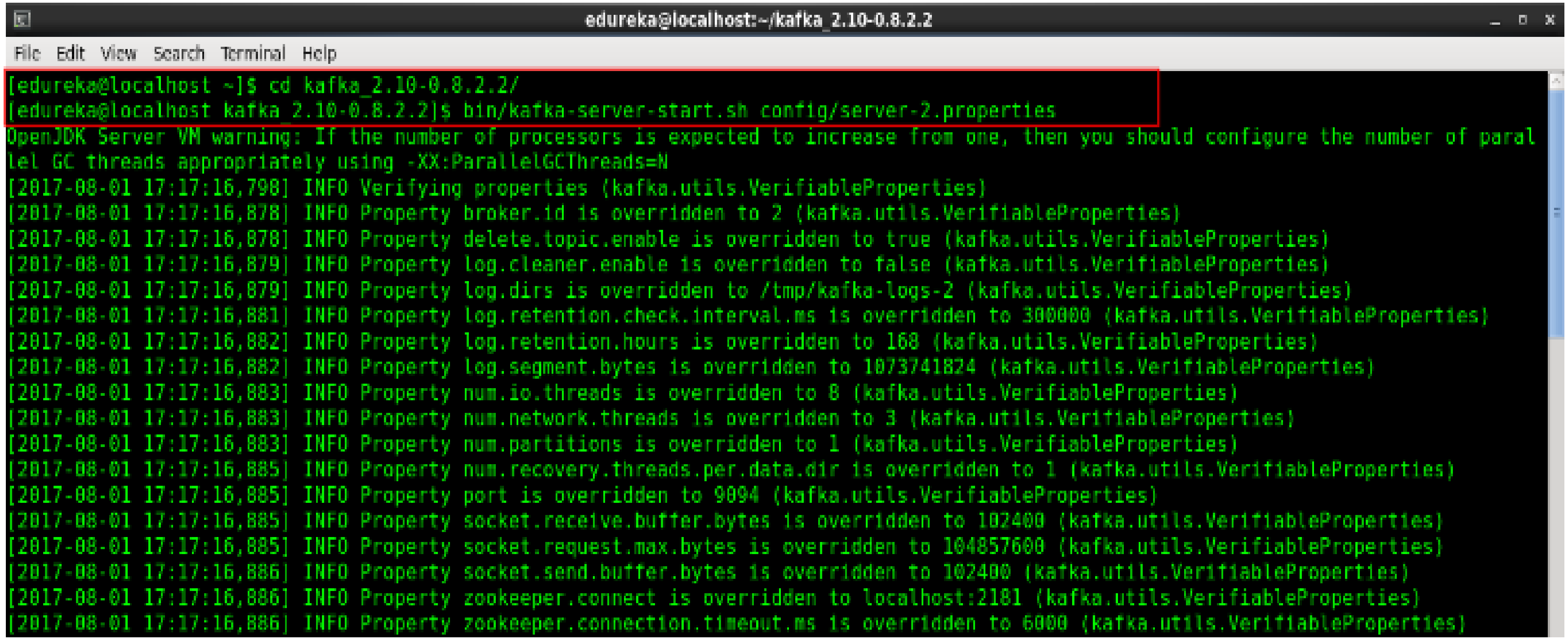


edureka@localhost:~/kafka_2.10-0.8.2.2
File Edit View Search Terminal Help

```
[edureka@localhost ~]$ cd kafka_2.10-0.8.2.2/
[edureka@localhost kafka_2.10-0.8.2.2]$ bin/kafka-server-start.sh config/server-1.properties
OpenJDK Server VM warning: If the number of processors is expected to increase from one, then you should configure the number of paral
lel GC threads appropriately using -XX:ParallelGCThreads=N
[2017-08-01 17:15:59,968] INFO Verifying properties (kafka.utils.VerifiableProperties)
[2017-08-01 17:16:00,053] INFO Property broker.id is overridden to 1 (kafka.utils.VerifiableProperties)
[2017-08-01 17:16:00,053] INFO Property delete.topic.enable is overridden to true (kafka.utils.VerifiableProperties)
[2017-08-01 17:16:00,054] INFO Property log.cleaner.enable is overridden to false (kafka.utils.VerifiableProperties)
[2017-08-01 17:16:00,055] INFO Property log.dirs is overridden to /tmp/kafka-logs-1 (kafka.utils.VerifiableProperties)
[2017-08-01 17:16:00,055] INFO Property log.retention.check.interval.ms is overridden to 300000 (kafka.utils.VerifiableProperties)
[2017-08-01 17:16:00,057] INFO Property log.retention.hours is overridden to 168 (kafka.utils.VerifiableProperties)
[2017-08-01 17:16:00,057] INFO Property log.segment.bytes is overridden to 1073741824 (kafka.utils.VerifiableProperties)
[2017-08-01 17:16:00,058] INFO Property num.io.threads is overridden to 8 (kafka.utils.VerifiableProperties)
[2017-08-01 17:16:00,058] INFO Property num.network.threads is overridden to 3 (kafka.utils.VerifiableProperties)
[2017-08-01 17:16:00,058] INFO Property num.partitions is overridden to 1 (kafka.utils.VerifiableProperties)
[2017-08-01 17:16:00,059] INFO Property num.recovery.threads.per.data.dir is overridden to 1 (kafka.utils.VerifiableProperties)
[2017-08-01 17:16:00,059] INFO Property port is overridden to 9093 (kafka.utils.VerifiableProperties)
[2017-08-01 17:16:00,059] INFO Property socket.receive.buffer.bytes is overridden to 102400 (kafka.utils.VerifiableProperties)
[2017-08-01 17:16:00,059] INFO Property socket.request.max.bytes is overridden to 104857600 (kafka.utils.VerifiableProperties)
[2017-08-01 17:16:00,060] INFO Property socket.send.buffer.bytes is overridden to 102400 (kafka.utils.VerifiableProperties)
[2017-08-01 17:16:00,060] INFO Property zookeeper.connect is overridden to localhost:2181 (kafka.utils.VerifiableProperties)
[2017-08-01 17:16:00,062] INFO Property zookeeper.connection.timeout.ms is overridden to 6000 (kafka.utils.VerifiableProperties)
```

Running Broker 2

Command: `bin/kafka-server-start.sh config/server-2.properties`

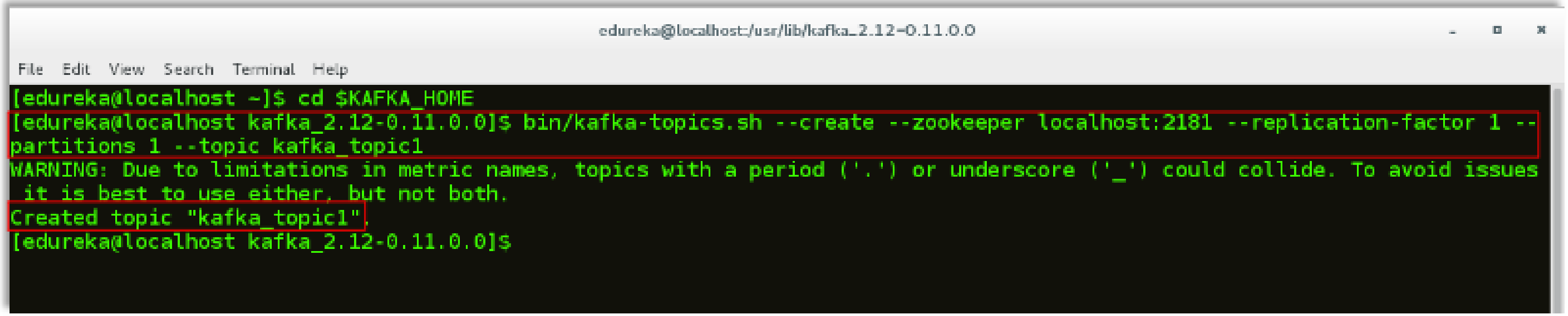


edureka@localhost:~/kafka_2.10-0.8.2.2
File Edit View Search Terminal Help

```
[edureka@localhost ~]$ cd kafka_2.10-0.8.2.2/
[edureka@localhost kafka_2.10-0.8.2.2]$ bin/kafka-server-start.sh config/server-2.properties
OpenJDK Server VM warning: If the number of processors is expected to increase from one, then you should configure the number of paral
lel GC threads appropriately using -XX:ParallelGCThreads=N
[2017-08-01 17:17:16,798] INFO Verifying properties (kafka.utils.VerifiableProperties)
[2017-08-01 17:17:16,878] INFO Property broker.id is overridden to 2 (kafka.utils.VerifiableProperties)
[2017-08-01 17:17:16,878] INFO Property delete.topic.enable is overridden to true (kafka.utils.VerifiableProperties)
[2017-08-01 17:17:16,879] INFO Property log.cleaner.enable is overridden to false (kafka.utils.VerifiableProperties)
[2017-08-01 17:17:16,879] INFO Property log.dirs is overridden to /tmp/kafka-logs-2 (kafka.utils.VerifiableProperties)
[2017-08-01 17:17:16,881] INFO Property log.retention.check.interval.ms is overridden to 300000 (kafka.utils.VerifiableProperties)
[2017-08-01 17:17:16,882] INFO Property log.retention.hours is overridden to 168 (kafka.utils.VerifiableProperties)
[2017-08-01 17:17:16,882] INFO Property log.segment.bytes is overridden to 1073741824 (kafka.utils.VerifiableProperties)
[2017-08-01 17:17:16,883] INFO Property num.io.threads is overridden to 8 (kafka.utils.VerifiableProperties)
[2017-08-01 17:17:16,883] INFO Property num.network.threads is overridden to 3 (kafka.utils.VerifiableProperties)
[2017-08-01 17:17:16,883] INFO Property num.partitions is overridden to 1 (kafka.utils.VerifiableProperties)
[2017-08-01 17:17:16,885] INFO Property num.recovery.threads.per.data.dir is overridden to 1 (kafka.utils.VerifiableProperties)
[2017-08-01 17:17:16,885] INFO Property port is overridden to 9094 (kafka.utils.VerifiableProperties)
[2017-08-01 17:17:16,885] INFO Property socket.receive.buffer.bytes is overridden to 102400 (kafka.utils.VerifiableProperties)
[2017-08-01 17:17:16,885] INFO Property socket.request.max.bytes is overridden to 104857600 (kafka.utils.VerifiableProperties)
[2017-08-01 17:17:16,886] INFO Property socket.send.buffer.bytes is overridden to 102400 (kafka.utils.VerifiableProperties)
[2017-08-01 17:17:16,886] INFO Property zookeeper.connect is overridden to localhost:2181 (kafka.utils.VerifiableProperties)
[2017-08-01 17:17:16,886] INFO Property zookeeper.connection.timeout.ms is overridden to 6000 (kafka.utils.VerifiableProperties)
```

Create a Kafka Topic

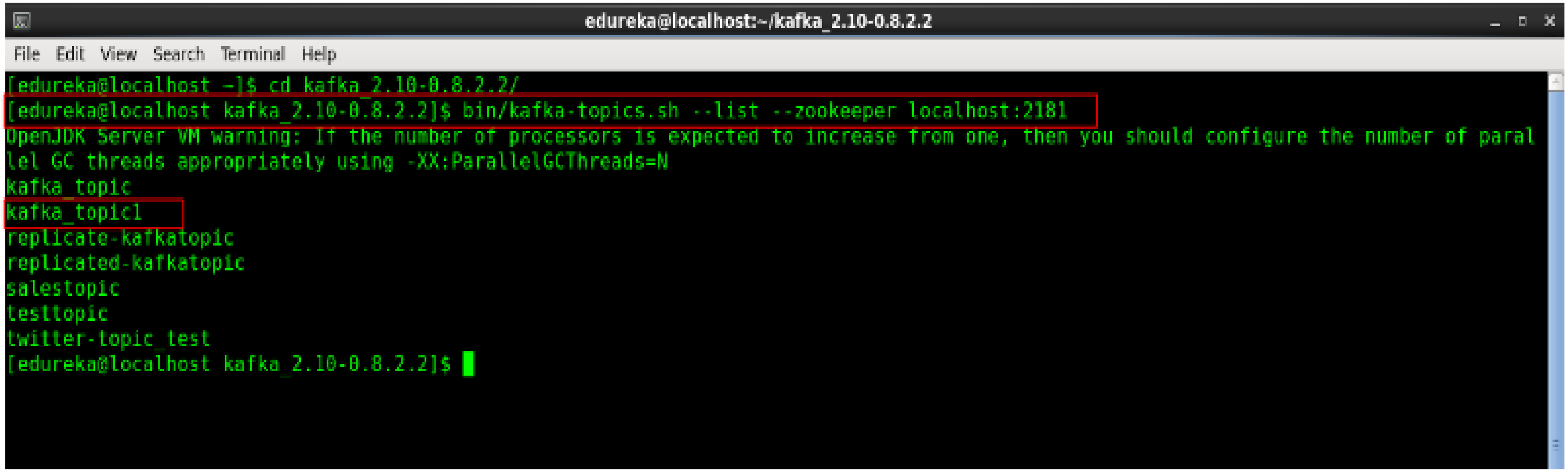
Command: `bin/kafka-topics.sh --create --zookeeper localhost:2181 --replication-factor 1 --partitions 1 --topic kafka_topic1`


edureka@localhost:/usr/lib/kafka_2.12-0.11.0.0
File Edit View Search Terminal Help

```
[edureka@localhost ~]$ cd $KAFKA_HOME
[edureka@localhost kafka_2.12-0.11.0.0]$ bin/kafka-topics.sh --create --zookeeper localhost:2181 --replication-factor 1 --
partitions 1 --topic kafka_topic1
WARNING: Due to limitations in metric names, topics with a period ('.') or underscore ('_') could collide. To avoid issues
 it is best to use either, but not both.
Created topic "kafka_topic1".
[edureka@localhost kafka_2.12-0.11.0.0]$
```

List Kafka Topics

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

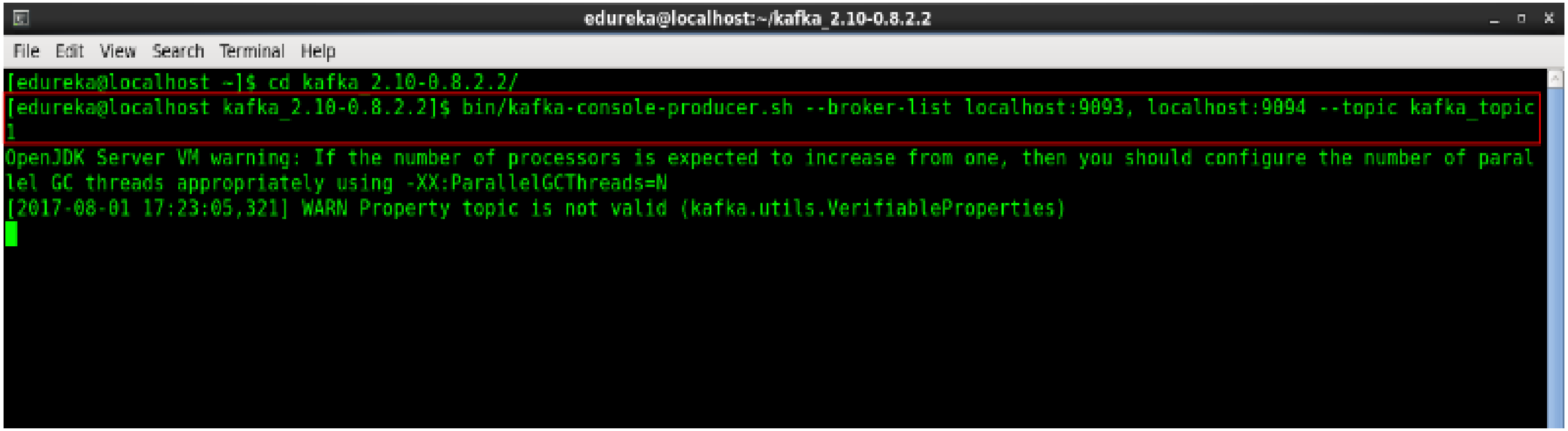


edureka@localhost:~/kafka_2.10-0.8.2.2
File Edit View Search Terminal Help

```
[edureka@localhost ~]$ cd kafka_2.10-0.8.2.2/
[edureka@localhost kafka_2.10-0.8.2.2]$ bin/kafka-topics.sh --list --zookeeper localhost:2181
OpenJDK Server VM warning: If the number of processors is expected to increase from one, then you should configure the number of paral
lel GC threads appropriately using -XX:ParallelGCThreads=N
kafka_topic
kafka_topic1
replicate-kafkatopic
replicated-kafkatopic
salestopic
testtopic
twitter-topic_test
[edureka@localhost kafka_2.10-0.8.2.2]$ 
```

Run Kafka Producer

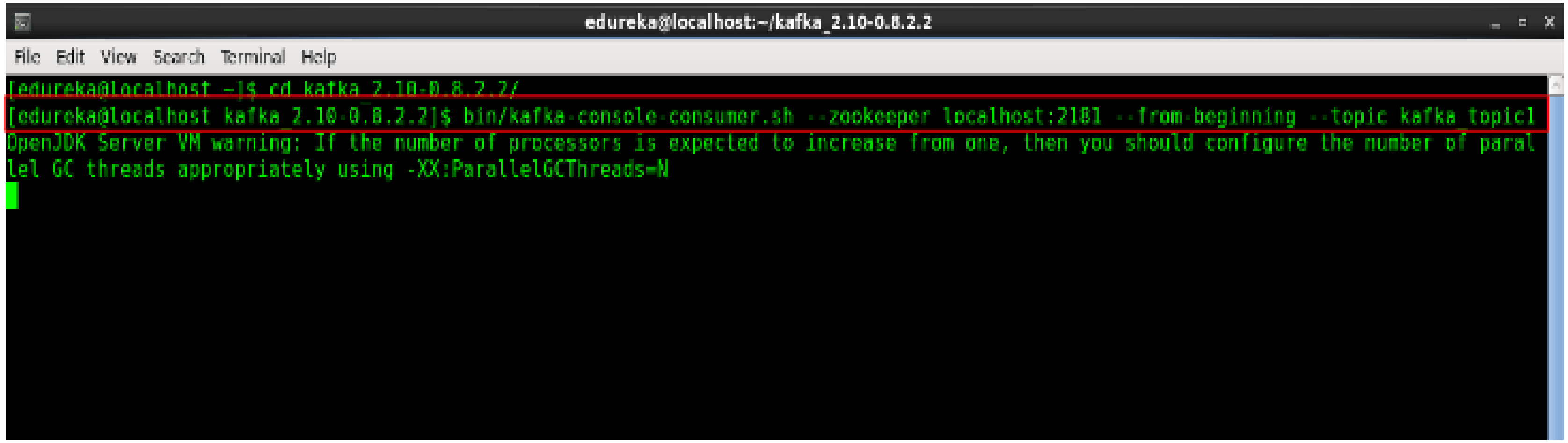
Command: `bin/kafka-console-producer.sh --broker-list localhost:9093, localhost:9094 --topic kafka_topic1`


edureka@localhost:~/kafka_2.10-0.8.2.2
File Edit View Search Terminal Help

```
[edureka@localhost ~]$ cd kafka_2.10-0.8.2.2/
[edureka@localhost kafka_2.10-0.8.2.2]$ bin/kafka-console-producer.sh --broker-list localhost:9093, localhost:9094 --topic kafka_topic
1
OpenJDK Server VM warning: If the number of processors is expected to increase from one, then you should configure the number of paral
lel GC threads appropriately using -XX:ParallelGCThreads=N
[2017-08-01 17:23:05,321] WARN Property topic is not valid (kafka.utils.VerifiableProperties)
```

Run Kafka Consumer

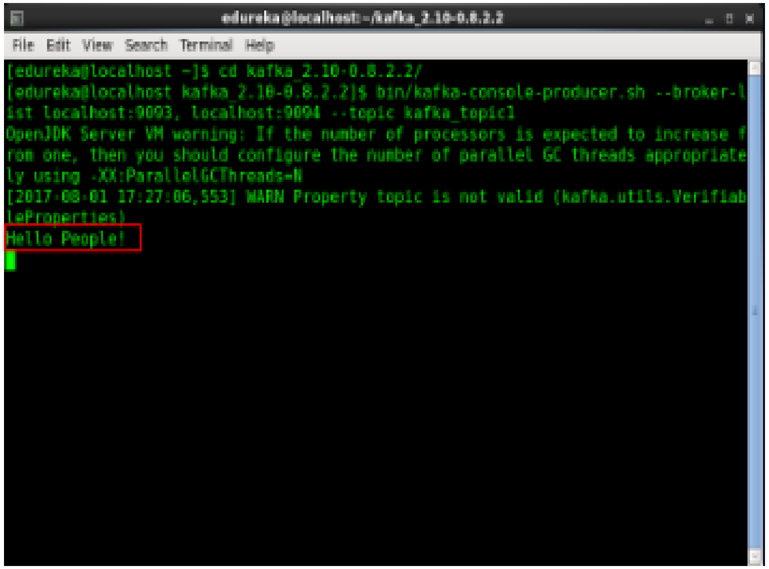
Command: `bin/kafka-console-consumer.sh --zookeeper localhost:2181 --from-beginning --topic kafka_topic1`


edureka@localhost:~/kafka_2.10-0.8.2.2
File Edit View Search Terminal Help

```
[edureka@localhost ~]$ cd kafka_2.10-0.8.2.2/
[edureka@localhost kafka_2.10-0.8.2.2]$ bin/kafka-console-consumer.sh --zookeeper localhost:2181 --from-beginning --topic kafka_topic1
OpenJDK Server VM warning: If the number of processors is expected to increase from one, then you should configure the number of paral
lel GC threads appropriately using -XX:ParallelGCThreads=N
```

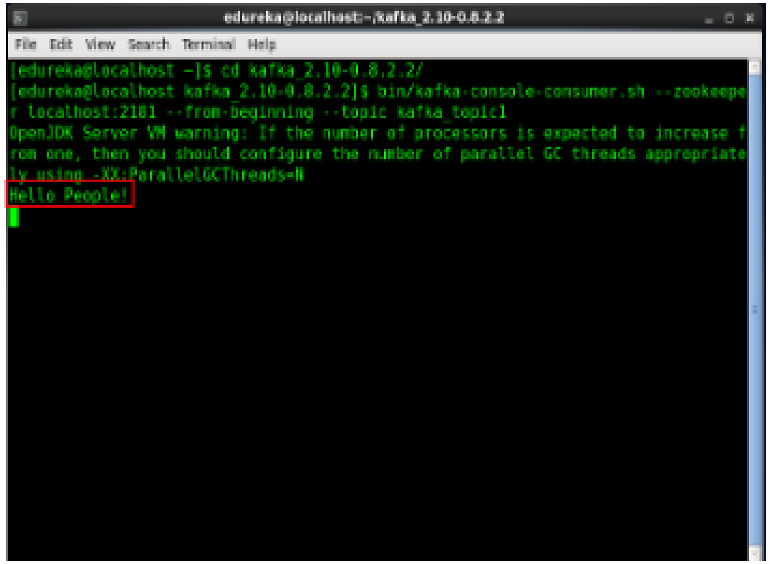
Sending Messages from Producer to Consumer

Producer


edureka@localhost:~/kafka_2.10-0.8.2.2
File Edit View Search Terminal Help

```
[edureka@localhost ~]$ cd kafka_2.10-0.8.2.2/
[edureka@localhost kafka_2.10-0.8.2.2]$ bin/kafka-console-producer.sh --broker-l
ist localhost:9093, localhost:9094 --topic kafka_topic1
OpenJDK Server VM warning: If the number of processors is expected to increase f
rom one, then you should configure the number of parallel GC threads appropriate
ly using -XX:ParallelGCThreads=N
[2017-08-01 17:27:06,553] WARN Property topic is not valid (kafka.utils.Verifiab
leProperties)
Hello People!
```

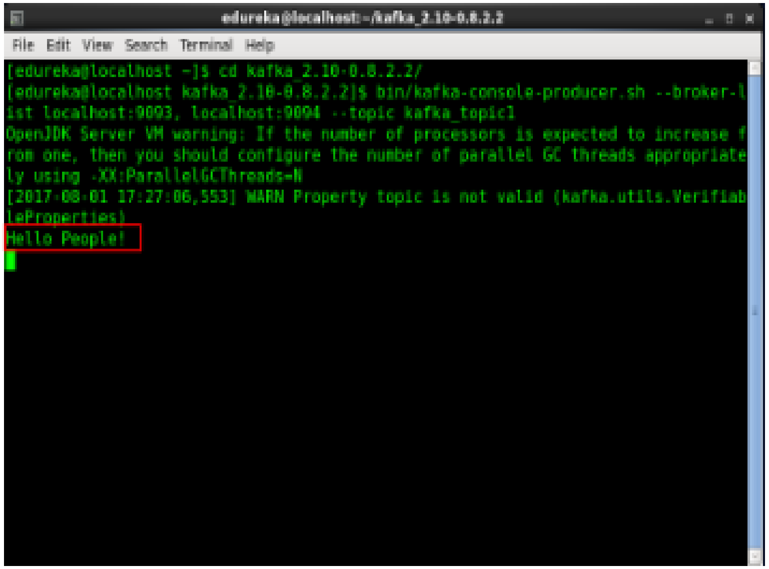
Consumer


edureka@localhost:~/kafka_2.10-0.8.2.2
File Edit View Search Terminal Help

```
[edureka@localhost ~]$ cd kafka_2.10-0.8.2.2/
[edureka@localhost kafka_2.10-0.8.2.2]$ bin/kafka-console-consumer.sh --zookeepe
r localhost:2181 --from-beginning --topic kafka_topic1
OpenJDK Server VM warning: If the number of processors is expected to increase f
rom one, then you should configure the number of parallel GC threads appropriate
ly using -XX:ParallelGCThreads=N
Hello People!
```

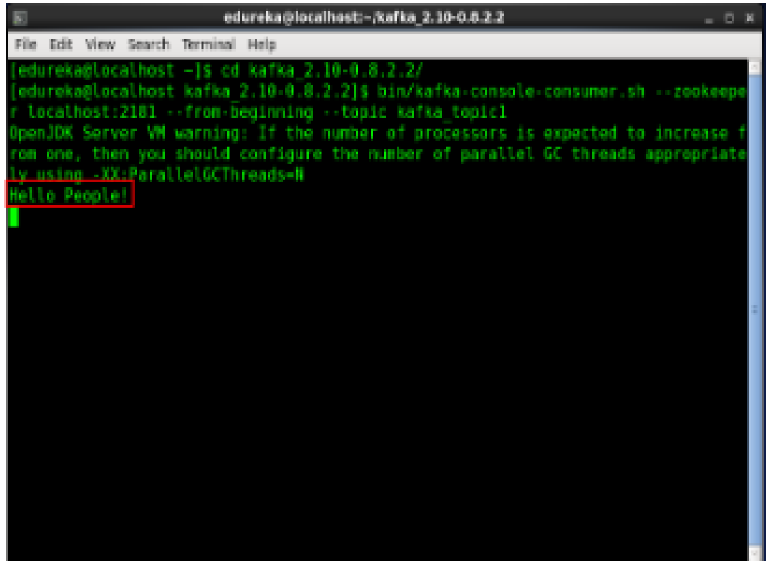
Sending Messages from Producer to Consumer

Producer


edureka@localhost:~/kafka_2.10-0.8.2.2
File Edit View Search Terminal Help

```
[edureka@localhost ~]$ cd kafka_2.10-0.8.2.2/
[edureka@localhost kafka_2.10-0.8.2.2]$ bin/kafka-console-producer.sh --broker-l
ist localhost:9093, localhost:9094 --topic kafka_topic1
OpenJDK Server VM warning: If the number of processors is expected to increase f
rom one, then you should configure the number of parallel GC threads appropriate
ly using -XX:ParallelGCThreads=N
[2017-08-01 17:27:06,553] WARN Property topic is not valid (kafka.utils.Verifiab
leProperties)
Hello People!
```

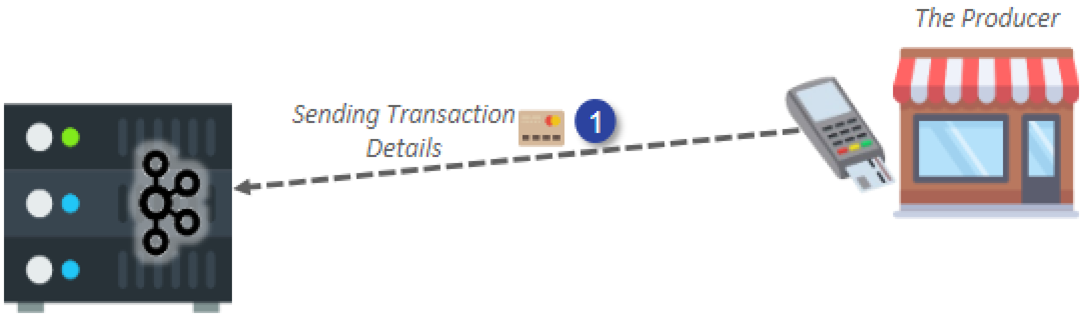
Consumer


edureka@localhost:~/kafka_2.10-0.8.2.2
File Edit View Search Terminal Help

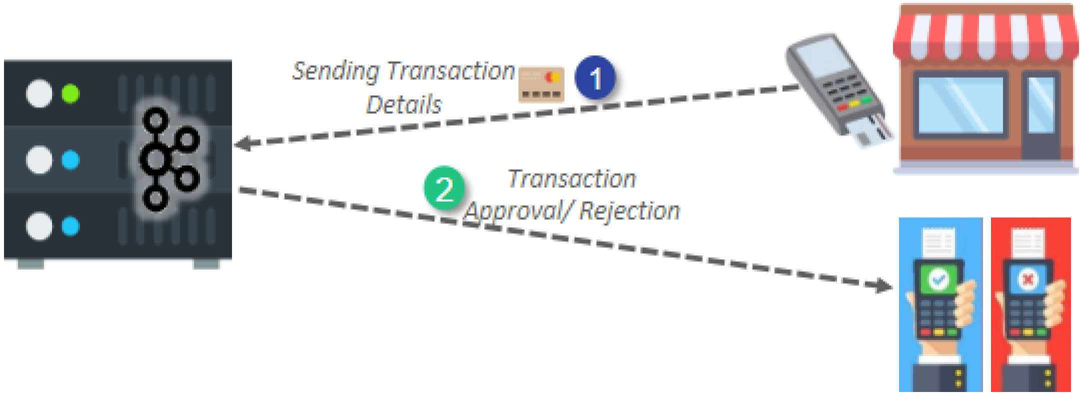
```
[edureka@localhost ~]$ cd kafka_2.10-0.8.2.2/
[edureka@localhost kafka_2.10-0.8.2.2]$ bin/kafka-console-consumer.sh --zookeepe
r localhost:2181 --from-beginning --topic kafka_topic1
OpenJDK Server VM warning: If the number of processors is expected to increase f
rom one, then you should configure the number of parallel GC threads appropriate
ly using -XX:ParallelGCThreads=N
Hello People!
```

Let’s examine Credit Card Processing System Use-case

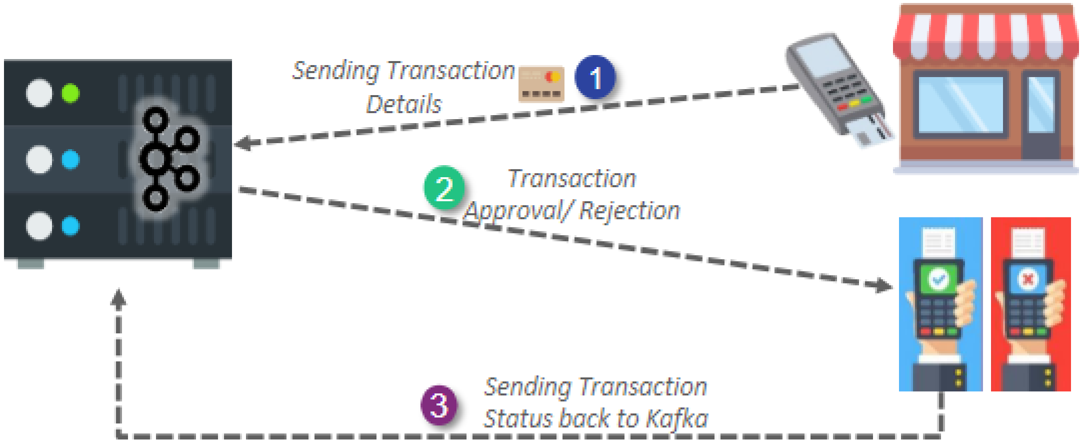
Credit Card Transaction Processing



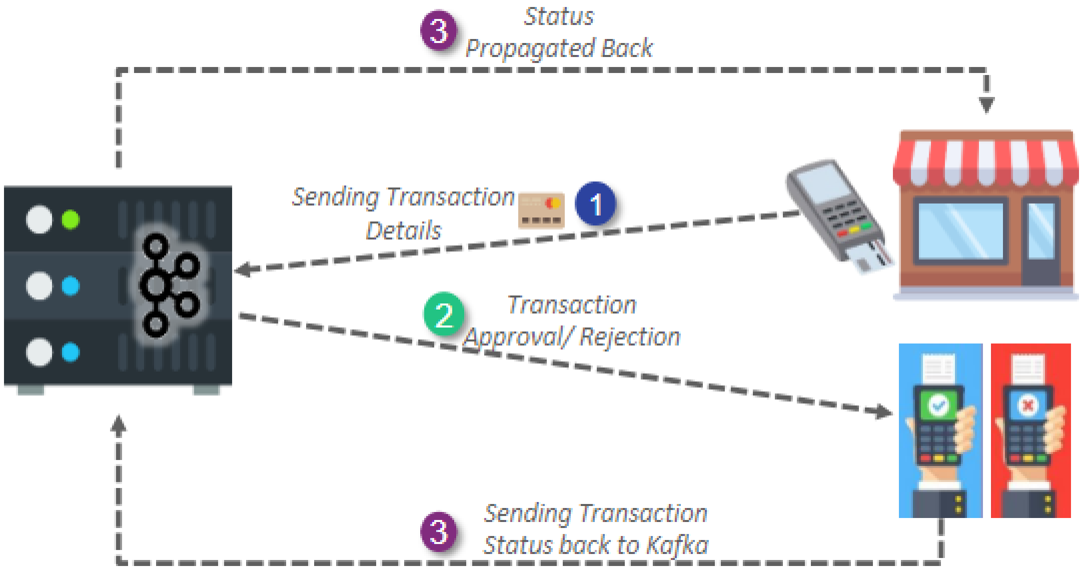
Credit Card Transaction Processing



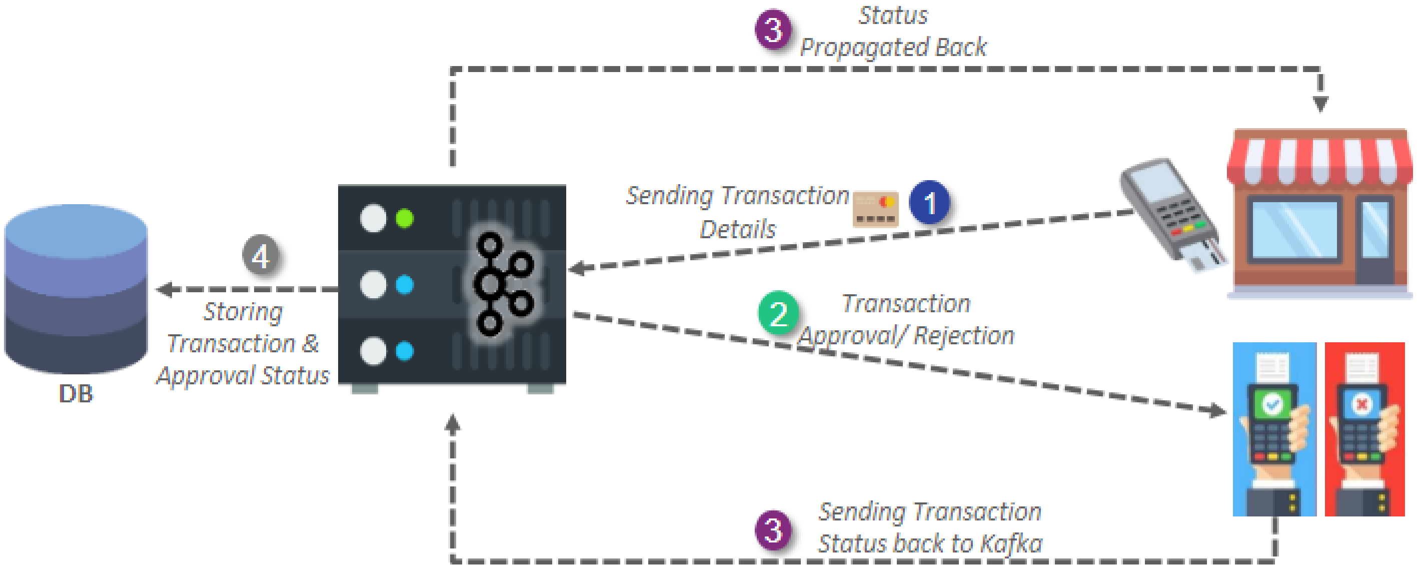
Credit Card Transaction Processing


Sending Transaction Details
1
Transaction Approval/ Rejection
2
Sending Transaction Status back to Kafka
3

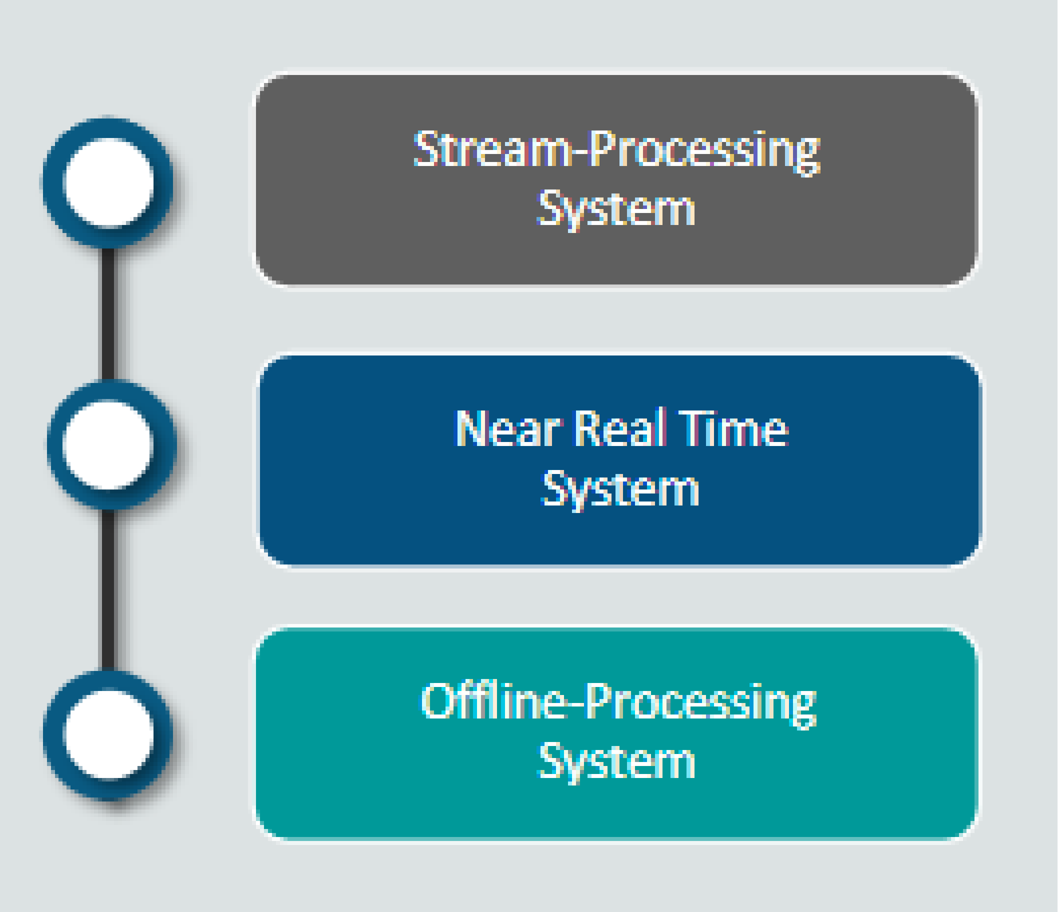
Credit Card Transaction Processing


3 Status Propagated Back
Sending Transaction Details
1
2 Transaction Approval/ Rejection
3 Sending Transaction Status back to Kafka

Credit Card Transaction Processing


3 Status Propagated Back
DB
4
Storing Transaction & Approval Status
Sending Transaction Details
1
2 Transaction Approval/ Rejection
3 Sending Transaction Status back to Kafka

Let’s break it down



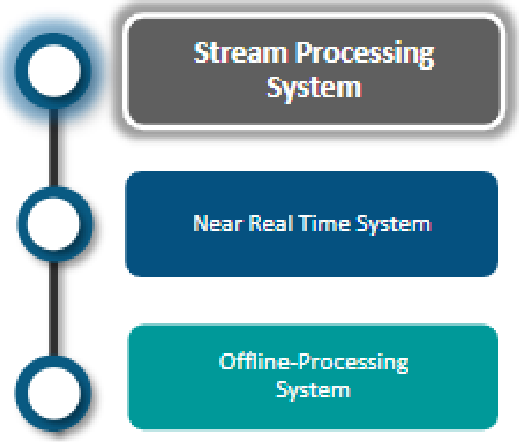
Stream-Processing System

Near Real Time System

Offline-Processing System

Stream-processing System

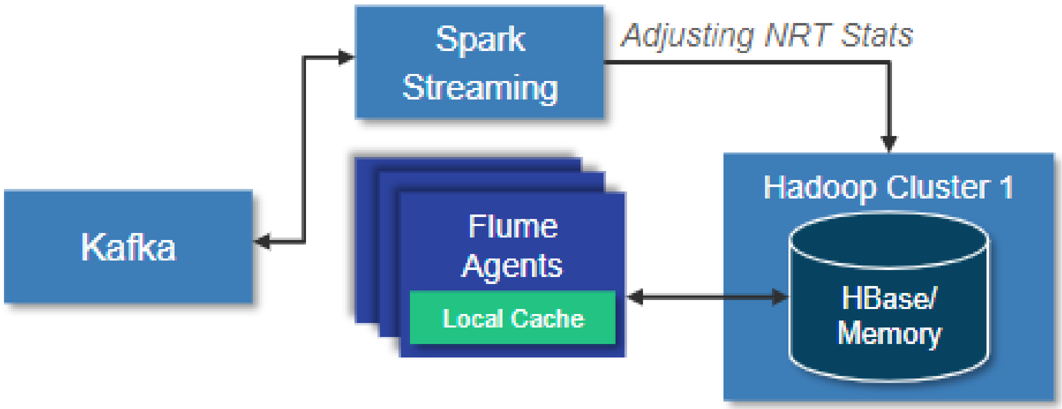
- System receives events and reply as fast as possible (< 100ms)
- Adjust parameters of the fraud-detection models



Stream Processing System

Near Real Time System

Offline-Processing System



Spark Streaming

Adjusting NRT Stats

Kafka

Flume Agents

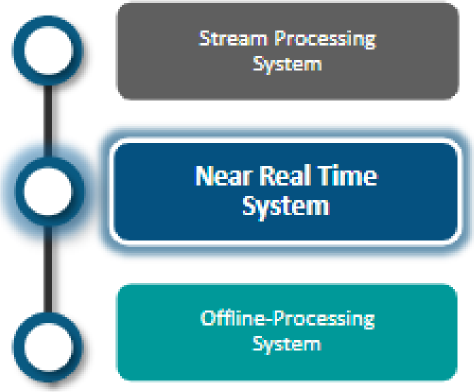
Local Cache

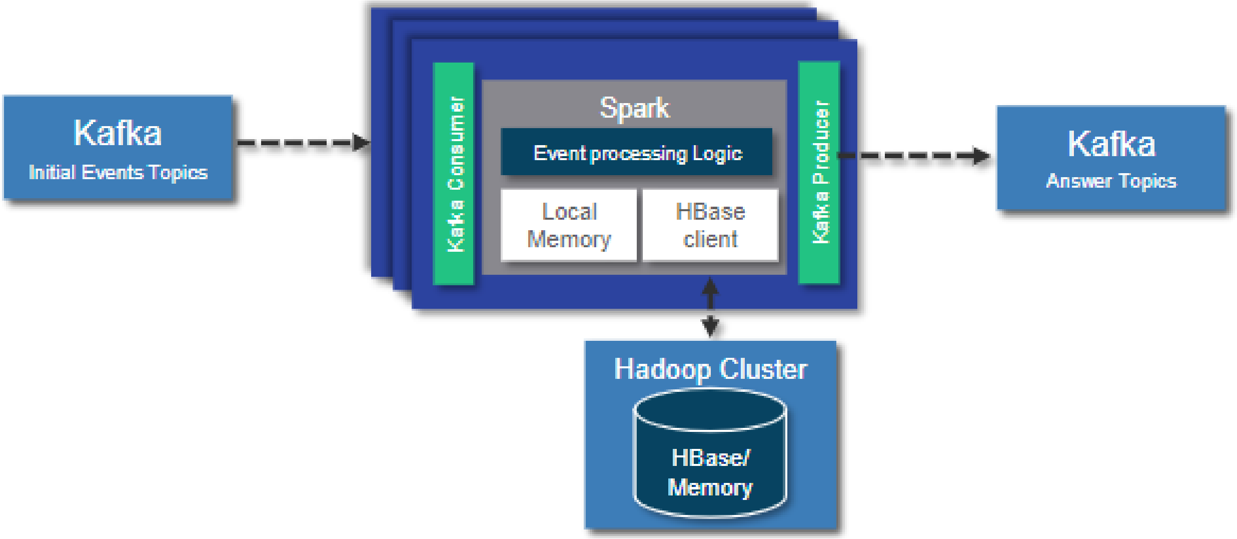
Hadoop Cluster 1

HBase/ Memory

Near Real-Time System

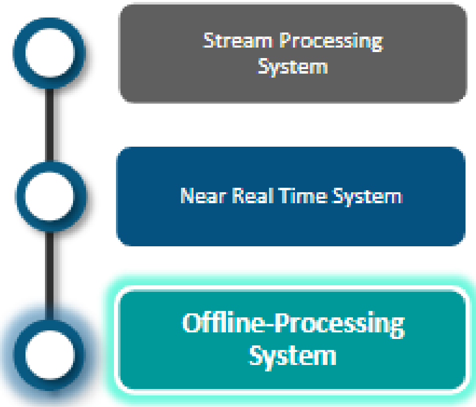
- Depends mostly on pattern matching and applying predefined rules
- Latency between few Seconds to few Minutes

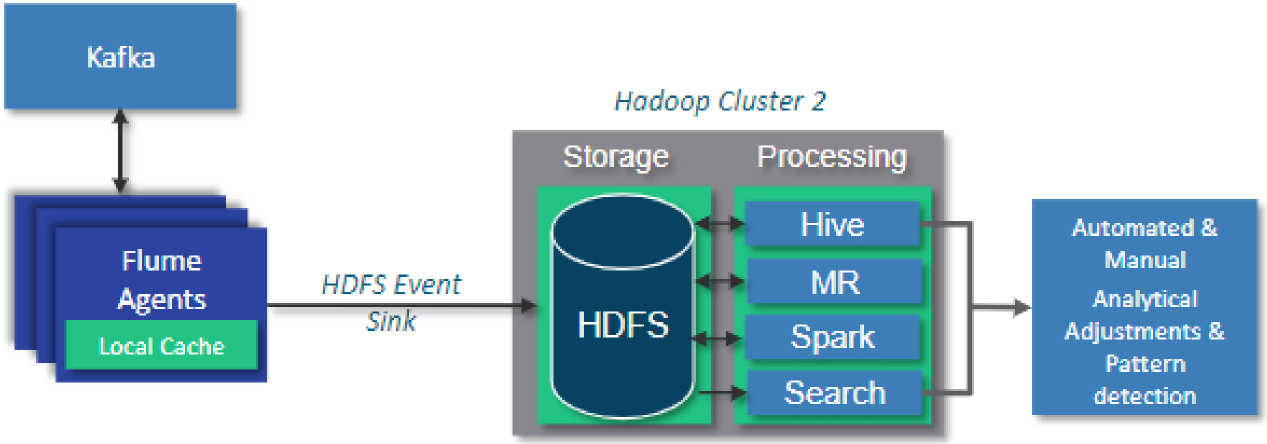




Offline Processing System

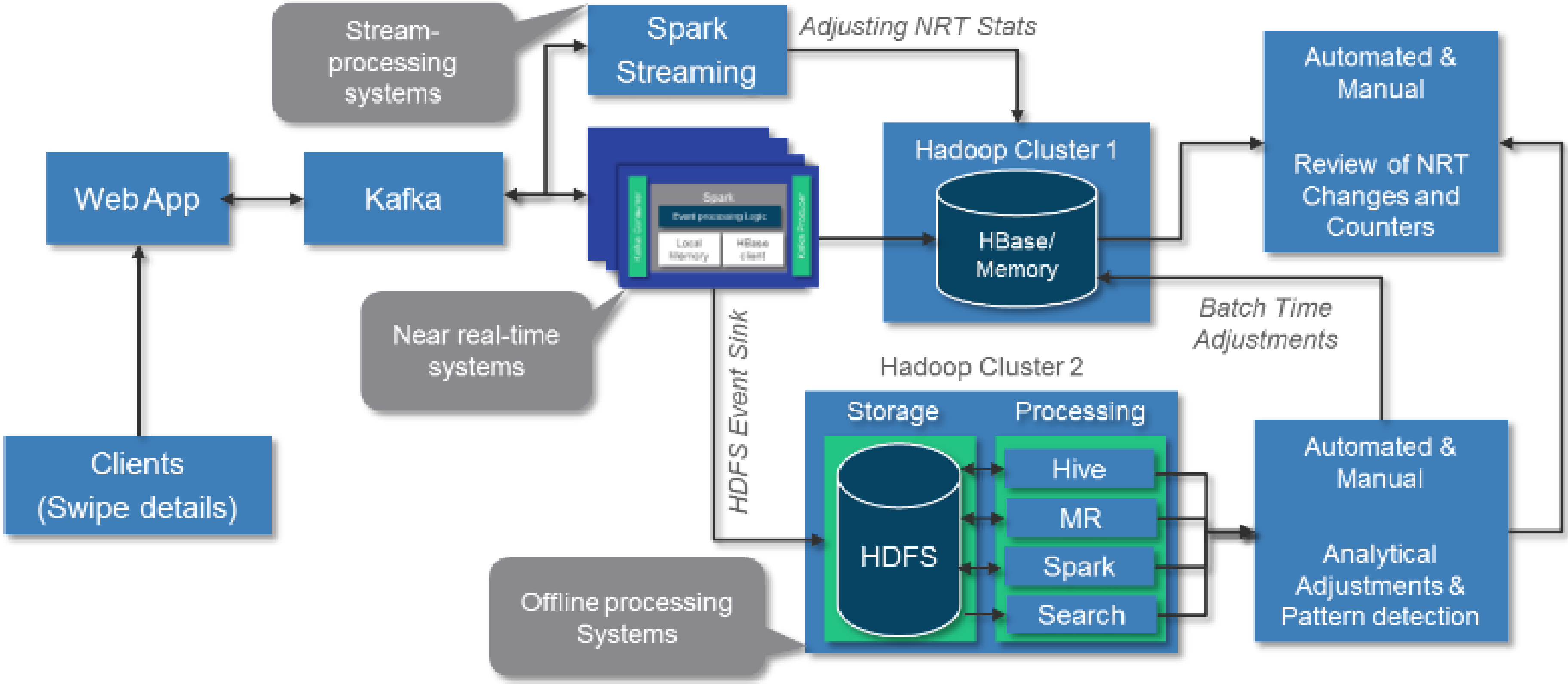
- Can execute anytime between from hours to months
- Focuses on improving the models themselves
- Data analysts explore the data using BI tools





Let’s looks at the complete picture of Credit Card Processing System

Credit Card Transaction Processing System



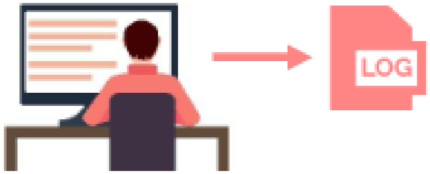
Third party Client APIs for Consumer & Producer

- Apart from built-in clients, Kafka has a binary wire protocol
- Applications can read & write messages to Kafka by sending byte sequences to Kafka's port
- Wire protocol can be implemented in different programming languages like Java, C++, Python, Go etc.

Let’s take a look at different Producer Application Use-cases

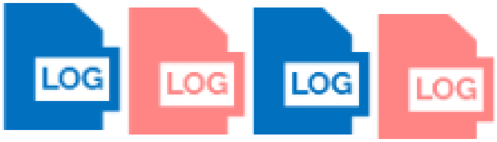
Kafka Producer Applications Use-cases

1 Recording User Activities for Auditing or Analysis



Recording Metrics 2

3 Storing Log Messages

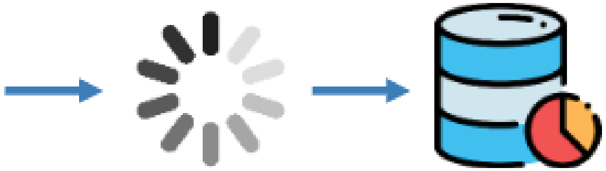


Kafka Producer Applications Use-cases

4 Recording Information from Smart Appliances

5 Communicating Asynchronously with other Applications

6 Buffering Information before Writing to a Database

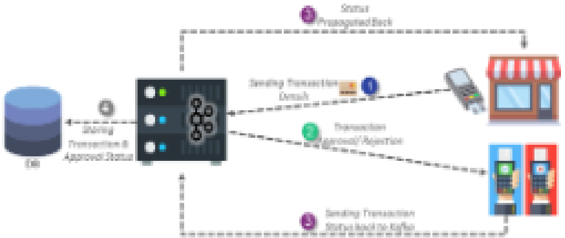


Let’s take a look at different Kafka Producer Scenarios

Kafka Producer Scenarios

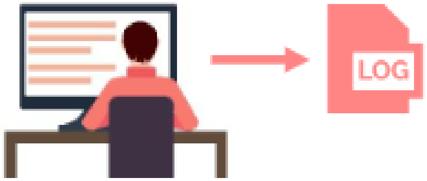
Scenario 1: Credit Card Transaction Processing

- It is critical, since you never lose a single message nor duplicate any messages
- Latency should be low (can be tolerated up to 500ms)
- Throughput should be very high (process a million messages a second)


Status Propagated Back
Sending Transaction Details
1
Transaction Approval/ Rejection
2
Storing Transaction & Approval Status
4
DB
Sending Transaction Status back to Kafka

Scenario 2: Clickstream Analysis

- Loss or a few duplicate messages can be tolerated
- Latency can be high as long as there is no impact on the user experience
- Throughput will depend on the level of activity



Different requirements will influence the way you use the producer API to write messages to Kafka and the configuration you use.

High Level Architecture of Kafka Producer

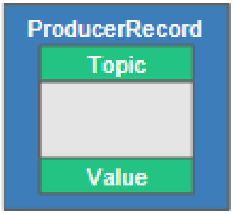
High Level Architecture of Kafka Producer

We can start producing messages to Kafka by creating a *ProducerRecord*

ProducerRecord

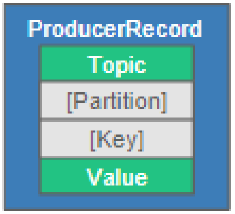
High Level Architecture of Kafka Producer

It must include the *topic* we want to send the record to and a *value*



High Level Architecture of Kafka Producer

We can also specify a *key* and/or a *partition*



ProducerRecord

Topic

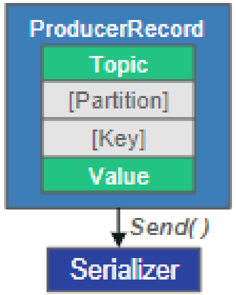
[Partition]

[Key]

Value

High Level Architecture of Kafka Producer

First the producer will *serialize* the key and value objects to *ByteArrays*



ProducerRecord

Topic

[Partition]

[Key]

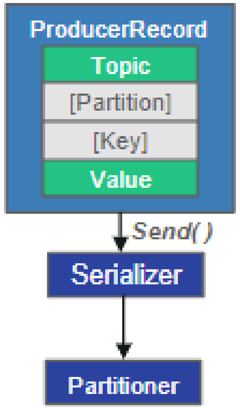
Value

Send( )

Serializer

High Level Architecture of Kafka Producer

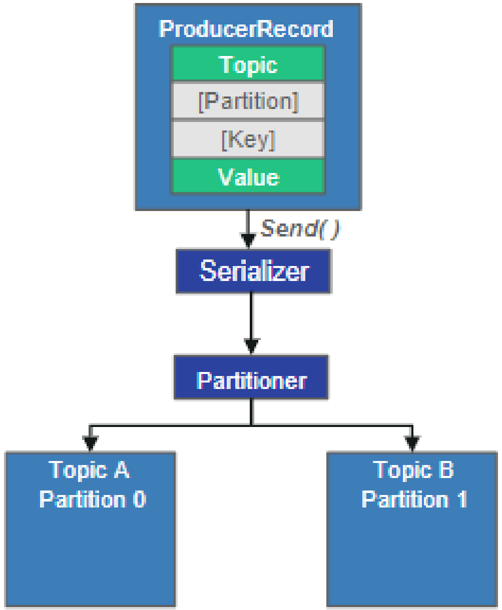
Next, the data is sent to a *partitioner*



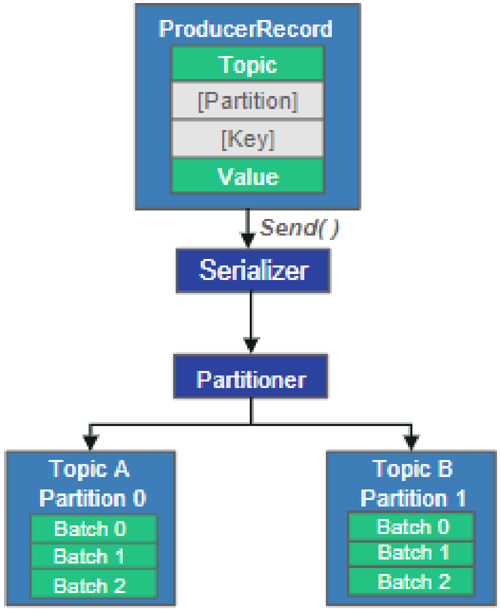
High Level Architecture of Kafka Producer

If partition is specified in *ProducerRecord*, the *partitioner* returns the *partition* we specified

As partition is selected, producer knows the topic and partition where the record will go

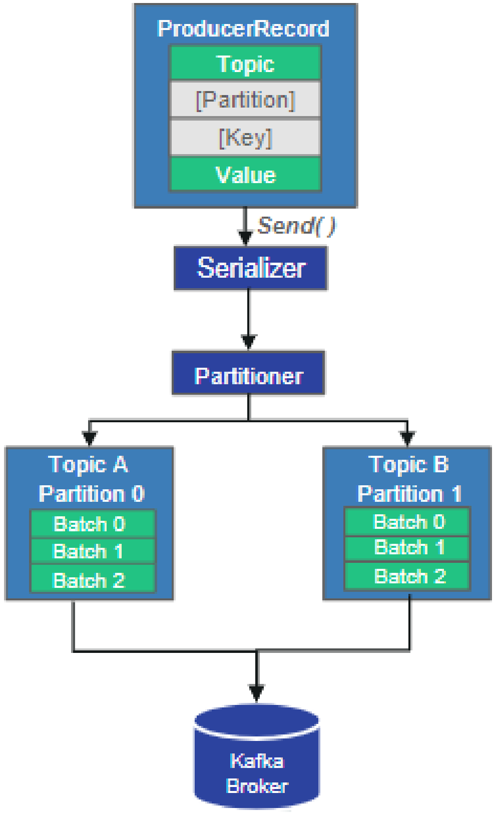


High Level Architecture of Kafka Producer



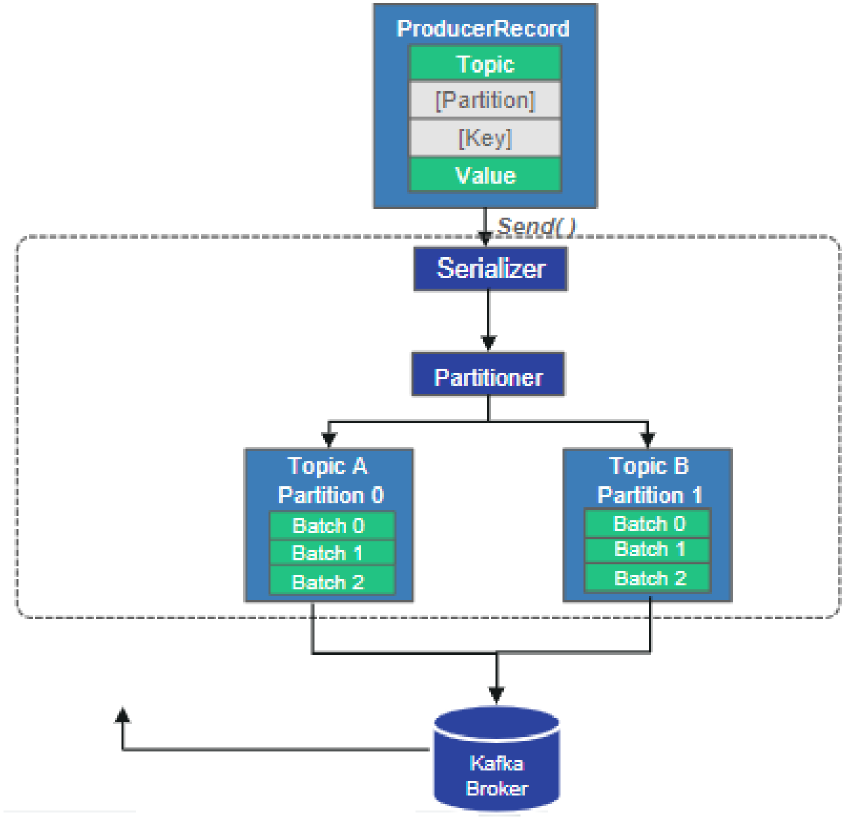
Adds the record to a *batch of records* that will also be sent to the same topic and partition

High Level Architecture of Kafka Producer



Separate thread is responsible for sending those batches of records to the appropriate *Kafka brokers*

High Level Architecture of Kafka Producer

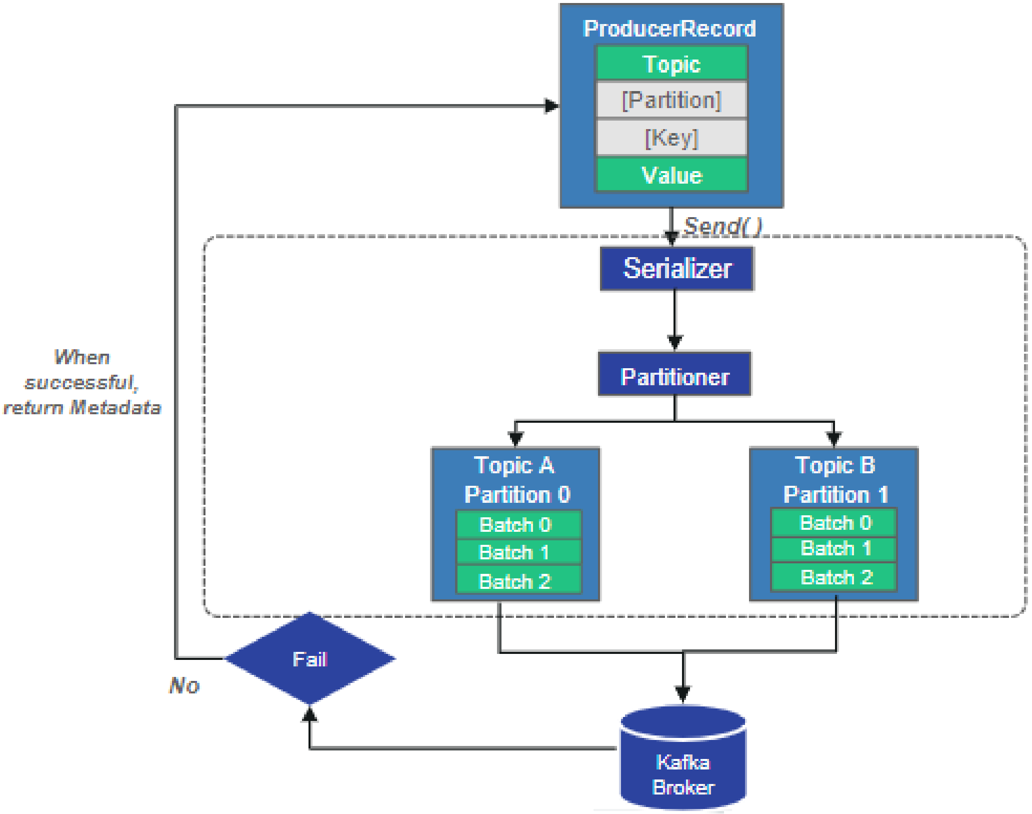


When the broker receives the messages, *it sends back a response*

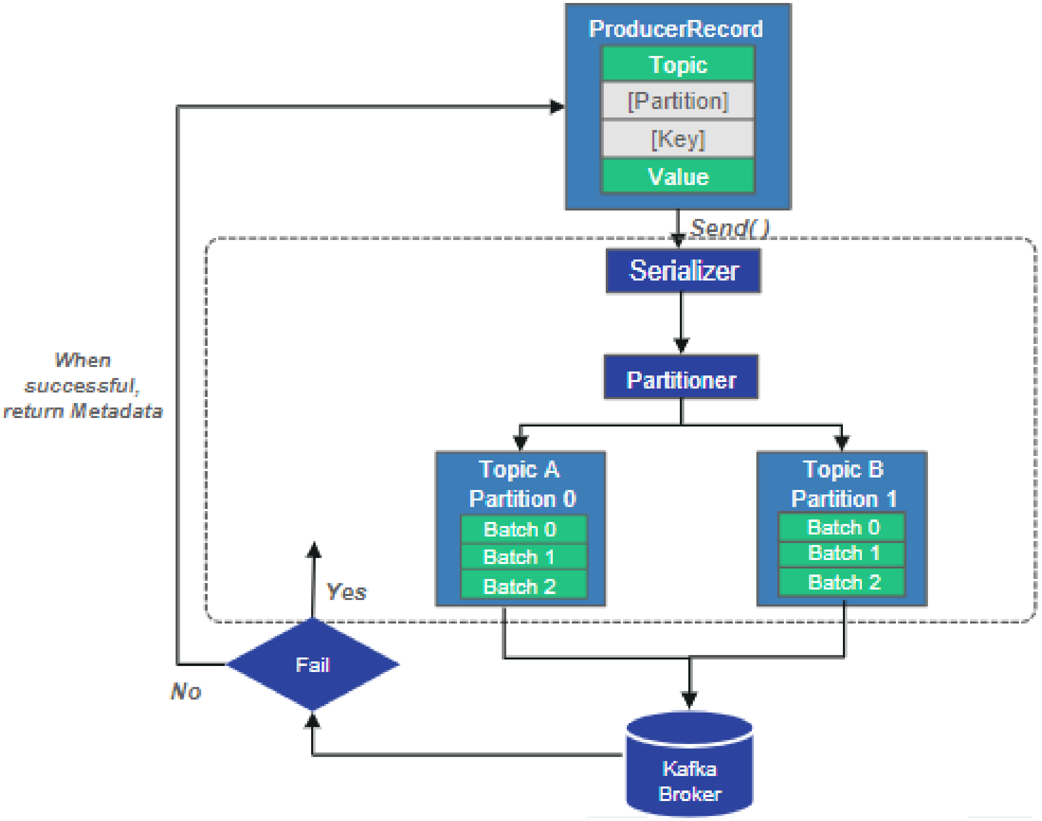
High Level Architecture of Kafka Producer

If the messages were successfully written, it will return a *RecordMetadata*

RecordMetadata contains the topic, partition, and the offset of the record within the partition



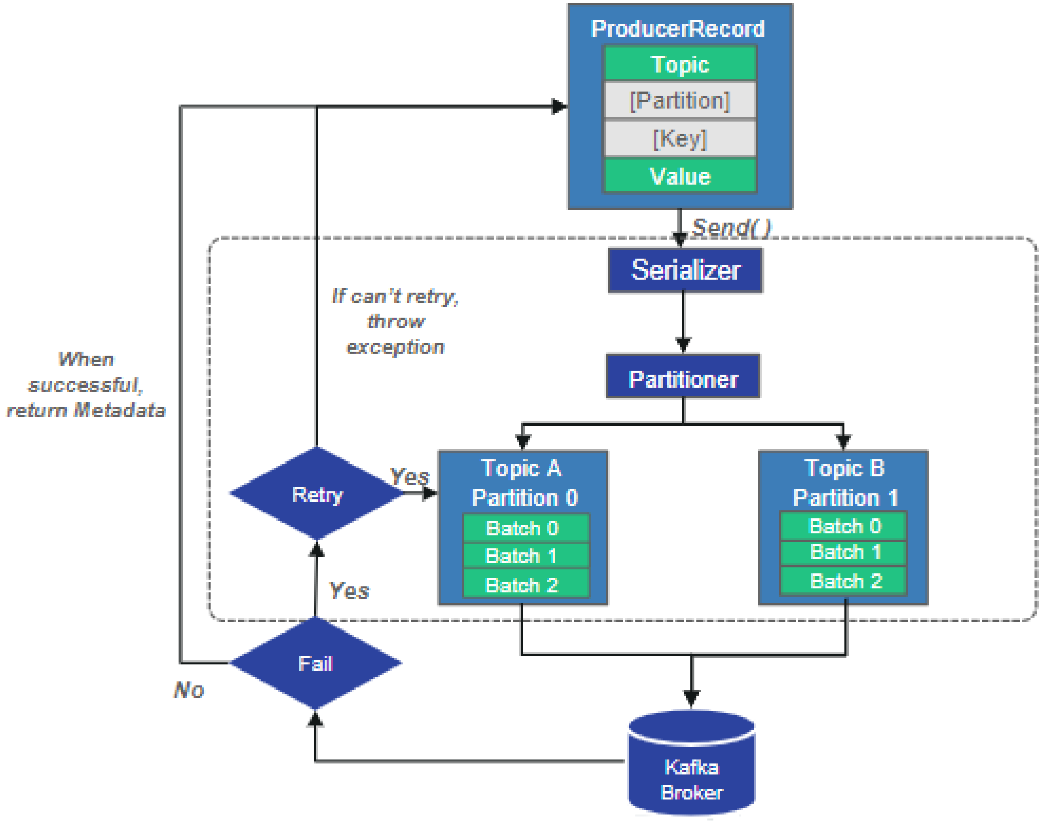
High Level Architecture of Kafka Producer



If the *broker failed* to write the messages, it will *return an error*

High Level Architecture of Kafka Producer

When the producer receives an error, it *retries sending the message* a few more times before returning an error



Let’s have a look at some important Kafka Producer Configuration Properties

Kafka Producer Configurations

Kafka producer has three mandatory properties:

bootstrap.servers

key.serializer

value.serializer

- List of *host:port* pairs of brokers, that the producer will use to establish initial connection
- No need to include all brokers, producer will get information after the initial connection
- Recommended to include at least two, in case one broker goes down

Kafka Producer Configurations

Kafka producer has three mandatory properties:

bootstrap.servers

key.serializer

value.serializer

- Name of a class that will be used to serialize the keys of the records
- Brokers expect byte arrays as keys and values of messages
- Serializer class should implements *org.apache.kafka.common.serialization.Serializer* interface.
- Producer will use this class to serialize the key object to a byte array
- Kafka client package includes ByteArraySerializer, StringSerializer, and IntegerSerializer,
- Setting *key.serializer* is required even if you intend to send only values

Kafka Producer Configurations

Kafka producer has three mandatory properties:

bootstrap.servers

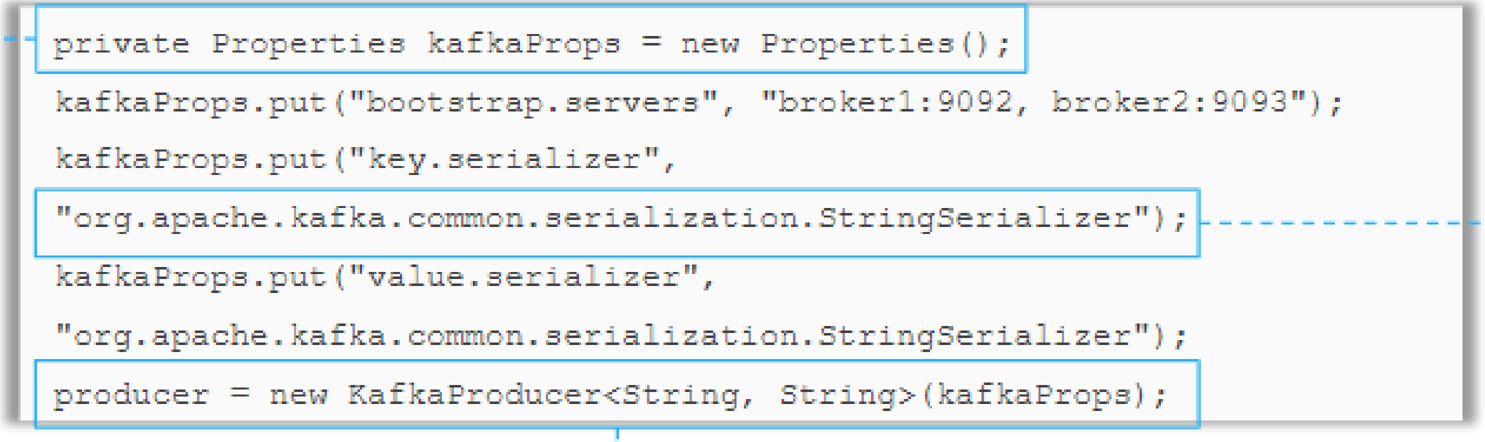
key.serializer

value.serializer

- Name of a class that will be used to serialize the values of the records
- Similarly as you set *key.serializer* to a name of a class
- Set *value.serializer* to a class that will serialize the message value object

Let’s see how to create a Kafka Producer

Create a Kafka Producer



```
private Properties kafkaProps = new Properties();
kafkaProps.put("bootstrap.servers", "broker1:9092, broker2:9093");
kafkaProps.put("key.serializer",
"org.apache.kafka.common.serialization.StringSerializer");
kafkaProps.put("value.serializer",
"org.apache.kafka.common.serialization.StringSerializer");
producer = new KafkaProducer<String, String>(kafkaProps);
```

We start with
a Properties object

Here we Create a new producer by setting
the appropriate key and value types &
passing the Properties object

Here we are using the
built-in *StringSerializer*

Let’s take a look at different types of errors

Types of Errors

KafkaProducer has two types of errors:

Retriable Error ✓

- *Retriable* errors are those that can be resolved by sending the message again
    - For example, a connection error can be resolved by reestablishing a connection, "no leader" error can be resolved when a new leader is elected for the partition
- *KafkaProducer* can be configured to retry those errors automatically

Non-Retriable Error ✗

- Some errors will not be resolved by retrying
- In those cases, KafkaProducer will not attempt a retry & will return the exception immediately
    - For example, "message size too large"

Let’s see different ways to send messages

Ways to send Messages - Fire & Forget

Kafka producer has three ways for sending messages:

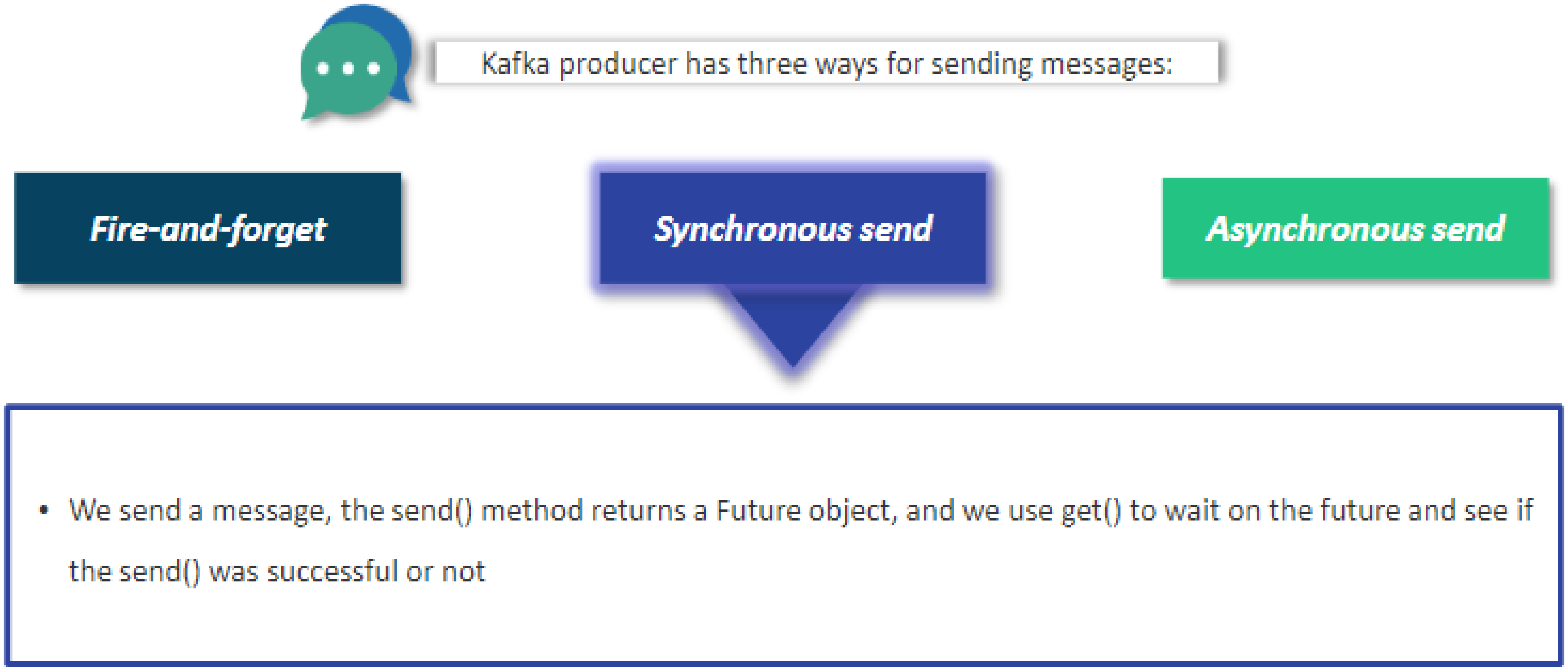
Fire-and-forget

Synchronous send

Asynchronous send

- We send a message to the server and don't really care if it arrives successfully or not
- Generally, messages arrive successfully, as Kafka is highly available
- Producer will retry sending messages automatically
- Some messages will get lost using this method

Ways to send Messages - Synchronous Send



Kafka producer has three ways for sending messages:

- We send a message, the send() method returns a Future object, and we use get() to wait on the future and see if the send() was successful or not

Ways to send Messages - Asynchronous Send

Kafka producer has three ways for sending messages:

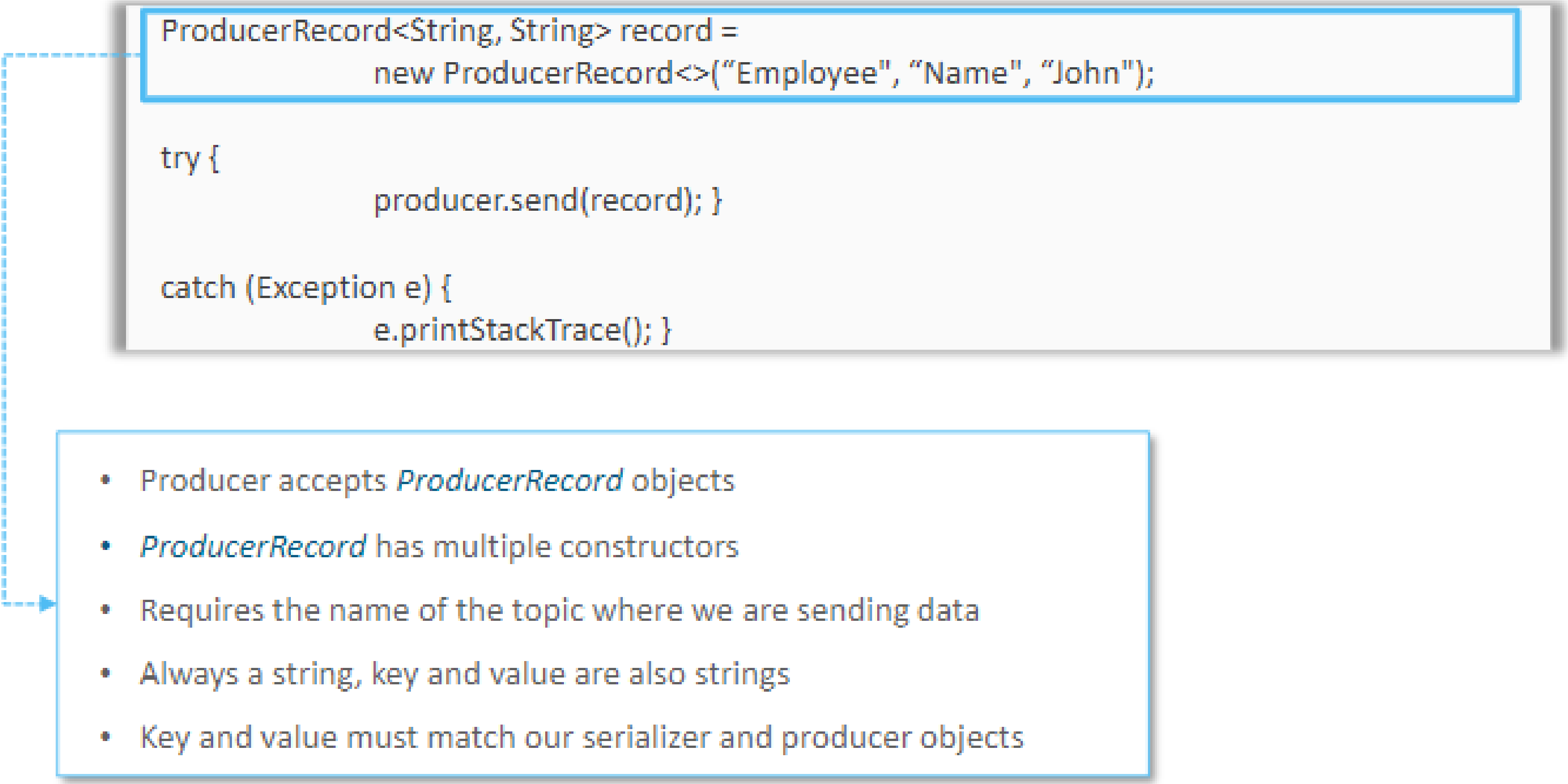
Fire-and-forget

Synchronous send

Asynchronous send

- We call the send() method with a callback function, which gets triggered when it receives a response from the Kafka broker

Sending Message in Fire & Forget way



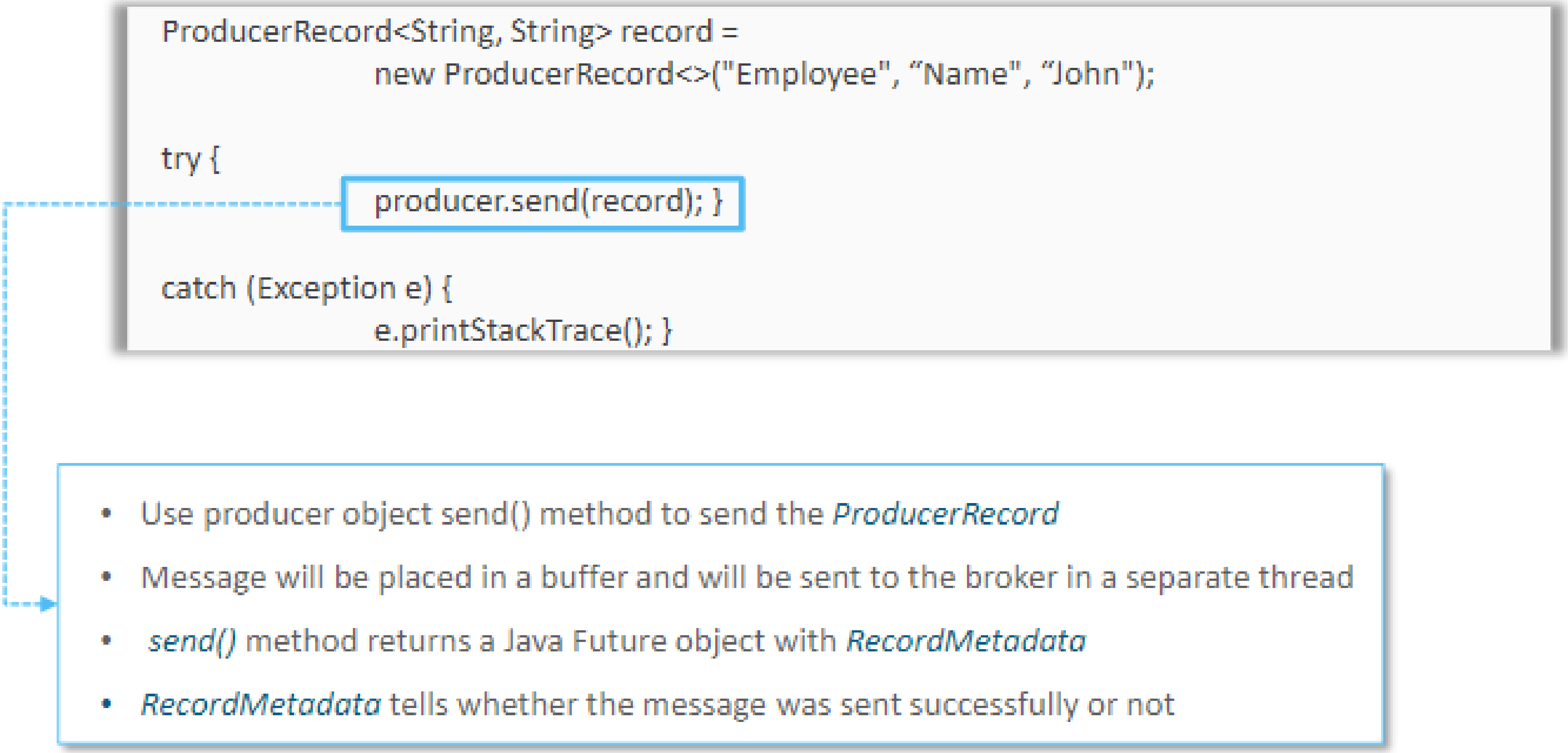
```
ProducerRecord<String, String> record =
                    new ProducerRecord<>("Employee", "Name", "John");

try {
                    producer.send(record); }

catch (Exception e) {
                    e.printStackTrace(); }
```

- Producer accepts *ProducerRecord* objects
- *ProducerRecord* has multiple constructors
- Requires the name of the topic where we are sending data
- Always a string, key and value are also strings
- Key and value must match our serializer and producer objects

Sending Message in Fire & Forget way



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ProducerRecord<String, String> record =
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try {
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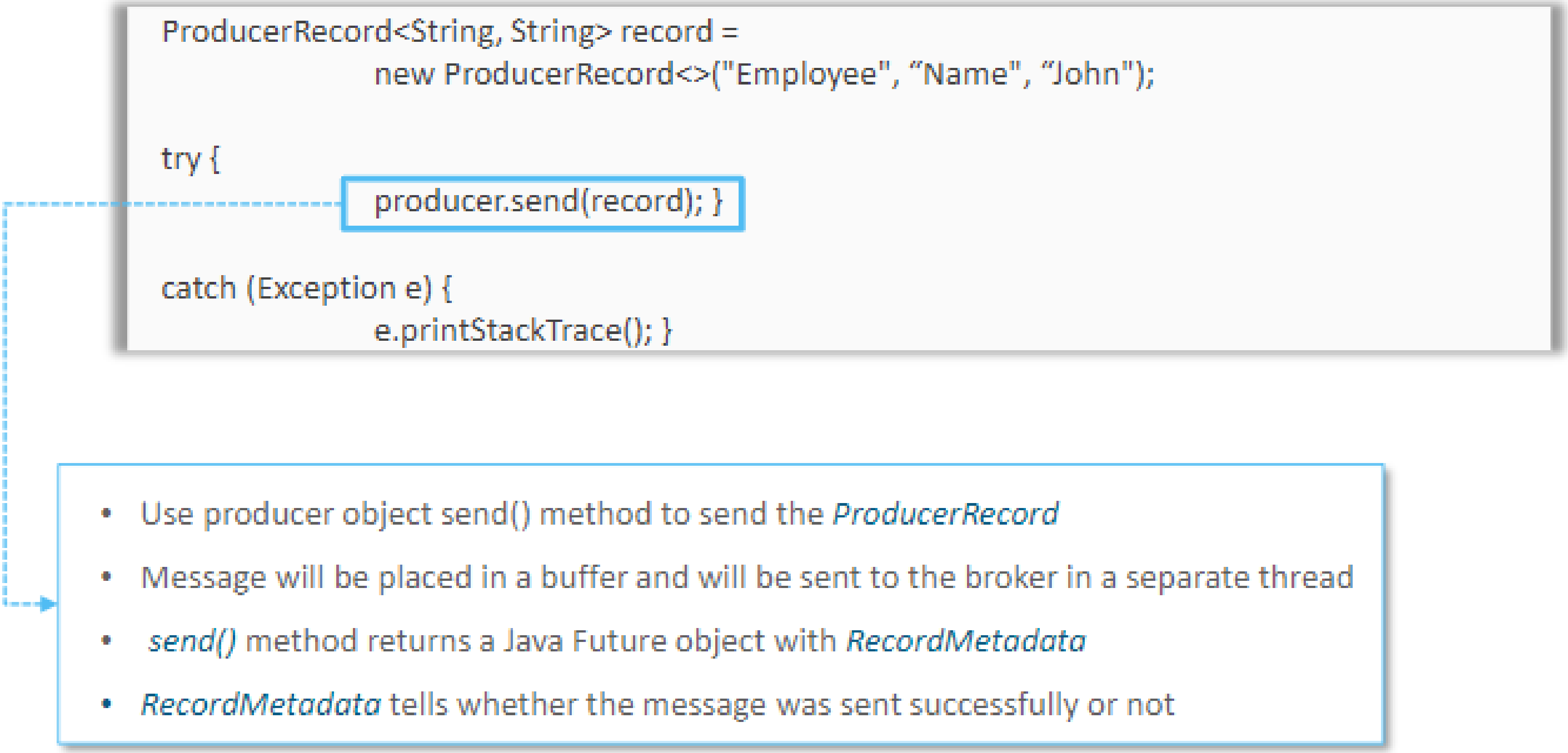
catch (Exception e) {
                    e.printStackTrace(); }
```

- Use producer object send() method to send the *ProducerRecord*
- Message will be placed in a buffer and will be sent to the broker in a separate thread
- *send()* method returns a Java Future object with *RecordMetadata*
- *RecordMetadata* tells whether the message was sent successfully or not

Sending Message in Fire & Forget way



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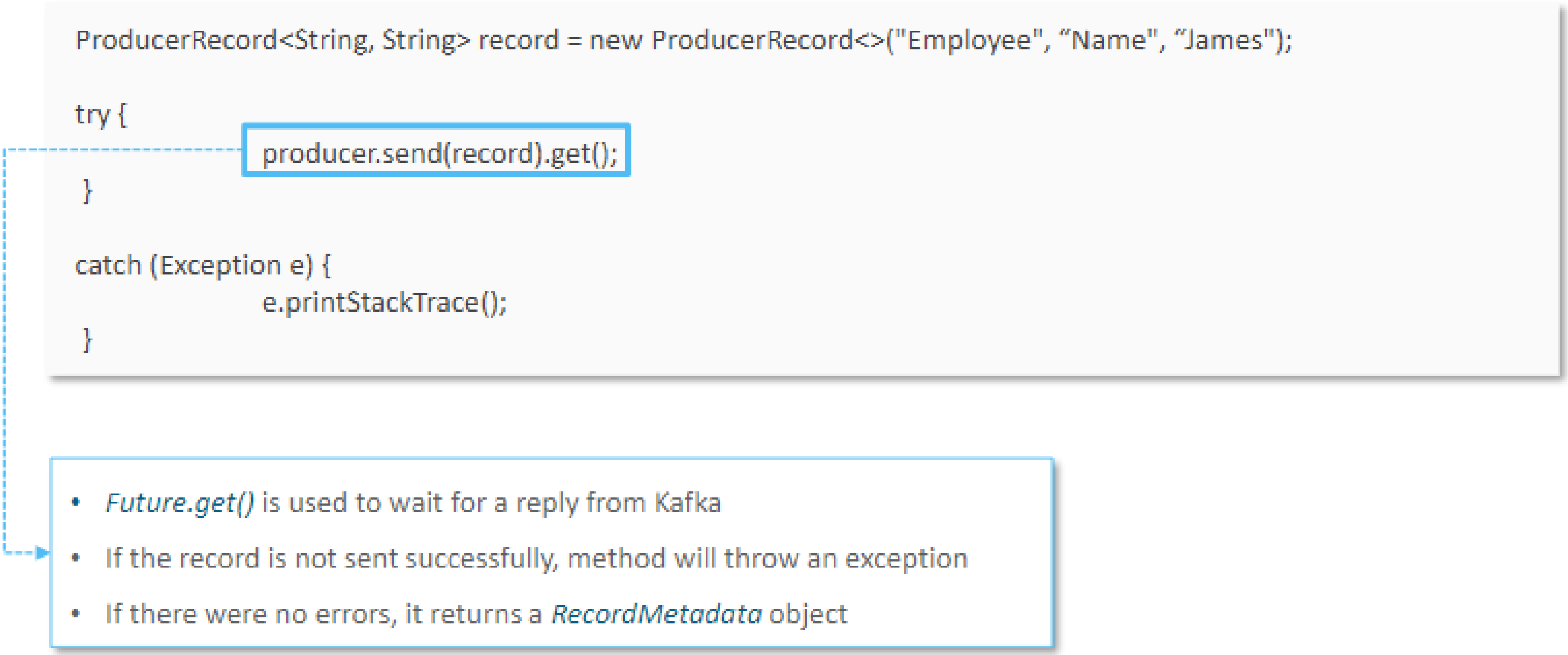
Sending Message Synchronously



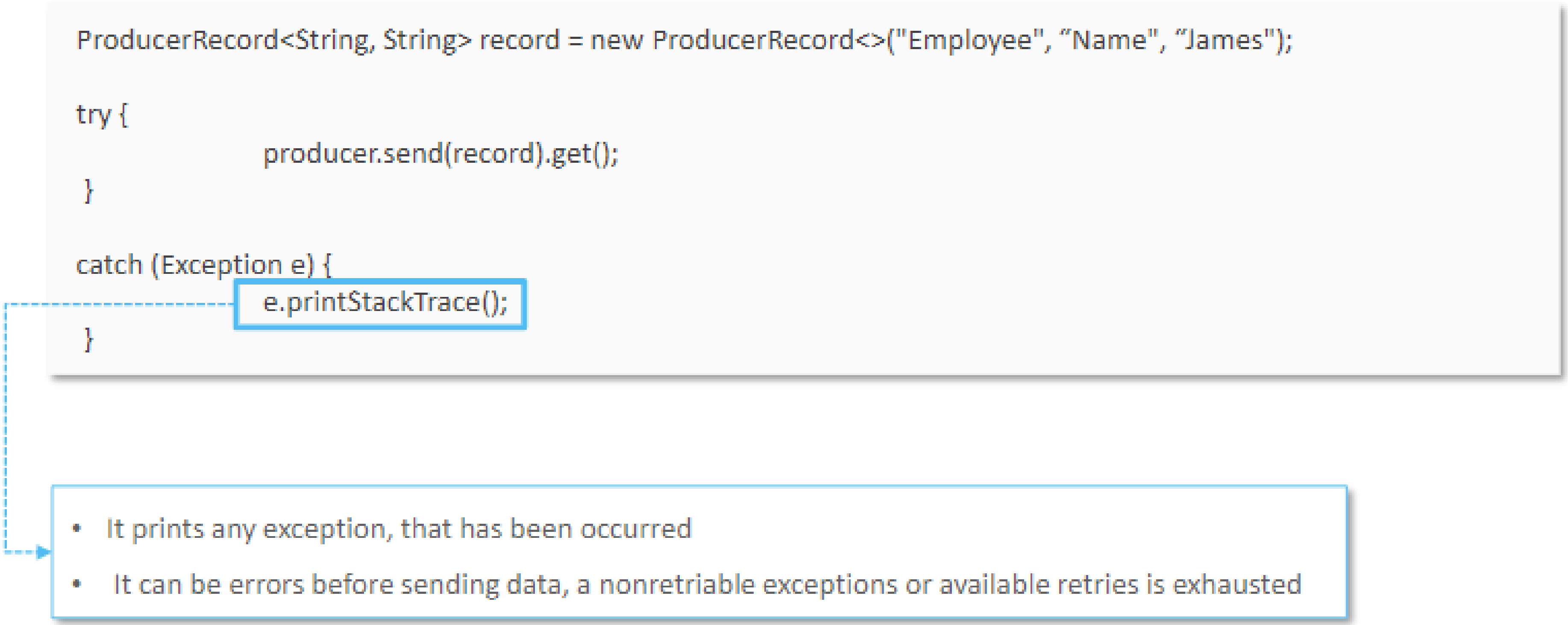
```
ProducerRecord<String, String> record = new ProducerRecord<>("Employee", “Name", “James");

try {
                    producer.send(record).get();
 }

catch (Exception e) {
                    e.printStackTrace();
 }
```

- *Future.get()* is used to wait for a reply from Kafka
- If the record is not sent successfully, method will throw an exception
- If there were no errors, it returns a *RecordMetadata* object

Sending Message Synchronously



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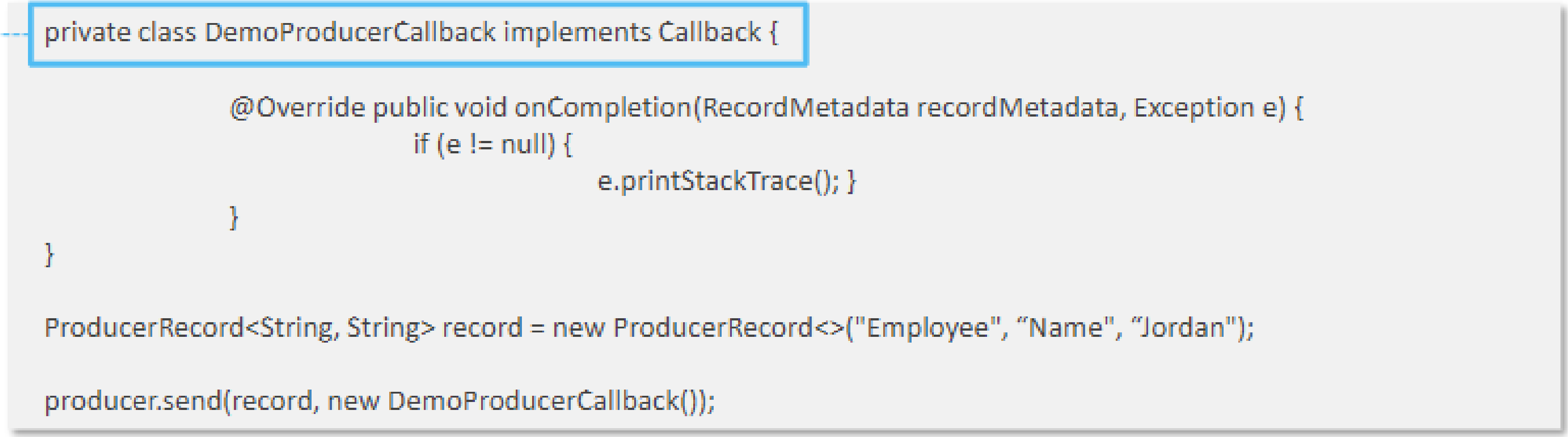
ProducerRecord<String, String> record = new ProducerRecord<>("Employee", “Name", “James");

try {
                    producer.send(record).get();
 }

catch (Exception e) {
                    e.printStackTrace();
 }
```

- It prints any exception, that has been occurred
- It can be errors before sending data, a nonretriable exceptions or available retries is exhausted

Sending Message Asynchronously



```
private class DemoProducerCallback implements Callback {

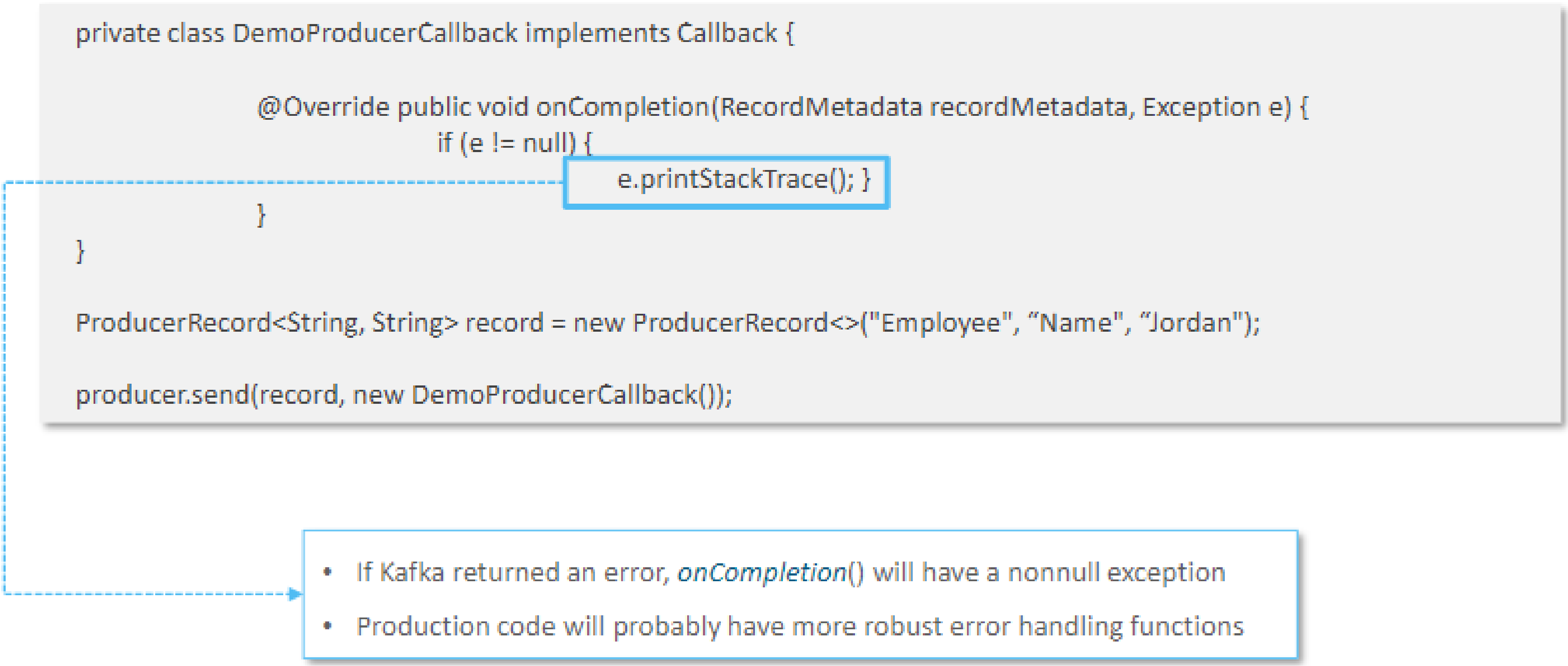
                @Override public void onCompletion(RecordMetadata recordMetadata, Exception e) {
                                if (e != null) {
                                                e.printStackTrace(); }
                }
}

ProducerRecord<String, String> record = new ProducerRecord<>("Employee", “Name", “Jordan");

producer.send(record, new DemoProducerCallback());
```

- To use callbacks, a class is needed that implements the *org.apache.kafka.clients.producer.Callback* interface
- It has a single function—*onCompletion()*

Sending Message Asynchronously



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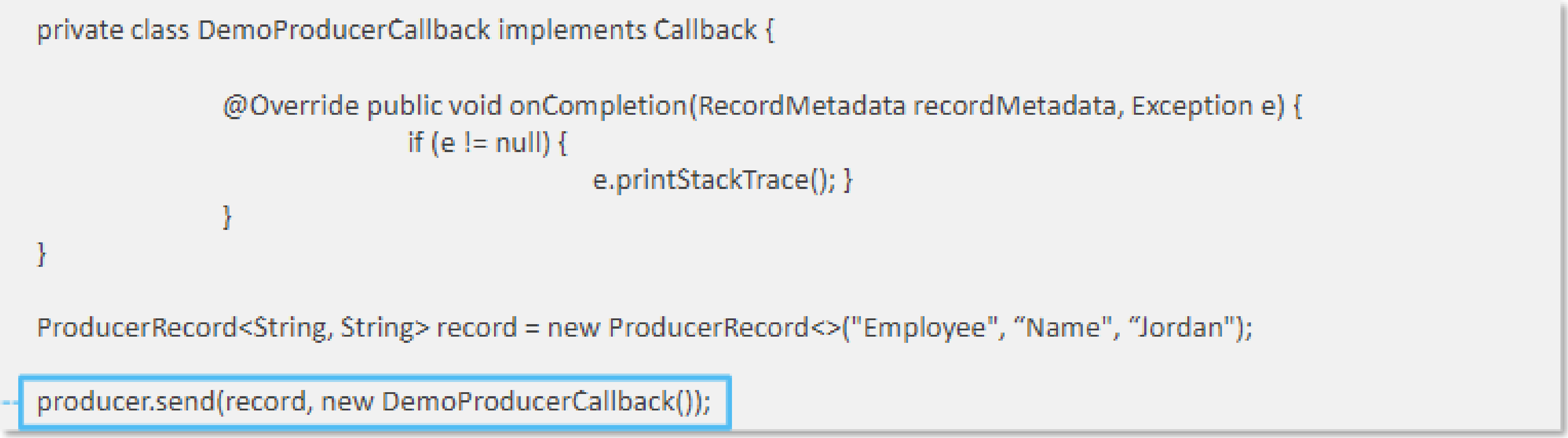
                                    e.printStackTrace(); }
            }
}

ProducerRecord<String, String> record = new ProducerRecord<>("Employee", “Name", “Jordan");

producer.send(record, new DemoProducerCallback());
```

- If Kafka returned an error, *onCompletion*() will have a nonnull exception
- Production code will probably have more robust error handling functions

Sending Message Asynchronously



```
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          @Override public void onCompletion(RecordMetadata recordMetadata, Exception e) {
                    if (e != null) {
                              e.printStackTrace(); }
          }
}

ProducerRecord<String, String> record = new ProducerRecord<>("Employee", “Name", “Jordan");

producer.send(record, new DemoProducerCallback());
```

- We pass a *Callback object* along when sending the record

More properties to configure Kafka Producers ..

Configuring Kafka Producers

ACKS

It controls how many partition replicas must receive the record before the producer can consider the write successful

Significant impact on how likely messages are to be lost

There are three allowed values for the acks parameter:

acks=0

- Producer will not wait for a reply from the broker before assuming the message was sent successfully
- If something went wrong and the broker did not receive the message
- Producer will not know about failure and the message will be lost
- Producer sends messages as fast as the network will support, it gives very high throughput

acks=1

- Producer will receive a success response from the broker after leader replica receives the message
- If the message can't be written to the leader, the producer will receive an error response
- It can retry sending the message, avoiding potential loss of data
- Throughput depends on whether we send messages synchronously or asynchronously

acks=all

- Producer will receive a success response from the broker once all in-sync replicas received the message
- It's the safest mode since you can make sure more than one broker has the message
- Message will survive even in the case of crash

Configuring Kafka Producers

buffer.memory

- Configures the amount of memory, producer will use to buffer messages before sending
- If messages are sent faster than they are delivered, producer may run out of space
- *Additional send() calls will either block or throw an exception (max.block.ms parameter)*

compression.type

- By default, messages are sent uncompressed
- Compression algorithms will be used to compress the data before sending it to the brokers
- *It could be snappy, gzip, or lz4*

Configuring Kafka Producers

retries

- If error is transient, it tells how many times the producer will retry sending the message
- By default, the producer will wait 100ms between retries
- Could be controlled by *retry.backoff.ms* parameter

client.id

- Used by the brokers to identify messages sent from the client
- Used in logging and metrics, and for quotas

receive.buffer.bytes and send.buffer.bytes

- Sizes of the TCP send and receive buffers used by the sockets when writing/reading data
- If these are set to -1, the OS defaults will be used

Configuring Kafka Producers

max.in.flight.requests.per.connection

- Controls how many messages the producer will send to the server without receiving responses
- Setting this high can increase memory usage while improving throughput
- Setting it too high can reduce throughput as batching becomes less efficient
- Setting to 1 will guarantee that messages will be written to the broker in the order they were sent

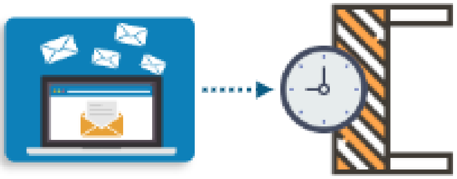
request.timeout.ms

- Controls how long the producer will wait for a reply from the server when sending data & requesting metadata
- If timeout is reached without reply, the producer will either retry sending or respond with an error

Configuring Kafka Producers

max.block.ms

- Controls how long the producer will block when calling send() & when explicitly requesting metadata via partitionsFor()
- Those methods block when the producer's send buffer is full or when metadata is not available
- When max.block.ms is reached, a timeout exception is thrown



max.request.size

- This setting controls the size of a produce request
- Caps both the size of the largest message that can be sent & the size of messages in a batch that the producer can send in one request

Serialization – What & How ?

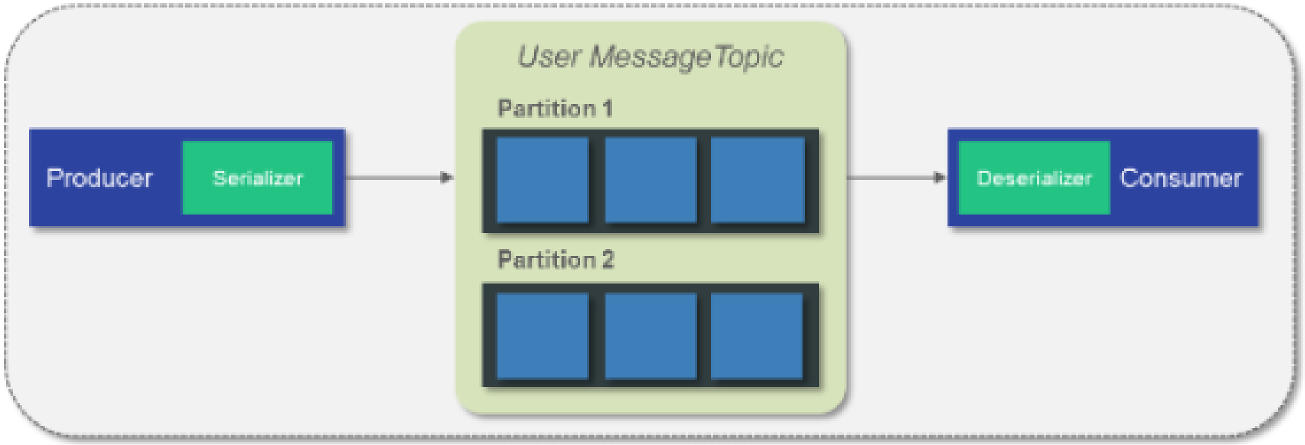
Serializers

Serialization is the process of translating data structures or object state into a format that can be stored, transmitted & reconstructed later

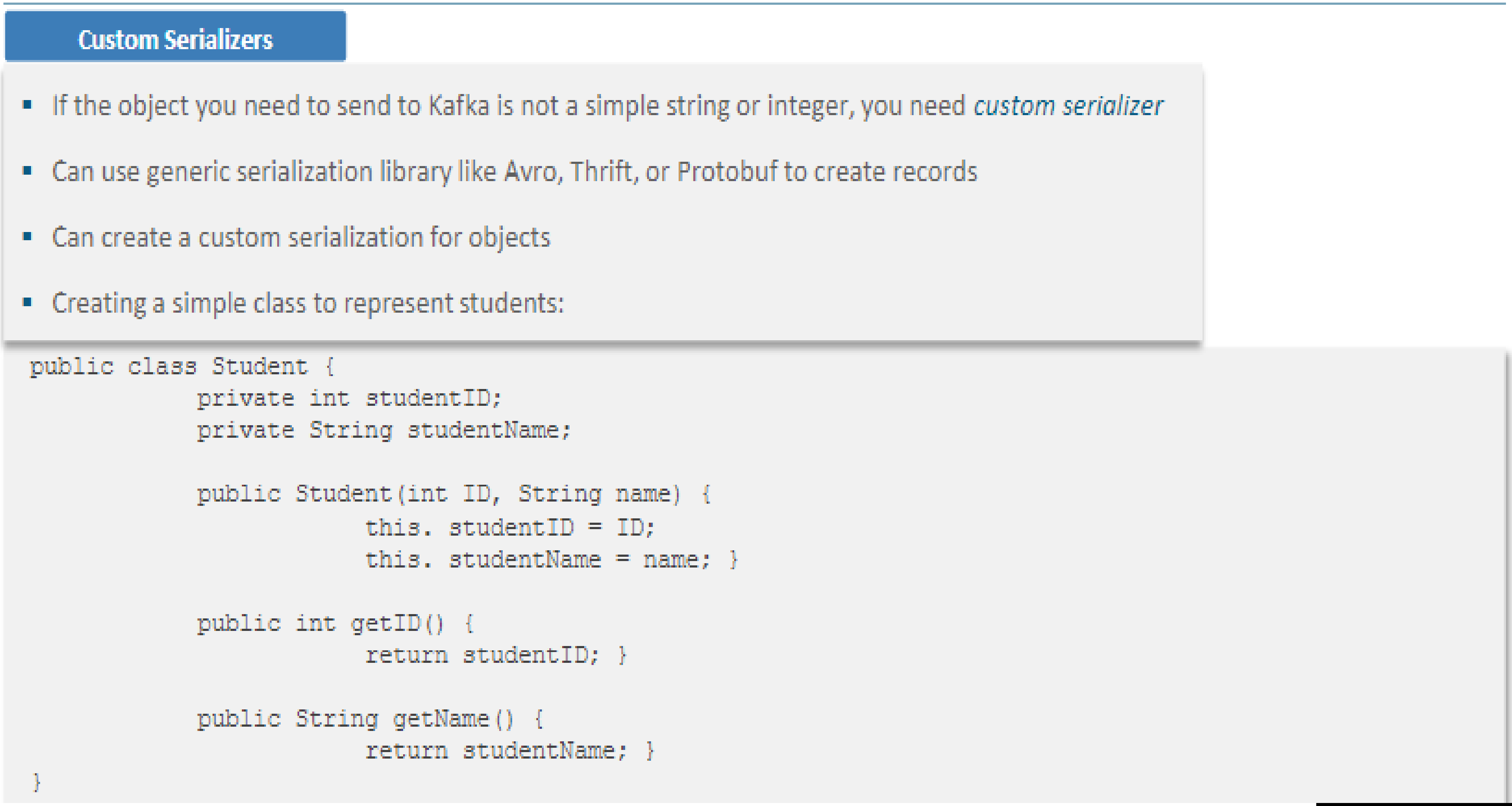
Producer configuration includes mandatory serializers

Default String serializer can be used

Kafka also includes serializers for integers and ByteArrays



Custom Serializers



Custom Serializers

- If the object you need to send to Kafka is not a simple string or integer, you need *custom serializer*
- Can use generic serialization library like Avro, Thrift, or Protobuf to create records
- Can create a custom serialization for objects
- Creating a simple class to represent students:

```
public class Student {
            private int studentID;
            private String studentName;

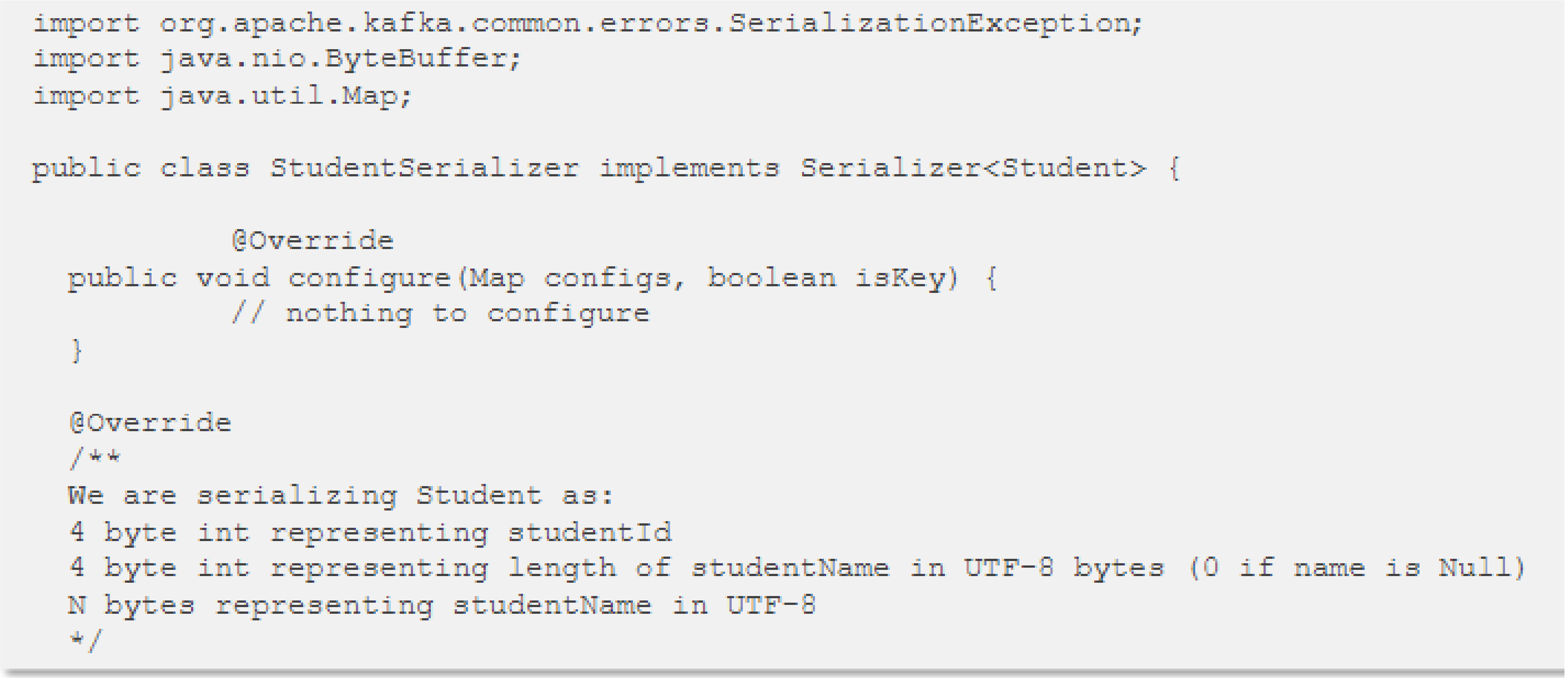
            public Student(int ID, String name) {
                        this. studentID = ID;
                        this. studentName = name; }

            public int getID() {
                        return studentID; }

            public String getName() {
                        return studentName; }
}
```

Creating Custom Serializer

E.g. - Creating a custom serializer for Student class



```
import org.apache.kafka.common.errors.SerializationException;
import java.nio.ByteBuffer;
import java.util.Map;

public class StudentSerializer implements Serializer<Student> {

           @Override
  public void configure(Map configs, boolean isKey) {
           // nothing to configure
  }

  @Override
  /**
  We are serializing Student as:
  4 byte int representing studentId
  4 byte int representing length of studentName in UTF-8 bytes (0 if name is Null)
  N bytes representing studentName in UTF-8
  */
```

Creating Custom Serializer

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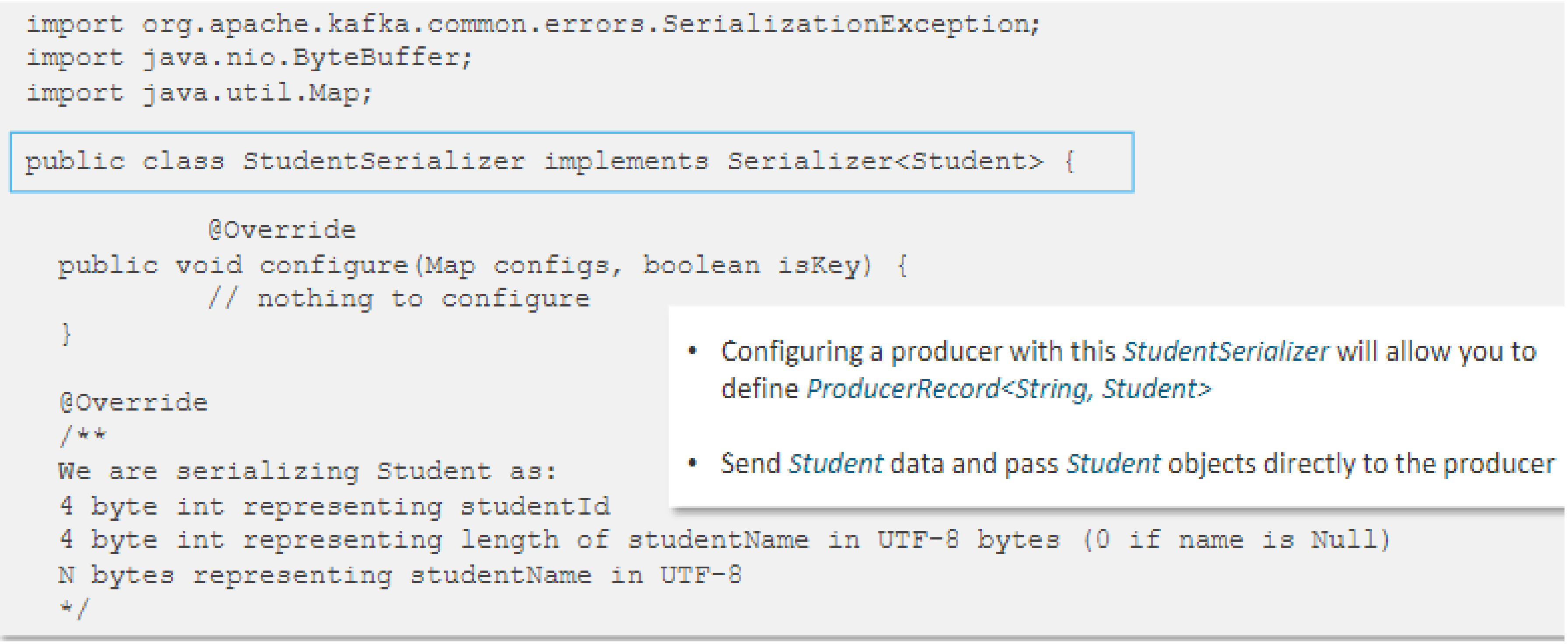

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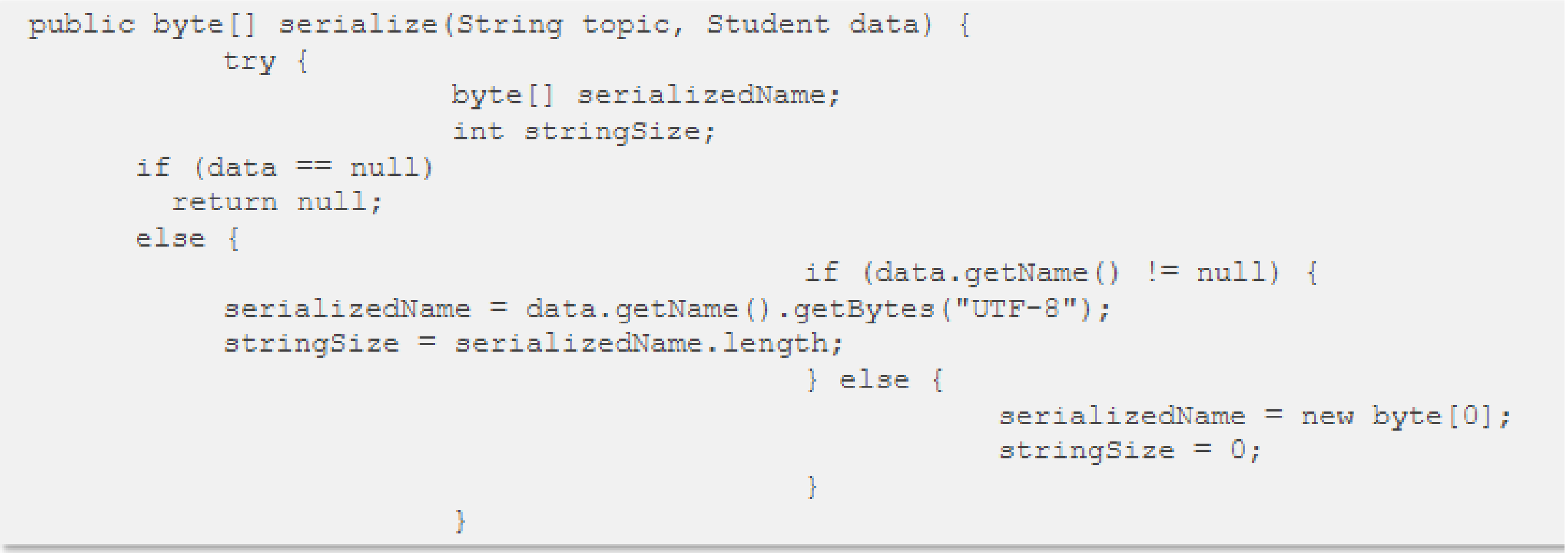
  We are serializing Student as:
  4 byte int representing studentId
  4 byte int representing length of studentName in UTF-8 bytes (0 if name is Null)
  N bytes representing studentName in UTF-8
  */
```

- Configuring a producer with this *StudentSerializer* will allow you to define *ProducerRecord<String, Student>*
- Send *Student* data and pass *Student* objects directly to the producer

Creating Custom Serializer

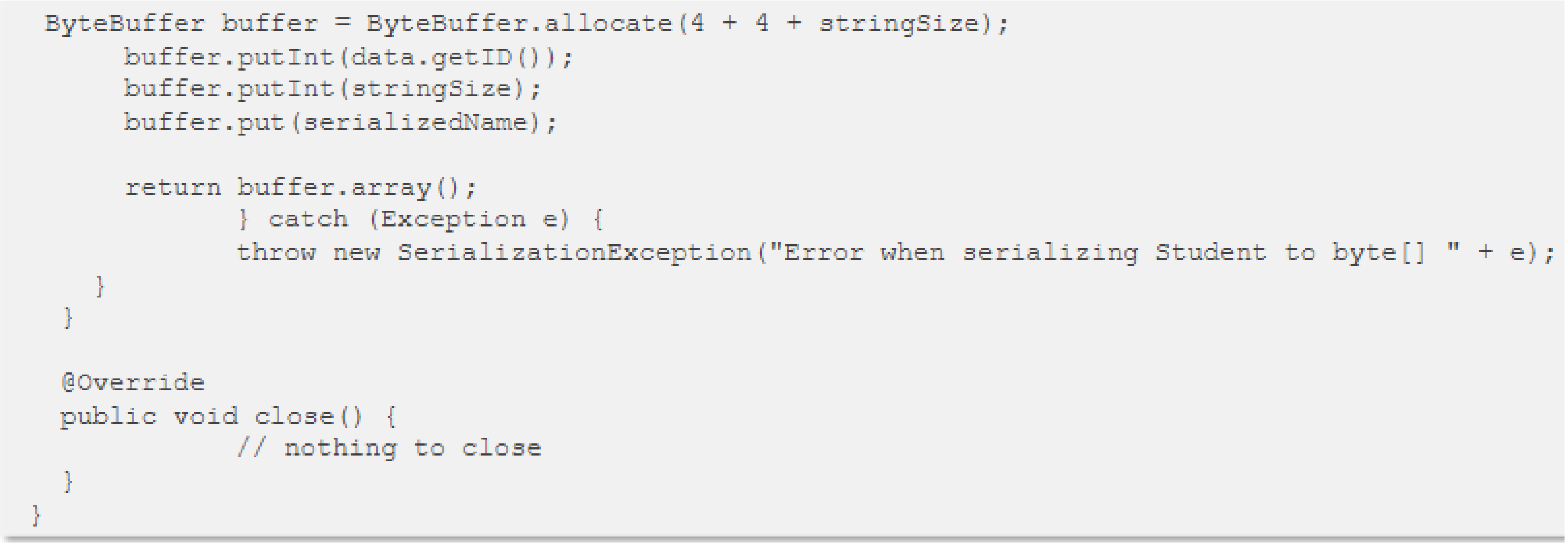
E.g. - Creating a custom serializer for Student class



```
public byte[] serialize(String topic, Student data) {
           try {
                        byte[] serializedName;
                        int stringSize;
      if (data == null)
        return null;
      else {
                                            if (data.getName() != null) {
           serializedName = data.getName().getBytes("UTF-8");
           stringSize = serializedName.length;
                                            } else {
                                                       serializedName = new byte[0];
                                                       stringSize = 0;
                                            }
                        }
```

Creating Custom Serializer

E.g. - Creating a custom serializer for Student class



```
 ByteBuffer buffer = ByteBuffer.allocate(4 + 4 + stringSize);
      buffer.putInt(data.getID());
      buffer.putInt(stringSize);
      buffer.put(serializedName);

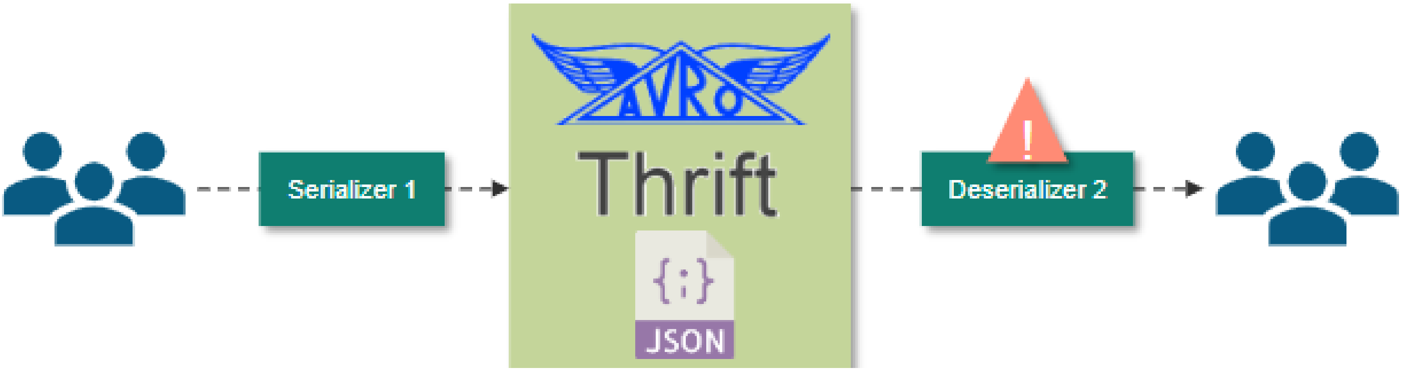
      return buffer.array();
             } catch (Exception e) {
             throw new SerializationException("Error when serializing Student to byte[] " + e);
    }
  }

  @Override
  public void close() {
             // nothing to close
  }
}
```

Serializer Challenges

If we need to change studentID to Long, or add a startDate field to *Student*, there will be compatibility issues between old and new messages.

- Debugging compatibility issues is fairly challenging
- If multiple teams are writing Student data to Kafka, they all need to use the same serializers & deserializer
- It's recommended using existing serializers and deserializers such as JSON, Apache Avro, Thrift, or Protobuf



Apache Avro Serialization

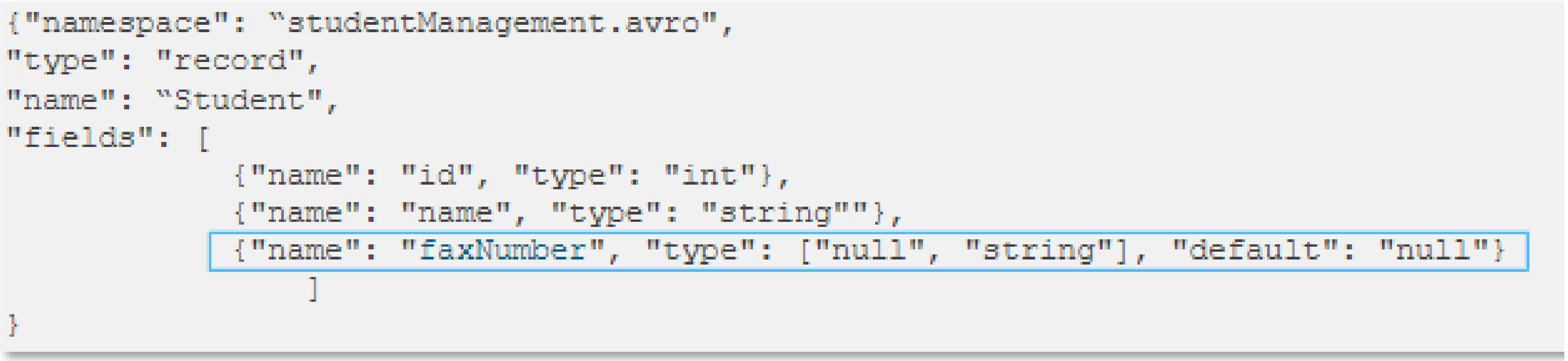
Serializing using Apache Avro

Avro data is described in a language-independent schema

- Apache Avro is a language-neutral data serialization format
- Created by Doug Cutting to provide a way to share data files with a large audience
- Schema is usually described in JSON

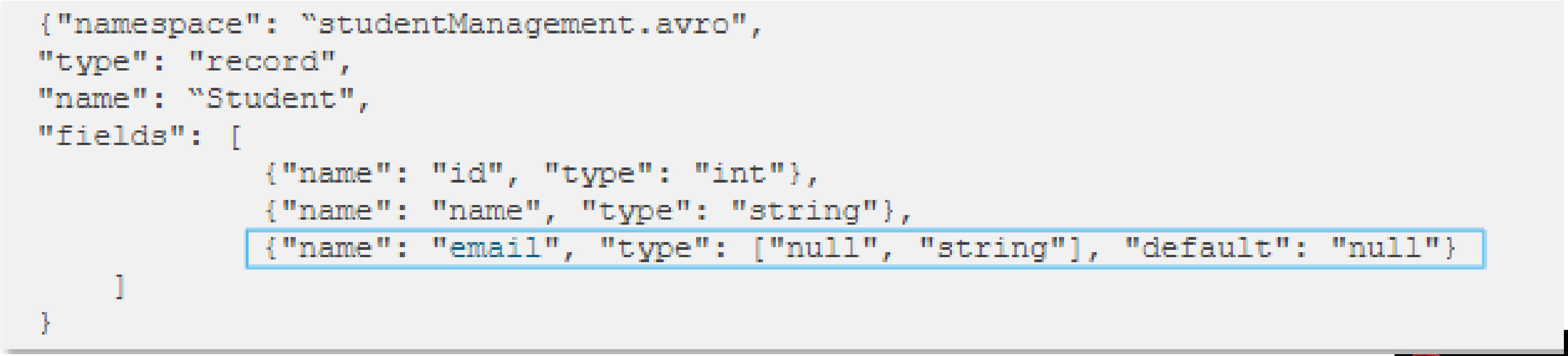
When the writing application switches to a new schema, the reading applications continues processing messages without requiring any change

Example - Serializing using Apache Avro



```
{"namespace": “studentManagement.avro",
"type": "record",
"name": “Student",
"fields": [
             {"name": "id", "type": "int"},
             {"name": "name", "type": "string""},
             {"name": "faxNumber", "type": ["null", "string"], "default": "null"}
                 ]
}
```

- id and name fields are mandatory, while fax number is optional and defaults to null
- In new version, we will upgrade fax number field to email field:



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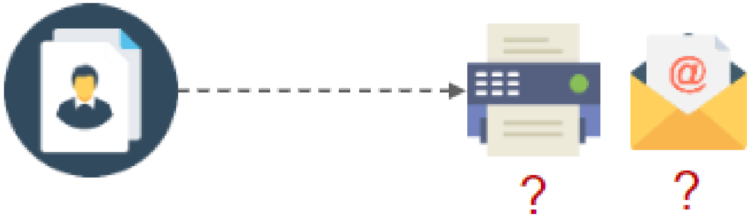
             {"name": "id", "type": "int"},
             {"name": "name", "type": "string"},
             {"name": "email", "type": ["null", "string"], "default": "null"}
     ]
}
```

Serializing using Apache Avro

- Old records will contain “faxNumber” & new records will contain “email”
- Pre-upgrade applications with the fax numbers and post-upgrade applications with email can handle all the events in Kafka
- Application will contain calls to methods -> getName(), getId(), and getFaxNumber().
- If it encounters a message with new schema, rest method will continue working with no modification but getFax Number() will return null
- If it encounters a message with old schema, getEmail() will return null



☛ *Even if schema is changed in the messages without changing the applications reading the data, there will be no exceptions or breaking errors and no need for expensive updates of existing data.*

Using Avro Records with Kafka

In Avro files storing schema in each record has a fairly reasonable overhead, storing the entire schema in each record will usually more than double the record size.

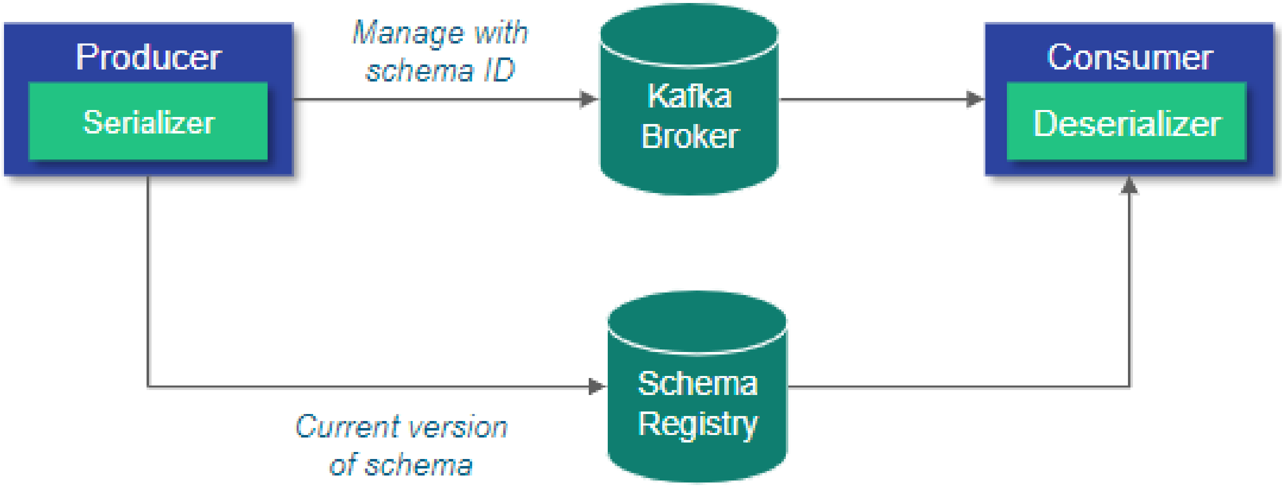
- Avro requires the entire schema while reading the record, so we need to locate the schema elsewhere
- For this, we follow a common architecture pattern and use a Schema Registry
- Schema Registries are open source options to choose from

Using Avro Records with Kafka

Stores all the *schemas* used to write data to Kafka in the *registry*

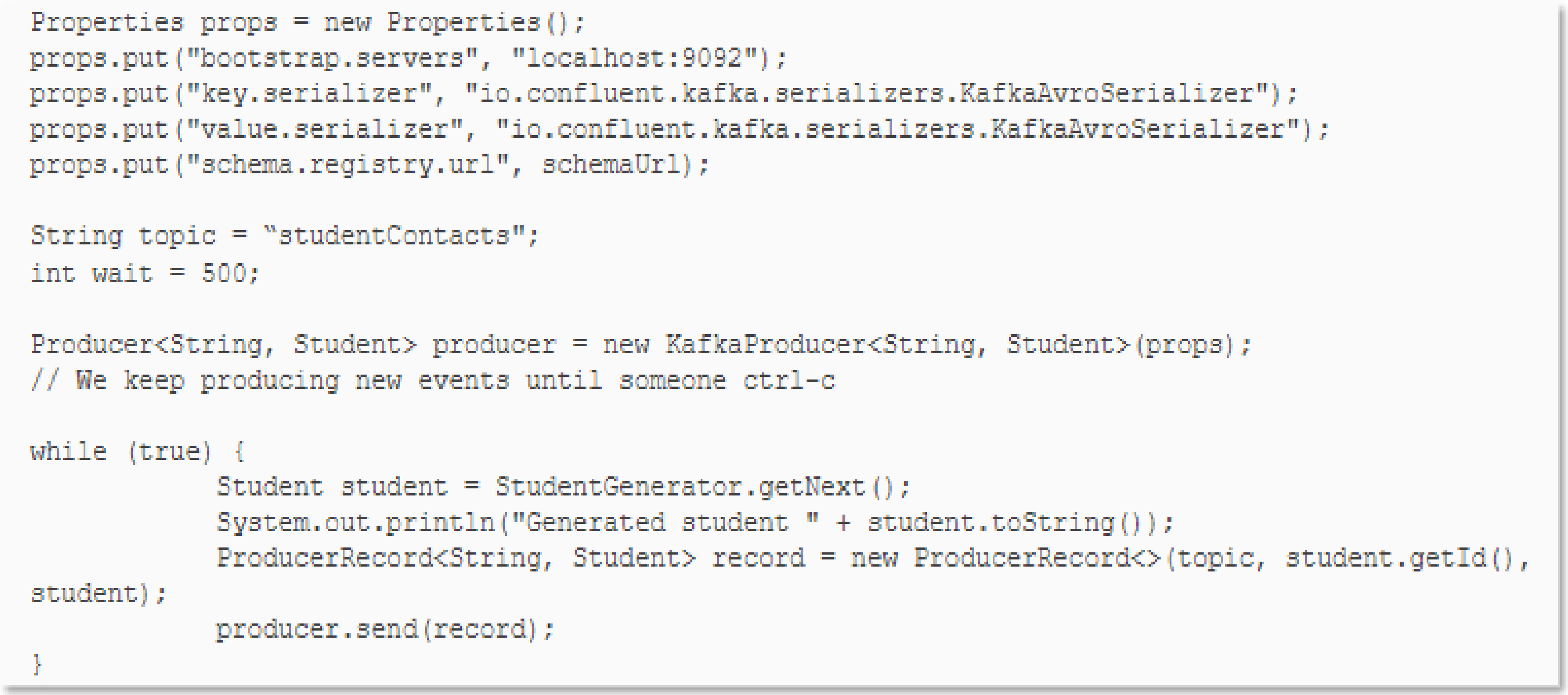
We *store* the *identifier* for the schema in the *record*

Storing the schema in the registry and pulling it up when required—is done in the serializers and deserializers



Using Avro Records with Kafka

Producing generated Avro objects to Kafka:



```
Properties props = new Properties();
props.put("bootstrap.servers", "localhost:9092");
props.put("key.serializer", "io.confluent.kafka.serializers.KafkaAvroSerializer");
props.put("value.serializer", "io.confluent.kafka.serializers.KafkaAvroSerializer");
props.put("schema.registry.url", schemaUrl);

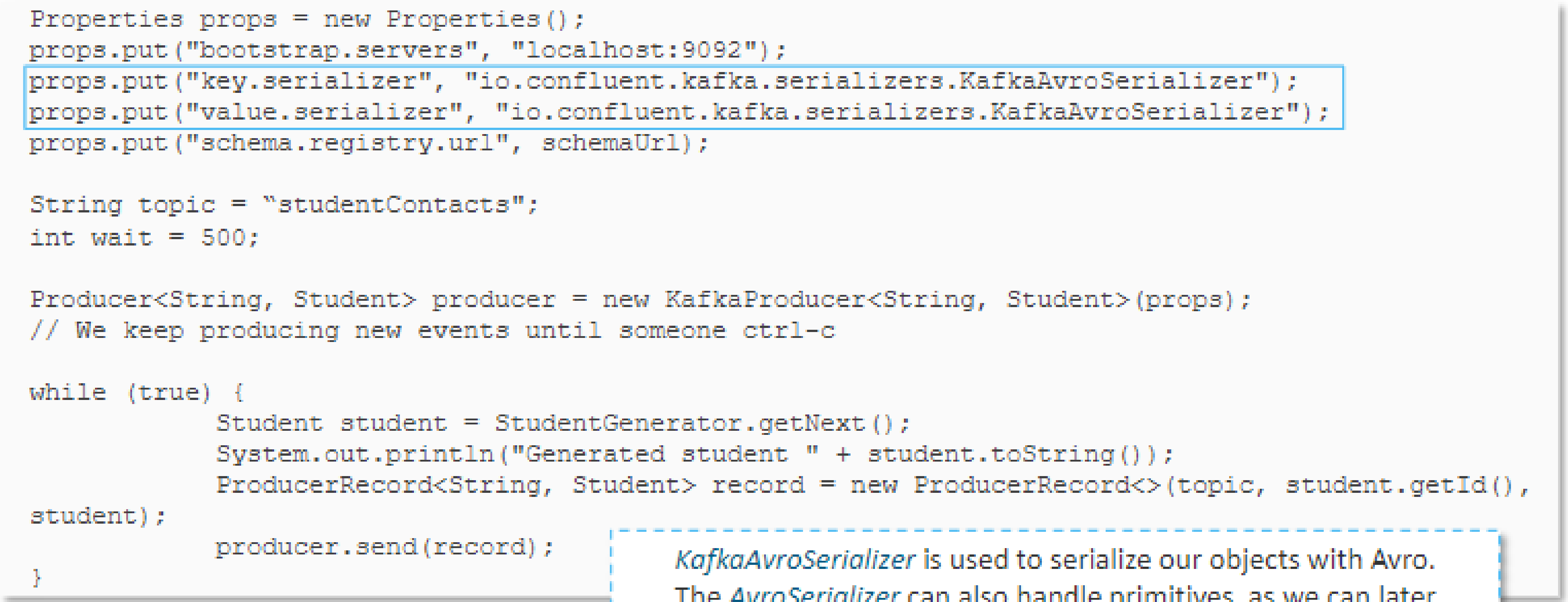
String topic = “studentContacts";
int wait = 500;

Producer<String, Student> producer = new KafkaProducer<String, Student>(props);
// We keep producing new events until someone ctrl-c

while (true) {
            Student student = StudentGenerator.getNext();
            System.out.println("Generated student " + student.toString());
            ProducerRecord<String, Student> record = new ProducerRecord<>(topic, student.getId(),
student);
            producer.send(record);
}
```

Using Avro Records with Kafka

Producing generated Avro objects to Kafka:



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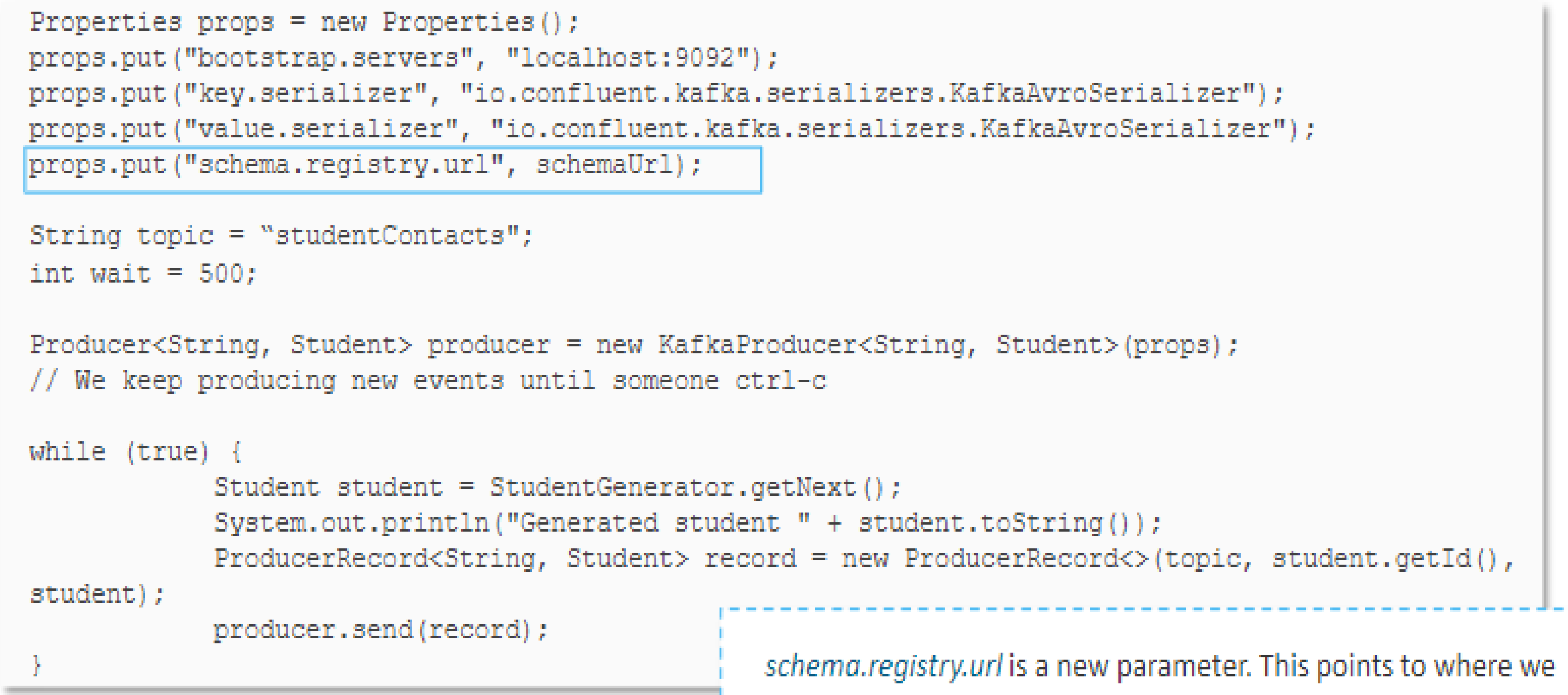
student);
            producer.send(record);
}
```

KafkaAvroSerializer is used to serialize our objects with Avro. The *AvroSerializer* can also handle primitives, as we can later use *String* as the record key and our student object as the value

Using Avro Records with Kafka

Producing generated Avro objects to Kafka:



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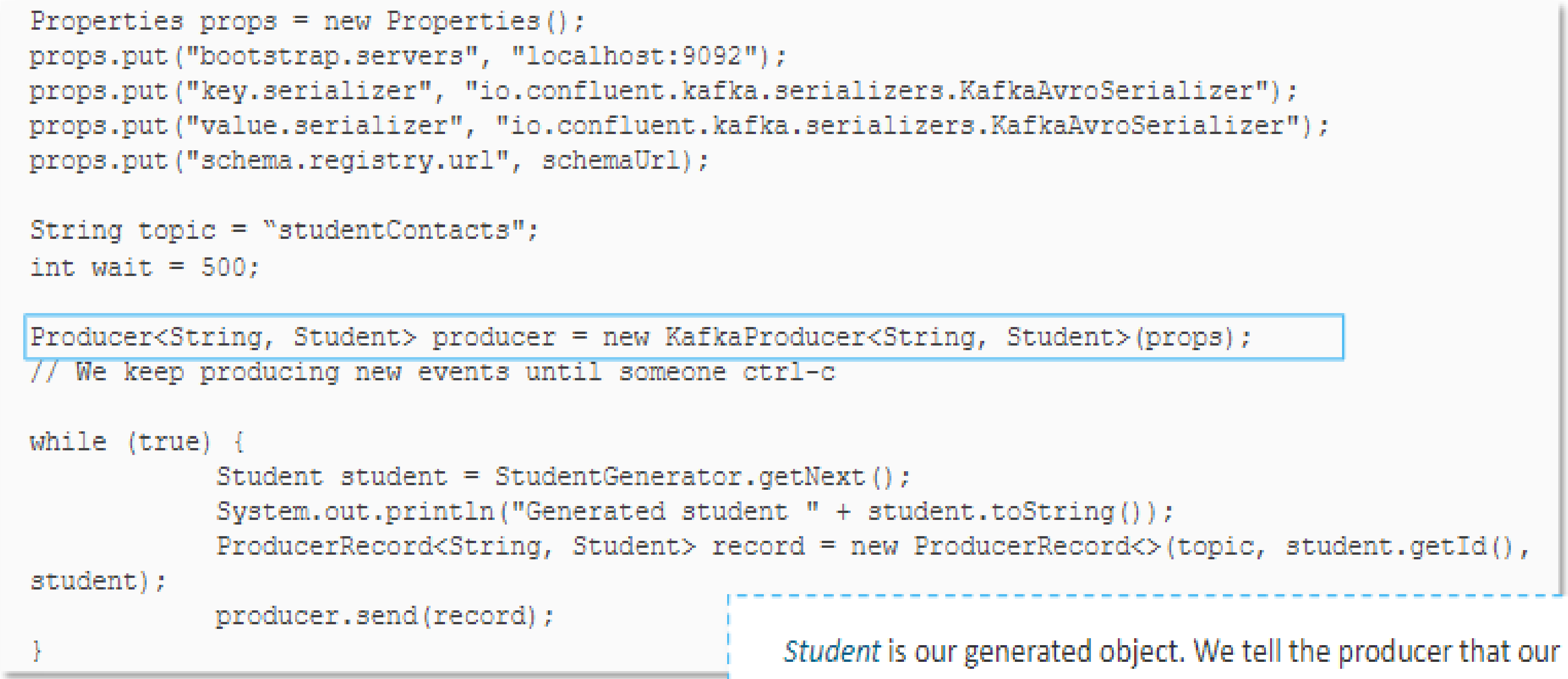
            System.out.println("Generated student " + student.toString());
            ProducerRecord<String, Student> record = new ProducerRecord<>(topic, student.getId(),
student);
            producer.send(record);
}
```

schema.registry.url is a new parameter. This points to where we store the schemas

Using Avro Records with Kafka

Producing generated Avro objects to Kafka:



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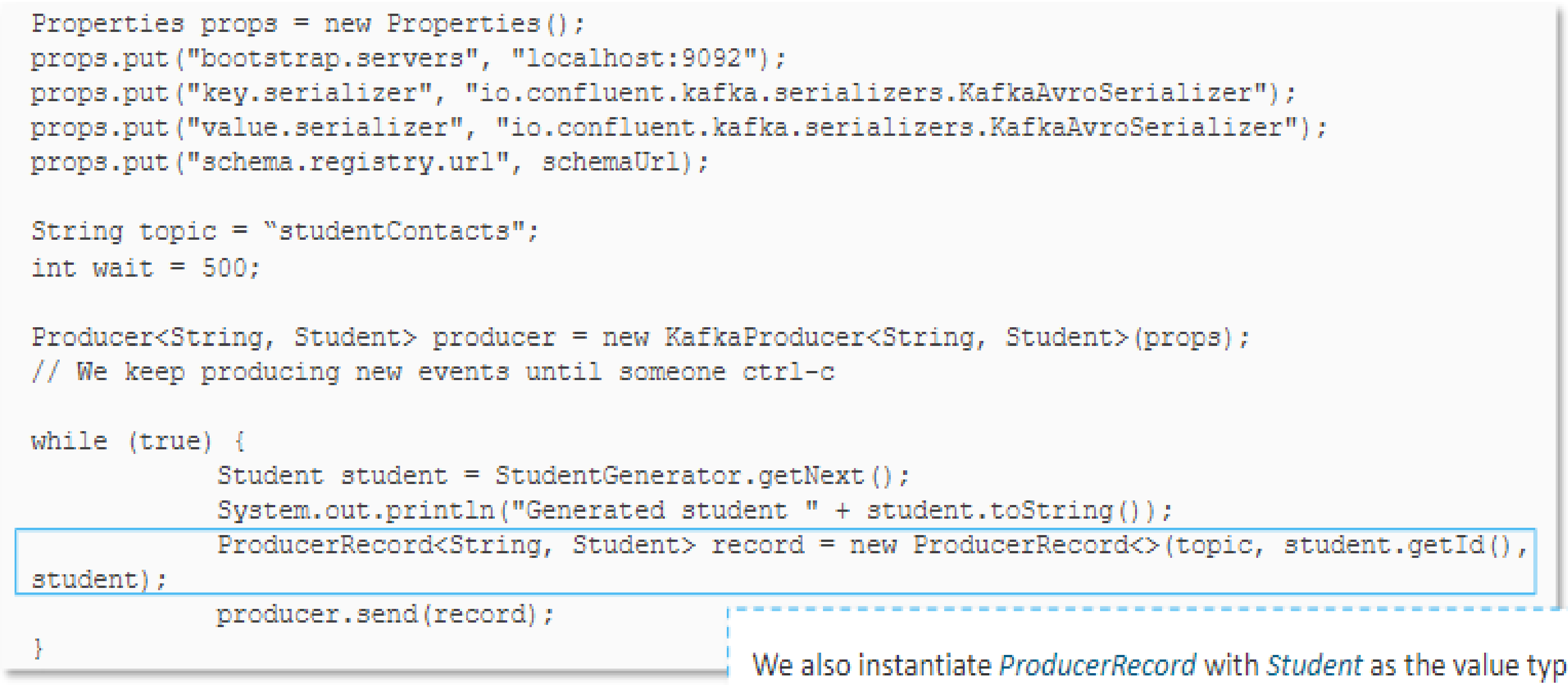
            Student student = StudentGenerator.getNext();
            System.out.println("Generated student " + student.toString());
            ProducerRecord<String, Student> record = new ProducerRecord<>(topic, student.getId(),
student);
            producer.send(record);
}
```

Student is our generated object. We tell the producer that our records will contain *Student* as the value

Using Avro Records with Kafka

Producing generated Avro objects to Kafka:



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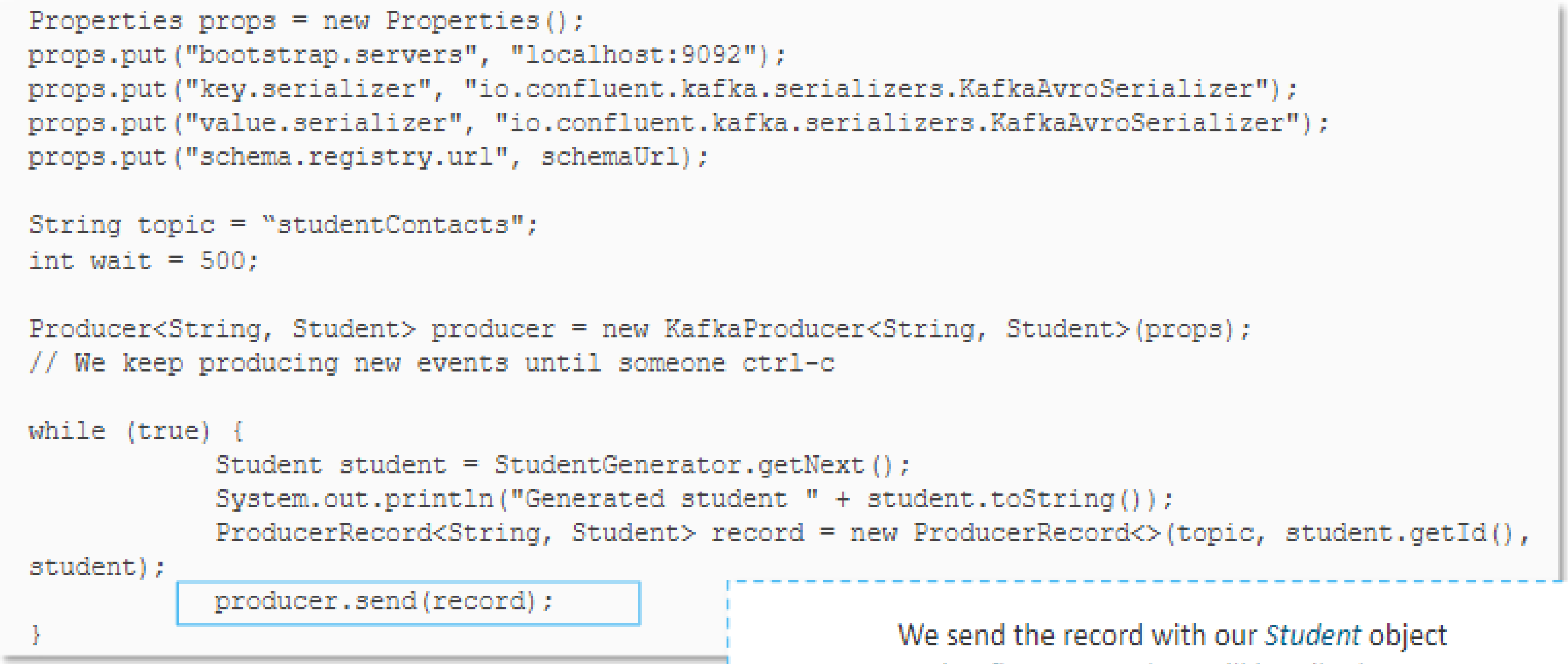
// We keep producing new events until someone ctrl-c

while (true) {
            Student student = StudentGenerator.getNext();
            System.out.println("Generated student " + student.toString());
            ProducerRecord<String, Student> record = new ProducerRecord<>(topic, student.getId(),
student);
            producer.send(record);
}
```

We also instantiate *ProducerRecord* with *Student* as the value type, and pass a *Student* object when creating the new record

Using Avro Records with Kafka

Producing generated Avro objects to Kafka:



```
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props.put("bootstrap.servers", "localhost:9092");
props.put("key.serializer", "io.confluent.kafka.serializers.KafkaAvroSerializer");
props.put("value.serializer", "io.confluent.kafka.serializers.KafkaAvroSerializer");
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int wait = 500;

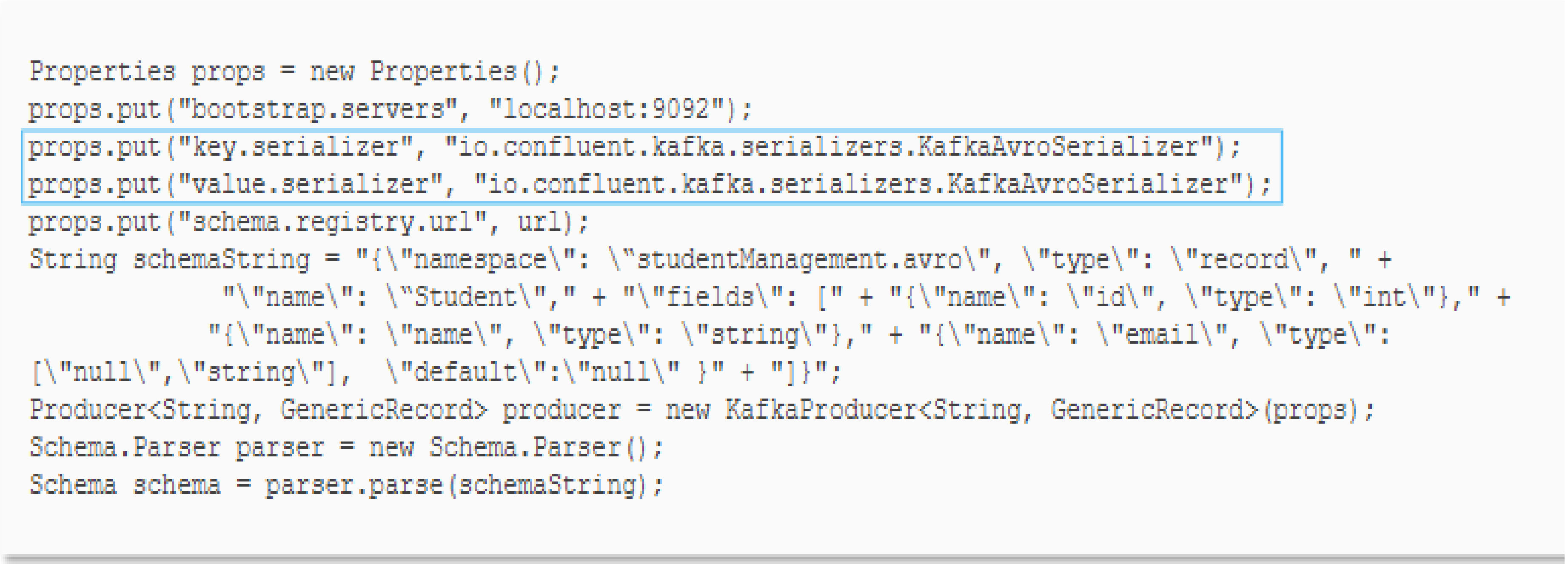
Producer<String, Student> producer = new KafkaProducer<String, Student>(props);
// We keep producing new events until someone ctrl-c

while (true) {
            Student student = StudentGenerator.getNext();
            System.out.println("Generated student " + student.toString());
            ProducerRecord<String, Student> record = new ProducerRecord<>(topic, student.getId(),
student);
            producer.send(record);
}
```

We send the record with our *Student* object and *KafkaAvroSerializer* will handle the rest

Let’s see how to provide schema in Avro records

Providing Schema in Avro Records



```
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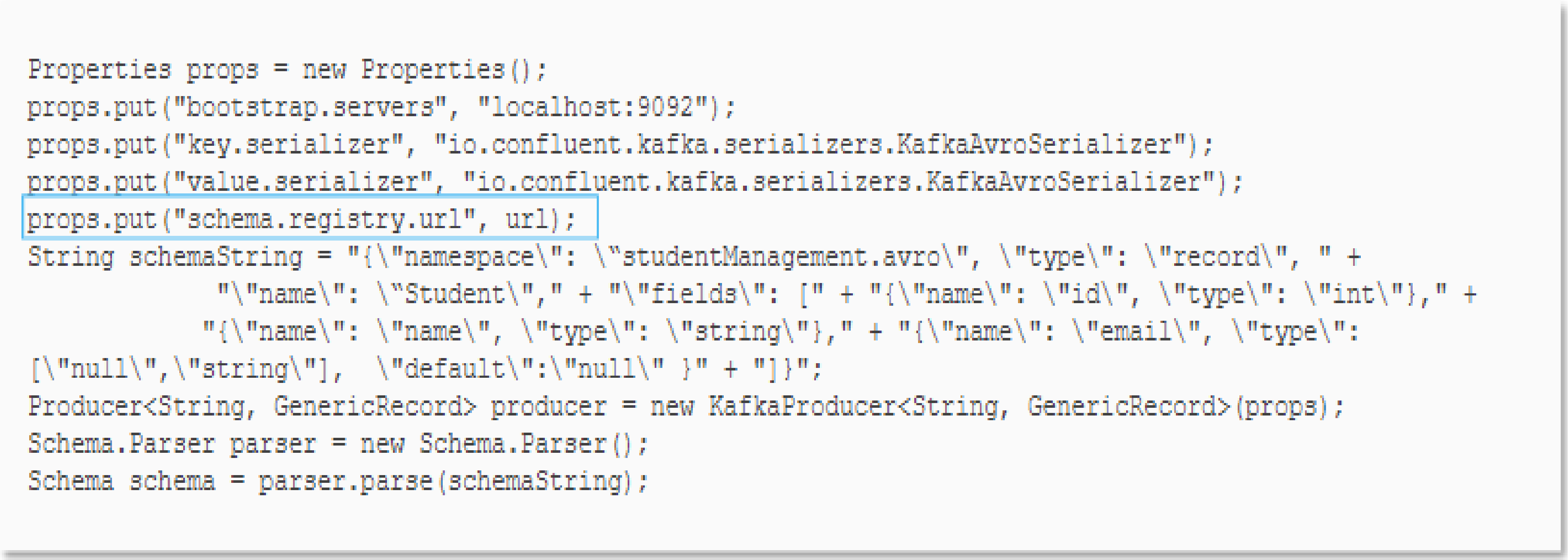
props.put("key.serializer", "io.confluent.kafka.serializers.KafkaAvroSerializer");
props.put("value.serializer", "io.confluent.kafka.serializers.KafkaAvroSerializer");
props.put("schema.registry.url", url);
String schemaString = "{\"namespace\": \“studentManagement.avro\", \"type\": \"record\", " +
             "\"name\": \“Student\"," + "\"fields\": [" + "{\"name\": \"id\", \"type\": \"int\"}," +
            "{\"name\": \"name\", \"type\": \"string\"}," + "{\"name\": \"email\", \"type\":
[\"null\",\"string\"],  \"default\":\"null\" }" + "]}";
Producer<String, GenericRecord> producer = new KafkaProducer<String, GenericRecord>(props);
Schema.Parser parser = new Schema.Parser();
Schema schema = parser.parse(schemaString);
```

We still use the same *KafkaAvroSerializer*

Providing Schema in Avro Records



```
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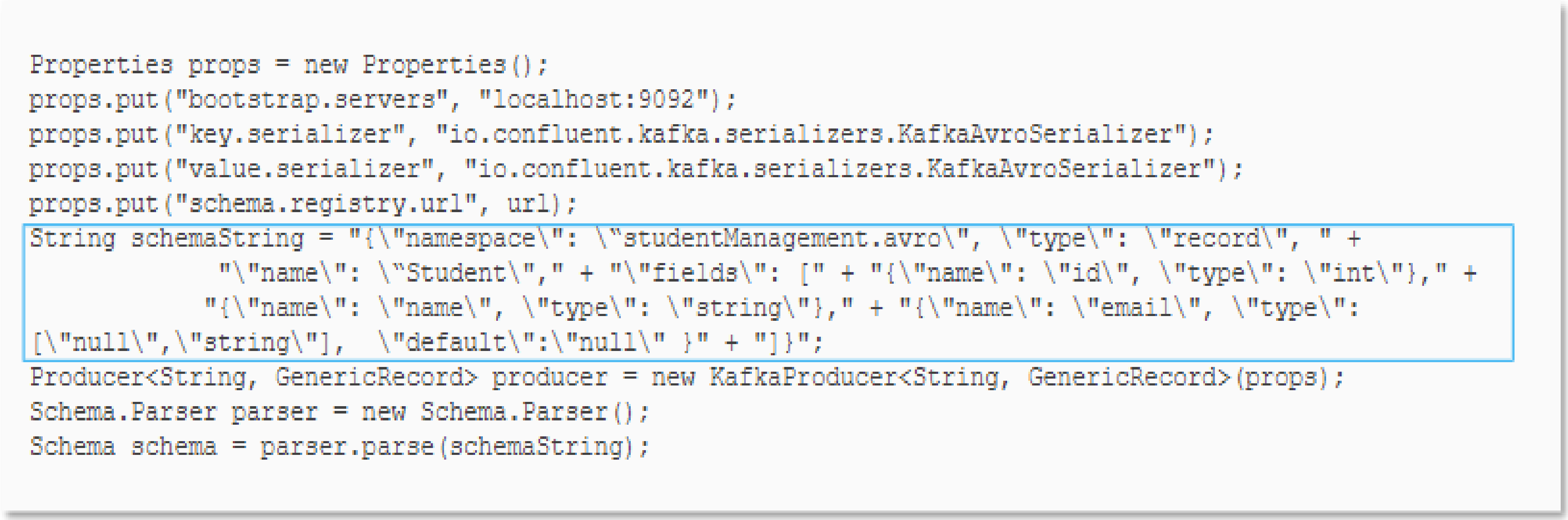
props.put("key.serializer", "io.confluent.kafka.serializers.KafkaAvroSerializer");
props.put("value.serializer", "io.confluent.kafka.serializers.KafkaAvroSerializer");
props.put("schema.registry.url", url);
String schemaString = "{\"namespace\": \"studentManagement.avro\", \"type\": \"record\", " +
             "\"name\": \"Student\"," + "\"fields\": [" + "{\"name\": \"id\", \"type\": \"int\"}," +
            "{\"name\": \"name\", \"type\": \"string\"}," + "{\"name\": \"email\", \"type\":
[\"null\",\"string\"],  \"default\":\"null\" }" + "]}";
Producer<String, GenericRecord> producer = new KafkaProducer<String, GenericRecord>(props);
Schema.Parser parser = new Schema.Parser();
Schema schema = parser.parse(schemaString);
```

And we provide the URI of the same schema registry.

Providing Schema in Avro Records



```
Properties props = new Properties();
props.put("bootstrap.servers", "localhost:9092");
props.put("key.serializer", "io.confluent.kafka.serializers.KafkaAvroSerializer");
props.put("value.serializer", "io.confluent.kafka.serializers.KafkaAvroSerializer");
props.put("schema.registry.url", url);
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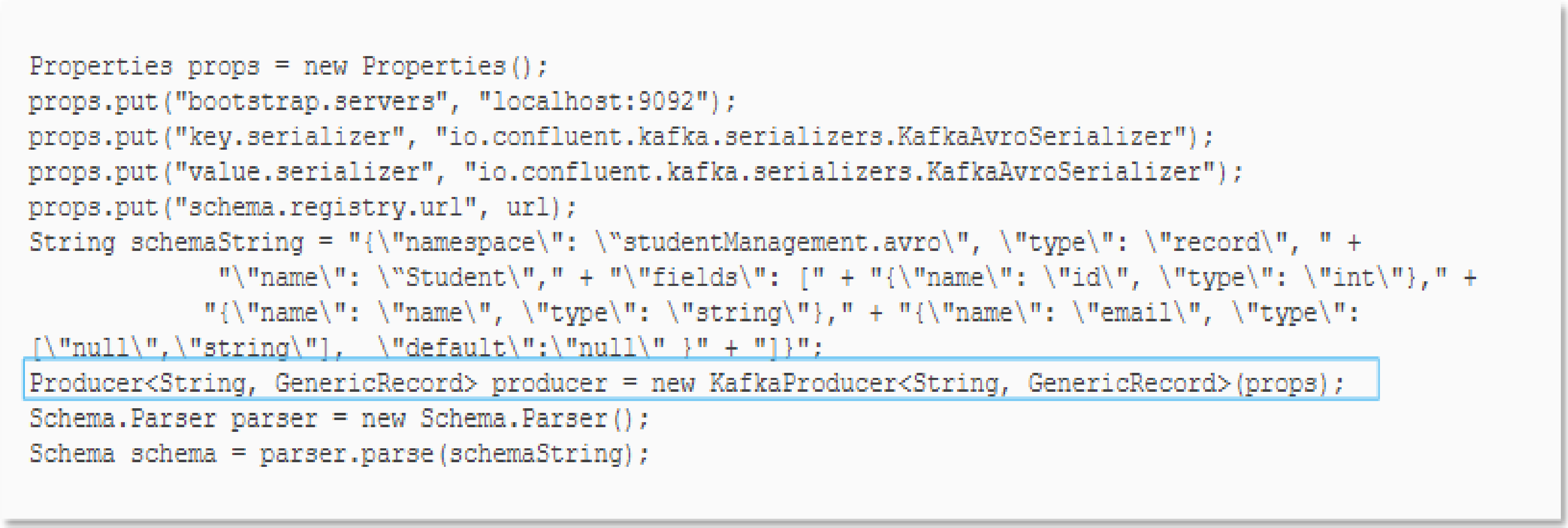
            "{\"name\": \"name\", \"type\": \"string\"}," + "{\"name\": \"email\", \"type\":
[\"null\",\"string\"],  \"default\":\"null\" }" + "]}";
Producer<String, GenericRecord> producer = new KafkaProducer<String, GenericRecord>(props);
Schema.Parser parser = new Schema.Parser();
Schema schema = parser.parse(schemaString);
```

But now we also need to provide the Avro schema, since it is not provided by the Avro-generated object.

Providing Schema in Avro Records



```
Properties props = new Properties();
props.put("bootstrap.servers", "localhost:9092");
props.put("key.serializer", "io.confluent.kafka.serializers.KafkaAvroSerializer");
props.put("value.serializer", "io.confluent.kafka.serializers.KafkaAvroSerializer");
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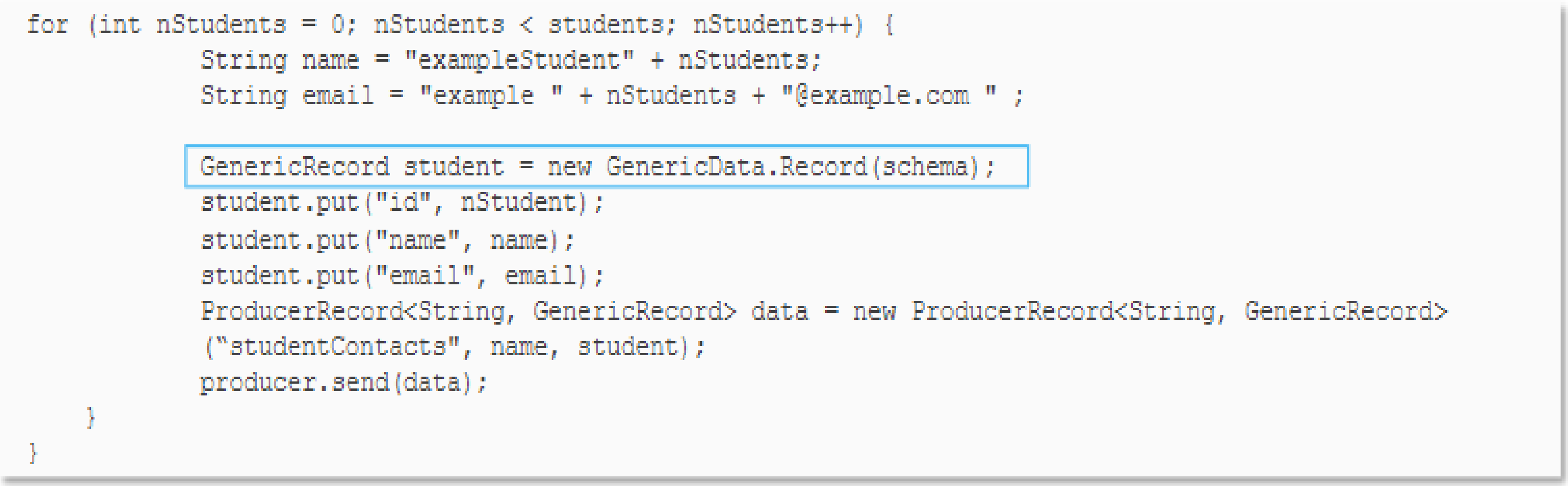
String schemaString = "{\"namespace\": \“studentManagement.avro\", \"type\": \"record\", " +
             "\"name\": \“Student\"," + "\"fields\": [" + "{\"name\": \"id\", \"type\": \"int\"}," +
            "{\"name\": \"name\", \"type\": \"string\"}," + "{\"name\": \"email\", \"type\":
[\"null\",\"string\"],  \"default\":\"null\" }" + "]}";
Producer<String, GenericRecord> producer = new KafkaProducer<String, GenericRecord>(props);
Schema.Parser parser = new Schema.Parser();
Schema schema = parser.parse(schemaString);
```

Our object type is an Avro *GenericRecord*, which we initialize with our schema and the data we want to write.

Providing Schema in Avro Records



```
for (int nStudents = 0; nStudents < students; nStudents++) {
            String name = "exampleStudent" + nStudents;
            String email = "example " + nStudents + "@example.com " ;

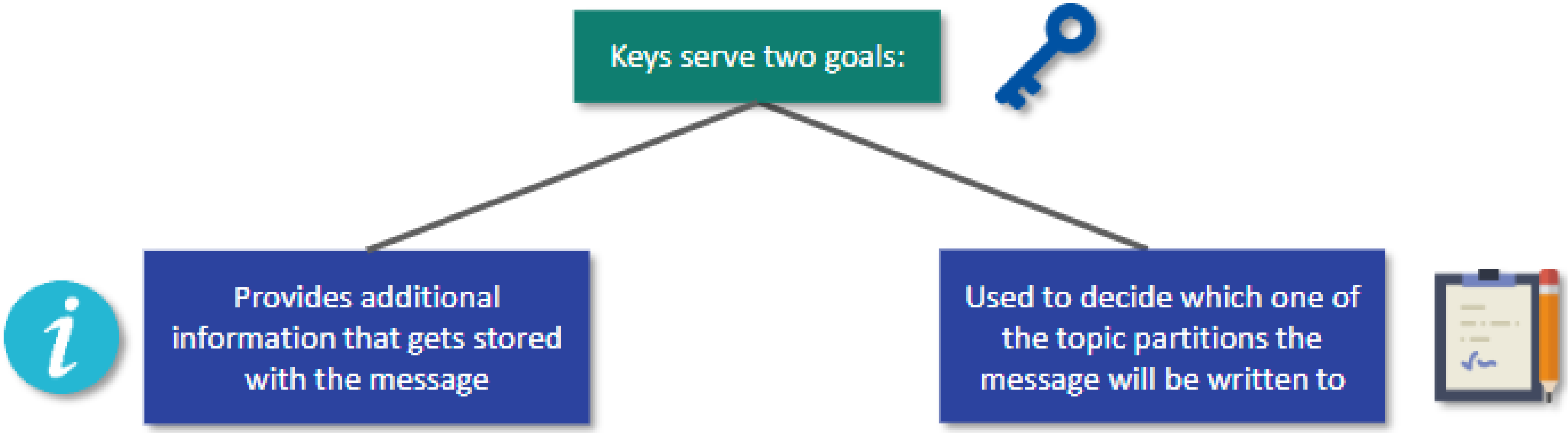
            GenericRecord student = new GenericData.Record(schema);
            student.put("id", nStudent);
            student.put("name", name);
            student.put("email", email);
            ProducerRecord<String, GenericRecord> data = new ProducerRecord<String, GenericRecord>
            ("studentContacts", name, student);
            producer.send(data);
    }
}
```

Value of the *ProducerRecord* is a *GenericRecord* that contains our schema and data
Serializer can fetch the schema from schema registry, and serialize the object data

Let’s take a look at What is a Partition?

Partitions

- *ProducerRecord* objects includes a topic name, key & value
- Kafka messages are key-value pairs
- *ProduceRecord* object can be with just a topic and a value
- Key is set to null by default
- Most applications produce records with keys



Keys serve two goals:

Provides additional information that gets stored with the message

Used to decide which one of the topic partitions the message will be written to

Partitions

- All messages with the same key will go to the same partition.
- All the records for a single key will be read by the same process.

To create a key-value record, you simply create a ProducerRecord as follows:

```
ProducerRecord<Integer, String> record = new ProducerRecord<>("Employee", “Name", “James");
```

While creating messages with a null key, you can simply leave the key out:

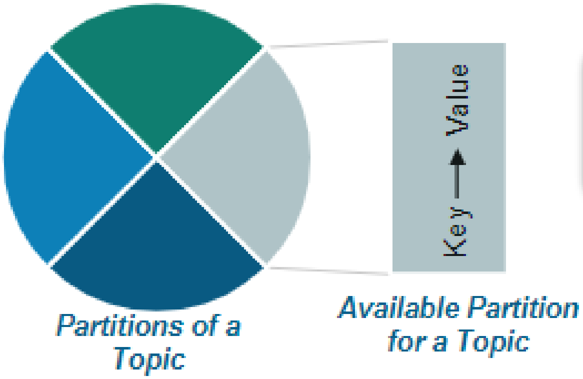
```
ProducerRecord<Integer, String> record = new ProducerRecord<>(“Employee", “James");
```

Here, the key will simply be set to *null*, which may indicate that a student name was missing on a form.

Partitions

If key is null and the default partitioner is used, the record is sent to one of the available partitions of the topic at random

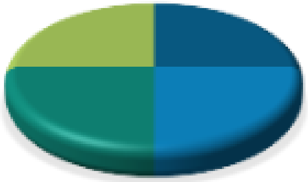
A round-robin algorithm will be used to balance the messages among the partitions

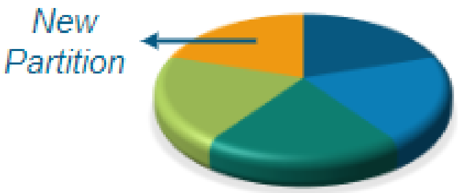


It's important that a key is always mapped to the same partition

Kafka hash the key, and use the result to map the message to a specific partition

Partitions





As the number of partitions is constant, records of a user will be written in a particular partition

This allows all kinds of optimization when reading data from partitions

If you add *new partitions* to the topic, old records can change partition

New records will get written to a different partition

☛ If partitioning keys is important, create topics with sufficient partitions and never add partitions

Implementing a Custom Partitioning Strategy

Kafka allow to partition data differently.

Scenario

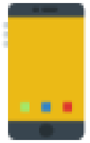
- There is a company that does so much business with their device called “*Calacs*”, that over 10% of their daily transactions are with this device.
- If you use default hash partitioning, the *Calacs* records will get allocated to the same partition as other accounts, resulting in one partition being about twice as large as the rest.

Problem

This can cause servers to run out of space and slows down processing.

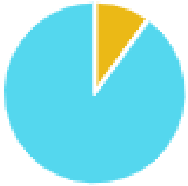
Solution

To solve this problem, we need to provide *Calacs* its own partition and then use hash



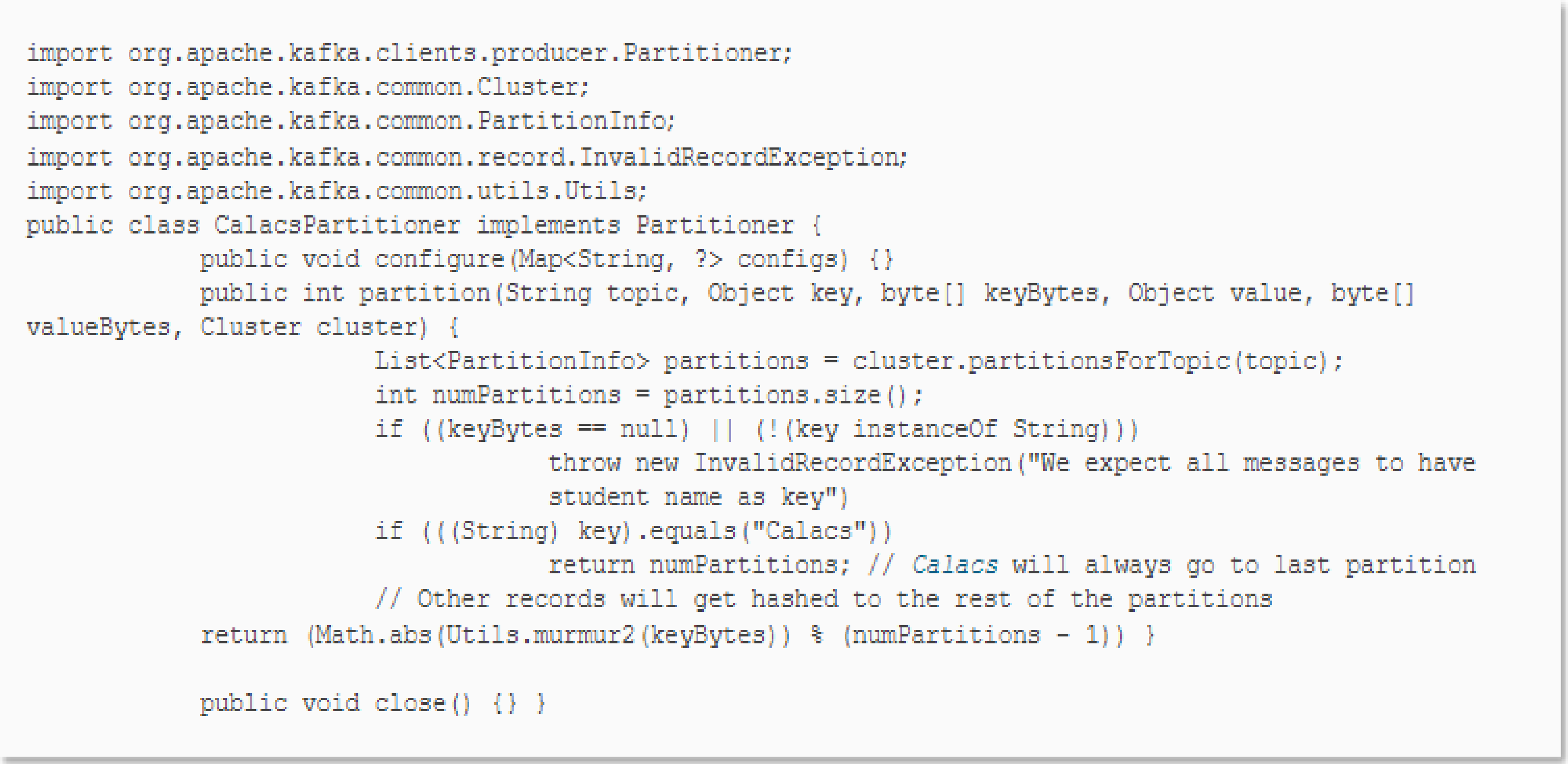
Calcs

Other devices



Sale

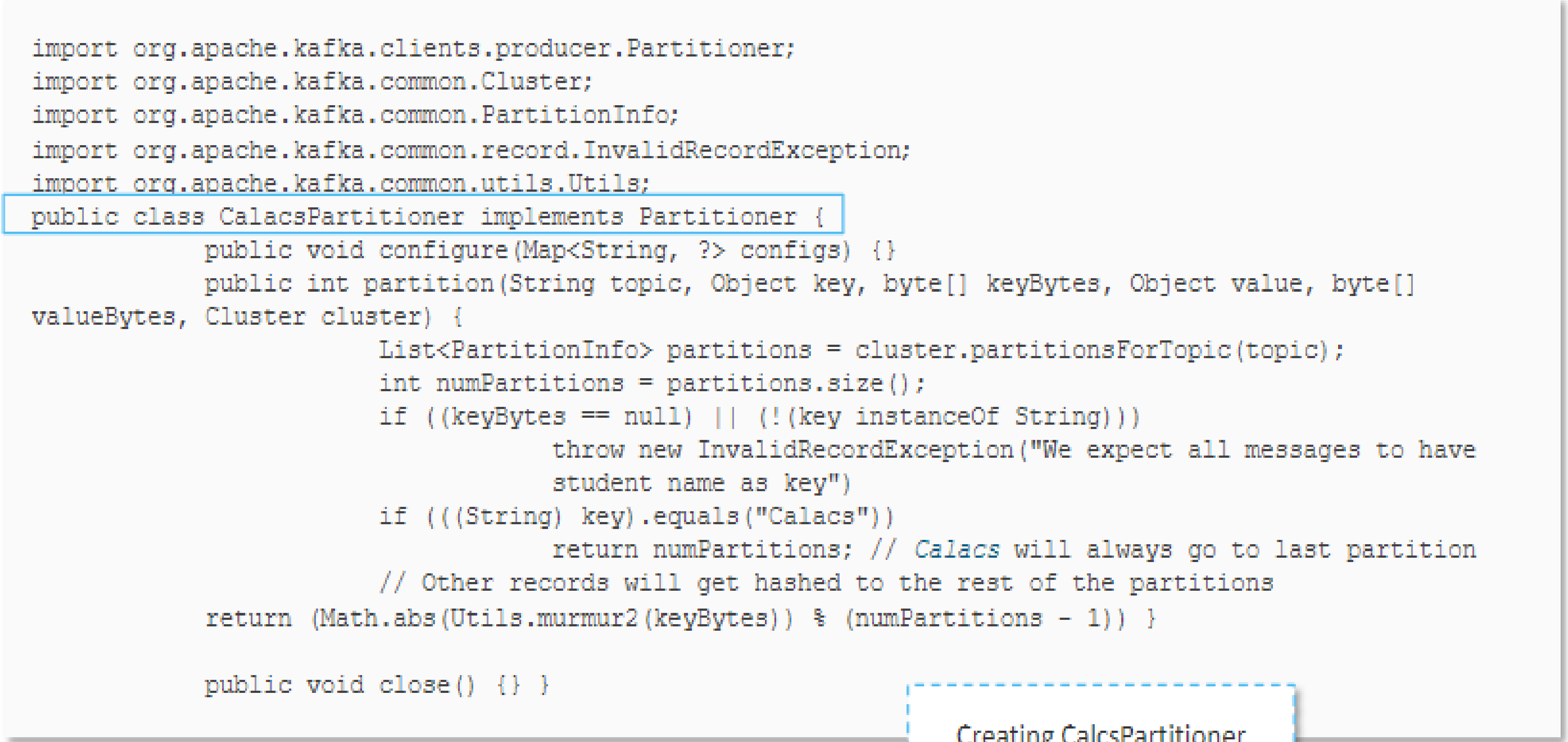
Implementing a Custom Partitioning Strategy



```
import org.apache.kafka.clients.producer.Partitioner;
import org.apache.kafka.common.Cluster;
import org.apache.kafka.common.PartitionInfo;
import org.apache.kafka.common.record.InvalidRecordException;
import org.apache.kafka.common.utils.Utils;
public class CalacsPartitioner implements Partitioner {
          public void configure(Map<String, ?> configs) {}
          public int partition(String topic, Object key, byte[] keyBytes, Object value, byte[]
valueBytes, Cluster cluster) {
                    List<PartitionInfo> partitions = cluster.partitionsForTopic(topic);
                    int numPartitions = partitions.size();
                    if ((keyBytes == null) || (!(key instanceOf String)))
                              throw new InvalidRecordException("We expect all messages to have
                              student name as key")
                    if (((String) key).equals("Calacs"))
                              return numPartitions; // Calacs will always go to last partition
                    // Other records will get hashed to the rest of the partitions
          return (Math.abs(Utils.murmur2(keyBytes)) % (numPartitions - 1)) }

          public void close() {} }
```

Implementing a Custom Partitioning Strategy



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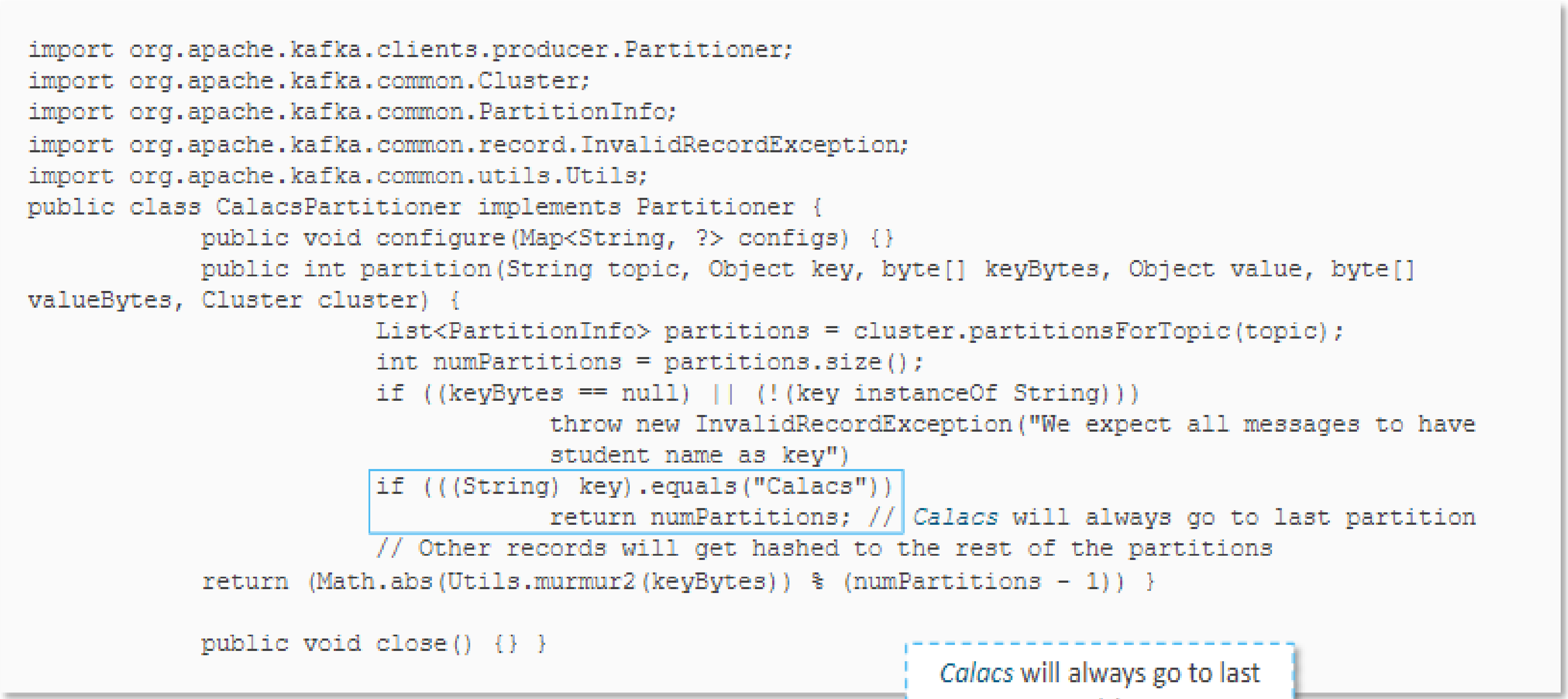
```

Creating CalcsPartitioner

Implementing a Custom Partitioning Strategy



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import org.apache.kafka.clients.producer.Partitioner;
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import org.apache.kafka.common.PartitionInfo;
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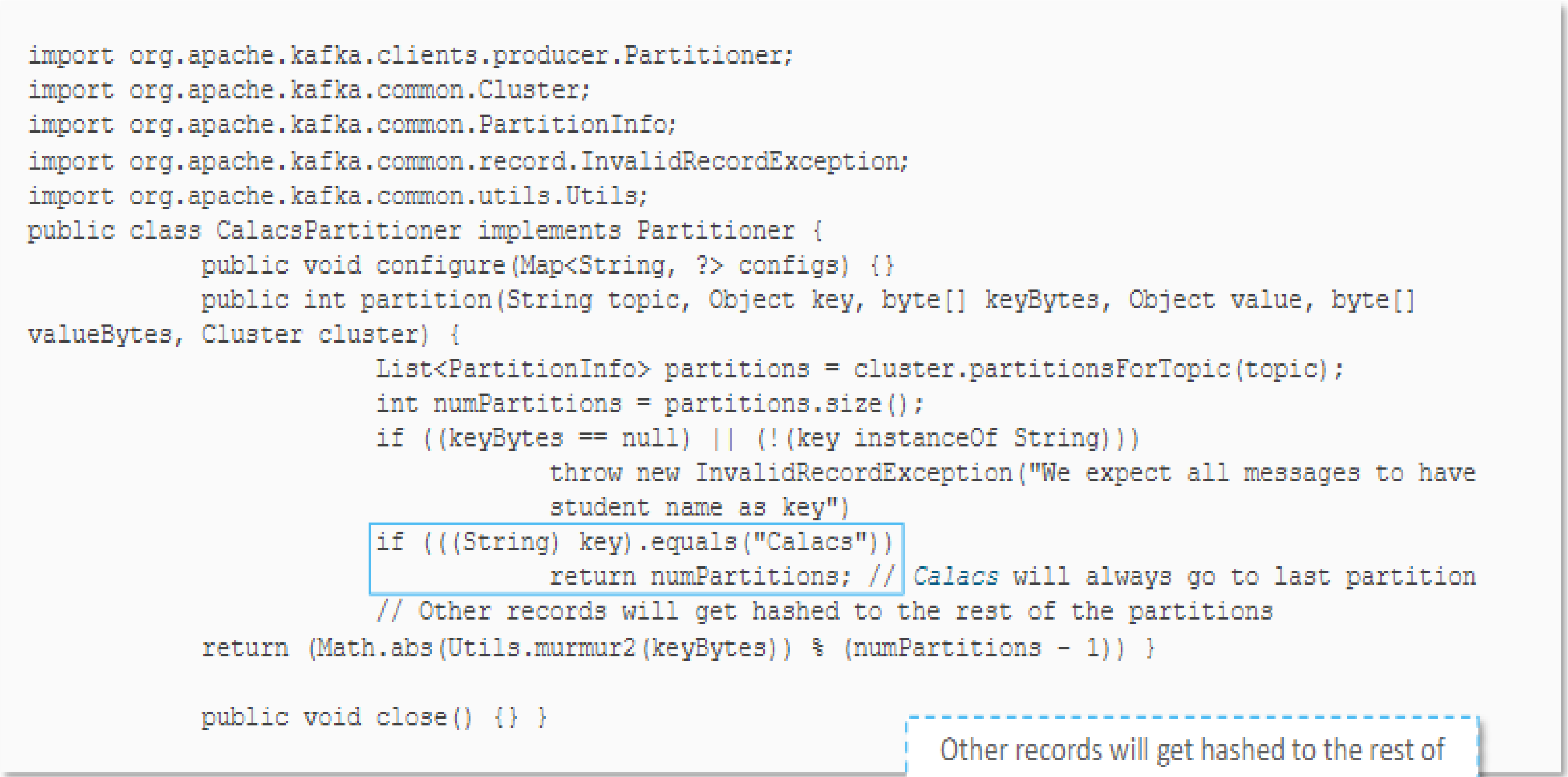
            public void close() {} }
```

Calacs will always go to last partition

Implementing a Custom Partitioning Strategy



```
import org.apache.kafka.clients.producer.Partitioner;
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import org.apache.kafka.common.PartitionInfo;
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            return (Math.abs(Utils.murmur2(keyBytes)) % (numPartitions - 1)) }

            public void close() {} }
```

Other records will get hashed to the rest of the partitions

Thank you!