

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 Sep 21 2025, 20:05:30
Humla v1.0

Overview

- **Architecture Overview**
- 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 in Enterprise Systems

- **Customer Organization**

- *Primary need:* Business process automation and optimization
- *Responsibilities:* Define business requirements, acceptance criteria, change management
- *Key roles:* Enterprise architect, business analysts, end users, IT administrators
- *Example:* Bank implementing new CRM system for customer management

- **Supplier Organization (System Integrator)**

- *Primary need:* Deliver tailored solutions meeting customer requirements
- *Responsibilities:* Solution design, customization, implementation, support
- *Key roles:* Solution architects, technical architects, developers, project managers
- *Example:* Accenture implementing SAP for manufacturing company

- **Vendor Organization (Technology Provider)**

- *Primary need:* Develop market-driven products and platforms
- *Responsibilities:* Product roadmap, R&D, platform maintenance, market analysis
- *Key roles:* Product managers, platform architects, developers, DevOps engineers
- *Example:* Microsoft developing Azure cloud services

Architect Roles and Responsibilities

- **Enterprise Architect**

- *Scope: Organization-wide architecture strategy and governance*
- *Focus: Business-IT alignment, application portfolio, data architecture*
- *Deliverables: Enterprise architecture blueprints, technology roadmaps*
- *Standards: TOGAF, industry-specific (eTOM for telecom)*

- **Solution Architect**

- *Scope: End-to-end solution design for specific business problems*
- *Focus: Requirements analysis, system integration, functional design*
- *Deliverables: Solution design documents, integration patterns, data flows*
- *Skills: Business analysis, system design, stakeholder management*

- **Technical Architect**

- *Scope: Technology implementation and infrastructure design*
- *Focus: Performance, scalability, security, technology selection*
- *Deliverables: Technical specifications, deployment guides, performance benchmarks*
- *Skills: Deep technical expertise, cloud platforms, DevOps practices*

Modern Technical Architect Roles

- **Cloud Architect**
 - *Cloud-native solutions, migration strategies, multi-cloud designs*
 - *AWS, Azure, GCP certifications and expertise*
- **Security Architect**
 - *Zero-trust architecture, compliance frameworks (GDPR, SOX)*
 - *Identity management, encryption, threat modeling*
- **Data Architect**
 - *Data lakes, data warehouses, real-time analytics*
 - *Data governance, privacy, master data management*
- **API Architect**
 - *API strategy, microservices design, API governance*
 - *REST, GraphQL, event-driven architectures*
- **DevOps Architect**
 - *CI/CD pipelines, infrastructure as code, monitoring*
 - *Kubernetes containerization observability platforms*

Overview

- Architecture Overview
- 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.*

Interface Example: REST API

- **Data** interface: JSON format
- **Function** interface: HTTP methods
 - *GET /customers/{id}* - retrieve customer
 - *POST /customers* - create customer
 - *PUT /customers/{id}* - update customer
- **Process** interface: state transitions
- **Technical** interface: HTTPS, port 443, authentication

Overview

- Architecture Overview
- 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



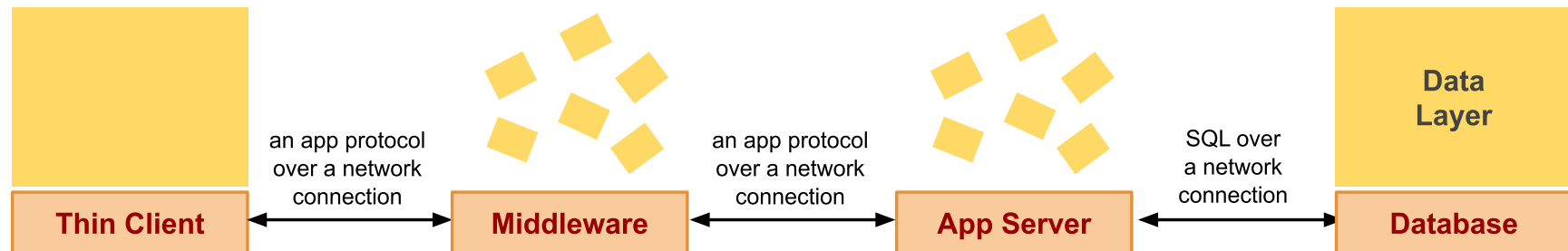
- Additional middleware layer
 - *provides value-added services for communications*
 - *individual servers or a compact solution (e.g., Enterprise Service Bus)*
- Drawbacks
 - *Monolithic apps are difficult to scale as a whole*
 - *Deployment overhead*
 - *A single technological environment for all app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