Design Patterns and Frameworks
1) Introduction

Prof. Dr. U. Aßmann
Chair for Software Engineering
Faculty of Informatics
Dresden University of Technology

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1) History and Introduction
2) Different classes of patterns
3) Where can patterns be used?

Literature (To Be Read)

- Start here: A. Tesanovic. What is a pattern? Paper in Design Pattern seminar, IDA, 2001. Available at course home page.
- Alternatively: GOF: Introduction.
- Brad Appleton. Patterns and Software: Essential Concepts and terminology. http://www.cmcrossroads.com/bradapp/docs/patterns-intro.html Compact introduction into patterns.
- http://www.hillside.net/plop/pastconferences.html

Secondary Reading

- D. Riehle, H. Zülinghoven, Understanding and Using Patterns in Software Development. Theory and Practice of Object Systems 2 (1), 1996. Explains different kinds of patterns. http://citeseer.ist.pst.edu/riehle96understanding.html

History

- Beginning of the 70s: the window and desktop metaphors (conceptual patterns)
  - Smalltalk group in Xerox Parc, Palo Alto
- 1978/79: MVC pattern for Smalltalk GUI. Goldberg and Reenskaug at Xerox Parc
  - During porting Smalltalk-78 for Norway in the Eureka Software Factory project [Reenskaug]
- 1979: Alexander's “The Timeless Way of Building”
  - Introduces the notion of a *pattern* and a *pattern language*
- 1987: W. Cunningham, K. Beck: OOPSLA paper “Using Pattern Languages for Object-Oriented Programs”
  - Discovered Alexander's work for software engineers by applying 5 patterns in Smalltalk
- 1991: Erich Gamma. Design Patterns. PhD Thesis
  - Working with ET++, one of the first window frameworks of C++
  - At the same time, Vlissides works on InterViews (part of Athena)
  - Pattern workshop at OOPSLA 91, organized by B. Anderson
- 1993: E. Gamma, R. Helm, R. Johnson, J. Vlissides. Design Patterns: Abstraction and Reuse of Object-Oriented Design. ECOOP 97 LNCS 707, Springer, 1993.
- 1994: First PLOP conference (Pattern Languages Of Programming)
- 1995: GOF book.
- 1997: Riehle on role models and design patterns
- 2005: Collaborations (class-role models) in UML
- 2005: First role-languages, such as Ceasar/J and ObjectTeams

Alexander’s Laws on Beauty

- Christopher Alexander. “The timeless way of building”. Oxford Press 1977.
  - Hunting for the “Quality without a name”:
  - When are things "beautiful"?
  - When do things “live”?
- Patterns grasp centers of beauty
- You have a language for beauty, consisting of patterns (a *pattern language*)
  - Dependent on culture
- Beauty cannot be invented
  - but must be combined/generated by patterns from a pattern language
- The “quality without a name” can be reached by pattern composition in pattern languages

The Most Popular Definition

A **Design Pattern** is a description of a standard solution for
- A standard design problem
- In a certain context

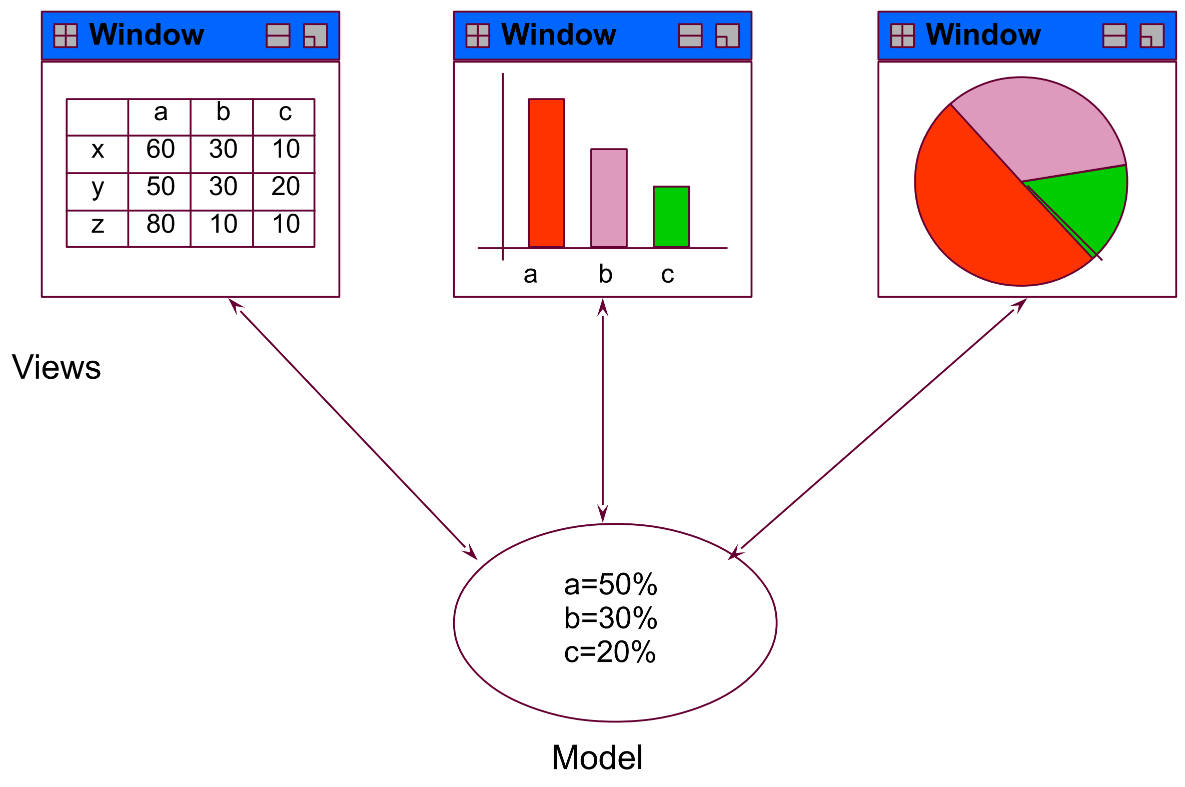
- Goal: Reuse of design information
  - A pattern must not be “new”!
  - A pattern writer must have a “aggressive disregard for originality”
- In this sense, patterns are well-known in every engineering discipline
  - Mechanical engineering
  - Electrical engineering
  - Architecture

Example: Model/View/Controller (MVC)

- MVC is a agglomeration of classes to control a user interface and a data structure
  - Developed by Goldberg/Reenskaug 1978, for Smalltalk
- MVC is a complex design pattern and combines the simpler ones compositum, strategy, observer.
- Ingredients:

Model:	Data structure or object, invisible
View:	Representation(s) on the screen
Controller:	Encapsulates reactions on inputs of users, couples model and views

Views as Observer

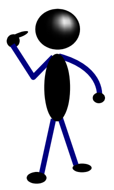


Patterns

- Pattern 1: Observer. Grasps relation between model and views
  - Views may register at the model (observers).
  - They are notified if the model changes. Then, every view updates itself by accessing the data of the model.
    - Views are independent of each other. The model does not know how views visualize it.
  - Observer decouples strongly.
- Pattern 2: Composite: *Views* may be *nested* (represents trees)
  - For a client class, Compositum unifies the access to root, inner nodes, and leaves
  - The MVC pattern additionally requires that
    - There is an abstract superclass View
    - The class CompositeView is a subclass of View
    - And can be used in the same way as View
- Pattern 3: Strategy: The relation between *controller* and *view* is a *Strategy.*
    - There may be different control strategies, lazy or eager update of views (triggering output), menu or keyboard input (taking input)
    - A view may select subclasses of *Controller,* even dynamically. Strategy allows for this dynamic exchange (variability)

What Does a Design Pattern Contain?

- A part with a “bad smell”
  - A structure with a bad smell
  - A query that proved a bad smell
  - A graph parse that recognized a bad smell
- A part with a “good smell” (standard solution)
  - A structure with a good smell
  - A query that proves a good smell
  - A graph parse that proves a good smell
- A part with “forces”
  - The context, rationale, and pragmatics
  - The needs and constraints



$$\text{“bad smell”} \xrightarrow{\text{forces}} \text{“good smell”}$$

Structure for Design Pattern Description (GOF Form)

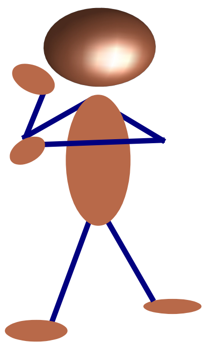
- **Name** (incl. Synonyms) (also known as)
- **Motivation** (purpose)
  - also “bad smells” to be avoided
- **Employment**
- **Solution** (the “good smell”)
  - Structure (Classes, abstract classes, relations): UML class or object diagram
  - Participants and their roles: textual details of classes
  - Interactions: interaction diagrams (MSC, statecharts, collaboration diagrams)
  - Consequences: advantages and disadvantages (pragmatics)
  - Implementation: variants of the design pattern
  - Code examples
- **Known Uses**
- **Related Patterns**

Purpose Design Pattern

- Design patterns create an “ontology of software design”
  - Improvement of the state of the art of software engineering
  - Fix a glossary for software engineering
  - A “software engineer” without the knowledge of patterns is a programmer
  - Prevent re-invention of well-known solutions
- Design patterns improve communication in teams
  - Between clients and programmers
  - Between designers, implementers and testers
  - For designers, to understand good design concepts
- Design patterns document abstract design concepts
  - Patterns are “mini-frameworks”
  - Documentation, In particular frameworks are documented by design patterns
  - May be used to capture information in reverse engineering
  - Improve code structure and hence, code quality

Standard Incentives For Using Patterns

- Easy System
  - System structure
  - Easy communication
  - Easy protocols
- Easy Testability
  - Null object
  - Static preprocessing
- Easy Evolution
- Easy Reuse!!



1.2 Different Kinds of Patterns

What is a Pattern?

- There is no “the pattern”
- At least, research is done in the following areas:
  - Conceptual patterns
  - Design Patterns
    - Different forms
  - Antipatterns
  - Implementation patterns (programming patterns, idioms, workarounds)
  - Process patterns
    - Reengineering patterns
  - Organizational patterns
- General definition:
- A pattern is the abstraction from a concrete form which keeps recurring in specific non-arbitrary contexts [Riehle/Zülinghoven, Understanding and Using Patterns in Software Development]

Conceptual Patterns

- A **conceptual pattern** is a pattern whose form is described by means of the terms and concepts from an application domain
  - Based on metaphors in the application domain
- Example: conceptual pattern “desktop”
  - Invented in Xerox Parc from A. Kay and others
    - Folders, icons, TrashCan
    - Drag&Drop as move actions on the screen
  - Basic pattern for all windowing systems
  - Also for many CASE tools for visual programming
  - Question: what is here the “abstraction from the concrete form”?
- We will revisit in the Tools-And-Materials (TAM) pattern language
  - It works on conceptual patterns such as “Tool”, “Material”, “Automaton”

Design Patterns, Different Definitions

- “A **Design Pattern** is a description of a standard solution for
    - A standard design problem
    - In a certain context”
- “A **design pattern** superimposes a *simple structure* of a relation in the static or dynamic semantics of a system”
    - Relations, interactions, collaborations
    - Nodes: objects, classes, packages
- “A **design pattern** is a named nugget of insight which conveys the essence of a proven solution to a recurring problem within a certain context amidst competing concerns” [Appleton]
- Question: what is here the “abstraction from the concrete form”? (in terms of Riehle/Züllighoven)

Different Types of Design Patterns

- **Fundamental Design Pattern (FDP)**
    - A pattern that cannot be expressed as language construct
- **Programming Pattern, Idiom, Language Dependent Design Pattern (LDDP)**
    - A pattern that exists as language construct in another programming language, but is not available in general
- **Architectural style** (Architectural pattern)
    - A design pattern that describes the coarse-grain structure of a (sub)system
    - A design pattern on a larger scale, for coarse-grain structure (macro structure)
- **Framework Instantiation Patterns**
    - Some design patterns couple framework variation points and application code (*framework instantiation patterns*)
    - Design patterns are “mini-frameworks” themselves, since they contain common structure for many applications
    - Design patterns are used in frameworks (that's how they originated)
    - Hence, this course must also say many things about frameworks

Programming Pattern (Idiom, LDDP)

- An *idiom* is a pattern whose form is described by means of programming language constructs.
- Example: The C idiom of check-and-returns for contract checking
  - The first book on idioms was Coplien's Advanced C++ Programming Styles and Idioms (1992), Addison-Wesley

```
public void processIt (Document doc) {
  // check all contracts of processIt
  if (doc == null) return;
  if (doc.notReady()) return;
  if (internalDoc == doc) return;

  // now the document seems ok
  internalProcessIt(doc);
}
```

```
private void internalProcessIt (Document doc) {
  // no contract checking anymore

  // process the document immediately
  walk(doc);
  print(doc);
}
```

Workaround

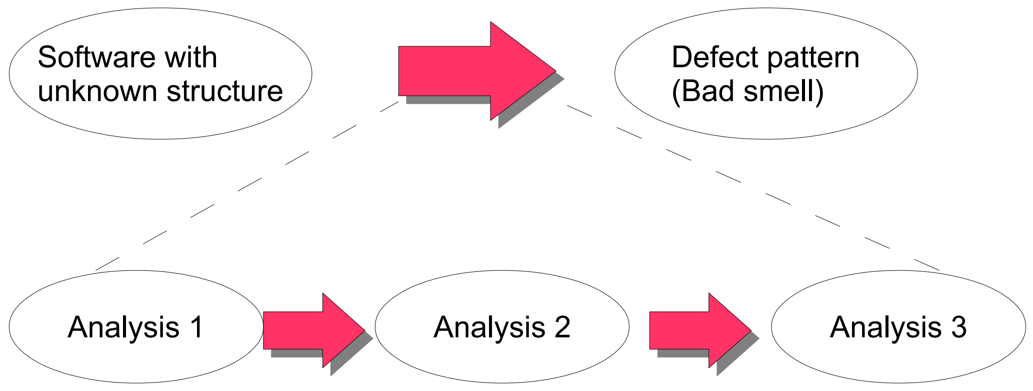
- A *workaround* is an idiom that works around a language construct that is not available in a language
- Example: Simulating polymorphism by if-cascades

```
public void processIt (Document doc) {
  // Analyze type of document
  if (doc->type == Text)
     processText((Text)doc);
  else i f (doc->type == Figure)
     processFigure((Figure)doc);
  else
     printf("unknown subtype of document");
}
```

```
void processText(Text t) {..}
void process Figure(Figure f) {..}
```

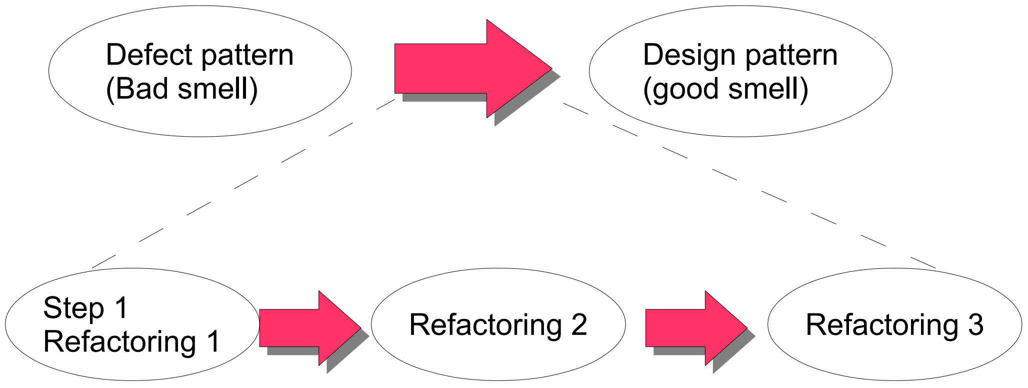
Antipatterns (Defect Patterns)

- Software can contain bad structure
  - No modular structure, only procedure calls
  - If-cascades instead of polymorphism
  - Casts everywhere
  - Spaghetti code (no reducible control flow graphs)
  - Cohesion vs Coupling (McCabe)
- Question: what is here the “abstraction from the concrete form”?



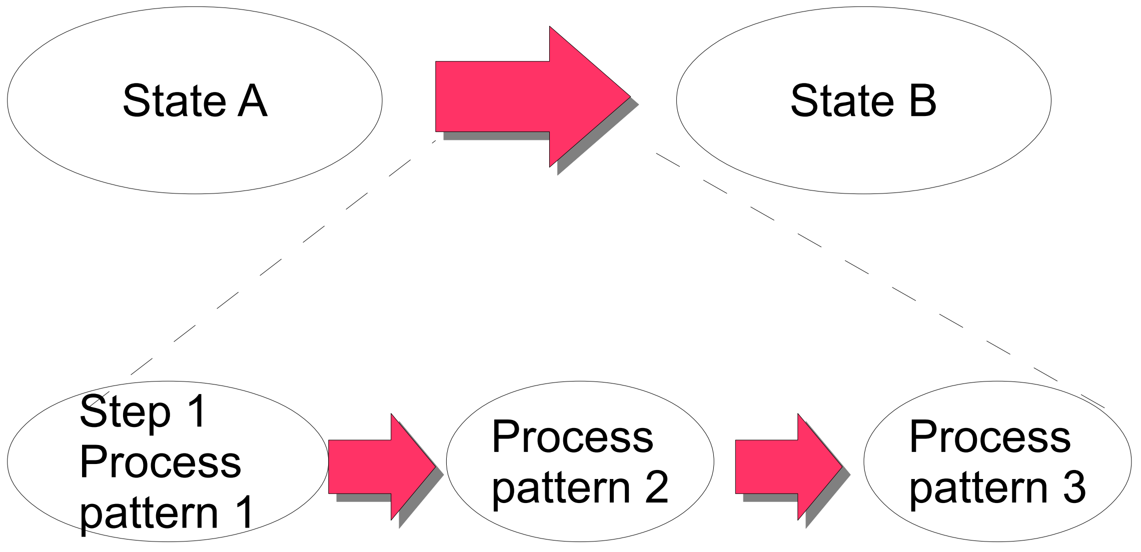
Refactorings Transform Antipatterns Into Design Patterns

- A DP can be a goal of a refactoring
- Structurally, a **refactoring** is an operator on the code (a metaprogram)
  - Semi-formal: Fowler's book on refactorings uses graph rewrite rules to indicate what the refactorings do
  - Formal: Refactorings can be realized in program transformation and metaprogramming libraries and tools
    - Recoder (recoder.sf.net) is such a tool
    - Eclipse, Netbeans contain refactorings



Process Patterns

- **Process patterns** are solutions for the process of making something



Process Patterns

- When process patterns are automized, they are called **workflow templates**
- Workflow management systems enable us to capture and design processes
  - ARIS on SAP
  - BPMN, BPEL
- Examples:
  - “Work-and-Let-Be-Granted”
  - “Delegate-Task-And-Resources-Together”
- Question: what is here the “abstraction from the concrete form”?

Reengineering Patterns

- Also in the software reengineering process, common (process) patterns can be identified
- Examples
  - “Read-All-Code-In-One-Hour”
  - “Write-Tests-To-Understand”
- S. Demeyer, S. Ducasse, O. Nierstrasz. Object-oriented Reengineering Patterns. Morgan-Kaufmann, 2003
- Question: what is here the “abstraction from the concrete form”?

Organizational Patterns

- Two well-known organizational patterns are
  - Hierarchical management
    - In which all communication can be described by the organizational hierarchy
  - Matrix organization
    - In which functional and organizational units talk to each other
- Question: what is here the “abstraction from the concrete form”?

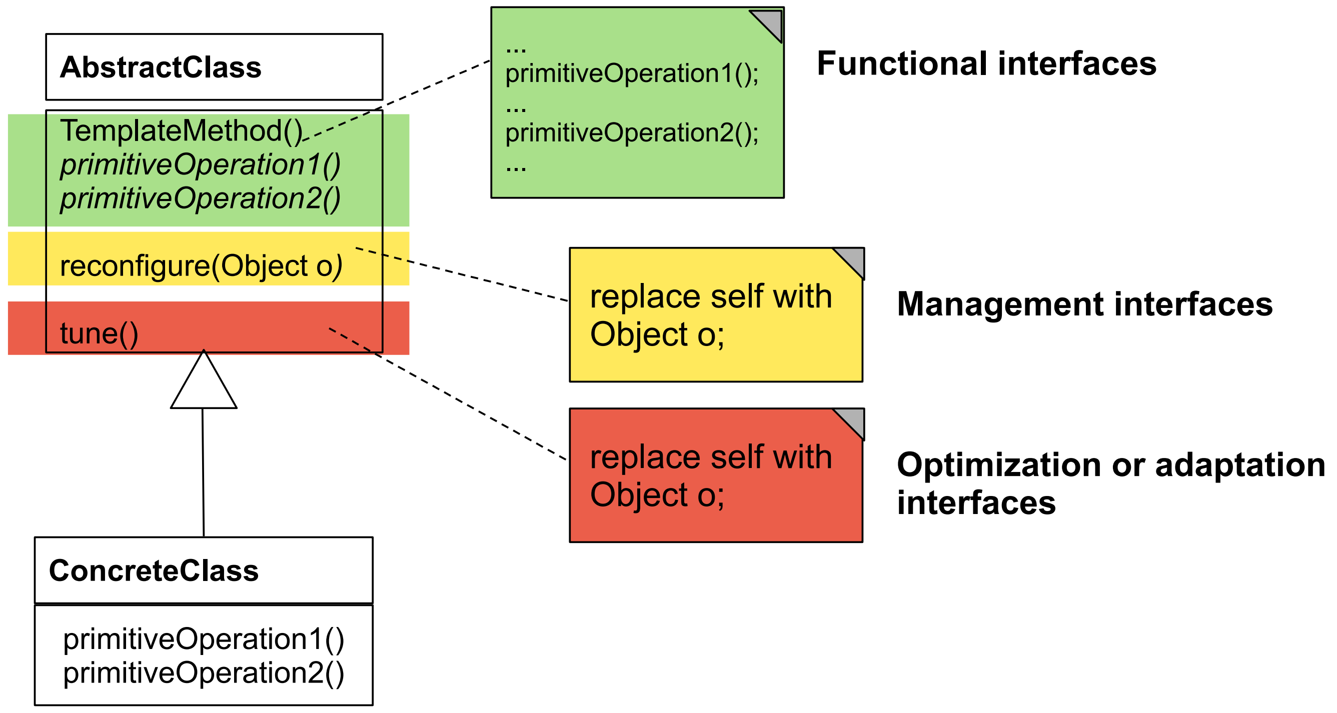
In This Course

- We will mainly treat design patterns
  - Conceptual patterns
  - Architectural patterns
  - Framework instantiation patterns
  - Very few LDDP and workarounds

Pattern Languages: Patterns in Context

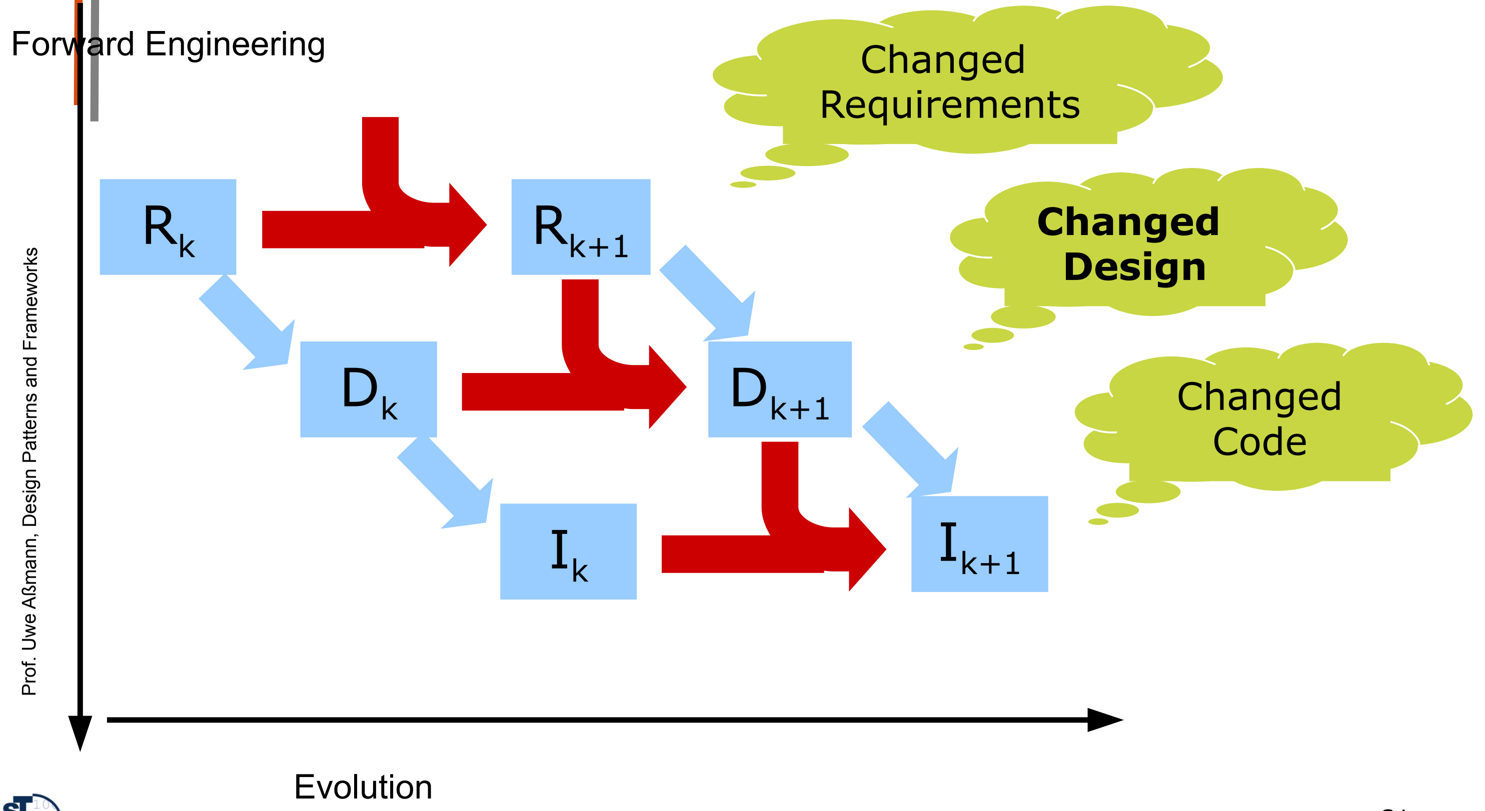
- According to Alexander, patterns occur in *pattern languages*
  - A set of related patterns for a set of related problems in a domain
  - Similar to a natural language, the pattern language contains a vocabulary for building artefacts
- A structured collection of patterns that build on each other to transform forces (needs and constraints) into an architecture [Coplien]
  - Patterns rarely stand alone. Each pattern works in a context, and transforms the system in that context to produce a new system in a new context.
  - New problems arise in the new system and context, and the next "layer" of patterns can be applied.
- We will treat one larger example, the TAM pattern language

General Remarks on Structure Diagrams

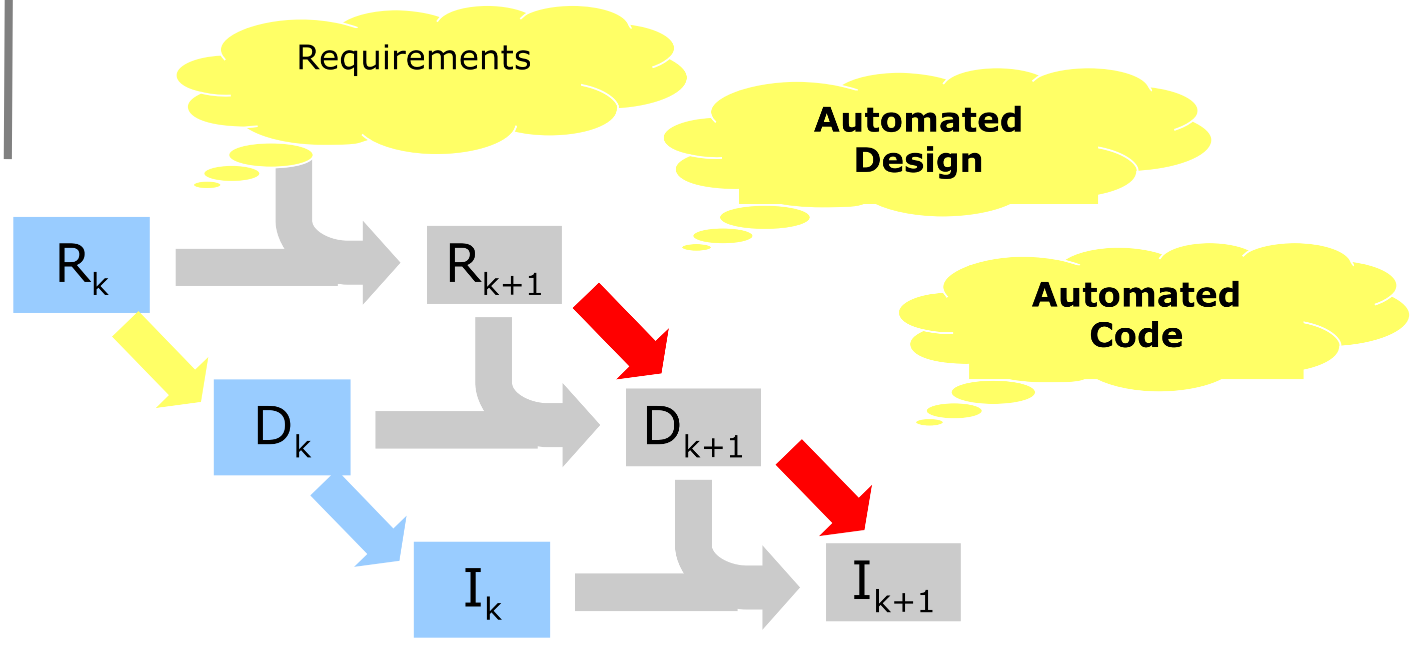


1.3 Where do Patterns Occur in Software Development?

Software Construction By Forward Engineering

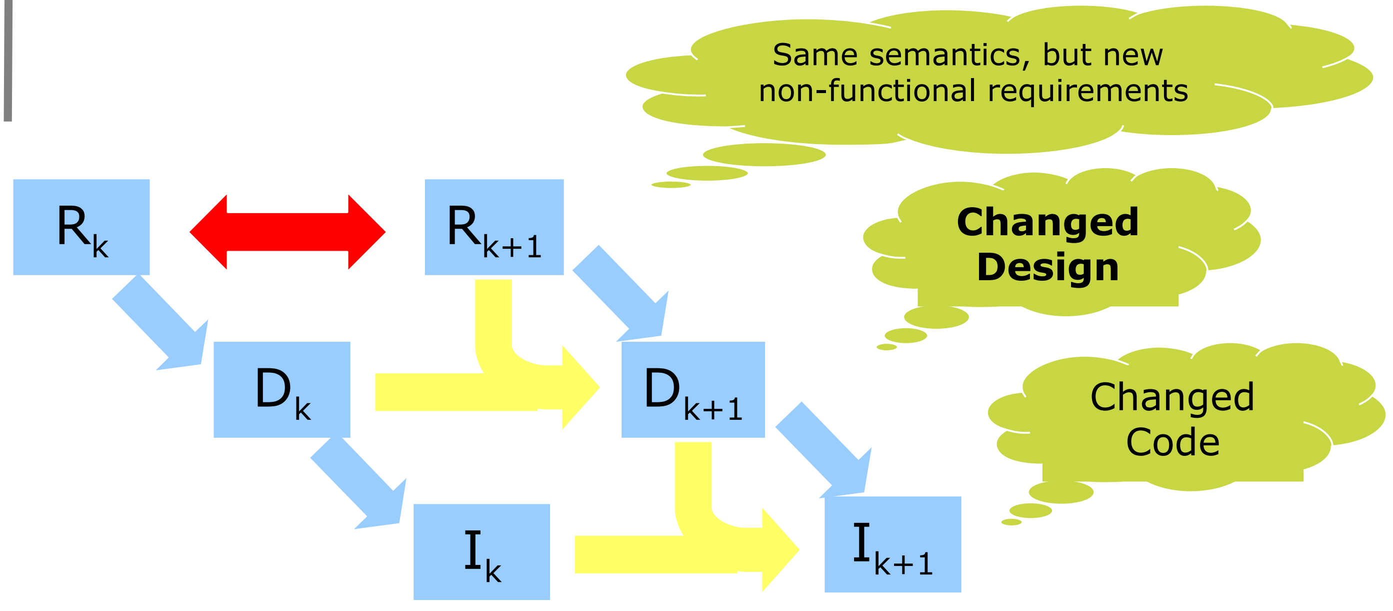


Automated Design (CASE)



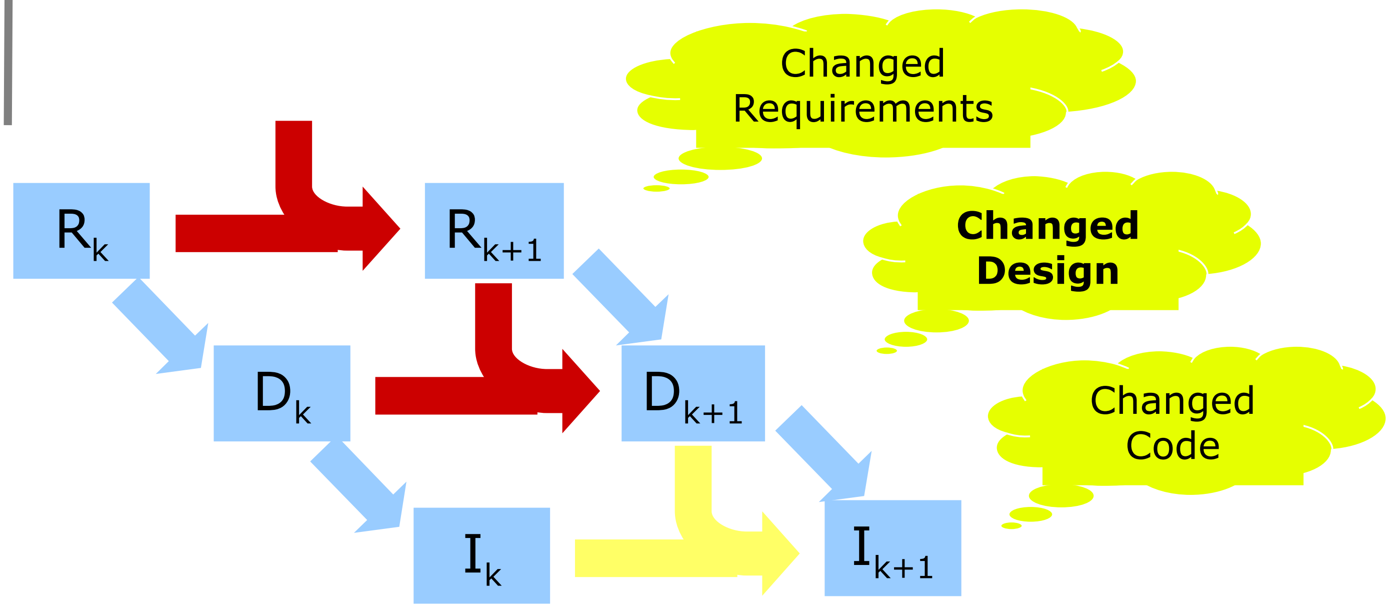
Support by CASE tools to a limited extend possible
Tools generate structure of design patterns into the code (e.g., Together)

Program Refinement



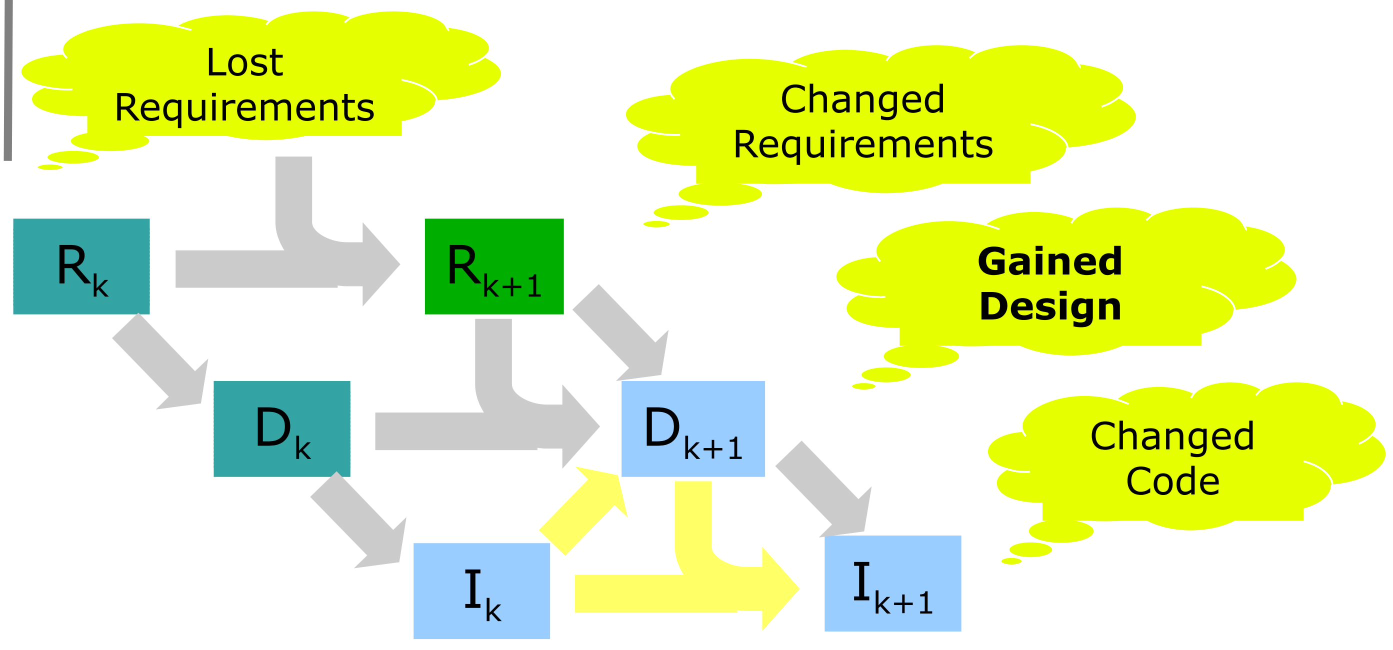
Needs new non-functional requirements. For instance, optimization patterns speed applications up; adapters and bridges can be used for checking consistency

Automated Software Evolution (XP-like)



In XP, many adaptations can be automized by employing refactoring tools

Reengineering



Automatic and semi-automatic recognition of design patterns is a hot research topic

The End