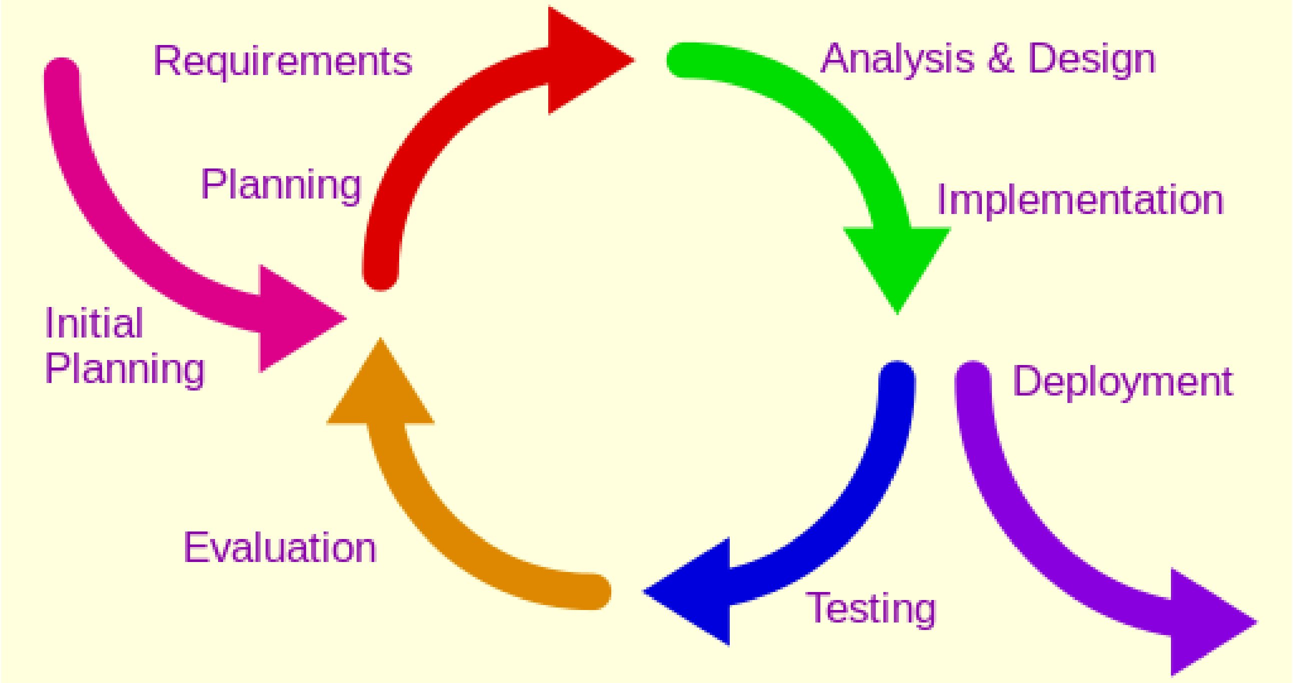
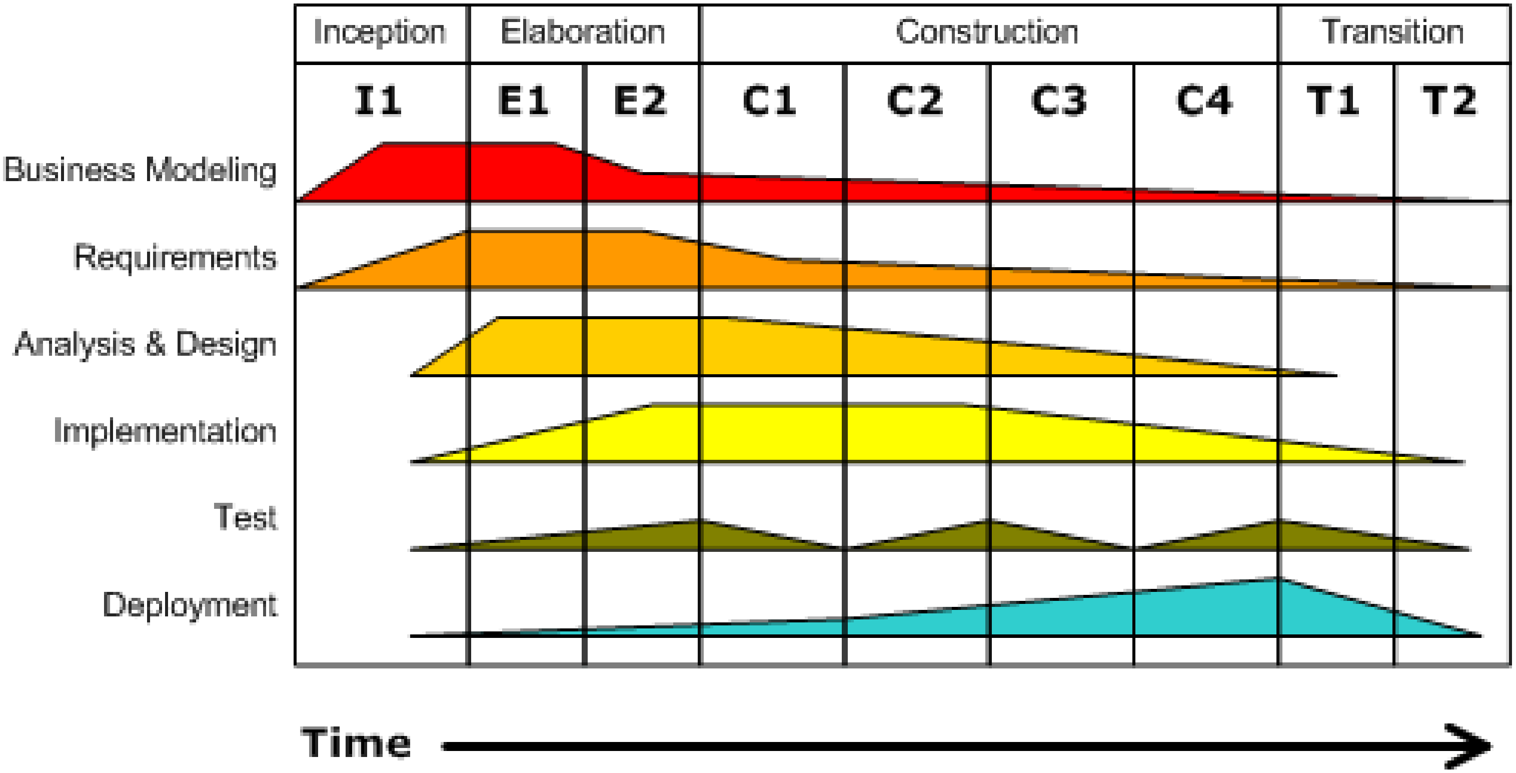
Software Design

SD

Iterative development model

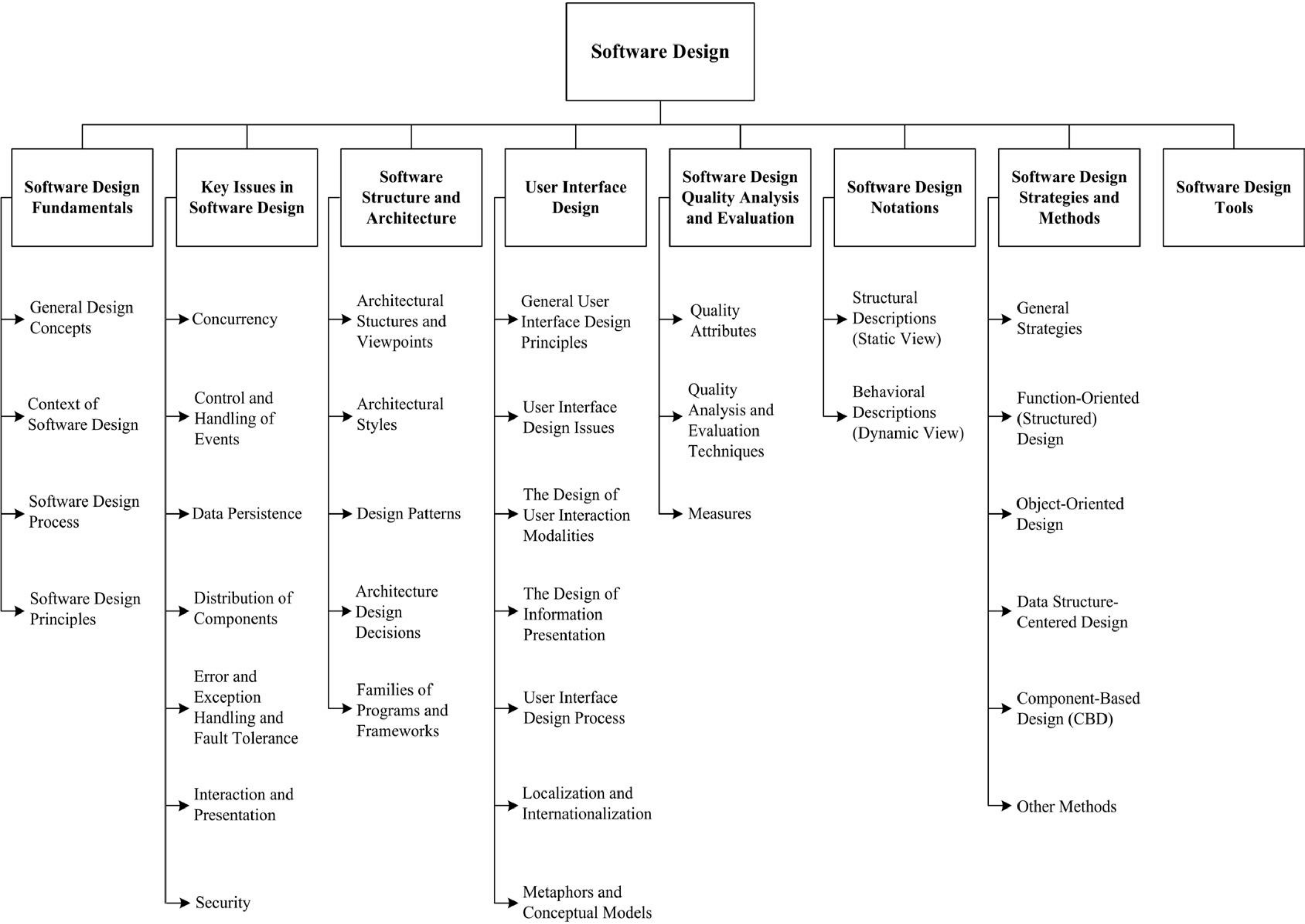


RUP model



Iterative Development

Business value is delivered incrementally in
time-boxed cross-discipline iterations.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SD Process

Software design consists of two **activities** that fit between software **requirements analysis** and software **construction**:

- ❑ Software **architectural** design – **high-level** design:
  - developing top-level structure and organization of software
  - identifying various components
- ❑ Software **detailed** design: specifies each component in **sufficient** detail to facilitate its construction

Fundamental Principles of SD - I

- **Abstraction** – view of an object that focuses on the information relevant to a **particular purpose** and ignores the remainder of the information:
  - Abstraction by specification:
    - procedural abstraction
    - data abstraction
    - control (iteration) abstraction
  - Abstraction by parameterization – representing the data as named parameters
- **Sufficiency and completeness** – a software component captures all the **important characteristics of an abstraction** and nothing more
- **Encapsulation and information hiding** – grouping and **packaging** the internal details of an abstraction and making those details inaccessible to external entities

Fundamental Principles of SD - II

- **Decomposition and modularization** – large software is divided into a number of smaller named components having well-defined interfaces that describe component interactions

- **Separation of interface and implementation** – defining a component by specifying a public interface (known to the clients) that is separate from the details of how the component is realized

- **Coupling and Cohesion:**
  - Coupling – a measure of the interdependence *among modules* in a computer program
  - Cohesion – a measure of the strength of association of the elements *within a module*

- **Primitiveness** – the design should be based on patterns that are easy to implement

Key Issues in SD

- **Concurrency** – decomposing software into **processes**, **tasks** and **threads** and dealing with related issues of efficiency, atomicity, synchronization and scheduling

- **Control and handling of events** – organizing data and control **flow** as well as handling reactive and temporal events through various mechanisms such as implicit invocation and call-backs

- **Data persistence** – handling long-lived data

- **Distribution of components** – distributing the software across the hardware, organizing communication of components, using middleware to deal with heterogeneous software

- **Interaction and presentation** – structuring and organizing interactions with users as well as the presentation of information

- **Error and exception handling and fault tolerance**

- **Security**
  - preventing unauthorized disclosure, creation, change, deletion or denial of access to information and other resources
  - tolerating security-related attacks or violations by limiting damage, continuing service, speeding repair and recovery, and failing and recovering securely
  - using of cryptology

Software Architecture

- **Architecture**:
  - strict sense -- **set of structures** needed to reason about system, which comprise software elements, **relations among them**, and properties of both
  - general sense -- set of views -- different high-level facets -- about software design at different levels of abstraction
- **Representation of a partial aspect** of a software architecture, that shows specific properties of a software system, by the views:
  - **logical view** -- satisfying functional requirements
  - **process view** -- concurrency issues
  - **physical view** -- distribution issues
  - **development view** -- how the design is broken down into **implementation units** with explicit representation of the dependencies among the units

Architectural Styles

- **Architectural styles** can be viewed as patterns describing the **high-level** organization of software
- Architectural style
  - specialization of element and relation types, together with a set of constraints on how they can be used
  - providing the software’s high-level organization
- Major architectural styles
  - General structures (layers, pipes and filters, blackboard)
  - Distributed systems (client-server, three-tiers, broker)
  - Interactive systems (**Model-View-Controller**, Presentation-Abstraction-Control)
  - Adaptable systems (microkernel, reflection)
  - Others (batch, interpreters, process control, rule-based).

Design Patterns

- **Design patterns** (GoF) can be used to describe details at a **lower level**:
  - Creational patterns
  - Structural patterns
  - Behavioral patterns

SD Notations

- **Structural Descriptions (Static View)**
  - **Class and object diagrams**
  - **Component diagrams**
  - Class responsibility collaborator cards
  - **Deployment diagrams**
  - Entity-relationship diagrams
  - Architecture description languages
  - Interface description languages
  - Structure charts
- **Behavioral Descriptions (Dynamic View)**
  - **Sequence diagrams**
  - **Activity diagrams**
  - Communication diagrams
  - Data flow diagrams
  - Decision tables and diagrams
  - Flowcharts
  - **State transition and state chart diagrams**
  - Formal specification languages
  - Pseudo code and program design languages

SD Quality Attributes

- Quality Attributes contribute to the quality of a software design:

  “-ilities” : maintainability, portability, testability, usability...

  “-nesses”: correctness, robustness ...

- Attributes **discernible** at runtime:

  performance, security, availability, functionality, usability

- Attributes **not discernible** at runtime:

  modifiability, portability, reusability, testability

- Attributes related to the architecture’s intrinsic qualities:

  conceptual integrity, correctness, completeness

Quality analysis and evaluation techniques

- **Software design reviews** – informal and formalized techniques to determine the **quality of design artifacts**:
  - architecture reviews
  - design reviews and inspections
  - scenario-based techniques
  - **requirements tracing**
- Security evaluation by design reviews
- Review of aids for installation, operation, and usage
- **Static analysis:** formal or semiformal static (**nonexecutable**) analysis that can be used to evaluate a design (fault tree analysis or automated cross-checking)
  - Design vulnerability analysis – static analysis for security weaknesses
  - Formal design analysis – using mathematical models that allow to predicate the behavior and validate the performance of the software instead of having to rely entirely on testing; can be used to detect residual specification and design errors
- **Simulation and prototyping:** dynamic techniques to evaluate a design for performance simulation or feasibility prototypes

Measures

- Measures are classified in two broad categories:
  - **function-based** (structured) design measures:
    - obtained by analysis of functional decomposition
    - generally represented using a structure chart (a hierarchical diagram), on which various measures can be computed
  - **object-oriented design measures**:
    - design structure is typically represented as a class diagram, on which various measures can be computed
    - measures on the properties of the internal content of each class
- Most measures depend on the approach used for producing design