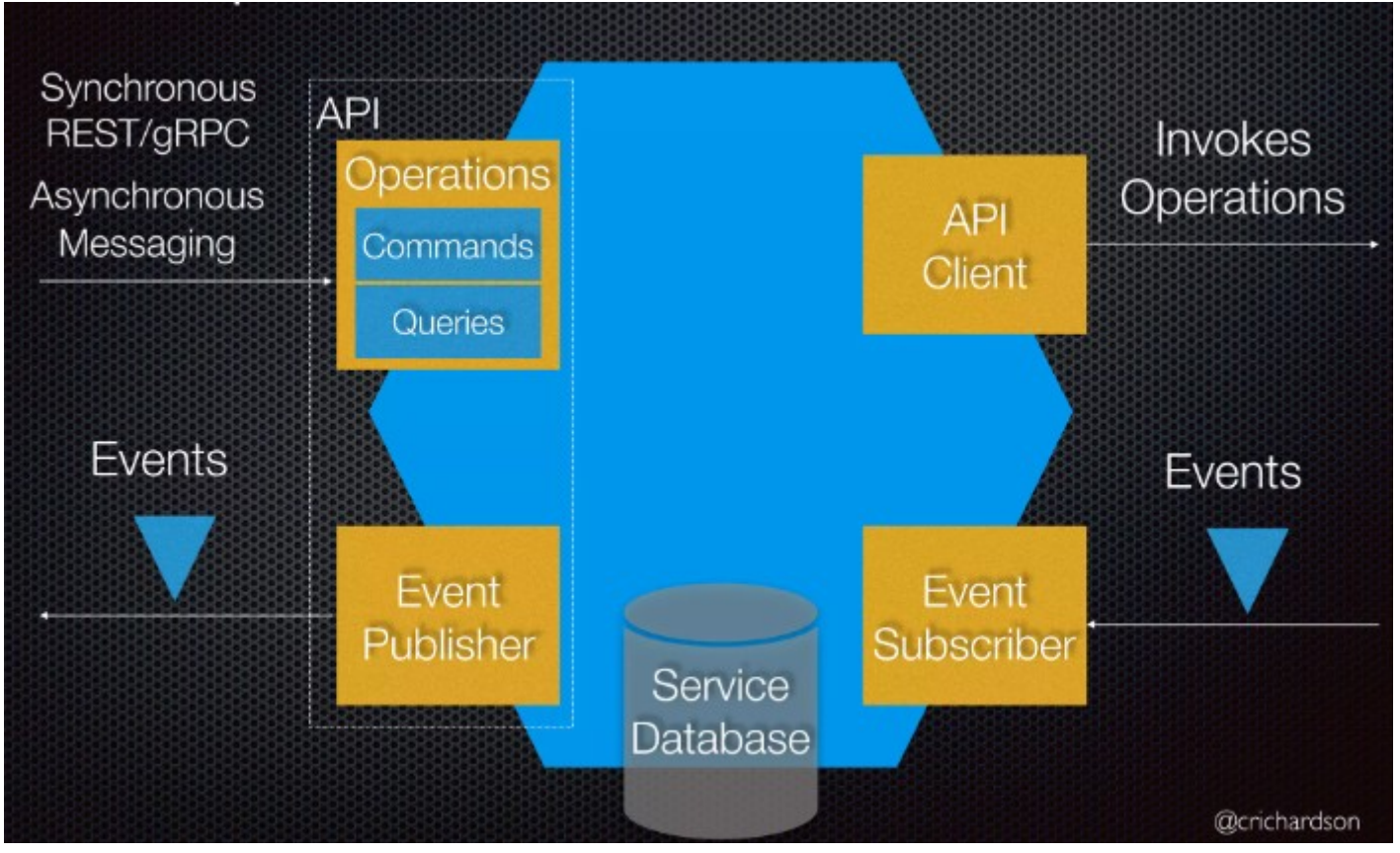
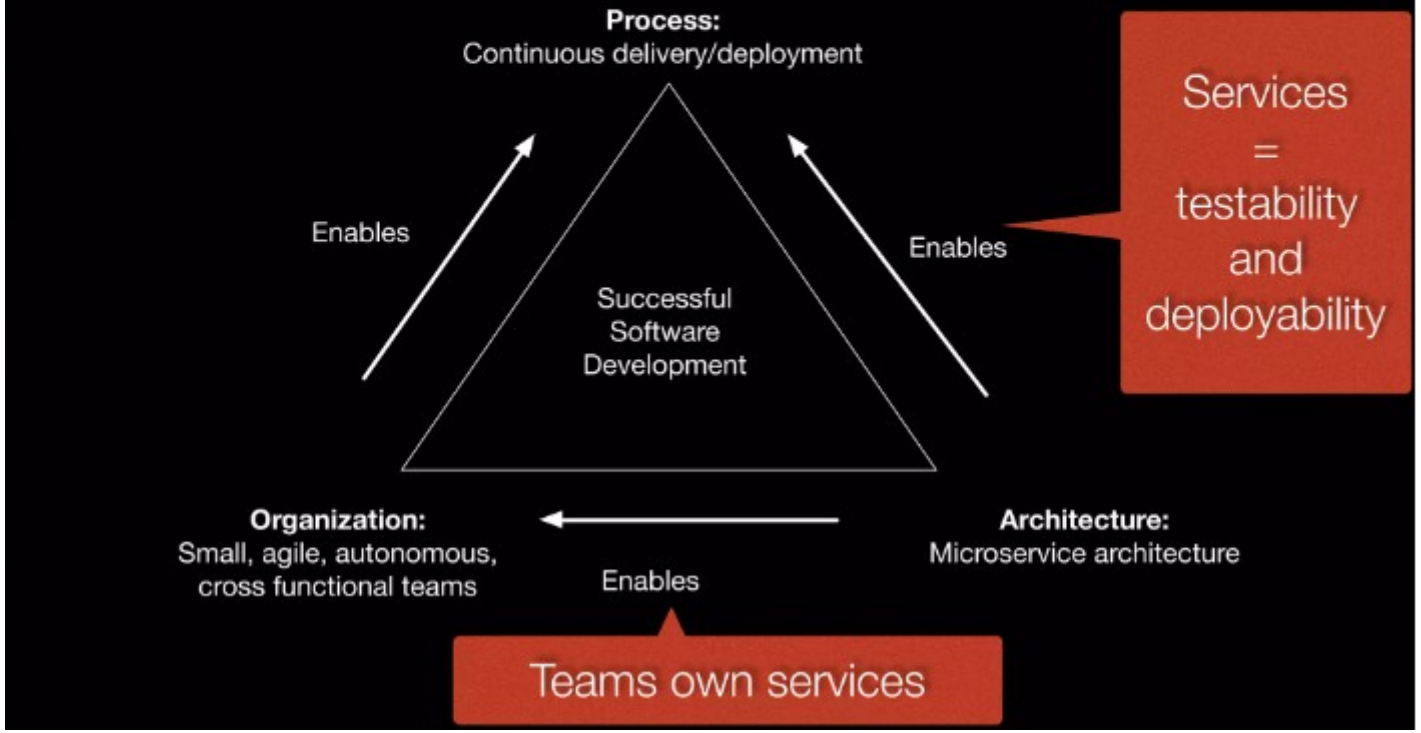
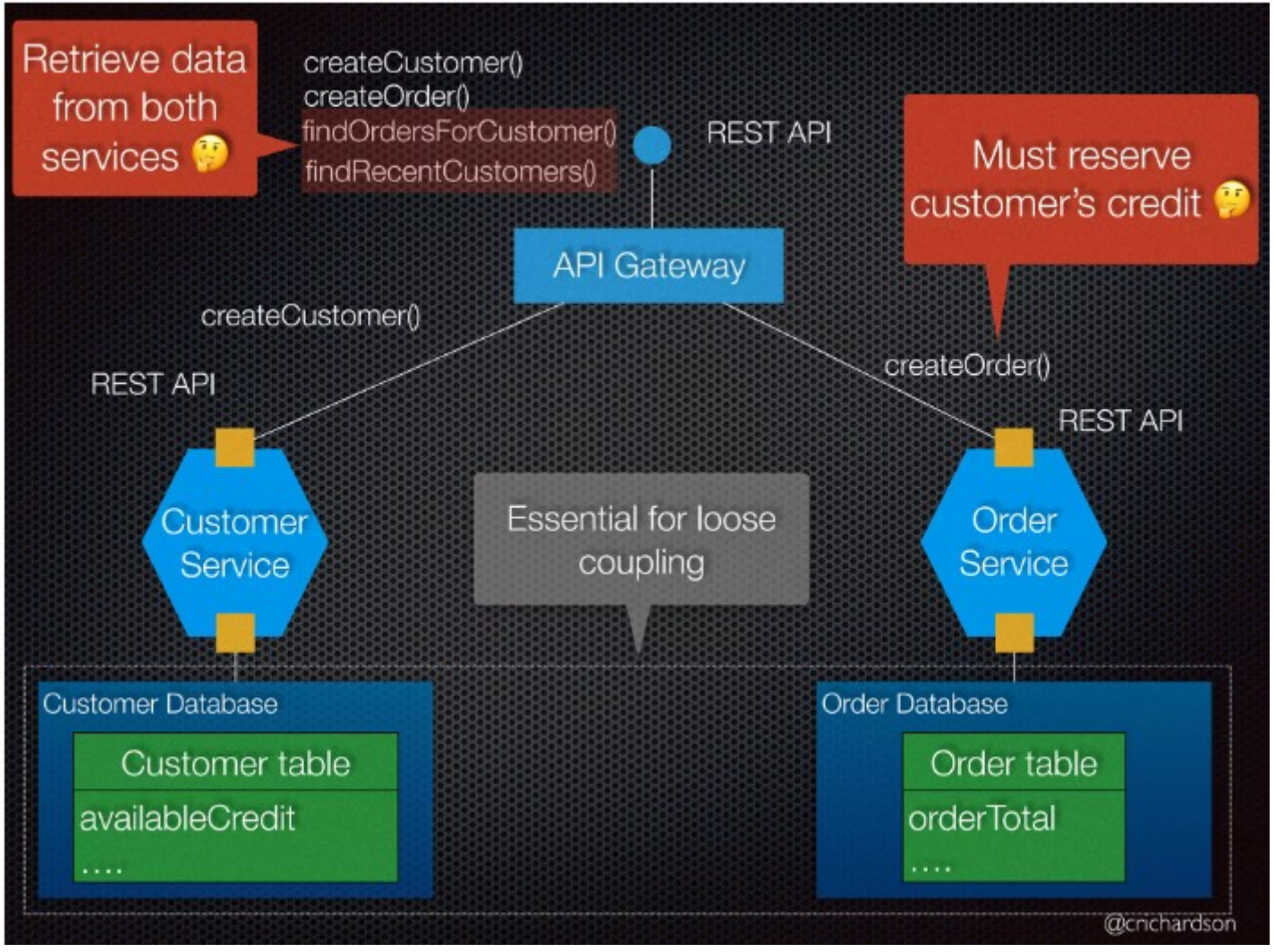
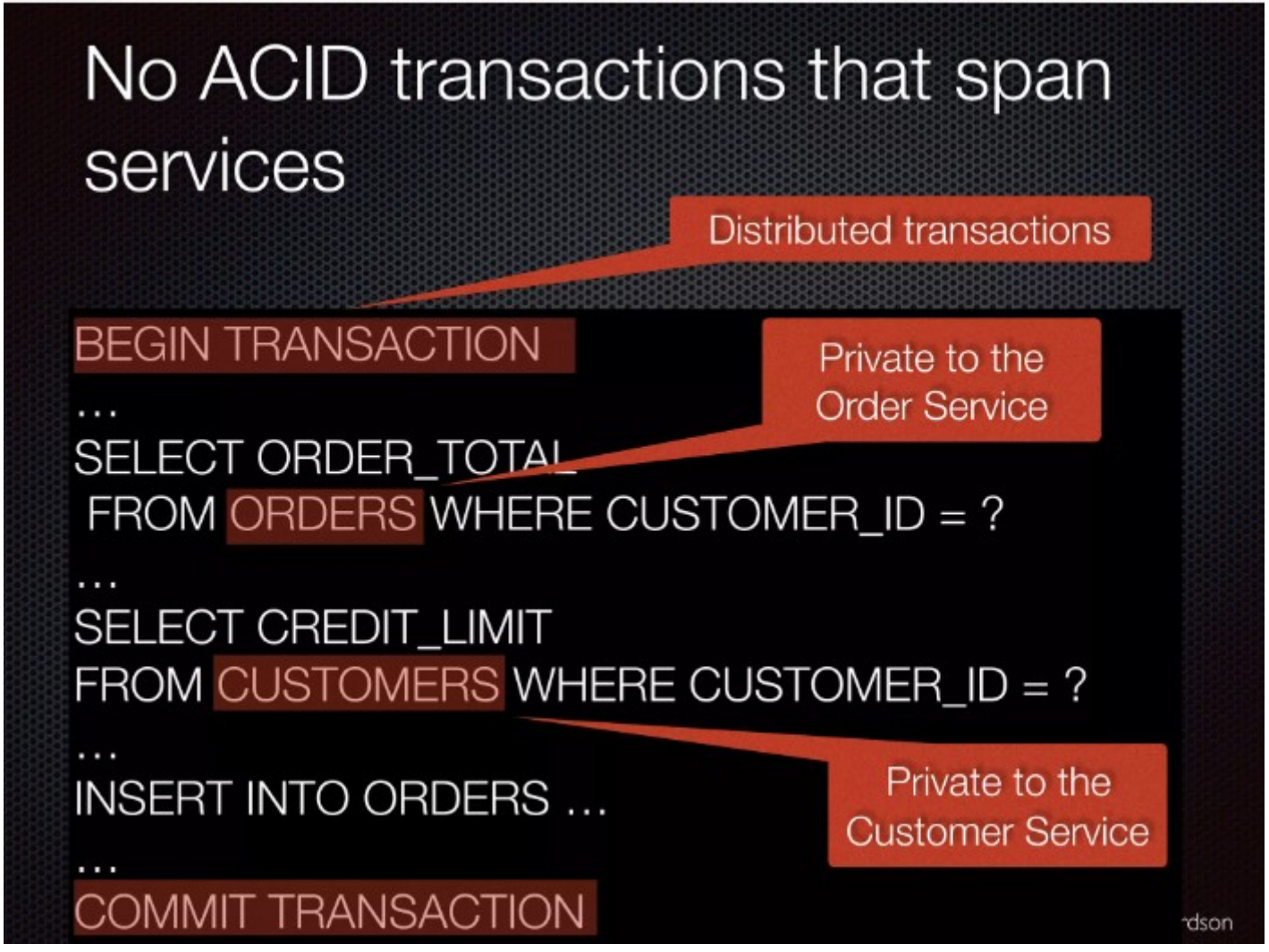

Synchronous
REST/gRPC
Asynchronous
Messaging
API
Operations
Commands
Queries
API
Client
Invokes
Operations
Events
Events
Event
Publisher
Service
Database
Event
Subscriber
@crichardson

# Microservices enable continuous delivery/deployment

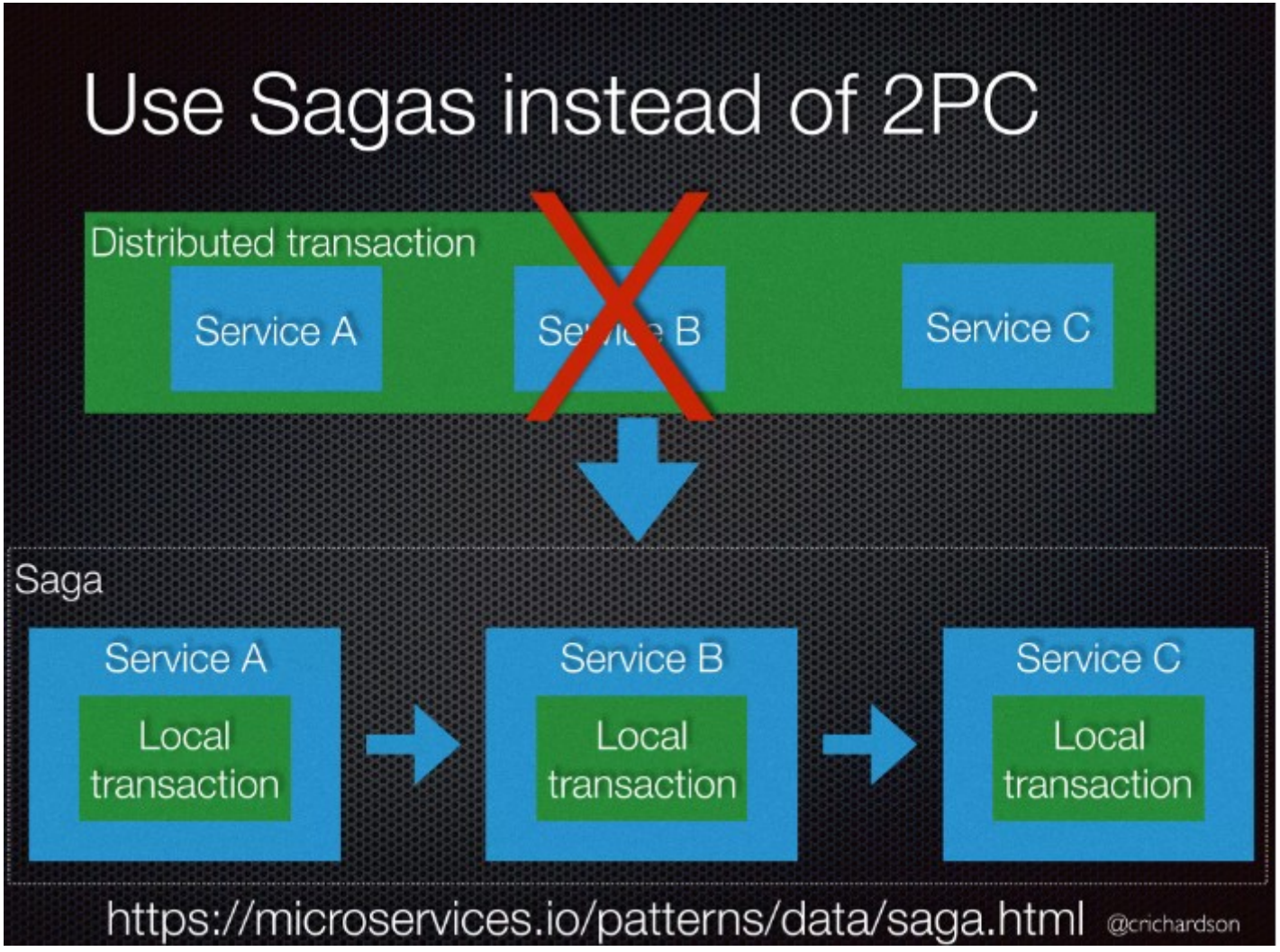


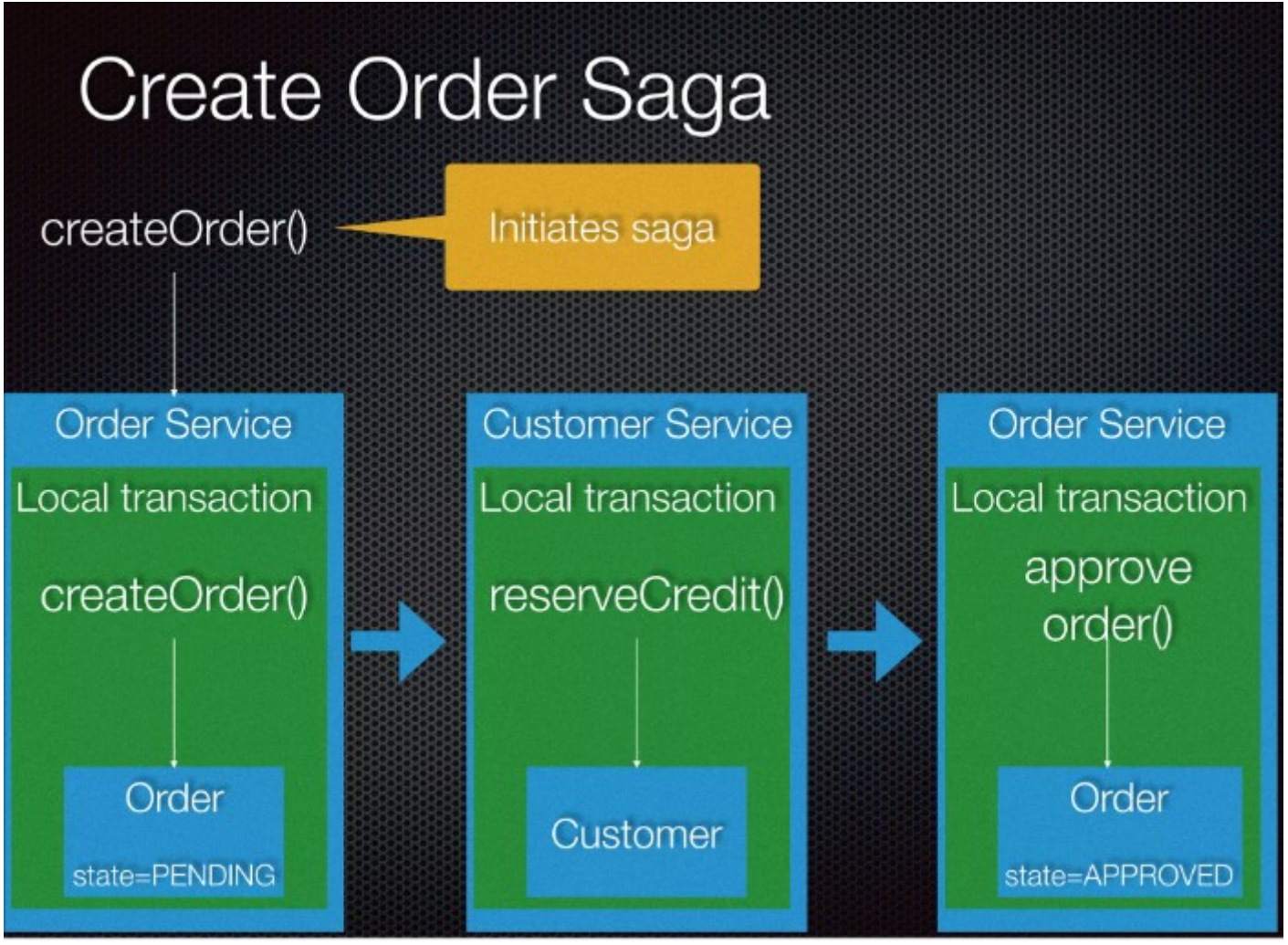

Retrieve data from both services
createCustomer()
createOrder()
findOrdersForCustomer()
findRecentCustomers()
REST API
Must reserve customer's credit
API Gateway
createCustomer()
REST API
createOrder()
REST API
Customer Service
Essential for loose coupling
Order Service
Customer Database
Customer table
availableCredit
....
Order Database
Order table
orderTotal
....
@crichardson


No ACID transactions that span services
Distributed transactions
BEGIN TRANSACTION
…
SELECT ORDER_TOTAL
FROM ORDERS WHERE CUSTOMER_ID = ?
Private to the Order Service
…
SELECT CREDIT_LIMIT
FROM CUSTOMERS WHERE CUSTOMER_ID = ?
…
INSERT INTO ORDERS …
Private to the Customer Service
…
COMMIT TRANSACTION

# Agenda

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


Use Sagas instead of 2PC
Distributed transaction
Service A
Service B
Service C
Saga
Service A
Local transaction
Service B
Local transaction
Service C
Local transaction
https://microservices.io/patterns/data/saga.html
@crichardson

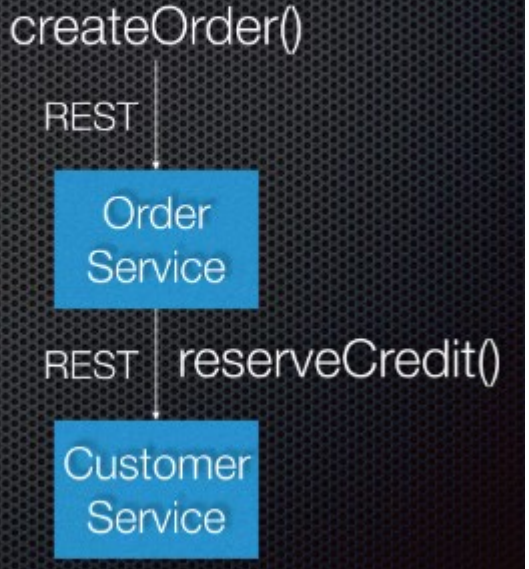

Create Order Saga
createOrder()
Initiates saga
Order Service
Local transaction
createOrder()
Order
state=PENDING
Customer Service
Local transaction
reserveCredit()
Customer
Order Service
Local transaction
approve order()
Order
state=APPROVED

# Saga design challenges

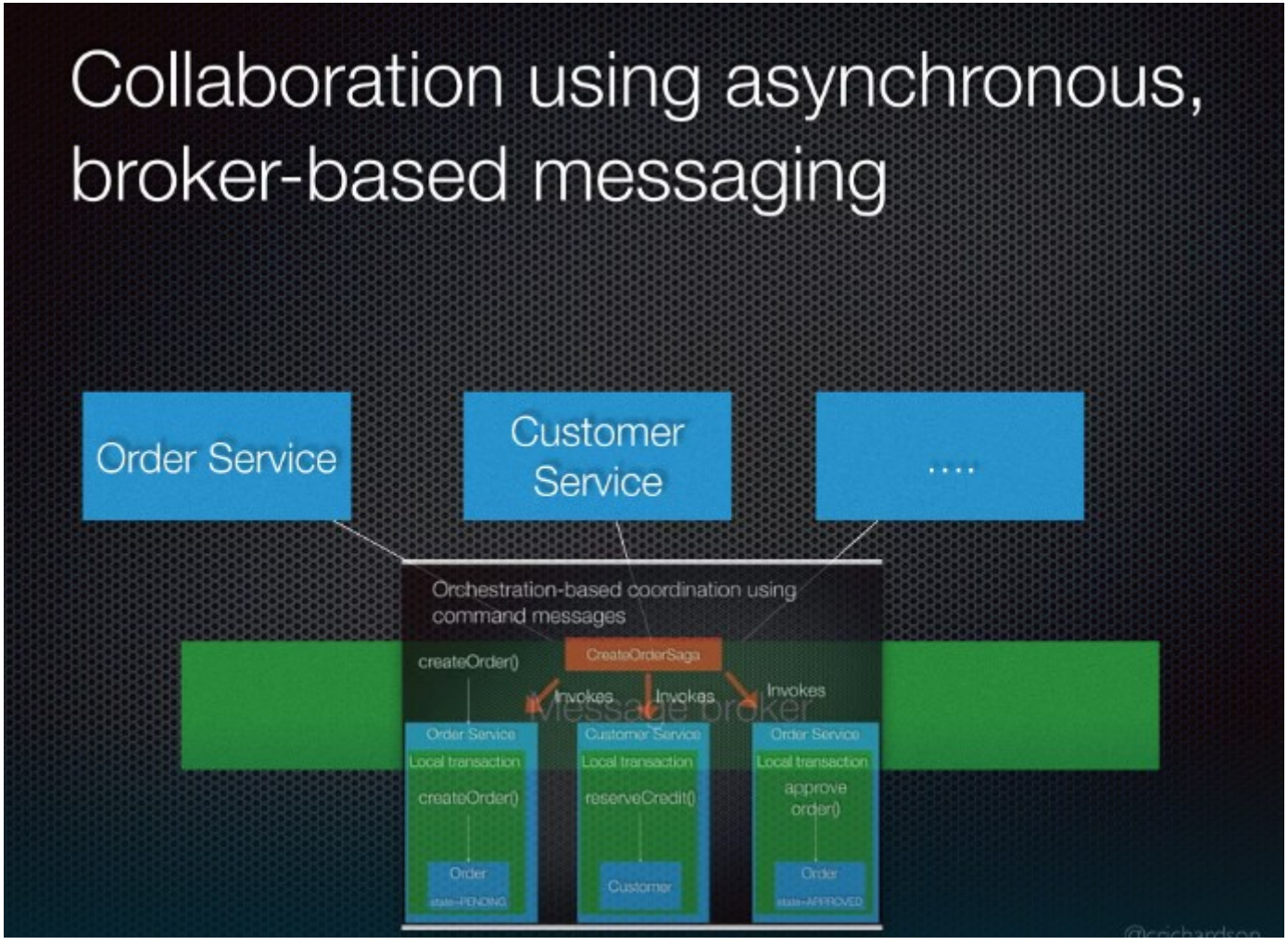
- API design
  - Synchronous REST API initiates asynchronous saga
  - When to send back a response?
- Rollback ⇒ compensating transactions
- Sagas are ACD - No I
  - Sagas are interleaved ⇒ anomalies, such as lost updates
  - Must use countermeasures

# 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



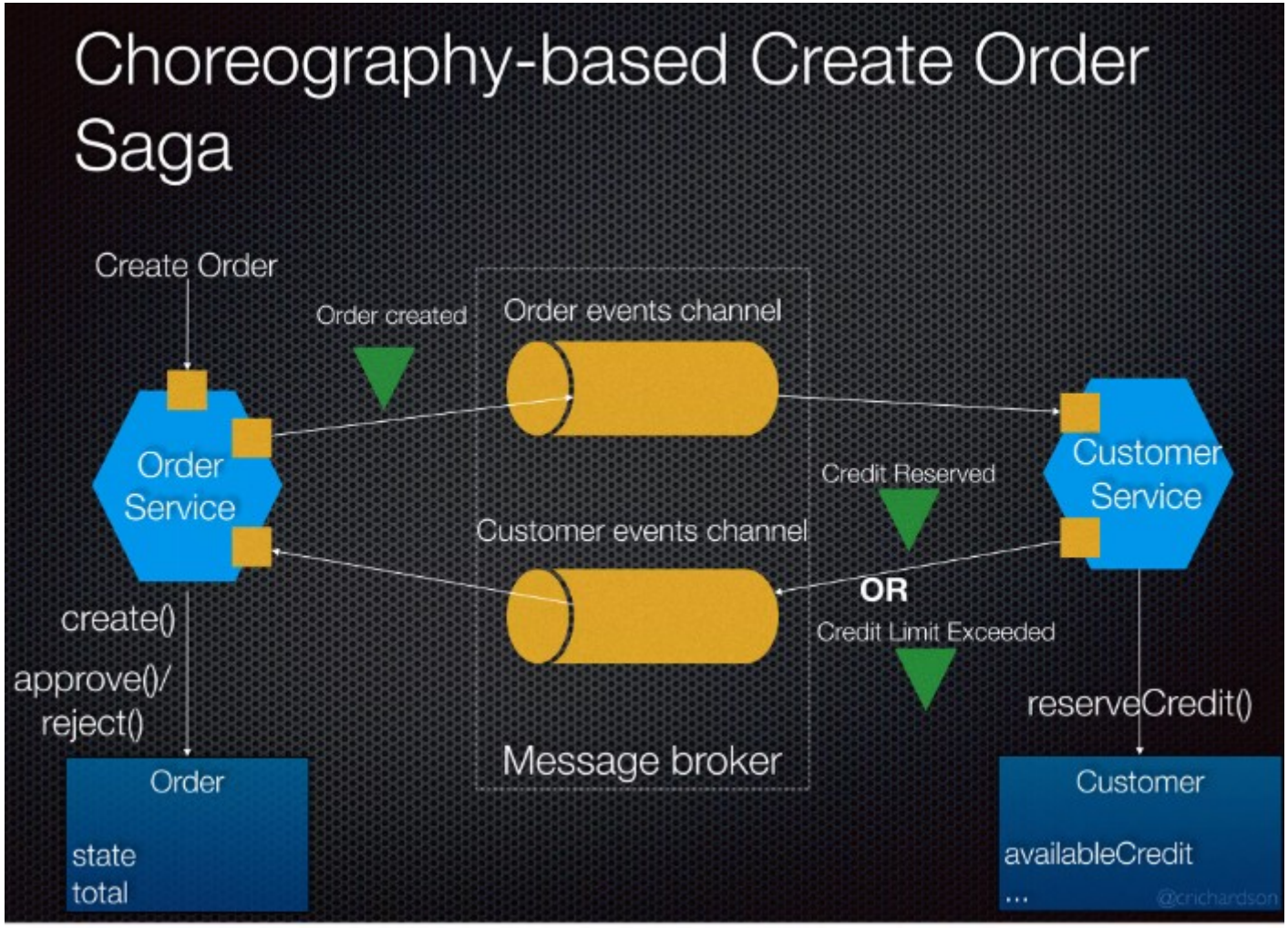
# Collaboration using asynchronous, broker-based messaging



# 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
  - …


Choreography: **distributed** decision making
vs.
Orchestration: **centralized** decision making


Choreography-based Create Order Saga
Create Order
Order created
Order events channel
Order Service
Customer Service
Credit Reserved
Customer events channel
OR
Credit Limit Exceeded
create()
approve()/
reject()
reserveCredit()
Message broker
Order
state
total
Customer
availableCredit
...
@crichardson

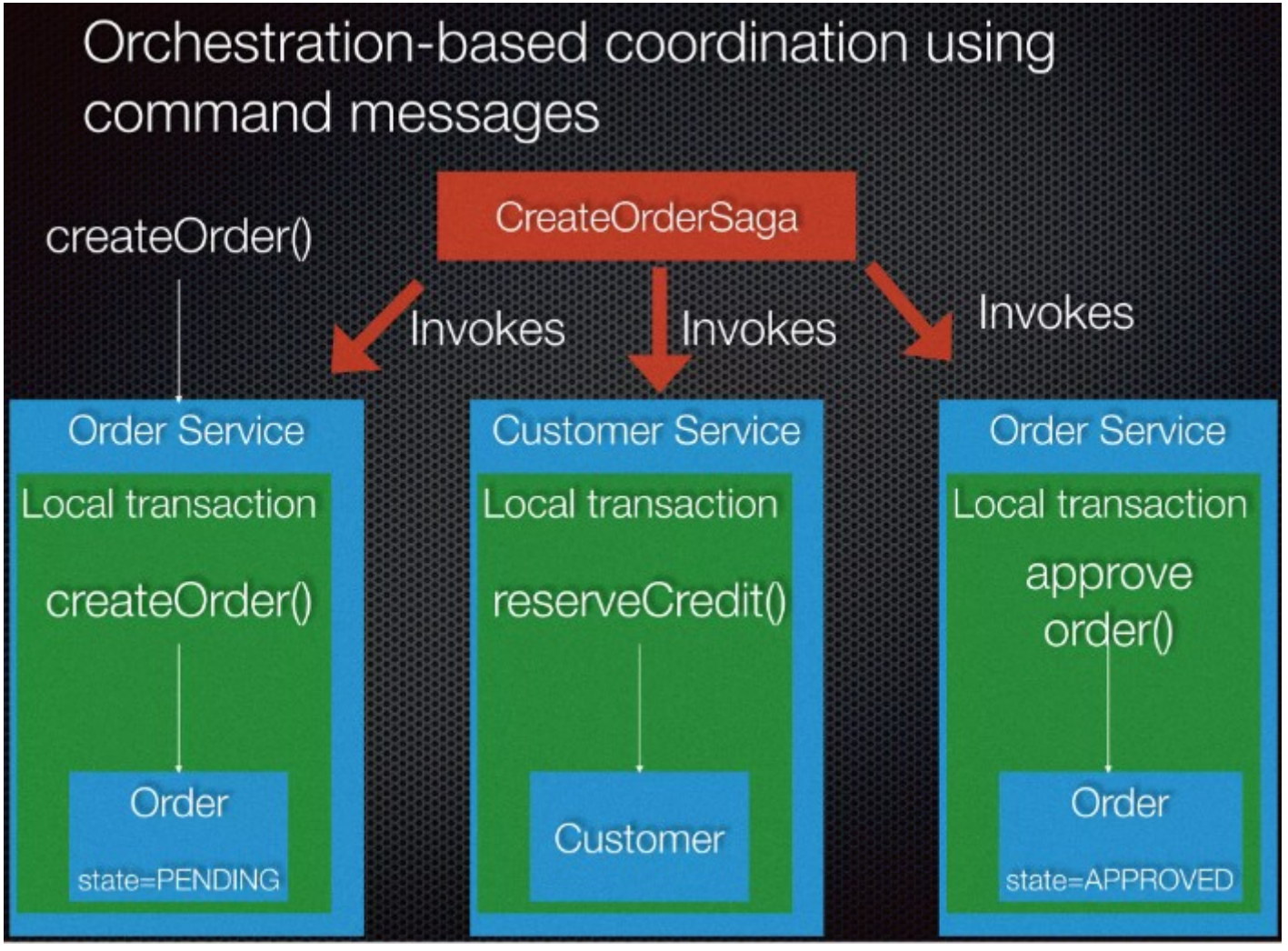
# Benefits and drawbacks of choreography

**Benefits**

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

**Drawbacks**

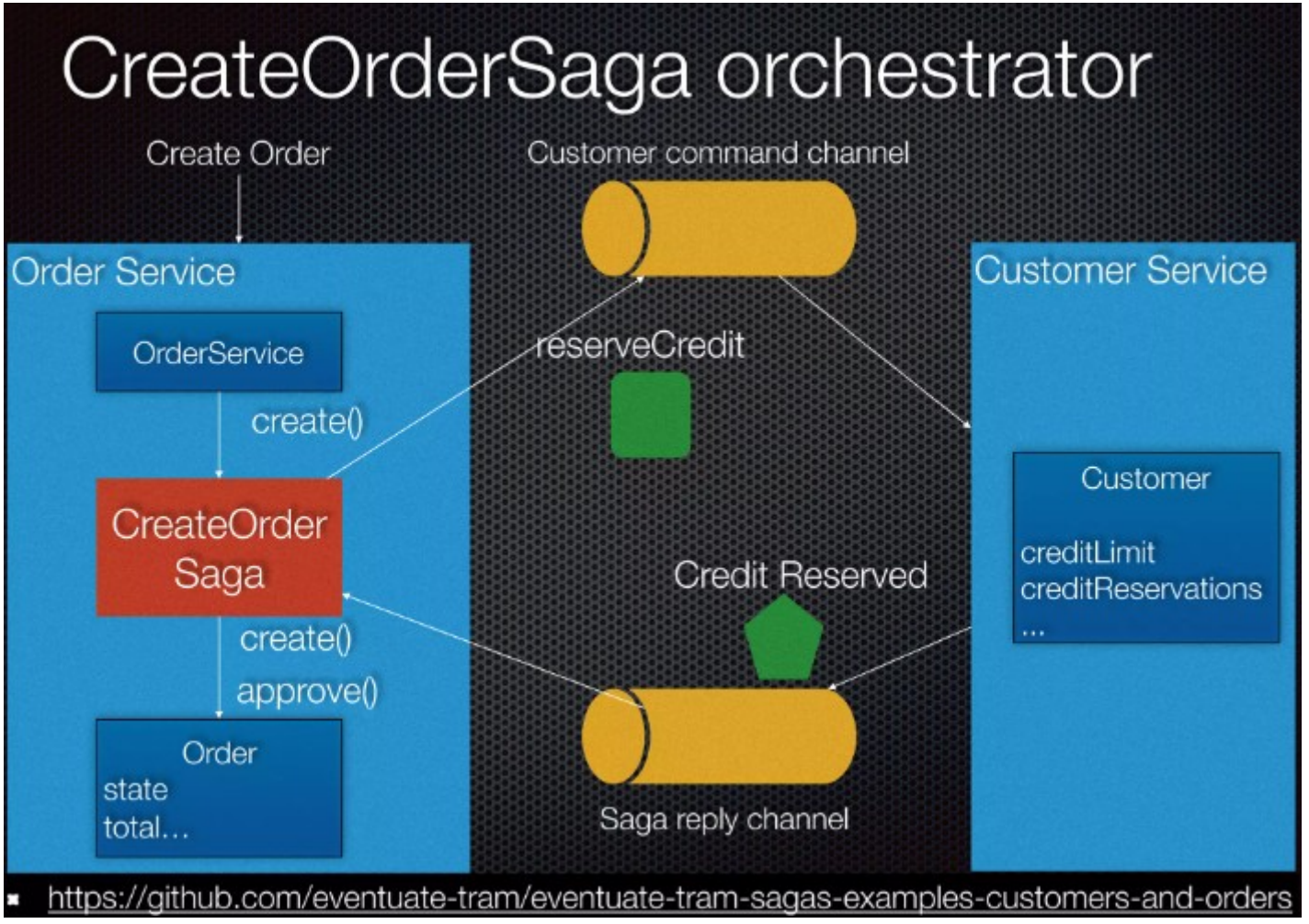
- Decentralized implementation - potentially difficult to understand
- Cyclic dependencies - services listen to each other's events, e.g. Customer Service **must know** about all Order events that affect credit
- Overloads domain objects, e.g. Order and Customer **know** too much
- Events = indirect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


Orchestration-based coordination using command messages
createOrder()
CreateOrderSaga
Invokes
Invokes
Invokes
Order Service
Local transaction
createOrder()
Order
state=PENDING
Customer Service
Local transaction
reserveCredit()
Customer
Order Service
Local transaction
approve order()
Order
state=APPROVED

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
Create Order
Customer command channel
Order Service
Customer Service
OrderService
reserveCredit
create()
CreateOrder Saga
Customer
creditLimit
creditReservations
...
Credit Reserved
create()
approve()
Order
state
total…
Saga reply channel
https://github.com/eventuate-tram/eventuate-tram-sagas-examples-customers-and-orders

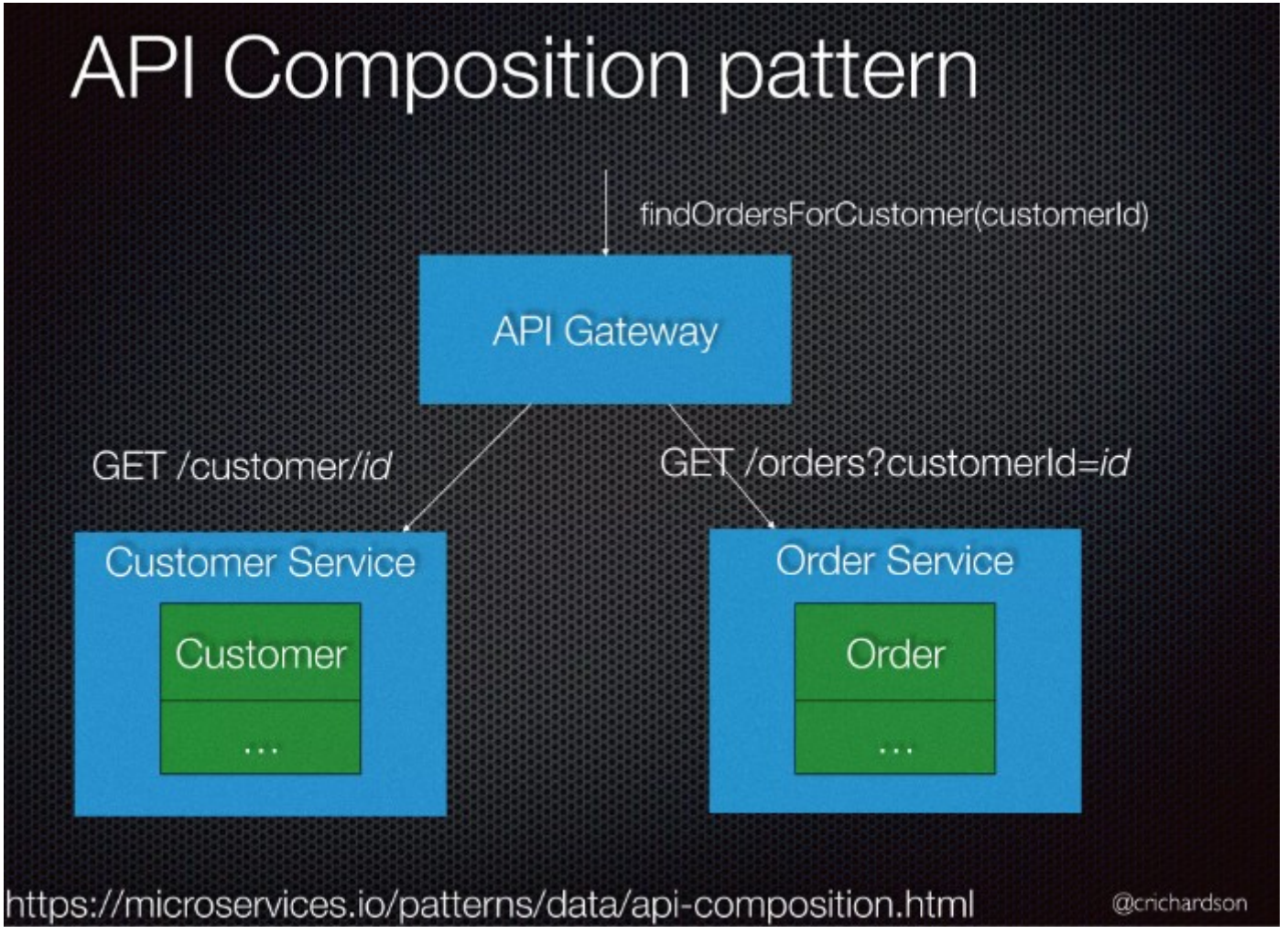
# Benefits and drawbacks of orchestration

**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

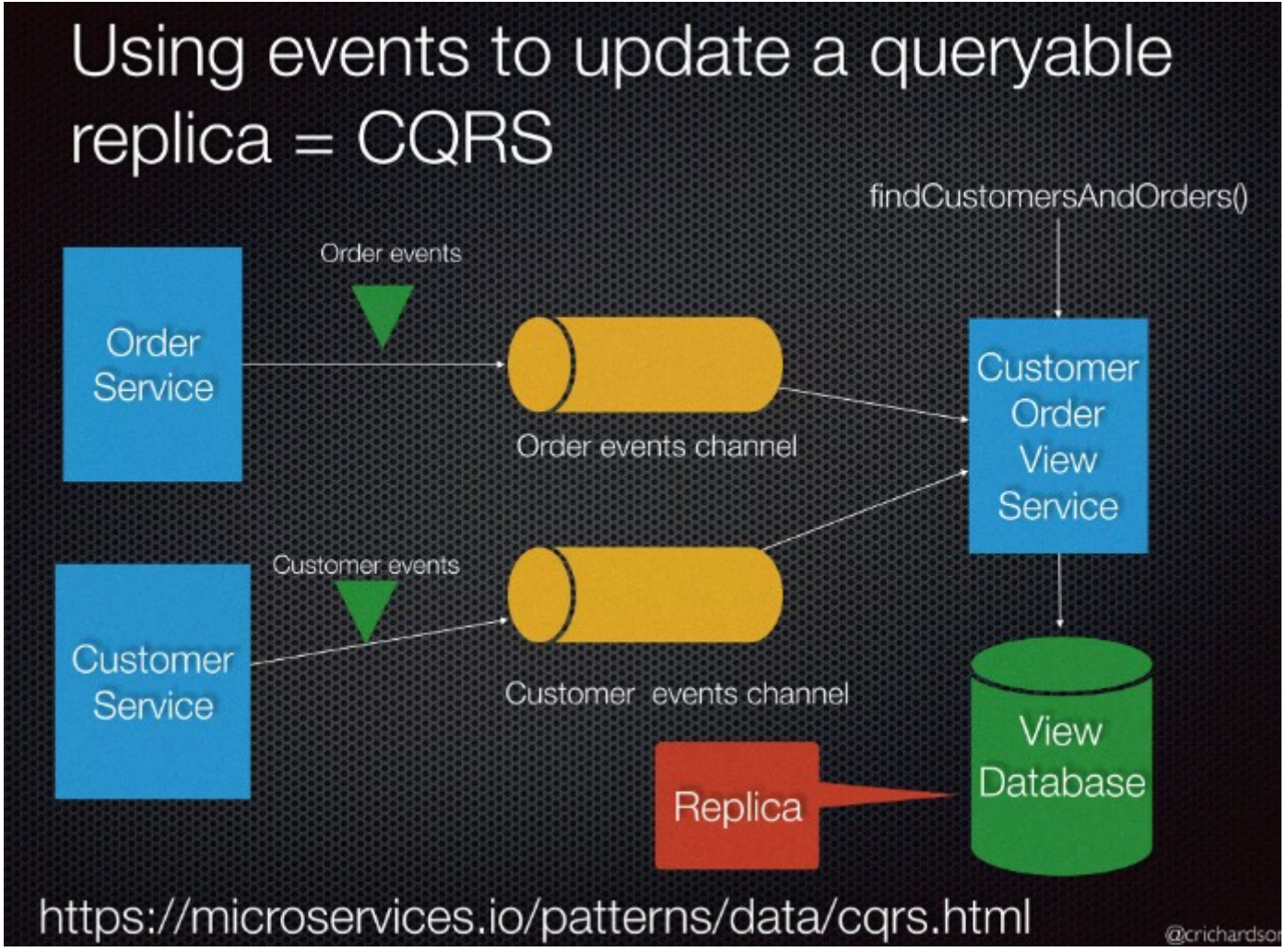
**Drawbacks**

- Risk of smart sagas directing dumb services

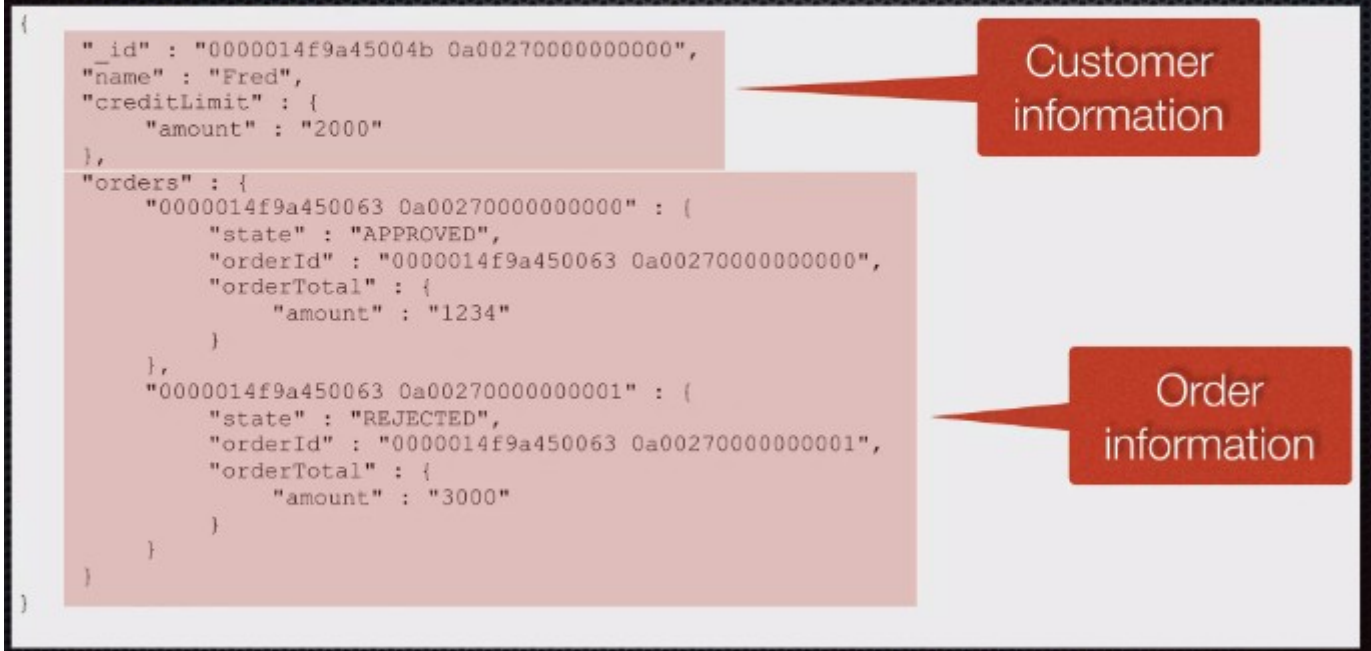

API Composition pattern
findOrdersForCustomer(customerId)
API Gateway
GET /customer/id
GET /orders?customerId=id
Customer Service
Customer
...
Order Service
Order
...
https://microservices.io/patterns/data/api-composition.html
@crichardson

# 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

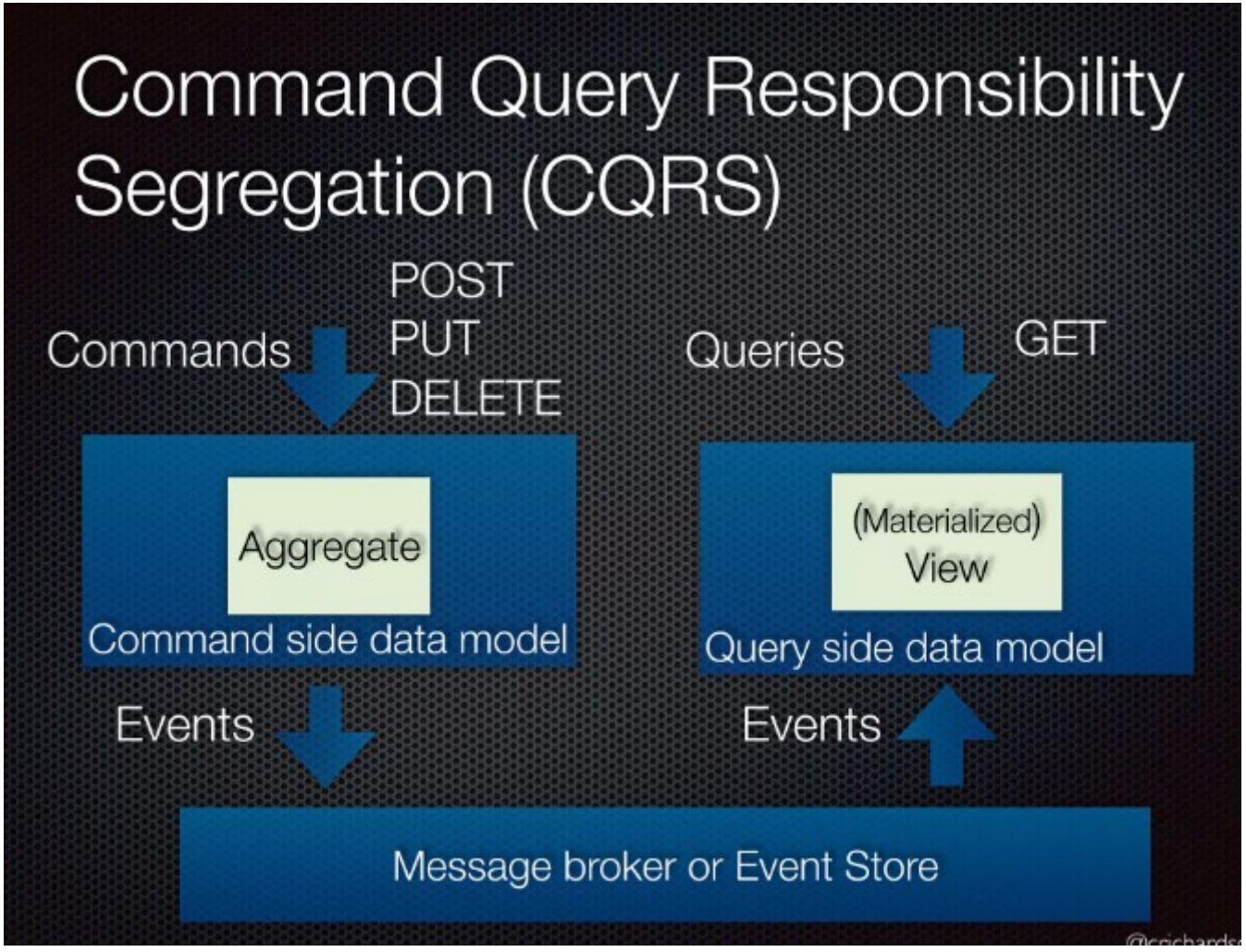

Using events to update a queryable replica = CQRS
findCustomersAndOrders()
Order events
Order Service
Order events channel
Customer Order View Service
Customer events
Customer Service
Customer events channel
View Database
Replica
https://microservices.io/patterns/data/cqrs.html
@crichardson

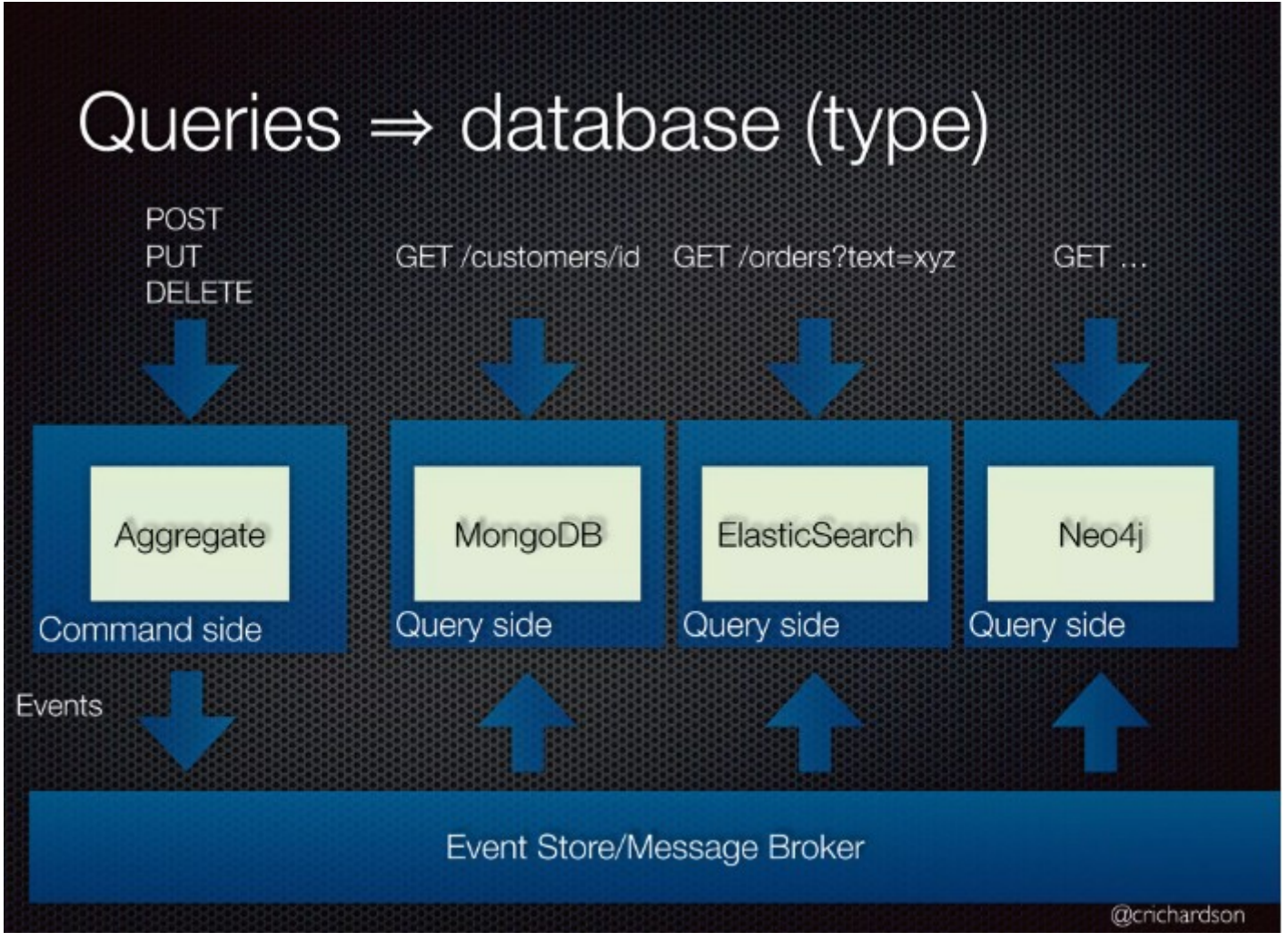
# Persisting a customer and order history in MongoDB




Denormalized = efficient lookup

@crichardson

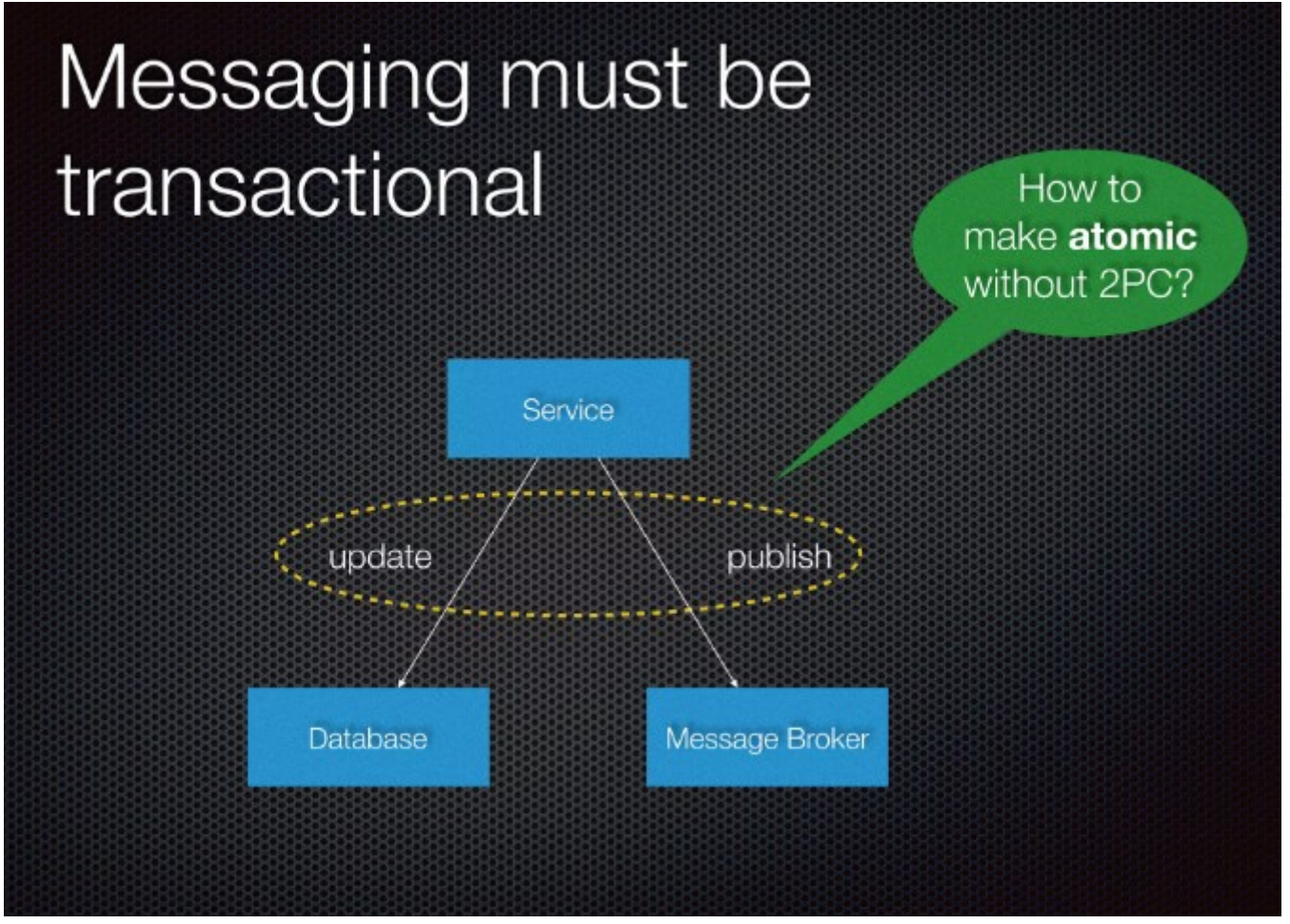

Command Query Responsibility Segregation (CQRS)
POST
PUT
DELETE
Commands
Queries
GET
Aggregate
Command side data model
(Materialized) View
Query side data model
Events
Events
Message broker or Event Store


Queries ⇒ database (type)
POST
PUT
DELETE
GET /customers/id
GET /orders?text=xyz
GET …
Aggregate
MongoDB
ElasticSearch
Neo4j
Command side
Query side
Query side
Query side
Events
Event Store/Message Broker
@crichardson

# 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

# Messaging must be transactional



# 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

# 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

# Spring Data for JPA example

```
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;
  }
}
```

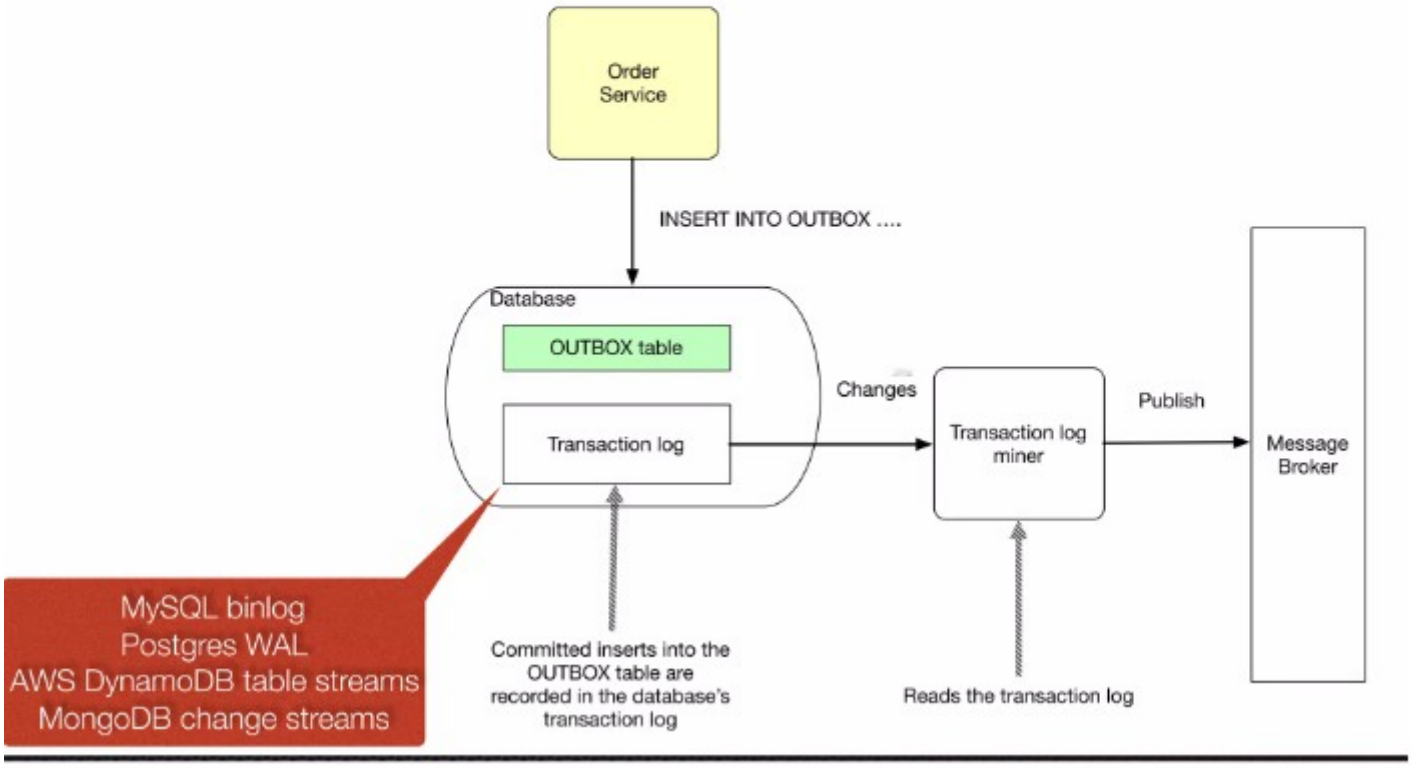
Save order

Publish event

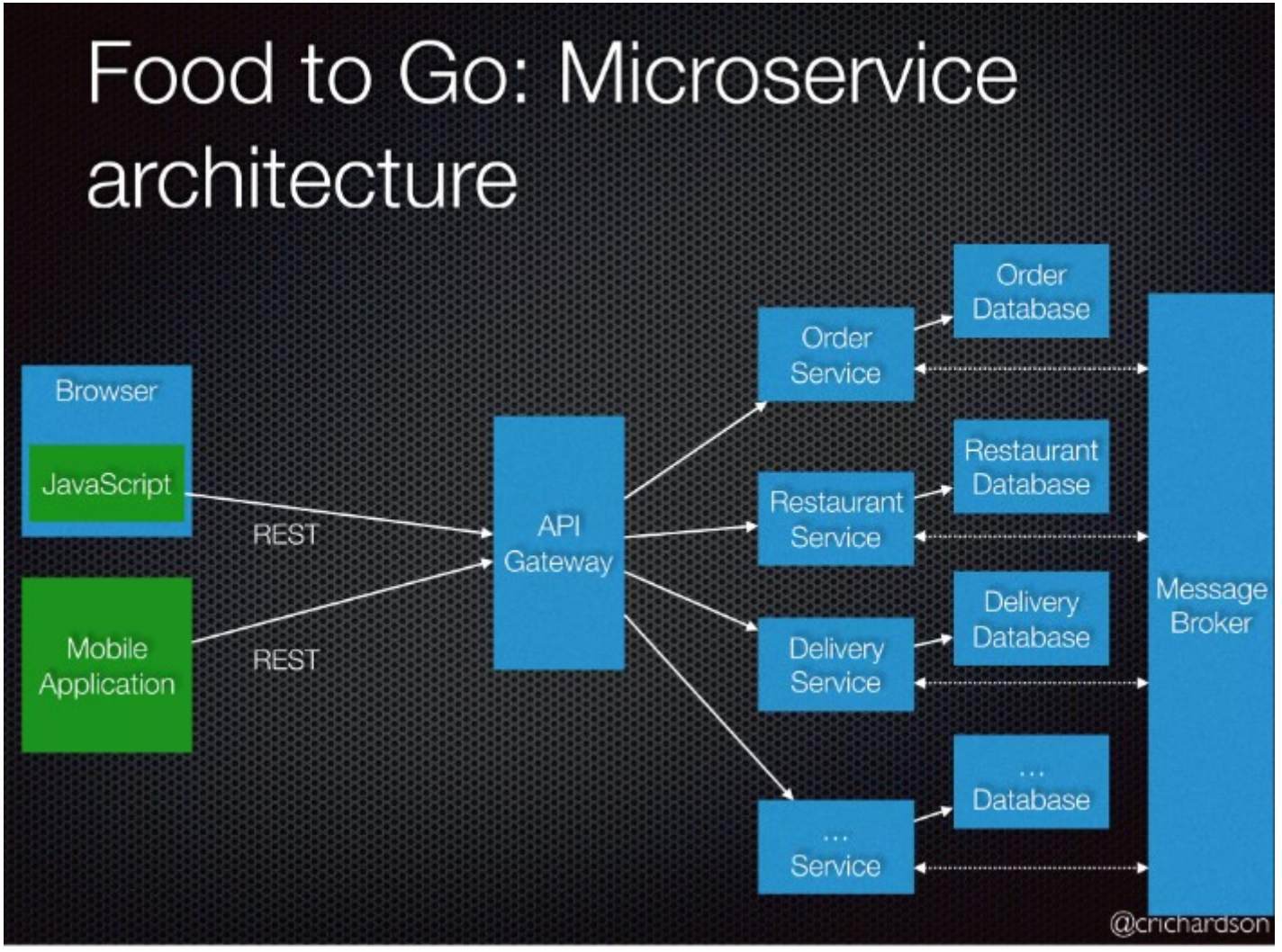
http://eventuate.io/exampleapps.html

@crichardson

# Transaction log tailing

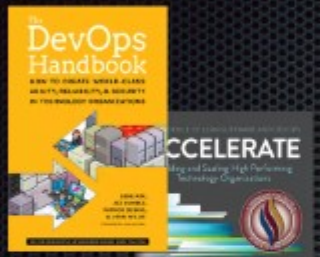


# Food to Go: Microservice architecture



# Why microservices: success triangle

Process: Lean + DevOps/Continuous Delivery & Deployment








S/W VUCA

Businesses must be nimble, agile and innovate faster

IT must deliver software rapidly, frequently, reliably and sustainably

Enables: Testability Deployability

Organization: Network of small, loosely coupled, teams

Enables: Loose coupling

Architecture: Microservices (sometimes)

@chrichardson

# Loose coupling is essential

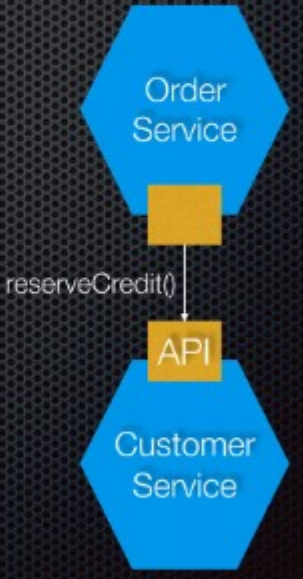
Services collaborate, e.g. Order Service must reserve customer credit

⇒

Coupling is inevitable

BUT

Services must be loosely coupled



## Runtime coupling

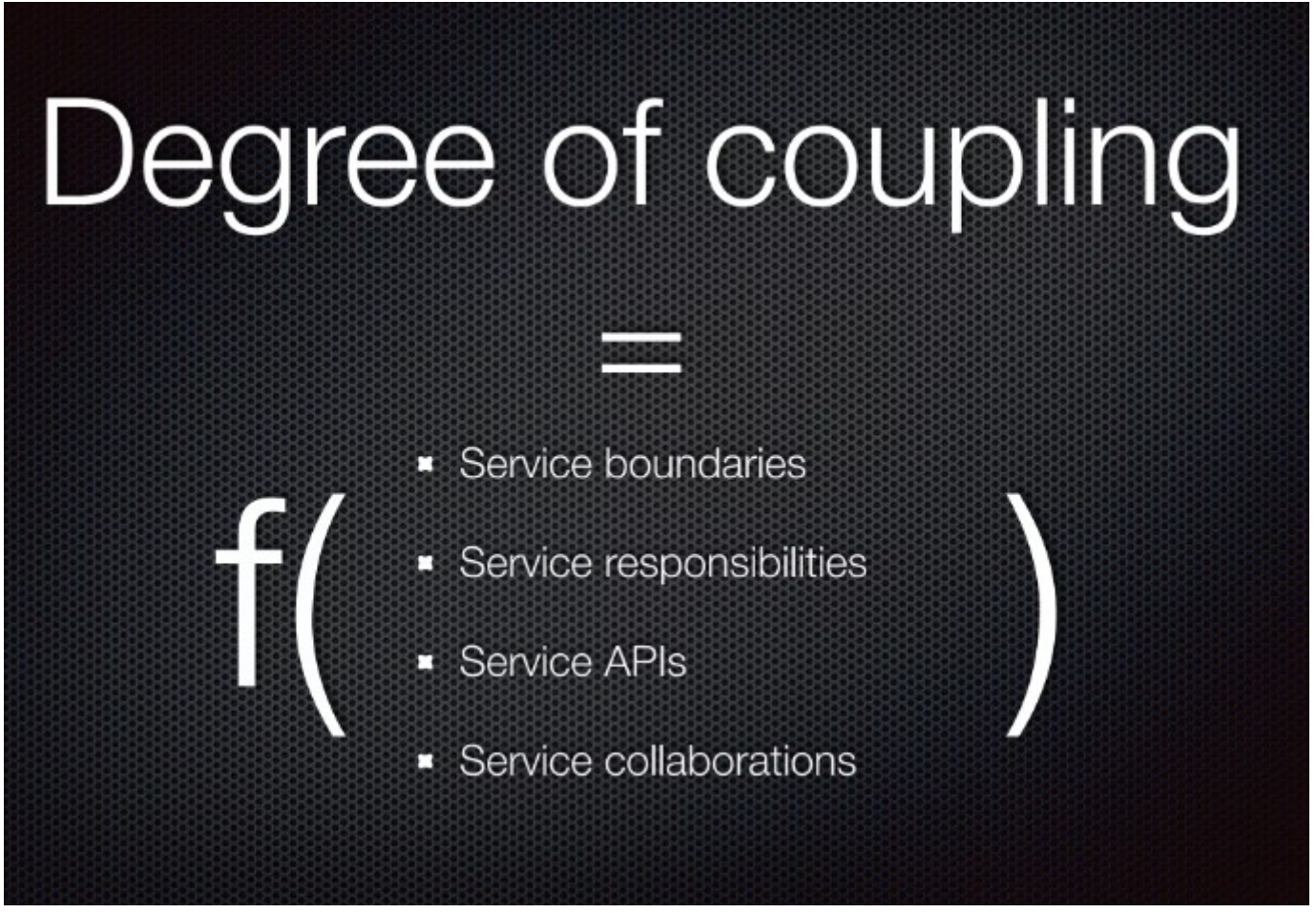
- Order Service cannot respond to a synchronous request (e.g. HTTP POST) until Customer Service responds
- Reduces availability

**VS**

## Design time coupling

- Change Customer Service ⇒ change Order Service
- Reduces development velocity

**Neither is guaranteed: you must design your services to be loosely coupled**


Degree of coupling
=
f(
Service boundaries
Service responsibilities
Service APIs
Service collaborations
)

# DRY (Don't repeat yourself) services

"Every piece of knowledge must have a single, unambiguous, authoritative representation within a system"

For example: Order Total

https://en.wikipedia.org/wiki/Don%27t_repeat_yourself

# DRY (Don't repeat yourself) services

"Every piece of knowledge must have a single, unambiguous, authoritative representation within a system"

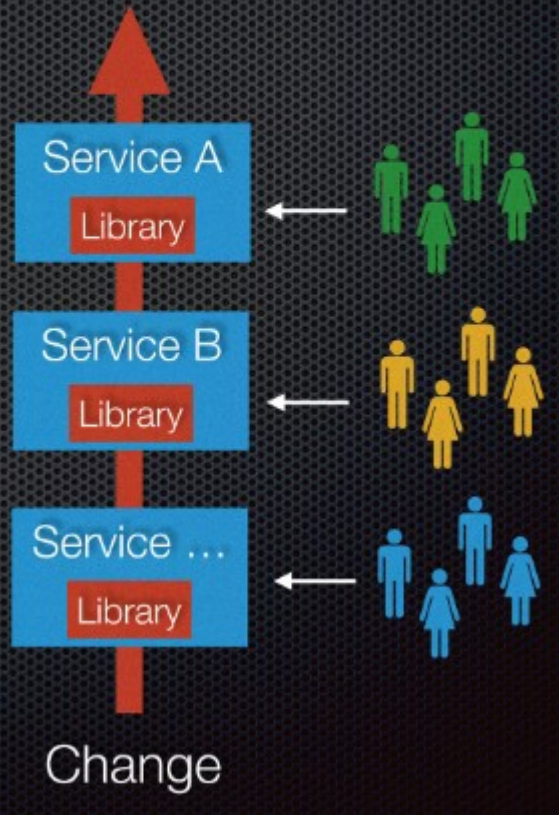
For example: Order Total

https://en.wikipedia.org/wiki/Don%27t_repeat_yourself

# Shared library that calculates Order Total != DRY

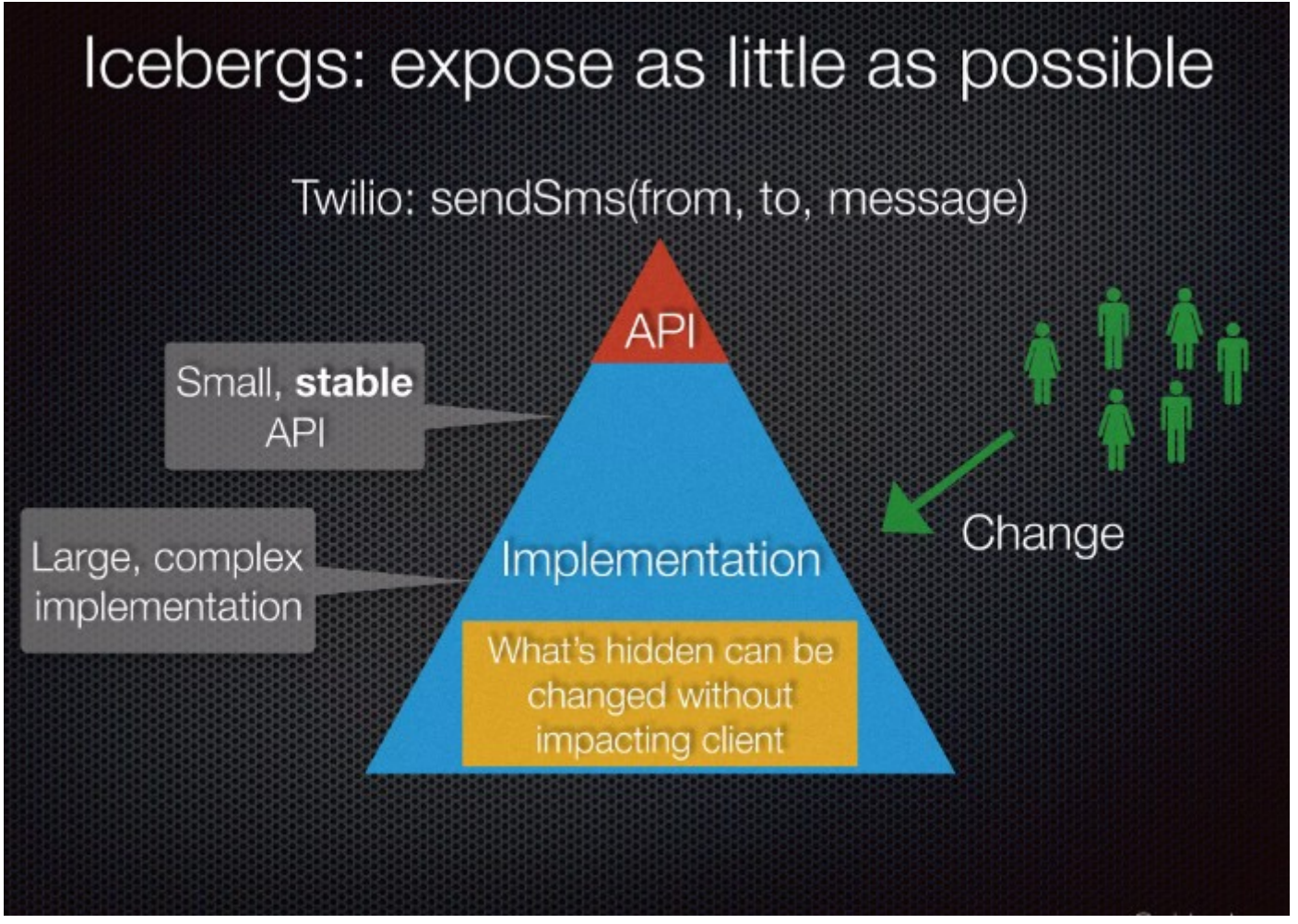
Shared libraries containing business logic that changes ⇒ requires multiple services to change/rebuild/ redeployed in lock step ❌

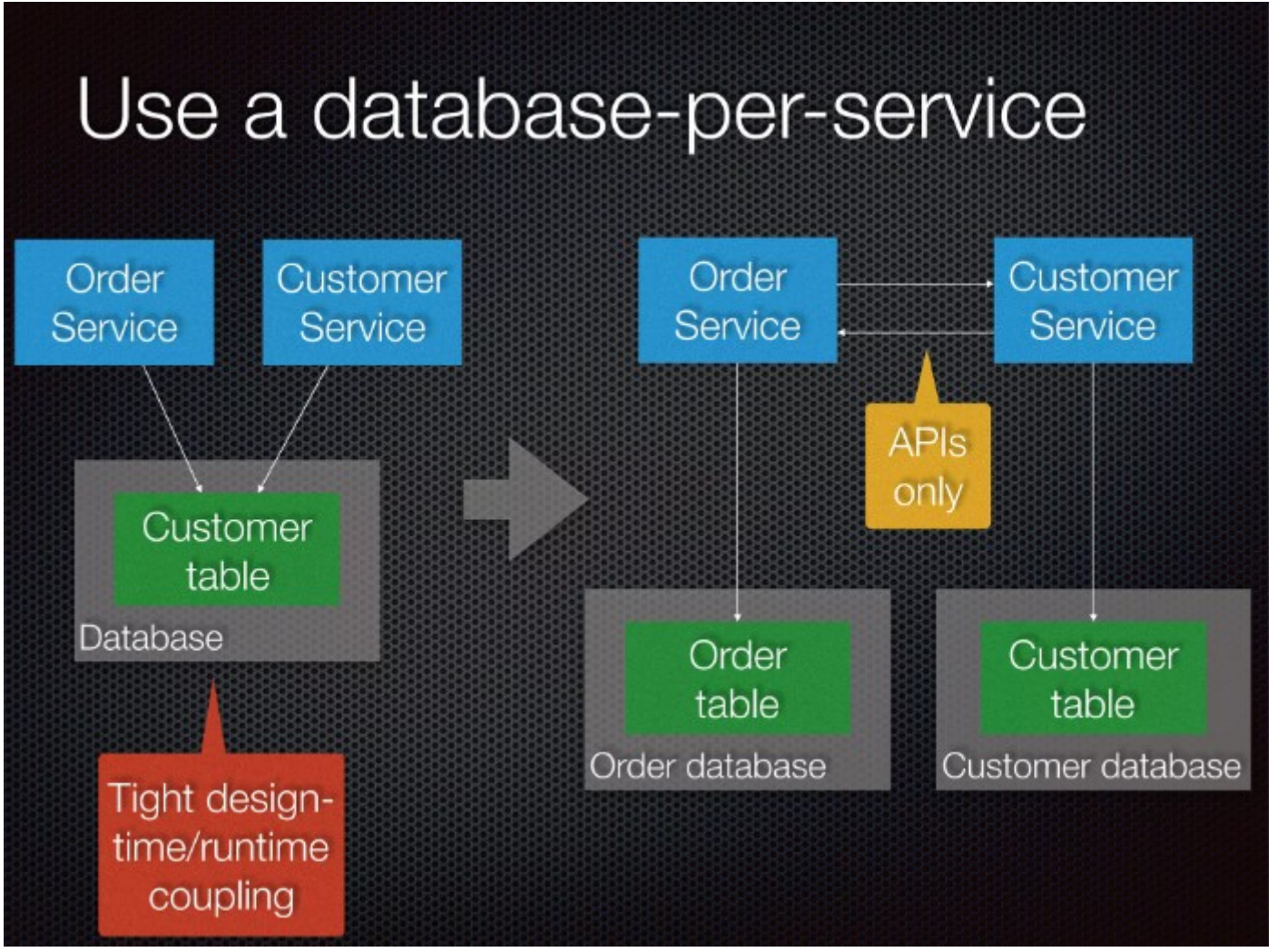
Shared utility libraries ✅



# Consume as little as possible

- Postel's Robustness principle: https://en.wikipedia.org/wiki/Robustness_principle
- Consumer-driven contract tests verify compliance
- Swagger/Protobuf-generated stubs parse everything!


Icebergs: expose as little as possible
Twilio: sendSms(from, to, message)
API
Small, stable API
Large, complex implementation
Implementation
What's hidden can be changed without impacting client
Change


Use a database-per-service
Order Service
Customer Service
Customer table
Database
Tight design-time/runtime coupling
Order Service
Customer Service
APIs only
Order table
Order database
Customer table
Customer database

# Essential: Use resilience patterns for synchronous communication

### 4. Resilience patterns

| name | how does it work? | description | slogans | links |
|---|---|---|---|---|
| **Retry** | repeats failed executions | Many faults are transient and may self-correct after a short delay. | "Insert coin to try again", "Maybe it's just a blip" | overview, documentation |
| **Circuit Breaker** | temporary blocks possible failures | When a system is seriously struggling, failing fast is better than making clients wait. | "Stop doing it if it hurts", "Give that system a break", "Baby, don't hurt me, no more" | overview, documentation, Feign, Retrofit |
| **Rate Limiter** | limits executions/period | Prepare for a scale and establish reliability and HA of your service. | "That's enough for this minute!", "Well, it'll work next time" | overview, documentation, Feign, Retrofit |
| **Time Limiter** | limits duration of execution | Beyond a certain wait, a success result is unlikely. | "Don't wait forever" | |
| **Bulkhead** | limits concurrent executions | Resources are isolated into pools so that if one fails, the others will continue. | "One fault shouldn't sink the whole ship", "Please, please, not all at once." | overview, documentation |
| **Cache** | memorizes a successful result | Some proportion of requests may be similar. | "You've asked that one before" | |
| **Fallback** | provides an alternative result for failures | Things will still fail - plan what you will do when that happens. | "Degrade gracefully", "A bird in the hand is worth two in the bush" | Try::recover, Spring, Feign |

*Above table is based on Polly: resilience policies.*

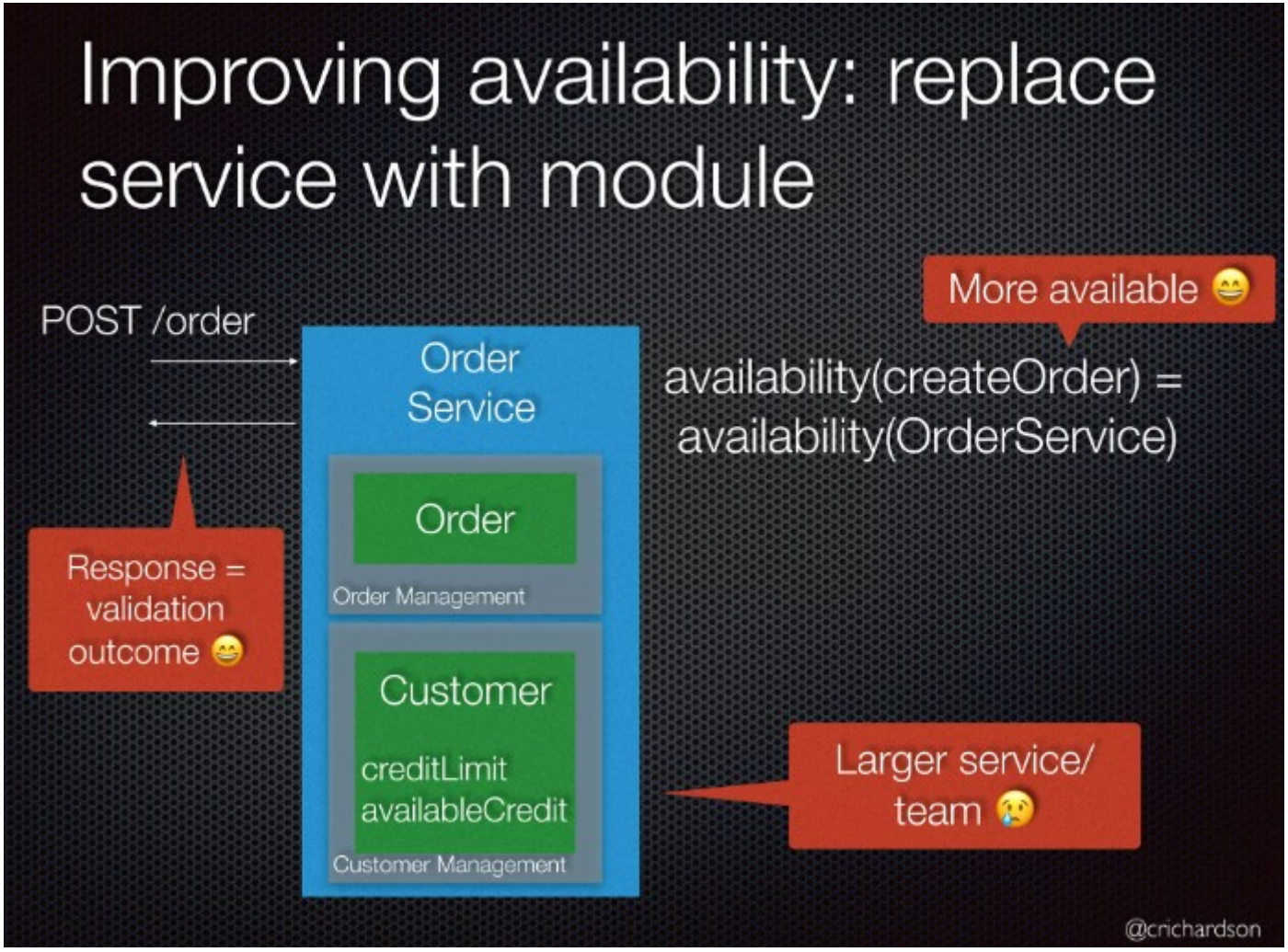
https://github.com/resilience4j/resilience4j#resilience-patterns

Self-contained service:

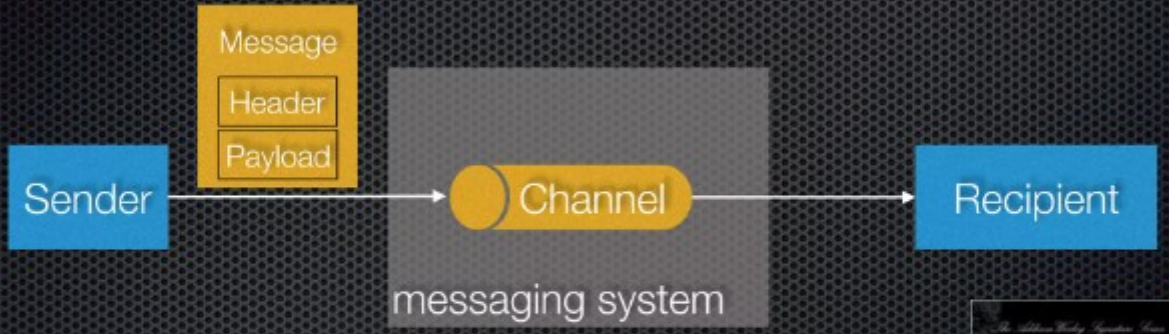
Can handle a synchronous request without waiting for a response from another service

https://microservices.io/patterns/decomposition/self-contained-service.html

# Improving availability: replace service with module

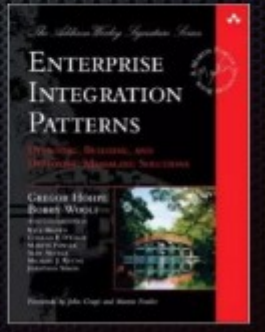


# Use asynchronous messaging



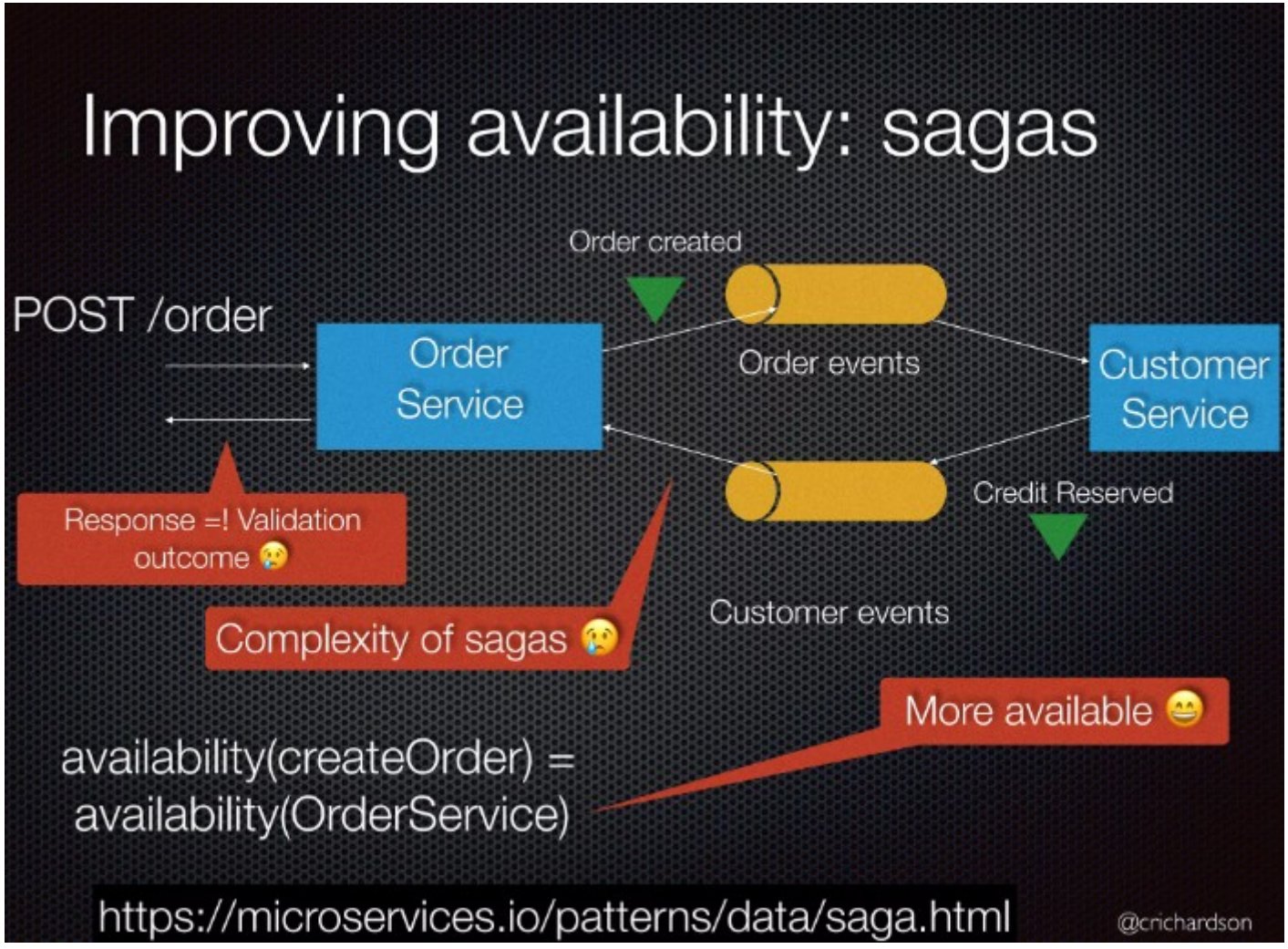

Channel types:

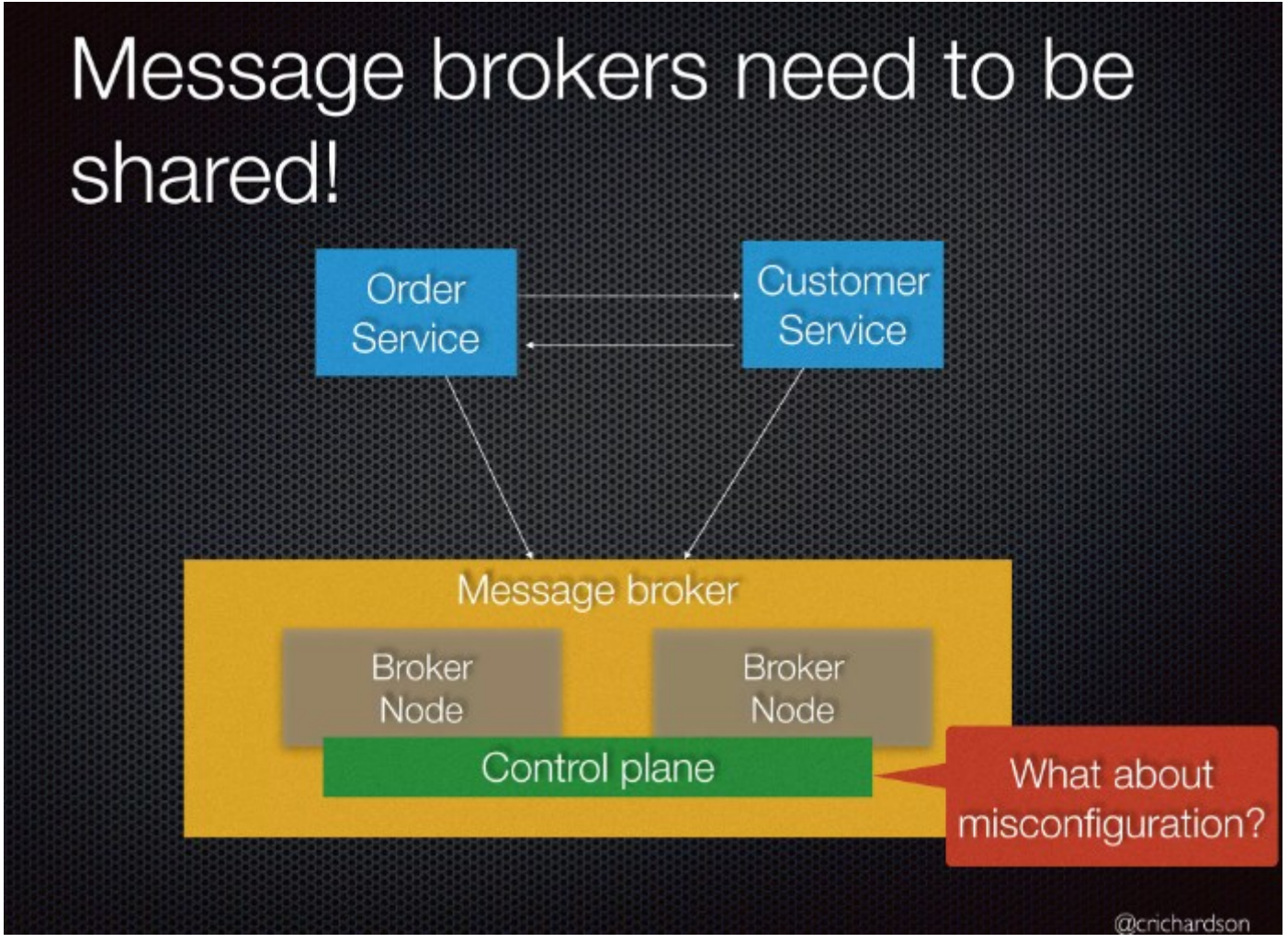
- Point-to-point
- Publish/Subscribe

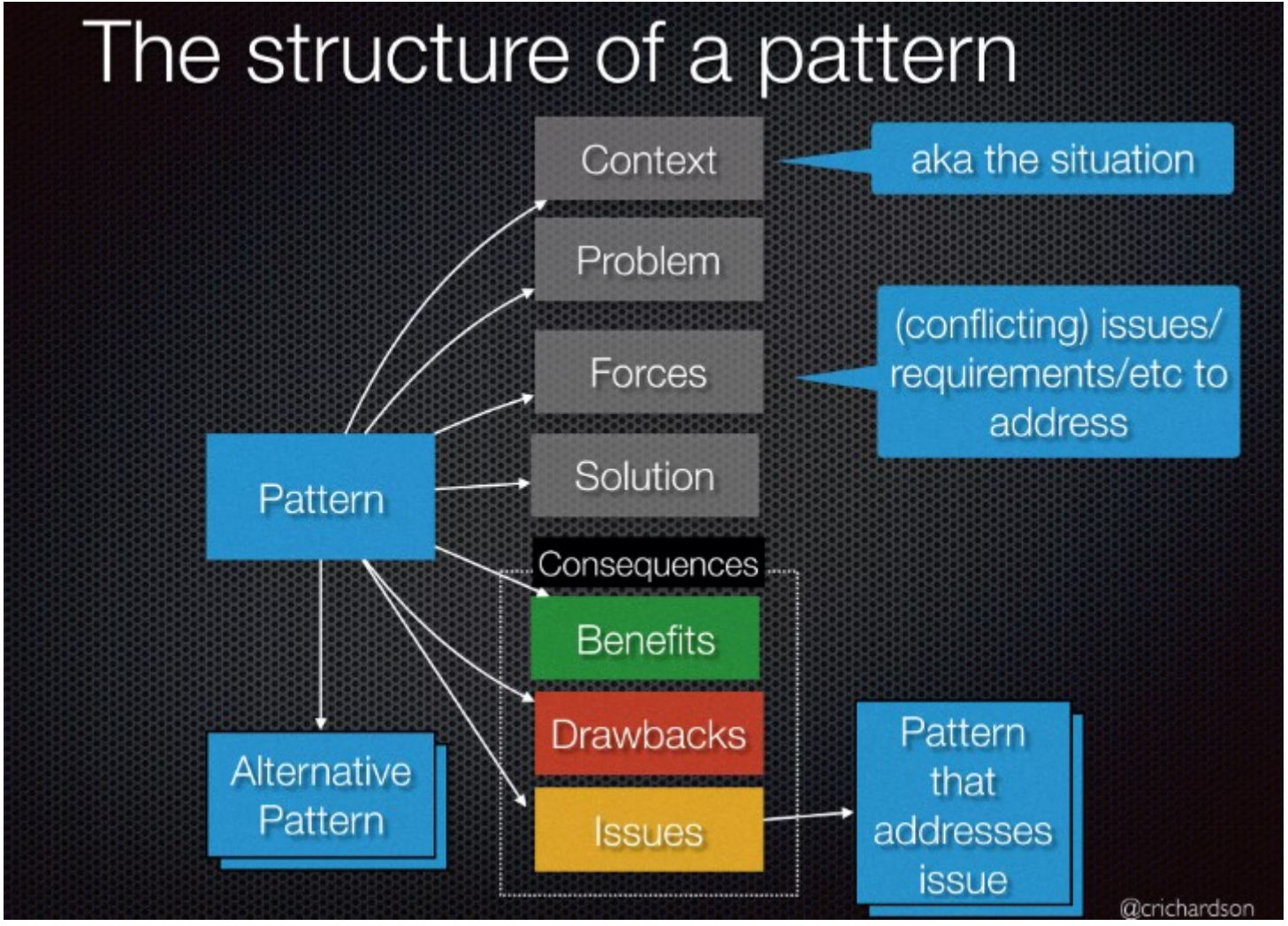



http://bit.ly/books-eip

@crichardson

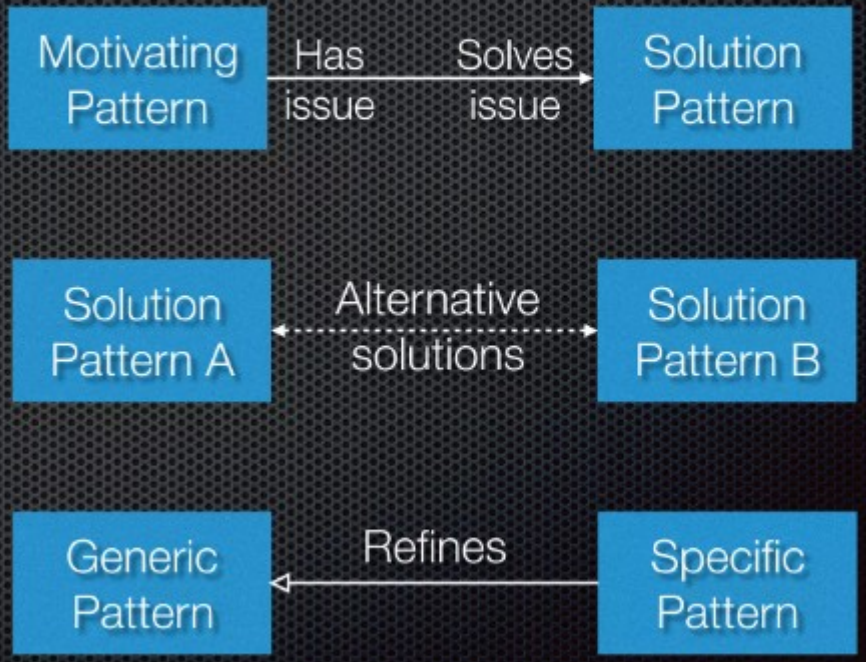

Improving availability: sagas
Order created
POST /order
Order Service
Order events
Customer Service
Credit Reserved
Response =! Validation outcome
Customer events
Complexity of sagas
More available
availability(createOrder) =
availability(OrderService)
https://microservices.io/patterns/data/saga.html
@crichardson


Message brokers need to be shared!
Order Service
Customer Service
Message broker
Broker Node
Broker Node
Control plane
What about misconfiguration?
@crichardson


The structure of a pattern
Context
aka the situation
Problem
Forces
(conflicting) issues/ requirements/etc to address
Pattern
Solution
Consequences
Benefits
Drawbacks
Issues
Alternative Pattern
Pattern that addresses issue
@crichardson

# Pattern language

A collection of related patterns that solve problems in a particular domain

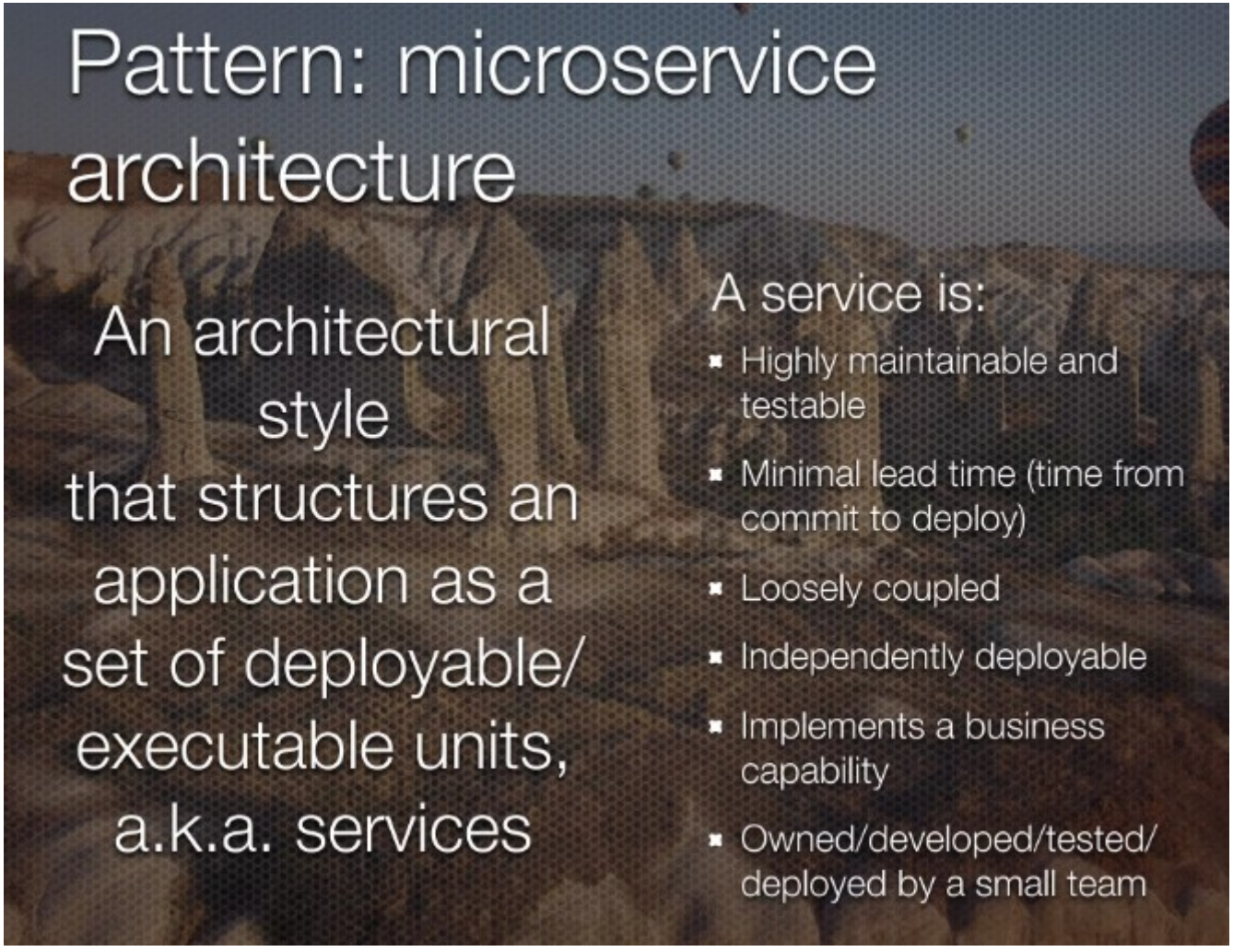

http://en.wikipedia.org/wiki/A_Pattern_Language

# The pattern language guides you when developing an architecture

- What architectural decisions you must make (a.k.a. problems to solve)
- For each decision/problem:
  - Available patterns
  - Trade-offs of each pattern

# The context, problem and forces

- Context: IT must deliver software rapidly, frequently, reliably and sustainably
- Problem: what's the architecture?
- Forces
  - Simplicity
  - Testability
  - Deployability
  - Modularity / Loose coupling
  - Evolvability (of technology stack)


Pattern: microservice architecture
An architectural style that structures an application as a set of deployable/ executable units, a.k.a. services
A service is:
Highly maintainable and testable
Minimal lead time (time from commit to deploy)
Loosely coupled
Independently deployable
Implements a business capability
Owned/developed/tested/ deployed by a small team

# Benefits and drawbacks

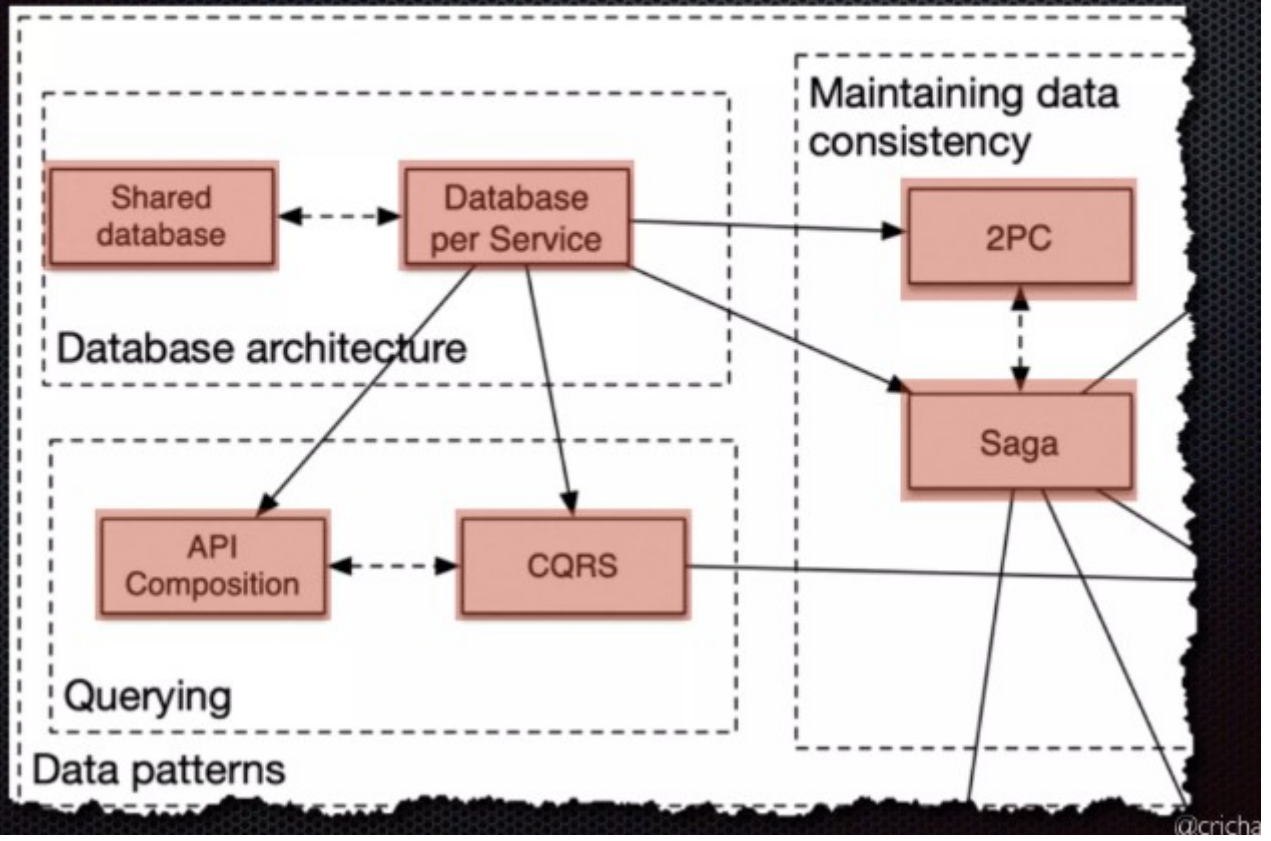
**Benefits**

- Multiple technology stacks/ incremental evolution
- Teams can deploy changes independently
- Fast deployment pipeline
- Improved fault isolation

**Drawbacks**

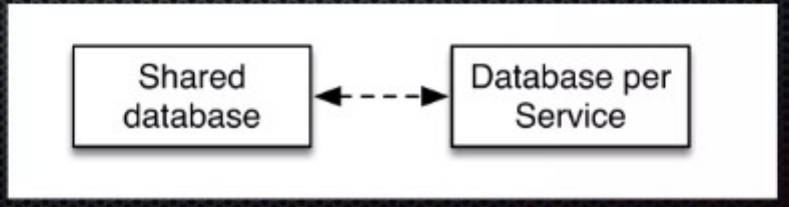
- Potential complexity of distributed architecture: eventual consistency, inter-service communication
- More complex operations: observability and troubleshooting

# Applying the data patterns



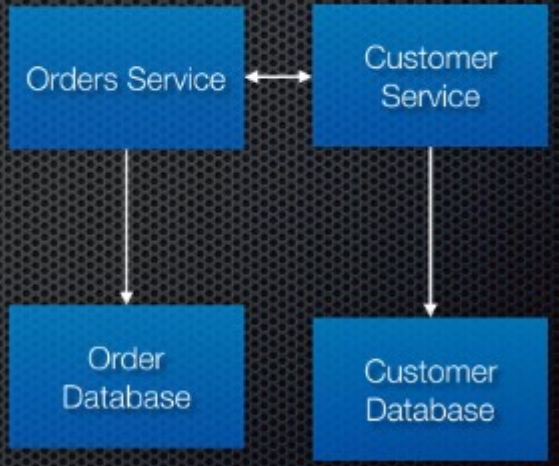
# What's the database architecture?

- Context:
  - You have applied the Microservice Architecture pattern
- Forces:
  - Services must be loosely coupled - both design-time and runtime



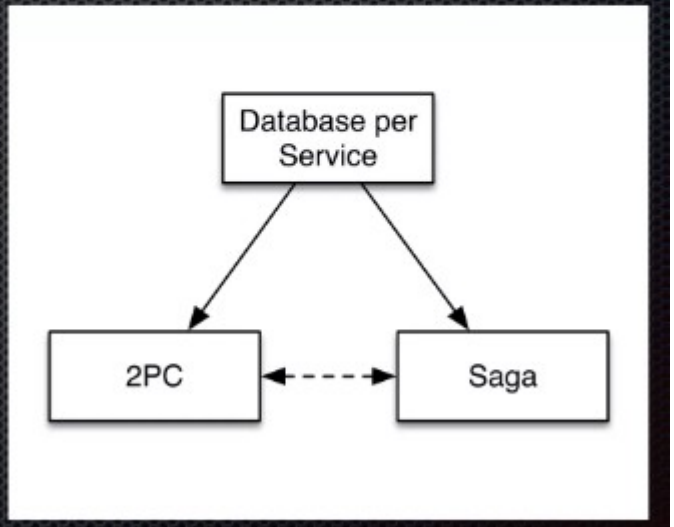
# Pattern: Database per Service

- Benefits:
  - Loose design-time coupling
  - Loose runtime coupling
- Drawbacks:
  - More complex, eventual consistency



# How to implement transactions?

- Context:
  - You have applied the Microservice architecture and Database per service patterns
- Problem:
  - How to implement transactions that span services/databases?
- Forces:
  - Services must be loosely coupled



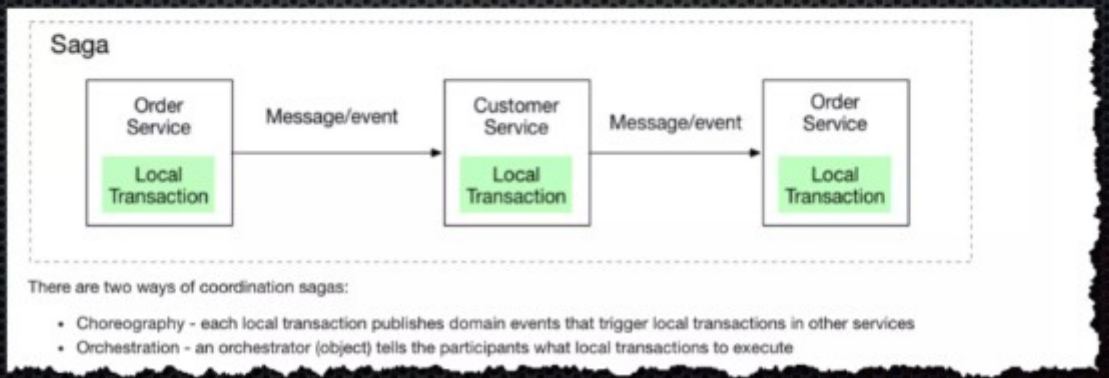
# Pattern: Saga

## Benefits

- Loose runtime coupling

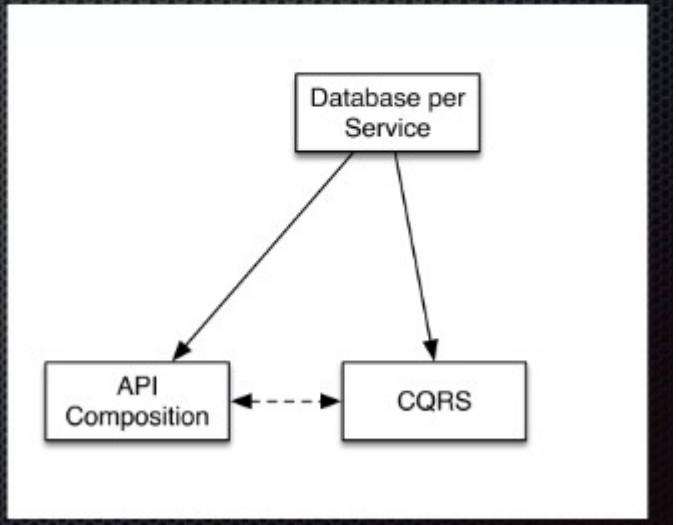
## Drawbacks

- Complexity of eventual consistency



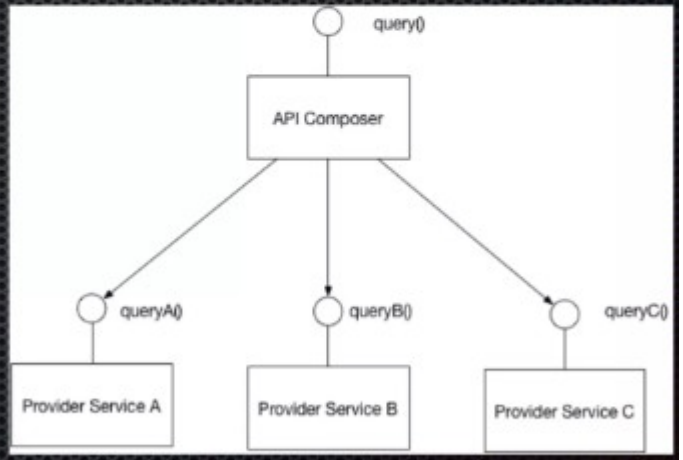
# How to implement queries?

- Context:
  - You have applied the Microservice architecture and Data per service patterns
- Problem:
  - How to implement queries that span services?
- Forces:
  - Services must be loosely coupled



# Pattern: API Composition

- Benefits:
  - Simple
- Drawbacks:
  - Tight runtime coupling
  - Potentially inefficient
  - Not transactionally consistent



# Pattern: CQRS

- Benefits:
  - Loose runtime coupling
  - Efficient queries
- Drawbacks:
  - Cost and complexity of replication
  - Not transactionally consistent