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





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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**

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Data Functions Processes Software Architecture Hardware Architecture Lecture 1: Information System Architectures, CTU Winter Semester 2025/2026, @TomasVitvar - 4-

Enterprise Architecture Data Functions Processes Software Architecture Hardware Architecture

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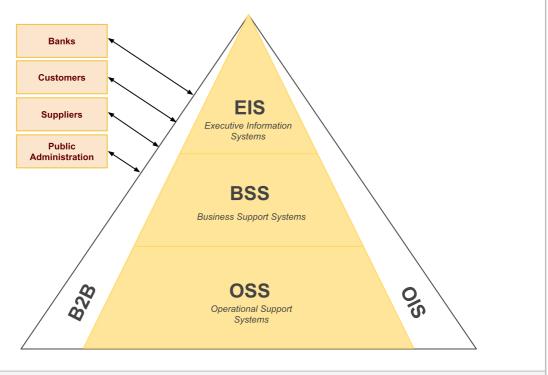
Enterprise Architecture Levels

- Defines a structure of an enterprise system
 - Abstracts from data, functions, processes, software, hardware
 - divides enterprise system into functional blocks applications
 - \rightarrow 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)
 - $\rightarrow \textit{Enterprise Application Integration (EAI)}$

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Enterprise Architecture Representation



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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

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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

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- Architecture Overview
- Software Architecture
 - Types, Separation of Concerns, Interface
 - Client/Server Architectures

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Software Architecture Types

- Centralized Client/Server (C/S)
 - Central server, a bunch of clients
 - monolithic, two-, three-, multi-tier architectures
 - Single point of failure!
 - \rightarrow when a server fails the whole system fails
 - → need for a scalable and **highly reliable** server-side solutions
 - Enterprise systems (mostly) use centralized solutions
 - \rightarrow 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

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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
 - \rightarrow 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

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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.

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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

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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

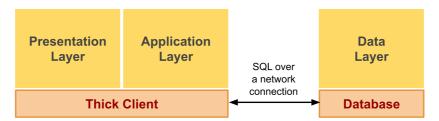
Drawbacks

- hard to maintain (updates, distribution of new versions)
- data security issues
- performance and scalability issues

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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

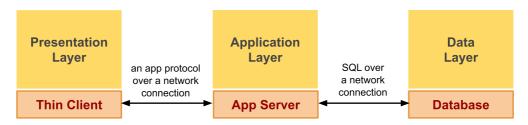
Drawbacks

- Thick client hard to maintain (reinstallation with every update)
- No app logic sharing (only through copies)
- Data-oriented integration (integrity in the app logic!)

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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

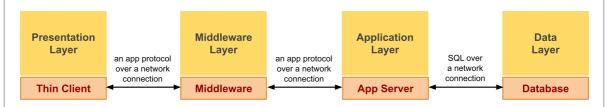
Drawbacks

- Spaghetti integration
- Limited, single app server scalability

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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

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Client/Server Architecture (microservices)



Microservice architecture

- Middleware, app and DB monoliths are microservice architecture
- Improved scalability and technology neutrality of app components

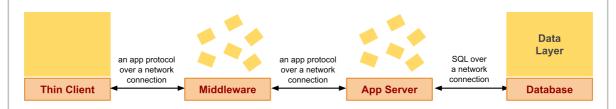
Service orchestration layer

- Kubernetes (K8s)
- Large K8s cluster for all, middleware, app, DB
- Separate K8s cluster

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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)

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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, ...

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