Software Engineering for Business Applications
Lecture Notes

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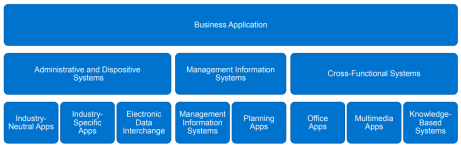
1 IT Support for Business Applications

1.1 Classification of Business Applications

- **Definition "Business Application":**
  - in narrower sense: totality of all programs, i.e. **application software**, and associated **data** for a concrete business use case
  - in broader sense: additionally **hardware**, **system software** and necessary **communication** facilities required for the use of application software
- **Two roles of Business Applications:**
  - **supporting**, **improving** or **automating** existing operational processes in bookeeping, accounting, etc. (size, speed, correctness...)
  - **enabling** new products and services (e.g. online shopping and banking)
- **Classification of Business Applications by Business Purpose:**



Examples of

  - **administrative systems:** financial accounting, payroll accounting, administration of stocks
  - **disposition systems:** calculation and cost accounting, material procurement, field service control
  - **management information systems (MIS):** use of internal company data, use of external data, combination of multiple data sources in a flexible form
  - **planning systems:** planning of individual functional areas, integrated planning of several functional areas, corporate planning
- **Cross-Cutting Applications:**
  - independent of compant hierarchy and fuctional domains
  - used either directly via user interface or programmatically via administration and disposition systems
  - *Examples:* office suites, groupware, workflow management systems

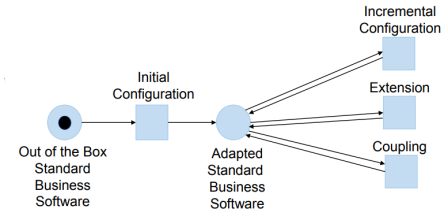
- **Enterprise Resource Planning (ERP): ERP system** is an integrated business application (suite, collection of programs), which supports all essential functions of administration, disposition and management with a common interface and a shared and integrated data management.
  - consists of platform and function-oriented application components that exchange info and events
  - is realized as (customizable) standard software
  - *Examples:* external accounting, controlling, procurement
  - Today's ERP systems support an **extended value chain**[1].

1.2 Standard and Custom Software

- **Standard Software vs. Custom Software:**
  - **Standard software** *(e.g. SAP)*
    - developed for specific **market**
    - distributed by a software house
    - can be used by **several companies**
    - implements "standard business processes" at its core
    - maintained by **manufacturer**, adapted to changes
    - must or can be **customized** to company (e.g. authorizations and roles, currencies)
  - **Custom software**
    - specifically developed for **one company**
    - tailored to specific business processes/requirements
    - result of a project for a known client
    - **individually** maintained and adapted to changes

[1] **Value chain** is a business model that describes the full range of activities needed to create a product or service.

- **Adaptation Techniques for Standard Business Software:**
  - Adaptation of operational standard software can be divided into **Configuration**, **Extension** and **Coupling** (= **Customizing**).



  - **Configuration** describes functionalities and techniques
    - that are obligatory on first deployment
    - that allow to define predefined settings
    - that lead to an individual variation of standard software
  - **Extension** describes functionalities and techniques
    - that are optional for productive use
    - that allow to map requirements not foreseen by manufacturer
    - implemented by manufacturer to expand the range of services
  - **Coupling** refers to functionalities and techniques
    - to connect external systems of other manufacturers
    - to connect external systems of the same type
    - that are predefined in the form of data file formats, APIs, or communication protocols
  - *Example:* mapping the structure of a company to SAP applications via organizational units (can be assigned to single or multiple apps)

- **Configuration: Challenges**
  - A **standard software** must
    - provide all relevant configuration options
    - support a wide range of different corporate structures and processes
    - check dependencies between these many variants
    - provide appropriate documentation about the effects of individual configurations
  - **Consequences:**
    - need for experts who are familier with configuration options of each release and componant
    - scarcity of such experts

    - expensive training
    - expensive consultancy services

- **Examples for Extensions:**
  - automation of **multi-step business workflows**
  - integration of company-specific calculations/rules/checks
  - connecting customers

- **Coupling Options:**
  - different coupling options depending on the scenario
  - programming language used for coupling
  - available mechanisms to couple

- **Multi Tenancy:** Software multitenancy is a software architecture in which a single instance of software runs on a server and serves multiple tenants (e.g. companies).
  - sevearal companies can be represented in one system
  - distinction between tenant-dependent and -independent data
  - supporting tenant-dependent authorization (e.g. A may only perform transactions in client 002)
  - individual adaptations of tenants (e.g. currency, couplings)

- **Multilingualism:**
  - **Multilingualism of a business information system** makes it possible to
    - store and display texts in different languages in the system
    - assing graphics and symbols specific to different languages
  - Multilingualism requires
    - that one system can process all relevant character sets at once
    - storage and recognition of words, numbers etc.
    - that a system can assign users to languages or user can choose their own
    - that texts (graphics, symbols) can be assigned to a language

- **Localization (l10n):** Adaptation of a software product to meet the language, culture, and other requirements of each locale (e.g. adaptation of graphics, currencies, date and time)

- **Internationalization (i18n):** Process of preparing a software-based product for localization (to support global markets)

1.3 Characteristics of Business Applications

- **Multiple Stakeholders and changing requirements:**
  - **Requirements Elicitation and Requirements Management**
    - many stakeholders, different views and concerns
    - Waterfall: upfront requirements document and/or technical specification => Req. Documentation
    - Issue: changing requirements once IT support is implemented
    - Agile: incremental and iterative => Agile Req. Engineering
    - typically, very large number of requirements
    - need for formalization and early consistency checking => Conceptual Modeling
    - need for cost and time prediction => Software Estimation
  - **Programming Challenges**
    - design, implement and test changes in an existing complex system => Change Mgmt.
    - deliver incremental changes without invalidating existing data => Release Mgmt.
    - parallel development at manufacturer and at customer site => Version Mgmt.
    - automated and quality-controlled assembly of application software => Build Mgmt.
- **Persistent Data and Concurrent Data Modification:**
  - **Data consistency** is a must:
    - many users perform **transactions** simultaneously on central databases
    - data must not be lost even in case of system failures.
  - **Programming challenges:**
    - database is managed by an independent application, on a different server / hardware
    - object orientation is not supported by common data bases
    - database concepts must be transferred to the application logic (transactions, rights, primary keys)
- **Distributed Actors and Data Repositories:**
  - **Many users access central data concurrently:**
    - users need data in different locations at different times
    - Client-Server architecture => Layered Architectures
    - web clients => REST protocol
  - **Programming challenges:**

    - software components must be able to found in network => Naming services
    - communication always via a network => Serialization[2] & failed execution
    - authentication and authorization => Security
    - concurrent accesses => Transactions

- **Integeration of Data and Application from (Semi-)Autonomous Sources:**
  - **Separation of applications and data repositories:**
    - multiple apps work on independent or shared data resources
    - multiple apps communicate with each other => RPC, Message Passing
    - business processes involve multiple apps => Workflow Mgmt. Systems
    - application landscapes with lots of interacting applications => Enterprise Architecture Mgmt.
  - **Programming challenges:**
    - integration of multiple languages and databases
    - loose coupling through interfaces to avoid code change propagationi
    - error recovery to avoid runtime failure propagation

- **Scalability:**
  - **Growing number of users and data volume**
    - business apps are used by thousands of employees world-wide around the clock
    - customers and business partners interact directly with business apps and expect real-time sub-second response times
    - volatile load (e.g. online shop in christmas season vs. summer season)
  - **Programming challenges:**
    - delayed execution of resource-intesive operations => Batch processing[3]
    - dynamically increasing/decreasing number of users => Instance pools
    - single server cannot handle the load => Load balancing, Caching

[2] **Serialization** is the process of translating a data structure into a format that can be stored or transmitted and reconstructed later.

[3] **Batch processing** is when a computer processes a number of tasks that it has collected in a group. It is designed to be a completely automated process, without human intervention.

2 Requirements Engineering

- **Software requirements** express the needs and constraints placed on a software product.
- **Requirements engineering** is concerned with **elicitation**, **analysis**, **specification** and **validation** of software requirements as well as the management of requirements.
- **Requirements Management** deals with the administration and maintenance of requirements documents, in particular:
  - change requirements (change management)
  - trace and link requirements (requirements tracing)
  - verify requirements

2.1 Traditional Requirements Engineering

- **Objectives of Requirements Management:**
  - **Efficient** preparation of **high quality** requirements and system specifications,
    - coordinated with all stakeholders (different objectives and interests)
    - coordinated with all specifications and constraints
    - evaluated according to profitability and feasibility
  - **Specification documents** are basis for:
    - contract negotiation and contractual agreements
    - coordination between the stakeholders (customers, developers)
    - design, realization, integration
    - software acceptance (test specification)
    - future developments, projects
- **Requirement Classification:** Distinction between functional and non-functional requirements and constraints:
  - **Functional requirements** describe interactions between the system and its environment independent of their realization.
  - **Non-functional requirements** describe general properties of the system.
  - **Restrictions (Constraints)** determine the solution space for the realization.
- **Stakeholder Management:** It includes

  - processes required to identify people that could impact or be impacted by the project
  - to analyze stakeholder expectations and their impact on the project
  - to develop appropriate management strategies for effectively engaging stakeholders in project decisions and execution

- **Requirement Specification:**
  - technical result document of requirement identification phase
  - **contains** stakeholder identification, functional and non-functional requirements, constraints, evaluation plan and metrics
  - list of all deliverables and services to be fulfilled by contractor within contract as defined by customer
  - **what** is to expect from the solution (product)
  - formulation of requirements should be as general as possible and as restrictive as necessary
  - enables the contractor to develop optimal solutions

- **Requirements Validation: Validation**, **Consistency check** (no conflicts), **Completeness check**, **Reality check**, **Verifiability**

- **Functional Specification:**
  - defines the purpose of the system
  - solution proposal created by contractor based on the requirement specification provided by client
  - **contains** target determination, product usage, environment (e.g. hardware), functions, UI, global test cases
  - system description or solution specification, which describes **how** the solutions is to be realized (concrete solution approaches)
  - the **what** from **requirement specification** is detailed

2.2 Agile Requirements Engineering

- **Requirements Engineering and Agile Software Development:**
  - **Agile software development** focuses more on **continuous collabration** (workshops, interviews etc.) with stakeholders instead of relying on **specification documents** (*example: SCRUM*)
  - **Traditional requirements engineering**
    * focuses on customer collabration mainly at an early phase of the project (longer change cycles)
    * emphasizes a heavy-weight process with extensive, **static specification documents**

  - **Agile requirements engineering**
    * fosters communication with the customer during the whole development process to **continuously update requirements**
    * focuses less on extensive documentation, but specification documents **might be necessary** because of legal or contracting reasons etc.
    * includes activities and artifacts that are similar to classical requirements engineering activities

- **Typical Requirement Artifacts in Agile Software Development:**
  - **user story**, **story card**, **use case**, **scenario**, **UML diagram**, **prototype**

- **User Stories:**
  - explanation of a software feature written from the perspective of the end user
  - most frequently used artifact in **agile software development**
  - mnemonic for writing good user stories: INVEST[4]

- **Typical Requirements Engineering Challenges:**
  - different interest groups can raise **conflicting requirements**
  - the people who **pay** for the system are rarely the ones who **use** it
  - the organization and the technical environment may **change** after the system rollout
  - requirements that change during implementation (Change Requests) can lead to additional costs -> project duration/milestones can be affected significantly

3 Conceptual Modeling with UML

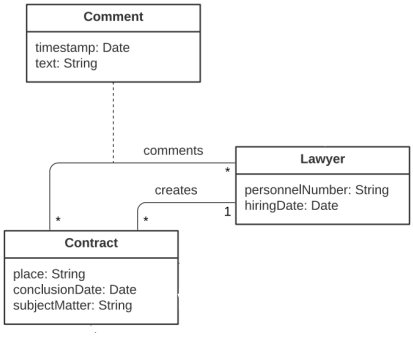
- **Conceptual Class Diagram vs. Implementation-Oriented Diagram:**

	Conceptual	Implementation-Oriented
Visibility (private, public)	No	Yes
Attributes with data types	Yes	Yes
Methods	No	Yes
Generalization / Inheritance	Sparingly	If useful / meaningful
Abstract classes	No	If useful / meaningful
Association classes	Yes	No (resolved)

- **Associations between Classes:**

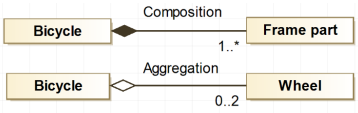
[4] independent, negotiable, valuable, estimable, small, testable

– **Multiplicity:**



A Lawyer can <u>*create*</u> ***multiple*** *Contracts, whereas every Contract has a* ***single*** *Lawyer.* -> <u>creates</u> (action) on the side of Lawyer (actor)

- **Aggregation:** implies a relationship where the child can exist independently of the parent (part of the parent)
- **Composition:** implies a relationship where the child <u>cannot exist</u> independent of the parent
- <u>*Example:*</u>



4 Software Estimation

4.1 Fundamentals of Estimation Methods

- **Software Estimation:**
  - In principle, software estimation relies on **forecasting effort**, from which cost and duration are derived.
  - Regardless of the project and software methodology applied, every initiative requires the definition of a **budget** and a specific **time frame** necessary to deliver a final outcome.
  - These two are obtained during the **early stages** of the project lifecycle through the process of estimation.

  - **Estimation** aims to provide an **approximation** of the amount of recources required to complete project activities and produce a product or service in accordance to specified **functional** and **non-functional characteristics**.
  - **Software estimation conducted in early phases of the project lifecycle:**
    * necessary for contract negotiations
    * predict expected efforts (and derived costs) for a software project before implementation
    * best possible estimation given the available info
  - **Agile estimation:**
    * estimation of individual requirements during project
    * incremental allocation of developers in the most efficient manner
    * cost estimates are made several times during development project with varying degrees of detail

- **Software Estimation: Cone of Uncertainty**
  - At the beginning of the project, not much is known about the product/project -> estimates underly high uncertainty
  - As the project progresses, more information is available -> decrease in uncertainty

- **Software Estimation: Costs**
  - **Cost categories:**
    * **Development costs:** costs to produce a software product
    * **Personnel costs:** major share of development costs for personnel
      · usually low costs for office materials etc. in relation to the personnel costs
      · proportionate allocation of CASE[5] environment costs (including hardware and software) for product development

4.2 Traditional Software Estimation

- **Sneed's Devil's Square:**
  - Quantity
  - Quality
  - Development duration
  - Cost

[5]Computer power-assisted software package Engineering

are mutually dependent.

- **Quantity:**
  - size of program code (example basis of assesment: LOC[6])
  - functional and data scope
  - possible additional weighting with complexity
- **Quality:**
  - higher quality requirements => greater effort
  - no **THE quality**, but different quality characteristics
- **Productivity:**
  - influenced by many different factors
  - number of communication links grows **quadratically** with the team size
- **Development time:**
  - need more members to shorten development time
  - more members => more communication effort
  - higher communication => decrease in productivity
- **Methods for Effort Estimation:**
  - **Estimation Strategies:**
    - **Top-Down:** estimation of the total project effort using mathematical algorithms based on the functional requirements
    - **Bottom-Up:** expenses for each expense item are calculated separately and added to calculate the total project effort
  - **Comparison methods:**
    - estimation based on effort analysis of already accomplished similar developments
  - **Algorithmic methods:**
    - effort calculated with algorithmic methods
    - based on statistical models or actual expenditure of already completed projects
  - **Key figure methods:**
    - total cost of the software product determined by estimating the cost of individual units or project phases
  - None of the listed basic methods alone is sufficient.

[6]Lines of Code

  - Depending on the point in time and knowledge of effort-relative data, one or the other method should be used.

- **Concrete Procedures for Effort Estimation:**
  - **Goal:** Combine advantages of several effort estimation methods to deliver accurate results. (*example: Function Point Method*)

- **Function Point Method:** It is a combined relation and weighting method.