Developing Microservices with Aggregates

Chris Richardson

Founder of Eventuate.io

Founder of the original CloudFoundry.com

Author of POJOs in Action

@crichardson

chris@chrisrichardson.net

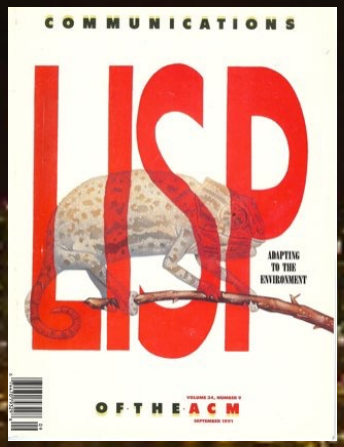
http://eventuate.io

SpringOne Platform

Presentation goal

Show how
Domain Driven Design Aggregates
and Microservices
are a perfect match

About Chris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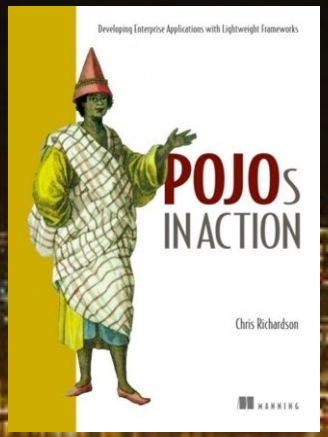
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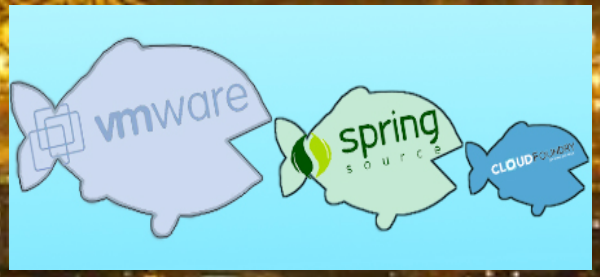
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About Chris

Consultant and trainer focusing on modern application architectures including microservices (http://www.chrisrichardson.net/)

About Chris

Founder of a startup that is creating a platform that makes it easier for developers to write transactional microservices

(http://eventuate.io)

For more information

http://learnmicroservices.io

Agenda

- The problem with Domain Models and microservices
- Overview of aggregates
- Maintaining consistency between aggregates
- Using event sourcing with Aggregates
- Example application

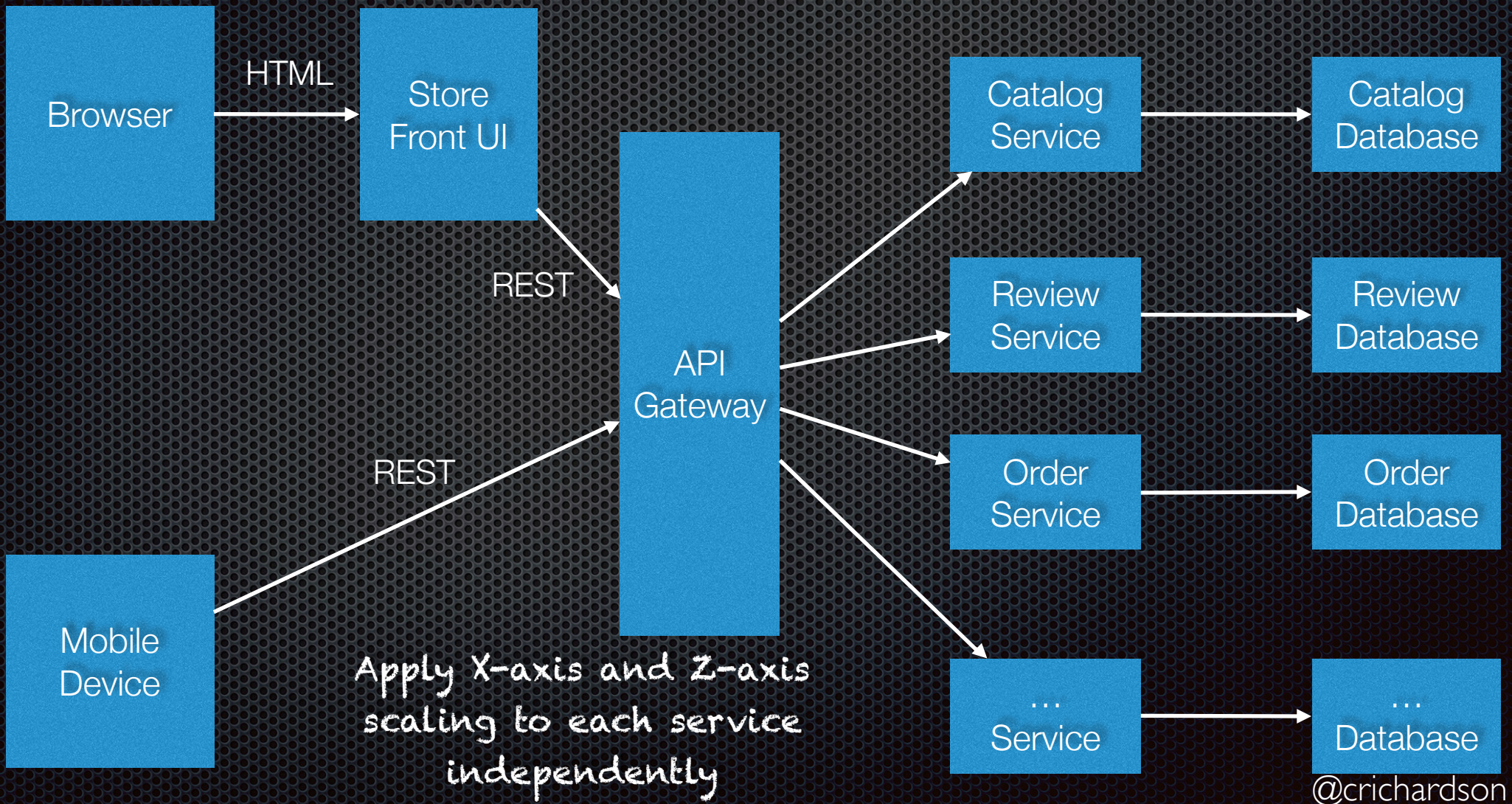
The Microservice architecture tackles complexity through modularization

Microservice

=

Business capability

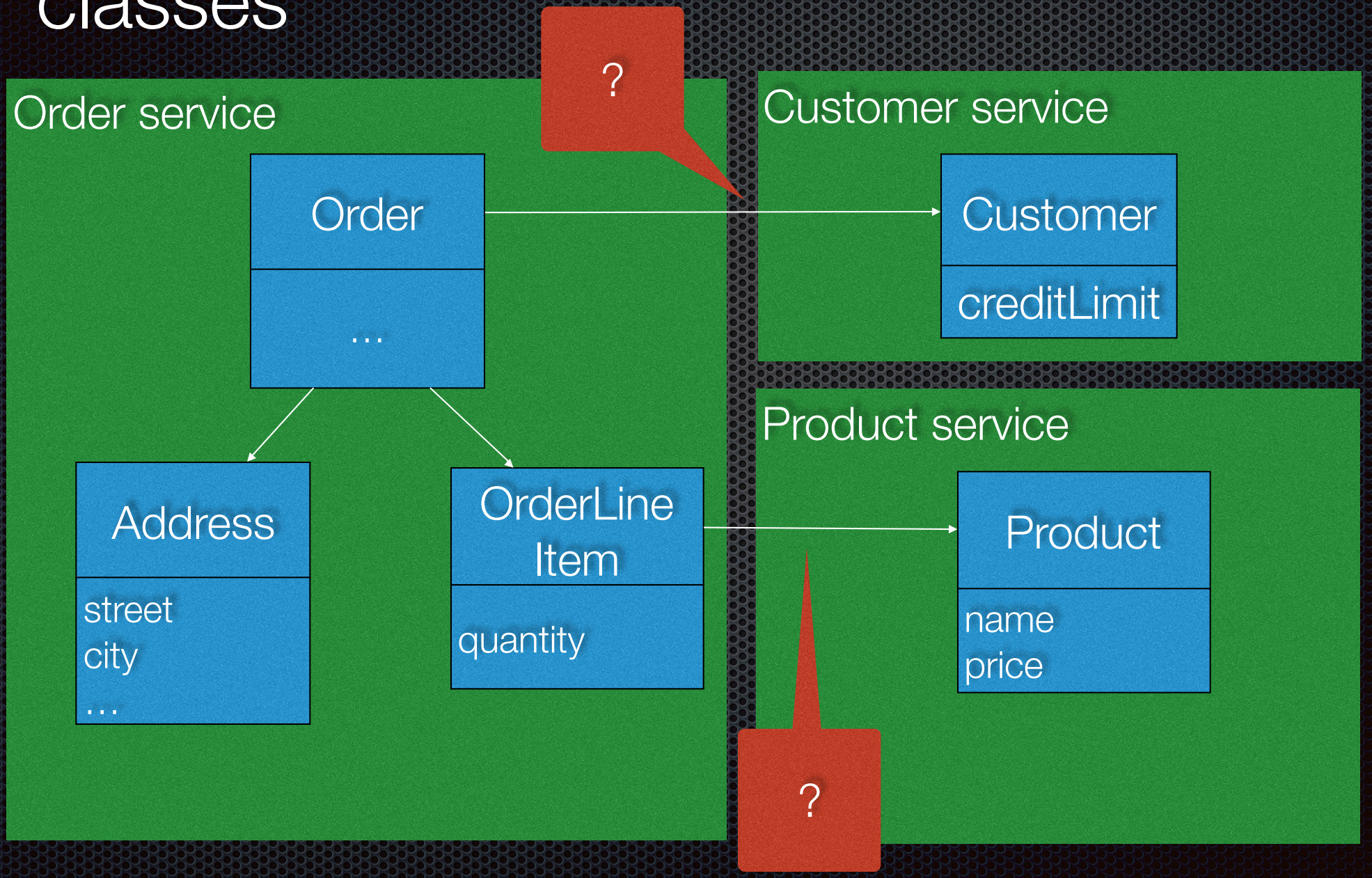
Microservice architecture



Service boundaries
enforce modularity

But there are challenges...

Domain model = tangled web of classes



Reliance on ACID transactions to enforce invariants

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

Simple and ACID 😀

But it violates encapsulation…

```
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

.. and requires 2PC

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

2PC is not a viable option

- Guarantees consistency

BUT

- 2PC is best avoided
- Not supported by many NoSQL databases etc.
- CAP theorem ⇒ 2PC impacts availability
- ….

Doesn't fit with the
NoSQL DB "transaction" model

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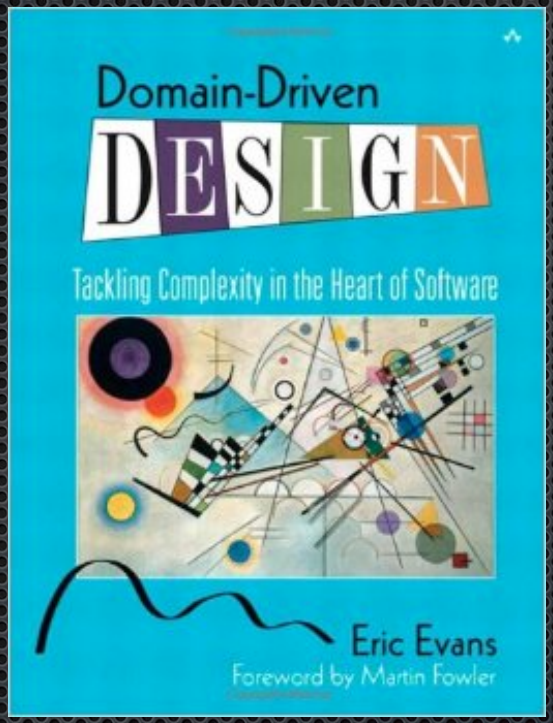
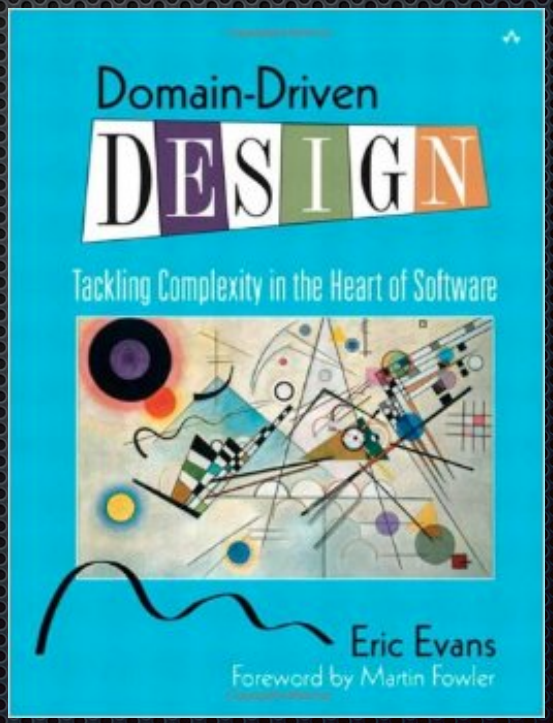
Domain Driven Design: read it!



Domain Driven Design - building blocks

- Entity
- Value object
- Services
- Repositories
- Aggregates

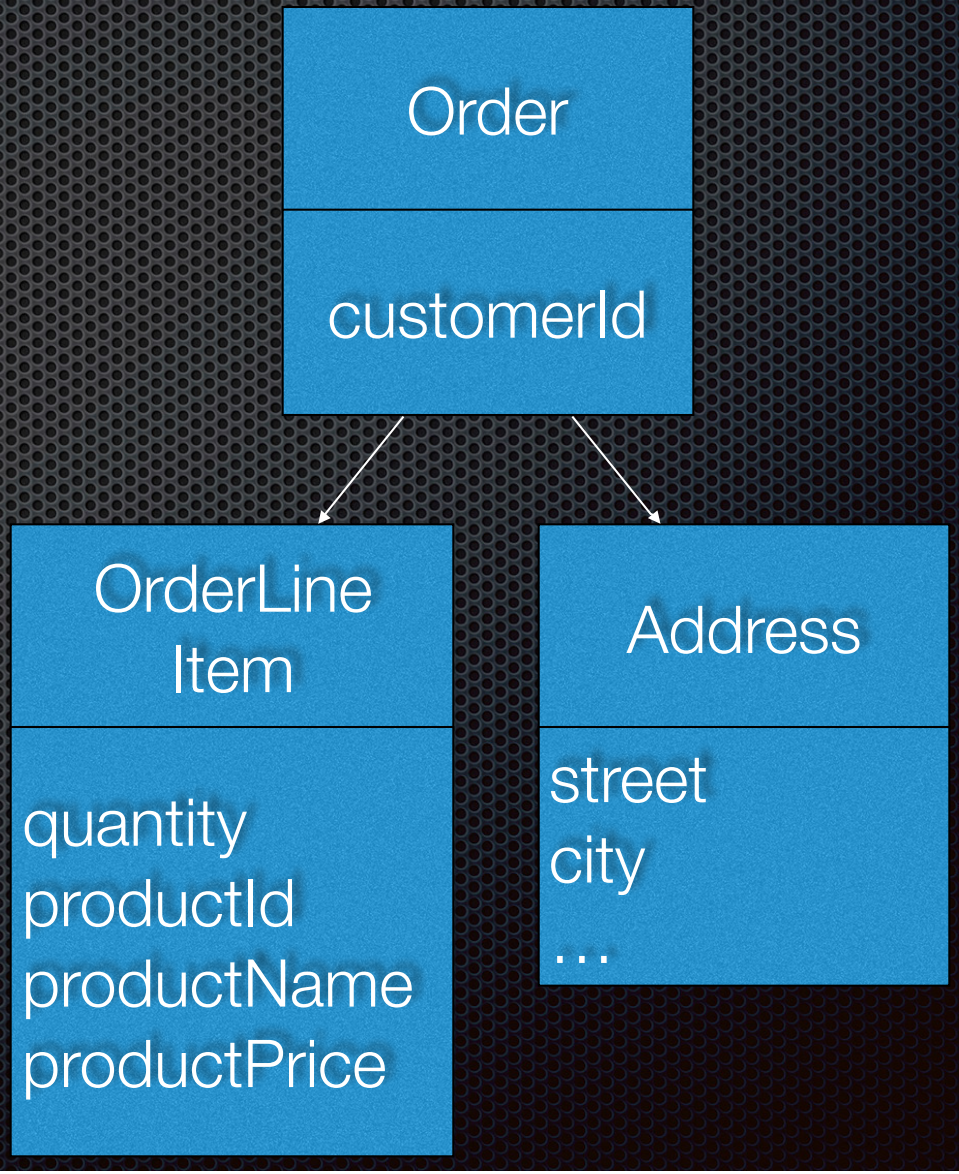
Adopted



Ignored
(at least by me)

About Aggregates

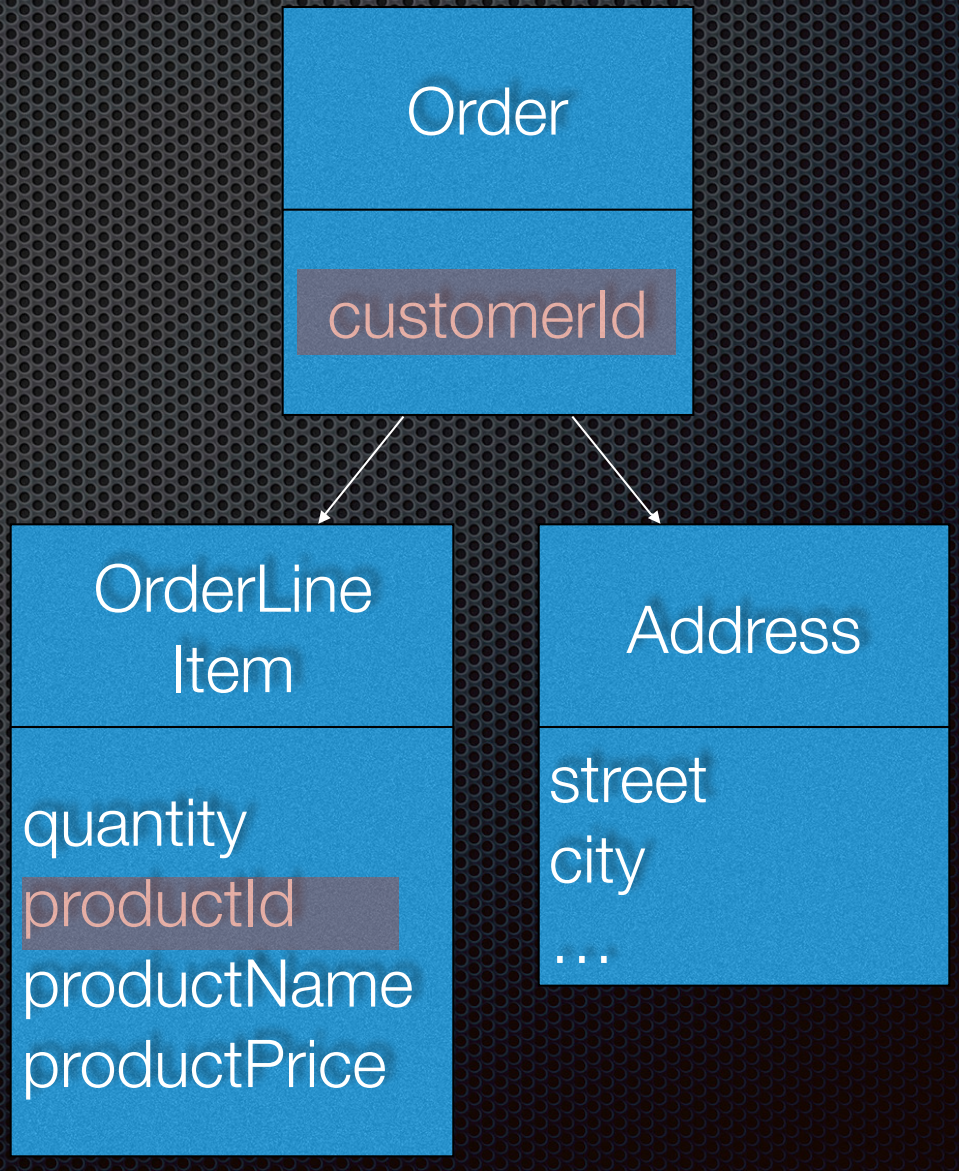
- Cluster of objects that can be treated as a unit
- Graph consisting of a root entity and one or more other entities and value objects
- Typically business entities are Aggregates, e.g. customer, Account, Order, Product, ….



Aggregate: rule #1

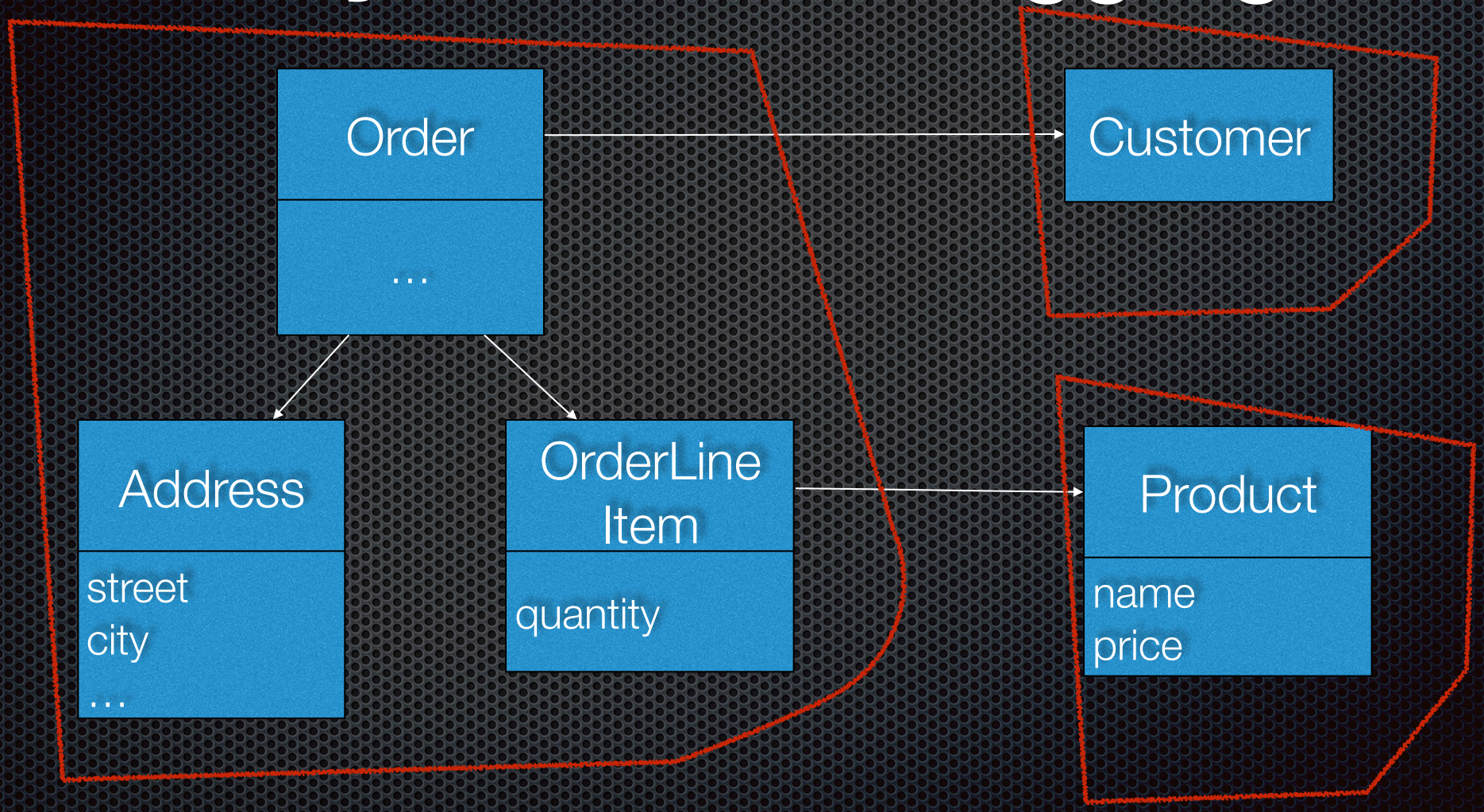
Reference other aggregate roots via **identity**

(primary key)

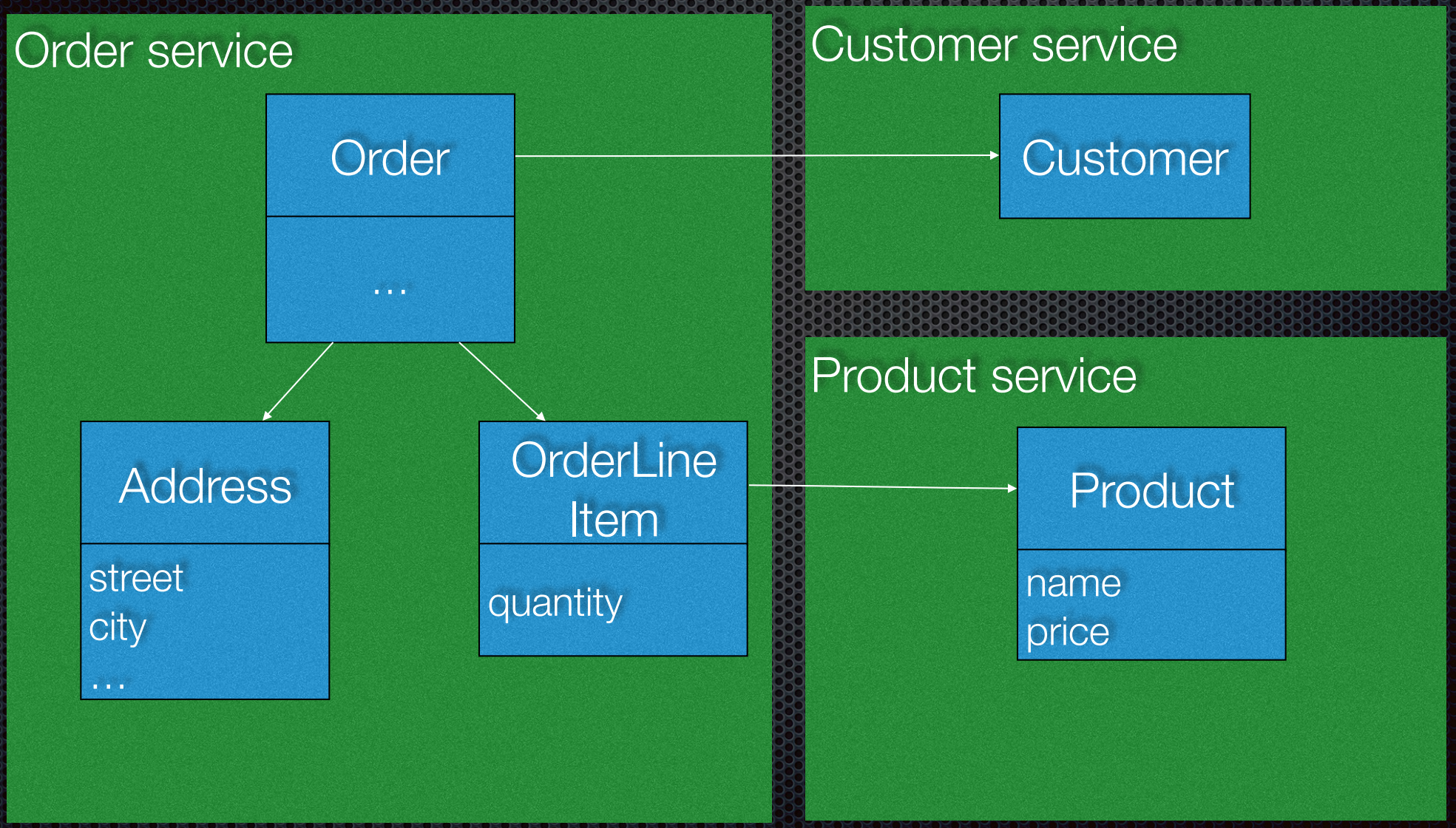


Foreign keys in a Domain Model?!?

Domain model = collection of **loosely** connected aggregates



Easily partition into microservices



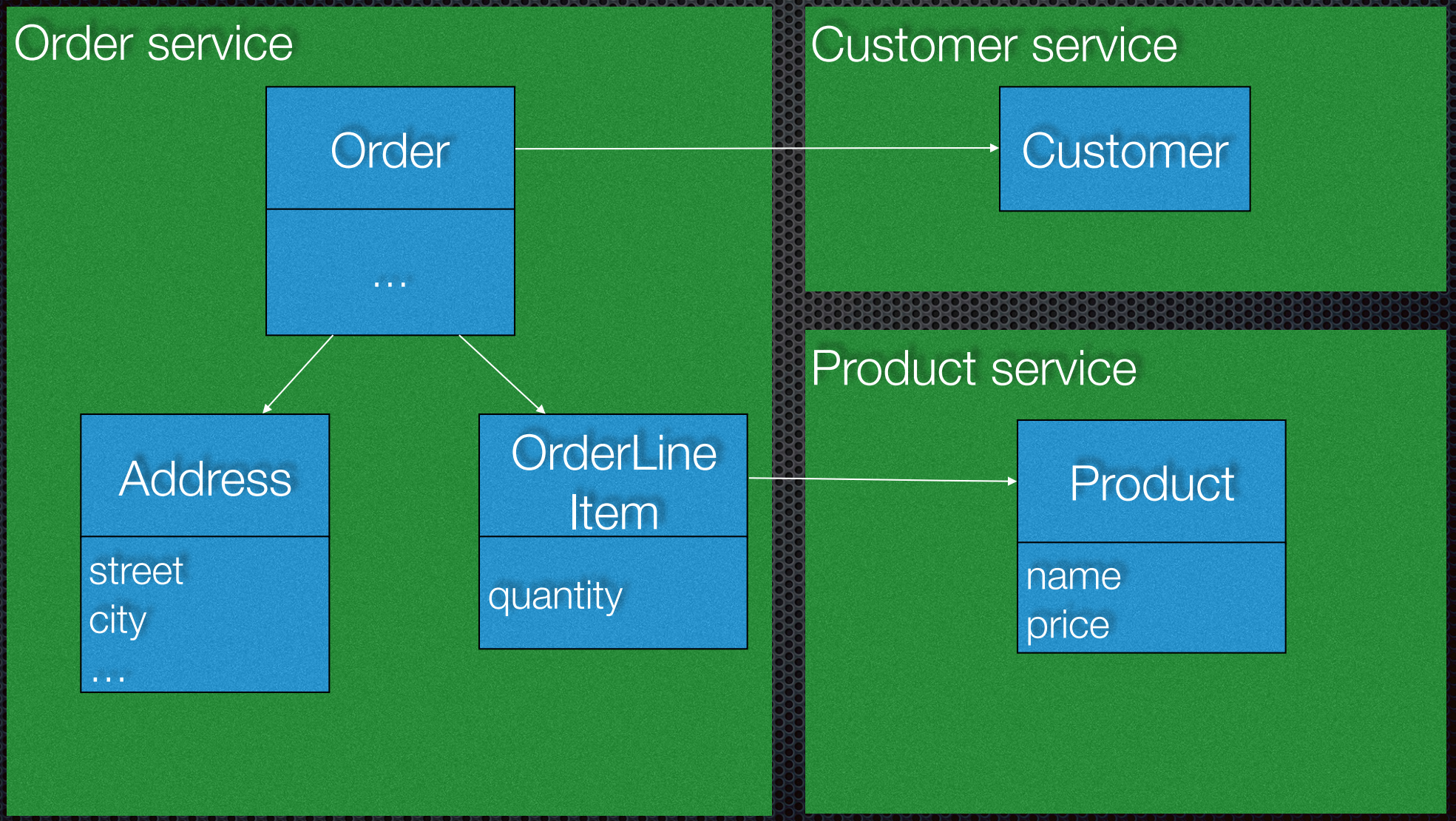
Aggregate rule #2

Transaction

=

processing **one** command by **one** aggregate

Transaction scope = service



Transaction scope

=

NoSQL database

“transaction”

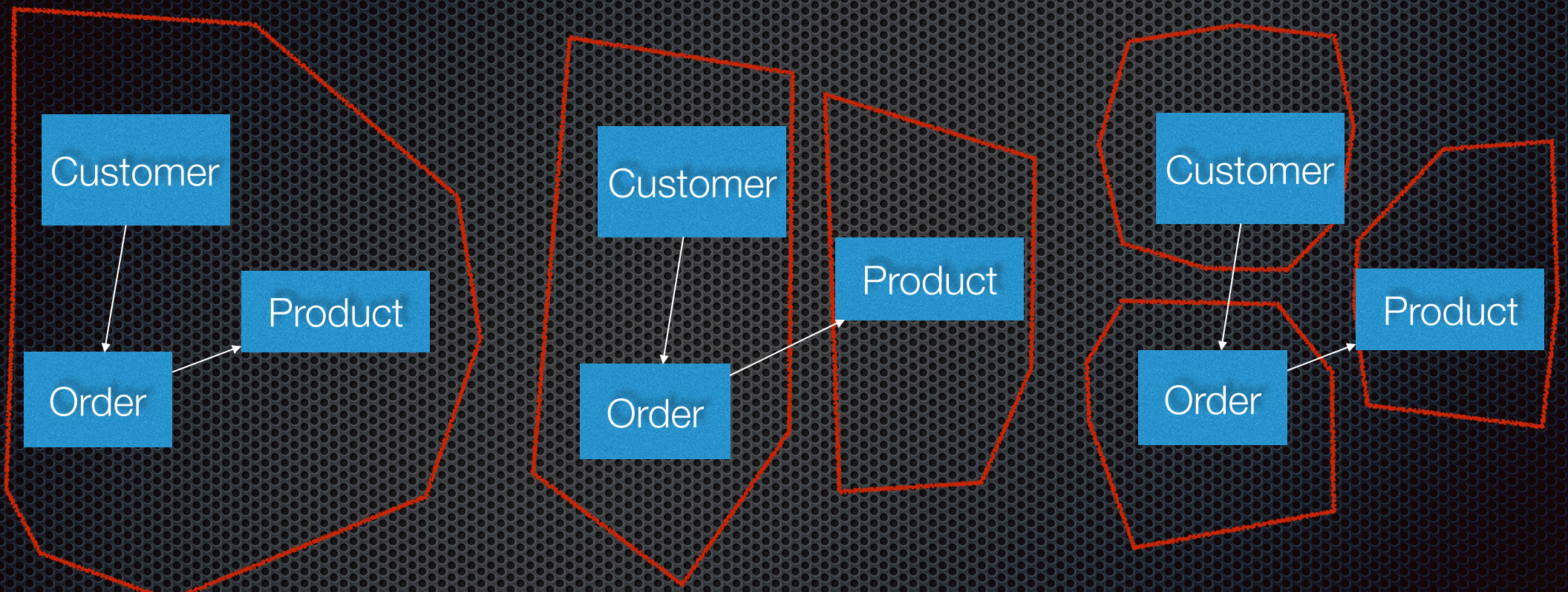
Aggregate granularity

- If an update must be atomic then it must be handled by a single aggregate

Therefore

- Aggregate granularity is important

Aggregate granularity



Consistency

Scalability/
User experience

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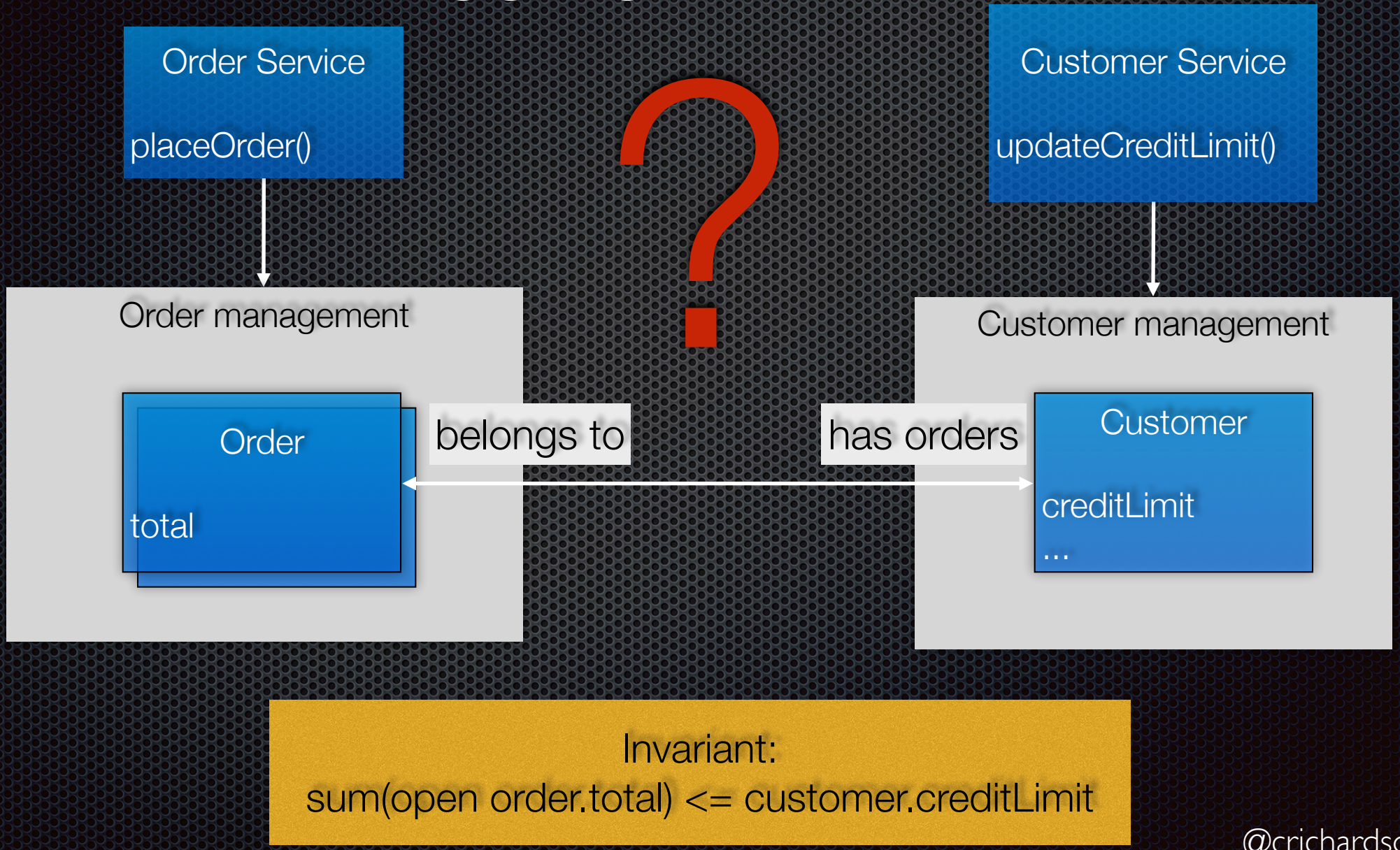
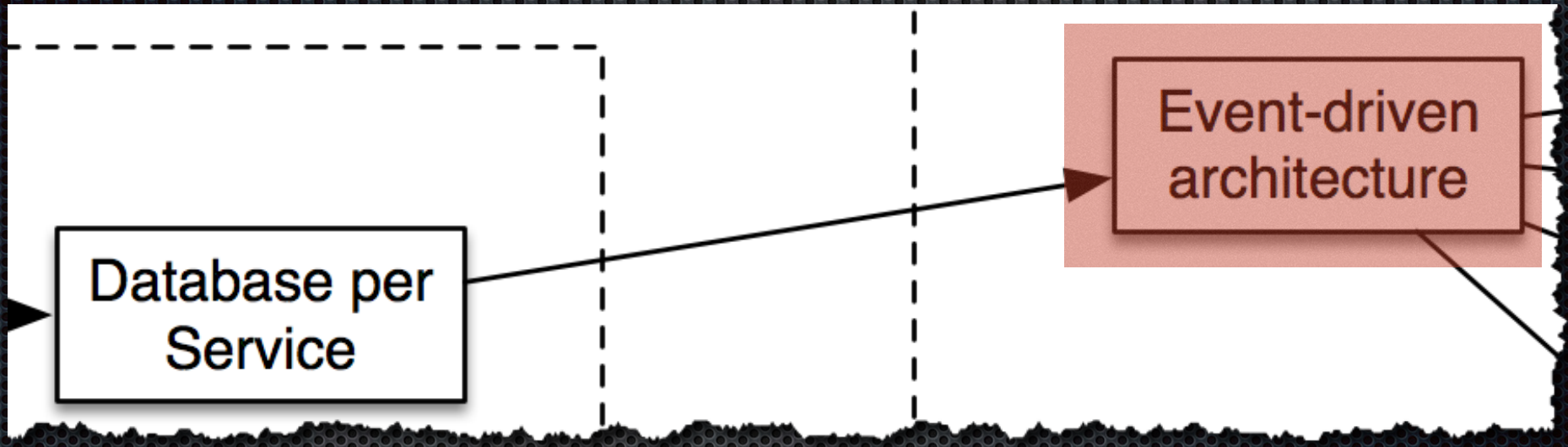
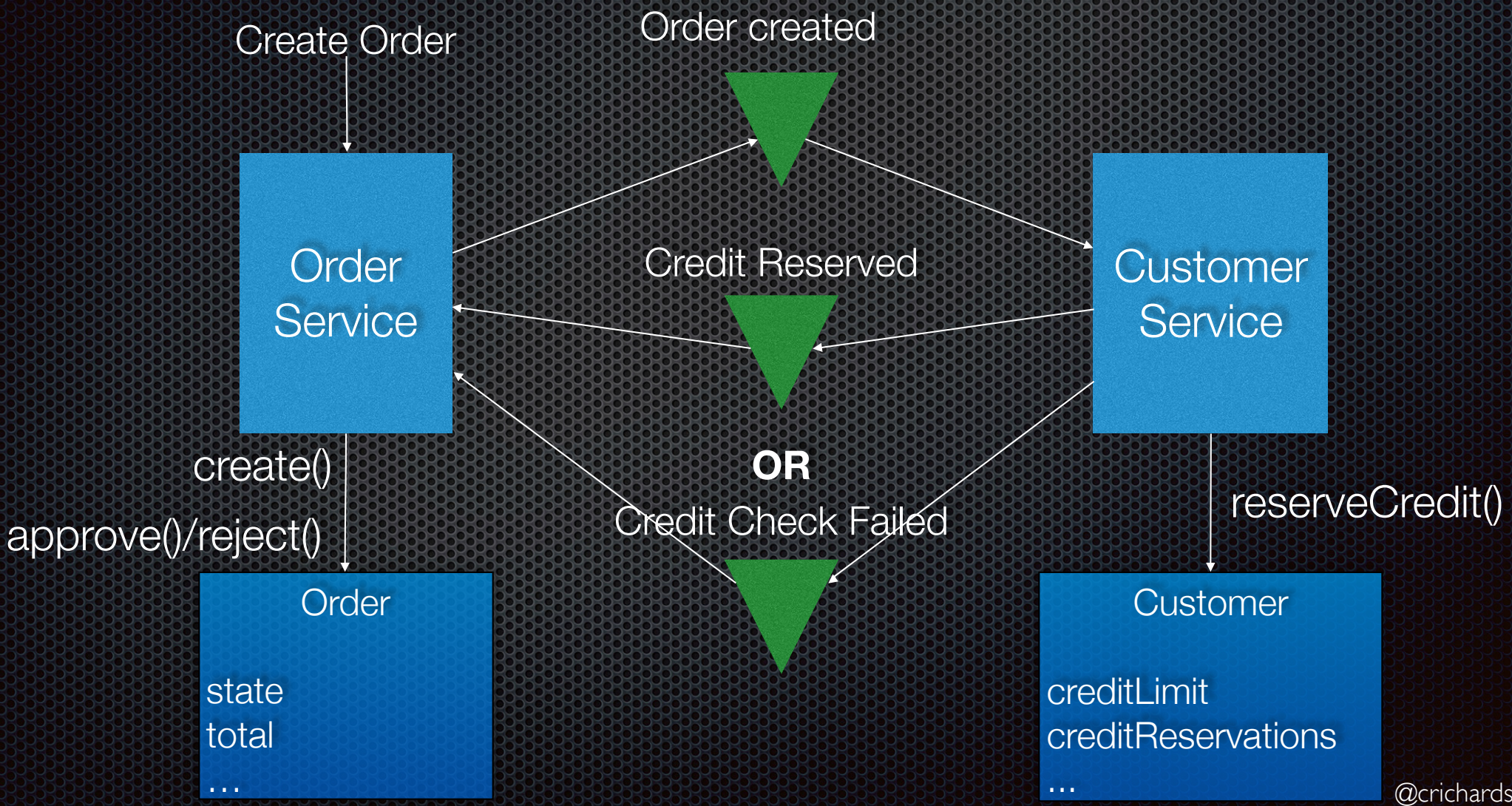
How to maintain data consistency between aggregates?



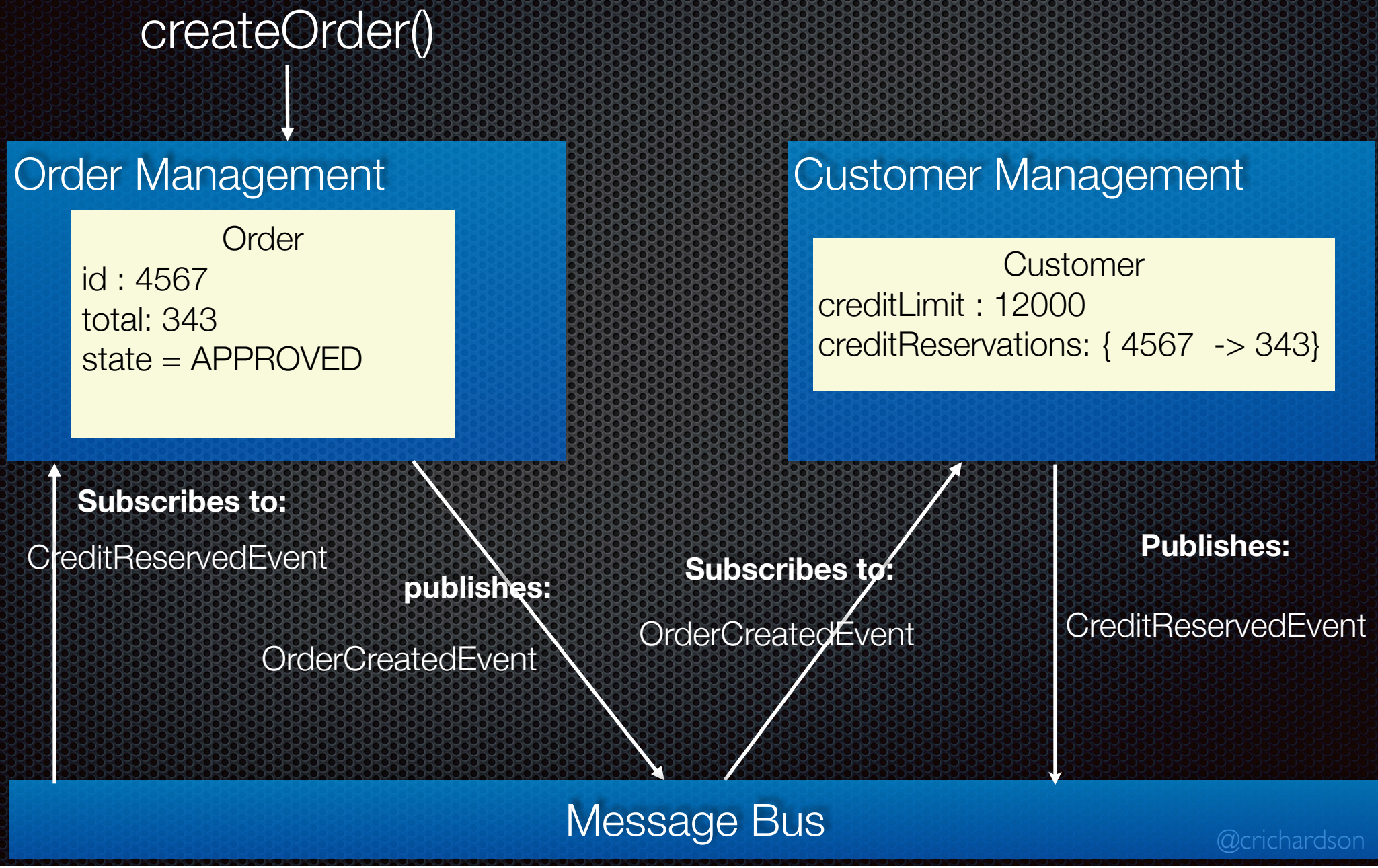
Event-driven architecture



Use event-driven, eventually consistent order processing



Eventually consistent credit checking



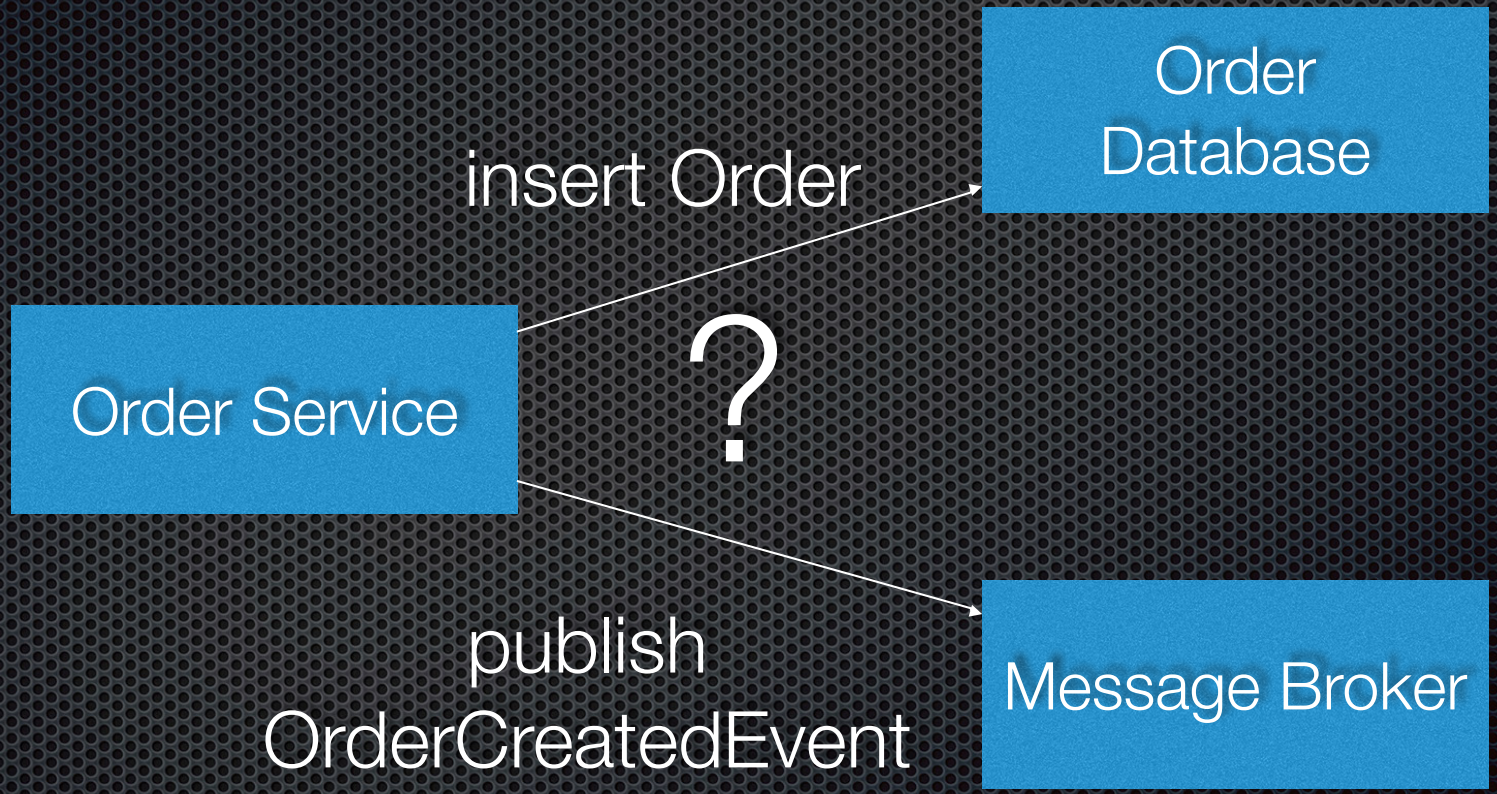
Complexity of compensating transactions

- ACID transactions can simply rollback

BUT

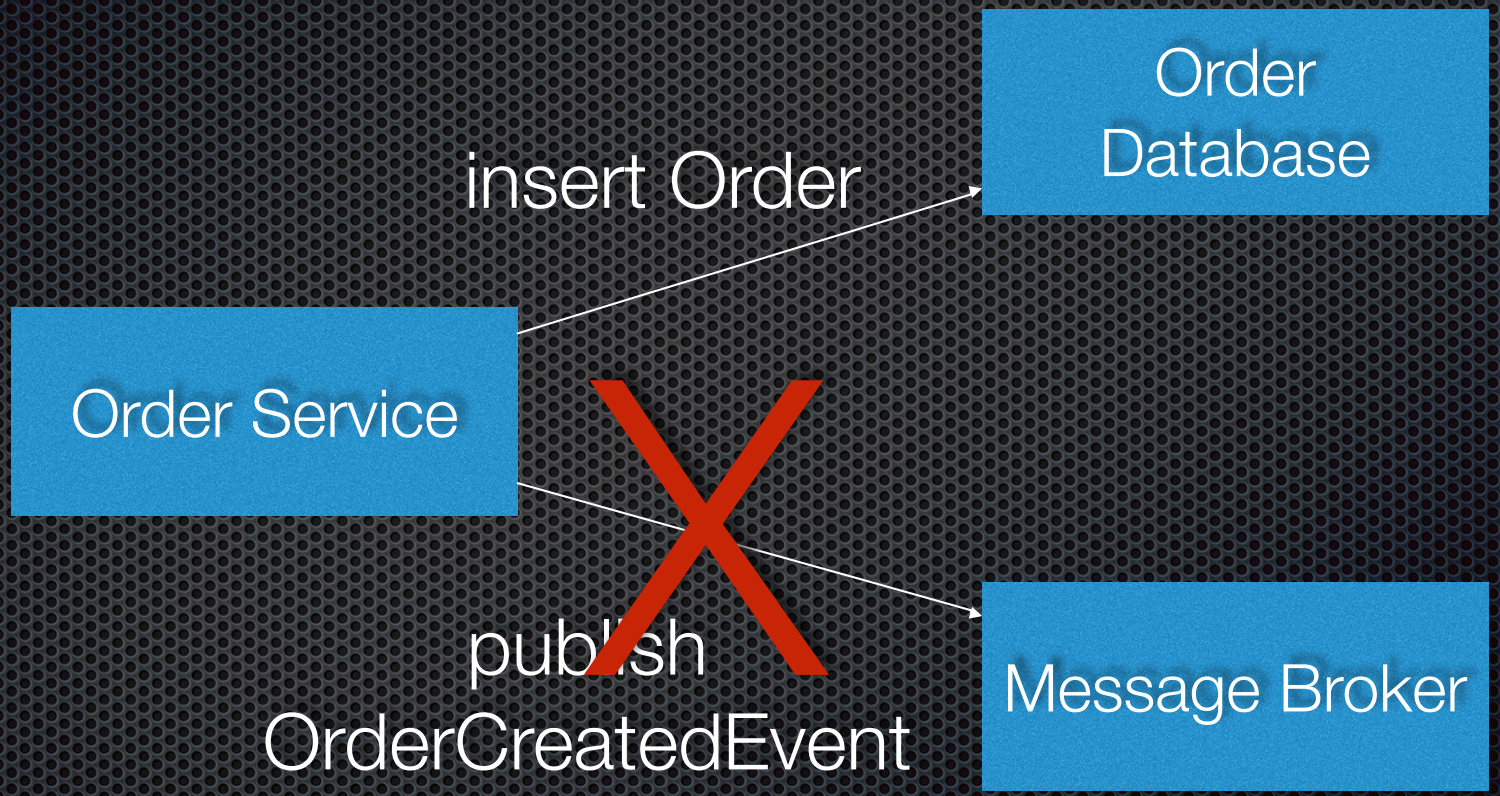
- Developer must write application logic to “rollback” eventually consistent transactions
- For example:
  - CreditCheckFailed => cancel Order
  - Money transfer destination account closed => credit source account
- Careful design required!

How atomically update database and publish an event



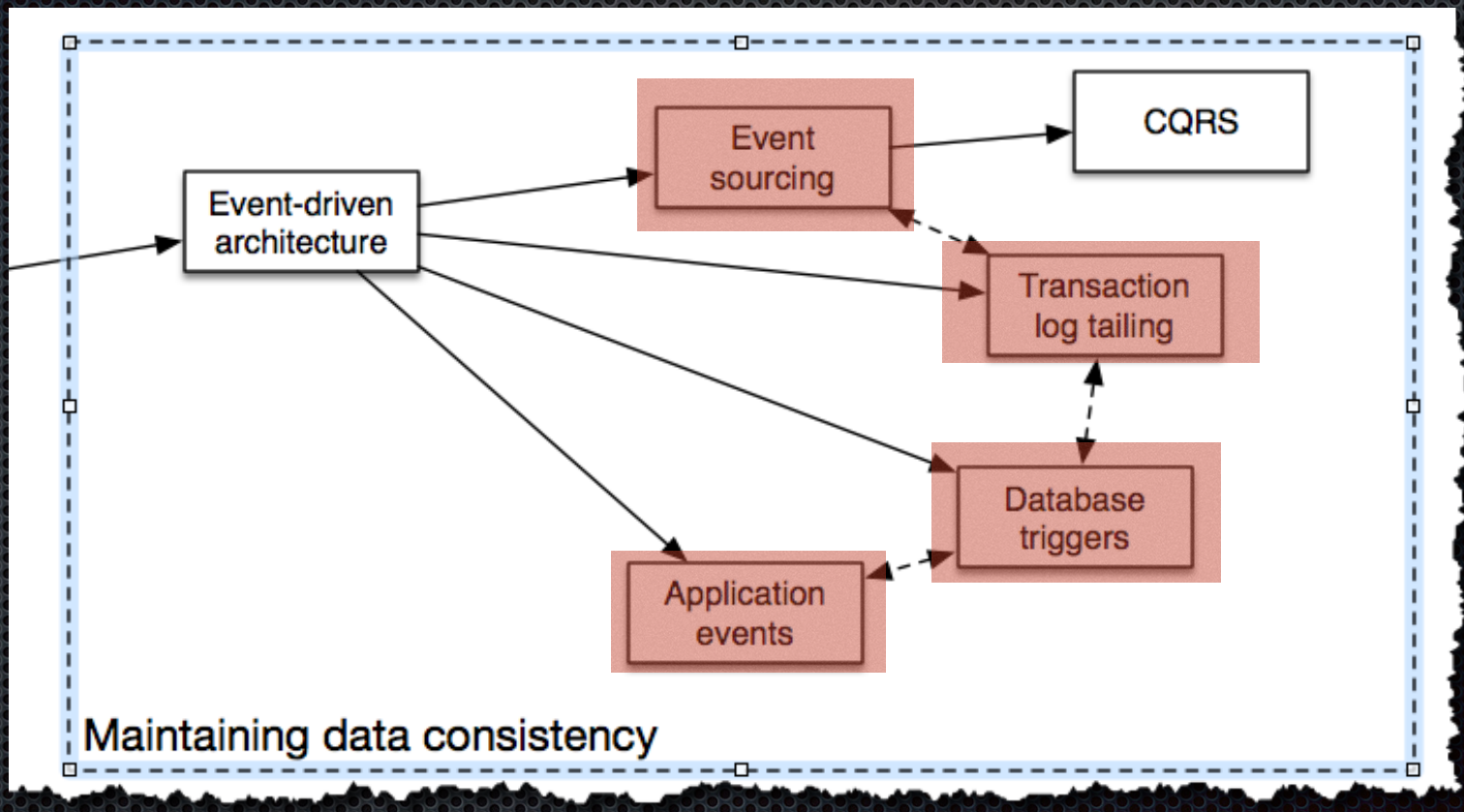
dual write problem

Failure = inconsistent system



2PC is not an option

Reliably publish events when state changes



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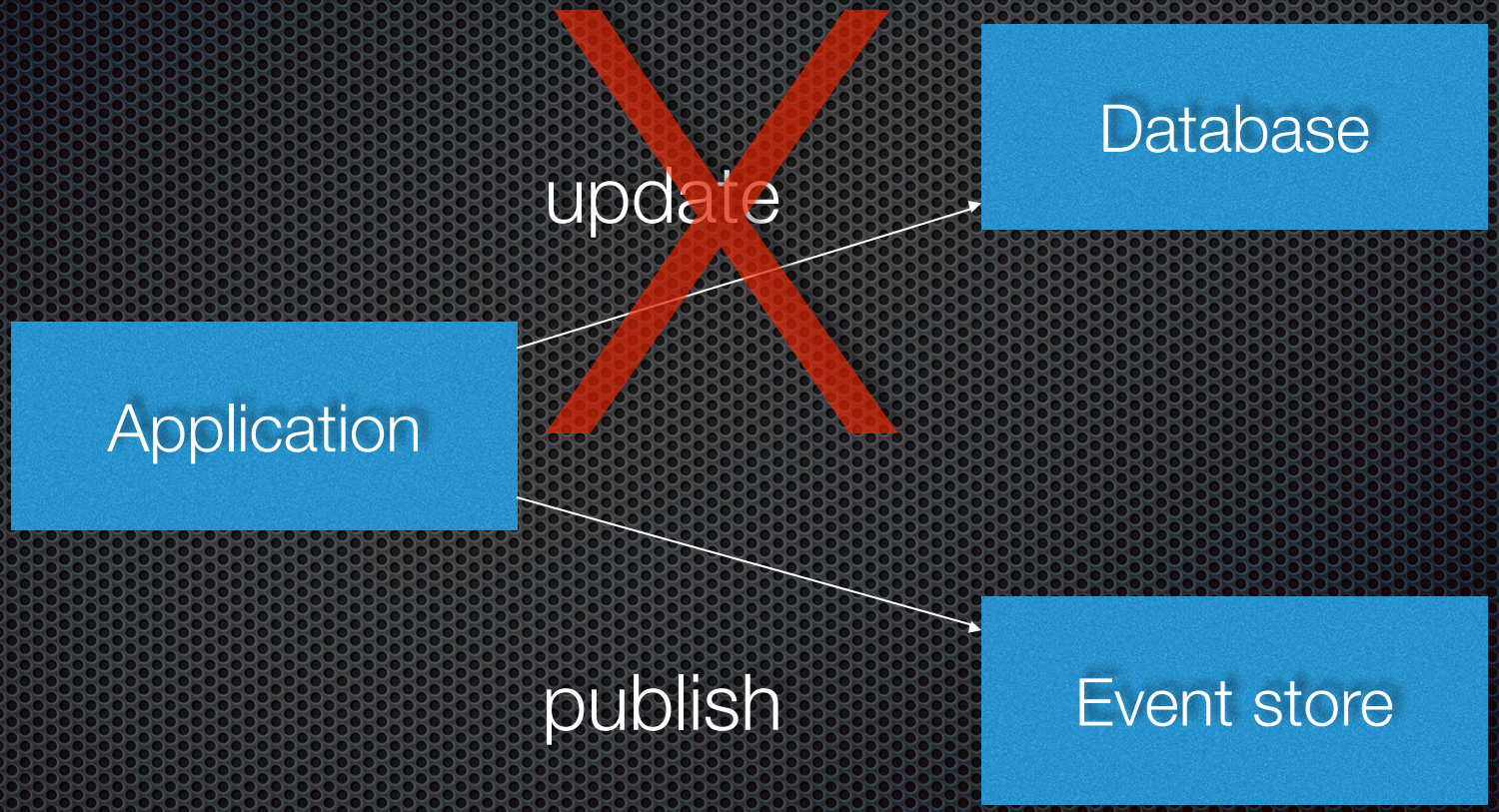
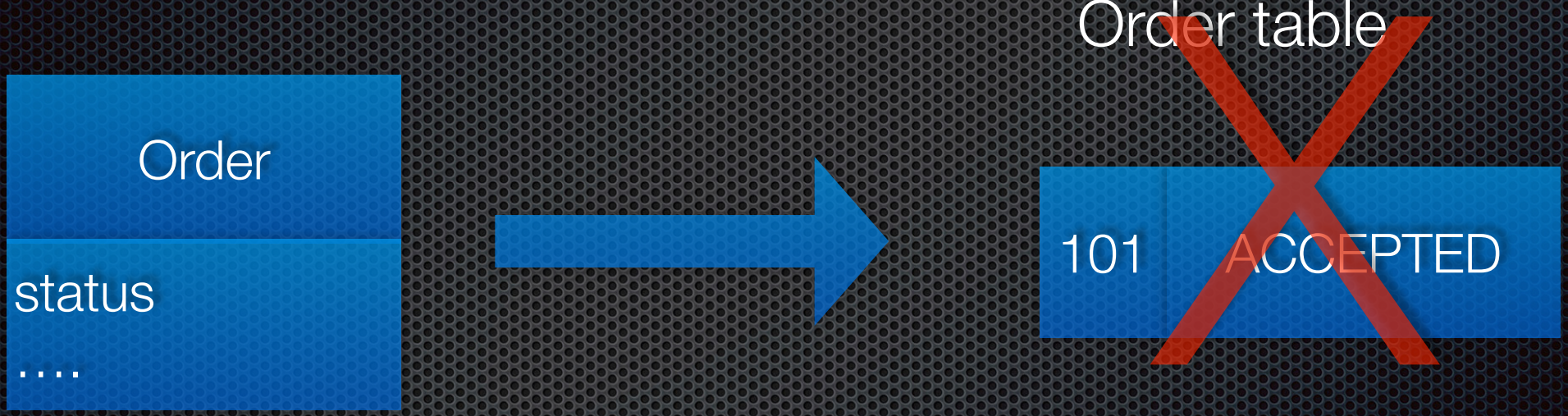
Event sourcing = event-centric persistence



Event sourcing

- For each domain object (i.e. DDD aggregate):
  - Identify (state changing) domain events, e.g. use Event Storming
  - Define Event classes
- For example, Order events: OrderCreated, OrderCancelled, OrderApproved, OrderRejected, OrderShipped

Persists events
NOT current state

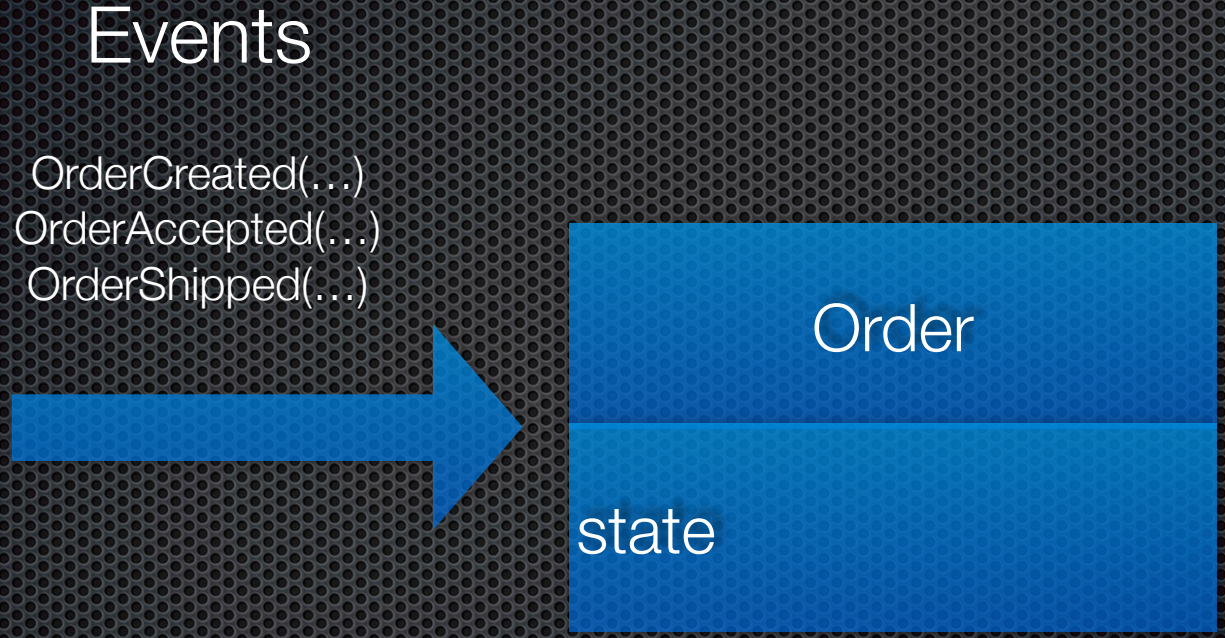


Persists events NOT current state

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 state

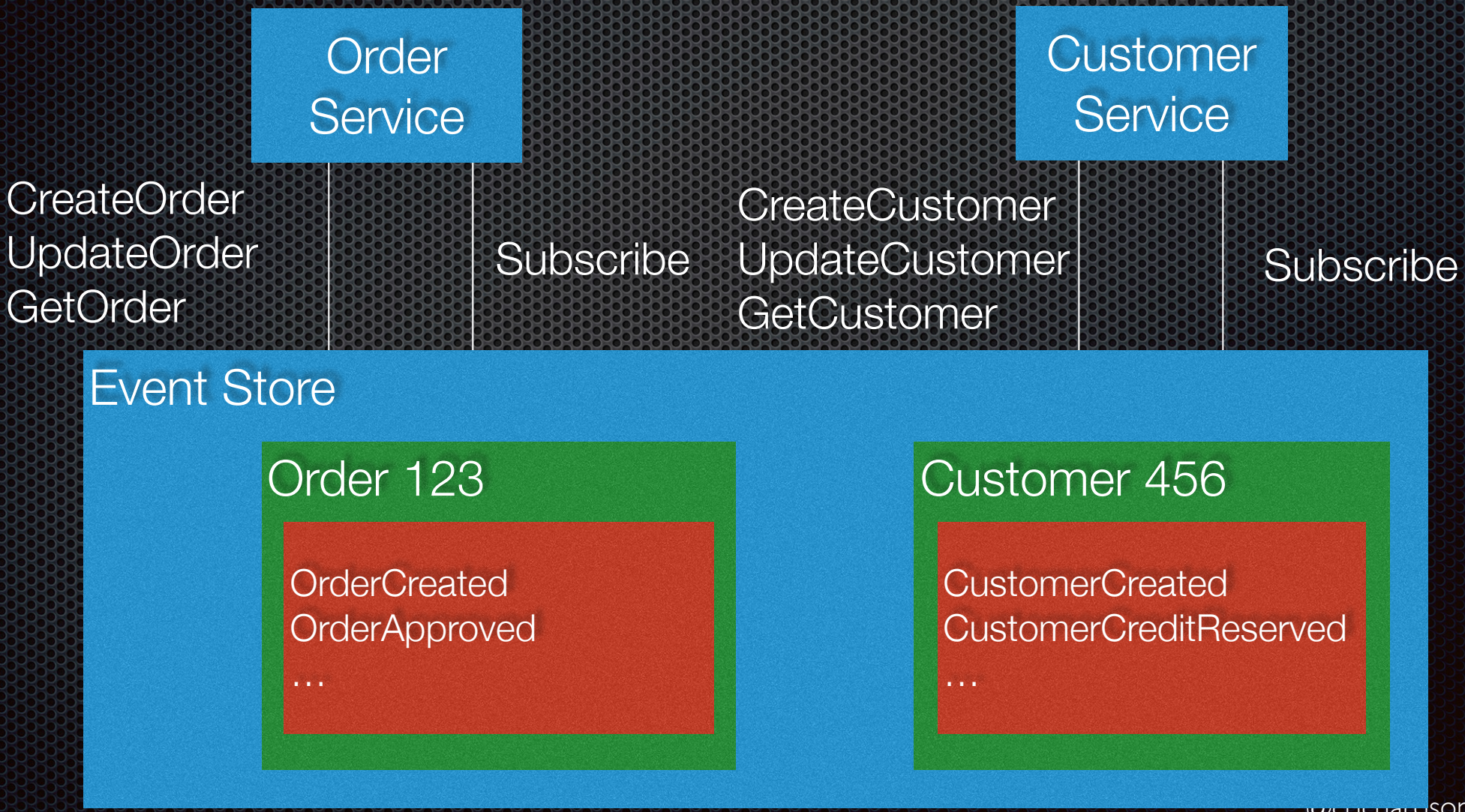


Periodically snapshot to avoid loading all events

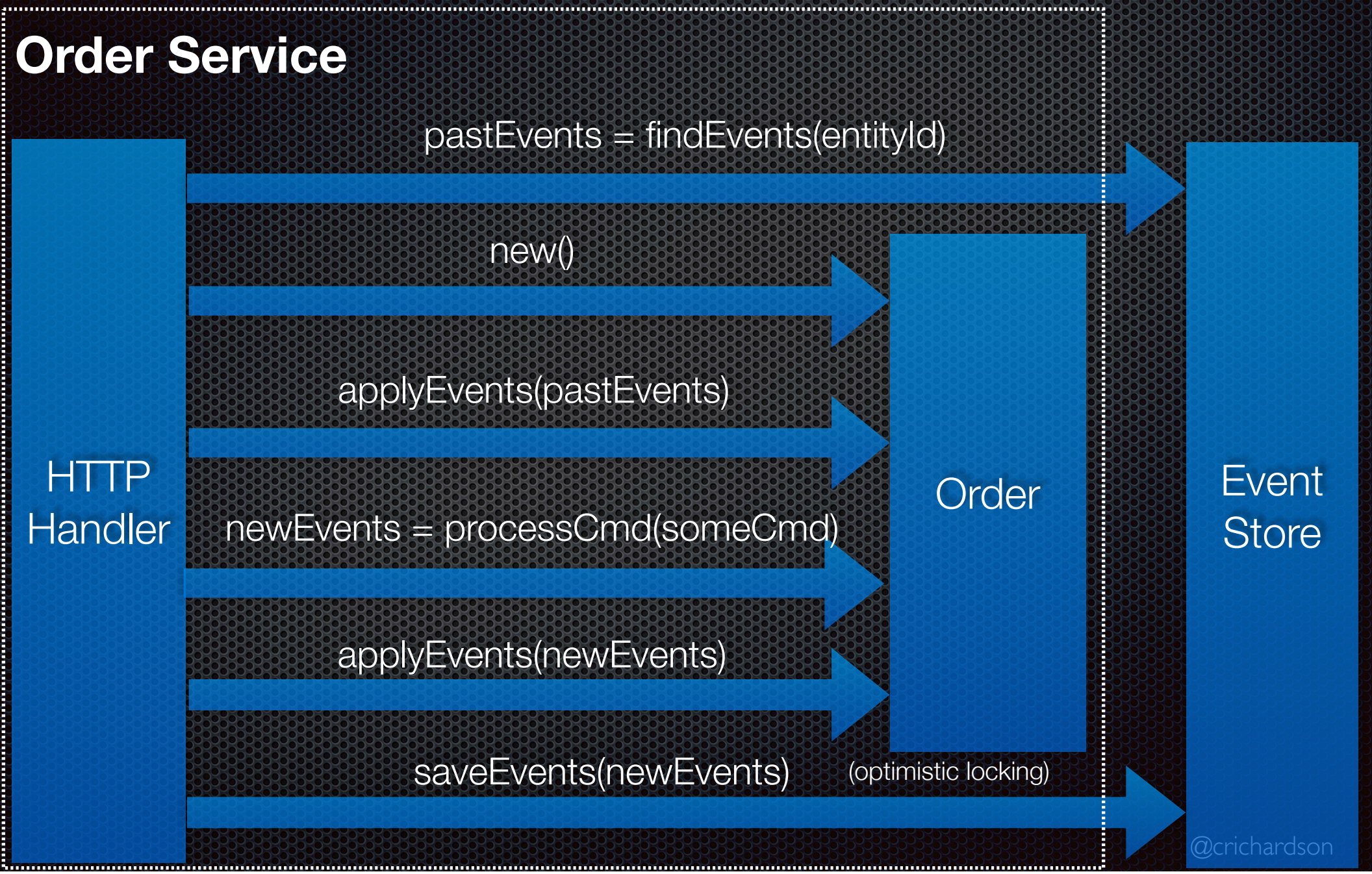
The present is a fold over history

currentState = foldl(applyEvent, initialState, events)

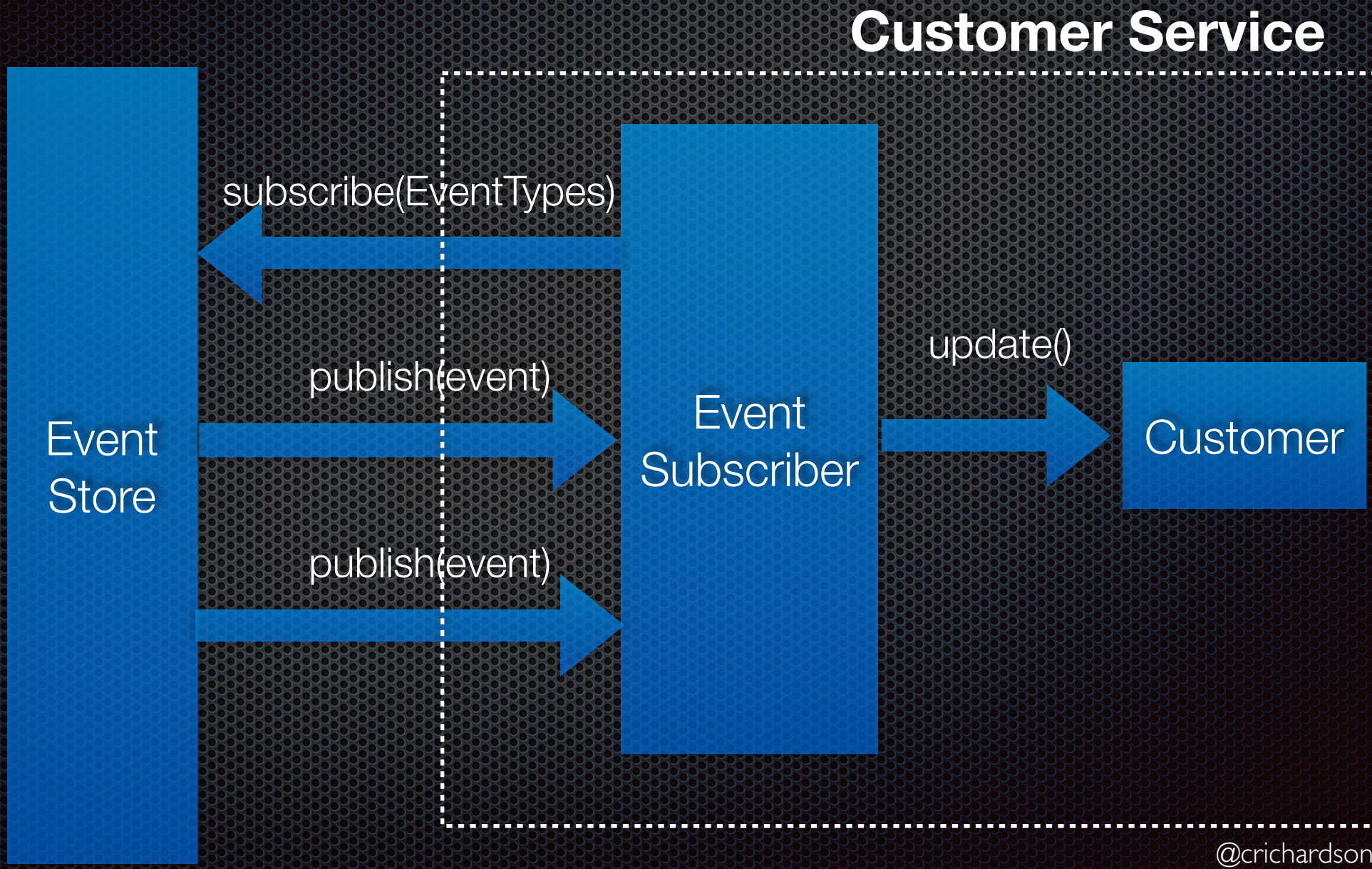
Application architecture



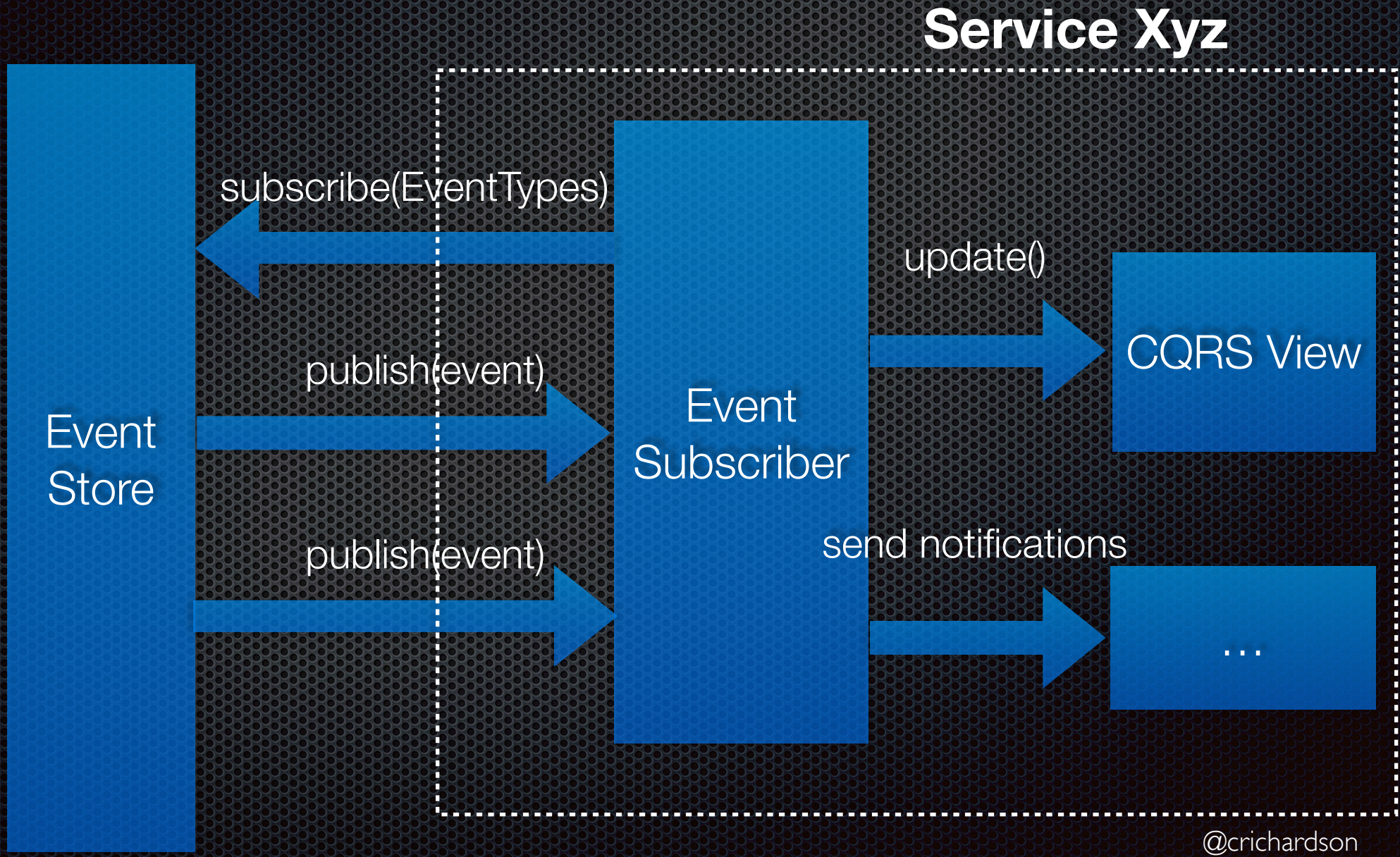
Request handling in an event sourced application



Event Store publishes events consumed by other services



Event Store publishes events consumed by other services



Event store = database + message broker

- Hybrid database and message broker
- Implementations:
  - Home grown/DIY
  - geteventstore.com by Greg Young
  - http://eventuate.io (mine)

Benefits of event sourcing

- Solves data consistency issues in a Microservice/NoSQL based architecture
- Reliable event publishing: publishes events needed by predictive analytics etc, user notifications,…
- Eliminates O/R mapping problem (mostly)
- Reifies state changes:
  - Built in, reliable audit log
  - temporal queries
- Preserved history ⇒ More easily implement future requirements

Drawbacks of event sourcing…

- Requires application rewrite
- Weird and unfamiliar style of programming
- Events = a historical record of your bad design decisions
- Must detect and ignore duplicate events
  - Idempotent event handlers
  - Track most recent event and ignore older ones
  - …

… Drawbacks of event sourcing

- Querying the event store can be challenging
- Some queries might be complex/inefficient, e.g. accounts with a balance > X
- Event store might only support lookup of events by entity id
- Must use Command Query Responsibility Segregation (CQRS) to handle queries ⇒ application must handle eventually consistent data

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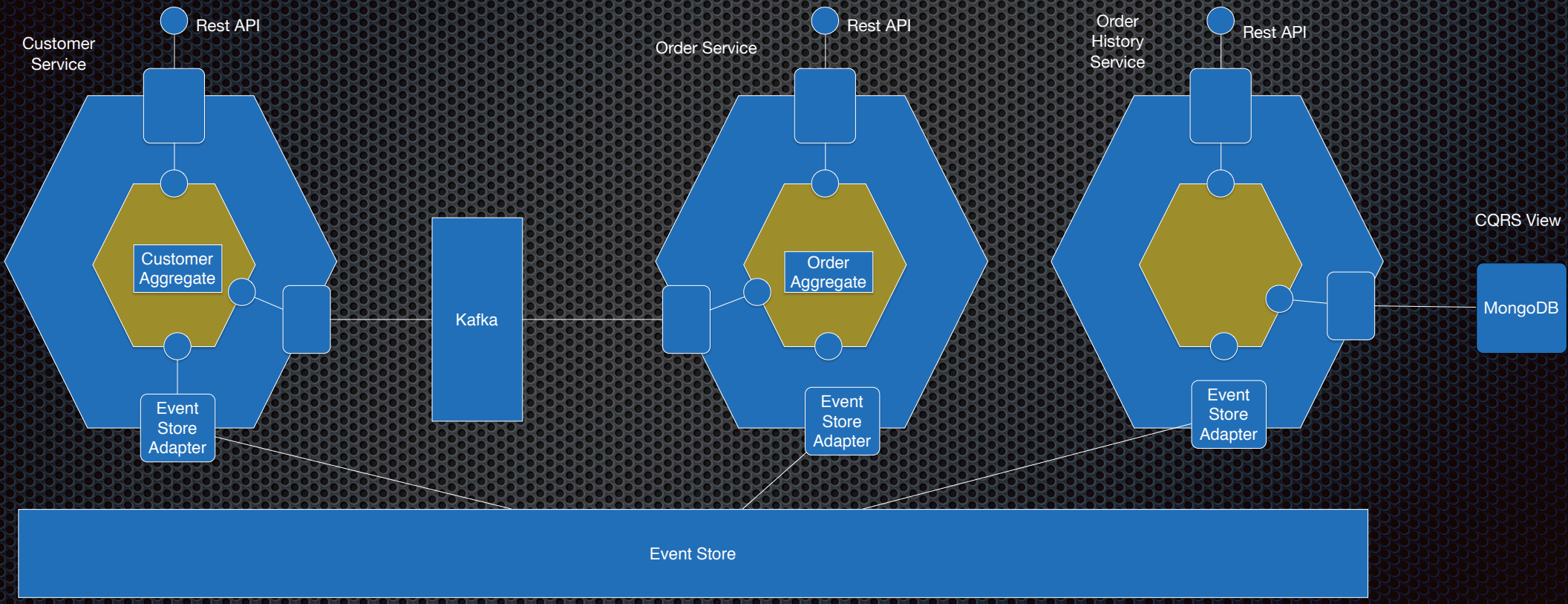
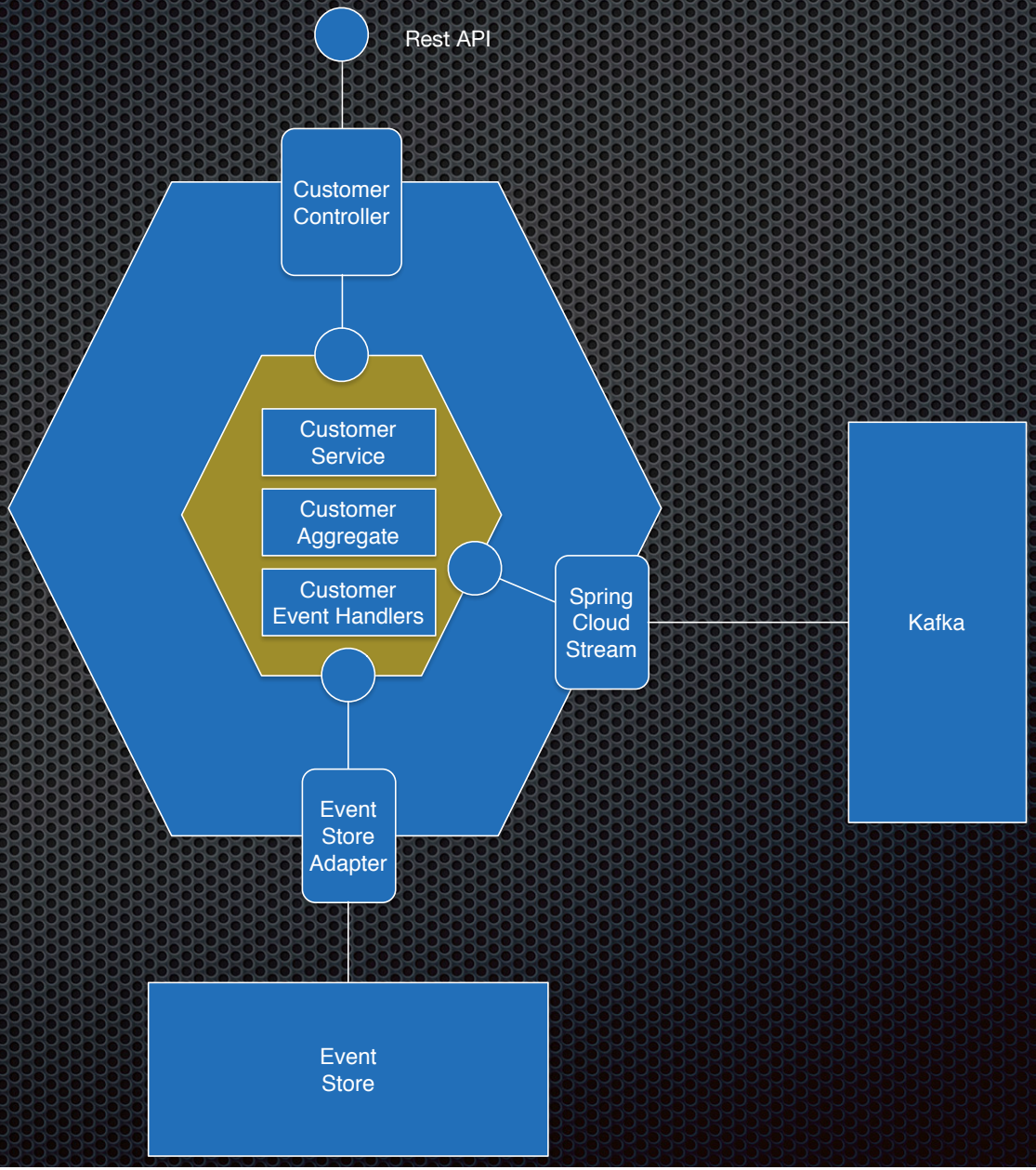
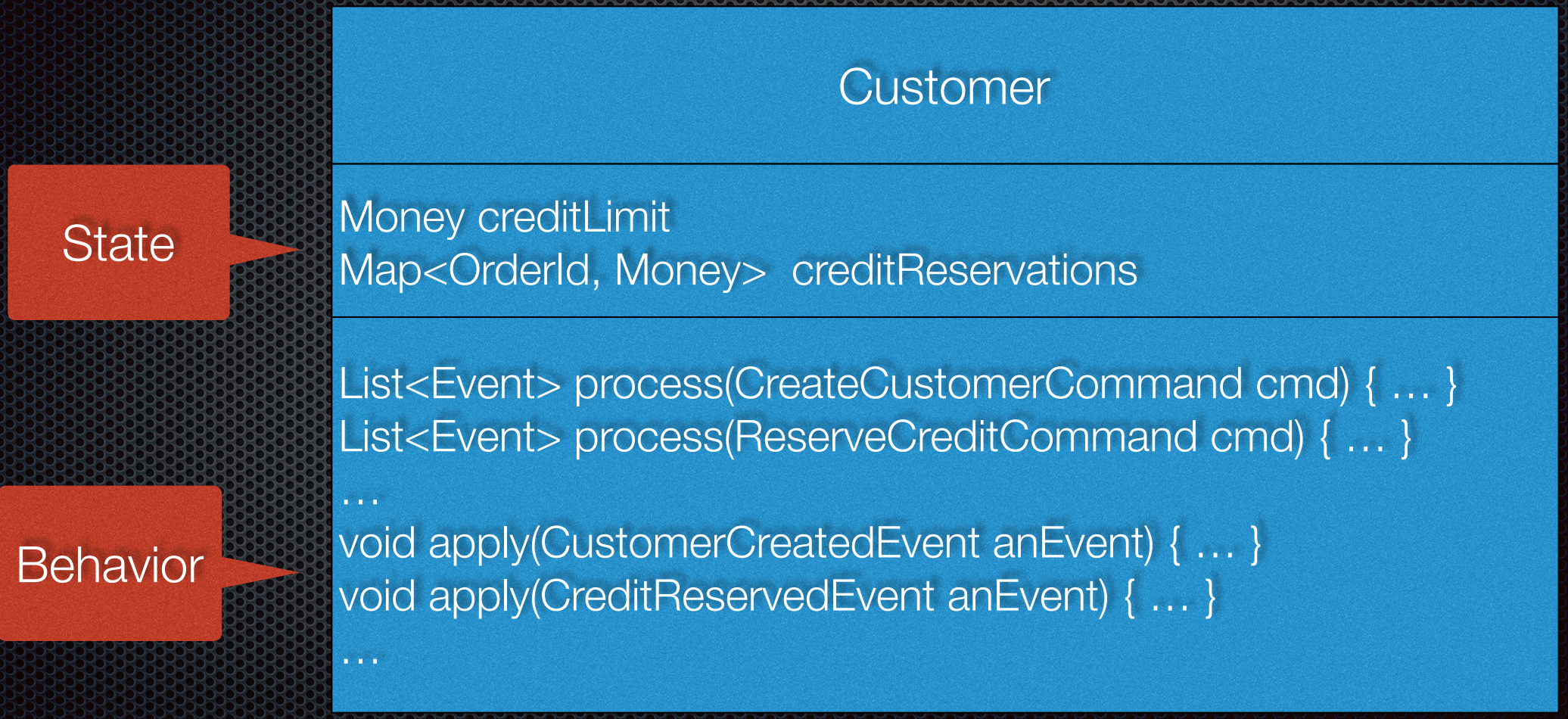
Orders and Customers example



Customer microservice



The Customer aggregate



Familiar concepts restructured

```
class Customer {

  public void reserveCredit(
       orderId : String,
       amount : Money) {

    // verify

    // update state
    this.xyz = …
}
```

```
public List<Event> process(
       ReserveCreditCommand cmd) {

   // verify
    …
   return singletonList(
     new CreditReservedEvent(…);
    )
  }
```

```
 public void apply(
      CreditReservedEvent event) {

     // update state
     this.xyz = event.xyz
}
```

Customer command processing

```
public class Customer extends ReflectiveMutableCommandProcessingAggregate<Customer, CustomerCommand> {

  private Money creditLimit;
  private Map<EntityIdentifier, Money> creditReservations;

  Money availableCredit() {
    return creditLimit.subtract(creditReservations.values().stream().reduce(Money.ZERO, Money::add));
  }

  Money getCreditLimit() { return creditLimit; }

  public List<Event> process(CreateCustomerCommand cmd) {
    return EventUtil.events(new CustomerCreatedEvent(cmd.getName(), cmd.getCreditLimit()));
  }

  public List<Event> process(ReserveCreditCommand cmd) {
    if (availableCredit().isGreaterThanOrEqual(cmd.getOrderTotal()))
      return EventUtil.events(new CustomerCreditReservedEvent(cmd.getOrderId(), cmd.getOrderTotal()));
    else
      return EventUtil.events(new CustomerCreditLimitedExceededEvent(cmd.getOrderId()));
  }

  public void apply(CustomerCreatedEvent event) {...}

  public void apply(CustomerCreditReservedEvent event) {...}

  public void apply(CustomerCreditLimitedExceededEvent event) {...}

}
```

Customer applying events

```
public class Customer extends ReflectiveMutableCommandProcessingAggregate<Customer, CustomerCommand> {

  private Money creditLimit;
  private Map<EntityIdentifier, Money> creditReservations;

  Money availableCredit() {...}

  Money getCreditLimit() { return creditLimit; }

  public List<Event> process(CreateCustomerCommand cmd) {...}

  public List<Event> process(ReserveCreditCommand cmd) {...}


  public void apply(CustomerCreatedEvent event) {
    this.creditLimit = event.getCreditLimit();
    this.creditReservations = new HashMap<>();
  }

  public void apply(CustomerCreditReservedEvent event) {
    this.creditReservations.put(event.getOrderId(), event.getOrderTotal());
  }

  public void apply(CustomerCreditLimitedExceededEvent event) {
    // Do nothing
  }

}
```

Customer Controller

```
@RestController
public class CustomerController {

    private CustomerService customerService;

    @Autowired
    public CustomerController(CustomerService customerService) {
        this.customerService = customerService;
    }

    @RequestMapping(value = "/customers", method = RequestMethod.POST)
    public CompletableFuture<CreateCustomerResponse>
                        createCustomer(@RequestBody CreateCustomerRequest createCustomerRequest) {
        return customerService.createCustomer(createCustomerRequest.getName(),
                                               createCustomerRequest.getCreditLimit())
                .thenApply(ewidv -> new CreateCustomerResponse(ewidv.getEntityId()));
    }
}
```

Creating a Customer

```
public class CustomerServiceImpl implements CustomerService {

  private final AggregateRepository<Customer, CustomerCommand> customerRepository;

  public CustomerServiceImpl(AggregateRepository<Customer, CustomerCommand> customerRepository) {
    this.customerRepository = customerRepository;
  }

  @Override
  public CompletableFuture<EntityWithIdAndVersion<Customer>>
                      createCustomer(String name, Money creditLimit) {
    return customerRepository.save(new CreateCustomerCommand(name, creditLimit));
  }
}
```

save() concisely specifies:
1. Creates Customer aggregate
2. Processes command
3. Applies events
4. Persists events

Event handling in Customers

Triggers BeanPostProcessor

Durable subscription name

```
@EventSubscriber(id = "customerWorkflow")
public class CustomerWorkflow {

  private Logger logger = LoggerFactory.getLogger(getClass());

  private Source source;

  public CustomerWorkflow(Source source) { this.source = source; }

  @EventHandlerMethod
  public CompletableFuture<?> reserveCredit(EventHandlerContext<OrderCreatedEvent> ctx) {
    OrderCreatedEvent event = ctx.getEvent();
    Money orderTotal = event.getOrderTotal();
    String customerId = event.getCustomerId();
    String orderId = ctx.getEntityId();

    return ctx.update(Customer.class, customerId, new ReserveCreditCommand(orderTotal, orderId))
            .handleAsync(
                    recoverWith(singletonMap(EntityNotFoundException.class, (t) -> {
                      rejectOrder(orderId);
                      return null;
                    })));
  }
```

1. Load Customer aggregate
2. Processes command
3. Applies events
4. Persists events

Publish message to Spring Cloud Stream (Kafka) when Customer not found

Summary

- Aggregates are the building blocks of microservices
- Use events to maintain consistency between aggregates
- Event sourcing is a good way to implement a event-driven architecture


@crichardson chris@chrisrichardson.net
Questions?
http://learnmicroservices.io