Events on the outside, on the inside and at the core

Chris Richardson

Founder of Eventuate.io

Founder of the original CloudFoundry.com

Author of POJOs in Action

@crichardson

chris@chrisrichardson.net

http://microservices.io

http://eventuate.io

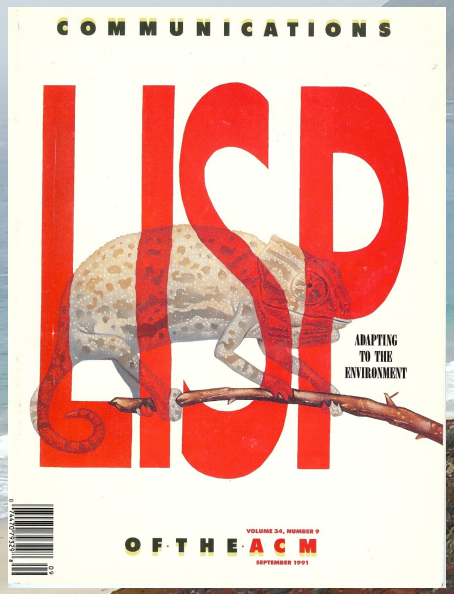
http://plainoldobjects.com

Presentation goal

Events play a key role in applications

Event sourcing enables the event-driven enterprise

About Chris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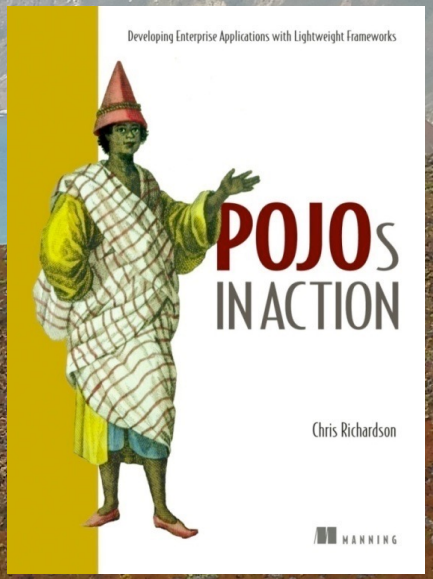
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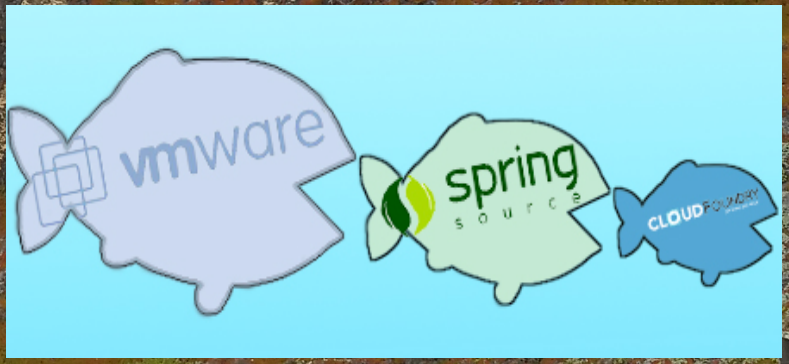

vmware
spring
source
CLOUDFOUNDRY

About Chris

Consultant and trainer focusing on microservices

http://www.chrisrichardson.net/

About Chris

Founder of a startup that is creating a platform that makes it easy for application developers to write microservices

http://eventuate.io

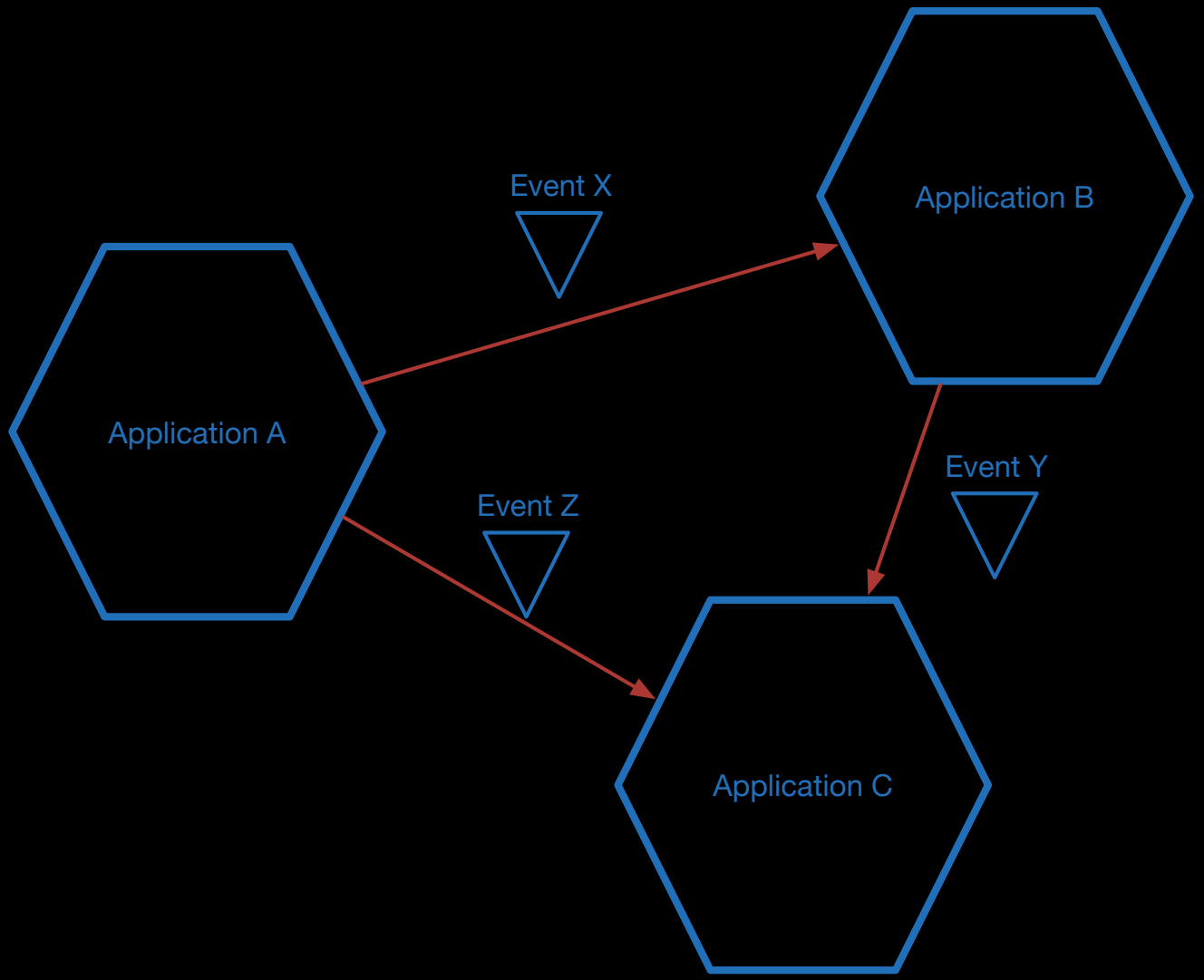
For more information

- https://github.com/cer/event-sourcing-examples
- http://microservices.io
- http://plainoldobjects.com/
- https://twitter.com/crichardson
- http://eventuate.io/

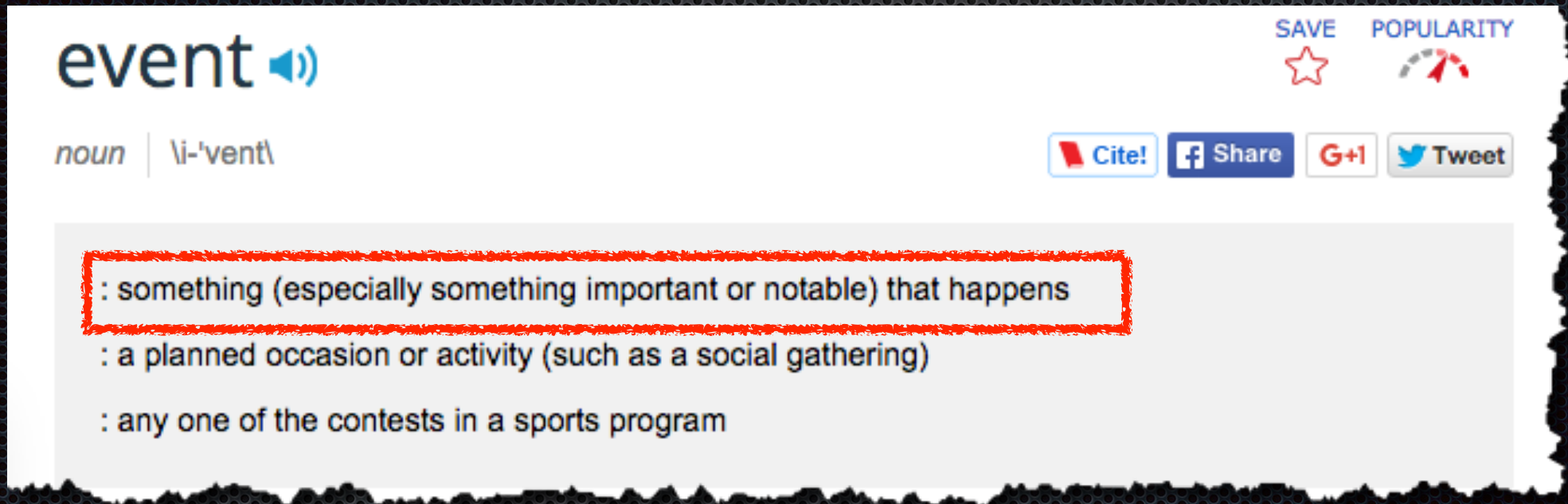
Agenda

- Events on the outside
- Events on the inside
- Events at the core with event sourcing
- Designing event-centric domain model

Events on the outside

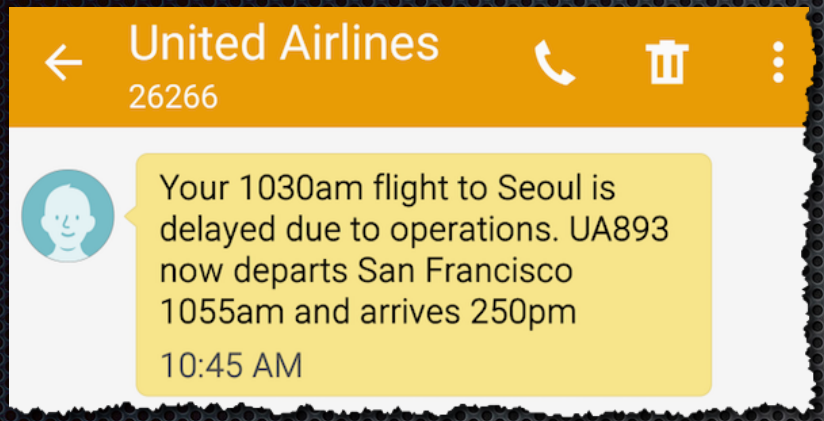


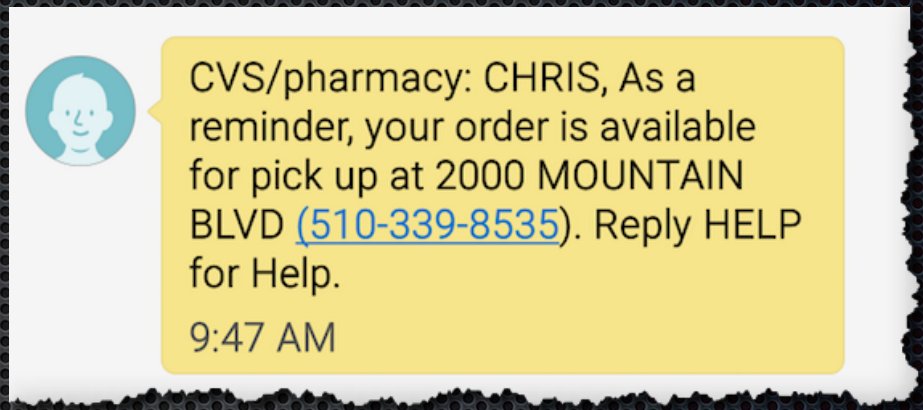
What's an event?

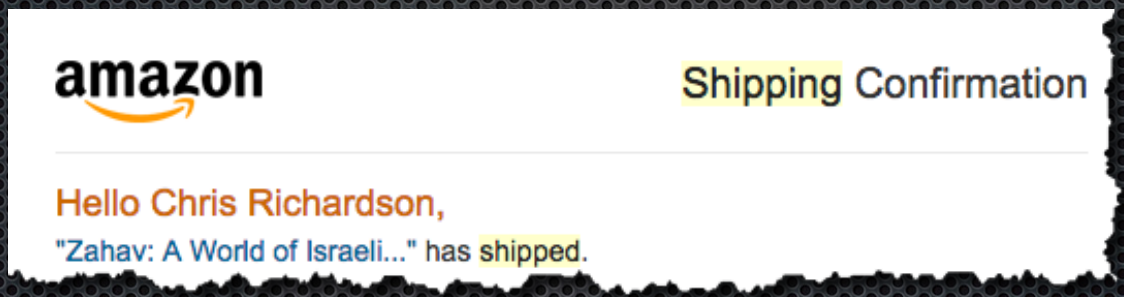


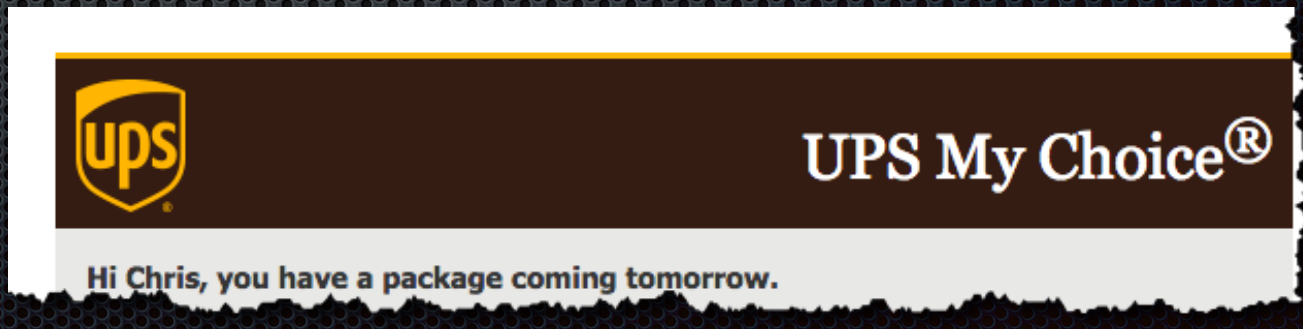
http://www.merriam-webster.com/dictionary/event

Examples of events









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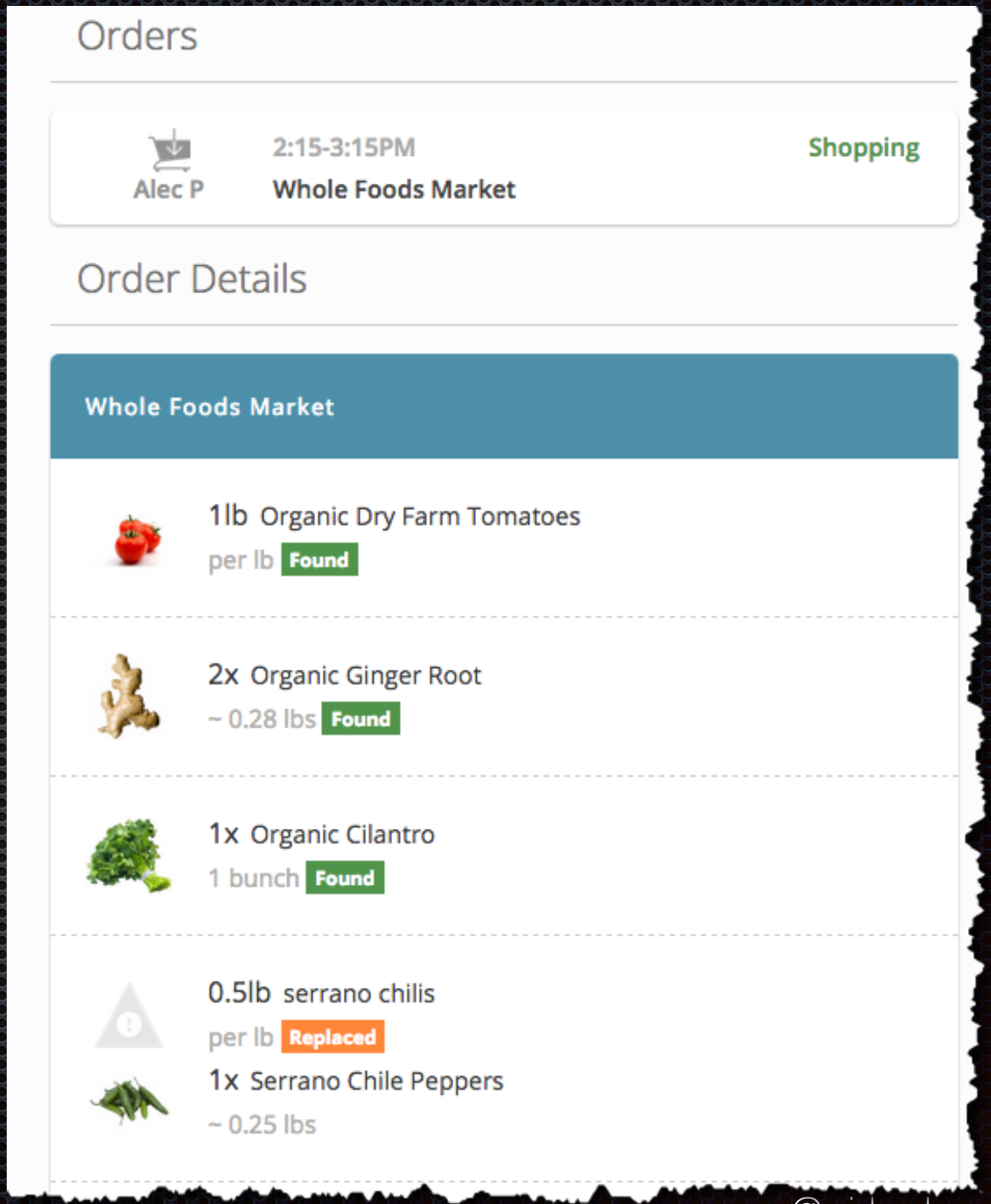
Instacart: event-driven grocery shopping



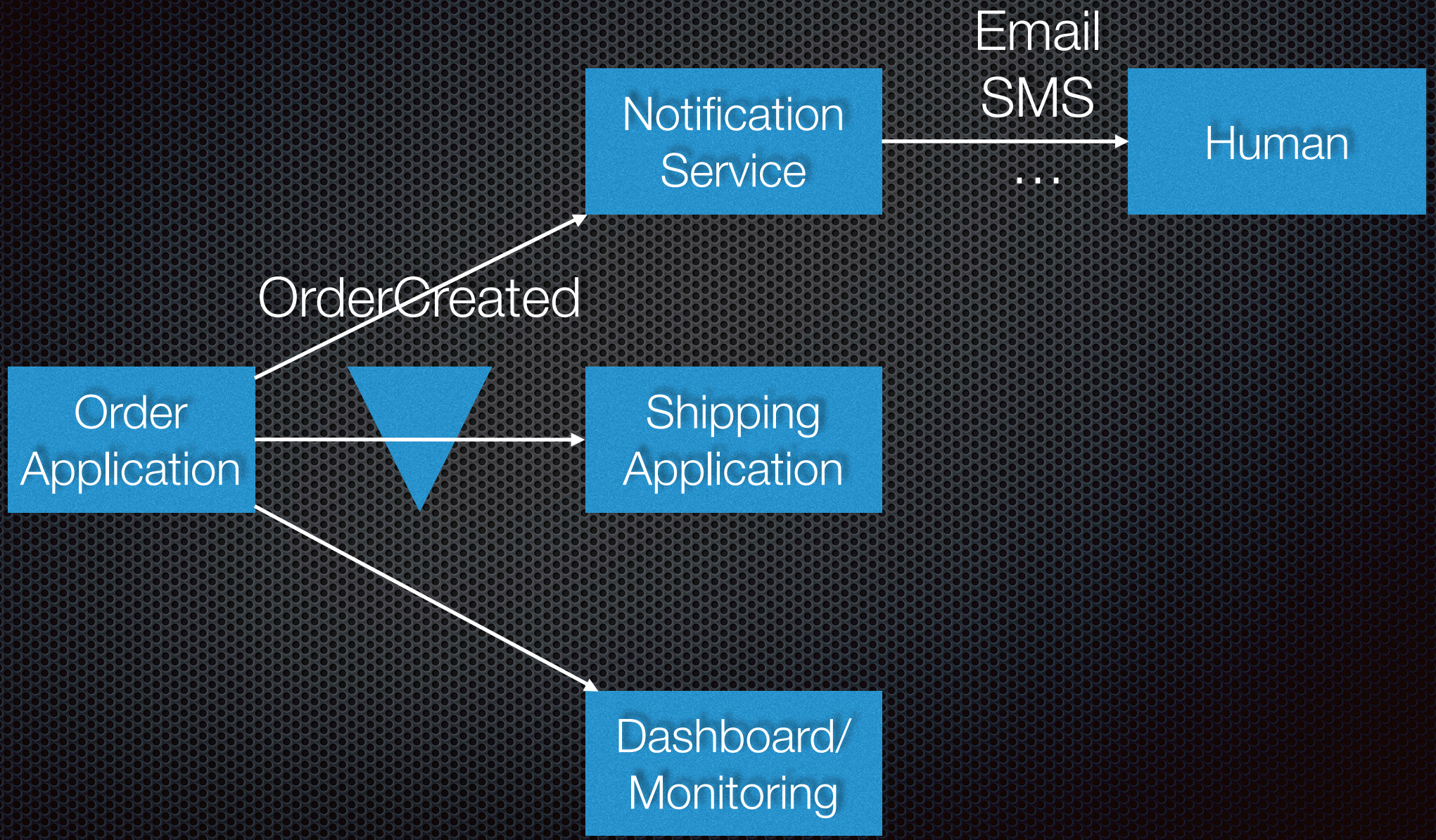
An event is produced when....

- Creation or update of a business object
- Attempt to violate a business rule

How to reliably generate events?

More on that later...

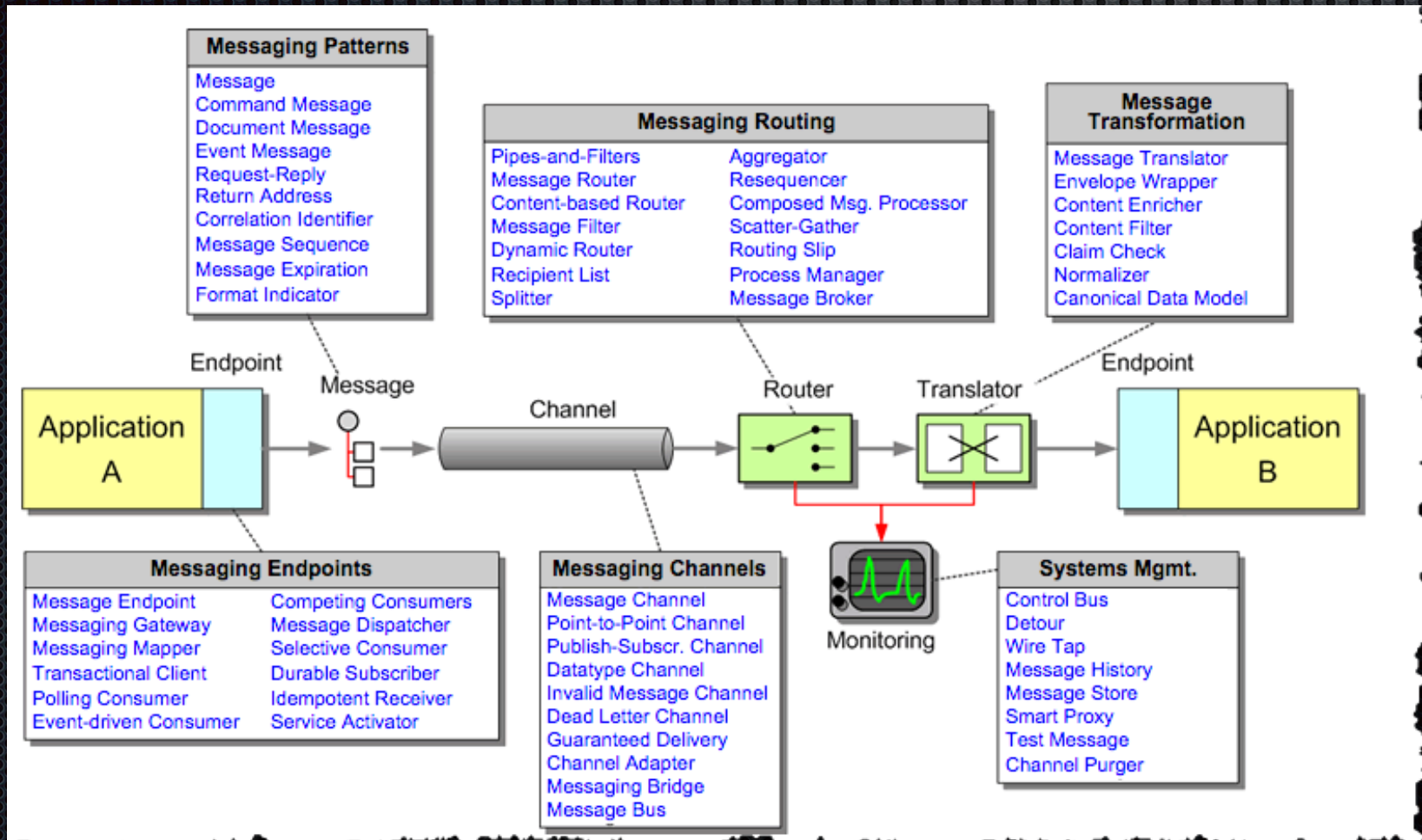
Who consumes an event?

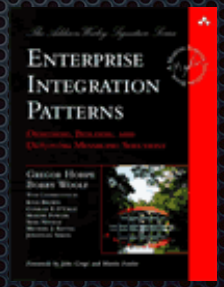


How to deliver events?

Inside the firewall

Enterprise integration patterns





- http://www.enterpriseintegrationpatterns.com/patterns/messaging/

Messaging-based IPC

Example messaging systems

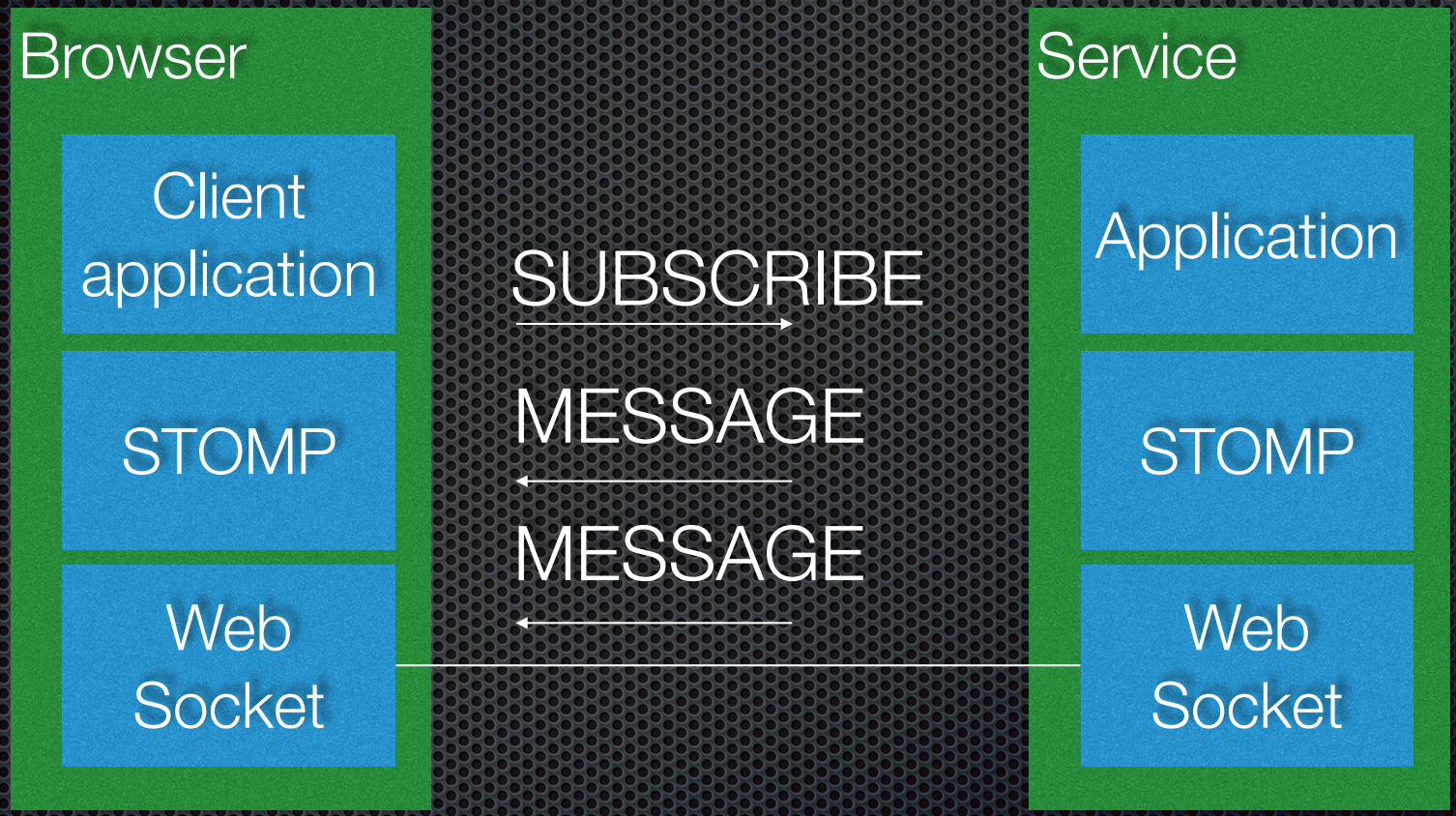
Outside the firewall

Polling for events

- HTTP
  - Periodically poll for events
- Atom Publishing Protocol (AtomPub)
  - Based on HTTP
  - Head is constantly changing
  - Tail is immutable and can be efficiently cached

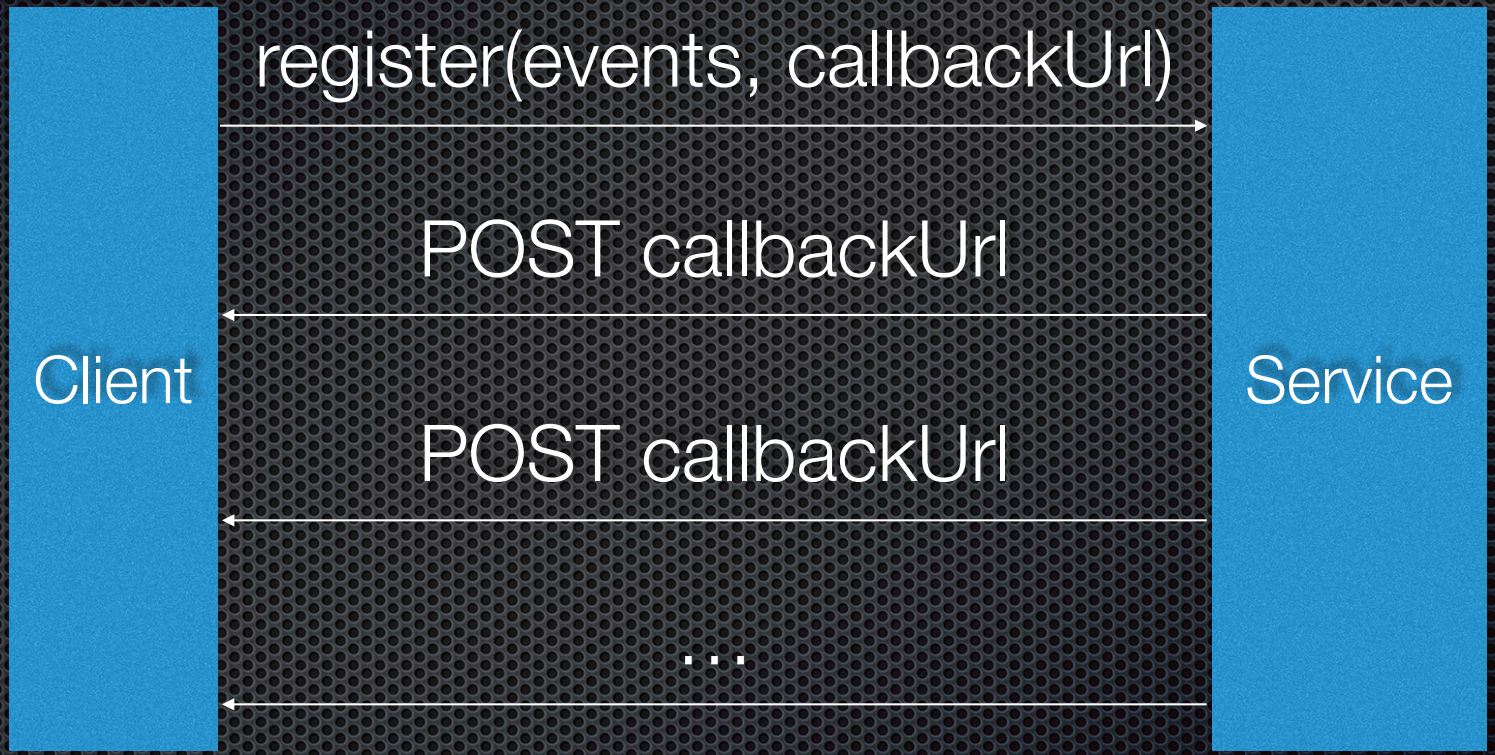
High-latency, inefficient

Using WebSockets



Low latency, more efficient, but what about past events?

Webhooks = user-defined HTTP callback



https://en.wikipedia.org/wiki/Webhook

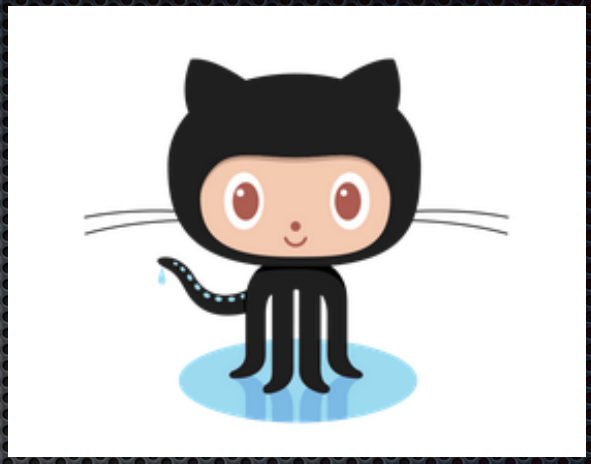
Low latency, more efficient, but what about past events?

WebHooks

=

web friendly publish/subscribe

Github webhooks



- https://developer.github.com/webhooks/
- Installed on an organization or repository
  - e.g. POST /repos/:owner/:repo/hooks
- Available events:
  - push - push to a repository
  - fork - repository is forked
  - pull_request - assigned, unassigned, …
  - push - push to a repository
  - …

Twilio - Telephony and SMS as a service

Manage resources
Send SMS
Initiate voice calls

REST API

Voice
SMS

Twilio

HTTP GET/
POST

Your
Application

TwiML doc

Phone number ⇒

SMS URL + VOICE URL

Webhooks handle incoming SMS and voice calls

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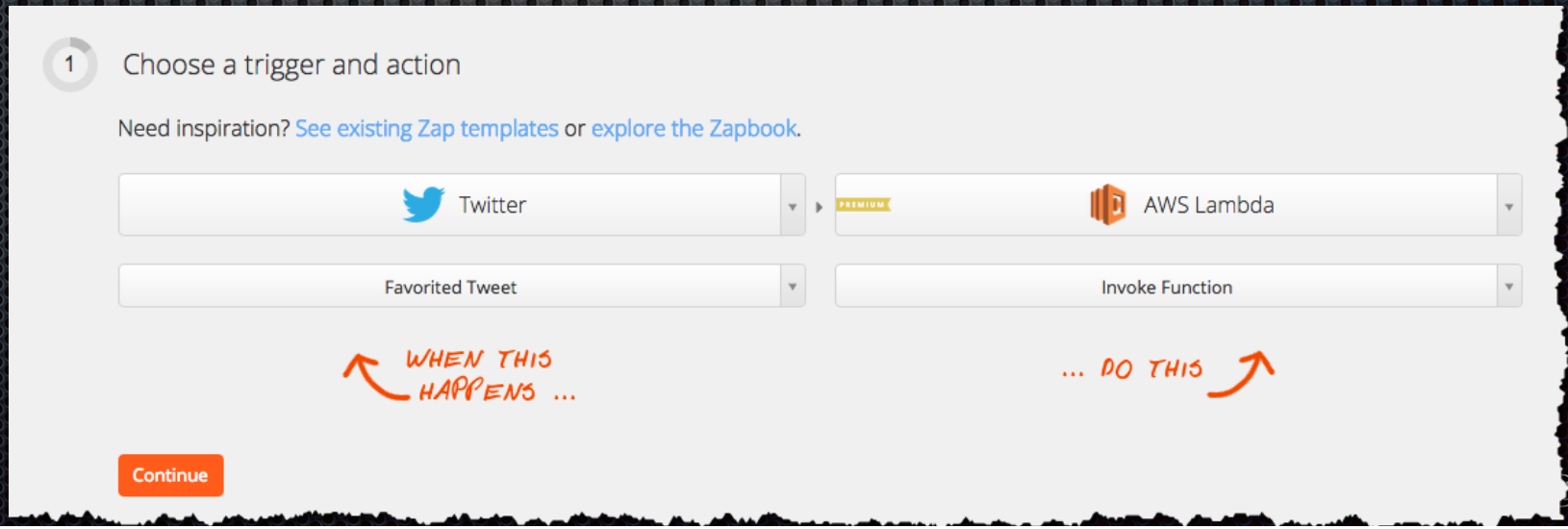
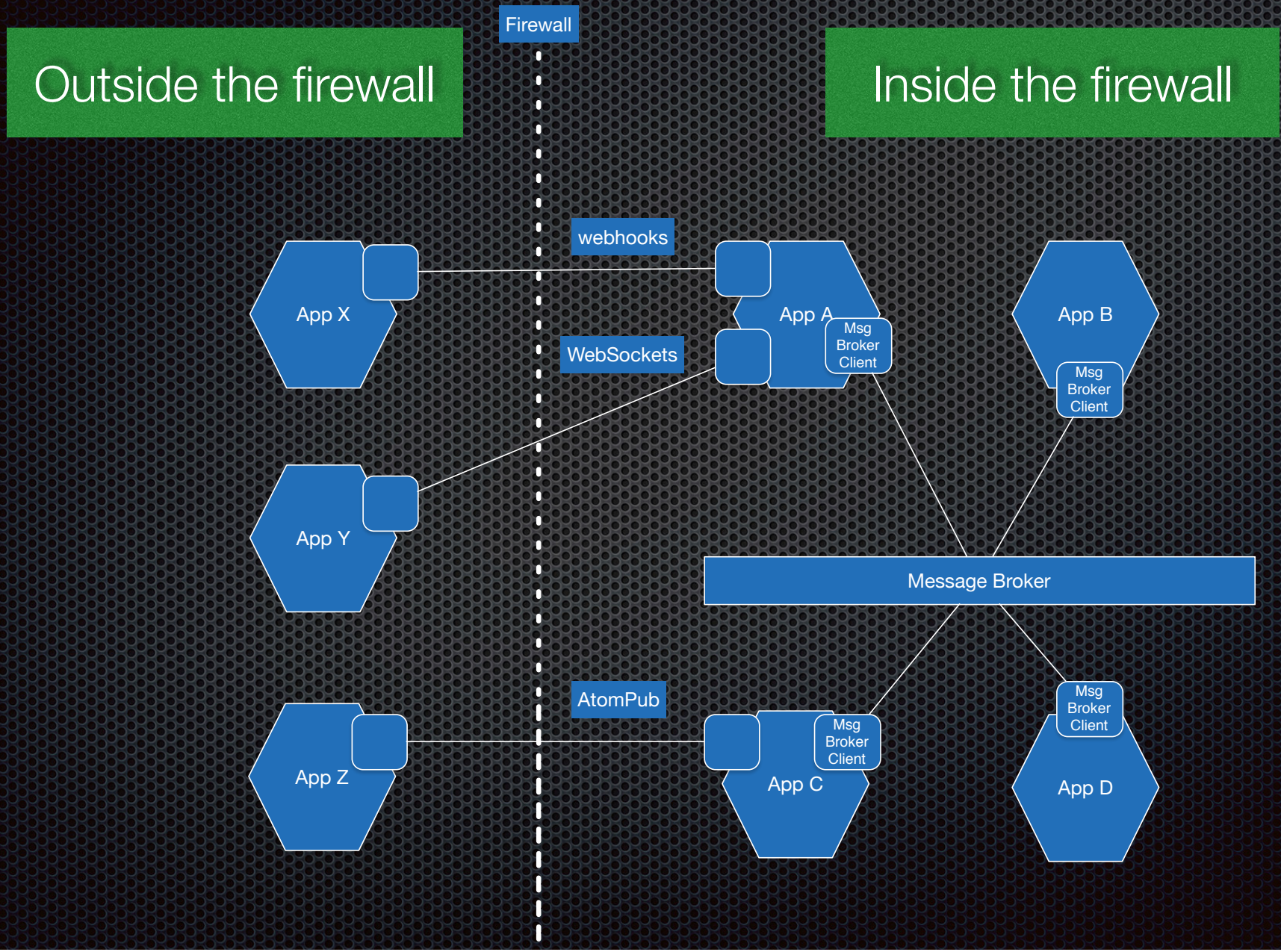
Integration hubs - Zapier, IFTTT

- Application abstraction:
  - Triggers - events published by application: polling or Webhooks
  - Action - operation supported by application, e.g. REST API end points



The event-driven enterprise



Agenda

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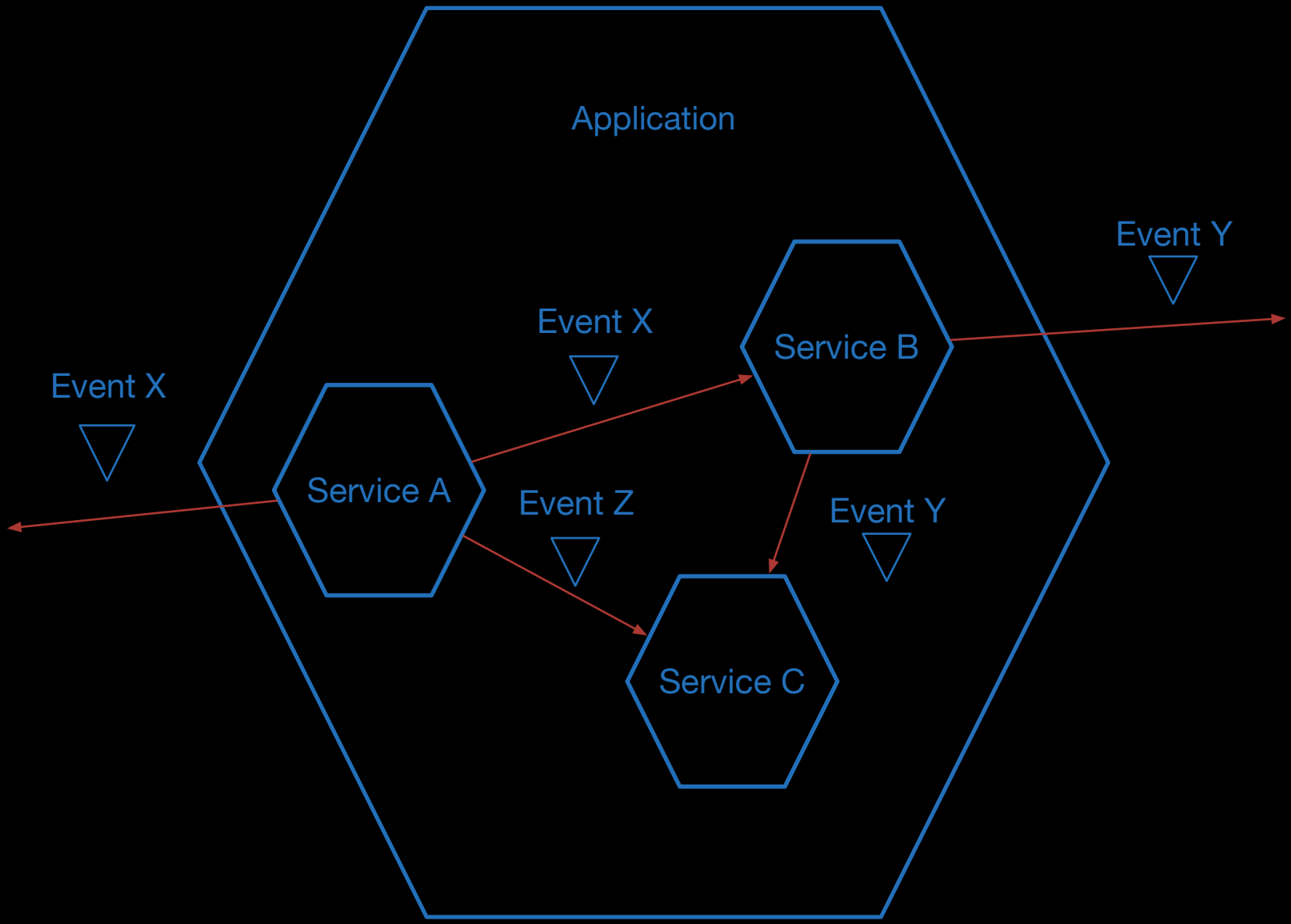
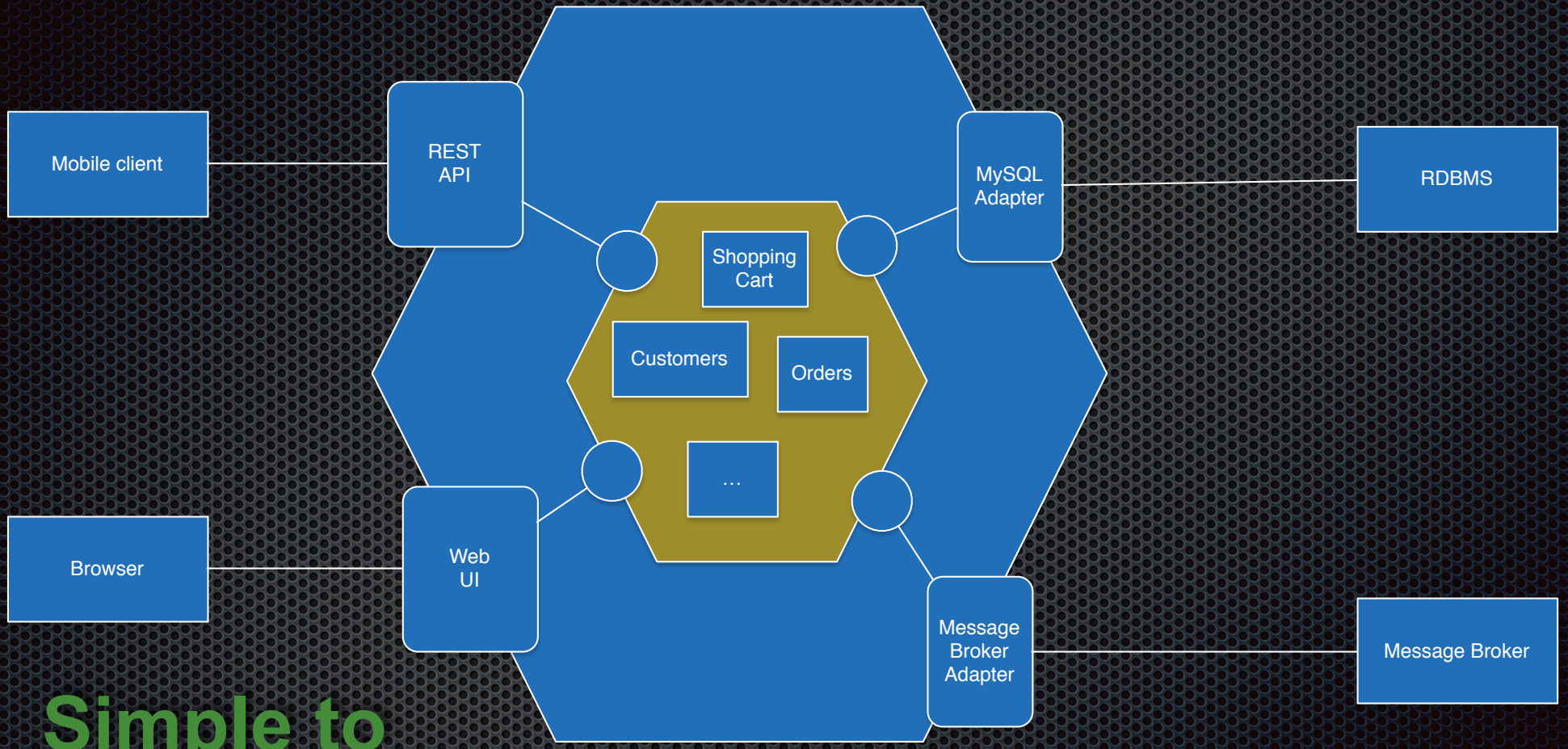
- Events on the inside
- Events at the core with event sourcing
- Designing event-centric domain model

Events on the inside



Traditional monolithic architecture



Simple to

develop

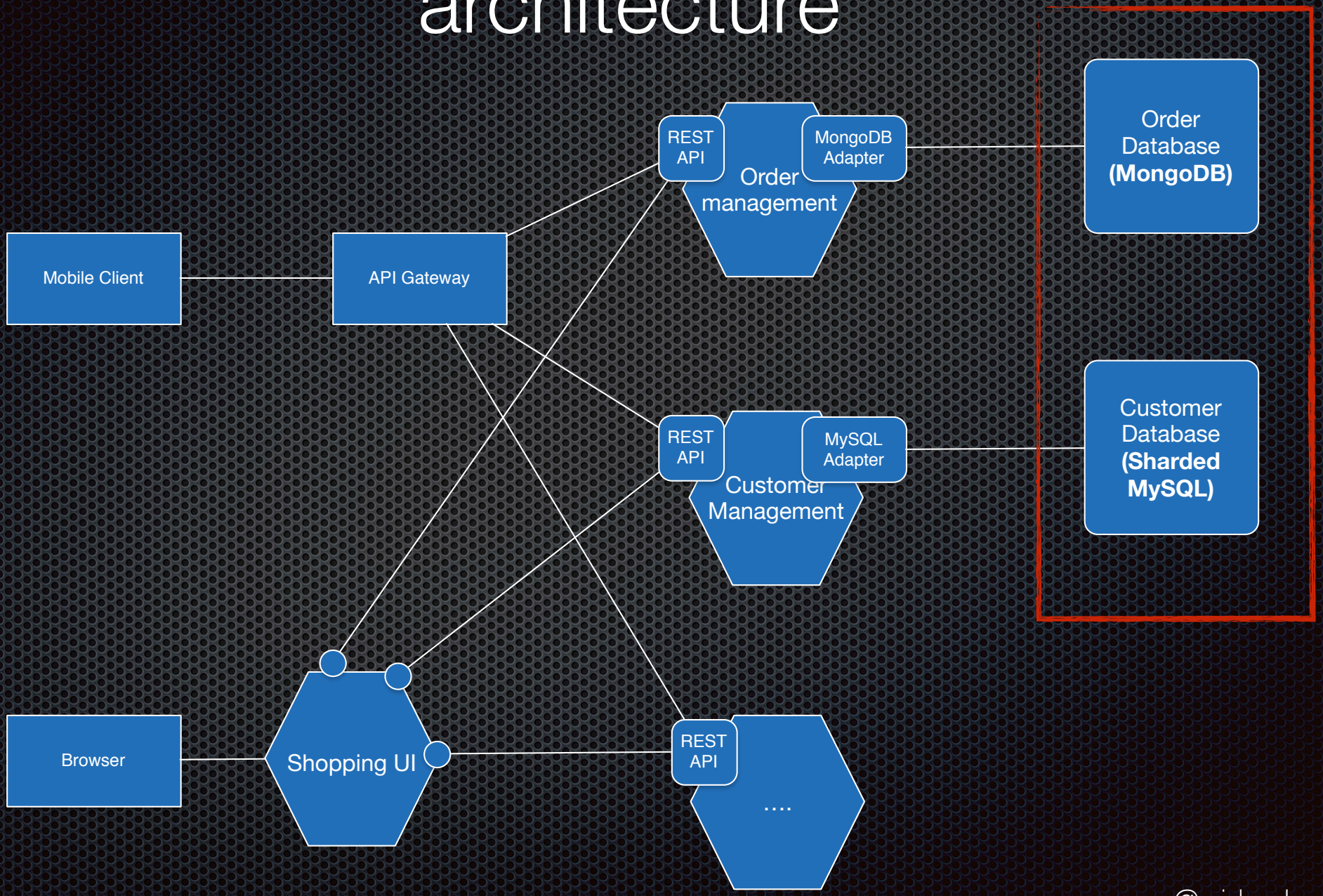
test

deploy

scale

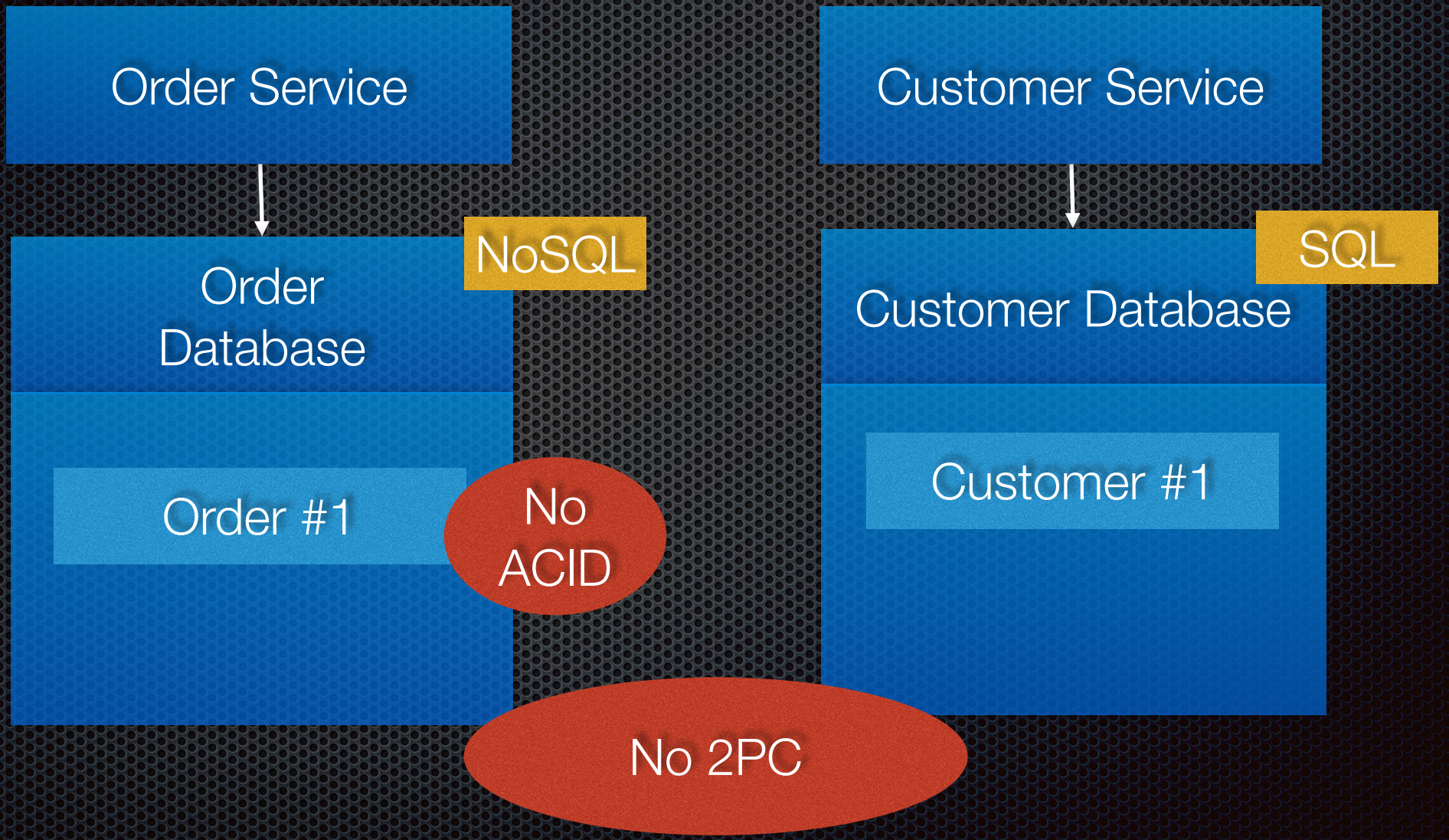

But that leads* to
monolithic hell
For large and/or complex applications...

Today: use a microservice, polyglot architecture

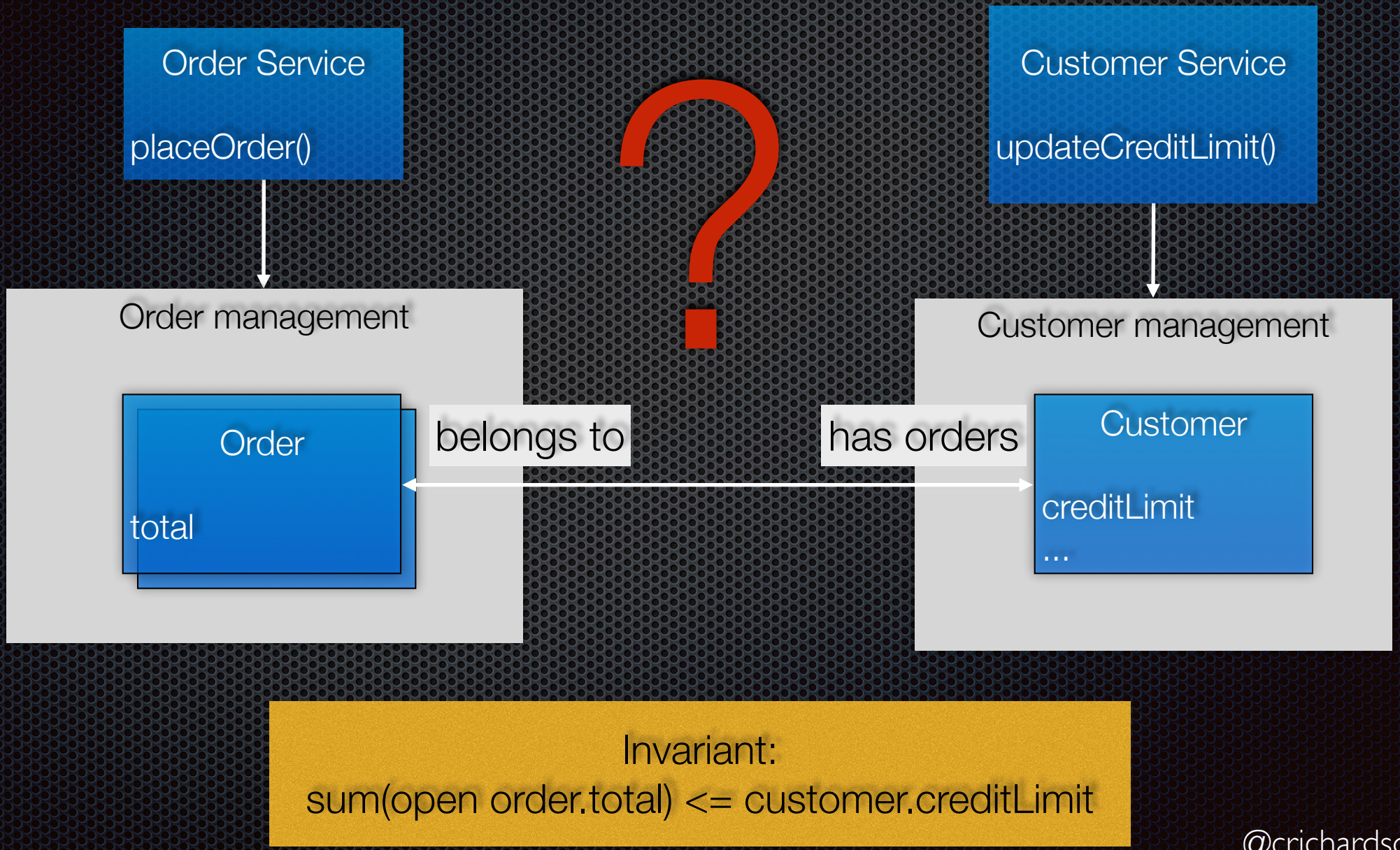


But now we have distributed data management problems

Example: placing an order



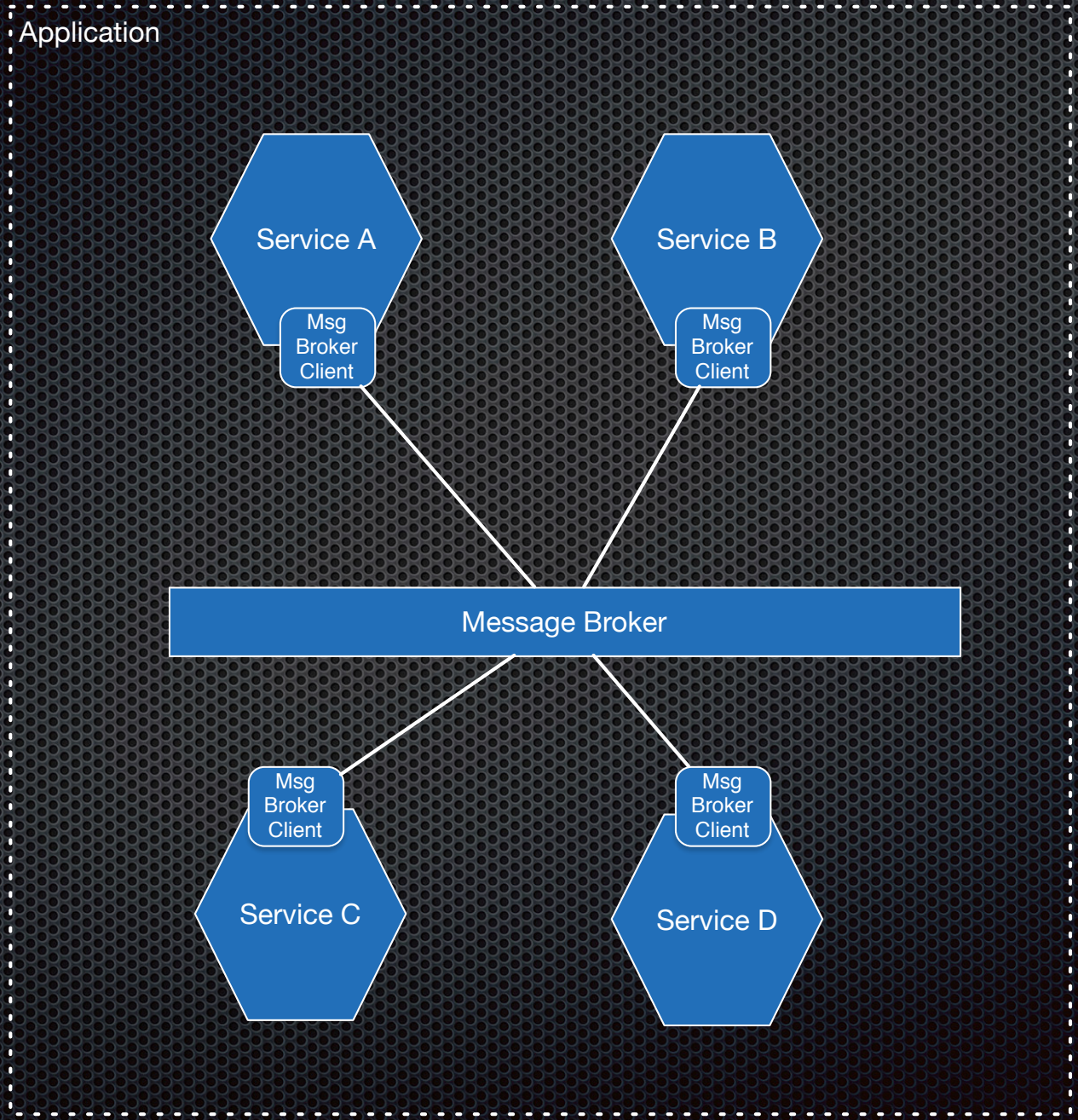
How to maintain invariants?



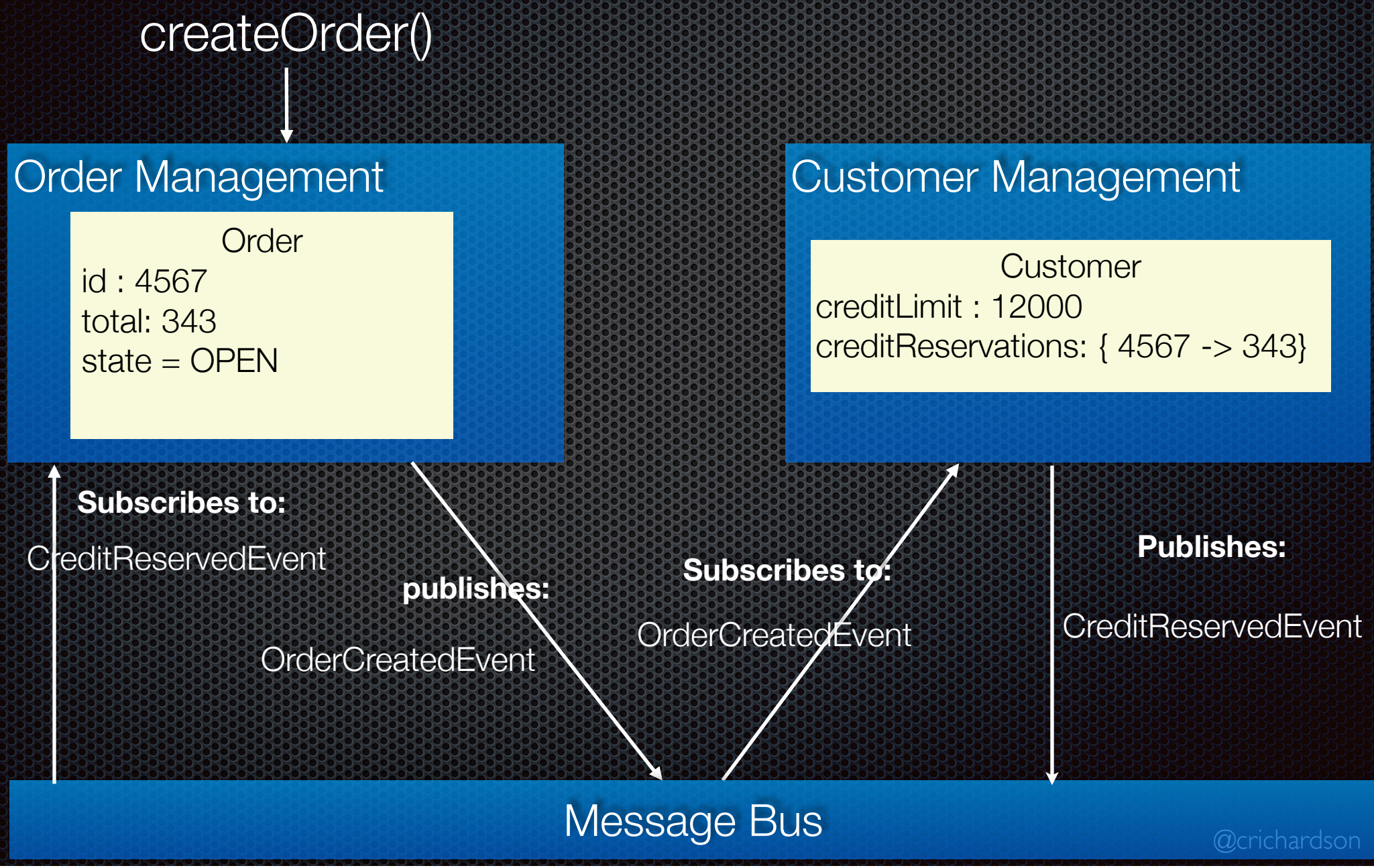
Use an event-driven architecture

- Services **publish** events when something important happens, e.g. state changes
- Services **subscribe** to events and update their state
  - Maintain **eventual consistency** across multiple aggregates (in multiple datastores)
  - Synchronize replicated data

Event-driven application architecture



Eventually consistent credit checking

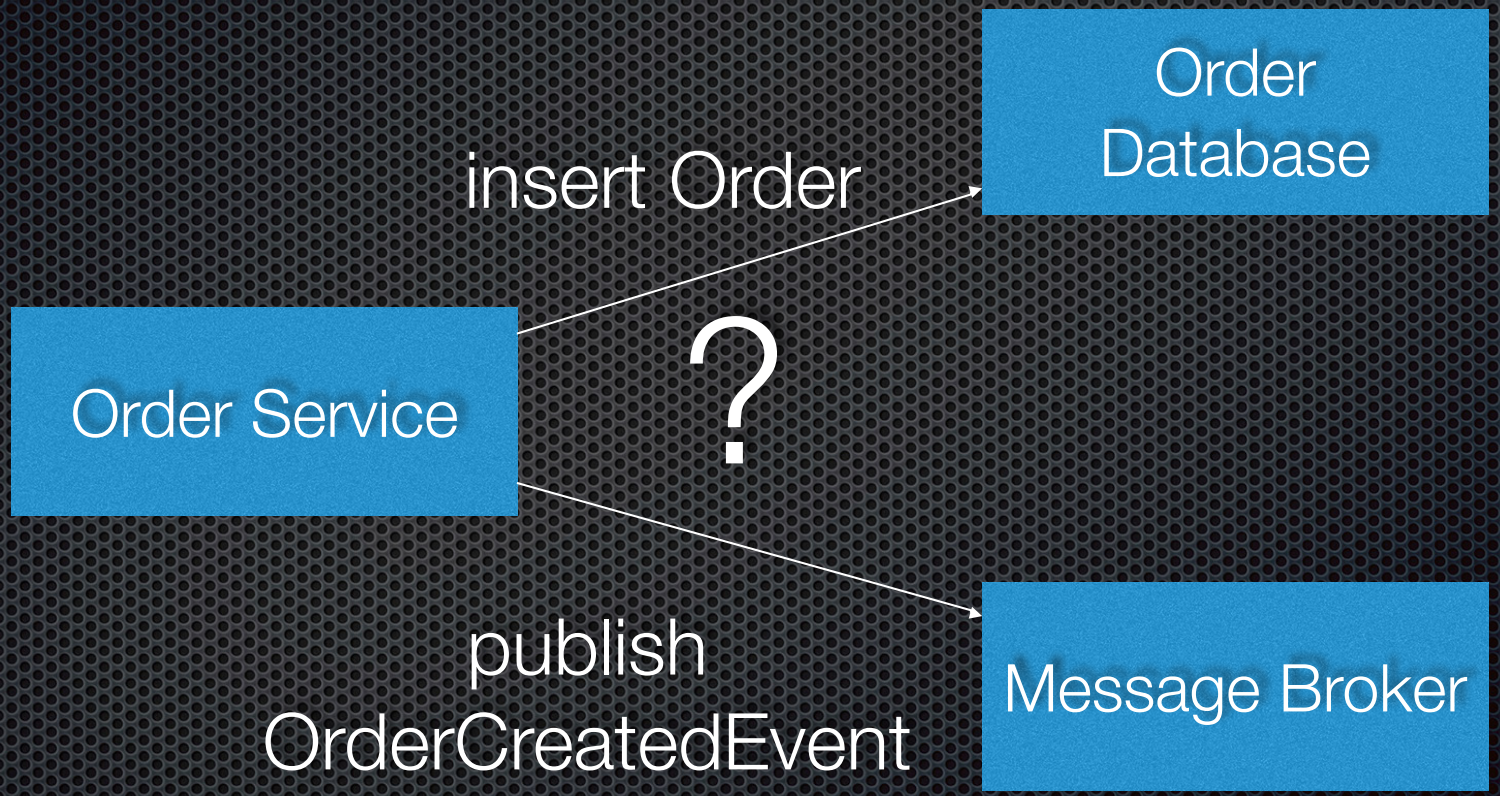


Now there are two problems to solve....

Problem #1: How to design eventually consistent business logic?

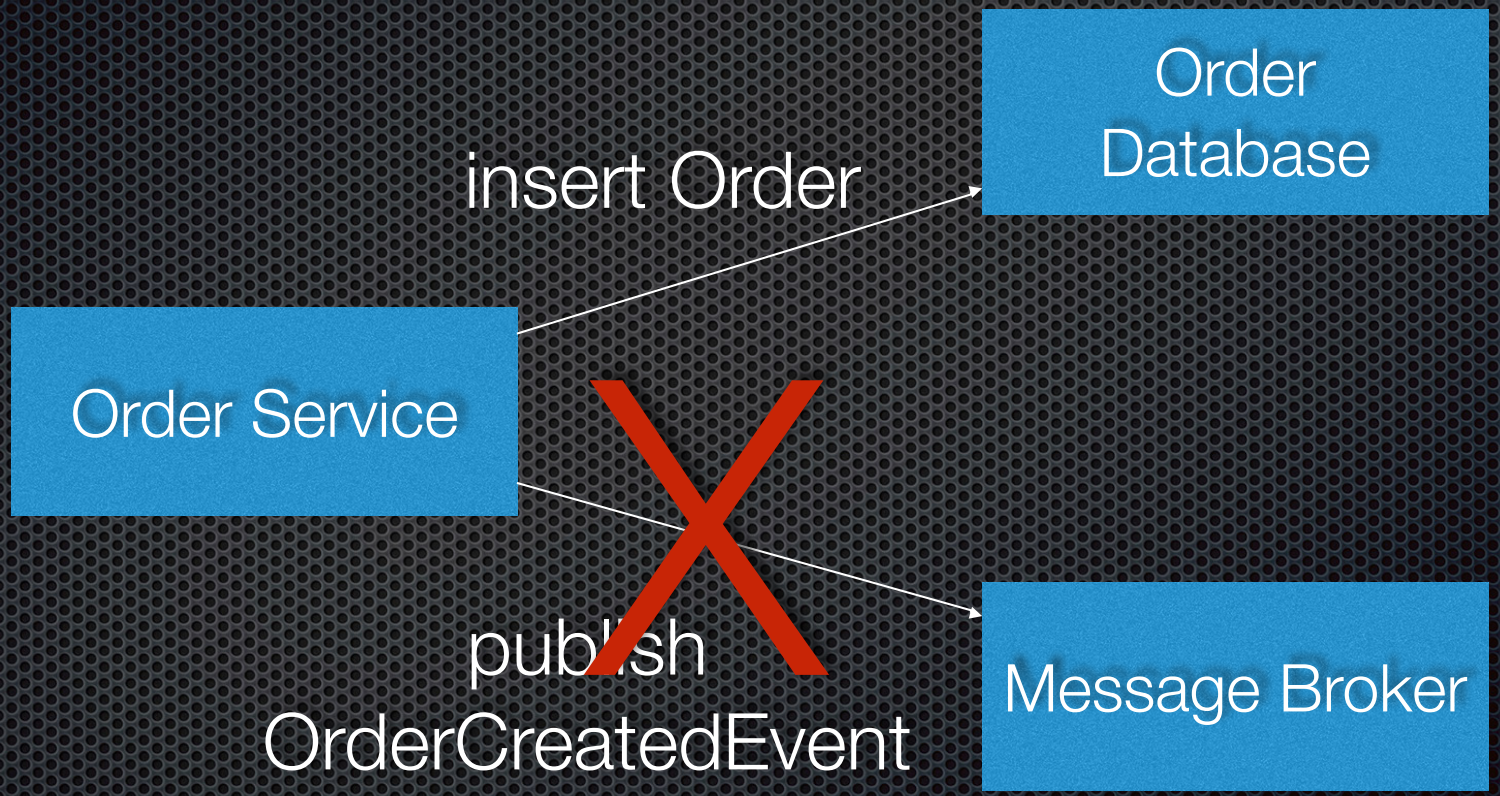
More on that later....

Problem #2: How to atomically update database and publish an event



dual write problem

Failure = inconsistent system




Two-phase commit
@crichardson

Agenda

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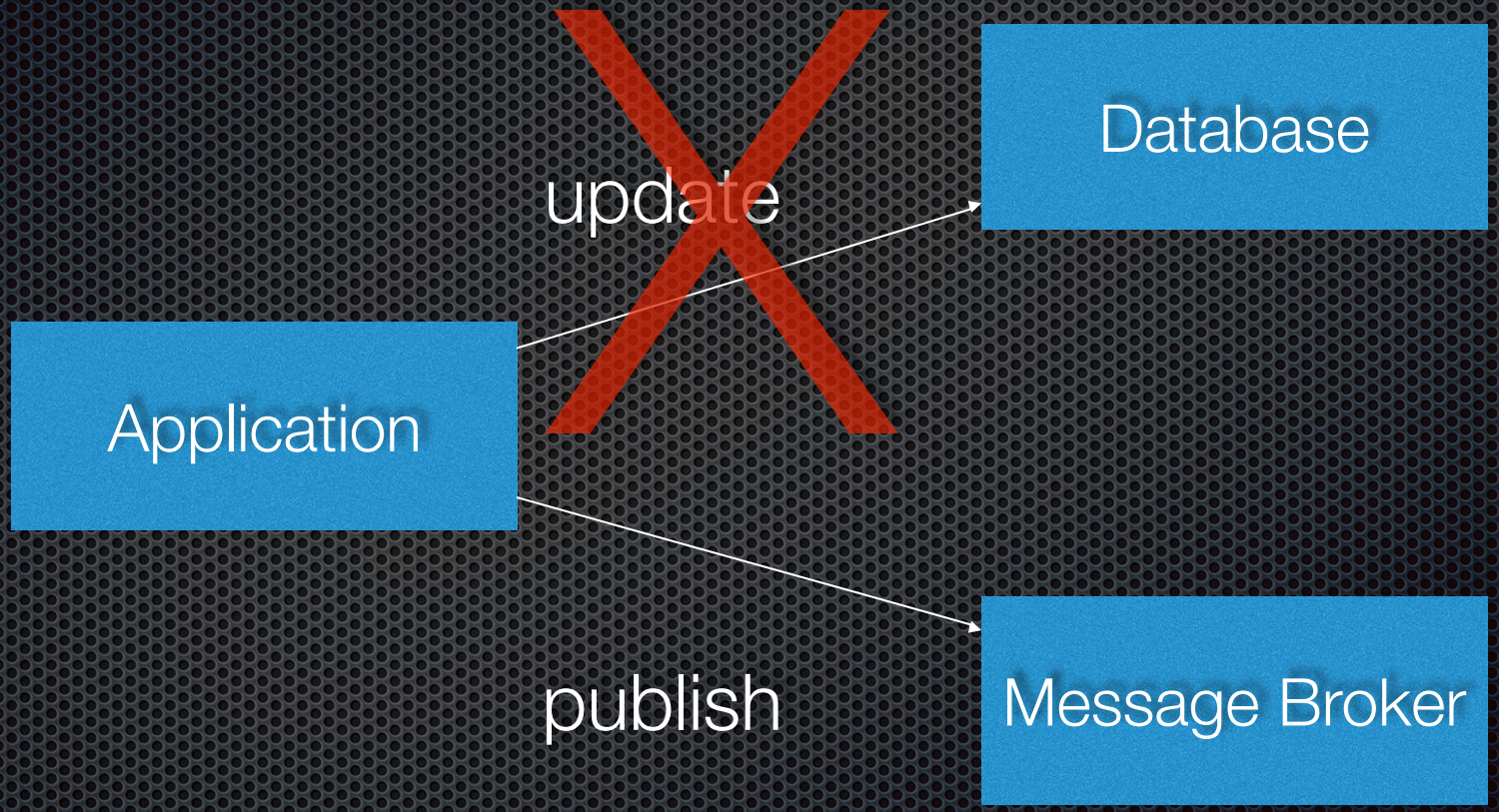
- Events on the inside
- Events at the core with event sourcing
- Designing event-centric domain model

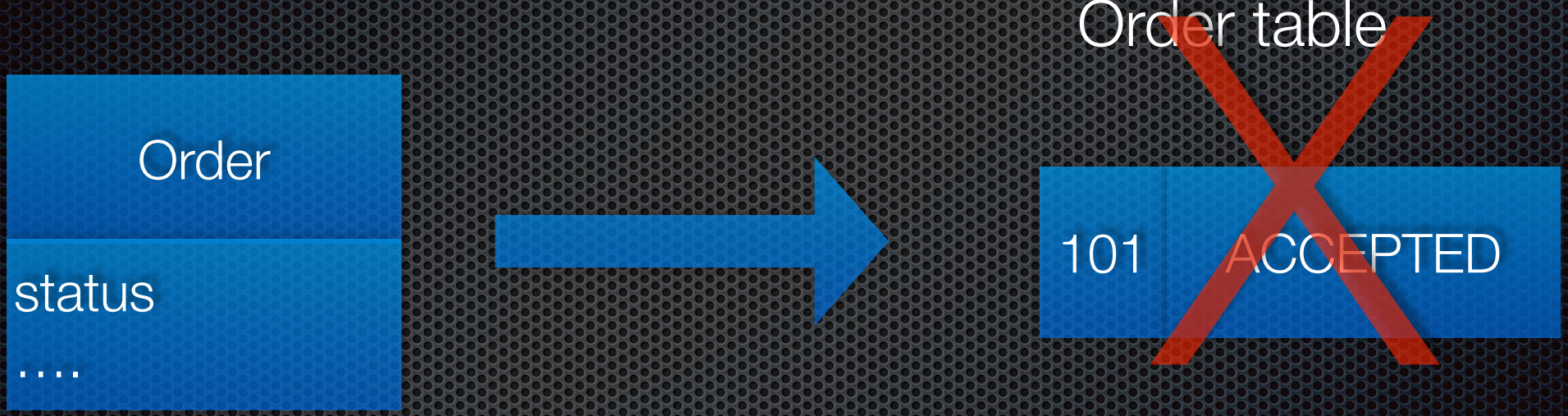
Just publish events



Event sourcing

- For each aggregate (business entity):
  - Identify (state-changing) domain events
  - Define Event classes
- For example,
  - ShoppingCart: ItemAddedEvent, ItemRemovedEvent, OrderPlacedEvent
  - Order: OrderCreated, OrderCancelled, OrderApproved, OrderRejected, OrderShipped

Persists events
NOT current state

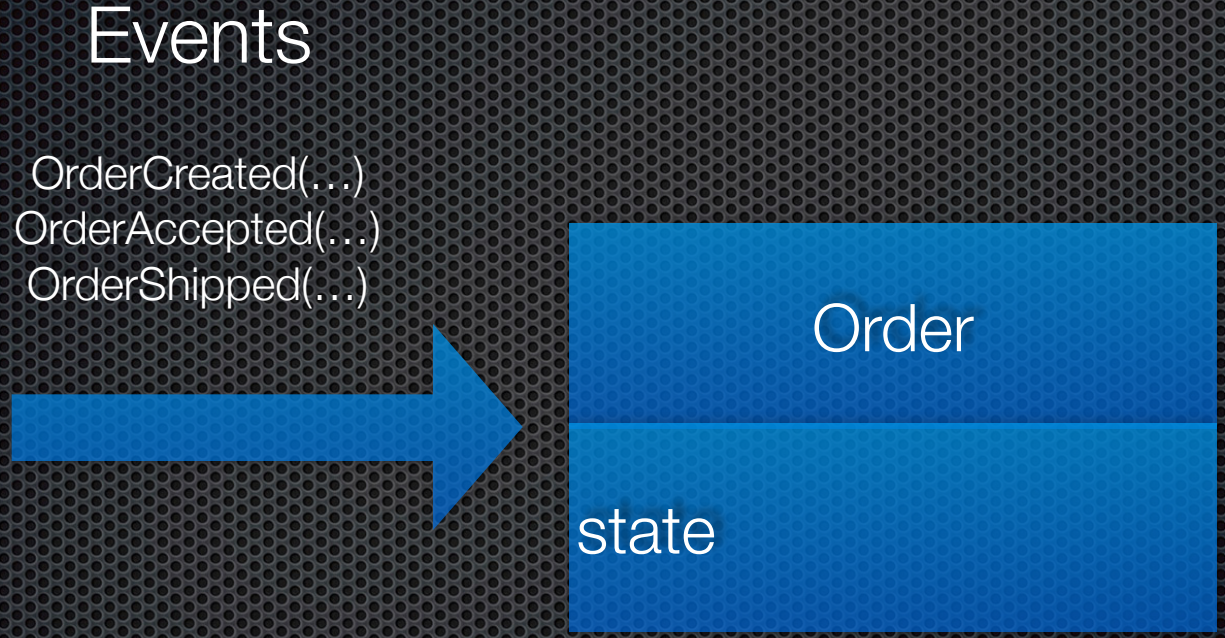


Persists events NOT current state

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

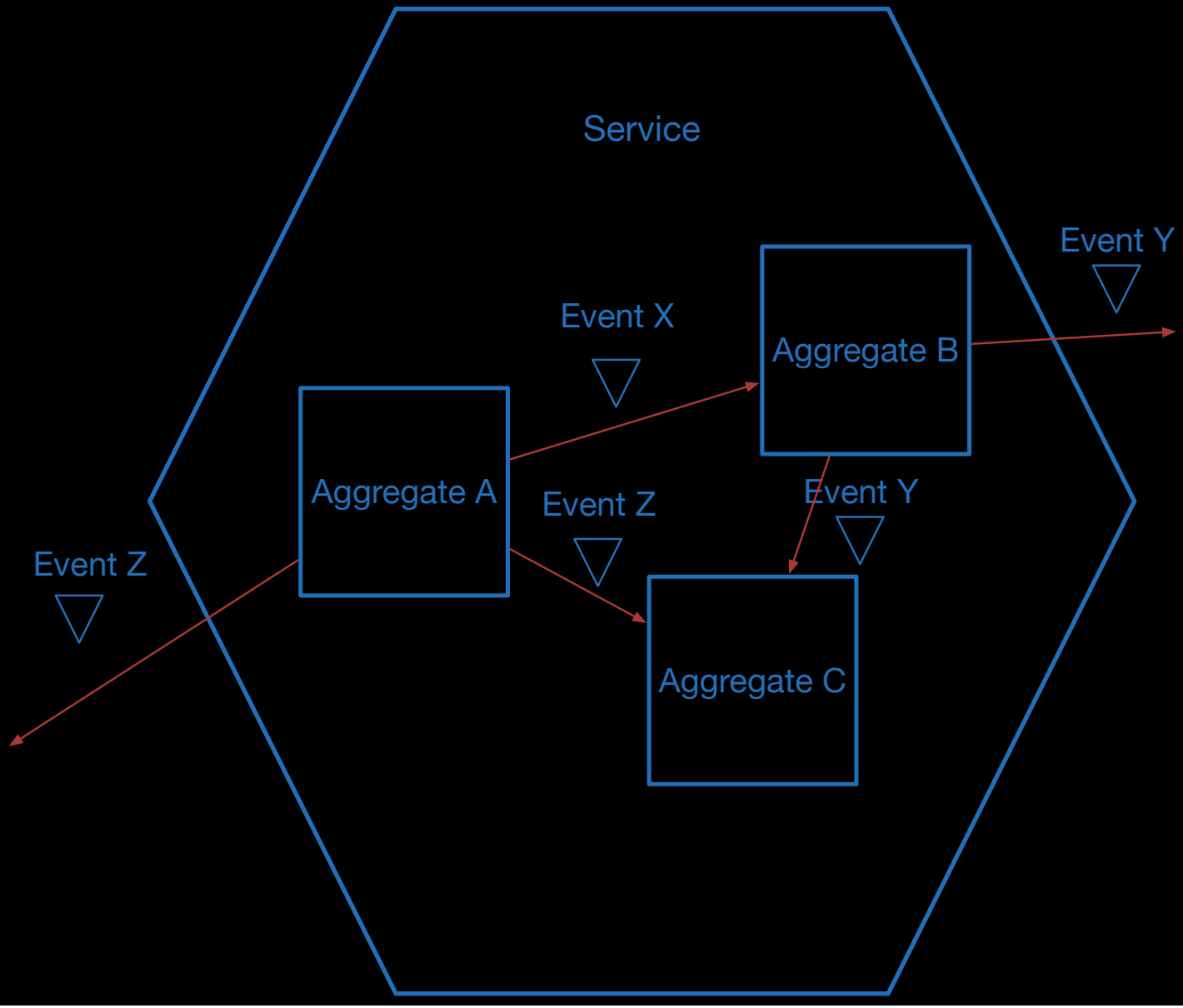


Periodically snapshot to avoid loading all events

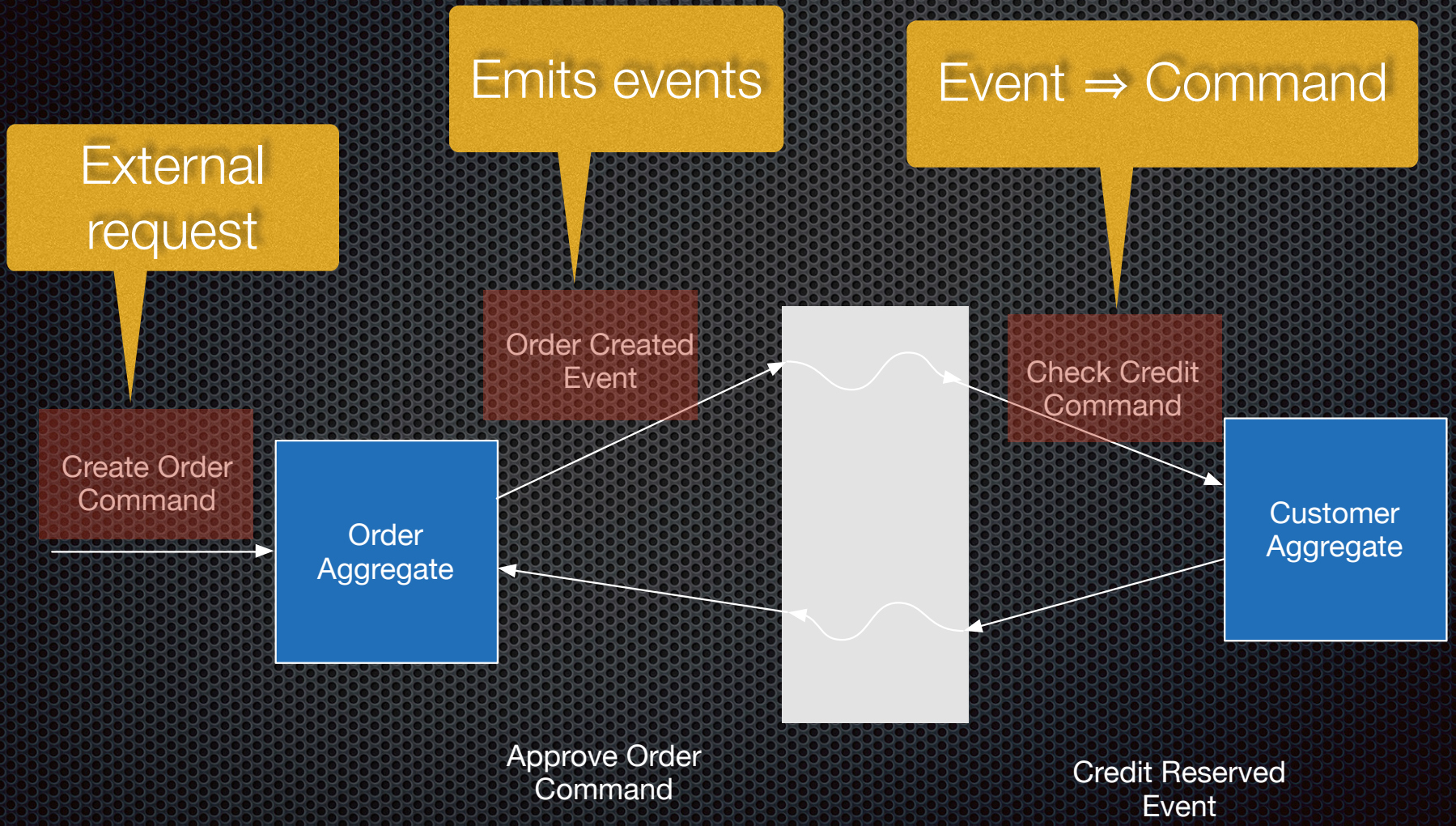
The present is a fold over history

currentState = foldl(applyEvent, initialState, events)

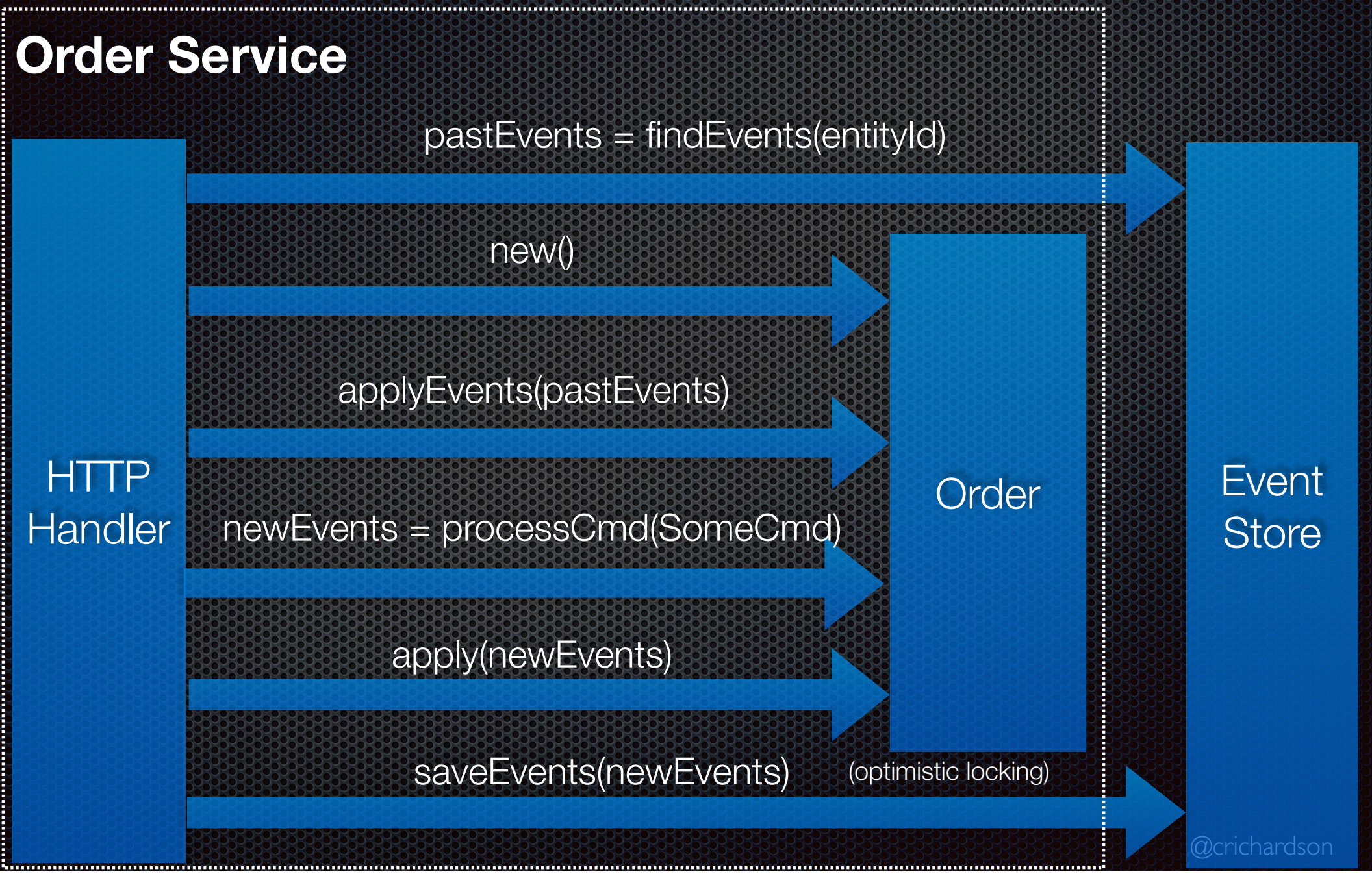
Events at the core



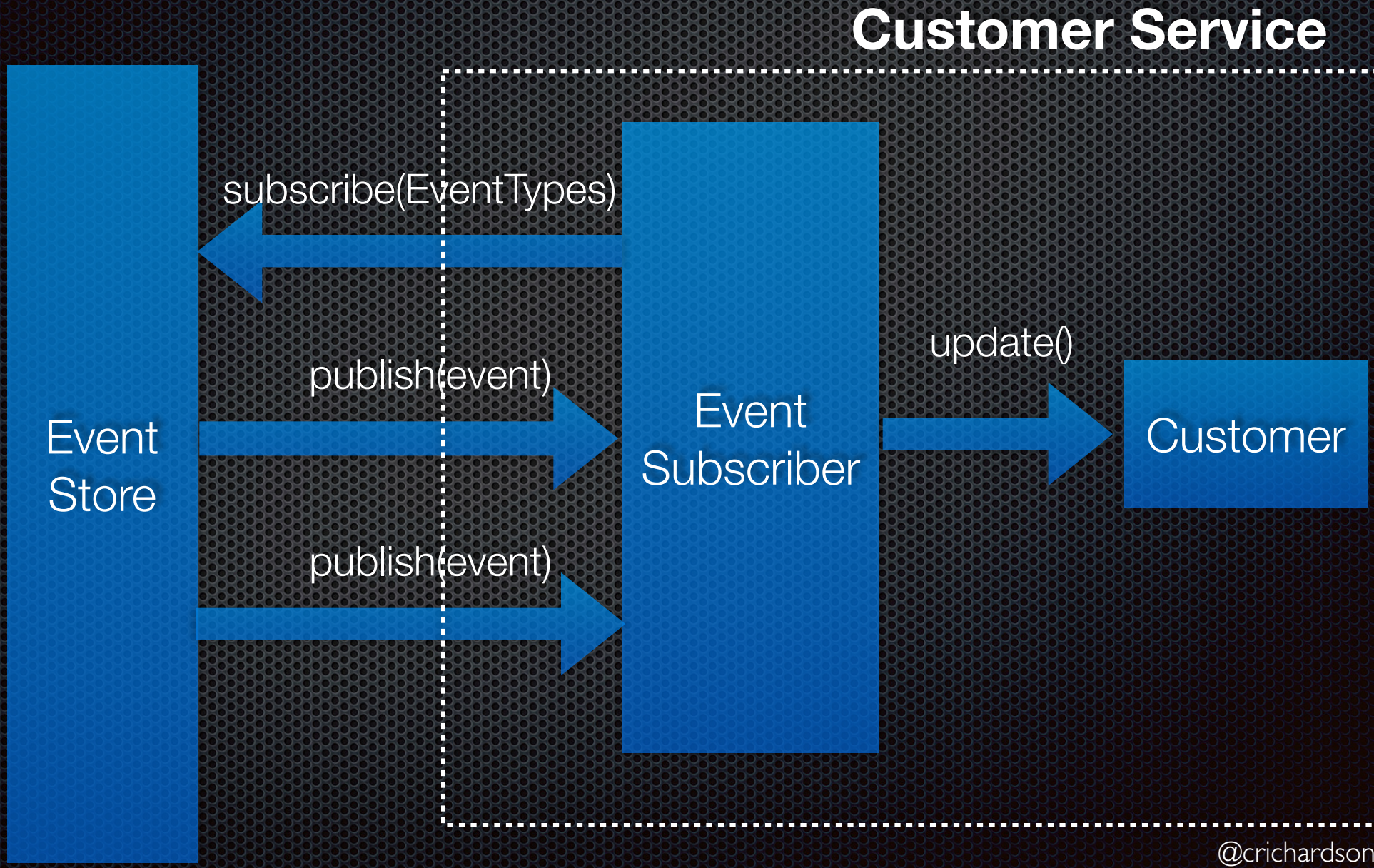
Domain logic = event-driven aggregates



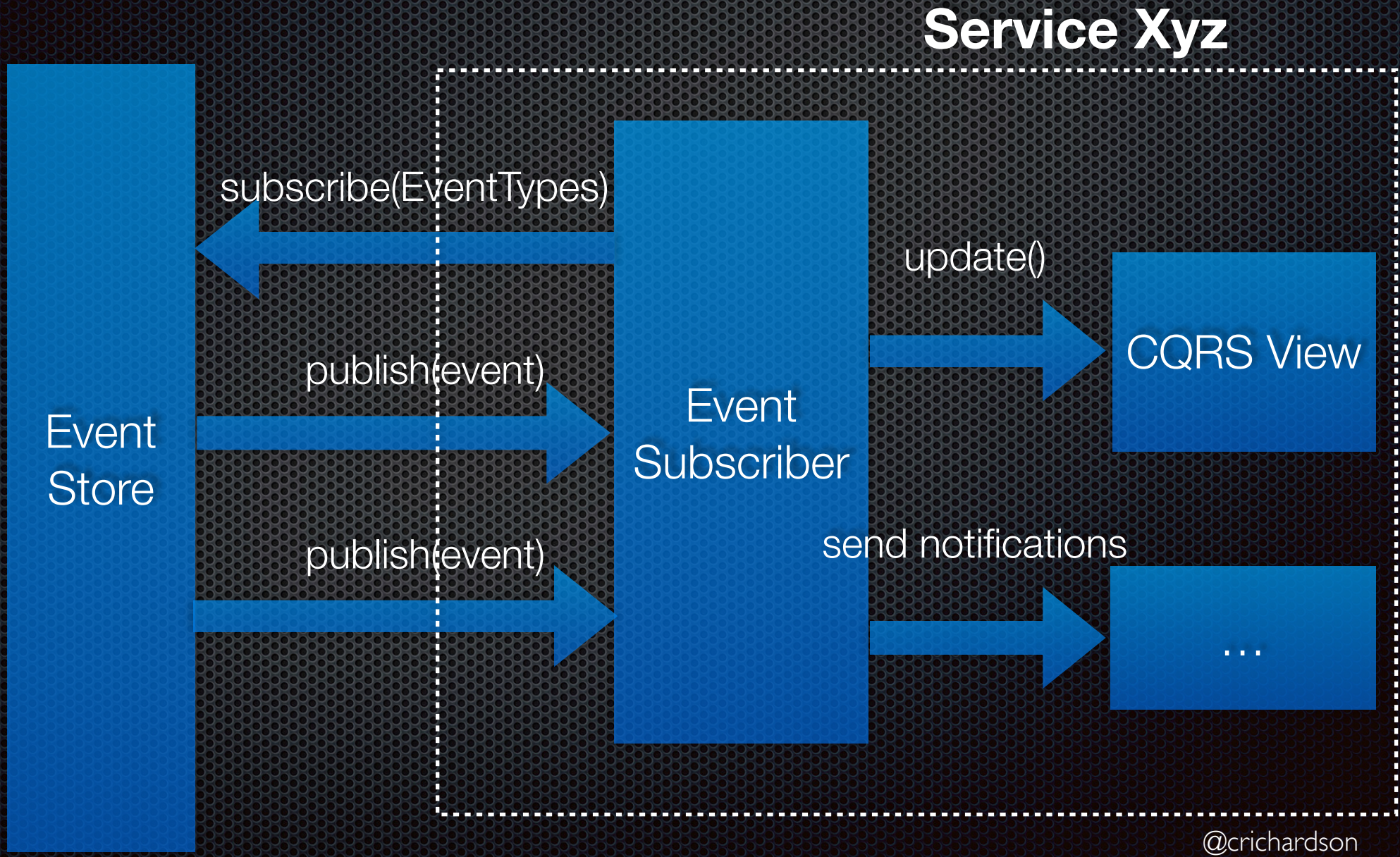
Request handling in an event sourced application



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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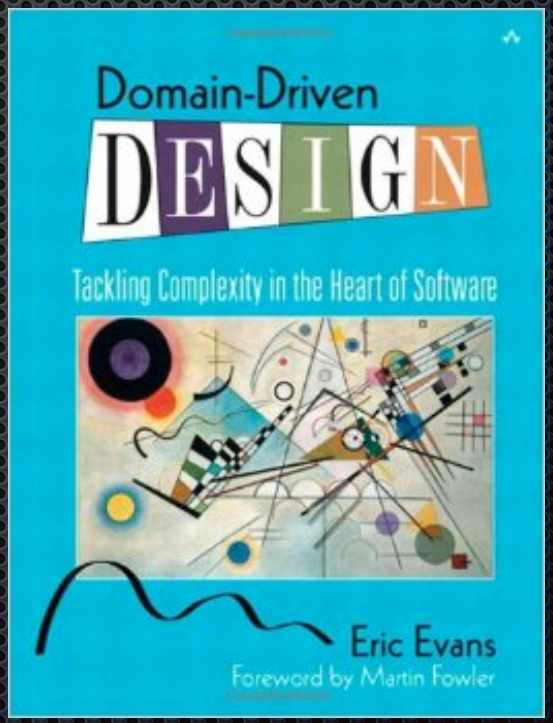
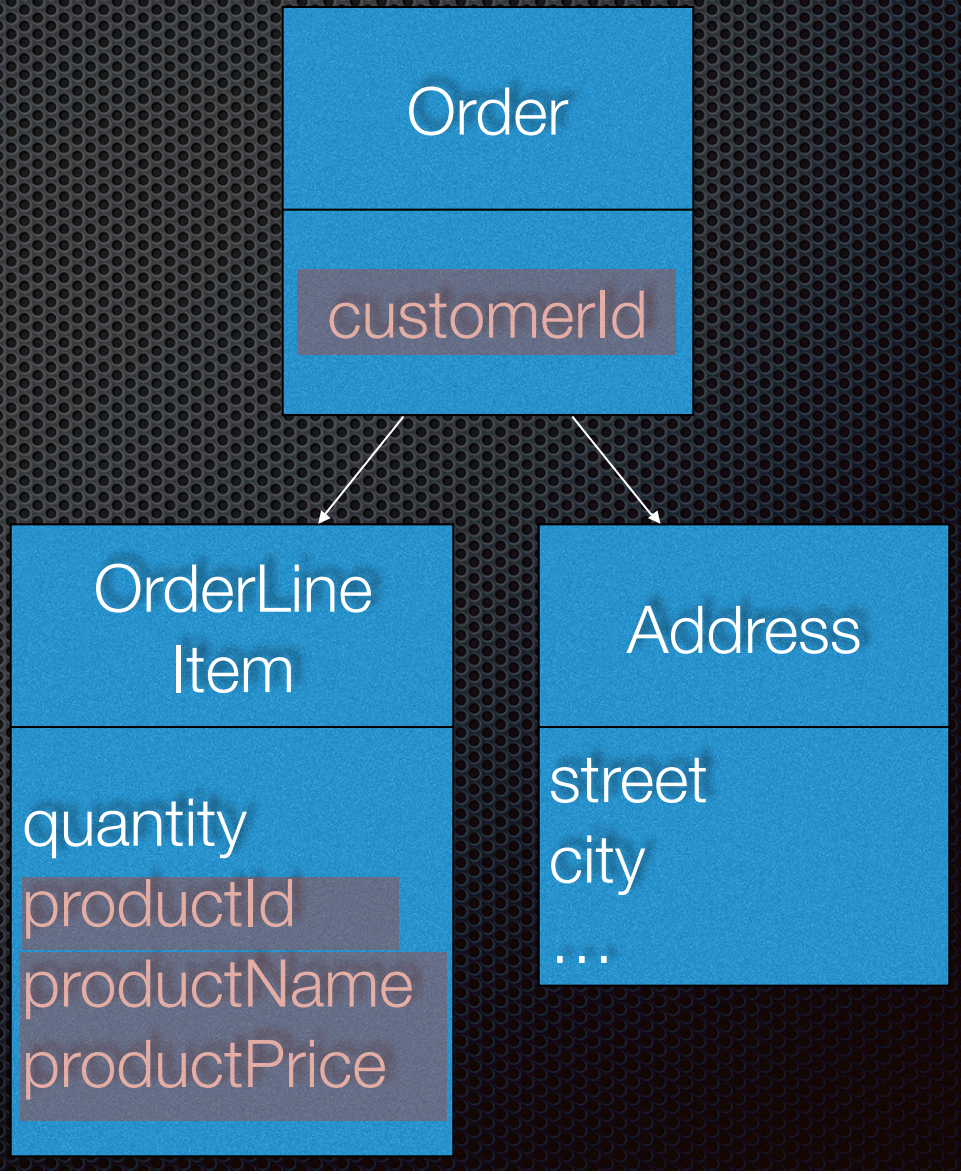
Use the familiar building blocks of DDD

- Entity
- Value object
- Services
- Repositories
- Aggregates ⟸ **essential**

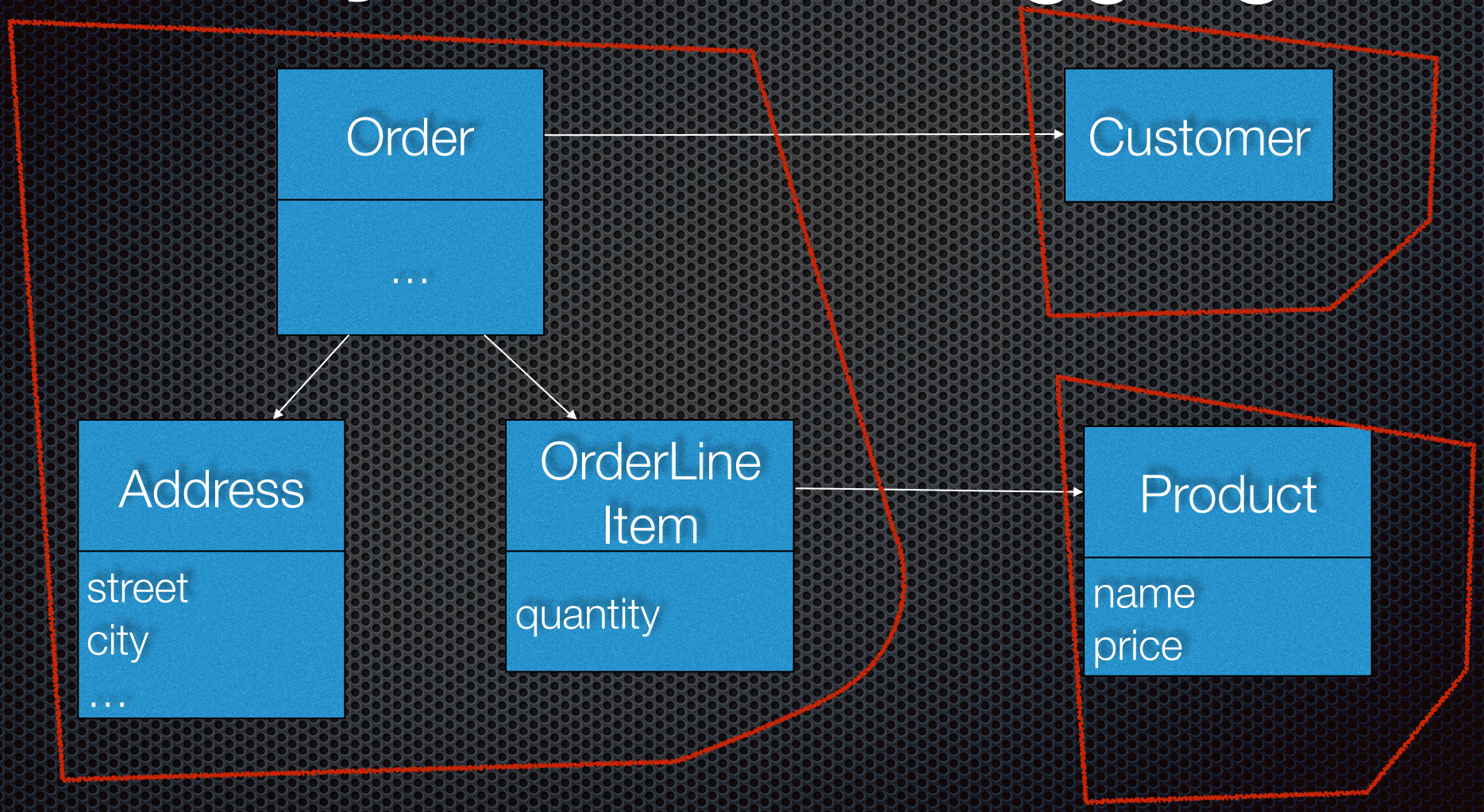


About Aggregates

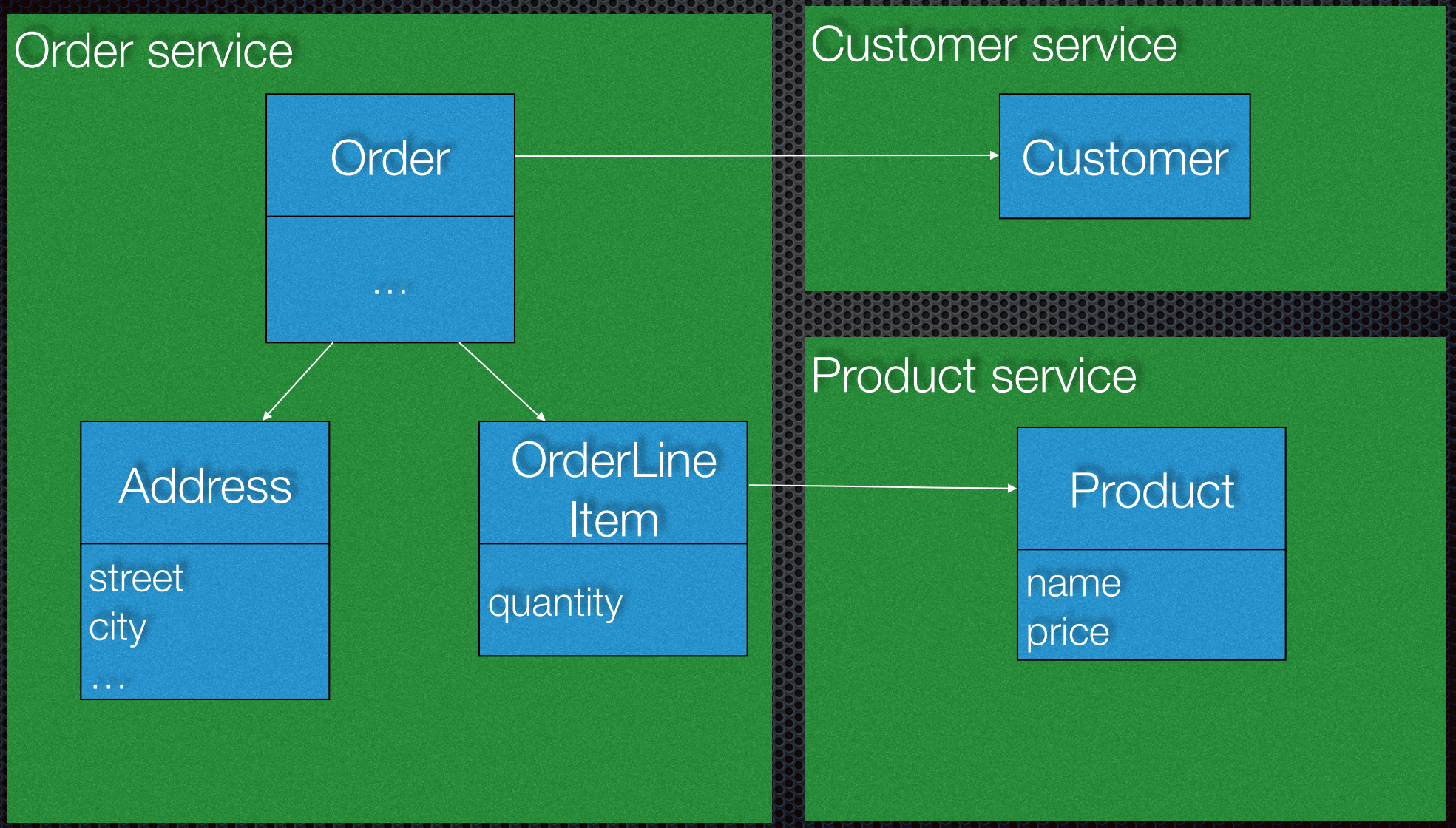
- Graph consisting of a root entity and one or more other entities and value objects
- Each core business entity = Aggregate: e.g. customer, Account, Order, Product, ….
- Reference other aggregate roots via primary key
- Often contains partial copy of other aggregates' data



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



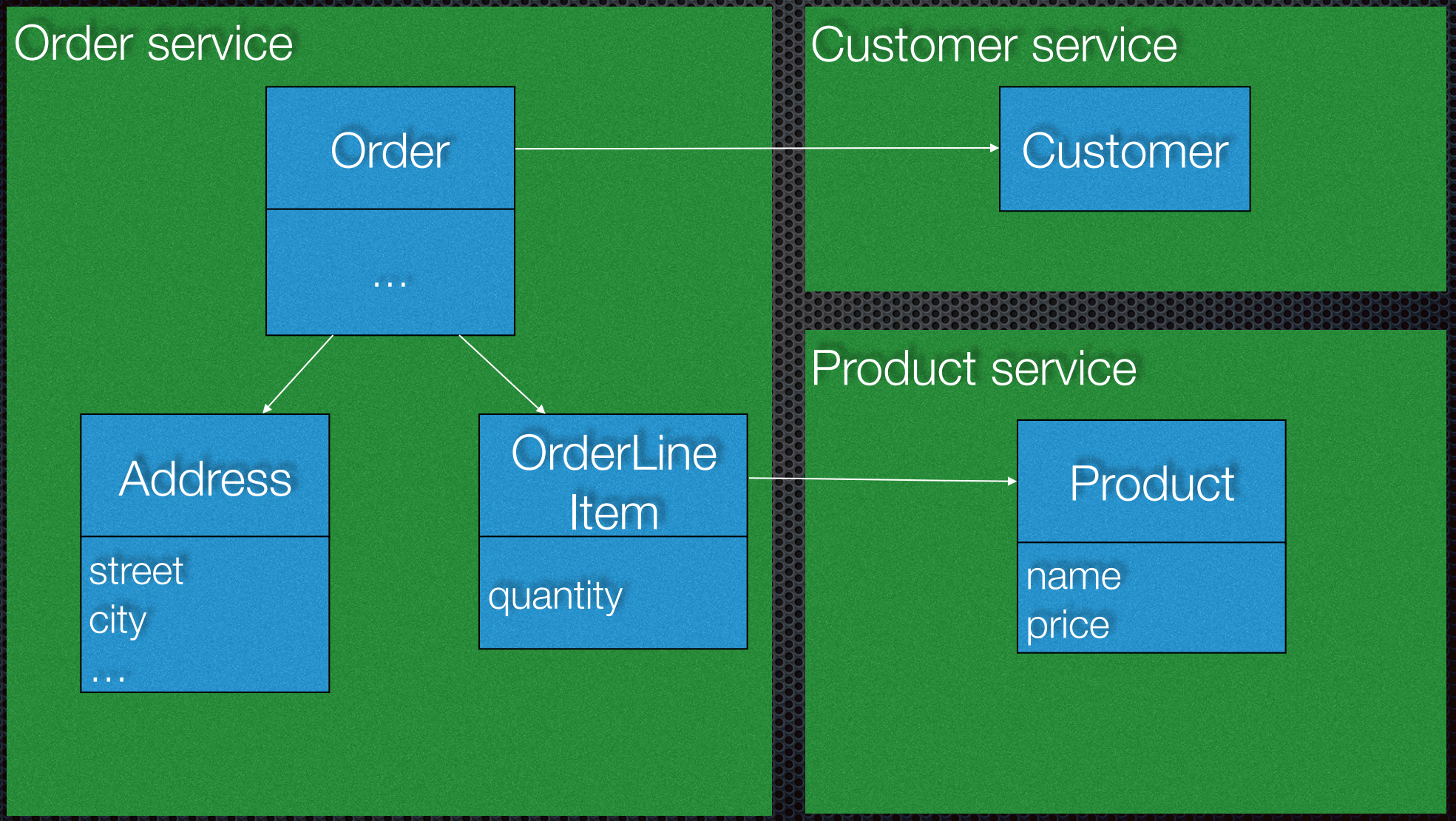
Easily partition into microservices



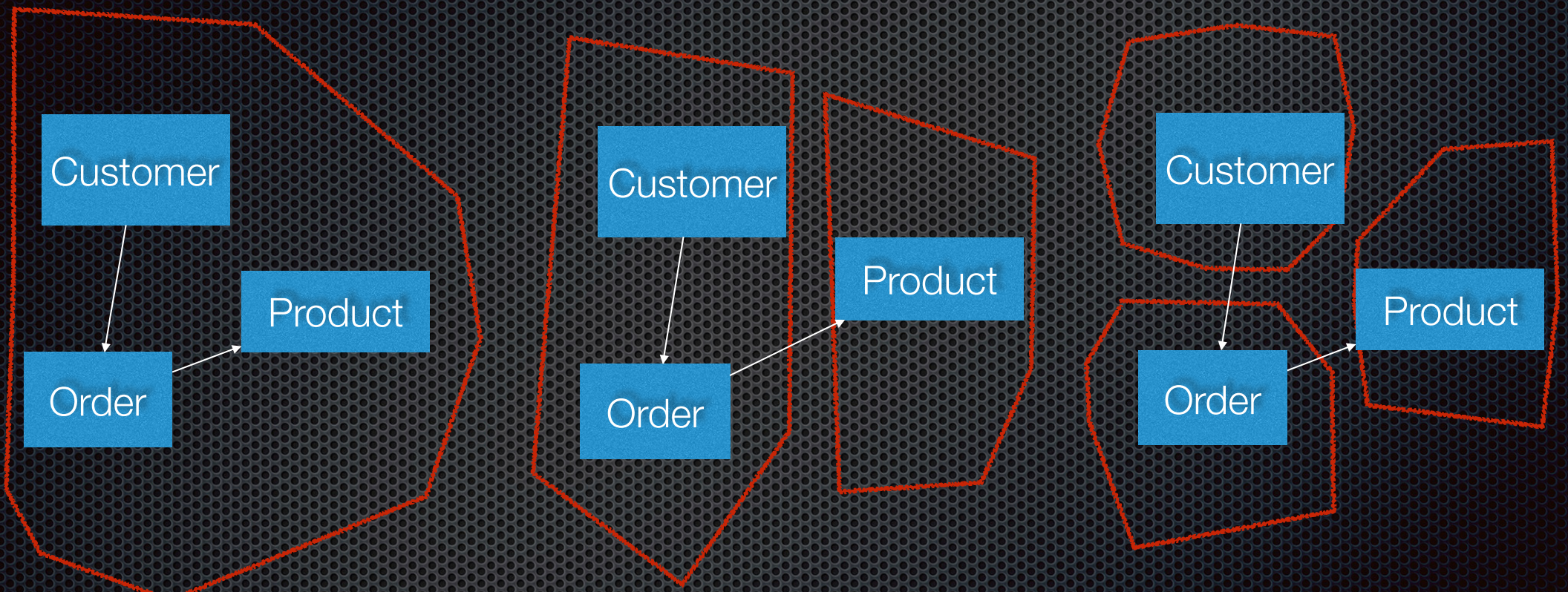
Transaction = processing one command by one aggregate

- No opportunity to update multiple aggregates within a transaction ⇒ event driven eventual consistency between aggregates
- If an update must be atomic (i.e. no compensating transaction) then it must be handled by a single aggregate
- **Therefore,** aggregate granularity is important

Transaction scope = service



Aggregate granularity

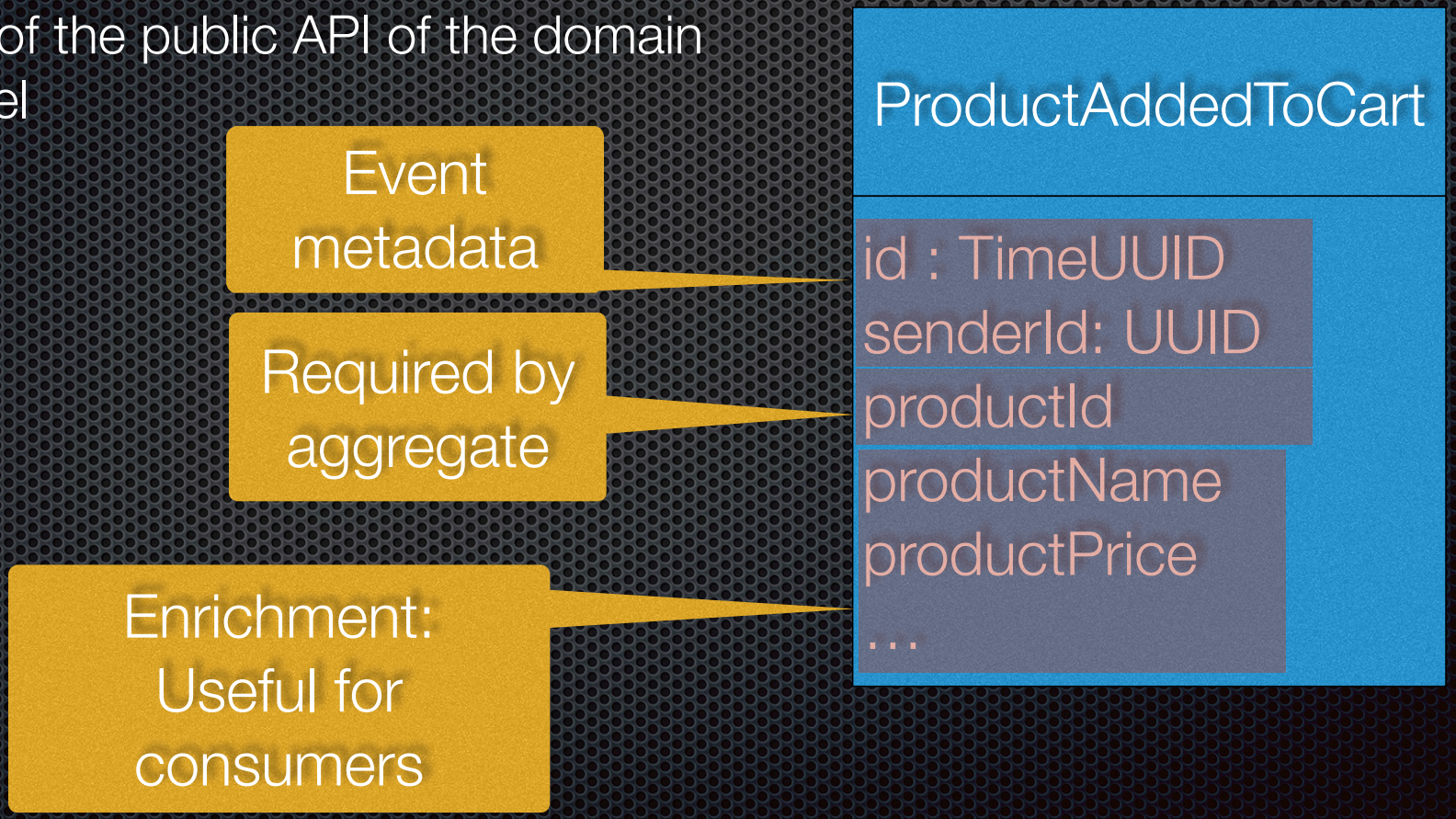


Consistency

Scalability/
User experience

Designing domain events

- Record state changes for an aggregate
- Part of the public API of the domain model



Example event

```
public class OrderCreatedEvent implements OrderEvent {
  private Money orderTotal;
  private EntityIdentifier customerId;

  @Override
  public boolean equals(Object obj) { return EqualsBuilder.reflectionEquals(this, obj); }

  @Override
  public int hashCode() { return HashCodeBuilder.reflectionHashCode(this); }

  public OrderCreatedEvent(EntityIdentifier customerId, Money orderTotal) {...}

  public Money getOrderTotal() { return orderTotal; }

  public EntityIdentifier getCustomerId() { return customerId; }
}
```

Designing commands

- Created by a service from incoming request
- Processed by an aggregate
- Immutable
- Contains value objects for
  - Validating request
  - Creating event
  - Auditing user activity

Example command

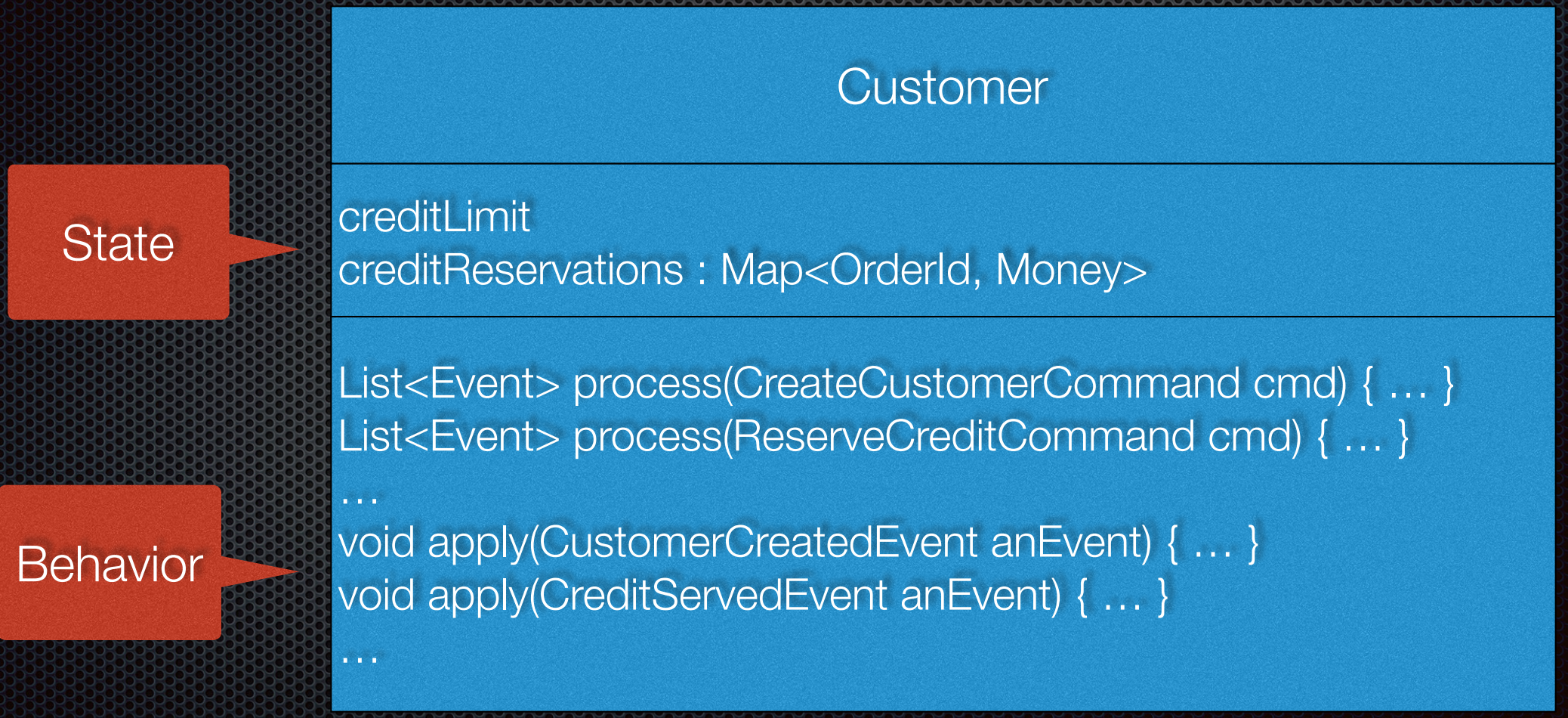
```
public class CreateCustomerCommand implements CustomerCommand {
  private final String name;
  private final Money creditLimit;

  public CreateCustomerCommand(String name, Money creditLimit) {...}

  public Money getCreditLimit() { return creditLimit; }

  public String getName() { return name; }
}
```

Various programming models

- “Traditional Java” mutable object-oriented domain objects
  - https://github.com/cer/event-sourcing-examples/tree/master/java-spring
- Functional Scala with immutable domain objects
  - https://github.com/cer/event-sourcing-using-scala-typeclasses
- Hybrid OO/Functional Scala with immutable domain objects
  - https://github.com/cer/event-sourcing-examples/tree/master/scala-spring

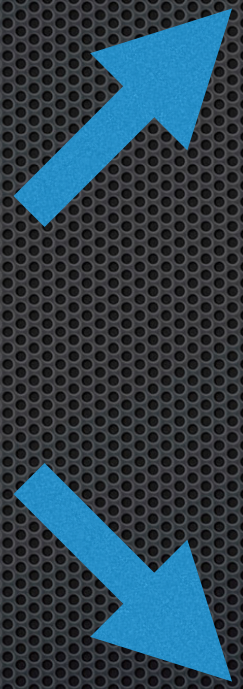
Hybrid OO/FP domain objects

OO = State + Behavior



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 … new CreditReservedCredit();
  }
```

```
 public void apply(
       CreditReservedCredit 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
  }

}
```

Creating an order

```
public class OrderServiceImpl implements OrderService {

  private final AggregateRepository<Order, OrderCommand> orderRepository;

  public OrderServiceImpl(AggregateRepository<Order, OrderCommand> orderRepository) {
    this.orderRepository = orderRepository;
  }

  @Override
  public Observable<EntityWithIdAndVersion<Order>>
        createOrder(EntityIdentifier customerId, Money orderTotal) {
    return orderRepository.save(new CreateOrderCommand(customerId, orderTotal));
  }
}
```

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

Event handling in Customers

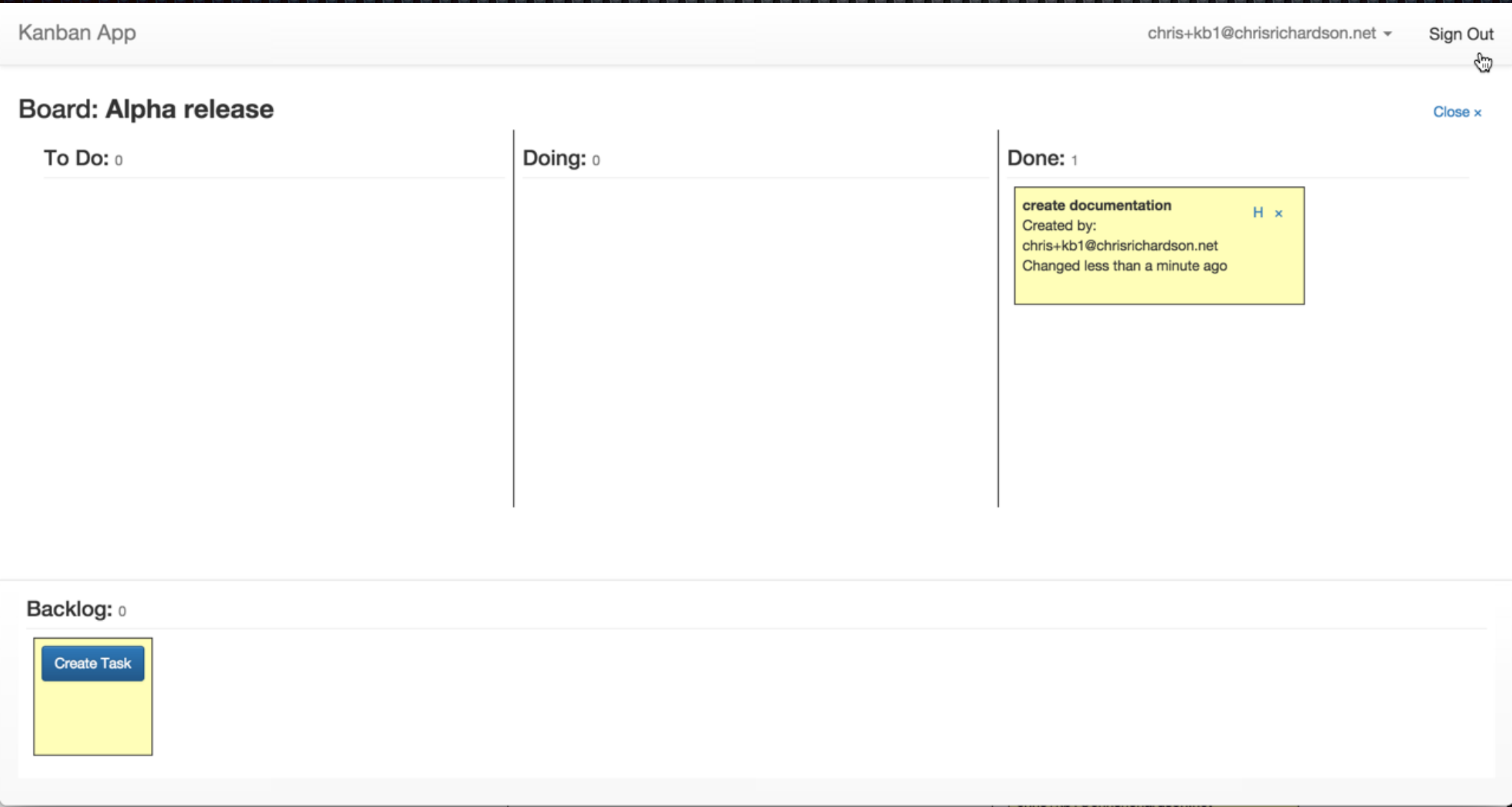
Triggers BeanPostProcessor

Durable subscription name

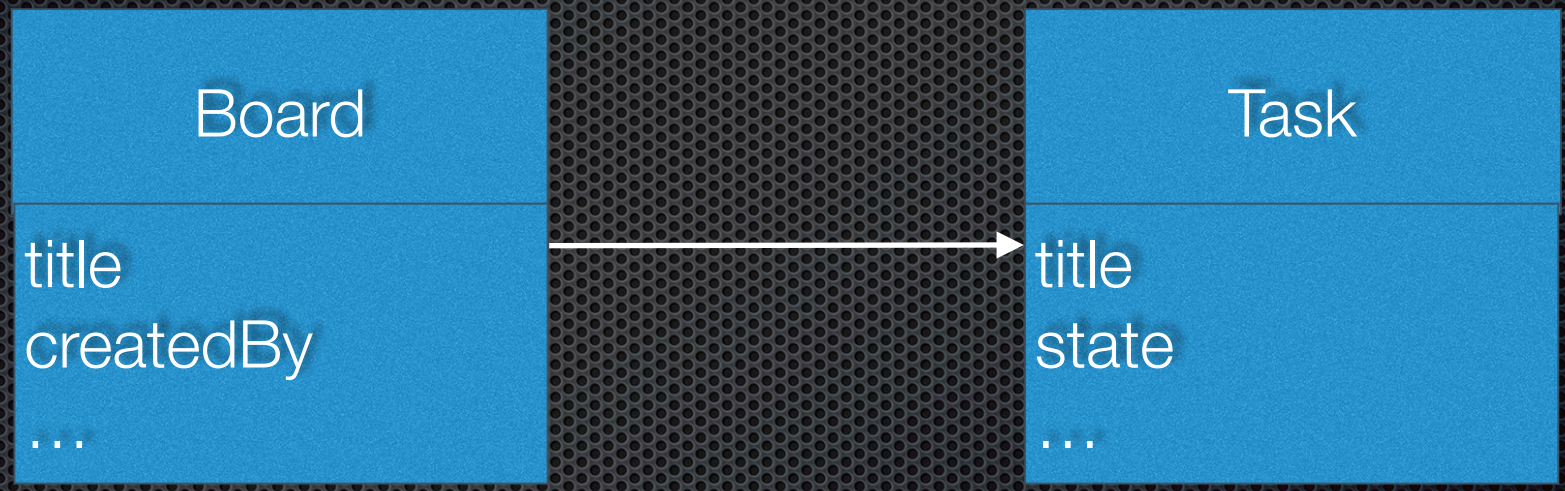
```
@EventSubscriber(id="customerWorkflow")
public class CustomerWorkflow {

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

    return ctx.update(Customer.class, customerId, new ReserveCreditCommand(orderTotal, orderId));
  }

}
```

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

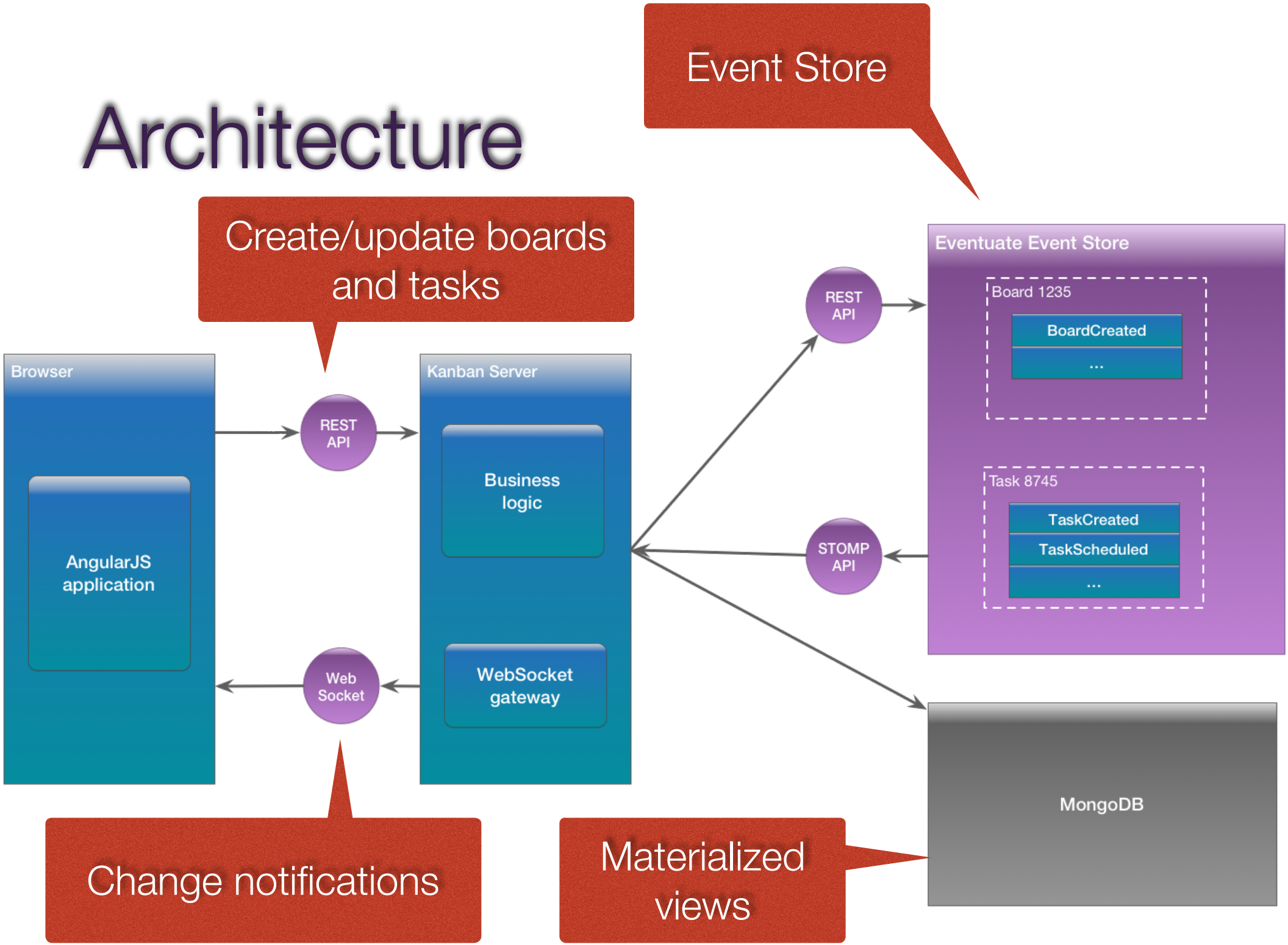
Kanban board example

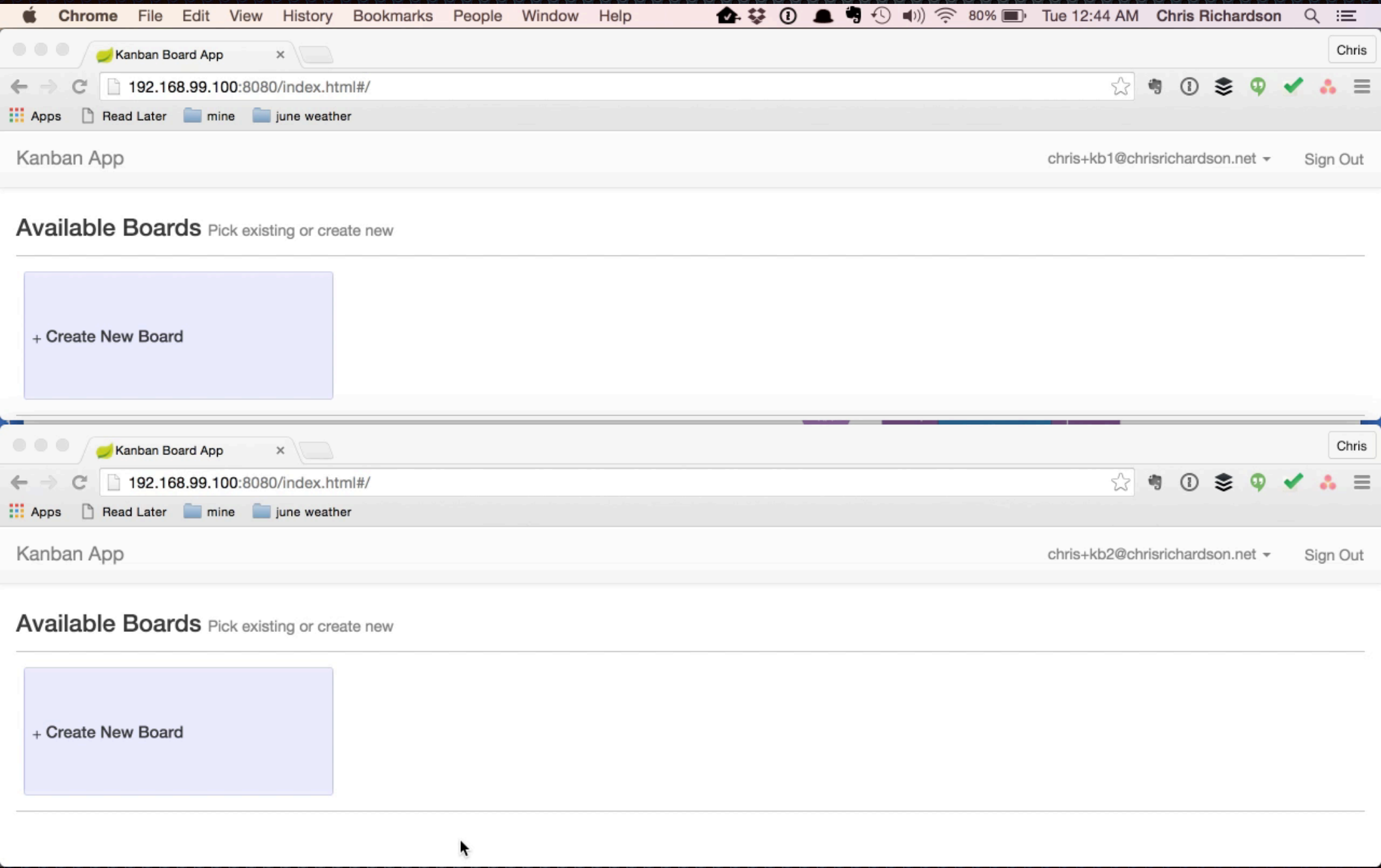


Kanban domain model



Architecture




Chrome File Edit View History Bookmarks People Window Help 80% Tue 12:44 AM Chris Richardson
Kanban Board App
Chris
192.168.99.100:8080/index.html#/
Apps Read Later mine june weather
Kanban App
chris+kb1@chrisrichardson.net
Sign Out
Available Boards Pick existing or create new
+ Create New Board
Kanban Board App
Chris
192.168.99.100:8080/index.html#/
Apps Read Later mine june weather
Kanban App
chris+kb2@chrisrichardson.net
Sign Out
Available Boards Pick existing or create new
+ Create New Board

Summary

- Events are a central to modern applications
- Events integrate applications
- Events maintain data consistency in a microservices architecture

⇒

- Build events into the core of your application using event sourcing


@crichardson chris@chrisrichardson.net
Questions?
http://plainoldobjects.com
http://microservices.io
http://eventuate.io