Middleware and Web Services
Lecture 1: Introduction to Architectures

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Overview

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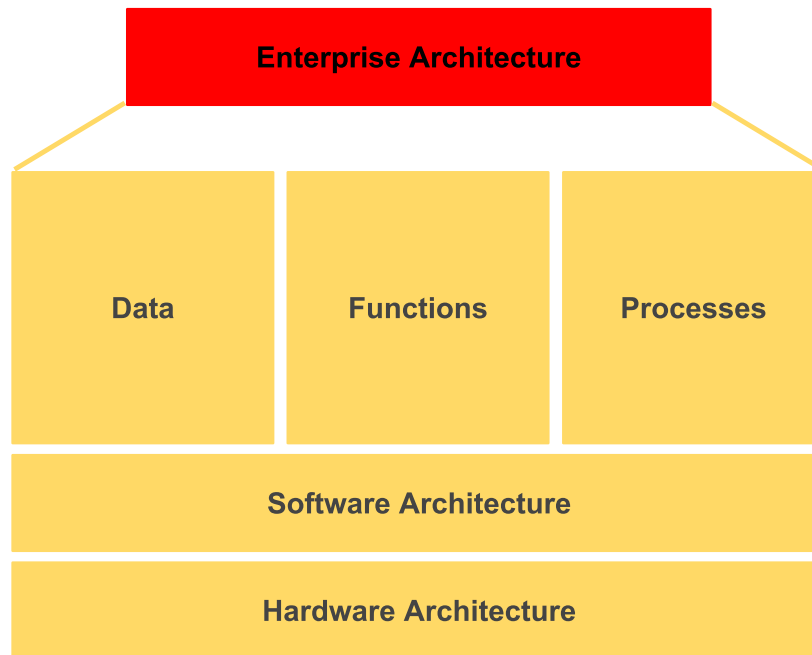- Software Architecture

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
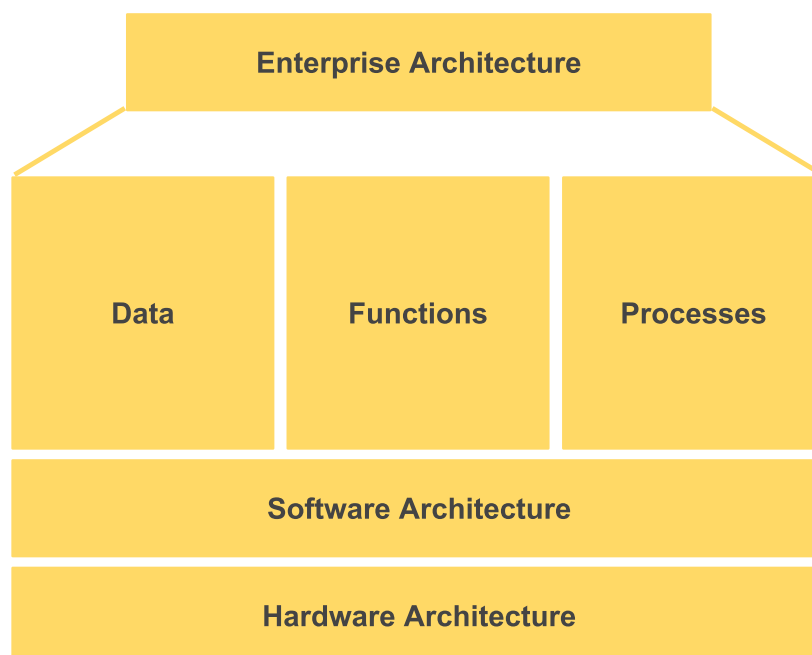
Enterprise Architecture

Enterprise Architecture Levels

- Defines a structure of an enterprise system
  - *Abstracts from data, functions, processes, software, hardware*
  - *divides enterprise system into functional blocks – **applications***
    - $\rightarrow$ *Order Management System (OMS)*
    - $\rightarrow$ *Customer Relationship System (CRM)*
    - $\rightarrow$ *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*
    - $\rightarrow$ *Business-to-Business (B2B)*
    - $\rightarrow$ *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)*

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  - *Integration*
- Software Architecture

Process Classification Framework

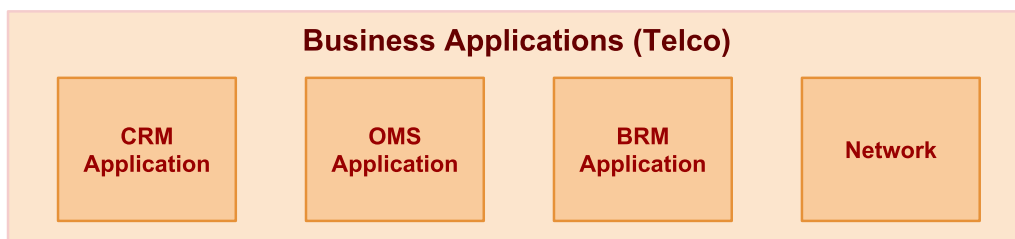|			
Level 0 **Business functions** *Business functions of the enterprise*	Manage Customer Service	Manage IT	Manage Financial Resources
Level 1 **Process Groups** *Defines groups of processes*	Develop Customer Care	Manage Customer Service Operations	Assure Services
Level 2 **Core Business Process** *Defines roles and high-level functions*	Manage Customer Service Requests	Perform CRM	Handle Orders
Level 3 **Business Activity** *Defines activities within a process, multiple roles*	Establish Order	Close Customer Order	Complete Order
Level 4 **Business Task** *Tasks are executed by a single actor (human or system)*	Sales Order Fulfillment	Provision Order	Bill Fulfillment Order
Level 5 **Business Step**	...	...	...

APQC
Process Classification
Framework (PCF)

Organization's
Implementation specific

Order Process Example in Telco

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

  Order Capture → Sales Order Fulfillment → Provision Order → Bill Fulfillment Order → Update Order

- ## Involved applications
  - *integrated applications*

  Business Applications (Telco)

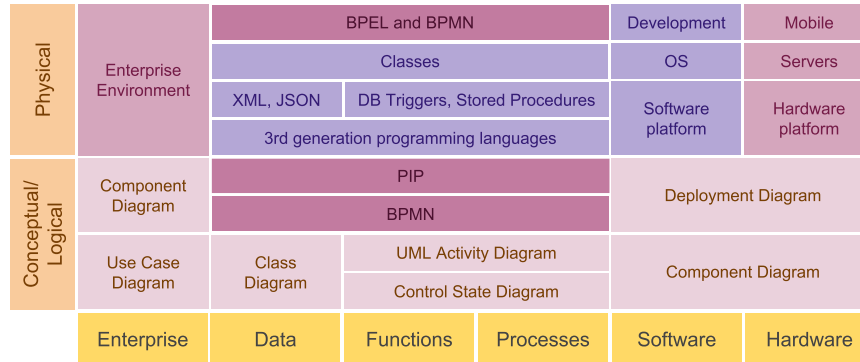 | CRM Application | OMS Application | BRM Application | Network |
  |---|---|---|---|

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 of Representations

- ## Languages to realize architectures
  - *development levels × architectural views*

Physical	Enterprise Environment	BPEL and BPMN			Development	Mobile
		Classes			OS	Servers
		XML, JSON	DB Triggers, Stored Procedures		Software platform	Hardware platform
		3rd generation programming languages				
Conceptual/ Logical	Component Diagram	PIP			Deployment Diagram	
		BPMN				
	Use Case Diagram	Class Diagram	UML Activity Diagram		Component Diagram	
			Control State Diagram			
	Enterprise	Data	Functions	Processes	Software	Hardware

Abbreviations
BPMN=Business Process Management Notation   BPEL=Business Process Execution Language
PIP=Partner Interface Process   UML=Unified Modeling Language

Legend
- Architectural view
- Development Level
- Example UML diagrams
- Example Business Standards
- Example implementation technologies
- Physical Operational Environment

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
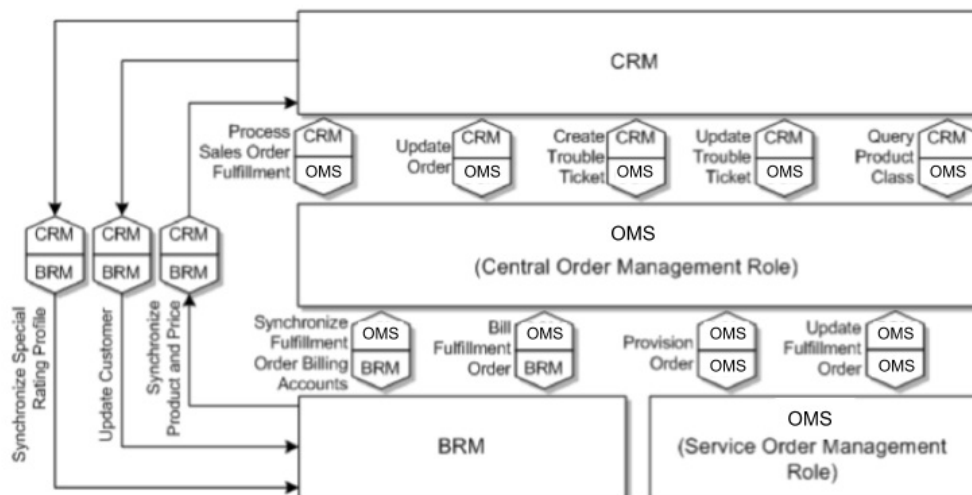
Integration Issues

- 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*

Overview

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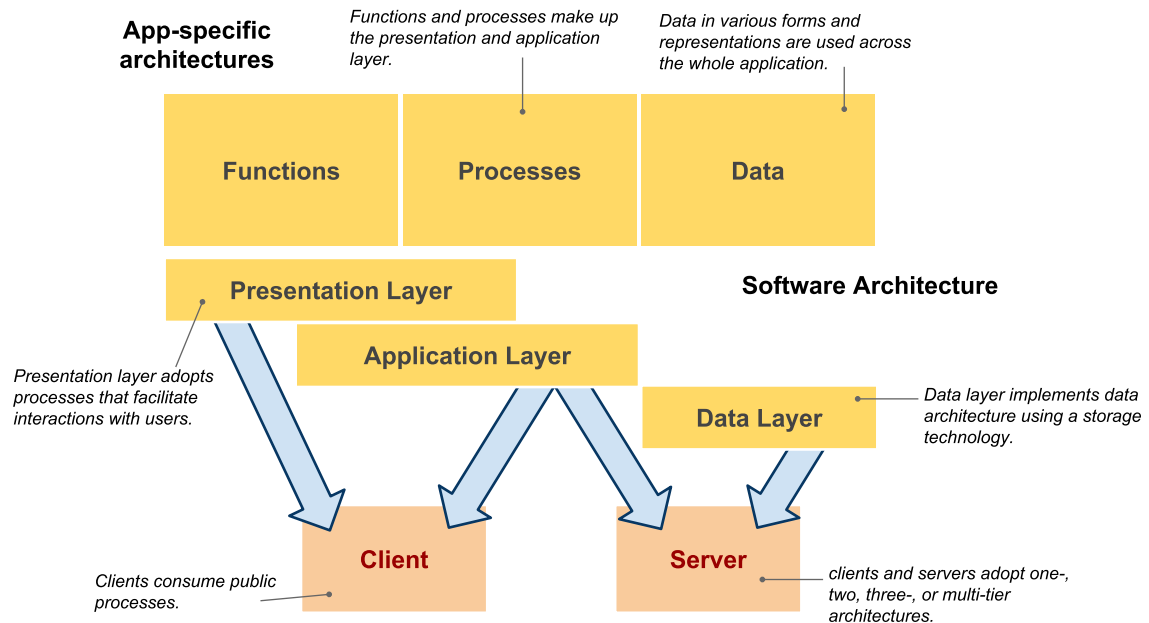 - *Client/Server Architectures*

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*
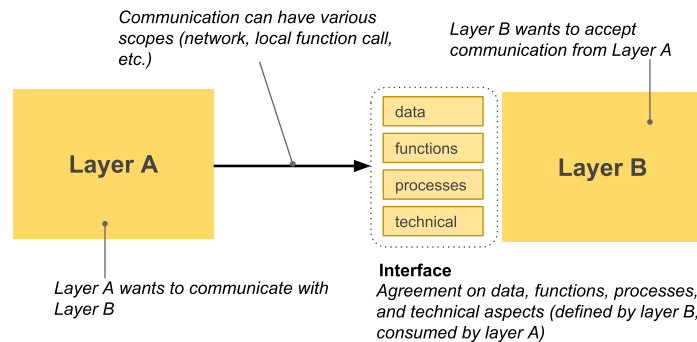
Software Architecture Layers

App-specific architectures

Functions and processes make up the presentation and application layer.

Data in various forms and representations are used across the whole application.

Functions	Processes	Data

Presentation Layer

Software Architecture

Application Layer

Presentation layer adopts processes that facilitate interactions with users.

Data Layer

Data layer implements data architecture using a storage technology.

Client

Server

Clients consume public processes.

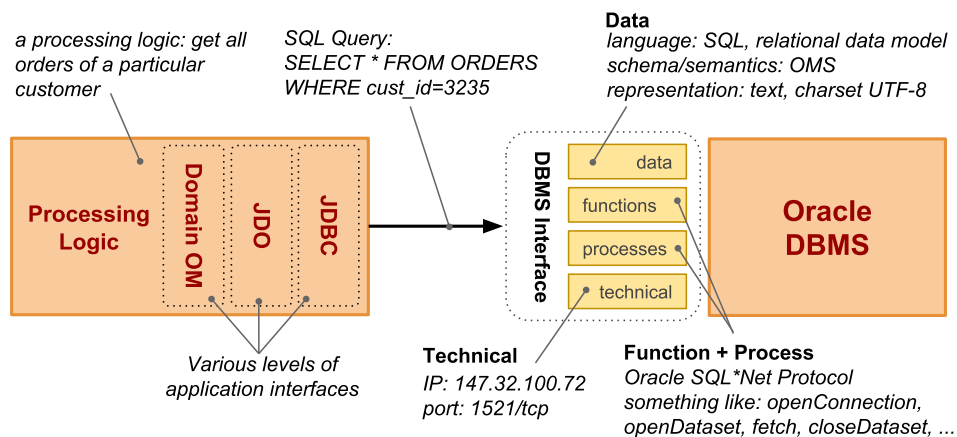*clients and servers adopt one-, two, three-, or multi-tier architectures.*

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 Scope

Communication can have various scopes (network, local function call, etc.)

Layer B wants to accept communication from Layer A

data
functions
processes
technical

Layer A

Layer B

Layer A wants to communicate with Layer B

Interface
Agreement on data, functions, processes, and technical aspects (defined by layer B, consumed by layer A)

- Scope
  - *local: layer A and B on one machine*
  - *network: layer A and B on separated machines (client/server)*
- Application Programming Interface (API) ~ local scope
  - *OS/complex apps' interface for extension development*
- Web Services and Web API (network scope)
  - *Web API is a new term – API of Web Applications*

Complex Interfaces

a processing logic: get all orders of a particular customer

SQL Query:
*SELECT * FROM ORDERS WHERE cust_id=3235*

Data
language: SQL, relational data model schema/semantics: OMS representation: text, charset UTF-8

Processing Logic

Domain OM

JDO

JDBC

DBMS Interface

data
functions
processes
technical

Oracle DBMS

Various levels of application interfaces

Technical
IP: 147.32.100.72 port: 1521/tcp

Function + Process
*Oracle SQL*Net Protocol something like: openConnection, openDataset, fetch, closeDataset, ...*

- 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*
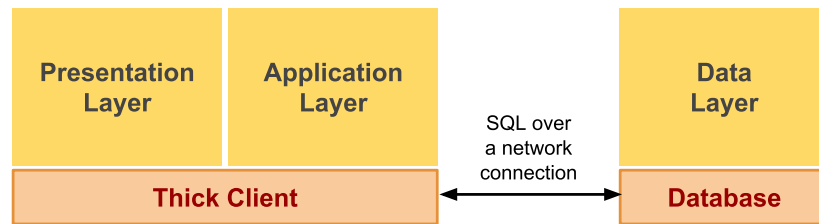
Overview

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

Monolithic Architecture

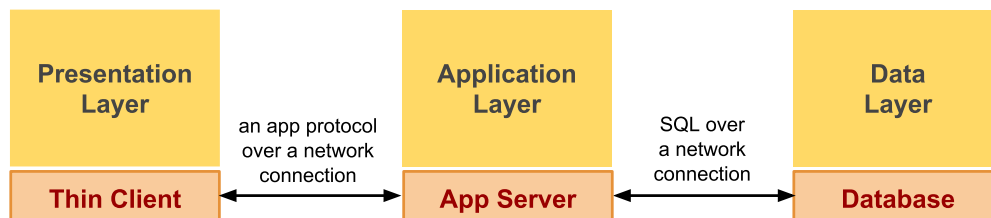| Presentation Layer	Application Layer	Data Layer

Desktop Application

- 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

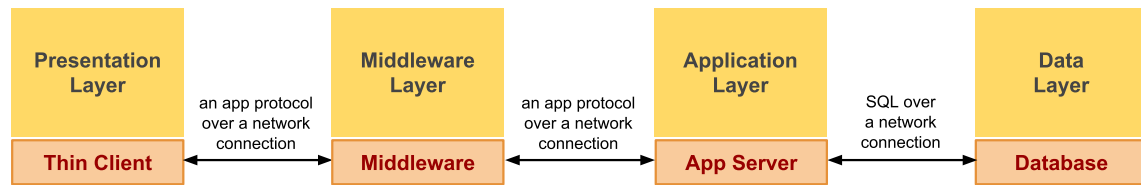| Presentation Layer	Application Layer		Data Layer
Thick Client		SQL over a network connection	**Database**

- 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

Presentation Layer		Application Layer		Data Layer
Thin Client	an app protocol over a network connection	**App Server**	SQL over a network connection	**Database**

- 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 (see Lecture 0)*
  - *Limited, single app server scalability*

Multi-tier Client/Server Architecture

Presentation Layer	an app protocol over a network connection	Middleware Layer	an app protocol over a network connection	Application Layer	SQL over a network connection	Data Layer
Thin Client	⟷	**Middleware**	⟷	**App Server**	⟷	**Database**

- ## Additional middleware layer
  - *loose coupling, shift towards peer-to-peer architectures*
  - *provides value-added services for communications*
  - *individual servers or a compact solution (e.g., Enterprise Service Bus)*

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, ...*