Design methods

- Functional decomposition
- Data Flow Design (SA/SD)
- Design based on Data Structures (JSD/JSP)
- OO is gOOd, isn’t it

List of possible design methods

- Decision tables
- E-R
- Flowcharts
- FSM
- JSD
- JSP
- LCP
- Meta IV
- NoteCards
- OBJ
- OOD
- PDL
- Petri Nets
- SA/SD
- SA/WM
- SADT
- SSADM
- Statecharts

Functional decomposition

- Extremes: bottom-up and top-down
- Not used as such; design is not purely rational:
  - clients do not know what they want
  - changes influence earlier decisions
  - people make errors
  - projects do not start from scratch
- Rather, design has a yo-yo character
- We can only fake a rational design process

Data flow design

- Yourdon and Constantine (early 70s)
- Nowadays version: two-step process:
  - Structured Analysis (SA), resulting in a logical design, drawn as a set of data flow diagrams
  - Structured Design (SD) transforming the logical design into a program structure drawn as a set of structure charts
Design based on data structures (JSP & JSD)

- JSP = Jackson Structured Programming (for programming-in-the-small)
- JSD = Jackson Structured Design (for programming-in-the-large)

JSP

- basic idea: good program reflects structure of its input and output
- program can be derived almost mechanically from a description of the input and output
- input and output are depicted in a structure diagram and/or in structured text/schematic logic (a kind of pseudocode)
- three basic compound forms: sequence, iteration, and selection)

Difference between JSP and other methods

- Functional decomposition, data flow design: Problem structure ⇒ functional structure ⇒ program structure
- JSP:
  Problem structure ⇒ data structure ⇒ program structure

JSD: Jackson Structured Design

- Problem with JSP: how to obtain a mapping from the problem structure to the data structure?
- JSD tries to fill this gap
- JSD has three stages:
  - modeling stage: description of real world problem in terms of entities and actions
  - network stage: model system as a network of communicating processes
  - implementation stage: transform network into a sequential design
JSD’s modeling stage

- JSD models the UoD as a set of entities
- For each entity, a process is created which models the life cycle of that entity
- This life cycle is depicted as a process structure diagram (PSD); these resemble JSP’s structure diagrams
- PSD’s are finite state diagrams; only the roles of nodes and edges has been reversed: in a PSD, the nodes denote transitions while the edges edges denote states

OOAD methods

- Three major steps:
  1. identify the objects
  2. determine their attributes and services
  3. determine the relationships between objects

(Part of) problem statement

Design the software to support the operation of a public library. The system has a number of stations for customer transactions. These stations are operated by library employees. When a book is borrowed, the identification card of the client is read. Next, the station’s bar code reader reads the book’s code. When a book is returned, the identification card is not needed and only the book’s code needs to be read.

Candidate objects

- software
- library
- system
- station
- customer
- transaction
- book
- library employee
- identification card
- client
- bar code reader
- book’s code
Carefully consider candidate list

- eliminate implementation constructs, such as “software”
- replace or eliminate vague terms: “system” ⇒ “computer”
- equate synonymous terms: “customer” and “client” ⇒ “client”
- eliminate operation names, if possible (such as “transaction”)
- eliminate individual objects (as opposed to classes). “book’s code” ⇒ attribute of “book copy”

Relationships

- From the problem statement:
  - employee operates station
  - station has bar code reader
  - bar code reader reads book copy
  - bar code reader reads identification card
- Tacit knowledge:
  - library owns computer
  - library owns stations
  - computer communicates with station
  - library employs employee
  - client is member of library
  - client has identification card

Result: initial class diagram

Usage scenario ⇒ sequence diagram
**OO as middle-out design**

- First set of objects becomes middle level
- To implement these, lower-level objects are required, often from a class library
- A control/workflow set of objects constitutes the top level

**OO design methods**

- Booch: early, new and rich set of notations
- Fusion: more emphasis on process
- RUP: full life cycle model associated with UML

**Booch’ method**

- Identify classes and objects
- Identify semantics of classes and objects
- Identify relationships between classes and objects
- Identify interface and implementation of classes and objects

**Fusion**

- **Analysis**
  - Object model
  - Interface model
- **Design**
  - Object interaction graphs
  - Visibility graphs
  - Class descriptions
  - Inheritance graphs
RUP

- Nine workflows, a.o. requirements, analysis and design
- Four phases: inception, elaboration, construction, transition
- Analysis and design workflow:
  - First iterations: architecture discussed in ch 11
  - Next: analyze behavior: from use cases to set of design elements; produces black-box model of the solution
  - Finally, design components: refine elements into classes, interfaces, etc.

Classification of design methods

- Simple model with two dimensions:
  - Orientation dimension:
    - Problem-oriented: understand problem and its solution
    - Product-oriented: correct transformation from specification to implementation
  - Product/model dimension:
    - Conceptual: descriptive models
    - Formal: prescriptive models

Classification of design methods (cnt’d)

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<td>IV</td>
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<td>VDM</td>
<td>Functional decomposition</td>
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Characteristics of these classes

- I: understand the problem
- II: transform to implementation
- III: represent properties
- IV: create implementation units
Caveats when choosing a particular design method

- Familiarity with the problem domain
- Designer’s experience
- Available tools
- Development philosophy

Object-orientation: does it work?

- do object-oriented methods adequately capture requirements engineering?
- do object-oriented methods adequately capture design?
- do object-oriented methods adequately bridge the gap between analysis and design?
- are oo-methods really an improvement?

Complexity

- measure certain aspects of the software (lines of code, # of if-statements, depth of nesting, ...)
- use these numbers as a criterion to assess a design, or to guide the design
- interpretation: higher value ⇒ higher complexity ⇒ more effort required (= worse design)

- two kinds:
  - intra-modular: inside one module
  - inter-modular: between modules

intra-modular

- attributes of a single module
- two classes:
  - measures based on size
  - measures based on structure
**Sized-based complexity measures**

- counting lines of code
  - differences in verbosity
  - differences between programming languages
  - `a := b` versus `while p <> nil do p := p`

- Halstead’s “software science”, essentially counting operators and operands

**Structure-based measures**

- based on
  - control structures
  - data structures
  - or both

- example complexity measure based on data structures: average number of instructions between successive references to a variable

- best known measure is based on the control structure: McCabe’s cyclomatic complexity

**Object-oriented metrics**

- **WMC**: Weighted Methods per Class
- **DIT**: Depth of Inheritance Tree
- **NOC**: Number Of Children
- **CBO**: Coupling Between Object Classes
- **RFC**: Response For a Class
- **LCOM**: Lack of COhesion of a Method

**OO metrics**

- **WMC, CBO, RFC, LCOM** most useful
  - Predict fault proneness during design
  - Strong relationship to maintenance effort

- Many OO metrics correlate strongly with size
Techniques for making good design decisions

- Using priorities and objectives to decide among alternatives
  - Step 1: List and describe the alternatives for the design decision.
  - Step 2: List the advantages and disadvantages of each alternative with respect to your objectives and priorities.
  - Step 3: Determine whether any of the alternatives prevents you from meeting one or more of the objectives.
  - Step 4: Choose the alternative that helps you to best meet your objectives.
  - Step 5: Adjust priorities for subsequent decision making.

Software Architecture (Chapter 11)

- What is it, why bother?
  - Architecture Design
  - Viewpoints and view models
  - Architectural styles
  - Architecture assessment
  - Role of the software architect

The Role of the Architect

Pre-architecture life cycle

stakeholders (few) ↔ requirements ↔ quality

agreement

development
Characteristics

- Iteration mainly on functional requirements
- Few stakeholders involved
- No balancing of functional and quality requirements

Architecture in the life cycle

- Iteration on both functional and quality requirements
- Many stakeholders involved
- Balancing of functional and quality requirements
Why Is Architecture Important?

- Architecture is the vehicle for stakeholder communication
- Architecture manifests the earliest set of design decisions
  - Constraints on implementation
  - Dictates organizational structure
  - Inhibits or enable quality attributes
- Architecture is a transferable abstraction of a system
  - Product lines share a common architecture
  - Allows for template-based development
  - Basis for training