Fast Data apps with Alpakka Kafka connector and Akka Streams

Sean Glover, Lightbend
@seg1o

Lightbend

Who am I?

I'm Sean Glover

- Principal Engineer at Lightbend
- Member of the Fast Data Platform team
- Organizer of Scala Toronto (scalator)
- Contributor to various projects in the Kafka ecosystem including Kafka, Alpakka Kafka (reactive-kafka), Strimzi, DC/OS Commons SDK

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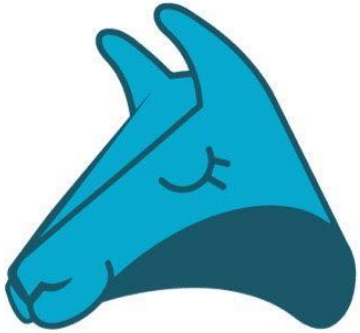
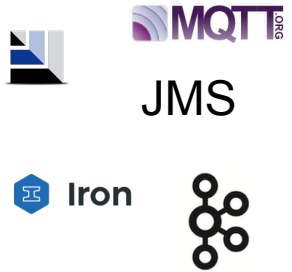


alpakka

> *The Alpakka project is an initiative to implement a library of integration modules to build stream-aware, reactive, pipelines for Java and Scala.*



Cloud Services

Data Stores

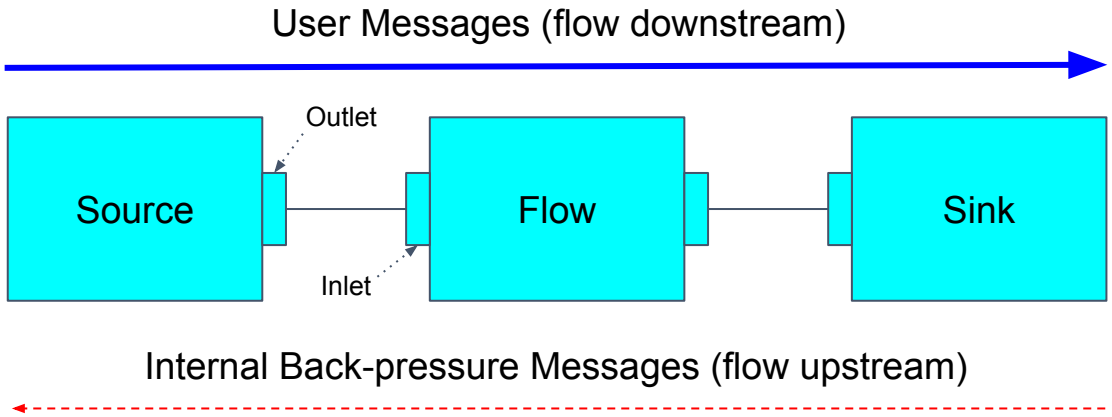
Messaging

This Alpakka Kafka connector lets you connect Apache Kafka to Akka Streams. It was formerly known as Akka Streams Kafka and even Reactive Kafka.

Top Alpakka Modules

Alpakka Module	Downloads in August 2018
Kafka	**61177**
Cassandra	15946
AWS S3	15075
MQTT	11403
File	10636
Simple Codecs	8285
CSV	7428
AWS SQS	5385
AMQP	4036

Akka Streams is a library toolkit to provide low latency complex event processing streaming semantics using the Reactive Streams specification implemented internally with an Akka actor system.


User Messages (flow downstream)
Outlet
Source
Flow
Sink
Inlet
Internal Back-pressure Messages (flow upstream)

Reactive Streams Specification

Reactive Streams is an initiative to provide a standard for asynchronous stream processing with non-blocking back pressure.

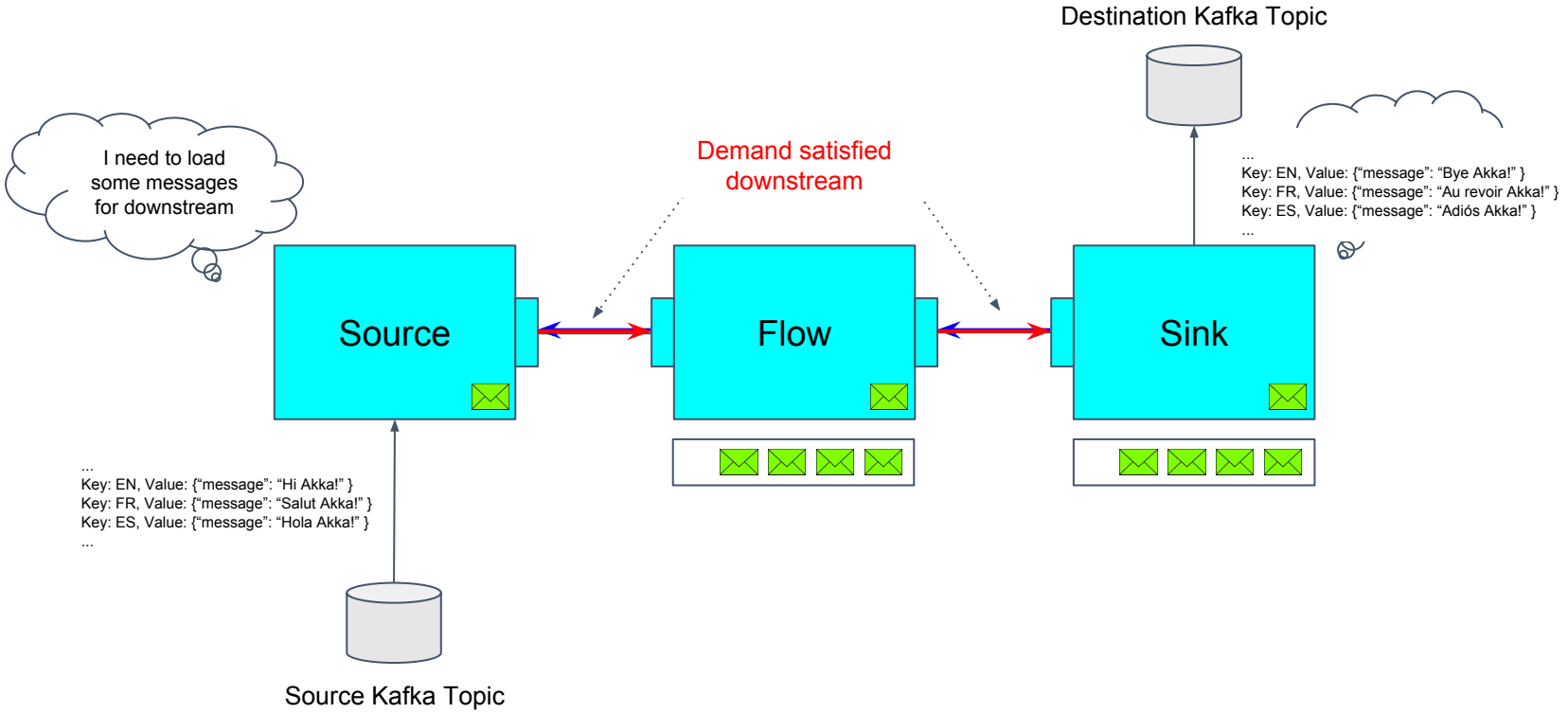
http://www.reactive-streams.org/

Reactive Streams Libraries

Spec now part of JDK 9

`java.util.concurrent.Flow`

Back-pressure



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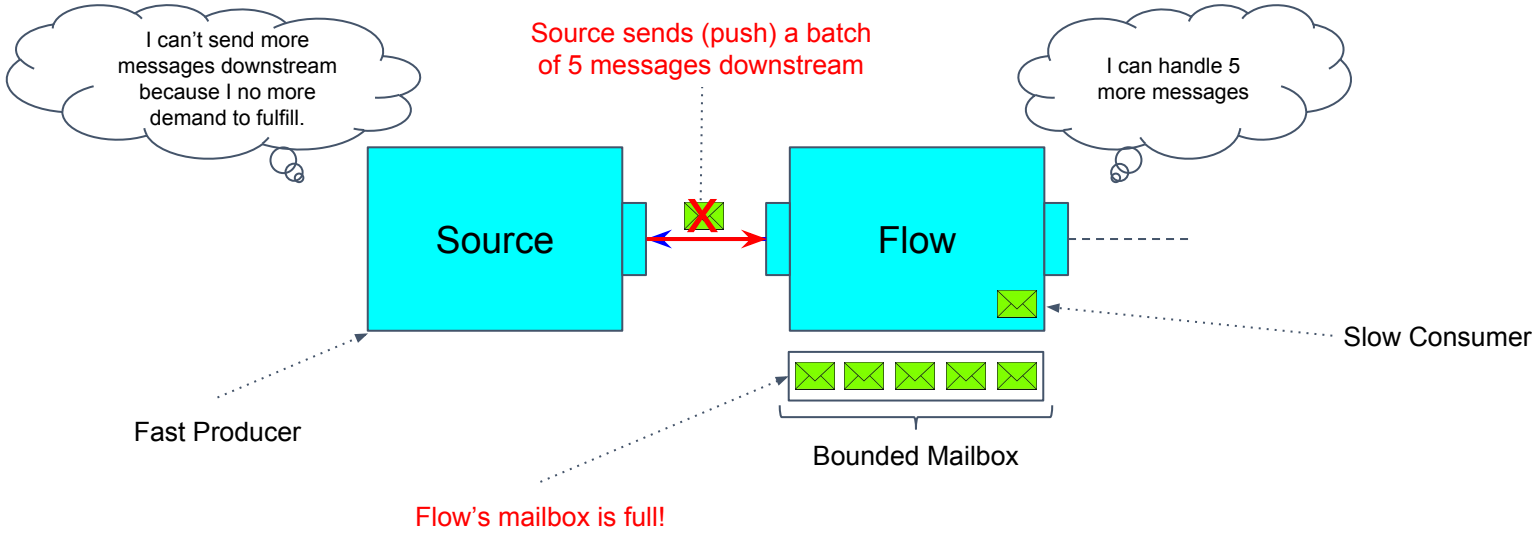
Dynamic Push Pull



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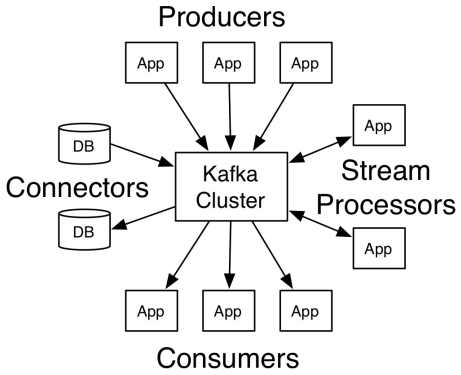
Akka Streams Factorial Example

```
import ...

object Main extends App {
 implicit val system = ActorSystem("QuickStart")
 implicit val materializer = ActorMaterializer()

 val source: Source[Int, NotUsed] = Source(1 to 100)
 val factorials = source.scan(BigInt(1))((acc, next) ⇒ acc * next)
 val result: Future[IOResult] =
   factorials
     .map(num => ByteString(s"$num\n"))
     .runWith(FileIO.toPath(Paths.get("factorials.txt")))
}
```

https://doc.akka.io/docs/akka/2.5/stream/stream-quickstart.html

Kafka

*Kafka is a distributed streaming system. It's best suited to support **fast**, **high volume**, and **fault tolerant**, data streaming platforms.*



Kafka Documentation

When to use Alpakka Kafka?

1. To build back-pressure aware integrations
2. Complex Event Processing
3. A need to model the most complex of graphs

Alpakka Kafka Setup

```
val consumerClientConfig = system.settings.config.getConfig("akka.kafka.consumer")
val consumerSettings =
 ConsumerSettings(consumerClientConfig, new StringDeserializer,  new ByteArrayDeserializer)
   .withBootstrapServers( "localhost:9092")
   .withGroupId( "group1")
   .withProperty(ConsumerConfig. AUTO_OFFSET_RESET_CONFIG, "earliest")

val producerClientConfig = system.settings.config.getConfig("akka.kafka.producer")
val producerSettings = ProducerSettings(system, new StringSerializer,  new ByteArraySerializer)
 .withBootstrapServers( "localhost:9092")
```

Alpakka Kafka config & Kafka Client config can go here

Set ad-hoc Kafka client config

Simple Consume, Transform, Produce Workflow

```
val control =
 Consumer
   .committableSource(consumerSettings, Subscriptions.topics("topic1", "topic2"))
   .map { msg =>
     ProducerMessage.Message[String, Array[Byte], ConsumerMessage.CommittableOffset](
       new ProducerRecord("targetTopic", msg.record.value),
       msg.committableOffset
     )
   }
   .toMat(Producer.commitableSink(producerSettings))(Keep.both)
   .mapMaterializedValue(DrainingControl.apply)
   .run()

// Add shutdown hook to respond to SIGTERM and gracefully shutdown stream
sys.ShutdownHookThread {
 Await.result(control.shutdown(), 10.seconds)
}
```

Committable Source provides Kafka offset storage committing semantics

Kafka Consumer Subscription

Transform and produce a new message with reference to offset of consumed message

Create `ProducerMessage` with reference to consumer offset it was processed from

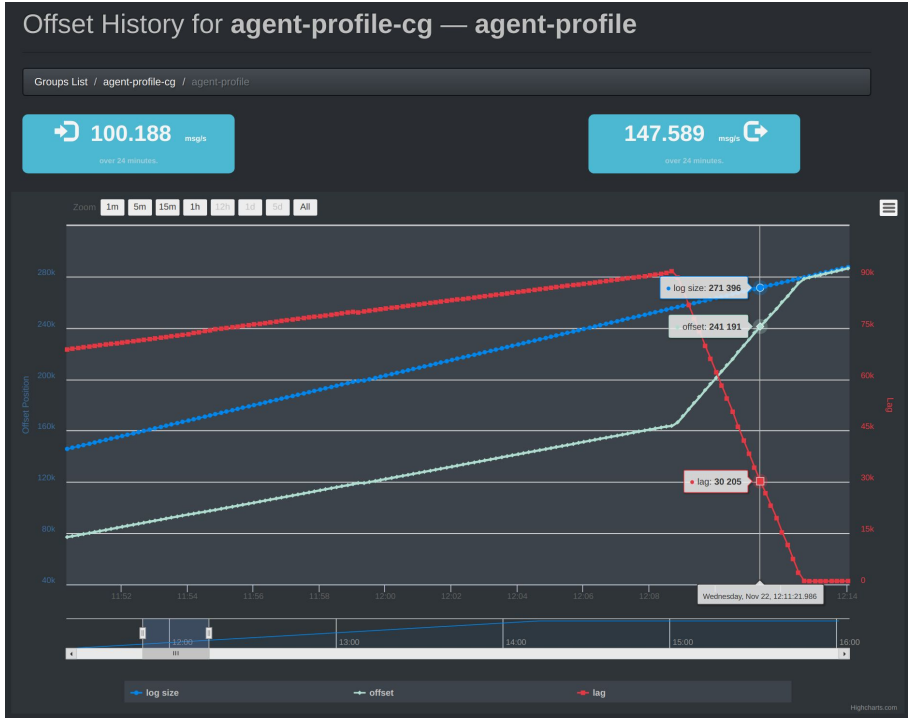
Produce `ProducerMessage` and automatically commit the consumed message once it's been acknowledged

Graceful shutdown on SIGTERM

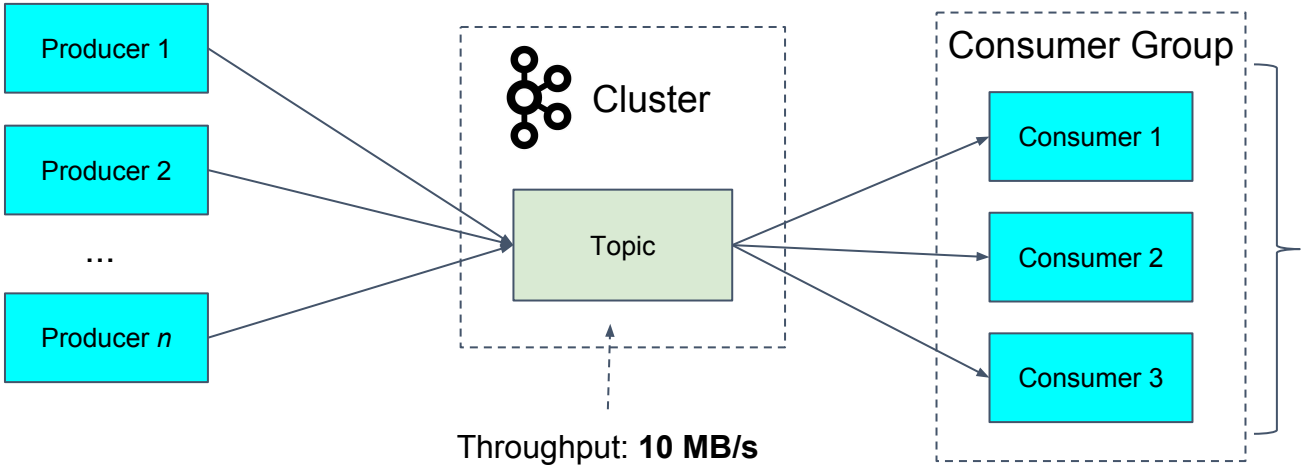
Consumer Groups

Why use Consumer Groups?

1. Easy, robust, and performant scaling of consumers to reduce **consumer lag**



Latency and Offset Lag



Consumer Throughput ~3 MB/s each

~9 MB/s

Total offset lag and latency is growing.

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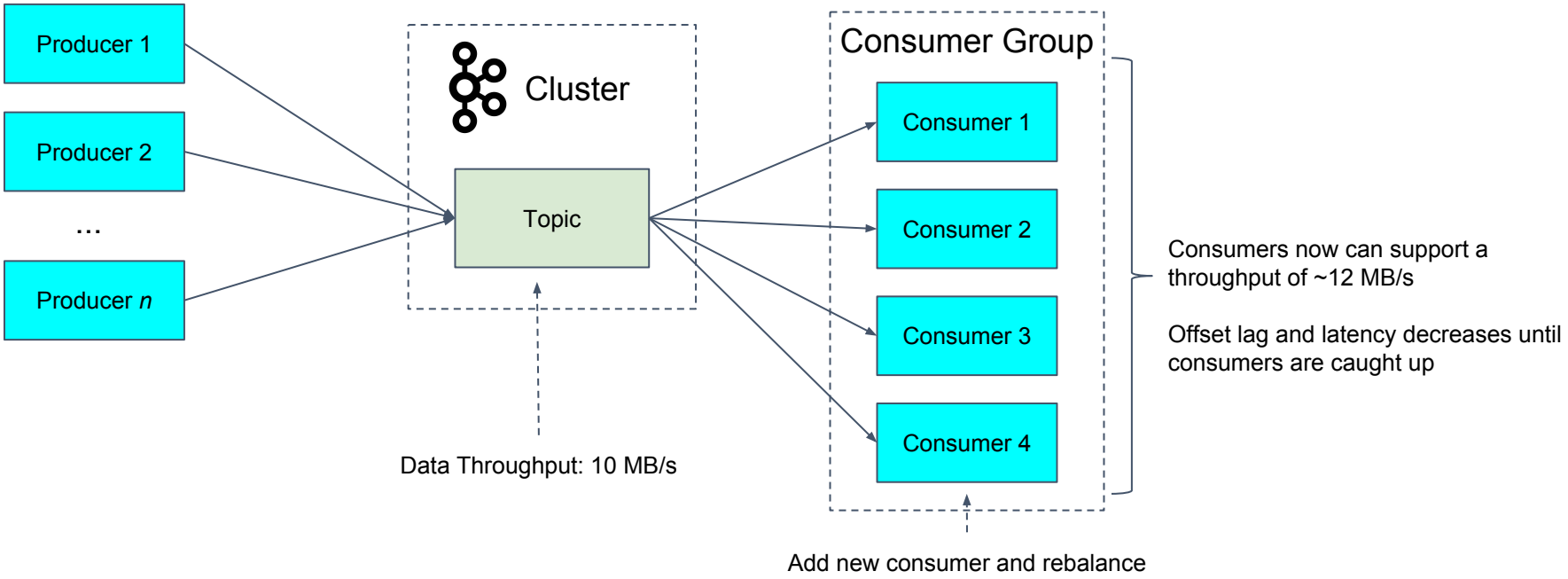
Latency and Offset Lag



Anatomy of a Consumer Group

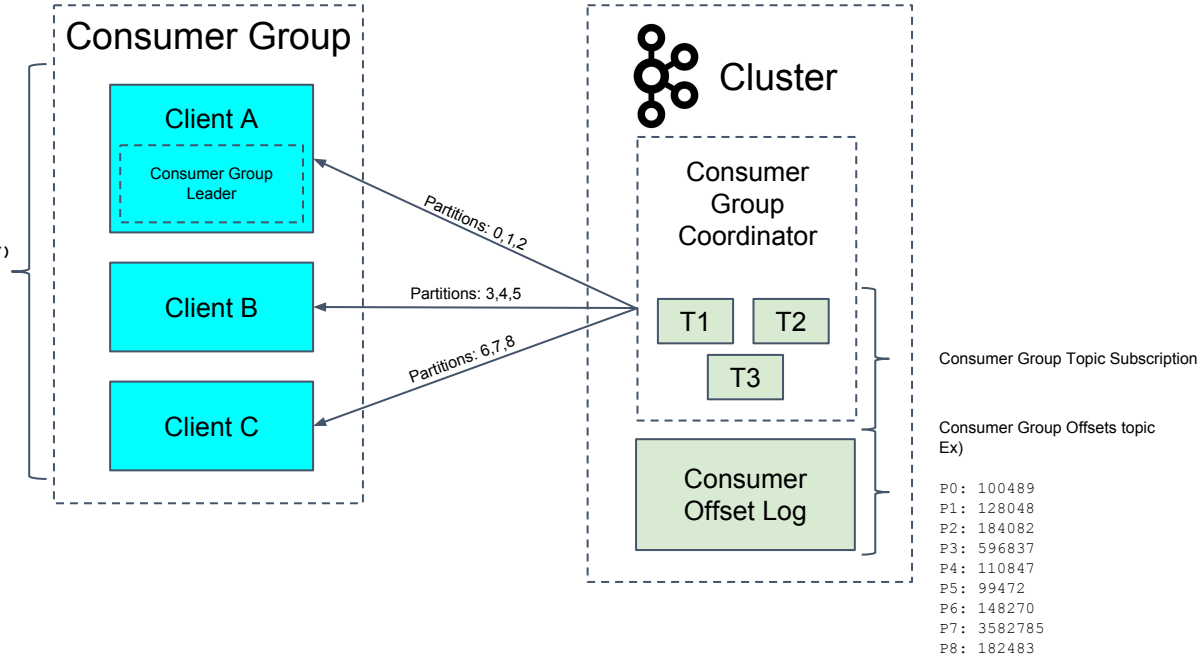
Important Consumer Group Client Config

Topic Subscription:

```
Subscription.topics("Topic1", "Topic2", "Topic3")
```

Kafka Consumer Properties:

```
group.id:                          ["my-group"]
session.timeout.ms:                [30000 ms]
partition.assignment.strategy:     [RangeAssignor]
heartbeat.interval.ms:             [3000 ms]
```

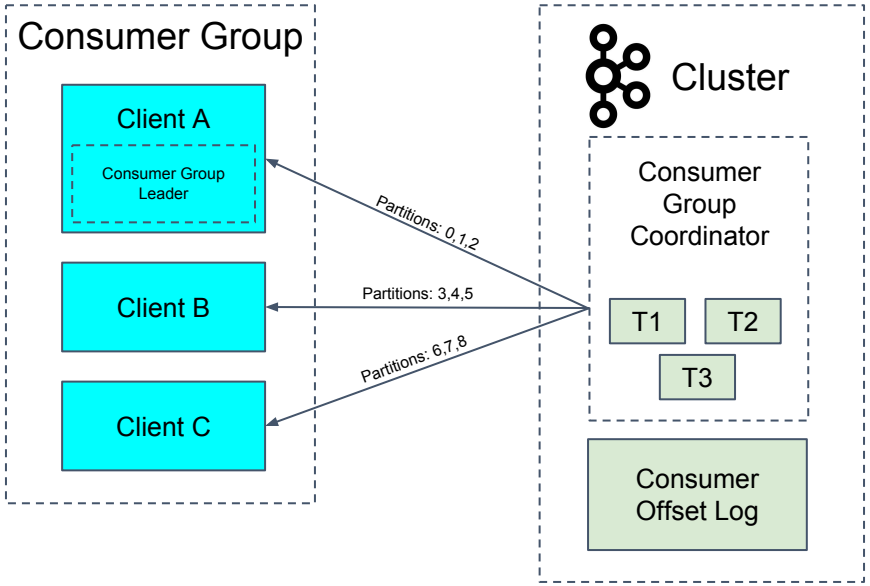


Consumer Group Topic Subscription

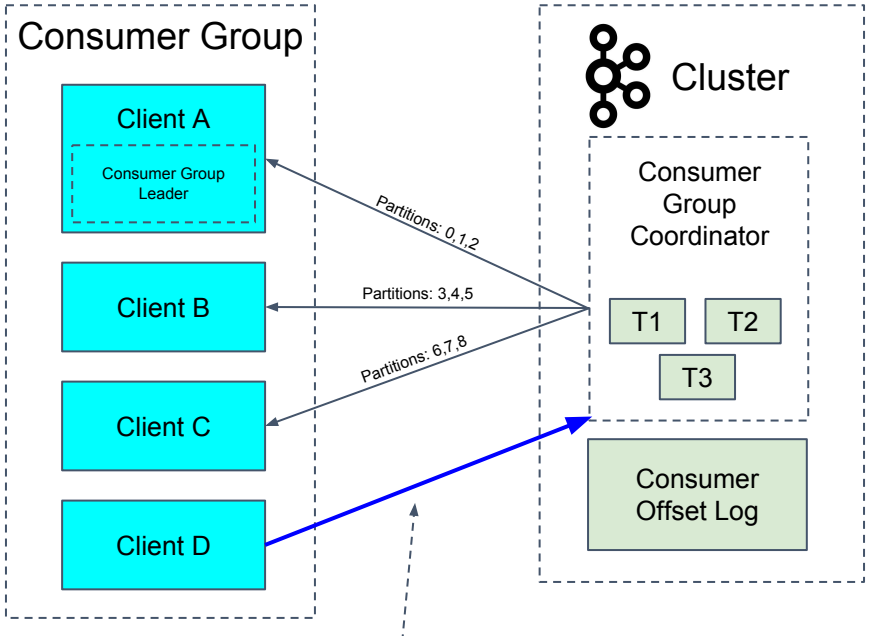
Consumer Group Offsets topic
Ex)

```
P0: 100489
P1: 128048
P2: 184082
P3: 596837
P4: 110847
P5: 99472
P6: 148270
P7: 3582785
P8: 182483
```

Consumer Group Rebalance (1/7)



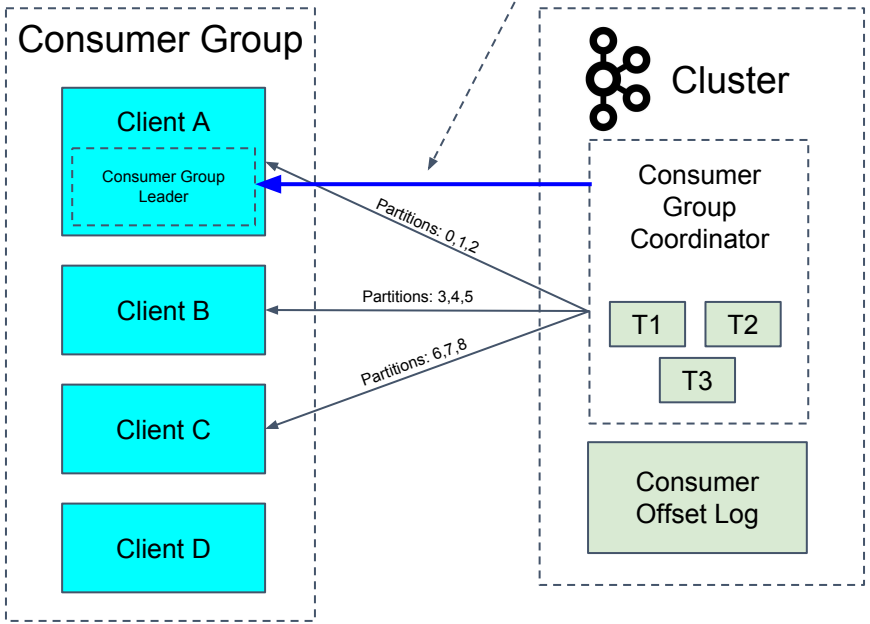
Consumer Group Rebalance (2/7)



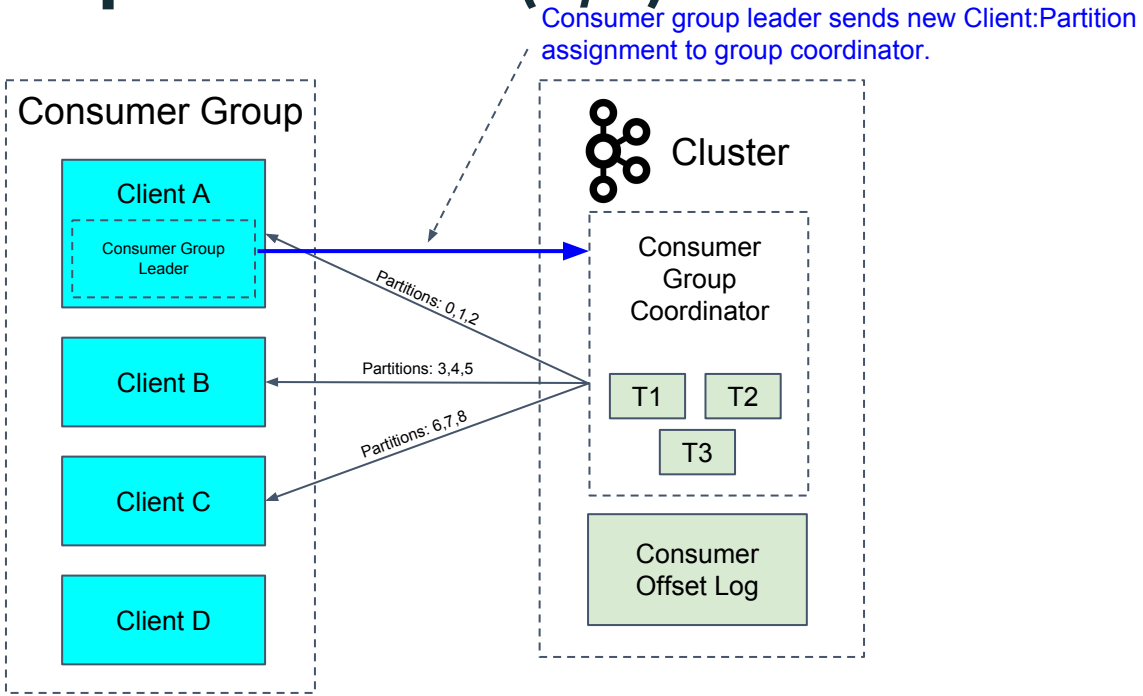
New Client D with same group.id sends a request to join the group to Coordinator

Consumer Group Rebalance (3/7)

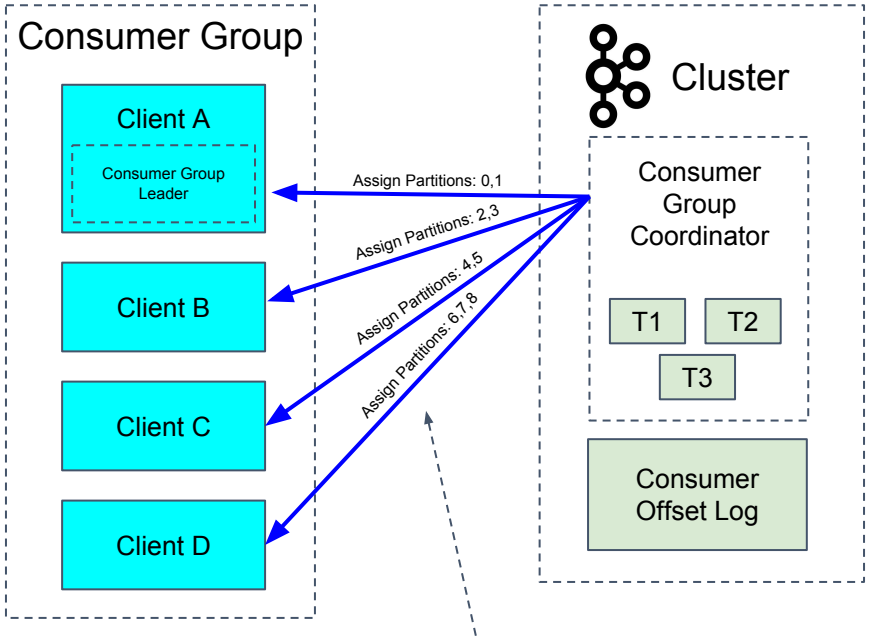
Consumer group coordinator requests group leader to calculate new Client:partition assignments.



Consumer Group Rebalance (4/7)

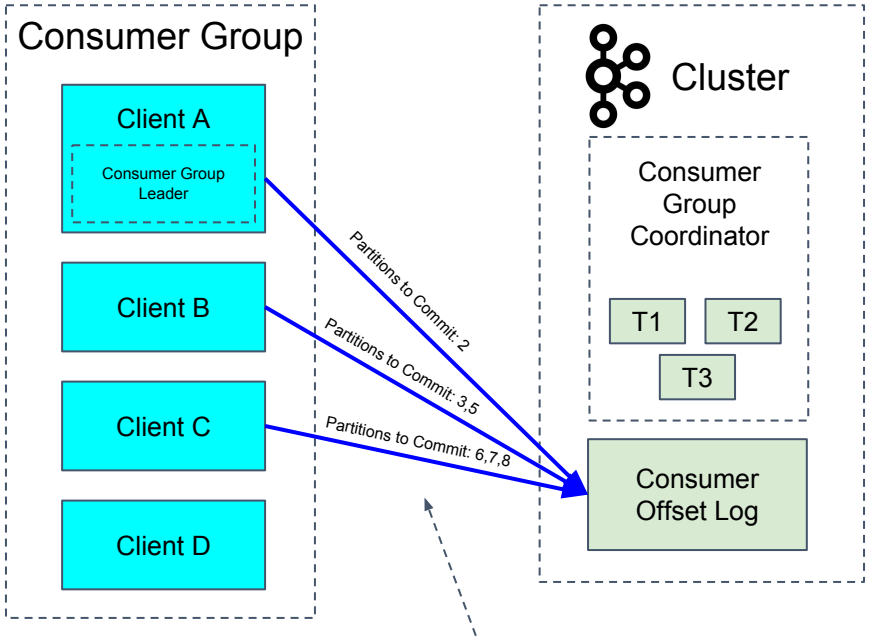


Consumer Group Rebalance (5/7)



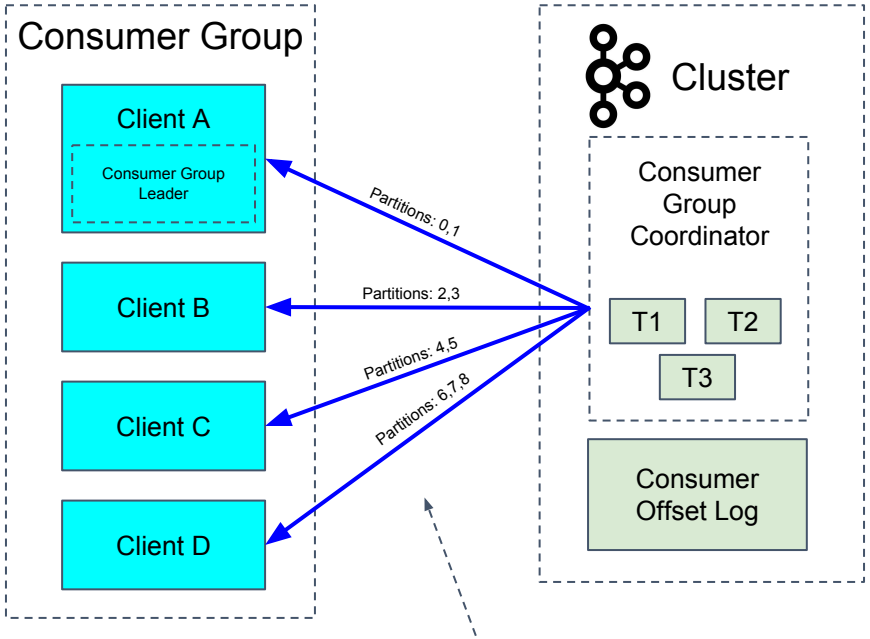
Consumer group coordinator informs all clients of their new Client:Partition assignments.

Consumer Group Rebalance (6/7)



Clients that had partitions revoked are given the chance to commit their latest processed offsets.

Consumer Group Rebalance (7/7)



Rebalance complete. Clients begin consuming partitions from their last committed offsets.

Commit on Consumer Group Rebalance

```
val consumerClientConfig = system.settings.config.getConfig("akka.kafka.consumer")
val consumerSettings = ConsumerSettings(consumerClientConfig, new StringDeserializer,  new ByteArrayDeserializer)
   .withGroupId("group1")

class RebalanceListener  extends Actor with ActorLogging {
  def receive: Receive = {
    case TopicPartitionsAssigned(sub, assigned) =>
    case TopicPartitionsRevoked(sub, revoked) =>
      commitProcessedMessages(revoked)
  }
}

val subscription = Subscriptions.topics("topic1", "topic2")
  .withRebalanceListener(system.actorOf(Props[RebalanceListener]))

val control = Consumer.committableSource(consumerSettings, subscription)
   ...
```

Declare a RebalanceListener Actor to handle assigned and revoked partitions

Commit offsets for messages processed from revoked partitions

Assign RebalanceListener to topic subscription.

Transactional “Exactly-Once”

Kafka Transactions

Transactions enable atomic writes to multiple Kafka topics and partitions. All of the messages included in the transaction will be successfully written or none of them will be.

Message Delivery Semantics

- At most once
- At least once
- “Exactly once” 

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Exactly Once Delivery vs Exactly Once Processing

Exactly-once message delivery is impossible between two parties where failures of communication are possible.

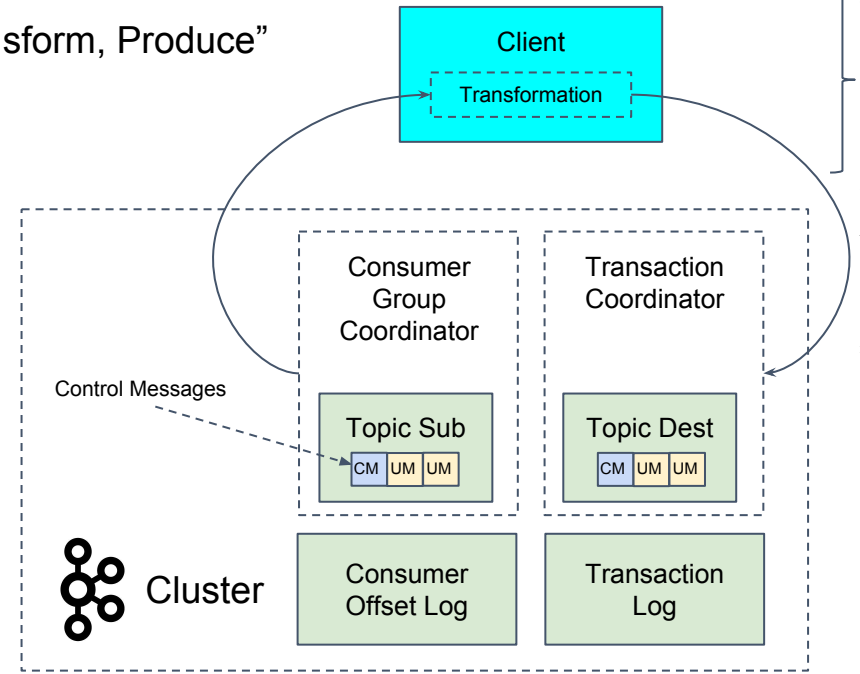
Two Generals/Byzantine Generals problem

Why use Transactions?

1. Zero tolerance for duplicate messages
2. Less boilerplate (deduping, client offset management)

Anatomy of Kafka Transactions

"Consume, Transform, Produce"



Important Client Config

Topic Subscription:

```
Subscription.topics("Topic1", "Topic2", "Topic3")
```

Destination topic partitions get included in the transaction based on messages that are produced.

Kafka Consumer Properties:

```
group.id:                                   "my-group"
isolation.level:                            "read_committed"
plus other relevant consumer group configuration
```

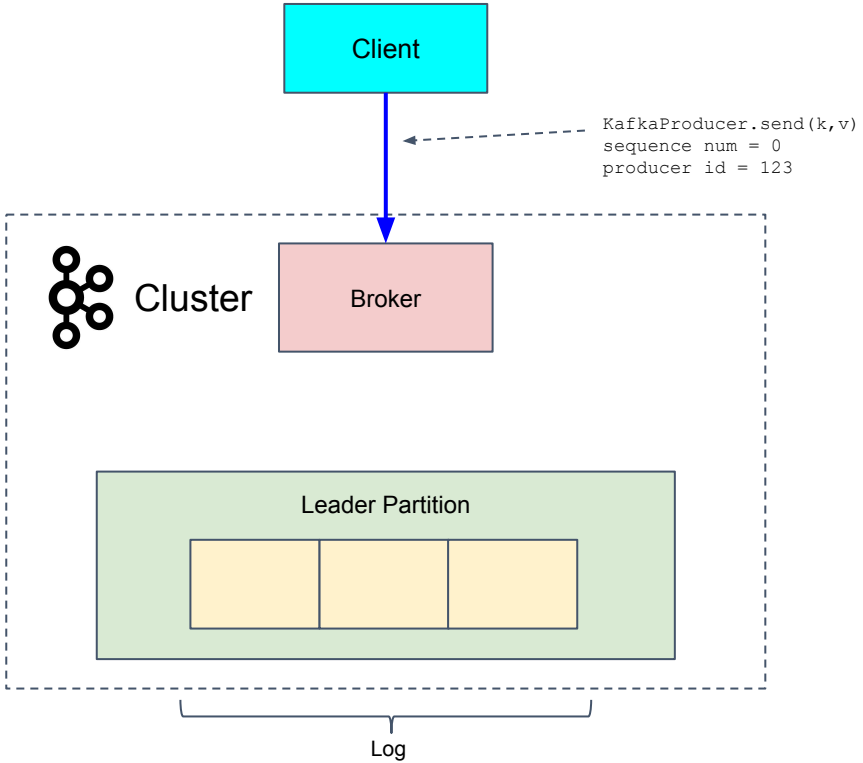
Kafka Producer Properties:

```
transactional.id:                           "my-transaction"
enable.idempotence:                         "true" (implicit)
max.in.flight.requests.per.connection:      "1" (implicit)
```

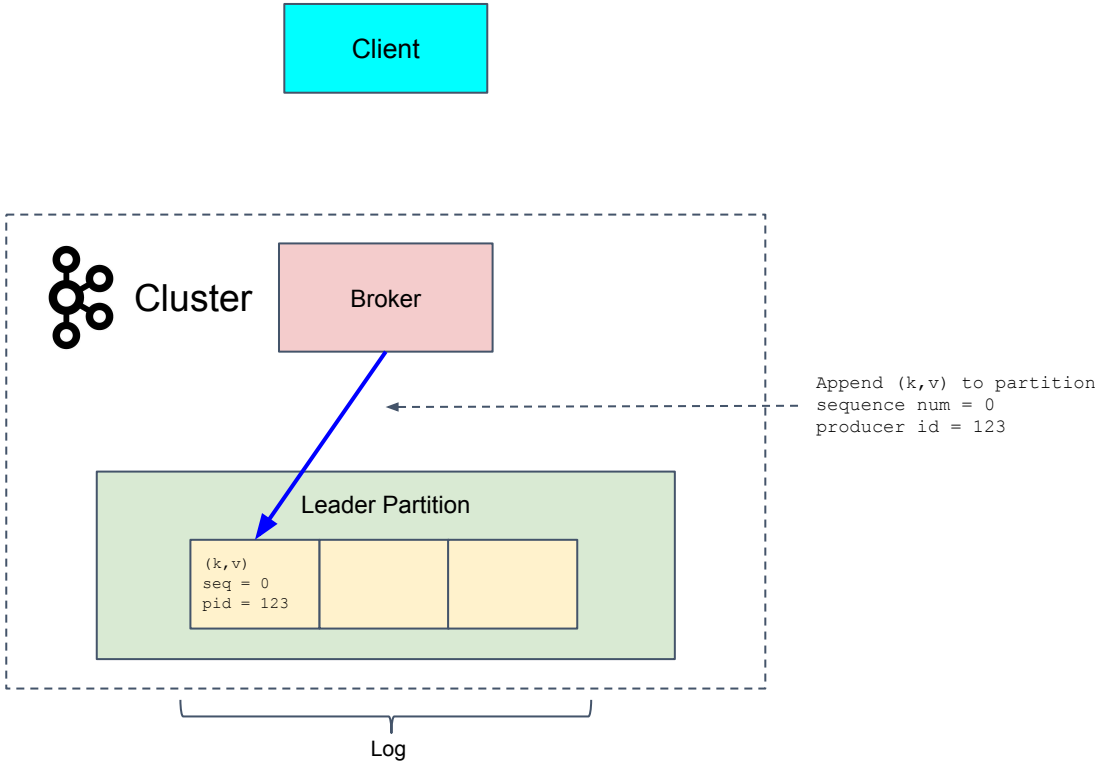
Kafka Features That Enable Transactions

1. Idempotent producer
2. Multiple partition atomic writes
3. Consumer read isolation level

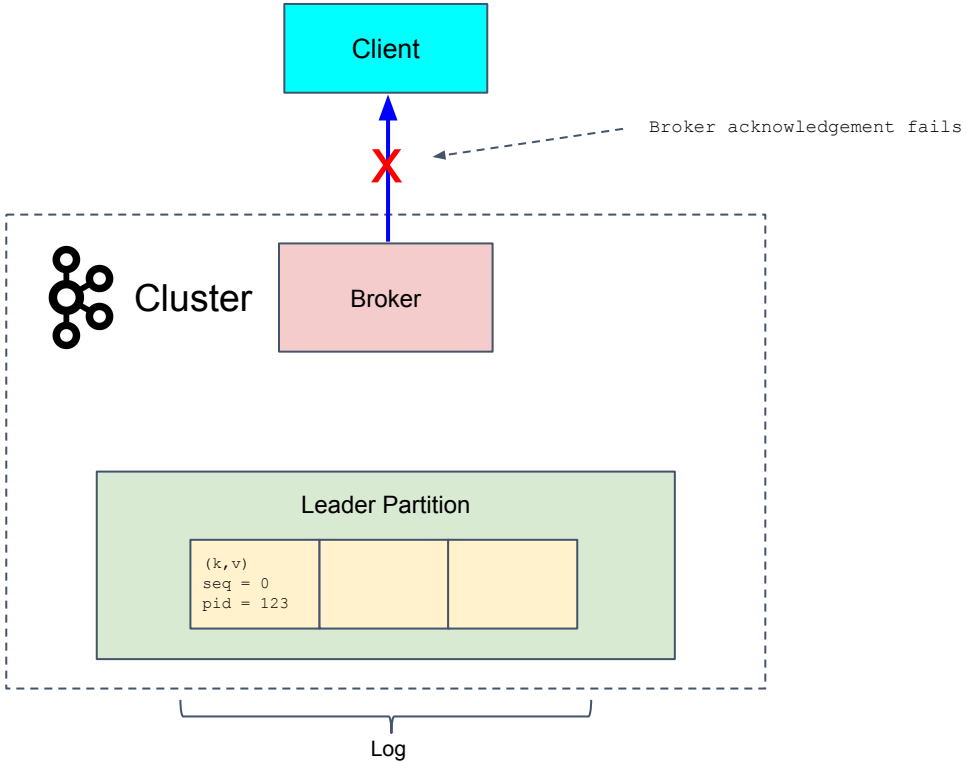
Idempotent Producer (1/5)



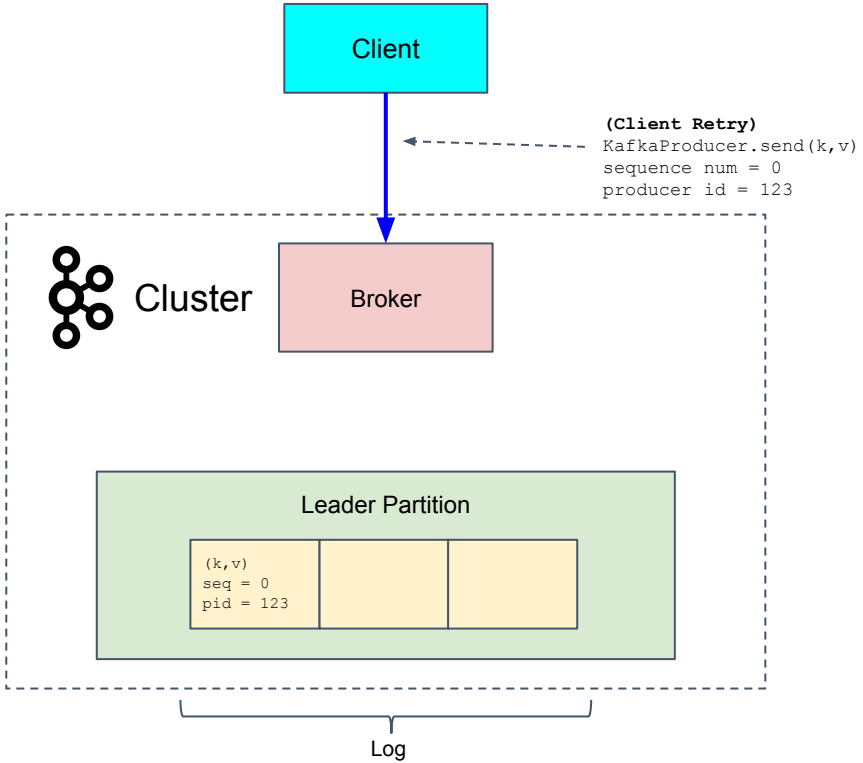
Idempotent Producer (2/5)



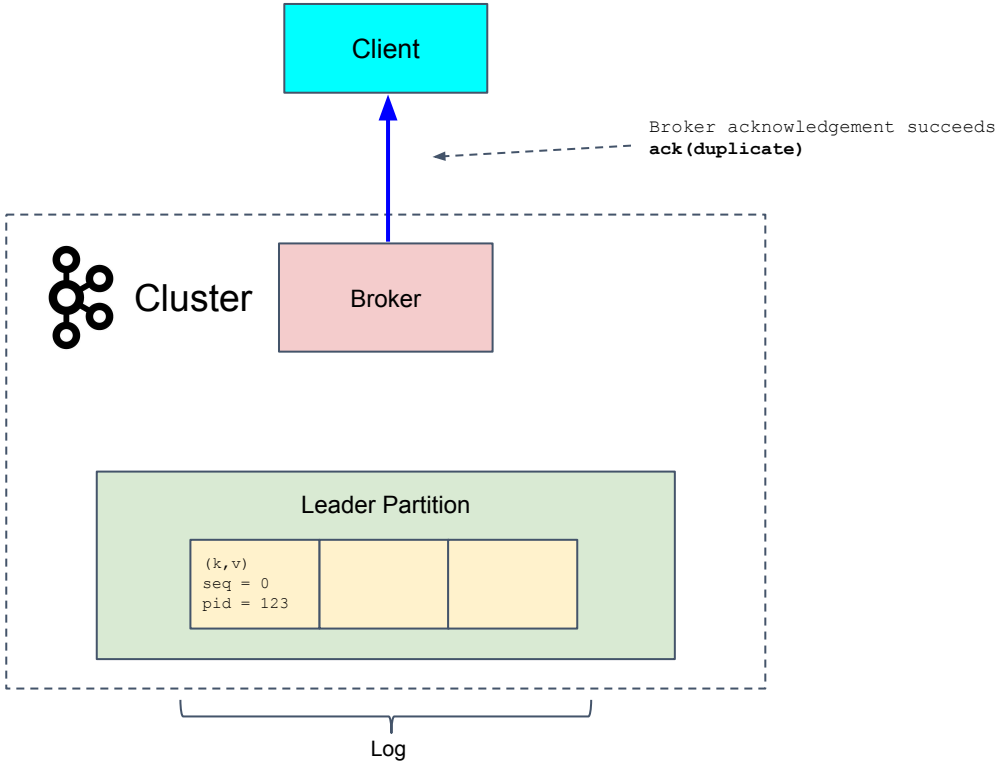
Idempotent Producer (3/5)



Idempotent Producer (4/5)

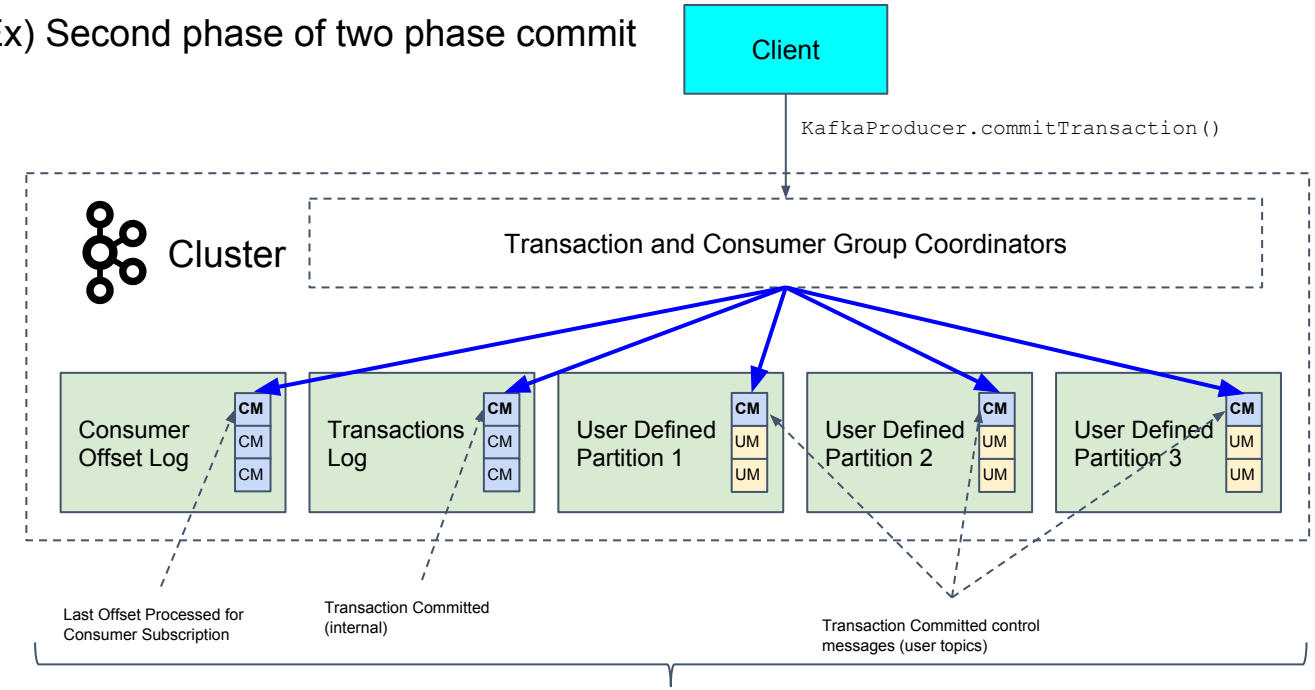


Idempotent Producer (5/5)



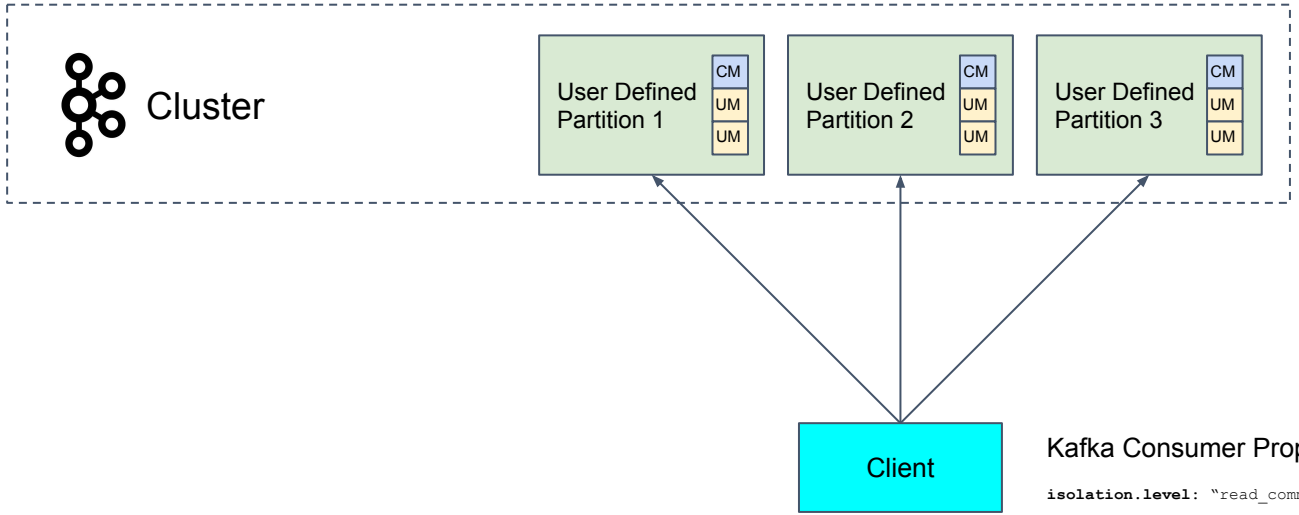
Multiple Partition Atomic Writes

Ex) Second phase of two phase commit



Multiple Partitions Committed Atomically, “All or nothing”

Consumer Read Isolation Level

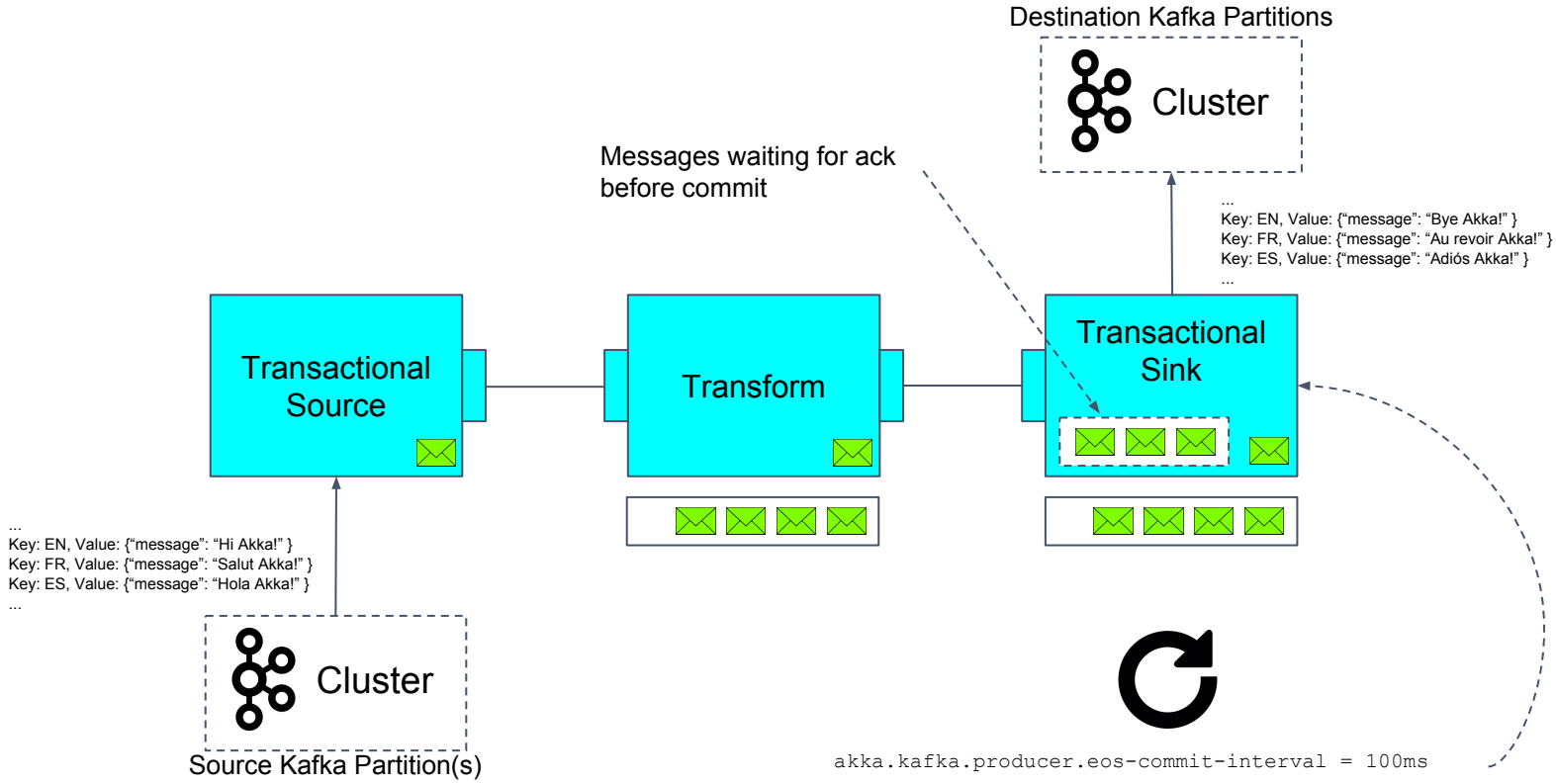


Transactional Pipeline Latency

Transaction Batches every 100ms

End-to-end Latency
~300ms

Alpakka Kafka Transactions



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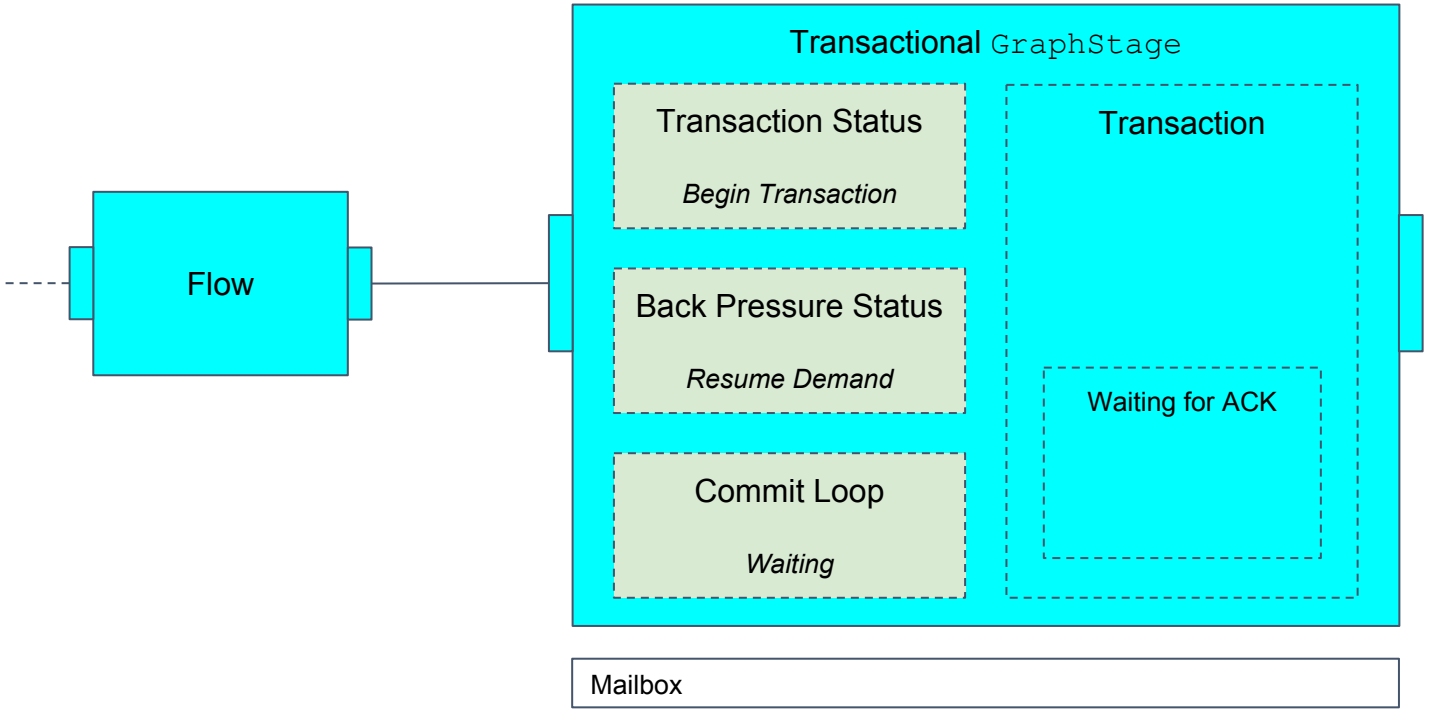
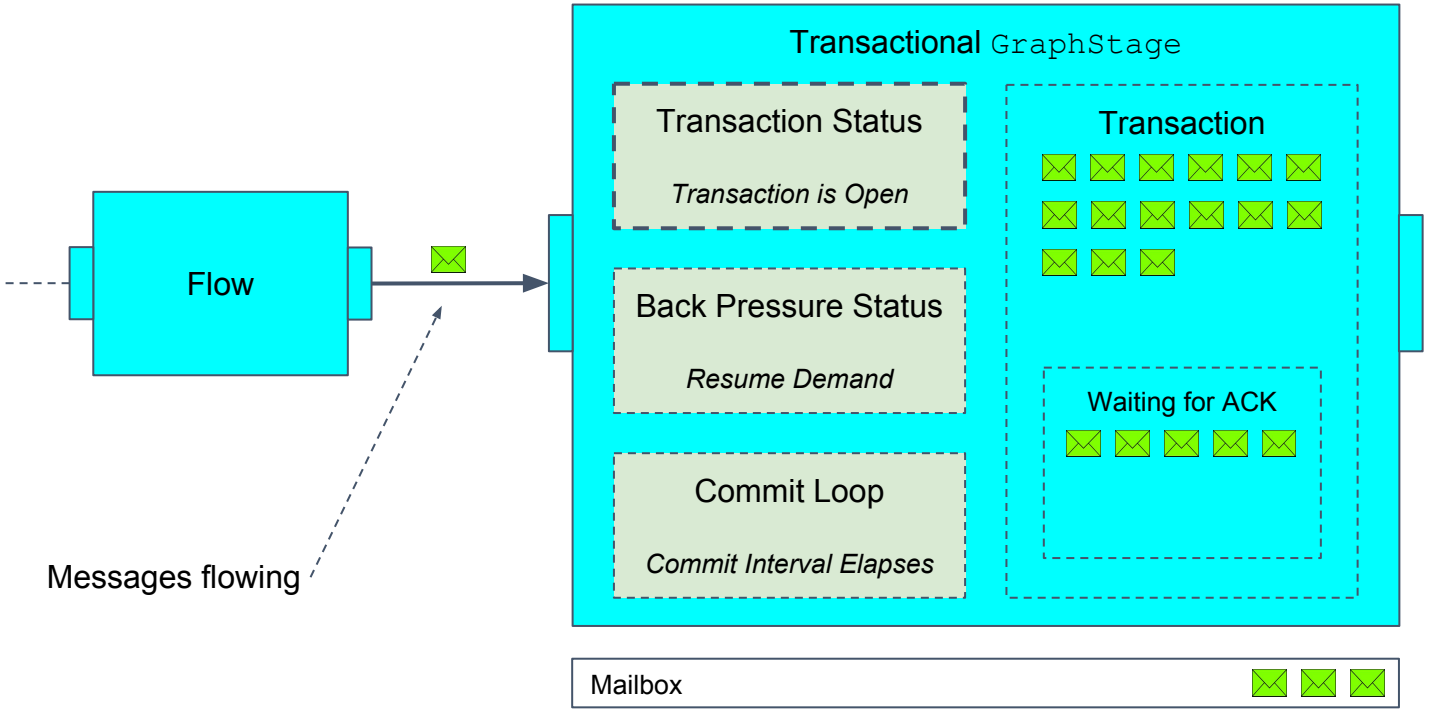
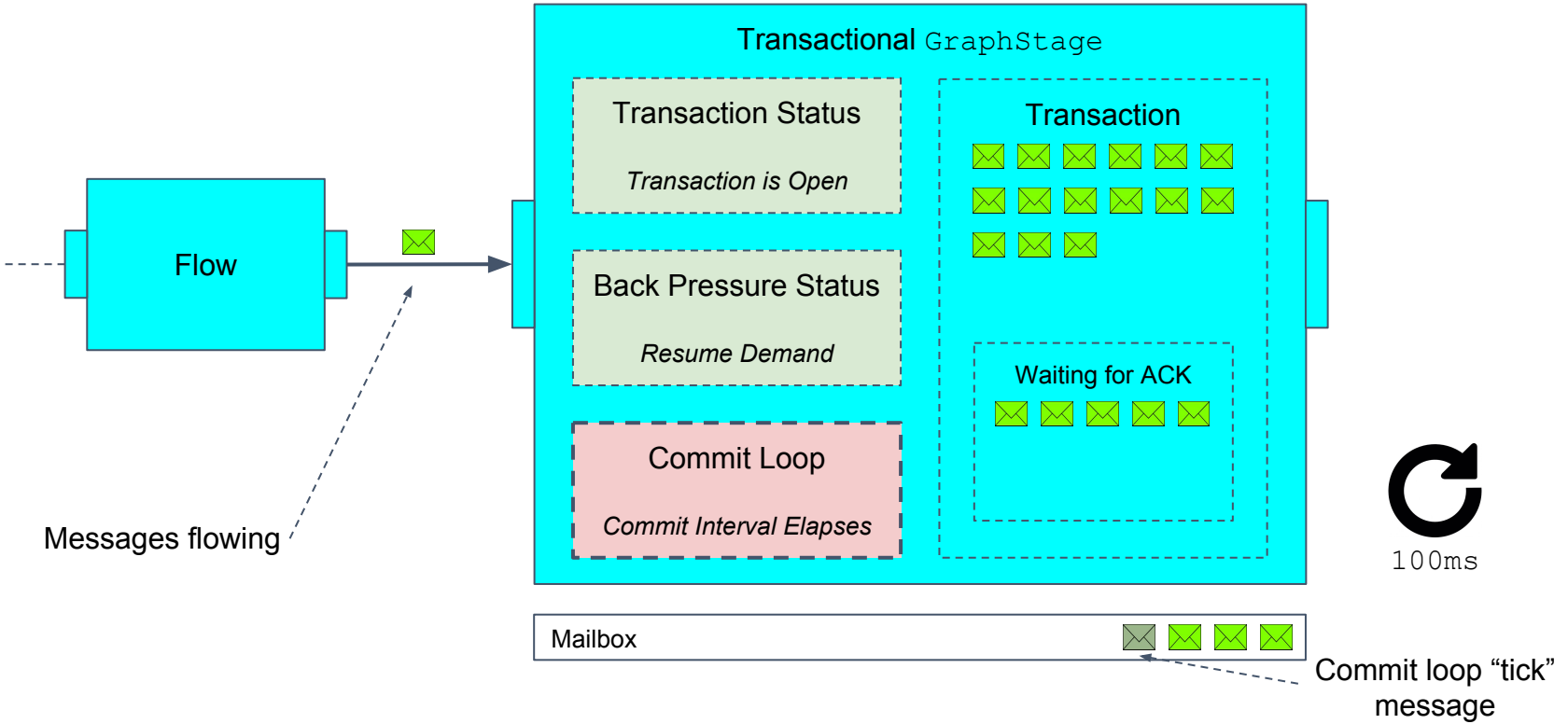
Transactional `GraphStage` (1/7)



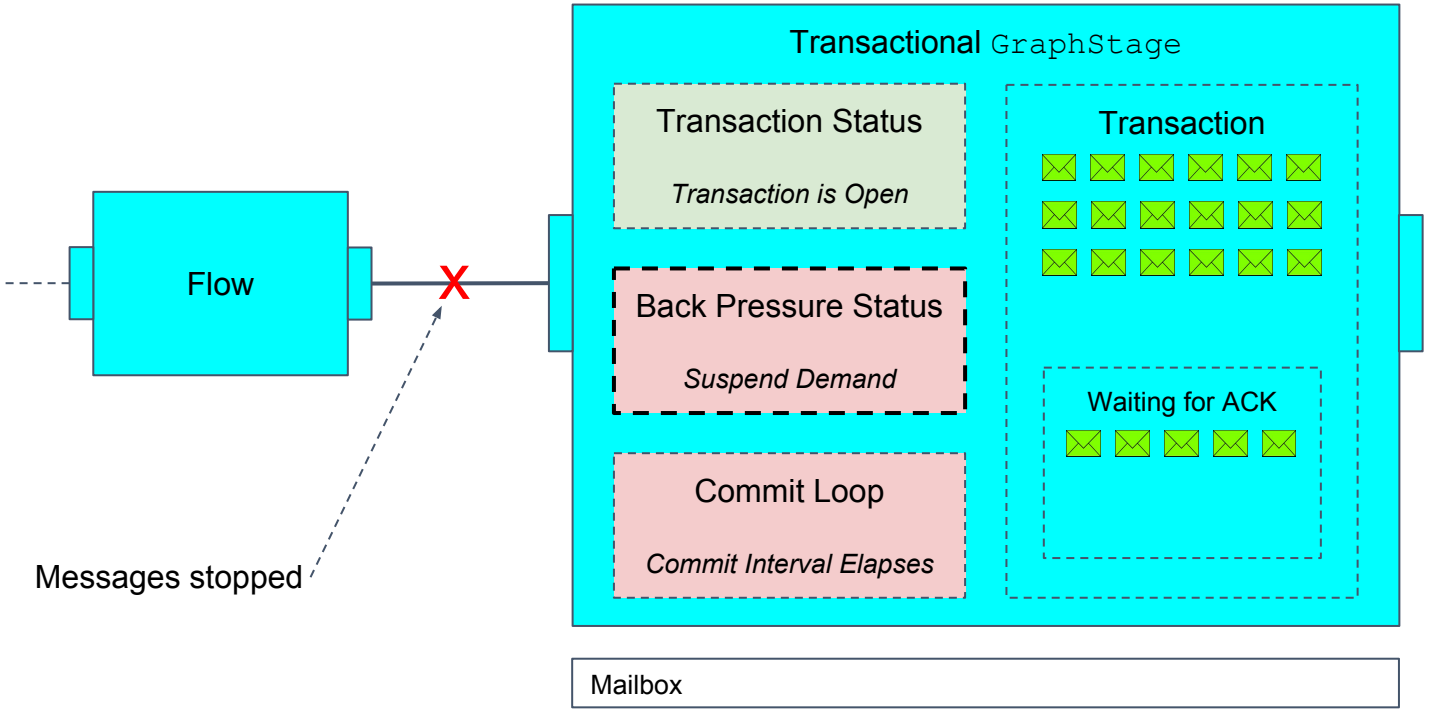
Transactional `GraphStage` (2/7)



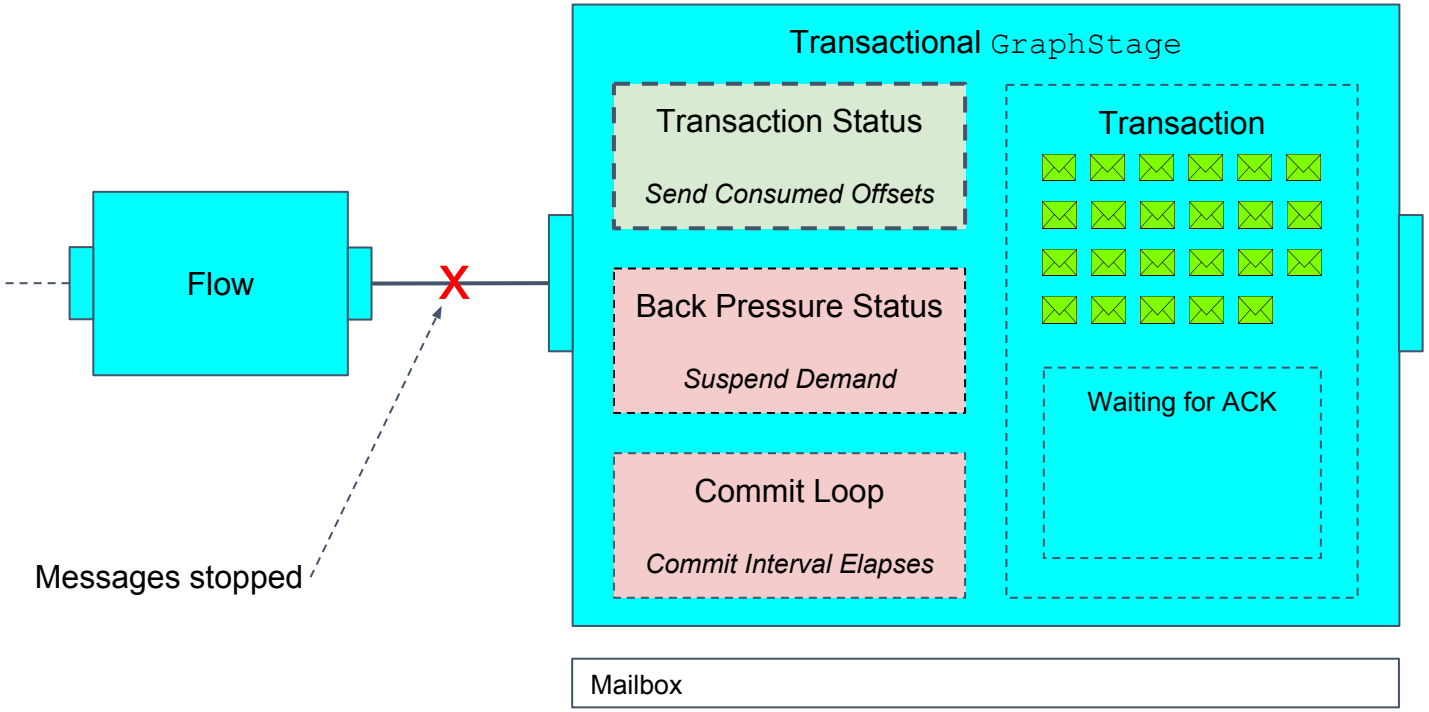
Transactional `GraphStage` (3/7)



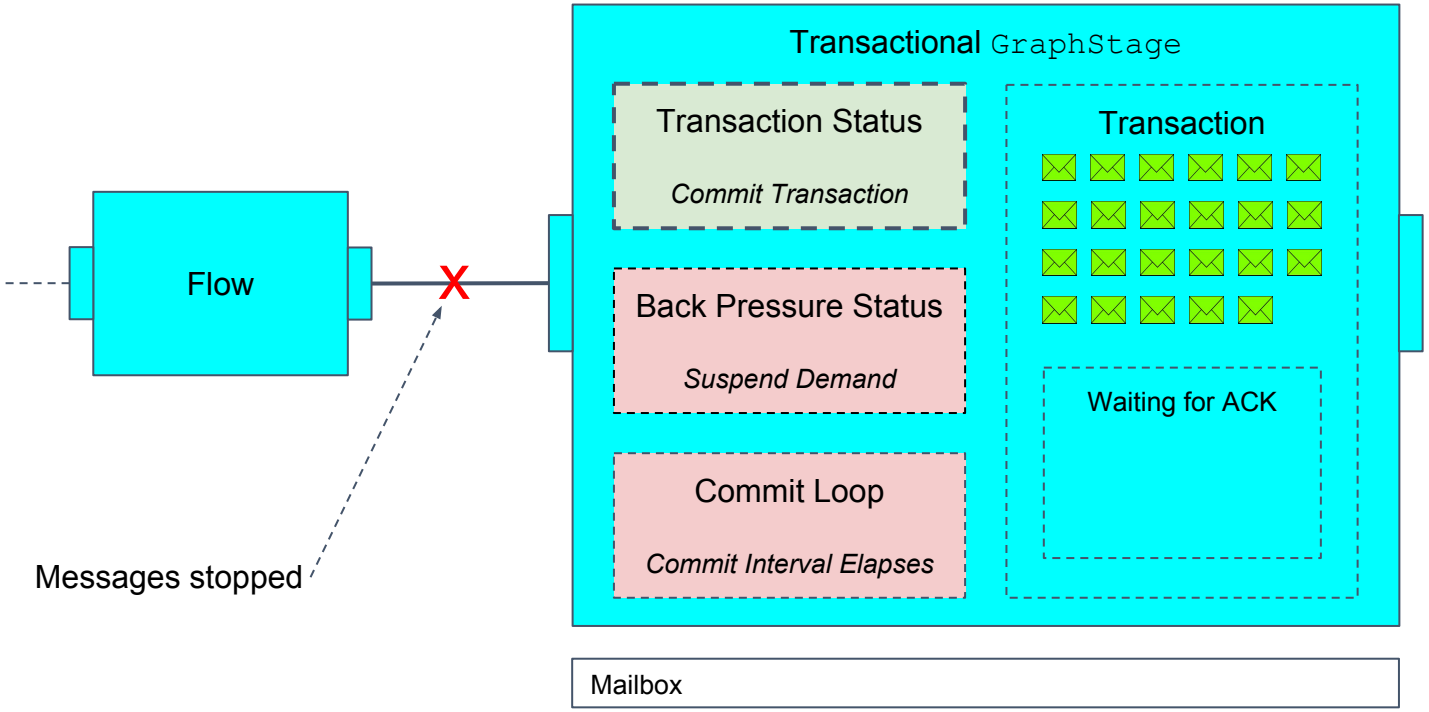
Transactional `GraphStage` (4/7)



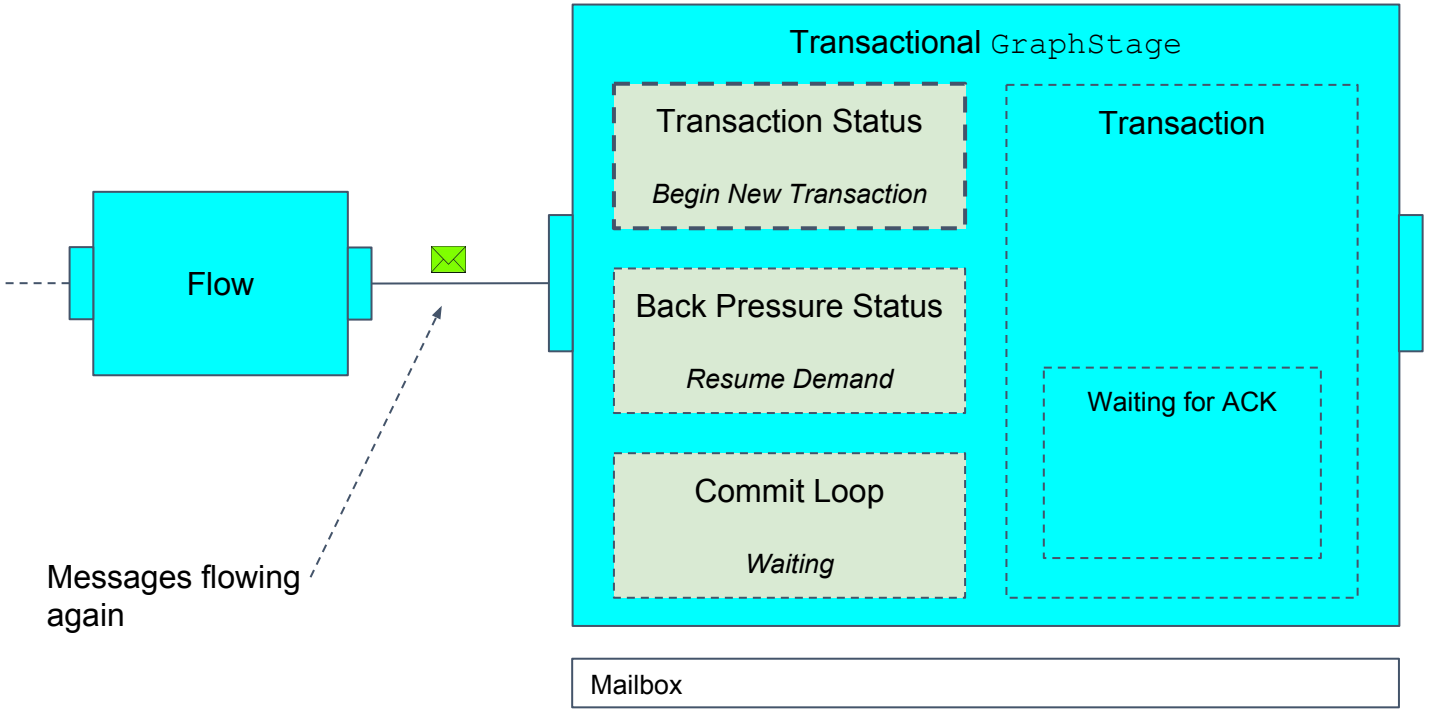
Transactional `GraphStage` (5/7)



Transactional `GraphStage` (6/7)



Transactional `GraphStage` (7/7)



Alpakka Kafka Transactions

```
val producerSettings = ProducerSettings(system, new StringSerializer,  new ByteArraySerializer)
 .withBootstrapServers( "localhost:9092")
 .withEosCommitInterval( 100.millis)

val control =
 Transactional
   .source(consumerSettings, Subscriptions. topics("source-topic"))
   .via(transform)
   .map { msg =>
     ProducerMessage. Message(new ProducerRecord[ String, Array[Byte]]( "sink-topic", msg.record.value),
       msg.partitionOffset)
   }
   .to(Transactional. sink(producerSettings, "transactional-id"))
   .run()
```

Optionally provide a Transaction commit interval (default is 100ms)

Use `Transactional.source` to propagate necessary info to `Transactional.sink` (CG ID, Offsets)

Call `Transactional.sink` or `.flow` to produce and commit messages.

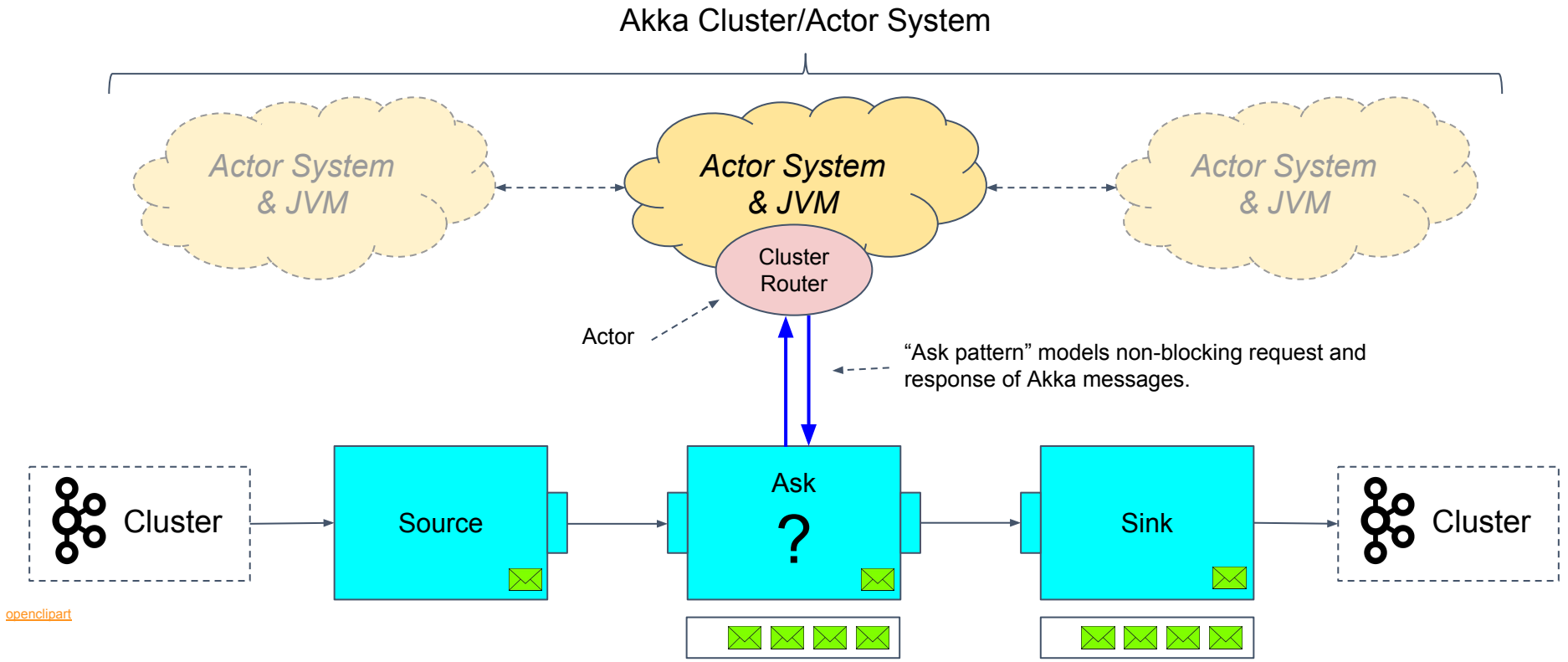
Complex Event Processing

What is Complex Event Processing (CEP)?

Complex event processing, or CEP, is event processing that combines data from multiple sources to infer events or patterns that suggest more complicated circumstances.

Foundations of Complex Event Processing, Cornell

Calling into an Akka Actor System



Actor System Integration

```
class ProblemSolverRouter  extends Actor {
  def receive = {
    case problem: Problem =>
      val solution = businessLogic(problem)
      sender() ! solution  // reply to the ask
  }
}
...
val control = Consumer
   .committableSource(consumerSettings, Subscriptions.topics("topic1", "topic2"))
   .map(parseProblem)
   .mapAsync(parallelism =  5)(problem => (problemSolverRouter ? problem).mapTo[Solution])
   .map { solution => ProducerMessage.Message[String, Array[Byte], ConsumerMessage.CommittableOffset](
       new ProducerRecord("targetTopic", solution.toBytes), solution.committableOffset)
   }
   .toMat(Producer.commitableSink(producerSettings))(Keep.both)
   .mapMaterializedValue(DrainingControl.apply)
   .run()
```

Transform your stream by processing messages in an Actor System. All you need is an `ActorRef`.

Use Ask pattern (`?` function) to call provided `ActorRef` to get an async response

Parallelism used to limit how many messages in flight so we don't overwhelm mailbox of destination Actor and maintain stream back-pressure.

Persistent Stateful Stages

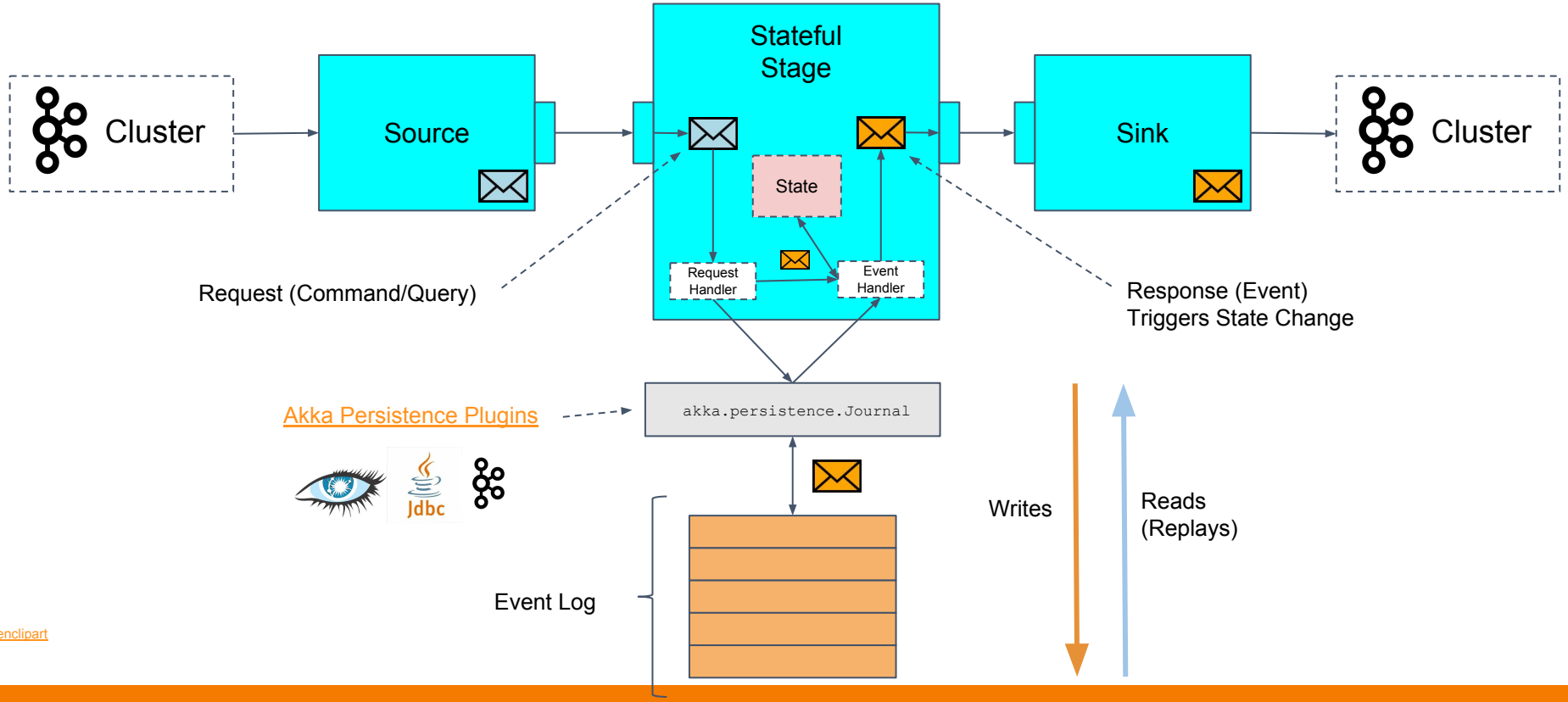
Options for implementing Stateful Streams

1. Provided Akka Streams stages: `fold`, `scan`, etc.
2. Custom GraphStage
3. Call into an Akka Actor System

Persistent Stateful Stages using Event Sourcing

1. Recover state after failure
2. Create an event log
3. Share state

Persistent `GraphStage` using Event Sourcing



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krasserm / **akka-stream-eventsourcing**

This project brings to Akka Streams what Akka Persistence brings to Akka Actors: persistence via event sourcing.

Public Domain Vectors

Experimental

New in Alpakka Kafka 1.0-M1

Alpakka Kafka 1.0M1 Release Notes

Released **Nov 6, 2018**. Highlights:

- Upgraded the Kafka client to version 2.0.0 #544 by @fr3akX
  - Support new API's from KIP-299: Fix Consumer indefinite blocking behaviour in #614 by @zaharidichev
- New Committer.sink for standardised committing #622 by @rtimush
- Commit with metadata #563 and #579 by @johnclara
- Factored out akka.kafka.testkit for internal and external use: see Testing
- Support for merging commit batches #584 by @rtimush
- Reduced risk of message loss for partitioned sources #589
- Expose Kafka errors to stream #617
- Java APIs for all settings classes #616
- Much more comprehensive tests

Conclusion


alpakka
kafka connector
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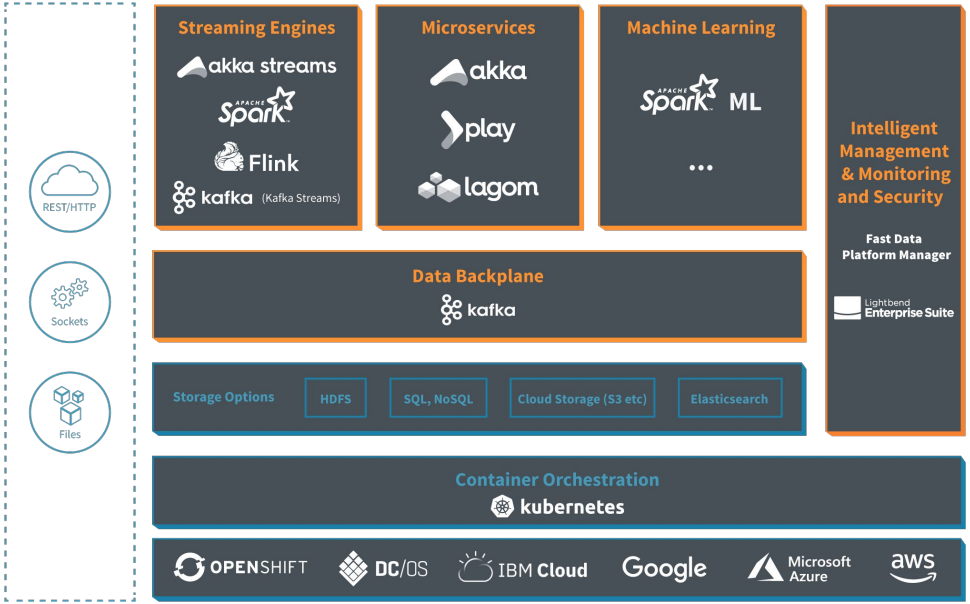
Lightbend Fast Data Platform



http://lightbend.com/fast-data-platform

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Thank You!

Sean Glover
@seg1o
in/seanaglover
sean.glover@lightbend.com

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