Fast Data apps with Alpakka Kafka connector

Sean Glover, Lightbend
@seg1o

Who am I?

I’m Sean Glover

- Senior Software 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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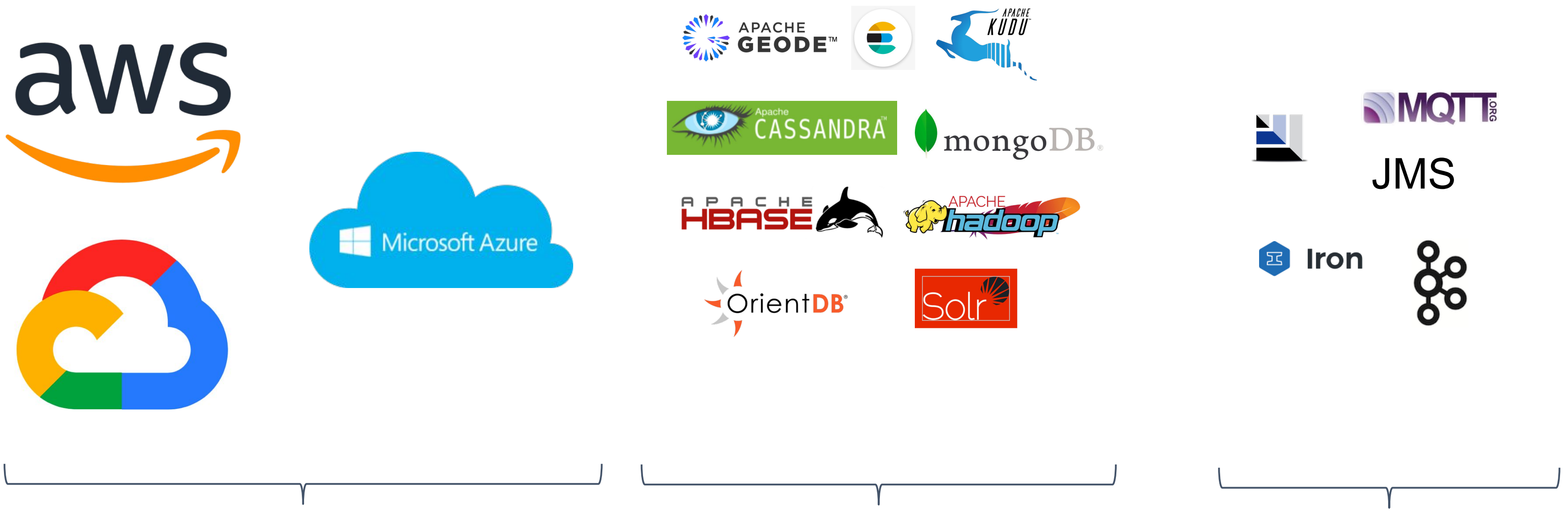
alpakka

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

alpakka



Cloud Services

Data Stores

Messaging

alpakka

kafka connector

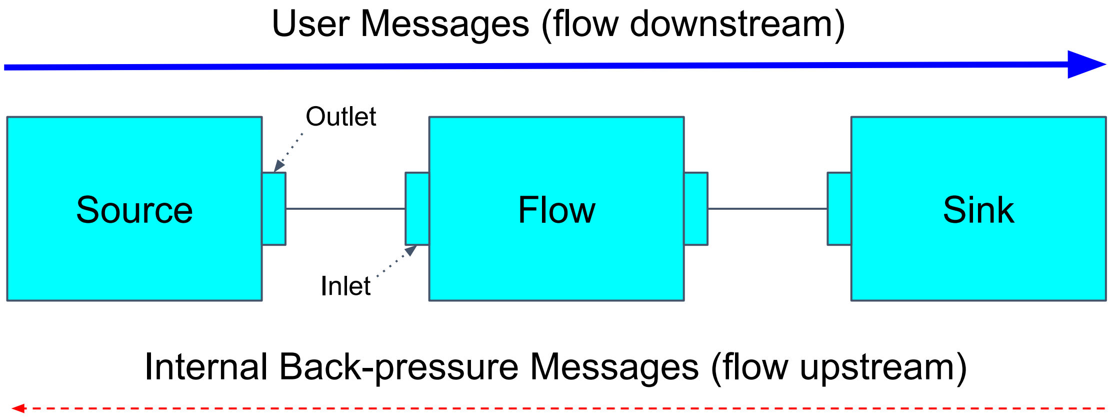
> “ *This Alpakka Kafka connector lets you connect Apache Kafka to Akka Streams. It was formerly known as Akka Streams Kafka and even Reactive Kafka.* ”

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

“ *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

akka streams

RxJava

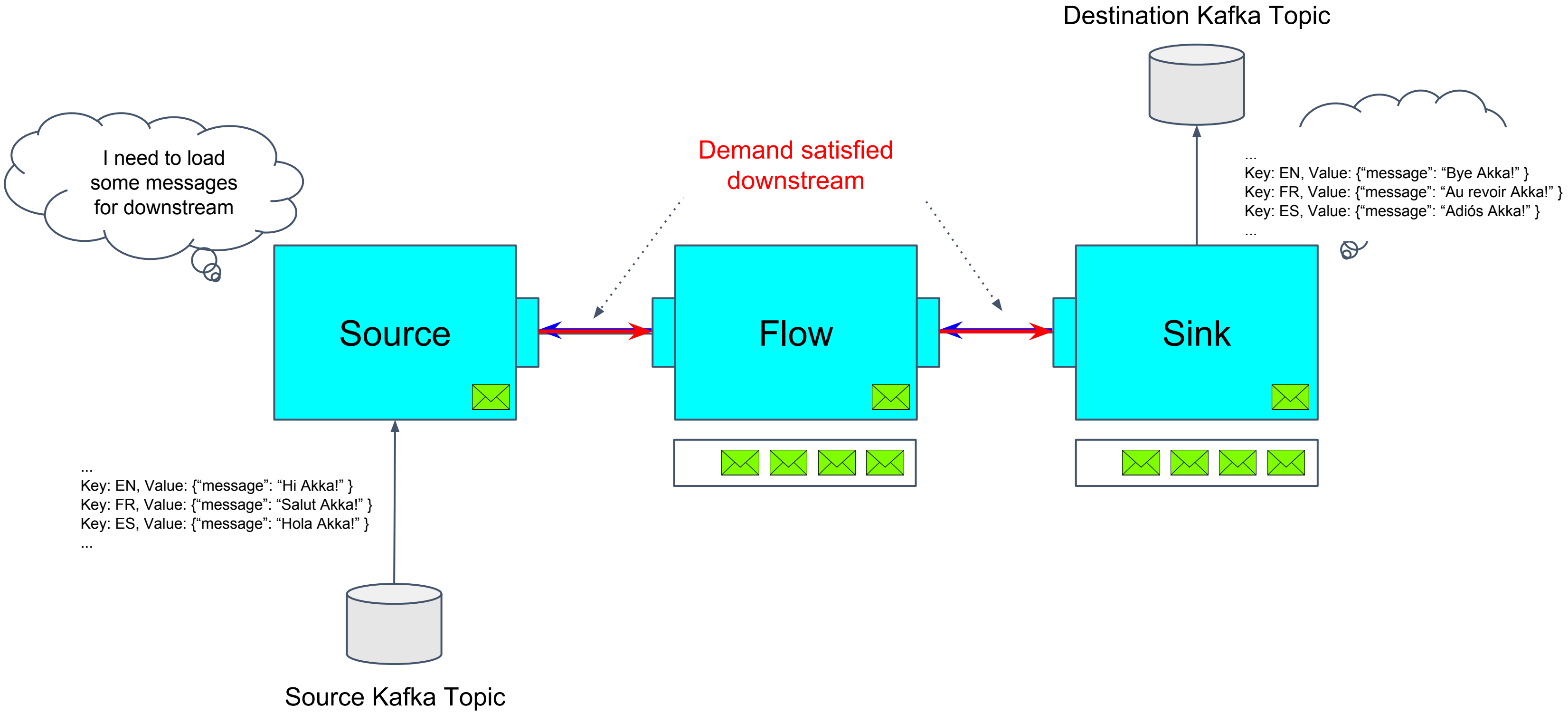
VERT.X

migrating to

Spec now part of JDK 9

`java.util.concurrent.Flow`

Back-pressure



Destination Kafka Topic
I need to load some messages for downstream
Demand satisfied downstream
Source
Flow
Sink
Source Kafka Topic

...
Key: EN, Value: {“message”: “Bye Akka!” }
Key: FR, Value: {“message”: “Au revoir Akka!” }
Key: ES, Value: {“message”: “Adiós Akka!” }
...

...
Key: EN, Value: {“message”: “Hi Akka!” }
Key: FR, Value: {“message”: “Salut Akka!” }
Key: ES, Value: {“message”: “Hola Akka!” }
...

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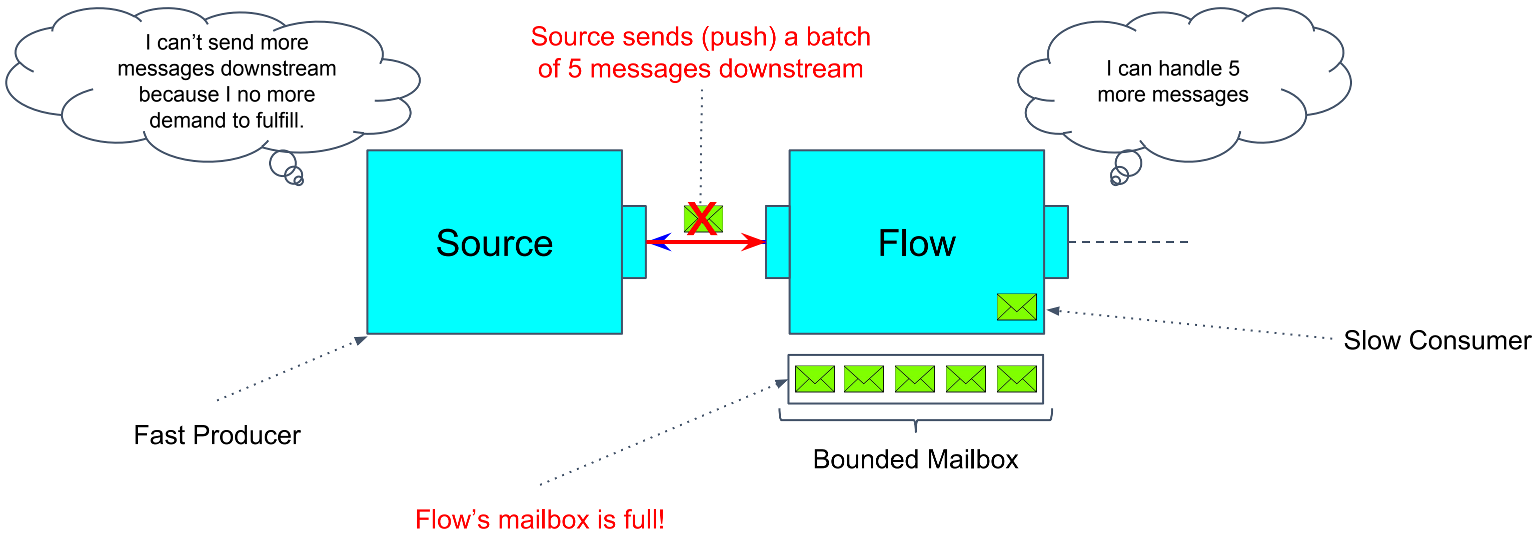
Dynamic Push Pull



I can't send more messages downstream because I no more demand to fulfill.

Source sends (push) a batch of 5 messages downstream

I can handle 5 more messages

Flow's mailbox is full!

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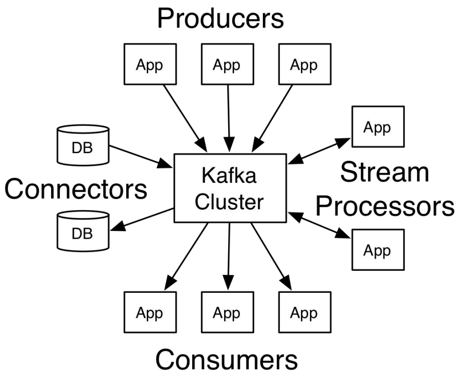
Kafka

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



Kafka Documentation

Why use Alpakka Kafka over Kafka Streams?

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

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

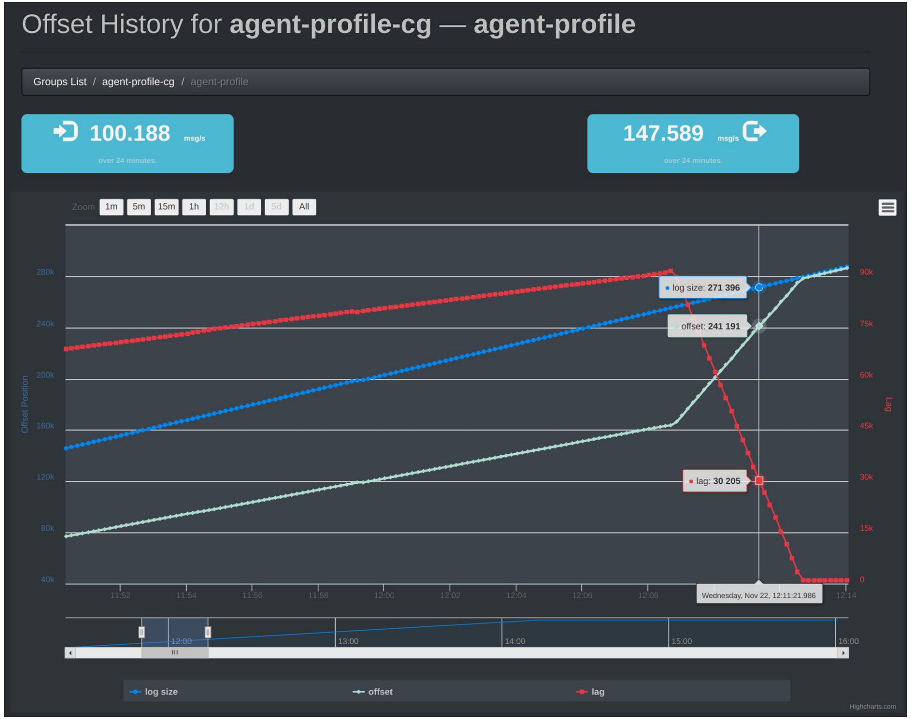
Produce `ProducerMessage` and automatically commit the consumed message once it's been acknowledged

Graceful shutdown on SIGTERM

Consumer Groups

Why use Consumer Groups?

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



Offset History for **agent-profile-cg — agent-profile**

Groups List / agent-profile-cg / agent-profile

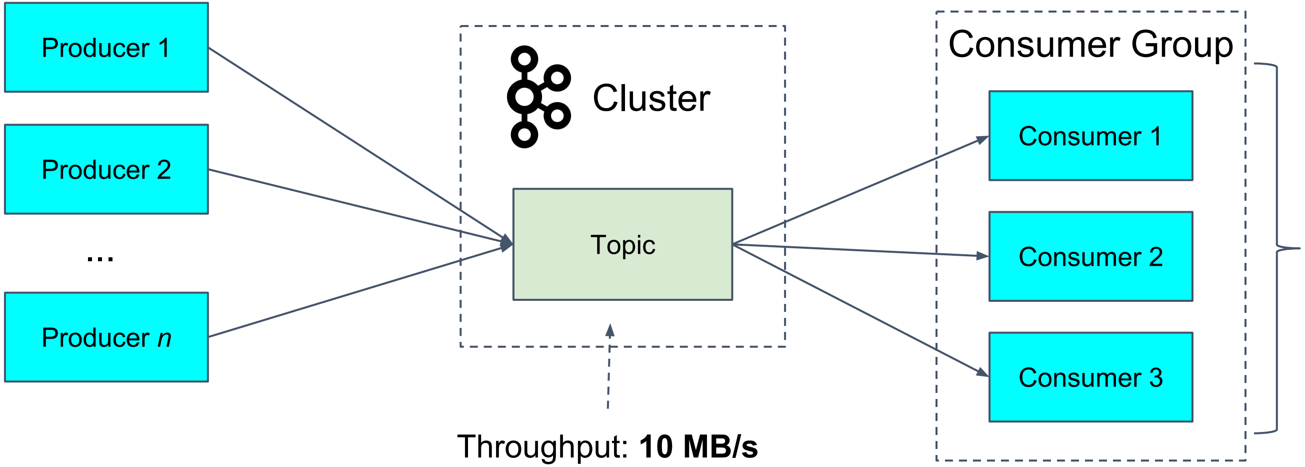
100.188 msg/s

over 24 minutes.

147.589 msg/s

over 24 minutes.

Latency and Offset Lag



Producer 1

Producer 2

...

Producer *n*

Cluster

Topic

Throughput: **10 MB/s**

Consumer Group

Consumer 1

Consumer 2

Consumer 3

Consumer Throughput ~3 MB/s each

~9 MB/s

Total offset lag and latency is growing.

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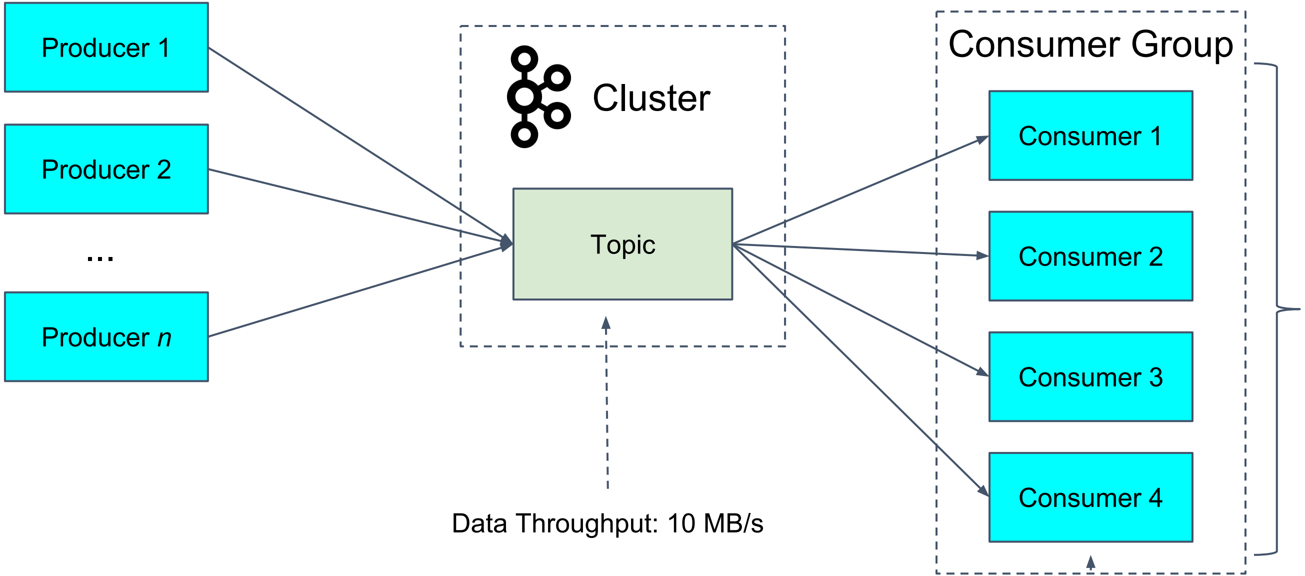
Latency and Offset Lag



Data Throughput: 10 MB/s

Add new consumer and rebalance

Consumers now can support a throughput of ~12 MB/s

Offset lag and latency decreases until consumers are caught up

Anatomy of a Consumer Group

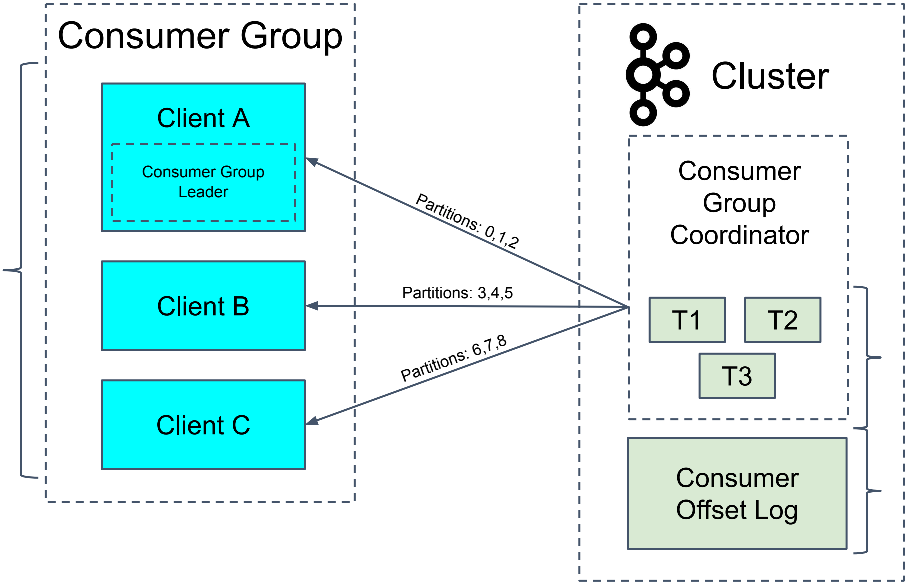
Important Consumer Group Client Config

Topic Subscription:

```
Subscription.topics(“Topic1”, “Topic2”, “Topic3”)
```

Kafka Consumer Properties:

```
group.id:                      [“”]
session.timeout.ms:            [30000 ms]
partition.assignment.strategy: [RangeAssignor]
heartbeat.interval.ms:         [3000 ms]
```

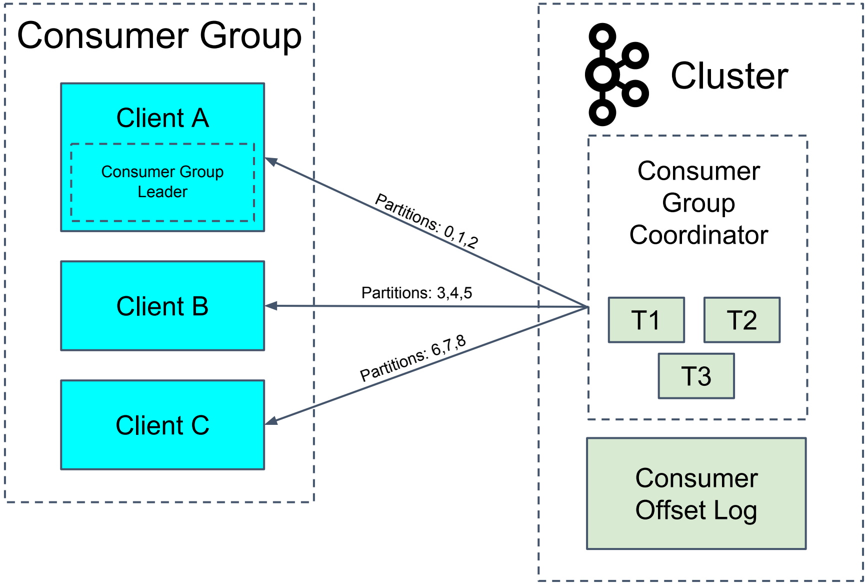


Consumer Group
Topic Subscription

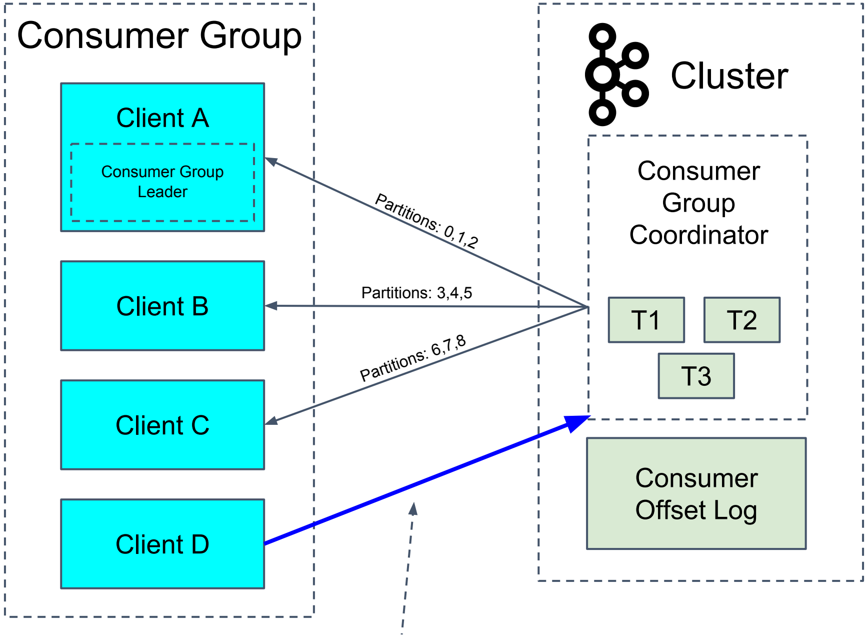
Consumer Group Offsets topic
Ex)

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

Consumer Group Rebalance (1/7)



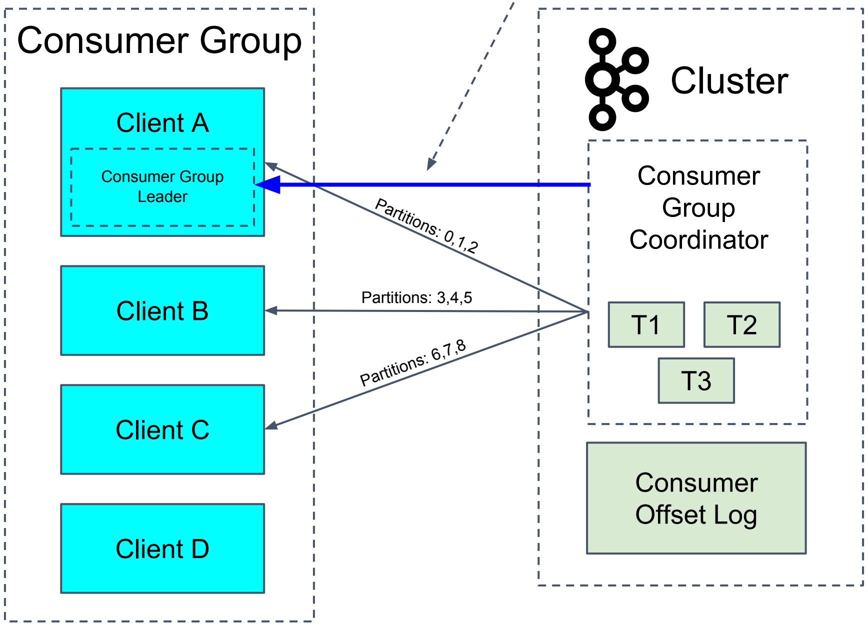
Consumer Group Rebalance (2/7)



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

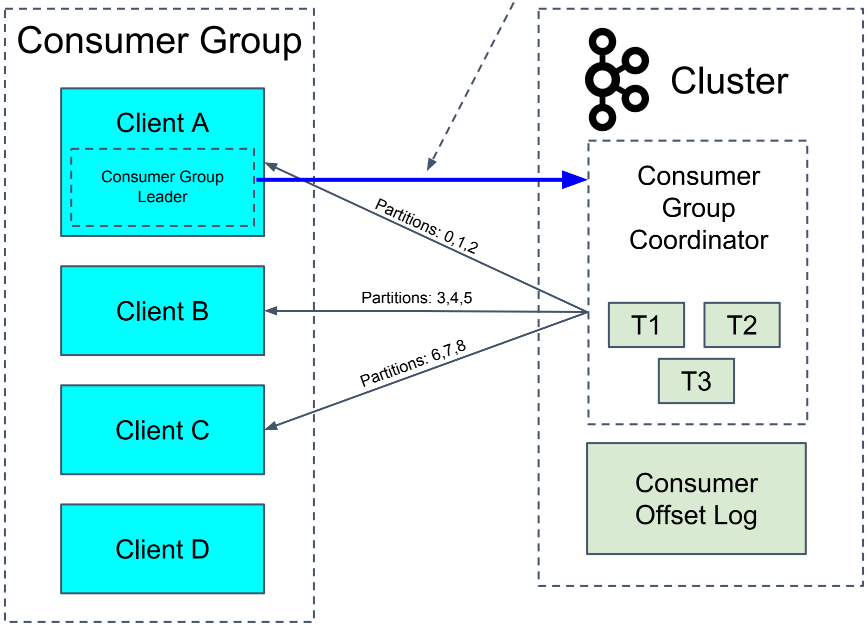
Consumer Group Rebalance (3/7)

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

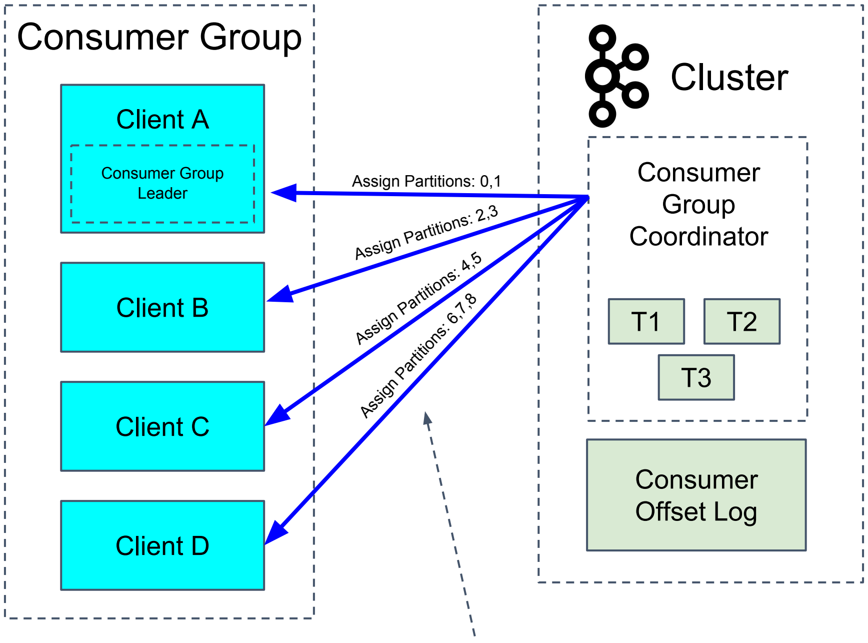


Consumer Group Rebalance (4/7)

Consumer group leader sends new Client:Partition assignment to group coordinator.

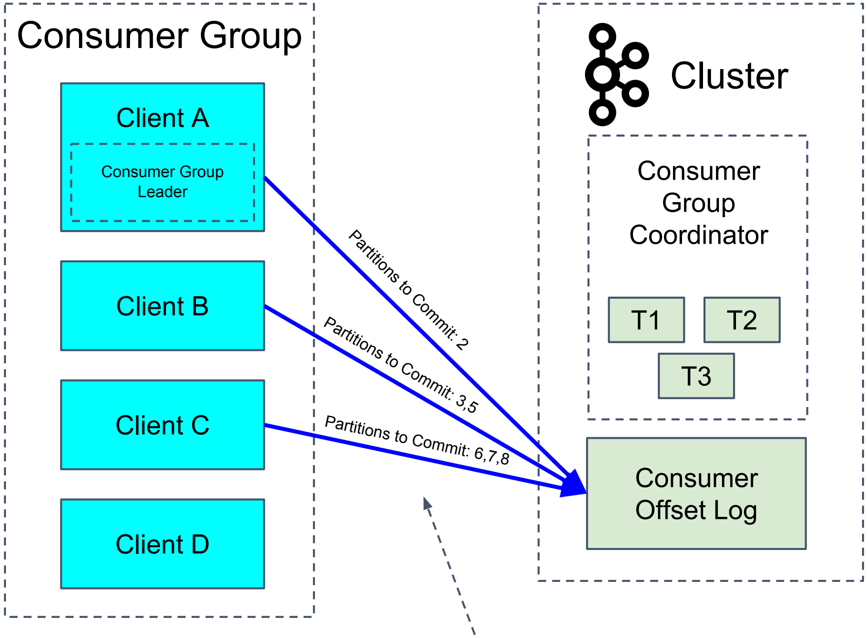


Consumer Group Rebalance (5/7)



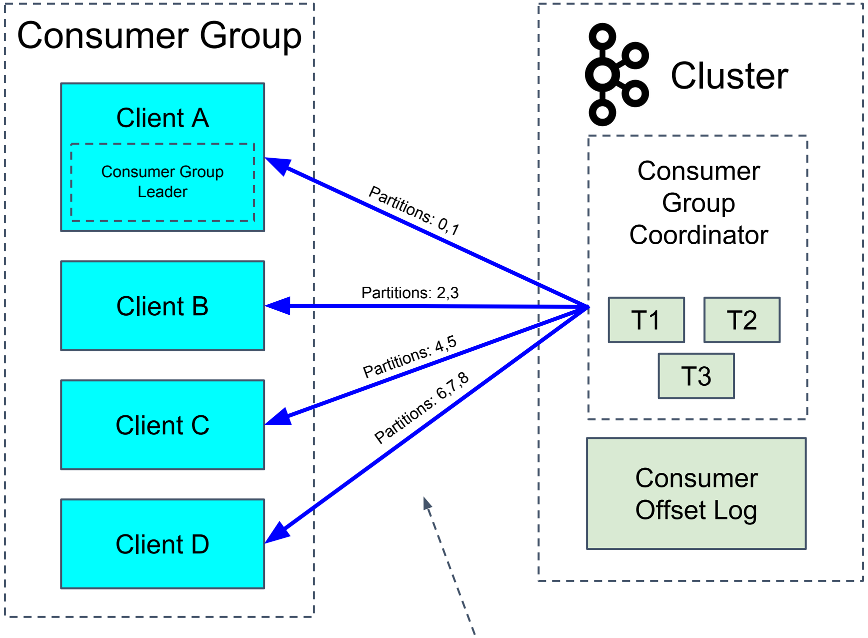
Consumer group coordinator informs all clients of their new Client:Partition assignments.

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.

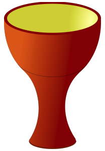
Transactional “Exactly-Once”

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.*

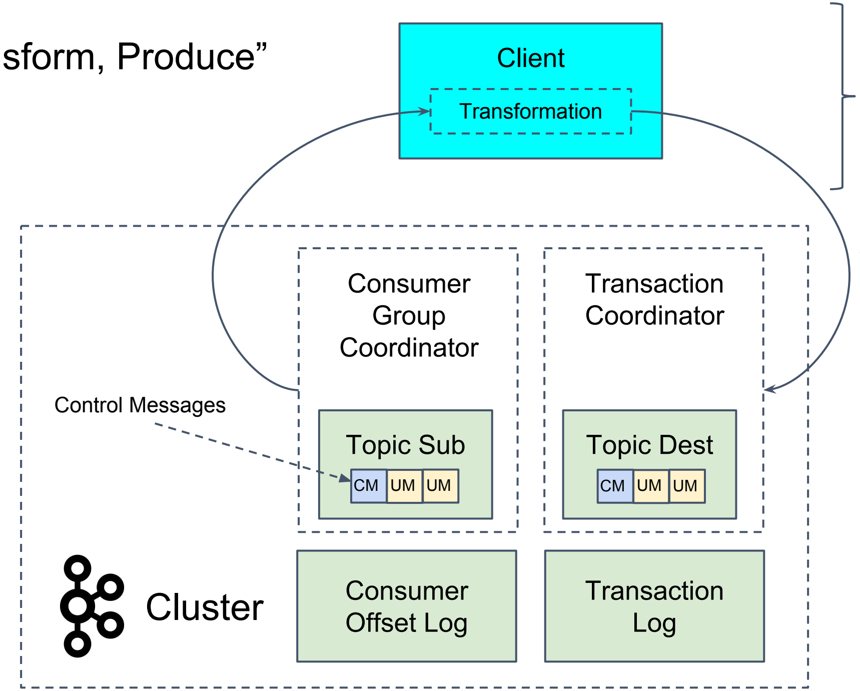
Two Generals/Byzantine Generals problem

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
```

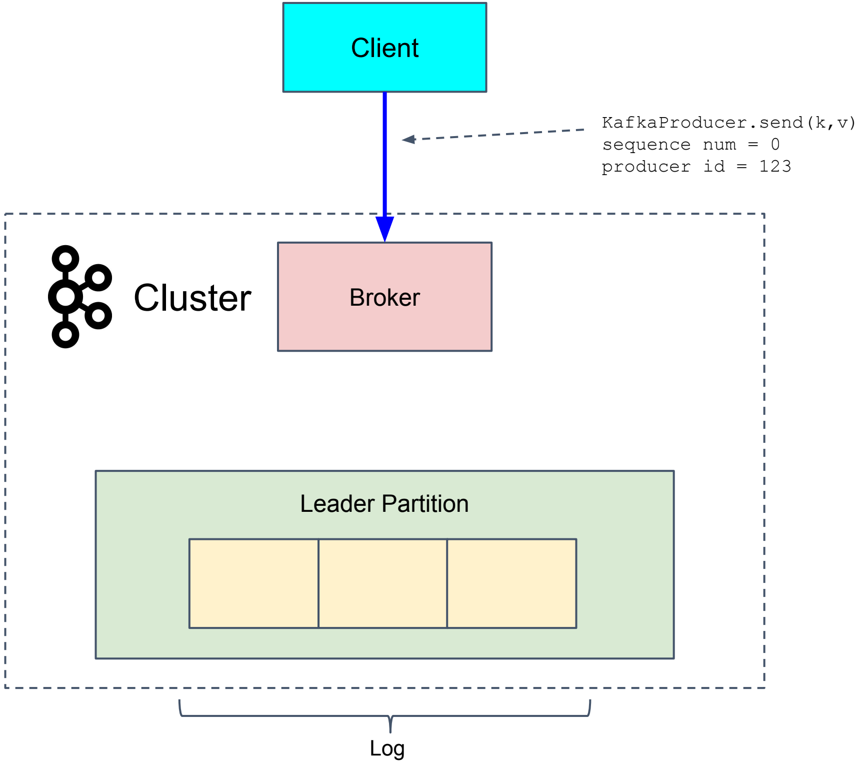
Kafka Producer Properties:

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

Kafka Features That Enable Transactions

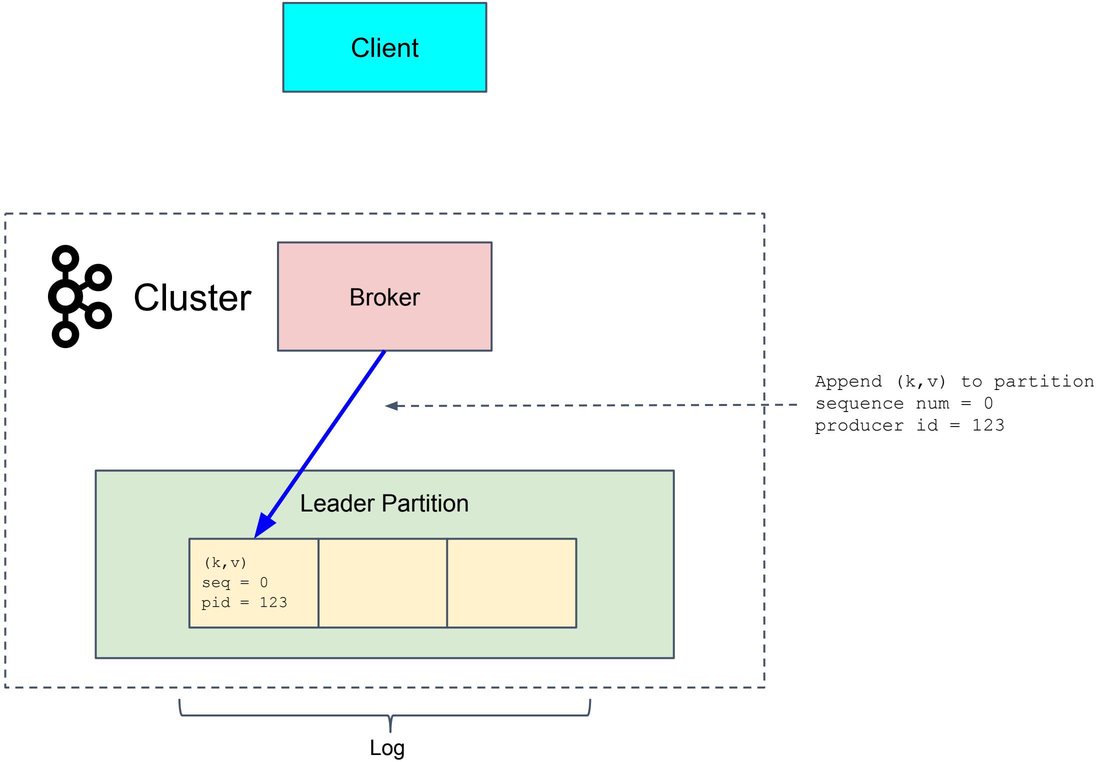
1. Idempotent producer
2. Multiple partition atomic writes
3. Consumer read isolation level

Idempotent Producer (1/5)



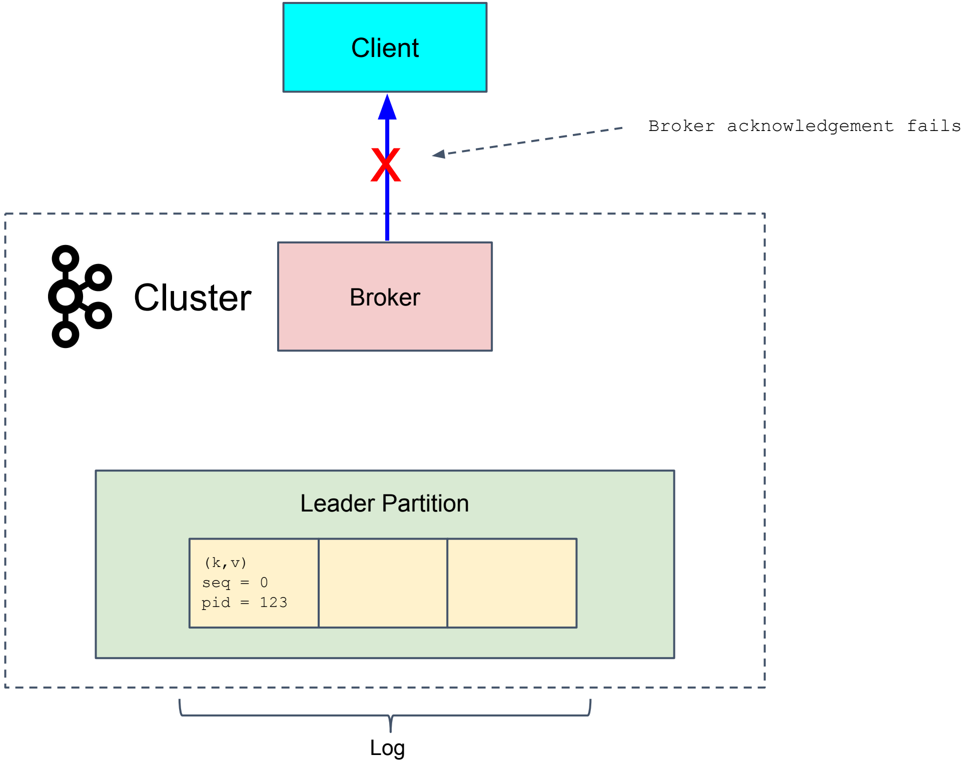
```
KafkaProducer.send(k,v)
sequence num = 0
producer id = 123
```

Idempotent Producer (2/5)

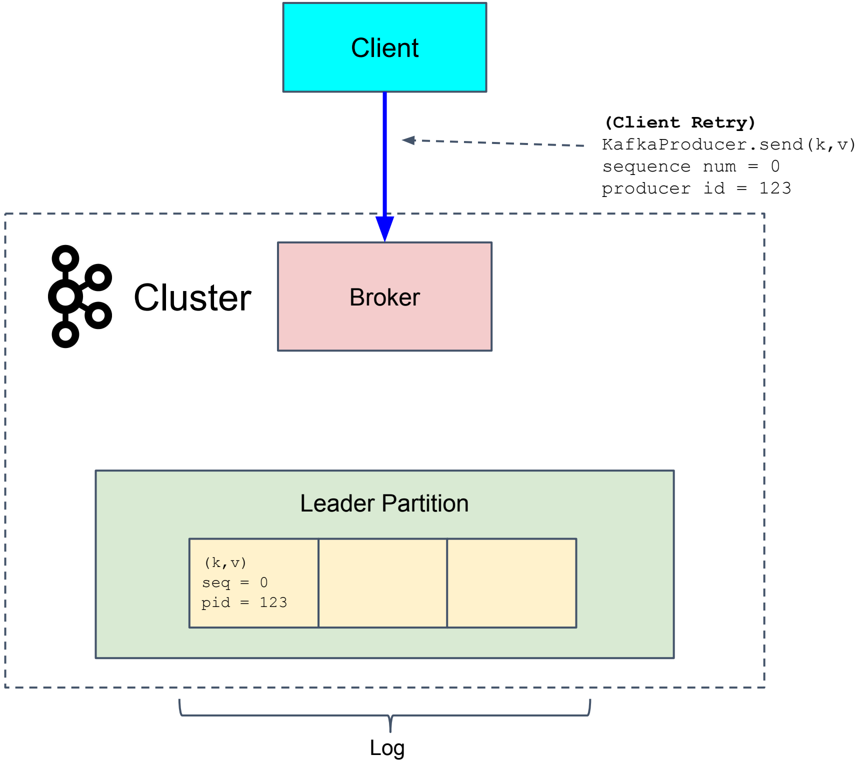


```
Append (k,v) to partition
sequence num = 0
producer id = 123
```

Idempotent Producer (3/5)

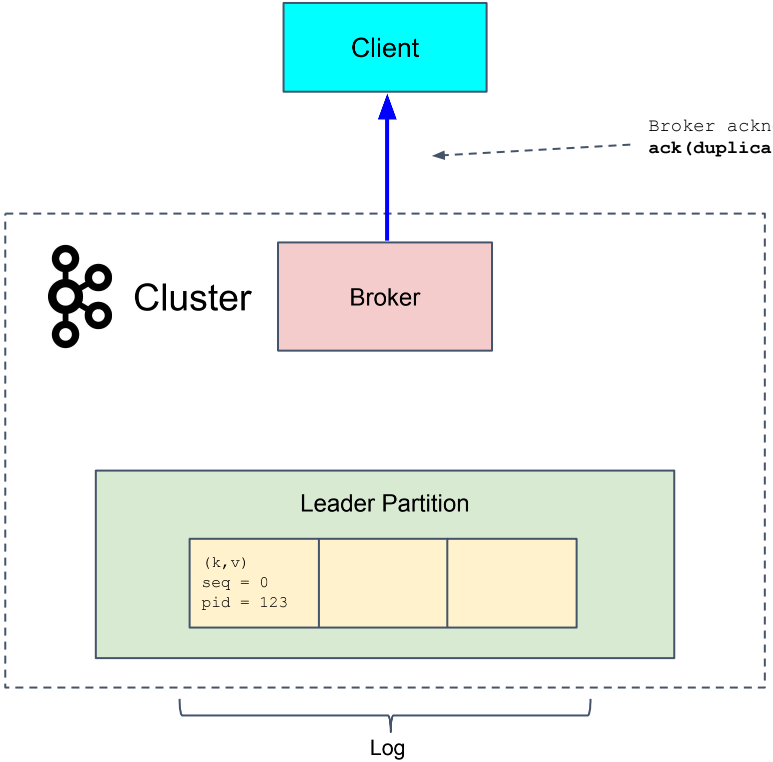


Idempotent Producer (4/5)



```
(Client Retry)
KafkaProducer.send(k,v)
sequence num = 0
producer id = 123
```

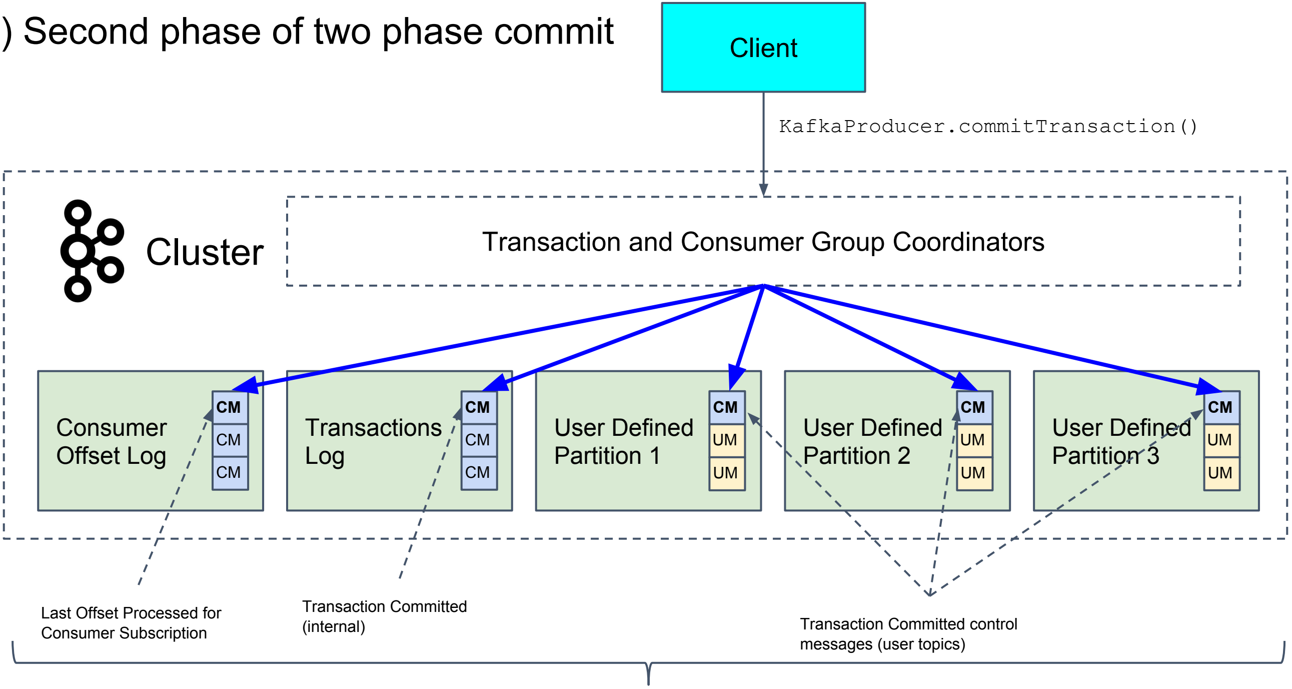
Idempotent Producer (5/5)



Broker acknowledgement succeeds
ack(duplicate)

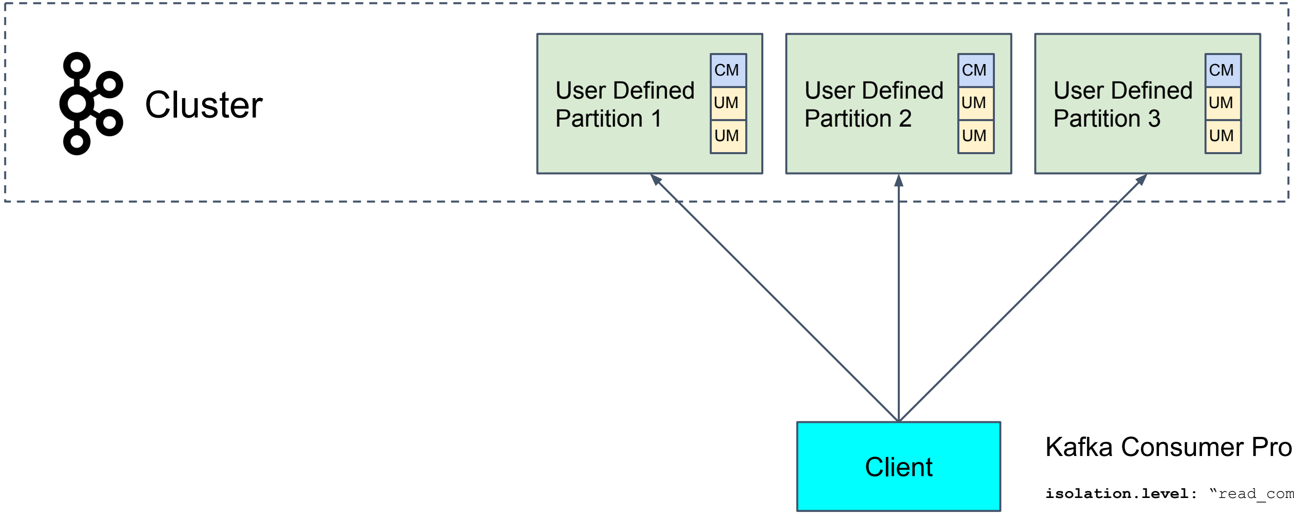
Multiple Partition Atomic Writes

Ex) Second phase of two phase commit


Client
KafkaProducer.commitTransaction()
Cluster
Transaction and Consumer Group Coordinators
Consumer Offset Log
CM
CM
CM
Transactions Log
CM
CM
CM
User Defined Partition 1
CM
UM
UM
User Defined Partition 2
CM
UM
UM
User Defined Partition 3
CM
UM
UM
Last Offset Processed for Consumer Subscription
Transaction Committed (internal)
Transaction Committed control messages (user topics)

Multiple Partitions Committed Atomically, “All or nothing”

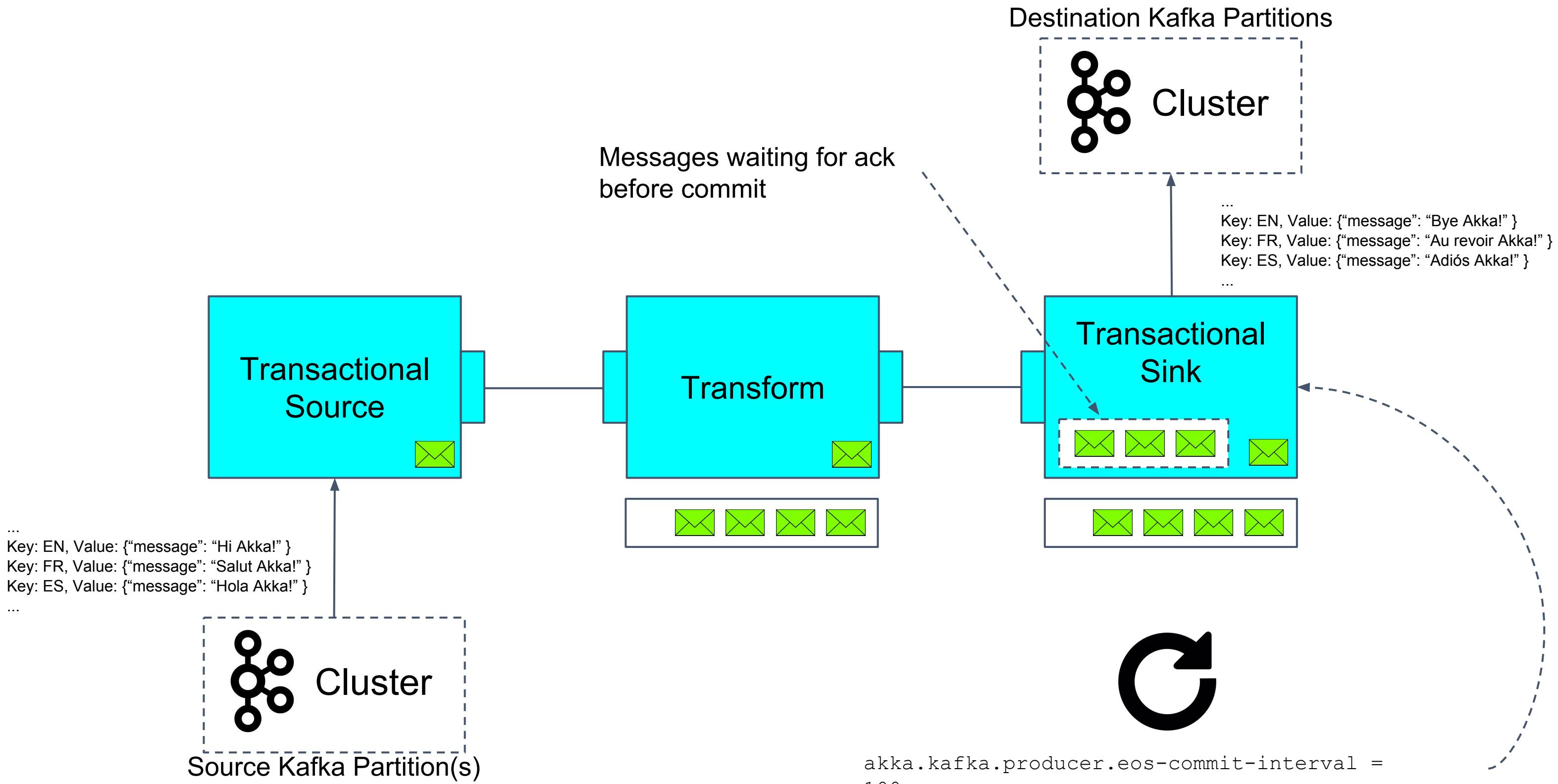
Consumer Read Isolation Level



Kafka Consumer Properties:

```
isolation.level: "read_committed"
```

Alpakka Kafka Transactions



Destination Kafka Partitions
Cluster
Messages waiting for ack before commit
Transactional Source
Transform
Transactional Sink
Cluster
Source Kafka Partition(s)

...
Key: EN, Value: {“message”: “Bye Akka!” }
Key: FR, Value: {“message”: “Au revoir Akka!” }
Key: ES, Value: {“message”: “Adiós Akka!” }
...

...
Key: EN, Value: {“message”: “Hi Akka!” }
Key: FR, Value: {“message”: “Salut Akka!” }
Key: ES, Value: {“message”: “Hola Akka!” }
...

```
akka.kafka.producer.eos-commit-interval =
100ms
```

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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)?

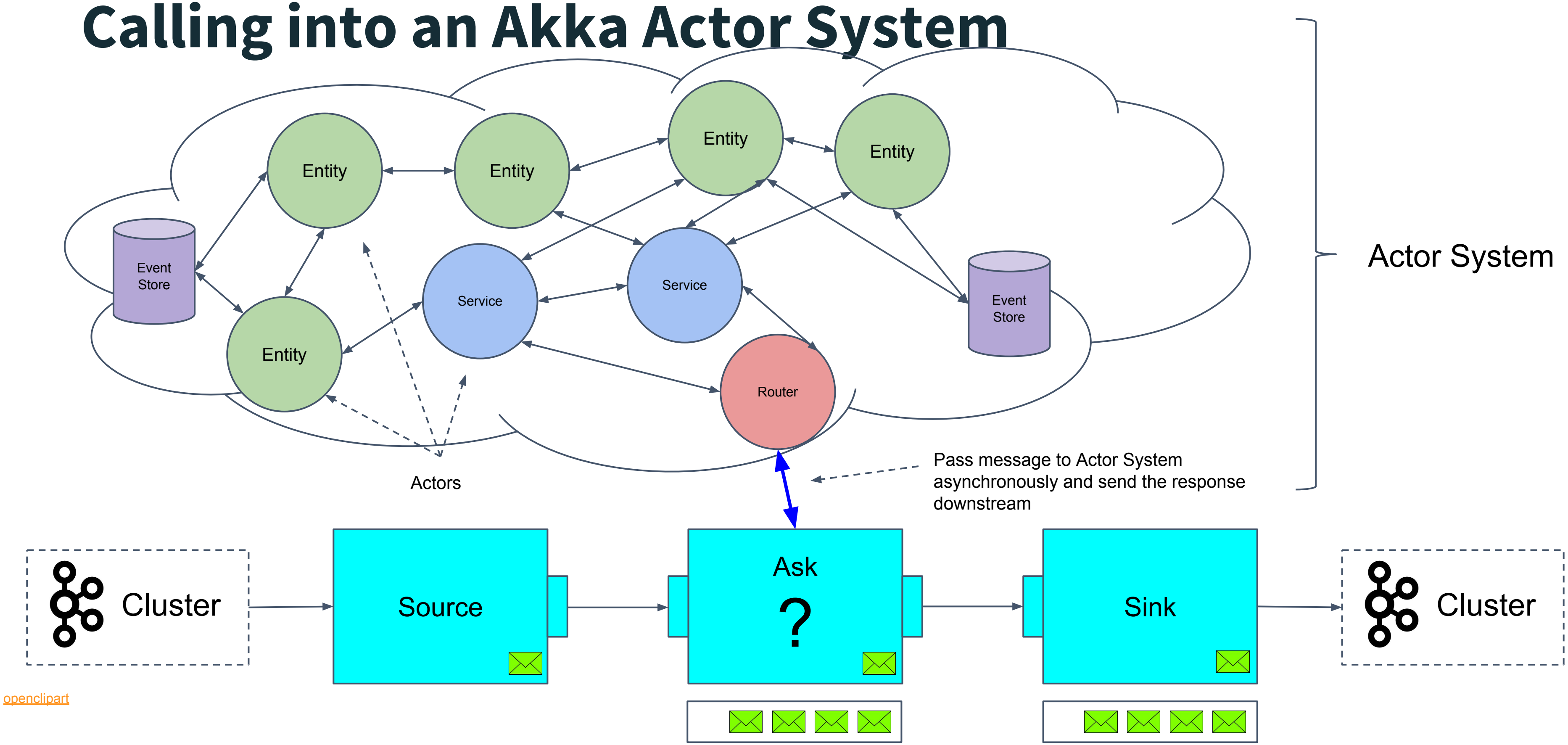
> *Complex Event Processing (CEP) has emerged as the unifying field for technologies that require processing and correlating distributed data sources in real-time.*

Foundations of Complex Event Processing, Cornell

Options for implementing Stateful Streams

1. Built-in Akka Streams stages for simple stateful operations: `fold`, `scan`, etc.
2. Custom `GraphStage`
3. **Call into an Akka Actor System**

Calling into an Akka Actor System



Pass message to Actor System asynchronously and send the response downstream

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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

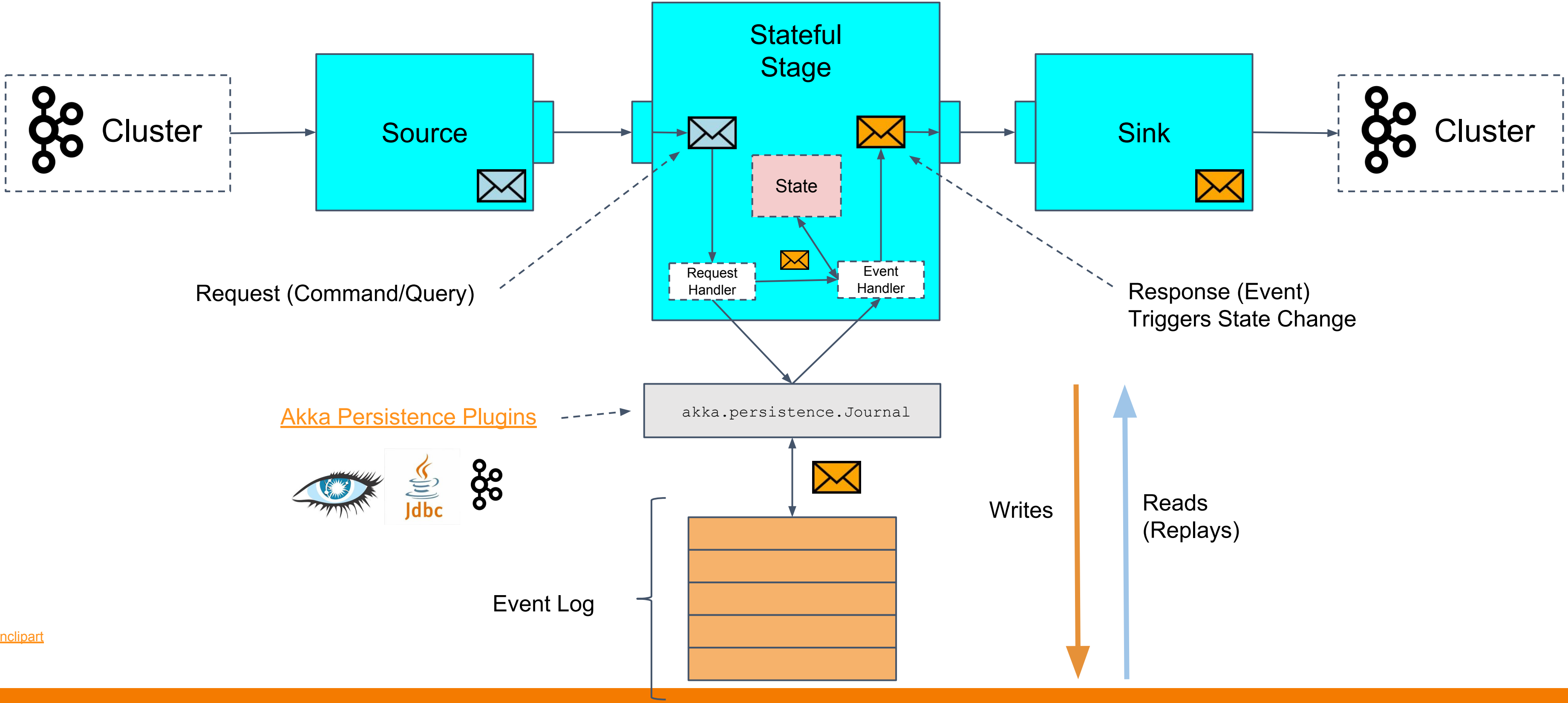
Parallelism used to limit how many messages in flight so we don’t overwhelm mailbox of destination Actor and maintain stream back-pressure.

Persistent Stateful Stages

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.*

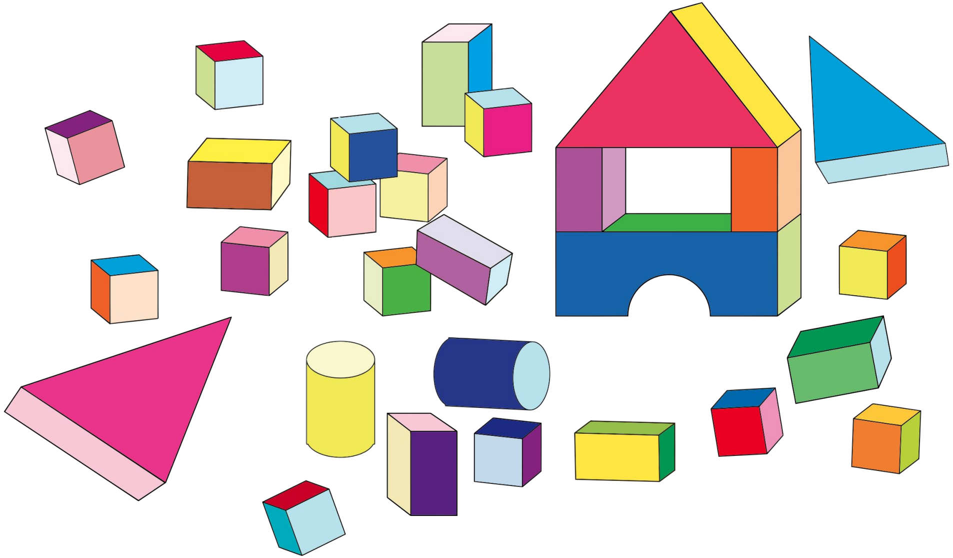
Experimental

Public Domain Vectors

Conclusion

alpakka

kafka connector



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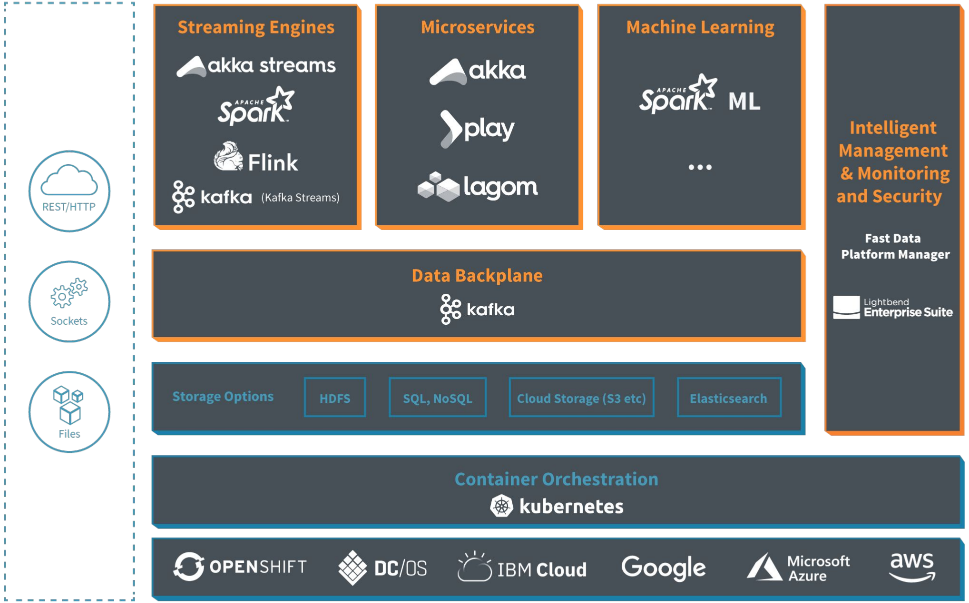
Lightbend Fast Data Platform



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

Lightbend

Thank You!

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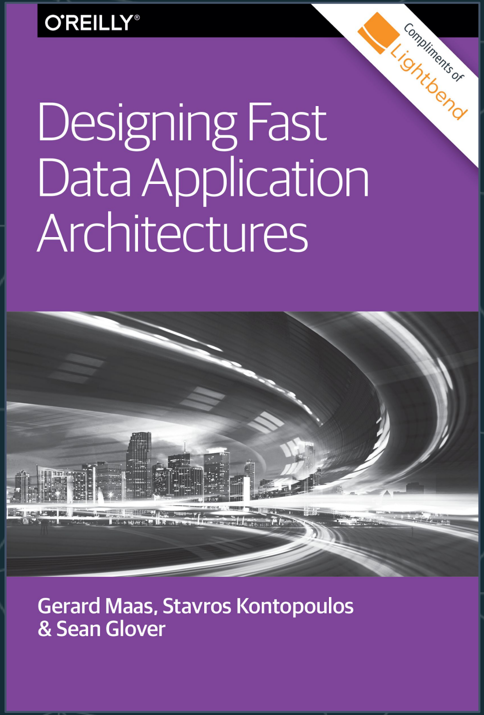
in/seanaglover

sean.glover@lightbend.com

Free eBook!

https://bit.ly/2J9xmZm


O'REILLY
Compliments of Lightbend
Designing Fast Data Application Architectures
Gerard Maas, Stavros Kontopoulos & Sean Glover