Middleware Architectures 1

Lecture 2: Service Architecture

doc. Ing. Tomáš Vitvar, Ph.D.
tomas@vitvar.com • @TomasVitvar • https://vitvar.com

Czech Technical University in Prague
Faculty of Information Technologies • Software and Web Engineering • https://vitvar.com/lectures

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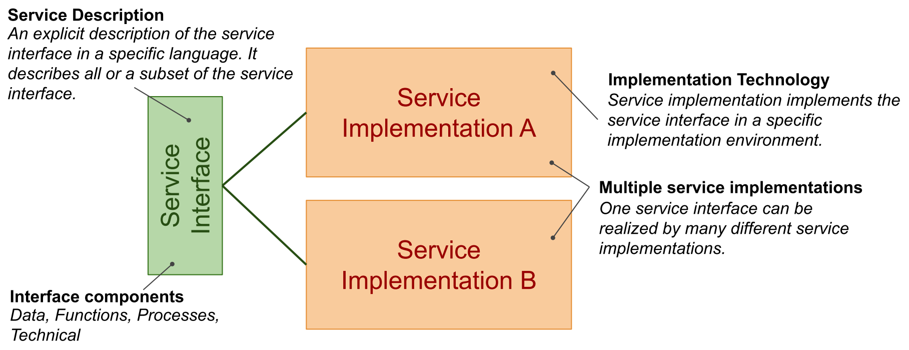
Overview

- Service Definition
- Integrating Applications
- Integration Patterns

Service Views

- Business view
  - *A service realizes an effect that brings a business value to a service consumer → for example, to pay for and deliver a book*
- Conceptual view
  - *reusability, loose coupling, contracting, discoverability*
- Logical view
  - *service interface, description and implementation*
  - *RPC-style and resource-oriented*
- Software architecture view
  - *business service (also application service) → external, exposed functionality of an application*
  - *middleware service → internal/technical, supports processing of requests*
- Technology architecture view
  - *REST/RESTful, GraphQL*
  - *XML-RPC/SOAP, RMI, gRPC*
  - *WebSocket, WebRTC, SSE*

Interface, Description and Implementation


Service Description
An explicit description of the service interface in a specific language. It describes all or a subset of the service interface.
Service Interface
Service Implementation A
Service Implementation B
Implementation Technology
Service implementation implements the service interface in a specific implementation environment.
Multiple service implementations
One service interface can be realized by many different service implementations.
Interface components
Data, Functions, Processes, Technical

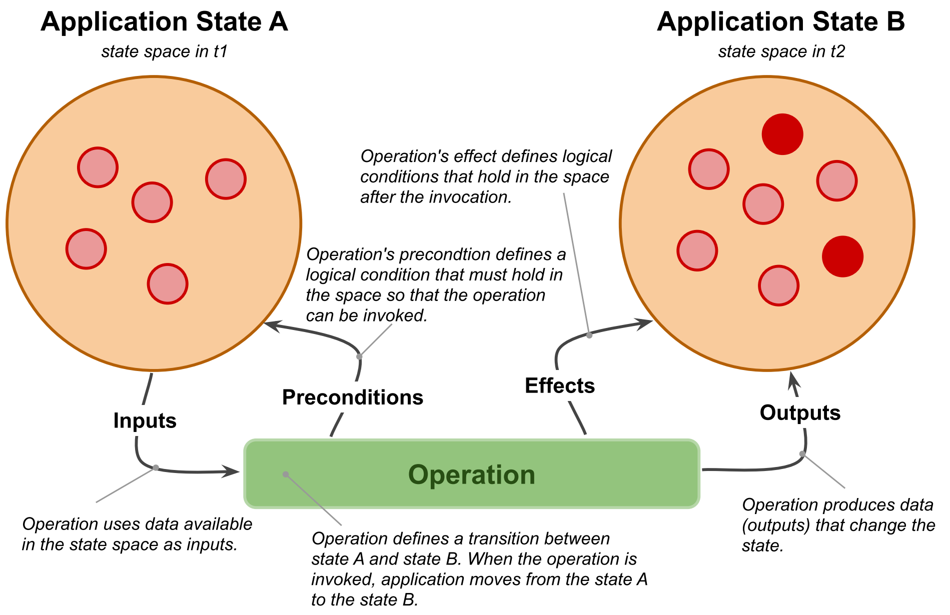
- Terminology clarification
  - *service ~ service interface + service implementation*
  - *REST/RESTful service ~ service interface that conforms to REST architectural style and HTTP protocol*
  - *Microservice ~ a set of services that realize an app's capability*
  - *Kubernetes service ~ a service that routes traffic to a set of pods*

Service Interface

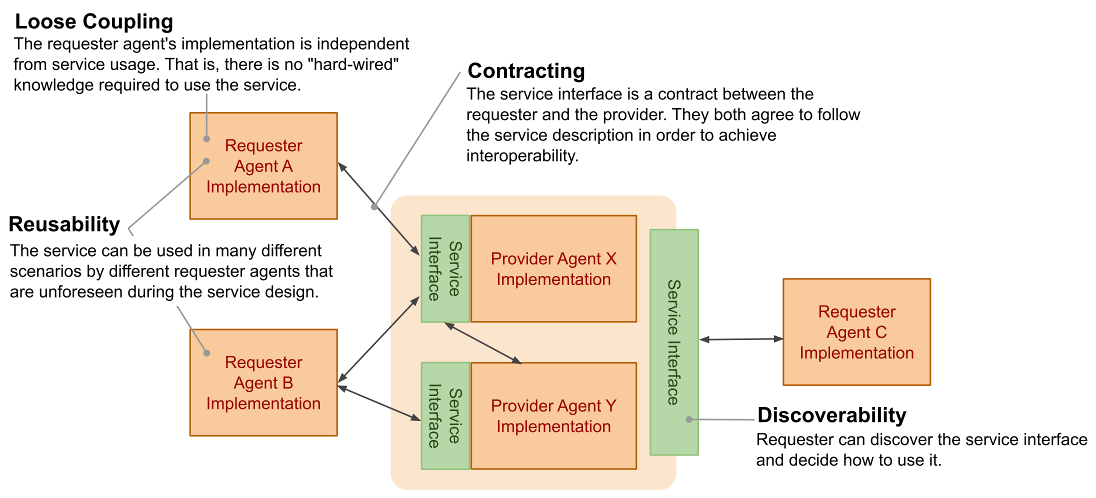
- Service interface components
  - *Data*
    - *→ Data model definition used by the service*
    - *→ for example, input and output messages, representation of resources*
  - *Functions*
    - *→ operations and input and output data used by operations*
  - *Process*
    - *→ public process: how to consume the service's functionality*
  - *Technical*
    - *→ security, usage aspects (SLA-Service Level Agreement)*
    - *→ other technical details such as IP addresses, ports, protocols, etc.*

Public Process

- A state diagram
  - *operation of a service defines a **state transition** between two states.*


Application State A
state space in t1
Application State B
state space in t2
Operation's effect defines logical conditions that hold in the space after the invocation.
Operation's precondtion defines a logical condition that must hold in the space so that the operation can be invoked.
Inputs
Preconditions
Effects
Outputs
Operation
Operation uses data available in the state space as inputs.
Operation defines a transition between state A and state B. When the operation is invoked, application moves from the state A to the state B.
Operation produces data (outputs) that change the state.

Service Characteristics



Loose Coupling
The requester agent's implementation is independent from service usage. That is, there is no "hard-wired" knowledge required to use the service.
Contracting
The service interface is a contract between the requester and the provider. They both agree to follow the service description in order to achieve interoperability.
Requester Agent A Implementation
Reusability
The service can be used in many different scenarios by different requester agents that are unforeseen during the service design.
Service Interface
Provider Agent X Implementation
Service Interface
Requester Agent C Implementation
Requester Agent B Implementation
Service Interface
Provider Agent Y Implementation
Discoverability
Requester can discover the service interface and decide how to use it.

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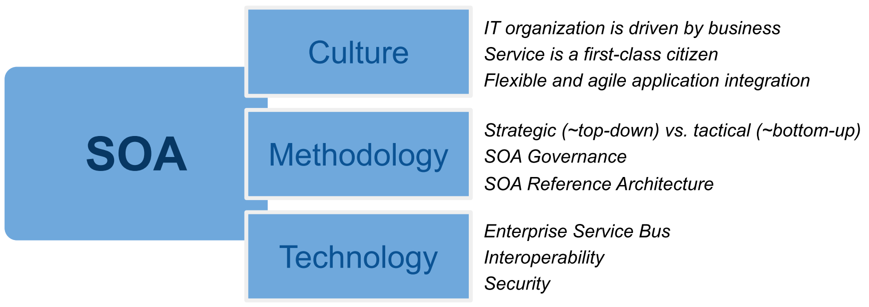
Integration and Interoperability

- Integration
  - *A process of connecting applications so that they can exchange and share capabilities, that is — information and functionalities.*
  - *Includes methodological approaches as well as technologies*
- Interoperability
  - *Ability of two or more applications to understand each other*
  - *Interoperability levels*
    - → *Data – syntax/structure and semantics*
    - → *Functions/Processes – syntax and semantics*
    - → *Technical aspects – protocols, network addresses, etc.*

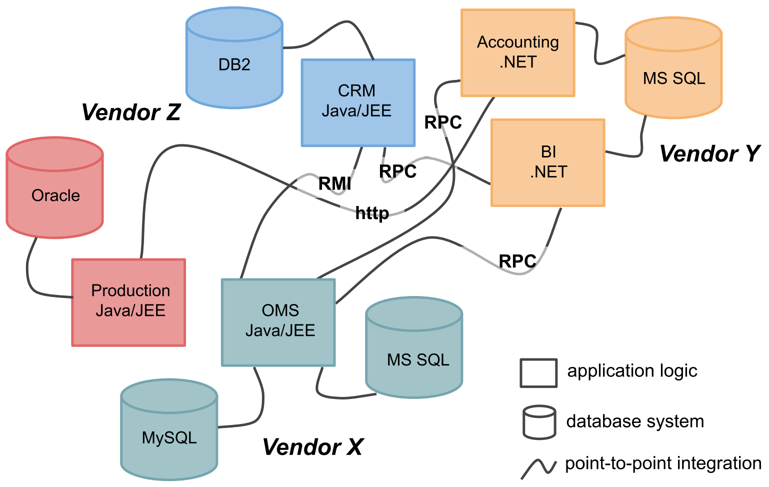
Service Oriented Architecture


SOA
Culture
IT organization is driven by business
Service is a first-class citizen
Flexible and agile application integration
Methodology
Strategic (~top-down) vs. tactical (~bottom-up)
SOA Governance
SOA Reference Architecture
Technology
Enterprise Service Bus
Interoperability
Security

- SOA supports two core business strategies
  - *Growing top-line revenue*
    - → *Enterprise reacts quickly to requirements from the market*
    - → *Business processes can be reconfigured rather than reimplemented*
  - *Improving bottom-line profit*
    - → *Saving development costs by resuing existing services*
- Pre-integrated solutions
  - *Out-of-the-box applications and integration solutions among them*

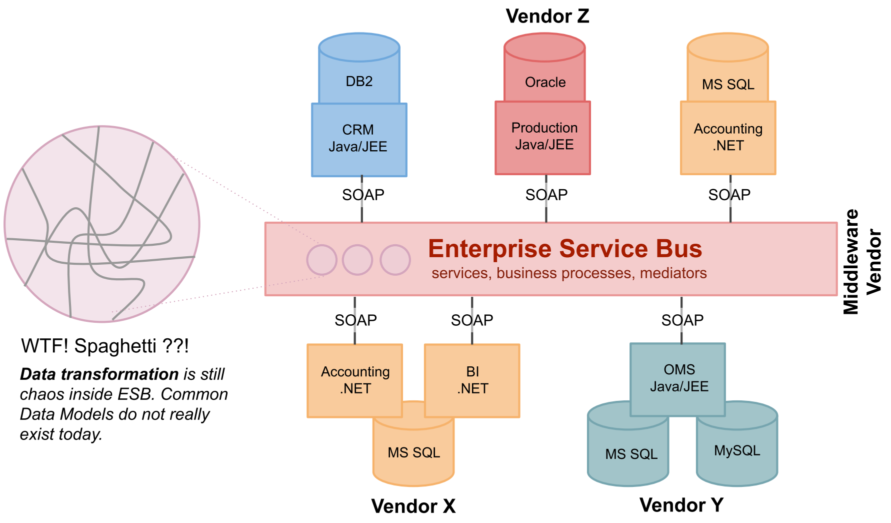
One-to-One Service Integration

- Direct integration of applications
  - *Multiple protocols problem, multiple vendor problem*
  - *Replication of integration functionalities such as interoperability solutions*



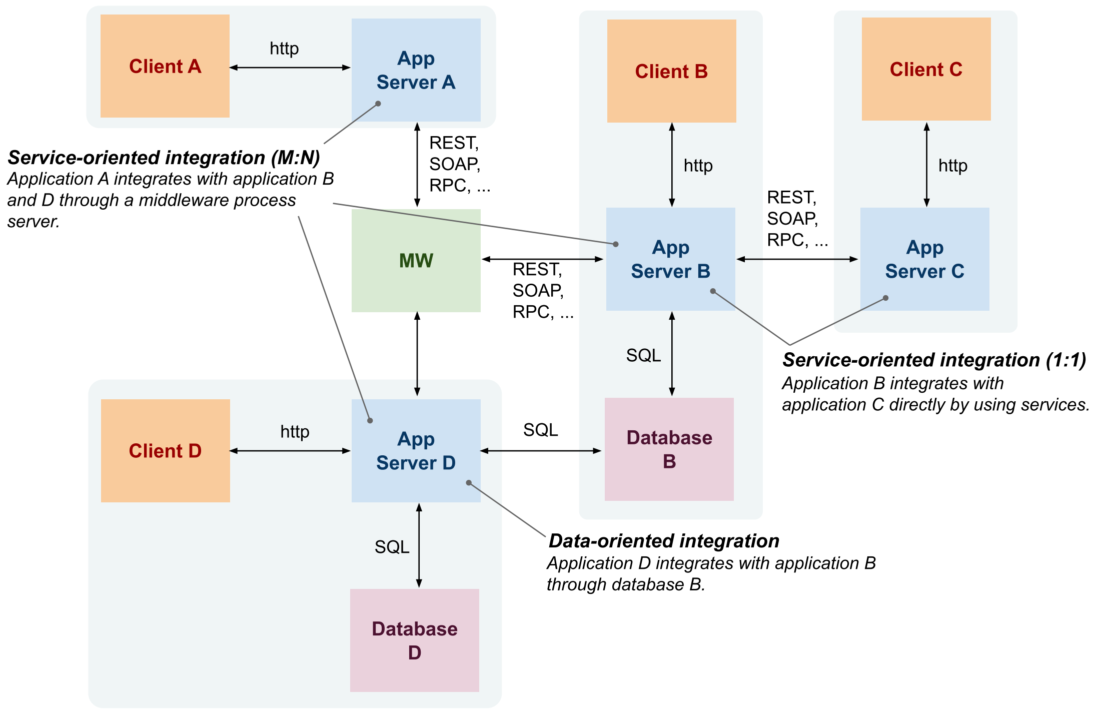
Many-to-Many Service Integration

- Enterprise Service Bus – central integration technology
  - *Realizes so called Service Oriented Architecture (SOA)*
  - *Contains various integration components such as process server, mediators, messaging middleware, identity management, etc.*

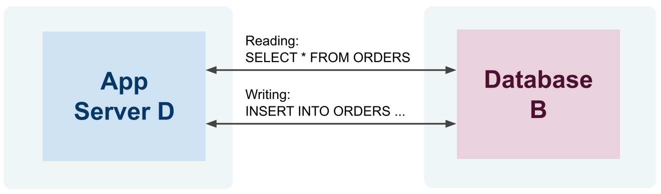


***Data transformation** is still chaos inside ESB. Common Data Models do not really exist today.*

Integration Approaches Overview

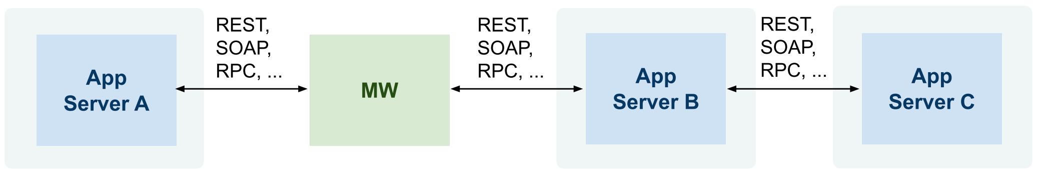

Client A
http
App Server A
REST, SOAP, RPC, ...
Service-oriented integration (M:N)
Application A integrates with application B and D through a middleware process server.
Client B
http
Client C
http
REST, SOAP, RPC, ...
App Server B
App Server C
MW
REST, SOAP, RPC, ...
SQL
Service-oriented integration (1:1)
Application B integrates with application C directly by using services.
Client D
http
App Server D
SQL
Database B
SQL
Data-oriented integration
Application D integrates with application B through database B.
Database D

Data-oriented Integration



- Third-party database access
  - *Application D accesses a database of application B directly by using SQL and a knowledge of database B structure and constraints*
  - *In the past: monolithic and two-tier client/server architectures*
  - *Today: ETL (Extract, Transform, Load) technologies*
- Problems
  - *App D must understand complex structures and constraints*
    - → *Data – very complex, includes structure and integrity constraints*
    - → *Functions/processes – hidden in integrity constraints*
    - → *Technical – access mechanisms can vary*

Service-oriented Integration



- Integration at the application layer
  - *Application exposes services that other applications consume*
  - *Services hide implementation details but only define interfaces for integration*
- Problems
  - *Can become unmanageable if not properly designed*
  - *Interoperability*
    - → *Data – limited to input and output messages only*
    - → *Functions/processes – limited to semantics of services*
    - → *Technical – access mechanisms can vary*

Integration and Types of Data

- Real-time data – Web services
  - *Service-oriented integration*
  - *online, realtime communication between a client and a service*
  - *Usually small data and small amount of service invocation in a process*
- Bulk data – ETL
  - *Data-oriented integration*
  - *processing of large amount of data in batches*
  - *Sometimes required for reconciliation across apps*
    - → *when real-time integration fails and there is poor error handling*
- **SOA provides both Web service and ETL capabilities**

Enterprise Service Bus

- ESB is a central intermediary in SOA
  – *Types of services: shared and infrastructure*
  – *Types of processes: Technical and Business*
- ESB Application
  – *Application running on an application server*
  – *Exposes functionality via Web service interface*
  – *Allows to communicate with various messaging protocols*
- Middlware Integration Patterns
  – *Technical-level interoperability – message broker*
  – *Location transparency*
  – *Dynamic routing*
  – *Session pooling*
  – *Message enrichment*
  – *Data transformation*
  – *Key mapping*

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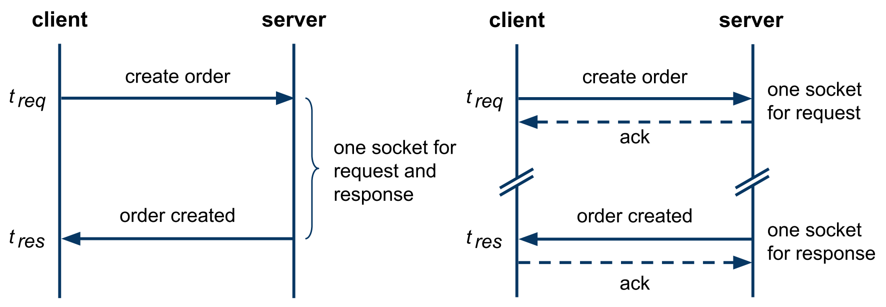
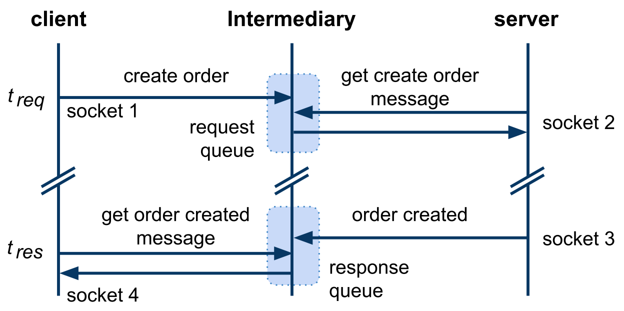
  – *Synchronous and Asynchronous Integration*
  – *Microservices Architecture*

Synchronous and Asynchronous Integration



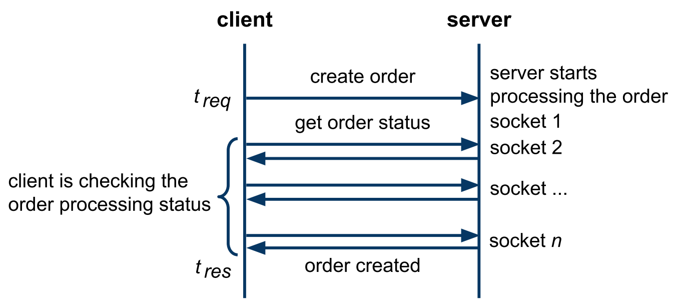
- Synchronous
  - *one socket, $|t_{req} - t_{res}|$ is small*
  - *easy to implement and deploy, only standard firewall config*
  - *only the server defines endpoint*
- Asynchronous
  - *request, response each has socket, client and server define endpoints*
  - *$|t_{req} - t_{res}|$ can be large (hours, even days)*
  - *harder to do across network elements (private/public networks issue)*

Asynchronous via Intermediary



- Intermediary
  - *A component that decouples a client-server communication*
  - *It increases reliability and performance*
    - *$\longrightarrow$ The server may not be available when a client sends a request*
    - *$\longrightarrow$ There can be multiple servers that can handle the request*
- Further Concepts
  - *Message Queues (MQ) – queue-based communication*
  - *Publish/Subscribe (P/S) – event-driven communication*

Asynchronous via Polling



- Polling – only clients open sockets
  - *A client performs multiple request-response interactions*
    - → *The first interaction initiates a process on the server*
    - → *Subsequent interactions check for the processing status*
    - → *The last interaction retrieves the processing result*
- Properties of environments
  - *A server cannot open a socket with the client (network restrictions)*
  - *Typically on the Web (a client runs in a browser)*

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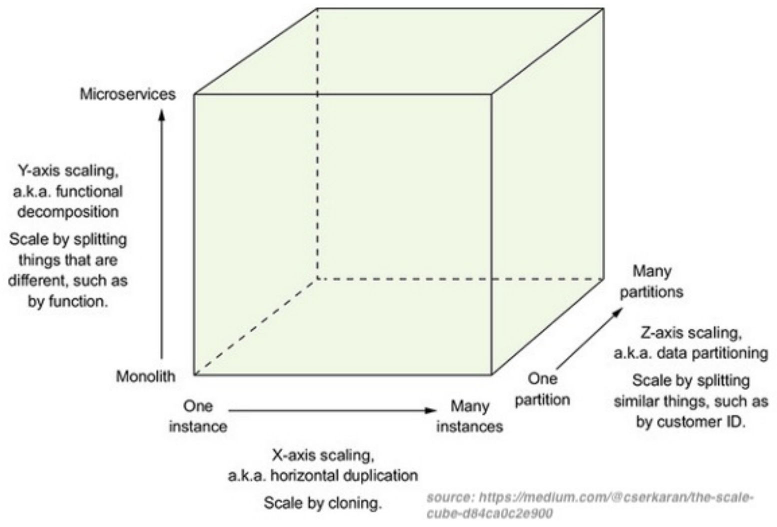
  - *Synchronous and Asynchronous Integration*
  - *Microservices Architecture*

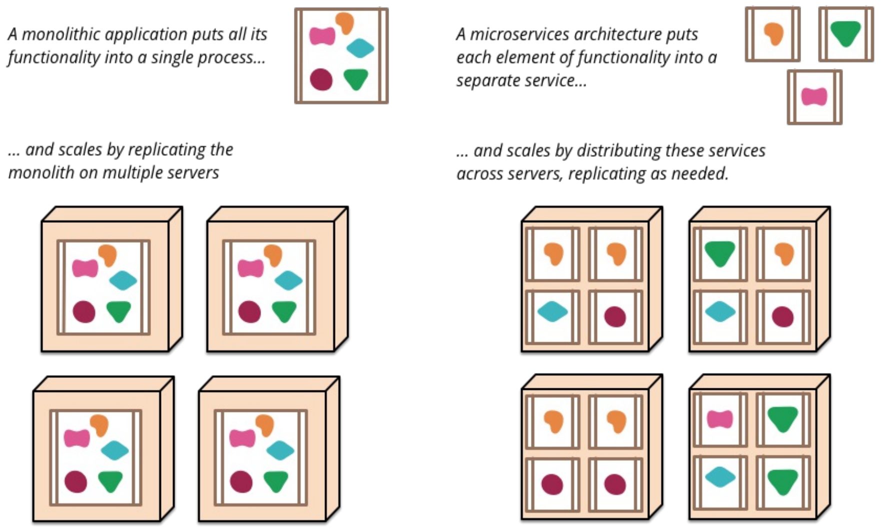
The Scale Cube

- Three-dimensional scalability model
  - *X-Axis scaling requests across multiple instances*
  - ***Y-Axis scaling decomposes an application into micro-services***
  - *Z-Axis scaling requests across "data partitioned" instances*


Microservices
Y-axis scaling, a.k.a. functional decomposition
Scale by splitting things that are different, such as by function.
Monolith
One instance
Many instances
X-axis scaling, a.k.a. horizontal duplication
Scale by cloning.
One partition
Many partitions
Z-axis scaling, a.k.a. data partitioning
Scale by splitting similar things, such as by customer ID.
source: https://medium.com/@cserkaran/the-scale-cube-d84ca0c2e900

Overview

- Emerging software architecture
  - *monolithic vs. decoupled applications*
  - *applications as independenly deployable services*


A monolithic application puts all its functionality into a single process...
A microservices architecture puts each element of functionality into a separate service...
... and scales by replicating the monolith on multiple servers
... and scales by distributing these services across servers, replicating as needed.

Major Characteristics

- Loosely coupled
  – *Integrated using well-defined interfaces*
- Technology-agnostic protocols
  – *HTTP, they use REST architecture*
- Independently deployable and easy to replace
  – *A change in small part requires to redeploy only that part*
- Organized around capabilities
  – *such as accounting, billing, recommendation, etc.*
- Impplemented using different technologies
  – *polyglot – programming languages, databases*
- Owned by a small team