

# Middleware Architectures 1

## Lecture 1: Information System Architectures

**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>



Modified: Sun Nov 19 2023, 19:53:57  
Humla v1.0

## Overview

- **Architecture Overview**
- Data, Functions and Processes
- Software Architecture

# Global Architecture

- A **structure** and a **behavior** of system's parts
- Complexity – views on the global architecture
  - *basic architectural views (also called dimensions):*  
*enterprise, data, functional, process, software, hardware.*
- Development
  - *basic **methodology** and **actors**:*  
*~ analysis, design, implementation, testing, maintenance*  
*~ end-user, architect, developer, administrator*
  - *basic architectural **development levels**:*  
*~ conceptual, logical, physical.*
- Global architecture and cloud computing
  - *data, functions, processes are application (domain) specific*
  - *software architecture defines a **software platform***
  - *hardware architecture defines an **infrastructure***

# Views



# Enterprise Architecture



## Enterprise Architecture Levels

- Defines a structure of an enterprise system
  - Abstracts from data, functions, processes, software, hardware
  - divides enterprise system into functional blocks – **applications**
    - Order Management System (OMS)
    - Customer Relationship System (CRM)
    - Billing and Revenue Management (BRM)
  - applications correspond to **domains** such as sales, finance, procurement, production, etc.
- Enterprise architecture levels
  - Operational Support Systems (OSS)
  - Business Support System (BSS)
  - Executive Information Systems (EIS)
  - Office Information Systems (OIS)
  - Integration
    - Business-to-Business (B2B)
    - Enterprise Application Integration (EAI)

# Enterprise Architecture Representation



## Organization Types

- Customer
  - *user needs: support for business processes*
  - *defines business requirements*
  - *roles: enterprise architect, developers, admins, users*
- Supplier (enterprise system/application provider)
  - *solutions and customization according to requirements*
  - *roles: technical and solution architects, developers, admins*
- Vendor (technology provider)
  - *product development according to market needs*
  - *roles: product managers, developers, reference users*

## Architect Roles

- Technical Architect
  - *Technical architecture design*
  - *technology configurations, performance*
- Solution Architect
  - *Requirements gathering, analysis*
  - *Solution design (data, functions, process)*
- Enterprise Architect
  - *High-level enterprise architecture design*
    - *Applications, processes, data models*
  - *Should be aligned with industry standards*
    - *APQC – American Productivity & Quality Center (Process Classification Framework)*
    - *TM Forum – eTOM – Enhanced Telekom Operations Map (Business Process Framework)*

## Overview

- Architecture Overview
- Data, Functions and Processes
  - *Integration*
- Software Architecture

# Process Classification Framework



## Order Process Example in Telco

- Order to Cash Process (O2C)
  - end-to-end (E2E) order process



- Involved applications
  - integrated applications



## Syntax and Domain Semantics

- Syntax
  - Data format, representation, serialization
  - Various languages at various architectural levels:  
*XML, JSON, Class/object models in a specific programming language, SQL, DB native structures, ...*
  - They have formal grammars, can be checked for the correct syntax
- Domain semantics
  - Meaning of terms in a domain they are being used
  - We understand meaning of terms:
    - Through syntax by using the natural language
    - Through some **agreement** among users of the terms
  - Every applications can use different semantics
    - Need to mediate data from one application to another

## Simplified Order Type Example



## Overview

- Architecture Overview
- Data, Functions and Processes
  - *Integration*
- Software Architecture

## Integrating Applications

- Intra-Enterprise Integration
  - *Applications exist in a specific area*
  - *Functions and data often overlap across areas*
  - *There is a need to integrate applications within enterprise:*
    - *Applications need to share the same data that are often in different formats.*
    - *Applications need to communicate – a result of one process may trigger another one.*
- Inter-Enterprise Integration
  - *Also called Business-to-Business Integration (B2B)*
  - *Automation support for communication and collaboration among enterprises*
  - *For example, B2B automates customers' orders processing, tracking orders, etc.*



## Integration Example – O2C



Lecture 1: Information System Architectures, CTU Winter Semester 2024/2025, @TomasVitvar

– 17 –

## Integration Issues

- Key to integration = **interface**
  - standards – data, functions, processes, technical aspects
    - enterprise standards, committee standards
    - unified environment from a single vendor
  - mediators
    - where standard do not work out
- Data
  - Message exchange formats, data representation
    - often standardized
  - Semantics of data
    - also standardized, more difficult
- Functions and processes
  - how apps' functionalities should be consumed and orchestrated, protocols, naming issues
  - A service concept

Lecture 1: Information System Architectures, CTU Winter Semester 2024/2025, @TomasVitvar

– 18 –

## Overview

- Architecture Overview
- Data, Functions and Processes
- Software Architecture
  - *Types, Separation of Concerns, Interface*
  - *Client/Server Architectures*

## Software Architecture Types

- Centralized – Client/Server (C/S)
  - *Central server, a bunch of clients*
  - *monolithic, **two**–, **three**–, **multi**–tier architectures*
  - *Single point of failure!*
    - *when a server fails the whole system fails*
    - *need for a scalable and **highly reliable** server-side solutions*
  - *Enterprise systems (mostly) use centralized solutions*
    - *But, enhanced with peer-to-peer principles*
- Decentralized – Peer-to-Peer (P2P)
  - *Reliability*
    - *when a node fails, other nodes take up its function*
  - *Scalability*
    - *multiple nodes can share the load*
    - *such as messaging systems in enterprise systems*

## Separation of Concerns

- Separation of Concerns
  - *also called Separation of Layers*
  - *Concern – any piece of interest (part) in the application*
    - *concerns should overlap in functionality as little as possible*
  - *Basic application concerns: data manipulation, data integrity, application logic, user-interactions*
  - *Software architecture separates concerns into layers*
    - *presentation, application, data*
- Interface
  - ~ *agreement on "how layers should communicate"*
  - *most important artifact in Separation of Concerns*
  - *If an interface is in place, application development and innovation can happen **independently** at each layer*

## Interface

- Definition
  - *Agreement (contract) between two or more layers during communication*
- May be achieved by
  - *Through standards (accepted or enforced),*
  - *Through a social agreement during design*
  - *A dominant position of a technology on the market*
- Interface includes subsets of domain architectures
  - *Subsets that are subject to communication between layers*
  - **data** – *defines communication language (syntax, semantics),*
  - **functions** – *defines entry points (operations),*
  - **processes** – *defines valid states and transitions between them*
  - **technical details** – *protocols, ports, IP addresses, etc.*

## Complex Interfaces



- More levels of interfaces
  1. DBMS native interface
  2. JDBC – universal connectors for various DBMS systems
  3. JDO – mapping of Java classes to data objects
  4. Domain Object Model (OM) – app-specific (~API, SDK)
    - try to be as universal as possible; cover many technologies

## Overview

- Architecture Overview
- Data, Functions and Processes
- Software Architecture
  - Types, Separation of Concerns, Interface
  - *Client/Server Architectures*

# Monolithic Architecture



- All layers on a single machine
  - usually non-portable apps; specific OS
  - first types of computer systems, typical for 90-ties
  - single-user only; standalone apps, minimal integration
  - technologies: third-gen programming languages, local storage systems
- Drawbacks
  - hard to maintain (updates, distribution of new versions)
  - data security issues
  - performance and scalability issues

# Two-tier Client/Server Architecture



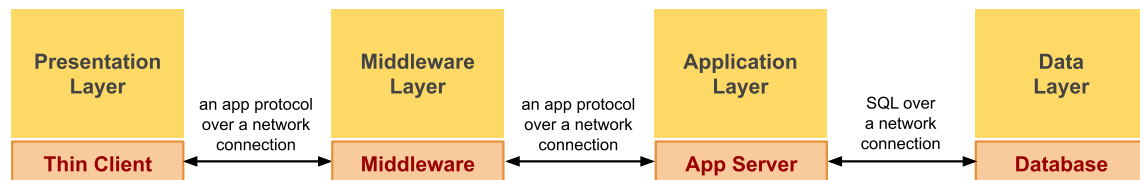
- Presentation and app layers separated with data
  - Thick client – desktop application, OS-dependent
  - Data on a separate server (DBMS)
  - Multi-user system, all sharing a database
  - Storage system of high performance, transactions support
  - SQL technology; native OS desktop application
- Drawbacks
  - Thick client hard to maintain (reinstallation with every update)
  - No app logic sharing (only through copies)
  - Data-oriented integration (integrity in the app logic!)

## Three-tier Client/Server Architecture



- All layers on separated machines
  - *Thin client – desktop application or interpreted code*
  - *Multi-user system, all sharing app logic and a database*
  - *App server of high performance, scalability*
- Drawbacks
  - *Spaghetti integration*
  - *Limited, single app server scalability*

## Multi-tier Client/Server Architecture



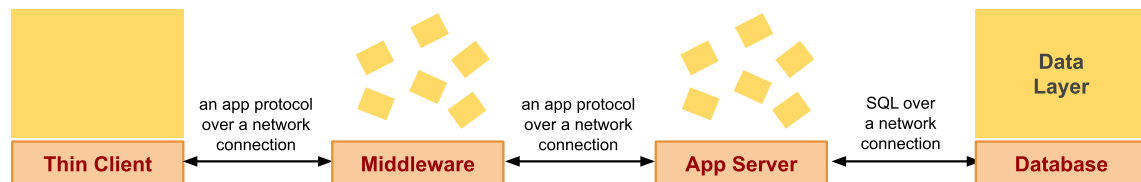
- Additional middleware layer
  - *provides value-added services for communications*
  - *individual servers or a compact solution (e.g., Enterprise Service Bus)*
- Drawbacks
  - *Monolithic apps are difficult to scale as a whole*
  - *Deployment overhead*
  - *A single technological environment for all app functions in the monolith*

## Client/Server Architecture (microservices)



- Microservice architecture
  - *Middleware, app and DB monoliths are microservice architecture*
  - *Improved scalability and technology neutrality of app components*
- Service orchestration layer
  - *Kubernetes (K8s)*
  - *Large K8s cluster for all, middleware, app, DB*
  - *Separate K8s cluster*

## Client/Server Architecture (microservices)



- Not-a-microservice Architecture
  - *Monoliths deployed to Kubernetes cluster*
  - *Improved Deployments (via container images)*
  - *Improved fail-over*
  - *Not cheaper (Kubernetes costs come into play)*

# Types of Middleware

- **Scalability**
  - *They help to achieve high performance through better scalability*
  - *Messaging Servers (message queues, publish/subscribe)*
  - *Load Balancers*
  - *Proxy servers, reverse proxy*
- **Functional**
  - *They help to achieve more flexible integration*
  - *Process servers*
  - *Repositories, registries of services/components*
  - *Mediators – data interoperability, process interoperability, technical interoperability (SOAP server)*
  - *Monitors for analytics of apps usages*
- **Security**
  - *Firewalls, Gateways, ...*