Micro Services Architecture

Part 1 : Infrastructure Comparison &
Design Styles (DDD, Event Sourcing / CQRS, Functional Reactive Programming)

Araf Karsh Hamid – Co Founder / CTO, MetaMagic Global Inc., NJ, USA

*A **Micro Service** will have its own Code Pipeline for build and deployment functionalities and it's scope will be defined by the Bounded Context focusing on the Business Capabilities and the interoperability between Micro Services will be achieved using message based communication.*

Pioneers in Microservices Implementation

New Entrants

Agenda

1

Architecture Styles

- Pros and Cons
- Micro Services Characteristics
- Monolithic Vs. Micro Services Architecture
- SOA Vs. Micro Services Architecture
- App Scalability Based on Micro Services
- Hexagonal Architecture

2

Design Styles

- Design Patterns
- Domain Driven Design
- Event Sourcing & CQRS
- Functional Reactive Programming

3

Scalability

- CAP Theorem
- Distributed Transactions : 2 Phase Commit
- SAGA Design Pattern
- Scalability Lessons from EBay
- Design Patterns
- References

Pros and Cons

Pros

1. Robust
2. Scalable
3. Testable (Local)
4. Easy to Change and Replace
5. Easy to Deploy
6. Technology Agnostic

Cons

1. Adds Complexity
2. Skillset shortage
3. Confusion on getting the right size
4. Team need to manage end-to-end of the Service (From UI to Backend to Running in Production).

Micro Services Characteristics

By James Lewis and Martin Fowler

Components via Services

Organized around **Business Capabilities**

Products NOT Projects

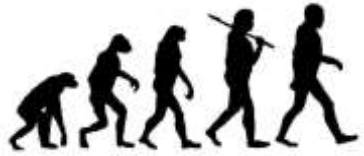
Smart Endpoints & Dumb Pipes

Decentralized Governance & Data Management

Infrastructure **Automation**

Design for **Failure**

Evolutionary Design



The key in making great and growable systems is much more to design how its modules communicate rather than what their internal properties and behaviors should be.
Alan Kay, 1998 email to the Squeak-dev list

Modularity ... is to a technological economy what the division of labor is to a manufacturing one.
W. Brian Arthur,
author of *e Nature of Technology*

We can scale our operation independently, maintain unparalleled system availability, and introduce new services quickly without the need for massive reconfiguration. —
Werner Vogels, CTO, Amazon Web Services

Micro Services System Design Model

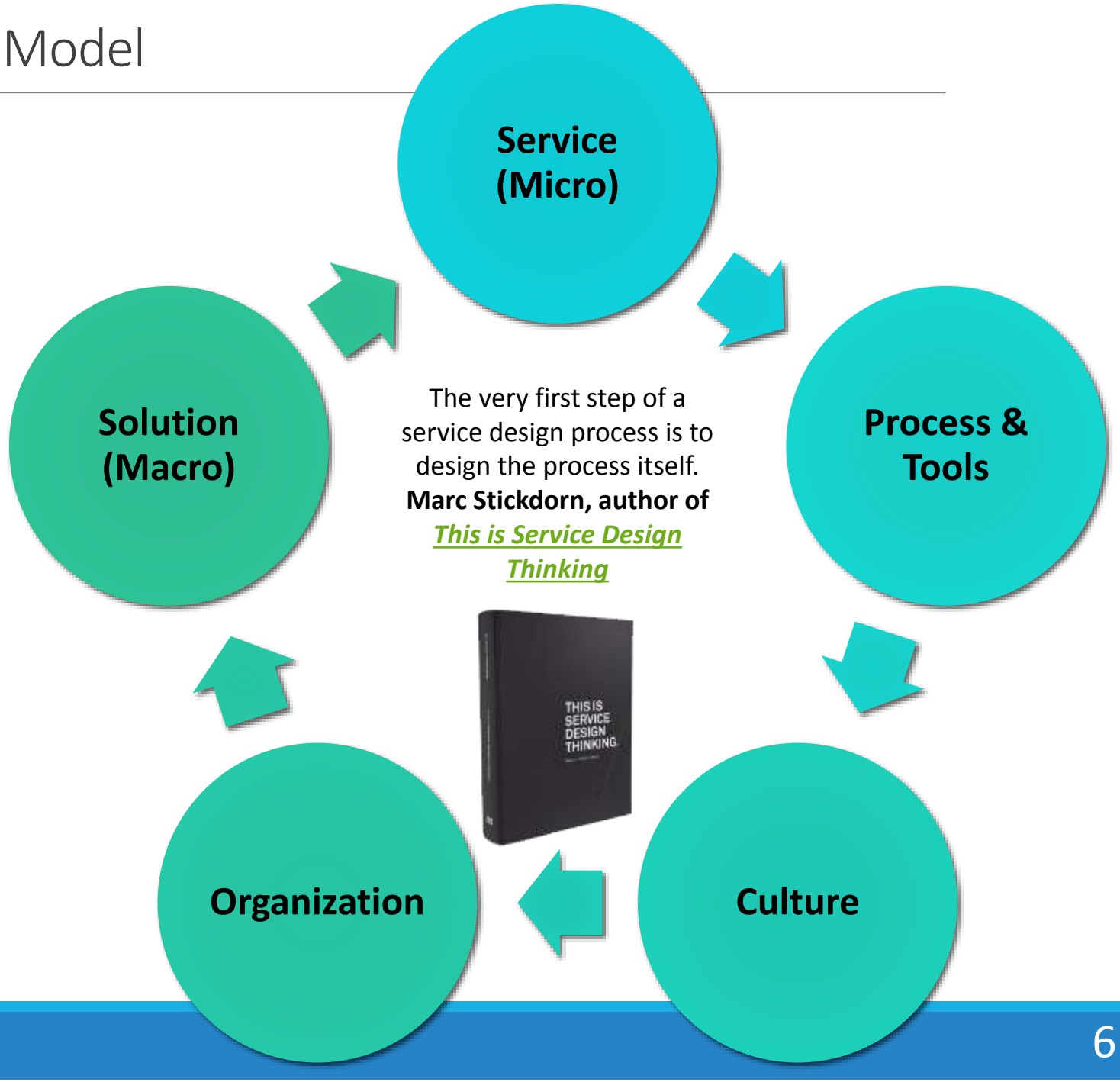
Service: Focuses on **a specific Business Capability**

Process & Tools: Development, Code Deployment, Maintenance and Product Management

Culture: A Shared set of values, beliefs by everyone. **Ubiquitous Language in DDD is an important aspect of Culture.**

Organization: Structure, Direction of Authority, Granularity, Composition of Teams.

Solution: Coordinate all inputs and outputs of multiple services. Macro level view of the system allows the designer to focus more on desirable system behavior.



Monolithic vs. Micro Services Example

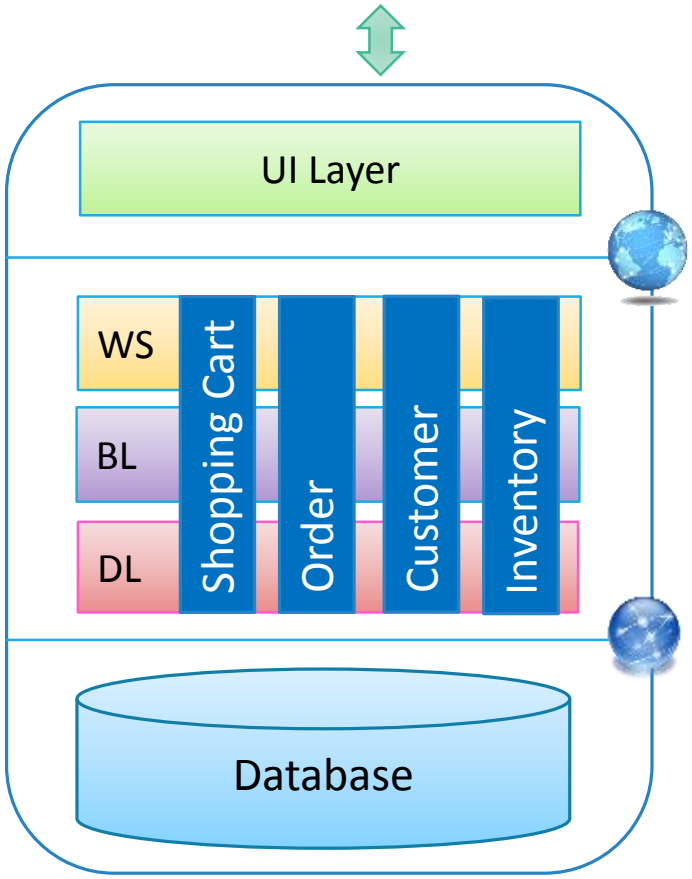




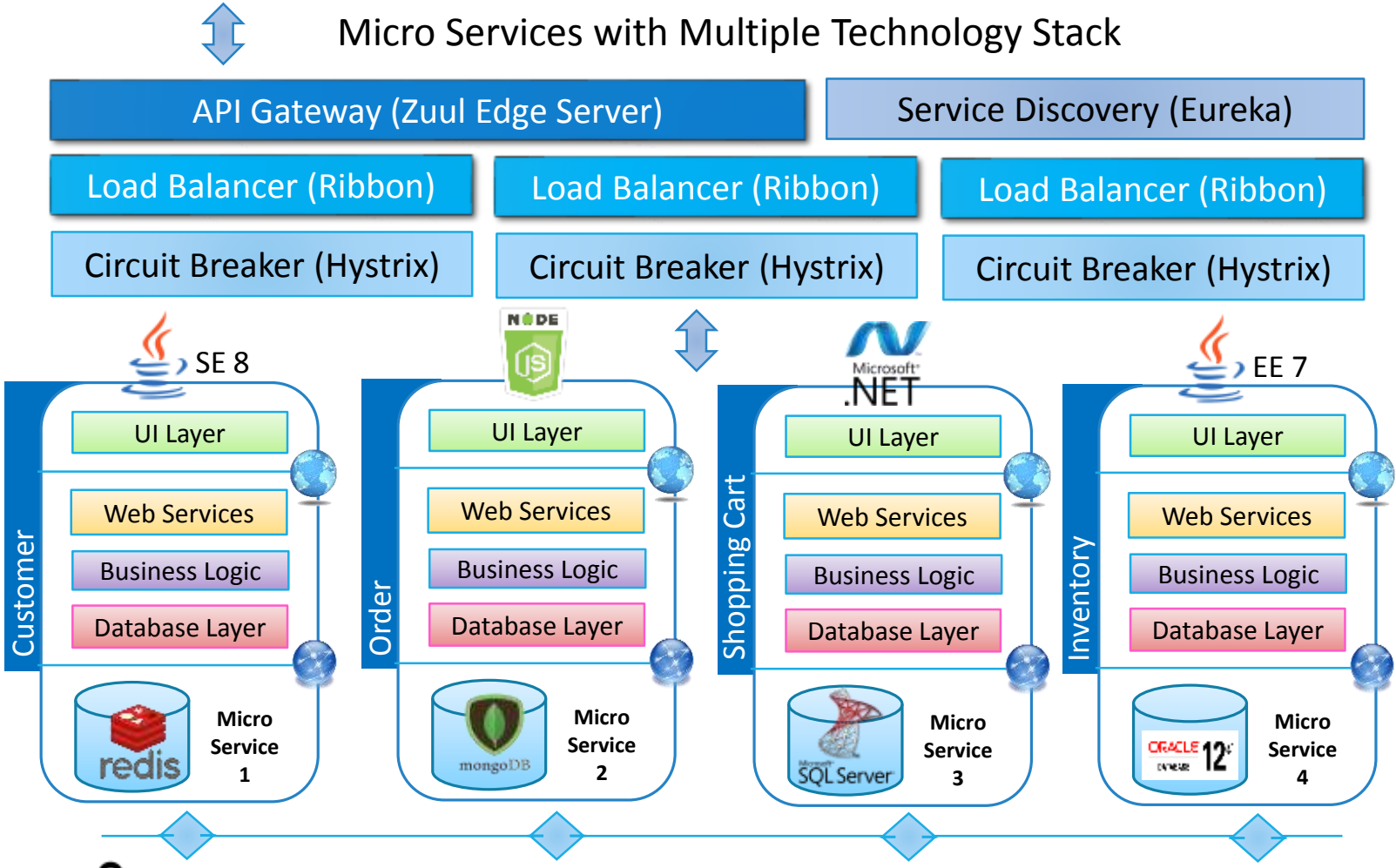

Existing aPaaS vendors creates Monolithic Apps.

This 3 tier model is obsolete now.

Source: Gartner Market Guide for Application Platforms Nov 23, 2016



Traditional Monolithic App using Single Technology Stack



SOA vs. Micro Services Example

Smart Pipes
Lot of Business logic resides in the Pipe

UI Layer

Messaging
REST / SOAP
HTTP
MOM
JMS
ODBC / JDBC
Translation

Enterprise Service Bus

Shopping Cart
Order
Customer
Inventory

Web Services
XML
WSDL
Addressing
Security
Registry
Management

Producers

Database

Shared Database

Traditional Monolithic App with SOA

Micro Services with Multiple Technology Stack

API Gateway

Service Discovery

Load Balancer

Circuit Breaker

Load Balancer

Circuit Breaker

Load Balancer

Circuit Breaker

SE 8

Customer
UI Layer
Web Services
Business Logic
Database Layer
redis
Micro Service 1

Order
UI Layer
Web Services
Business Logic
Database Layer
mongoDB
Micro Service 2

Shopping Cart
UI Layer
Web Services
Business Logic
Database Layer
SQL Server
Micro Service 3

kafka
Event Stream

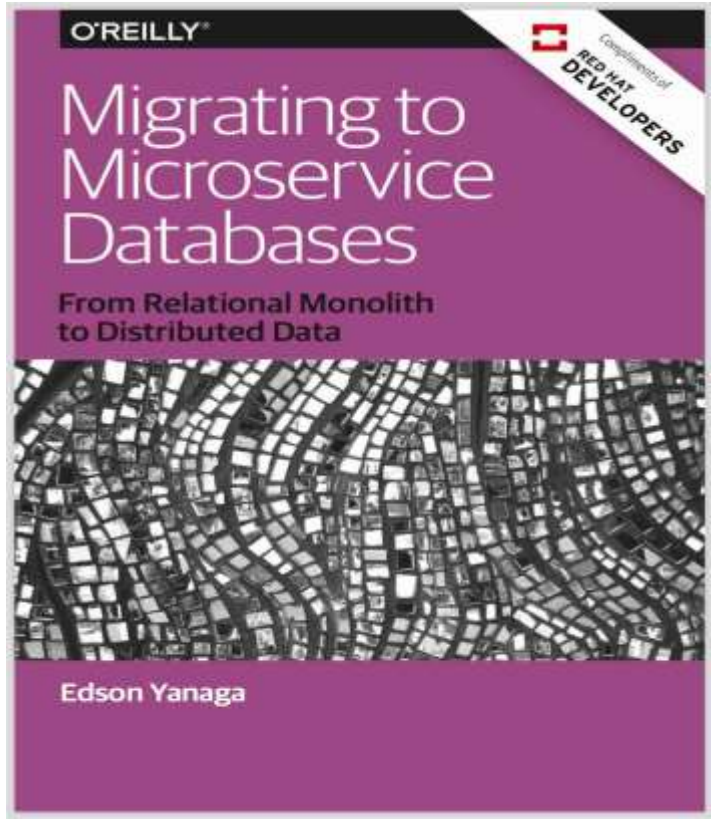
API Gateway Features (Zuul)

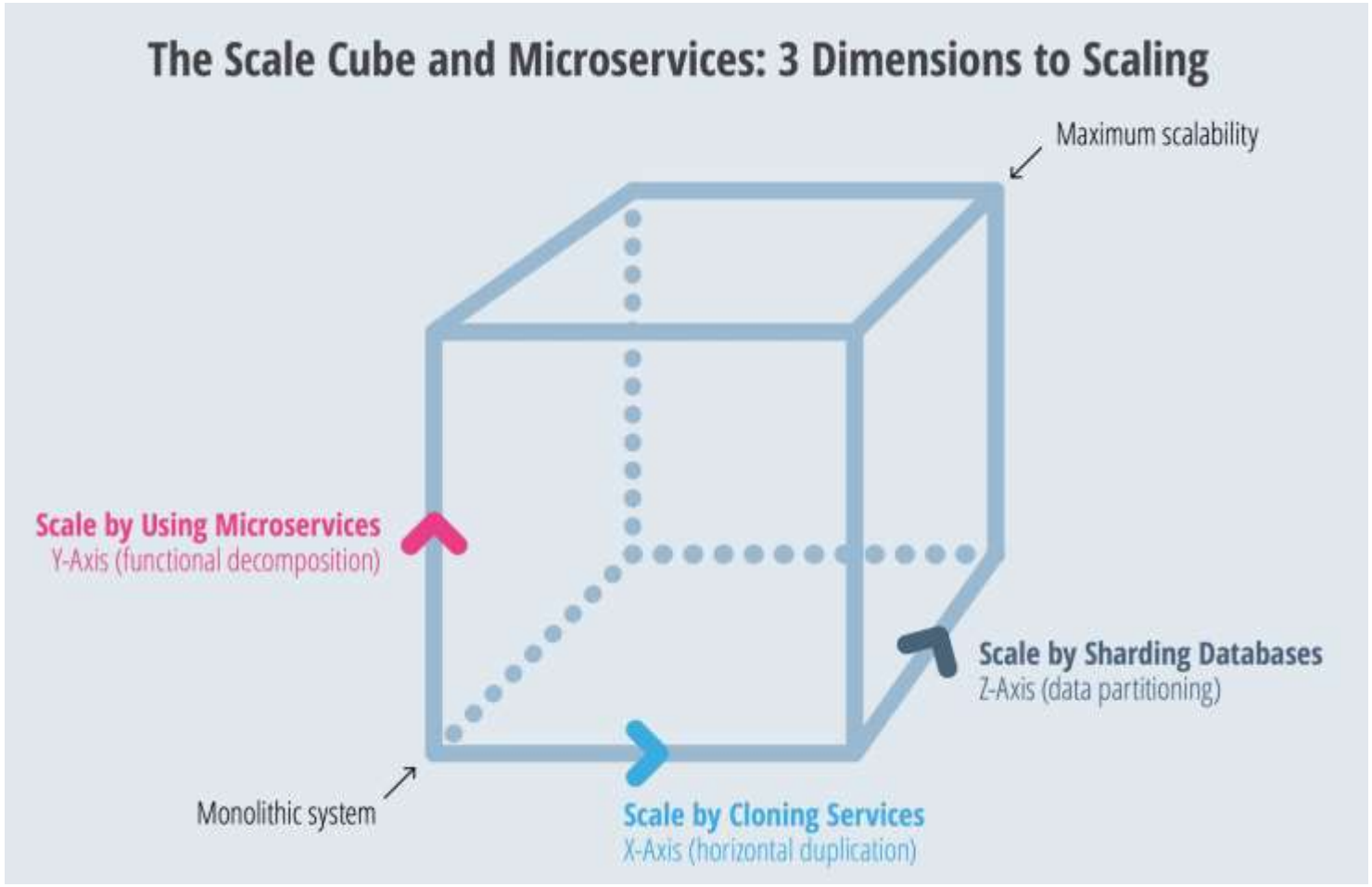
- **Authentication and Security:** identifying authentication requirements for each resource.
- **Insights and Monitoring**: tracking meaningful data and statistics.
- **Dynamic Routing:** dynamically routing requests to different backend..
- **Stress Testing:** gradually increasing the traffic.
- **Load Shedding:** allocating capacity for each type of request and dropping requests.
- **Static Response handling:** building some responses directly.
- **Multi region Resiliency:** routing requests across AWS regions.

- **Hystrix** is used to wrap calls to our origins, which allows us to shed and prioritize traffic when issues occur.
- **Ribbon** is our client for all outbound requests from Zuul, which provides detailed information into network performance and errors, as well as handles software load balancing for even load distribution.
- **Turbine** aggregates fine-grained metrics in real-time so that we can quickly observe and react to problems.
- **Archaius** handles configuration and gives the ability to dynamically change properties.

Source: https://dzone.com/articles/spring-cloud-netflix-zuul-edge-serverapi-gatewayga

App Scalability based on micro services architecture

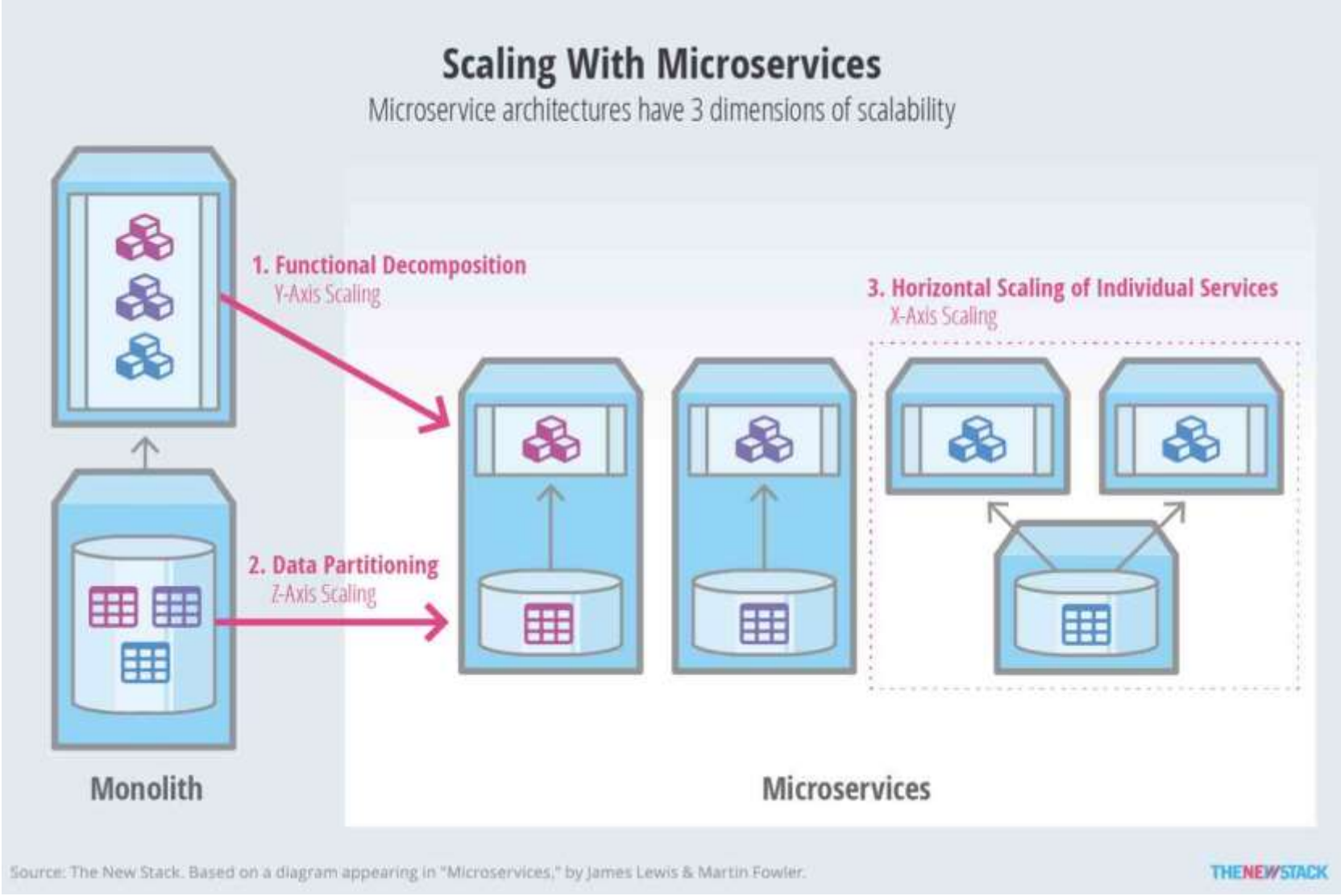




Source: The NewStack. Based on the Art of Scalability by By Martin Abbot & Michael Fisher

Scale Cube and Micro Services

1. Functional Decomposition
2. Avoid locks by Database Sharding
3. Cloning Services



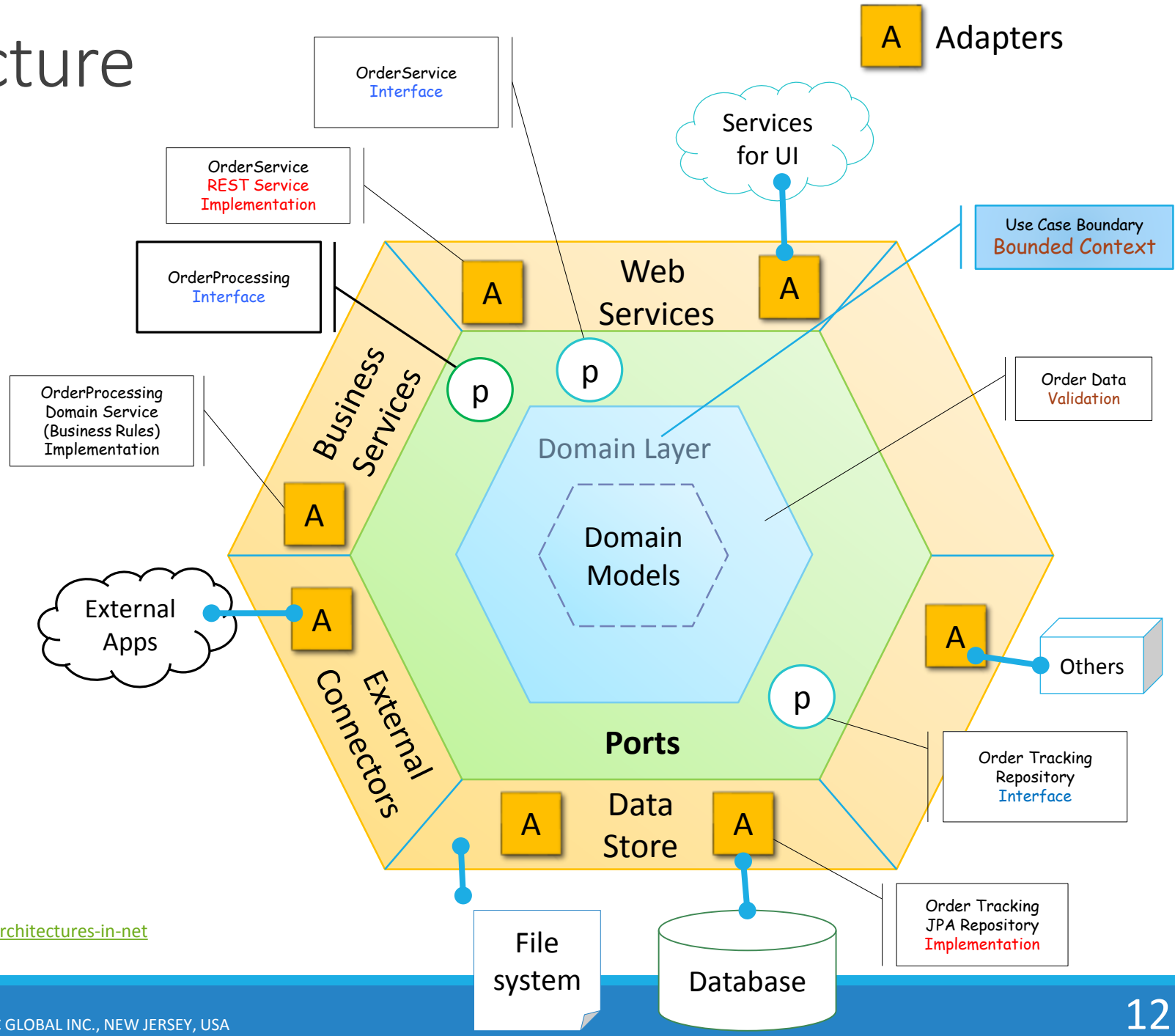
Hexagonal Architecture

Ports & Adapters

The layer between the **Adapter** and the **Domain** is identified as the **Ports** layer. The Domain is inside the port, adapters for external entities are on the outside of the port.

The notion of a “port” invokes the OS idea that any device that adheres to a known protocol can be plugged into a port. Similarly many adapters may use the Ports.

- Reduces Technical Debt
- Dependency Injection
- Auto Wiring



Source : http://alistair.cockburn.us/Hexagonal+architecture
https://skillsmatter.com/skillscasts/5744-decoupling-from-asp-net-hexagonal-architectures-in-net

Micro Services Workshop Setup

HTTP Server
All UI Code is bundled

Micro Services with Multiple Technology Stack

API (Zuul) Gateway

LB = Ribbon | LB = Ribbon | LB = Ribbon | LB = Ribbon

CB = Hystrix | CB = Hystrix | CB = Hystrix | CB = Hystrix

Config Server (Spring)

Service Discovery (Eureka)

Product
SE 8
UI Layer
Web Services
Business Logic
Database Layer
Micro Service 1
With 4 node cluster
PostgroSQL

Shopping Cart
SE 8
UI Layer
Web Services
Business Logic
Database Layer
mongoDB
Micro Service 2

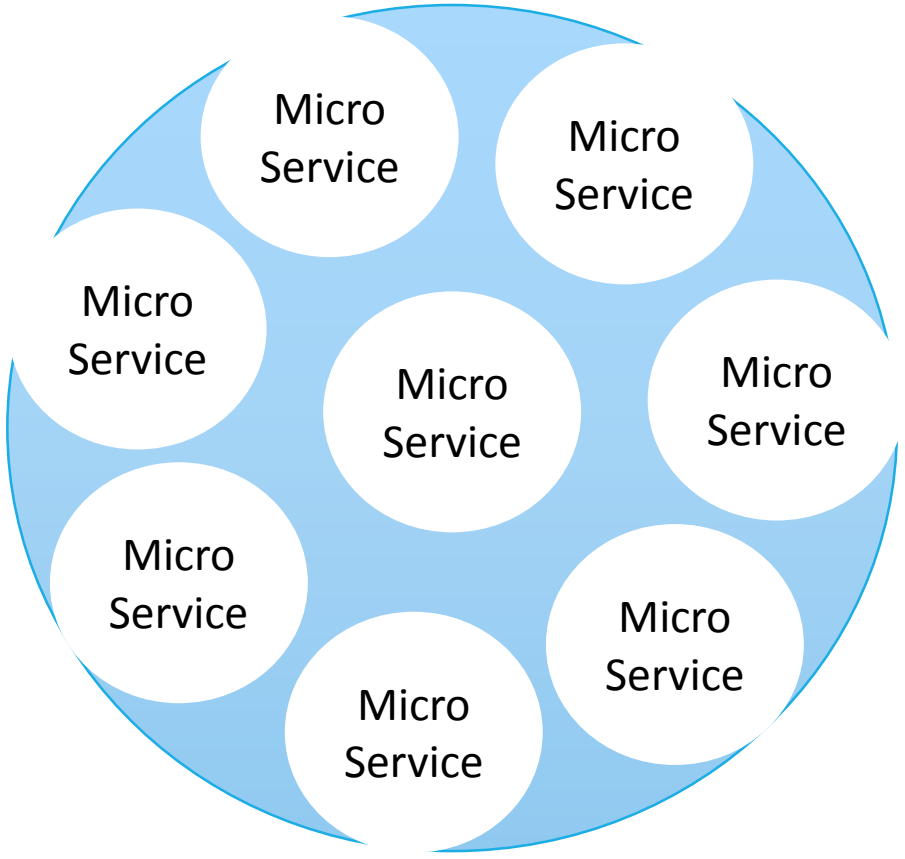
Order
SE 8
UI Layer
Web Services
Business Logic
Database Layer
Micro Service 3
With 2 node
Cluster
PostgroSQL

Customer
NODE
UI Layer
Web Services
Business Logic
Database Layer
Micro Service 4
With 2 node
cluster
redis

Virtual Private Network

kafka
Event Stream

Summary – Micro Services Intro



Key Features

1. Small in size
2. Messaging–enabled
3. Bounded by contexts
4. Autonomously developed
5. Independently deployable
6. Decentralized
7. Language–agnostic
8. Built and released with automated processes

Benefits

1. Robust
2. Scalable
3. Testable (Local)
4. Easy to Change and Replace
5. Easy to Deploy
6. Technology Agnostic

Martin Fowler – Micro Services Architecture
https://martinfowler.com/articles/microservices.html
Dzone – SOA vs Micro Services : https://dzone.com/articles/microservices-vs-soa-2

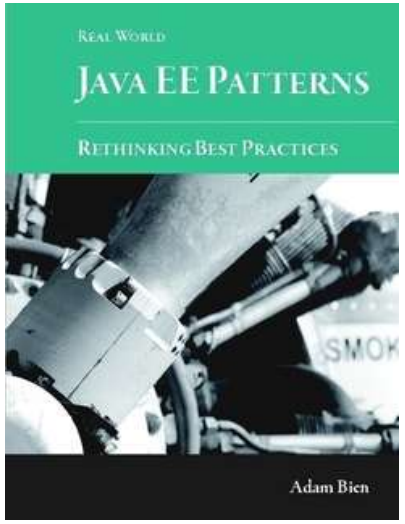
2

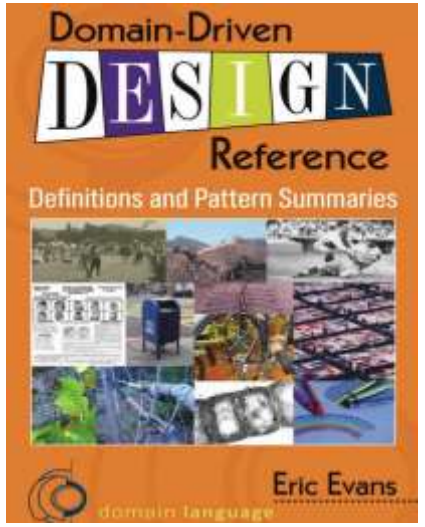
Design Styles

- Domain Driven Design
  - Understanding Requirement Analysis
  - Bounded Context
  - Context Map
  - Aggregate Root
- Event Sourcing & CQRS
  - CRUD
  - ES and CQRS
  - Event Sourcing Example
- Functional Reactive Programming
  - 4 Building Blocks of RxJava
  - Observable and Observer Design Pattern
  - Comparison : Iterable / Streams / Observable
  - Design Patterns : Let it Crash / SAGA

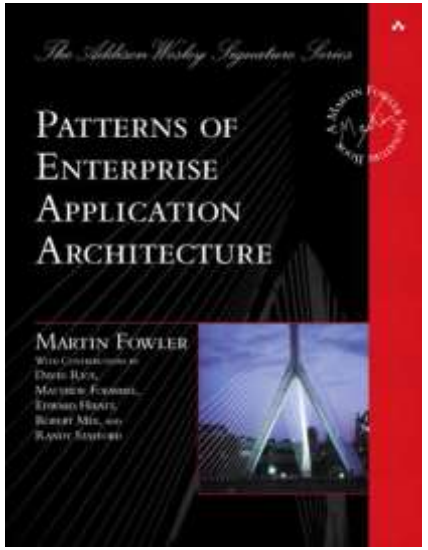
It's not necessary that you need to use all these patterns. You will be using these based on your technical requirement

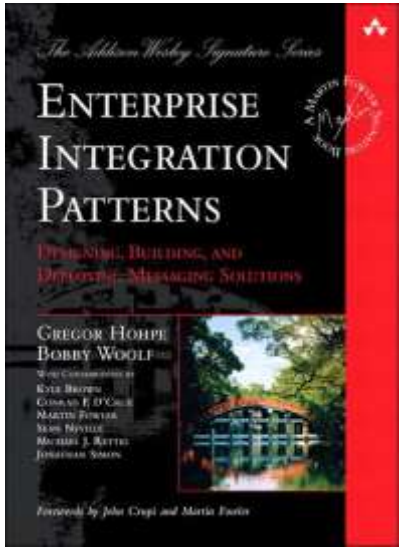
Design Patterns – Holy Grail of Developers

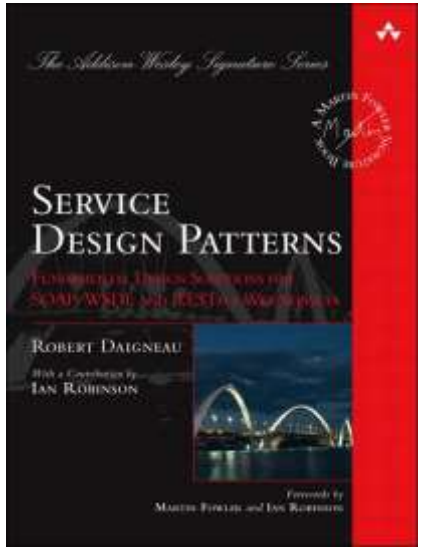


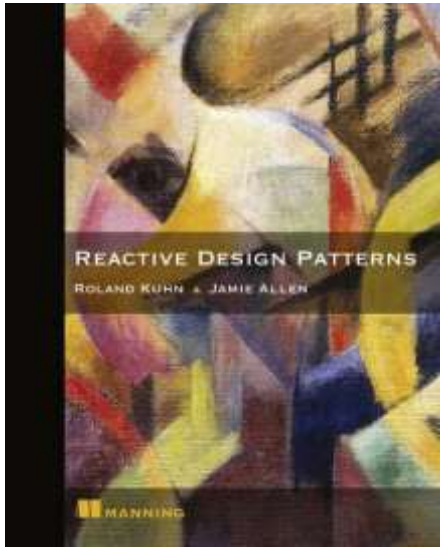


Design Patterns are solutions to general problems that software developers faced during software development.

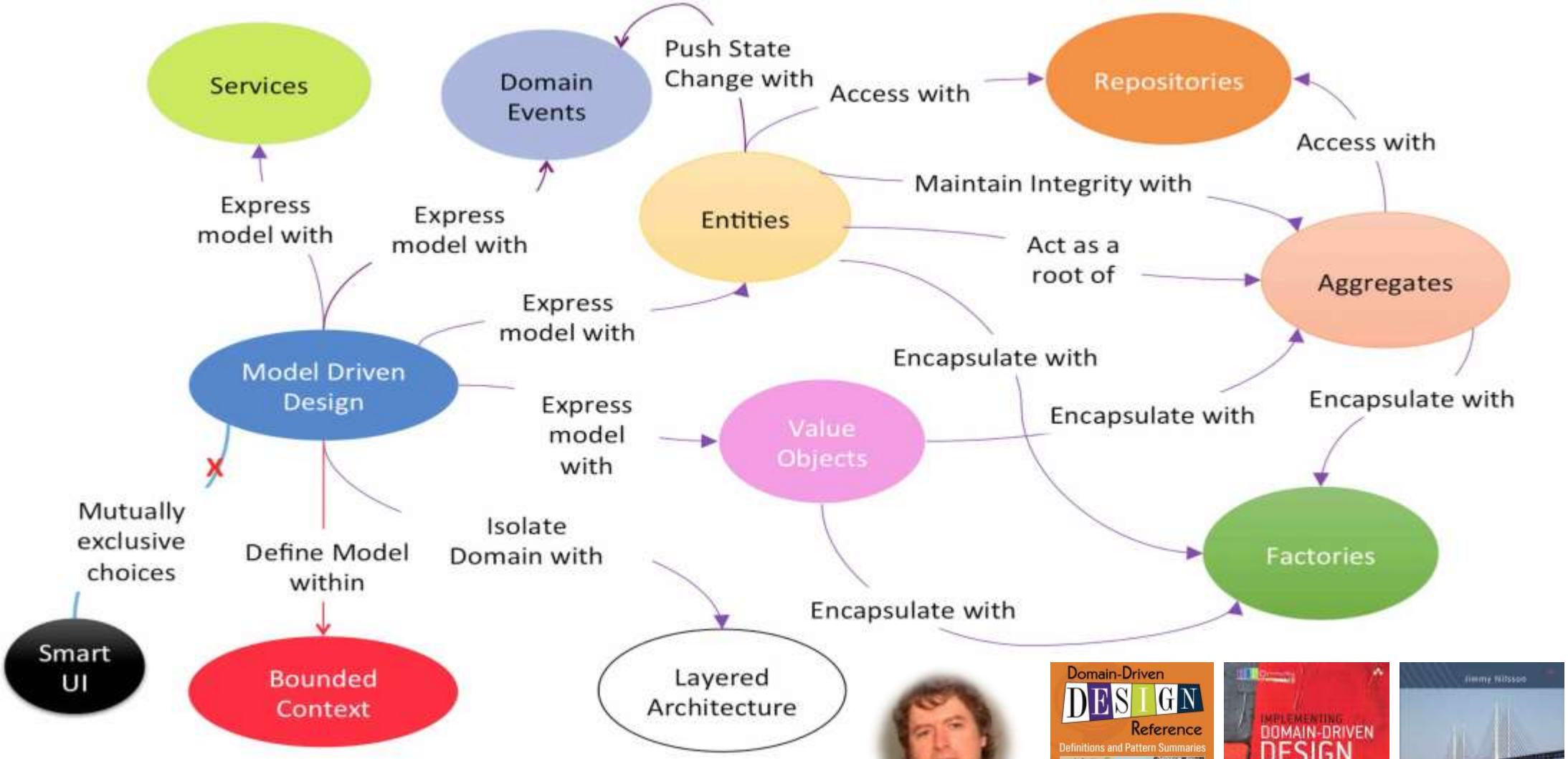


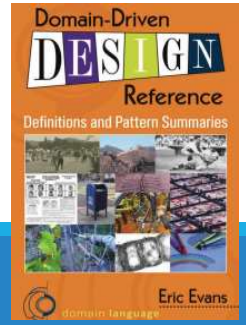


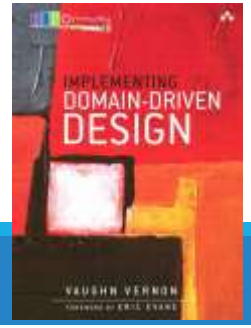




Domain Driven Design







Source: Domain-Driven Design Reference by Eric Evans

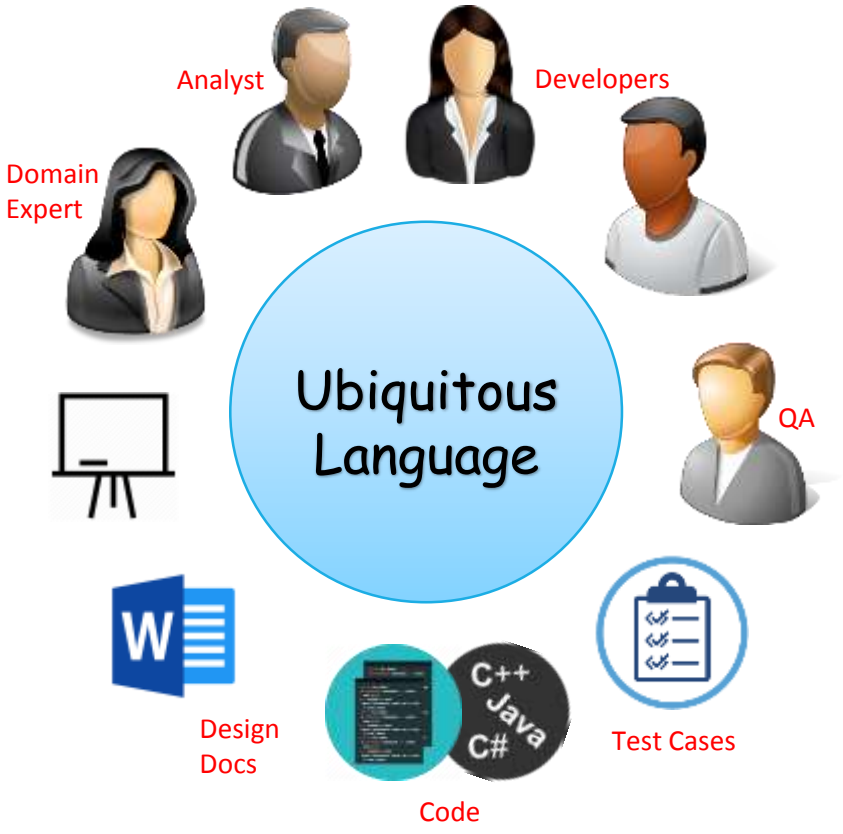
Ubiquitous Language : Understanding Requirement Analysis using DDD

Ubiquitous Language → Vocabulary shared by all involved parties → Used in all forms of spoken / written communication

Restaurant Context – Food Item :

Eg. Food Item (Navrathnakurma) can have different meaning or properties depends on the context.

- In the Menu Context it's a Veg Dish.
- In the Kitchen Context it's is recipe.
- And in the Dining Context it will have more info related to user feed back etc.



Ubiquitous Language using BDD

As an insurance Broker
I want to know who my Gold Customers are
So that I sell more

Given	Customer John Doe exists
When	he buys insurance ABC for $1000 USD
Then	He becomes a Gold Customer

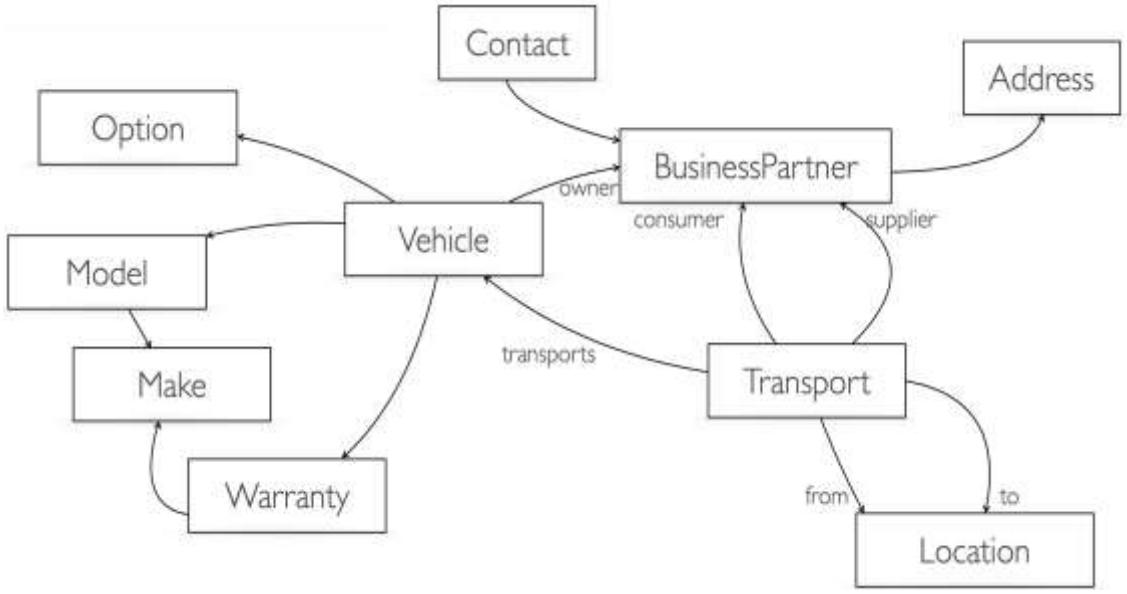
BDD – Behavior Driven Development

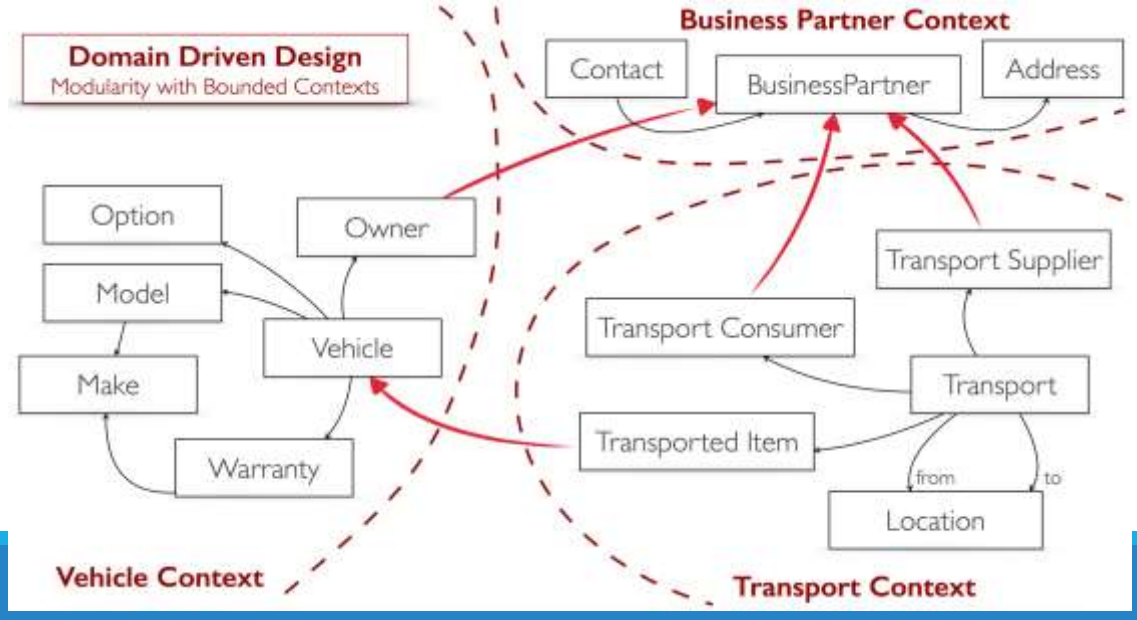
Understanding Requirement Analysis using DDD

Bounded Context

Areas of the domain treated independently

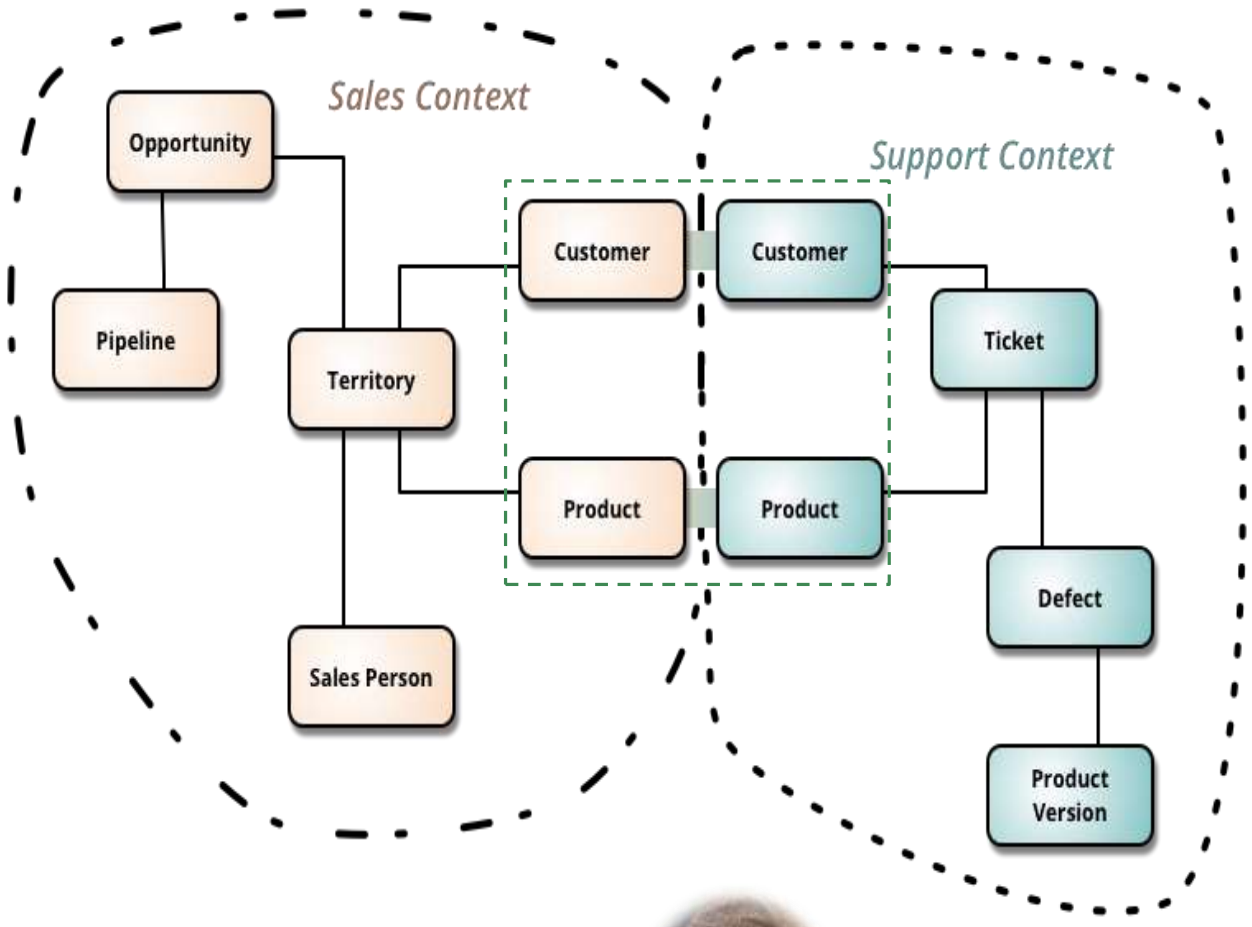
Discovered as you assess requirements and build language





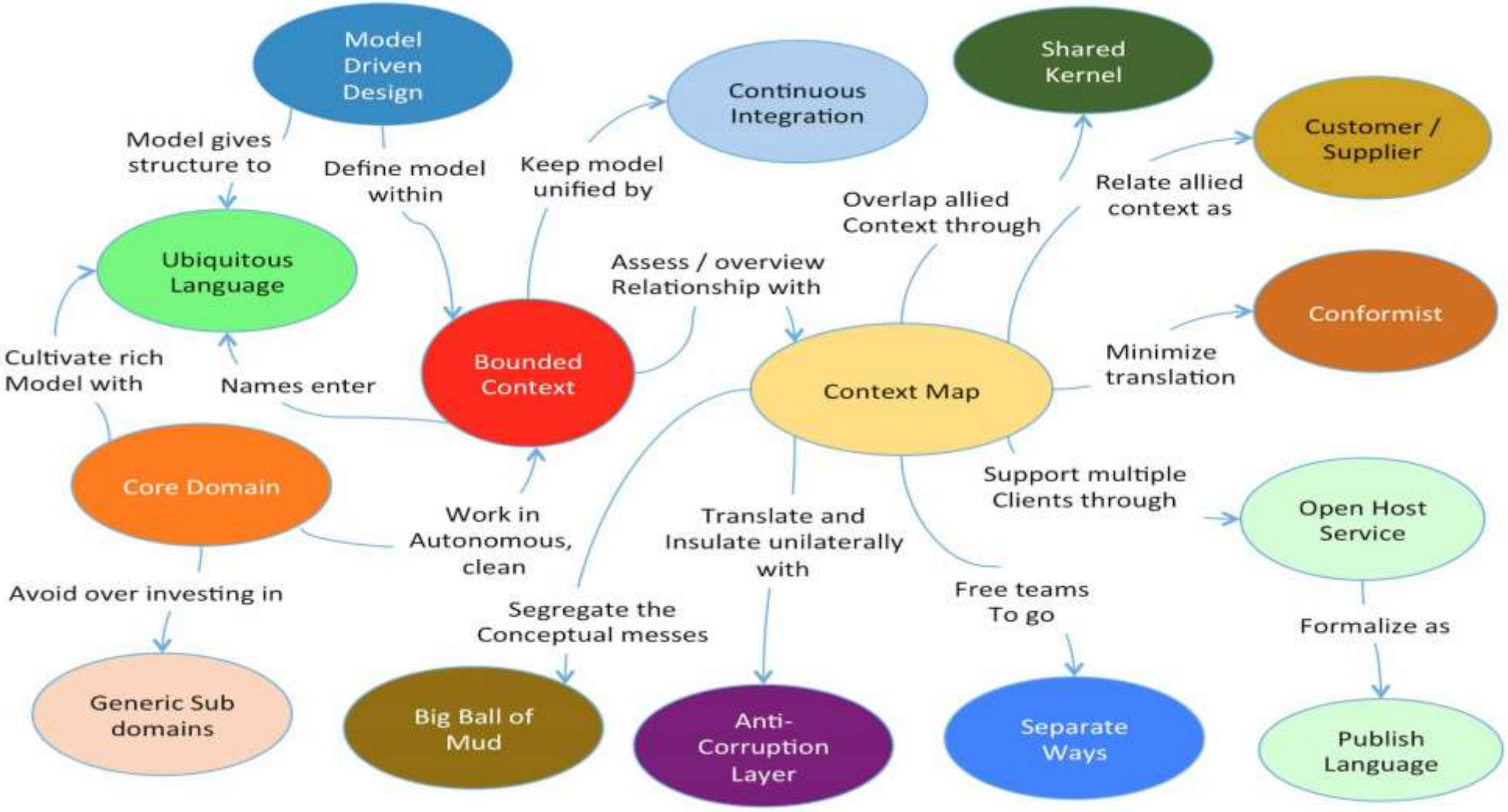
DDD : Understanding Bounded Context

- DDD deals with large models by dividing them into different Bounded Contexts and being explicit about their interrelationships.
- Bounded Contexts have both unrelated concepts
  - Such as a support ticket only existing in a customer support context
  - But also share concepts such as products and customers.
- Different contexts may have completely different models of common concepts with mechanisms to map between these polysemic concepts for integration.



Source: BoundedContext By Martin Fowler : http://martinfowler.com/bliki/BoundedContext.html

DDD : Context Map



Source: Domain-Driven Design Reference by Eric Evans

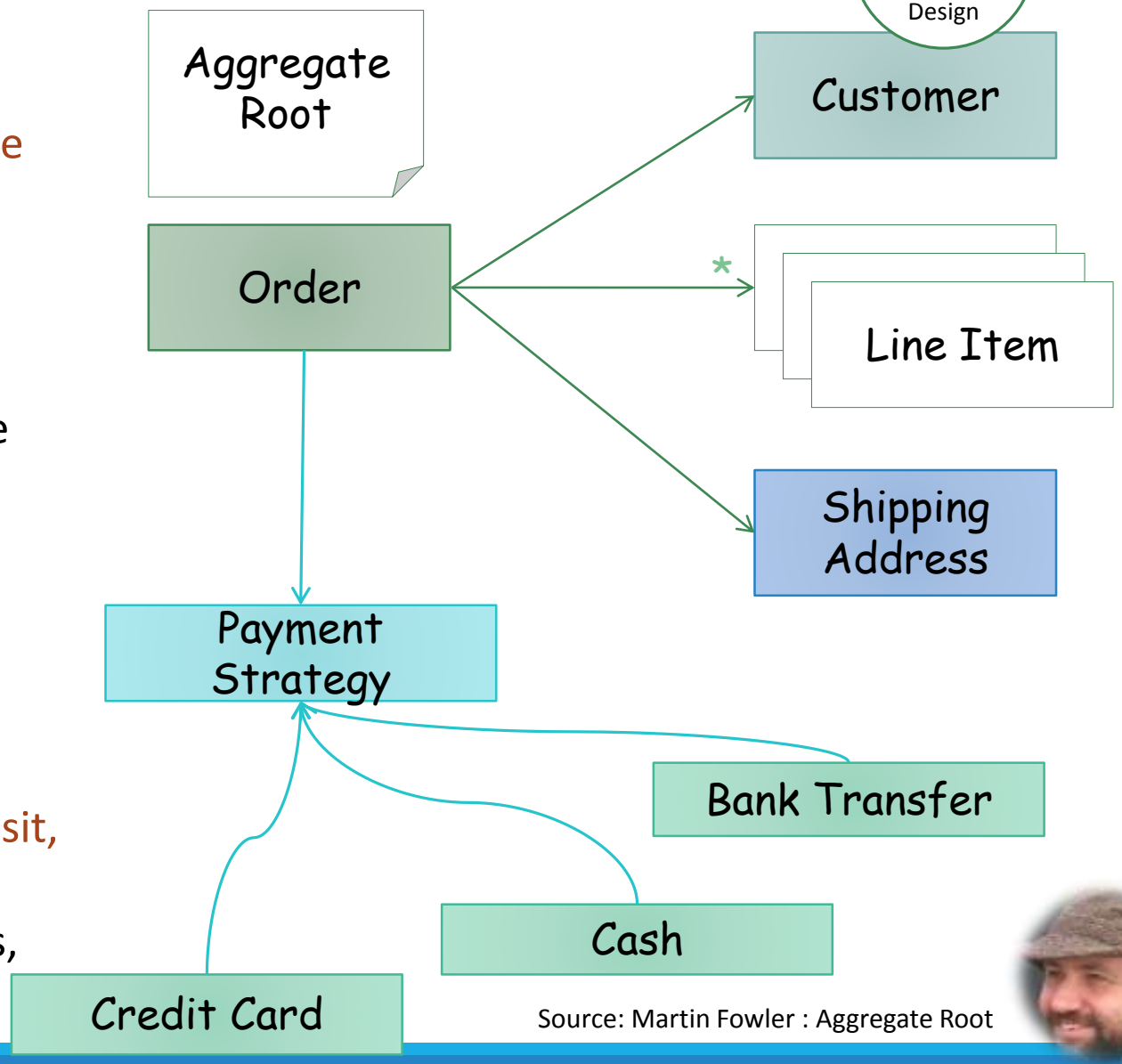
Understanding Aggregate Root

- An aggregate will have one of its component objects be the aggregate root. Any references from outside the aggregate should only go to the aggregate root. The root can thus ensure the integrity of the aggregate as a whole.

- Aggregates are the basic element of transfer of data storage - you request to load or save whole aggregates. Transactions should not cross aggregate boundaries.

- Aggregates are sometimes confused with collection classes (lists, maps, etc.).

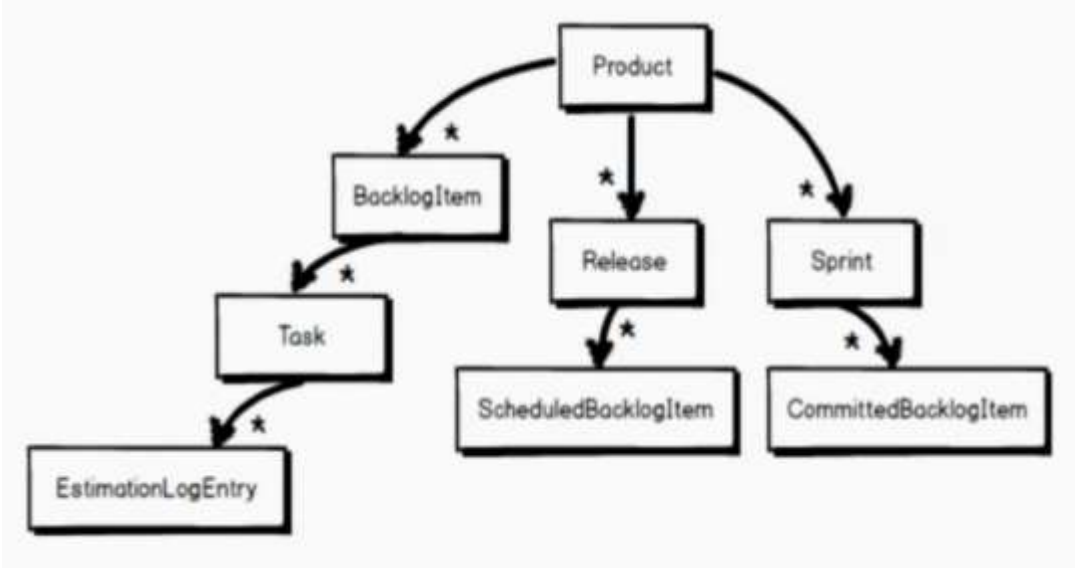
- Aggregates are domain concepts (order, clinic visit, playlist), while collections are generic. An aggregate will often contain multiple collections, together with simple fields.



Source: Martin Fowler : Aggregate Root

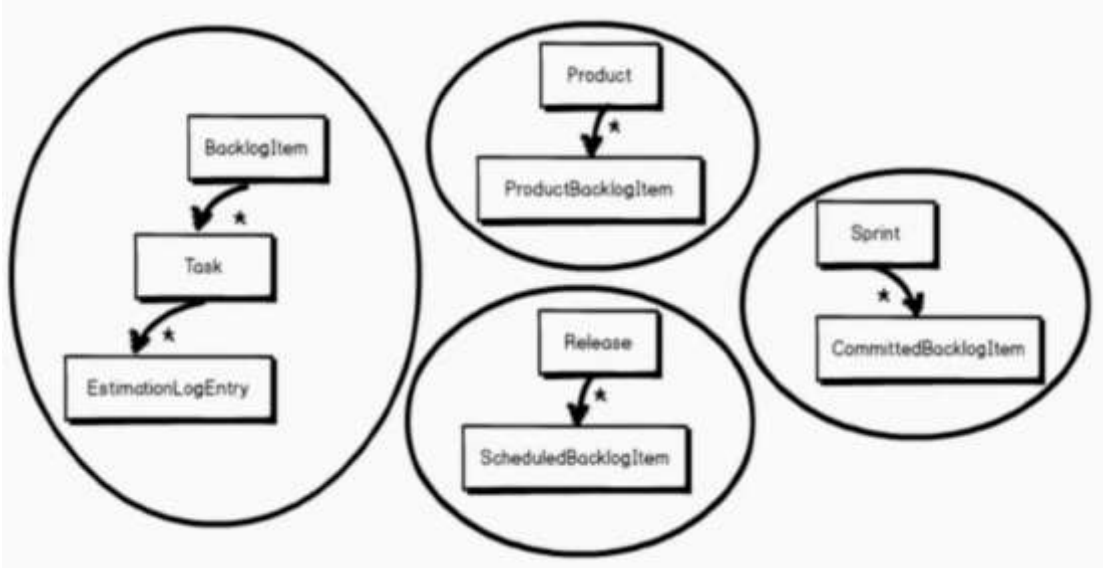
Designing and Fine Tuning Aggregate Root

Aggregate Root - #1



Super Dense Single Aggregate Root
Results in Transaction concurrency issues.

Aggregate Root - #2



Super Dense Aggregate Root is split into 4 different smaller Aggregate Root in the 2nd Iteration.

Working on different design models helps the developers to come up with best possible design.

Source : Effective Aggregate Design Part 1/2/3 : Vaughn Vernon
http://dddcommunity.org/wp-content/uploads/files/pdf_articles/Vernon_2011_1.pdf

Rules for Building Aggregate Roots

1. Protect True Invariants in Consistency Boundaries. This rule has the added implication that you should modify just one Aggregate instance in a single transaction. In other words, when you are designing an Aggregate composition, plan on that representing a transaction boundary.

2. **Design Small Aggregates.** The smallest Aggregate you can design is one with a single Entity, which will serve as the Aggregate Root.

3. Reference Other Aggregates **Only By Identity.**

4. Use **Eventual Consistency** Outside the Consistency Boundary. This means that ONLY ONE Aggregate instance will be required to be updated in a single transaction. All other Aggregate instances that must be updated as a result of any one Aggregate instance update can be updated within some time frame (using a Domain Event). The business should determine the allowable time delay.

5. Build Unidirectional Relationship from the Aggregate Root.

Data Transfer Object vs. Value Object

A small simple object, like money or a date range, whose equality isn't based on identity.

Data Transfer Object	Value Object
A DTO is just a data container which is used to transport data between layers and tiers.	A Value Object represents itself a fix set of data and is similar to a Java enum.
It mainly contains of attributes and it's a serializable object.	A Value Object doesn't have any identity, it is entirely identified by its value and is immutable.
DTOs are anemic in general and do not contain any business logic.	A real world example would be Color.RED, Color.BLUE, Currency.USD

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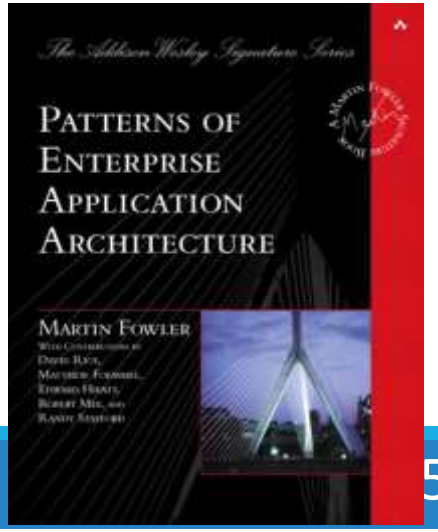
P of EAA

Java EE 7 Retired the DTO

In Java EE the RS spec became the de-facto standard for remoting, so the implementation of serializable interface is no more required. To transfer data between tiers in Java EE 7 you get the following for FREE!

1. JAXB : Offer JSON / XML serialization for Free.
2. Java API for JSON Processing – Directly serialize part of the Objects into JSON



DTO – Data Transfer Object

401
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An object that carries data between processes in order to reduce the number of method calls.

Problem: How do you preserve the simple semantics of a procedure call interface without being subject to the latency issues inherent in remote communication?

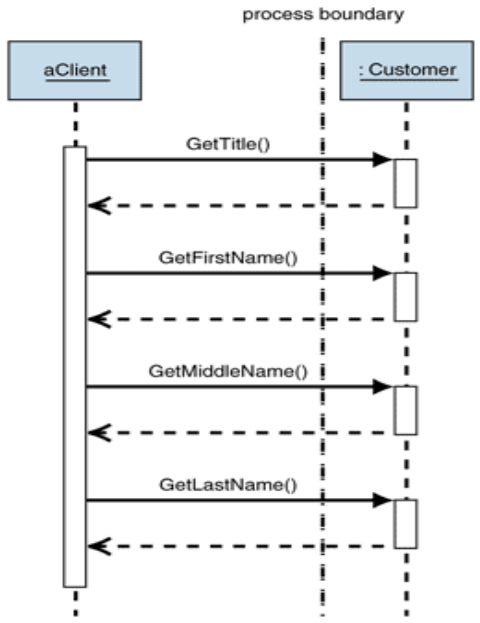
Benefits

1. Reduced Number of Calls
2. Improved Performance
3. Hidden Internals
4. Discovery of Business objects

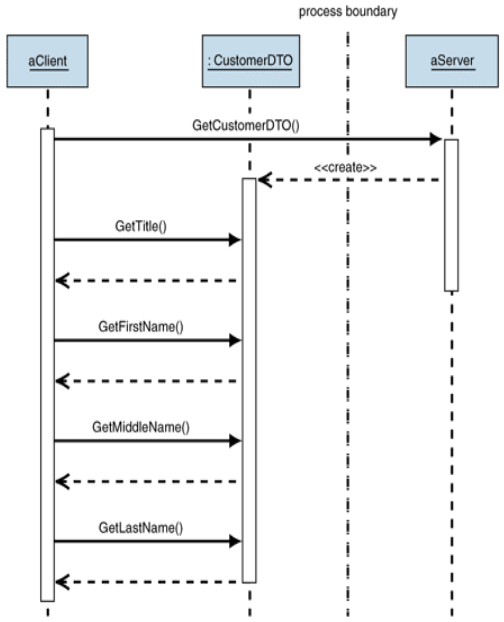
Liabilities

1. Class Explosion
2. Additional Computation
3. Additional Coding Effort

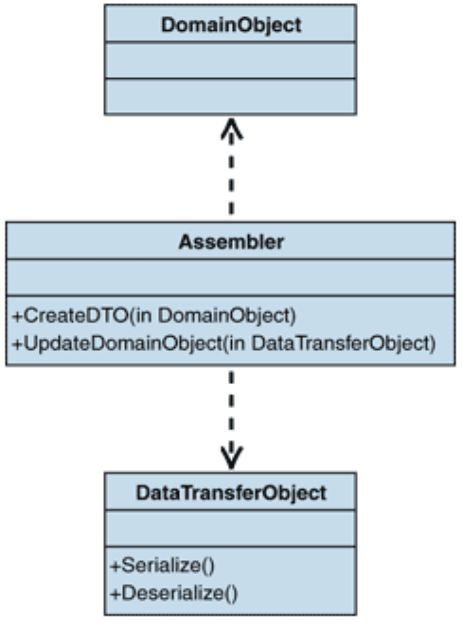
The Problem



The Solution



Assembler Pattern



Security Considerations

Data obtained from untrusted sources, such as user input from a Web page, should be cleansed and validated before being placed into a DTO. Doing so enables you to consider the data in the DTO relatively safe, which simplifies future interactions with the DTO.

https://msdn.microsoft.com/en-us/library/ms978717.aspx

DTO – Data Transfer Object

An object that carries data between processes in order to reduce the number of method calls.

401
P of EAA

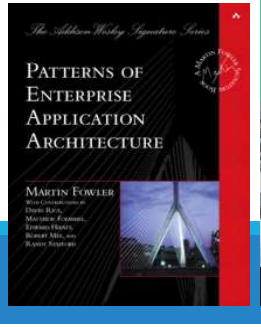
Don't underestimate the cost of [using DTOs].... It's significant, and it's painful - perhaps second only to the cost and pain of object-relational mapping.

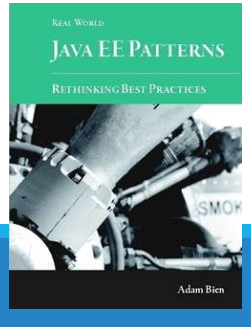
Another argument I've heard is using them in case you want to distribute later. This kind of speculative distribution boundary is what I rail against. Adding remote boundaries adds complexity.

One case where it is useful to use something like a DTO is when you have a significant mismatch between the model in your presentation layer and the underlying domain model.

In this case it makes sense to make presentation specific facade/gateway that maps from the domain model and presents an interface that's convenient for the presentation.

Patterns of Enterprise Application Architecture : Martin Fowler
http://martinfowler.com/books/eaa.html





The most misused pattern in the Java Enterprise community is the DTO.

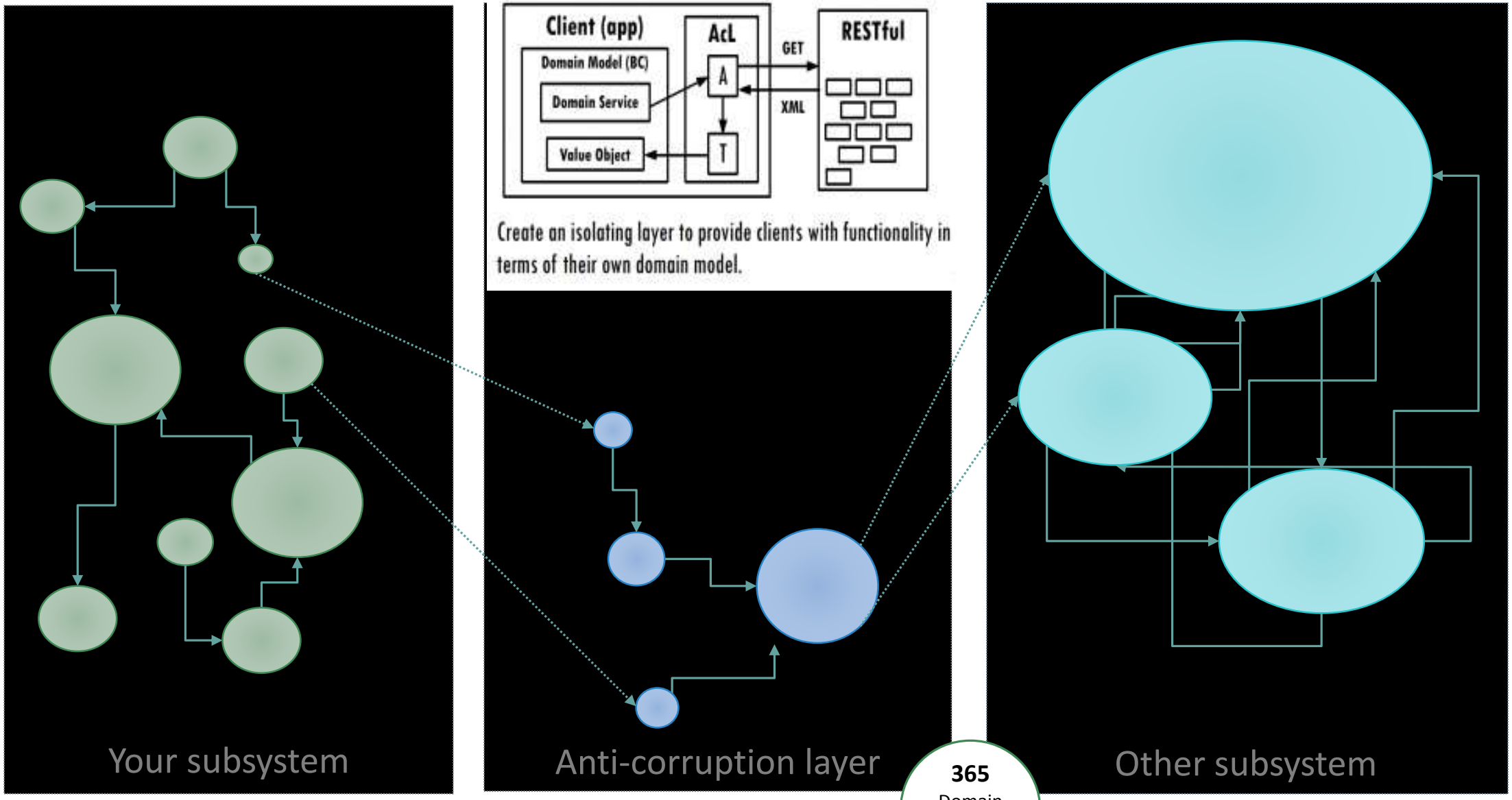
DTO was clearly defined as a solution for a distribution problem.

DTO was meant to be a coarse-grained data container which efficiently transports data between processes (tiers).

On the other hand considering a dedicated DTO layer as an investment, rarely pays off and often lead to over engineered bloated architecture.

Real World Java EE Patterns
Adam Bien
http://realworldpatterns.com

Anti Corruption Layer – ACL



365 Domain Driven Design

Repository Pattern

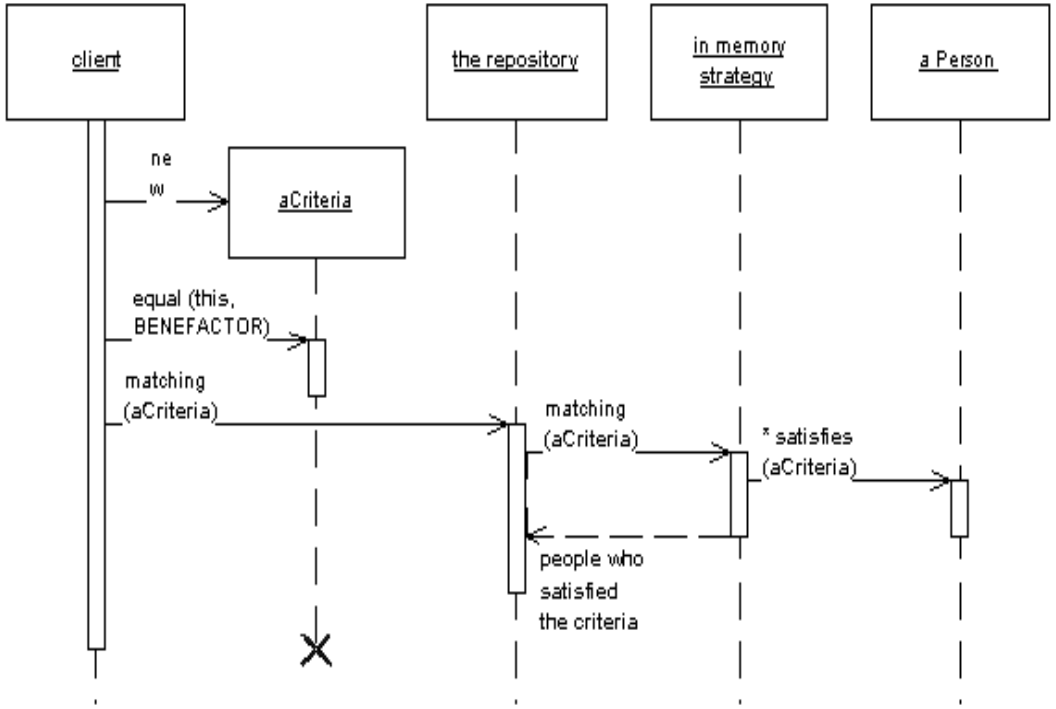
322
P of EAA

Mediates between the domain and data mapping layers using a collection-like interface for accessing domain objects.

Objectives

Use the Repository pattern to achieve one or more of the following objectives:

- You want to maximize the amount of code that can be tested with automation and to isolate the data layer to support unit testing.
- You access the data source from many locations and want to apply centrally managed, consistent access rules and logic.
- You want to implement and centralize a caching strategy for the data source.
- You want to improve the code's maintainability and readability by separating business logic from data or service access logic.
- You want to use business entities that are strongly typed so that you can identify problems at compile time instead of at run time.
- You want to associate a behavior with the related data. For example, you want to calculate fields or enforce complex relationships or business rules between the data elements within an entity.
- You want to apply a domain model to simplify complex business logic.



Conceptually, a Repository encapsulates the set of objects persisted in a data store and the operations performed over them, providing a more object-oriented view of the persistence layer. Repository also supports the objective of achieving a clean separation and one-way dependency between the domain and data mapping layers.

Repository Pattern Source:
Martin Fowler : http://martinfowler.com/eaaCatalog/repository.html | Microsoft : https://msdn.microsoft.com/en-us/library/ff649690.aspx

Anemic Domain Model : Anti Pattern

- There are objects, many named after the nouns in the domain space, and these objects are connected with the rich relationships and structure that true domain models have.
- The catch comes when you look at the behavior, and you realize that there is hardly any behavior on these objects, making them little more than bags of getters and setters.
- The fundamental horror of this anti-pattern is that it's so contrary to the basic idea of object-oriented design; which is to combine data and process together.
- The anemic domain model is really just a procedural style design, exactly the kind of thing that object bigots like me (and Eric) have been fighting since our early days in Smalltalk.

```java
package com.fusionfire.examples.commons.utils;

import java.util.ArrayList;

public class AnemicUser {

    private String name;

    private boolean isUserLocked;

    private ArrayList<String> addresses;

    public String getName() {
        return name;
    }

    public void setName(String name) {
        this.name = name;
    }

    public boolean isUserLocked() {
        return isUserLocked;
    }

    public void setUserLocked(boolean isUserLocked) {
        this.isUserLocked = isUserLocked;
    }

    public ArrayList<String> getAddresses() {
        return addresses;
    }

    public void setAddresses(ArrayList<String> addresses) {
        this.addresses = addresses;
    }
}
```

- lockUser()
- unlockUser()
- addAddress(String address)
- removeAddress(String address)

Source: Anemic Domain Model By Martin Fowler : http://martinfowler.com/bliki/AnemicDomainModel.html

Procedural Design Vs. Domain Driven Design

```java
@Stateless
public class ShipmentService {
  public final static int BASIC_COST = 5;

  @PersistenceContext
  private EntityManager em;

     public int getShippingCosts(int loadId) {
        Load load = em.find(Load.class, loadId);
        return computeShippingCost(load);
     }

     int computeShippingCost(Load load){
        int shippingCosts = 0;
        int weight = 0;
        int defaultCost = 0;
        for (OrderItem orderItem : load.getOrderItems()) {
            LoadType loadType = orderItem.getLoadType();
            weight = orderItem.getWeight();
            defaultCost = weight * 5;
            switch (loadType) {
                case BULKY:
                    shippingCosts += (defaultCost + 5);
                    break;
                case LIGHTWEIGHT:
                    shippingCosts += (defaultCost - 1);
                    break;
                case STANDARD:
                    shippingCosts += (defaultCost);
                    break;
                default:
                throw new IllegalStateException("Unknown type: " + loadType);
            }
        }
        return shippingCosts;
     }
}
```

1. Anemic Entity Structure
2. Massive IF Statements
3. Entire Logic resides in Service Layer
4. Type Dependent calculations are done based on conditional checks in Service Layer

Domain Driven Design with Java EE 6
By Adam Bien | Javaworld

Source: http://www.javaworld.com/article/2078042/java-app-dev/domain-driven-design-with-java-ee-6.html

Polymorphic Business Logic inside a Domain object

```java
@Entity
public class Load {

    @OneToMany(cascade = CascadeType.ALL)
    private List<OrderItem> orderItems;
    @Id
    private Long id;

    protected Load() {
        this.orderItems = new ArrayList<OrderItem>();
    }

    public int getShippingCosts() {
        int shippingCosts = 0;
        for (OrderItem orderItem : orderItems) {
            shippingCosts += orderItem.getShippingCost();
        }
        return shippingCosts;
    }
//...
}
```

Computation of the total cost realized inside a rich Persistent Domain Object (PDO) and not inside a service.

This simplifies creating very complex business rules.

Domain Driven Design with Java EE 6
By Adam Bien | Javaworld

Source: http://www.javaworld.com/article/2078042/java-app-dev/domain-driven-design-with-java-ee-6.html

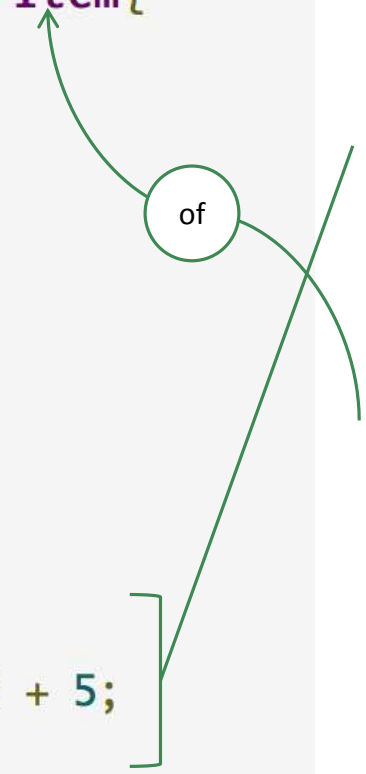
Type Specific Computation in a Sub Class

```java
@Entity
public class BulkyItem extends OrderItem{

    public BulkyItem() {
    }

    public BulkyItem(int weight) {
        super(weight);
    }

    @Override
    public int getShippingCost() {
        return super.getShippingCost() + 5;
    }
}
```



We can change the computation of the shipping cost of a Bulky Item without touching the remaining classes.

Its easy to introduce a new Sub Class without affecting the computation of the total cost in the Load Class.

Domain Driven Design with Java EE 6
By Adam Bien | Javaworld

Source: http://www.javaworld.com/article/2078042/java-app-dev/domain-driven-design-with-java-ee-6.html

Object Construction : Procedural Way Vs. Builder Pattern

Procedural Way

```
Load load = new Load();
OrderItem standard = new OrderItem();
standard.setLoadType(LoadType.STANDARD);
standard.setWeight(5);
load.getOrderItems().add(standard);
OrderItem light = new OrderItem();
light.setLoadType(LoadType.LIGHTWEIGHT);
light.setWeight(1);
load.getOrderItems().add(light);
OrderItem bulky = new OrderItem();
bulky.setLoadType(LoadType.BULKY);
bulky.setWeight(1);
load.getOrderItems().add(bulky);
```

Builder Pattern

```
Load build = new Load.Builder().
    withStandardItem(5).
    withLightweightItem(1).
    withBulkyItem(1).
    build();
```

Domain Driven Design with Java EE 6
By Adam Bien | Javaworld

Source: http://www.javaworld.com/article/2078042/java-app-dev/domain-driven-design-with-java-ee-6.html

DDD – Summary

1. Ubiquitous Language
2. Aggregate Root
3. Value Object
4. Domain Events
5. Data Transfer Object
6. Repository Pattern
7. Context Map

More on this in Event Sourcing and CQRS Section.

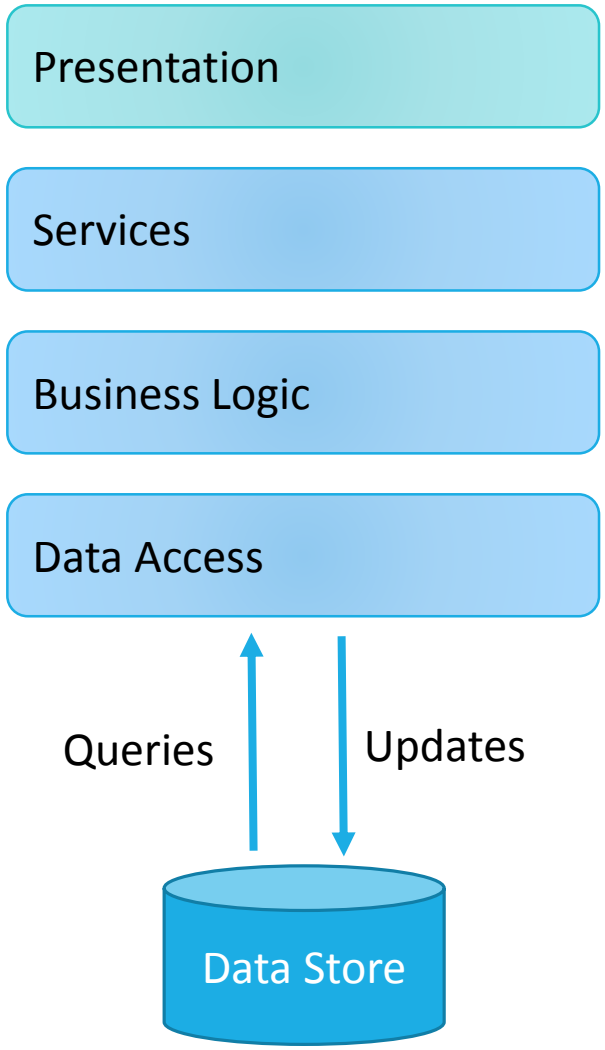
CRUD / CQRS & Event Sourcing

A brief introduction, more in Part 2 of the Series Event Storming and SAGA

CRUD and CQRS

Source: https://docs.microsoft.com/en-us/azure/architecture/patterns/cqrs
https://blogs.msdn.microsoft.com/maarten_mullender/2004/07/23/crud-only-when-you-can-afford-it-revisite

Traditional CRUD Architecture

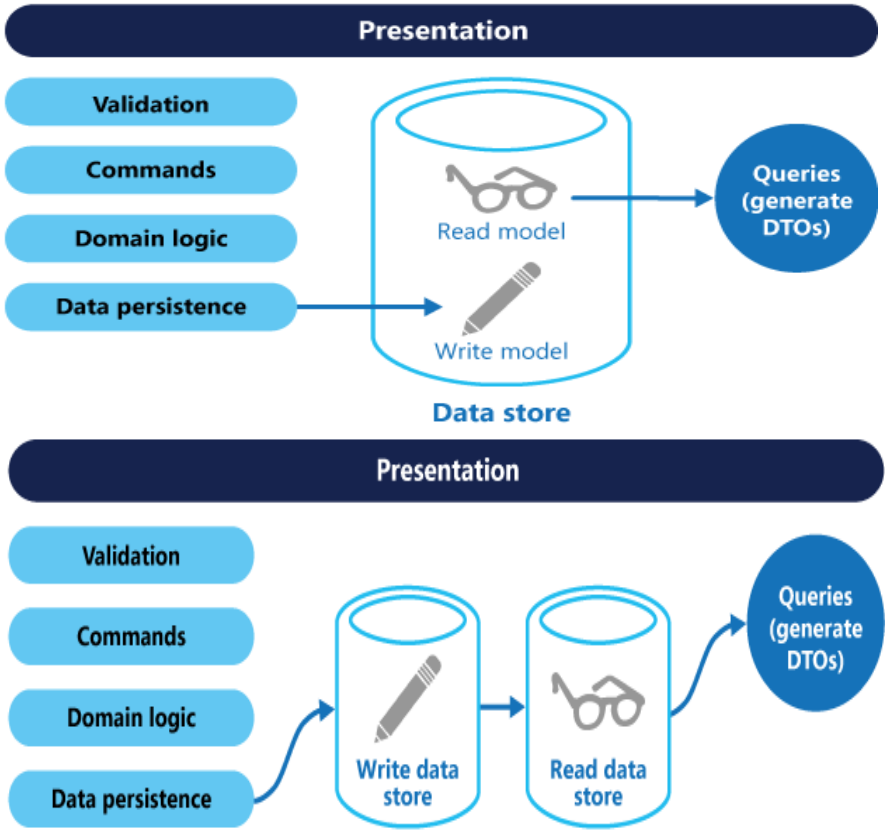


CRUD Disadvantages

- **A mismatch between the read and write** representations of the data.
- It **risks data contention when records are locked in the data store** in a collaborative domain, where multiple actors operate in parallel on the same set of data. These risks increase as the complexity and throughput of the system grows.
- It can make **managing security and permissions more complex** because each entity is subject to both read and write operations, which might expose data in the wrong context.

Event Sourcing & CQRS (Command and Query Responsibility Segregation)

- In traditional data management systems, both commands (updates to the data) and queries (requests for data) are executed against the same set of entities in a single data repository.
- CQRS is a pattern that segregates the operations that read data (Queries) from the operations that update data (Commands) by using separate interfaces.
- CQRS should only be used on specific portions of a system in Bounded Context (in DDD).
- CQRS should be used along with Event Sourcing.



Java Axon Framework Resource : http://www.axonframework.org

MSDN – Microsoft https://msdn.microsoft.com/en-us/library/dn568103.aspx | Martin Fowler : CQRS – http://martinfowler.com/bliki/CQRS.html

Axon Framework For Java

CQS : Bertrand Meyer

Greg Young

Event Sourcing Intro

Standard CRUD Operations – Customer Profile – Aggregate Root

Profile Created	Title Updated	New Address added	Notes Removed
Time T1	T2	T3	T4

Event Sourcing and Derived Aggregate Root

Commands

1. Create Profile
2. Update Title
3. Add Address
4. Delete Notes

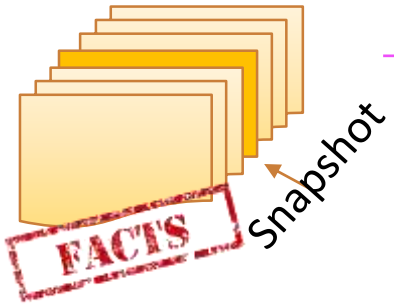
2

Events

1. Profile Created Event
2. Title Updated Event
3. Address Added Event
4. Notes Deleted Event

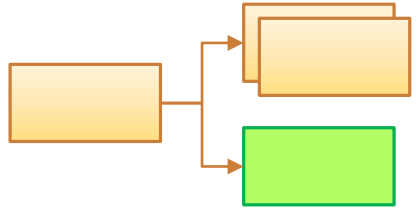
3

Event store



Single Source of Truth

Derived



Current State of the Customer Profile

4

Greg Young

Event Sourcing and CQRS Design Example

Domain

The example focus on a concept of a Café which tracks the visit of an individual or group to the café. When people arrive at the café and take a table, a tab is opened. They may then order drinks and food. Drinks are served immediately by the table staff, however food must be cooked by a chef. Once the chef prepared the food it can then be served.

Events

- TabOpened
- DrinksOrdered
- FoodOrdered
- DrinksCancelled
- FoodCancelled
- DrinksServed
- FoodPrepared
- FoodServed
- TabClosed

An Event Stream which is an **immutable** collection of events up until a specific version of an **aggregate**.

The purpose of the version is to implement optimistic locking:

Commands

- OpenTab
- PlaceOrder
- AmendOrder
- MarkDrinksServed
- MarkFoodPrepared
- MarkFoodServed
- CloseTab

Commands are things that indicate **requests** to our domain. While an event states that something certainly happened, a command may be **accepted** or **rejected**.

An accepted command leads to zero or more events being emitted to incorporate new facts into the system. A rejected command leads to some kind of exception.

Aggregates

- A Single Object, which doesn't reference any others.
- An isolated Graph of objects, with One object designated as the Root of the Aggregate.

Exception

- CannotCancelServedItem
- TabHasUnservedItem
- MustPayEnough

An important part of the modeling process is thinking about the things that can cause a command to be refused.

Source: http://cqrs.nu/tutorial/cs/01-design

Event Storming : Restaurant Dining Example – Customer Journey

1 Processes

When people arrive at the Restaurant and take a table, a Table is opened. They may then order drinks and food. Drinks are served immediately by the table staff, however food must be cooked by a chef. Once the chef prepared the food it can then be served. Table is closed when the bill is prepared.

Customer Journey thru Dinning Processes

2 Commands

- Add Drinks
- Add Food
- Update Food

- **Open Table**
- Add Juice
- Add Soda
- Add Appetizer 1
- Add Appetizer 2

- Remove Soda
- Add Food 1
- Add Food 2
- Place Order
- **Close Table**

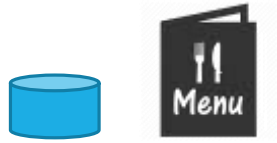
- Serve Drinks
- Prepare Food
- Serve Food

- **Prepare Bill**
- Process Payment

4 ES Aggregate

- Dinning Order
- Billable Order

Food Menu | Dining | Kitchen | Order | Payment



Microservices

3 Events

- Drinks Added
- Food Added
- Food Updated
- Food Discontinued

- Table Opened
- Juice Added
- Soda Added
- Appetizer 1 Added
- Appetizer 2 Added

- Remove Soda
- Food 1 Added
- Food 2 Added
- Order Placed
- Table Closed

- Juice Served
- Soda Served
- Appetizer Served
- Food Prepared
- Food Served

- Bill Prepared
- Payment Processed

- Payment Approved
- Payment Declined
- Cash Paid

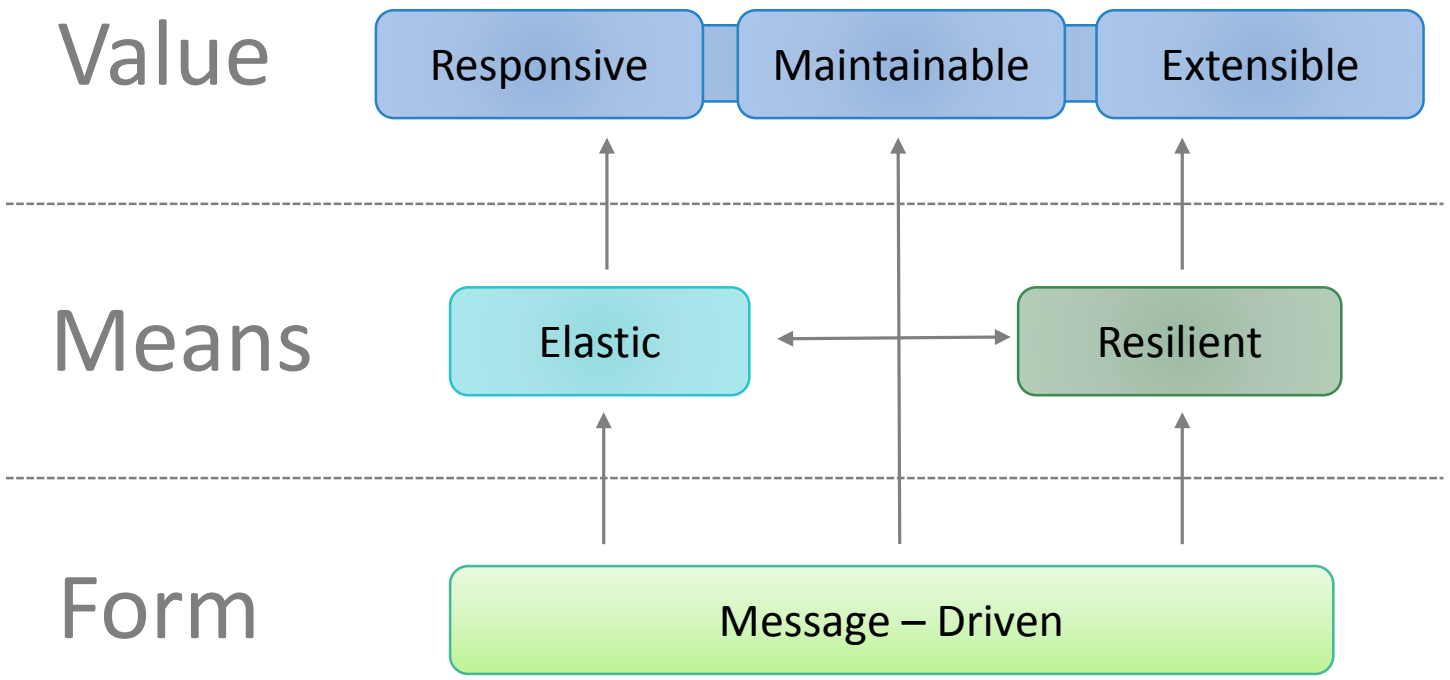
The purpose of this example is to demonstrate the concept of ES / CQRS thru Event Storming principles.

Summary – Event Sourcing and CQRS

1. Immutable Events
2. Events represents the state change in Aggregate Root
3. Aggregates are Derived from a Collection of Events.
4. Separate Read and Write Models
5. Commands (originated from user or systems) creates Events.
6. Commands and Queries are always separated and possibly reads and writes using different data models.

Functional Reactive Programming

Functional Reactive Programming



Principles		What it means?
Responsive	thus	React to users demand
Resilient	thus	React to errors and failures
Elastic	thus	React to load
Message-Driven	thus	React to events and messages

1. A ***responsive, maintainable & Extensible*** application is the goal.
2. A *responsive* application is both ***scalable (Elastic)*** and ***resilient***.
3. Responsiveness is impossible to achieve without both scalability and resilience.
4. A ***Message-Driven*** architecture is the foundation of scalable, resilient, and ultimately responsive systems.

Reactive Extensions (Rx) Source: http://reactivex.io/

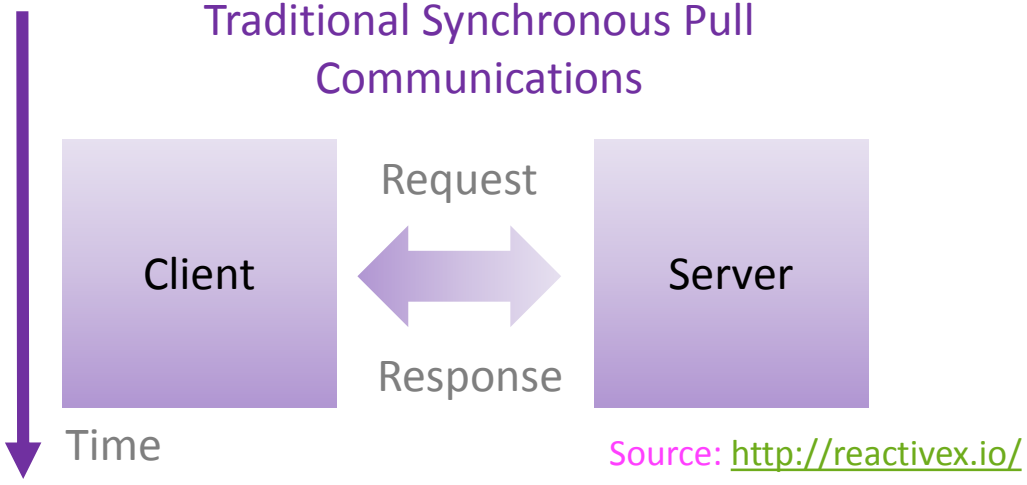
4 Building Blocks of RxJava

Reactive Extensions (Rx)

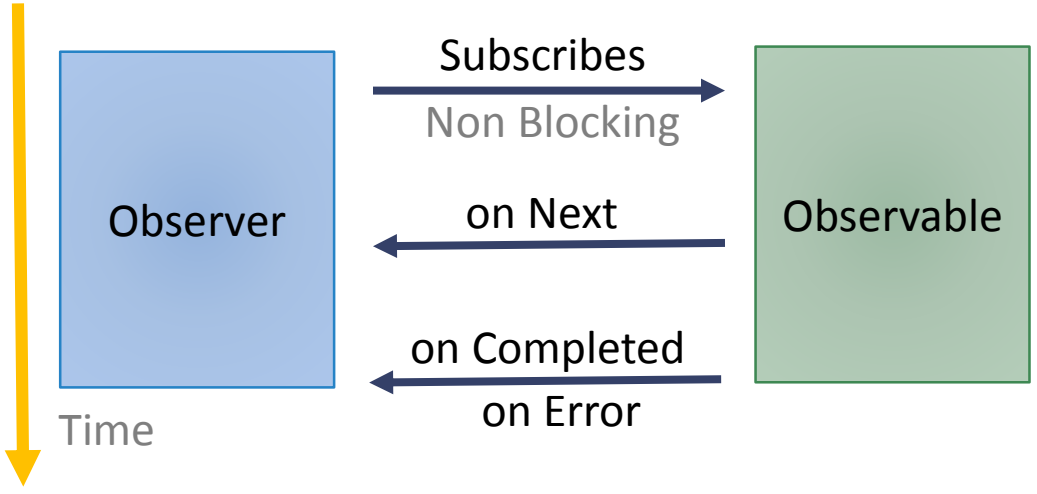
1 **Observable** Source of Data Stream [Sender]

2 **Observer** Listens for emitted values [Receiver]

1. The Observer subscribes (listens) to the Observable
2. Observer react to what ever item or sequence of items the Observable emits.
3. Many Observers can subscribe to the same Observable



Source: http://reactivex.io/



4 Building Blocks of RxJava

3

Schedulers

Schedulers are used to manage and control concurrency.

1. observeOn: Thread Observable is executed
2. subscribeOn: Thread subscribe is executed

4

Operators

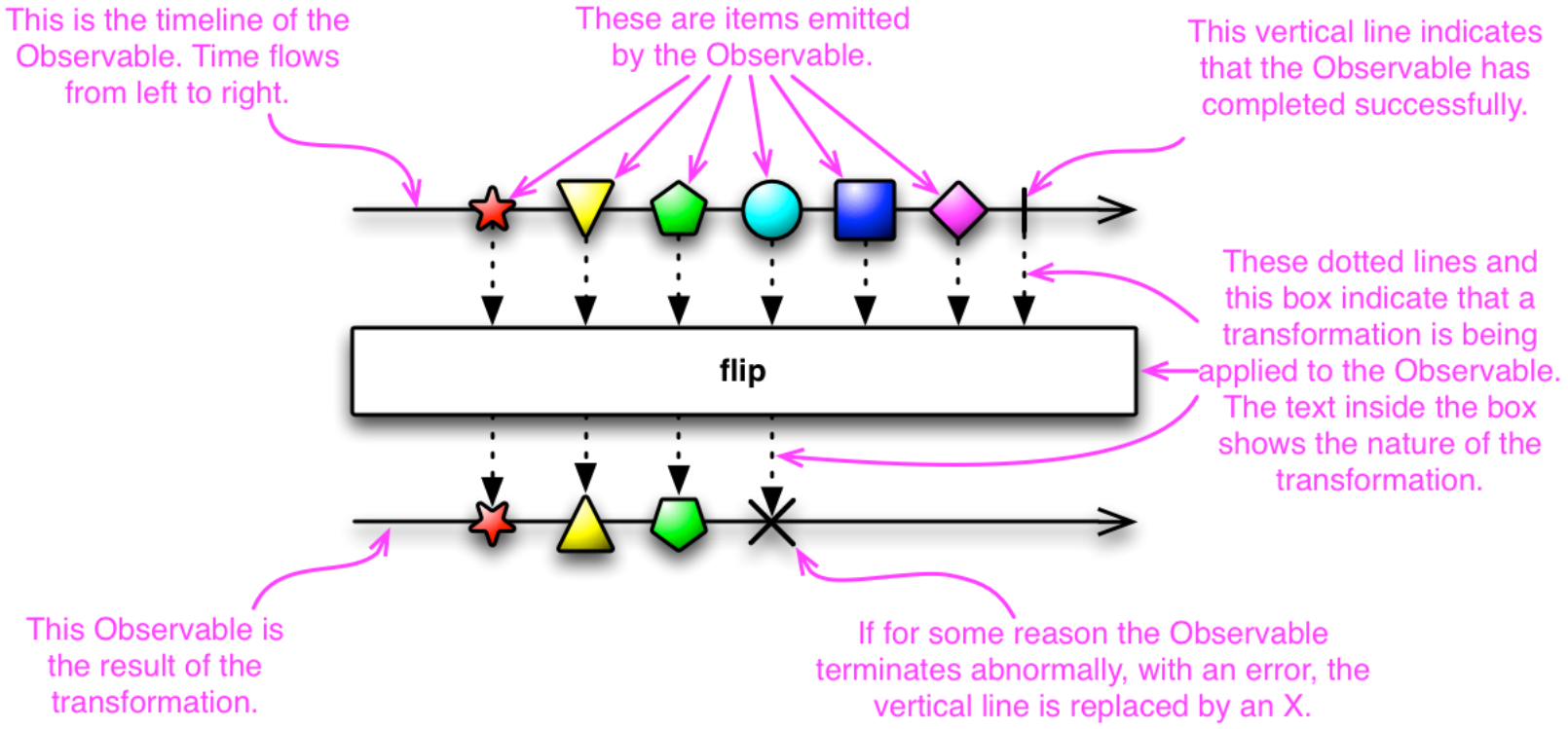
- Content Filtering
- Time Filtering
- Transformation

Operators that let you Transform, Combine, Manipulate, and work with the sequence of items emitted by Observables

Source: http://reactivex.io/

Observable Design Pattern (Marble Diagram)

- An *Observer* *subscribes* to an *Observable*.
- Then that observer reacts to whatever item or sequence of items the Observable *emits*.



Reactive Extensions (Rx)

Source: http://reactivex.io/RxJava/javadoc/index.html?rx/Observable.html | http://rxmarbles.com

Observable / Observer Design Pattern

- Allows for Concurrent Operations: the observer does not need to block while waiting for the observable to emit values
- Observer waits to receive values when the observable is ready to emit them
- Based on push rather than pull

Source: http://reactivex.io/RxJava/javadoc/index.html?rx/Observable.html

What's missing from GOF Observer Pattern

1. The ability for the producer to signal to the consumer that there is no more data available (a foreach loop on an Iterable completes and returns normally in such a case; an Observable calls its observer's onComplete method)
2. The ability for the producer to signal to the consumer that an error has occurred (an Iterable throws an exception if an error takes place during iteration; an Observable calls its observer's onError method)
3. Multiple Thread Implementations and hiding those details.
4. Dozens of Operators to handle data.

Source: http://reactivex.io/intro.html

Compare Iterable Vs. Observable

Observable is the asynchronous / push dual to the synchronous pull Iterable

Observables are:

- Composable: Easily chained together or combined
- Flexible: Can be used to emit:
  - A scalar value (network result)
  - Sequence (items in a list)
  - Infinite streams (weather sensor)
- Free from callback hell: Easy to transform one asynchronous stream into another

Event	Iterable (Pull)	Observable (Push)
Retrieve Data	T next()	onNext(T)
Discover Error	throws Exception	onError (Exception)
Complete	!hasNext()	onComplete()

Source: http://reactivex.io/RxJava/javadoc/index.html?rx/Observable.html

Comparison : Iterable / Streams / Observable

Java 6 – Blocking Call

```
/**
 * Iterable Serial Operations Example
 * Java 6 & 7
 */
public void testIterable(AppleBasket _basket) {

    Iterable<Apple> basket = _basket.iterable();
    FruitProcessor<Apple> fp =
            new FruitProcessor<Apple>("IT");
    try {

        // Serial Operations
        for(Apple apple : basket) {
            fp.onNext(apple);
        }

        fp.onCompleted();

    } catch (Exception e) {
        fp.onError(e);
    }
}
```

First Class Visitor (Consumer) Serial Operations

Java 8 – Blocking Call

```
/**
 * Parallel Streams Example
 * Java 8 with Lambda Expressions
 */
public void testParallelStream(AppleBasket _basket) {

    Collection<Apple> basket = _basket.collection();
    FruitProcessor<Apple> fp =
            new FruitProcessor<Apple>("PS");

    try {

        // Parallel Operations
        basket
            .parallelStream()
            .forEach(apple -> fp.onNext(apple));

        fp.onCompleted();
    } catch (Exception e) {
        fp.onError(e);
    }
}
```

Parallel Streams (10x Speed)
Still On Next, On Complete and On Error are Serial Operations

Rx Java - Freedom

```
/**
 * Observable : Completely Asynchronous - 1
 * Functional Reactive Programming : Rx Java
 */
public void testObservable1() {

    Observable<Apple> basket = fruitBasketObservable();
    Observer<Apple> fp = fruitProcessor("01");

    basket
        .observeOn(Schedulers.computation())
        .subscribeOn(Schedulers.computation())
        .subscribe(
                apple -> fp.onNext(apple),
                throwable -> fp.onError(throwable),
                () -> fp.onCompleted()
                );
}
```

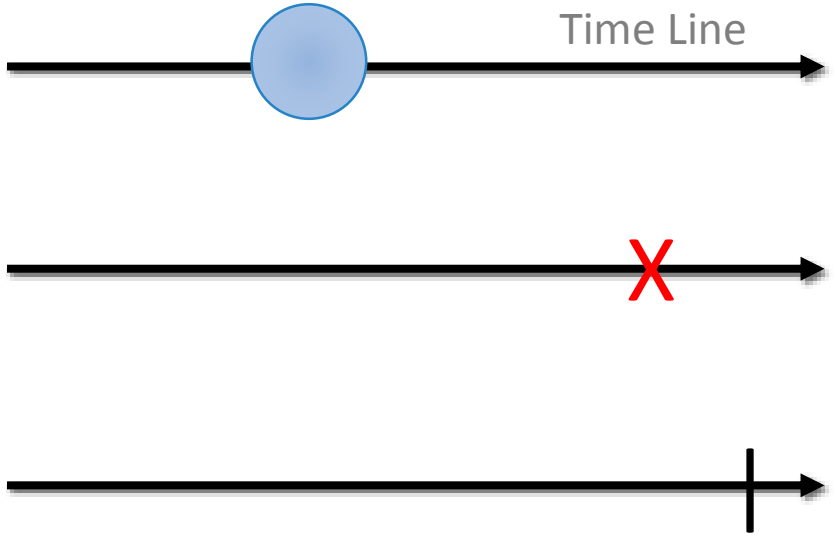
Completely Asynchronous Operations

Source Code: https://github.com/meta-magic/rxjava

Observer<T> Contract

Methods:

- onNext(T)
- onError(Throwable T)
- onComplete()



onError / onComplete called exactly once

Source: http://reactivex.io/RxJava/javadoc/index.html?rx/Observable.html

Reactive Extensions (Rx)

RxJava Scheduler Details

- If you want to introduce multithreading into your cascade of Observable operators, you can do so by instructing those operators (or particular Observables) to operate on particular *Schedulers*.

- By default, an Observable and the chain of operators that you apply to it will do its work, and will notify its observers, on the same thread on which its Subscribe method is called.

- The SubscribeOn operator changes this behavior by specifying a different Scheduler on which the Observable should operate. TheObserveOn operator specifies a different Scheduler that the Observable will use to send notifications to its observers.

Source: http://reactivex.io/documentation/scheduler.html

Functional Reactive Programming : Design Patterns

Single Component Pattern

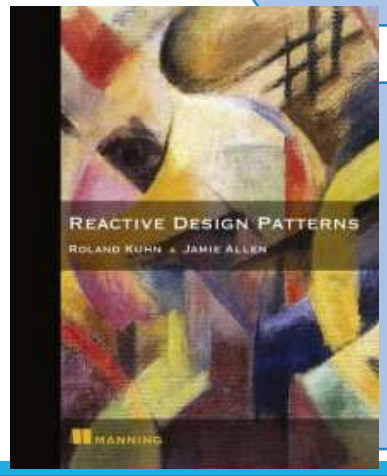
A Component shall do ONLY one thing, But do it in FULL.

Single Responsibility Principle By DeMarco : Structured Analysis & System Specification (Yourdon, New York, 1979)

Let-It-Crash Pattern

Prefer a FULL component restart to complex internal failure handling.

Candea & Fox: Crash-Only Software (USENIX HotOS IX, 2003)
Popularized by Netflix Chaos Monkey. Erlang Philosophy



Saga Pattern

Divide long-lived distributed transactions into quick local ones with compensating actions for recovery.

Pet Helland: Life Beyond Distributed Transactions CIDR 2007

Summary – Functional Reactive Programming

1. A ***responsive, maintainable & Extensible*** application is the goal.
2. A ***responsive*** application is both ***scalable (Elastic)*** and ***resilient***.
3. Responsiveness is impossible to achieve without both scalability and resilience.
4. A ***Message-Driven*** architecture is the foundation of scalable, resilient, and ultimately responsive systems.

3

Scalability

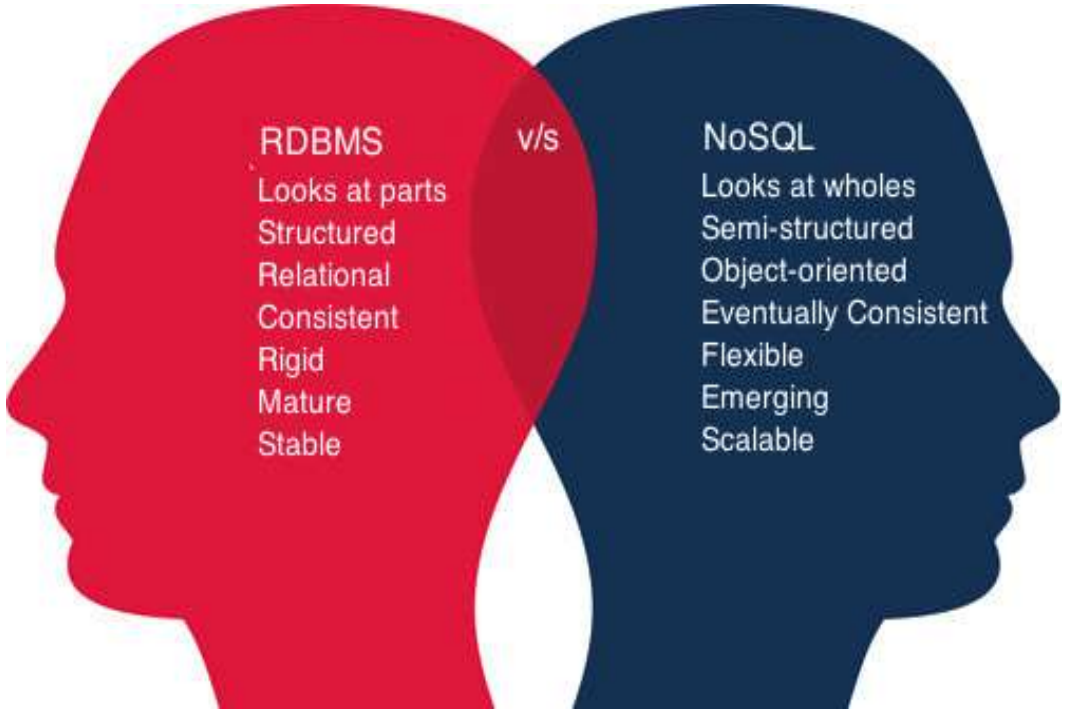
- CAP Theorem
- Distributed Transactions : 2 Phase Commit
- SAGA Design Pattern
- Scalability Lessons from EBay
- Design Patterns
- References

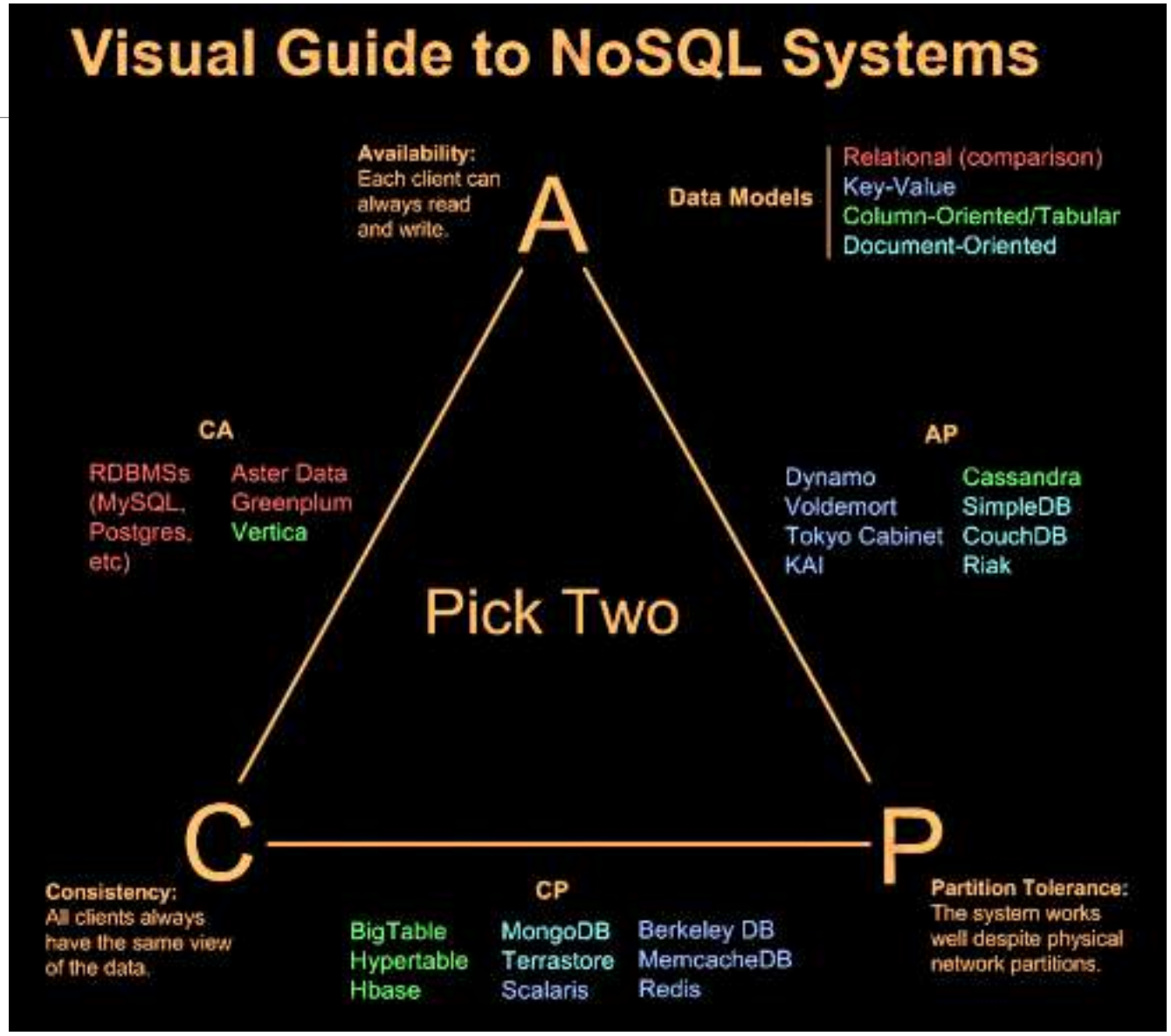
CAP Theorem

by Eric Allen Brewer

Pick Any 2!!

Say NO to 2 Phase Commit ☺





"In a network subject to communication failures, it is impossible for any web service to implement an atomic read / write shared memory that guarantees a response to every request."

Source: http://en.wikipedia.org/wiki/Eric_Brewer_(scientist)

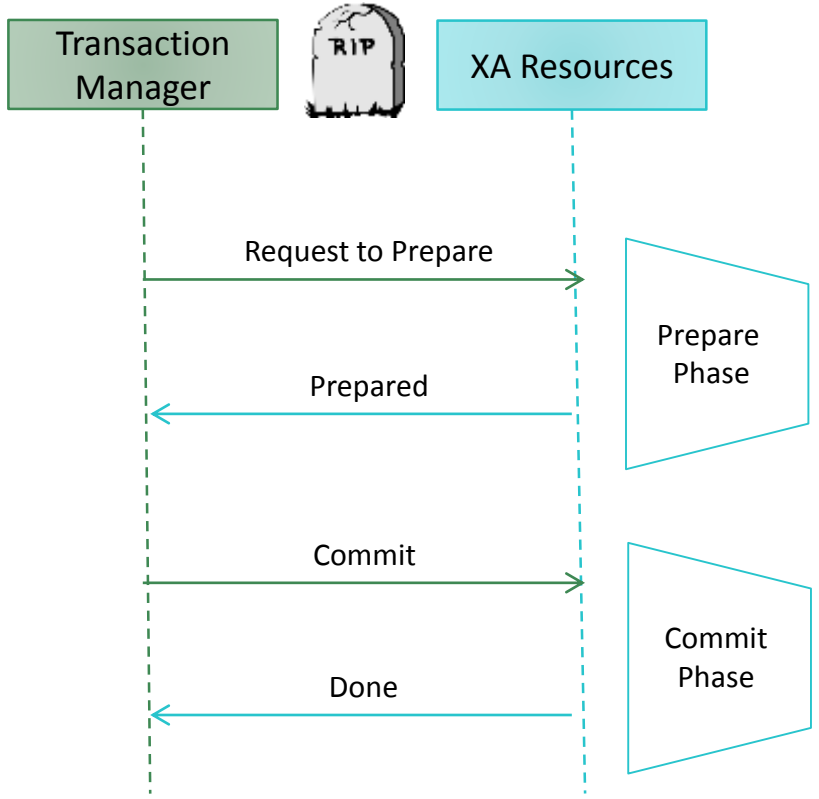
CAP 12 years later: How the "Rules have changed" : http://www.infoq.com/articles/cap-twelve-years-later-how-the-rules-have-changed

Distributed Transactions : 2 Phase Commit

2 PC or not 2 PC, Wherefore Art Thou XA?

How does 2PC impact scalability?

- Transactions are committed in two phases.
- This involves communicating with every database (XA Resources) involved to determine if the transaction will commit in the first phase.
- During the second phase each database is asked to complete the commit.
- While all of this coordination is going on, locks in all of the data sources are being held.
- ***The longer duration locks create the risk of higher contention.***
- *Additionally,* ***the two phases require more database processing time than a single phase commit.***
- **The result is lower overall TPS in the system.**



Solution : Resilient System

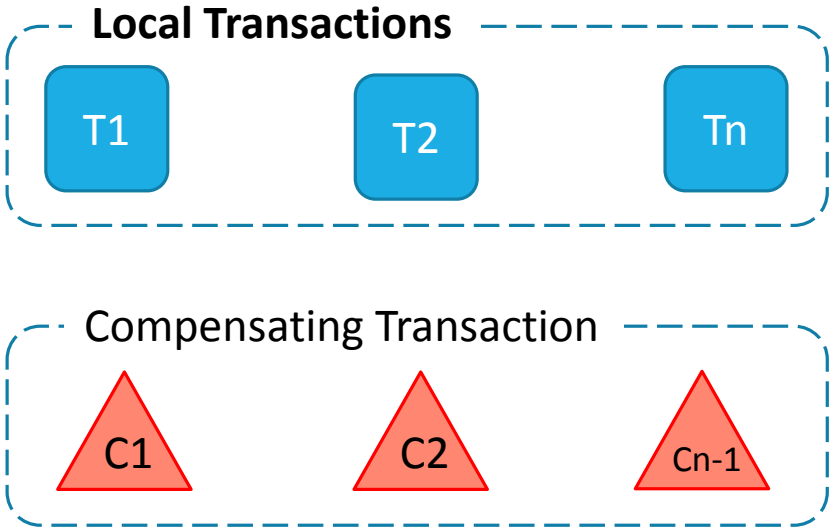
- Event Based
- Design for failure
- Asynchronous Recovery
- Make all operations idempotent.
- Each DB operation is a 1 PC

Source : Pat Helland (Amazon) : Life Beyond Distributed Transactions Distributed Computing : http://dancres.github.io/Pages/

SAGA Design Pattern instead of 2PC

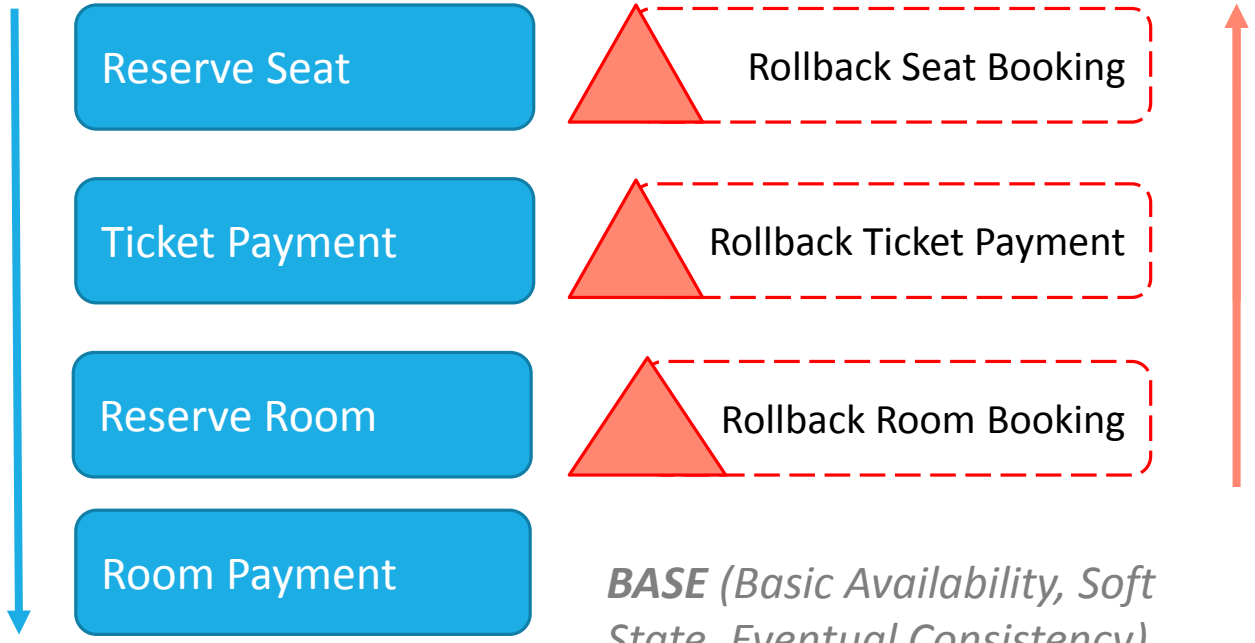
Long Lived Transactions (LLTs) *hold on to DB resources for relatively long periods of time, significantly delaying the termination of shorter and more common transactions.*

Divide long–lived, distributed transactions into quick local ones with compensating actions for recovery.



Source: SAGAS (1987) Hector Garcia Molina / Kenneth Salem, Dept. of Computer Science, Princeton University, NJ, USA

Flight Ticket & Hotel Booking Example



BASE *(Basic Availability, Soft State, Eventual Consistency)*

Scalability Best Practices : Lessons from ebay

	Best Practices	Highlights
#1	Partition By Function	• Decouple the Unrelated Functionalities. • Selling functionality is served by one set of applications, bidding by another, search by yet another. • 16,000 App Servers in 220 different pools • 1000 logical databases, 400 physical hosts
#2	Split Horizontally	• Break the workload into manageable units. • eBay's interactions are stateless by design • All App Servers are treated equal and none retains any transactional state • Data Partitioning based on specific requirements
#3	Avoid Distributed Transactions	• 2 Phase Commit is a pessimistic approach comes with a big COST • **CAP Theorem** (Consistency, Availability, Partition Tolerance). Apply any two at any point in time. • @ eBay No Distributed Transactions of any kind and NO 2 Phase Commit.
#4	Decouple Functions Asynchronously	• If Component A calls component B synchronously, then they are tightly coupled. For such systems to scale A you need to scale B also. • If Asynchronous A can move forward irrespective of the state of B • SEDA (Staged Event Driven Architecture)
#5	Move Processing to Asynchronous Flow	• Move as much processing towards Asynchronous side • Anything that can wait should wait
#6	Virtualize at All Levels	• Virtualize everything. eBay created their on O/R layer for abstraction
#7	Cache Appropriately	• Cache Slow changing, read-mostly data, meta data, configuration and static data.

Source: http://www.infoq.com/articles/ebay-scalability-best-practices

15 April 2018

Summary

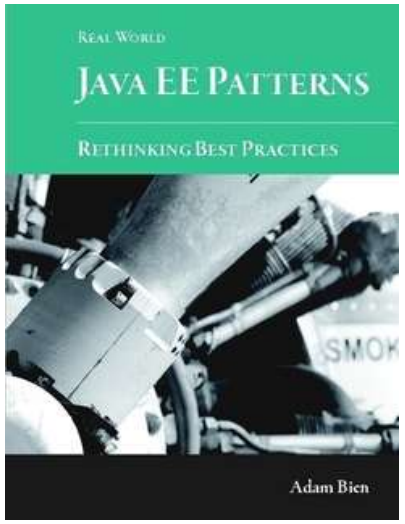
1. Highly Scalable & Resilient Architecture
2. Technology Agnostic
3. Easy to Deploy
4. SAGA for Distributed Transaction
5. Faster Go To Market

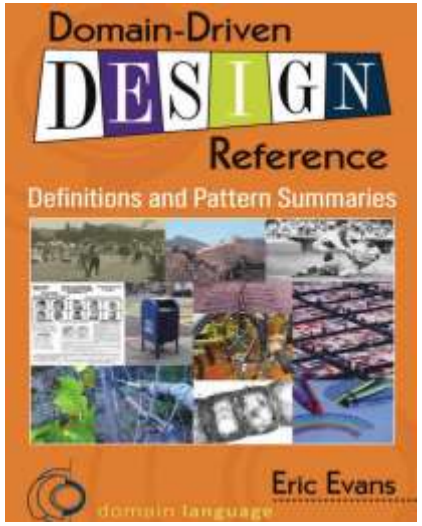
In a Micro Service Architecture,

The **services tend to get simpler**, but the **architecture tends to get more complex**.

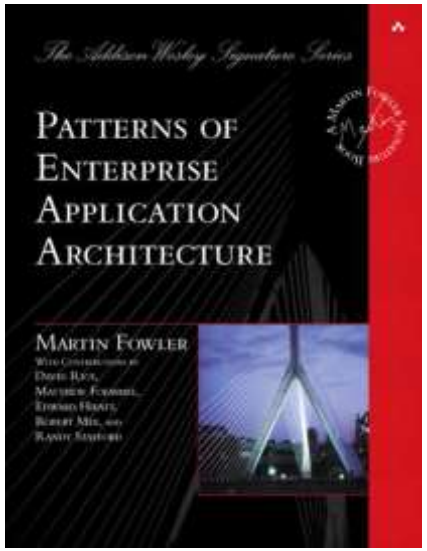
That **complexity** is often managed with **Tooling, Automation, and Process.**

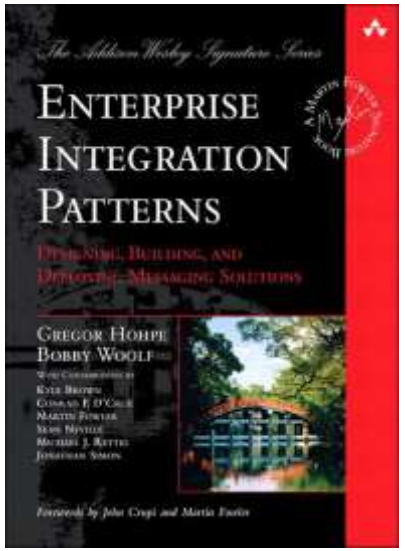
Design Patterns

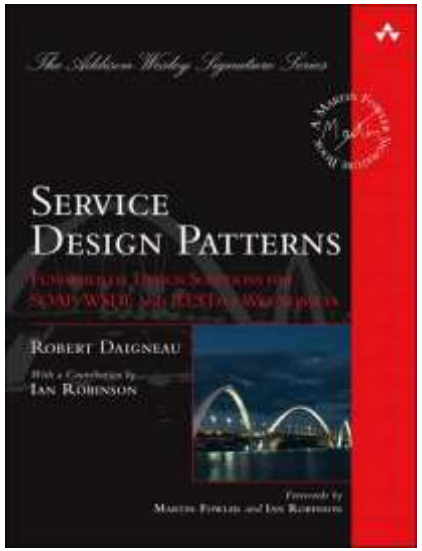


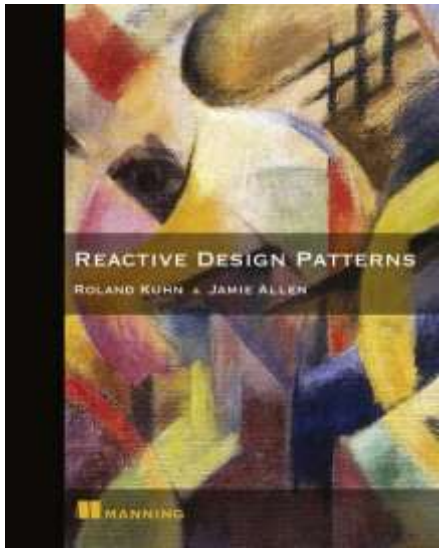


Design Patterns are solutions to general problems that software developers faced during software development.









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Thank you

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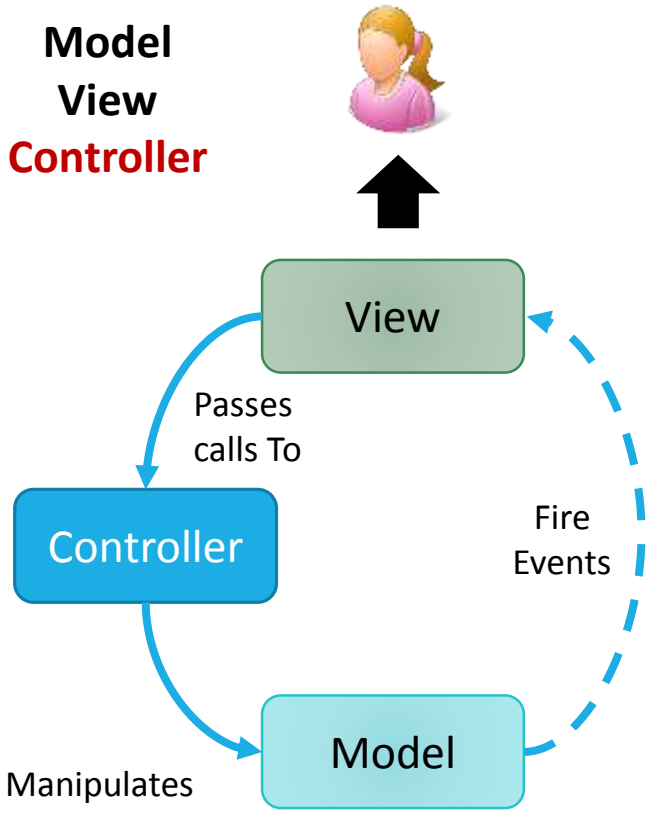
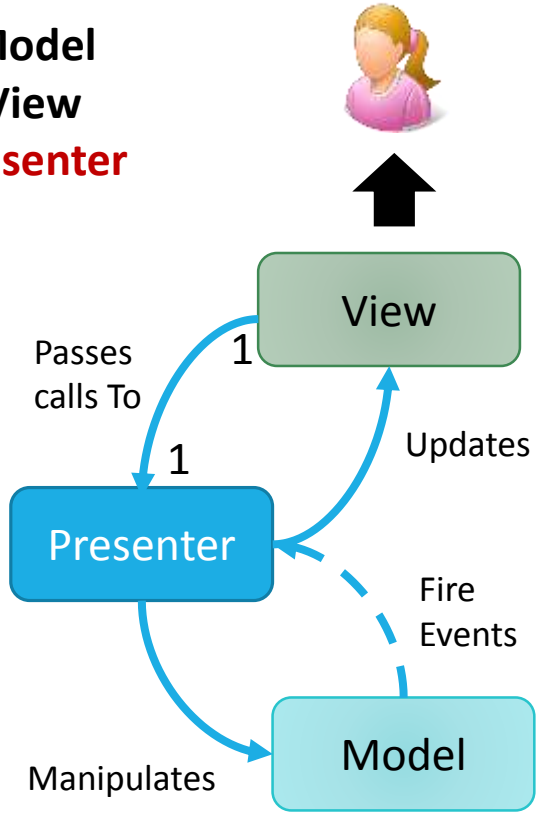
UI Design Patterns

Model
View
Controller



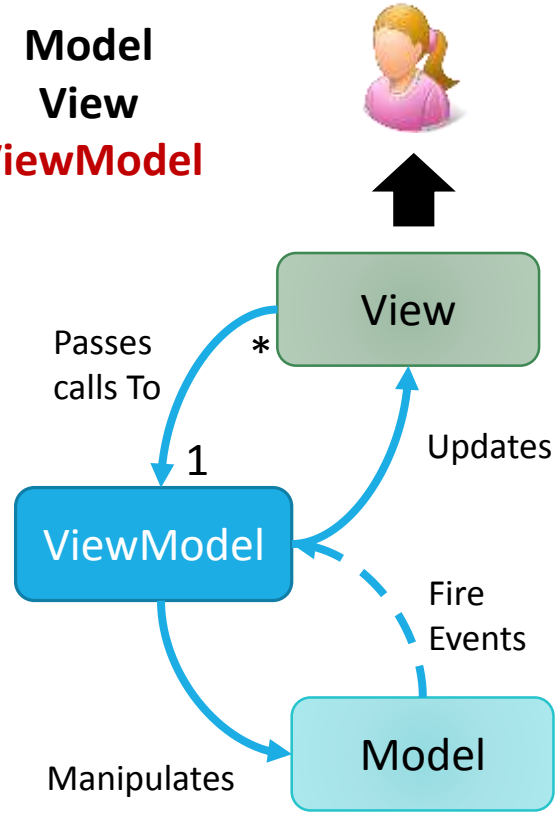
- The **Controller** is responsible to process incoming requests. It receives input from users via the View, then process the user's data with the help of Model and passing the results back to the View.
- Typically, it acts as the coordinator between the View and the Model.

Model
View
Presenter



- The **Presenter** is responsible for handling all UI events on behalf of the view. This receive input from users via the View, then process the user's data with the help of Model and passing the results back to the View.
- Unlike view and controller, **view and presenter are completely decoupled from each other's and communicate to each other's by an interface**. Also, presenter does not manage the incoming request traffic as controller.
- **Supports two-way data binding between View and ViewModel.**

Model
View
ViewModel

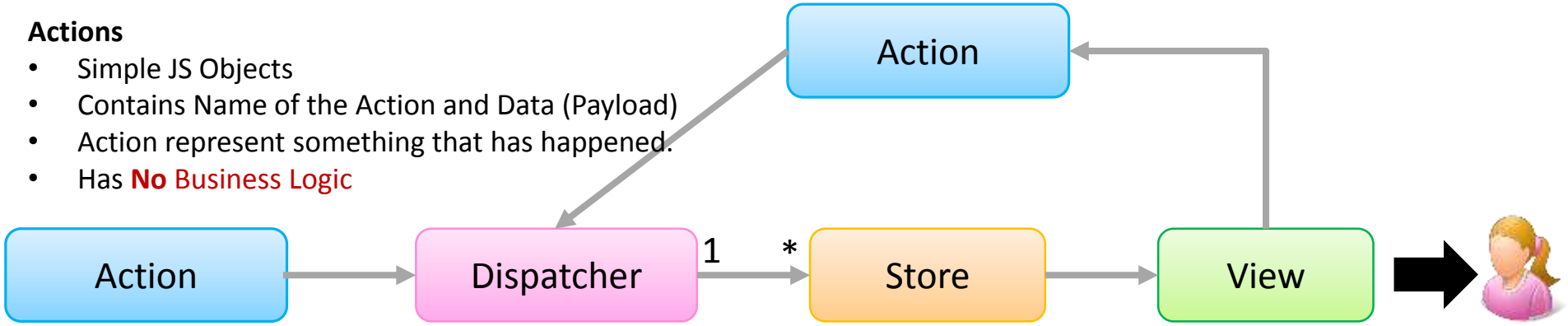


- The View Model is responsible for exposing methods, commands, and other properties that helps to maintain the state of the view, manipulate the model as the result of actions on the view, and trigger events in the view itself.
- There is **many-to-one** relationship between View and ViewModel means many View can be mapped to one ViewModel.
- **Supports two-way data binding between View and ViewModel.**

UI Design Patterns
MVC / MVP / MVVM

Actions

- Simple JS Objects
- Contains Name of the Action and Data (Payload)
- Action represent something that has happened.
- Has **No** Business Logic



Every action is sent to all Stores via callbacks the stores register with the Dispatcher

Dispatcher

- Single Dispatcher per Application
- Manages the Data Flow View to Model
- Receives Actions and dispatch them to Stores

Stores

- Contains state for a Domain (Vs. Specific Component)
- **In Charge** of modifying the Data
- Inform the views when the Data is changed by emitting the Changed Event.

Controller-Views

- Listens to Store changes
- Emit Actions to Dispatcher

Flux Core Concepts

1. One way Data Flow
2. No Event Chaining
3. Entire App State is resolved in store before Views Update
4. Data Manipulation ONLY happen in one place (Store).

UI Design Patterns
Flux / Redux

Redux Core Concepts

1. One way Data Flow
2. No Dispatcher compared to Flux
3. Immutable Store

Available for React & Angular

Store

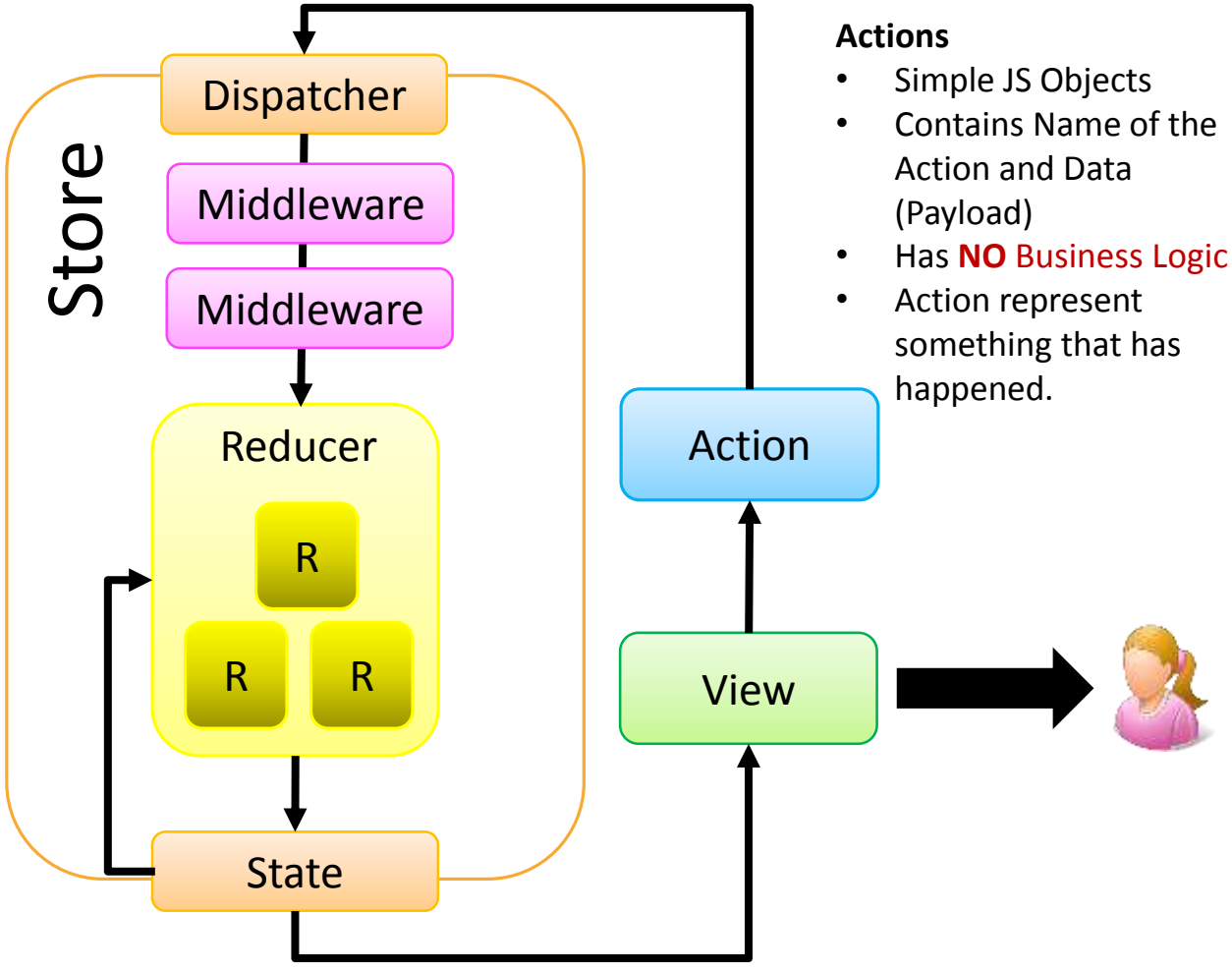
- Multiple View layers can **Subscribe**
- View layer to **Dispatch** actions
- Single Store for the Entire Application
- Data manipulation logic moves out of store to Reducers

Middleware

- Handles External calls
- Multiple Middleware's can be chained.

Reducer

- **Pure** JS Functions
- No External calls
- Can combine multiple reducers
- A function that specifies how the state changes in response to an Action.
- Reducer does **NOT modify** the state. It returns the **NEW State**.



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UI Design Patterns Redux