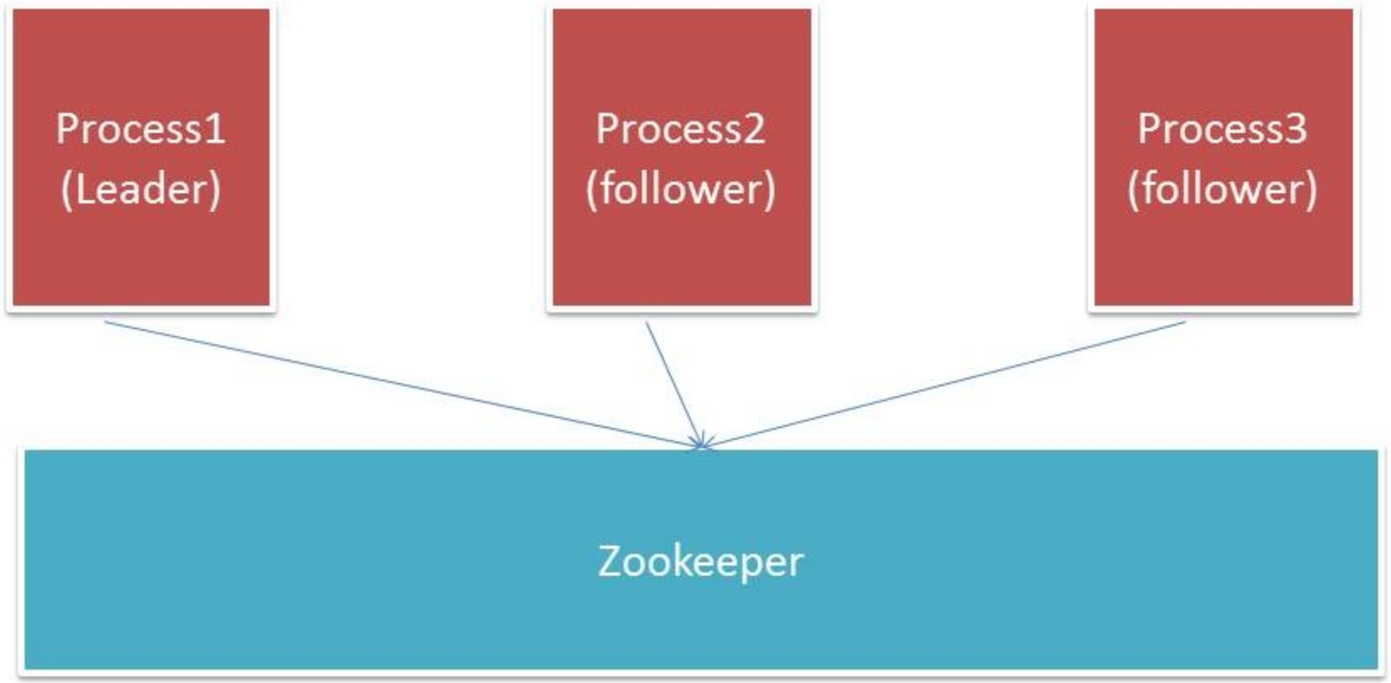
Welcome to the World of Distributed Messaging Queue

What is zookeeper?

- An open source, high performance coordination service for distributed application.
- Role of zookeeper
  - Configuration management
  - Distributed cluster management
    - Node join/leave
  - Leader election in distributed application
  - Distributed synchronization - Lock

Leader election

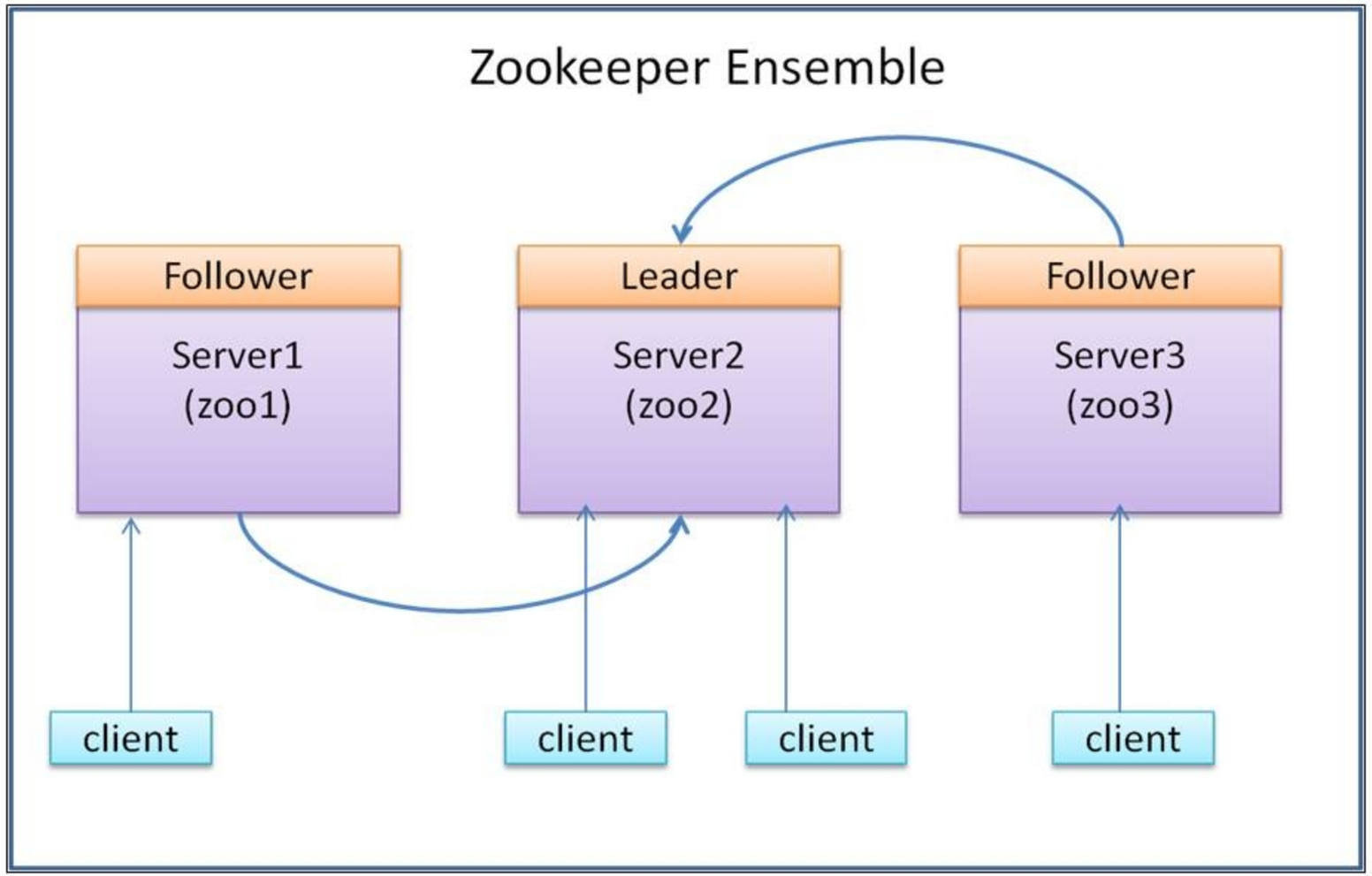


Applications and Companies which are using Zookeeper

Zookeeper Architecture

- One node in the cluster acts as the leader, while the rest are followers.
- All write requests come from clients are forwarded to leader node while follower's nodes only handle the read request.
- Limitation of Zookeeper?
  - We can't increase the write performance of Zookeeper ensemble by increase the number of nodes because all write operations go through the leader.

Zookeeper Architecture



1. Clients only connect to a single zookeeper server.
2. Client can read from any zookeeper node but writes go through the leader node.

Zookeeper configuration

- **dataDir**:- The directory to store the in-memory database snapshots and transactional log.
- **clientPort**:- The port used to listen for client connections.

Installation of Zookeeper cluster

- Download the latest stable Zookeeper release from the Zookeeper site (http://zookeeper.apache.org/releases.html). At this moment the latest version is zookeeper-3.4.6.
- Set ZK_HOME environment variable on each machine
- Create the configuration file zoo.cfg at $ZK_HOME/conf directory on each machine

Installation of Zookeeper cluster

- Add the following properties to zoo.cfg file on each machine:

```
tickTime=2000
dataDir=/var/zookeeper
clientPort=2181
initLimit=5
syncLimit=2
server.1=zoo1:2888:3888
server.2=zoo2:2888:3888
server.3=zoo3:2888:3888
```

- Where, zoo1, zoo2 and zoo3 are the IP's of Zookeeper nodes.

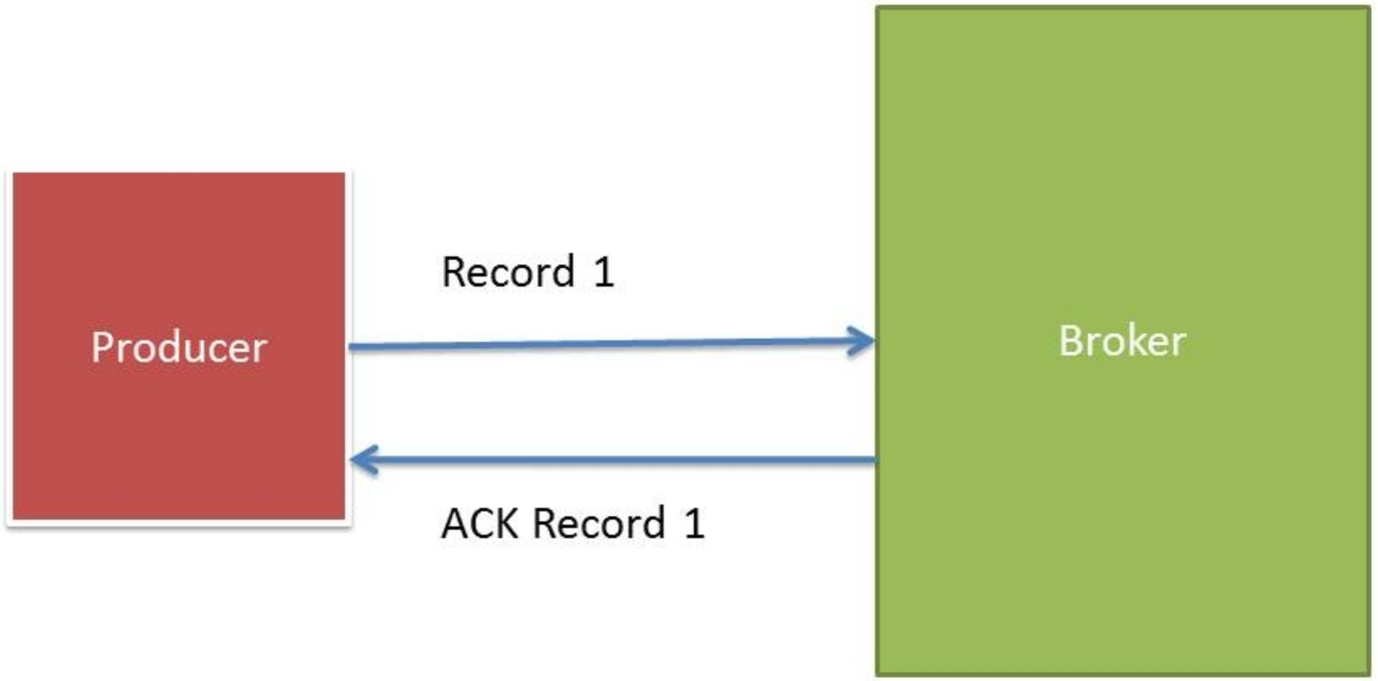
Kafka Produce Type

- Types of Producer
  - Sync
  - Async
- Sync : Producer push message in Kafka and wait for an acknowledgement.
- Async: Producer continuous push messages into Kafka without waiting for acknowledgement

Kafka Produce Type

- The **producer.type** property is used to Define the producer type.
- Valid values are (1) **async** for asynchronous send and (2) **sync** for synchronous send.
- Data may loss in case of **async** producer.

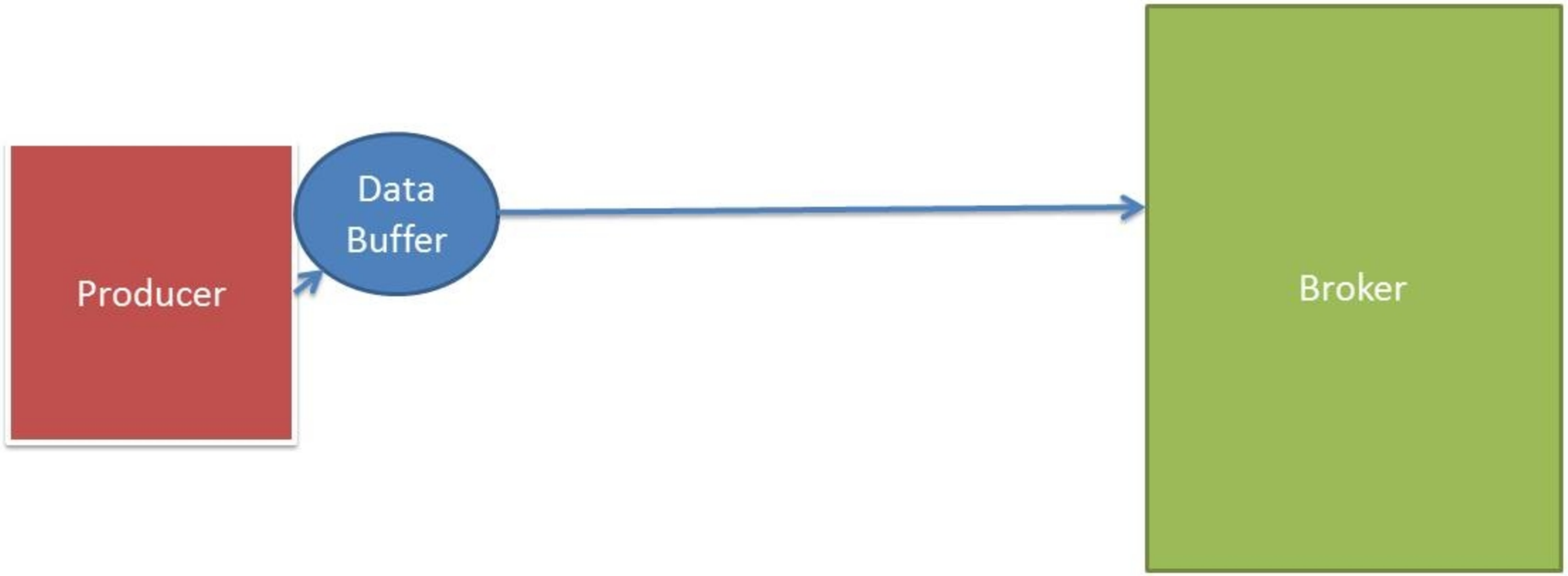
Sync Producer



Advantage of Async Producer

- **Async** producer allow to batch the set of messages and store them in one go. By using, Async producer we can achieve the better throughput
- **Aysnc** Producer increase the latency.
  - How?
  - It buffers the data for certain amount of time, which will delay the processing of record.

Async Producer



Async Producer Configuration

- The property **batch.num.messages** define the number of message you want to send in one batch.
- The property **queue.buffering.max.ms** define the maximum time to buffer data. For example a setting of 100 will try to batch together 100ms of messages to send at once.
- What will happen? If user set both the properties:
  - The producer will wait until **batch.num.messages** size reach or **queue.buffer.max.ms** is reached.

Async Producer Configuration

- The property **queue.buffering.max.messages** define the maximum number of unsent messages that can be queued up the producer when using async mode before either the producer must be blocked or data must be dropped.
- The property **queue.enqueue.timeout.ms** define the amount of time to block before dropping messages when running in async mode and the buffer has reached **queue.buffering.max.messages**.
  - If set to 0 events will be enqueued immediately or dropped if the queue is full (the producer send call will never block).
  - If set to -1 the producer will block indefinitely and never willingly drop a send.

Can we batch the messages in Sync Producer?

- **Answer:** Kafka doesn't support batching in case of sync producer.

- We can perform the manual batching at producer end and sent the list of batches as single Kafka record.

- Data may lost while preparing the batching at producer end.

- We need to write the custom encoder/decoder to covert list into bytes and vice versa. As we need to serialize the data before sending over network

More Producer configuration

- request.required.acks:
  - 0, which means that the producer never waits for an acknowledgement from the broker.
  - 1, which means that the producer gets an acknowledgement after the leader replica has received the data.
  - -1, which means that the producer gets an acknowledgement after all in-sync replicas have received the data.
- request.timeout.ms:
  - The amount of time the broker will wait trying to meet the **request.required.acks** requirement before sending back an error to the client.

Async Producer – Hands-on

- Push data into Kafka
- Consumer to consume data from Kafka
- Again, start pushing data into Kafka and abruptly killed the producer
- Some data will be lost

Sync Producer batching – Hand-on

- Push the batch of 10 records in each send request.
- We need to write the custom serializer/deserializer to serialize list into bytes.
- We can write serializer by implements the kafka. serializer.encoder interface.

ISR – In Sync Replica

- All the replica which are in sync with leader is called In sync replica
- The leader keeps track of the set of "in sync" nodes. If a follower dies, gets stuck, or falls behind, the leader will remove it from the list of in sync replicas.
- How leader will identify, whether the replica is in-sync with leader or not?

ISR- In Sync Replica

- replica.lag.max.messages
  - If a replica falls more than this many messages behind the leader, the leader will remove the follower from ISR and treat it as dead.
- replica.lag.time.max.ms
  - If a follower hasn't sent any fetch requests for this window of time, the leader will remove the follower from ISR (in-sync replicas) and treat it as dead.

ISR – In Sync Replication

- This ISR set is persisted to ZooKeeper whenever it changes. Because of this, any replica in the ISR is eligible to be elected leader.
- A message is considered "committed" when all in sync replicas for that partition have applied it to their log.
- Only committed messages are ever given out to the consumer. This means that the consumer need not worry about potentially seeing a message that could be lost if the leader fails.

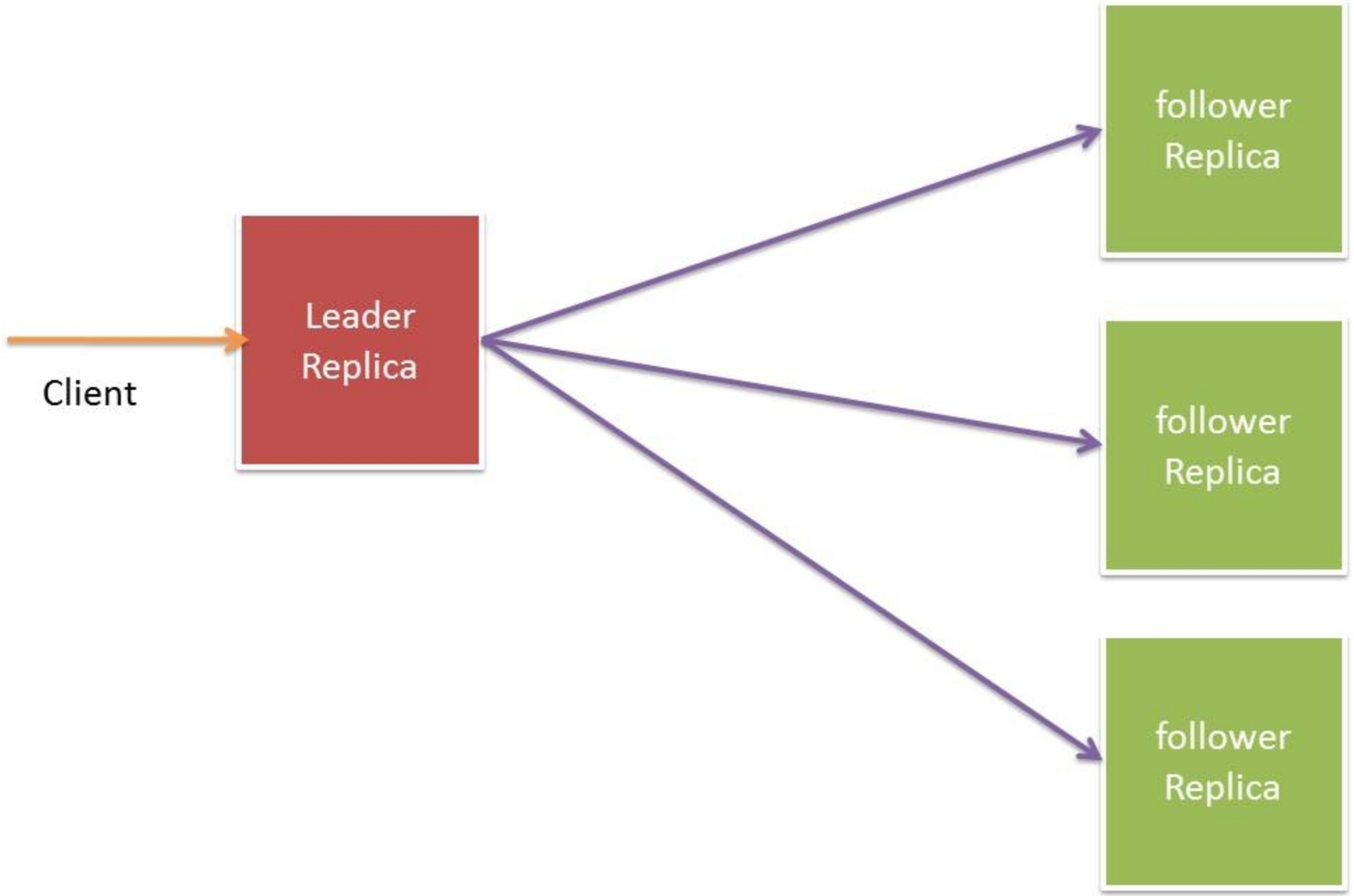
Replication

- There are two typical approaches of maintaining strongly consistent replicas:
  - The primary-backup approach
  - The quorum-based approach

Primary Replication

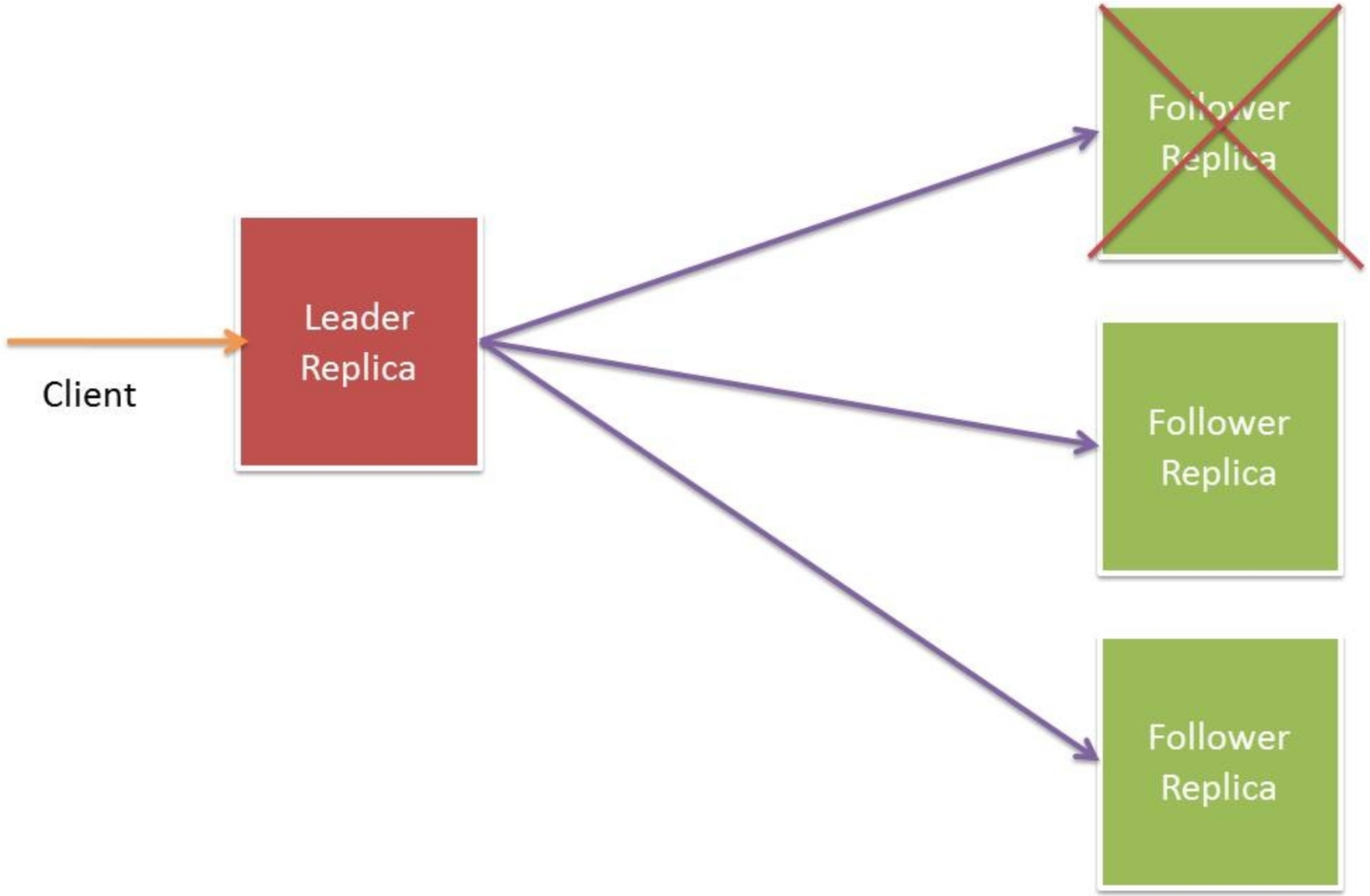
- Primary Approach:
  - In primary-backup replication, the leader waits until the write completes on every replica in the group (ISR) before acknowledging the client**. If one of the replicas is down, the leader drops it from the current group and continues to write to the remaining replicas.** A failed replica is allowed to rejoin the group if it comes back and catches up with the leader.

Primary Replication



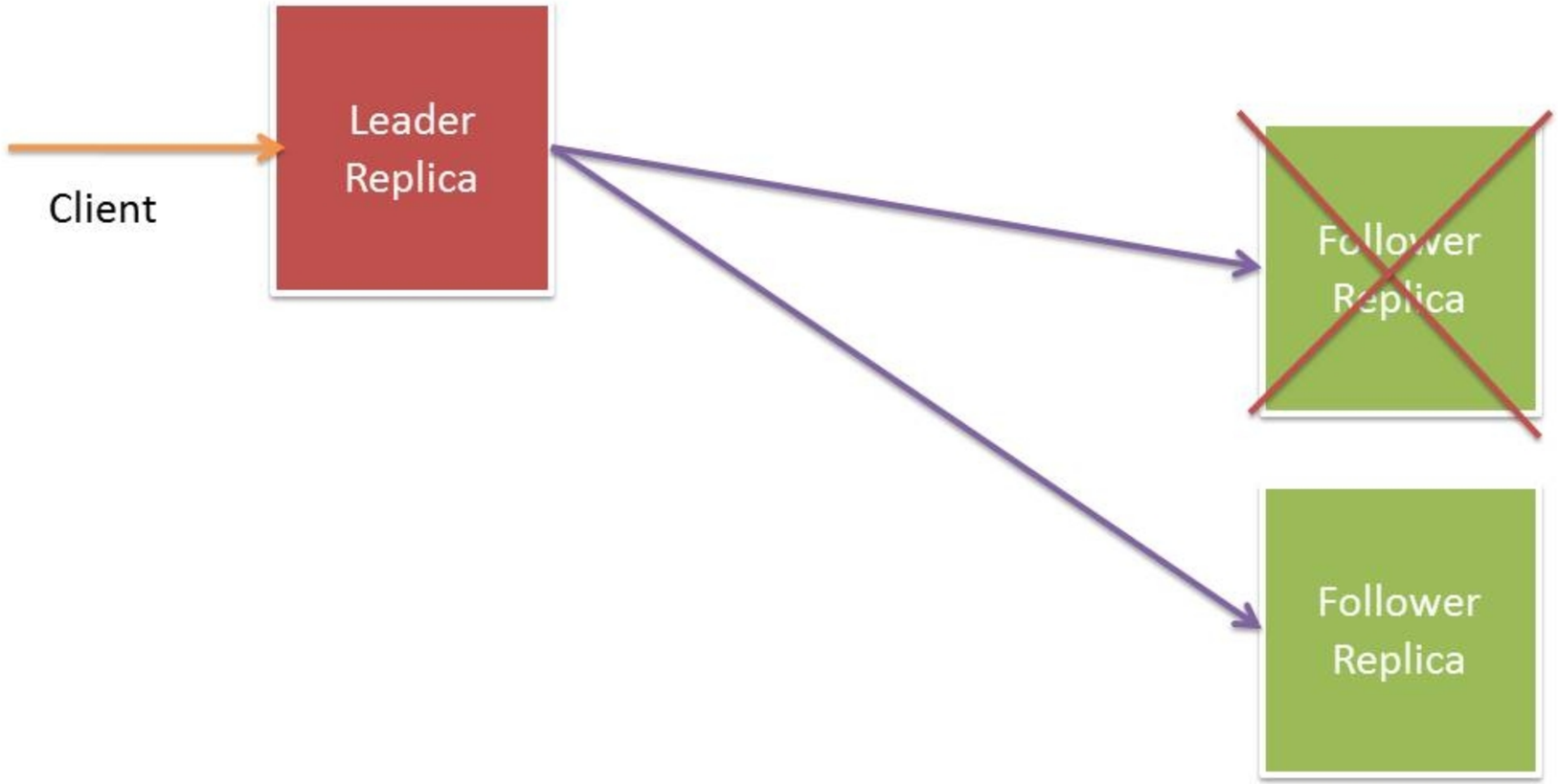
Send data to all in sync replica.

Primary Replication



- Send data to all in sync replica.
- If follower is down or lack behind with leader, then it will remove it from the list of ISR
- Sync Producer continue able to push data

Primary Replication

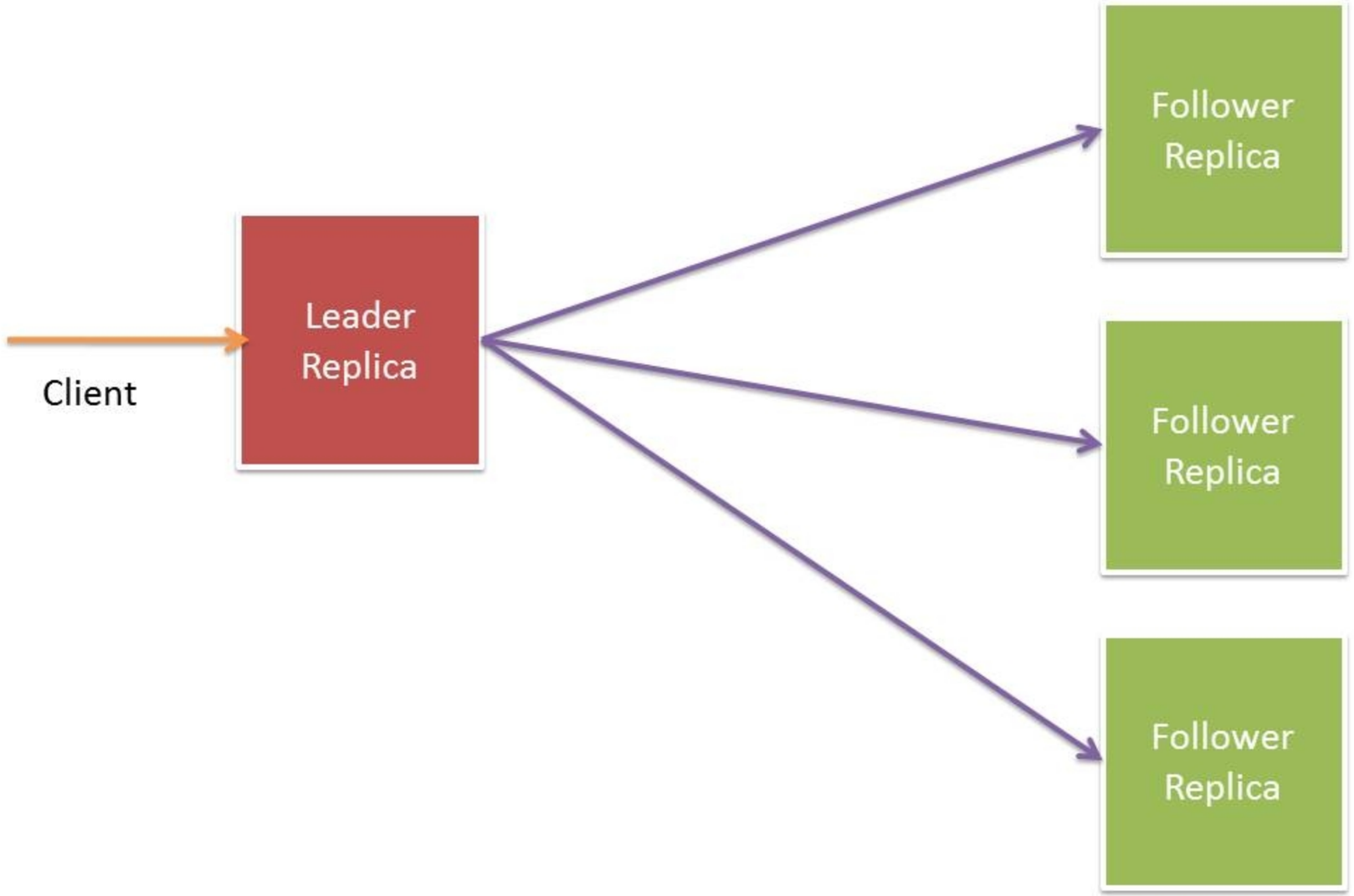


- Send data to all in sync replica.
- If follower is down or lack behind with leader, then it will remove form the list of ISR
- Sync Producer continue able to push data even single node is running

Quorum Replication

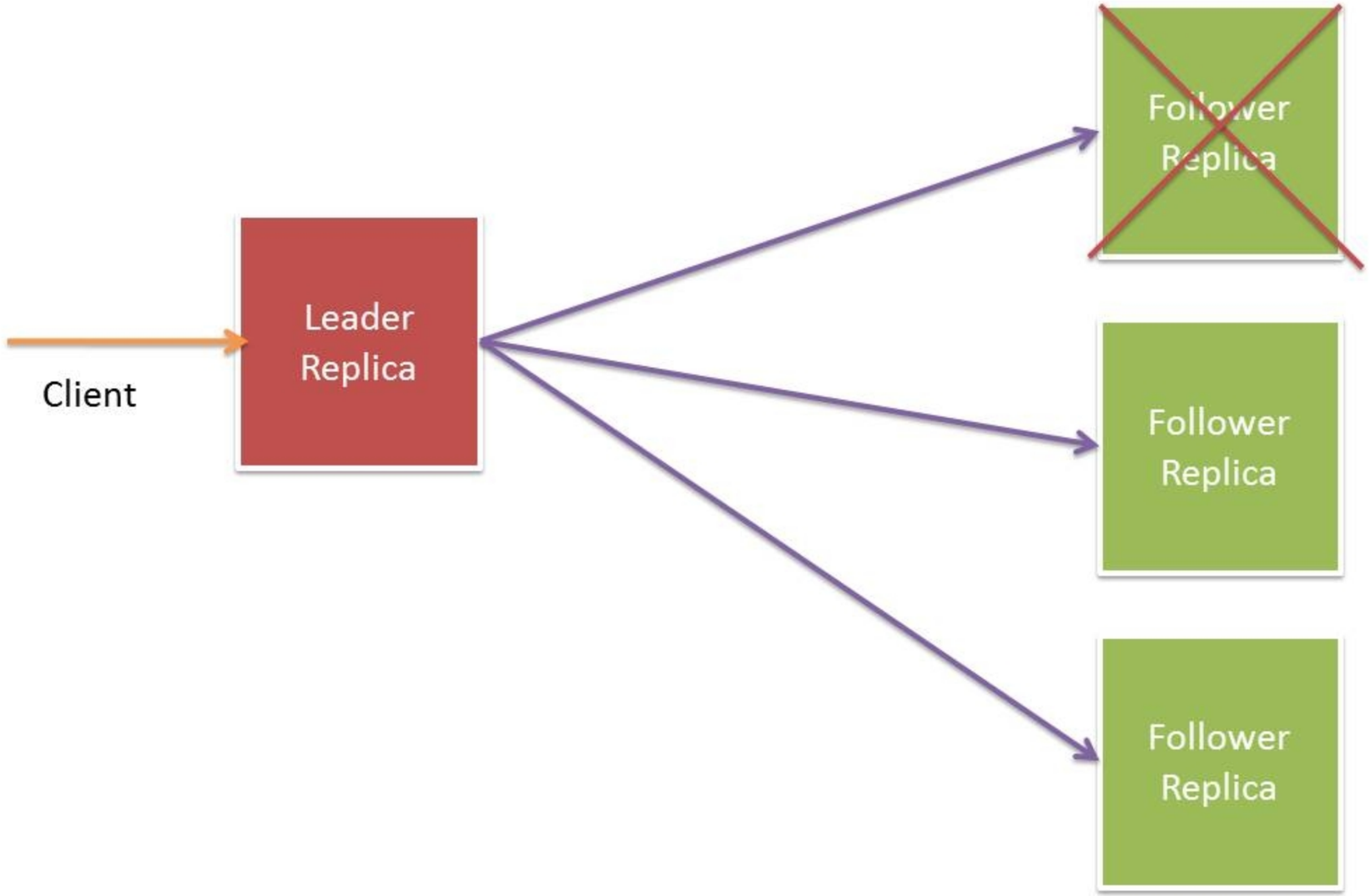
- Quorum Approach:
  - The leader waits until a write completes on a majority of the replicas. The size of the replica group doesn't change even when some replicas are down.
  - For example: If you have 2f+1 replica, then f+1 replica must be available

Quorum Replication



Send data to all in sync replica.

Quorum Replication



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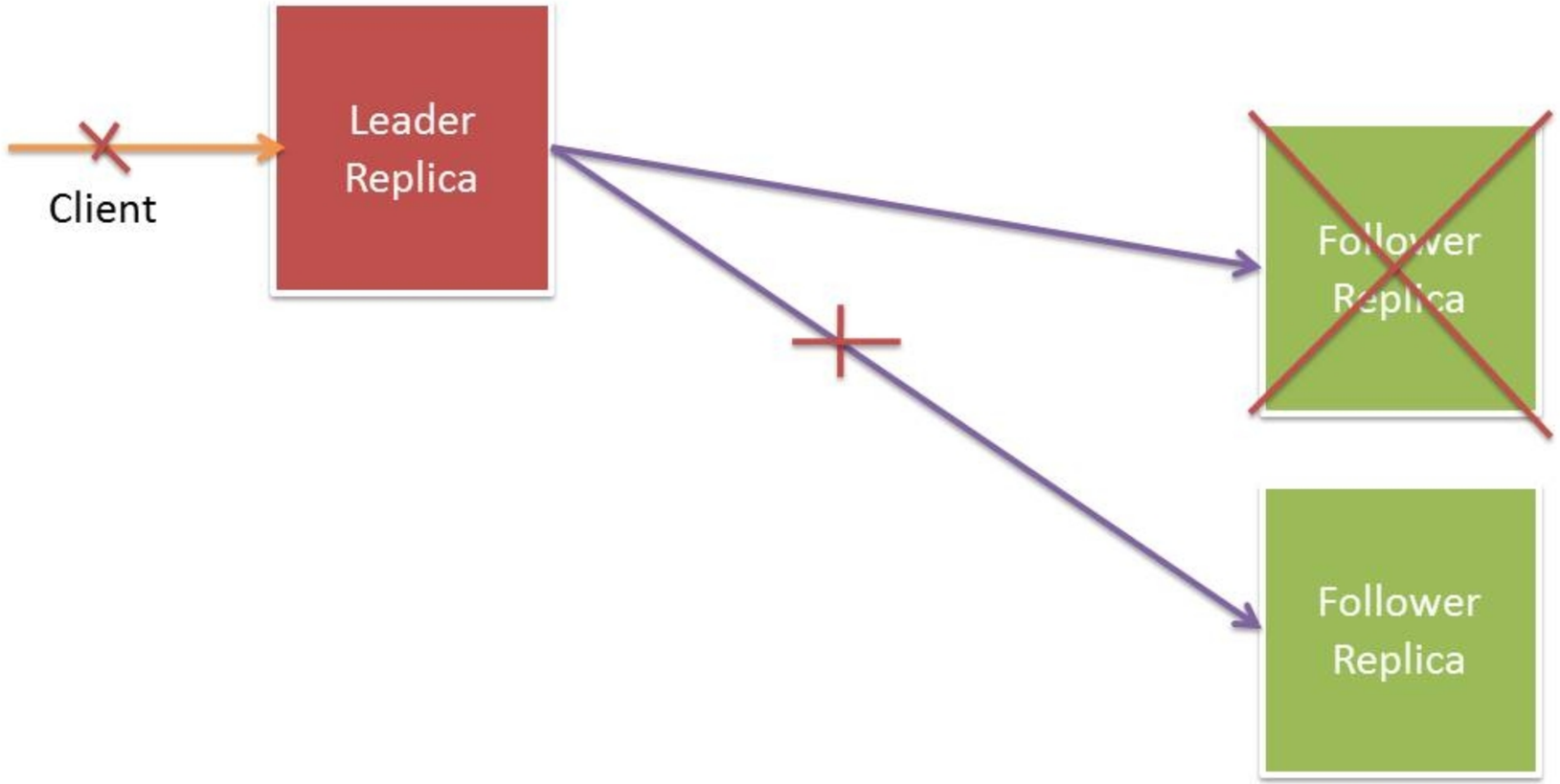
Quorum Replication



- Send data to all in sync replica.
- If follower is down or lack behind with leader, then it will remove form the list of ISR
- Sync Producer stop pushing data and producer get the error because majority of follower must be running

Replication

- How much fault tolerance primary-based approach support?
  - With f replicas, primary-backup replication can tolerate f-1 failures
- How much fault tolerance quorum-based approach support?
  - If there are 2f+1 replicas, quorum-based replication can tolerate f replica failures. If the leader fails, it needs at least f+1 replicas to elect a new leader.
  - The architecture design of quorum based replica is very similar to zookeeper

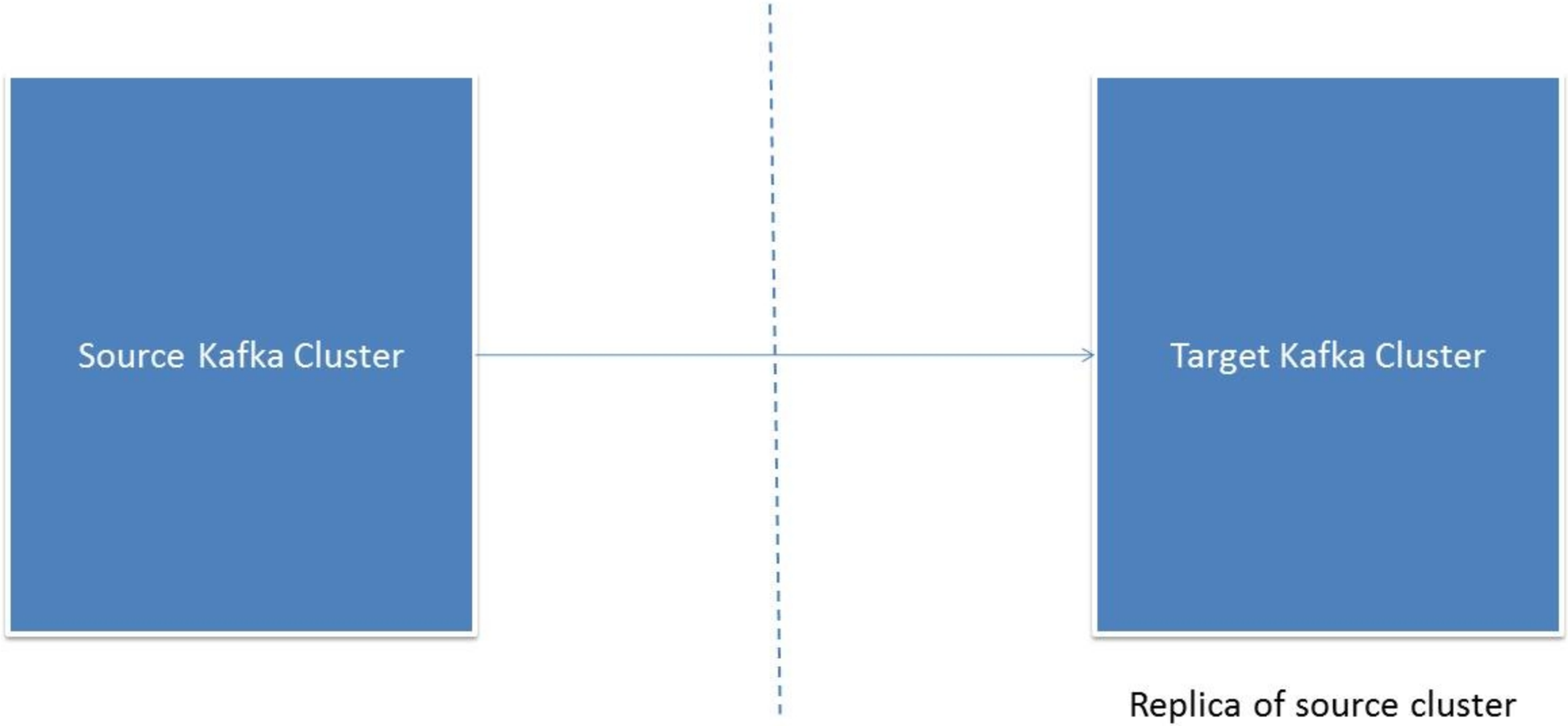
How failed replica join the cluster again?

- All the replica store the offset of the last committed message (high watermark) in a partition.
- When a failed replica is restarted, it first recovers the latest HW from disk.
- Follower truncates its log.
  - Why follower truncates its log?
  - This is necessary since messages after the HW are not guaranteed to be committed and may need to be thrown away.
  - Then, the replica becomes a follower and starts fetching messages after the HW from the leader.
  - Once it has fully caught up, the replica is added back to the ISR and the system is back to the fully replicated mode.

Mirroring Kafka

- What is mirroring?
  - Replicate the data or messages between two separate cluster
  - The process of replicating data *between* Kafka clusters. The name "**mirroring**" is used to avoid confusion with the replication that happens amongst the nodes in a single cluster.

Mirroring Kafka

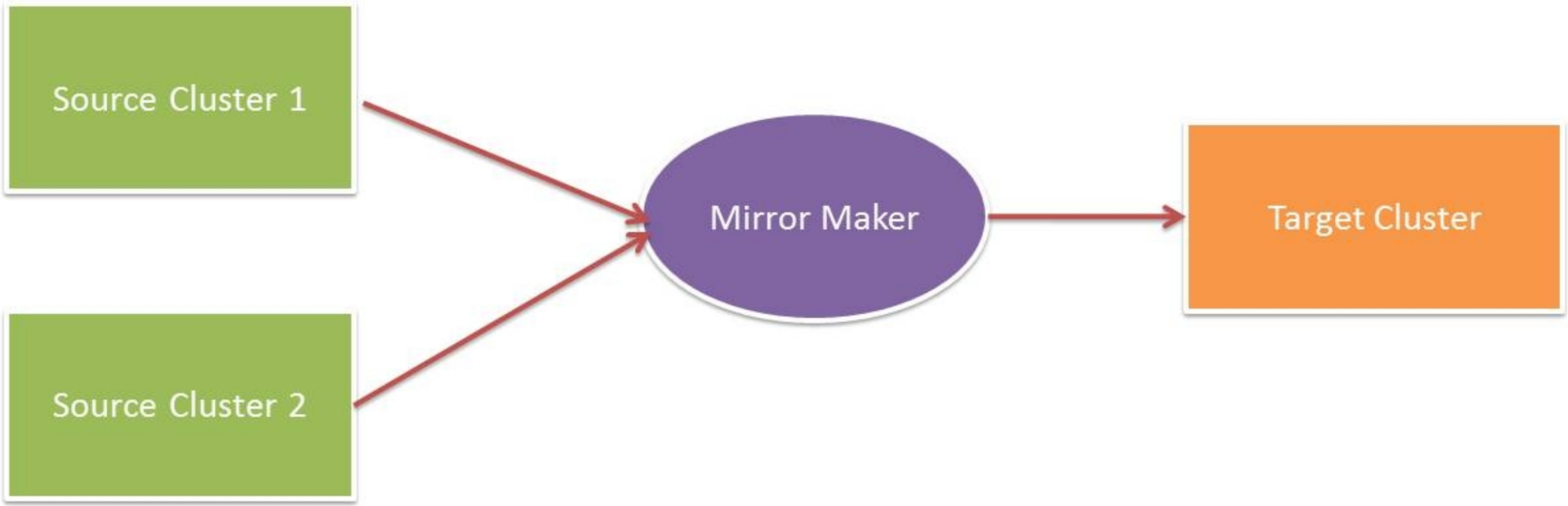


Mirroring Kafka

- Advantage of mirroring
  - It help us to protect our data in case of geographical disaster or if whole cluster goes down

How Mirroring work?

How Mirroring work?



Role of Mirror Maker

- Mirror maker is a process which contains the instances of producer and consumer or you can say mirror maker is little more than a Kafka consumer and producer hooked together.
- Consumer pull the data from source cluster and producer push the data into target cluster.
- In Mirroring, the source and target cluster are independent entities and they can have different number of partitions for same topic.
- In mirror maker, we can specify the list of **Whitelist** topics and **Blacklist** topics

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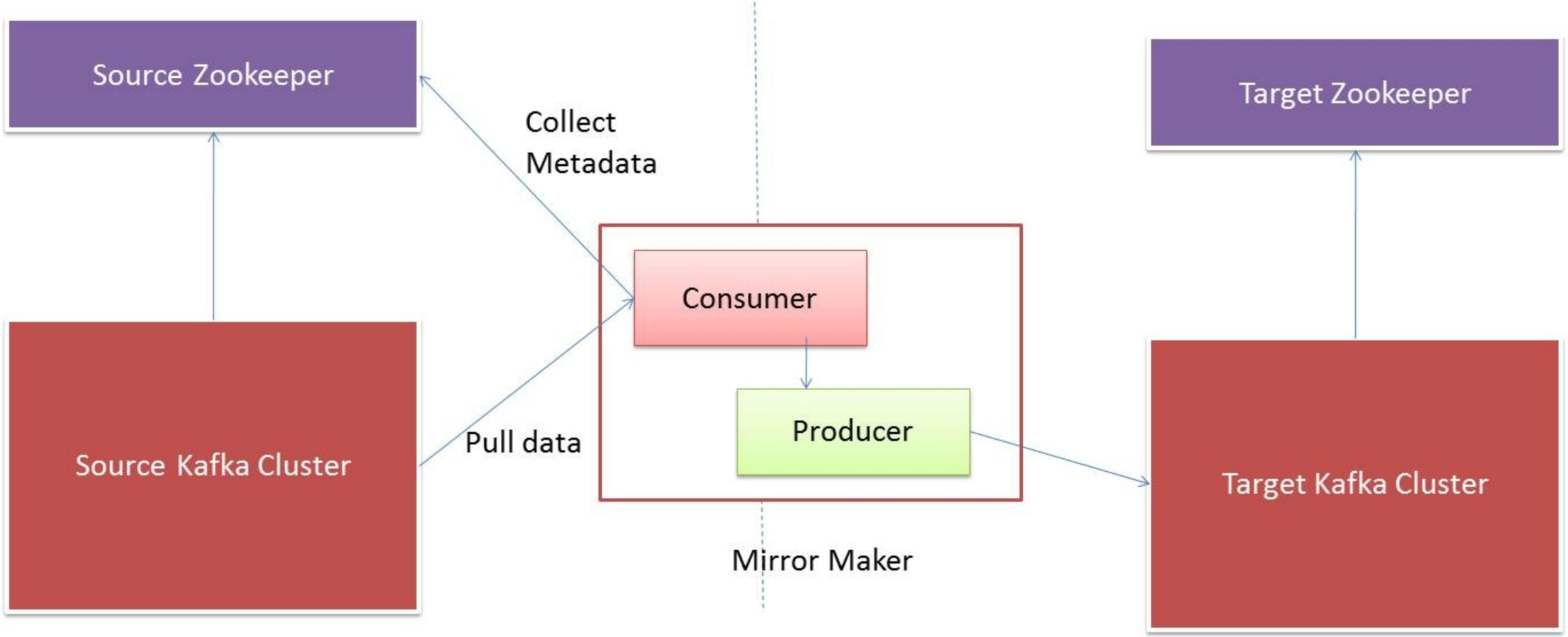
End to End working of Mirroring



Role of Mirror Maker

- In mirror maker, we can specify the list of **Whitelist** topics and **Blacklist** topics
- **Whitelist** contains the regular expression for the topics which we want to push into mirror cluster
- **Blacklist** contains the regular expression for the topics which we don't want to push into mirror cluster

Kafka Mirroring – Hands-on

- Steps to perform the mirroing:
  - Start the Zookeeper and Kafka on machine1 (cluster1 – source cluster)
  - Start the Zookeeper and Kafka on machine2 (cluster2 – Target cluster)
  - Create “mirror” topic on cluster1 and producer some data
  - Create “mirror” topic on target cluster (cluster2) and also start the console consumer to read the data from “mirror” topic
  - Start the mirrorMaker
    - bin/kafka-run-class.sh kafka.tools.MirrorMaker --consumer.config **consumer.properties** --num.streams 2 --producer.config **producer.properties** --whitelist=".*“
    - The **consumer.properties** contains the details of source cluster.
    - The **producer.properties** contains the details of target cluster

Mirror Maker consumer

 # IP of the source zookeeper cluster
zookeeper.connect=localhost:2181
 # timeout in ms for connecting to zookeeper
zookeeper.connection.timeout.ms=1000000

#consumer group id
group.id=test-consumer-group

#consumer timeout
#consumer.timeout.ms=5000

Mirror Maker Producer

 # Broker IP and Port of target kafka cluster
metadata.broker.list=localhost:9093

 # name of the partitioner class for partitioning events; default partition spreads data randomly
#partitioner.class=

 # specifies whether the messages are sent asynchronously (async) or synchronously (sync)
producer.type=sync

 # specify the compression codec for all data generated: none , gzip, snappy.
 # the old config values work as well: 0, 1, 2 for none, gzip, snappy, respectivally
compression.codec=none

 # message encoder
serializer.class=kafka.serializer.DefaultEncoder

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