Enterprise architecture patterns

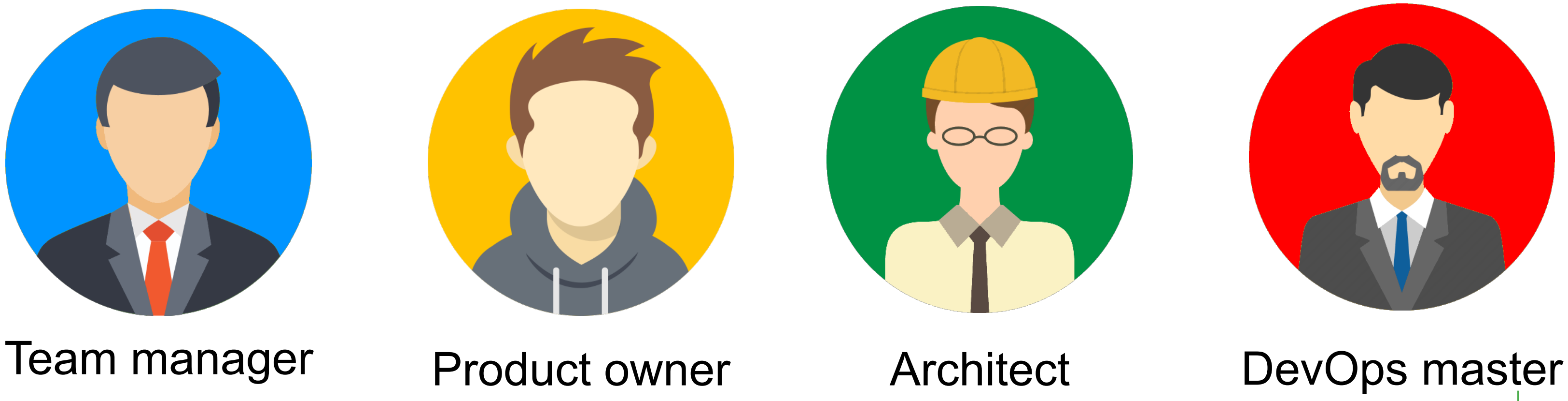
UA.DETI.IES - 2022/23

Recap

1. Software development process
   – Different models (sequential, incremental, evolutionary, …)

2. Agile development methods
   – Agile principles and project management

3. DevOps Technical benefits
   – Continuous integration and software delivery

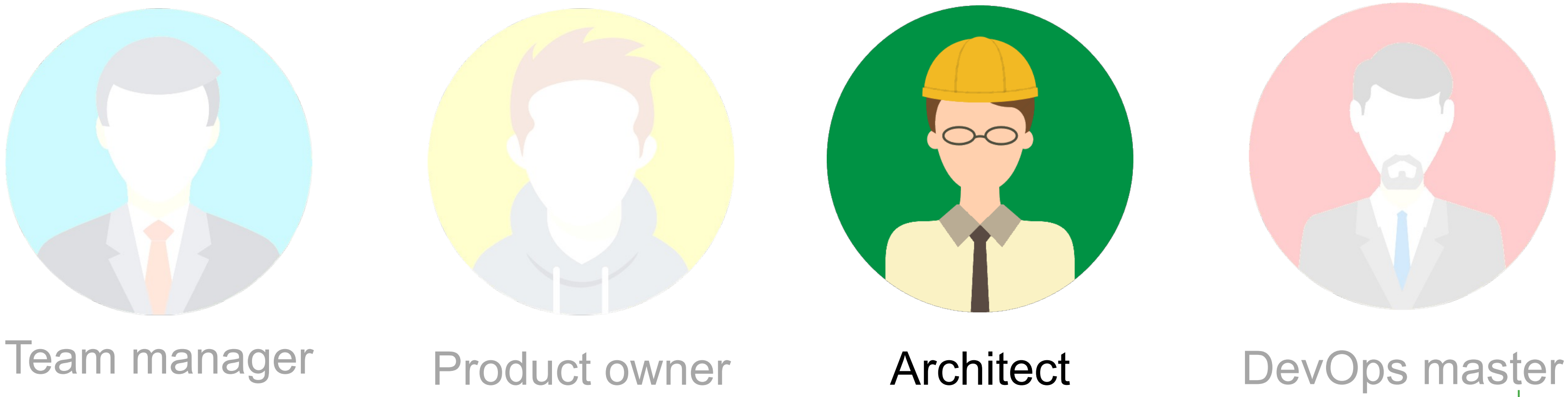


Recap

1. Software development process
   – Different models (sequential, incremental, evolutionary, ...)

2. Agile development methods
   – Agile principles and project management

3. DevOps Technical benefits
   – Continuous integration and software delivery



UNIVERSIDADE DE AVEIRO

Software architecture?

- Architecture is the **highest-level concept** of the expert developers.

  "In most successful software projects, the expert developers working on that project have a shared understanding of the **system design**.

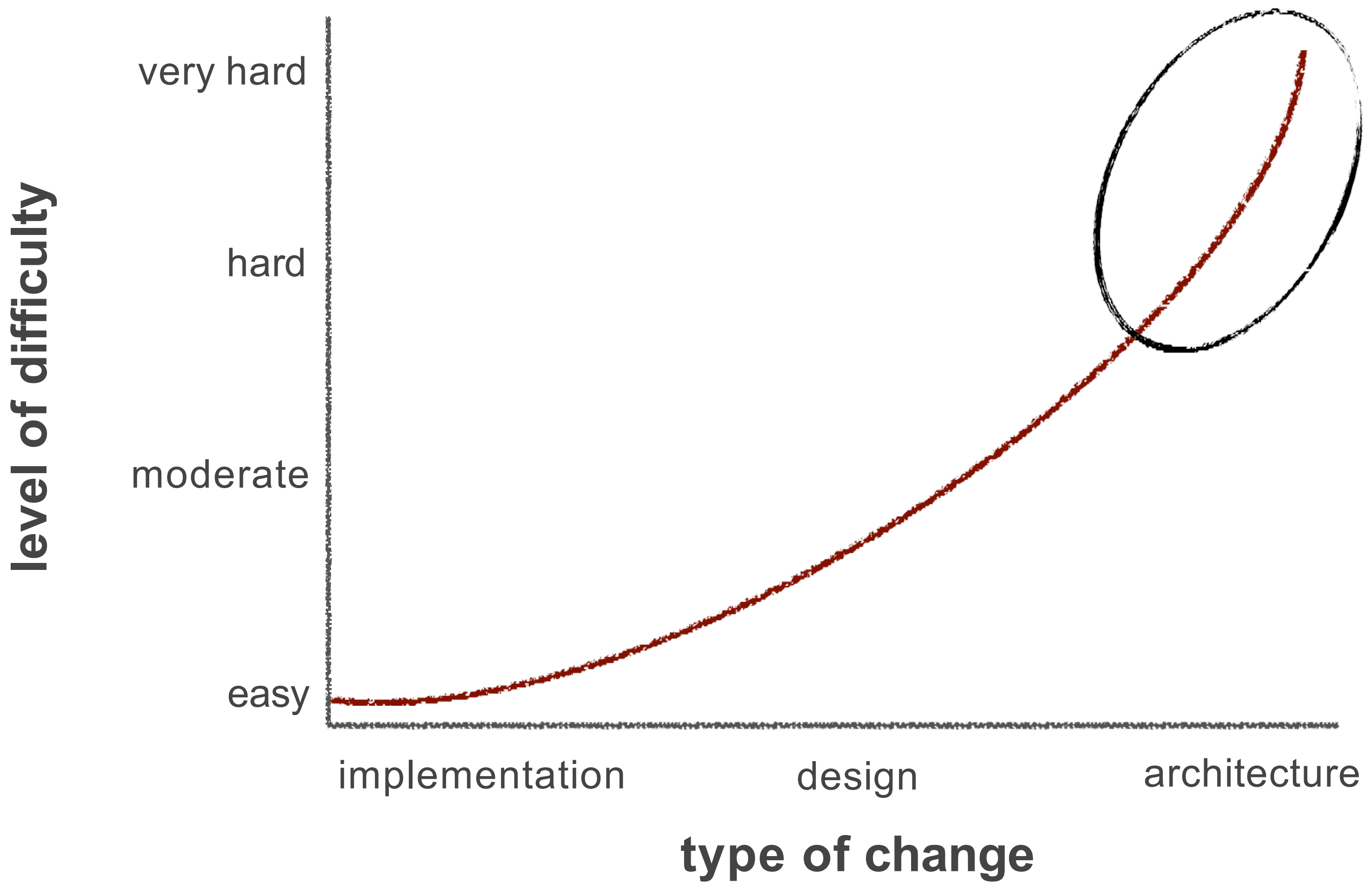
  This shared understanding is called 'architecture'.

  This understanding includes **how the system is divided** into components and how the components interact through interfaces.

  These components are usually composed of smaller components, but the architecture only includes the components and interfaces that are understood by all the developers."

  http://martinfowler.com/ieeeSoftware/whoNeedsArchitect.pdf

Architecture decisions



Architecture decisions

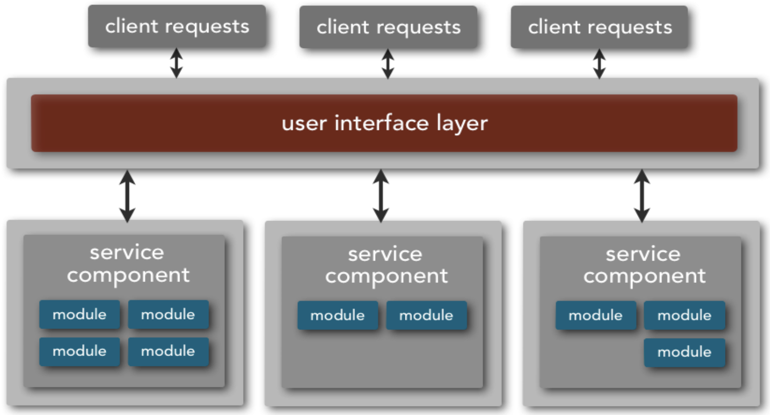
- The decision to use a **web-based** user interface for your application

- The decision to use java server faces as your **web framework**

JavaServer™ Faces JSF

Architecture decisions

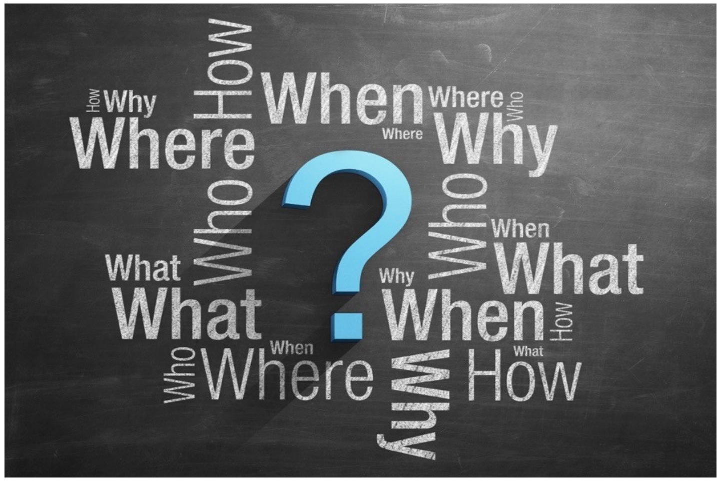
- The decision that components should be **distributed** remotely for better scalability



- the decision to use rest to **communicate** between distributed components

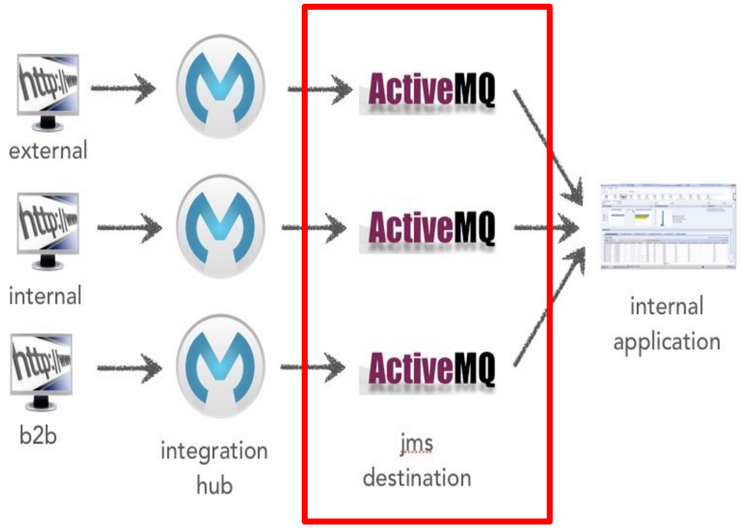
Justifying architecture decisions

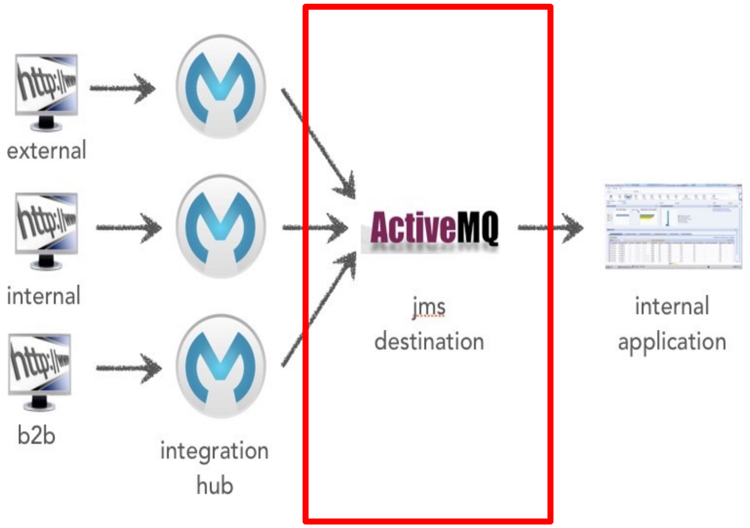
- **Groundhog day** anti-pattern
  - Important architectural decisions that were once made get lost, forgotten or are not communicated effectively
  - No one understands why a decision was made so it keeps getting discussed over and over and over...



Justifying decisions – Example

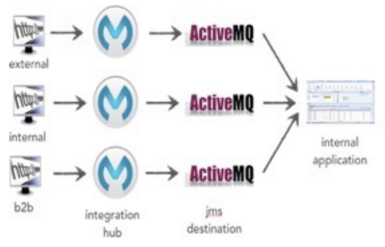
- Dedicated broker instances?
- Or a centralized broker?

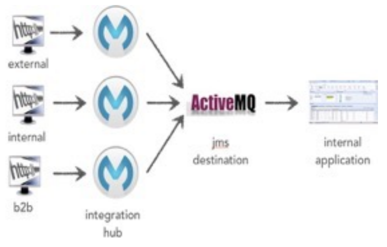




Justifying decisions – Example

- **Identify the conditions and constraints**
  - broker only used for hub access
  - low transaction volumes expected
  - application logic may be shared between different types of client applications (e.g., internal and external)
- **Analyze each option based on conditions**
  - broker usage and purpose
  - overall message throughput
  - internal application coupling
  - single point of failure
  - performance bottleneck
- **... Solution?**





Justifying decisions – Example

- Architecture **decision**:
  - centralized broker

- **Justification**:
  - the internal applications should not have to know from which broker instance the request came from
  - only a single broker connection is needed
    - allowing for the expansion of additional hub instances with no application changes.
  - due to low request volumes the performance bottleneck is not an issue;
    - single point of failure can be addressed through failover nodes.

Documenting and communicating

- Establish early on where your decisions will be documented and **make sure every team member knows** where to go to find them
  - In a central document or wiki, rather than multiple files spread throughout a crowded shared drive

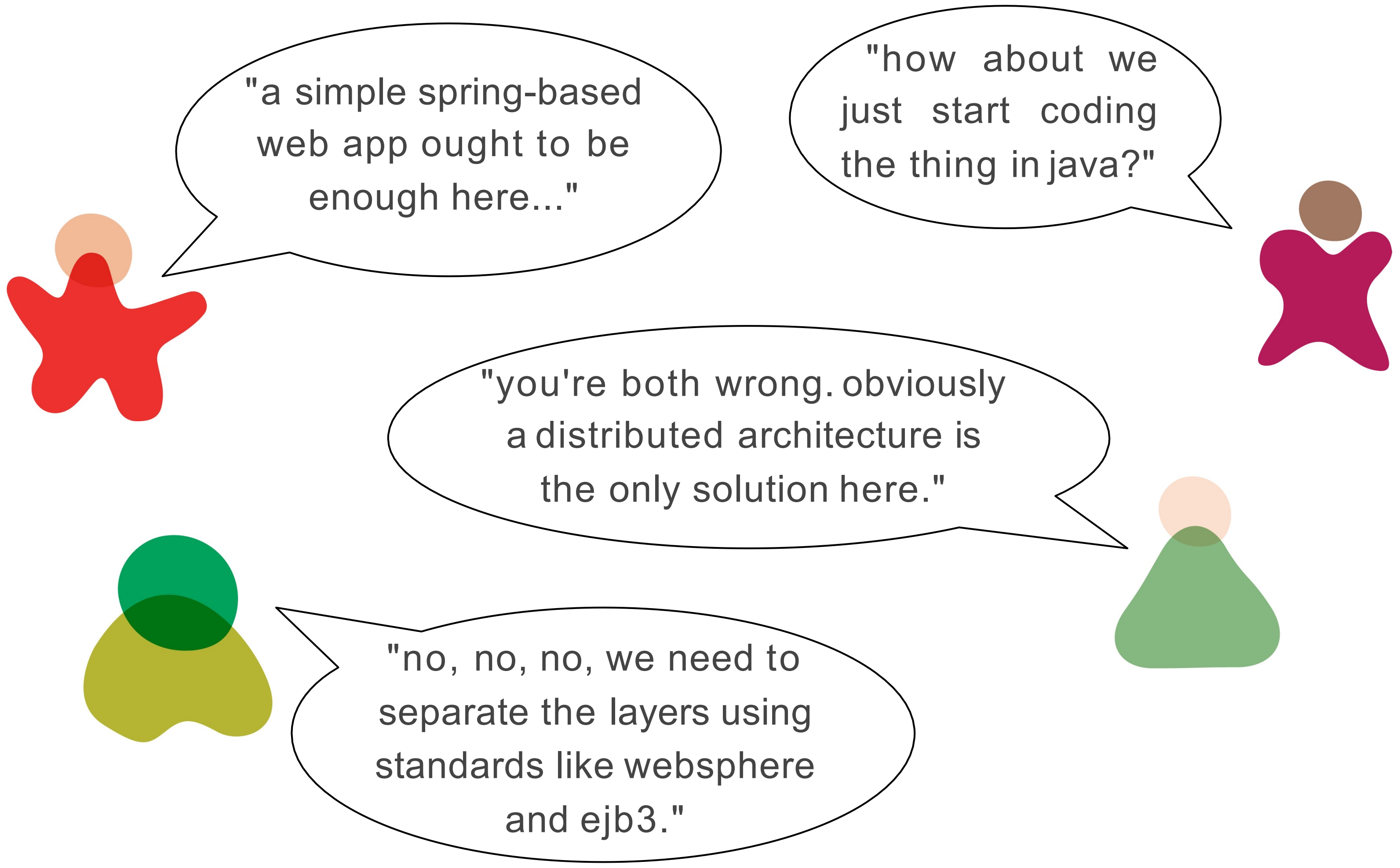
- Email-driven solutions (… not 😐)
  - people forget, lose, or don't know an architecture decision was made
  - therefore, don't implement the architecture correctly

Avoid Witches brew architecture

- Architectures designed by groups resulting in a complex mixture of ideas and no clear vision

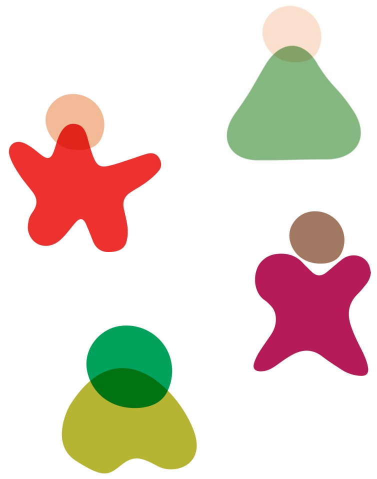
UNIVERSIDADE DE AVEIRO

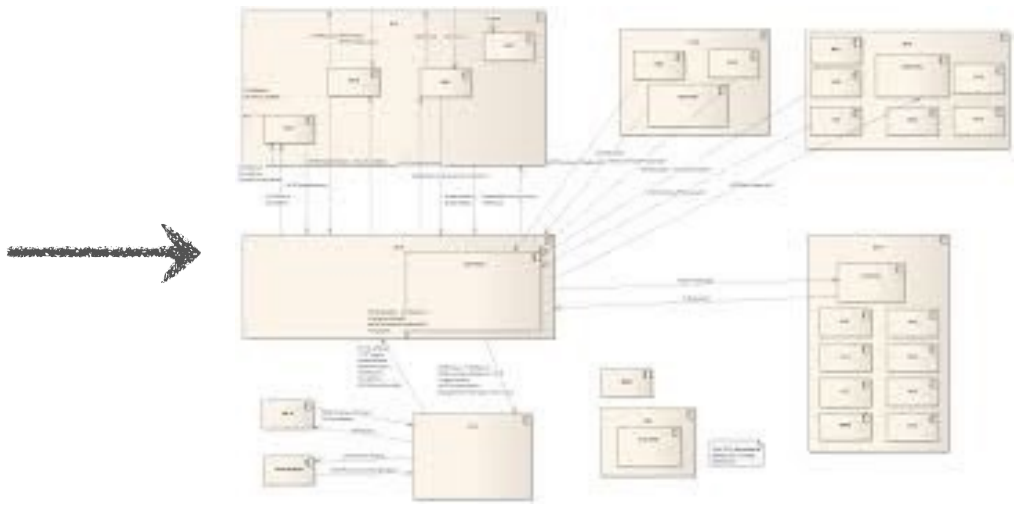
The problem


"a simple spring-based web app ought to be enough here..."
"how about we just start coding the thing in java?"
"you're both wrong. obviously a distributed architecture is the only solution here."
"no, no, no, we need to separate the layers using standards like websphere and ejb3."

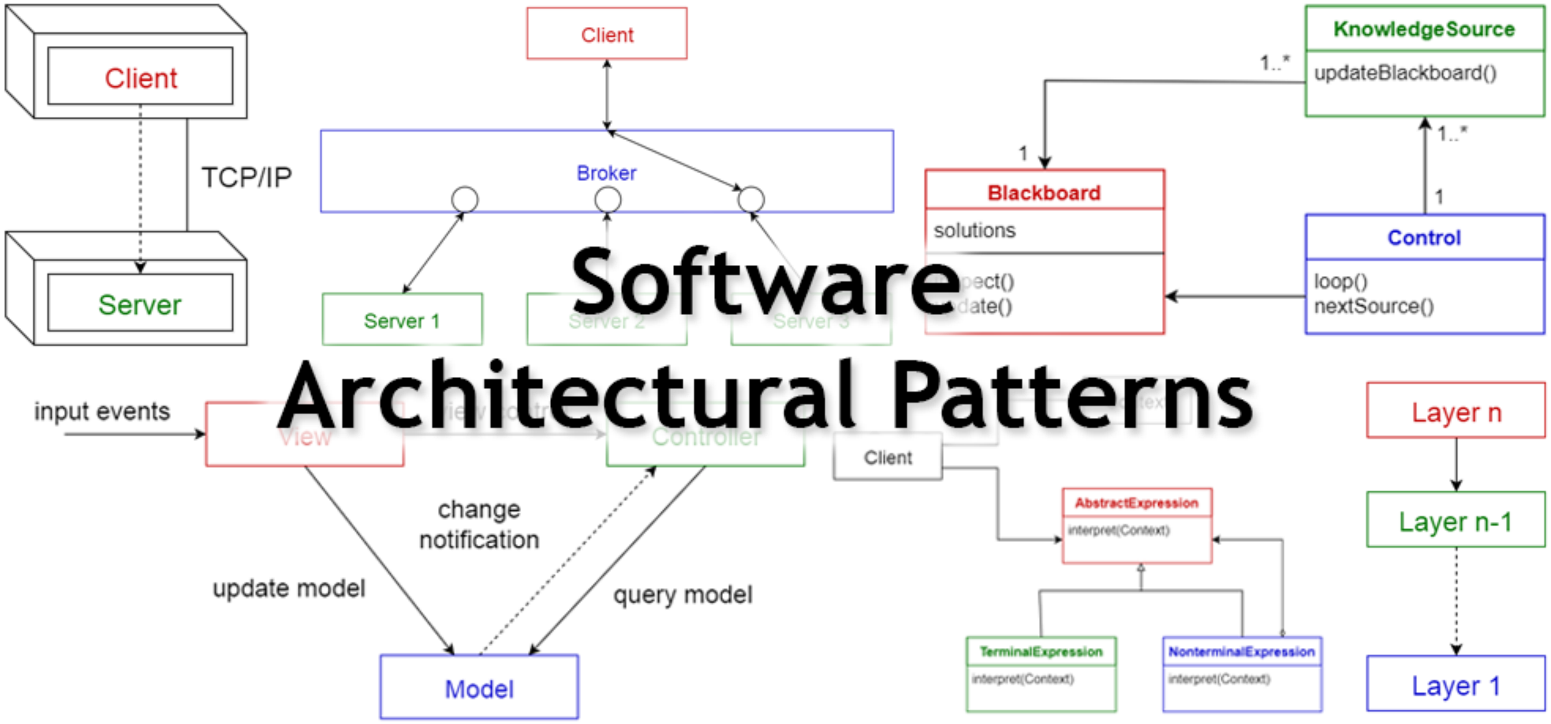
The goal

- Using collective knowledge and experience to arrive at a unified vision for the architecture

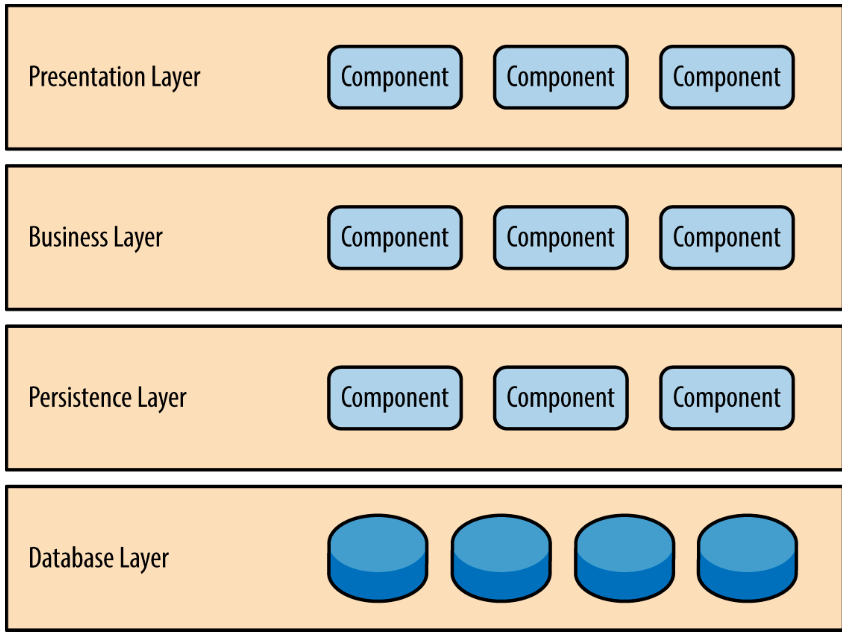


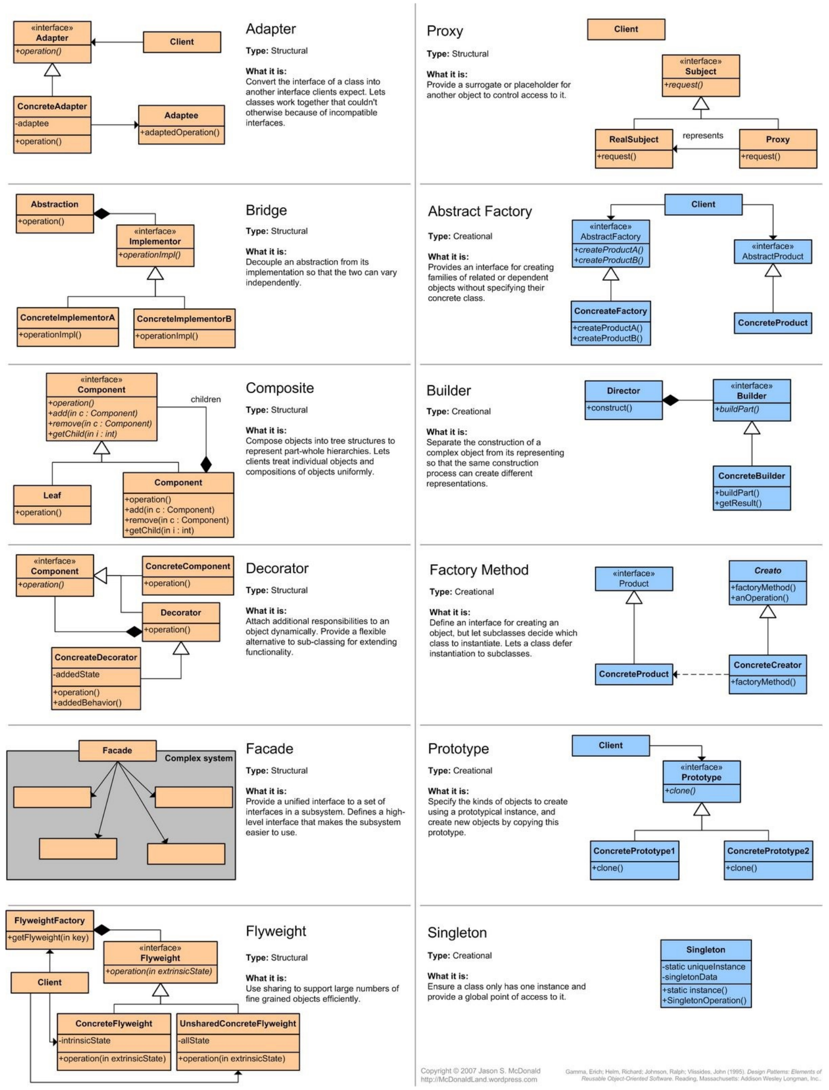


Architecture Patterns



Architectures, Components, Classes





Adapter

Type: Structural

What it is:
Convert the interface of a class into another interface clients expect. Lets classes work together that couldn't otherwise because of incompatible interfaces.

Proxy

Type: Structural

What it is:
Provide a surrogate or placeholder for another object to control access to it.

Bridge

Type: Structural

What it is:
Decouple an abstraction from its implementation so that the two can vary independently.

Abstract Factory

Type: Creational

What it is:
Provides an interface for creating families of related or dependent objects without specifying their concrete class.

Composite

Type: Structural

What it is:
Compose objects into tree structures to represent part-whole hierarchies. Lets clients treat individual objects and compositions of objects uniformly.

Builder

Type: Creational

What it is:
Separate the construction of a complex object from its representing so that the same construction process can create different representations.

Decorator

Type: Structural

What it is:
Attach additional responsibilities to an object dynamically. Provide a flexible alternative to sub-classing for extending functionality.

Factory Method

Type: Creational

What it is:
Define an interface for creating an object, but let subclasses decide which class to instantiate. Lets a class defer instantiation to subclasses.

Facade

Type: Structural

What it is:
Provide a unified interface to a set of interfaces in a subsystem. Defines a high-level interface that makes the subsystem easier to use.

Prototype

Type: Creational

What it is:
Specify the kinds of objects to create using a prototypical instance, and create new objects by copying this prototype.

Flyweight

Type: Structural

What it is:
Use sharing to support large numbers of fine grained objects efficiently.

Singleton

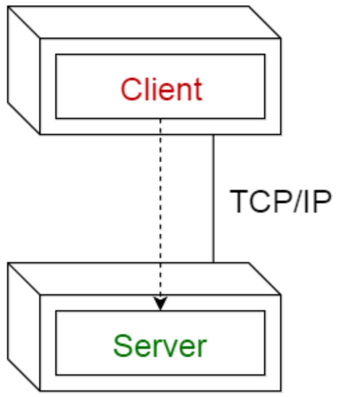
Type: Creational

What it is:
Ensure a class only has one instance and provide a global point of access to it.

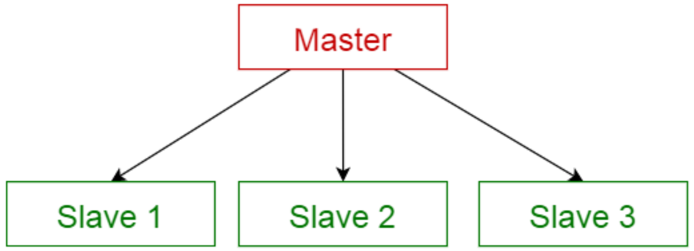
Gamma, Erich; Helm, Richard; Johnson, Ralph; Vlissides, John (1995). *Design Patterns: Elements of Reusable Object-Oriented Software*. Reading, Massachusetts: Addison Wesley Longman, Inc..

(Simpler) Architecture Patterns

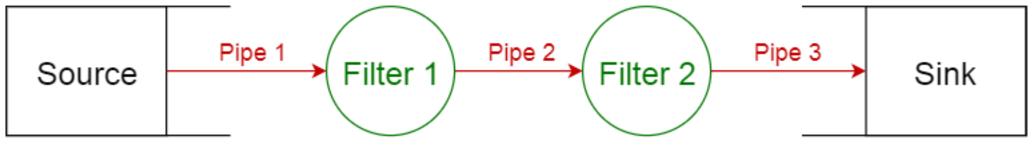
- Client-server pattern
  - online apps, email, ..



- Master-slave pattern
  - multi-threaded apps, database replication



- Pipe-filter pattern
  - Compilers, streamed processes, buffering or synch



Architecture Patterns

- Microkernel Architecture

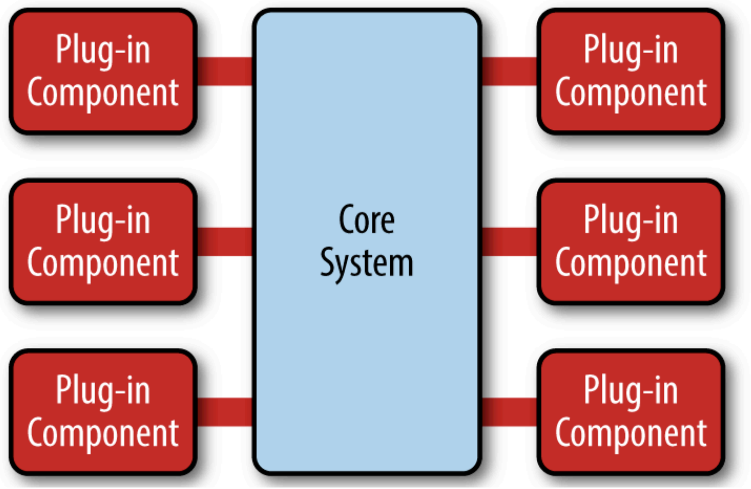
- Layered Architecture
- Event-Driven Architecture

- Service-oriented Architecture
- Microservices Architecture

- Space-Based Architecture

Microkernel Architecture

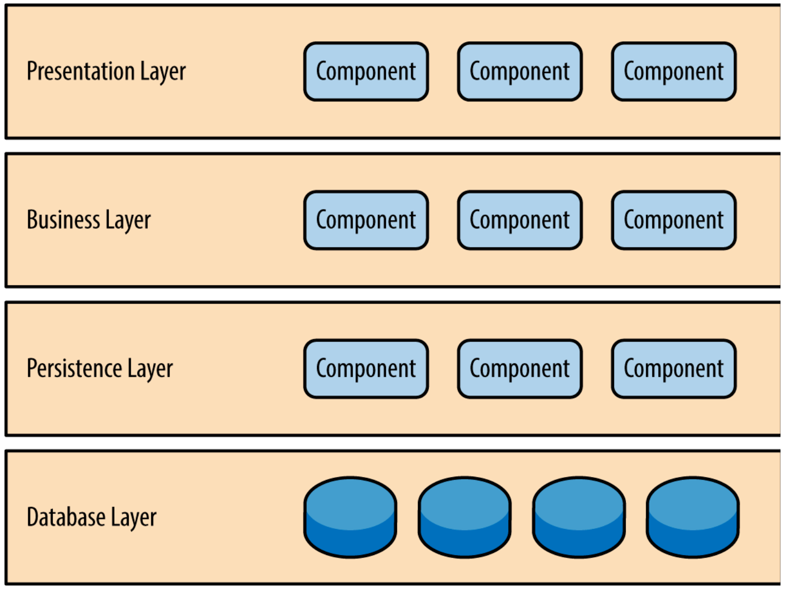
- **Core** application (stable) + **plugins** (dynamic)
  - New application features are added as plug-ins
  - Extensibility, feature separation and isolation.



- It can be embedded or used as part of another architecture pattern.
- A good first choice for product-based applications.

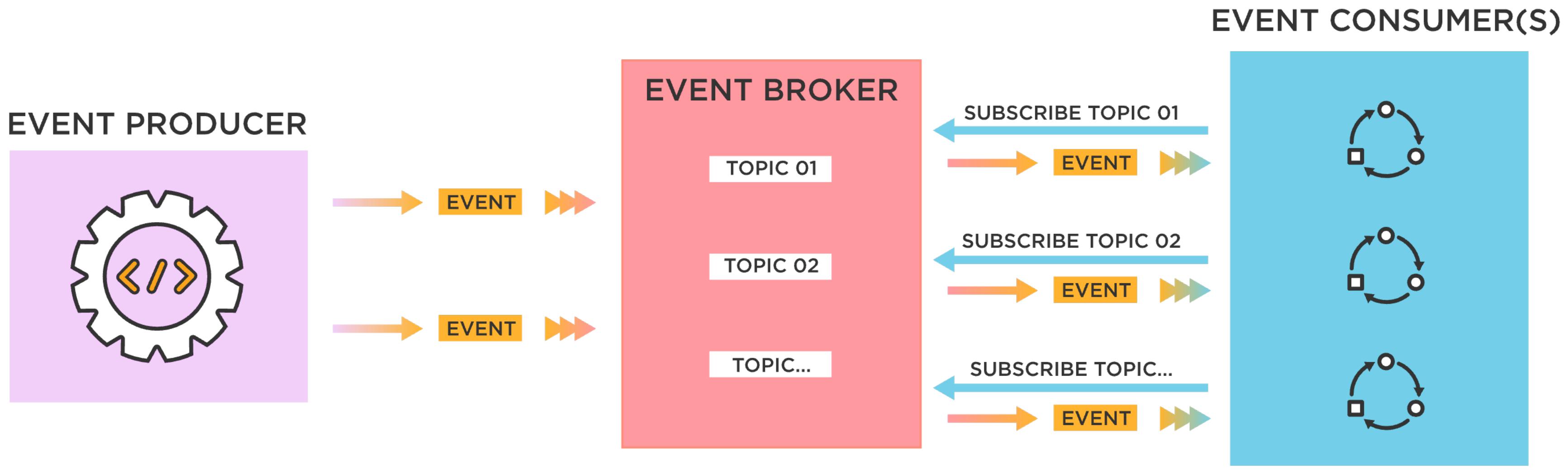
Layered Architecture (n-tier)

- The most common architecture pattern.
- A *de facto* standard for most Java EE applications.
- Each layer has a specific role and responsibility.
  - Separation of concerns
- Closely matches the organizational structures found in most companies.
- Solid general-purpose pattern
  - making it a good starting point for most applications



Event-driven Architecture

- **Distributed and asynchronous**
  - used to produce highly scalable applications.
  - AKA, message-driven or stream processing



Event-driven Architecture

- The event-driven architecture pattern is a relatively **complex** pattern to implement
  - Primarily due to its asynchronous distributed nature
- **Lack of atomic transactions** for a single business process
  - Event processor components are highly decoupled and distributed
  - It is very difficult to maintain a transactional unit of work across them
- A key aspect is the **creation, maintenance, and governance** of the event-processor component contracts.

Architecture Patterns (*recap*)

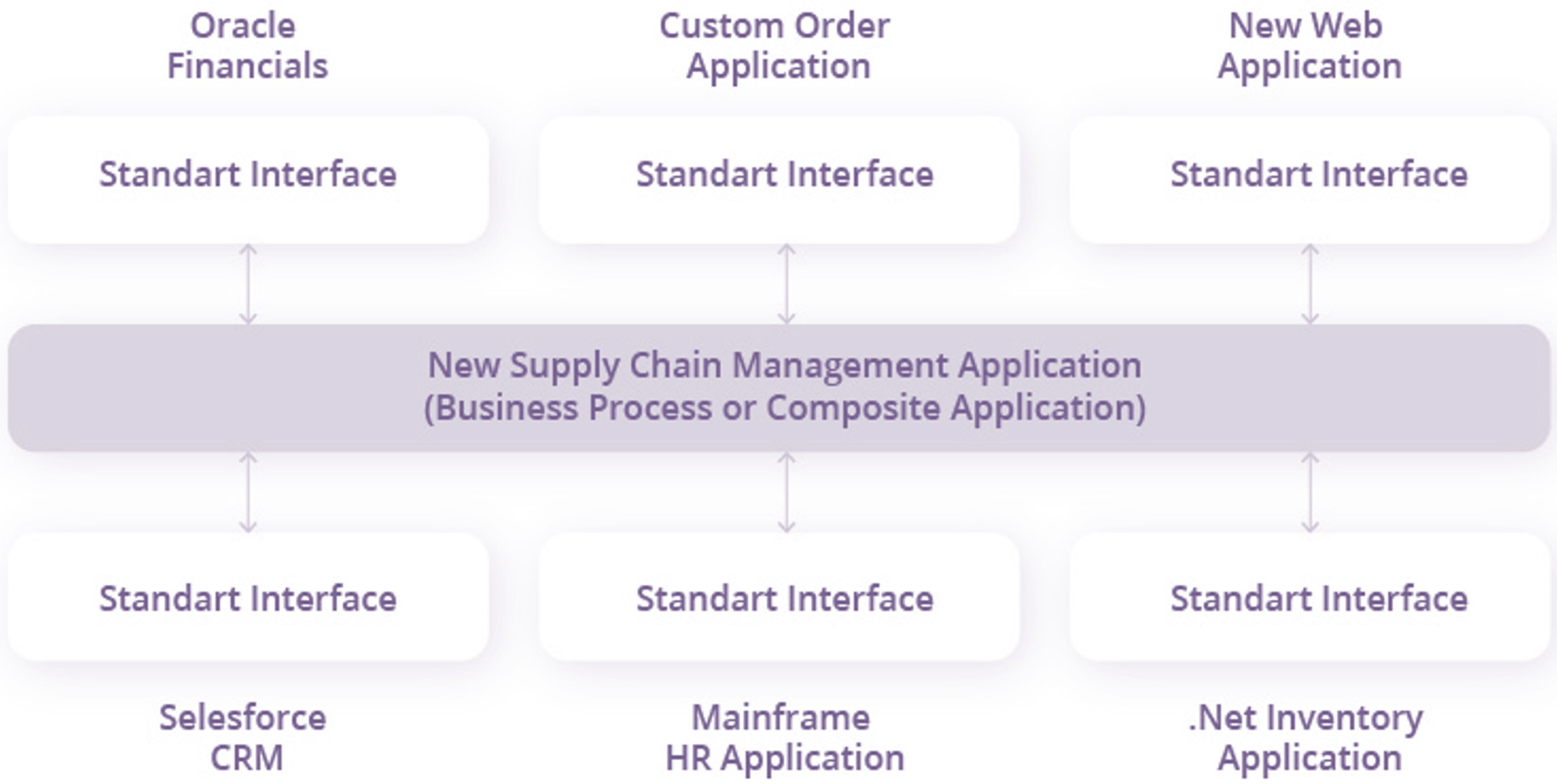
- Microkernel Architecture

- Layered Architecture
- Event-Driven Architecture

- **Service-oriented Architecture**
- Microservices Architecture

- Space-Based Architecture

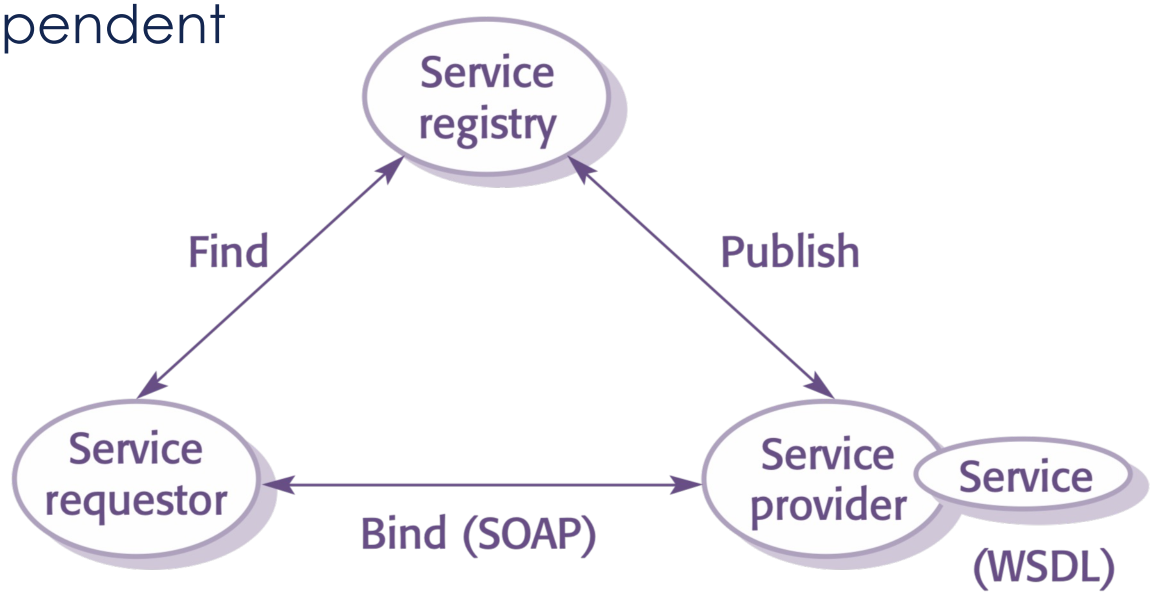
Service-Oriented Architecture (SOA)



Service-Oriented Architecture (SOA)

- A means of developing distributed systems where the components are stand-alone services

- Key characteristics
  - Standardized Service Contracts
  - Language-independent
  - Loose Coupling
  - Abstraction
  - Reusability
  - Autonomy
  - Statelessness
  - Discoverability
  - Composability



SOAP (Simple Object Access Protocol)

- A protocol based on XML language.
  - Platform and language independent communication.
- The structure of SOAP messages:
  - An Envelope identifying the XML document as a SOAP msg
  - A Header element that contains header attributes
  - A Body containing call and response information
  - A Fault element containing errors and status information

```xml
<?xml version="1.0"?>
<soap:Envelope
xmlns:soap="http://www.w3.org/2003/05/soap-envelope/"
soap:encodingStyle="http://www.w3.org/2003/05/soap-encoding">
<soap:Header>
...
</soap:Header>
<soap:Body>
...
      <soap:Fault>
       ...
      </soap:Fault>
</soap:Body>
</soap:Envelope>
```

RESTful web services

- SOAP/WSDL based web services
  - Not as simple as the acronym would suggest.
  - Criticized as 'heavyweight' standards that are over-general and inefficient.

- An alternative…

- **REST (REpresentational State Transfer)**

RESTful web services

- An architectural style based on **transferring representations of resources** from a server to a client.

- **It is simpler than SOAP/WSDL** for implementing web services

- RESTful services involve a lower overhead than so-called 'big web services'
  - are used by many organizations implementing service-based systems

https://nordicapis.com/rest-better-than-soap-yes-use-cases/

REST (REpresentational State Transfer)

- When REST is used, requests can be sent to various endpoints through **GET**, **PUT**, **POST** and **DELETE** HTTP requests.
- Provides a stateless, simpler and lightweight way of communicating with a system.
- It uses JSON format to send and receive data.
  - This format is a simple text containing a series of attribute-value pairs

```
{ "trade":
   {
       "cust_id": "12345",
       "cusip": "037833100",
       "shares": "1000",
   }
}
```

Resources

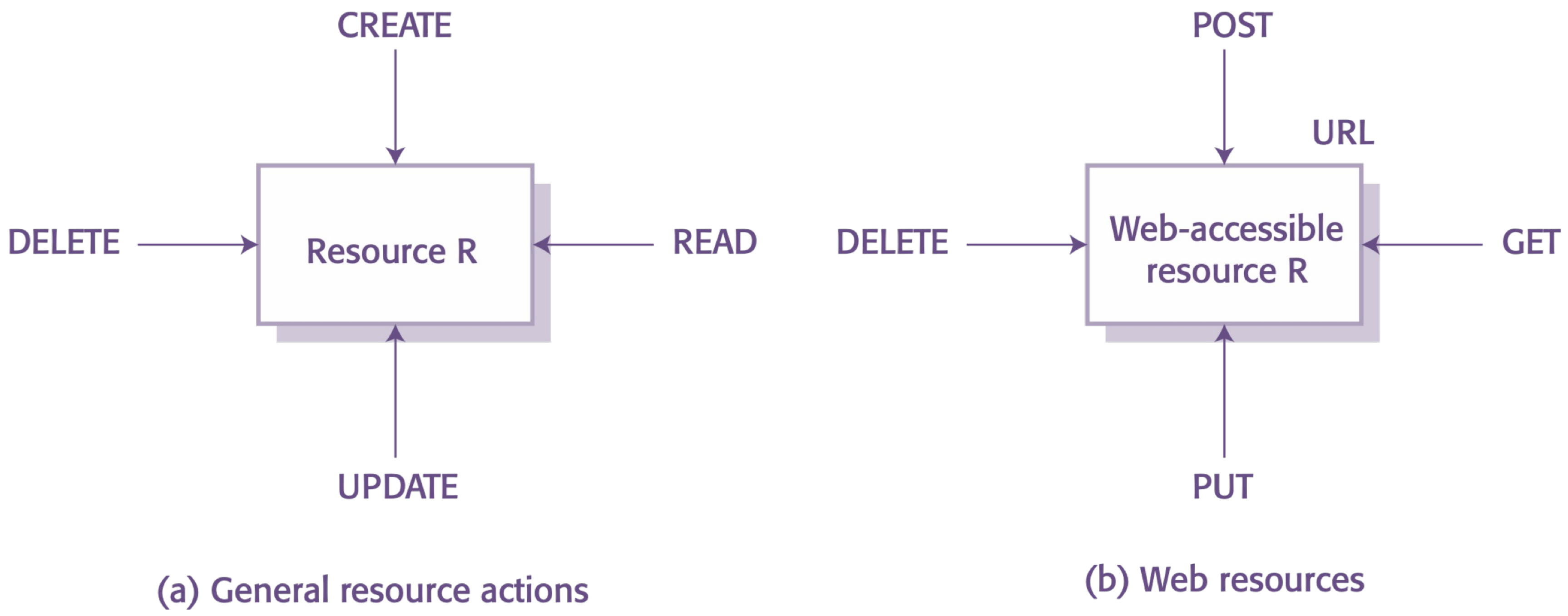
- The fundamental element in a RESTful architecture is a resource

- Essentially, a resource is simply a data element such as a catalogue, a medical record, or a document
  - http://api.ipma.pt/file-example/1110600.json
  - http://api.ipma.pt/open-data/distrits-islands.json

- In general, resources may have multiple representations, i.e., they can exist in different formats.
  - JSON, TXT, DOC, PDF, HTML, …

Resource operations

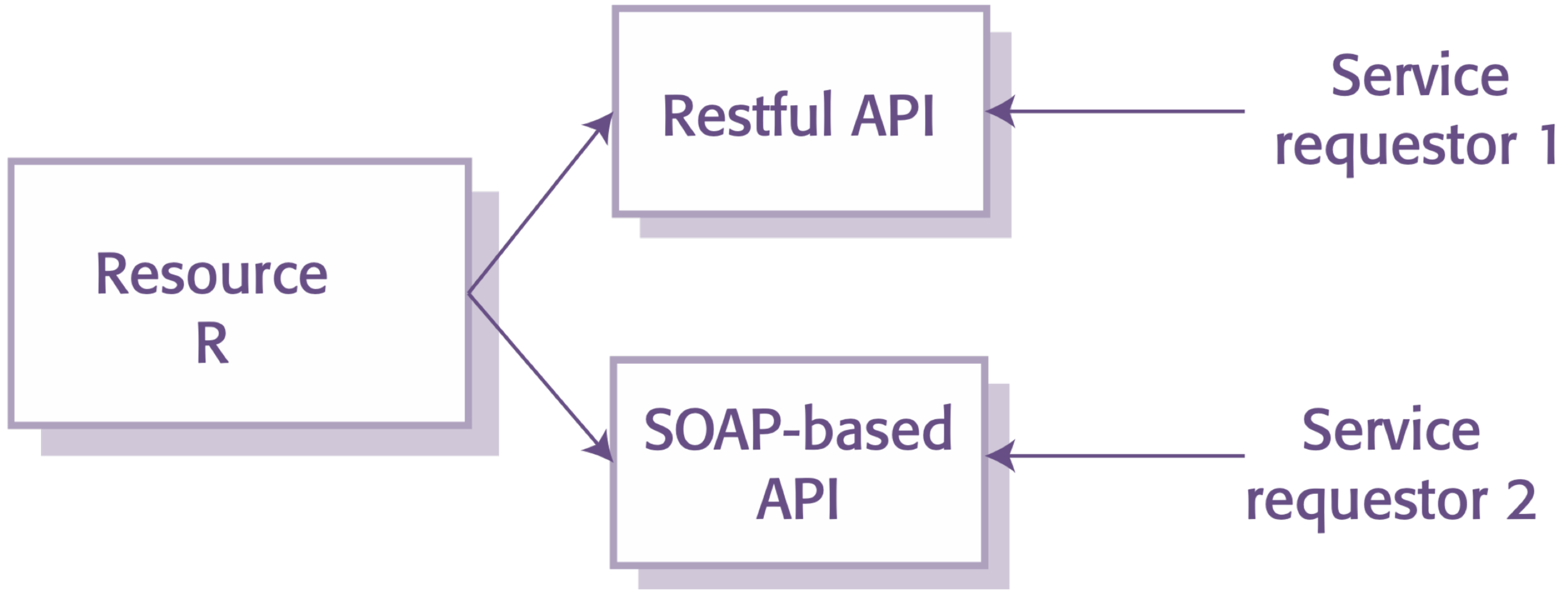
- Create – bring the resource into existence
- Read – return a representation of the resource
- Update – change the value of the resource
- Delete – make the resource inaccessible



Disadvantages of RESTful approach

- It can be difficult to design a set of RESTful services to represent complex resources/interfaces
- There are no standards for RESTful interface description
  - so service users must rely on informal documentation to understand the interface
- When using RESTful services, we have to implement our own infrastructure for monitoring and managing the quality of service and the service reliability
  - e.g. REST does not impose any sort of security like SOAP
  - SOAP requires less plumbing code than REST services design

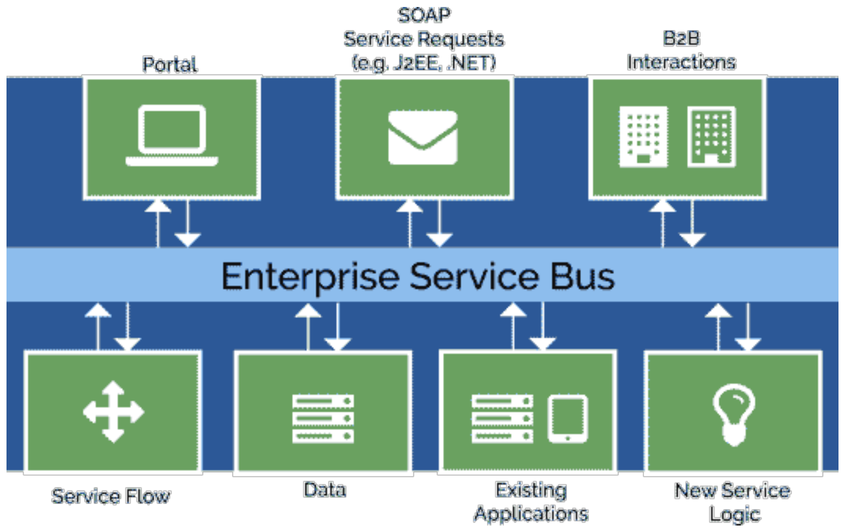
RESTful and SOAP-based APIs



SOA topology

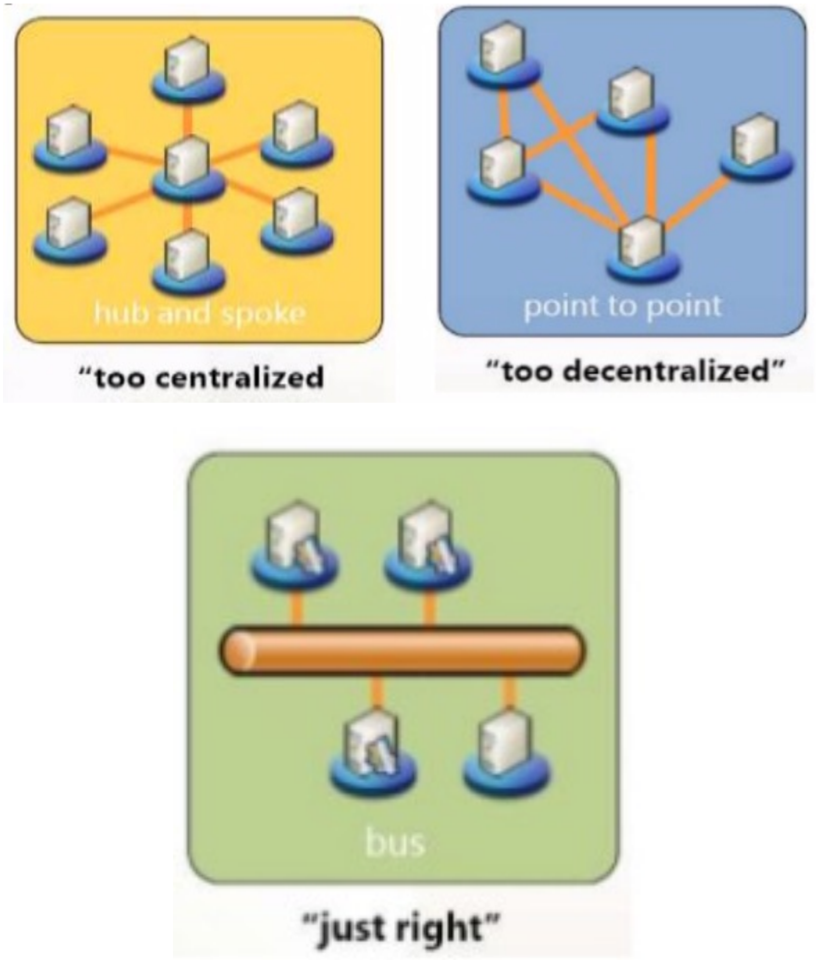
- SOA was primarily used to develop Monolithic application, though it has evolved from there

- Many organizations use now SOA to resolve integration complexities.
  - Organizations in this case heavily depend on **Enterprise Service Bus** (ESB) technologies (messaging middleware).
  - All services are accessed through the ESB.



Key Characteristics of ESB

- Streamlines development
- Supports multiple binding strategies
- Performs data transformation
- Intelligent routing
- Real time monitoring
- Exception handling
- Service security



Architecture Patterns (*recap*)

- Microkernel Architecture

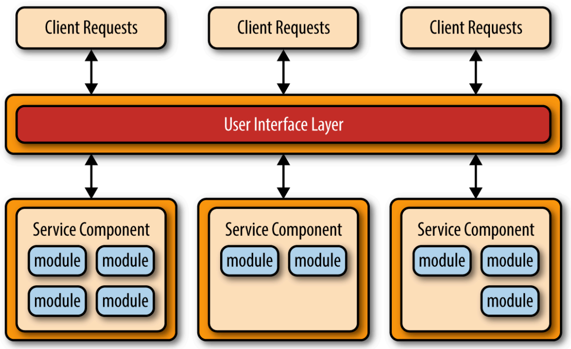
- Layered Architecture
- Event-Driven Architecture

- Service-oriented Architecture
- Microservices Architecture

- Space-Based Architecture

Microservices Architecture

- It evolved from **two main sources:**
  - applications developed using the layered pattern
  - distributed applications developed using service-oriented architecture



- The first characteristic is the notion of **separately deployed units.**
  - Each service component is deployed as a separate unit, allowing for easier deployment and decoupling

- **Distributed architecture**
  - all the components are fully decoupled
  - communication through JMS, AMQP, REST, SOAP, RMI, etc.

UNIVERSIDADE DE AVEIRO

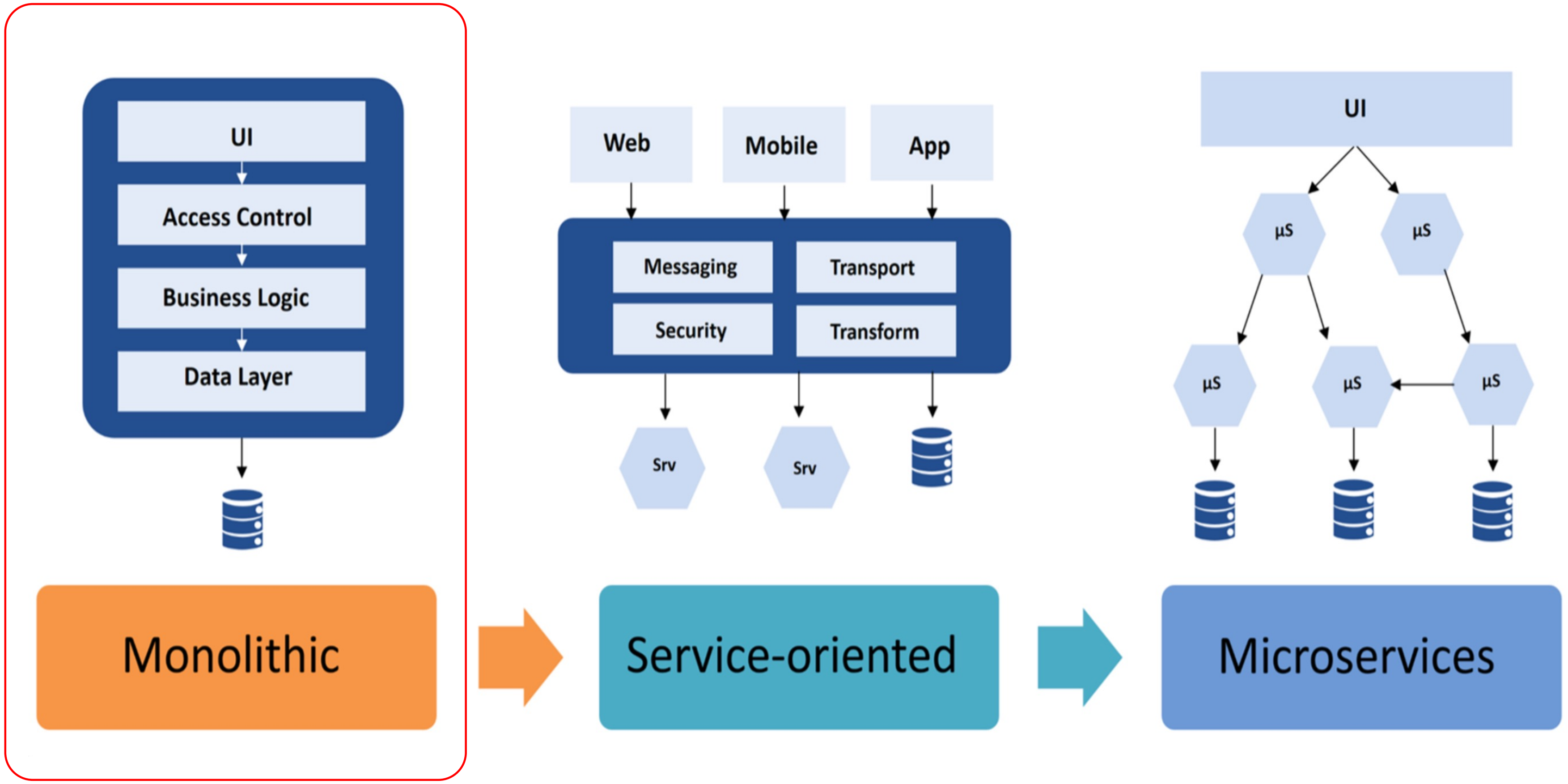
Microservices Architecture

- Applications are generally <u>more robust</u>, <u>provide better scalability</u>, and can <u>more easily support continuous delivery</u>
  - Capability to do real-time production deployments

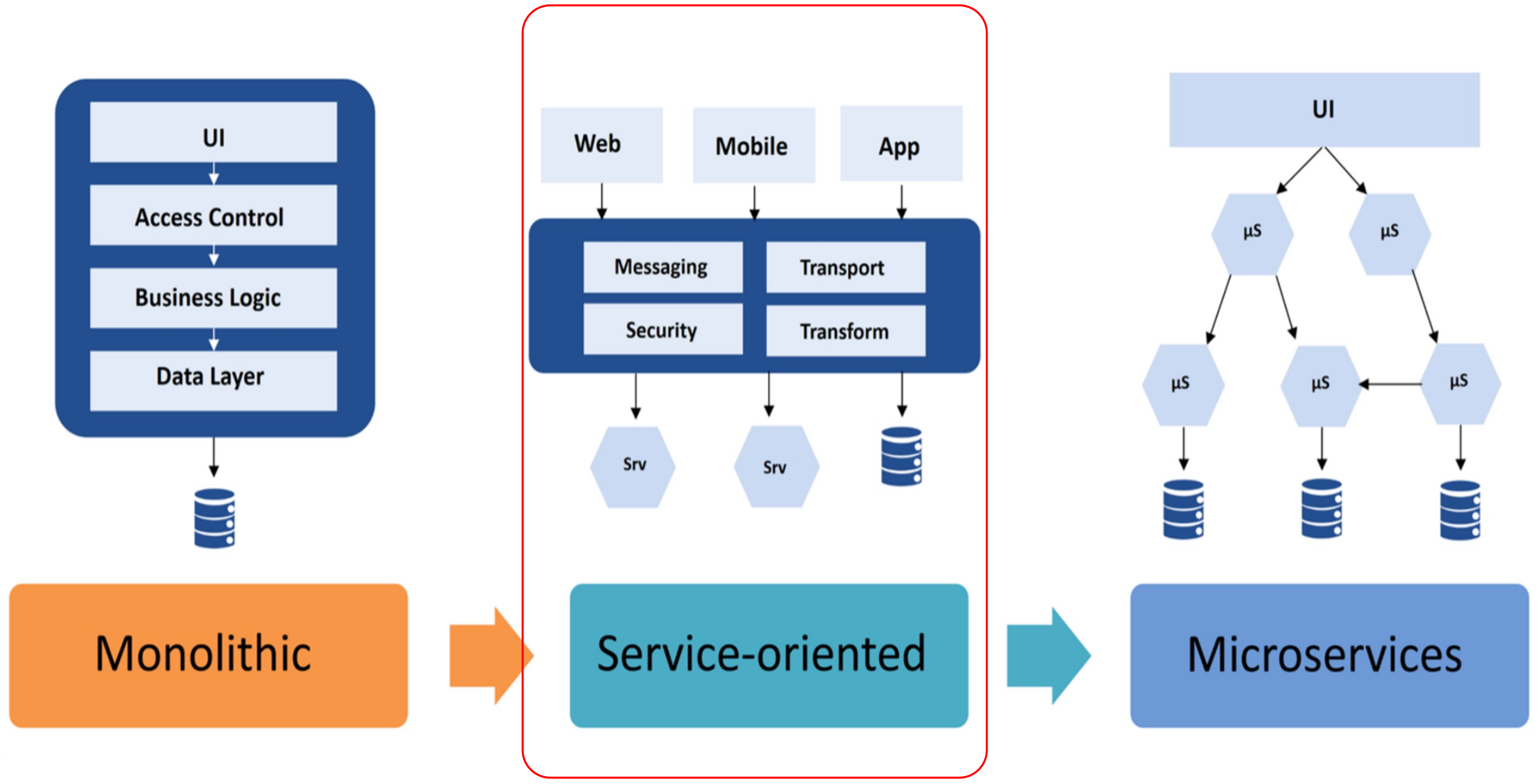
- Only the service components that change need to be deployed

- But ... distributed architecture
  - it shares some of the same complex issues found in the event-driven architecture pattern, including contract creation, maintenance, and government, remote system availability, and remote access authentication and authorization.

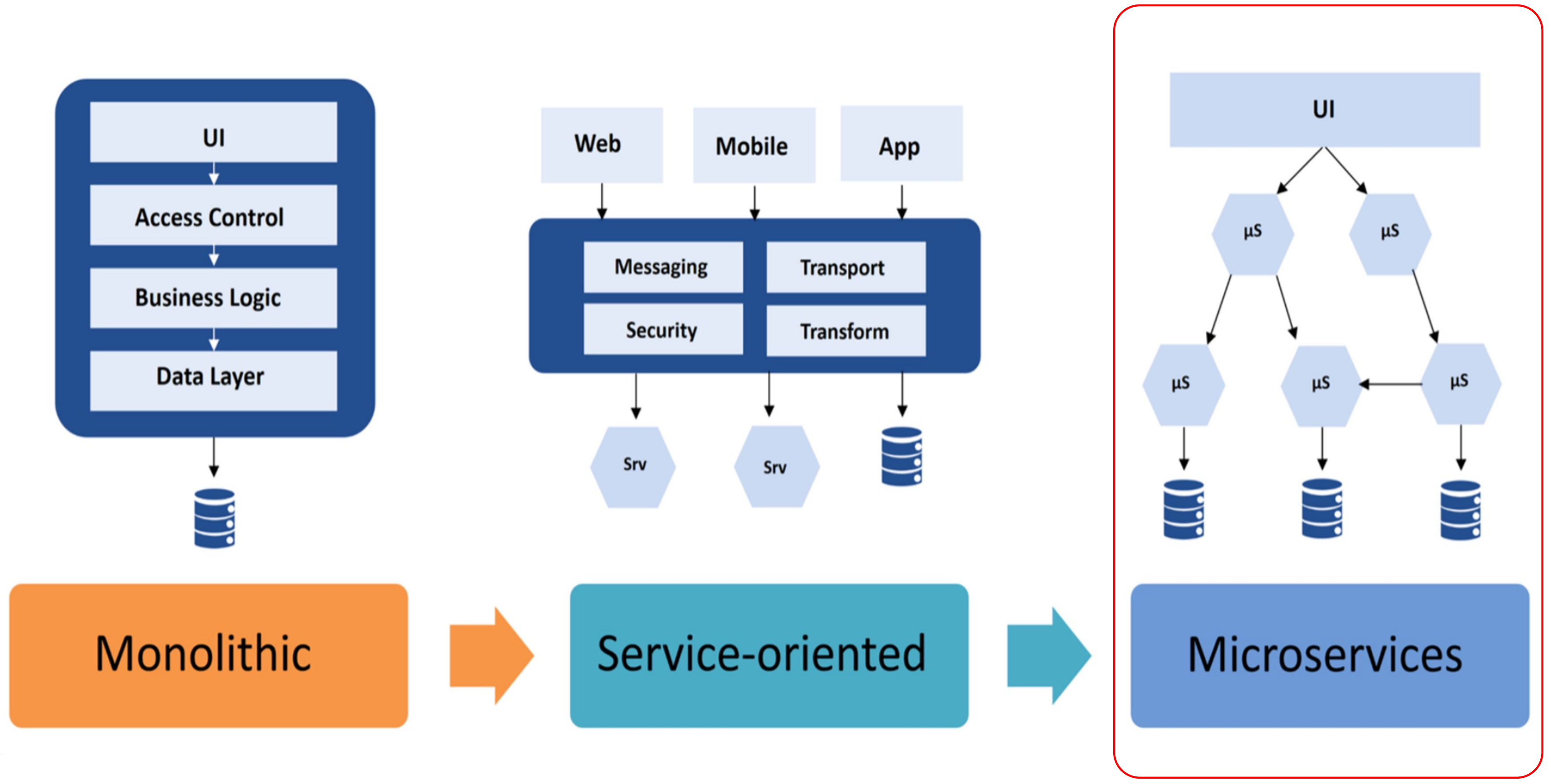
SOA vs. Microservices



SOA vs. Microservices



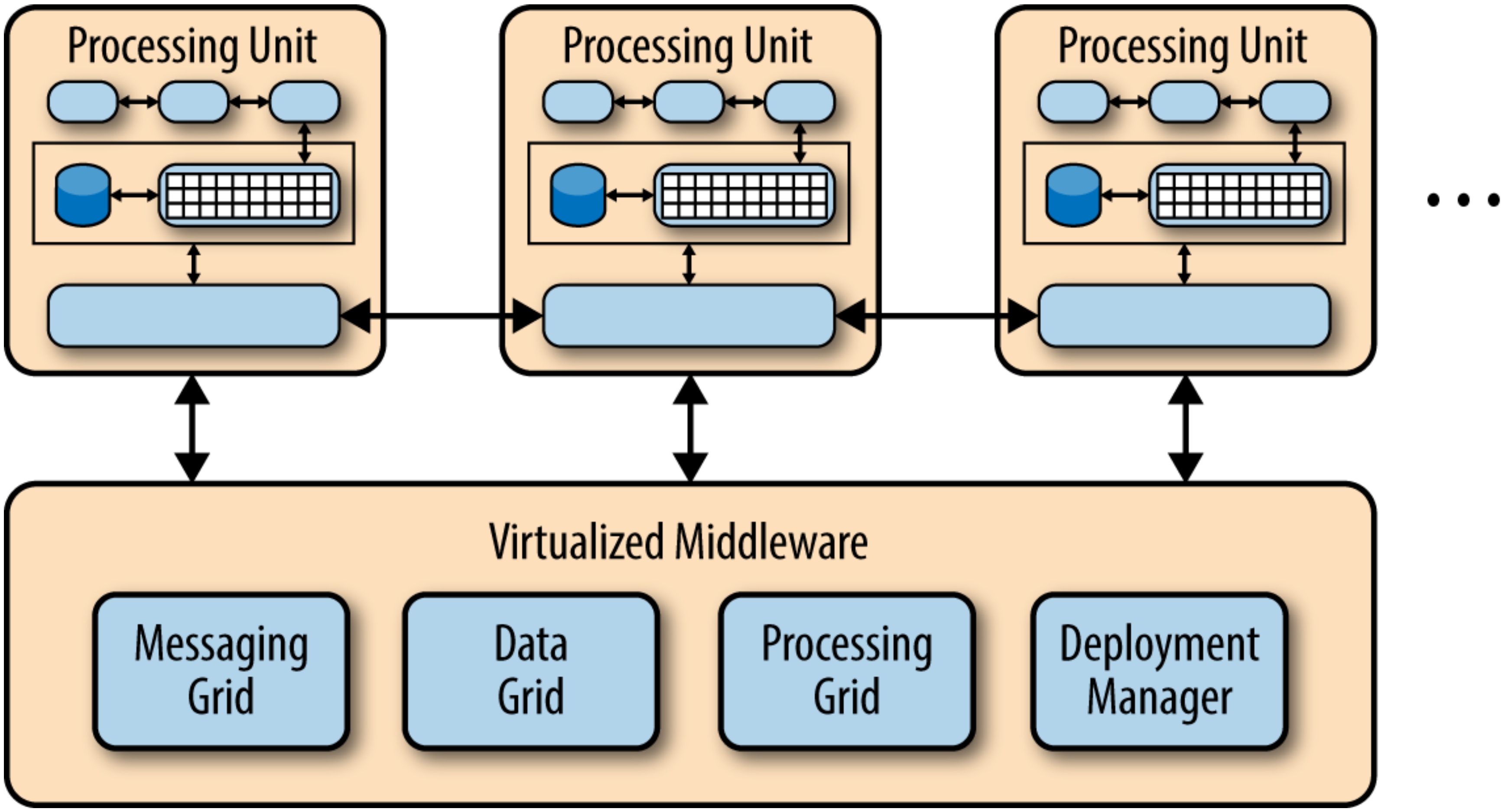
SOA vs. Microservices



Space-Based Architecture

- **Web-based applications**
  - Bottlenecks start appearing as the user load increases
    - first at the web-server layer, then at the application-server layer, and finally at the database-server layer
- Specifically designed to address **scalability and concurrency** issues
  - It is often a better approach than trying to scale out a database into a non-scalable architecture
- A good choice for applications with variable load
  - (e.g., social media sites, bidding and auction sites).

Space-Based Architecture



Space-Based Architecture

- Example
  - Bidding auction site

1. The application would receive a bid for a particular item
2. Record that bid with a timestamp
3. Update the latest bid information for the item
4. Send the information back to the browser.

Summary

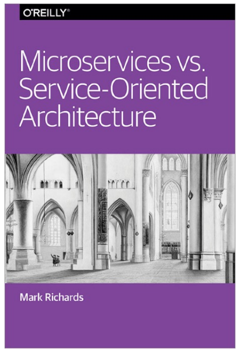
- A **software architecture** is a description of how a software system is organized
  - Properties of a system such as:
    - Performance
    - Security
    - Availability
- Architectural design include **decisions** on:
  - the type of application
  - the distribution of the system

Summary

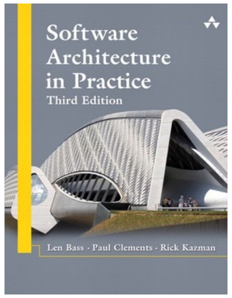
- Architectures may be **documented** from several different perspectives
  - Possible views include:
    - a conceptual view,
    - a logical view,
    - a process view,
    - a development view,
    - a physical view.
- Architectural **patterns** are a means of reusing knowledge about generic system architectures
  - They describe the architecture,
    - explain when it may be used
    - point out its advantages and disadvantages

Resources & Credits

- Ian Sommerville, *Software Engineering*, 10th Edition, Pearson, 2016 (chapters 6, 17, 18)



- Mark Richards, *Microservices vs. Service-Oriented Architecture*, O'Reilly, 2015
- Mark Richards, *Software Architecture Fundamentals Workshop* https://conferences.oreilly.com/software-architecture


Software Architecture in Practice
Third Edition
Len Bass · Paul Clements · Rick Kazman

- Rick Kazman, Paul Clements, Len Bass, *Software Architecture in Practice*, Addison-Wesley, 2012

Extra resources

- Rick Kazman, Paul Clements, Len Bass, Software Architecture in Practice, Third Edition, 2012

- Comparing architetures in java ecosystem
  - https://www.dineshonjava.com/software-architecture-patterns-and-designs/