PULSAR

Guaranteed "effectively-once" messaging semantic

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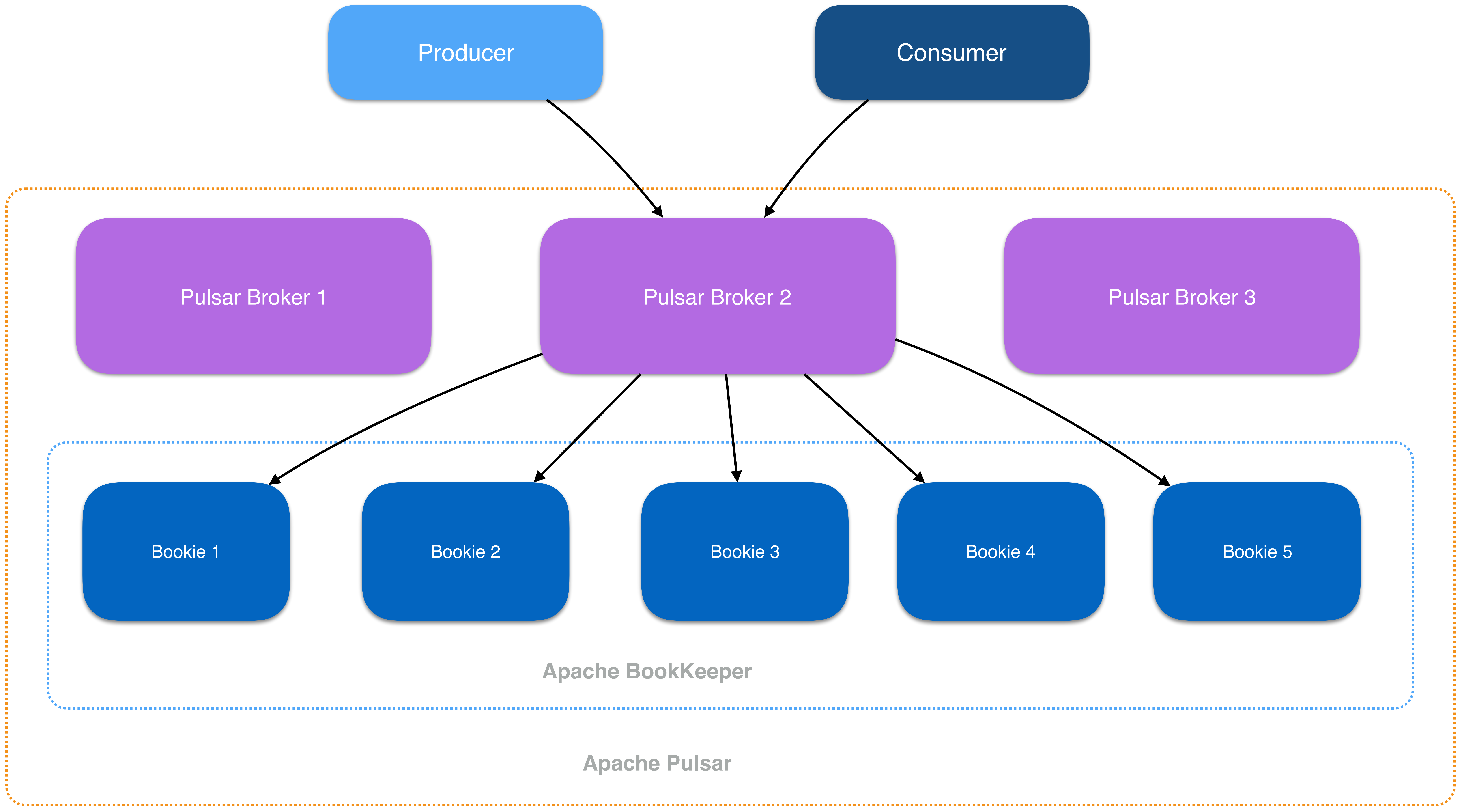
What is Apache Pulsar?

- Distributed pub/sub messaging
- Backed by a scalable log store — Apache BookKeeper
- Streaming & Queuing
- Low latency
- Multi-tenant
- Geo-Replication

Architecture view



- Separate layers between brokers bookies
- Broker and bookies can be added independently
- Traffic can be shifted very quickly across brokers
- New bookies will ramp up on traffic quickly

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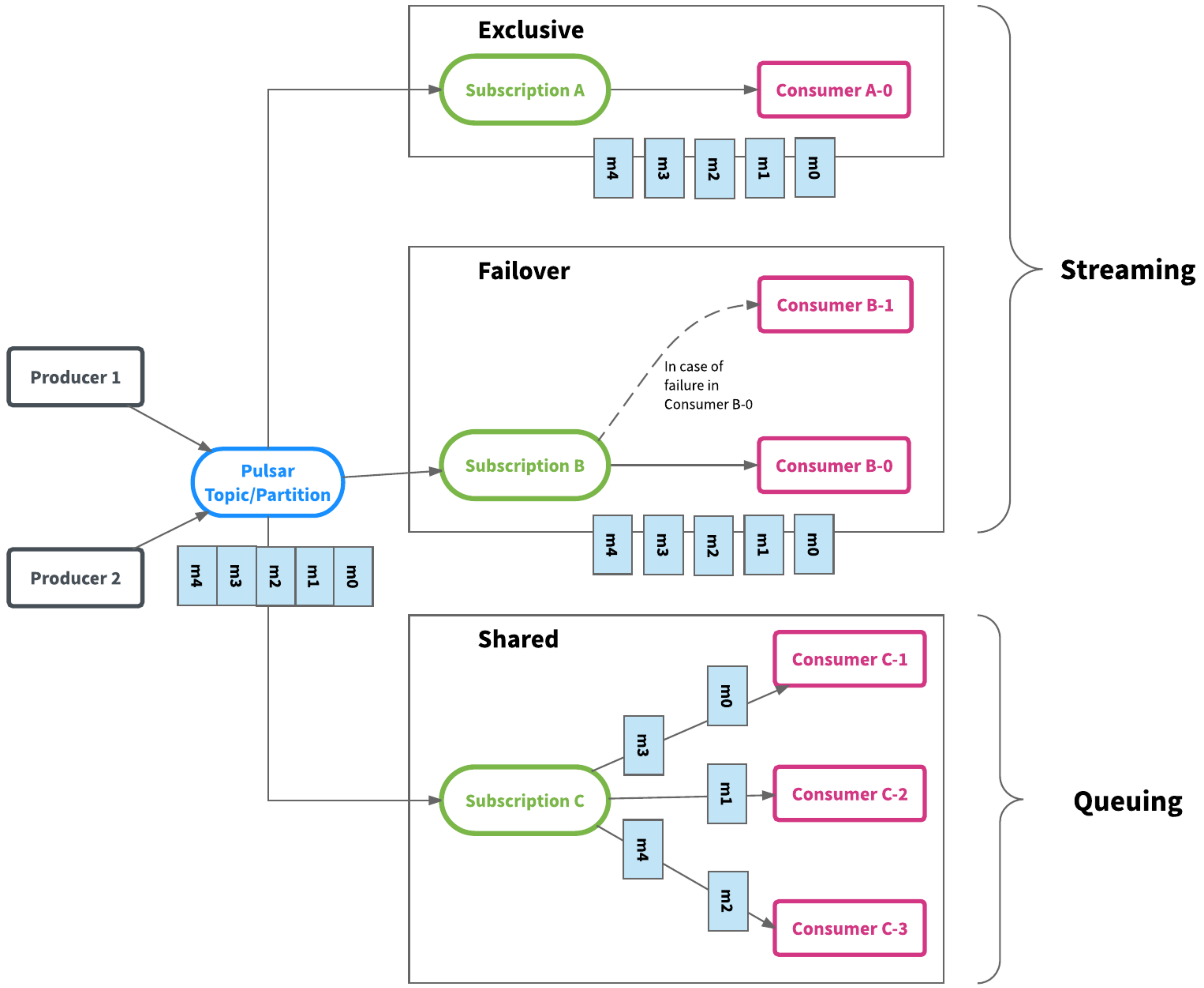
Messaging model



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Messaging semantics

At most once

At least once

Exactly once

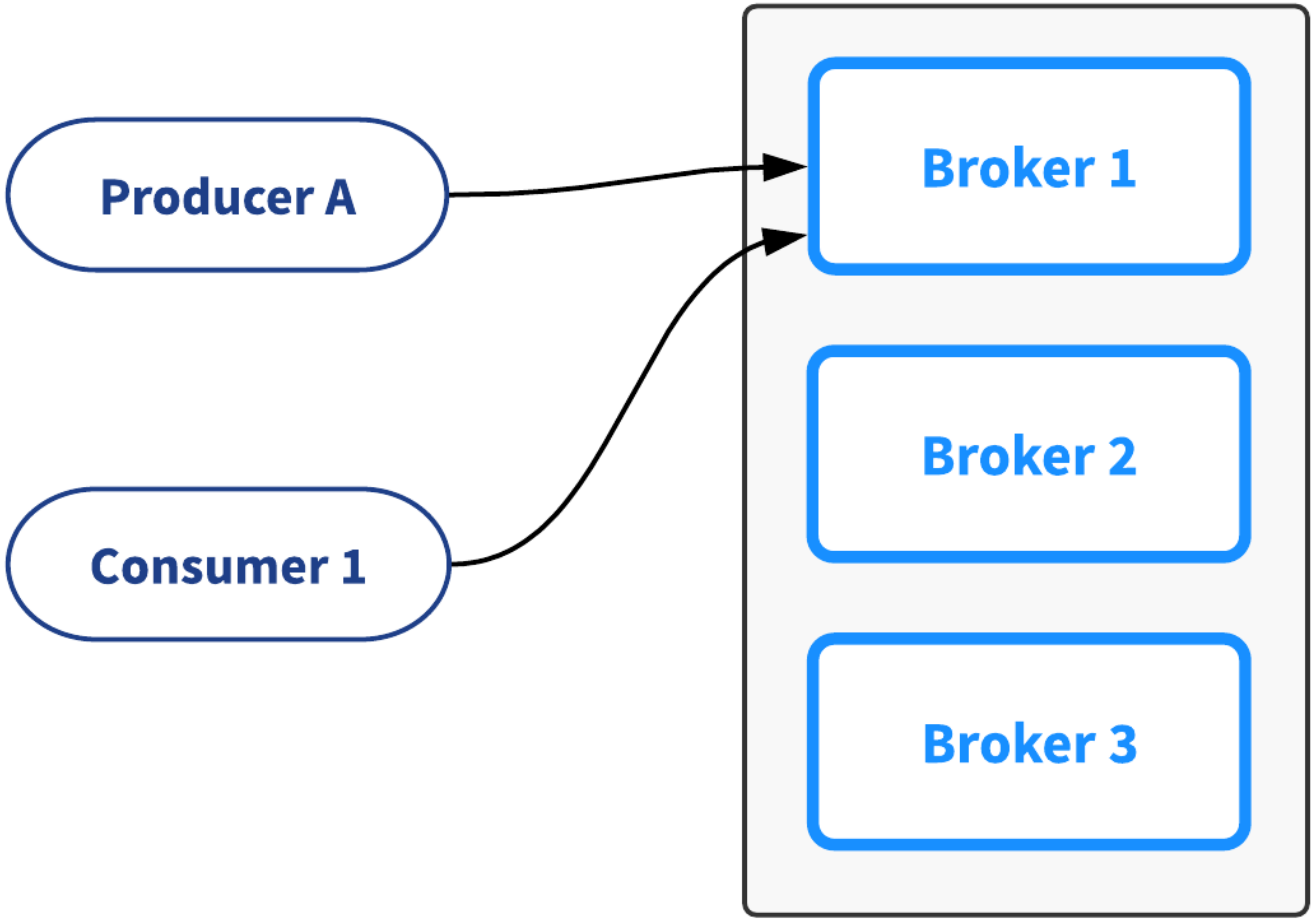
“Exactly once”

- There is no agreement in industry on what it *really* means
- Any vendor has claimed exactly once at some point
- Many caveats… “*only if there are no crashes…*”
- No formal definition of exactly once — unlike “*consensus*” or “*atomic broadcast*”

“Effectively once”

- Identify and discard duplicated messages with 100% accuracy
- In presence of any kind of failures
- Messages can be received and processed more than once
- …but *effects on the resulting state will be observed only once*

What can fail?



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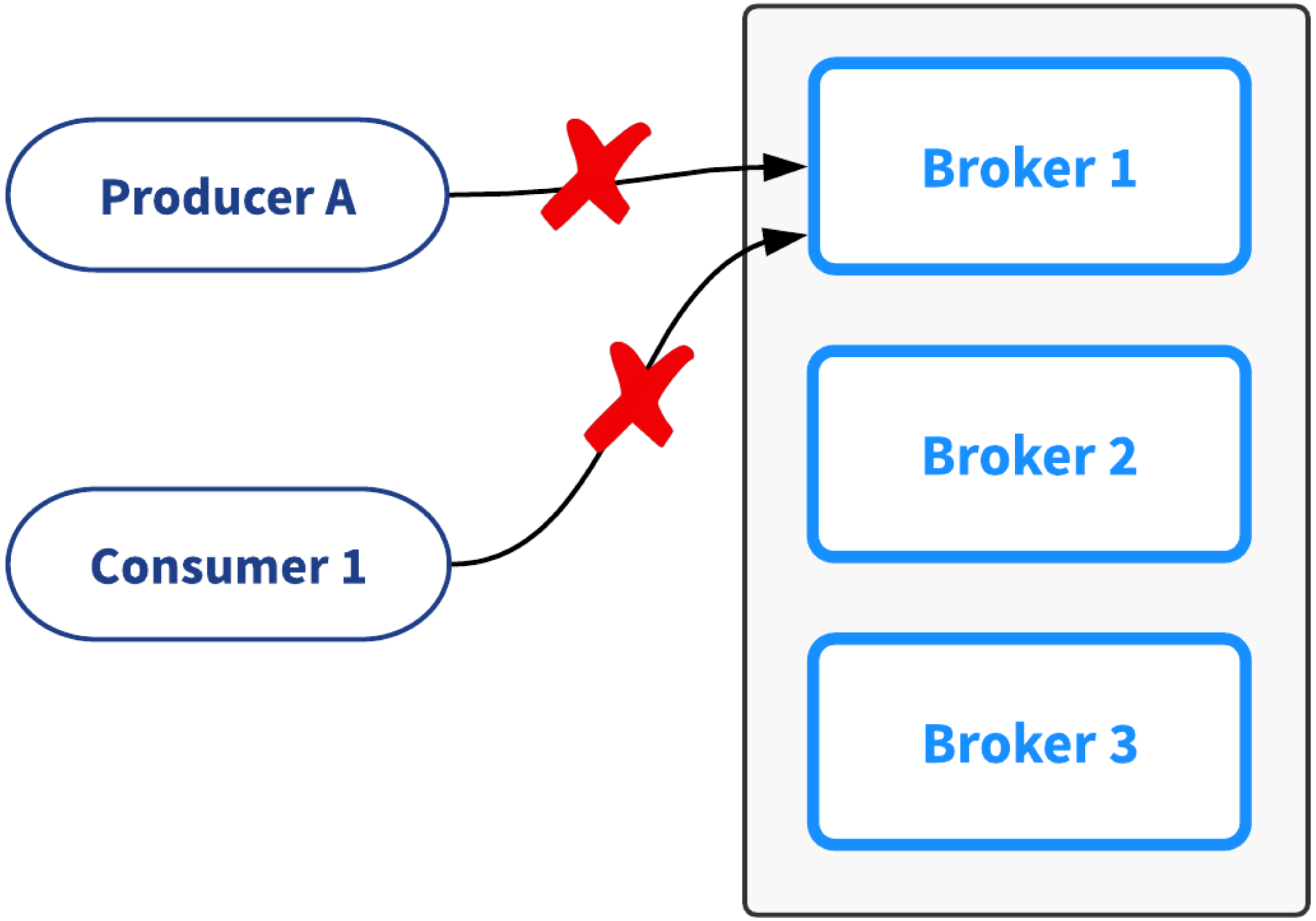

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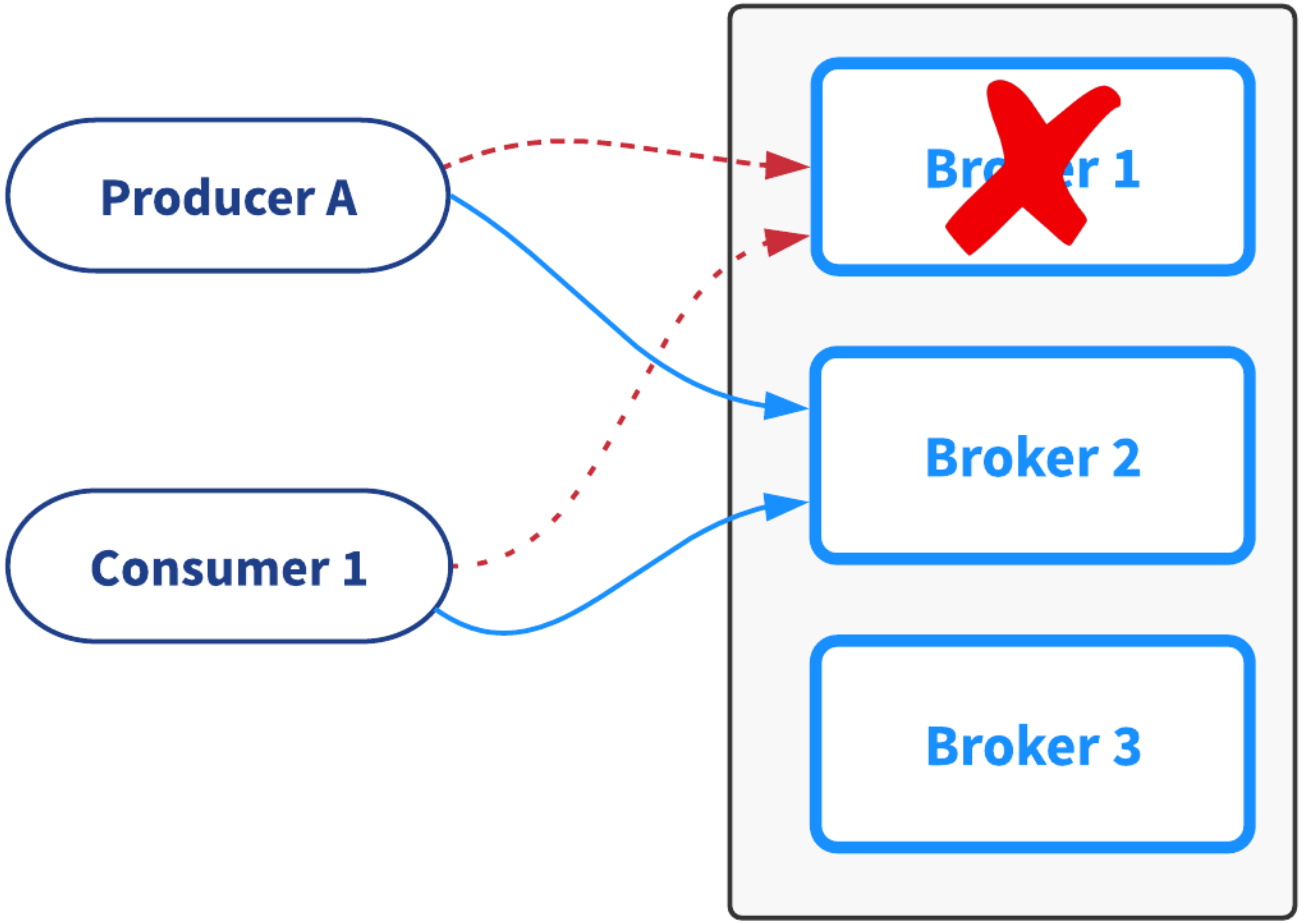

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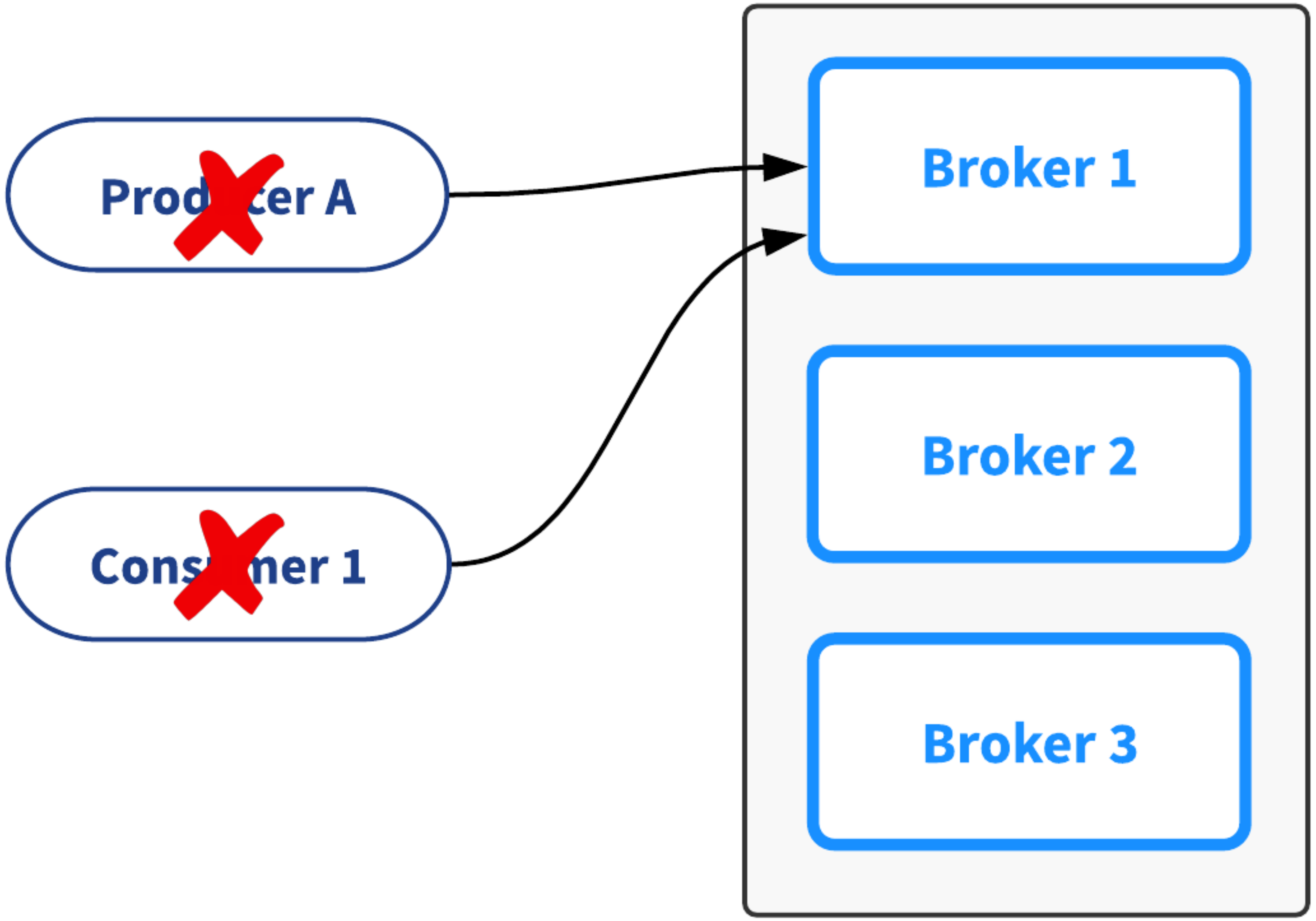
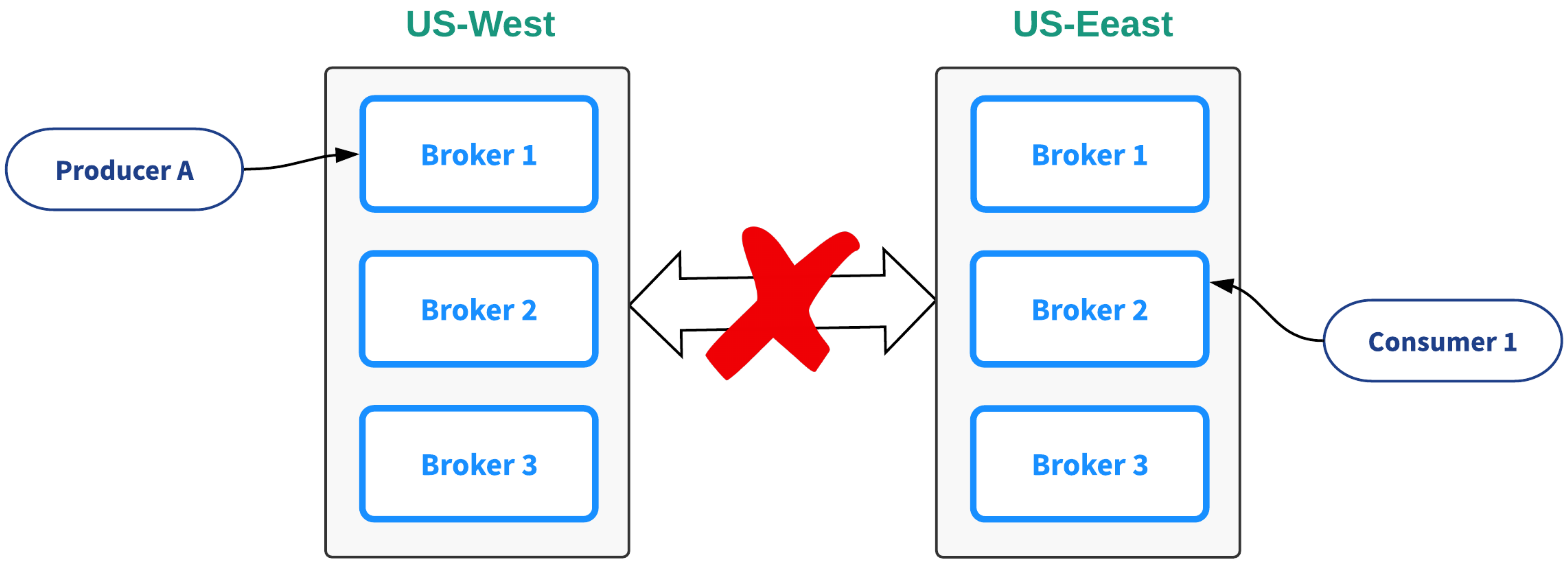


What can fail? — Geo-Replication



Breaking the problem

1. Store the message once — *”producer idempotency”*
2. Allow applications to “*process data only-once*”

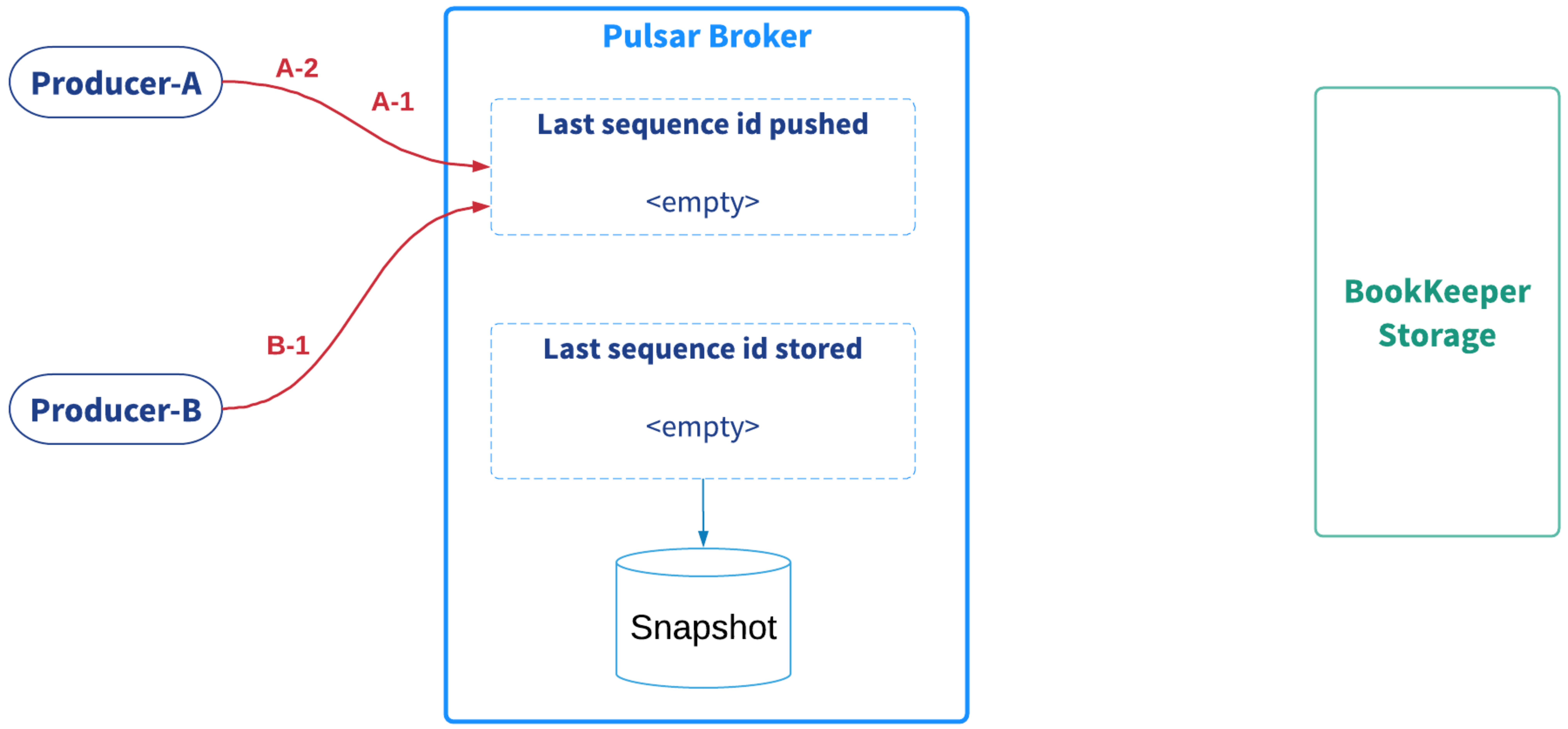
Idempotent producer

- Pulsar broker detects and discards messages that are being retransmitted
- It works when a broker crashes and topic is reassigned
- It works when a producer application crashes

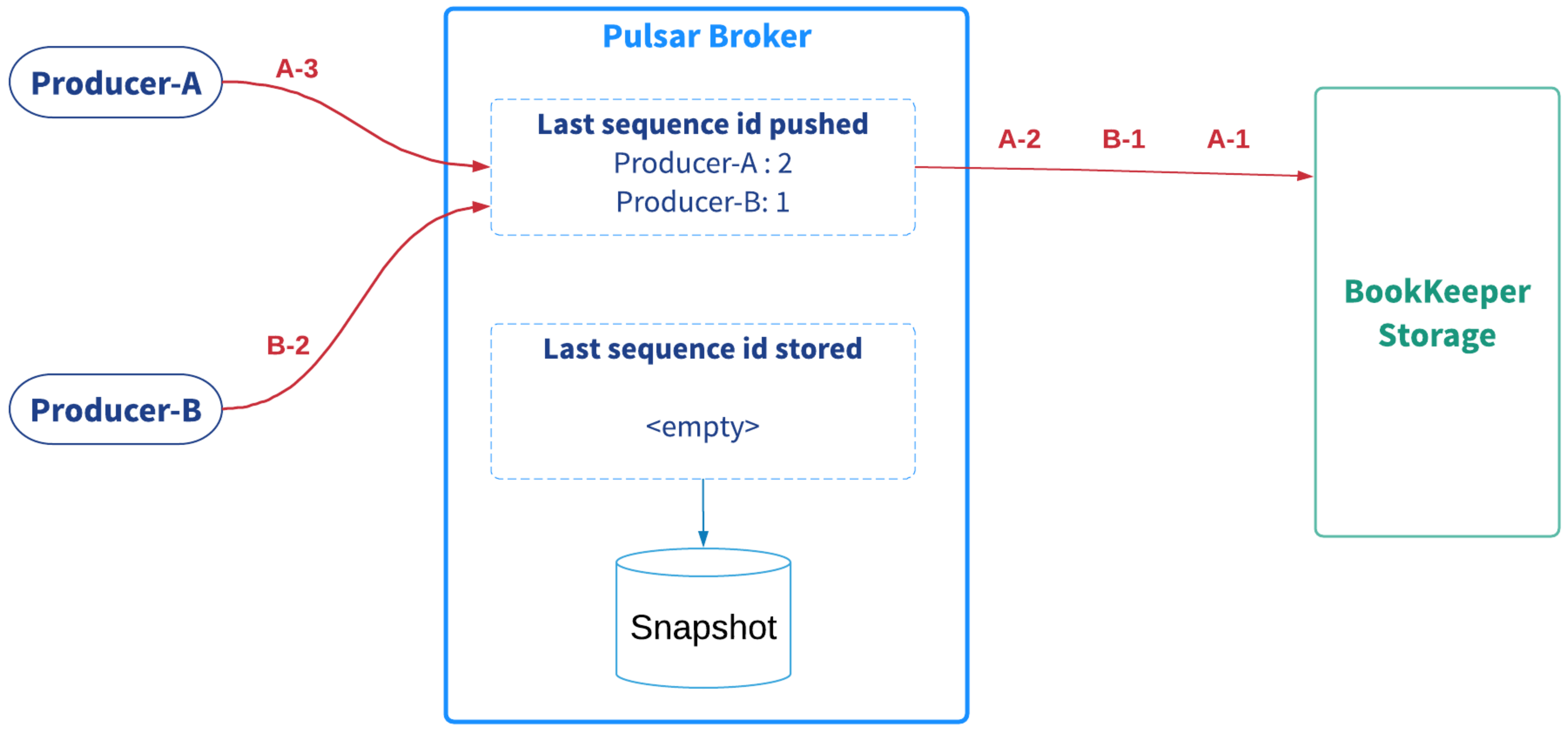
Identifying producers

- Use “sequence ids” to detect retransmissions
- Each producer on a topic has it own sequence of messages
- Use “producer-name” to identify producers

Detecting duplicates



Detecting duplicates



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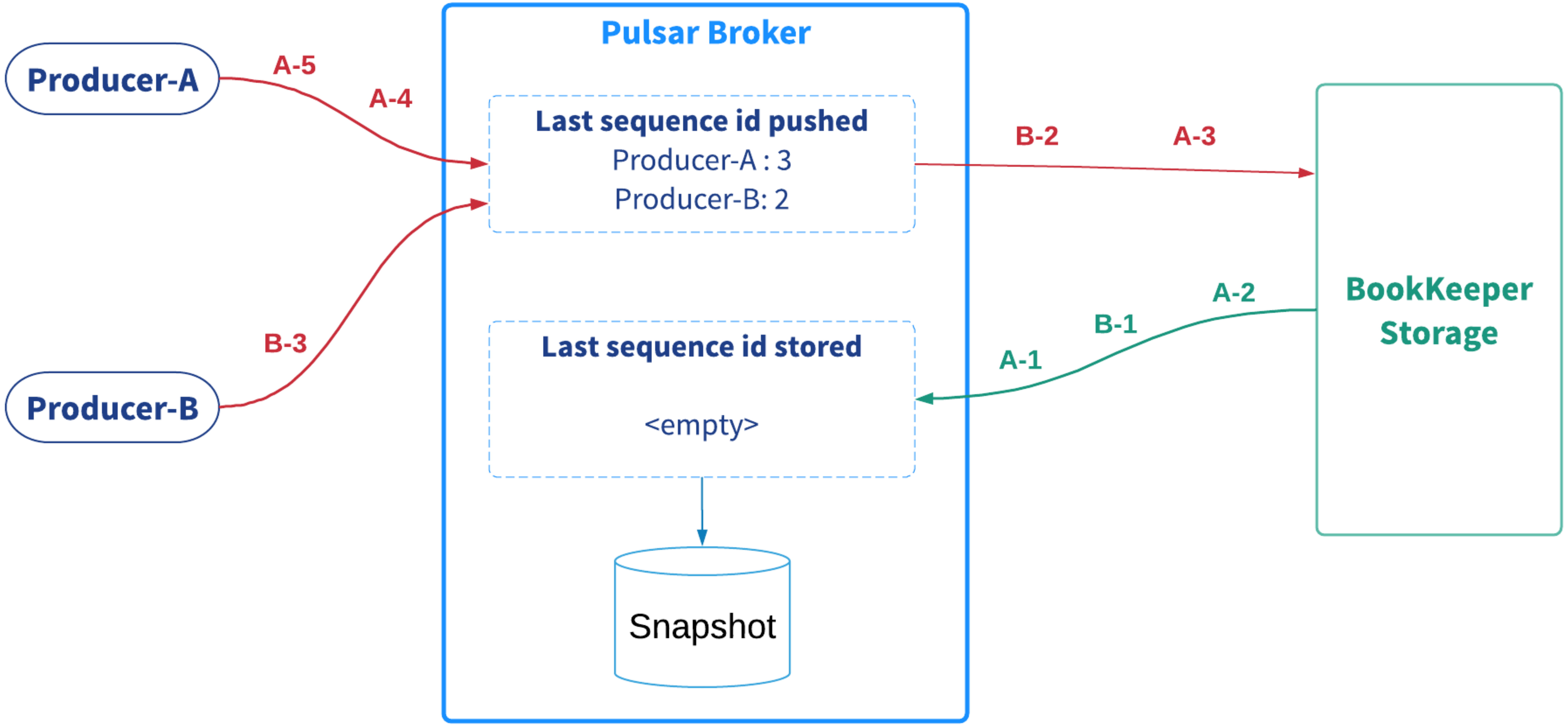

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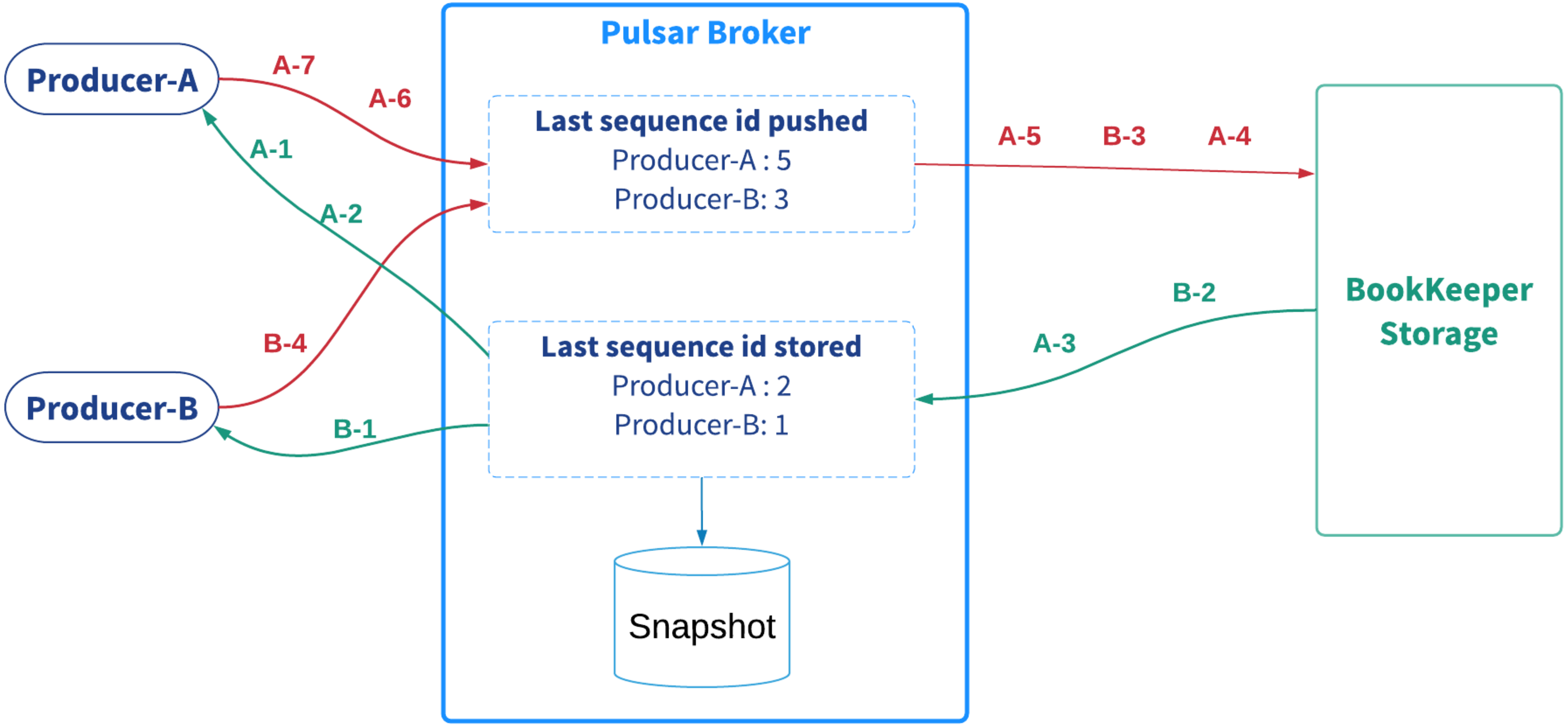

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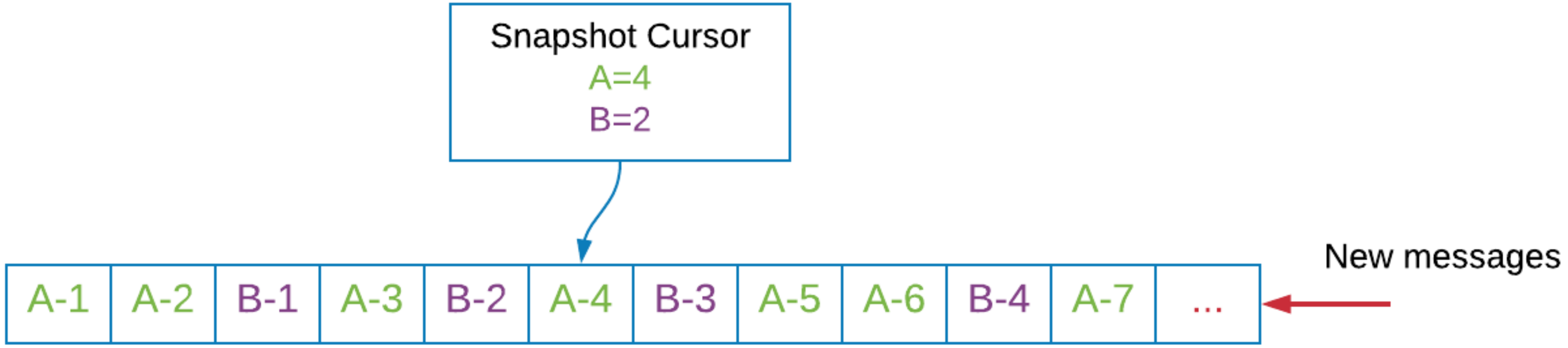
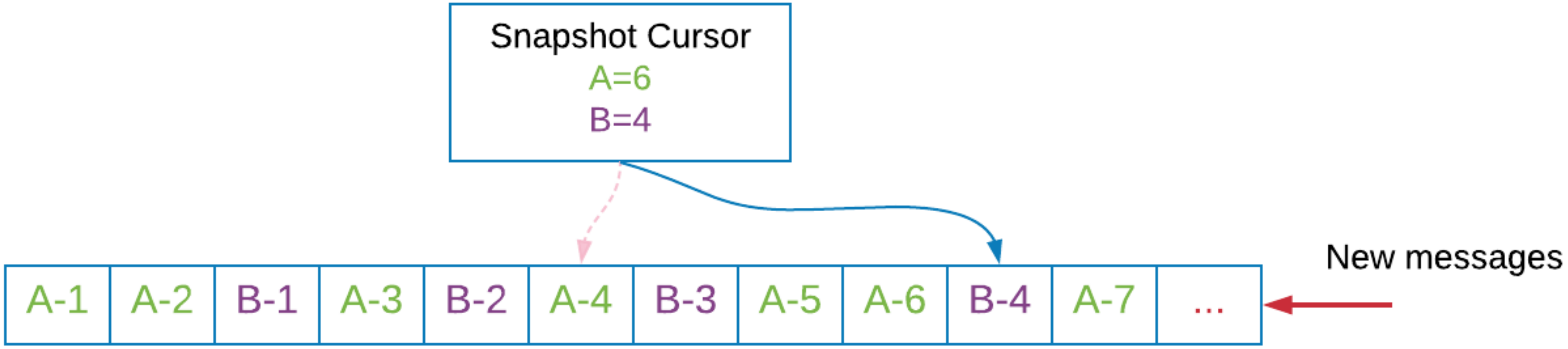
Sequence Id snapshot



Sequence Id snapshot



Sequence Id snapshot

- Snapshots are taken every N entries to limit recovery time
- Snapshot & cursor updates are atomic
- Cursor updates are stored in BookKeeper — durable & replicated
- On recovery
  - Load the snapshot from the cursor
  - Replay the entries from the cursor position

What if application producer crashes?

- Pulsar needs to identify the new producer as being the same “logical” producer as before
- In practice, this is only useful if you have a “*replayable*” source (eg: file, stream, …)

Resuming a producer session

```
ProducerConfiguration conf = new ProducerConfiguration();
conf.setProducerName("my-producer-name");
conf.setSendTimeout(0, TimeUnit.SECONDS);
Producer producer = client.createProducer(MY_TOPIC, conf);

// Get last committed sequence id before crash
long lastSequenceId = producer.getLastSequenceId();
```

Using sequence Ids

```
// Fictitious record reader class
RecordReader source = new RecordReader("/my/file/path");

long fileOffset = producer.getLastSequenceId();
source.seekToOffset(fileOffset);

while (source.hasNext()) {
    long currentOffset = source.currentOffset();
    Message msg = MessageBuilder.create()
        .setSequenceId(currentOffset)
        .setContent(source.next()).build();

   producer.send(msg);
}
```

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Consuming messages only once

- Pulsar Consumer API is very convenient
  - Managed subscription — tracking individual messages

```
Consumer consumer = client.subscribe(MY_TOPIC, MY_SUBSCRIPTION_NAME);

while (true) {
    Message msg = consumer.receive();
    // Process the message...
    consumer.acknowledge(msg);
}
```

Effectively-once with Consumer

- Consumer is very simple but doesn’t allow a large degree of control
- Processing and acknowledge are not atomic
- To achieve “effectively once” we need to rely on an external system to deduplicate the processing results. Eg:
    - RDBMS — Keep the message id as a column with a “unique” index
    - Critical write to update the state — `compareAndSet()` or similar

Pulsar Reader

- Reader is a low level API to receive data from a Pulsar topic
- There is no managed subscription
- Application always specifies the message id where it wants to start reading from

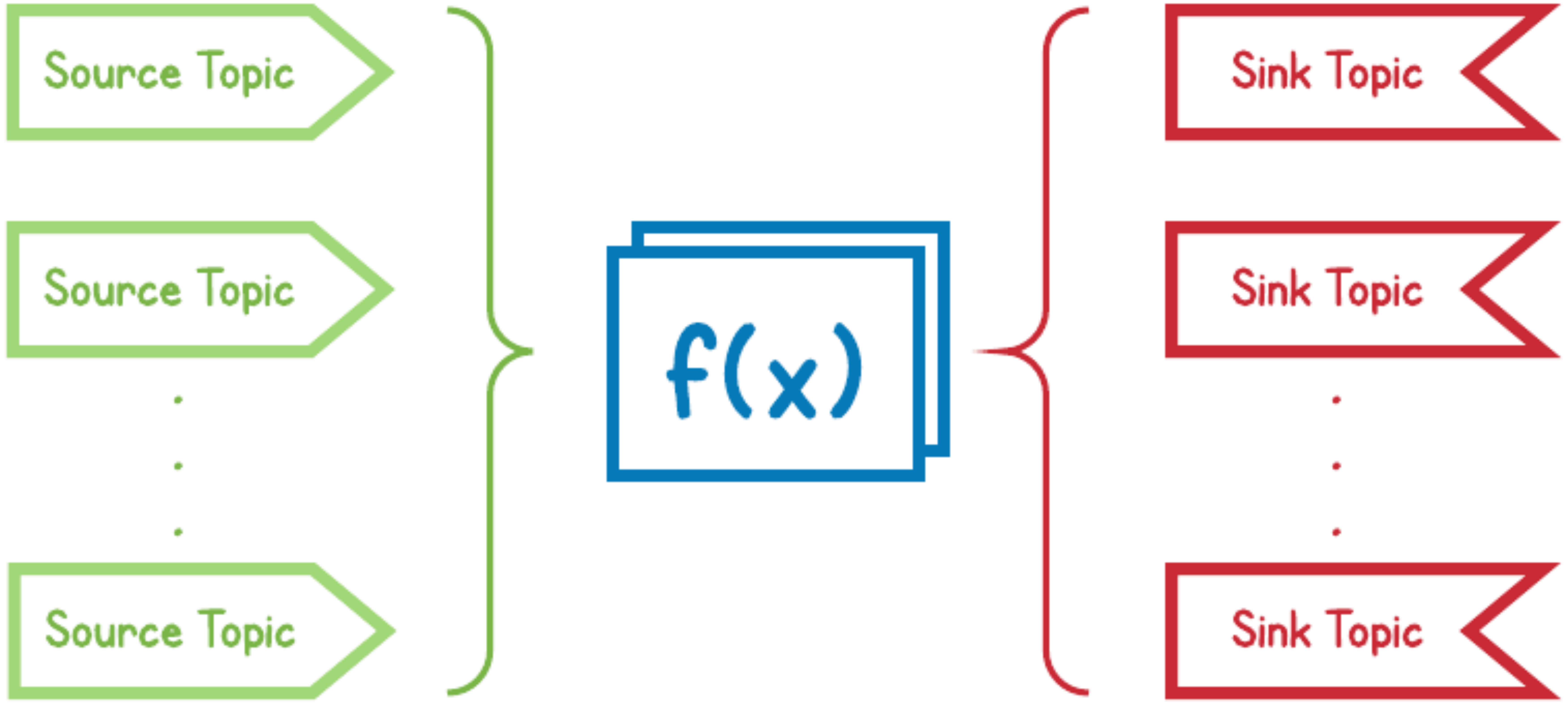
Reader example

```
MessageId lastMessageId = recoverLastMessageIdFromDB();
Reader reader = client.createReader(MY_TOPIC, lastMessageId,
                                    new ReaderConfiguration());

while (true) {
    Message msg = reader.readNext();
    byte[] msgId = msg.getMessageId().toByteArray();

    // Process the message and store msgId atomically
}
```

Example — Pulsar Functions



Pulsar Functions

- A function gets messages from 1 or more topics
- An instance of the function is invoked to process the event
- The output of the function is published on 1 or more topics
- Super simple to use — No SDK required — Python example:

```
def process(input):
    return input + '!'
```

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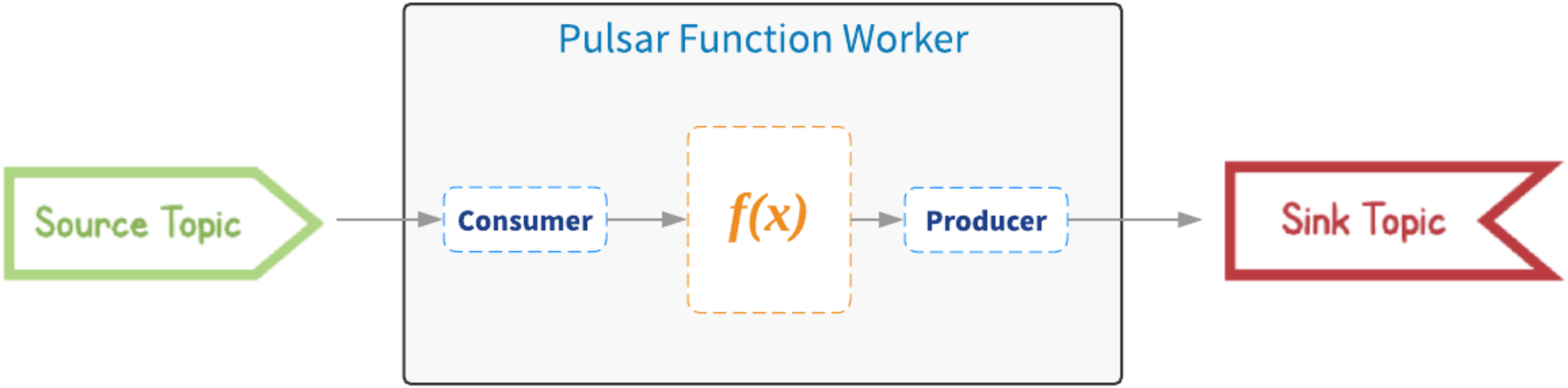
Pulsar Functions



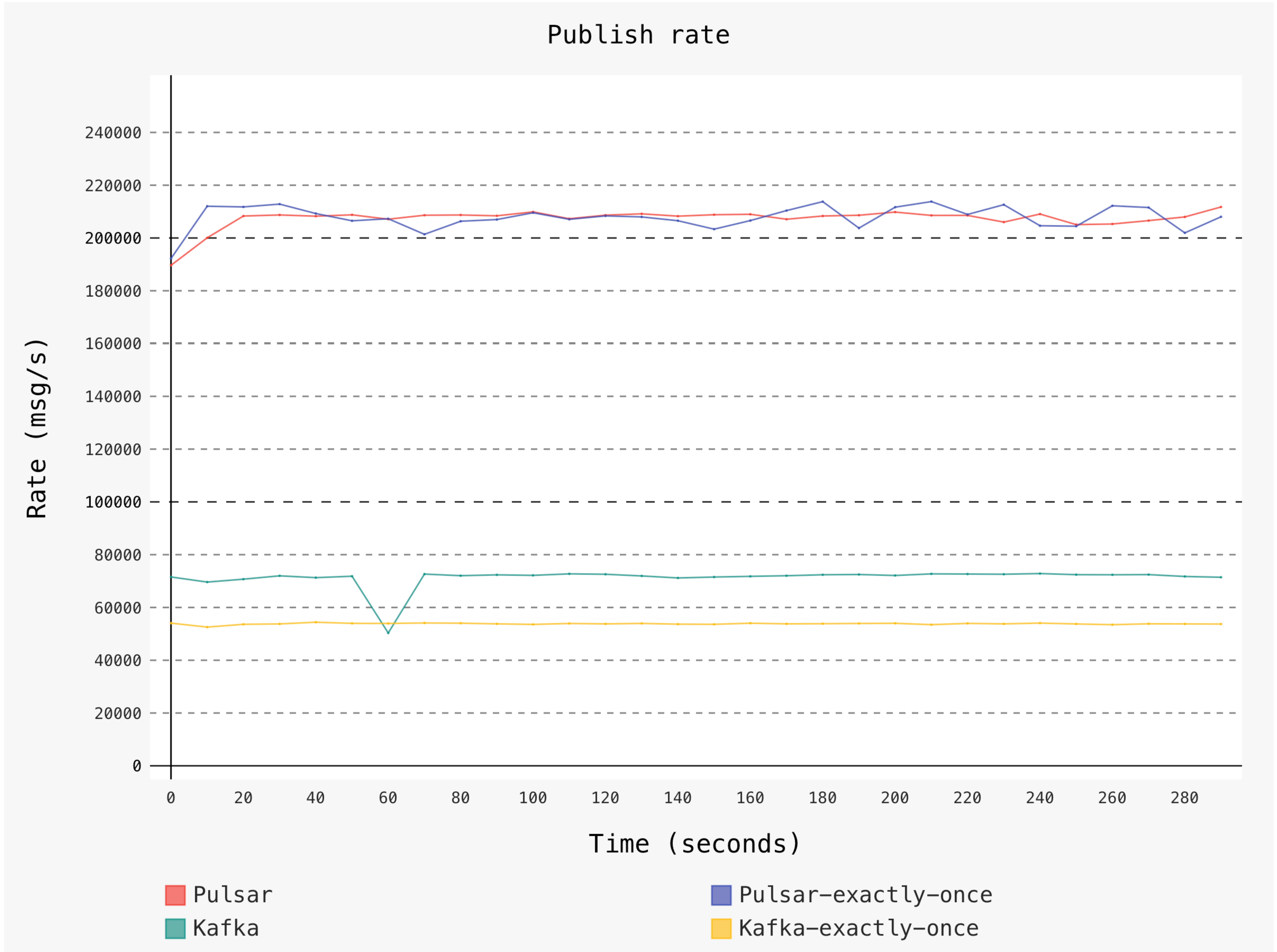
Effectively once with functions

- Use the message id from source topic as sequence id for sink topic
- Works with “Consumer” API
- When consuming from multiple topics or partitions, creates 1 producer per each source topic/partition, to ensure monotonic sequence ids

Performance

- Pulsar approach guarantees deduplication in all failure scenarios
- Overhead is minimal: 2 in memory hashmap updates
- No reduction in throughput — No increased latency
- Controllable increase in recovery time

Performance — Benchmark



OpenMessaging Benchmark

1 Topic / 1 Partition

1 Partition / 1 Consumer

1Kb msg

Difference with Kafka approach

	Kafka	**Pulsar**
Producer Idempotency	Best-effort (in memory only)	Guaranteed after crash
Transactions	2 phase commit	No transactions
Dedup across producer sessions	No	Yes
Dedup with geo-replication	No	Yes
Throughput	Lower (1 in-flight message/batch for ordering)	Equal

Curious to Learn More?

- Apache Pulsar — https://pulsar.incubator.apache.org
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