

# Middleware Architectures 1

## Lecture 2: Service Architectures

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Modified: Sun Nov 19 2023, 19:53:57  
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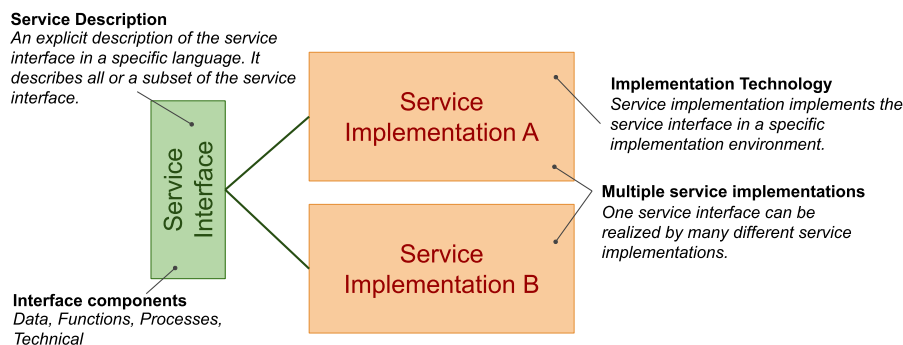
## Overview

- **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
  - *encapsulation, reusability, loose coupling, contracting, abstraction, discoverability, composability*
- Logical view
  - *service interface, description and implementation*
  - *message-oriented 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 SSF*

## Interface, Description and Implementation



- Terminology clarification
  - *service ~ service interface + service implementation*
  - *WSDL service ~ service description in WSDL language*
  - *SOAP service ~ a service interface is possible to access through SOAP protocol; there is a WSDL description usually available too.*
  - *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*

## 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.



# 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.

## Reusability

The service can be used in many different scenarios by different requester agents that are unforeseen during the service design.

## 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.

## Abstraction

Service interface is abstracted from underlying service implementation as well as all software and hardware technology.

## Discoverability

Requester can discover the service interface and decide how to use it.

## Encapsulation

The provider agent implementation is hidden to the requester agent accessing the service. The requester agent only knows the service interface to consume its functionality.

## Composability

It is possible to compose services into more complex processes. Such processes can again be accessed as services.

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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 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.



# Integration Approaches Overview



## 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*
- Middleware 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



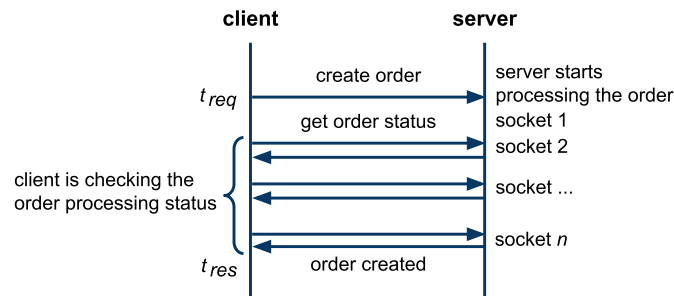
- **Synchronous**
  - one socket,  $|t_{req} - t_{res}|$  is small
  - easy to implement and deploy, only standard firewall config
  - only the server defines endpoint
- **Asynchronous**
  - request, response each has socket, client and server define endpoints
  - $|t_{req} - t_{res}|$  can be large (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
    - The server may not be available when a client sends a request
    - 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

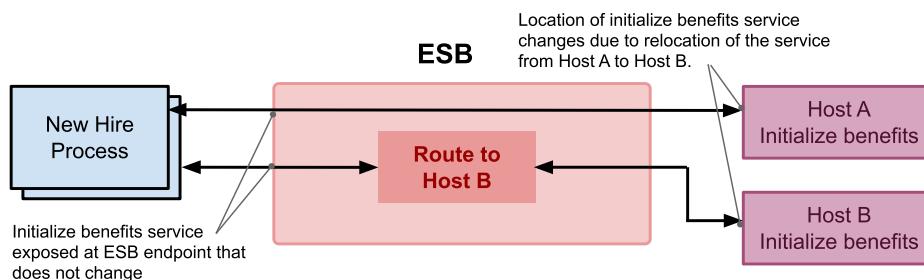
## Asynchronous via Polling



- 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)

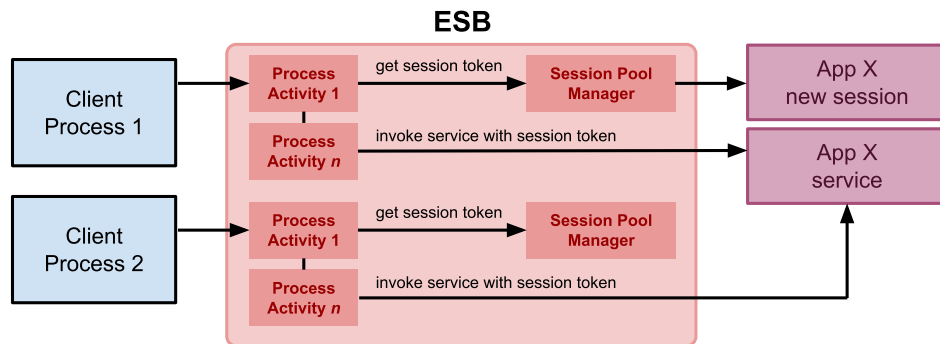
## Location Transparency

- Location transparency
  - ESB can hide changes in location of services
  - Such changes will not affect clients
  - Can also be used for load balancing for multiple service instances



## Session Pooling

- Session Pooling
  - ESB can maintain a pool of connections (session tokens) to a back-end app when creating a new connection is expensive
  - A single session token can be reused by multiple instances of business processes

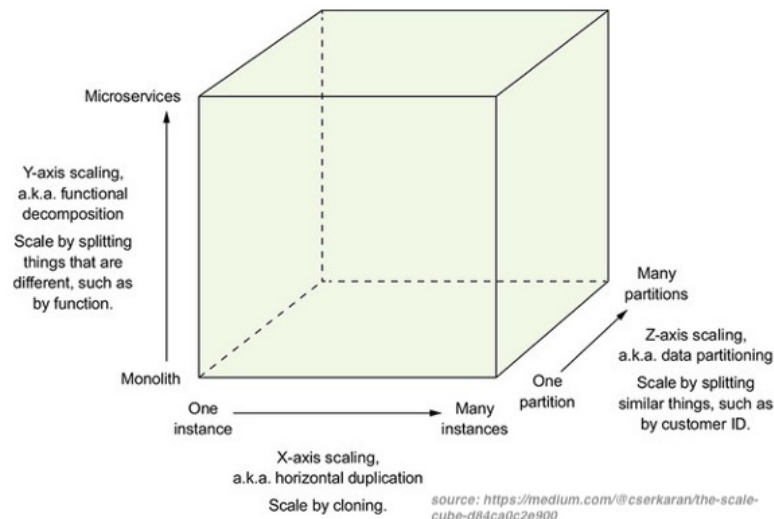


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  - *Microservices Architecture*

# 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*



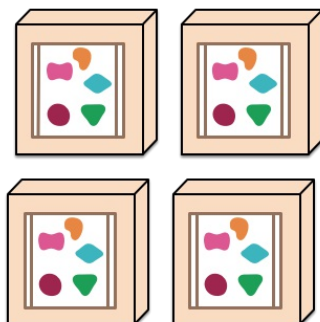
## Overview

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

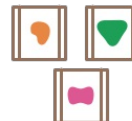
A monolithic application puts all its functionality into a single process...



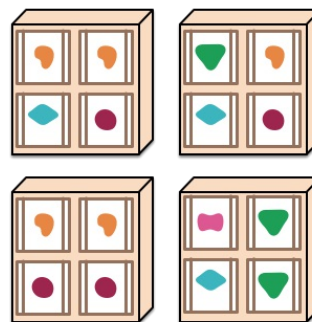
... and scales by replicating the monolith on multiple servers



A microservices architecture puts each element of functionality into a separate service...



... 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.*
- Implemented using different technologies
  - *polyglot – programming languages, databases*
- Owned by a small team