Not Just Events: Developing Asynchronous Microservices

Chris Richardson

Founder of Eventuate.io

Founder of the original CloudFoundry.com

Author of POJOs in Action and Microservices Patterns

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http://learn.microservices.io

GOTO CHICAGO 2019

Presentation goal

Implementing transactions and queries in a microservice architecture using asynchronous messaging

Presentation goal

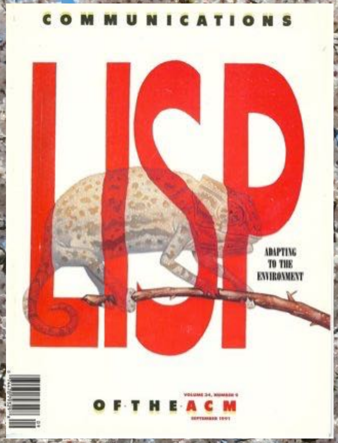
Microservices > REST

Microservices > Events

Microservices != Event Sourcing

Apache Kafka != Event Store

About Chris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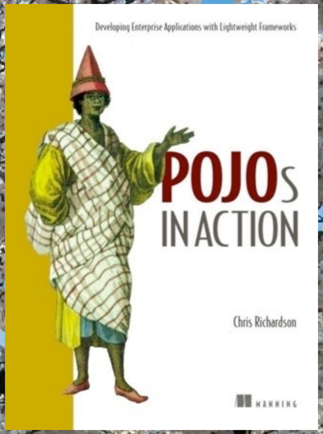
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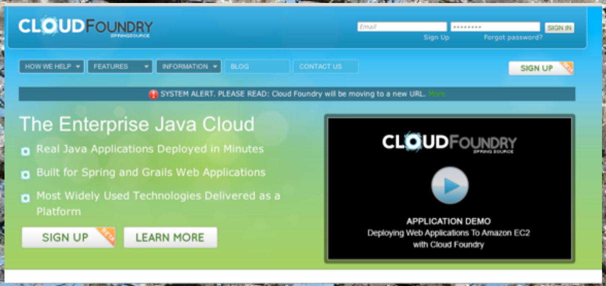
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About Chris

Consultant and trainer focussed on helping organizations adopt the microservice architecture

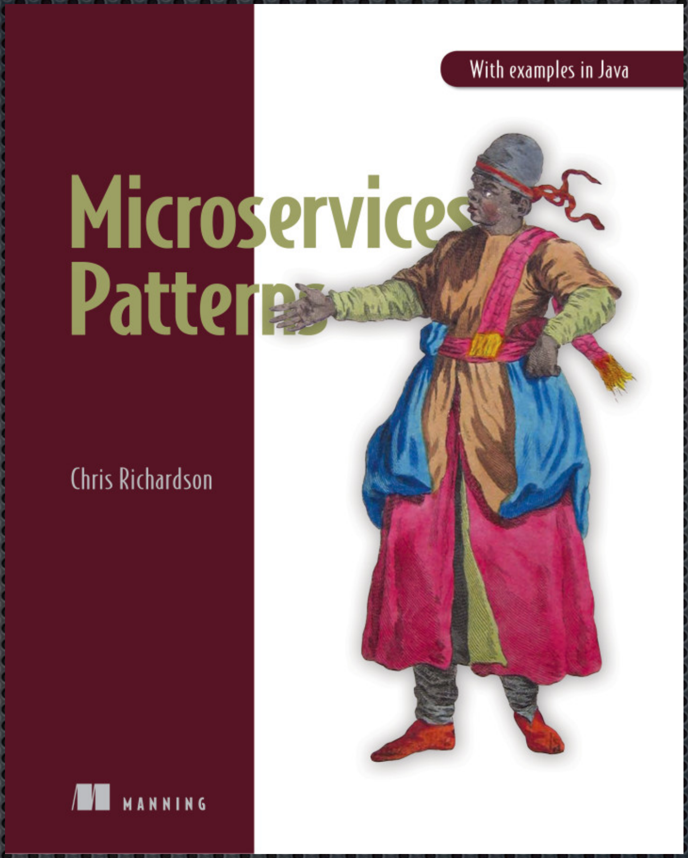
(http://www.chrisrichardson.net/)

About Chris

Founder of a startup that is creating
an open-source/SaaS platform
that simplifies the development of
transactional microservices
(http://eventuate.io)

eventuate

About Chris



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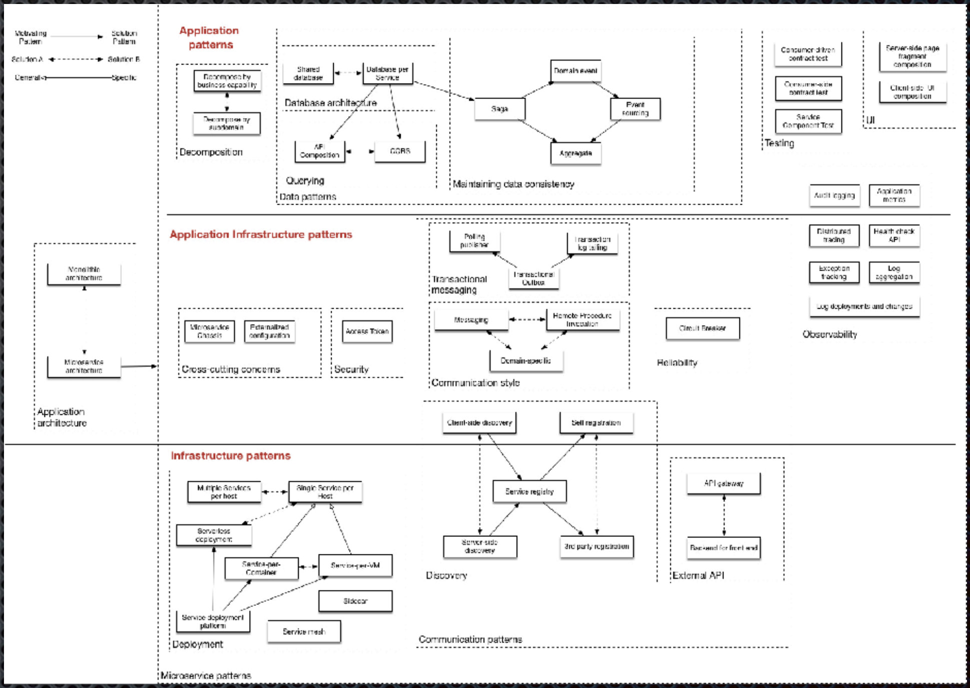
About Chris: microservices.io

- Microservices pattern language
- Articles
- Code examples
- Microservices Assessment Platform - http://microservices.io/platform

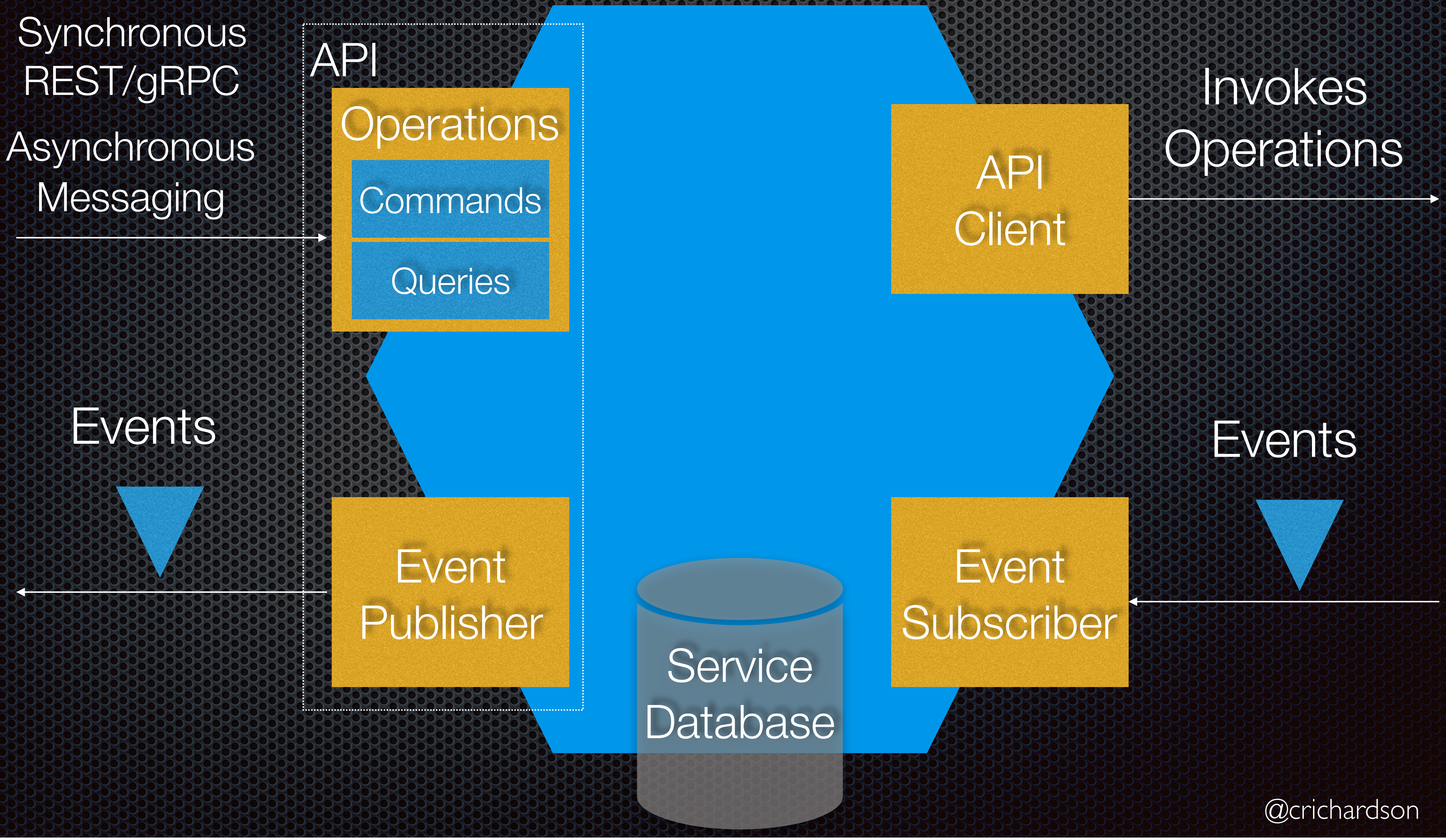


Agenda

- Transactions, queries and microservices
- Managing transactions with sagas
- Implementing queries with CQRS
- Implementing transactional messaging

The microservice architecture **structures** an application as a **set of loosely coupled services**

Service = independently deployable component



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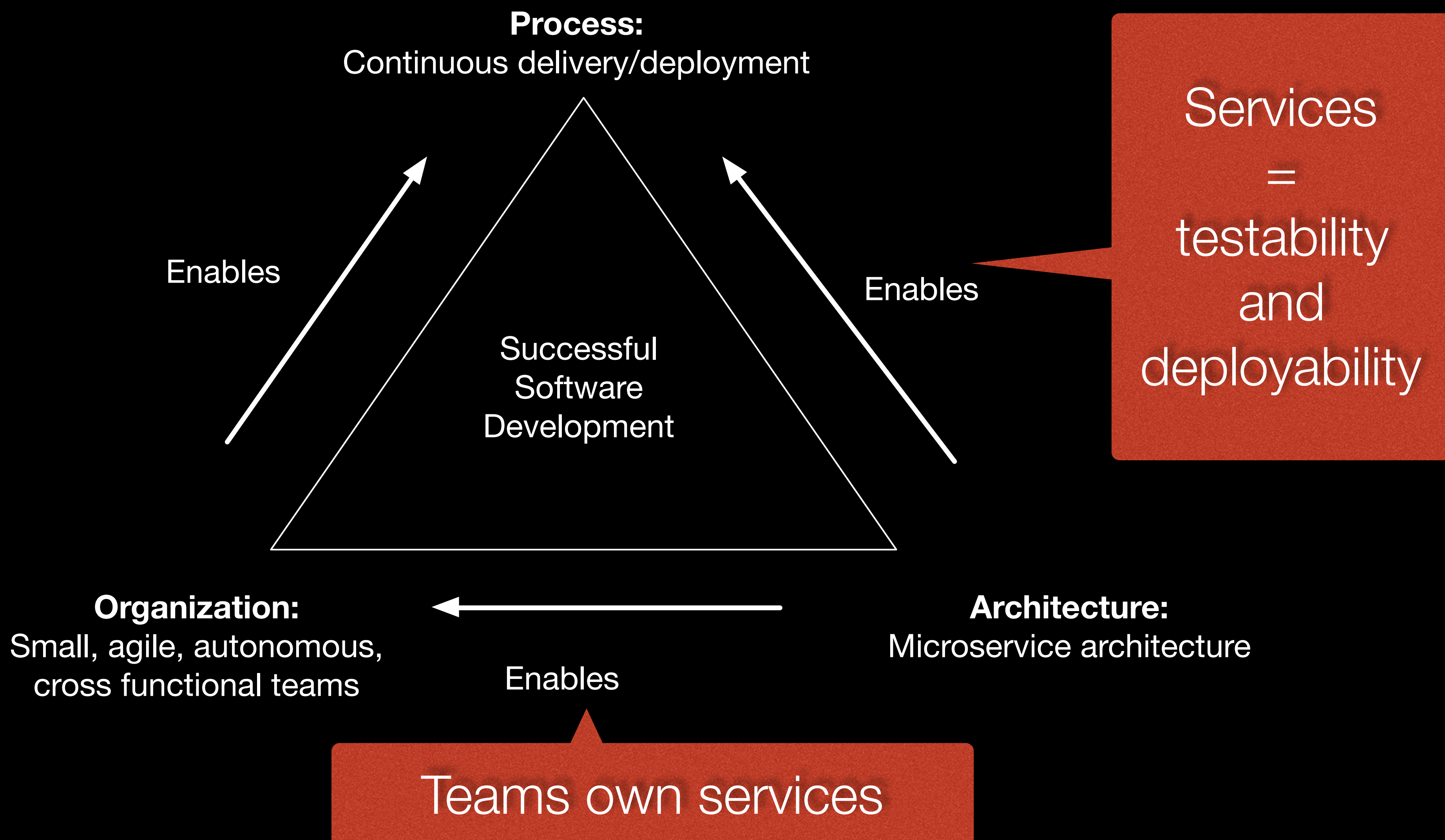
Microservices enable continuous delivery/deployment



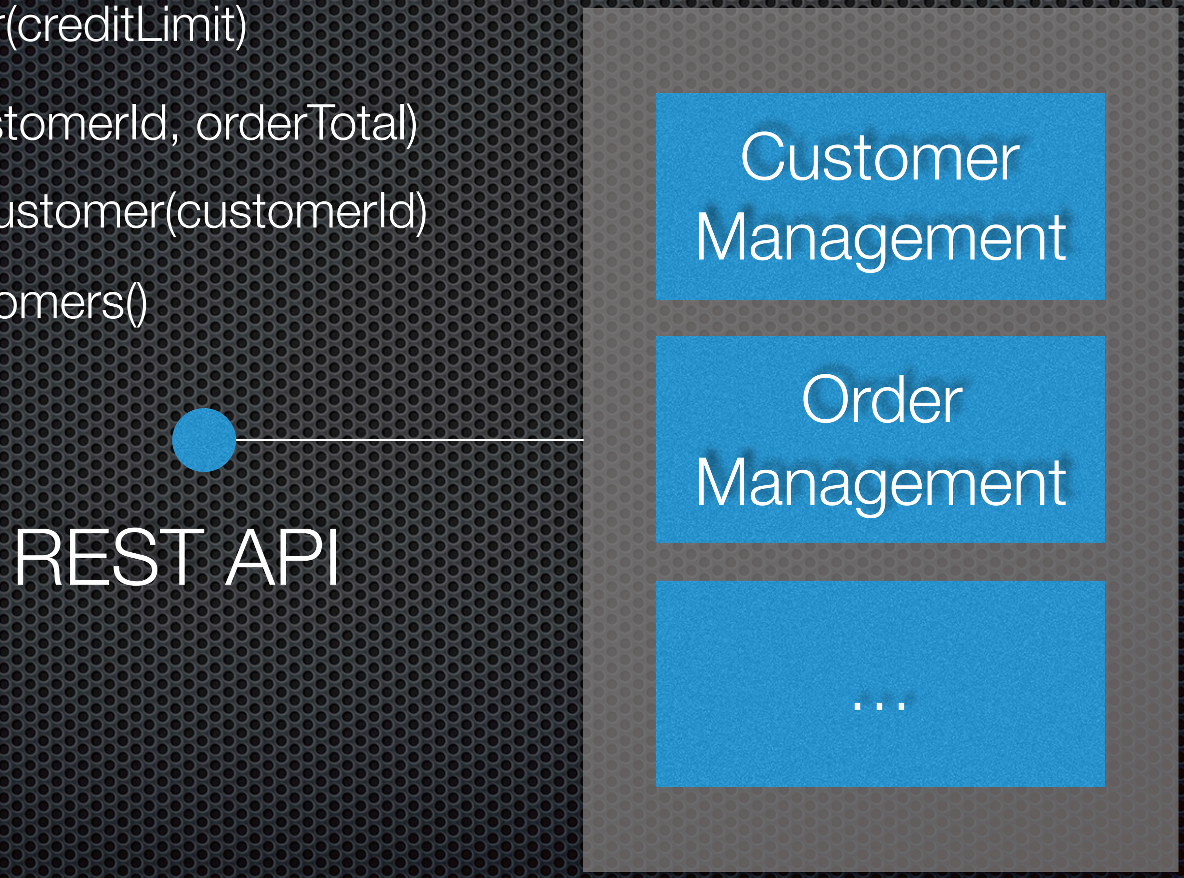
Let’s imagine that you are building an online store API

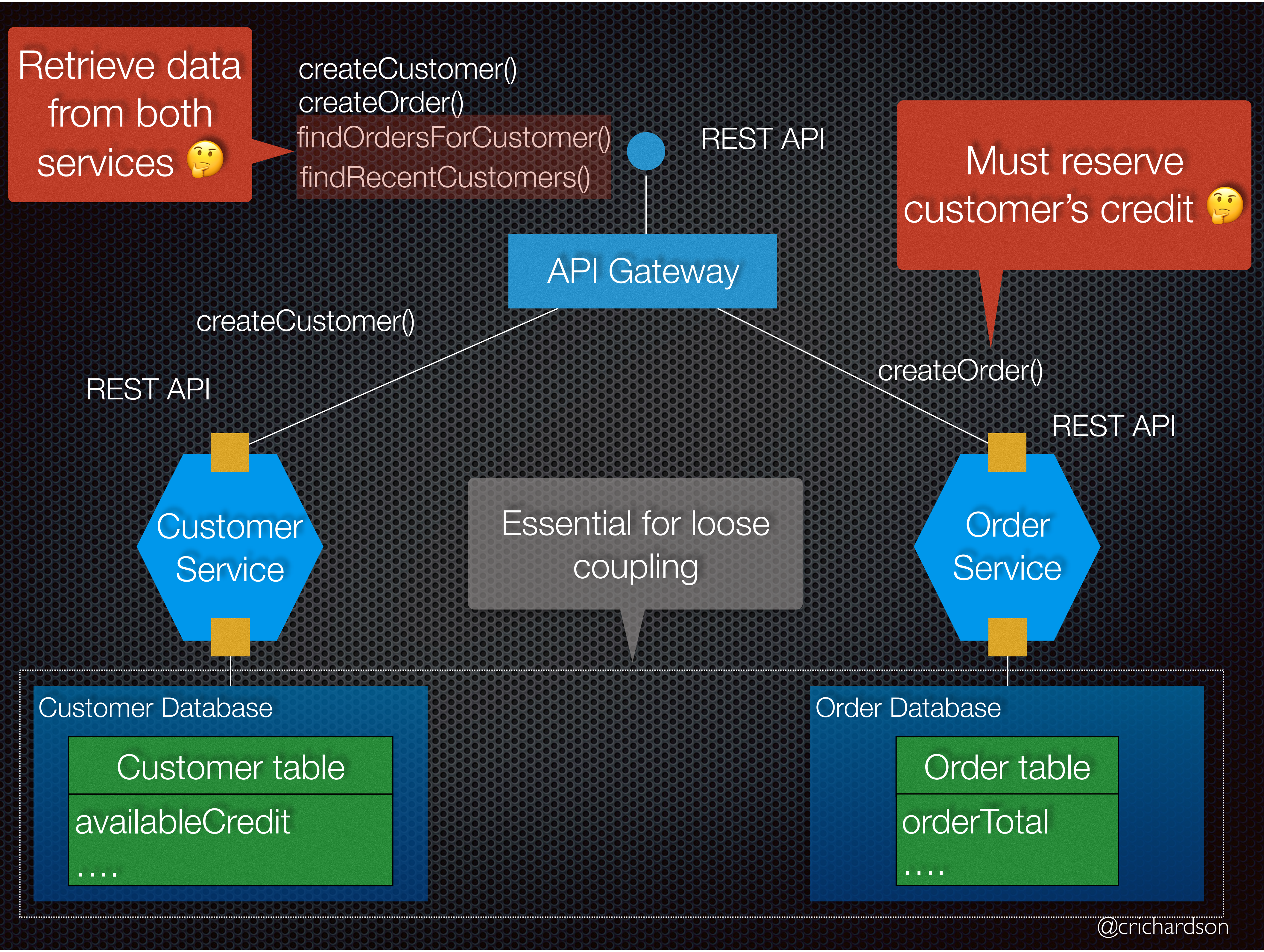
createCustomer(creditLimit)

createOrder(customerId, orderTotal)

findOrdersForCustomer(customerId)

findRecentCustomers()




Retrieve data from both services 🤔
createCustomer()
createOrder()
findOrdersForCustomer()
findRecentCustomers()
REST API
Must reserve customer's credit 🤔
API Gateway
createCustomer()
createOrder()
REST API
REST API
Customer Service
Essential for loose coupling
Order Service
Customer Database
Customer table
availableCredit
....
Order Database
Order table
orderTotal
....
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No ACID transactions that span services

Distributed transactions

```
BEGIN TRANSACTION
…
SELECT ORDER_TOTAL
 FROM ORDERS WHERE CUSTOMER_ID = ?
…
SELECT CREDIT_LIMIT
FROM CUSTOMERS WHERE CUSTOMER_ID = ?
…
INSERT INTO ORDERS …
…
COMMIT TRANSACTION
```

Private to the Order Service

Private to the Customer Service

rdson

Querying across services is not straightforward

Private to Customer Service

Private to Order Service

```
SELECT *
FROM CUSTOMER c, ORDER o
WHERE
   c.id = o.ID
     AND c.id = ?
```

Find customer and their orders

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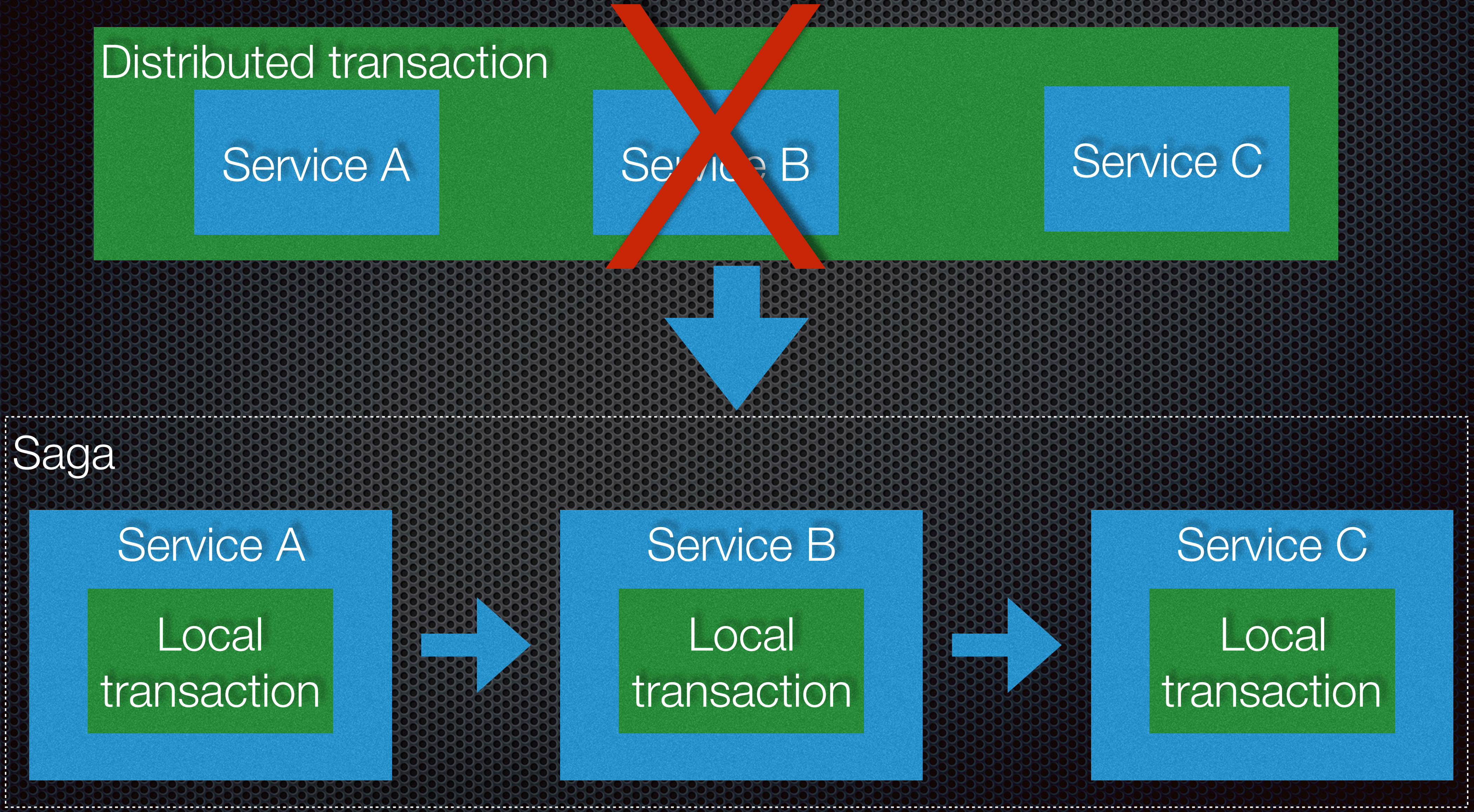
From a 1987 paper

SAGAS

Hector Garcia-Molina
Kenneth Salem

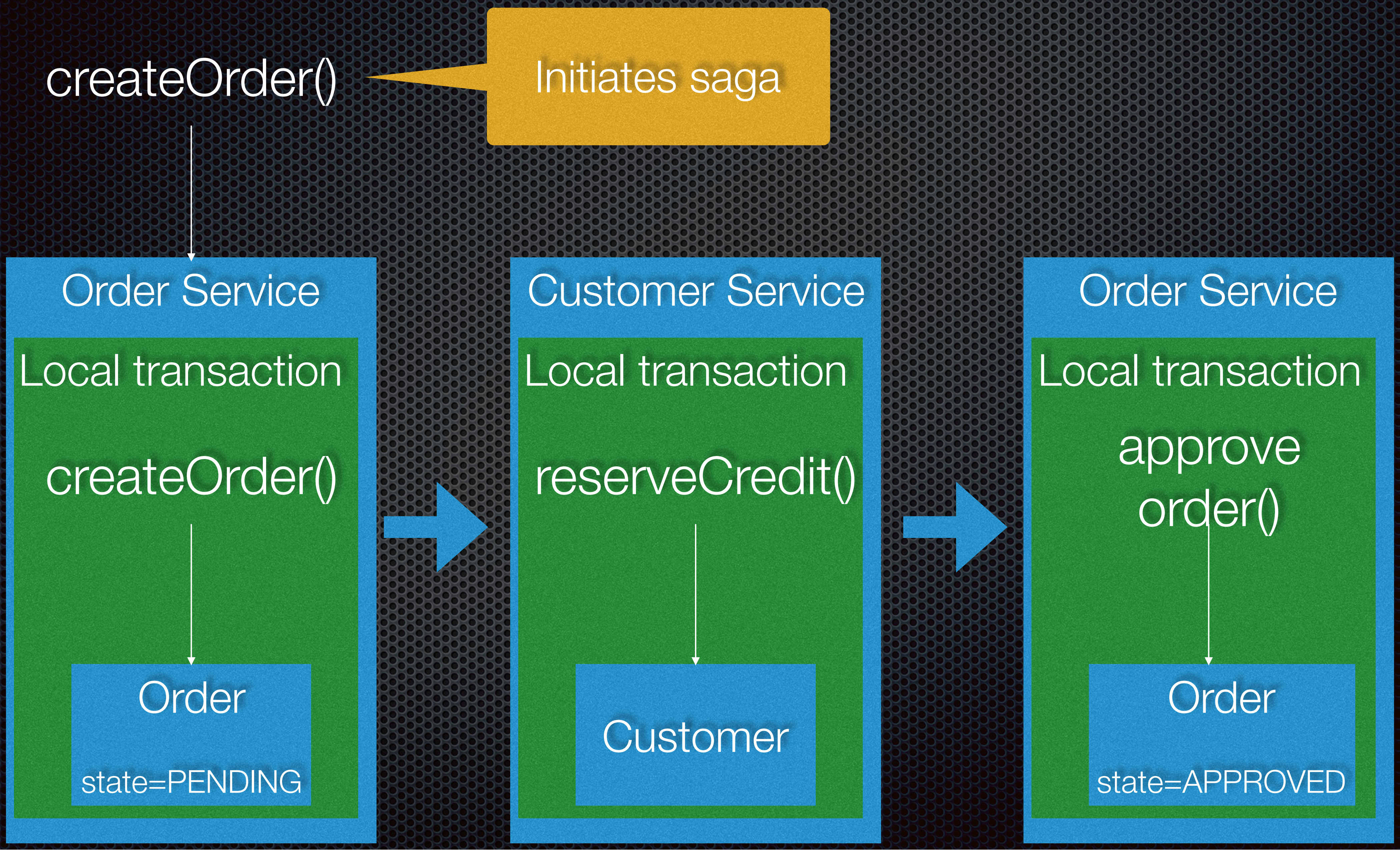
Department of Computer Science
Princeton University
Princeton, N J 08544

Use Sagas instead of 2PC



https://microservices.io/patterns/data/saga.html

Create Order Saga



Saga design challenges

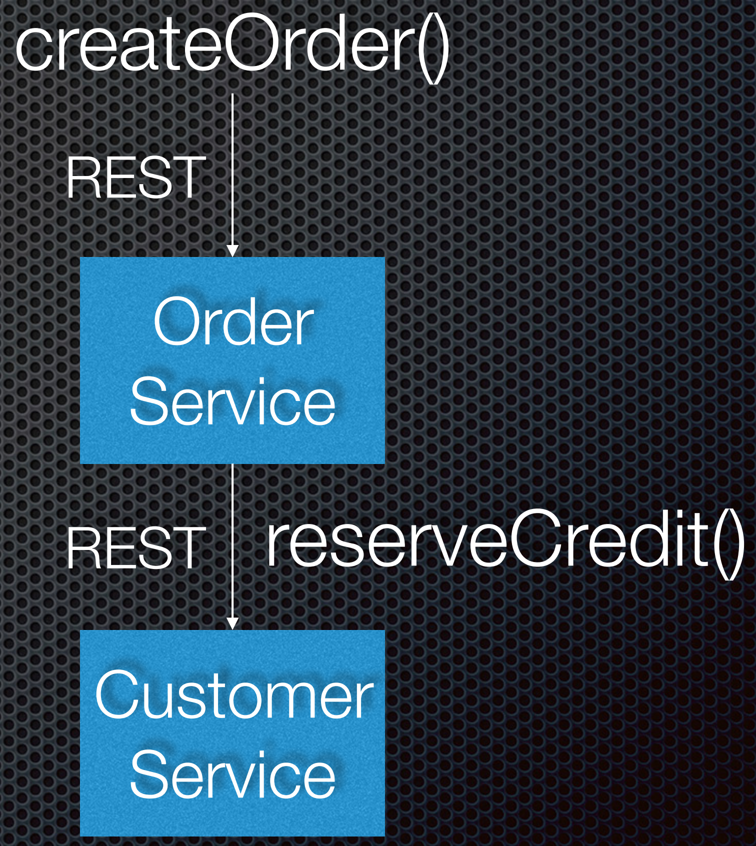
- API design
  - Synchronous REST API initiates asynchronous saga
  - When to send back a response?
- Rollback ⇒ compensating transactions
- Sagas are ACD - No I
  - Sagas are interleaved ⇒ anomalies, such as lost updates
  - Must use countermeasures

https://www.slideshare.net/chris.e.richardson/saturn-2018-managing-data-consistency-in-a-microservice-architecture-using-sagas

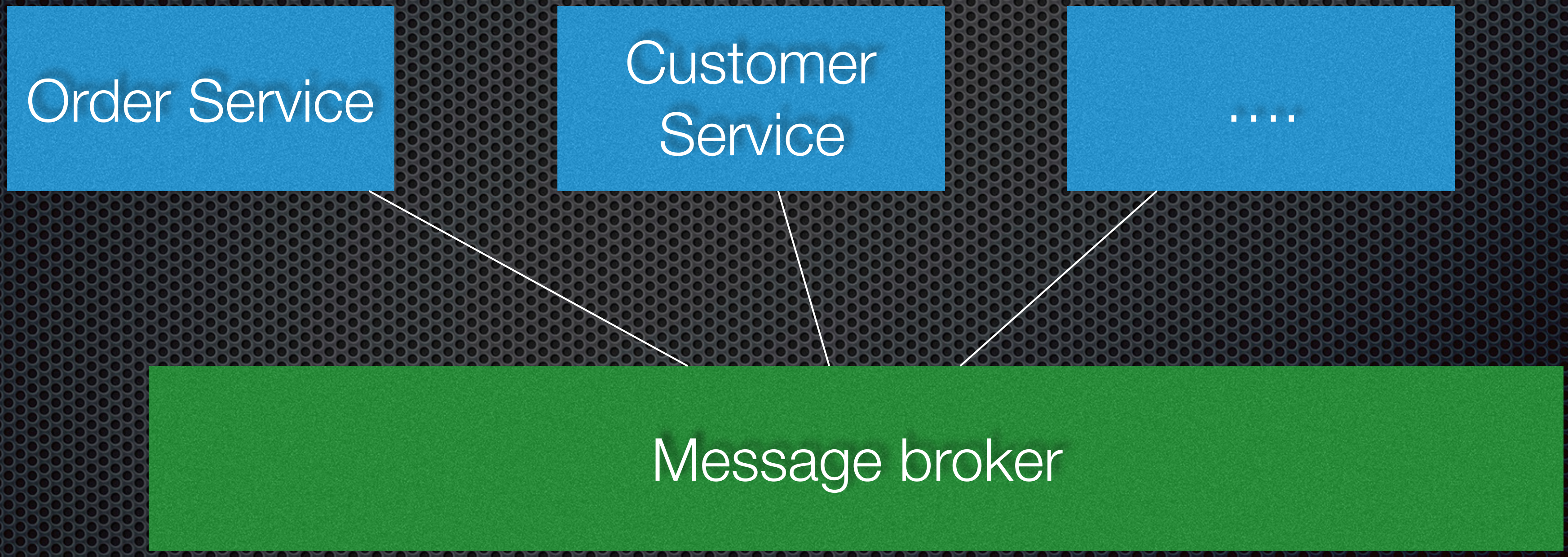
How do the saga participants communicate?

- Synchronous communication, e.g. REST = temporal coupling
- Client and server need to be both available
- Customer Service fails ⇒

  retry provided it's idempotent
- Order Service fails ⇒ Oops



Collaboration using asynchronous, broker-based messaging



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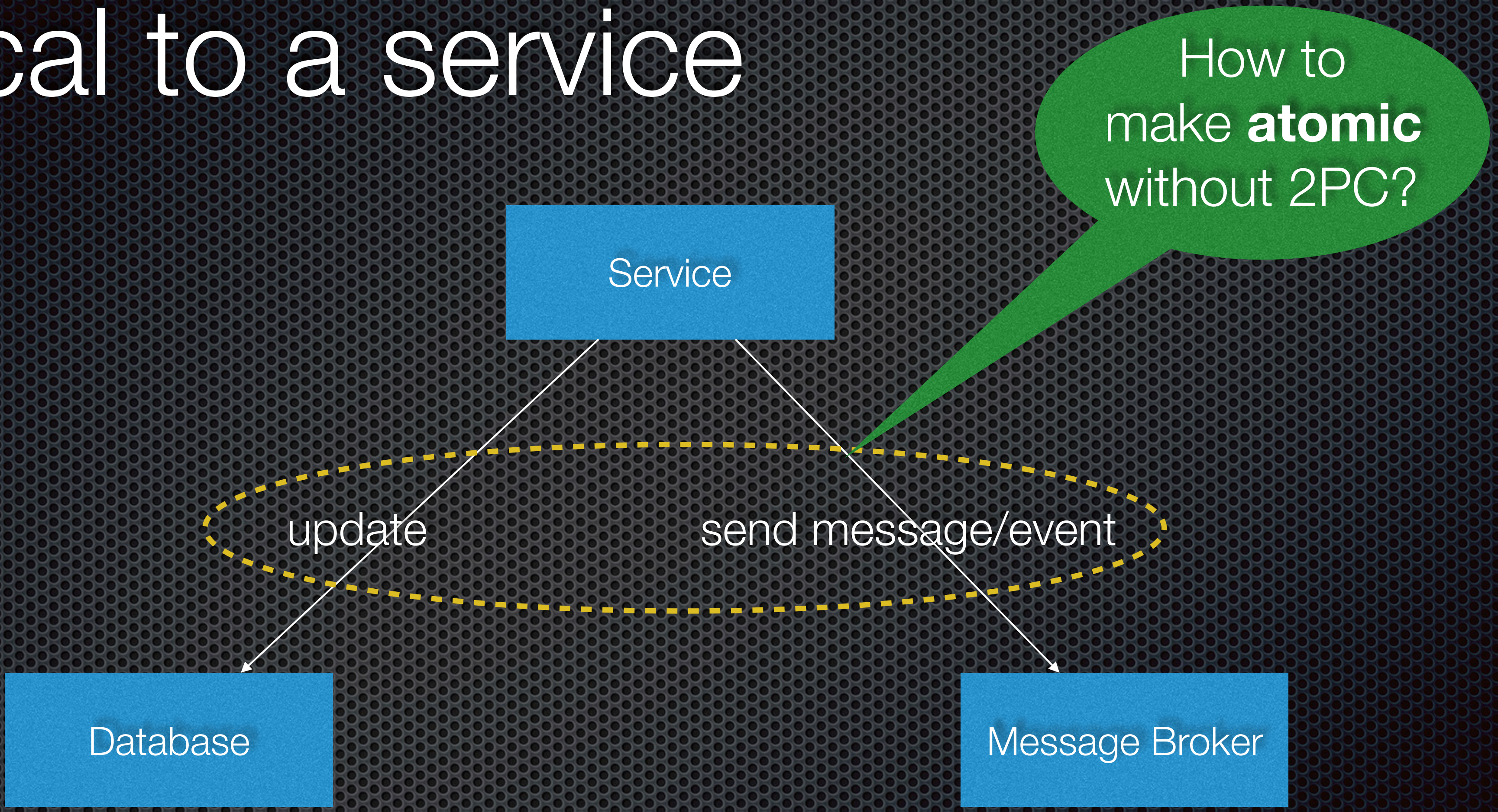
About the message broker

- At least once delivery
  - Ensures a saga completes when its participants are temporarily unavailable
- Ordered delivery
- Mechanism for scaling consumers that preserves ordering e.g.
  - Apache Kafka consumer group
  - ActiveMQ message group
  - …

Saga step = a transaction local to a service



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How to sequence the saga transactions?

- After the completion of transaction Ti “something” must decide what step to execute next
- Success: which T(i+1) - branching
- Failure: C(i - 1)

Choreography: **distributed** decision making

vs.

Orchestration: **centralized** decision making

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- Transactions, queries and microservices
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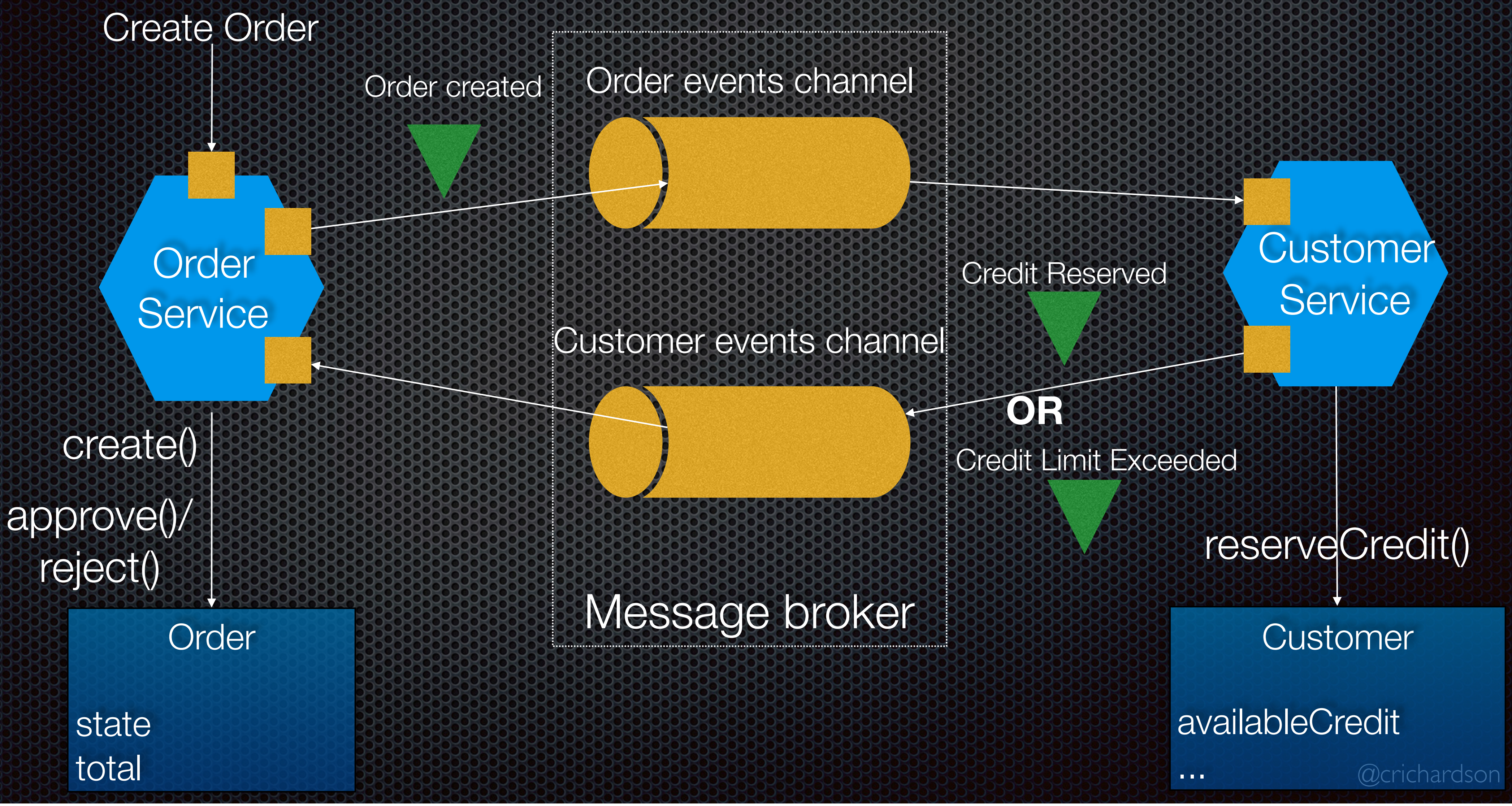
  - Overview
  - Choreography
  - Orchestration
- Implementing queries with CQRS
- Implementing transactional messaging

Choreography-based Create Order Saga



Benefits and drawbacks of choreography

Benefits

- Simple, especially when using event sourcing
- Participants are loosely coupled

Drawbacks

- Decentralized implementation - potentially difficult to understand
- Cyclic dependencies - services listen to each other's events, e.g. Customer Service **must know** about all Order events that affect credit
- Overloads domain objects, e.g. Order and Customer **know** too much
- Events = indirect way to make something happen

https://github.com/eventuate-examples/eventuate-examples-java-customers-and-orders

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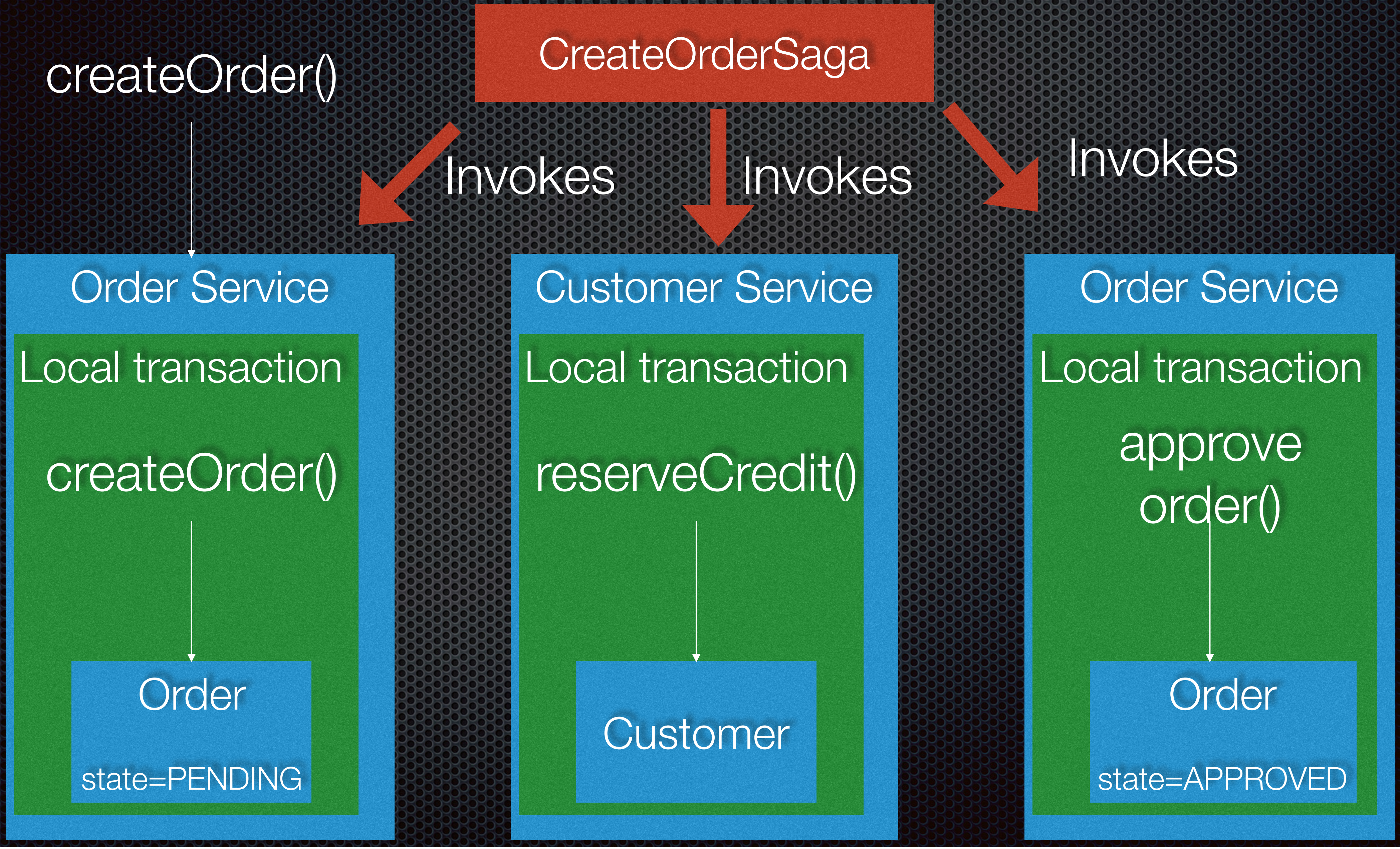
Orchestration-based coordination using command messages

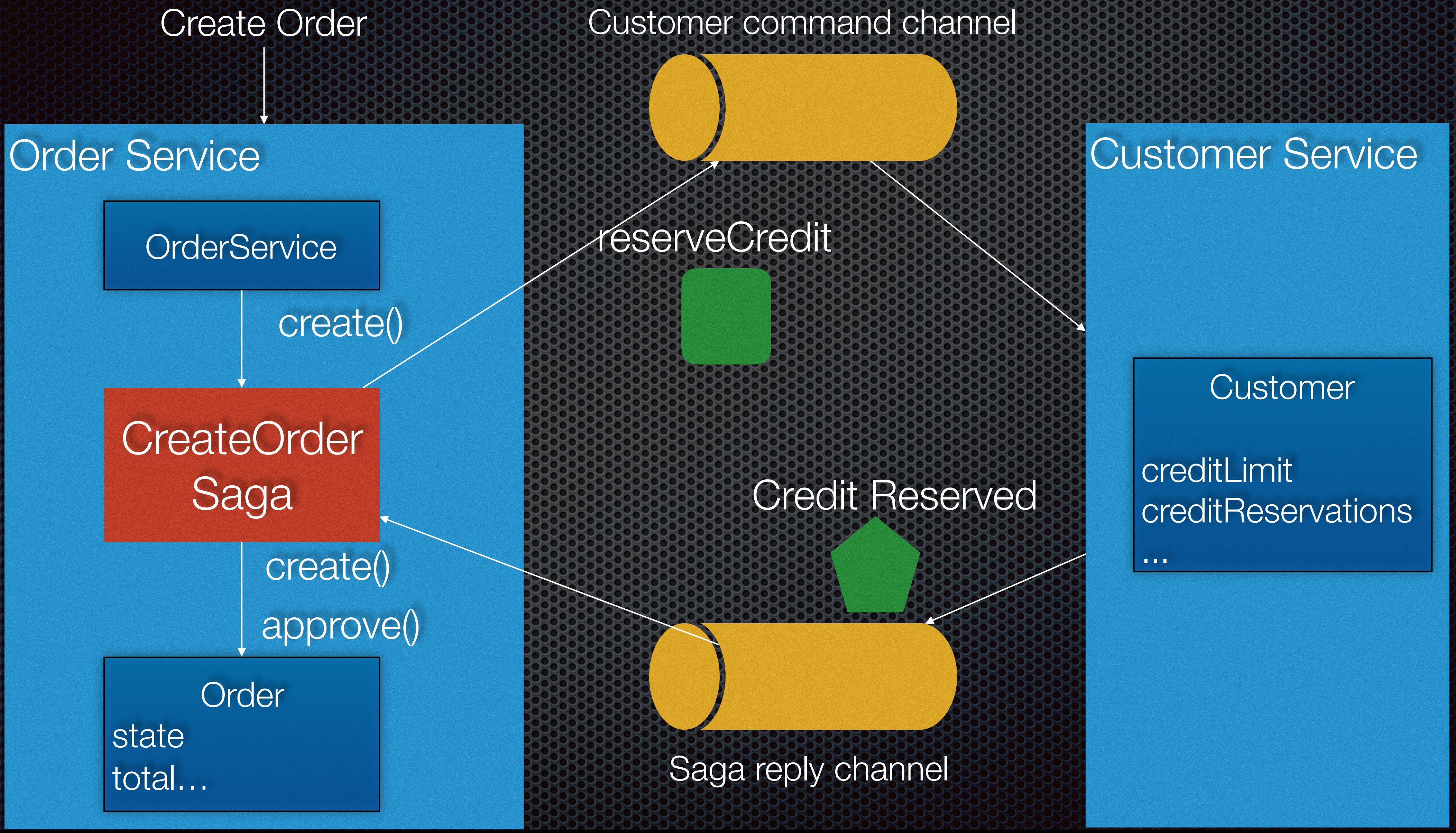


A saga (orchestrator)
is a **persistent object**
that
implements a state machine
and
invokes the participants

Saga orchestrator behavior

- On create:
  - Invokes a saga participant
  - Persists state in database
  - Wait for a reply
- On reply:
  - Load state from database
  - Determine which saga participant to invoke next
  - Invokes saga participant
  - Updates its state
  - Persists updated state
  - Wait for a reply
  - …

CreateOrderSaga orchestrator



- https://github.com/eventuate-tram/eventuate-tram-sagas-examples-customers-and-orders

Benefits and drawbacks of orchestration

Benefits

- Centralized coordination logic is easier to understand
- Reduced coupling, e.g. Customer Service knows less. Simply has API for managing available credit.
- Reduces cyclic dependencies

Drawbacks

- Risk of smart sagas directing dumb services

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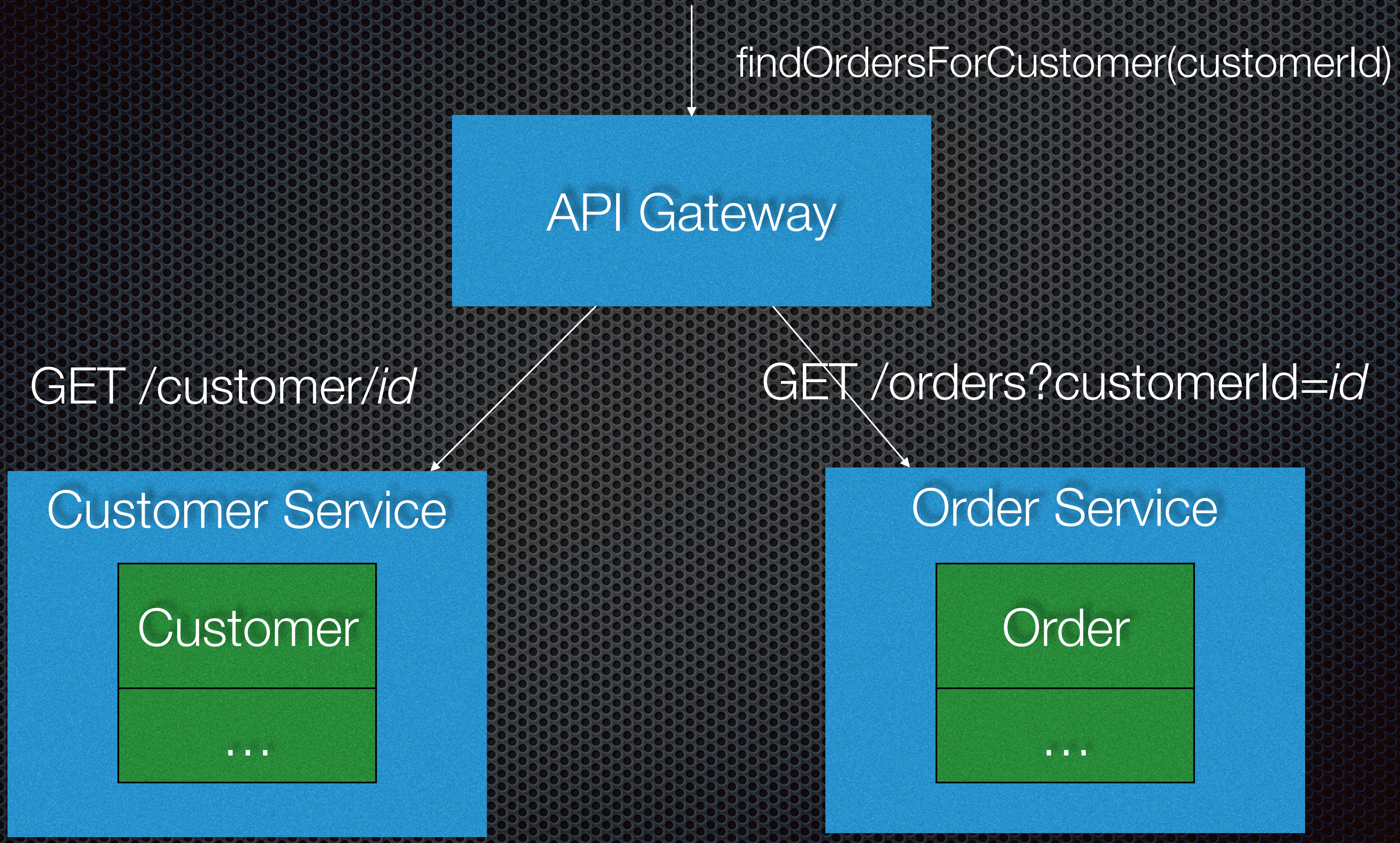
Queries often retrieve data owned by multiple services

API Composition pattern



https://microservices.io/patterns/data/api-composition.html

Find recent, valuable customers

Customer Service

Order Service

```
SELECT *
FROM CUSTOMER c, ORDER o
WHERE
    c.id = o.ID
      AND o.ORDER_TOTAL > 100000
      AND o.STATE = 'SHIPPED'
      AND c.CREATION_DATE > ?
```

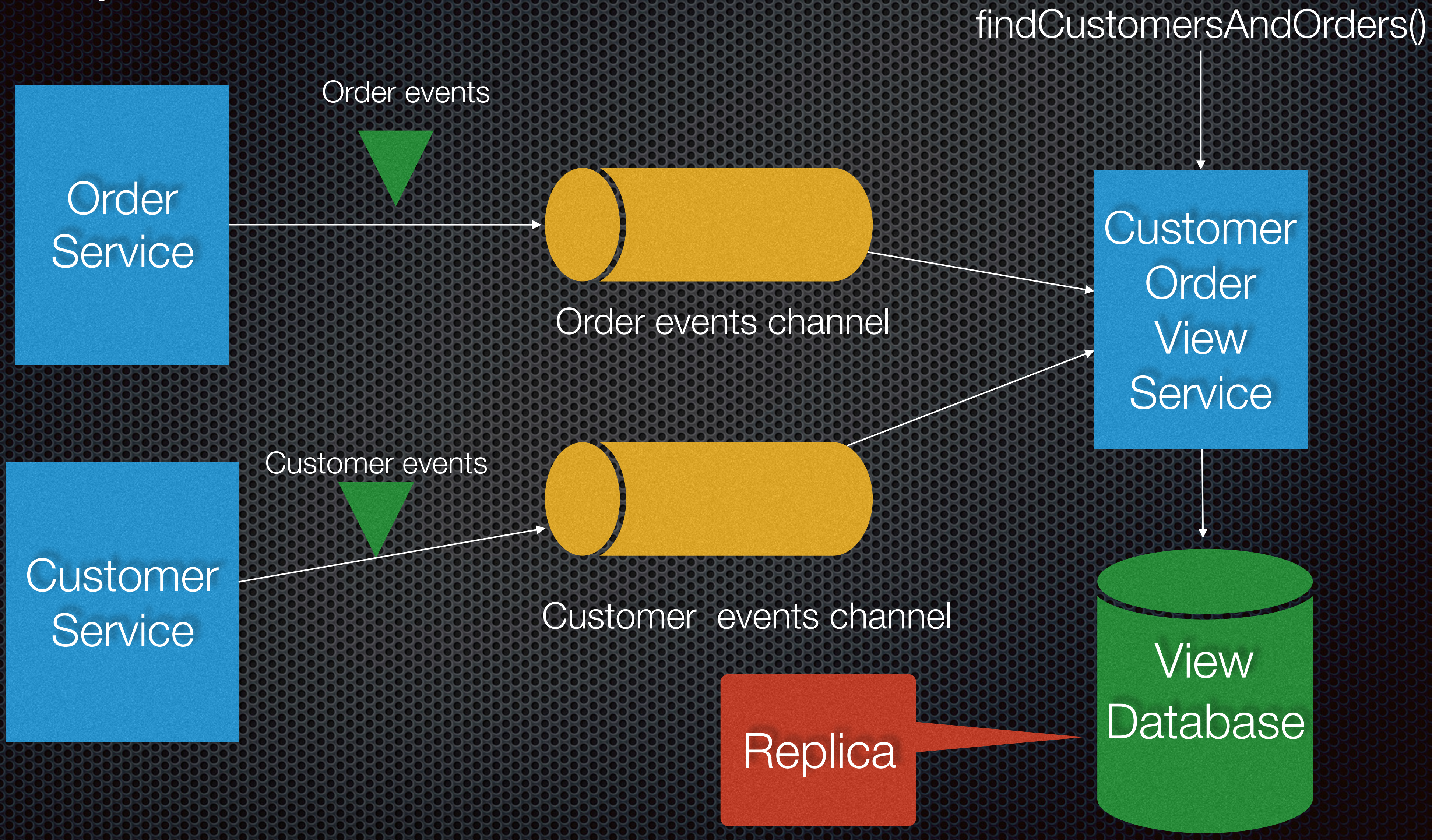
Not efficiently implemented using API Composition

API Composition would be inefficient

- 1 + N strategy:
  - Fetch recent customers
  - Iterate through customers fetching their shipped orders
  - Lots of round trips ⇒

    high-latency
- Alternative strategy:
  - Fetch recent customers
  - Fetch recent orders
  - Join
  - 2 roundtrips but potentially large datasets ⇒ inefficient

Using events to update a queryable replica = CQRS



https://microservices.io/patterns/data/cqrs.html

Persisting a customer and order history in MongoDB

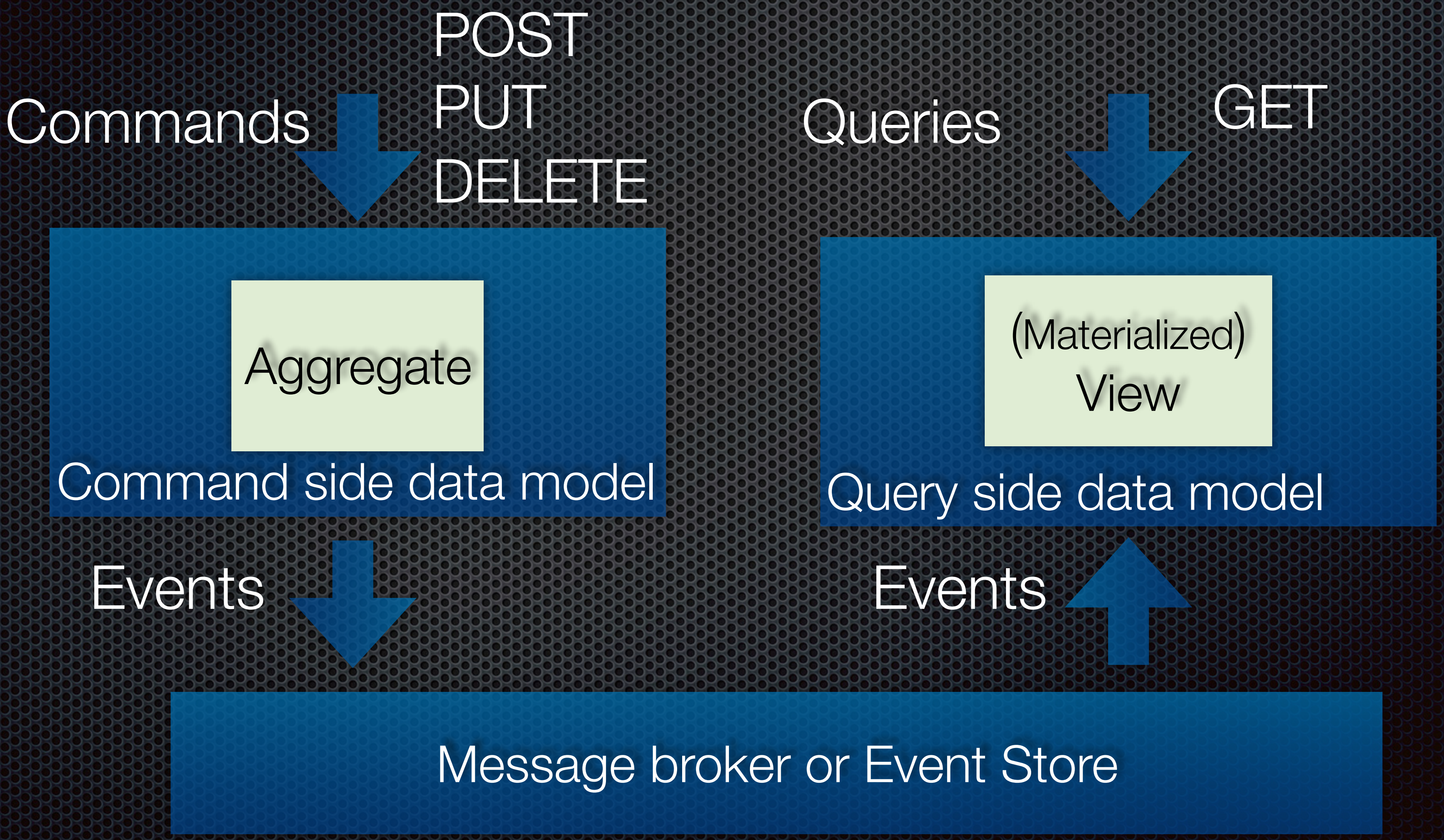
```
{
    "_id" : "0000014f9a45004b 0a00270000000000",
    "name" : "Fred",
    "creditLimit" : {
        "amount" : "2000"
    },
    "orders" : {
        "0000014f9a450063 0a00270000000000" : {
            "state" : "APPROVED",
            "orderId" : "0000014f9a450063 0a00270000000000",
            "orderTotal" : {
                "amount" : "1234"
            }
        },
        "0000014f9a450063 0a00270000000001" : {
            "state" : "REJECTED",
            "orderId" : "0000014f9a450063 0a00270000000001",
            "orderTotal" : {
                "amount" : "3000"
            }
        }
    }
}
```

Customer information

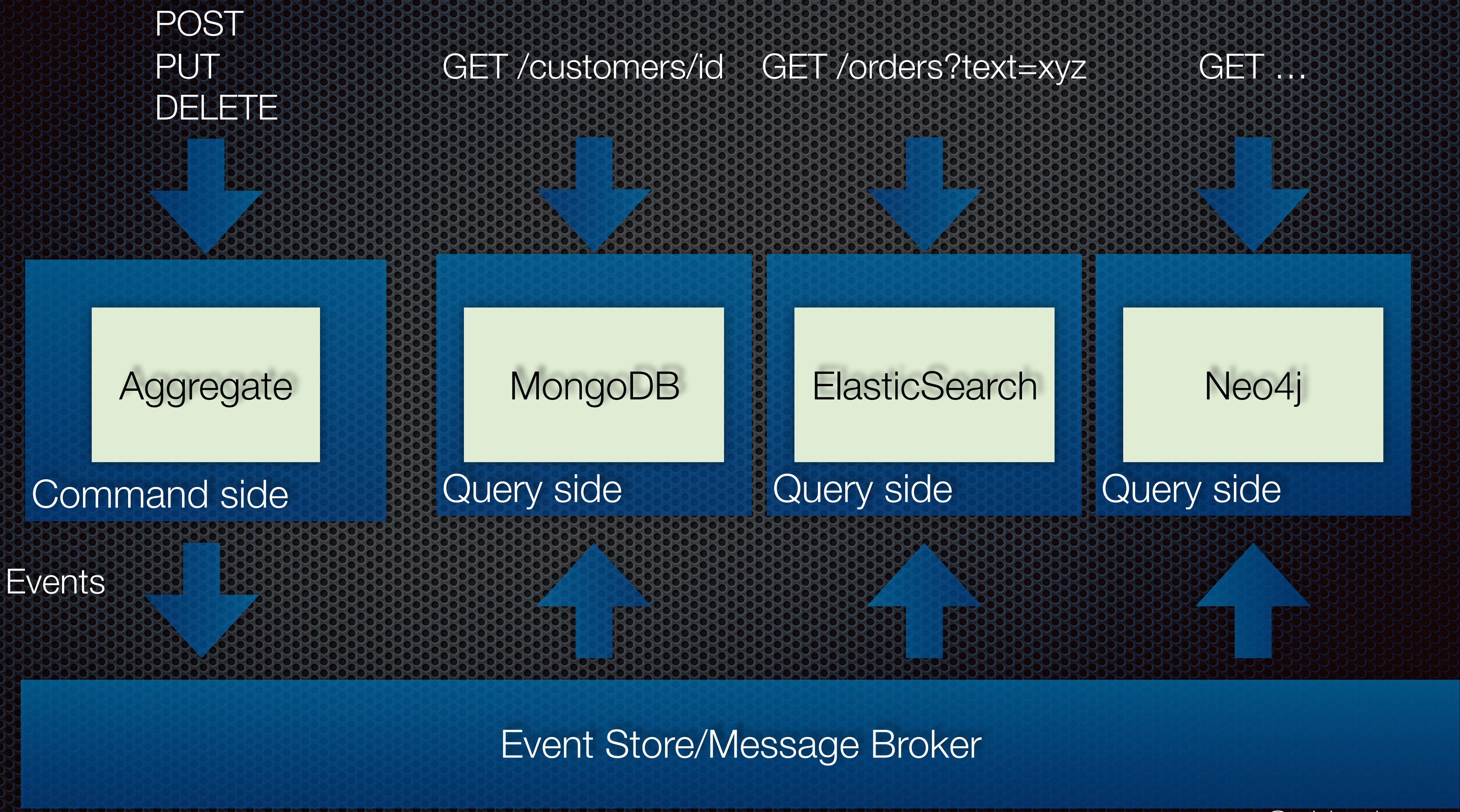
Order information

Denormalized = efficient lookup

Command Query Responsibility Segregation (CQRS)



Queries ⇒ database (type)



CQRS views are disposable

- Rebuild when needed from *source of truth*
- Using event sourcing
  - (Conceptually) replay all events from beginning of time
- Using traditional persistence
  - “ETL” from *source of truth* databases

Handling replication lag

- Lag between updating command side and CQRS view
- Risk of showing stale data to user
- Either:
  - Update UI/client-side model without querying
  - Use updated aggregate version to “wait” for query view to be updated

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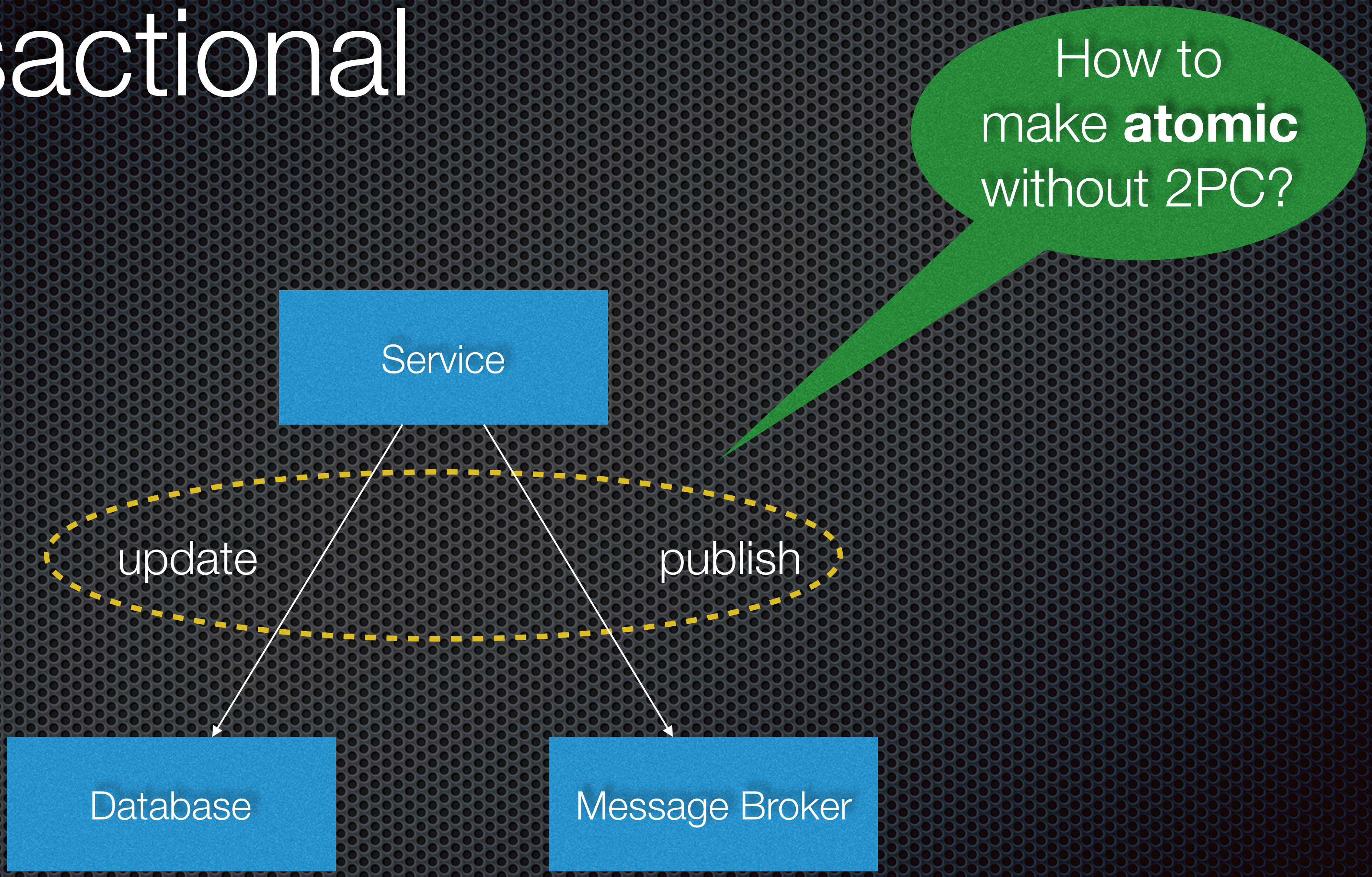
Messaging must be transactional

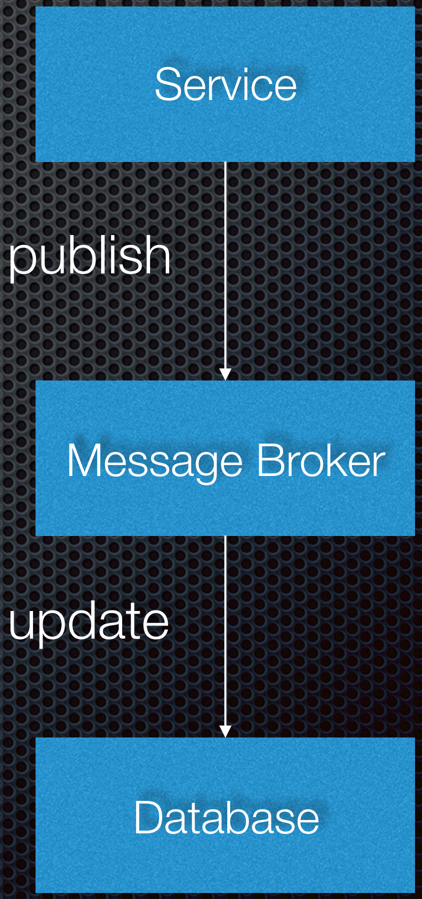


Publish to message broker first?

- Guarantees atomicity

BUT

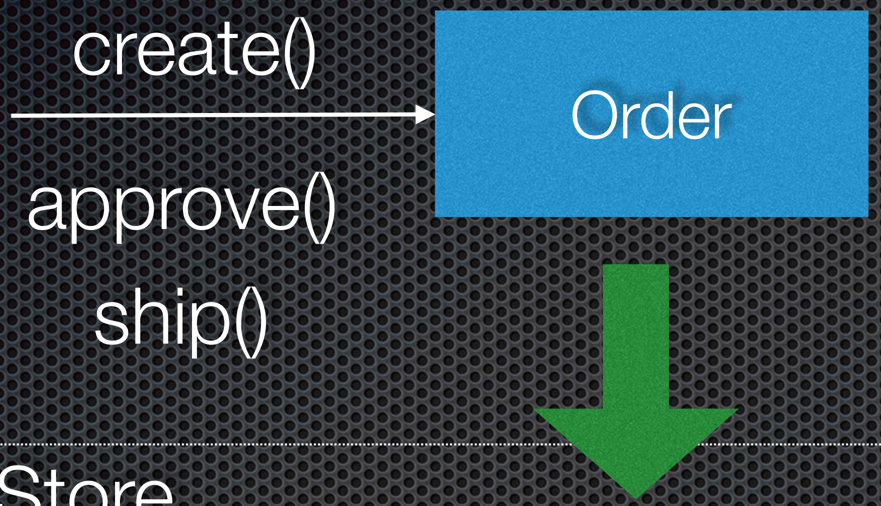
- Service can't read its own writes
- Difficult to write business logic



Option: Event sourcing
=
Event centric approach to business logic and persistence

http://eventuate.io/

Event sourcing: persists an object as a sequence of events

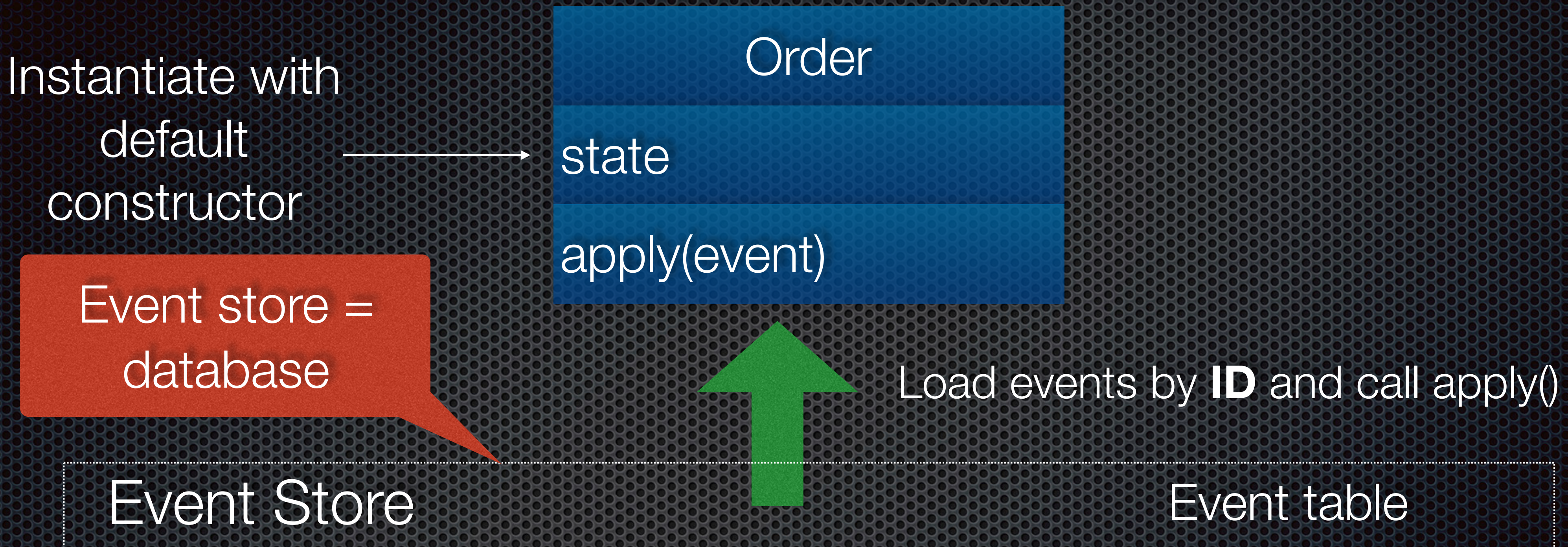


Event Store

Event table

Entity id	Entity type	Event id	Event type	Event data
101	Order	901	OrderCreated	…
101	Order	902	OrderApproved	…
101	Order	903	OrderShipped	…

Replay events to recreate in memory state

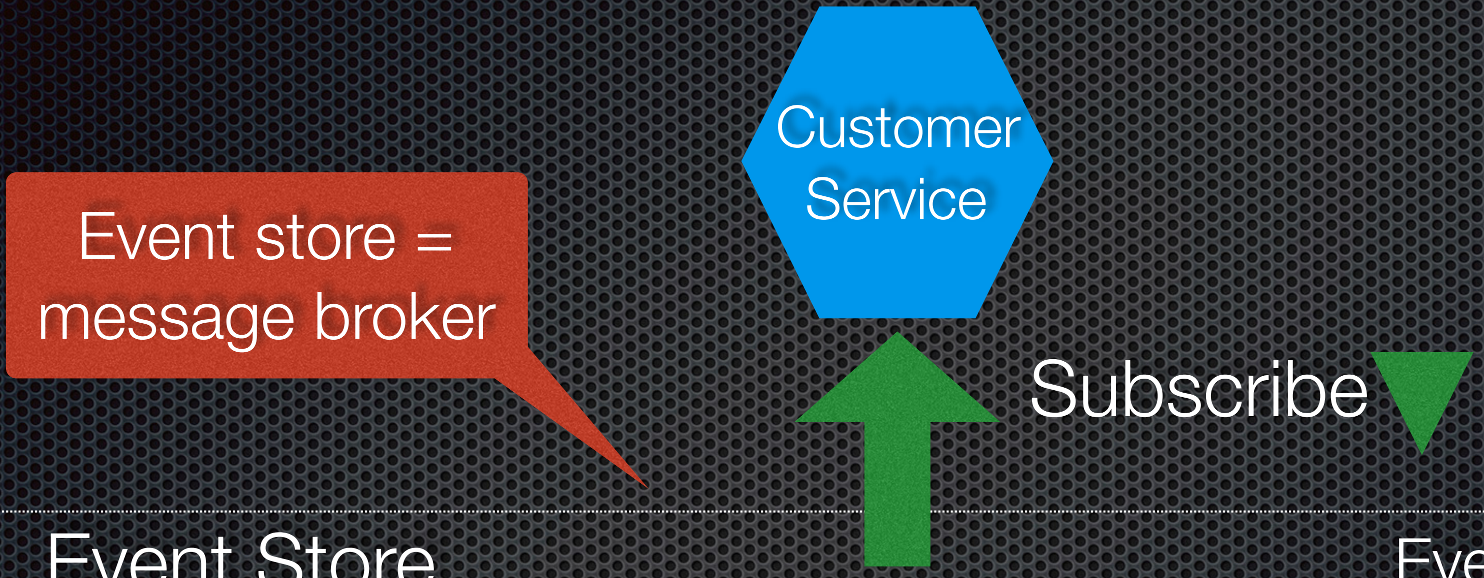


Entity id	Entity type	Event id	Event type	Event data
101	Order	901	OrderCreated	…
101	Order	902	OrderApproved	…
101	Order	903	OrderShipped	…

FYI:

Apache Kafka != event store

Event sourcing guarantees: state change ⇒ event is published



Event Store

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Entity id	Entity type	Event id	Event type	Event data
101	Order	901	OrderCreated	…
101	Order	902	OrderApproved	…
101	Order	903	OrderShipped	…

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Other benefits of event sourcing

Preserves history of domain objects

Supports temporal queries

Simplifies retroactive correction

Built-in auditing

Drawbacks of event sourcing

Unfamiliar programming model

Evolving the schema of long-lived events

Event store only supports PK-based access ⇒ requires CQRS ⇒ less consistent reads

Drawbacks of event sourcing

Good fit for choreography-based sagas
BUT orchestration is more challenging
⇒
Use event handler to translate event
into command/reply message

Option:

Traditional persistence (JPA, MyBatis,…)

+

Transactional outbox pattern

https://github.com/eventuate-tram/eventuate-tram-core

Spring Data for JPA example

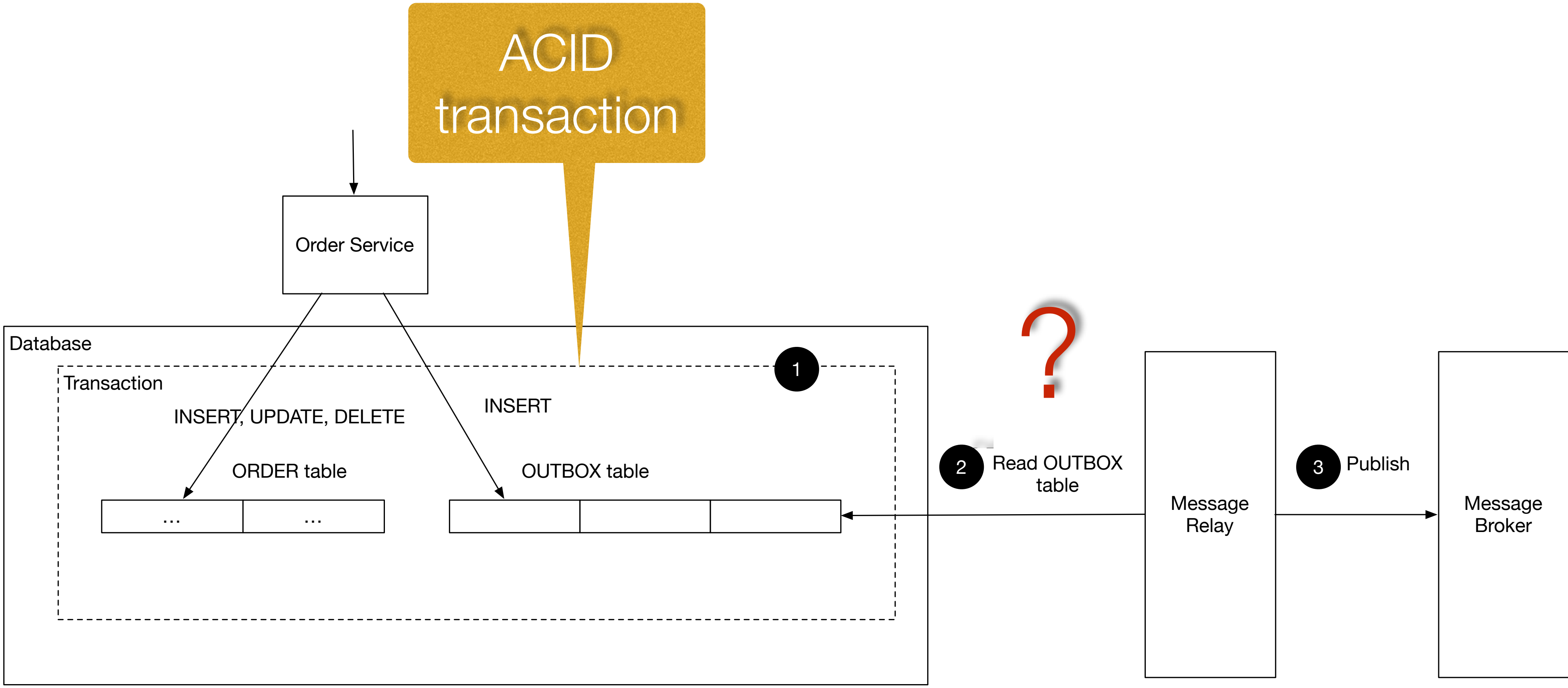
```java
public class OrderService {

  @Autowired
  private DomainEventPublisher domainEventPublisher;

  @Autowired
  private OrderRepository orderRepository;

  @Transactional
  public Order createOrder(OrderDetails orderDetails) {
    Order order = Order.createOrder(orderDetails);
    orderRepository.save(order);
    domainEventPublisher.publish(Order.class,
            order.getId(),
            singletonList(new OrderCreatedEvent(order.getId(), orderDetails)));
    return order;
  }
}
```

Save order

Publish event

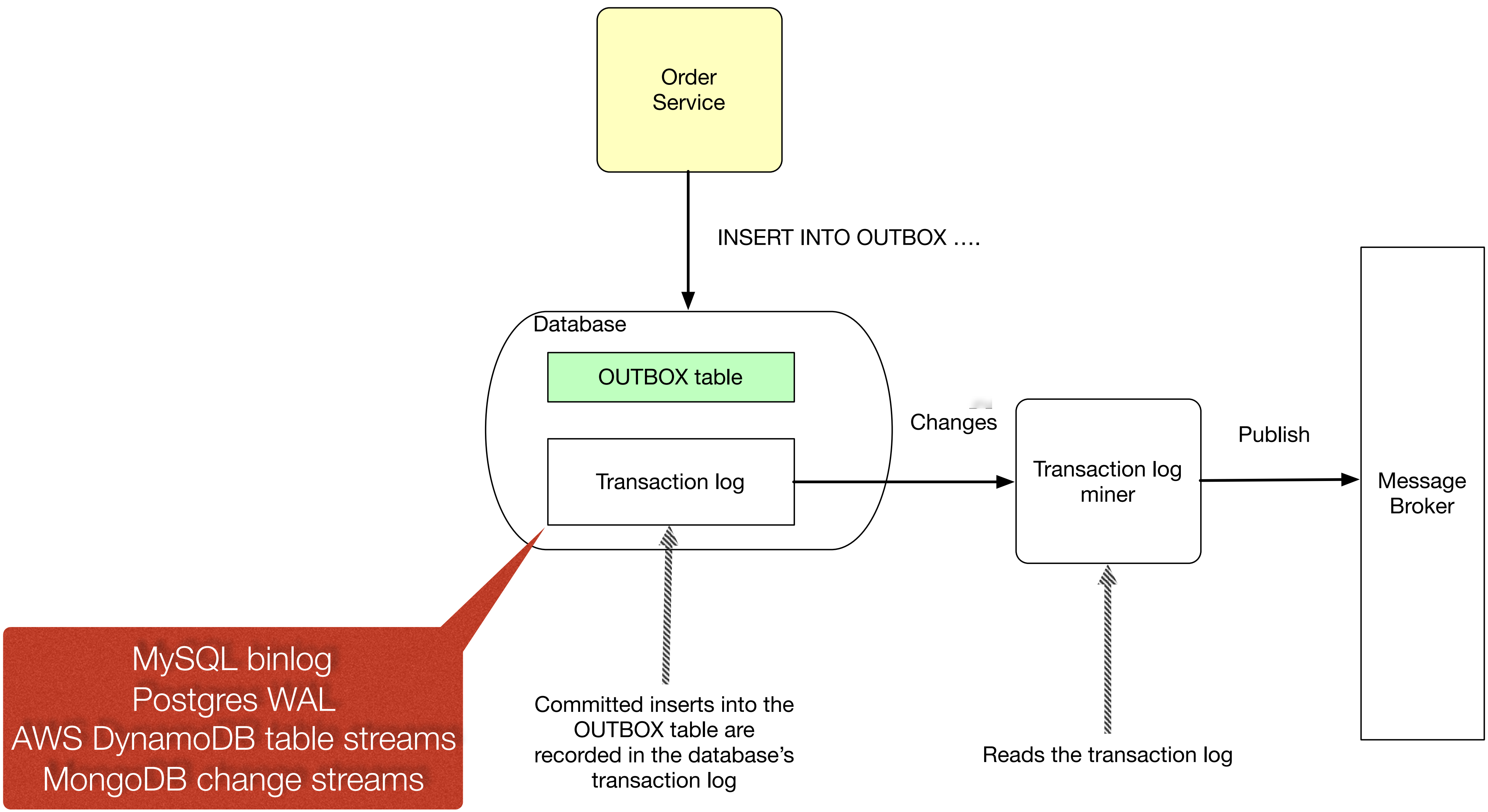
http://eventuate.io/exampleapps.html

Transactional Outbox pattern



- https://microservices.io/patterns/data/transactional-outbox.html
- https://eventuate.io/

Transaction log tailing



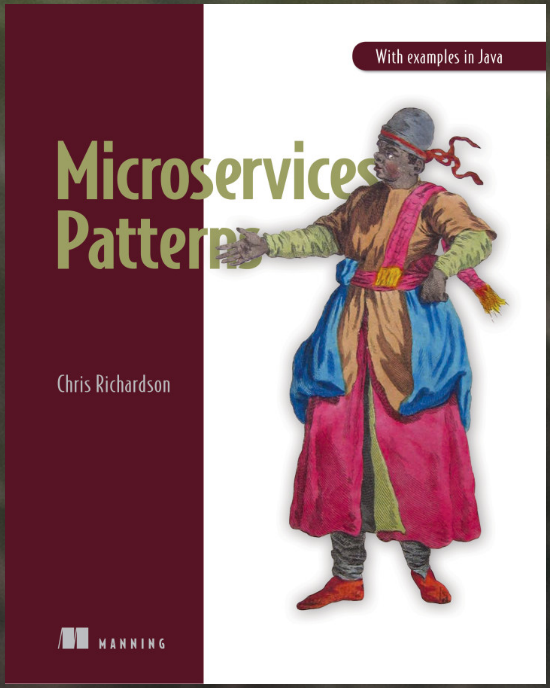
Polling the message table

- Simple
- Works for all databases
- BUT what about polling frequency

Summary

- Use asynchronous messaging to solve distributed data management problems
- Services publish events to implement
  - choreography-based sagas
  - queries using CQRS views
- Services send command/reply messages to implement orchestration-based sagas
- Services must atomically update state and send messages
  - Event sourcing
  - Transactional outbox

@crichardson chris@chrisrichardson.net



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