Architecture and the 3D Cube

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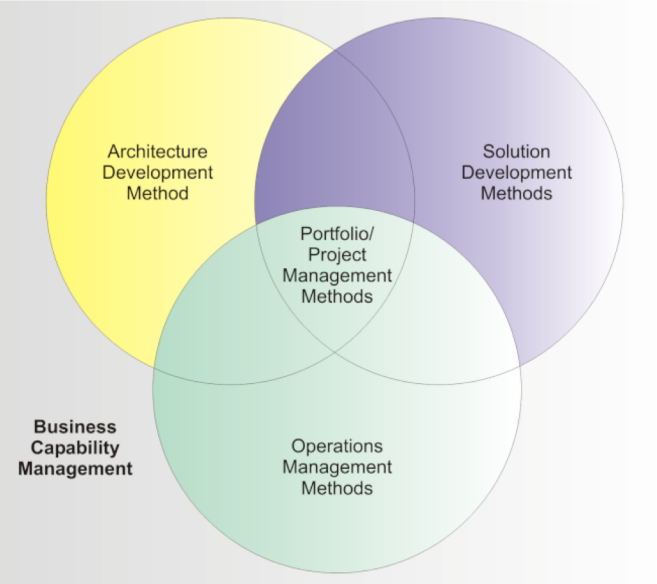
Agenda

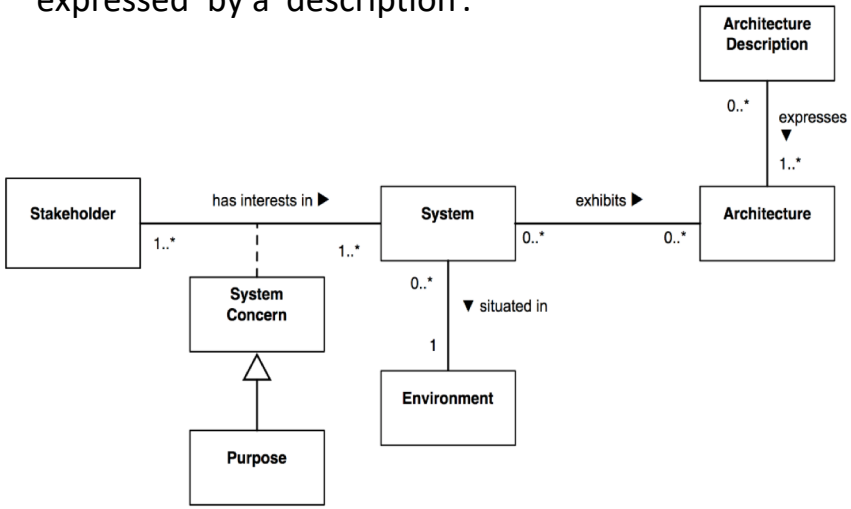
- Stakeholders and Views
- Prior Approaches
- The 3D Cube:
  - Service Tiers
  - Layers
  - Qualities
  - Stakeholder Views
- System Architecture Document
- Value of the Cube

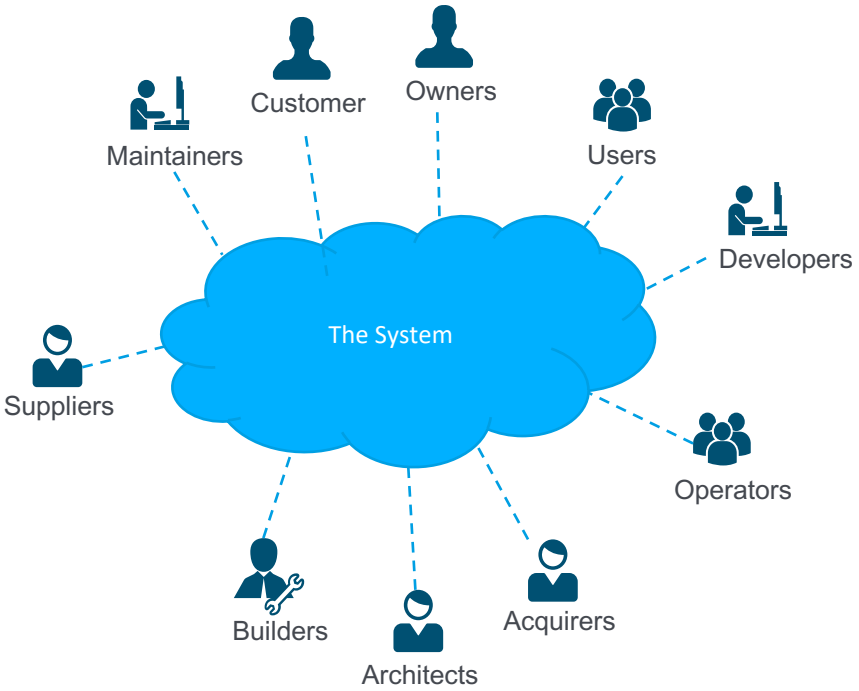


This is a short introduction, all aspects are detailed in further packs.

Stakeholders

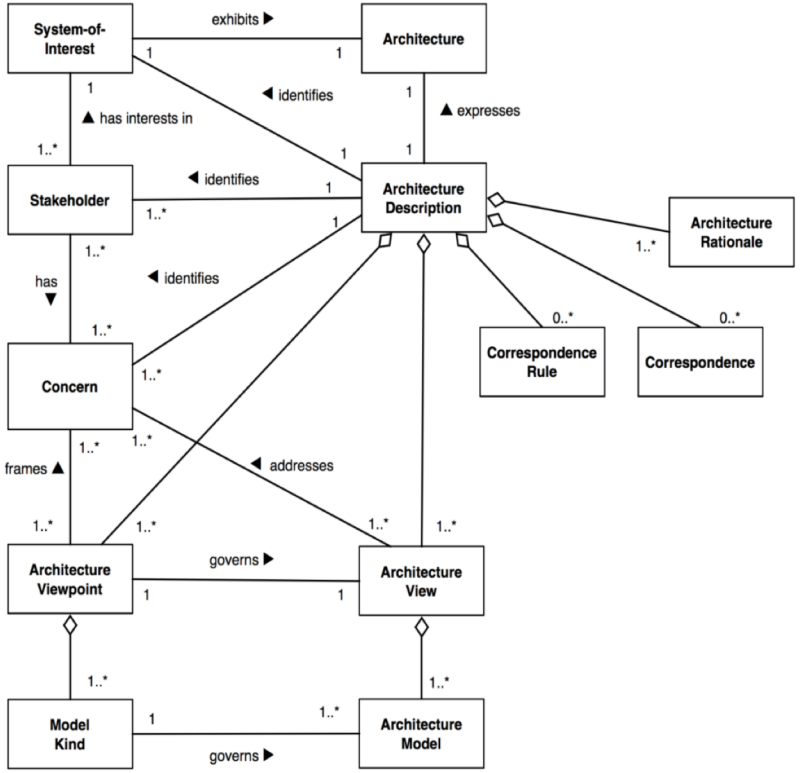
- A stakeholder is any person or group who have some vested interest or concerns about the system.
- Each Stakeholders has a different need or concern and views the system in a different way; they have points of view.
- A deployed system ‘exhibits’ an architecture ‘expressed’ by a ‘description’.





Architecture Description ISO Standard

System	Collection of components (business and technical) organized to accomplish a specific function or set of functions
Architecture	The system's fundamental organization, embodied in its components, their relationships to each other and to the environment, and the principles guiding its design and evolution
Architecture Description	Collection of artifacts that document an architecture – *to meet the concerns of stakeholders*
Stakeholder	Person (or group of people) who has a key role in, or concern about, the system
Concern	Key interests that are crucially important to the stakeholders in the system and determine the acceptability of the system
View	Representation of a whole system from the perspective of a related set of concerns
Viewpoint	Defines the perspective from which a view is taken: • How to construct and use a view • Information that should appear in the view • Modeling techniques for expressing and analysing the information • Rationale for these choice



Ref: ISO/IEC/IEEE 42010 *Systems and software engineering — Architecture description*

What is Architecture?

Architecture is a set of structuring principles that enables a system to be comprised of a set of simpler systems each with its own local context that is independent of but not inconsistent with the context of the larger system as a whole.

Sun

"...the structure or structures of the system, which comprise software components, the externally visible properties of those components, and the relationships among them. By "externally visible" properties, we are referring to those assumptions other components can make of a component, such as its provided services, performance characteristics, fault handling, shared resource usage, and so on "

Bass, Clements, Kaxman, *Software Architecture in Practice*

More Definitions

The structure of the components of a program/system, their interrelationships, and principles and guidelines governing their design and evolution over time .

Garlan and Perry, 1995

...beyond the algorithms and data structures of the computation; designing and specifying the overall system structure emerges as a new kind of problem. Structural issues include gross organization and global control structure; protocols for communication, synchronization, and data access; assignment of functionality to design elements; physical distribution; composition of design elements; scaling and performance; and selection among design alternatives .

Garlan and Shaw, 1993

A set of... design elements that have a particular form .

Perry and Wolf, 1992

Architecture has 3 main Common Themes

1. Done for a Purpose
2. Structure and Organization
3. Done to the Degree Required

Done for a Purpose – The Purpose of Architecture:

- Explain why the form of a system has come to be.
- Provide an holistic view of a solution.
- Produce views of the system for particular stakeholders.
- Ensure requirements can be satisfied (especially NFR's and ASUC’s).
- Mitigate risk and reduce uncertainty.
- Manage complexity.
- Make project management possible:
  - Decomposition allows Work Breakdown Structures to be managed
- Satisfy budget and schedule.
- Justify purchasing decisions.
- Makes designers/implementers productive.
- Re-use existing assets.

Structure and Organisation

- Define the Context, the between the system and its environment
- Decomposition
  - Subsystems / Components / Configurations
    - Boundaries / Interfaces
    - Relationships
    - Overlapping concerns
  - Needed Mechanisms
- Instantiation / Selection
  - Mechanisms, tools, libraries, etc.
  - Patterns
  - Balance buy vs. build
- Examples
  - Providing examples e.g. motifs, patterns, etc.
  - Leveraging examples e.g. reference architectures, comparable solutions, etc.

Done to the Degree Required to:

- Mitigate Risks;
- Solve the “hard” problems; the ASUCs.
- Ensure the requirements, especially the NFRs are satisfiable:
  - Security
  - Scalability
  - Availability
  - etc
- Structure teams and allow them to operate in relative independence.

Architect's Concern

- Making a complex thing "buildable"
  - Specify a reasoned decomposition, instantiation, and structural foundation;
  - Make sub teams of designers and implementers productive;
  - Enable sub teams to operate in relative isolation;
  - Facilitate planning and tracking around these teams.
- Derive technical requirements from business requirements
- Such that:
  - Requirements are met and tracked
  - Derived technical requirements are clear
  - Systemic qualities are achieved

Architecture Vs Design

Design is Concerned withthem	Architecture is concerned with
Depth	Breadth and some depth
The code	What is important besides the code
Problem solving by accounting for details	Problem solving by applying solutions that encapsulate detail
Up-to-date general knowledge and maybe specific product knowledge	Up-to-date general *and* system-level product knowledge
What happens when a button is pushed?	How often the button is pushed, how many users are simultaneously pushing the button, where the users physically are when they push the button
Self or small team	Structure of teams, large solution with multiple teams and keeping them teams together: • Maintain arch. Integrity • Communicate & lead

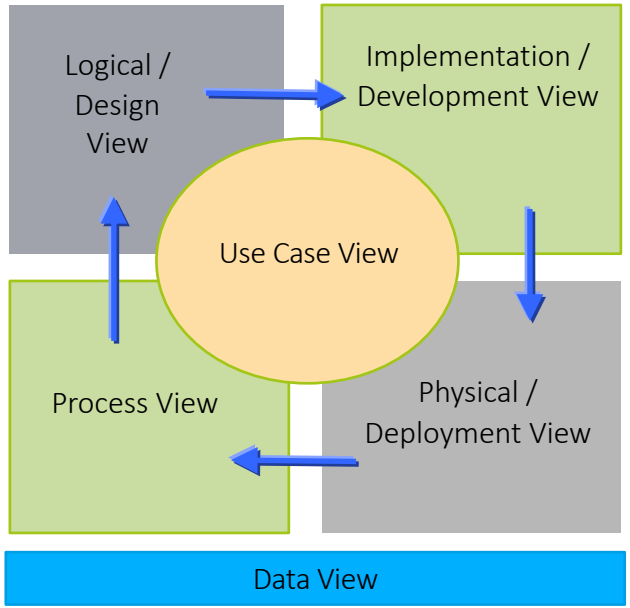
Views and Viewpoints

Have been many different View / ViewPoint Models

8 of them are:

1. RUP 4+1 Views – Philip Kruchten, 1995 (IEEE Software);
2. Siemens Four – Soni, Nord & Hofmeister, 1995;
3. Business Component Factory – Herzum & Sims 1999;
4. SEI View Model – Clements et al, 2002;
5. Garland & Anthony 2003;
6. ISO RM-ODP - *ISO/IEC 10746;*
7. Microsoft DDD
8. Rozanski & Woods – 7 Viewpoints 2012;

RUP 4+1 Views – Philip Kruchten, 1995 (IEEE Software)

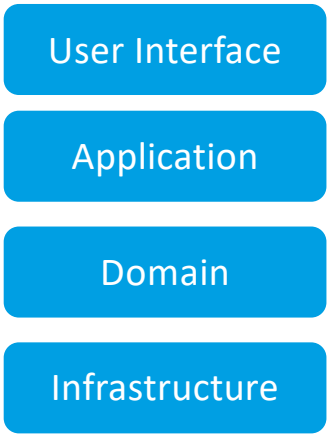


- An ‘ancient’ model from last century.
- Variety of naming schemes and many interpretations……
- Issues:
  - What are viewpoints ?
  - Where are the services, platforms, infrastructure, etc ?
  - Where are the NFRs, that drive Architecture; not the Functional Use Cases !!!!
  - Someone added a Data View ?
  - Out of date for SOA, Cloud…
  - So generic it provides little value
  - Where are the tiers/layers ?
  - etc…..

A detailed document on issues with 4+1, comparing the Cube, is available on request.

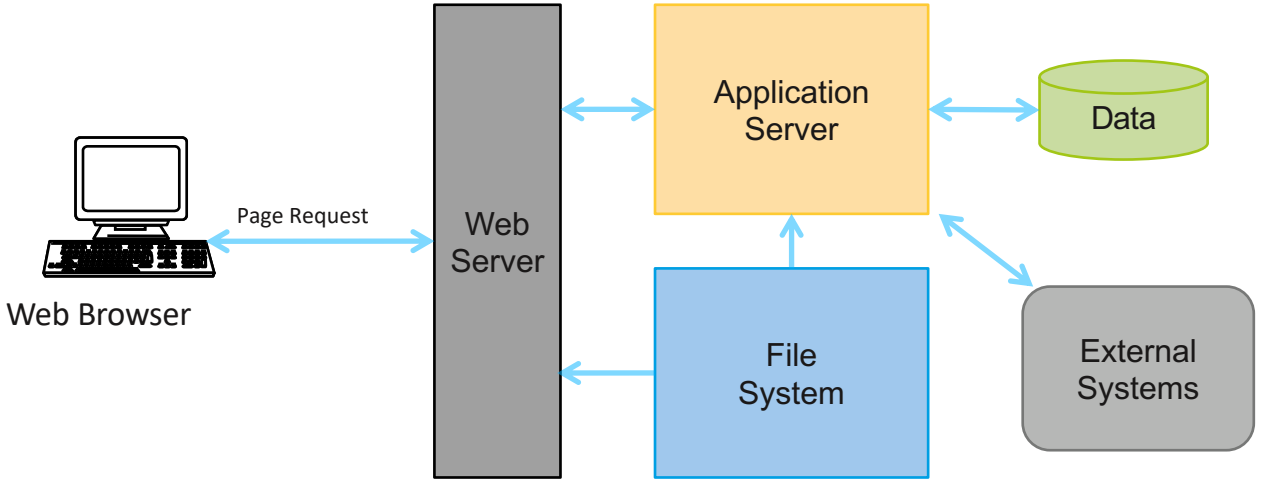
Six Common Layering Models

1. DDD – Eric Evans
2. Enterprise Java - Brown
3. Core J2EE – origin of Cube from Sun
4. Microsoft DNA
5. Microsoft DDD – updated DNA, based on Domain Driven Patterns
6. EJB Design - Marinescu
7. Fowler
8. .Net Enterprise Design - Nilson



Web Architecture - Back in 2001

"The Architecture of Web Applications", Grady Booch, 1 Jun 2001

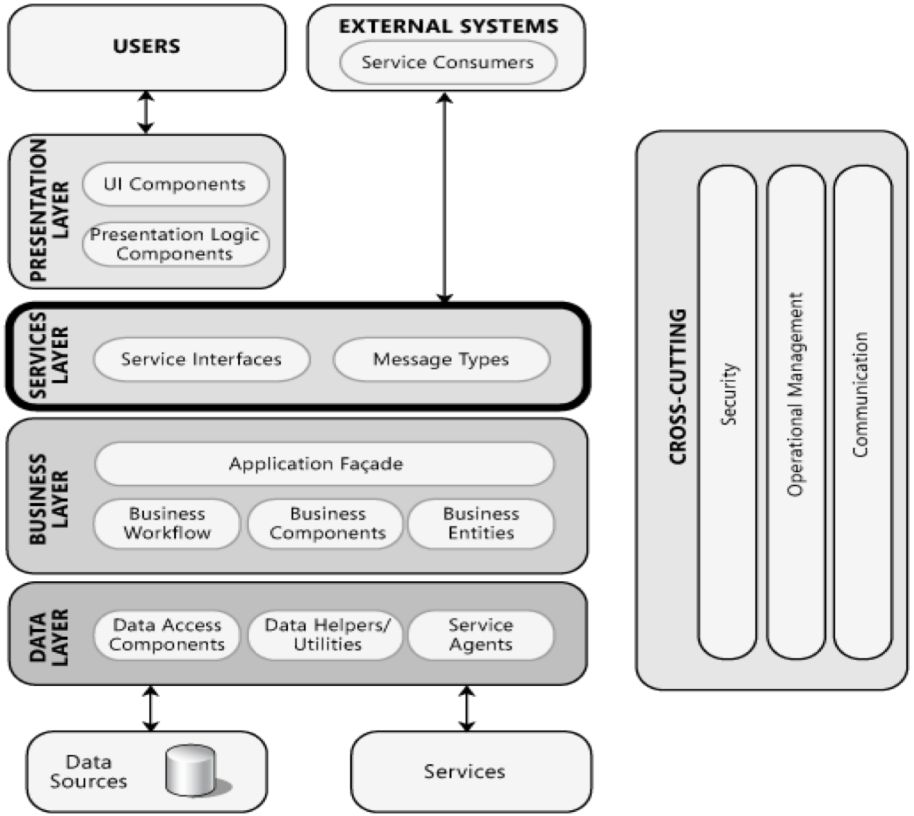


Issue: This is a single very specific, simplistic and high level view.

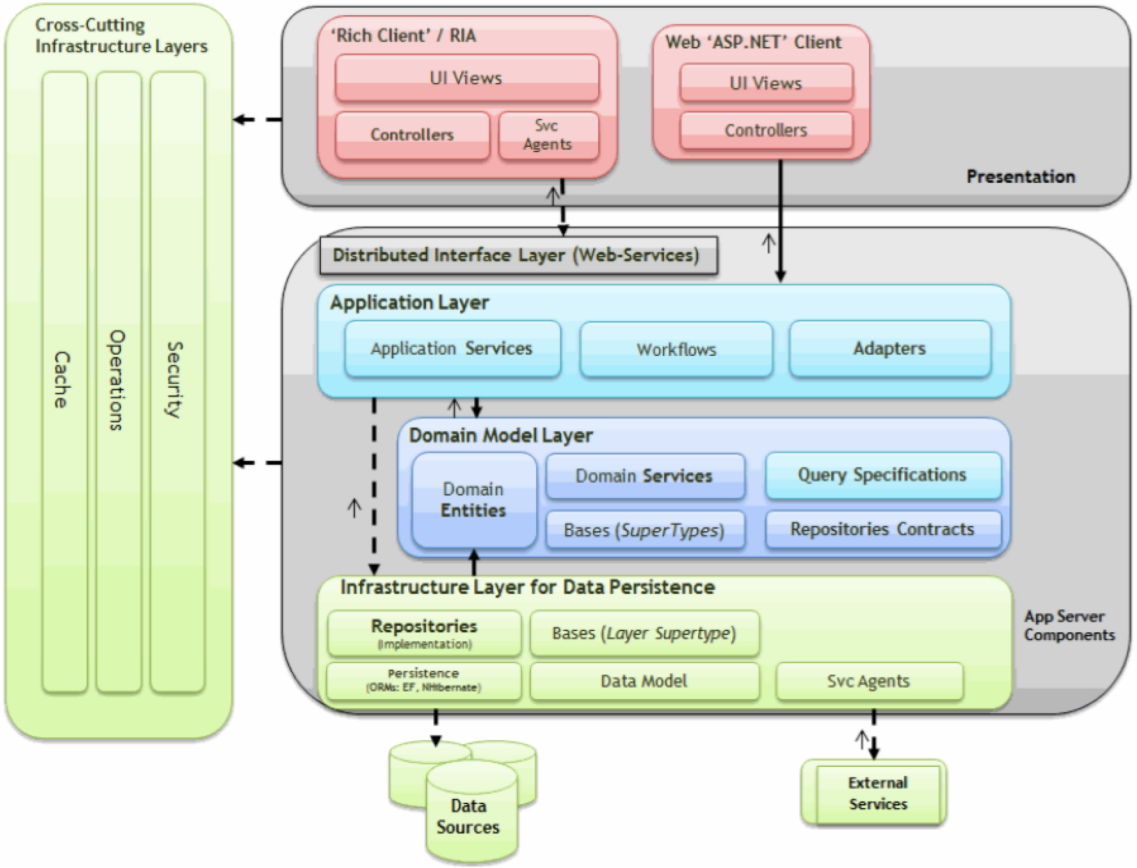
MicroSoft Application Architecture (Early)

Add:

- Layers
  - Service Layer
    - B2B by-passing presentation
- Components
- Patterns
- Cross-cutting concerns

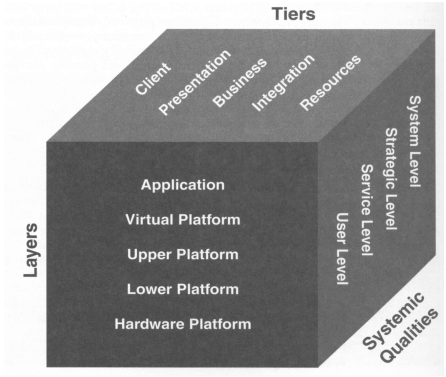


Microsoft DDD N-Layer Architecture Style (Recent)

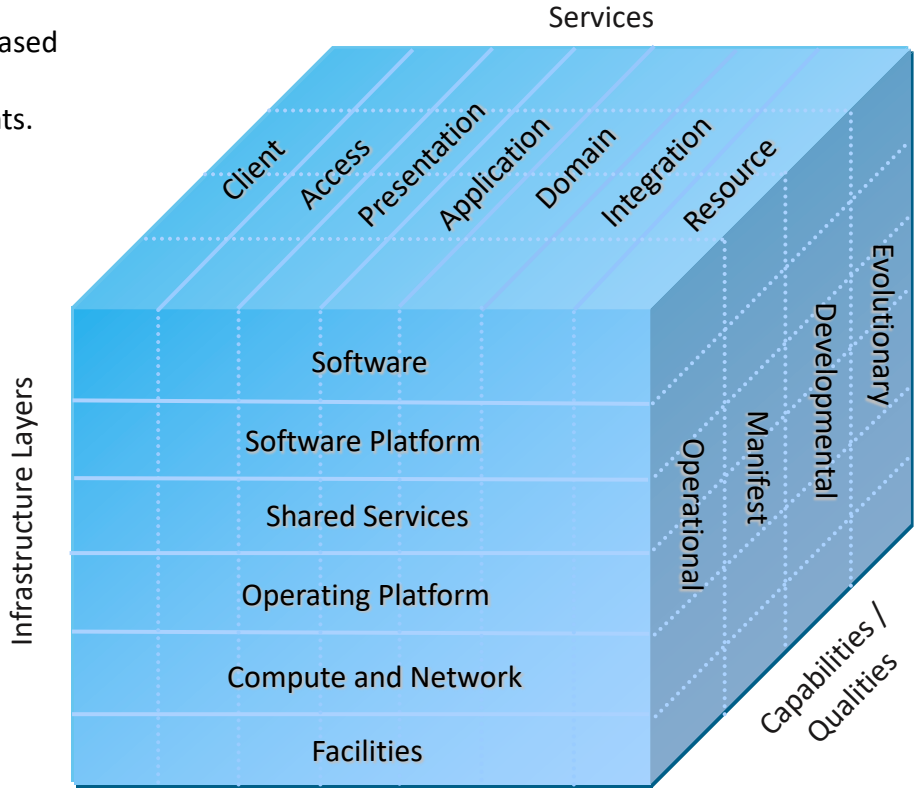


The 3D Cube

- A 3-D Conceptual Partitioning of an N-Tier or Service Based Composite System (Application).
- Provides a well defined context for views and viewpoints.
- Originally published in 2001 by Sun.
- Things have changed, and improved:
  - Cloud, Containers, DevOps;
  - Evolutionary Architecture;
  - Microservices, API, Lambda;
  - Polyglot(Java, .Net, Ruby…)



Old (2000)



New (2017)

What is an Application ?

“A deployed and operational IT system that supports business functions and services; for example, a payroll. Applications use data and are supported by multiple technology components but are distinct from the technology components that support the application.”

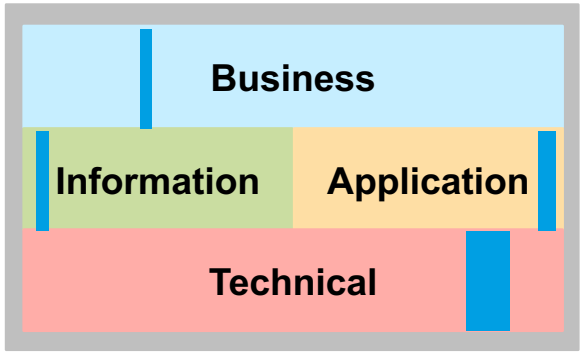
TOGAF

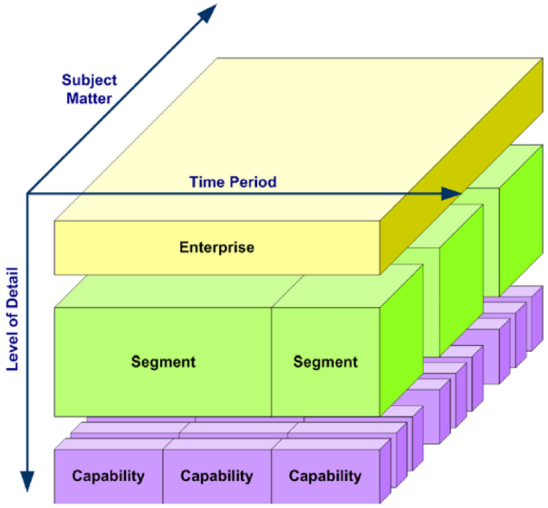
“A deployable collection of software components which uses computing technology to perform automated processes that support one or more business functions and which may utilises persistent or temporary data stores.”

Kim

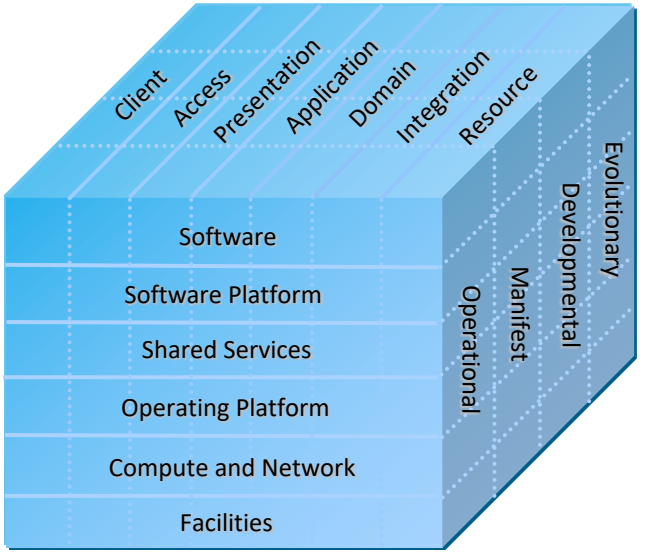
A Software Application is essentially a social construct, and the boundaries between application can be hard to determine. It could be defined by the team building and operating it, funding, a set of business capabilities, a set of initiates delivering an objective, acquisitions and by bounded context.

The Cube and an Enterprise Architecture





A cube provides a capability; a thin slice across each of the 4 enterprise architecture domains



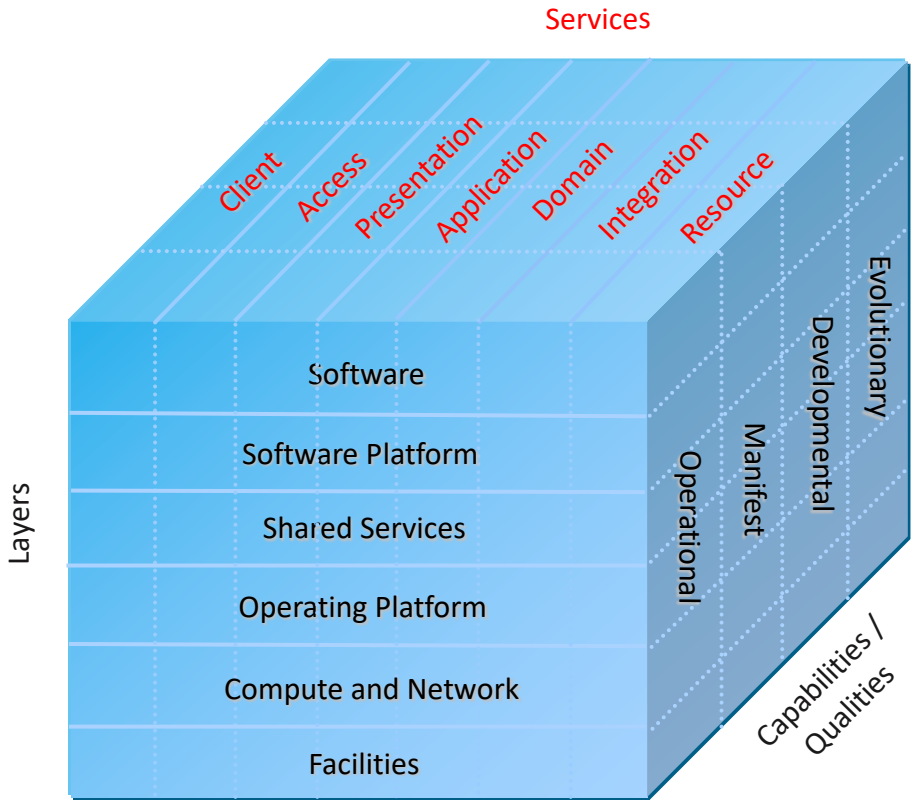
The Service Tiers

The Services

A Service is a *component* boundary that exists to provide isolation. The components provides a distributed or specific role, responsibility or service, supporting a business process.

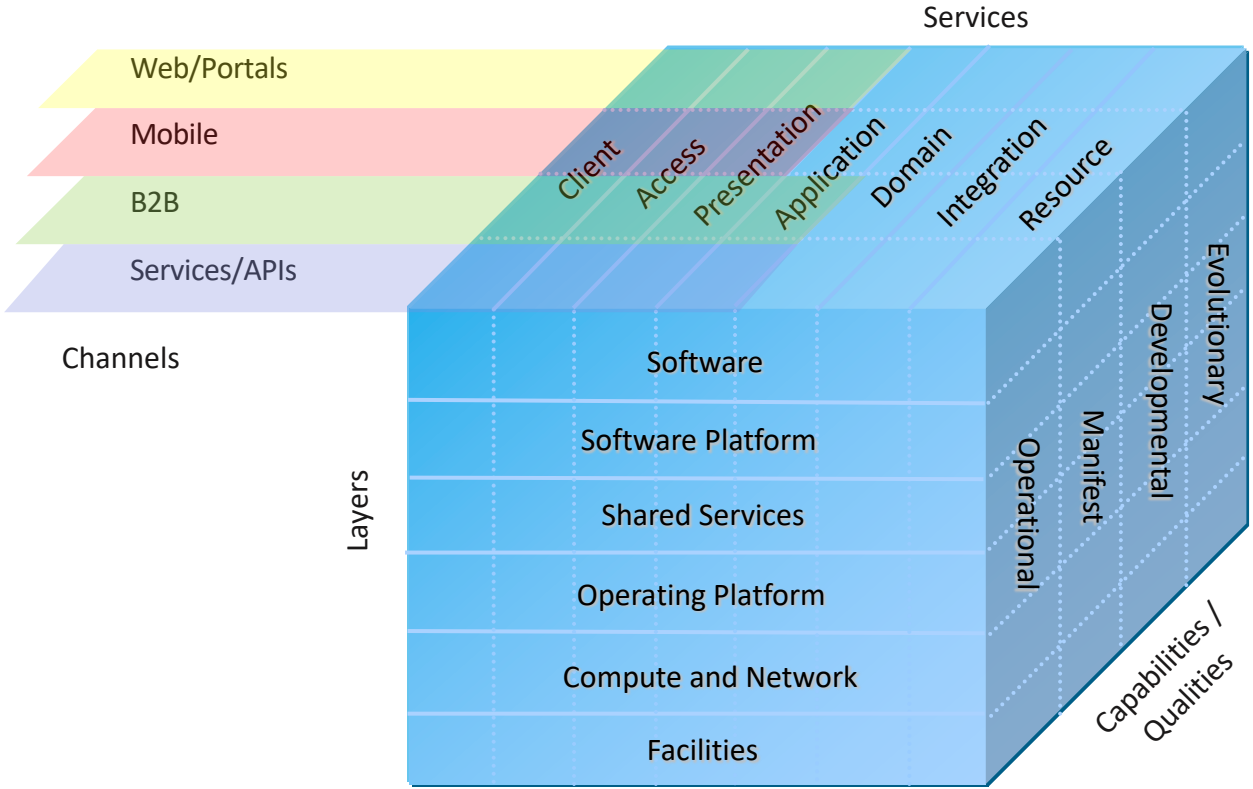
The services are tiered:

- applies the layering decomposition pattern to system structure;
- may not reside on the same physical box;
- may not be provided by the same technology and infrastructure;
- may be in different locations, distributed and reside on different devices;
- are a primary technique for building scalable systems that support continuous delivery and dev ops;
- can be layered; where *Layers* are logical slices that carry out specific system responsibilities.



Channels Reach Into Services via Channels

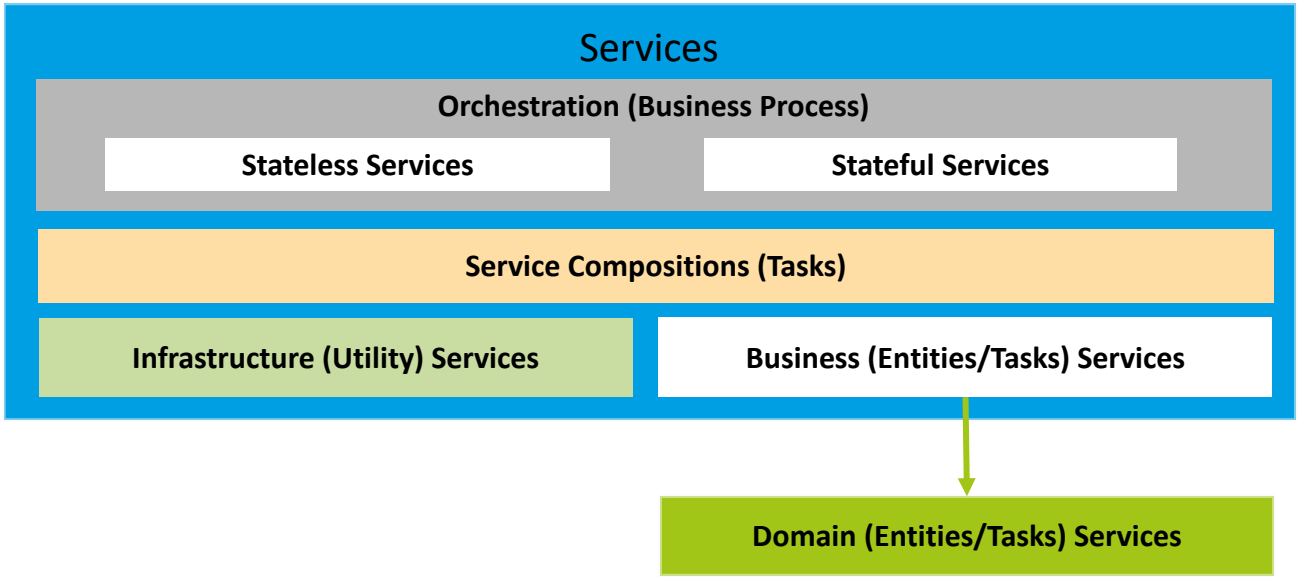
Clients (users) via various channels, access the organisation's services.



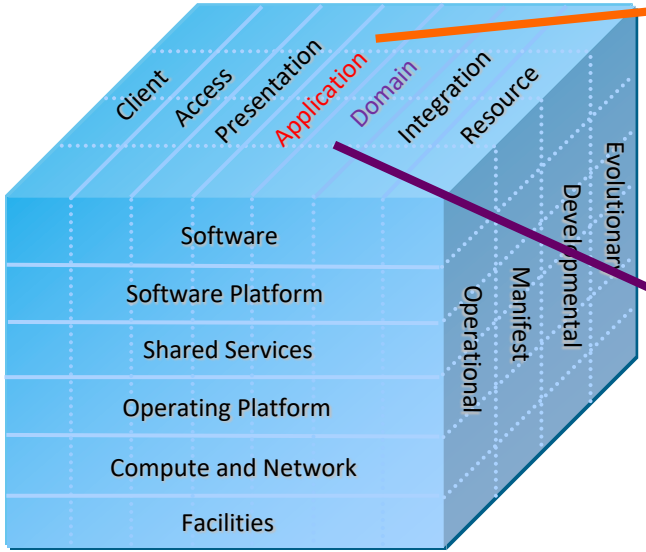
Service Layering

OASIS defines service as:

> "A mechanism to enable access to one or more capabilities, where the access is provided using a prescribed interface and is exercised consistent with constraints and policies as specified by the service description."



Application Layer Services Vs Domain Layer Services



Distributed Services
- APIs, REST
- Web Services
- Micro/Macro(SOA) services

Application Services
- Application Tasks (stateless)
- Application Workflow
- Adapters

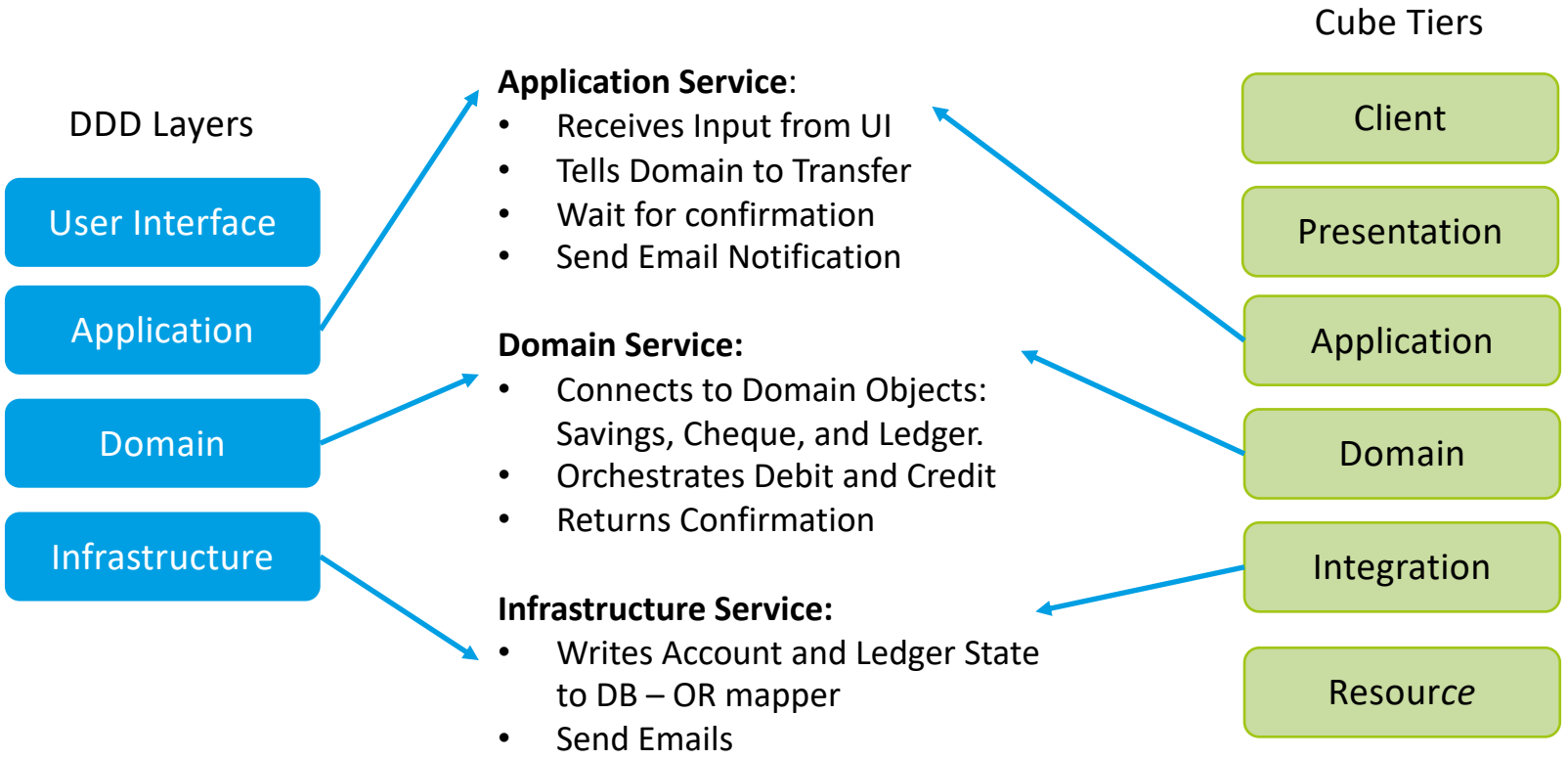
Domain Services
e.g. TransferFunds

DDD Domain Objects
- Service
- Entities
- Aggregate
- Specification
- Value Object

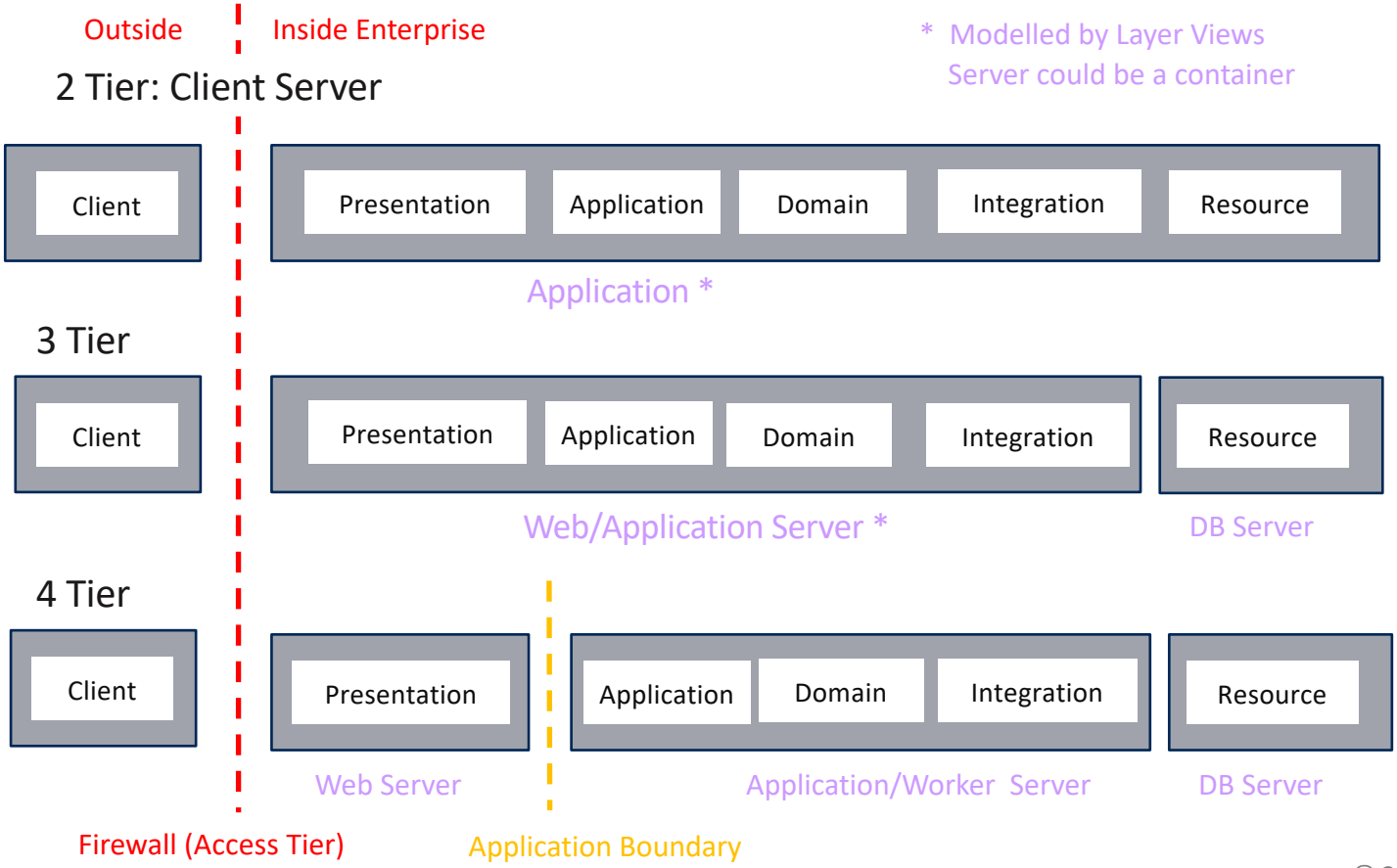
Domain Events

Application Services coordinate the technical plumbing (like using a Unit of Work and Transactions) so that the Domain Layer is as clean as possible and expresses its 'entity' logic clearly.

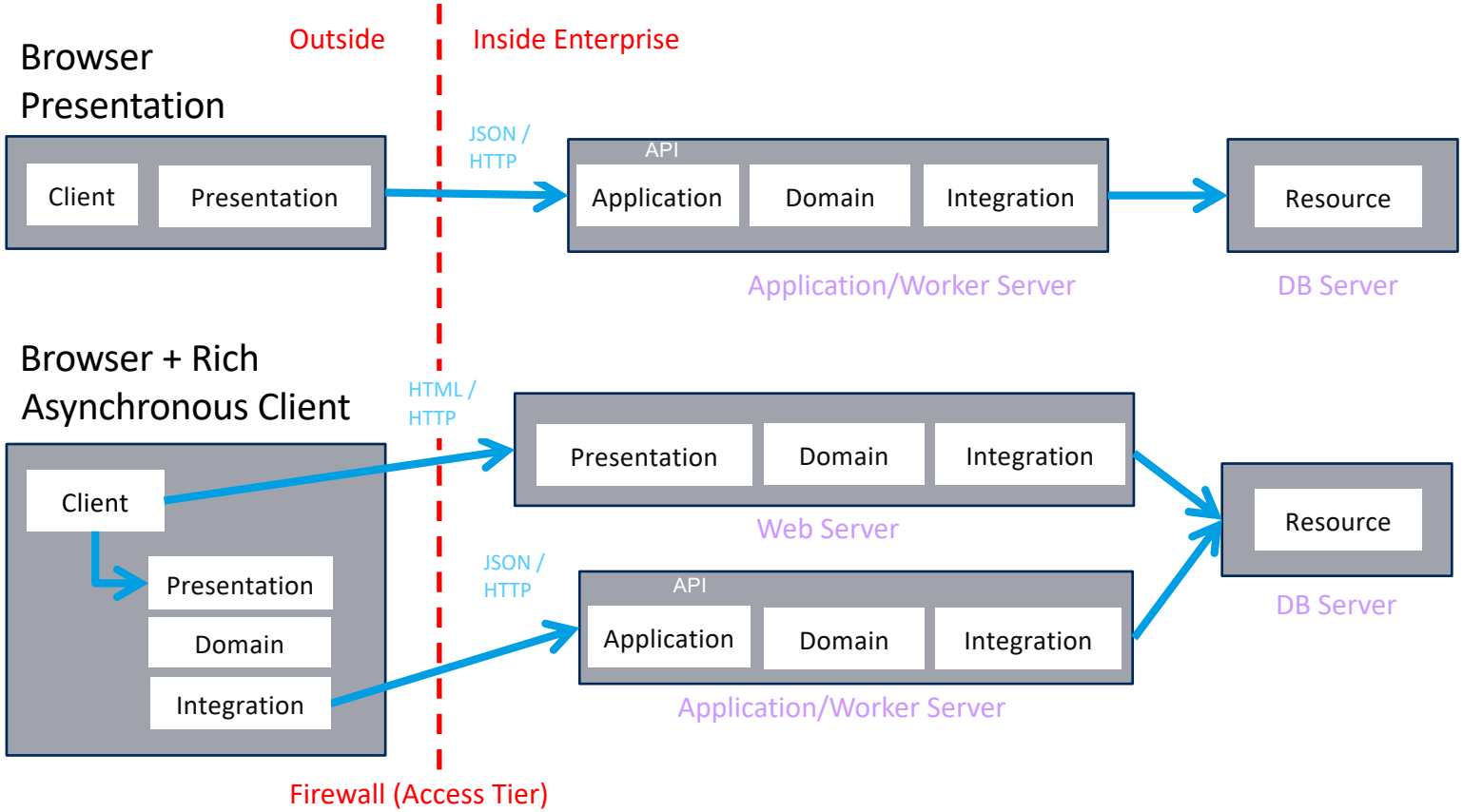
DDD Example – Transfer Funds From Savings to Cheque Accounts



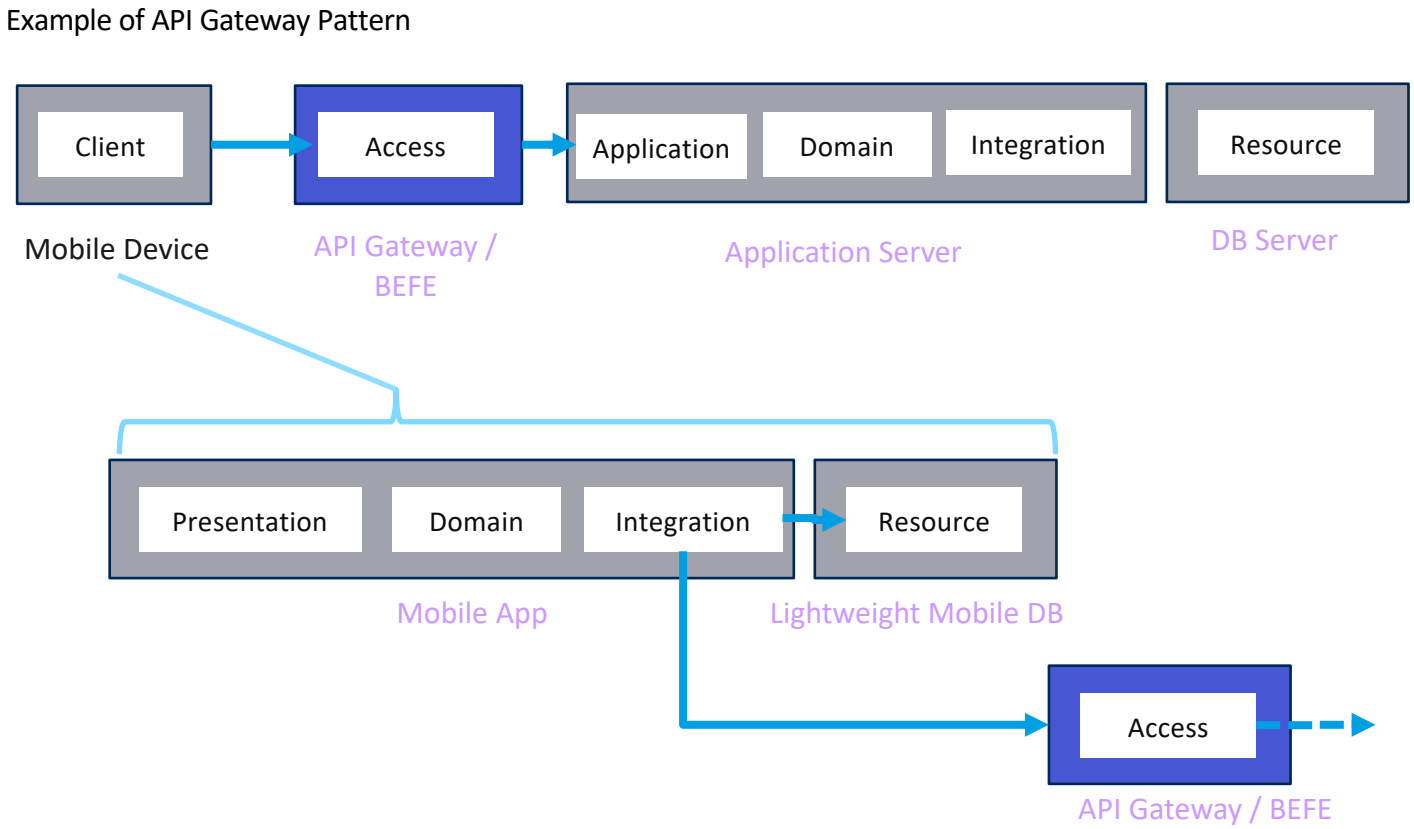
Physical Vs Logical Tiering – Runtime Structure Decision



Physical Tiering – Example: Web Rich Client / API Model

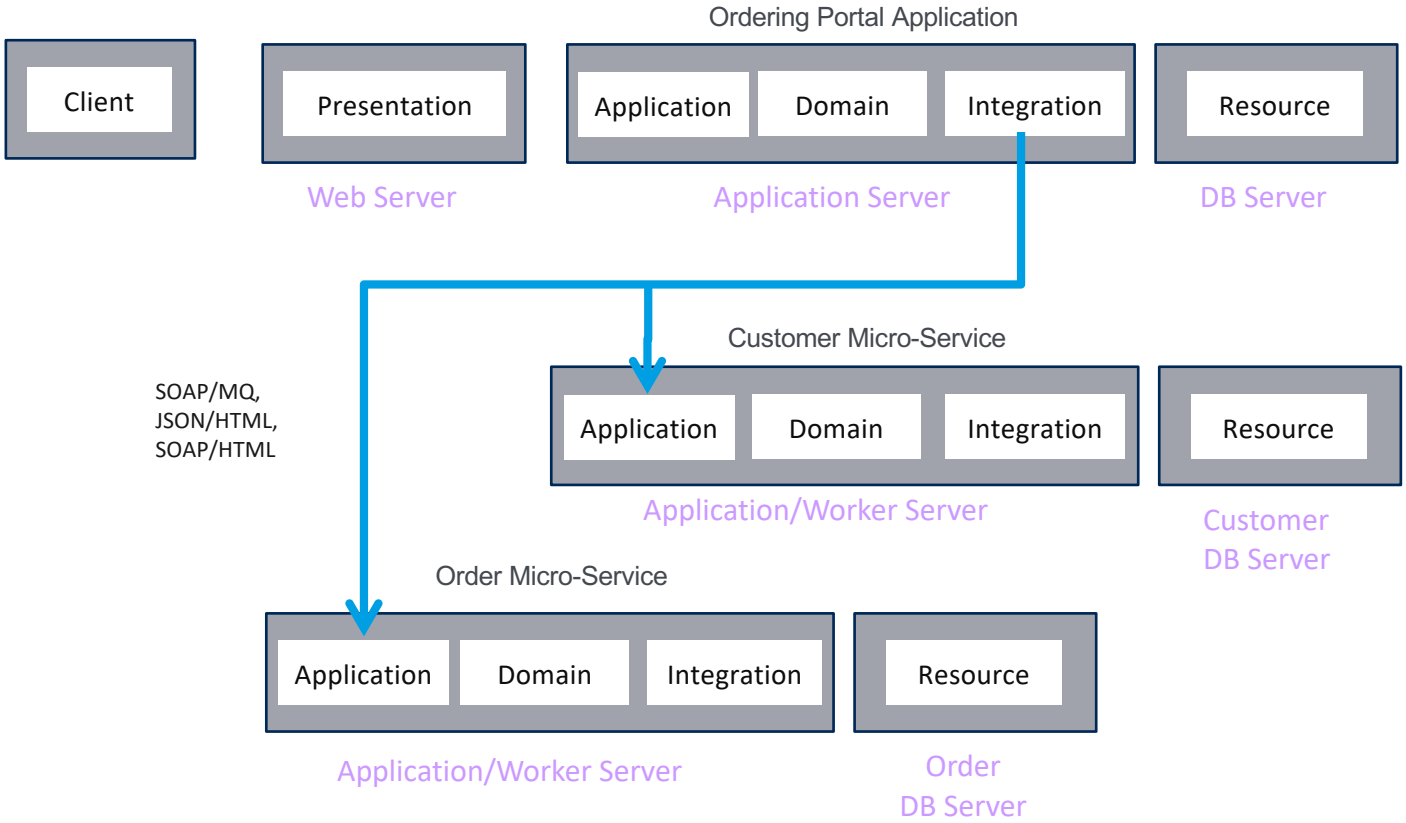


Gateway Example: Mobile Device via API to Business



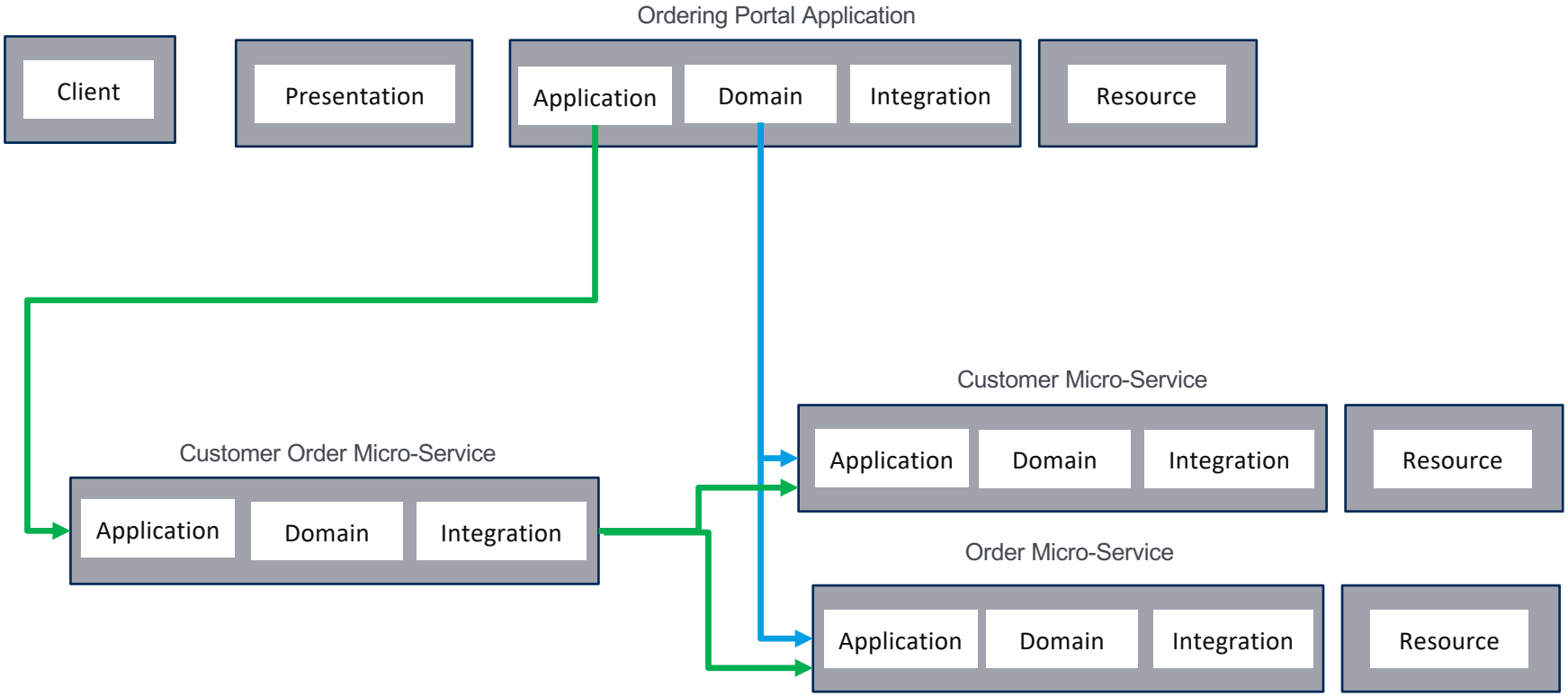
Service Re-use Example: SOA / Microservices Model

Ordering Portal Application calls the two Services independently and composes the results

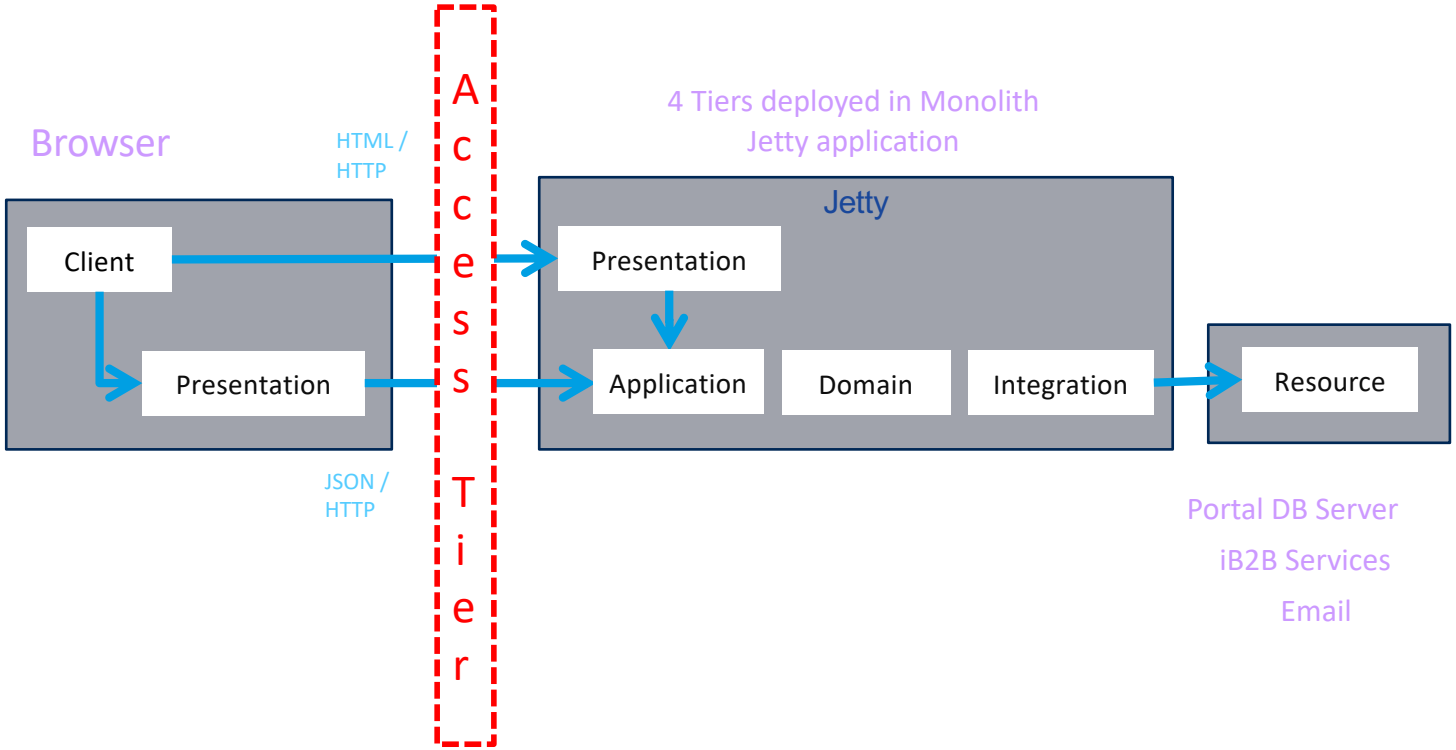


Service Orchestration Example

Ordering Portal Application calls the Customer Order MS that Services composes (orchestrates) the results



Example: Ordering Portal Tiers and Deployment

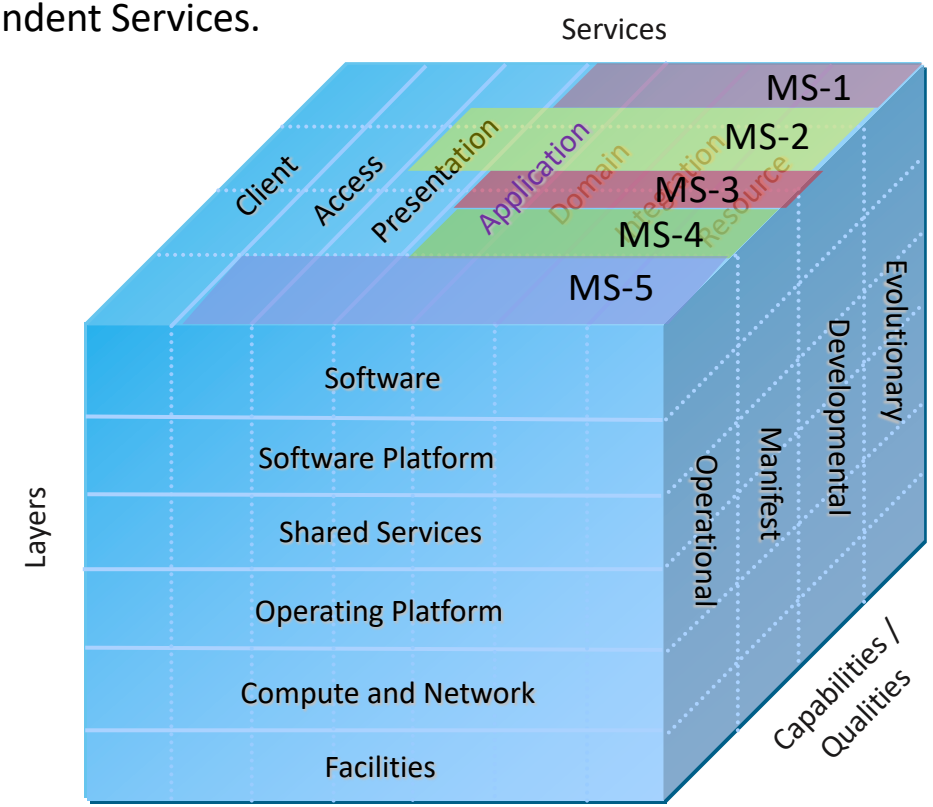


Examples: Global Site Selector, WAF, Load Balancers, Apache Proxy, WebGate, API Gateway, BEFE

Microservices / Self Contained System - Slice the Tiers

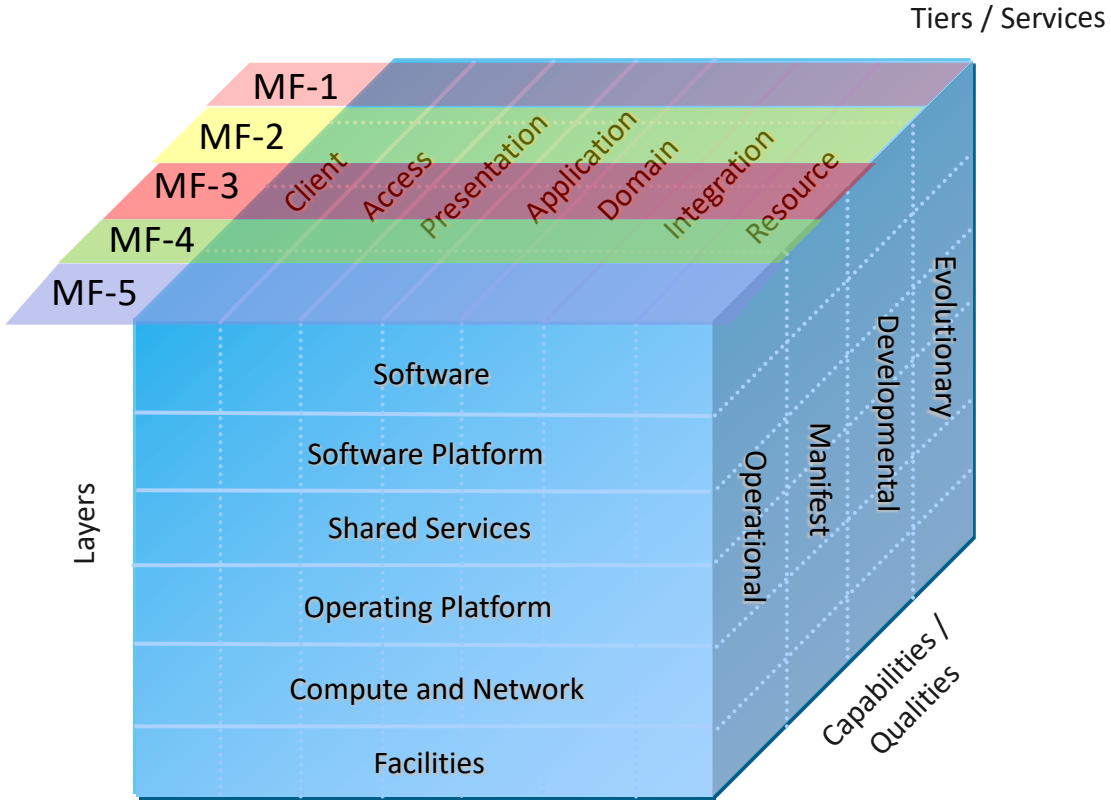
Decompose, slice, the domain into independent Services.

- May separate a Monolith into separate Bounded Contexts each provided by an independent system/service;
- Two approaches:
  1. **'Self Contained System' (SCS)** is a vertical slice of a Monolith that is autonomous, it has its own UI, business logic and data storage.
  2. **'Microservices'** also cut across the Tiers for a specific part of the business domain; however unlike and SCS they share tiers/services;
     - 'API Gateway' provides Access via boundary external/internal or domain/subdomain;
     - Microservices may provide their own Presentation, e.g. Protobuf/ JSON/HTML/XML…..
     - Domain services may be Orchestrated by the Services Layer

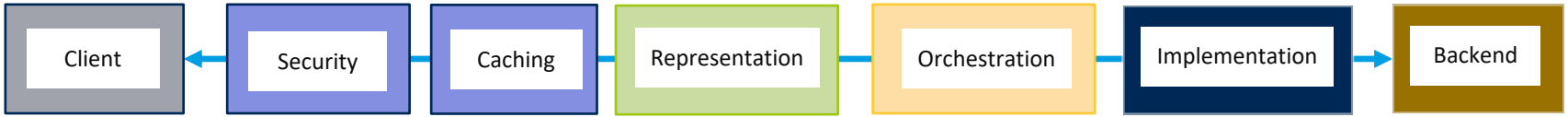


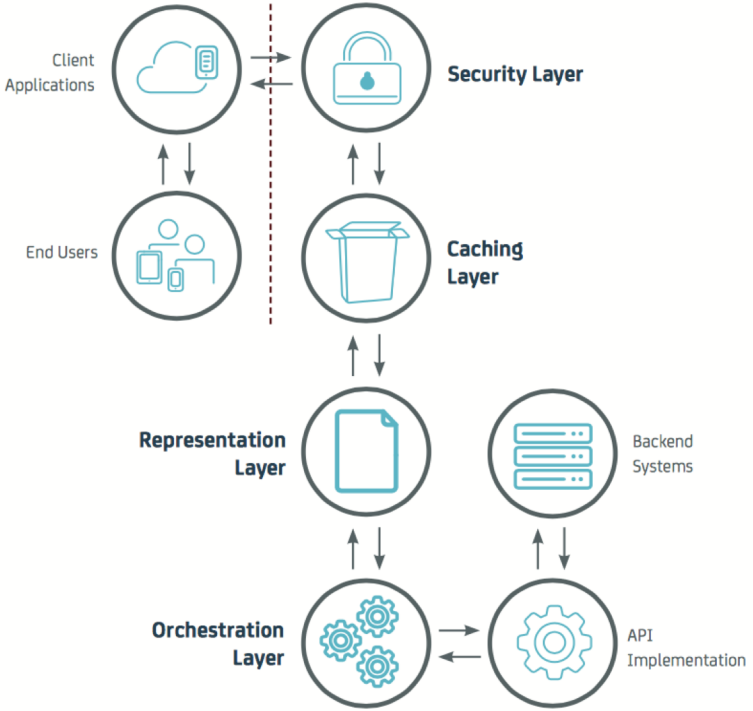
MicroFront Ends / Self Contained System - Slice the Tiers

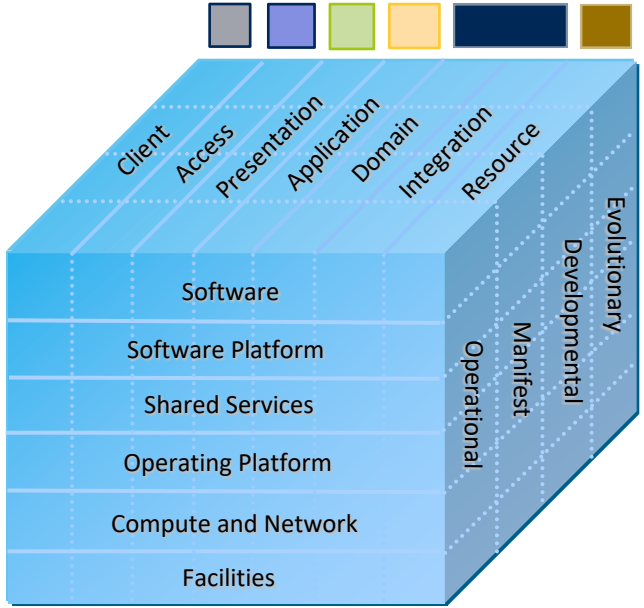
- Micro Front Ends (MFs) may separate a Front End Monolith into separate Bounded Contexts as with backend)
- The idea behind MFs is to think about a website or web app as a composition of features which are owned by independent teams.
- Each team has a distinct area of business or mission it cares about and specialises in.
- A team is cross functional and develops its features end-to-end, from database to user interface.



CAs Layered API Architecture - To Cube / Tiers





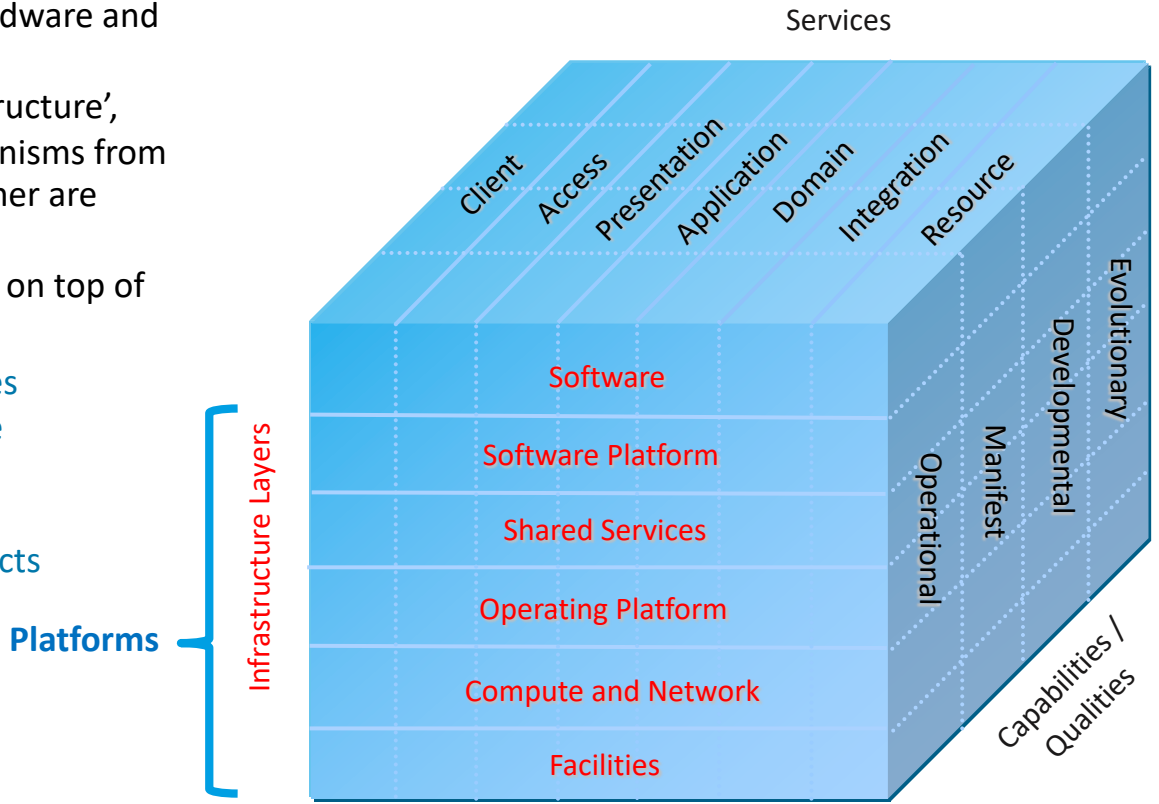


Infrastructure Layers

The Layers - Infrastructure

Infrastructure Layers Provide the Hardware and Software Stack at each Service Tier.

- Decouples the supporting 'Infrastructure', cross cutting concerns and mechanisms from the Tiers and Services, so the former are easier to model and understand.
- The 'Software' is the code written on top of the platforms:
  - The Software Platform provides 'Standards' or a framework we build against, that implicitly require infrastructure.
  - The Operating Platform abstracts away the Boxes and Wires (Compute and Network).
  - Facilities are deployment locations, environments and physical access points.
  - Provide Context for views



Software Platform has implicit Software Infrastructure Layer

The **Software Platform** offers portability, exposing a software standard, such as J2EE, JEE or SQL, and provides for choice of implementation. **Software Infrastructure** layer implements it, and is vendor/provider specific. Example Application Servers include: Glassfish, JBOSS, Wildfly, Tomcat, TomcatEE, Geronimo, Jetty, Jonas, Resin etc. There are many SQL Server implementations.

Software Platform.	JEE	JEE	JSP	SQL	SQL	SQL
Software Infrastructure	Weblogic Application Server	Wildfly	Apache Tomcat	MYSQL	Oracle	AWS RDS

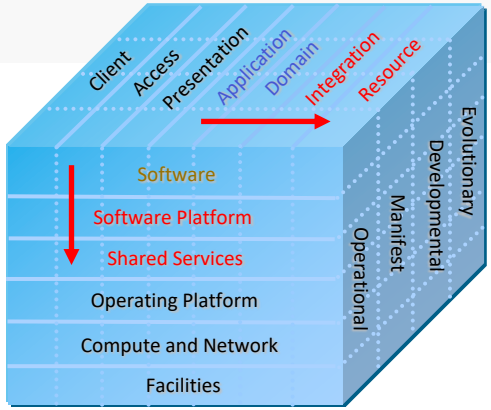
Despite being a distinct layer, it is implicit in the cube, being so tightly coupled with the Software Platform. Often the Infrastructure and Platform are all provided and not standardised, for example NOSQL DBMSs, e.g. MONGO. The Infrastructure can also be provided in the layer below as a shared service like AWS RDS. ***When there is distinct infrastructure it should be described.***

Kafka Example

```
<dependency>
<groupId>org.springframework.cloud</groupId>
<artifactId>spring-cloud-stream</artifactId>
</dependency>

<dependency>
<groupId>org.springframework.cloud</groupId>
<artifactId>spring-cloud-starter-stream-kafka</artifactId>
</dependency>

<dependency>
<groupId>postgresql</groupId>
<artifactId>postgresql</artifactId>
<version>9.1-901.jdbc4</version>
<dependency>
```

Java Streams & Repository Standards

Kafka, DBMS



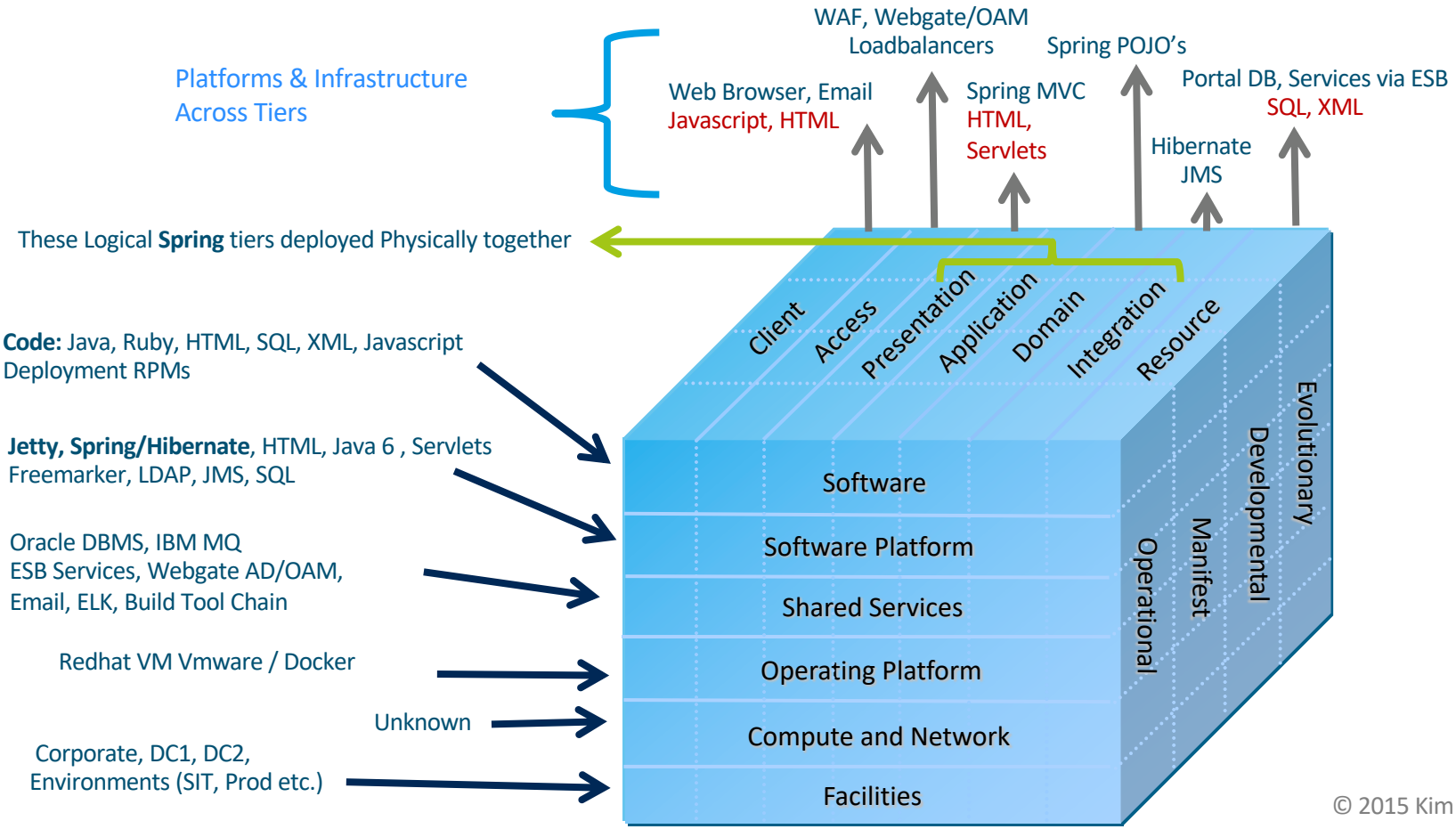
App Service Processes Stream (Java Standard)
Software Platform hides Kafka

```
@SpringBootApplication
public class Application {

@StreamListener(Sink.INPUT)
public void statusSink(MessageModel messEvent) {
      logger.debug("Received an event Type: {} Status:
      {}", messEvent.getOrderId(),
      messEvent.getStatus());
      orderService.updateOrderStatus(messEvent.getOrderId
      (),messEvent.getStatus());
}
```

Service, Domain Entity, Repository, Resource

```
@Service
public class OrderService {

@HystrixCommand
public void updateOrderStatus(String orderId, String
status)
      {
      logger.debug("Getting the Order by OrderID");
      Order order = orderRepository.findByOrderId(orderId);
      order.setStatus(status);
      orderRepository.save(order);
      logger.debug("updated Order Status");
      }
}
```

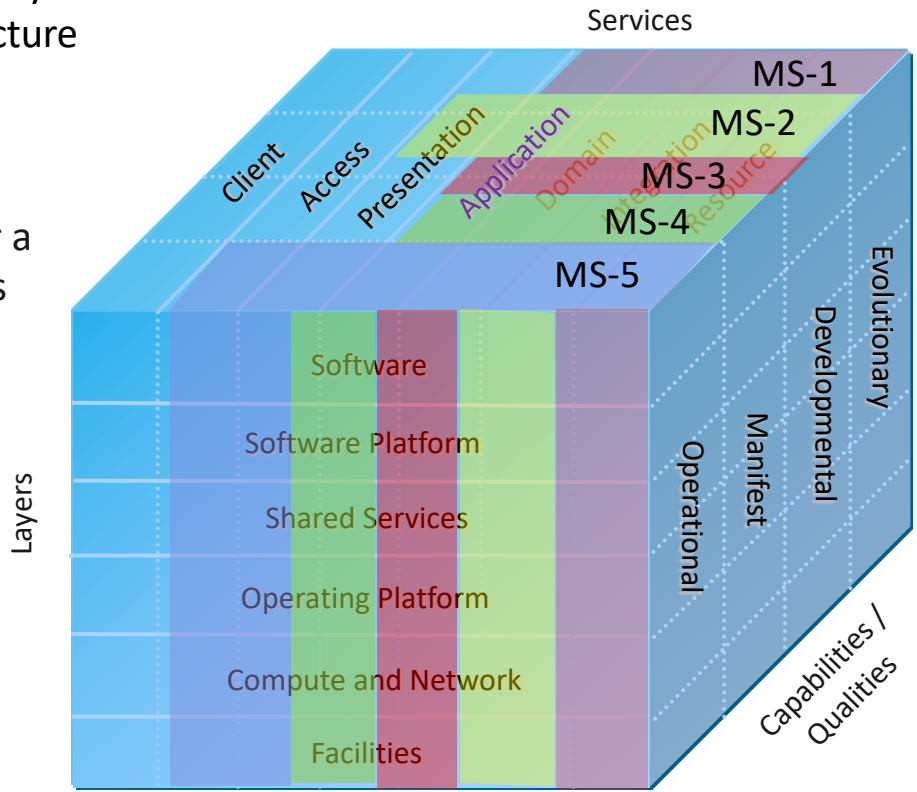
Example: Product Ordering Web Site



Microservices provide the Service Tiers and the Layers

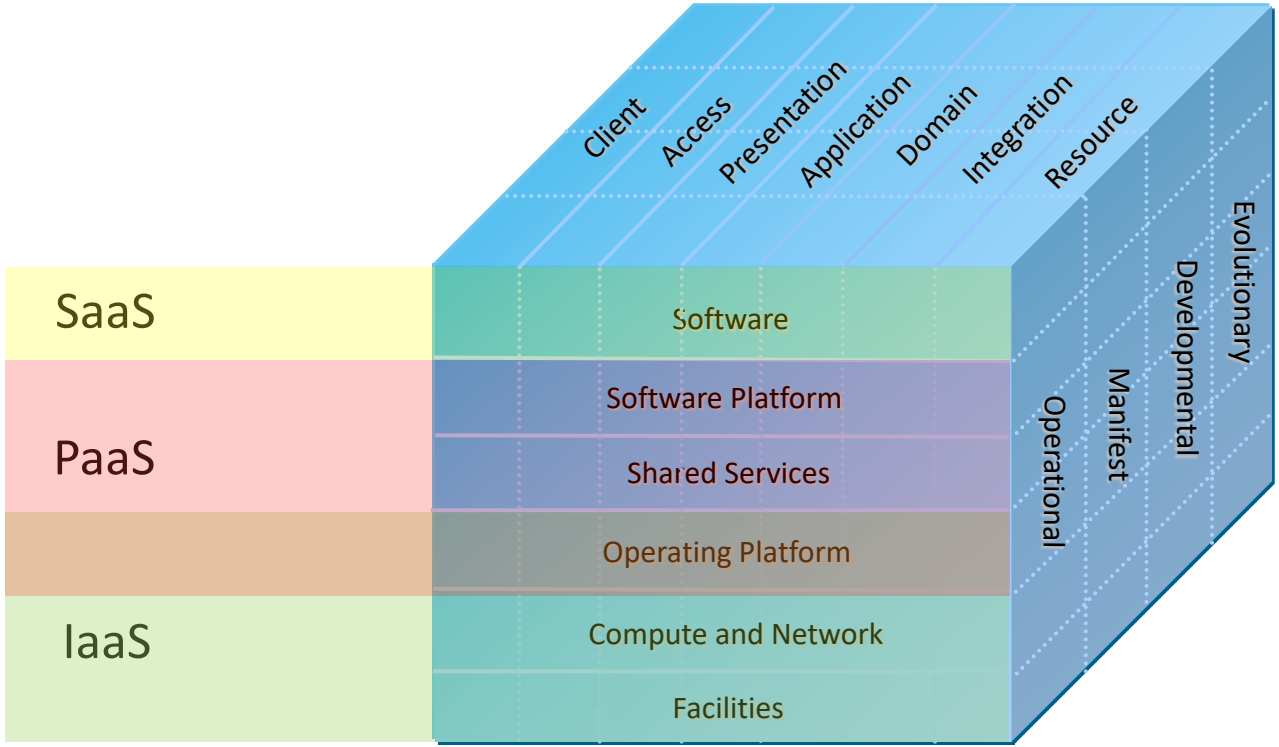
Microservices may be provided by different frameworks, infrastructure and platforms; polyglot.

- Each Microservice may use different stacks;
- cutting across the layers for a specific part of the business domain.



Layers ‘As A Service’

The layers help model the use of cloud PaaS or IaaS components and the production of SaaS solutions. The point where PaaS and IaaS separate is not often clear.



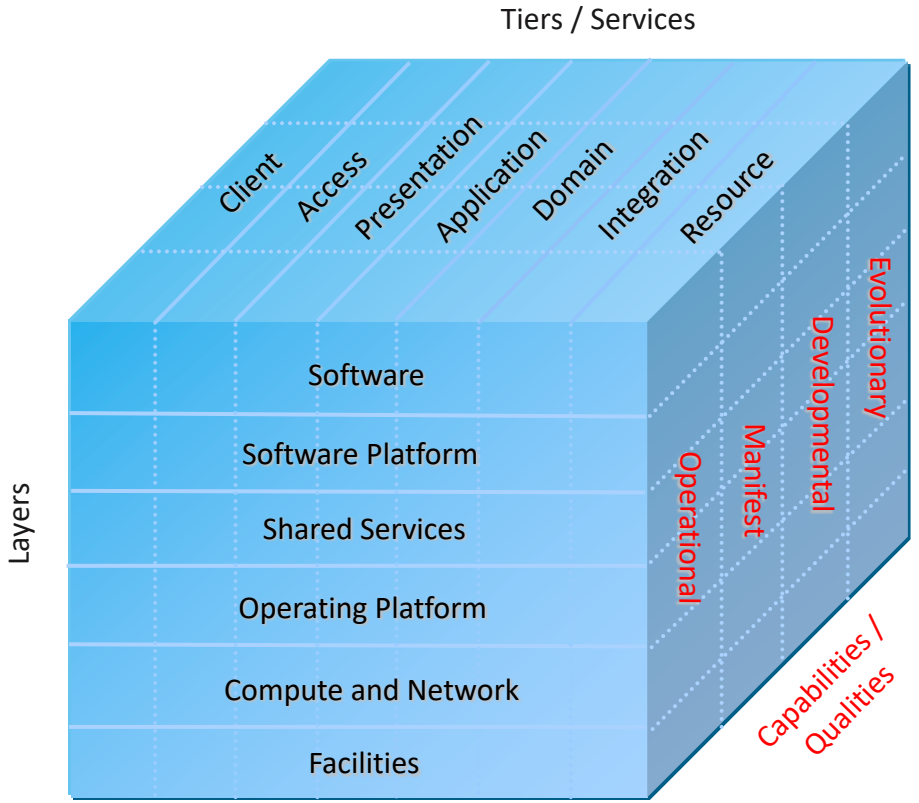
The Qualities

The Qualities

Architecture is primarily
Driven by System Qualities and Capabilities.

Achieving the qualities determines the success of the architecture.

- These are critical for Continuous and Evolutionary Approaches to Architecture;
- Operational Capabilities are key early on for Continuous Delivery/Integration;
- Record the tactics, decisions and justifications in meeting the goals with this solution.



Types of Quality

Type Of Quality	Who	When	How
Manifest	End user and business stakeholders	After initial release, production.	Test, customer satisfaction, business objectives, analytics.
Operational *	IT Operations, IT Service Management, IT Security, Business Security, Maintenance and Support.	Development operations, release-time, after release	Test, customer satisfaction, operational metrics.
Developmental *	Developers, Dev-Ops, PMs, Architects.	During and throughout development and delivery.	Productivity metrics, Velocity, delivery frequency.
Evolutionary	Developers, business stakeholders, Architects	After initial release	Strategy and Business Performance

*** These are the Architecturally Significant drivers for Continuous Delivery (CD).**
CD requires specific qualities to be addressed early.

Continuous Architecture 'Book' Principles

1. Architect Products – not Projects;
2. Focus on **Quality Attributes** – not on Functional Requirements;
3. Delay design decisions until they are absolutely necessary;
4. Architect for Change – Leverage "The Power of Small";
5. Architect for **Build, Test and Deploy**;
6. **Model the organization** of your teams after the design of the system you are working on;

Points 2, 5 and 6 are about Qualities.

by Pierre Pureur, Murat Erder

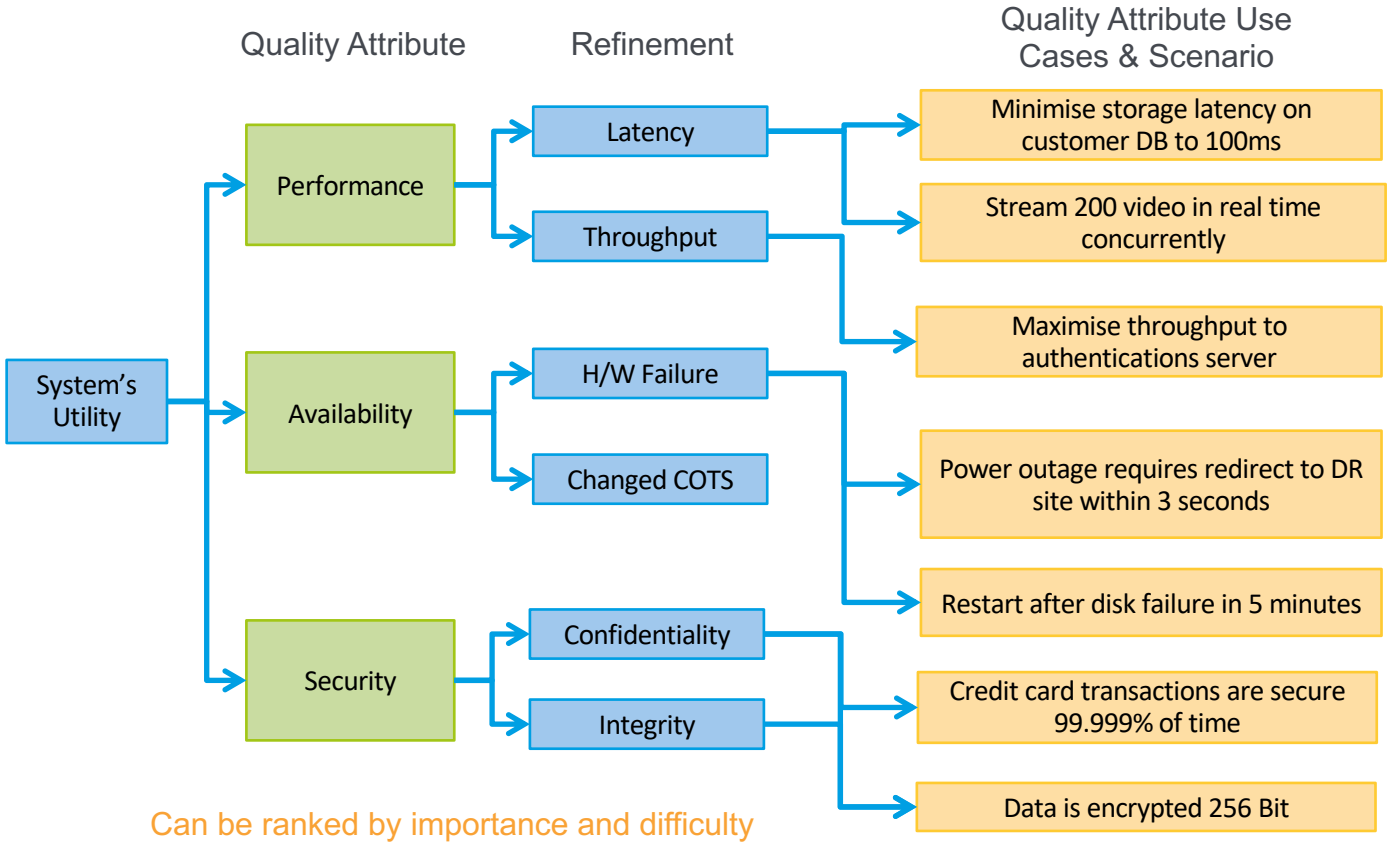
Qualities List by Type

Key	Red = Continuous Architecture is driven by Continuous Delivery(CD)/Integration Focused Quality Drivers Purple = Immediately Impacted by CD Qualities.

Manifest	Performance
	Availability
	Usability
	Reliability
	Accessibility
	Mobility
Developmental	Buildability
	Testability
	Understandability
	Code Quality Measurability
	Conceptual Integrity
	Budgetability
	Planability
	Traceability
	Development Distributability
	Modularity / Packagability

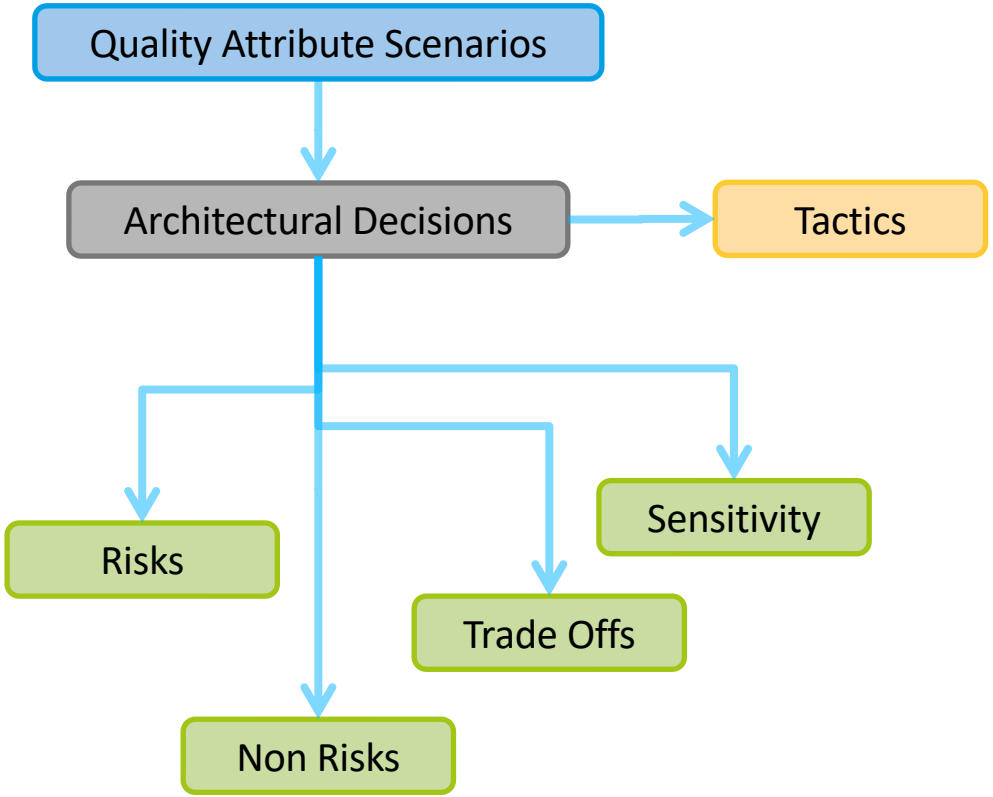
Operational	Throughput
	Security
	Manageability
	Maintainability
	Serviceability
	Deployability
	Reproducibility
Evolutionary	Scalability / Elasticity
	Variability
	Flexibility
	Extensibility
	Reusability
	Portability
	Integratability

Quality Tree – Capturing NFRs - Example,



Can be ranked by importance and difficulty

Scenarios and Architectural Decisions



Scenarios result in multiple architectural decisions.

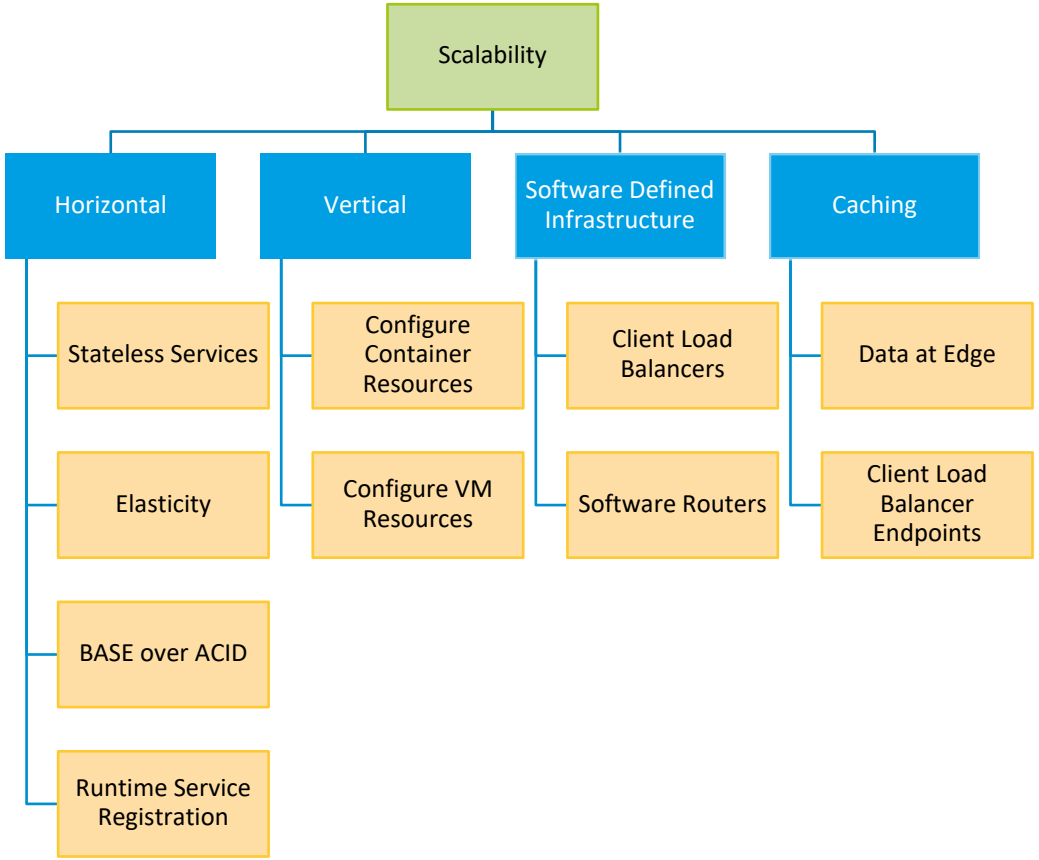
Architectural decisions involve tactics, one or more becomes the chosen solution.

- Need to Justify the choice.

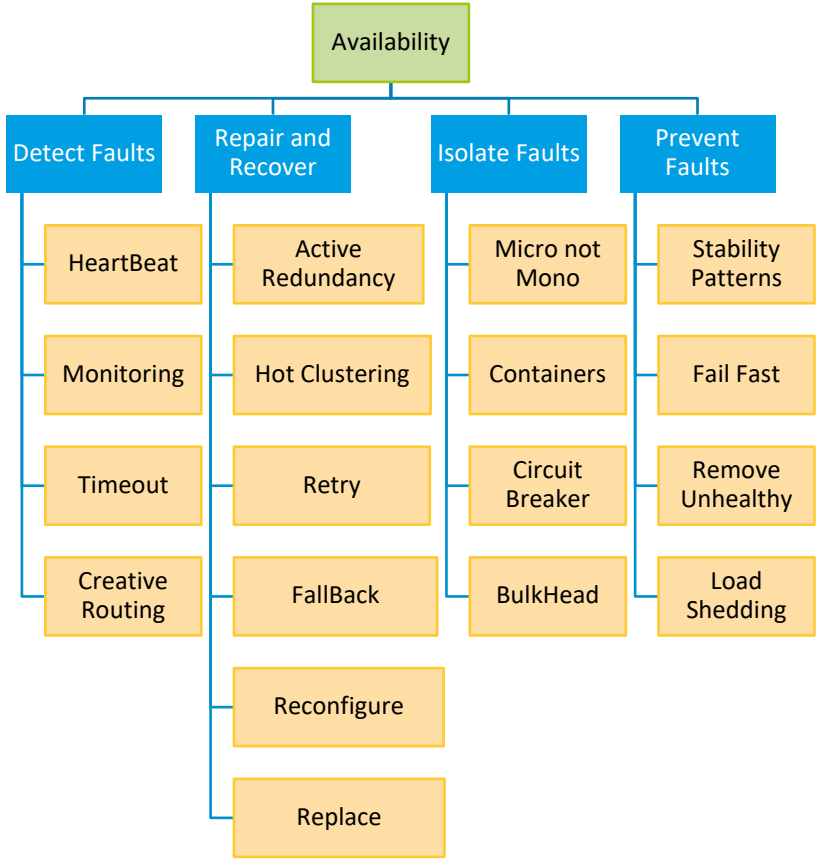
Each decision has:

- Risks
- Non risks
- Sensitivities
- Trade offs

Microservice Scalability Tactics



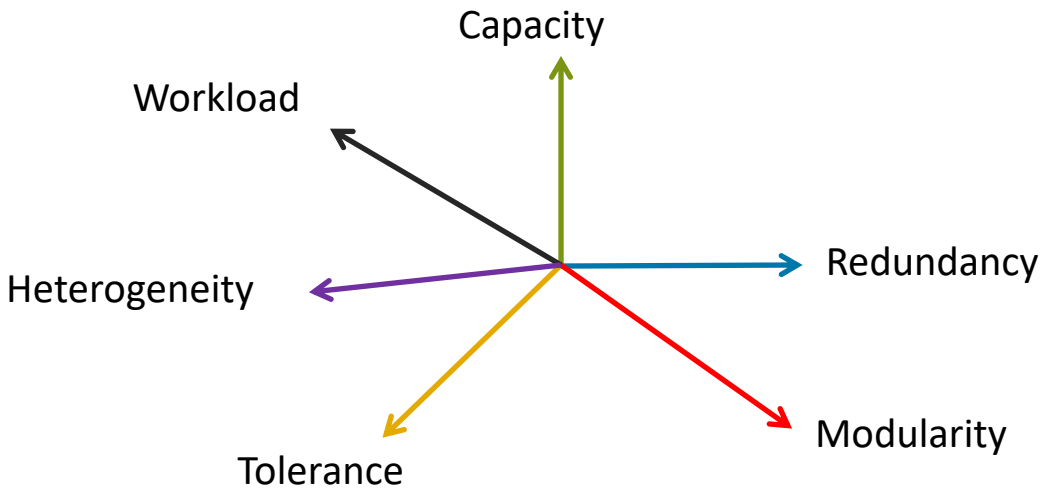
Microservice Availability Tactics



Architectural Dimensions

Architectural Dimensions

An architectures' Tiers and Layers can be evaluated across 6 independent variables:



Architectural Dimensions

Dimension	Description
Capacity	Height: The raw power in a component, e.g. CPU Speed, network Bandwidth, disk storage capacity. Increased by Vertical Scaling.
Redundancy	Width: Multiple system that work on the same job in parralel. Increased via Horizontal Scaling.
Modularity	How system is decomposed and then distributed. How far into the system you have to go to get detail.
Tolerance	Time to fulfil a user request, perceived performance.
Workload	Work being done at a point in the system. Workload consumes capacity.
Heterogeneity	Diversity in technologies.

Dimensions Impact QOS

Increasing a dimension either increases or decreases QOS

Increase Dimension	Scaleability	Availability	Reliability	Extensibility	Manageability	Maintainability	Performance	Security
Capacity	+	+					+	
Redundancy	+	+	+	+	-		+/-	-
Modularity	+	-	-	+		+		+
Tolerance	+	+	+		+		+	
Workload	+	+					+	
Heterogeneity	+/-	-		-	-	-	+/-	-

\+ Increase
\- Decrease
+/- Both increase and decrease

Intersections

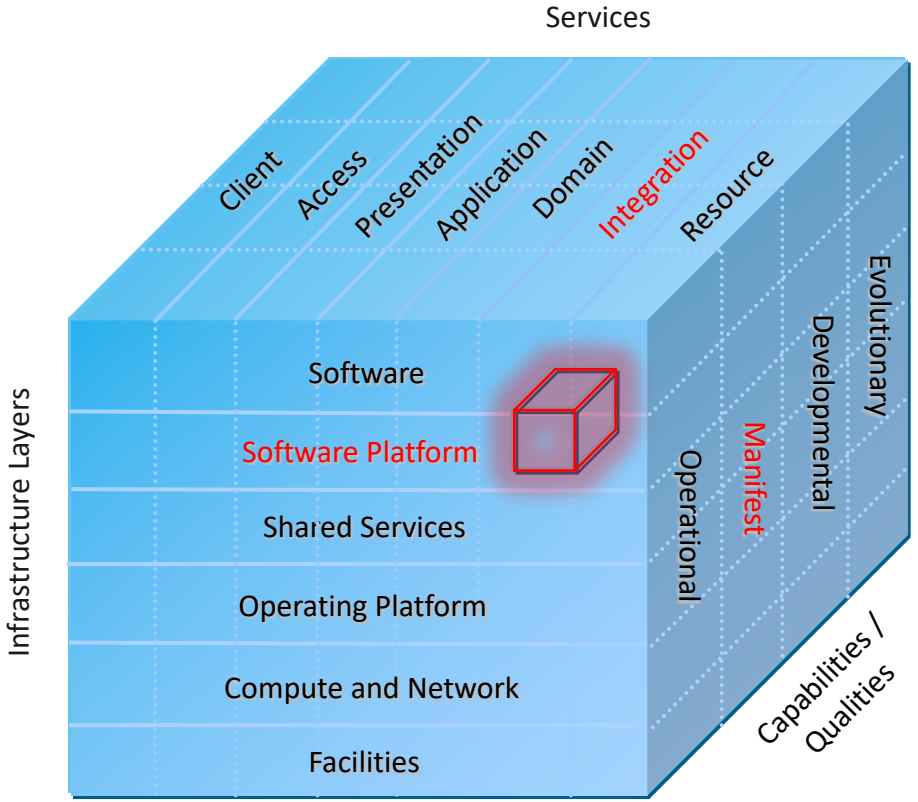
Value: Intersections of Dimensions - Example

The intersections of the 3 dimensions provoke specific evaluation of architecture;

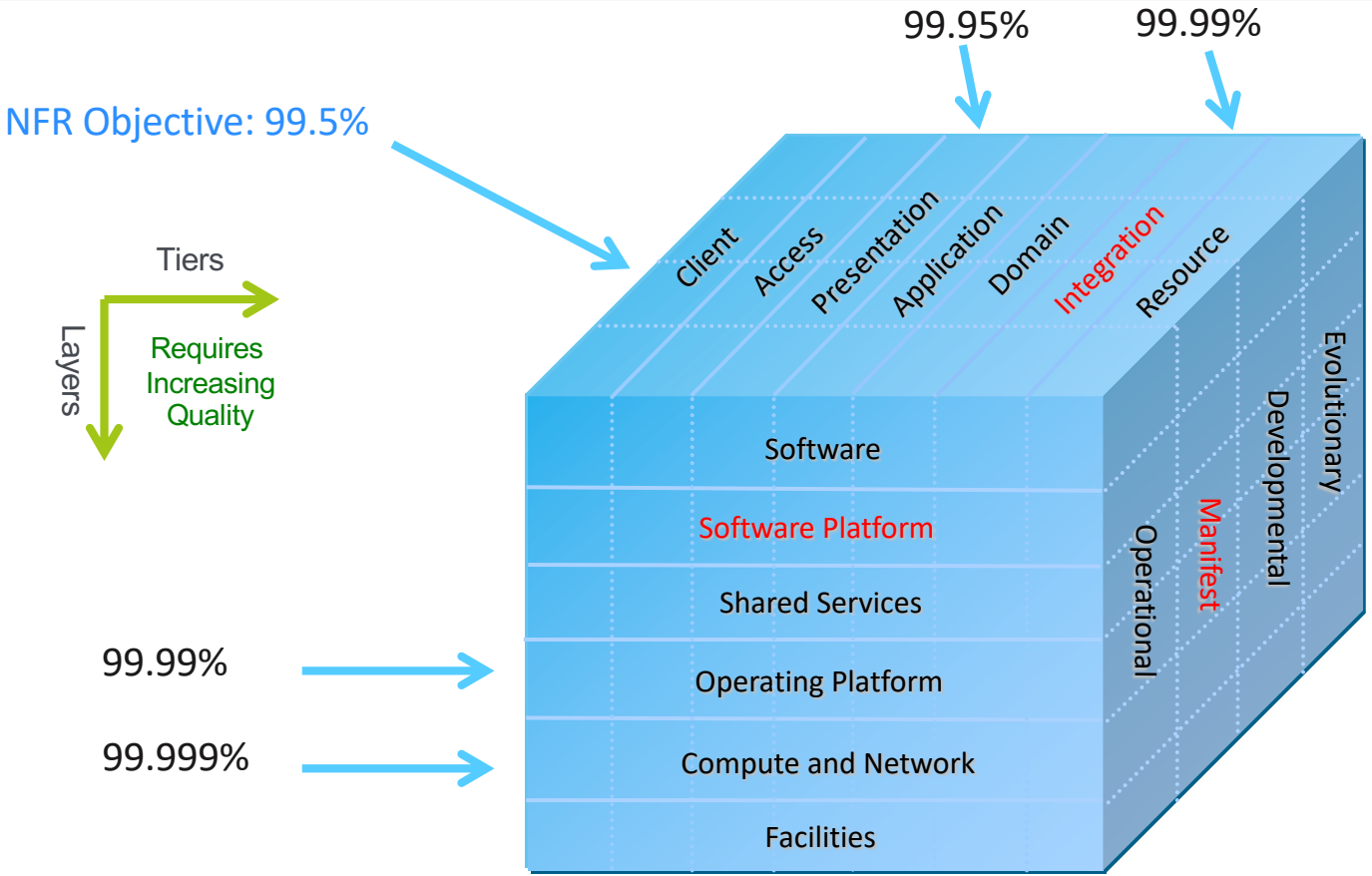
What **Infrastructure** delivers specific **Qualities** for the **Tiers and Services** ?

Ask, for example:

- How Sensitive is Availability to issues with the Software Platform at the Integration Tier ?
- How will issues here manifest to the user ?



Availability



Reusability

In Mythical Man Month (1974) Fred Brooks suggests that re-usable code costs three times as much to develop as single use code.

API / SOA Services built Tactically or Strategically for re-use.

- $$'s to get to *Shared Services.*
- New qualities: scalability, etc…

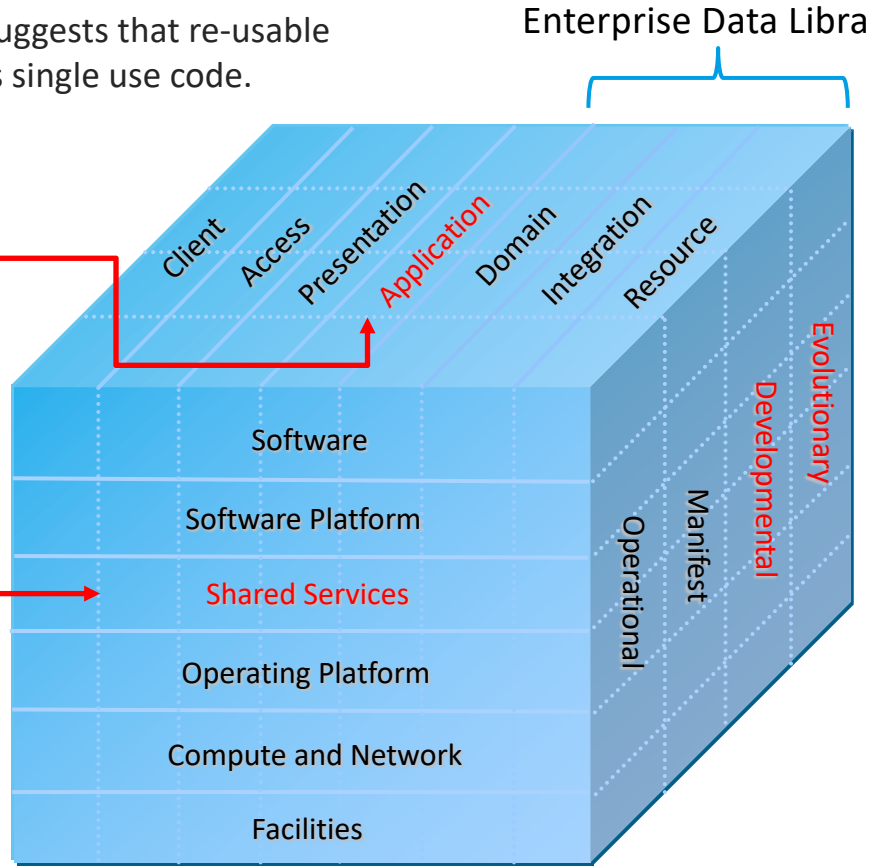
Harder - Costly

Code, Patterns

Frameworks, Platforms

VMs, Containers

Easier - Cheaper



Re-use by layers

3 Types of Reuse:

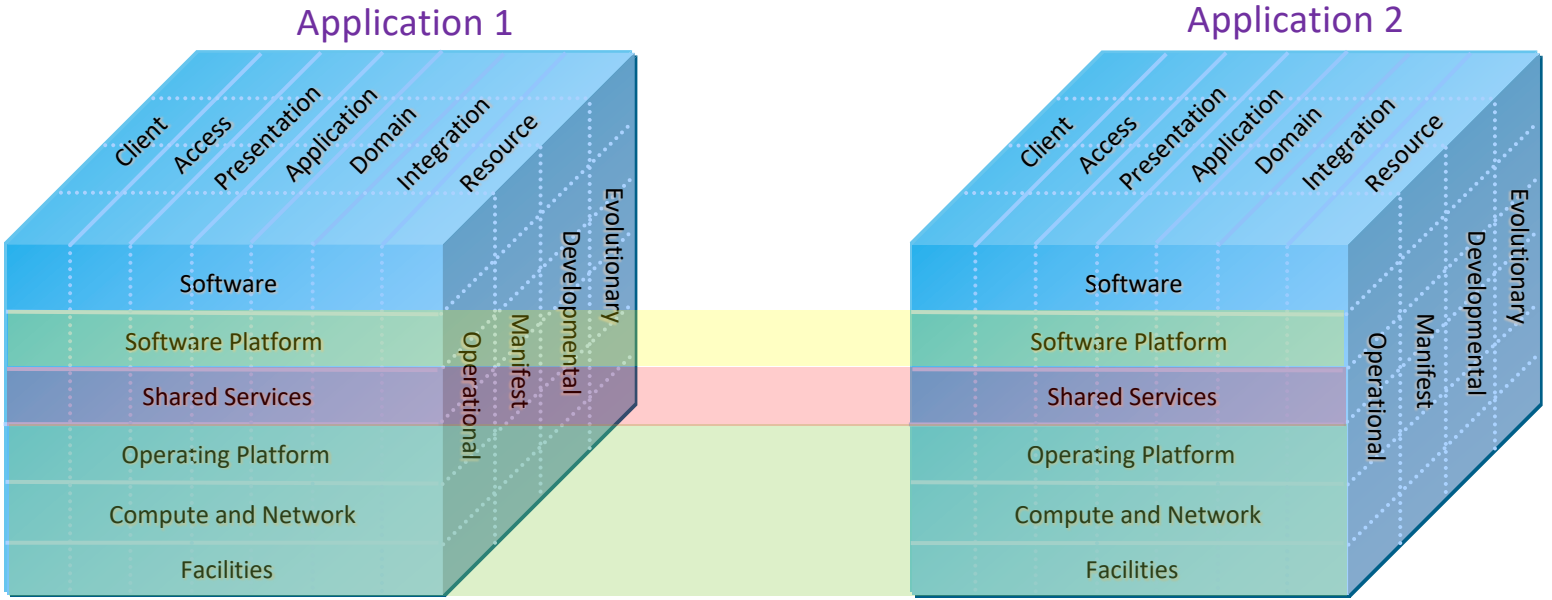
1. *Black-box* - the artifact is used unmodified → only one copy to maintain *(measured)*
2. *White-box* - the artifact is modified for use on projects → multiple copies to maintain *(not measured)*
3. *As-example* - ideas are drawn from the artifact *(not measured)*

Layers	Across All	Each Layer
Application	• Solutions • Designs • Requirements	Code (cut& Paste), Libraries, White Box, Black Box, Common Business Services, Business Service, Utilities Modules, Libraries
Software Platform	Models Styles Patterns Architectural Design Platform Specifications Views	Languages, Black Box (Frameworks, Platforms)
Shared Services		Services (SOA) Custom Mechanisms Incorporated Mechanisms – many are part of products
Operating Platform		Reuse whole layer VMs, Containers, Deployment/Build Scripts Incorporated Mechanisms
Compute & Network		Reuse whole layer

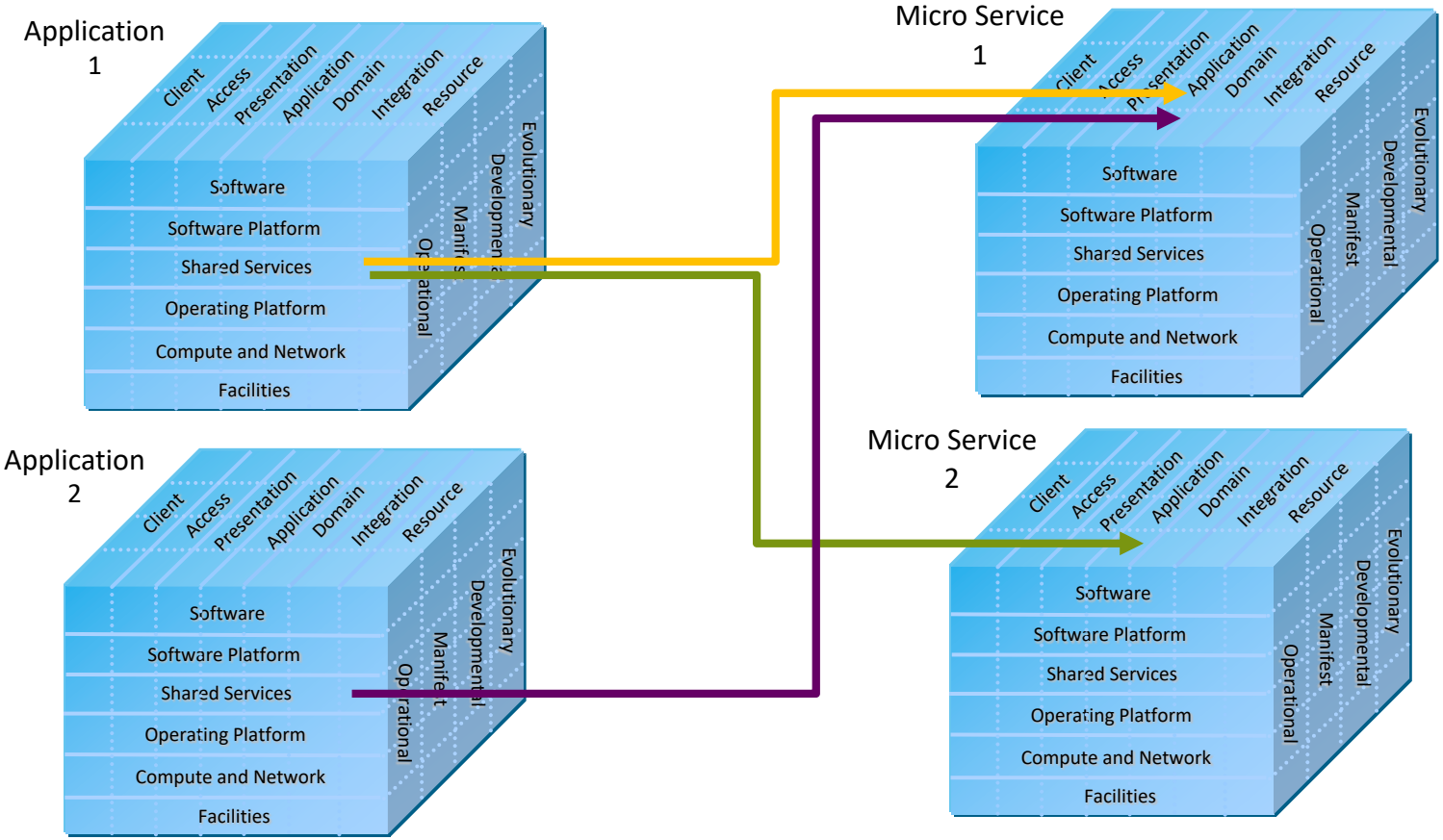
The Cubes across the Enterprise

Applications and Services can share infrastructure, including: Enterprise Services, Hardware, Network and Facilities.

- Shared and cross cutting concerns can be moved into their own PAD (physically shared) or Reference Architecture Document (conceptually shared)
- The Layers where a shared 'Platform' starts and ends varies.



Composite Applications and Micro Services



"a system Is comprised of a set of simpler systems"

The Views

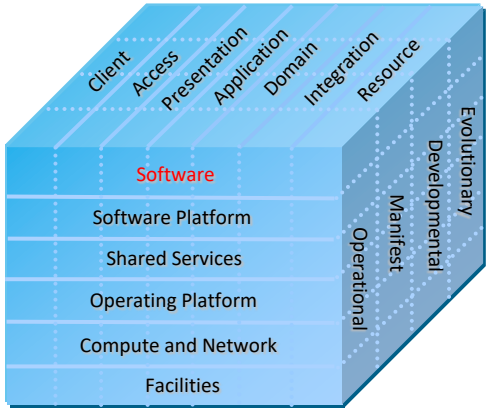
Static Vs Runtime Views - The code is all you need ?

"An object-oriented program's runtime structure often bears little resemblance to its code structure. The code structure is frozen at compile-time; it consists of classes in fixed inheritance relationships. A program's runtime structure consists of rapidly changing networks of communicating objects.

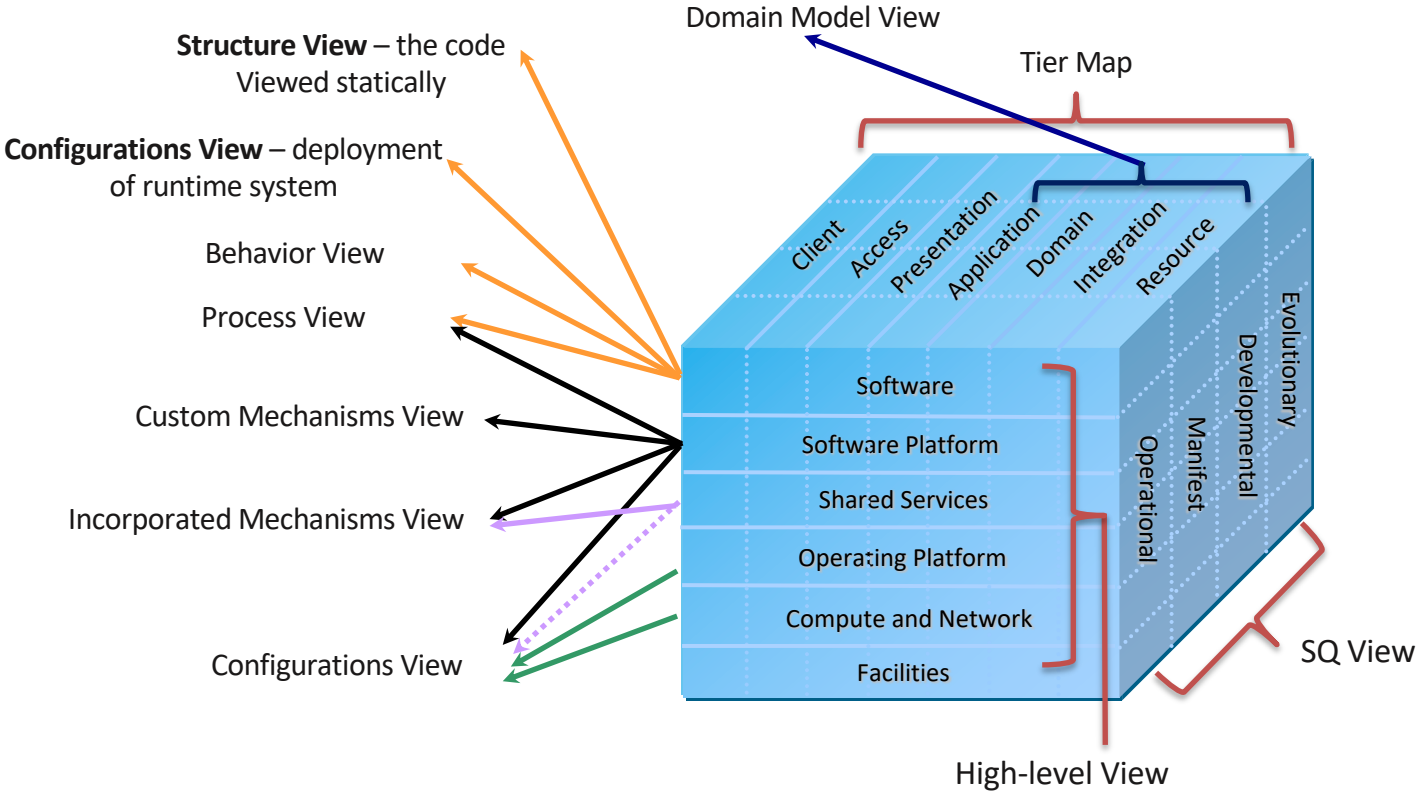
In fact, the two structures are largely independent. Trying to understanding one from the other is like trying to understand the dynamism of living ecosystems from the static taxonomy of plants and animals, and vice versa."

Gamma, Helms, Johnson, and Vlissides

- It is often suggested that the code has the last say over describing a system.
- However, the code is just one view; a very static view of the application.
- It sais nothing about the dynamic system, how it is deployed, horizontally scaled, where, when and to what the code is deployed, and how the qualities are delivered;
- Static Vs Runtime are just 2 views - there are many more, required to support the many stakeholders viewpoints.



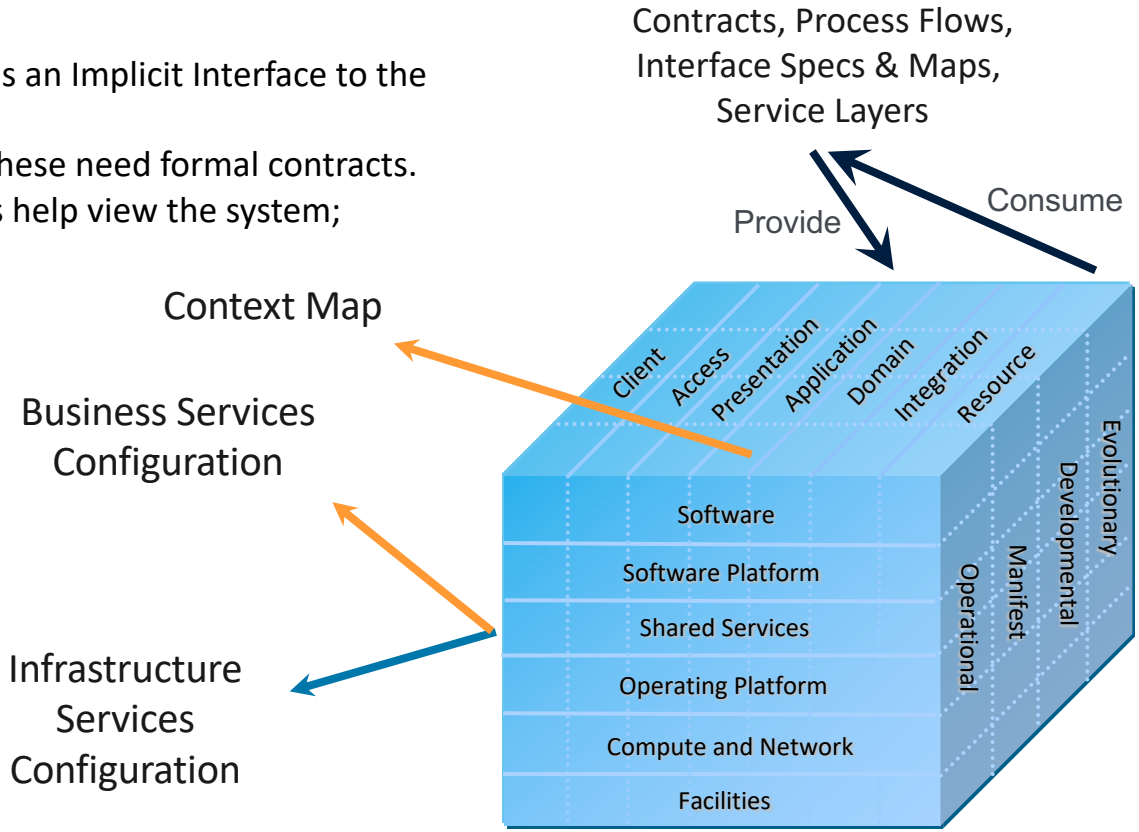
The Cube – The Context for Organising Stakeholder Views



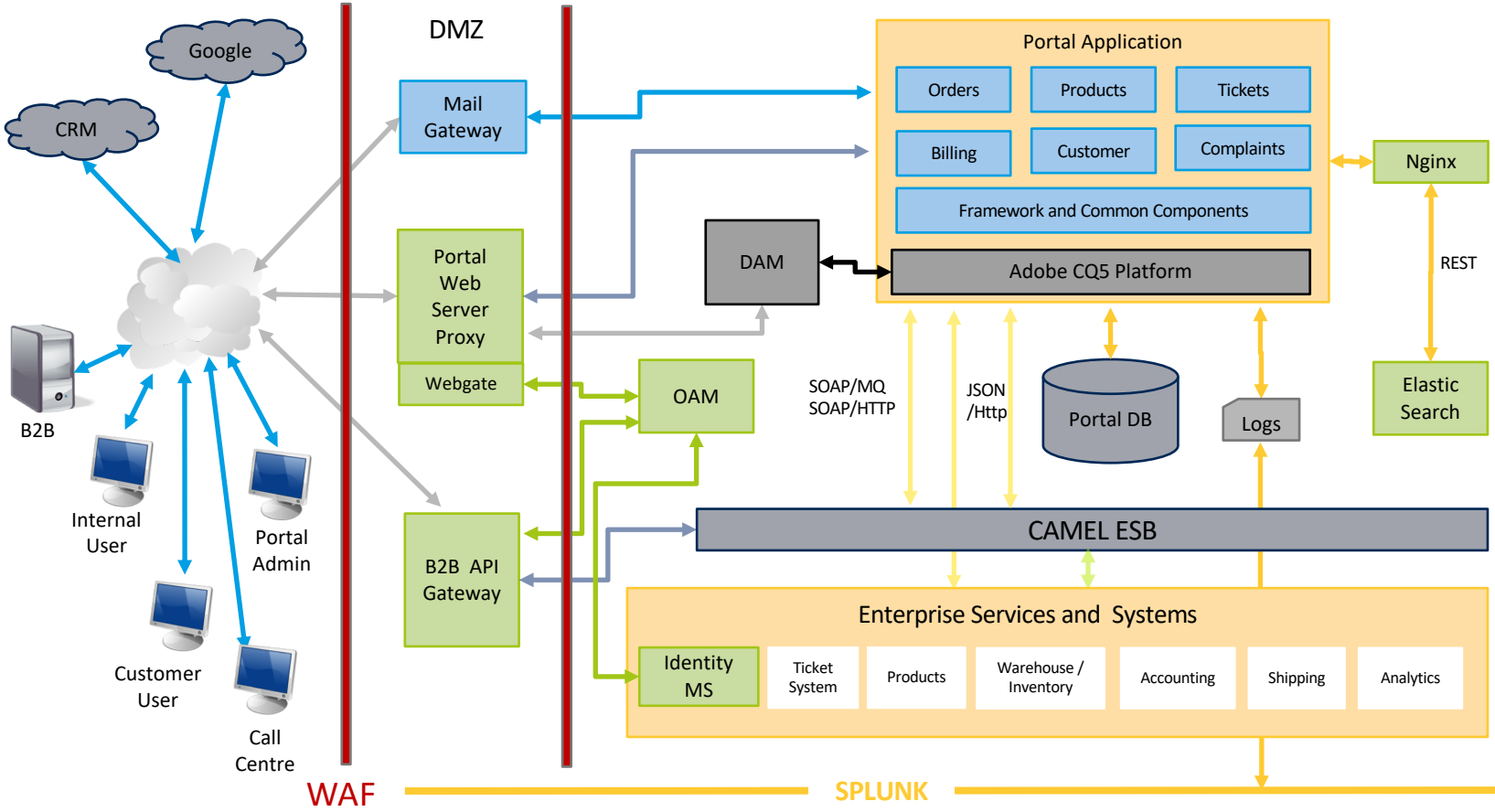
Interface Contracts

Each Tier/ Layer has an Implicit Interface to the next; layering.

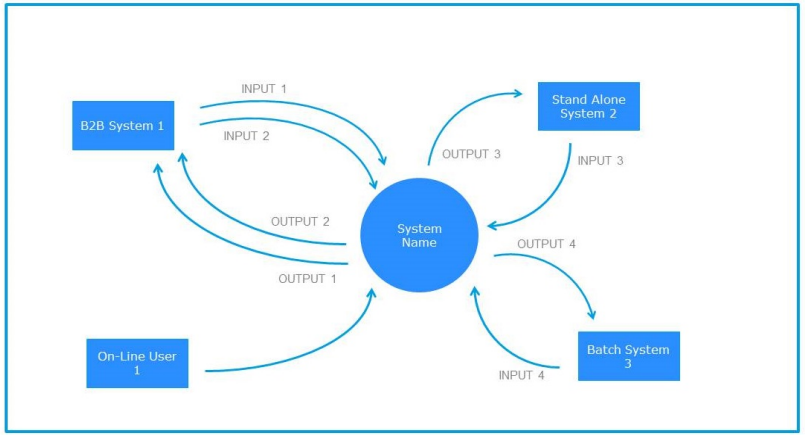
- Only some of these need formal contracts.
- Other artefacts help view the system;



High Level View – Ordering Portal and API Example



High Level Views – Context and Scope

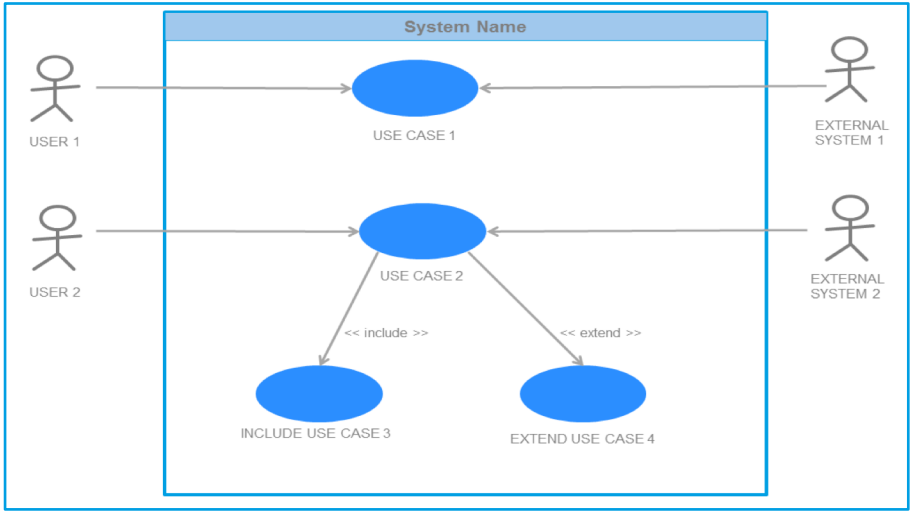


The Solution Context artefact helps define the scope of the system at an early stage in the project.

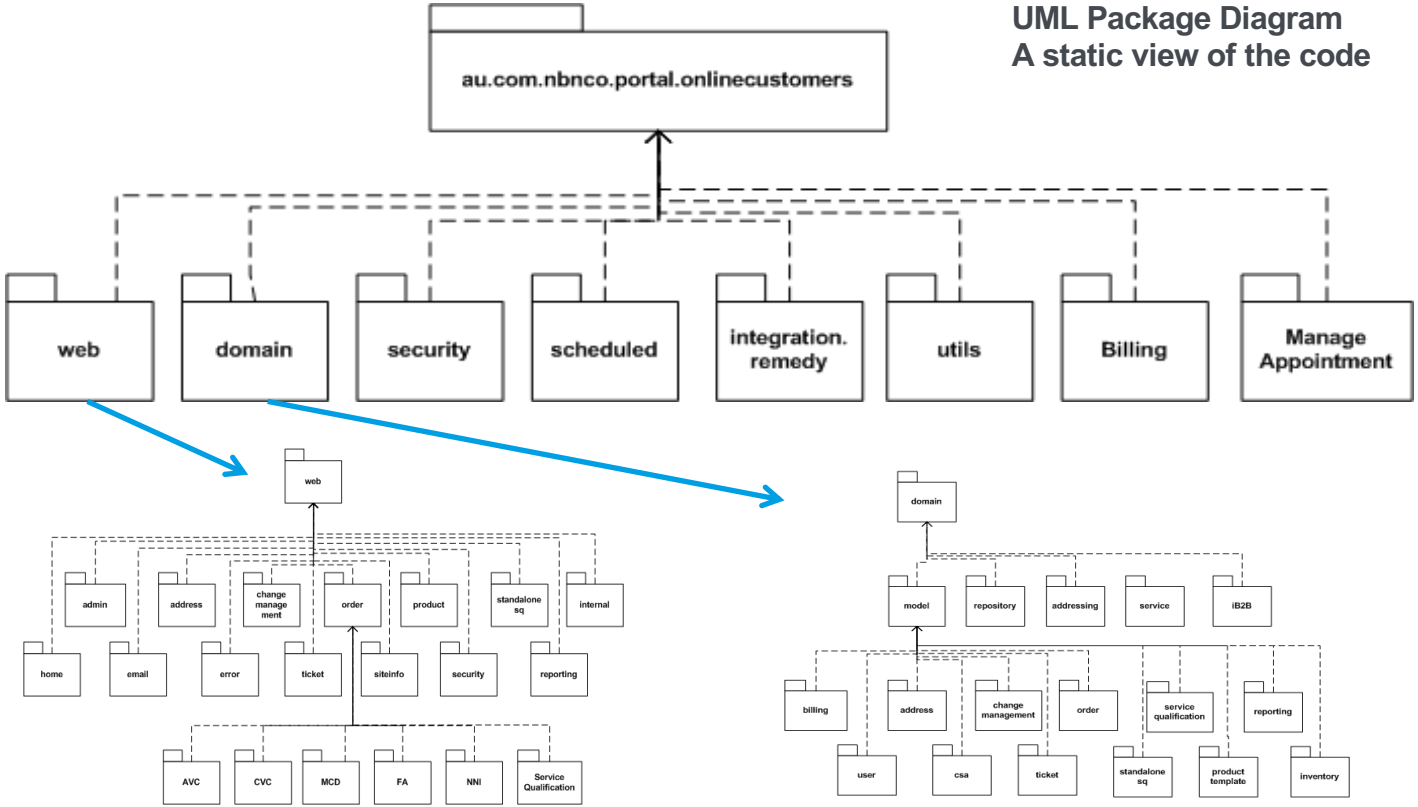
- Used amongst the key stakeholders to set expectations, gain agreement on the scope and assist in delineating the project team and client responsibilities.
- Can be developed Iteratively

A Use Case Diagram describes the scope from point of view of the various users of the system and how they achieve their goals.

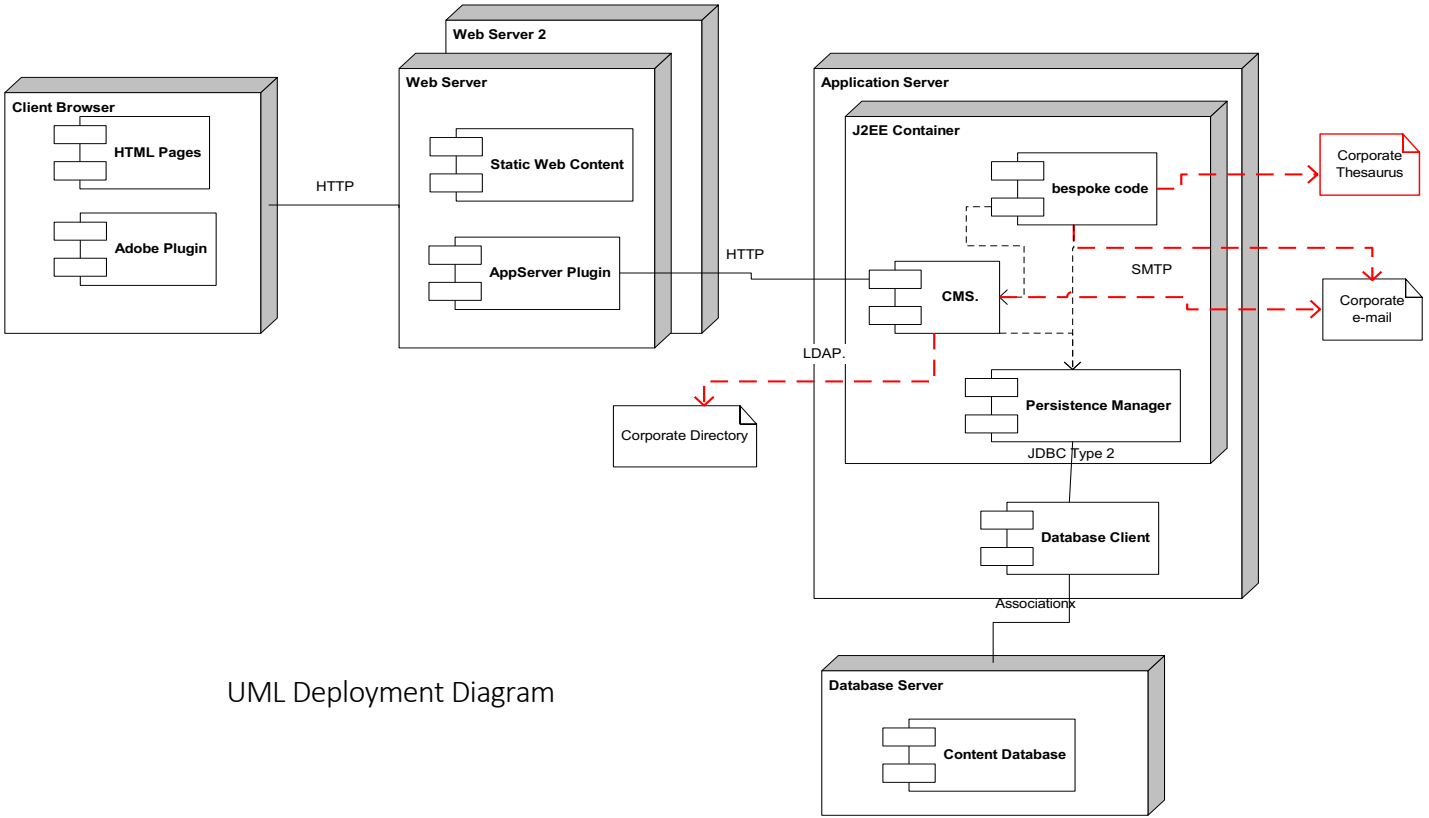
- Shows how actors use the system or how they are are impacted.
- Provides some visibility into the system explaining the systems capabilities.



Application Structure View - Example

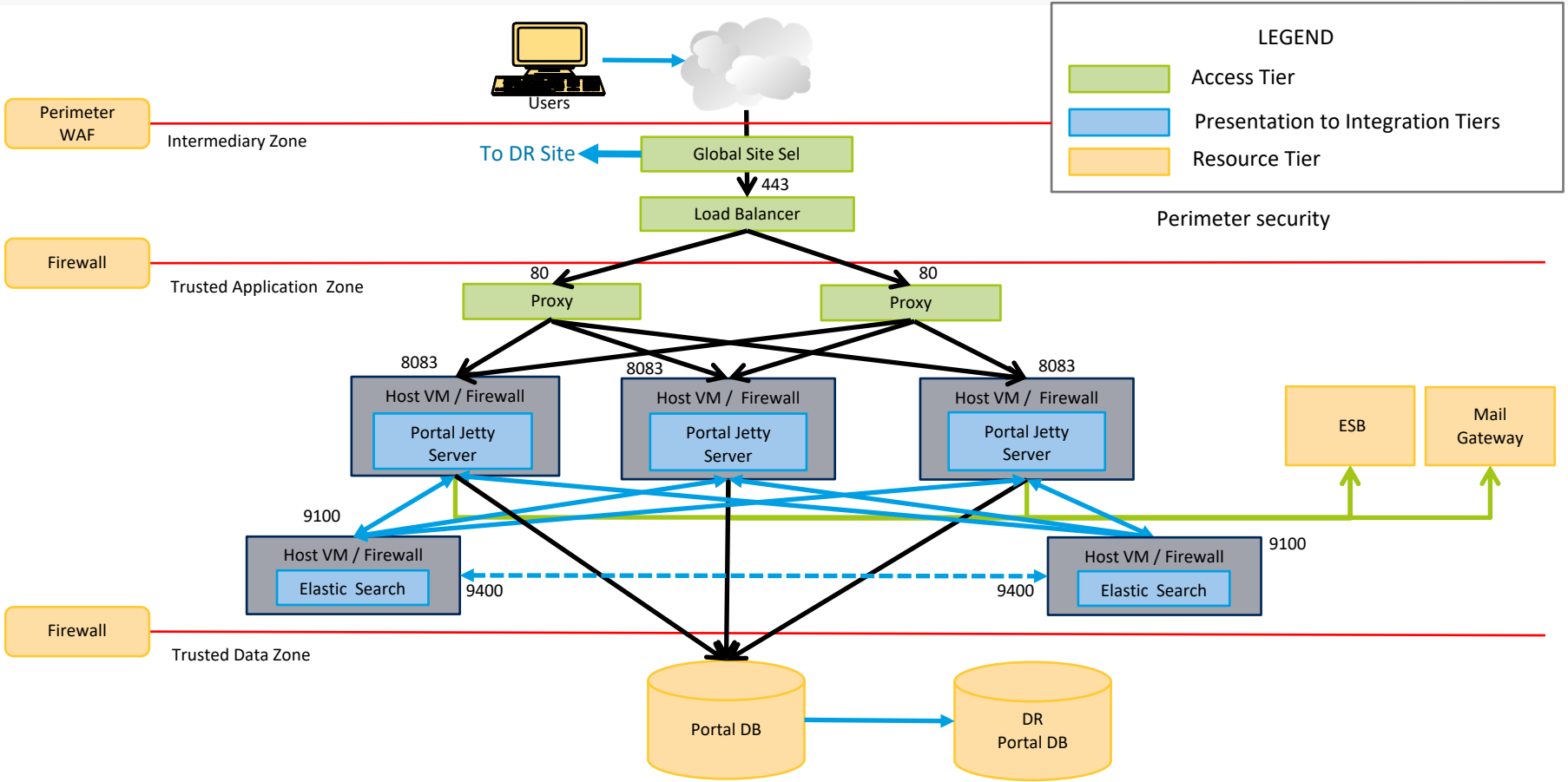


Application Configuration View – Runtime Deployment - Example



UML Deployment Diagram

Network Configuration + Tiers across Security zones



Tier Map View – Entity/Data Management at each Tier - Example

Data gets transformed and managed by different technology as it goes up the Tiers

Arch Decision	Presentation	Service	Domain/Integration	Resource
Data Structure	Value objects and JSP helper beans	XML/JSON	JEE Entity beans with POJO by-value dependents	SQL primitive types and Oracle BLOBs for images
Collection Handling	Lists of value objects	List of XML/JSON Array	List of Entity Bean keys	Relational tables
Query API	JEE and JQuery calls	XPATH (XML Only)	JEE calls	Relational tables and views for reads, stored procedures for updates
Navigational API	No local navigation	XML as above	Embedded by-value dependent objects, otherwise through canned services	SQL
Integrity Management	Local format validation for structured fields, drop-down lists from back-end data sources	XSD (XML Only)	Full integrity checking with some redundancy with resource and client tiers; exception errors with explanation strings	Foreign key and some triggers in database
Transaction Control	None	XML - WS Atomic Transactions JSON None	For each method invocations using EJB mechanisms	Transaction boundaries managed externally, SQL isolation level of repeatable reads

Qualities View – Describe the Solution Tactics - Example

How are the 'relevant' qualities achieved at each layer.

Layers	Component	Security	Throughput	Scalability	Reliability Availability	Manageability
Application	Order Web Page (Java, JSP)	UID & Password	Minimal session state, Lazy Finish	Separable Order System interface	Replicated Session, Loosely coupled functions	Common LDAP User records
Software Platform	Apache Tomcat	SSL, LDAP ACLs, Webgate Proxy	Resource pooling	App Server Clustering	Primary/ Secondary LDAP	Remote SNMP admin
Operating Platform	VMWare VM	Restricted user base, VM isolation	VM Memory On demand	VM Memory On demand, VM duplication	VM Restart (Test, pre-prod environments)	Remote SNMP admin, VMware vSphere vMotion
Compute & Network	Cisco UCS	Restricted user base, physical isolation, firewalls	Load balanced, dedicated server, multi-processor	Expandable width, expandable processor	Clustering, redundant network connections	Remote SNMP admin

Viewpoint Models / Artefacts

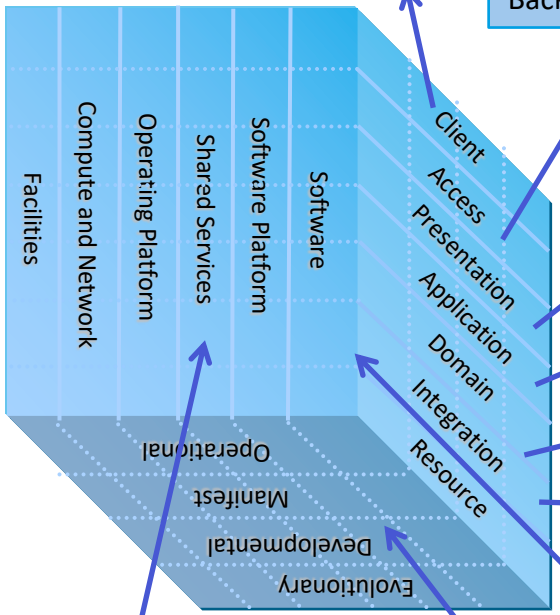
Layer	View	Typical Model/Artefact
High Level		A functional description of the application that all stakeholders can appreciate. A custom graphic, system context or UML use case diagram.
Application	Structure	Mainly UML package, Composite Structure diagrams. UML **class, object, State machine when required.**
	Configuration	UML component or deployment diagrams. Component diagrams can be overlaid on deployment diagrams. Include Interfaces and Ports.
	Behaviour	Patterns, Process diagrams, BPM models, Tier Map. UML Sequence, Activity, Communication and Interaction Diagrams.
	Tier Map Data @ Layer	Tier Map (Across Layers) - Information Model (IA), Domain Object Model, Class/Object or ER Models.
	Process	UML Object Diagram with Process Annotation, Sequence, Communication and Timing Diagrams.
Software Platform	Incorporated Mechanisms	UML Component/Interface Diagrams, Reference to APIs, Specs/Contracts.
	Custom Mechanisms	UML diagrams as for the Application Layer. **UML Interface Diagram Reference to APIs, Specs/Contracts**
Shared Services	Configuration	**UML Component Diagram, reference to Services, APIs, Specs/Contracts**
Operating Platform	Configuration	UML deployment diagram showing nodes and dependencies
Compute & Network	Configuration	Compute and Storage : UML deployment diagram showing nodes and dependencies. Network: Diagram (Routers, Load Balancers, Firewalls etc..)
Systemic Qualities		Systemic Qualities Decisions / Tactics by Layer

Views by Stakeholders (subset)

Layer	View	Architect/ Reviewer	Cost Reviewer	Designer/ Builder	Project Mngr	Maintainer	Operator/ Installer
Application	Structure	P	S	P	P	P	
	Config	S	P	S	S	S	P
	Behaviour	S		P		P	
	Process	P		S		P	
Software Platform	Incorp Mechs	P	P	S	S	P	
	Custom Mechs	P	S	P	P	P	
Shared Services	Config	S	P	S	S	S	P
Operating	Config	S	P	S	S	S	P
C&N	Config	S	P	S	S	S	P
Systemic Qualities		P		S		P	

P = Primary Interest
S = Secondary Interest

Patterns View – Organised by the cube - Example



Web, Mobile, App

API Gateway
Backend Front End

- MVC
- Front Controller
- MVP
- PM
- MVVM
- Service Worker

- Application Controller
- MacroServices
- MicroServices
- Unit of Work
- Remote Facade

- Service
- Entities
- Aggregate
- Specification
- Value Object

- Repository
- Data Mapper
- Table Module (TM)
- Transaction Script (TS)
- Active Record (AR)
- Query Object
- Table Data Gateway
- Row Data Gateway
- DAO
- Circuit Breaker
- Client Load Balancer
- Bulkhead

- Service Registry
- Configuration Service
- Monitoring Service
- Authorisation

Horizontal Scaling
Immutable Servers

- Separated Interface
- DTO
- Adapter
- Command
- Observer
- Feature Toggle

SAD* Structure – The Word Template - Part 1

1. **Introduction**
   - 1.1. Background
   - 1.2. Purpose
   - 1.3. Scope

2. **Goals and Requirements**
   - 2.1. Quality of Service Goals
   - 2.2. Technical Requirements
   - 2.3. Constraints and Dependencies
     - 2.3.1. Development Process and Team
     - 2.3.2. Environment and Technology
     - 2.3.3. Delivery and Deployment
   - 2.4. Assumptions

3. **Risks and Architecturally Significant Requirements**
   - 3.1. Risks Addressed
   - 3.2. Architecturally Significant Requirements

4. **High Level Solution Overview**

5. **Software Application Layer**
   - 5.1. Structure View
     - 5.1.1. Client Tier
     - 5.1.2. Access Tier
     - 5.1.3. Presentation Tier
     - 5.1.4. Services Tier
     - 5.1.5. Domain Tier
     - 5.1.6. Integration Tier
     - 5.1.7. Resource Tier
   - 5.2. Configurations View
   - 5.3. Behaviour View
   - 5.4. Process View
   - 5.5. Security and Identity
     - 5.5.1. Identity Management
     - 5.5.2. Access Management
     - 5.5.3. Encryption / Tokens / Certificates
   - 5.6. Data Across Tiers
   - 5.7. Evolutionary Considerations

Evolutionary Considerations – where are we heading strategically, next release, architectural runway.

*SAD = System Architecture Document

SAD Structure – Part 2

6. **Software Platform Layer**
   - 6.1. Client Tier
   - 6.2. Presentation Tier
   - 6.3. Integration tier
   - 6.4. Resources Tier
   - 6.5 **Software Infrastructure**
     - 7.1. Incorporated Mechanisms
     - 7.2. Custom Mechanisms
   - 7.3. Evolutionary Considerations

8. **Enterprise Services and Infrastructure**
   - 8.1. Services Configuration View
   - 8.2. Infrastructure Configuration View
   - 8.3. Evolutionary Considerations

9. **Operating Platform Layer**
   - 9.1. Configurations View
   - 9.2. Evolutionary Considerations

10. **Compute and Network Layer**
    - 10.1. Configurations View
    - 10.2. Evolutionary Considerations

11. **Facilities**

11. **Qualities of Service Review**
    - 11.1. Availability
    - 11.2. Scalability
    - 11.3. Performance
    - 11.5. Agility, Extensibility and Flexibility
    - 11.6. Security, etc

For each Quality / Concern

Item	Description
Requirement	
Architectural Solution	
Validation Strategy	
Evolutionary Considerations	

Solution Arch Document (Common Mini EA Based Style)

1. Introduction
2 Capability Definition
   - 2.1 Business Rationale
   - 2.2 Business Drivers
   - 2.3 Scope
   - 2.3.1 Objectives
   - 2.4 Core Functional Requirements
3 Business Context Overview

4 Solution Overview
   - 4.1 Key Non-Functional Requirements

5 Solution Phase Overview
   - 5.1 Current Solution
   - 5.2 Proposed Solution
   - 5.3 Identified Future Capabilities

6 High Level Process Overview
   - 6.2 AS-IS Process Impacts

7 Application Architecture
   - **7.1 Platform and Capabilities**
   - **7.2 Application Context**
   - **7.3 Capabilities Definitions**
   - **7.5 Non Functional Considerations**

8 Data Architecture

9 Integration Architecture

10 Technical Architecture

A mini EA, a segment capability.

11 Data Conversions and Migrations

13 Risks, Issue, Assumptions and Dependencies

14 Architectural Decisions

Solution Arch Document (4+1 Based Style)

1 Introduction

2 Scope

3. Software Architecture

4. Architectural Goals & Constraints

5. Logical Architecture

6. Process Architecture

7. Development Architecture

8. Physical Architecture

9. Scenarios

10. Size and Performance

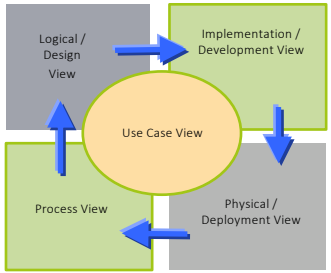
11. Quality

Appendices

A. Acronyms and Abbreviations

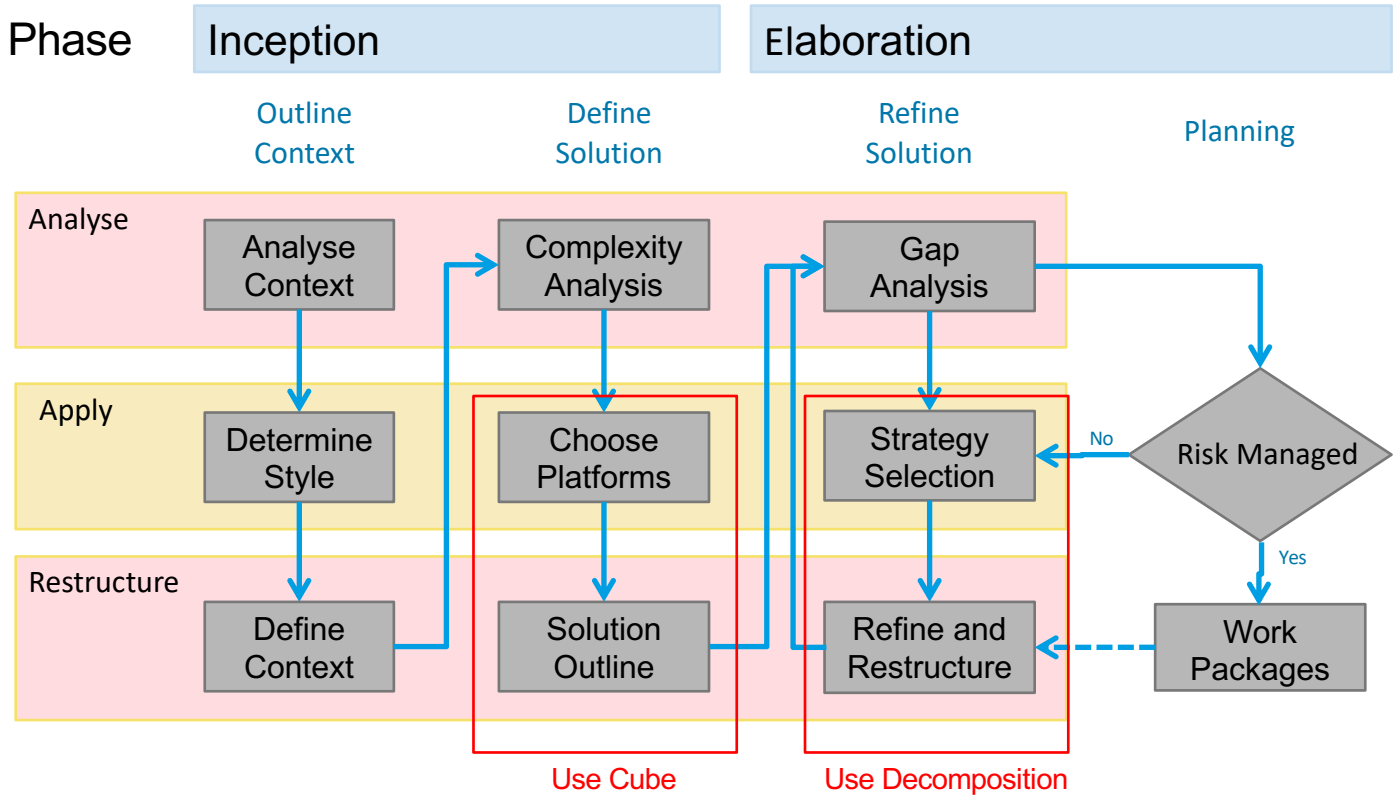
B. Definitions

C. Design Principles



The Approach

Cube Architecture Approach in RUP Lifecycle (Phases)



Cube Architecture Steps

Choose Platforms Step:

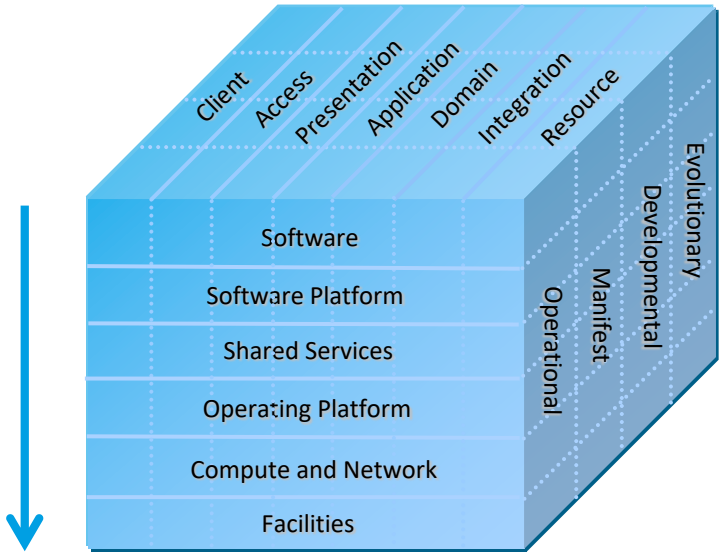
While Risks/Gaps do {

- Select
- Instantiate
- Determine Arch Significant Items
- Analyse Gaps
- Analyse Risks

For each Tier {

- Determine the Software and Hardware Stack
- Document Incrementally using Cube Template

}



12 Decomposition Heuristics fit in Subsumption Groups

Always consider applying all 12 heuristics

Heuristic (subsumption) group

Obey group ordering (1-5)

Order is not important within a group

Group	Order	Heuristic
One	1	Bounded Context/Teams
Two	2	Layering/Service Tiering
	3	Distribution
	4	Exposure
	5	Functionality
	6	Generality
	7	Aspectual
Three	8	Coupling & Cohesion
	9	Volatility
Four	10	Configuration
Five	11	Planning & Tracking
	12	Work Assignment

2 Dimensions of Cube

Decomposition Heuristics

Heuristic	Description
Bounded Context/Teams	Partition the domain into areas with a common ubiquitous language. Understand relationship types. Structure teams within contexts to be independent and autonomous.
Layering/Service Tiering	Ordering of concerns; cohesive services within a layer, expose via interface – low coupling.
Distribution	Partitioning by distribution among computational resources, provides scalability;
Exposure	Decide what to expose to other components, via interfaces. Separate implementation.
Functionality	Decompose into Functional units ,e.g. service groupings within the problem space.
Generality	How general or specific to make something to make it reusable across projects or products.
Aspectual	Cross-cutting concerns, implemented as aspects, e.g. logging, security.
Coupling & Cohesion	Partition by Reducing Coupling and Increasing Cohesion.
Volatility	Isolate things that are more, verses less likely to change, or things that simply change on different schedules.
Configuration	Systems must support different configurations (for environments, pricing, usability, performance, security, etc.)
Planning & Tracking	Break a big thing apart so that work can be defined in smaller time units against the smaller parts.
Work Assignment	Partition by physically-distributed teams, matching skill-sets, security areas (clearance), and contractual concerns.

Micro ‘Service’

A microservice architecture is:

“a *service-oriented architecture composed of loosely coupled elements that have bounded contexts*.”

Adrian Cockcroft (Director of Web Engineering Netflix)

"The microservice architectural style is an approach to developing a single application as a suite of small services, each running in its own process and communicating with lightweight mechanisms, often an HTTP resource API. These services are built around business capabilities and independently deployable by fully automated deployment machinery.”

Martin Fowler in March 2014

Microservice Method

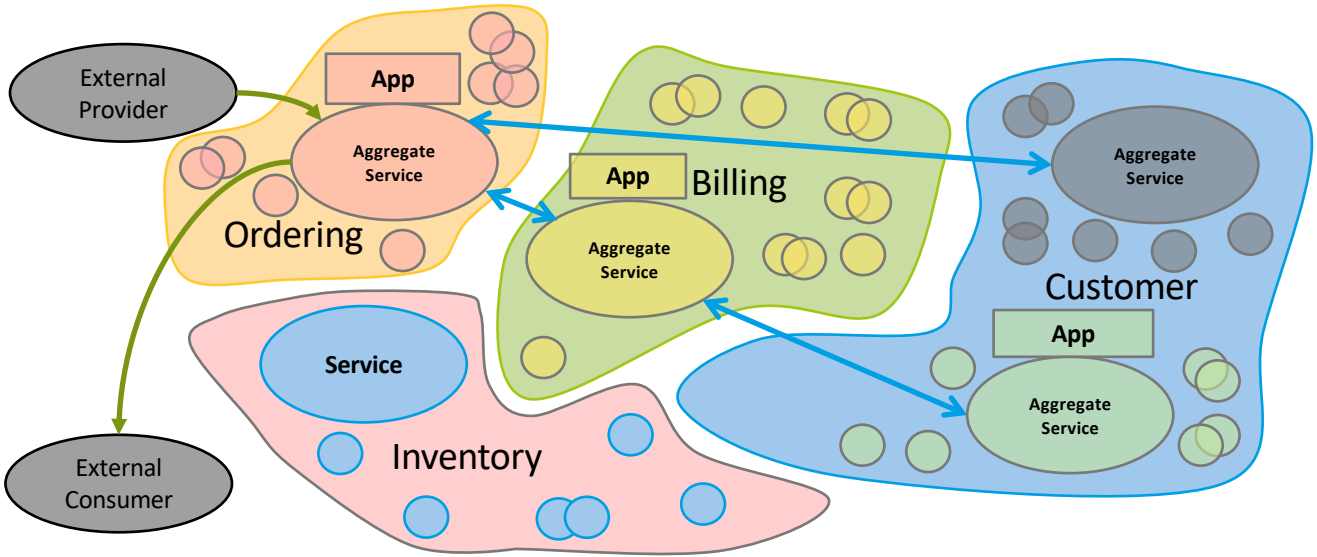
1. Start by analysing the business domain to understand the application's functional requirements. The output of this step is an informal description of the domain, which can be refined into a more formal set of domain models.
    1. Ensure the NFRs, and constraints are also understood. Each microservice may have different NFRs.
2. Next, define the *bounded contexts* of the domain. Each bounded context contains a domain model that represents a particular subdomain of the larger application.
3. Within a bounded context, apply tactical DDD patterns to define entities, aggregates, and domain services.
4. Use the results from the previous step to identify the microservices in your application.

MicroServices - Separated by Concern (Bounded Context)

The business can be broken into 'Small' Fine Grained services that exists within within bounded contexts.

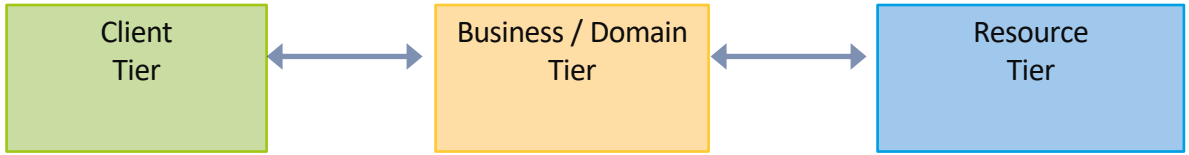
Theses contexts have a separation of concerns and capability, that are independently and continuously deployed, managed, monitored.

- Applications may be made up of 100's of MicroServices;
- May need to provide encompassing aggregates of these for consumers to consume more easily;
- Need to provide a way for consumers to find and use services.



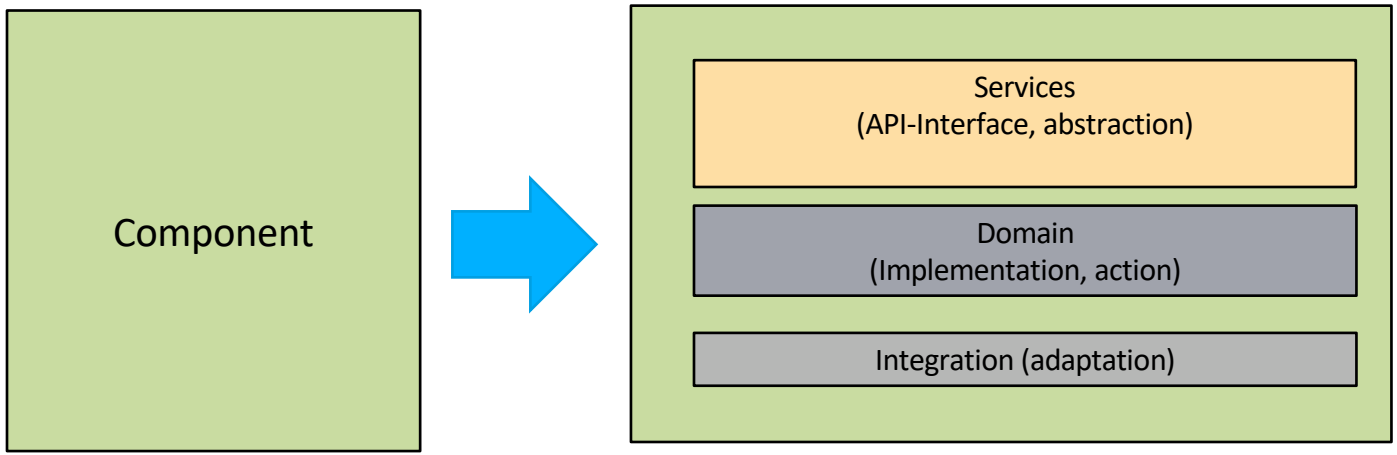
Distribution (Tiering)

- Decomposition according to some ordering principle, typically partitioning and **distribution** among computational resources (containers/VMs/boxes).
- Primary technique for building scalable systems.
- Separation of concerns to separate layers and then deploy each separately to separate tiers.
- Example: 3 Tier System



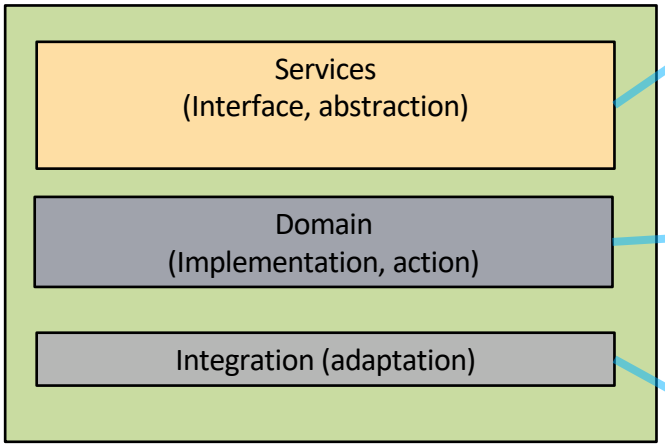
Exposure - Break Monolith into Layers

- Decide what to expose to other components, via an API
- Any given component fundamentally has three different aspects (layers)



Micro Service Layers – Exposing a Component

Applying the layered architecture pattern to components, e.g. a Microservice component



- Protocol Abstraction – Client channel
- Logical Abstraction – expose for particular use cases

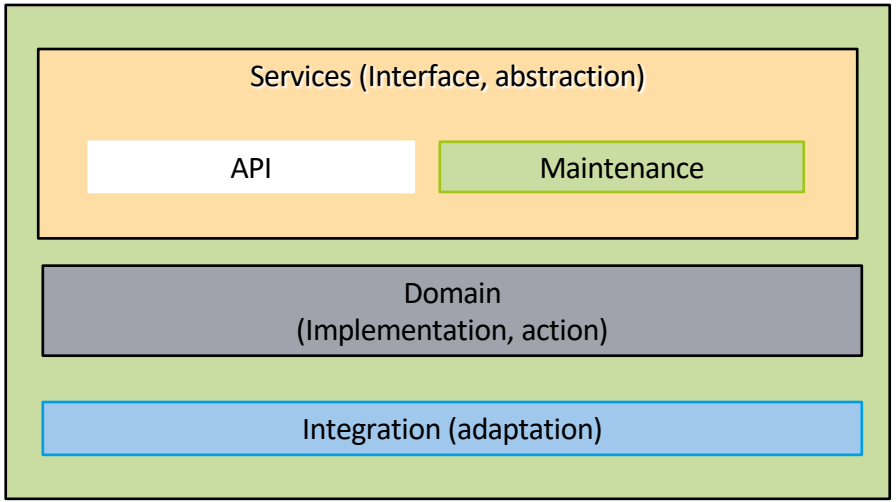
- Application Logic Implementation, Workflow/Orchestration.
- Manage Data

- Logical Adaption - of tiers below for what we need (transform and protect via anti corruption layer)
- Protocol Adaption – connect and to talk to tier below

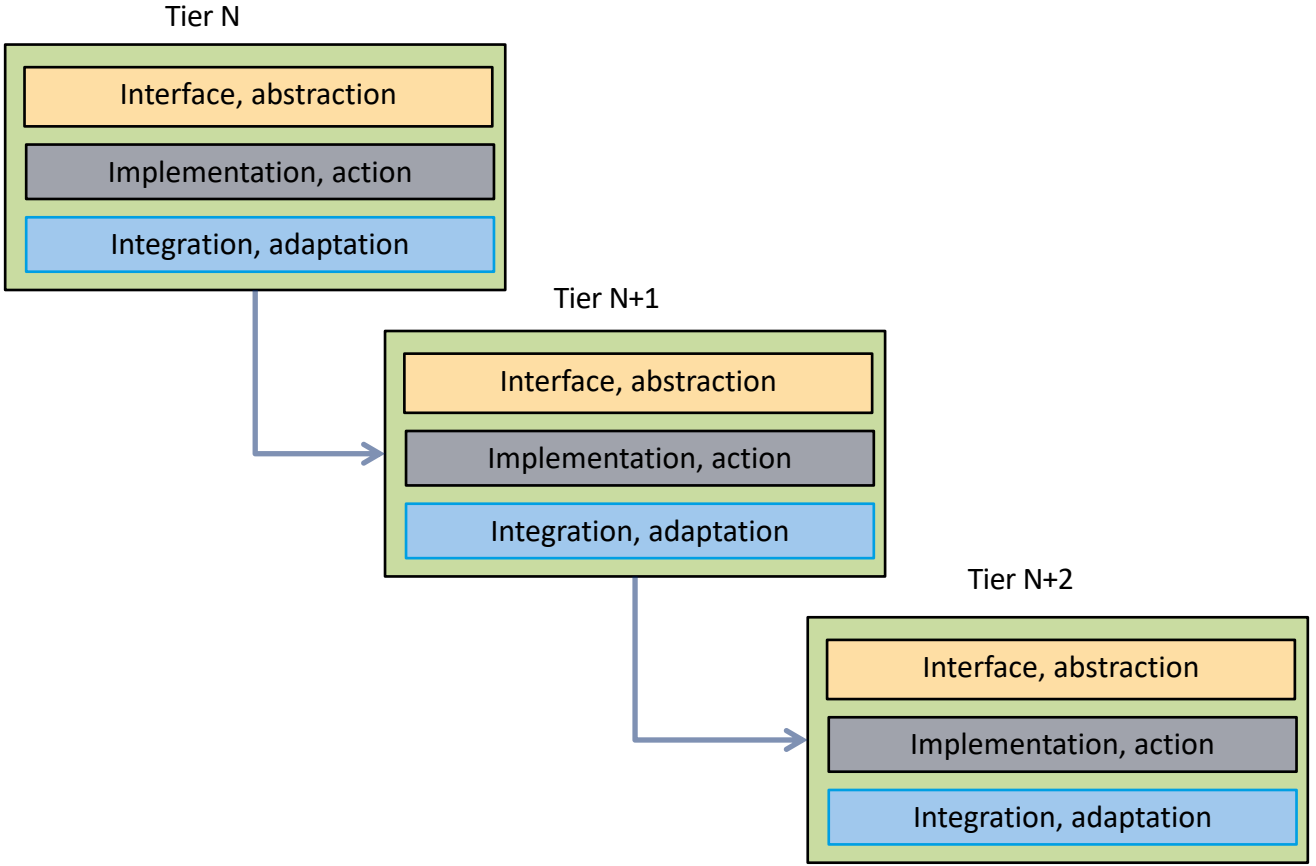
Exposure – Add Operations Interfaces

For complex units these may be broken apart into several pieces, and Interfaces for both:

- API (Data and Business Functions)
- Maintenance (Operations), Management of the Component



Exposing Tiers - Layers



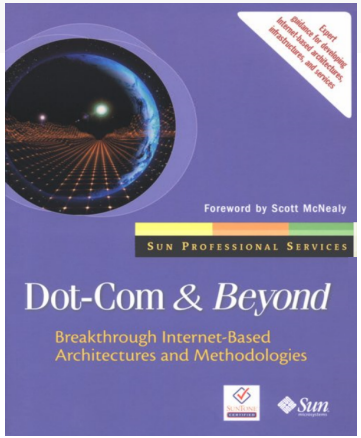
The Value of the Cube – a tool for analysing your architecture

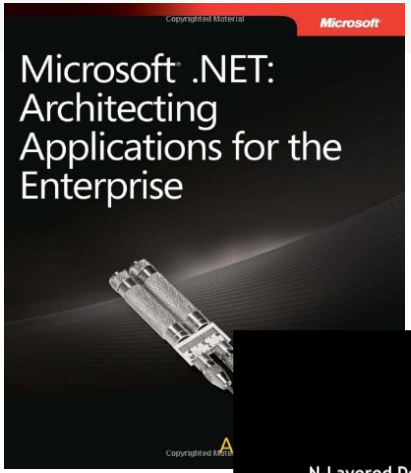
- Make Architecture Orthogonality Explicit by Clarifying:
  - **Tiers**: Conceptual, Logical and Physical:
    - Services;
    - Decomposition Decisions;
    - Deployment Decisions.
  - **Layers**: of Software/Hardware, Platforms and Infrastructure;
  - **Qualities Of Service (QOS)**
    - Cross Cutting concerns that drive continuous architecture.
- Provide Views and Viewpoints:
  - Provide a clear set, relevant to stakeholders;
  - Organised in context, within layers, across tiers and QOS.
- A Framework that is both:
  - Descriptive – use to analyse, review, evaluate and explain existing systems;
  - Prescriptive – model new systems.
- Basis for an architectural process and decision making.
- Covers:
  - Modern Styles: N-Tier, SOA, Micro-Services and Cloud(PaaS, Iaas, SaaS)
- Benefits: Agility, Continuous Delivery, Reuse

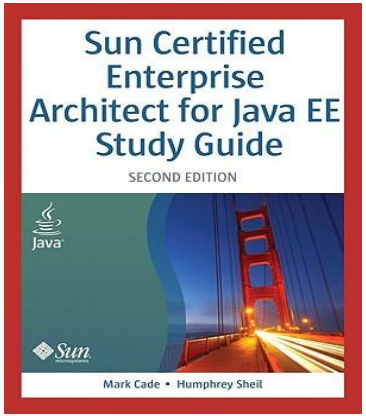
References:

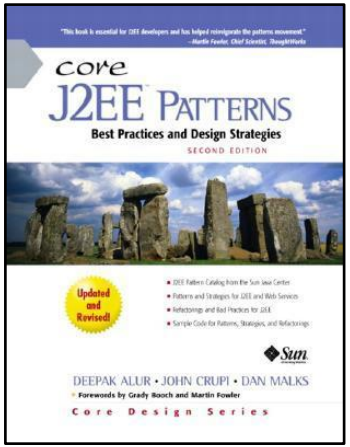
Cube was basis of:

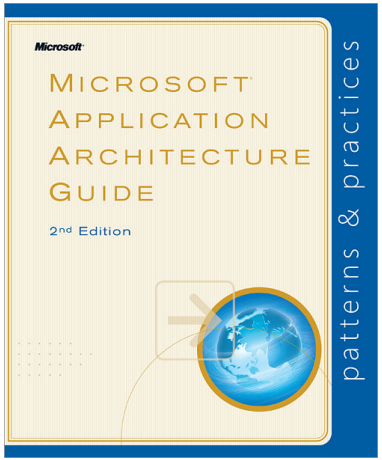
- Sun's 'Dot-Com & Beyond' - Architecture Methodology Published: June 11, 2001;
- Sun Certified Enterprise Architect for Java EE Study Guide, 2010;
- J2EE Core Patterns;











Extended to cover .Net platforms

The End

Pattern Notes

- **Transaction Script:** A business component that captures procedural user actions and business logic, e.g. order product, book a flight, in a procedure/method.
- **Command Object**: Encapsulate request processing in a separate object with a common execution interface. Used to represent the script, the action.
- **Table Module**: A business component that handles the business logic for a whole DB table, e.g. customer_table, order_table. Although an object is used, it represents a DB table, not a domain object.
- **Active Record:** An object that wraps a record in a DB table or view, represents a row of data. Object holds table/entity attributes, with CRUD methods.
- **Data Mapper.** A mapping layer between objects and the database structure that is used to move data from one structure to another while keeping them independent.
- **Data Transfer Object.** An object that stores the data transported between processes, reducing the number of method calls required.
- **Query Object.** An object that represents a database query.
- **Repository.** An in-memory representation of a data source that works with domain entities.
- **Row Data Gateway.** An object that acts as a gateway to a single record in a data source.
- **Table Data Gateway.** An object that acts as a gateway to a table or view in a data source and centralizes all of the select, insert, update, and delete queries.
- **Record Set:** in memory representation of a DB table;