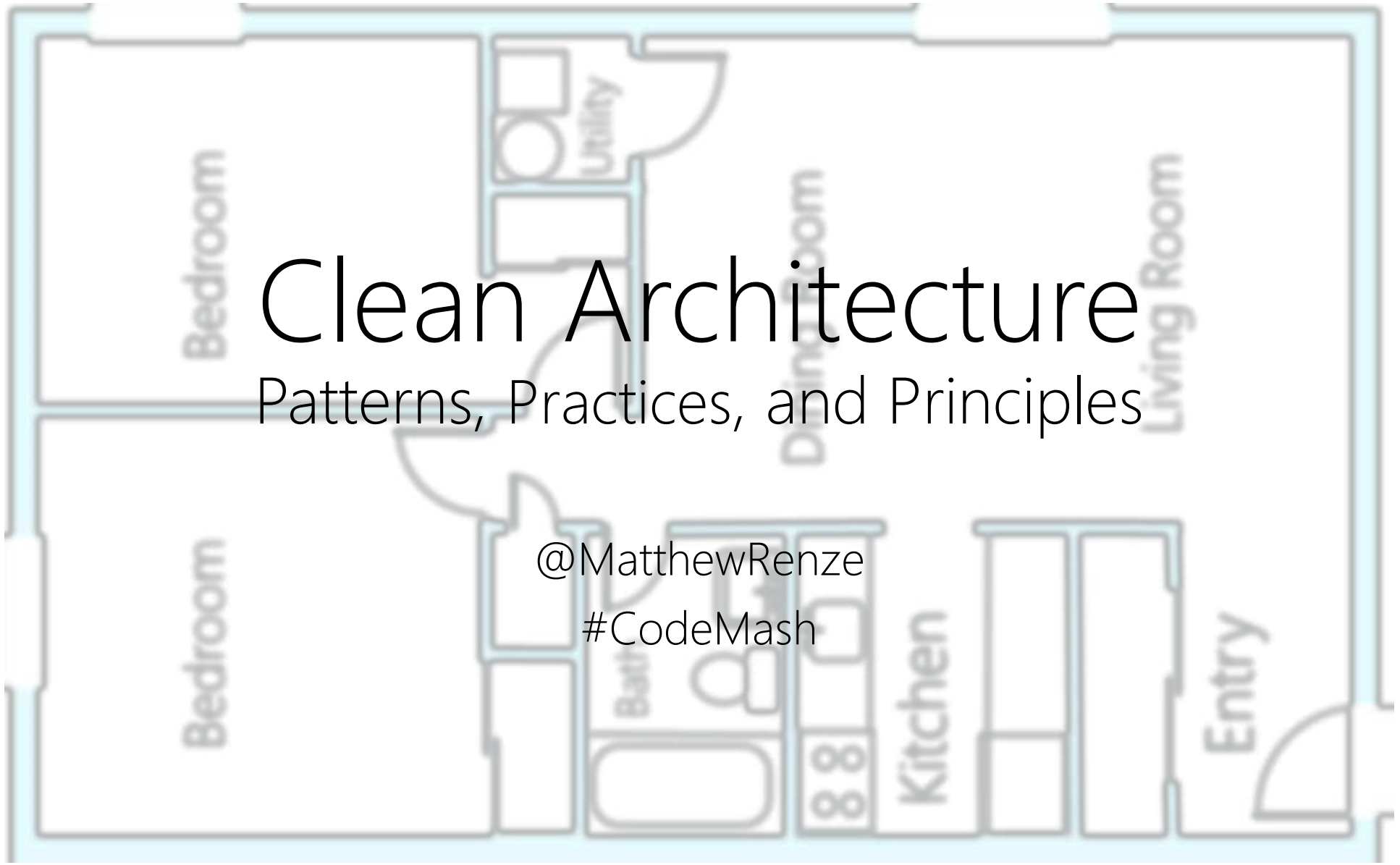
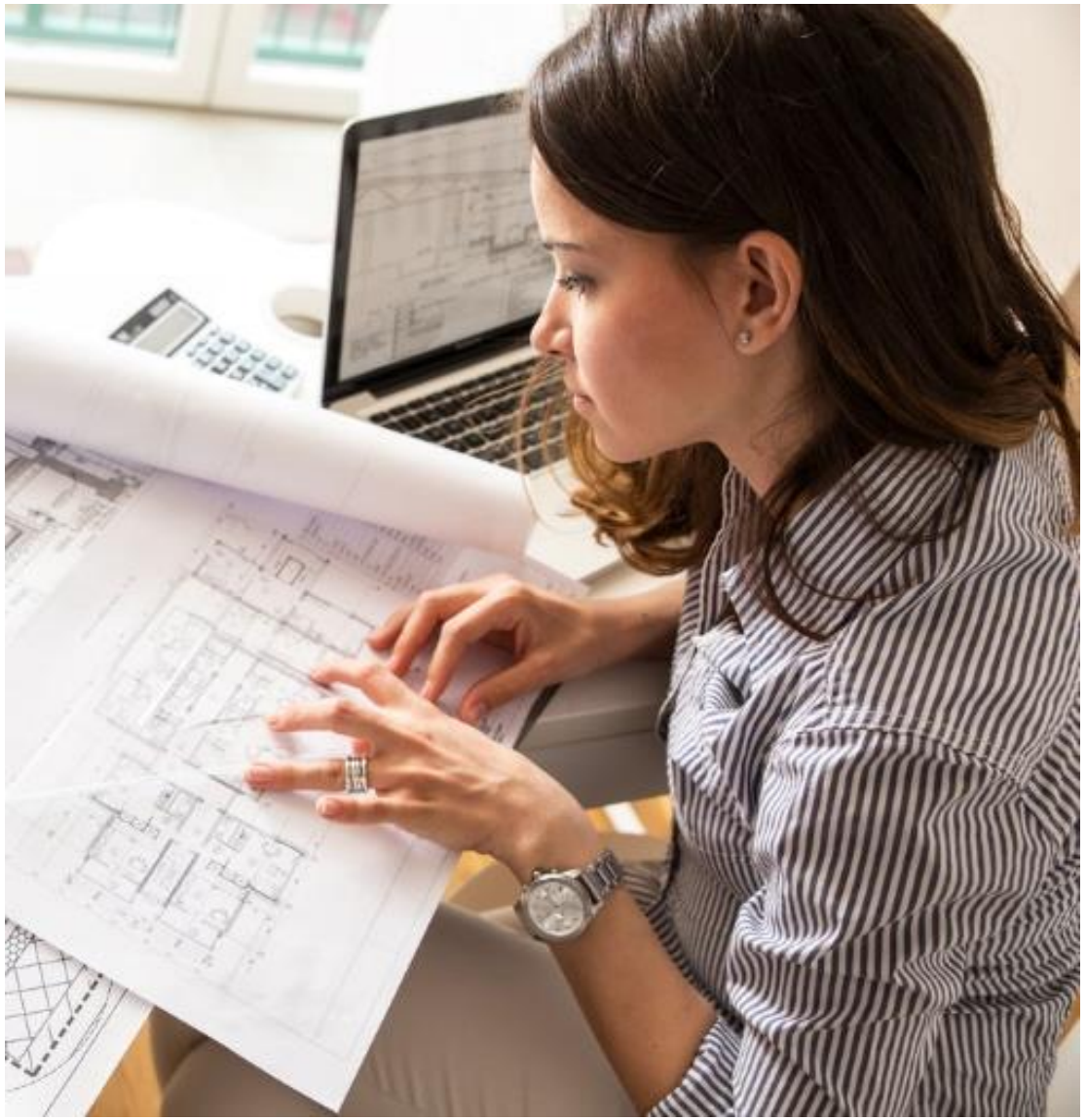



# Clean Architecture

## Patterns, Practices, and Principles

@MatthewRenze

#CodeMash



# Overview

1. Clean Architecture

# Overview

1. Clean Architecture
2. Domain-Centric Architecture

# Overview

1. Clean Architecture
2. Domain-Centric Architecture
3. Application Layer

# Overview

1. Clean Architecture
2. Domain-Centric Architecture
3. Application Layer
4. Commands and Queries

# Overview

1. Clean Architecture
2. Domain-Centric Architecture
3. Application Layer
4. Commands and Queries
5. Functional Organization

# Overview

1. Clean Architecture
2. Domain-Centric Architecture
3. Application Layer
4. Commands and Queries
5. Functional Organization
6. Microservices

# Focus

Enterprise Architecture

# Focus

Enterprise Architecture

Modern equivalent of 3-Layer

# Focus

Enterprise Architecture

Modern equivalent of 3-Layer

Generally applicable

# Focus

Enterprise Architecture

Modern equivalent of 3-Layer

Generally applicable

6 Key Points

# Focus

Enterprise Architecture

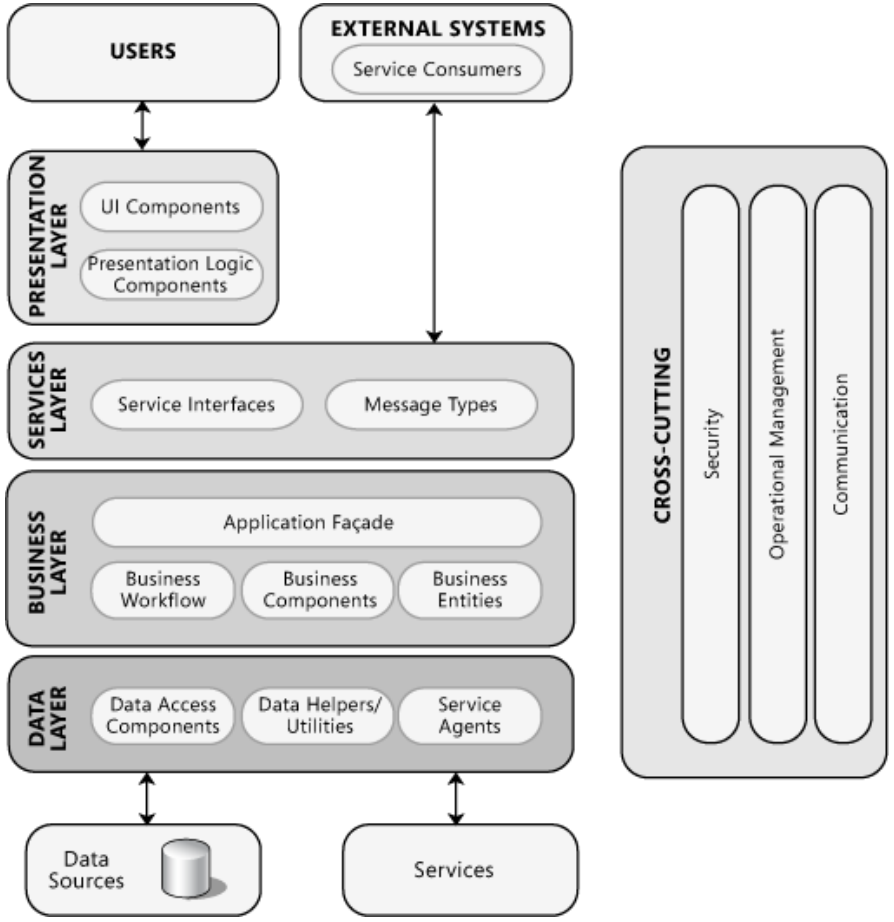
Modern equivalent of 3-Layer

Generally applicable

6 Key Points

Q & A

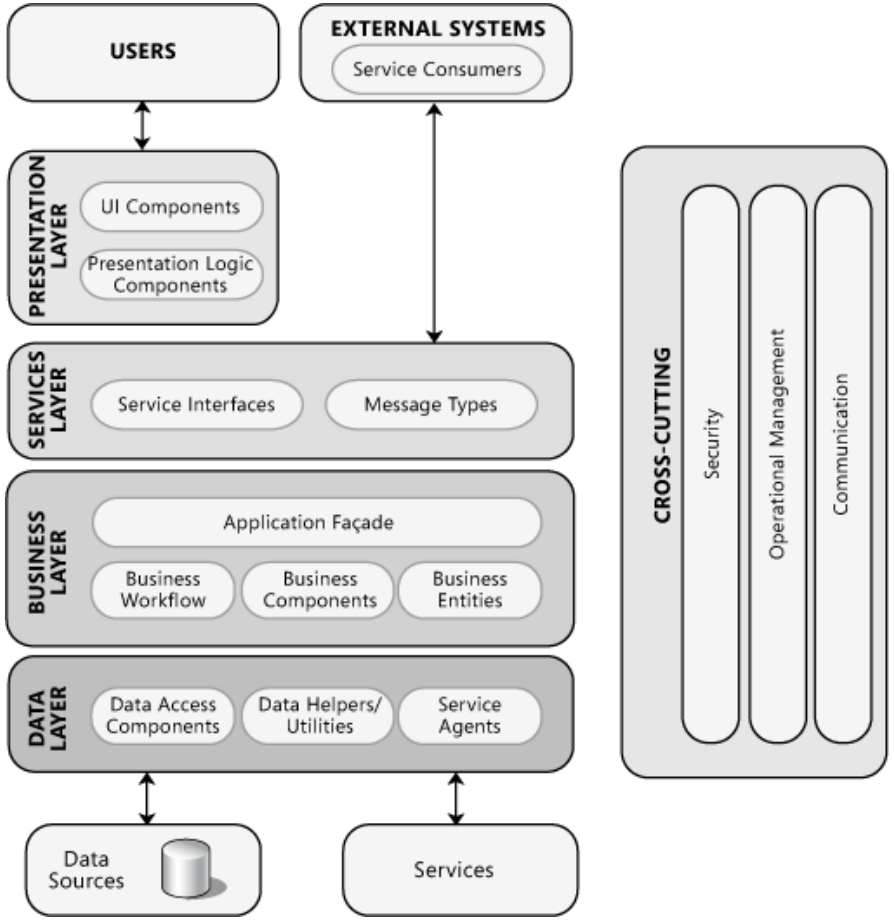
# What is Software Architecture?




Source: http://msdn.microsoft.com/en-us/library/ff650706.aspx

# What is Software Architecture?

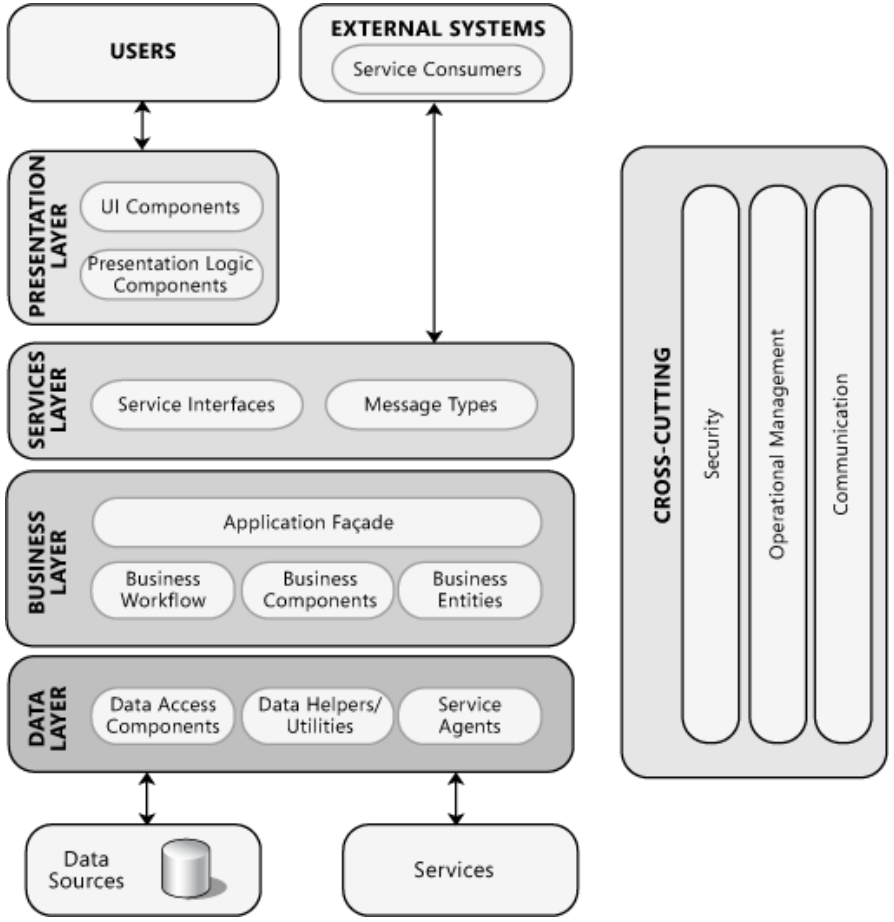
High-level




Source: http://msdn.microsoft.com/en-us/library/ff650706.aspx

# What is Software Architecture?

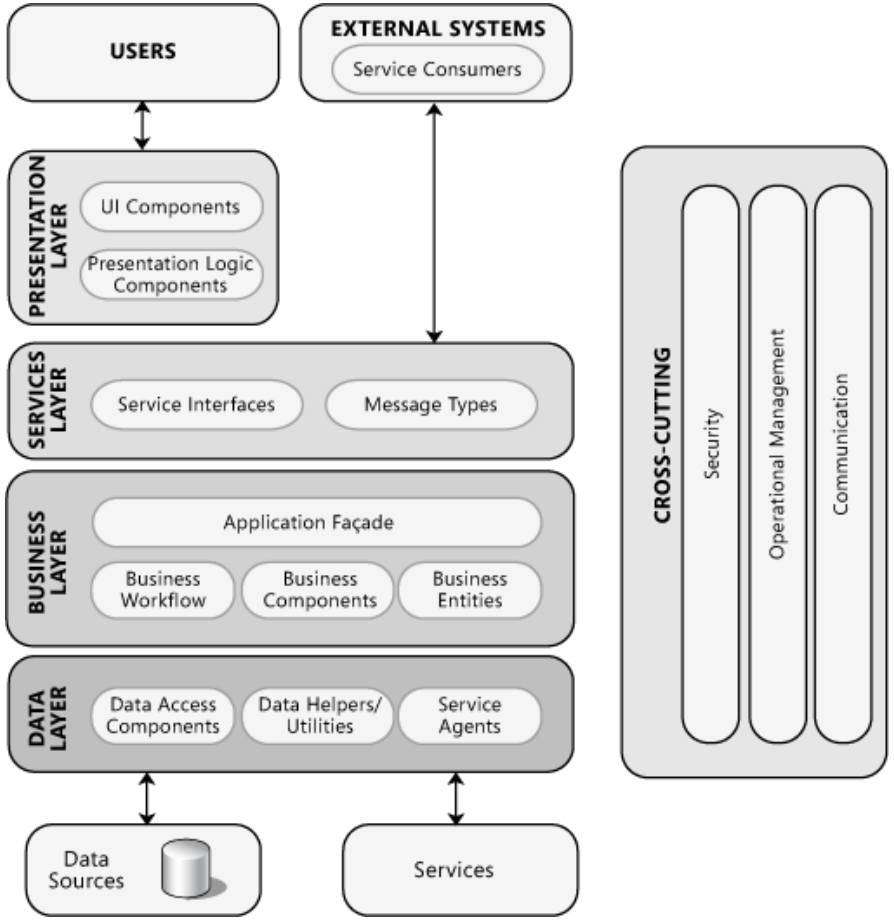
High-level
Structure




Source: http://msdn.microsoft.com/en-us/library/ff650706.aspx

# What is Software Architecture?

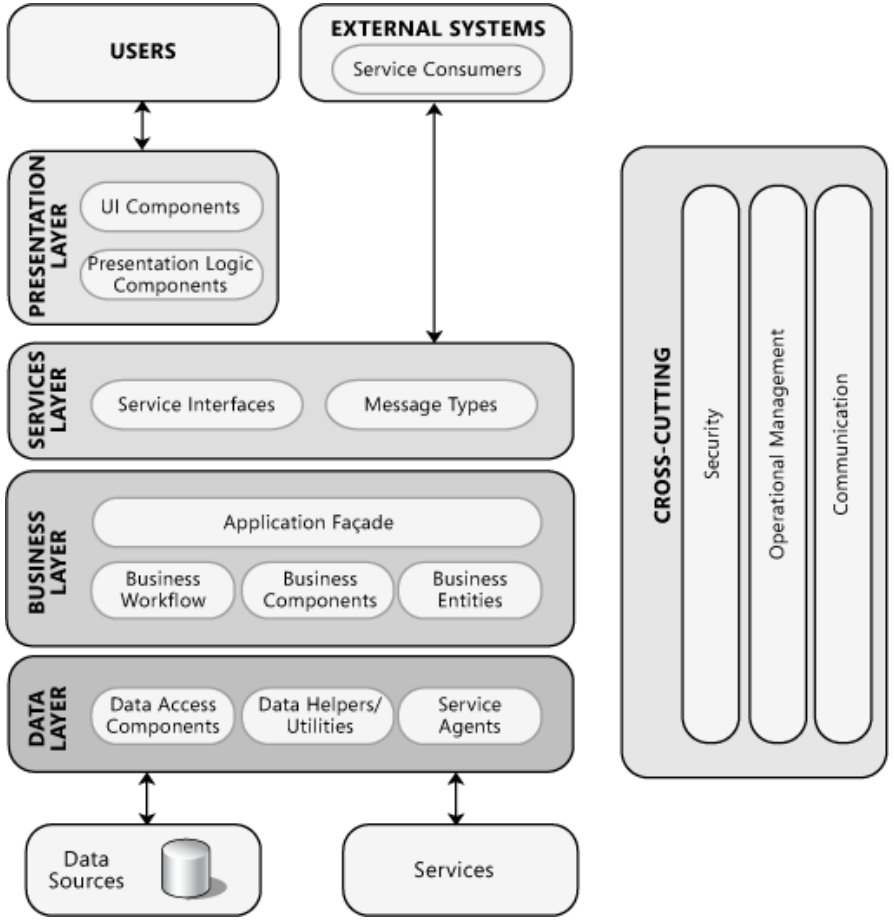
High-level
Structure
Layers




Source: http://msdn.microsoft.com/en-us/library/ff650706.aspx

# What is Software Architecture?

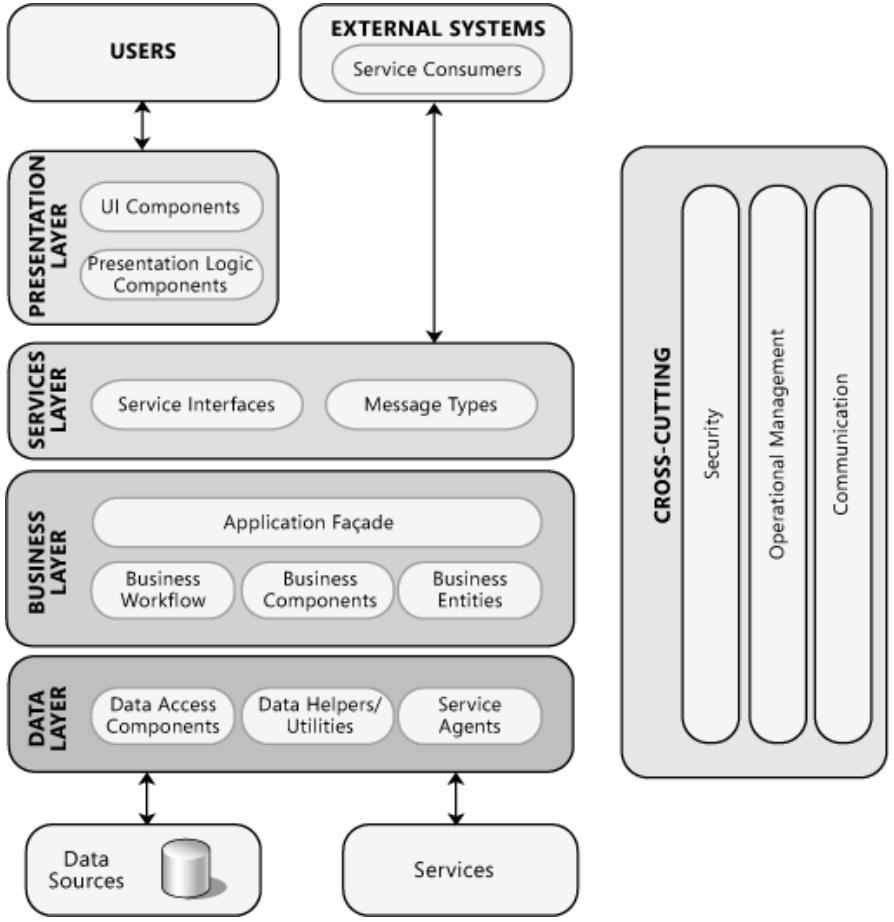
High-level
Structure
Layers
Components




Source: http://msdn.microsoft.com/en-us/library/ff650706.aspx

# What is Software Architecture?

High-level
Structure
Layers
Components
Relationships

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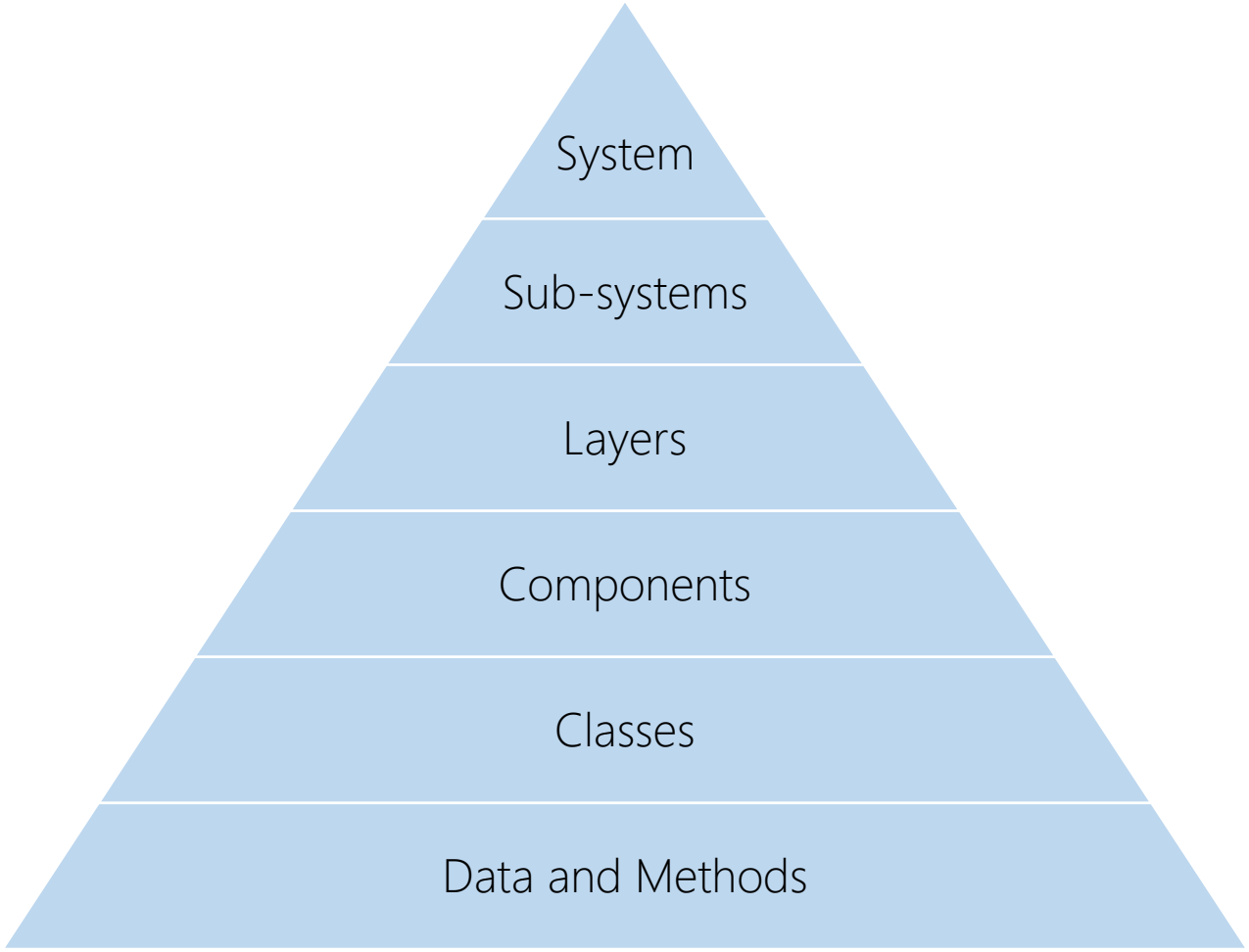
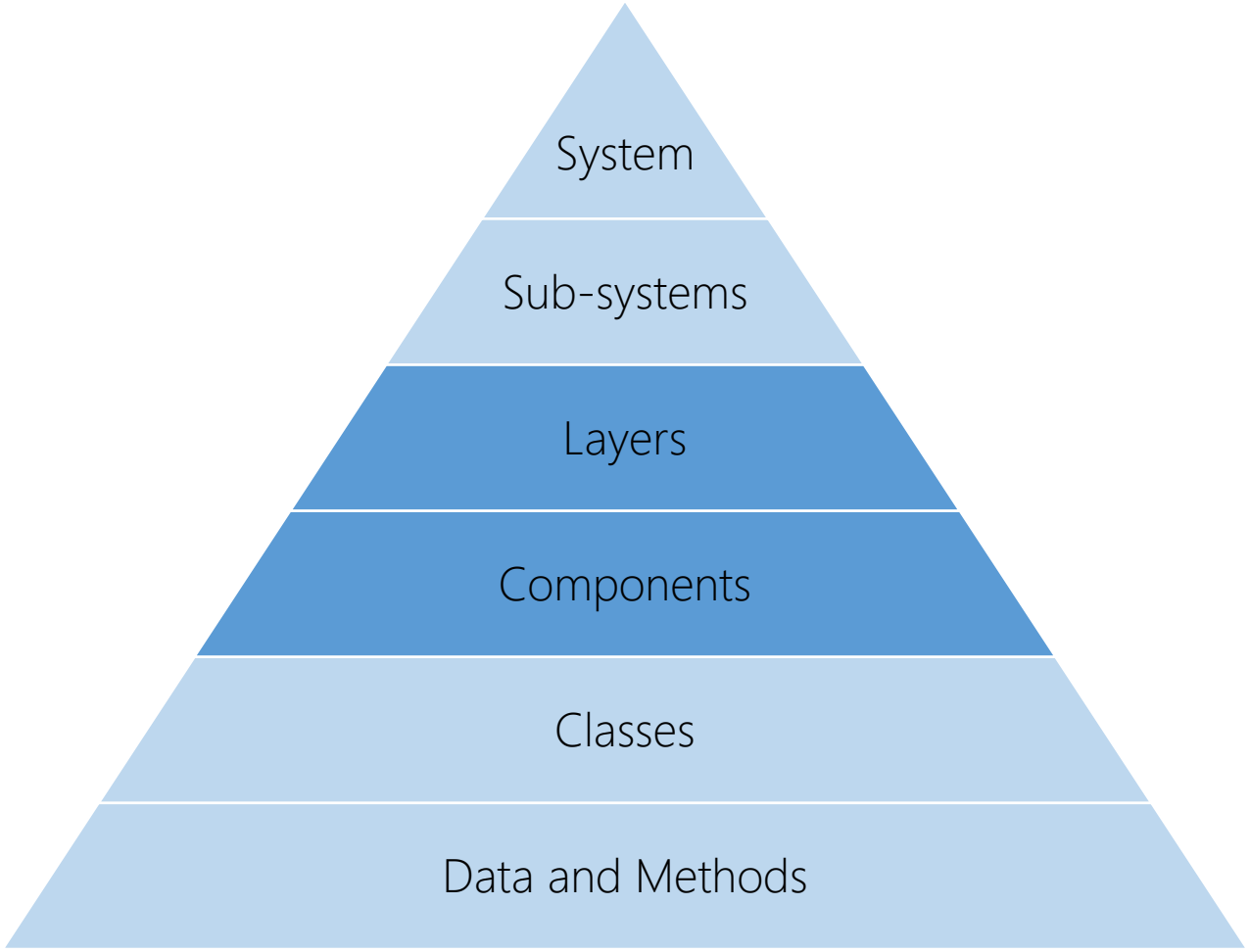
# Levels of Architectural Abstraction



# Levels of Architectural Abstraction



# Messy vs Clean Architecture

# Messy vs Clean Architecture

# Messy vs Clean Architecture

# What Is Bad Architecture?

Complex
Inconsistent
Incoherent
Rigid
Brittle
Untestable
Unmaintainable

# What Is Clean Architecture?

Simple
Understandable
Flexible
Emergent
Testable
Maintainable

# What Is Clean Architecture?

Architecture that is designed for the inhabitants of the architecture…
not for the architect… or the machine

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Architecture that is designed for the
inhabitants of the architecture…
not for the architect… or the machine

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Architecture that is designed for the inhabitants of the architecture…
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# Why Is Clean Architecture Important?

Cost/benefit

# Why Is Clean Architecture Important?

Cost/benefit

Minimize cost to maintain

# Why Is Clean Architecture Important?

Cost/benefit

Minimize cost to maintain

Maximize business value

# Why Is Clean Architecture Important?

Cost/benefit

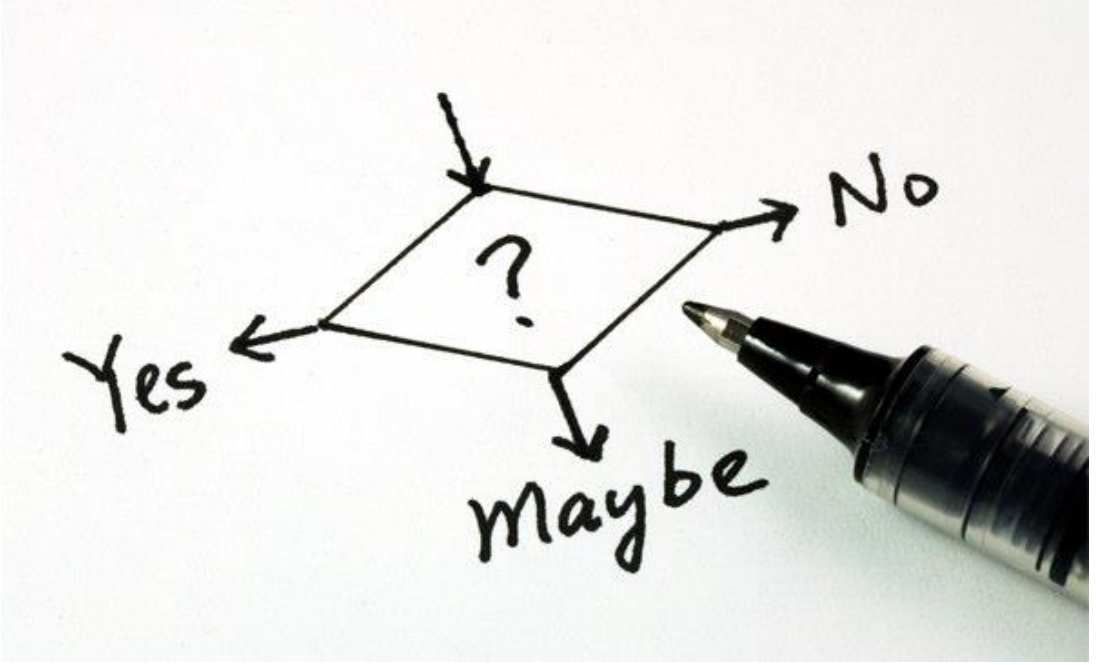
Minimize cost to maintain

Maximize business value

Maximize total ROI

# Decisions, Decisions, Decisions…

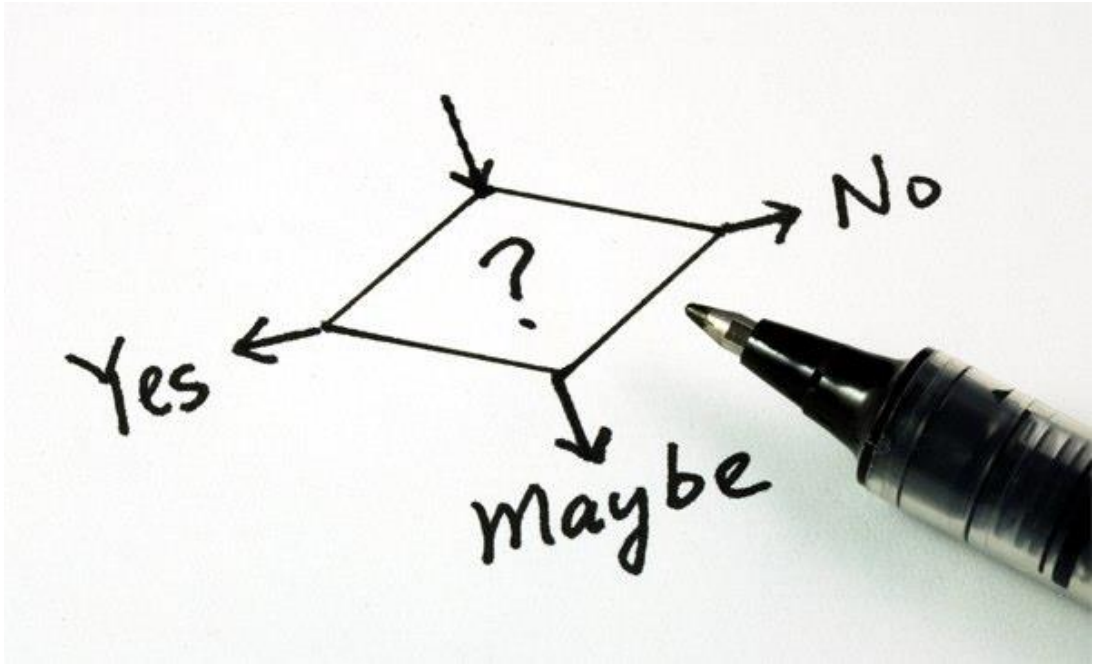
Context is king



# Decisions, Decisions, Decisions…

Context is king

All decisions are a tradeoff

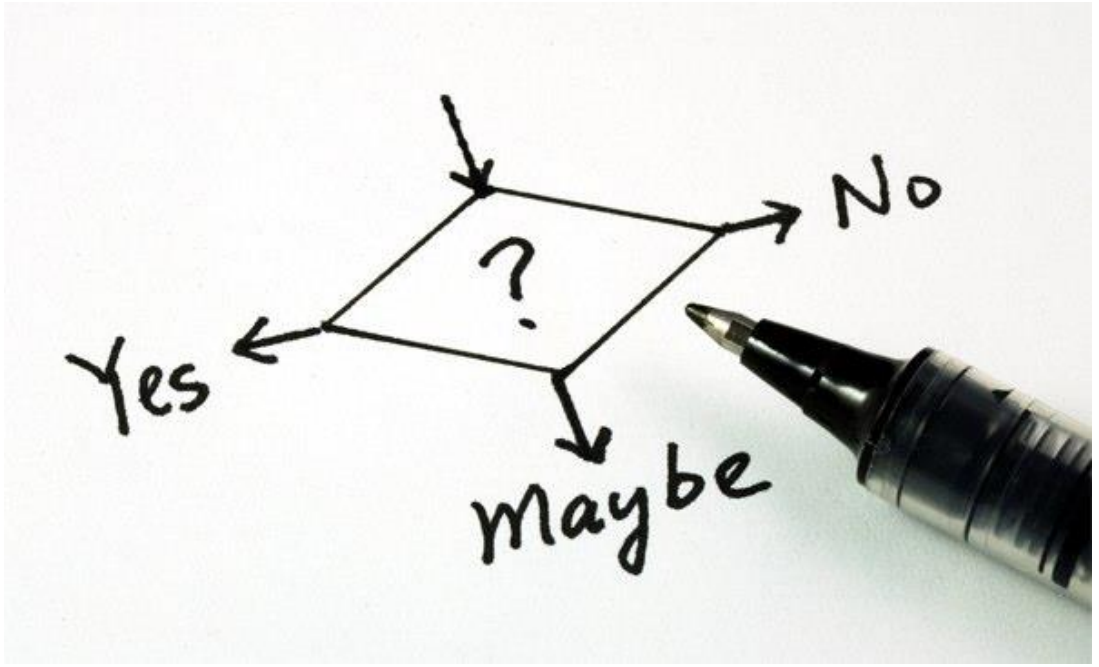


# Decisions, Decisions, Decisions…

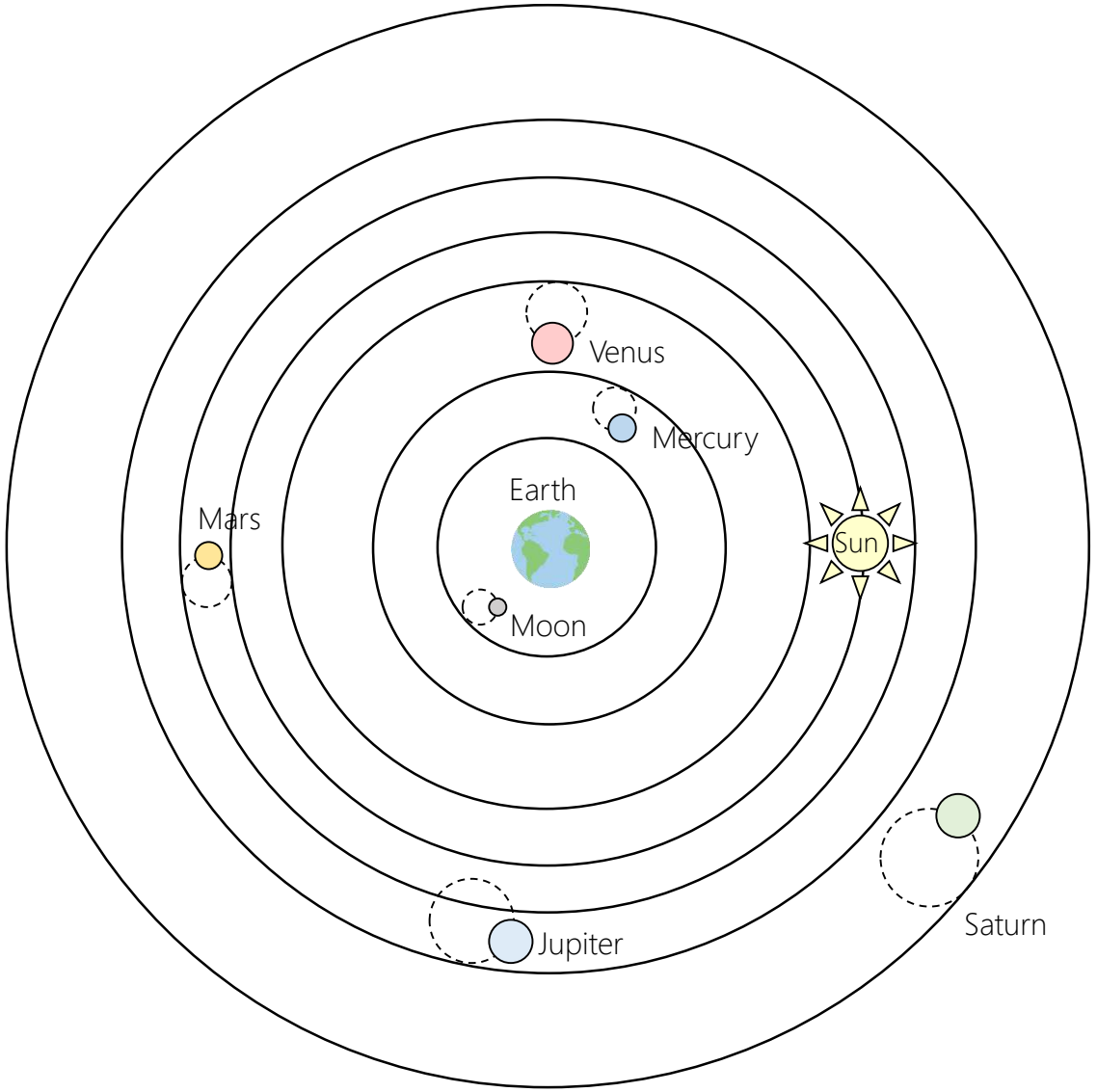
Context is king

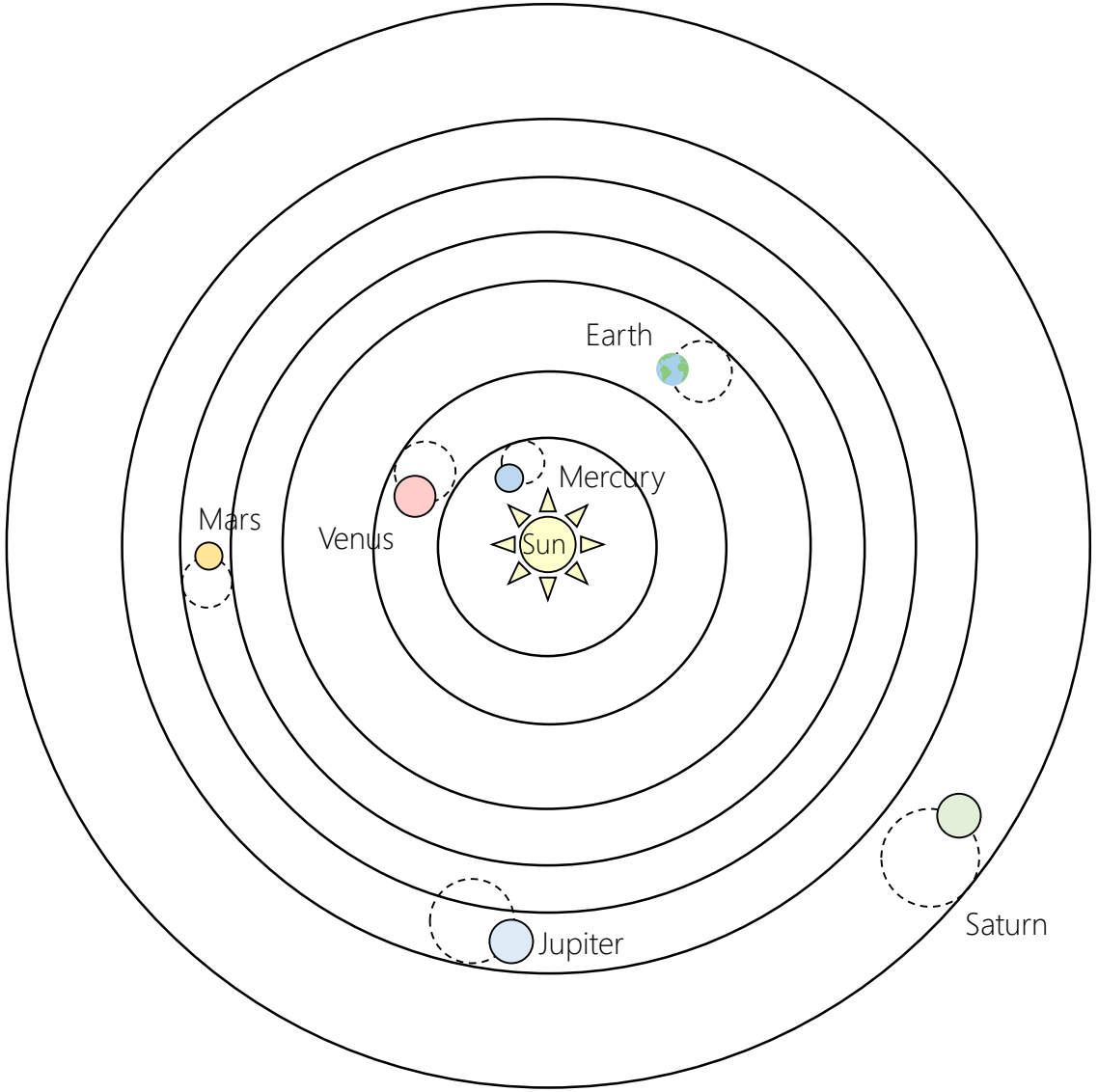
All decisions are a tradeoff

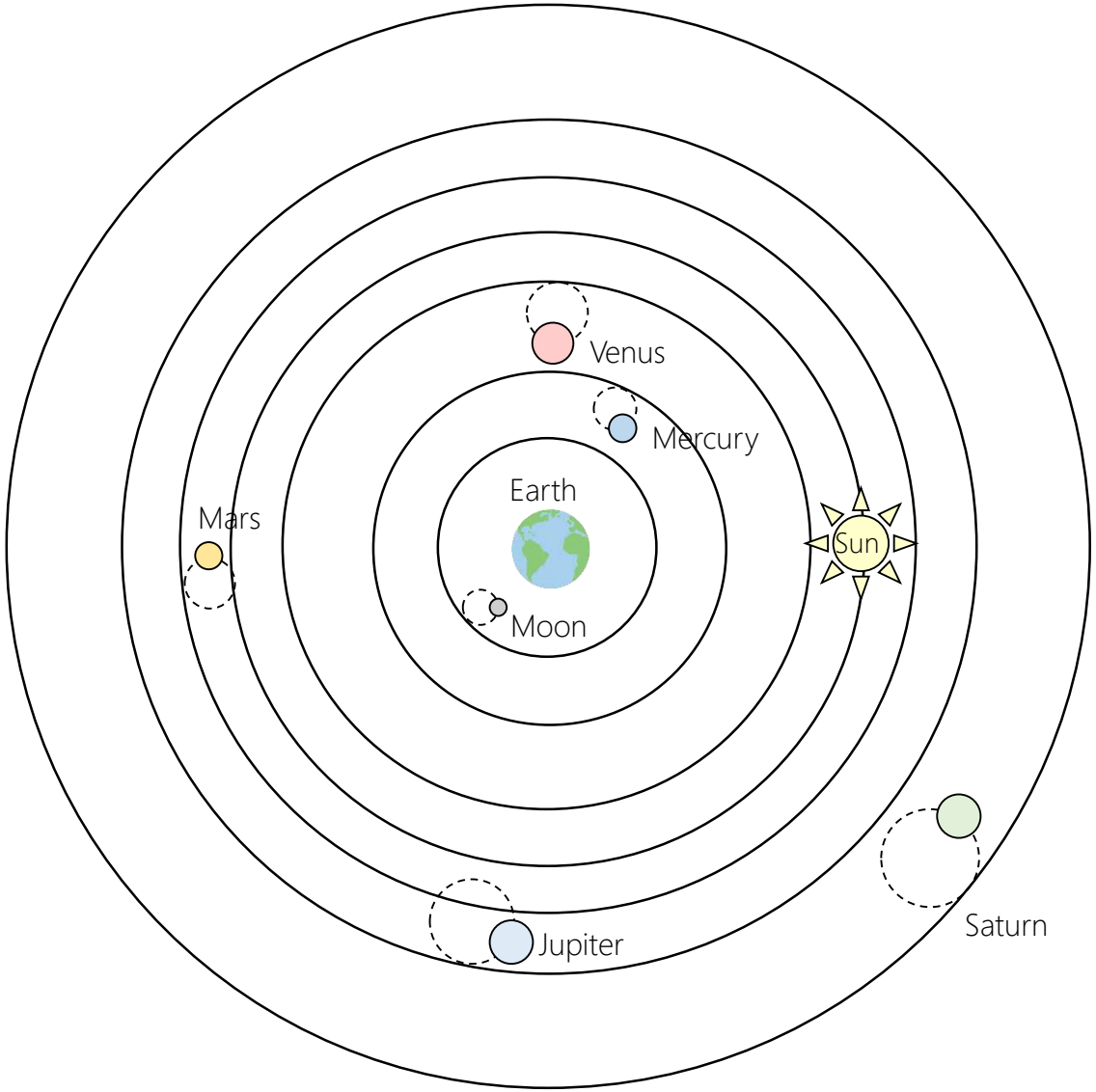
Use your best judgement



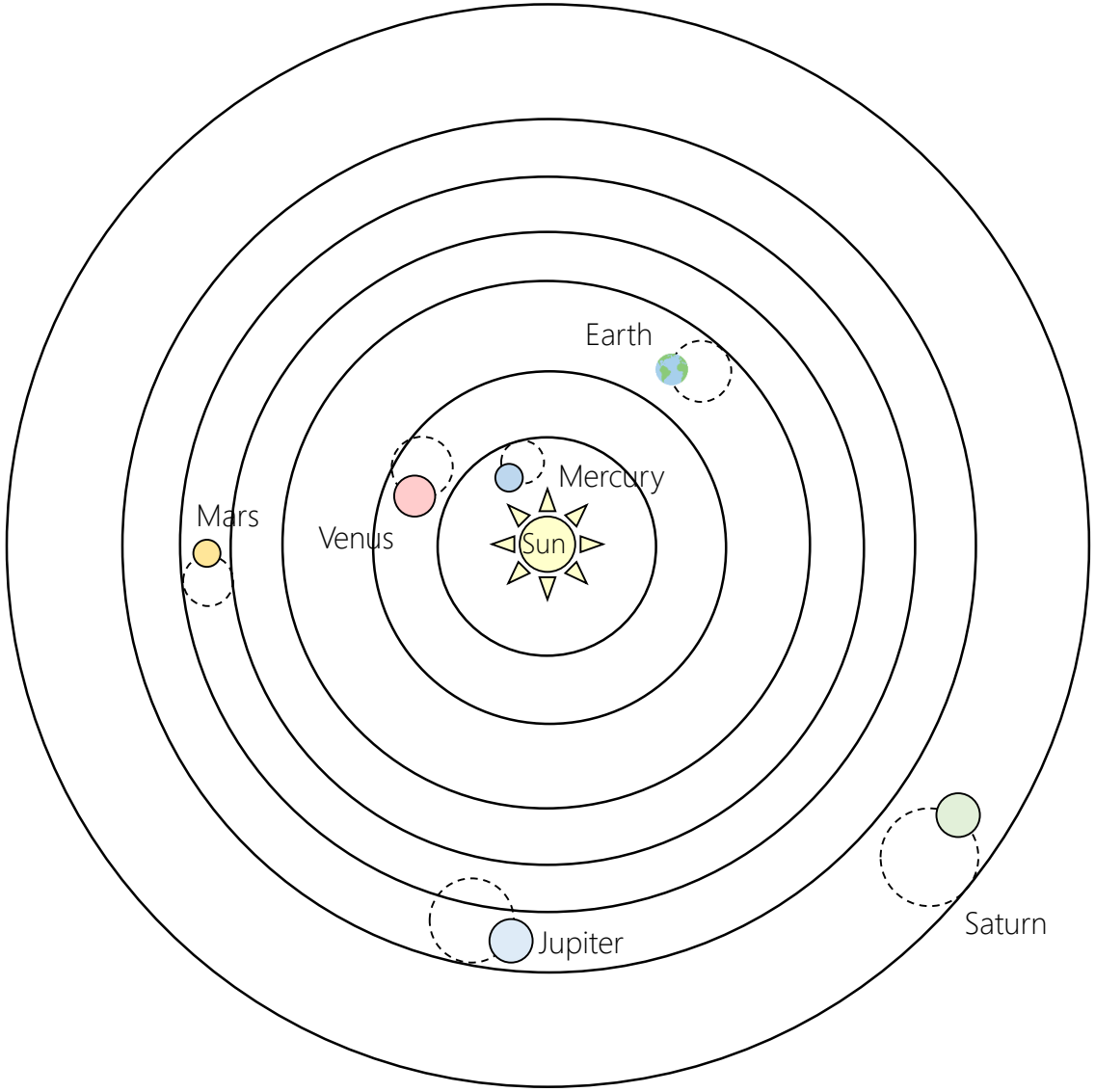
# Domain-Centric Architecture


Venus
Mercury
Earth
Mars
Sun
Moon
Jupiter
Saturn


Earth
Mercury
Mars
Venus
Sun
Jupiter
Saturn

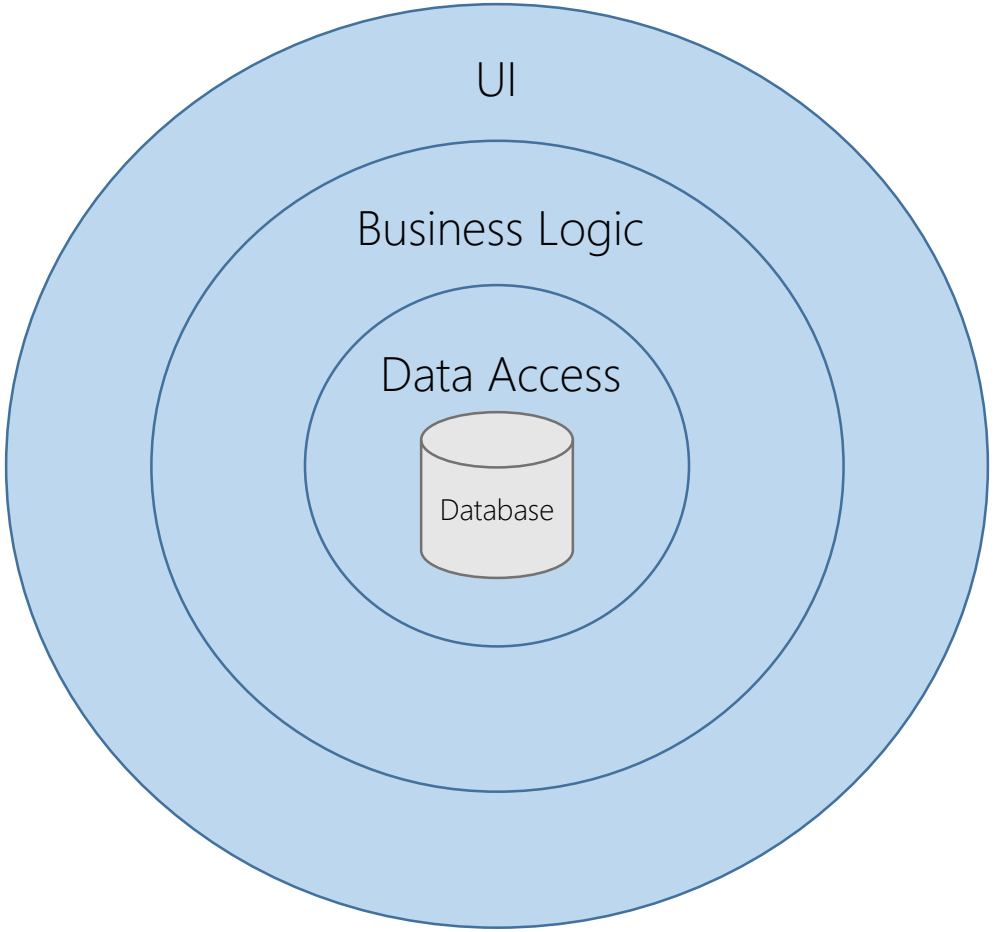



Geocentric Model

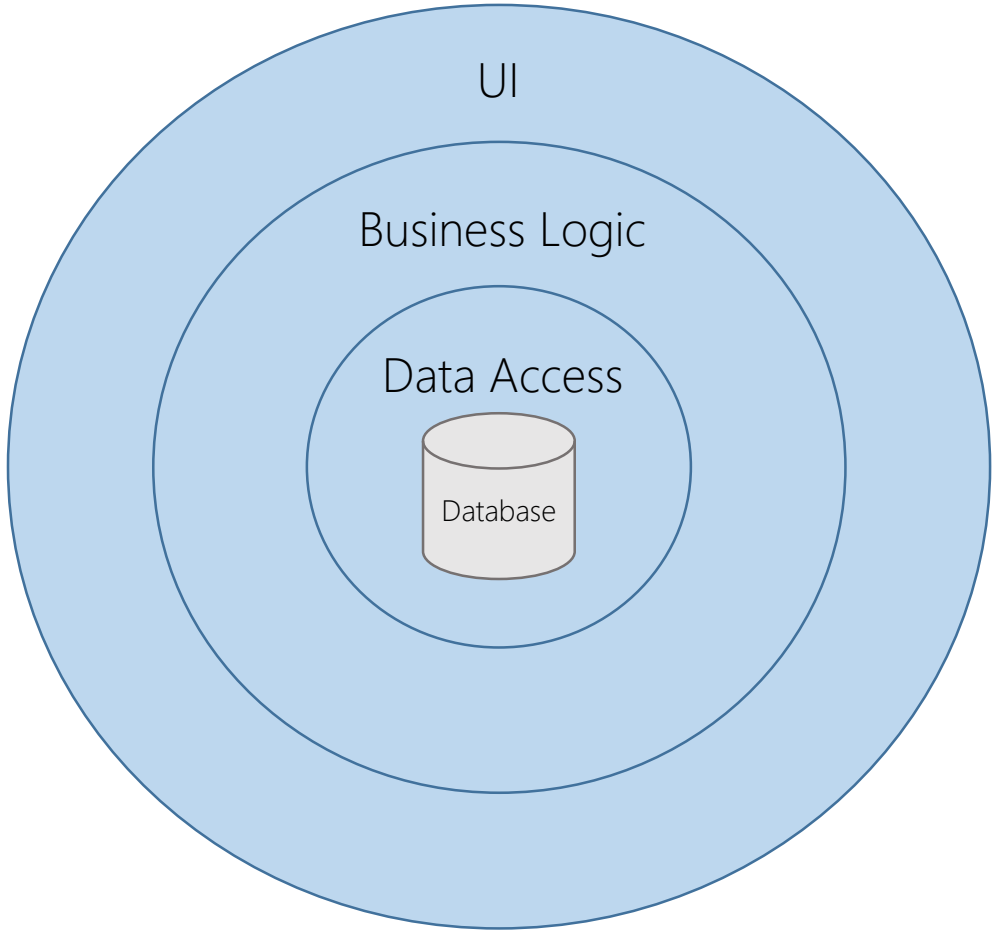



Heliocentric Model

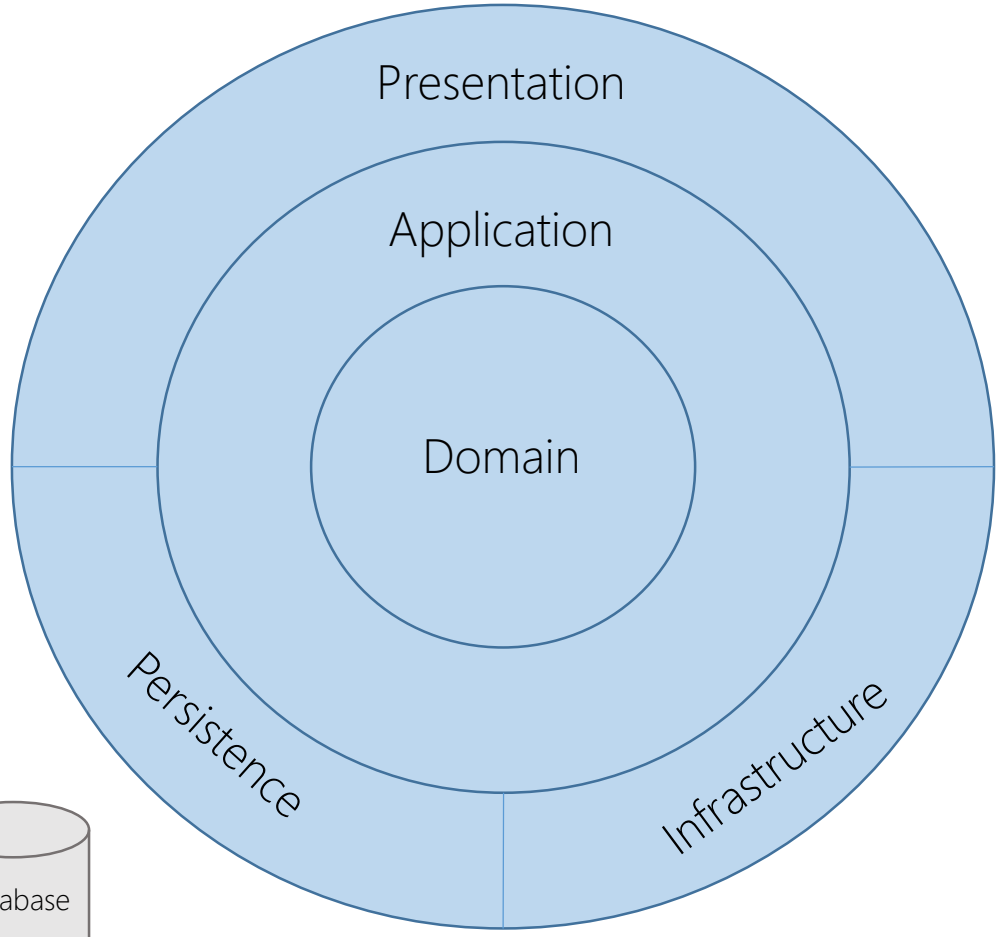
# Classic 3-layer Database-centric Architecture



# Database- vs. Domain-centric Architecture







*"The first concern of the architect is to make sure that the house is usable, it is not to ensure that the house is made of brick."*

– Uncle Bob

# Essential vs. Detail

# Essential vs. Detail

Space is essential

# Essential vs. Detail

Space is essential

Usability is essential

# Essential vs. Detail

Building material is a detail

# Essential vs. Detail

Building material is a detail

Ornamentation is a detail

# Essential vs. Detail

# Essential vs. Detail

Domain is essential

# Essential vs. Detail

Domain is essential

Use cases are essential

# Essential vs. Detail

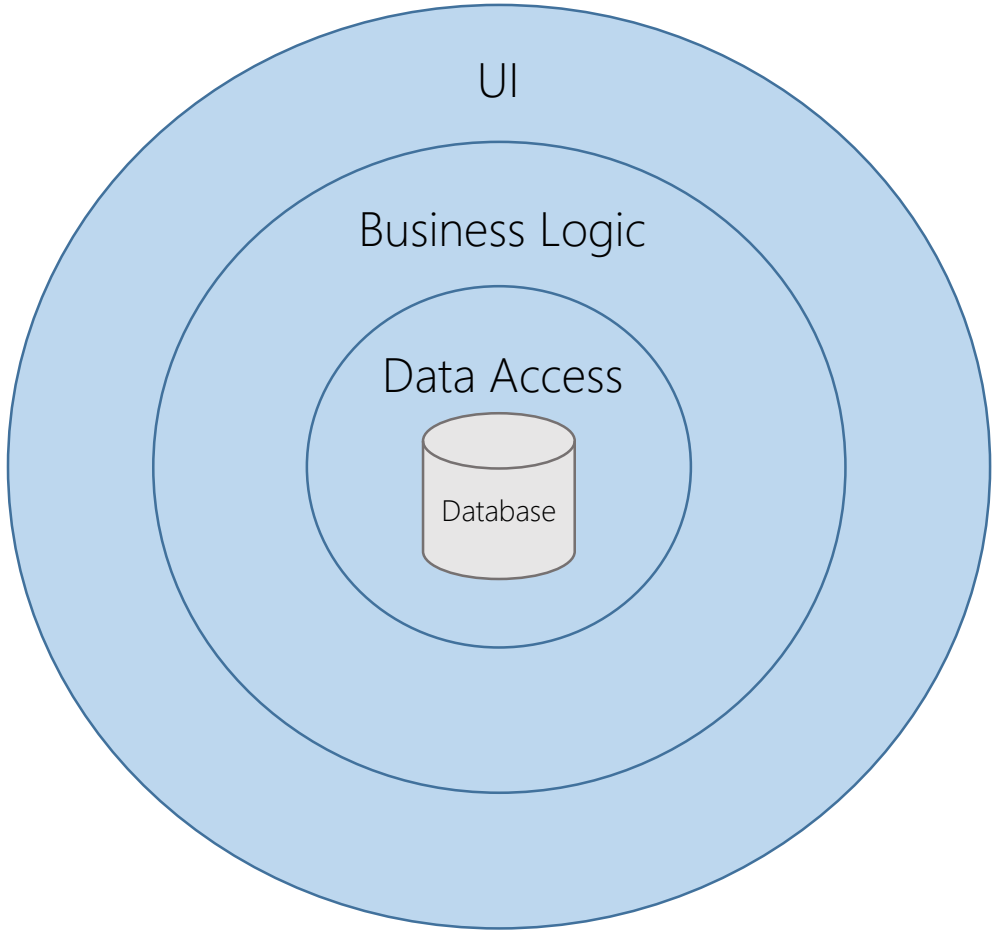
Presentation is a detail

# Essential vs. Detail

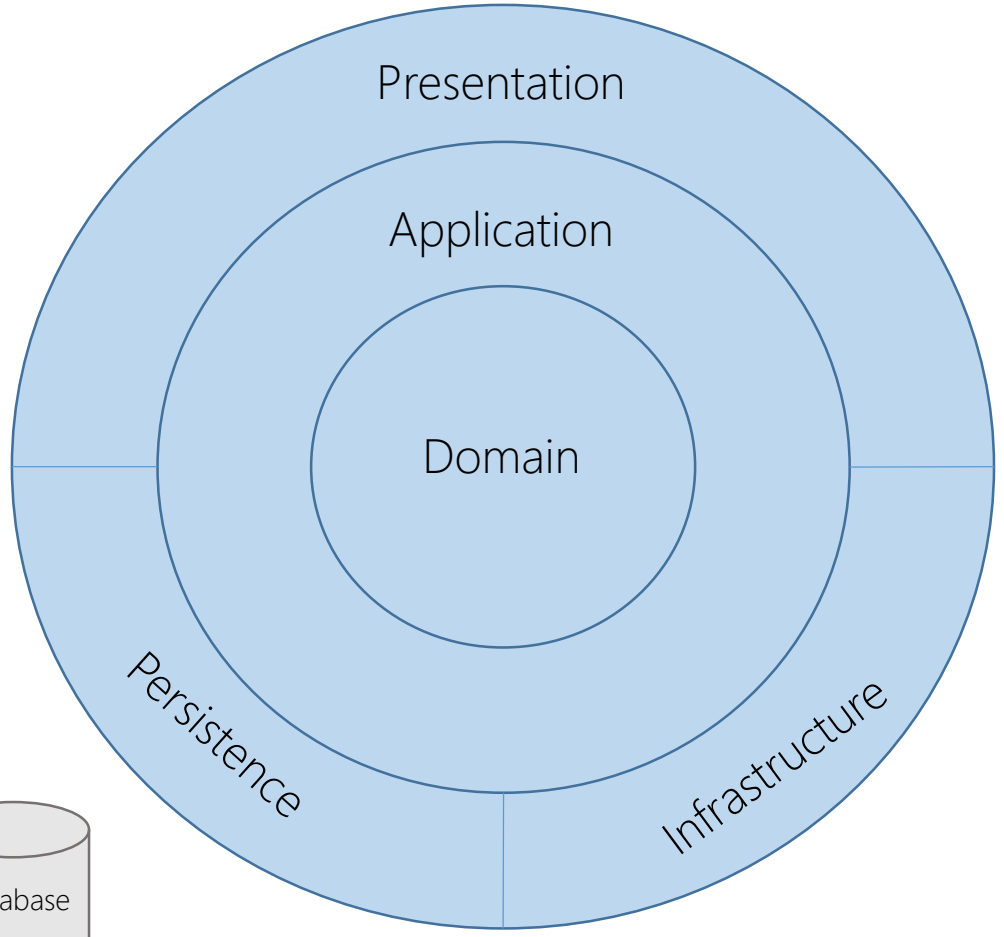
Presentation is a detail

Persistence is a detail

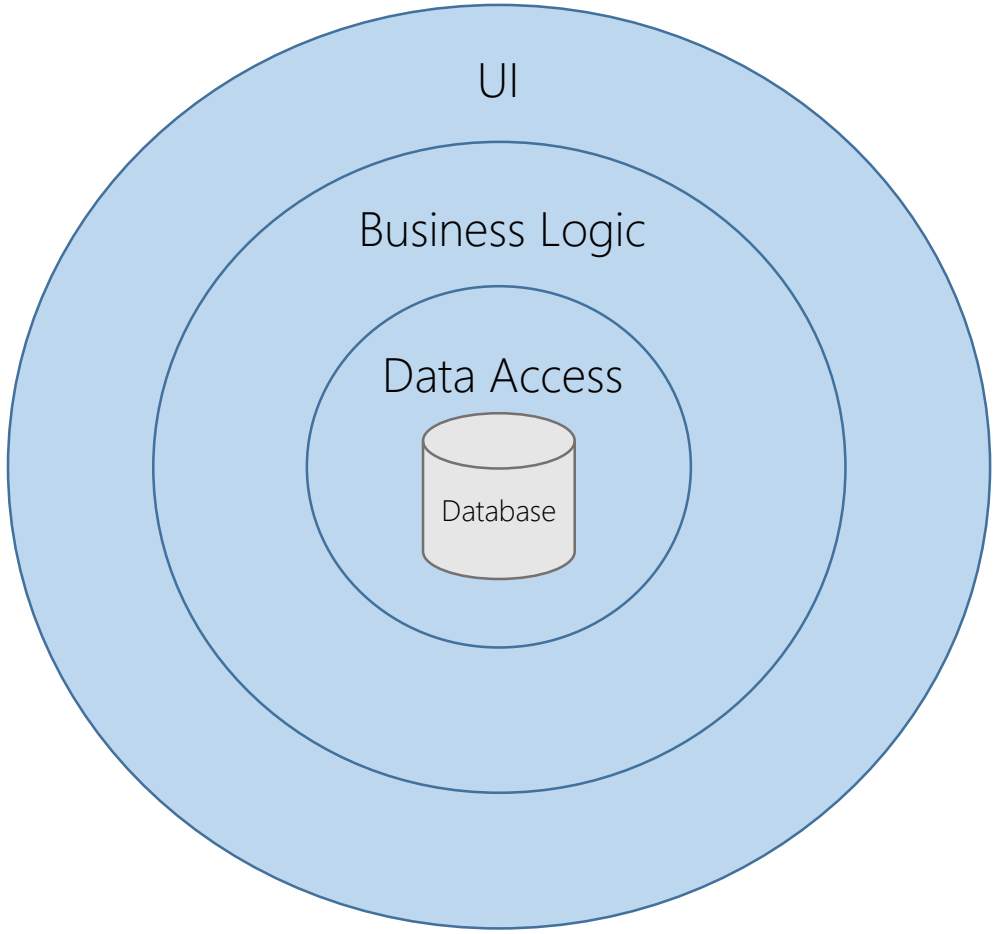
# Database- vs. Domain-centric Architecture





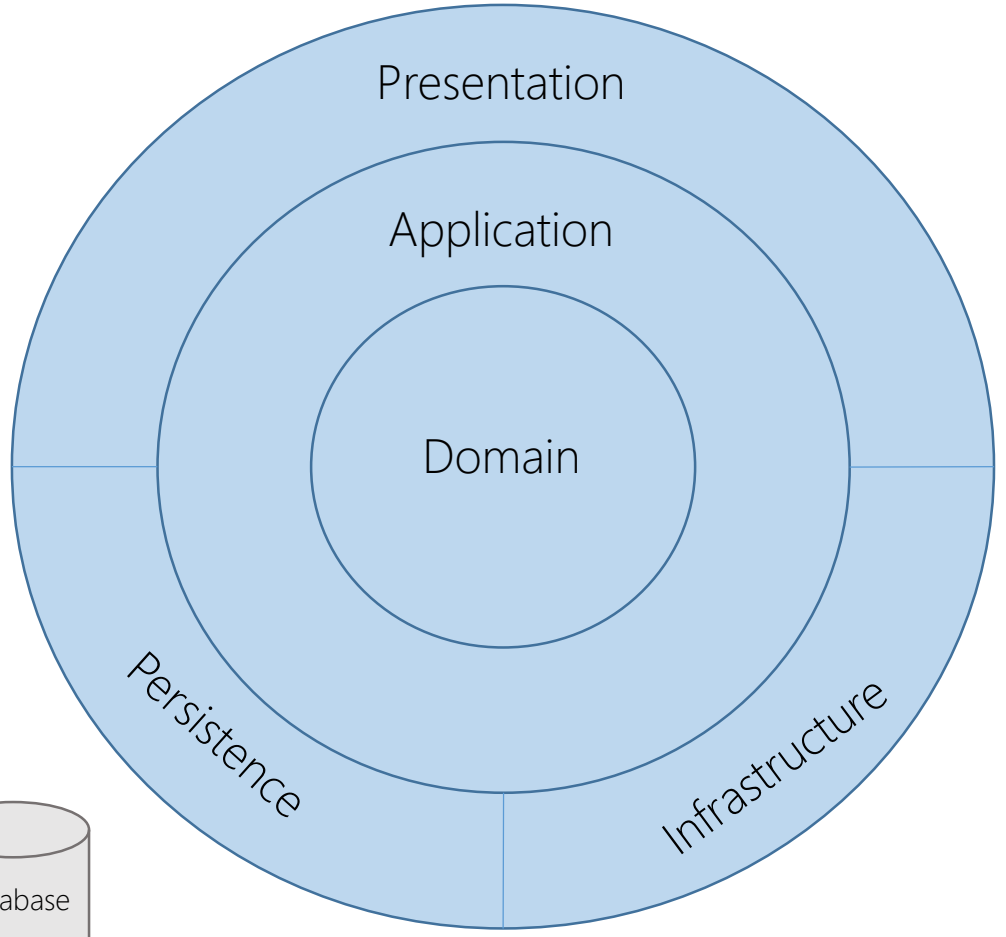


# Database- vs. Domain-centric Architecture

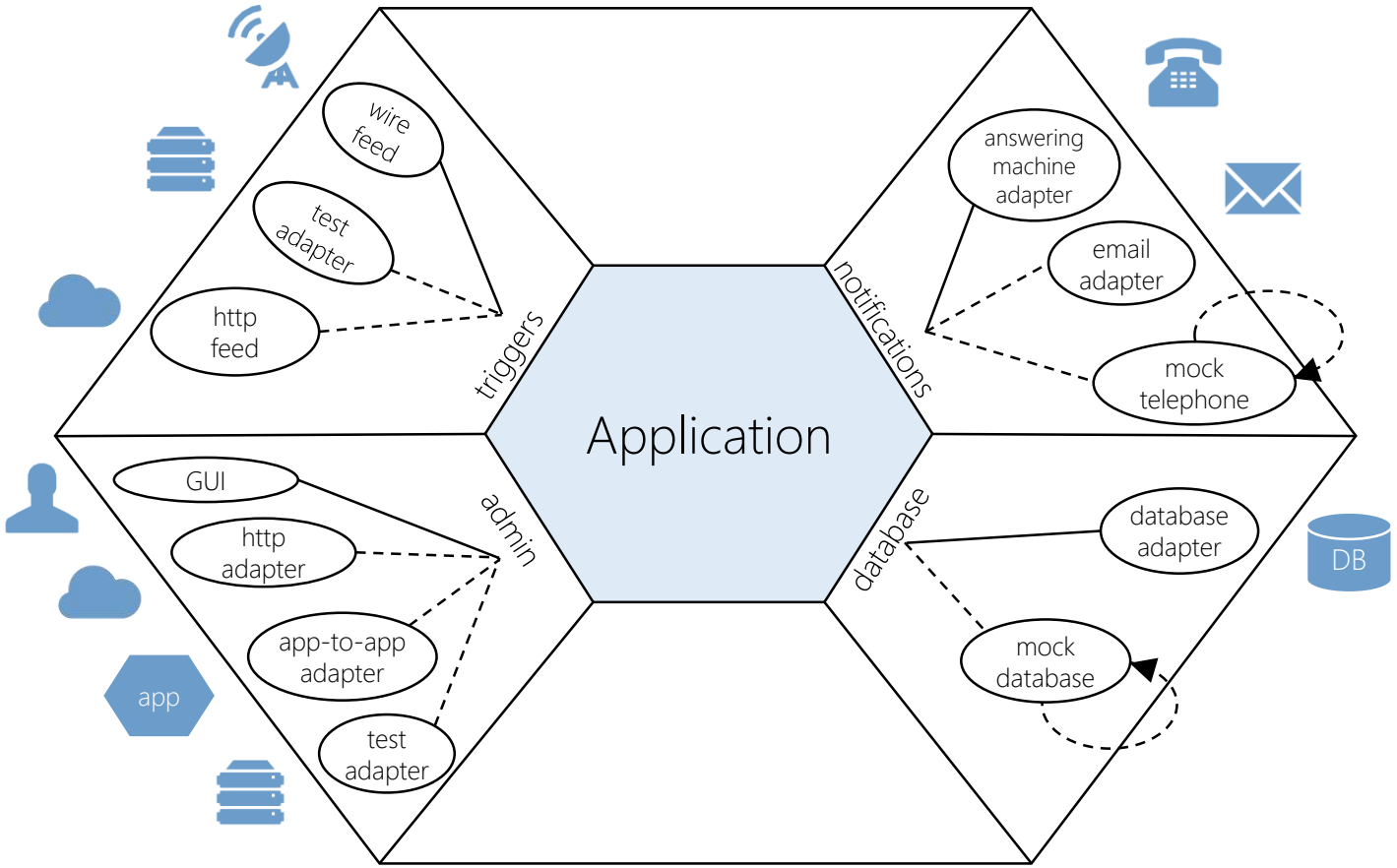



# Database- vs. Domain-centric Architecture



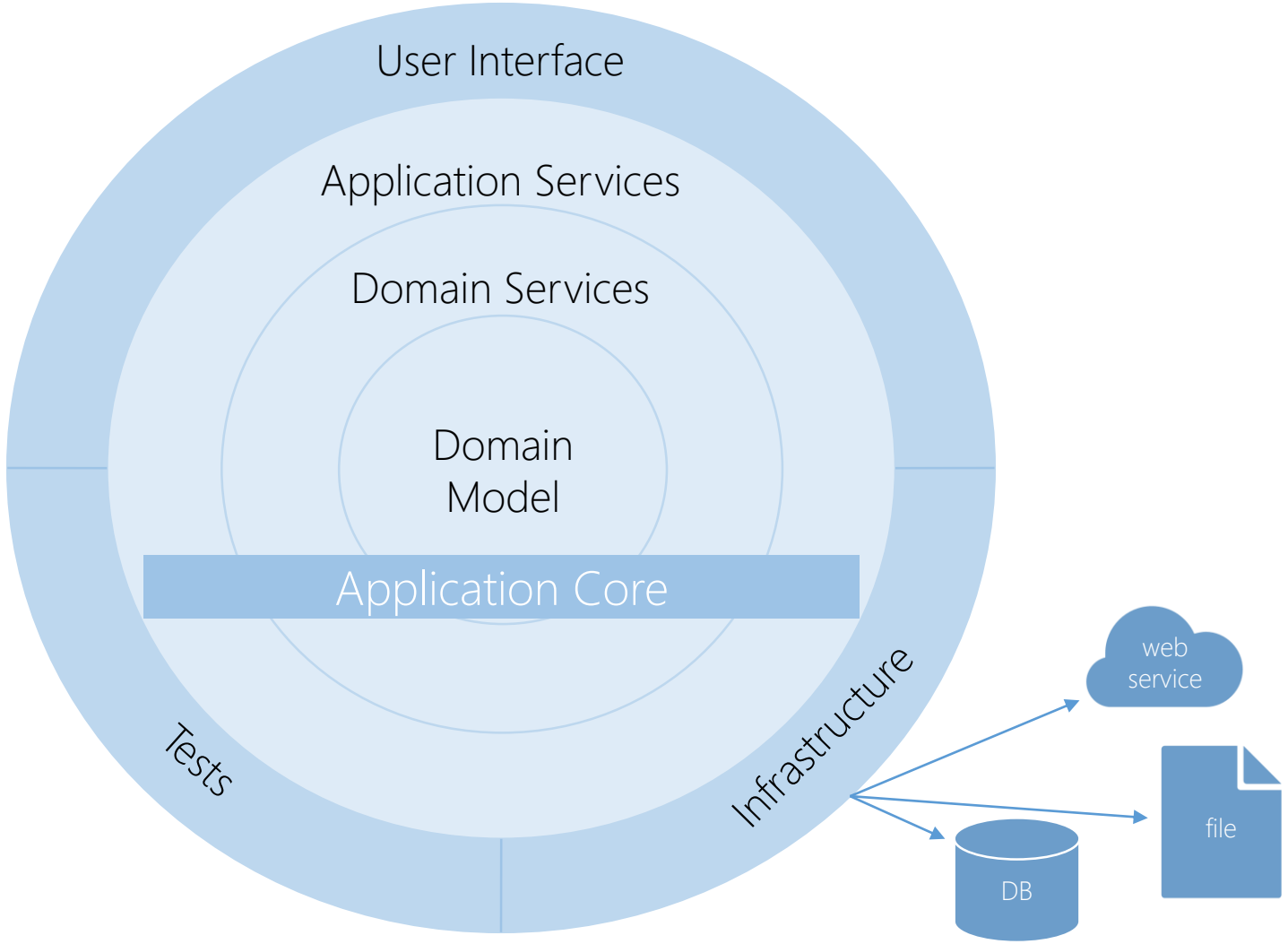


# Hexagonal Architecture



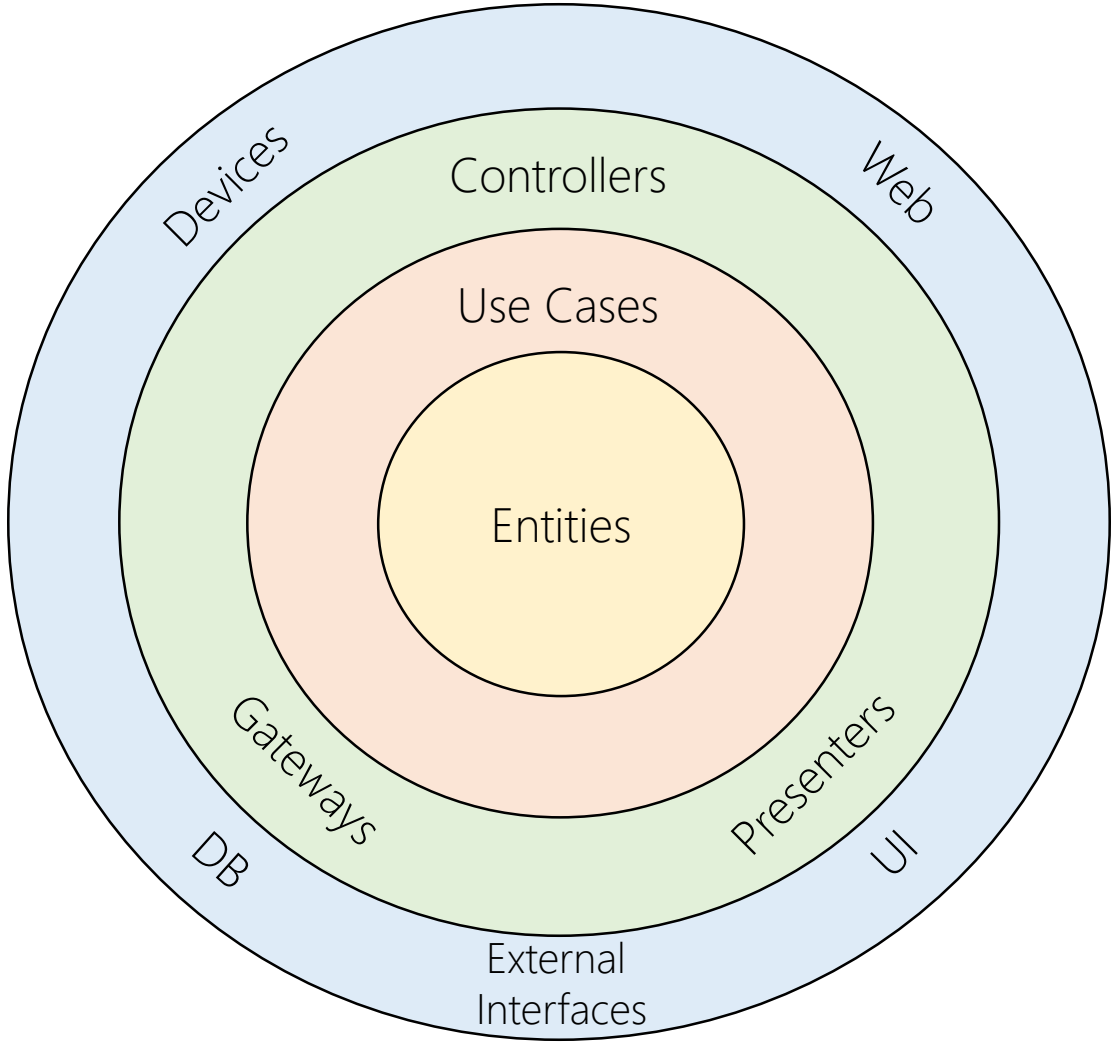

Original source: http://alistair.cockburn.us/Hexagonal+architecture

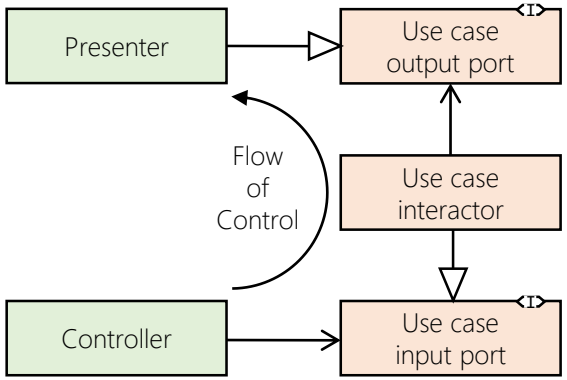
# Onion Architecture




Original source: http://jeffreypalermo.com/blog/the-onion-architecture-part-2/

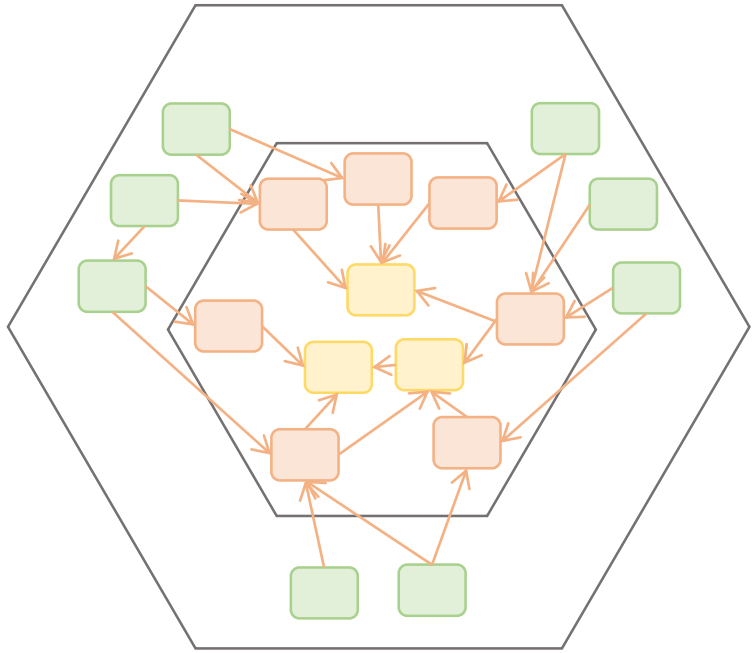
# Clean Architecture



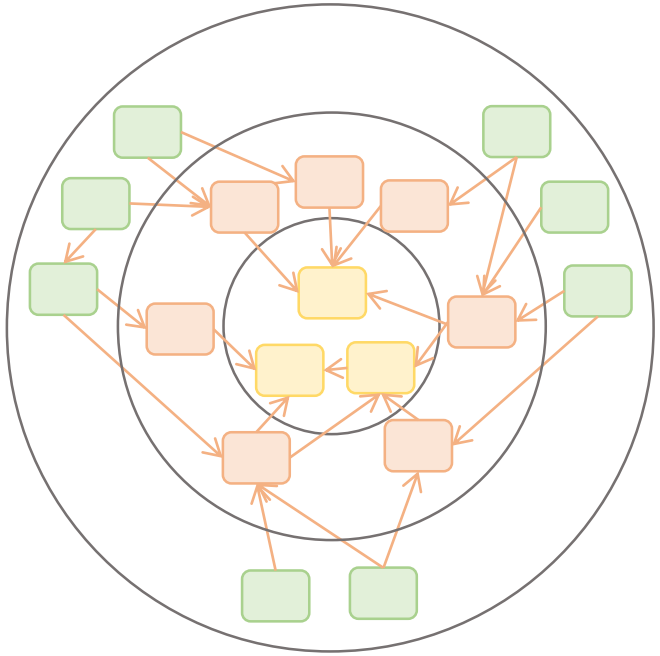




Original source: http://blog.8thlight.com/uncle-bob/2012/08/13/the-clean-architecture.html

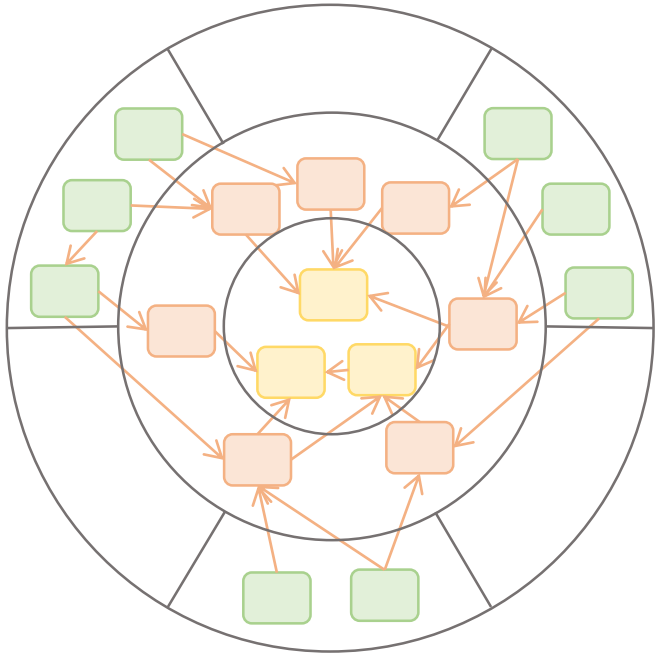
# It's All the Same Thing



Hexagonal



Onion



Clean

Original Source: http://blog.ploeh.dk/2013/12/03/layers-onions-ports-adapters-its-all-the-same/

# Why Use Domain-Centric Architecture?

## Pros

Focus on essential

# Why Use Domain-Centric Architecture?

## Pros

Focus on essential

Less coupling to details

# Why Use Domain-Centric Architecture?

## Pros

Focus on essential

Less coupling to details

Necessary for DDD

# Why Use Domain-Centric Architecture?

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Less coupling to details

Necessary for DDD

## Cons

Change is difficult

# Why Use Domain-Centric Architecture?

## Pros

Focus on essential

Less coupling to details

Necessary for DDD

## Cons

Change is difficult

Requires extra thought

# Why Use Domain-Centric Architecture?

## Pros

Focus on essential

Less coupling to details

Necessary for DDD

## Cons

Change is difficult

Requires extra thought

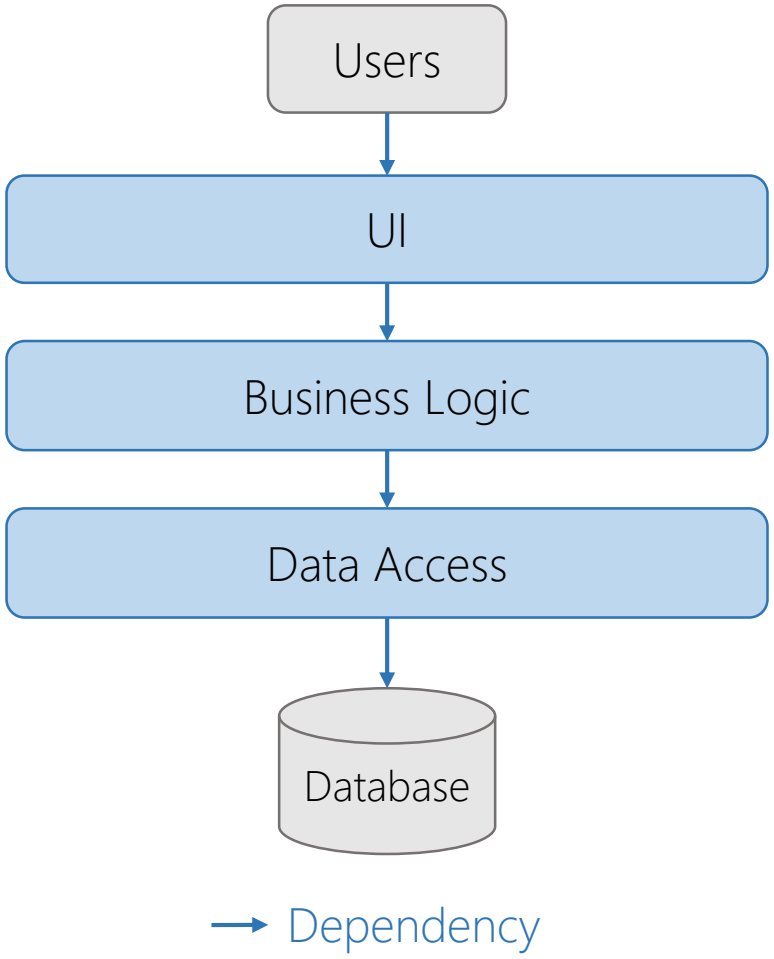
Initial higher cost

# Application Layer

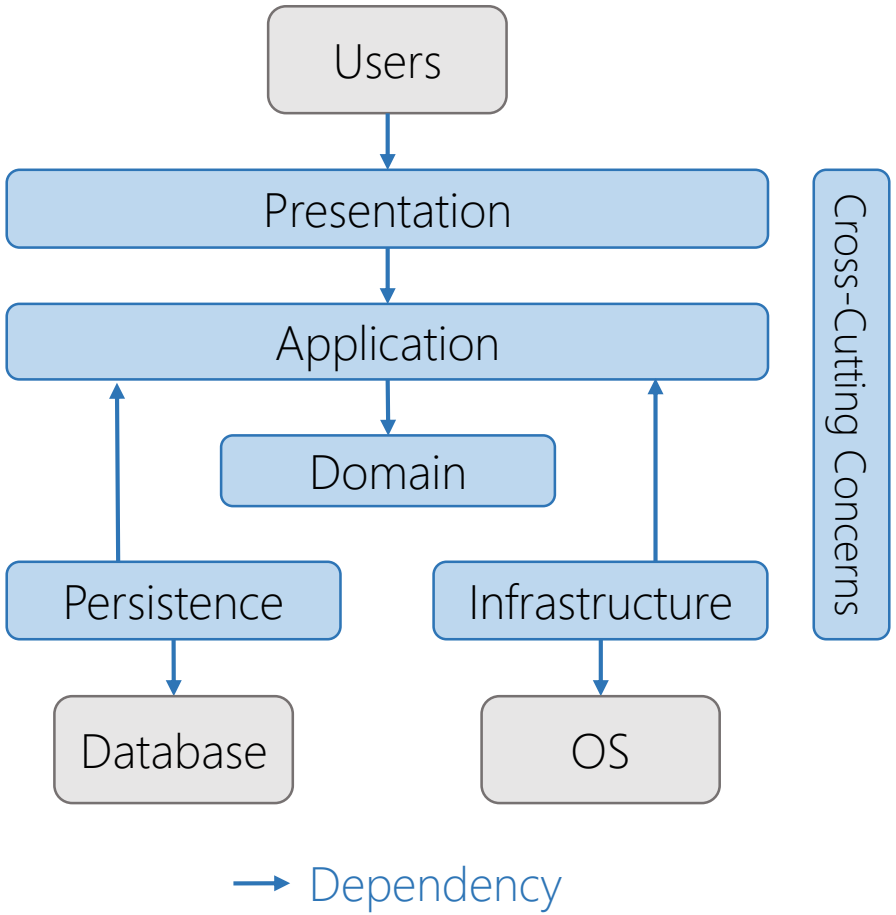
# What Are Layers?

Levels of abstraction
Single-Responsibility Principle
Developer roles / skills
Multiple implementations
Varying rates of change

# Classic 3-Layer Architecture

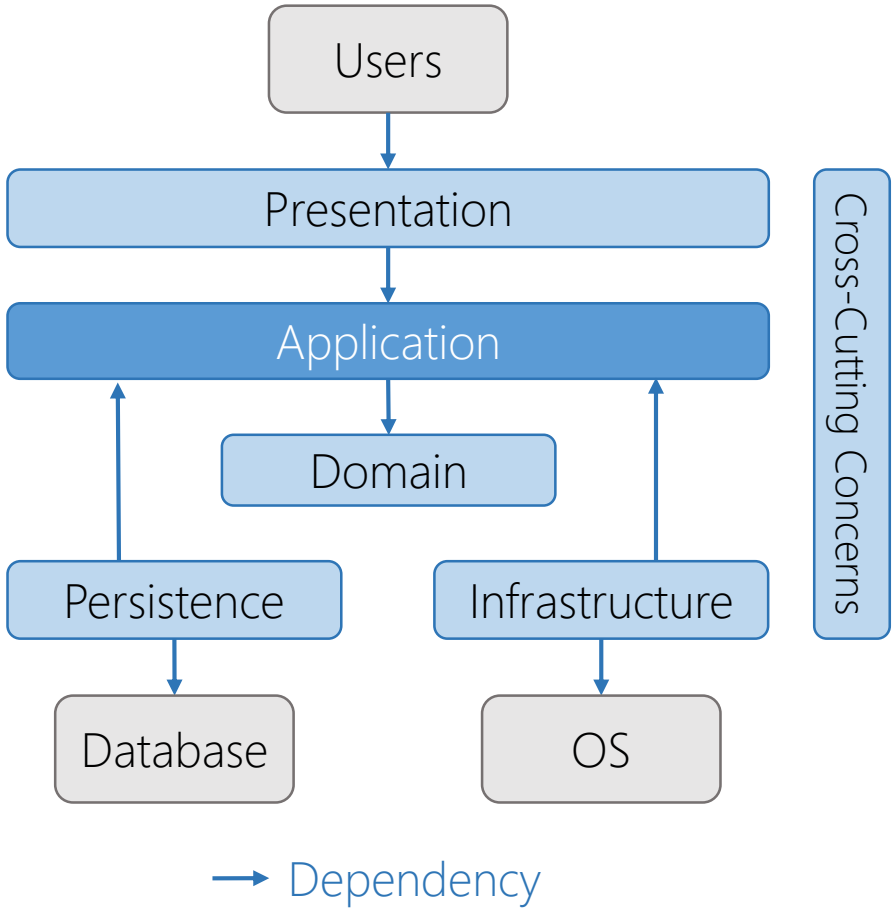


# Modern 4-Layer Architecture



# Application Layer

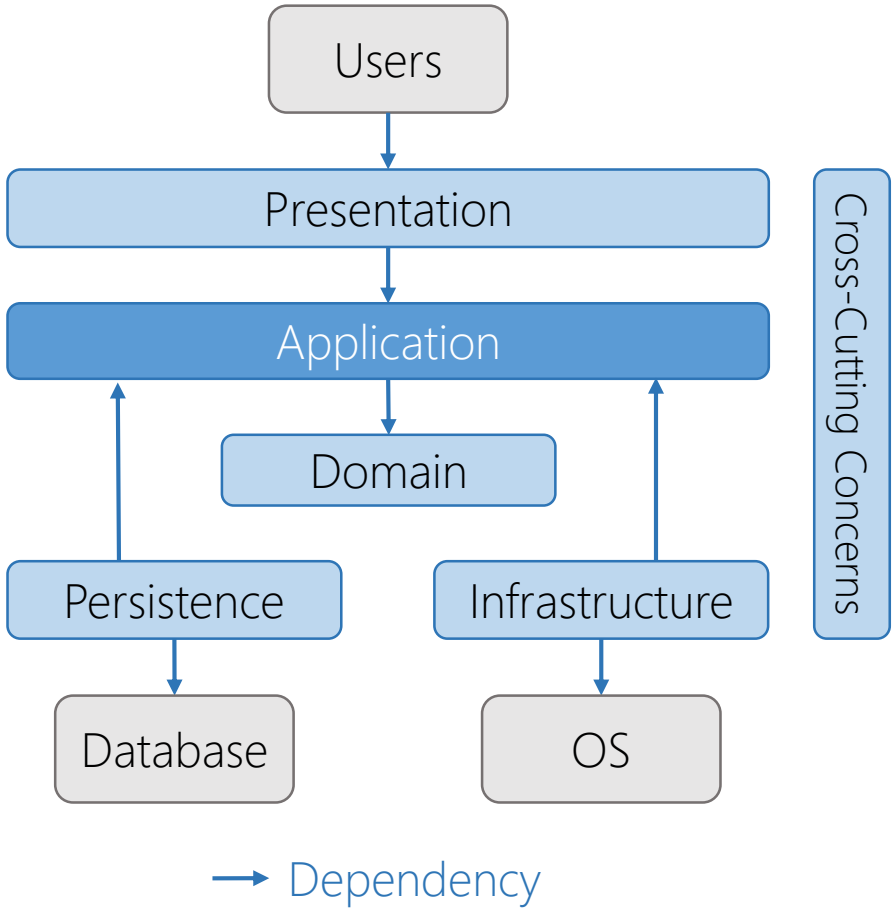
Implements use cases



# Application Layer

Implements use cases

High-level application logic

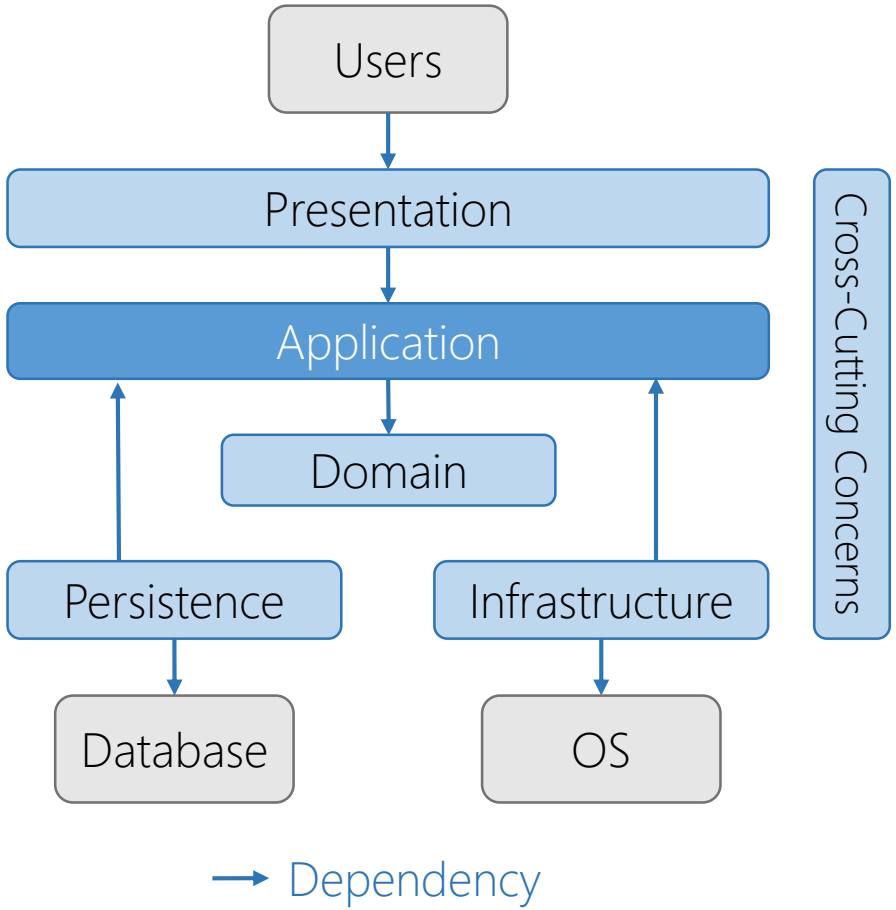


# Application Layer

Implements use cases

High-level application logic

Knows about domain



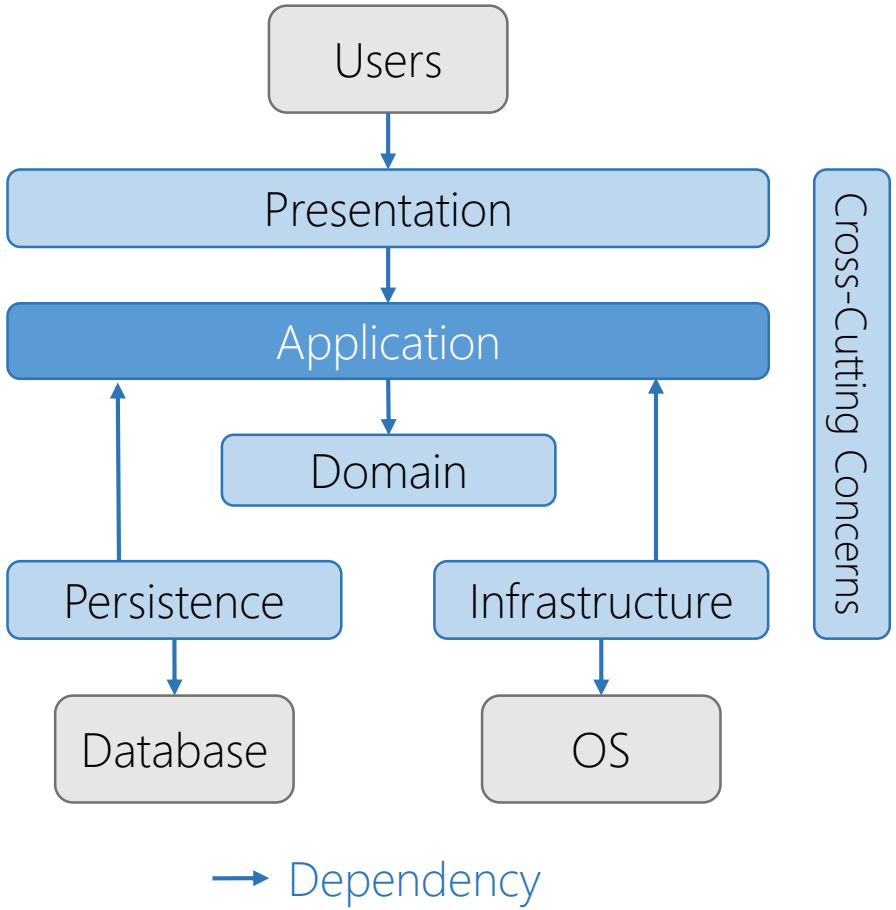
# Application Layer

Implements use cases

High-level application logic

Knows about domain

No knowledge of other layers



# Application Layer

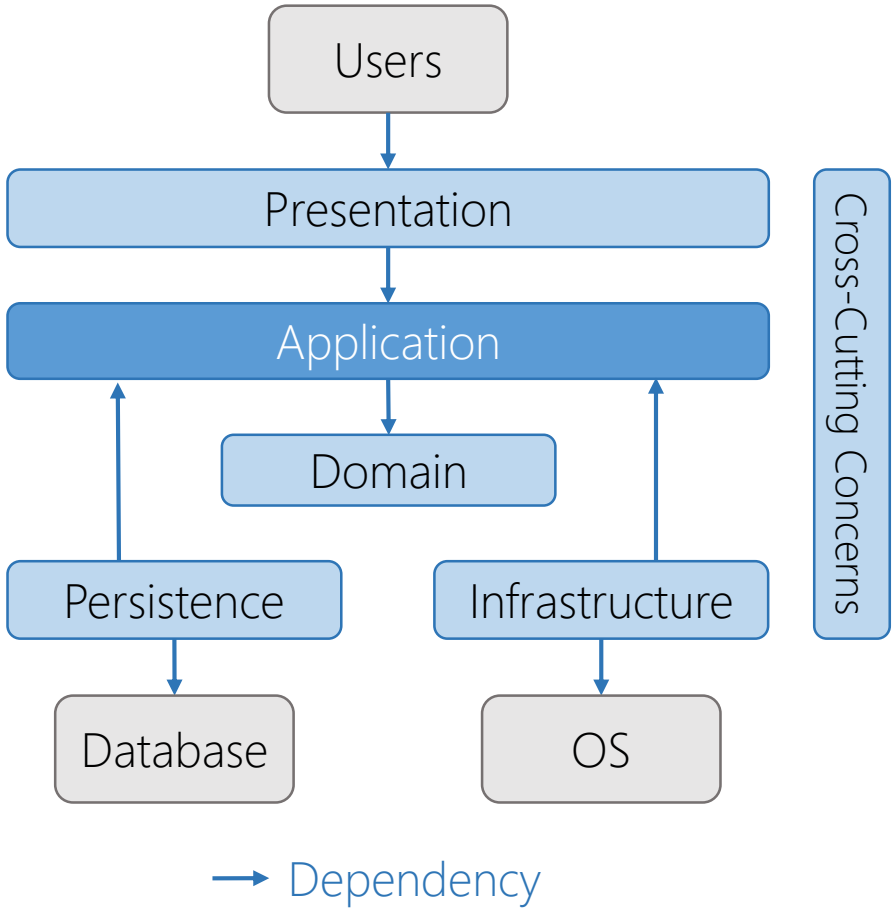
Implements use cases

High-level application logic

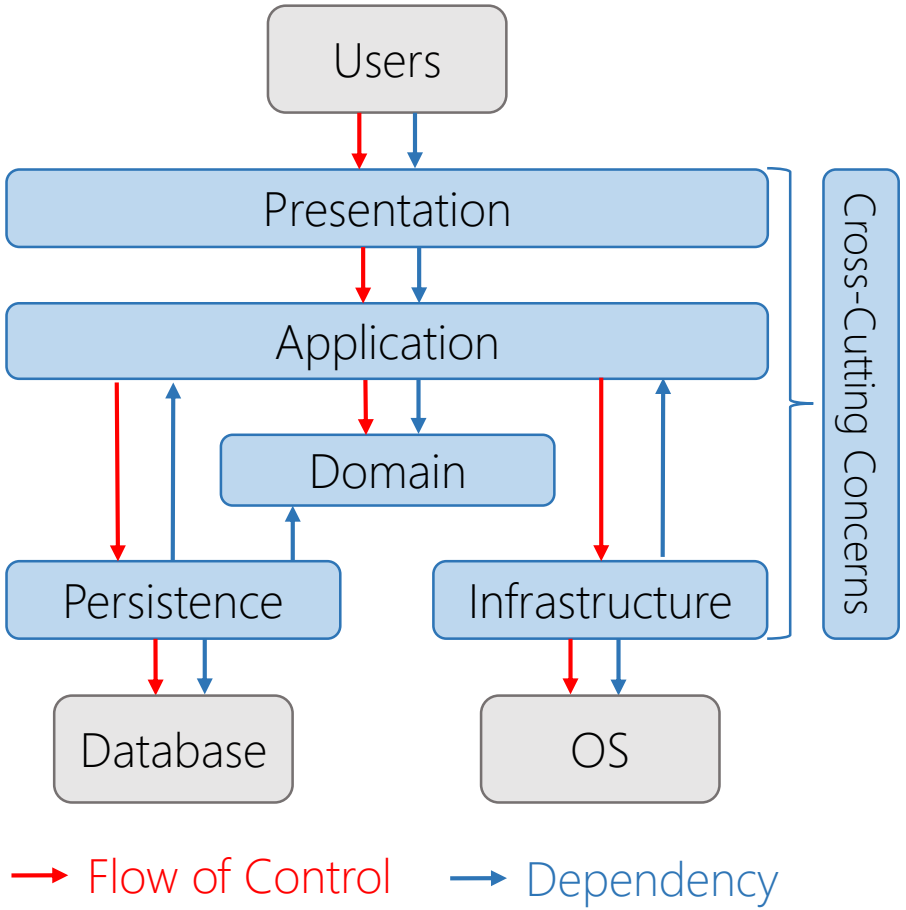
Knows about domain

No knowledge of other layers

Contains interfaces for details

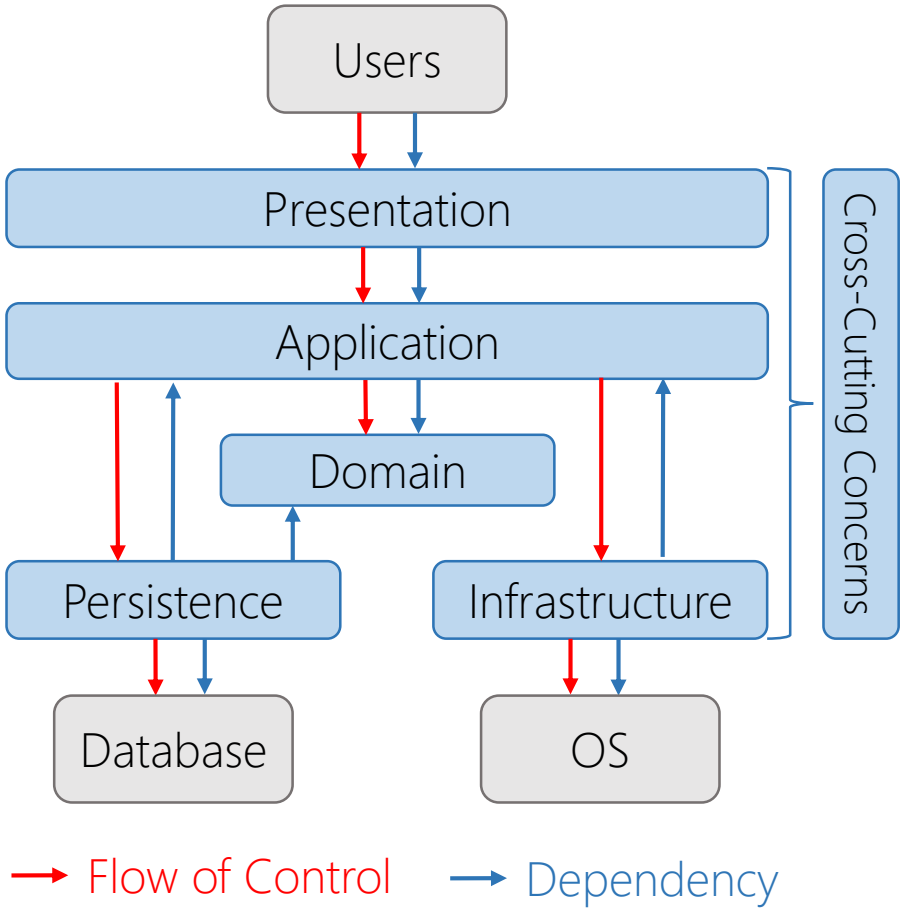


# Layer Dependencies



# Layer Dependencies

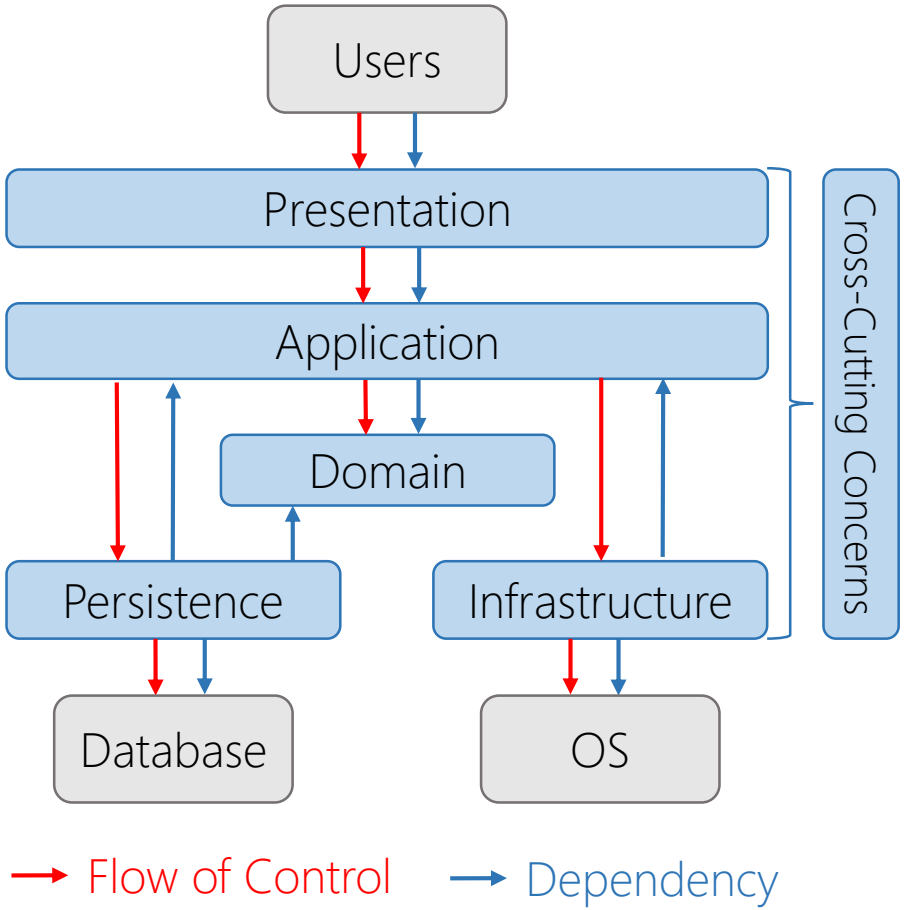
Dependency inversion



# Layer Dependencies

Dependency inversion

Inversion of control

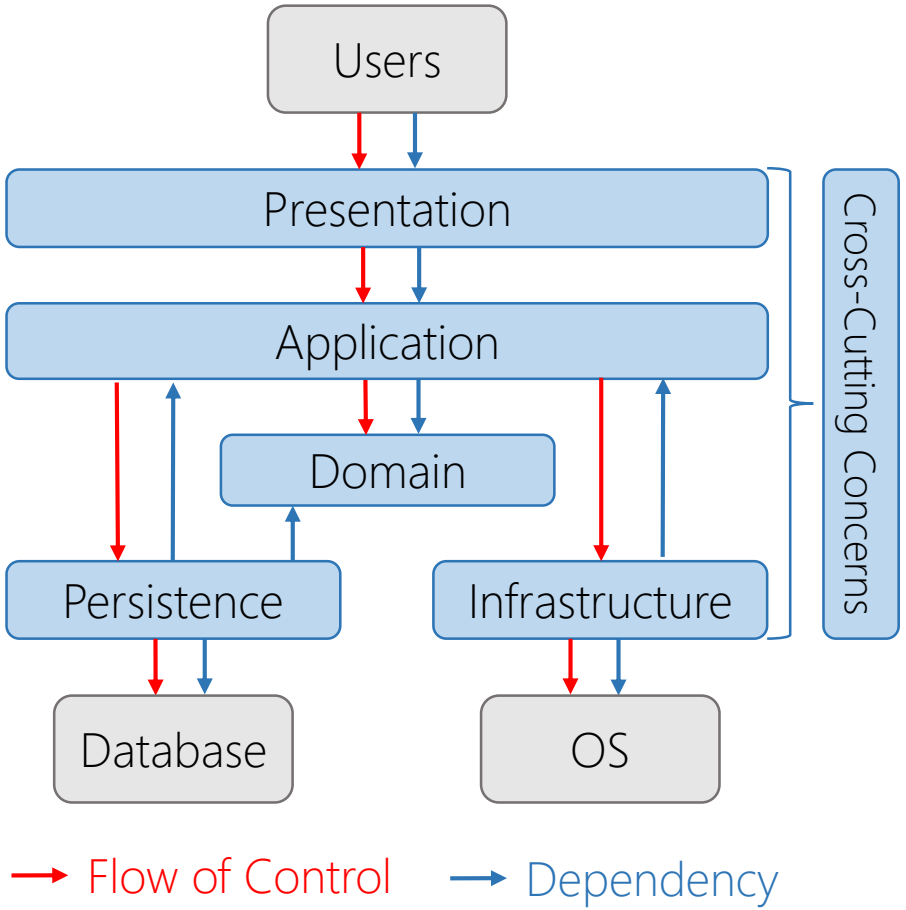


# Layer Dependencies

Dependency inversion

Inversion of control

Independent deployability



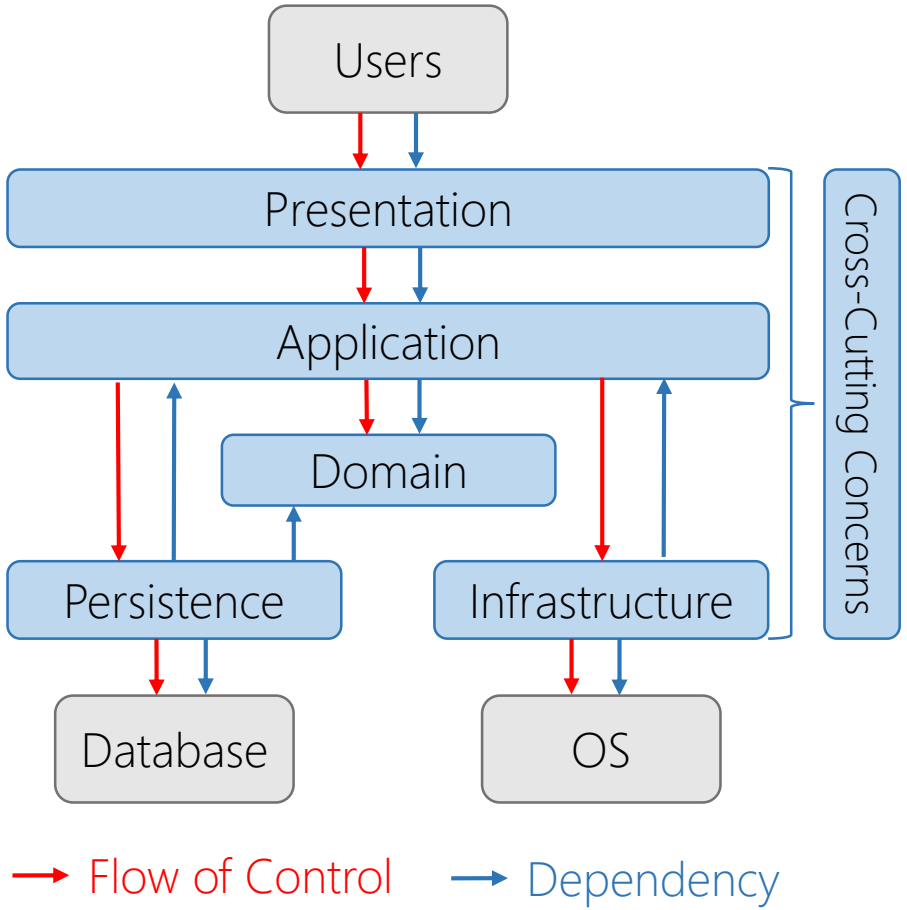
# Layer Dependencies

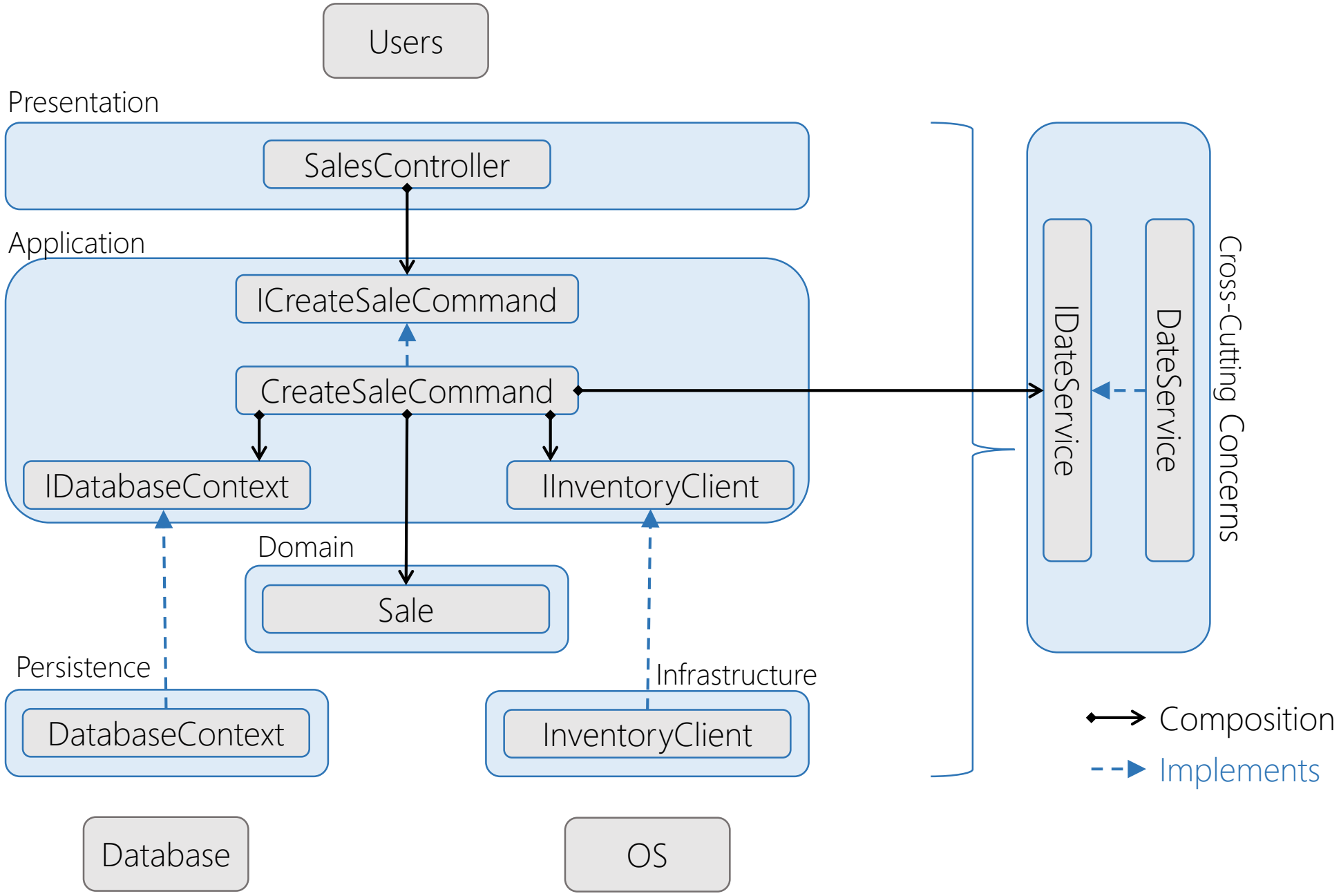
Dependency inversion

Inversion of control

Independent deployability

Flexibility and maintainability




Users
Presentation
SalesController
Application
ICreateSaleCommand
CreateSaleCommand
IDatabaseContext
IInventoryClient
Domain
Sale
Persistence
DatabaseContext
Infrastructure
InventoryClient
Database
OS
IDateService
DateService
Cross-Cutting Concerns
Composition
Implements

# Why Use an Application Layer?

## Pros

Focus is on use cases

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Focus is on use cases

Easy to understand

# Why Use an Application Layer?

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Easy to understand

Follows DIP

# Why Use an Application Layer?

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## Cons

Additional cost

# Why Use an Application Layer?

## Pros

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Follows DIP

## Cons

Additional cost

Requires extra thought

# Why Use an Application Layer?

## Pros

Focus is on use cases

Easy to understand

Follows DIP

## Cons

Additional cost

Requires extra thought

IoC is counter-intuitive

# Commands and Queries

# Command-Query Separation

## Command

Does something

Should modify state

Should not return a value

# Command-Query Separation

## Command

Does something

Should modify state

Should not return a value

## Query

Answers a question

Should not modify state

Always returns a value

# Command-Query Separation

## Command

Does something

Should modify state

Should not return a value *(ideally)*

## Query

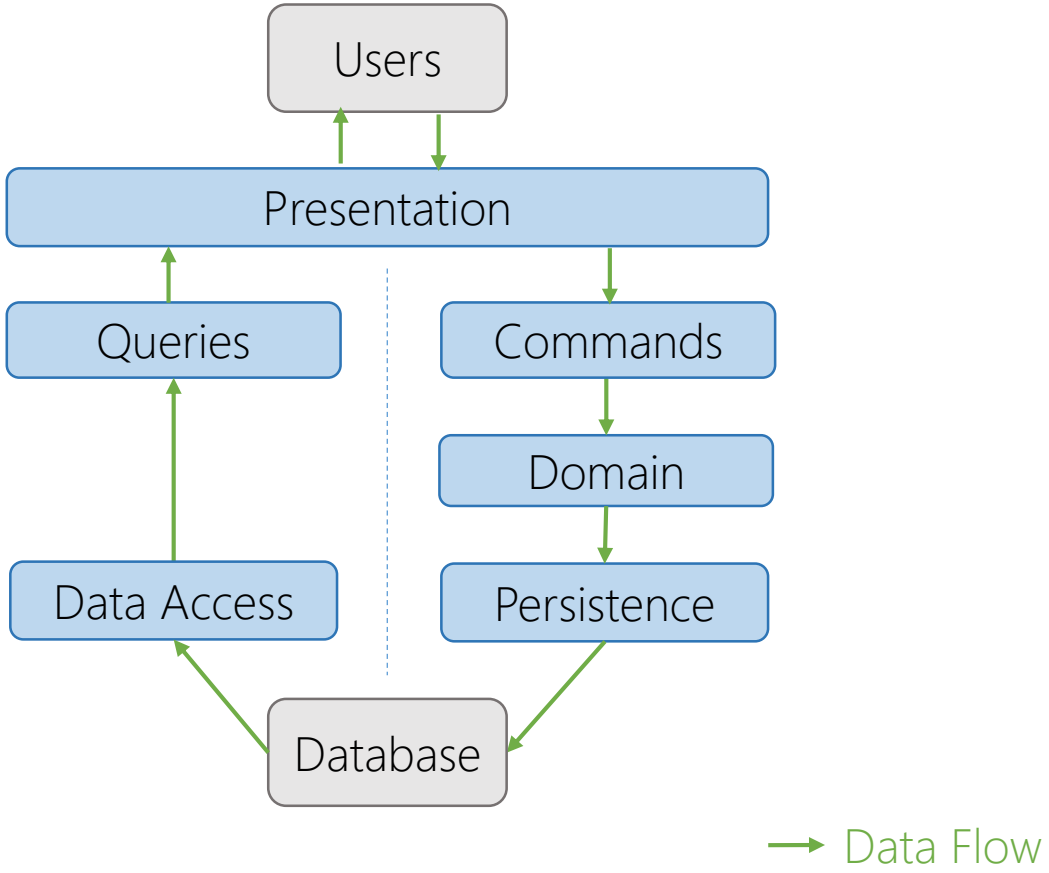
Answers a question

Should not modify state

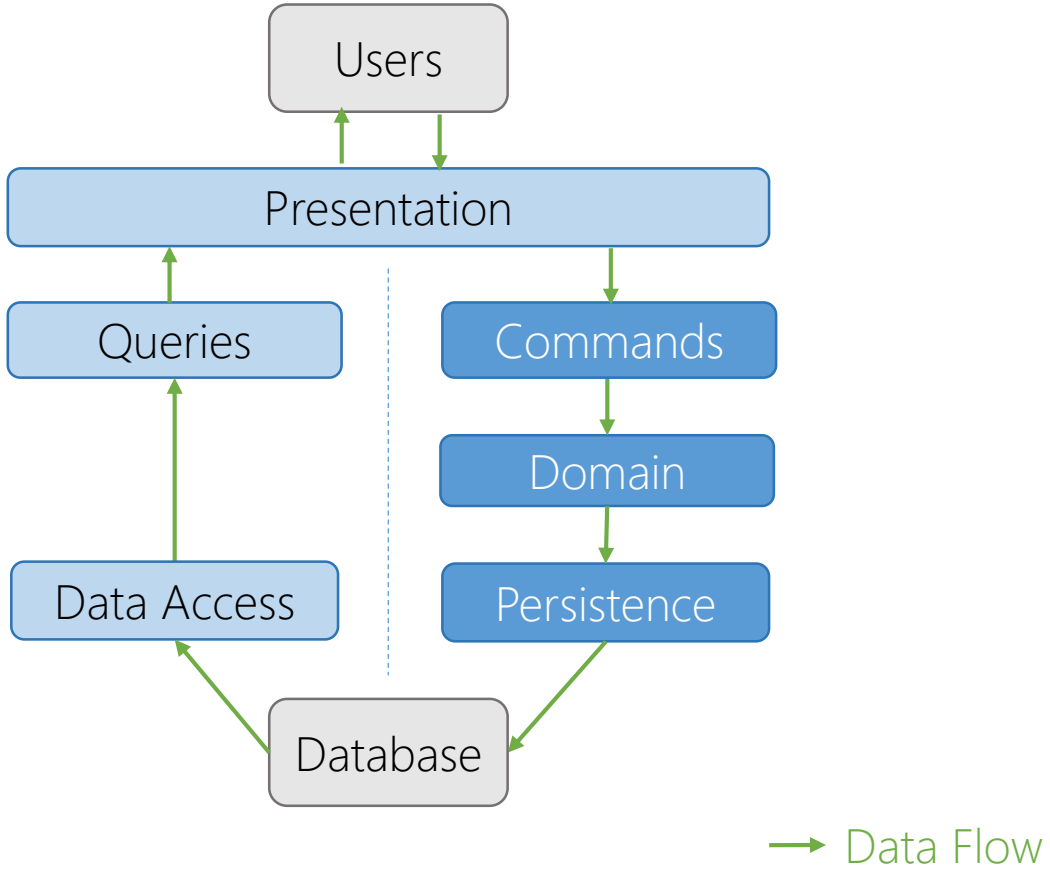
Always returns a value

Avoid mixing the two!

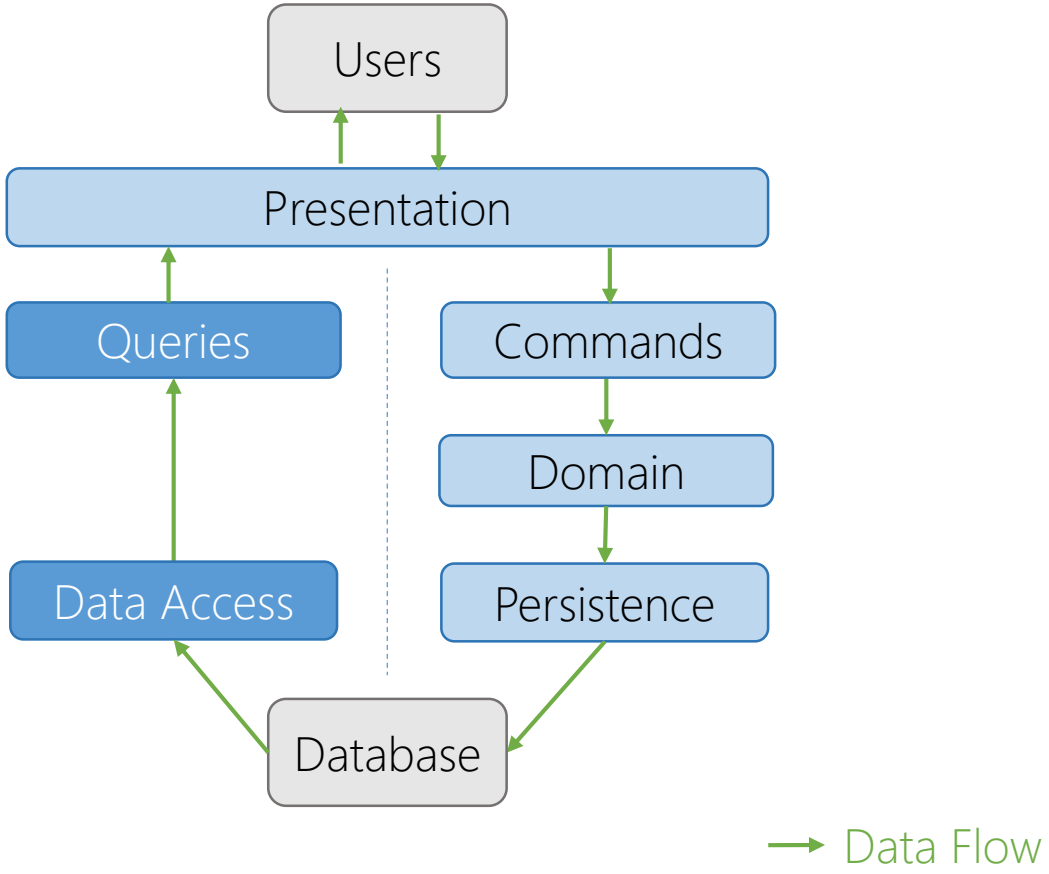
# CQRS Architectures



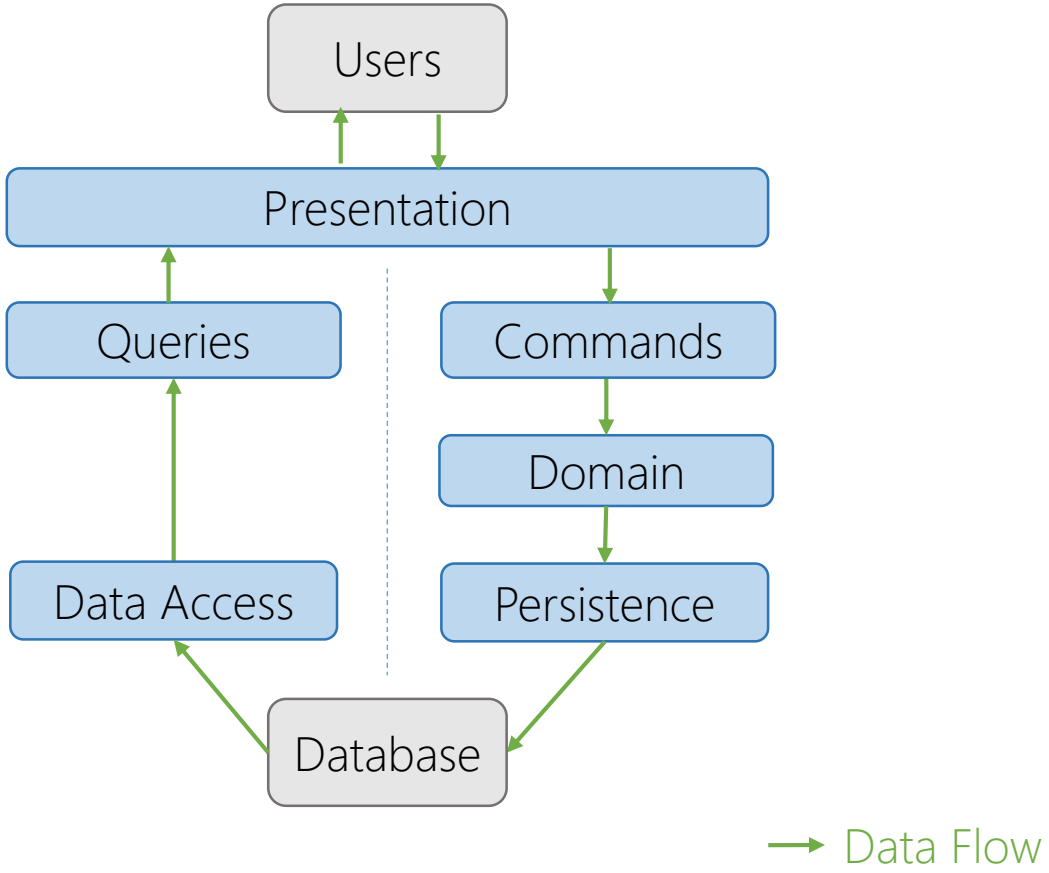
# CQRS Architectures



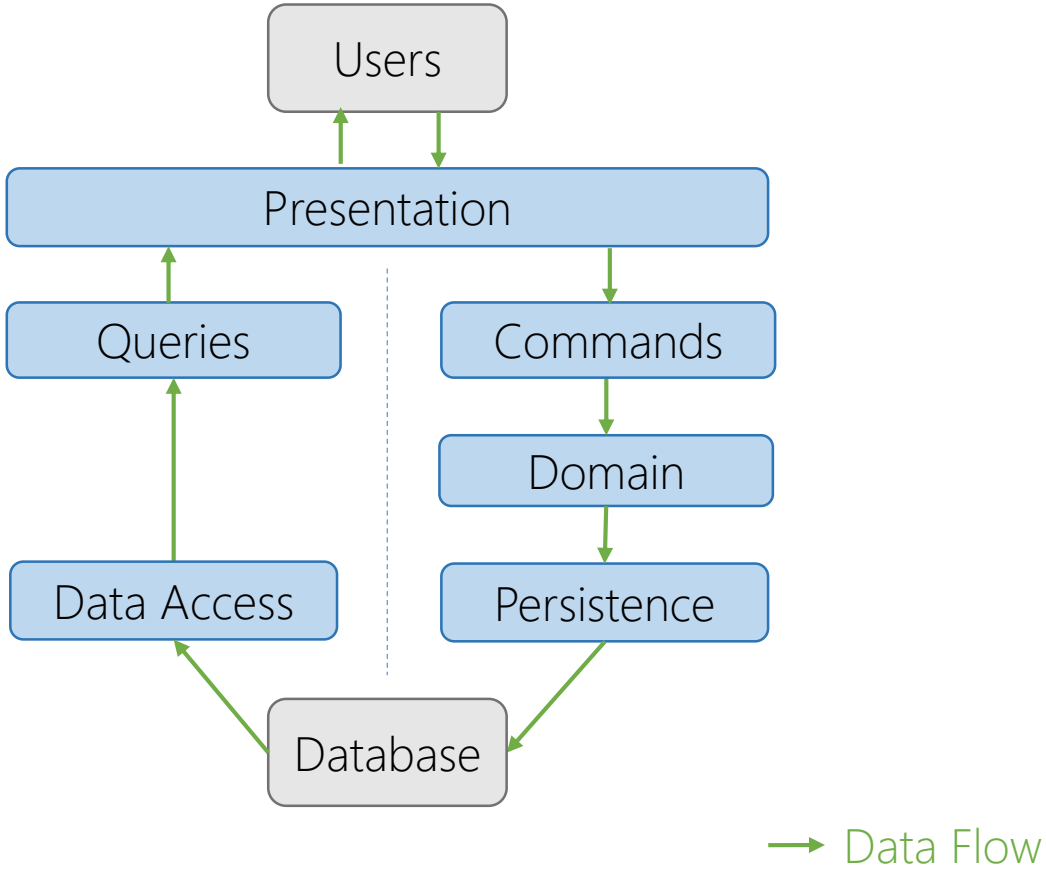
# CQRS Architectures



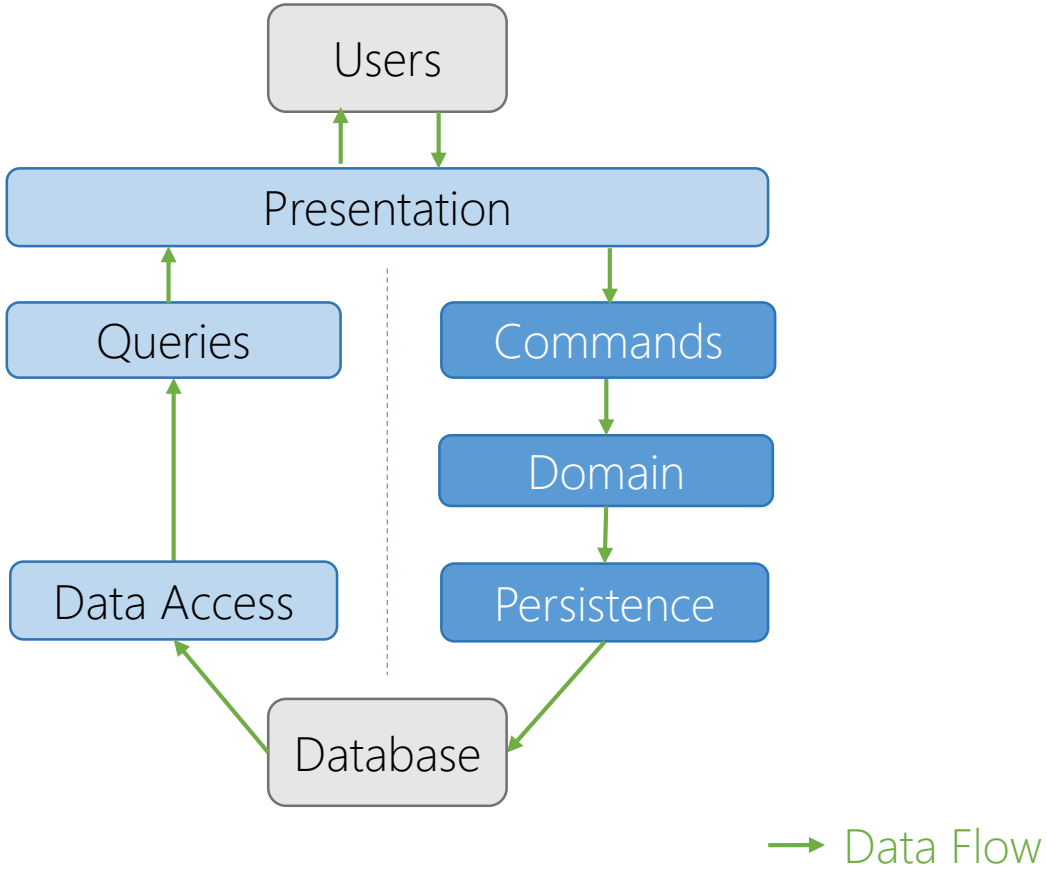
# CQRS Architectures



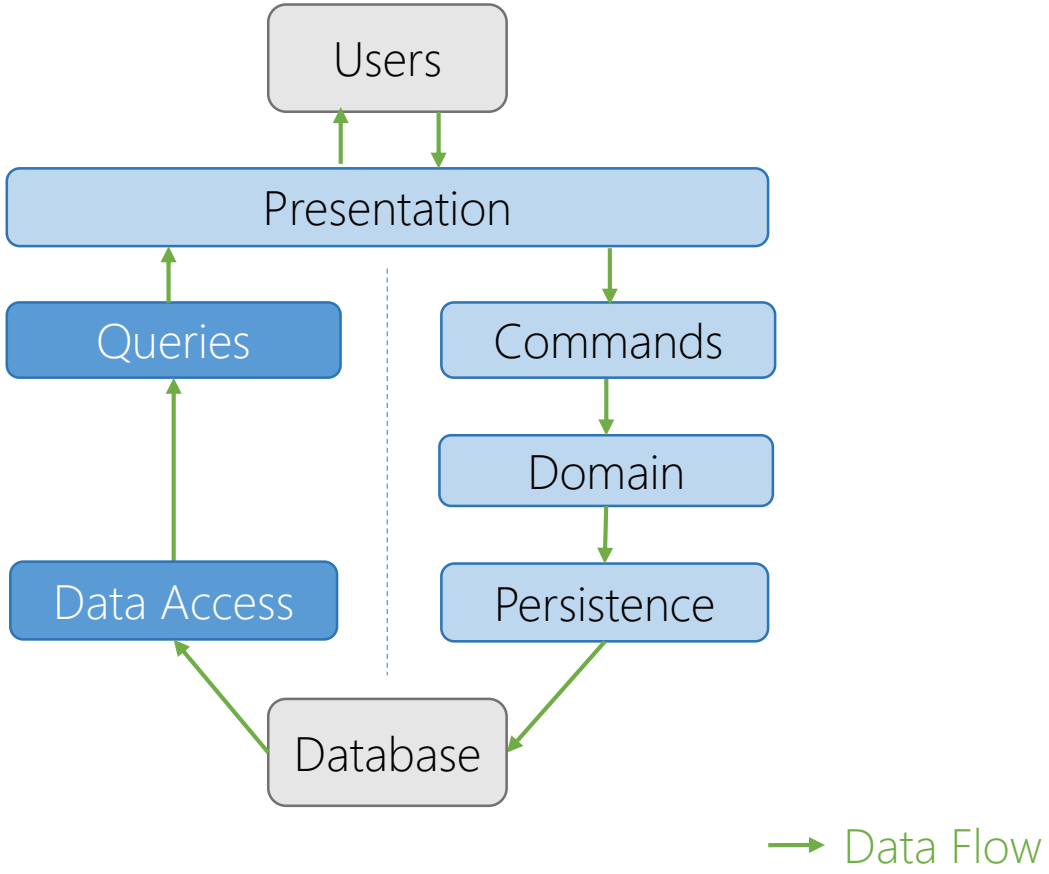
# CQRS Type 1 – Single Database



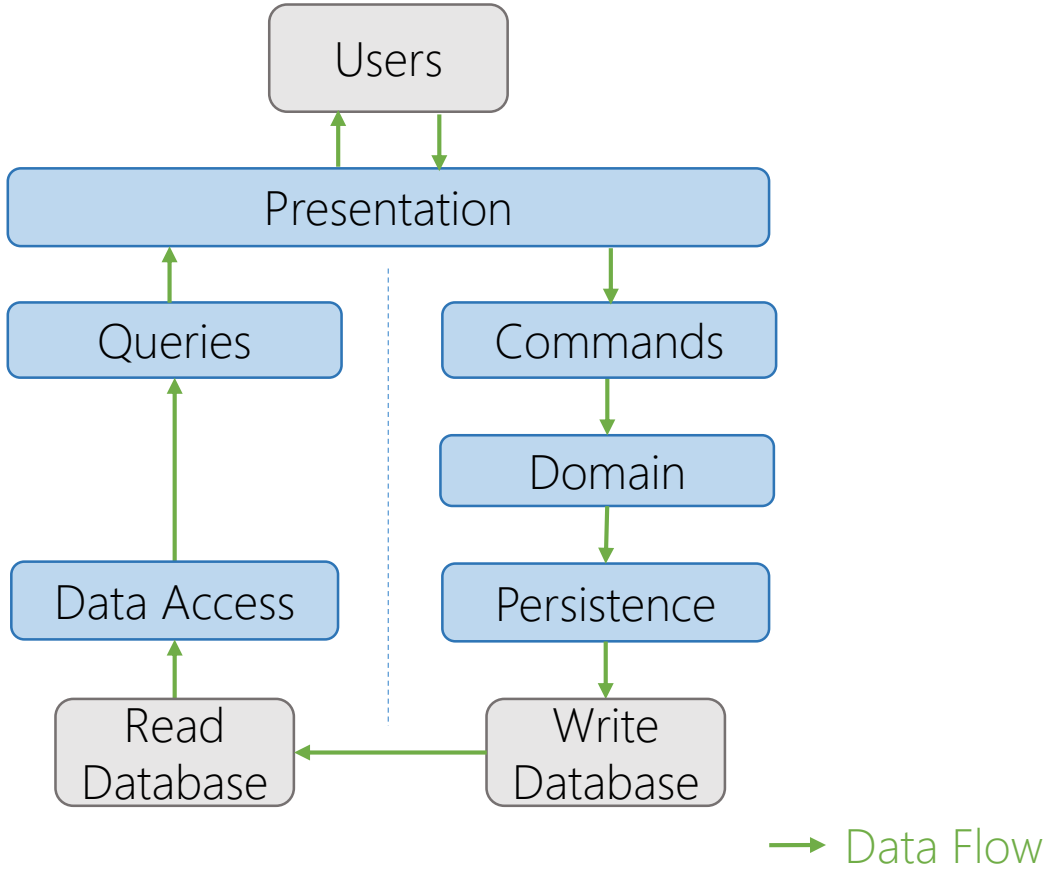
# CQRS Type 1 – Single Database



# CQRS Type 1 – Single Database



# CQRS Type 2 – Read/Write Databases



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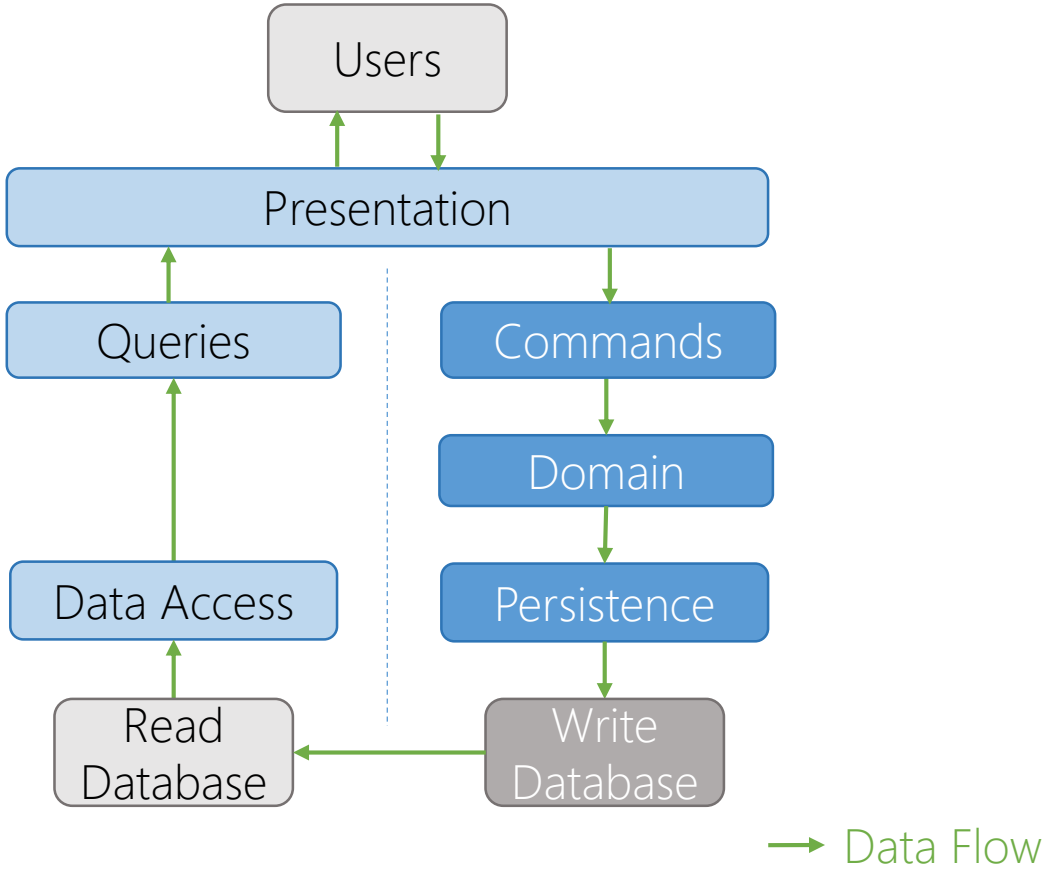

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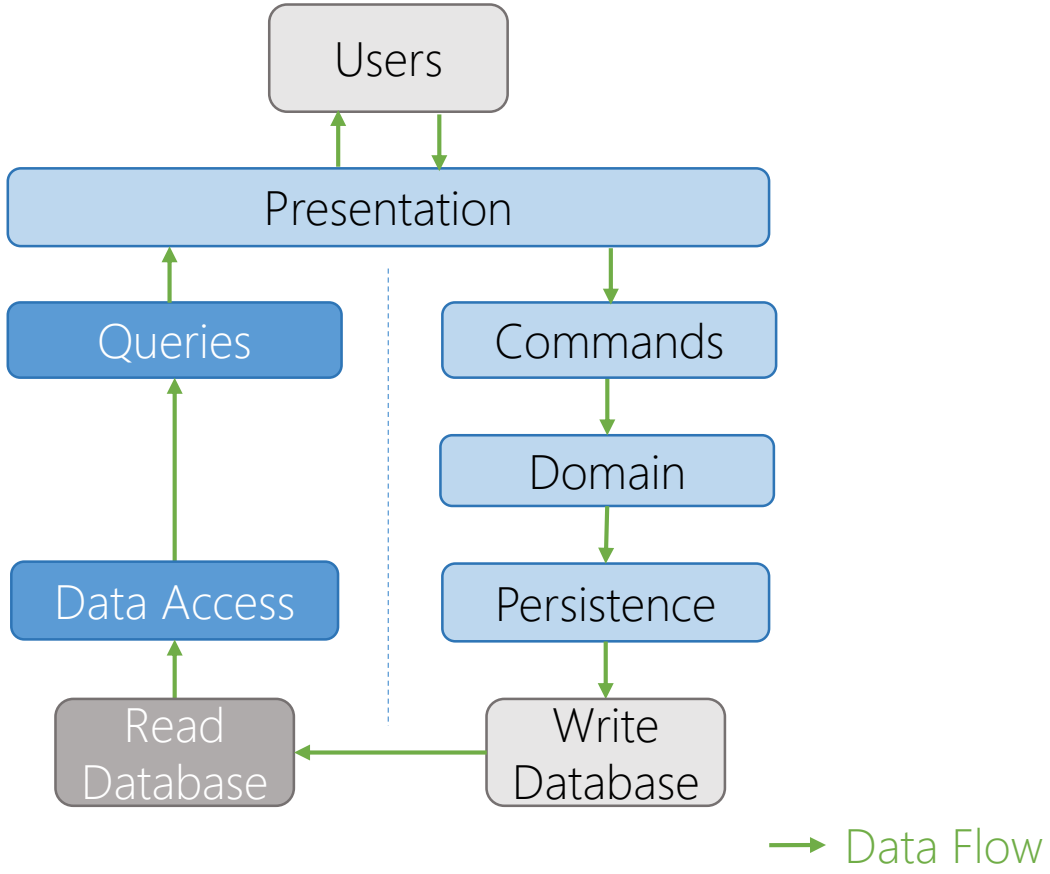

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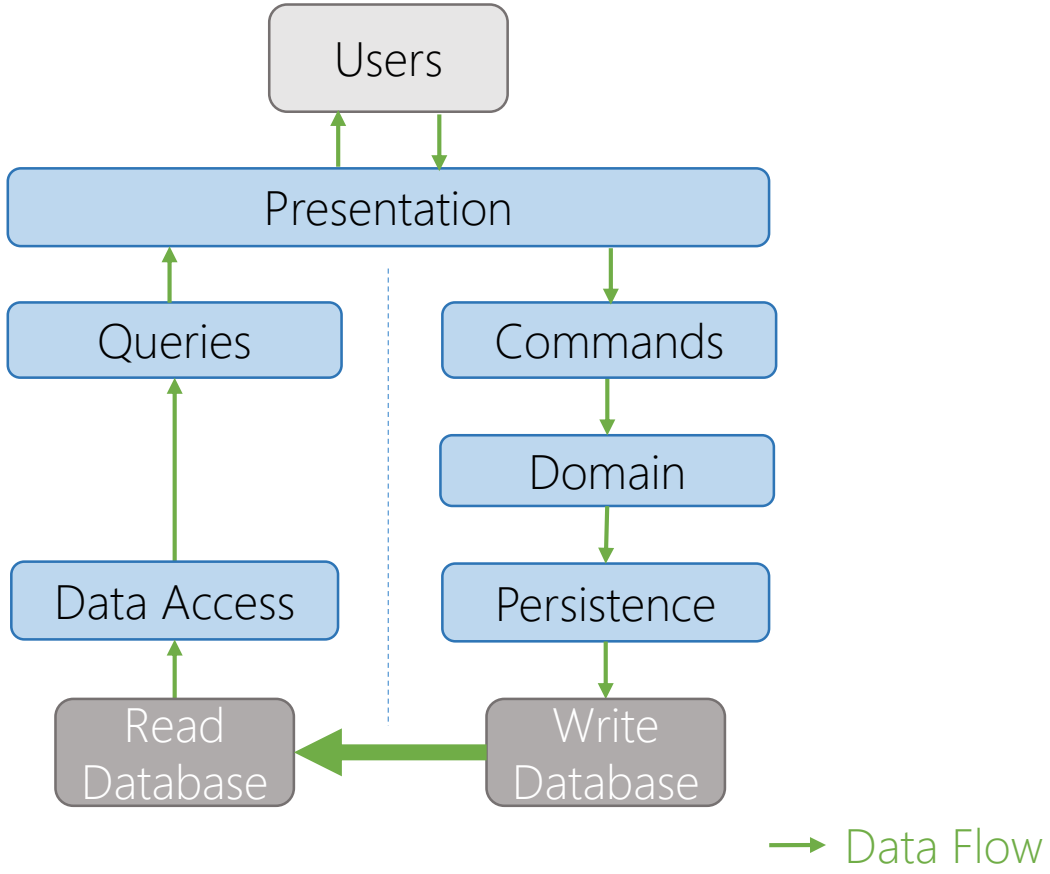

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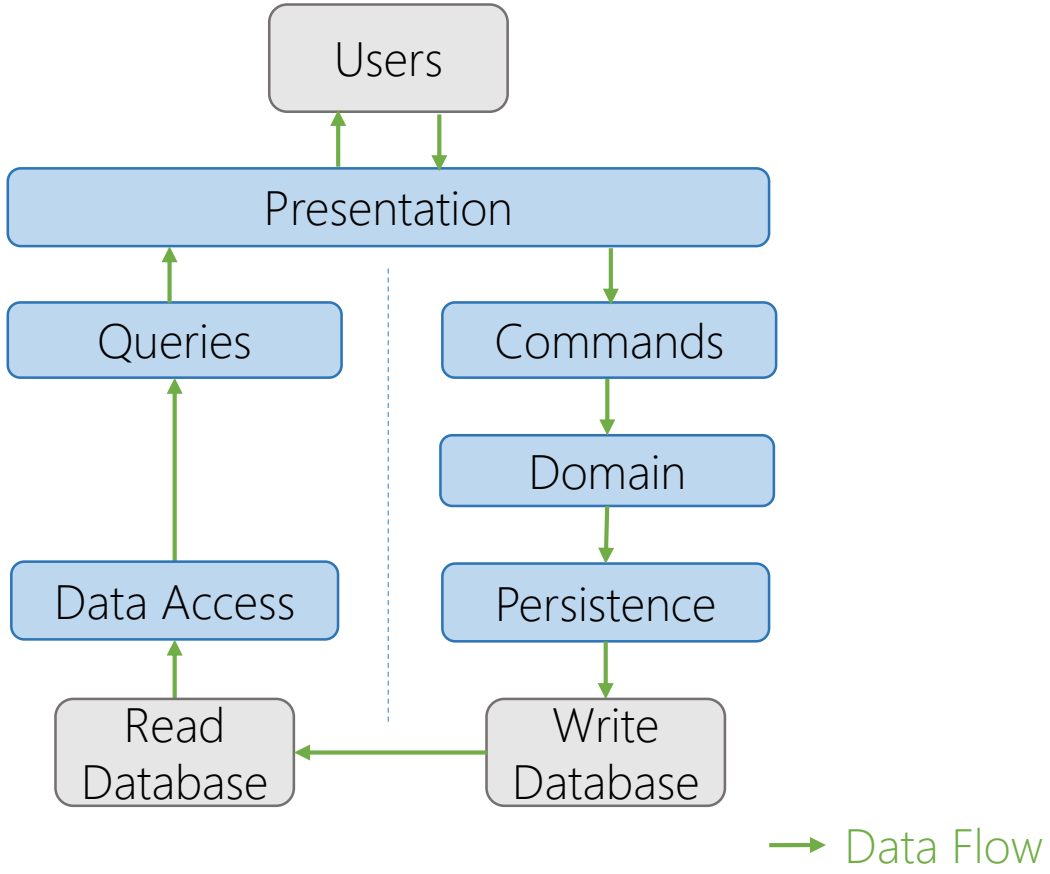
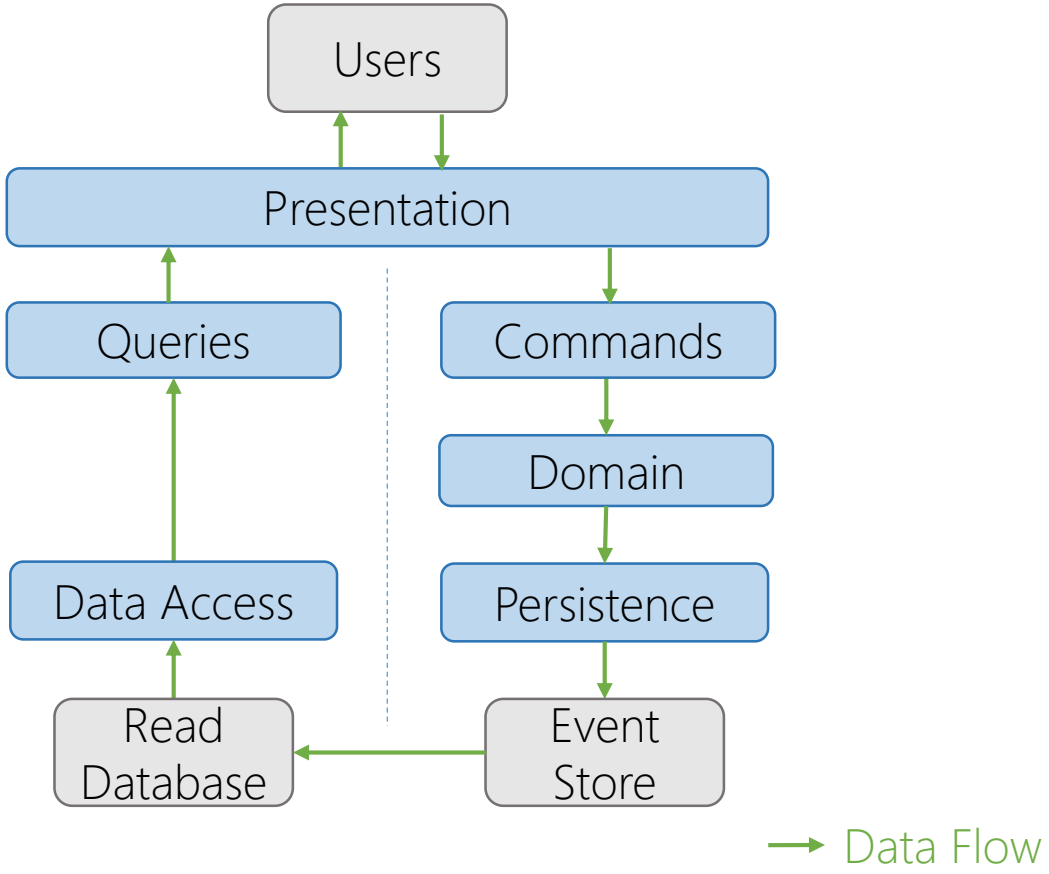
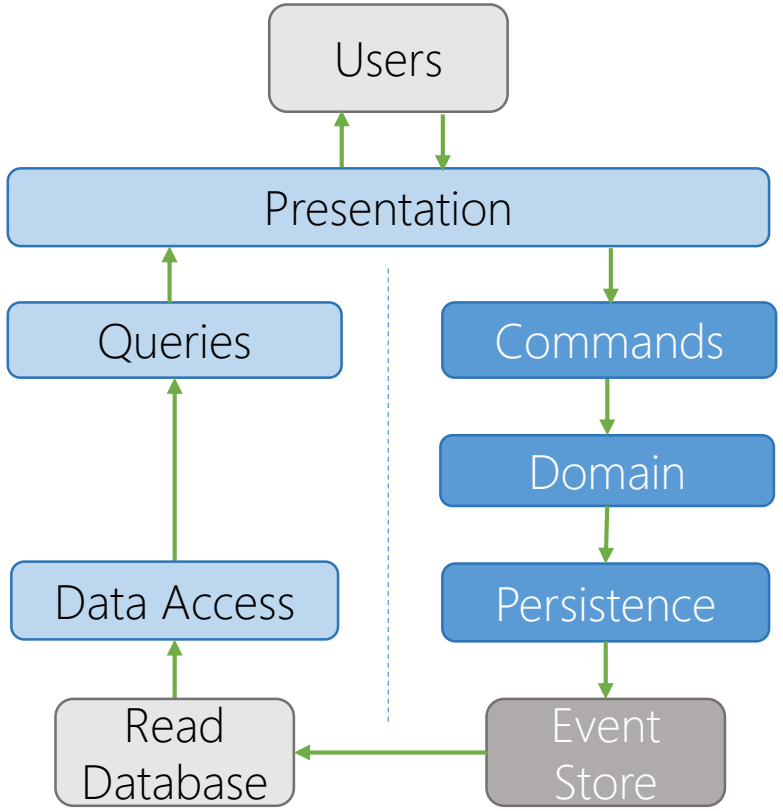


# CQRS Type 3 – Event Sourcing

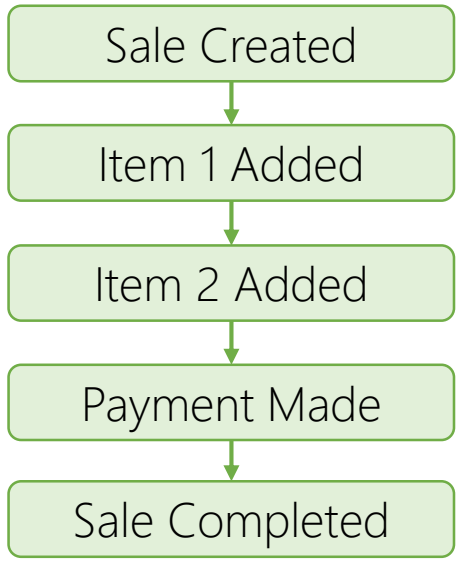


# CQRS Type 3 – Event Sourcing

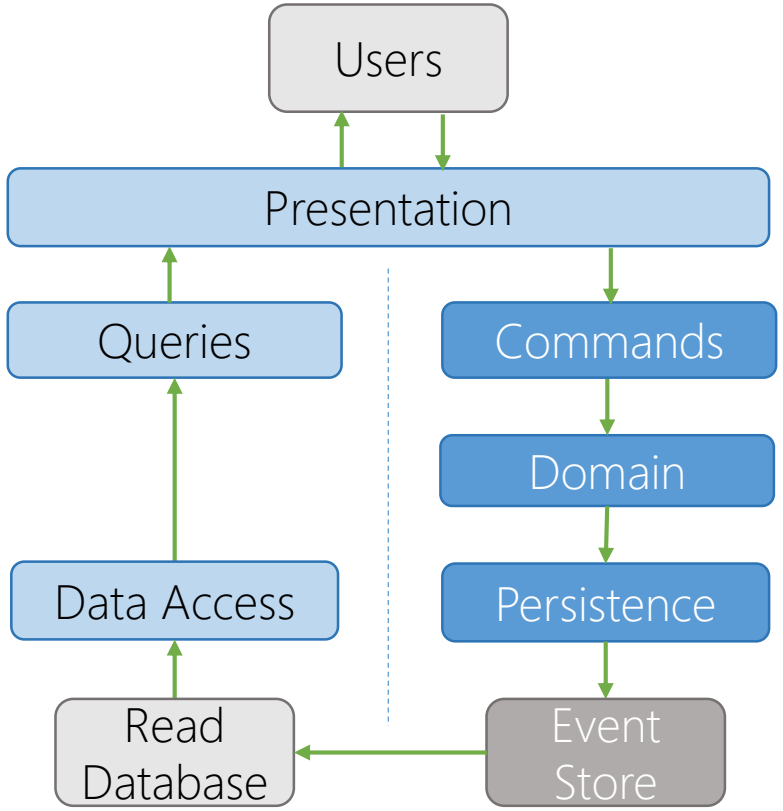



Data Flow

Events



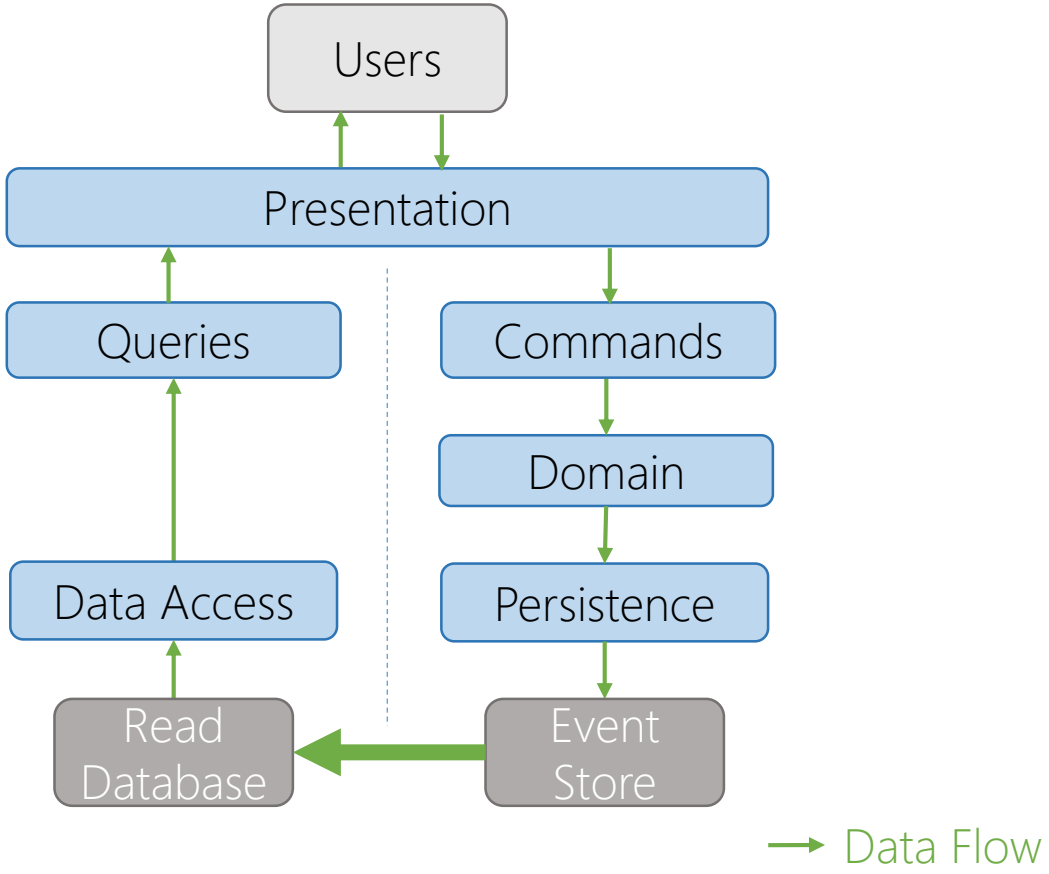
# CQRS Type 3 – Event Sourcing



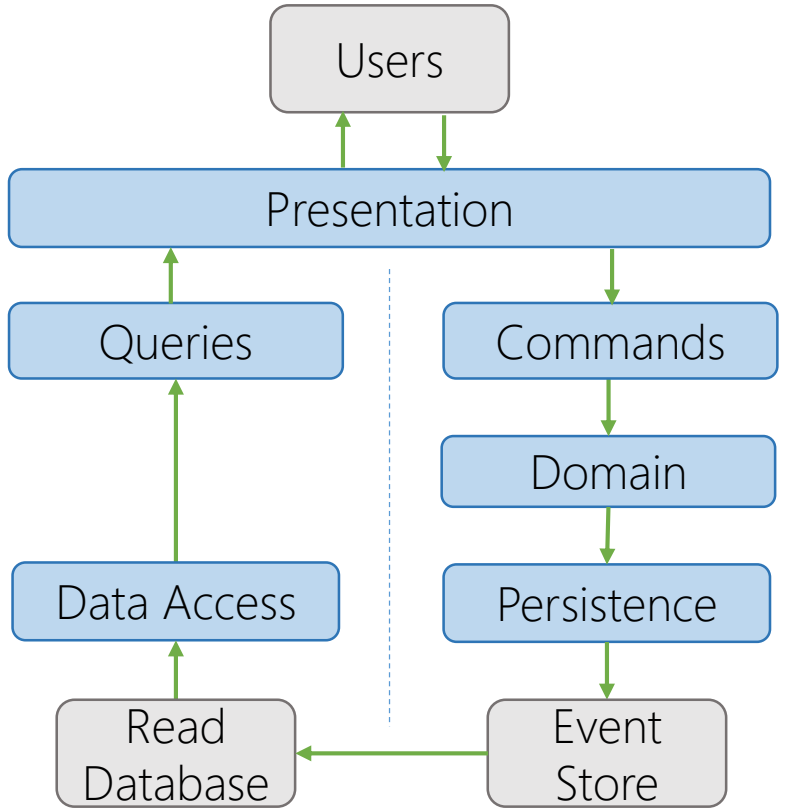

Data Flow

Events

# CQRS Type 3 – Event Sourcing

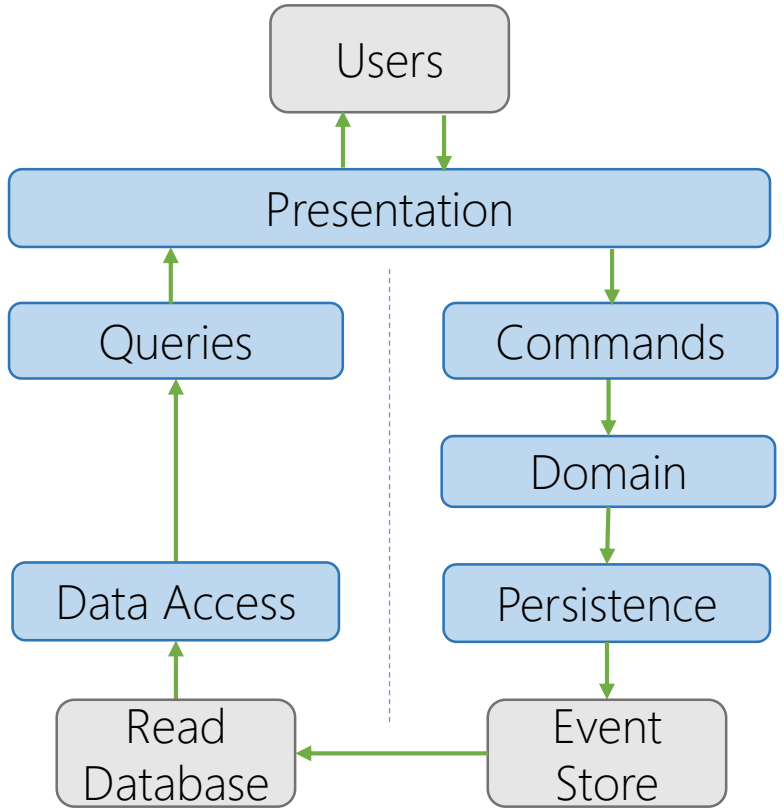


# CQRS Type 3 – Event Sourcing



# CQRS Type 3 – Event Sourcing

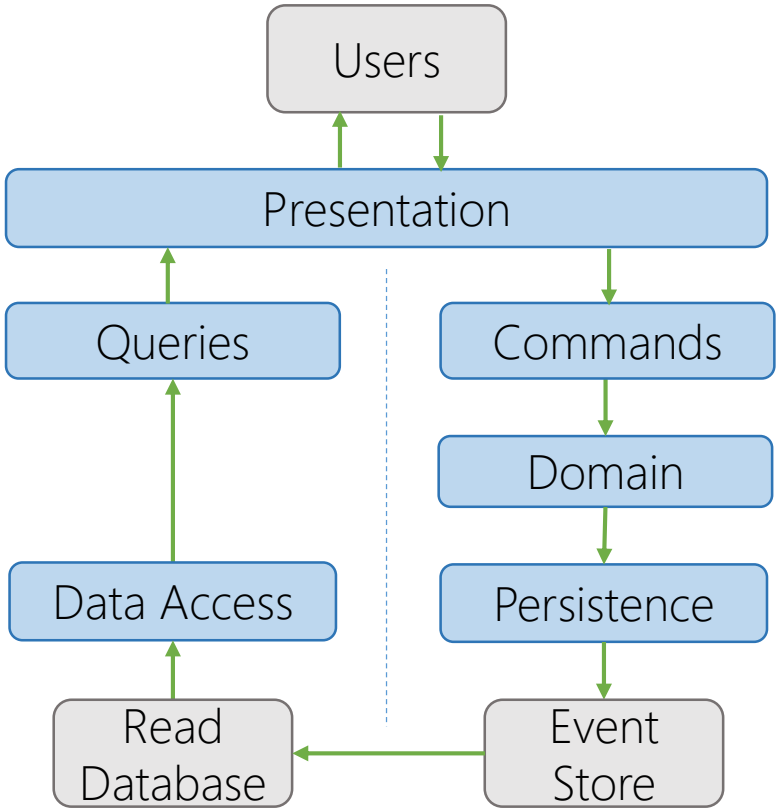
Complete audit trail



# CQRS Type 3 – Event Sourcing

Complete audit trail

Point-in-time reconstruction

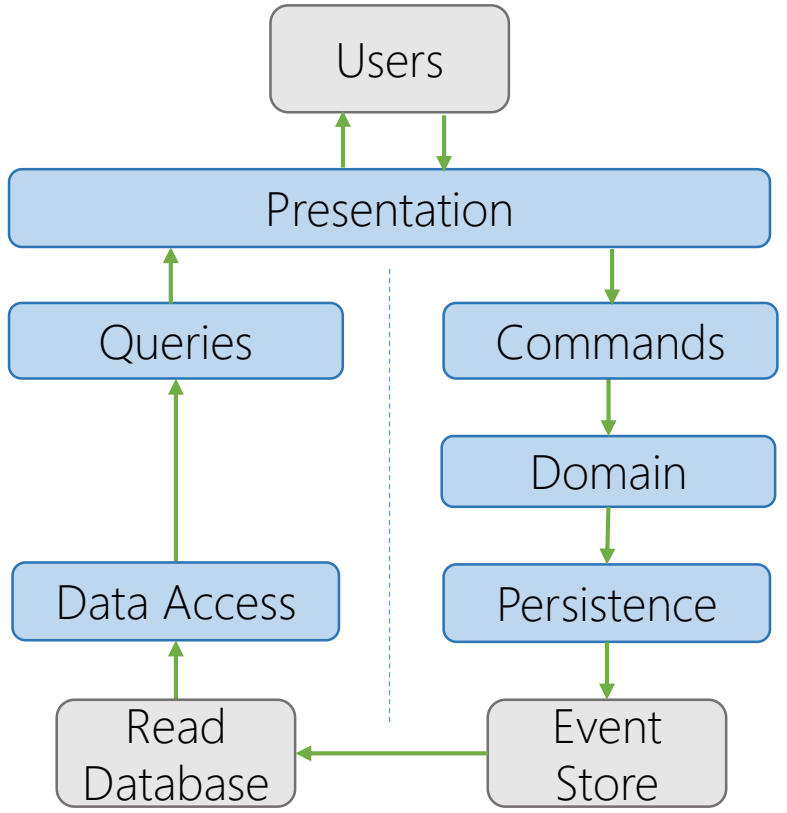


# CQRS Type 3 – Event Sourcing

Complete audit trail

Point-in-time reconstruction

Replay events



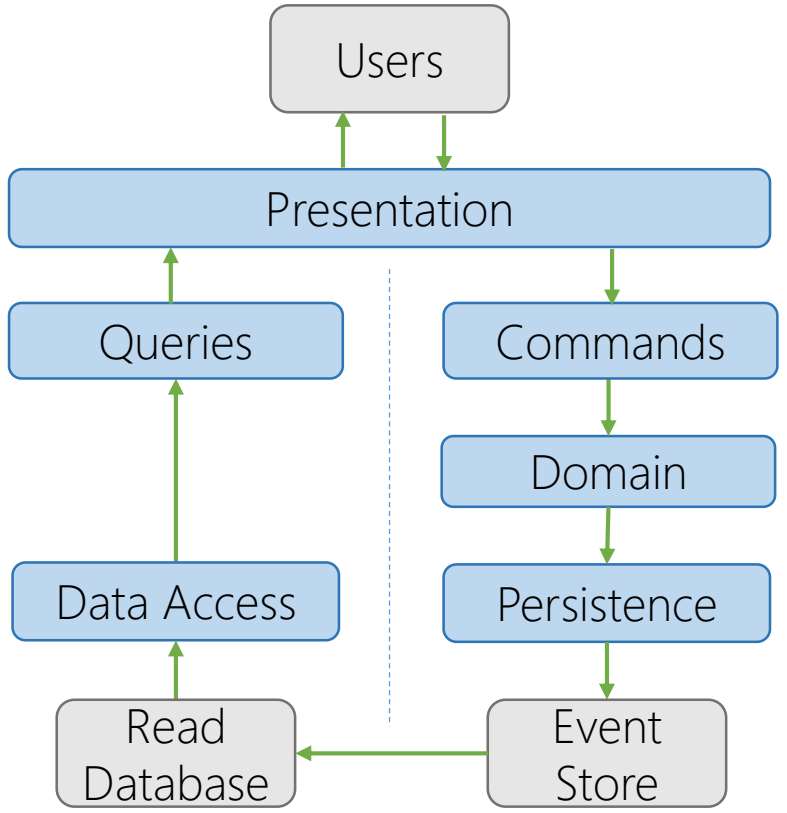
# CQRS Type 3 – Event Sourcing

Complete audit trail

Point-in-time reconstruction

Replay events

Rebuild production database



# Why Use CQRS?

## Pros

More efficient design

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Simpler within each stack

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Inconsistent across stacks

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Inconsistent across stacks

Type 2 is more complex

# Why Use CQRS?

## Pros

More efficient design

Simpler within each stack

Optimized performance

## Cons

Inconsistent across stacks

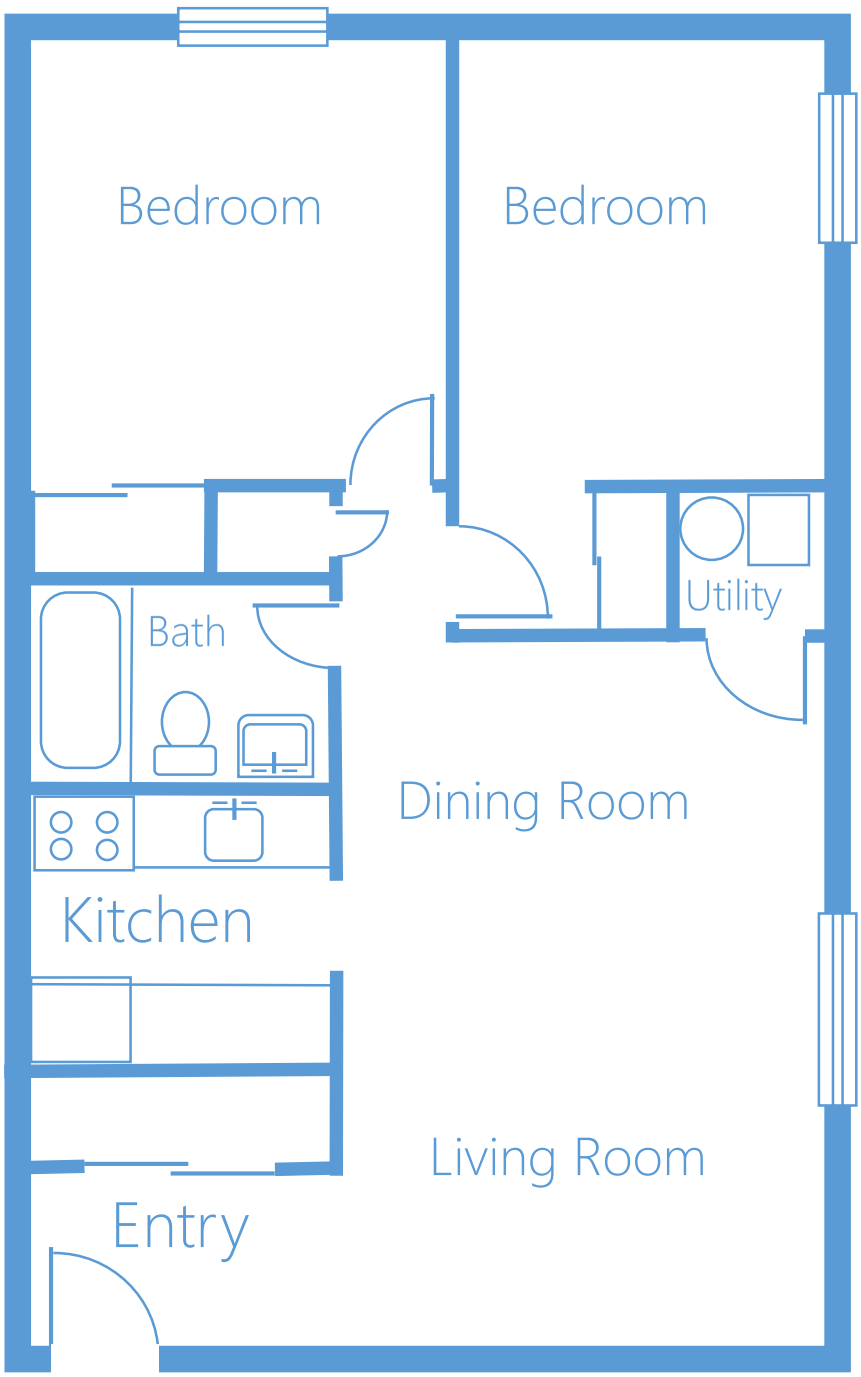
Type 2 is more complex

Type 3 might be overkill

# Functional Organization

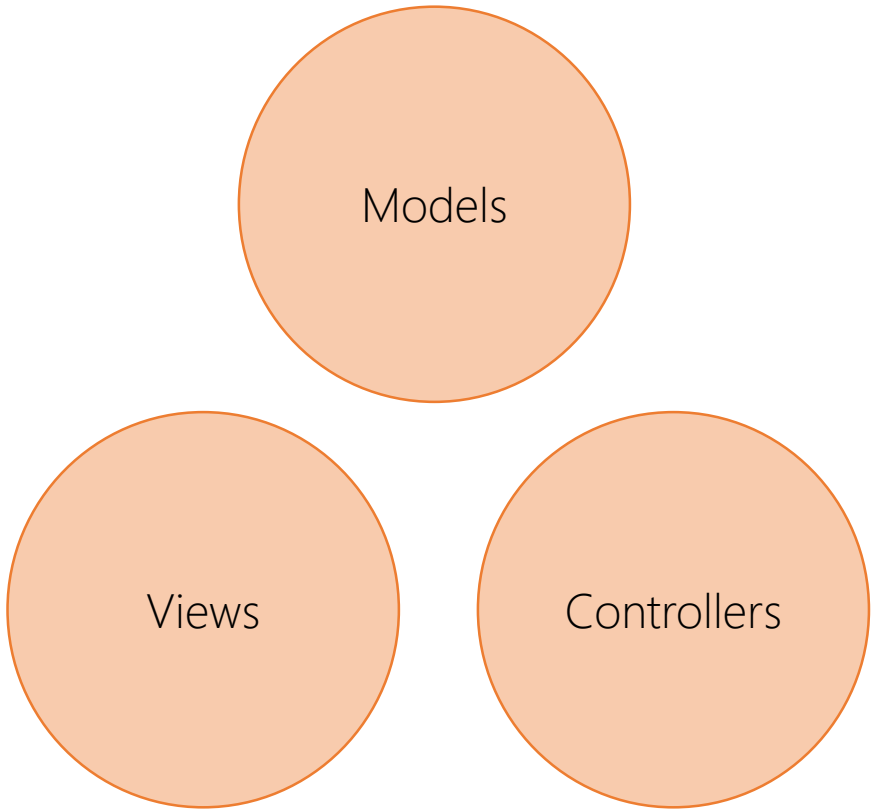
"The architecture should scream
the intent of the system!"

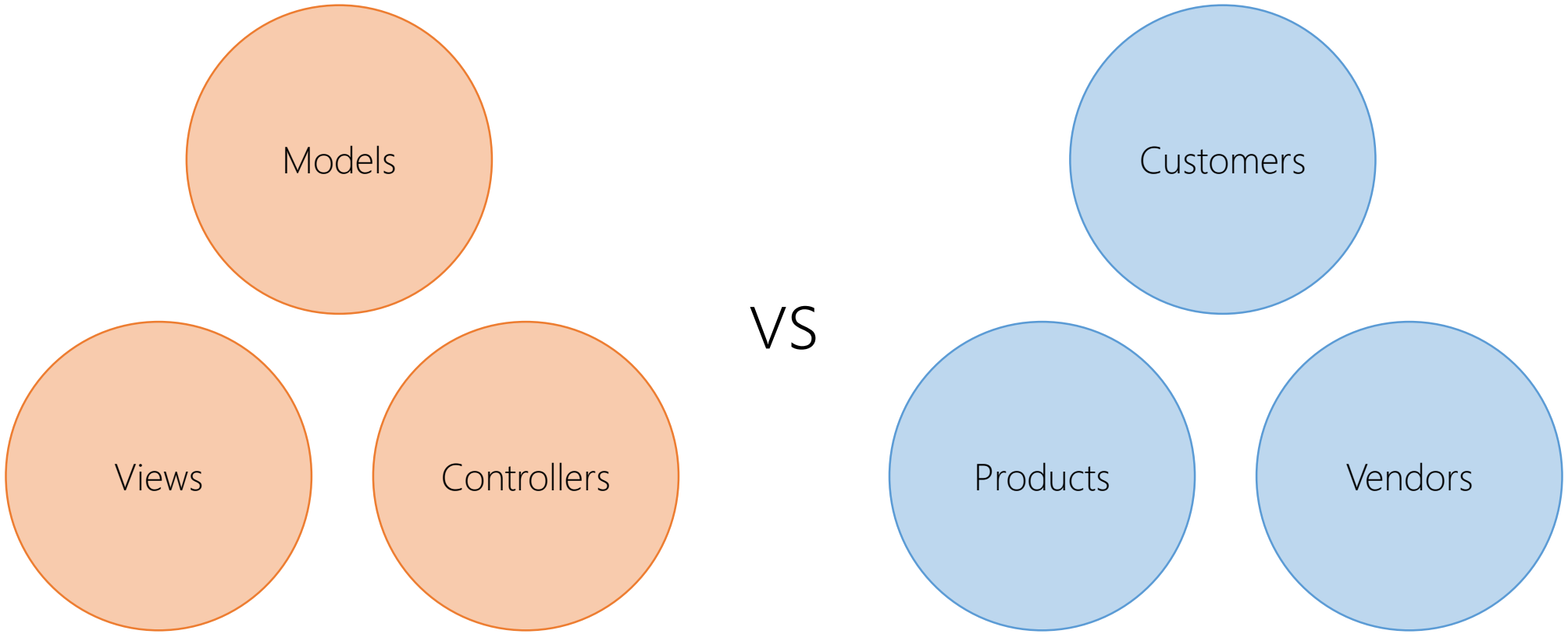
– Uncle Bob


Bedroom
Bedroom
Utility
Bath
Dining Room
Kitchen
Living Room
Entry


Utility
Bath

| Material | Quantity | Cost |
|---|---|---|
| Appliances | 5 | $5,000 |
| Cabinets | 10 | $2,500 |
| Doors | 15 | $750 |
| Fixtures | 12 | $2,400 |
| Floors | 9 | $4,000 |
| Walls | 20 | $10,000 |
| Windows | 8 | $2,500 |


Models
Views
Controllers


Models
Views
Controllers
VS
Customers
Products
Vendors

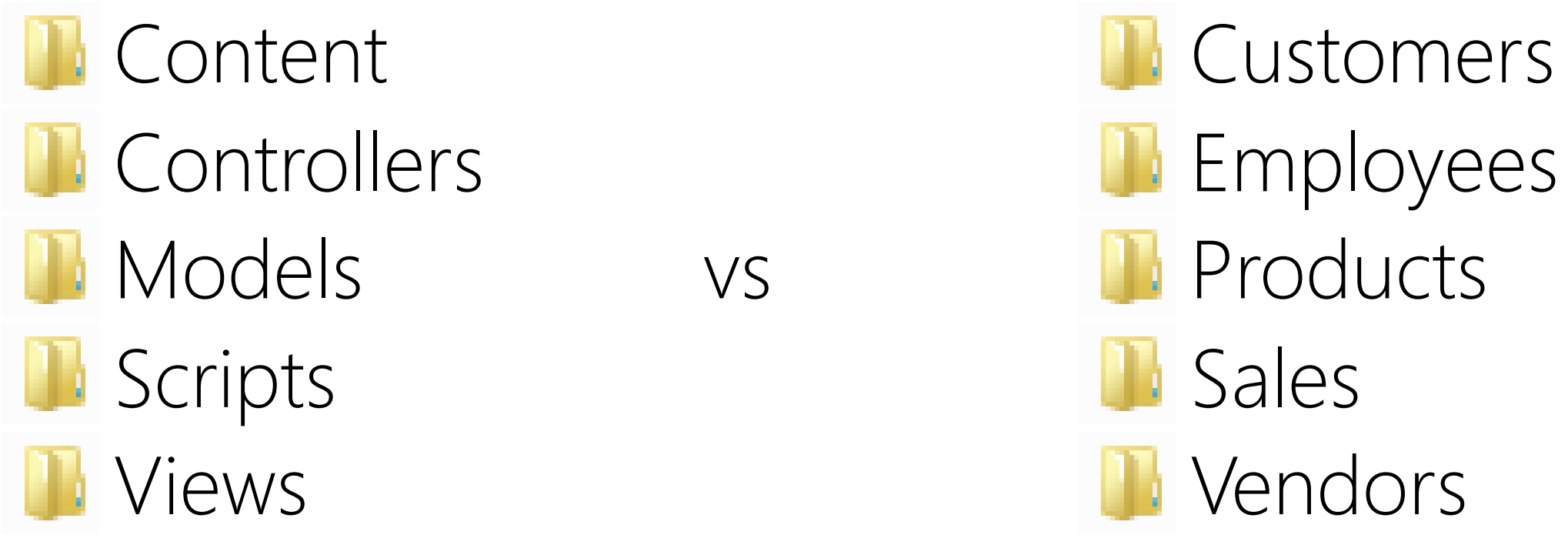
Content

Controllers

Models

Scripts

Views

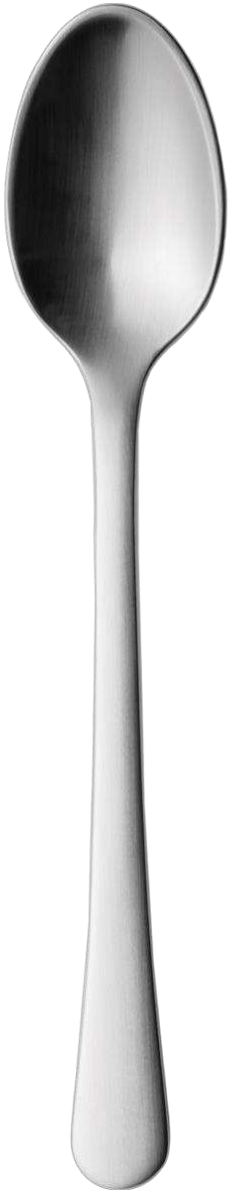

Content
Controllers
Models
Scripts
Views
vs
Customers
Employees
Products
Sales
Vendors

# So what?


512




VS


# Why Use Functional Organization

## Pros

Spatial locality

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## Pros

Spatial locality

Easy to navigate

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Avoid vendor lock-in

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Lose framework conventions

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## Cons

Lose framework conventions

Lose automatic scaffolding

# Why Use Functional Organization

## Pros

Spatial locality

Easy to navigate

Avoid vendor lock-in

## Cons

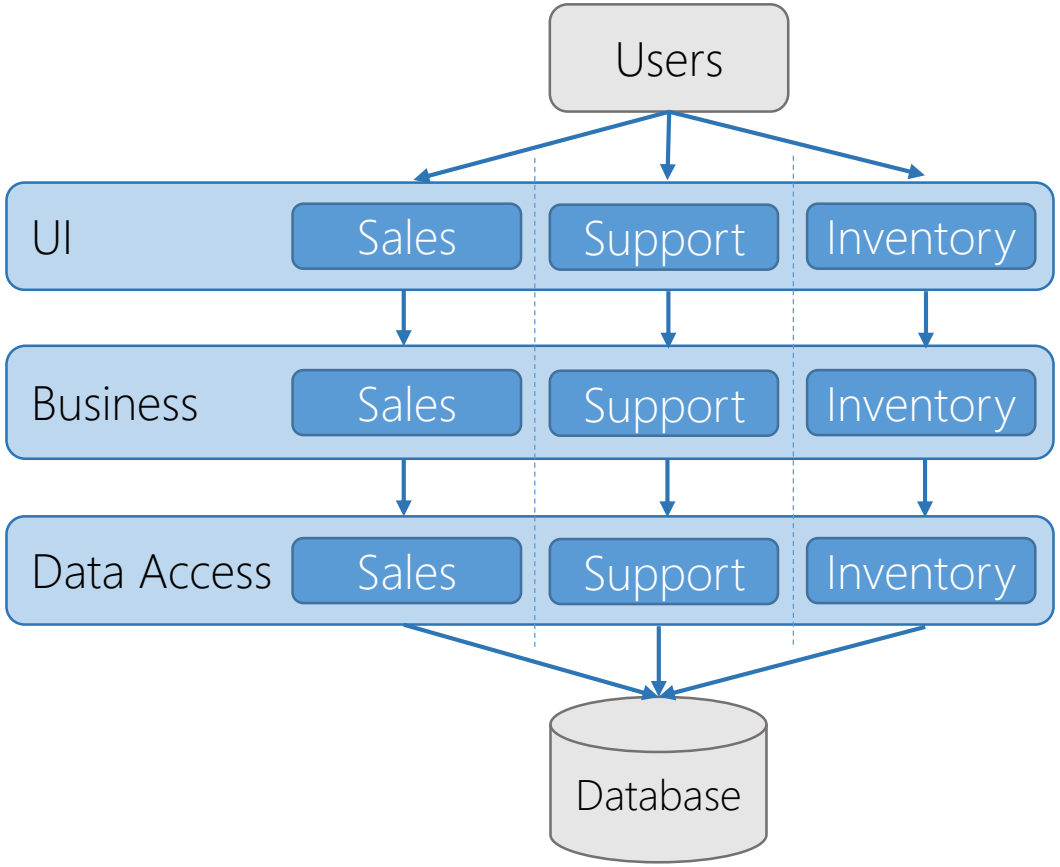
Lose framework conventions

Lose automatic scaffolding

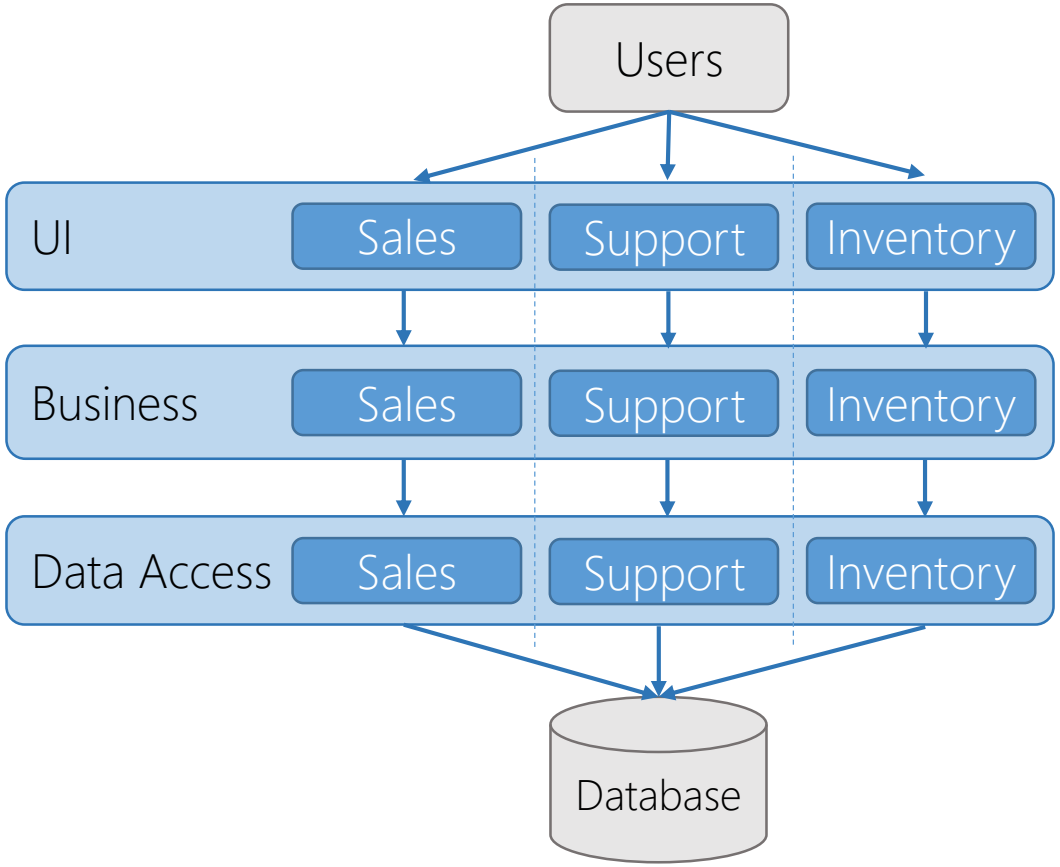
Categorical is easier at first

# Microservices

# Components


Users
UI
Sales
Support
Inventory
Business
Sales
Support
Inventory
Data Access
Sales
Support
Inventory
Database

# Components


Users
UI
Sales
Support
Inventory
Business
Sales
Support
Inventory
Data Access
Sales
Support
Inventory
Database

# Problem Domain

## Sales

Sales Opportunity

Contact

Sales Person

Product

Sales Territory

## Support

Support Ticket

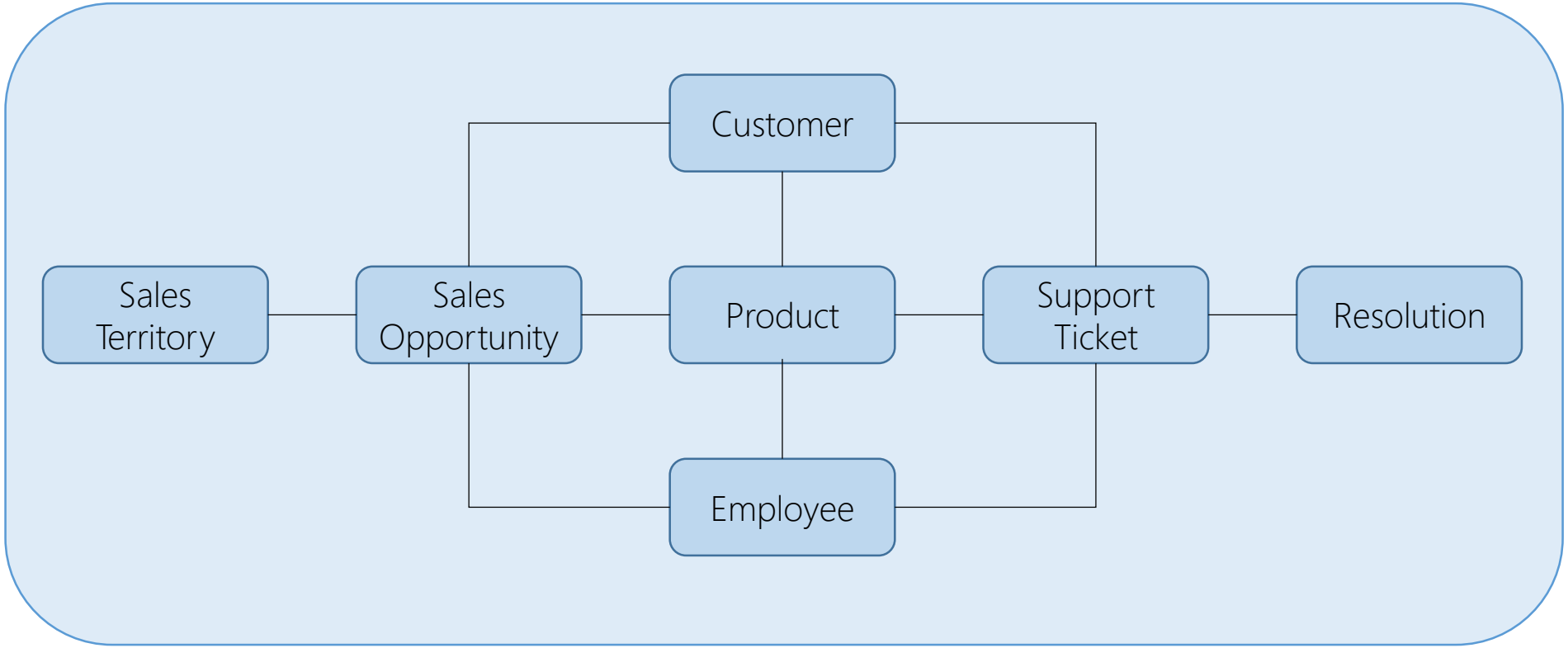
Customer

Support Person

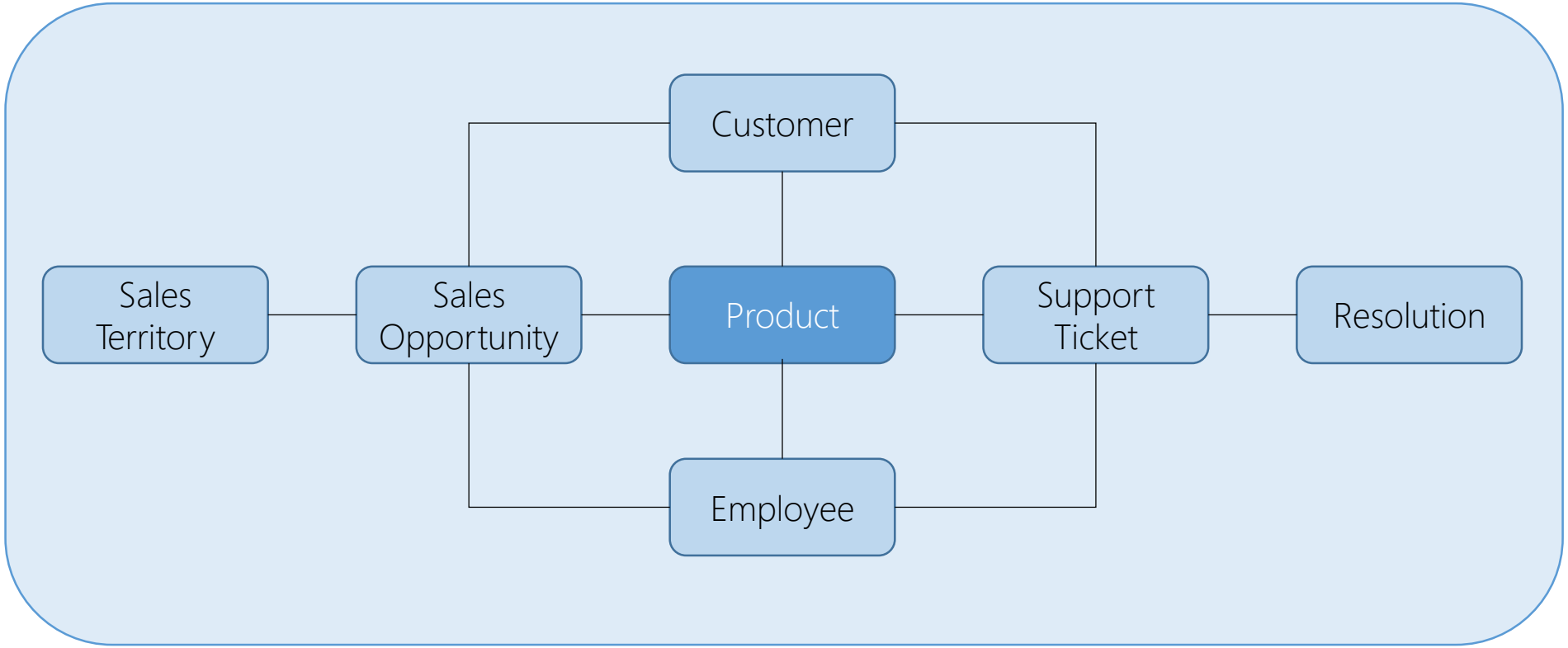
Product

Resolution

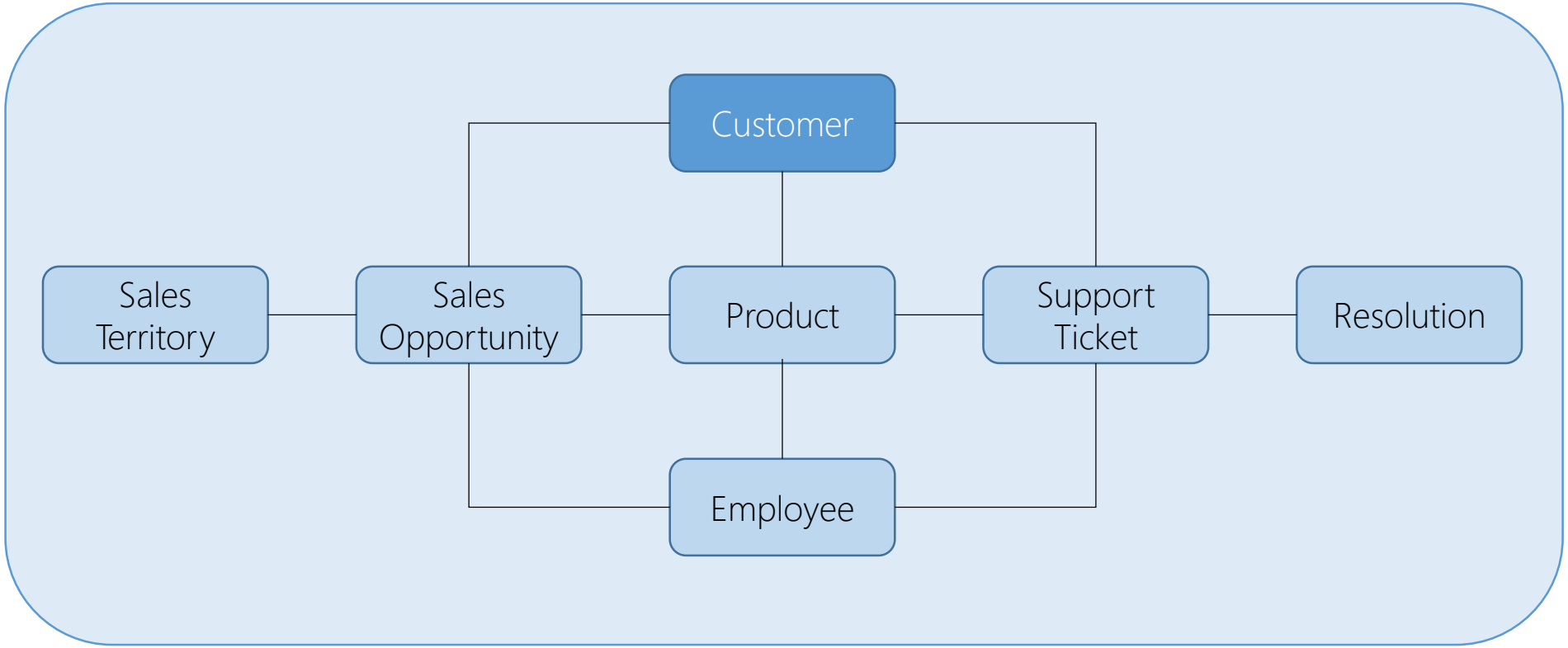
# Single Domain Model



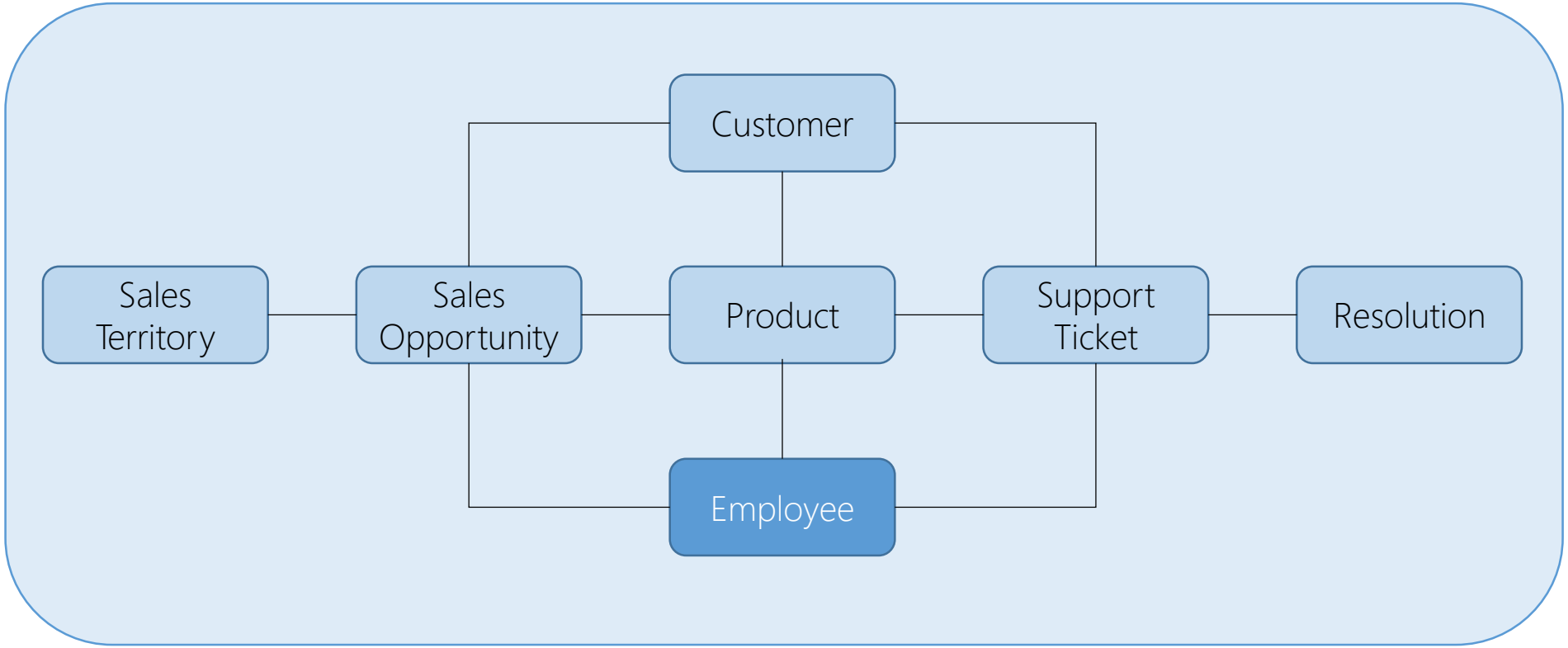
# Single Domain Model



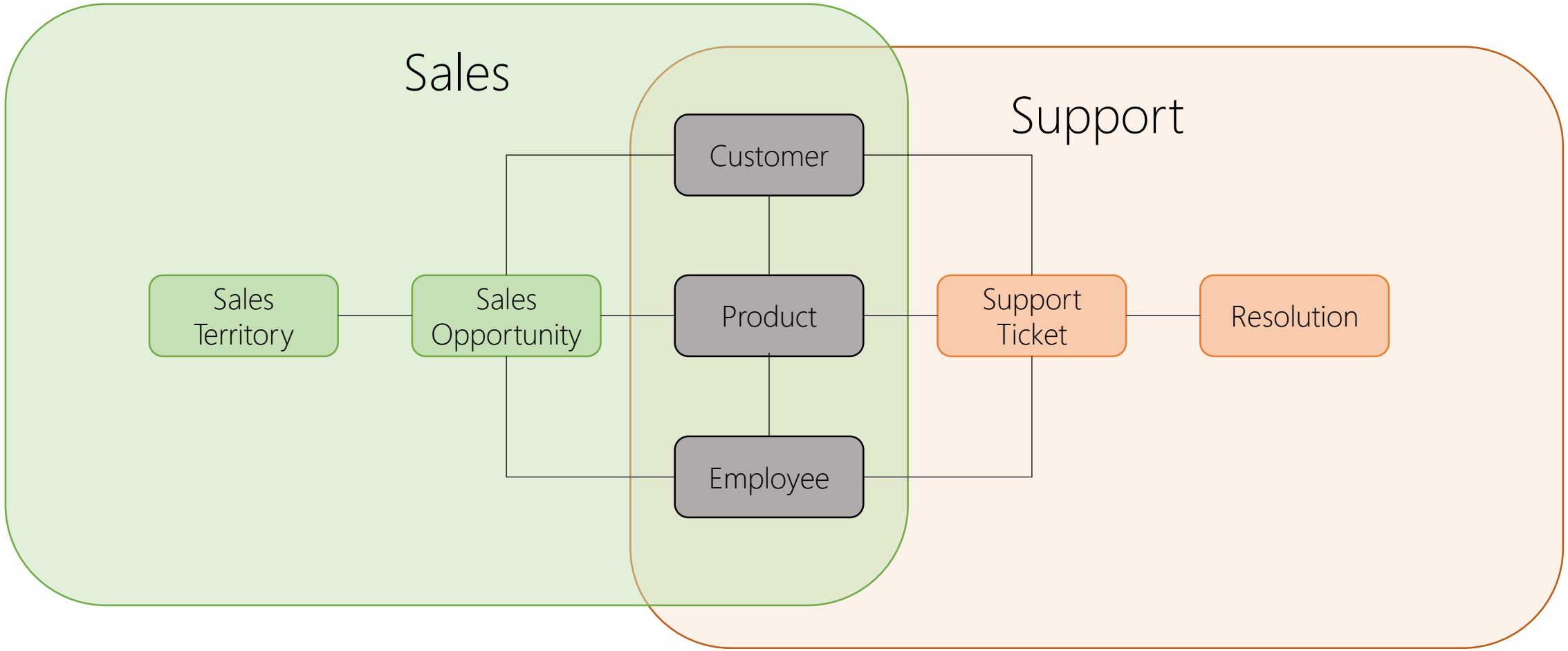
# Single Domain Model



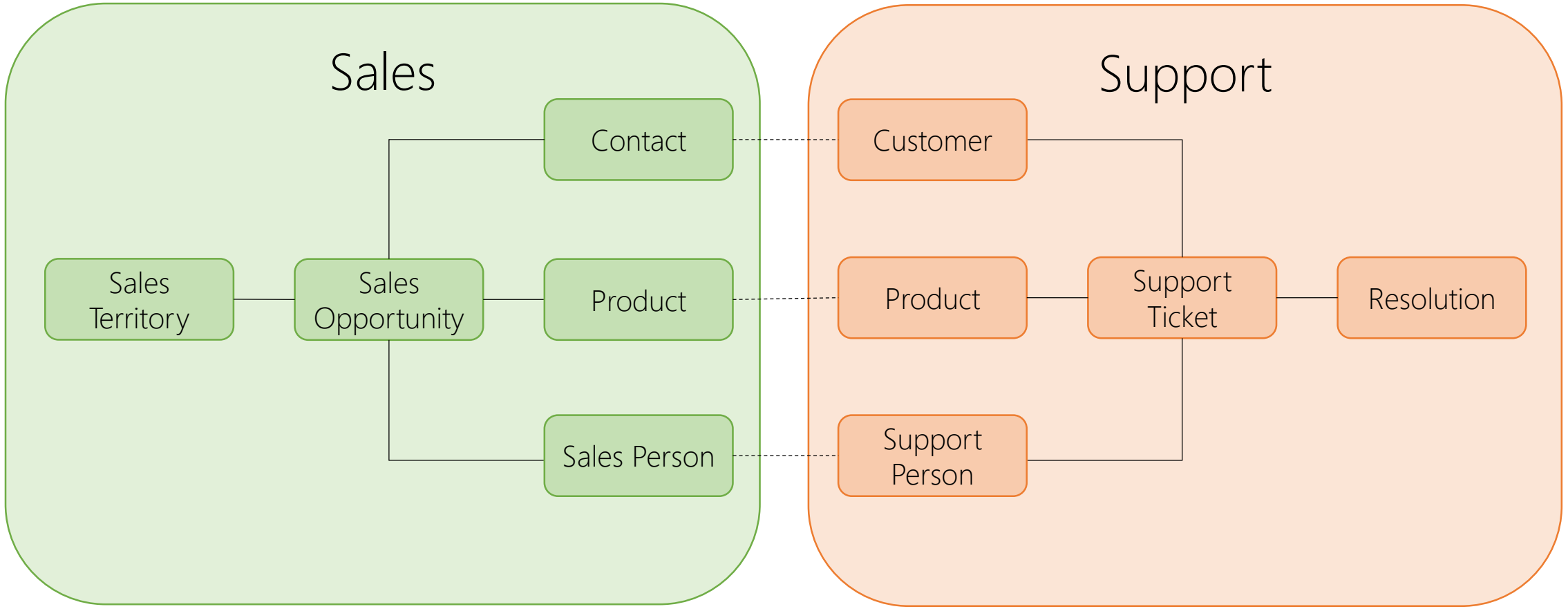
# Single Domain Model



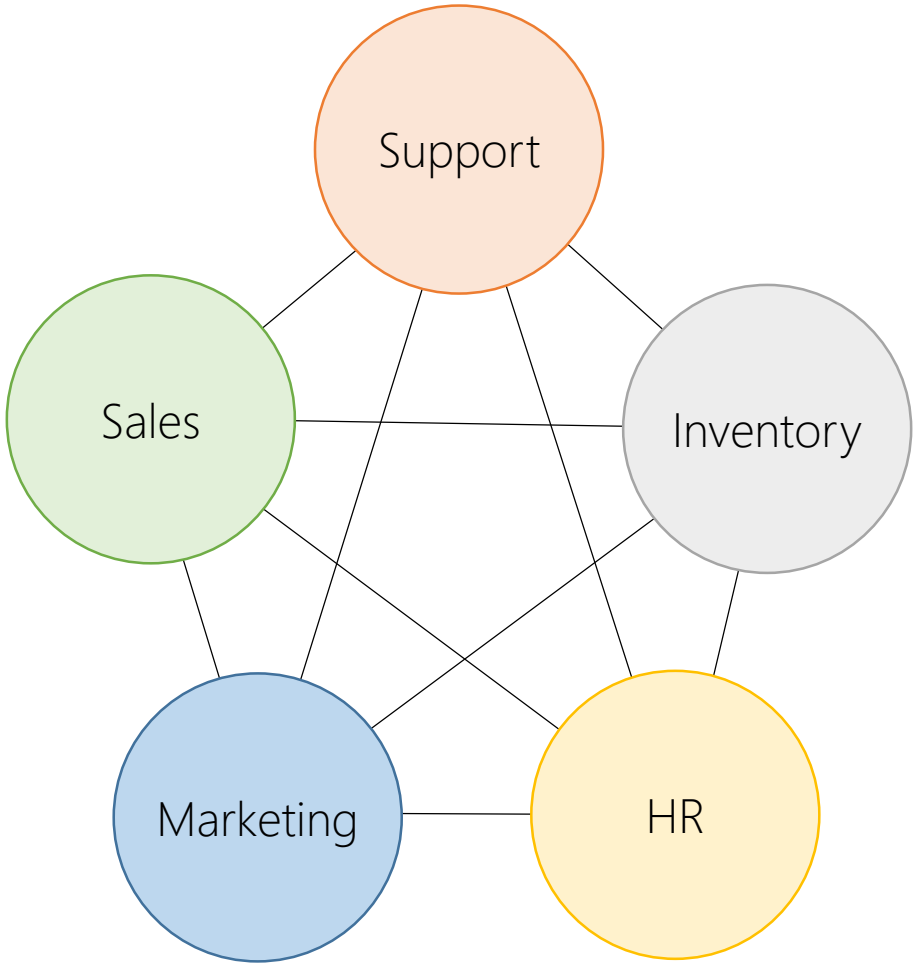
# Overlapping Contexts



# Bounded Contexts

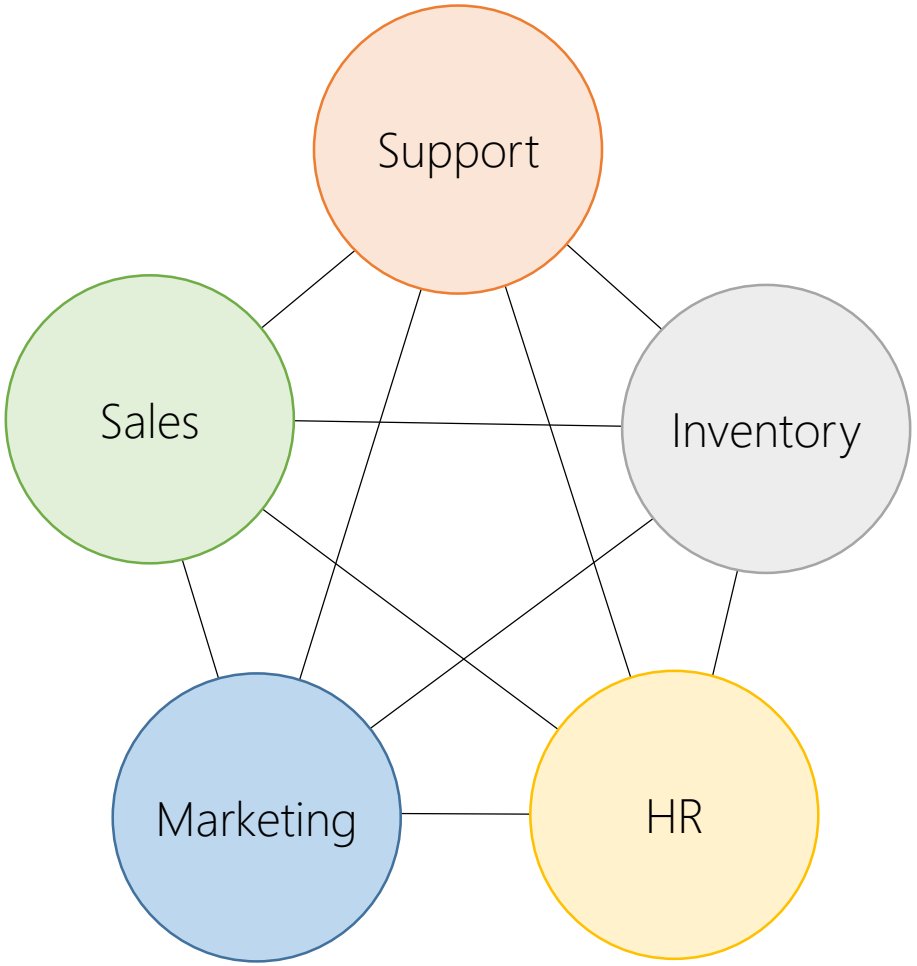


# Microservice Architectures



# Microservice Architectures

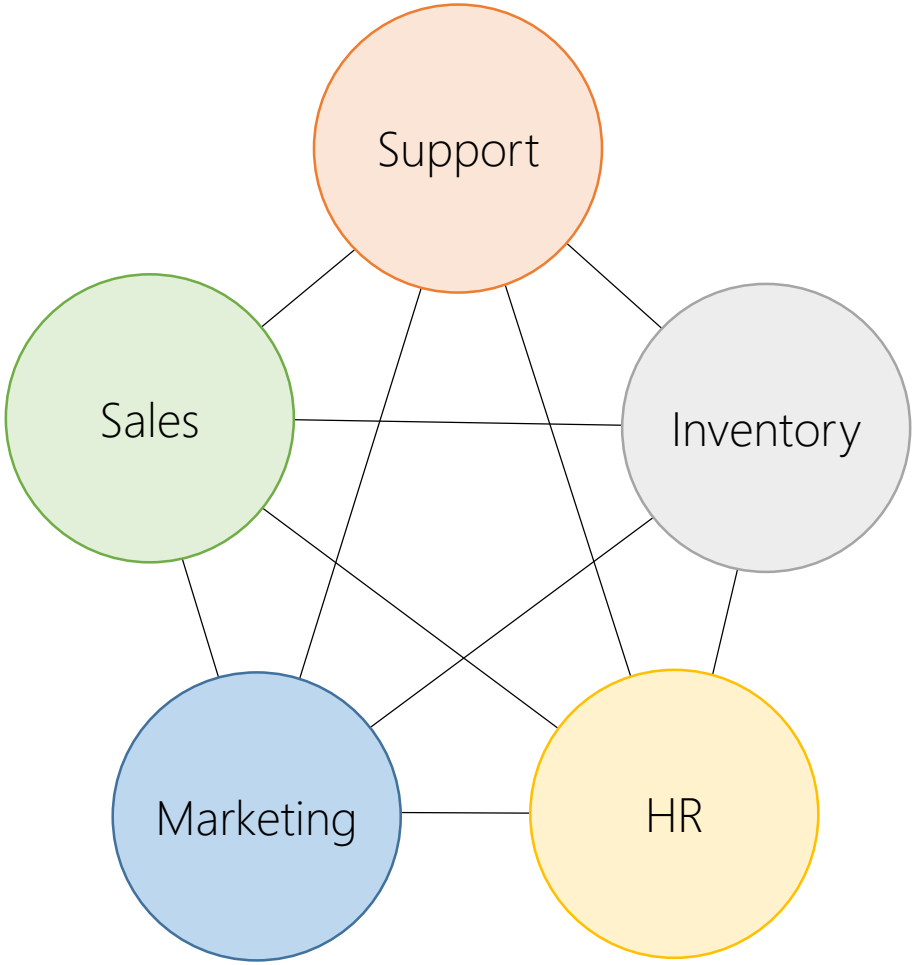
Subdivide system



# Microservice Architectures

Subdivide system

Light-weight APIs

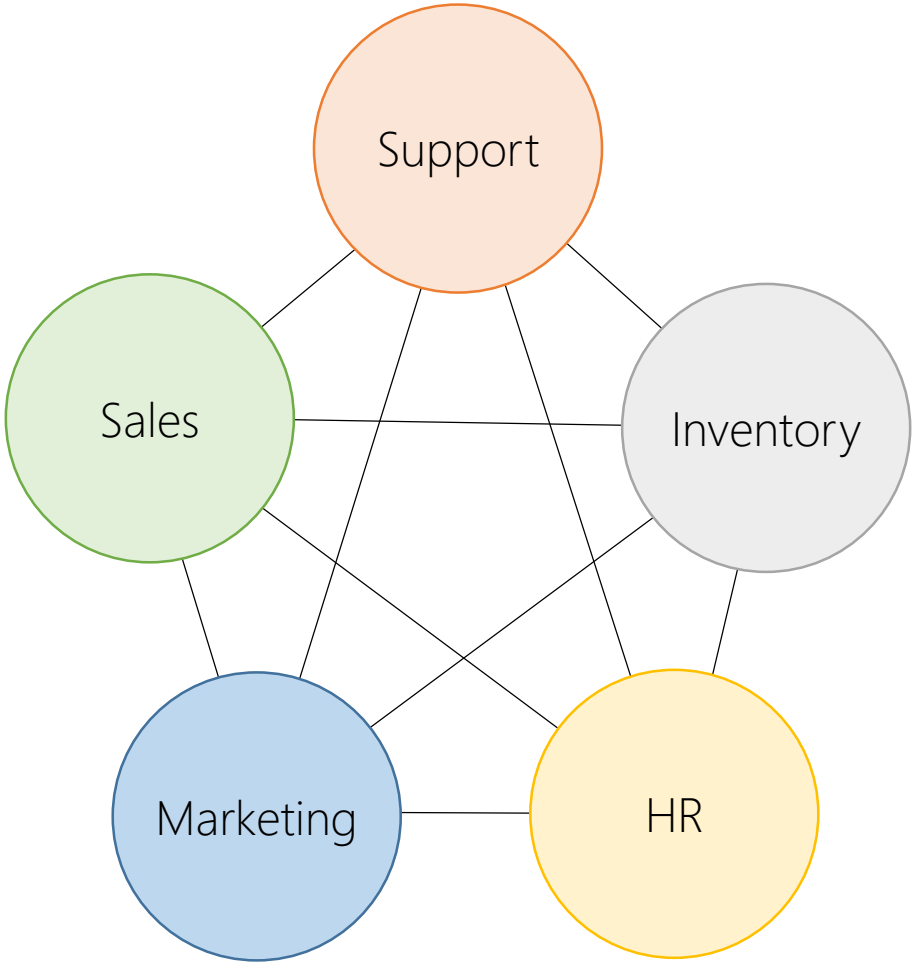


# Microservice Architectures

Subdivide system

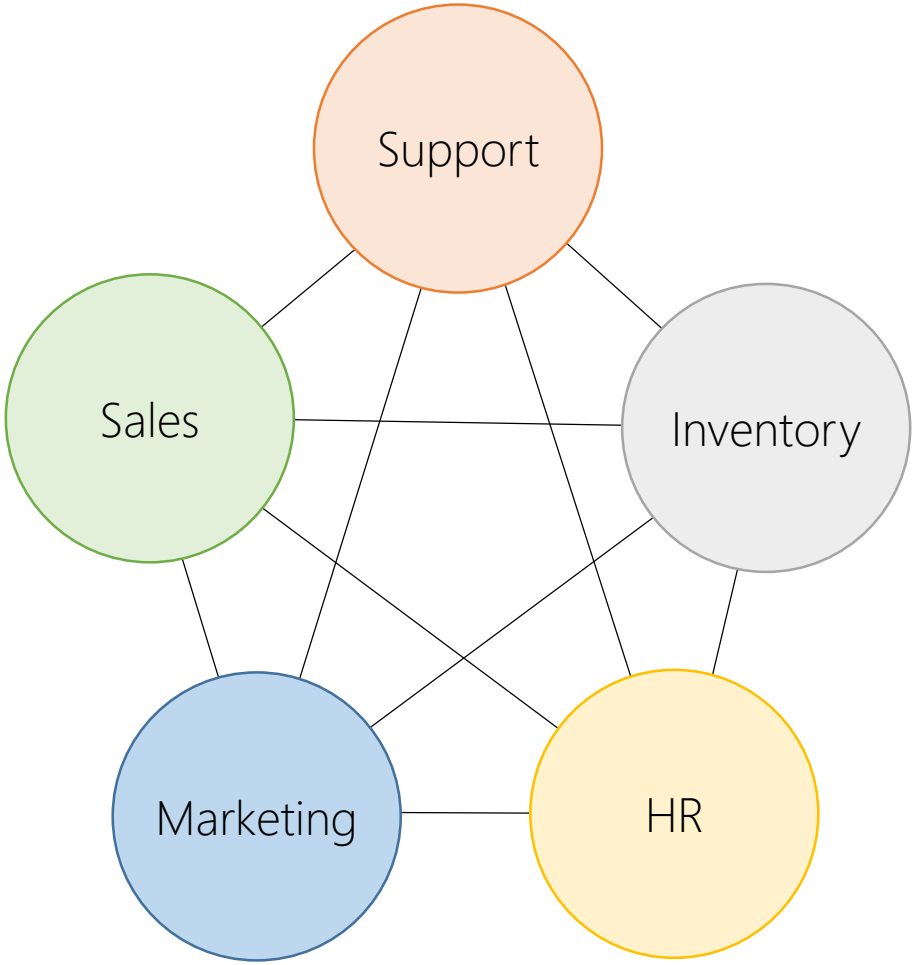
Light-weight APIs

Small teams



# Microservice Architectures

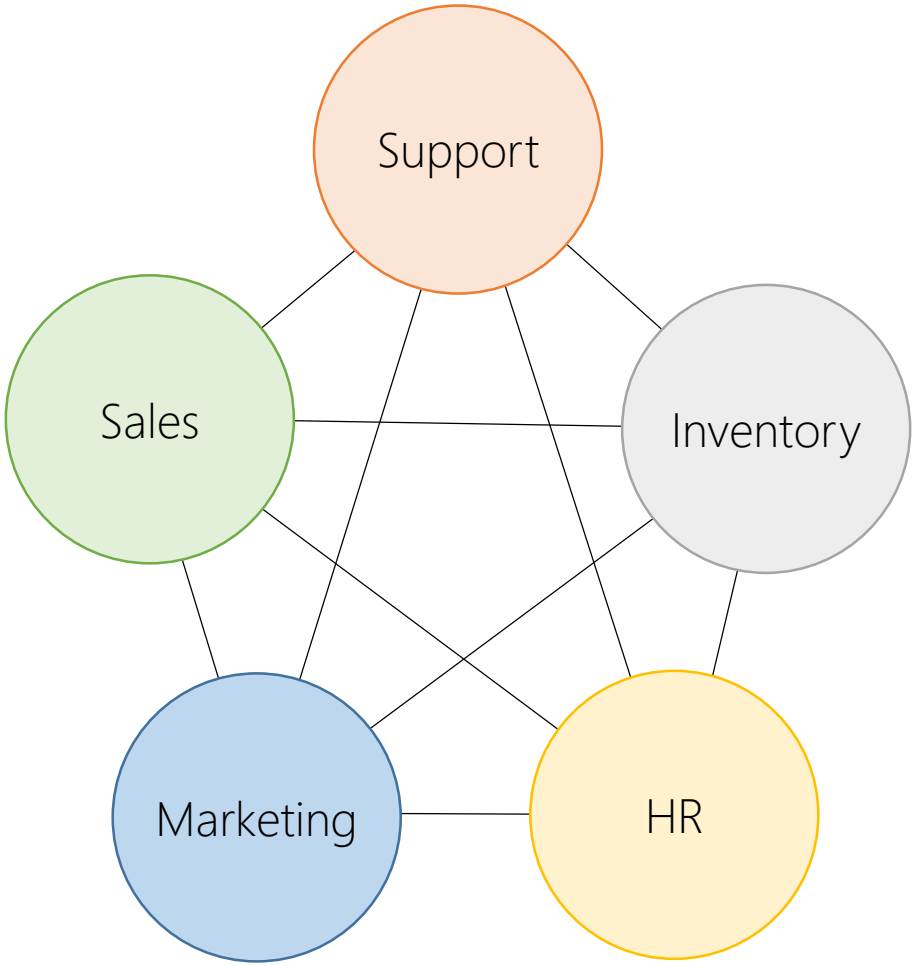
Independent



# Microservice Architectures

Independent

Similar to SOA

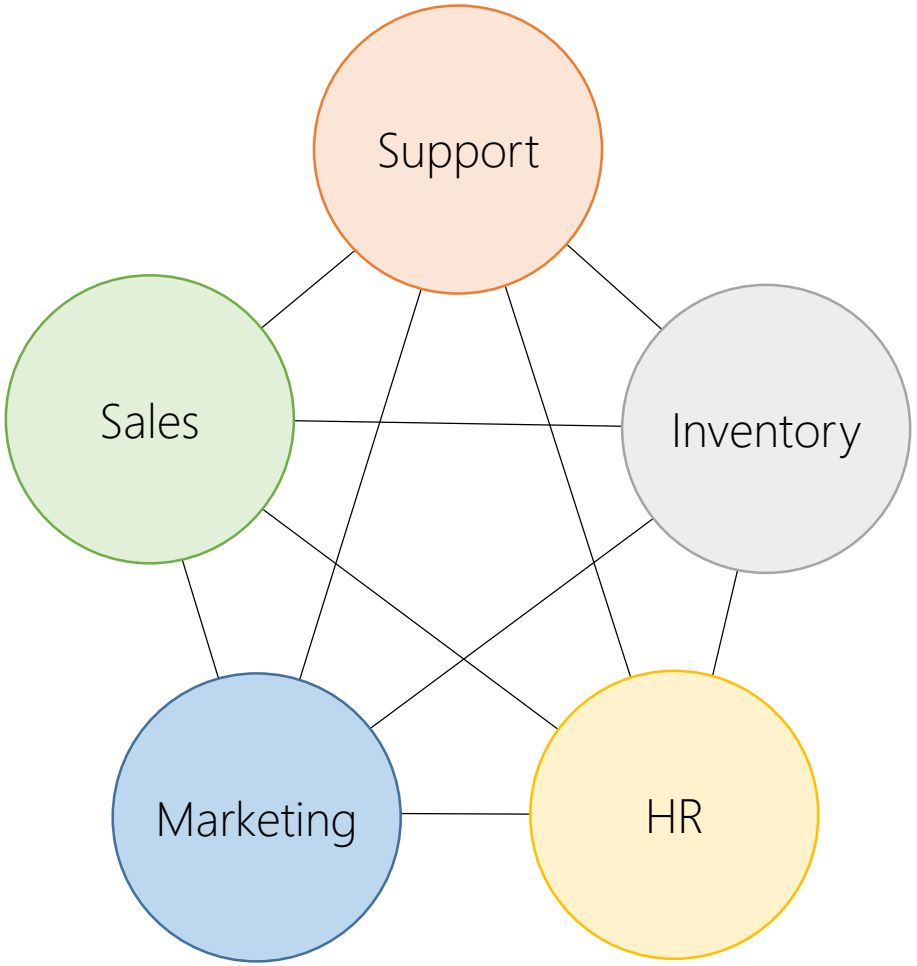


# Microservice Architectures

Independent

Similar to SOA

Size matters



# Why Use Microservices?

## Pros

Less cost for large domains

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Smaller teams

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Independence

# Why Use Microservices?

## Pros

Less cost for large domains

Smaller teams

Independence

## Cons

Only for large domains

# Why Use Microservices?

## Pros

Less cost for large domains

Smaller teams

Independence

## Cons

Only for large domains

Higher up-front cost

# Why Use Microservices?

## Pros

Less cost for large domains

Smaller teams

Independence

## Cons

Only for large domains

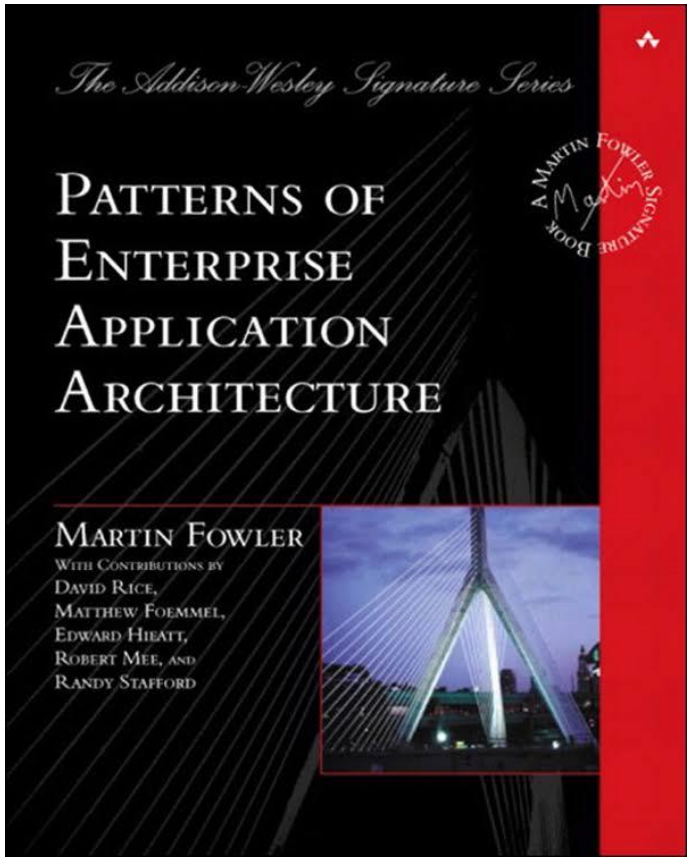
Higher up-front cost

Distributed system costs

# Code Demo

# Where to Go Next?

# Where to Go Next?



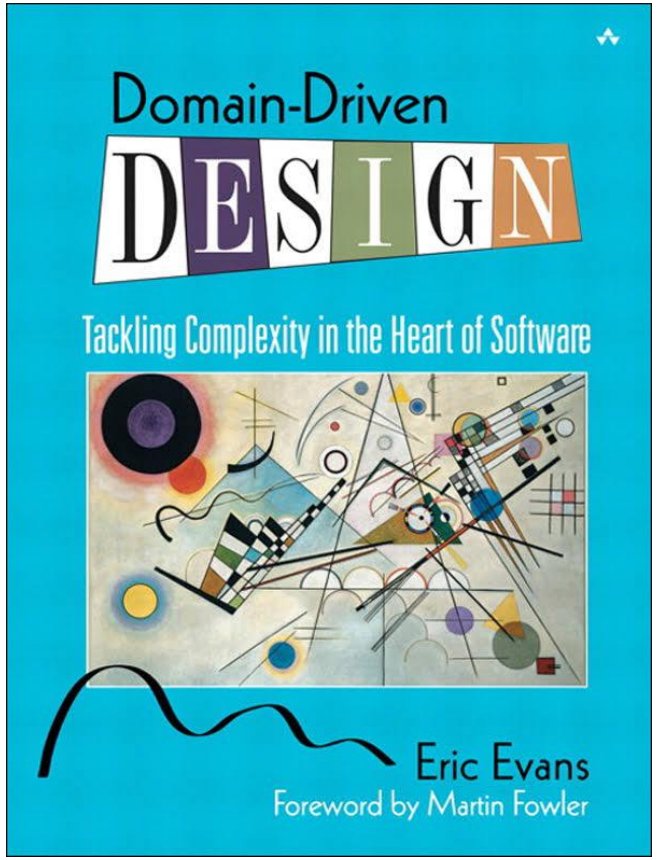

Martin Fowler

# Where to Go Next?


http://cleancoders.com/

Robert C. Martin

# Where to Go Next?




Eric Evans

# Where to Go Next?

Greg Young


Udi Dahan

# Where to Go Next?

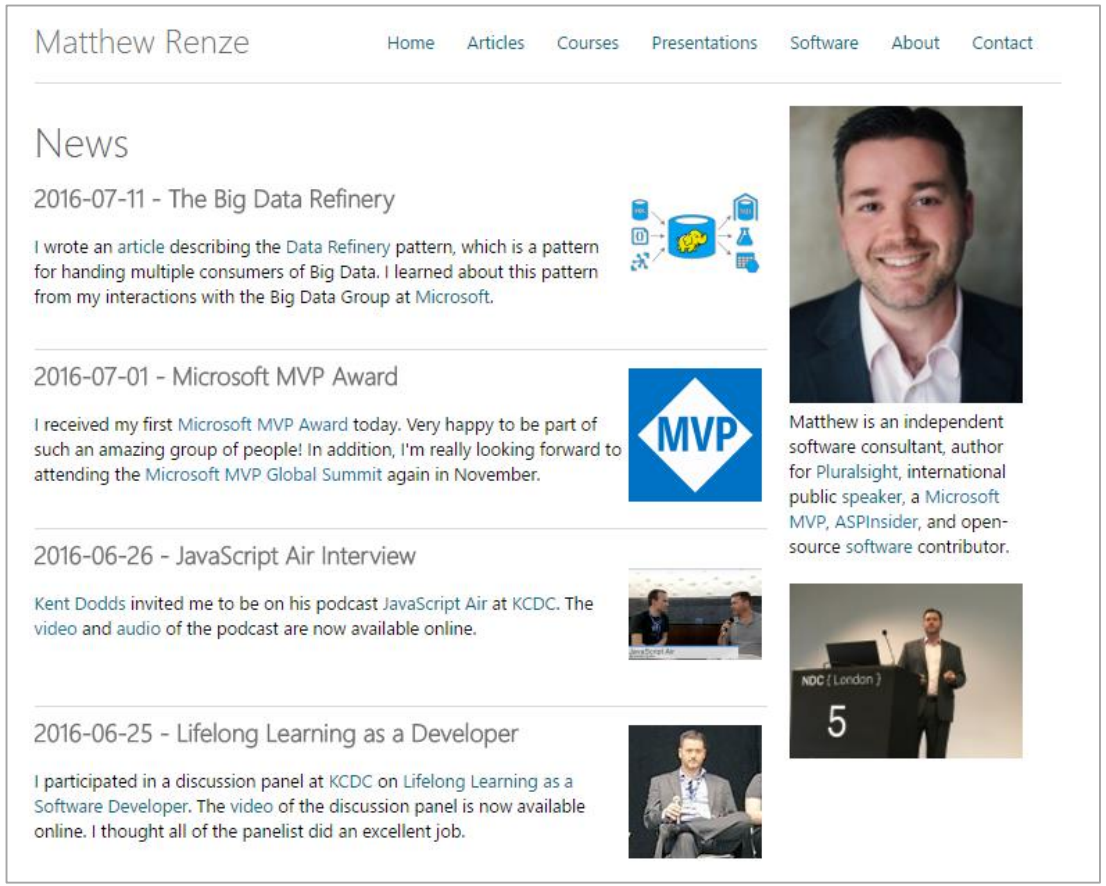
Articles

Courses

Presentations

Source Code

Videos




www.matthewrenze.com

# Clean Architecture: Patterns, Practices, and Principles

## INTRODUCTION

**Matthew Renze**
SOFTWARE CONSULTANT
@matthewrenze www.matthewrenze.com

www.pluralsight.com/authors/matthew-renze

# Conclusion

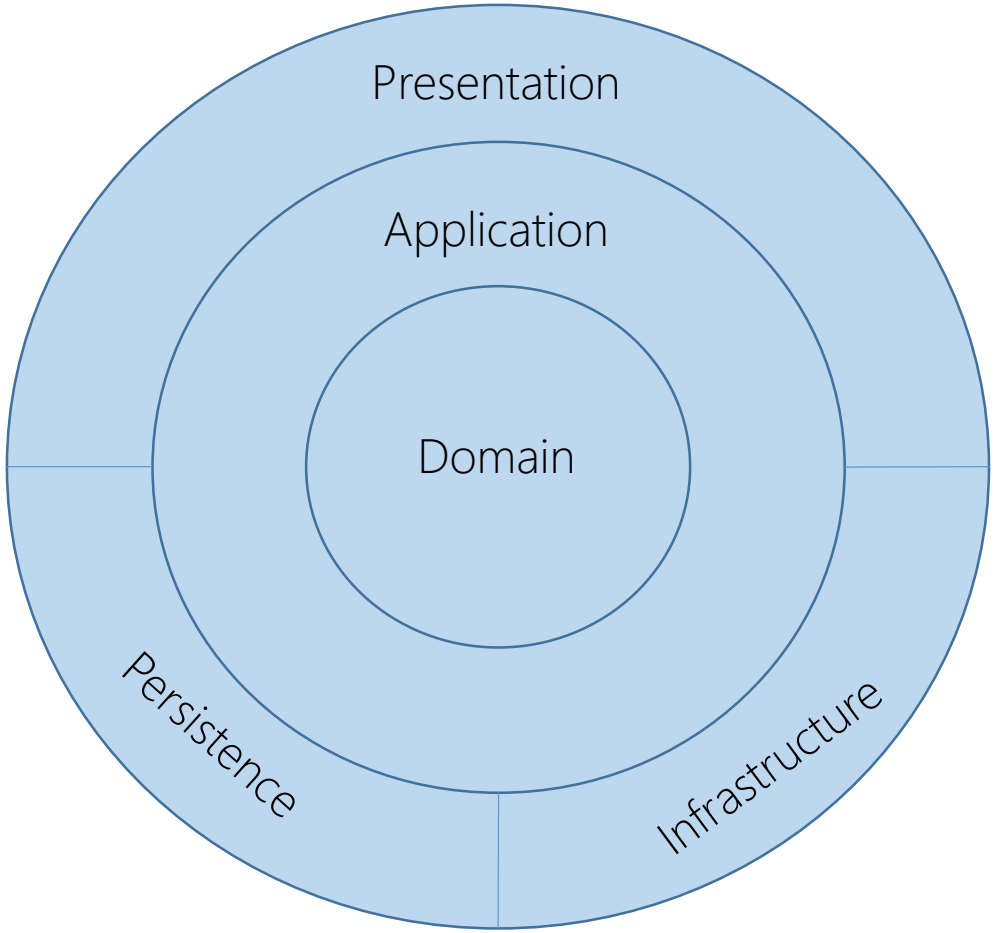
# Summary

Focus on the inhabitants

# Summary

Focus on the inhabitants

Domain-centric Architecture

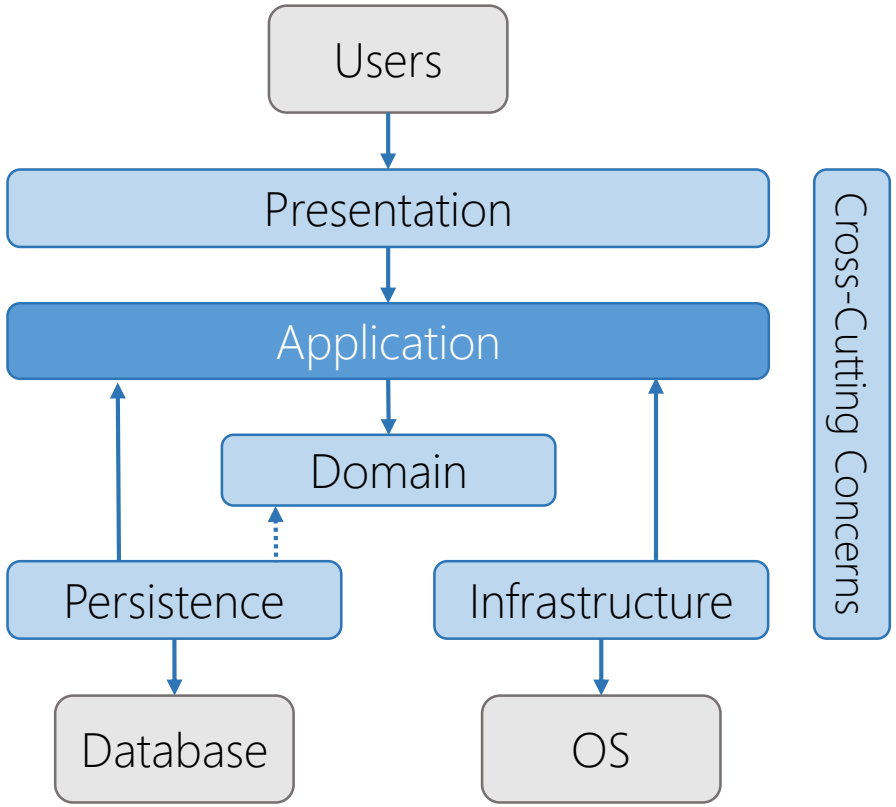


# Summary

Focus on the inhabitants

Domain-centric Architecture

Application Layer



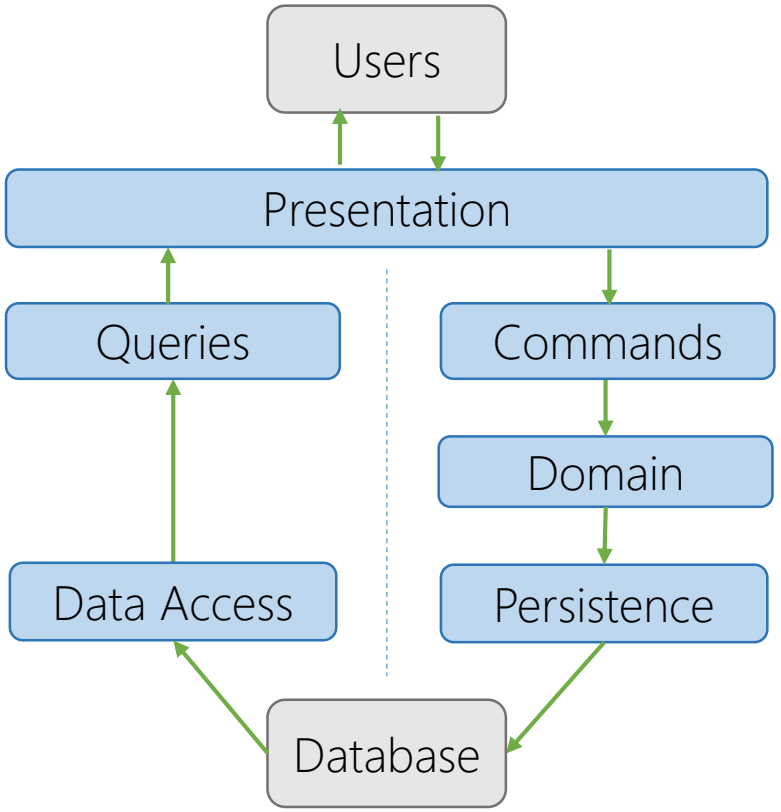
# Summary

Focus on the inhabitants

Domain-centric Architecture

Application Layer

Commands and Queries



# Summary

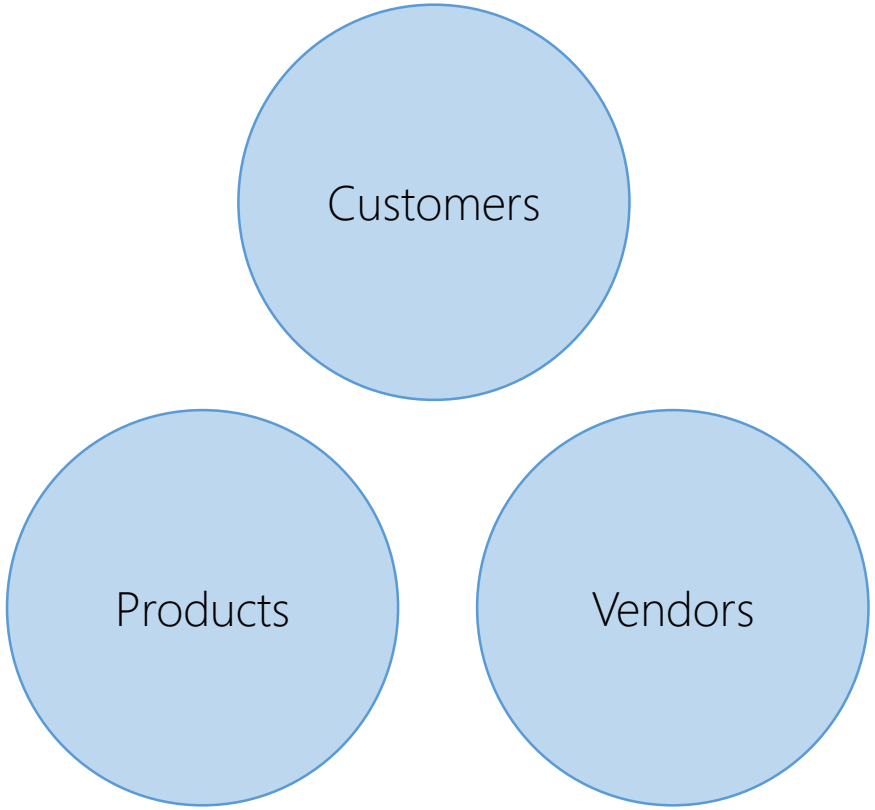
Focus on the inhabitants

Domain-centric Architecture

Application Layer

Commands and Queries

Functional Cohesion



# Summary

Focus on the inhabitants

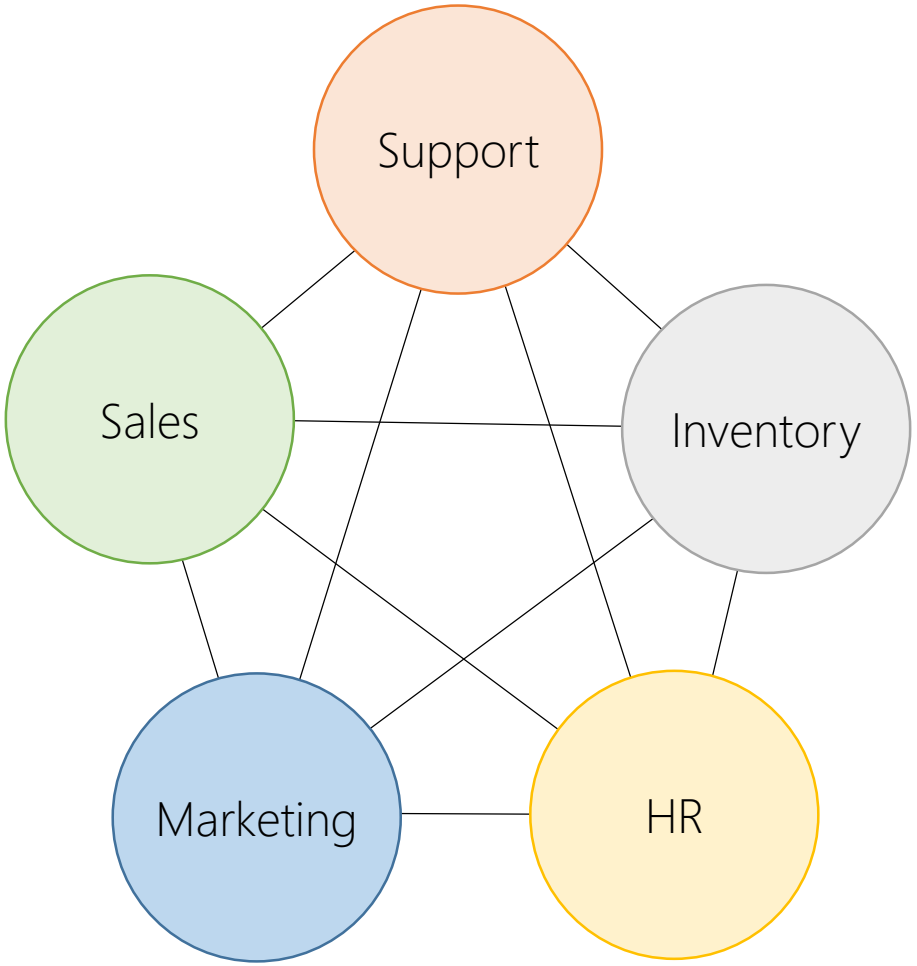
Domain-centric Architecture

Application Layer

Commands and Queries

Functional Cohesion

Bounded Contexts



# Feedback

Very important to me!

One thing you liked?

One thing I could improve?

# Contact Info

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Thank You! : )