

Design Patterns and Frameworks

1) Introduction

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1) History and Introduction

2) Different classes of patterns

3) Where can patterns be used?



Literature (To Be Read)

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- ▶ 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

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- ▶ 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

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- ▶ 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

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- ▶ 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

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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)

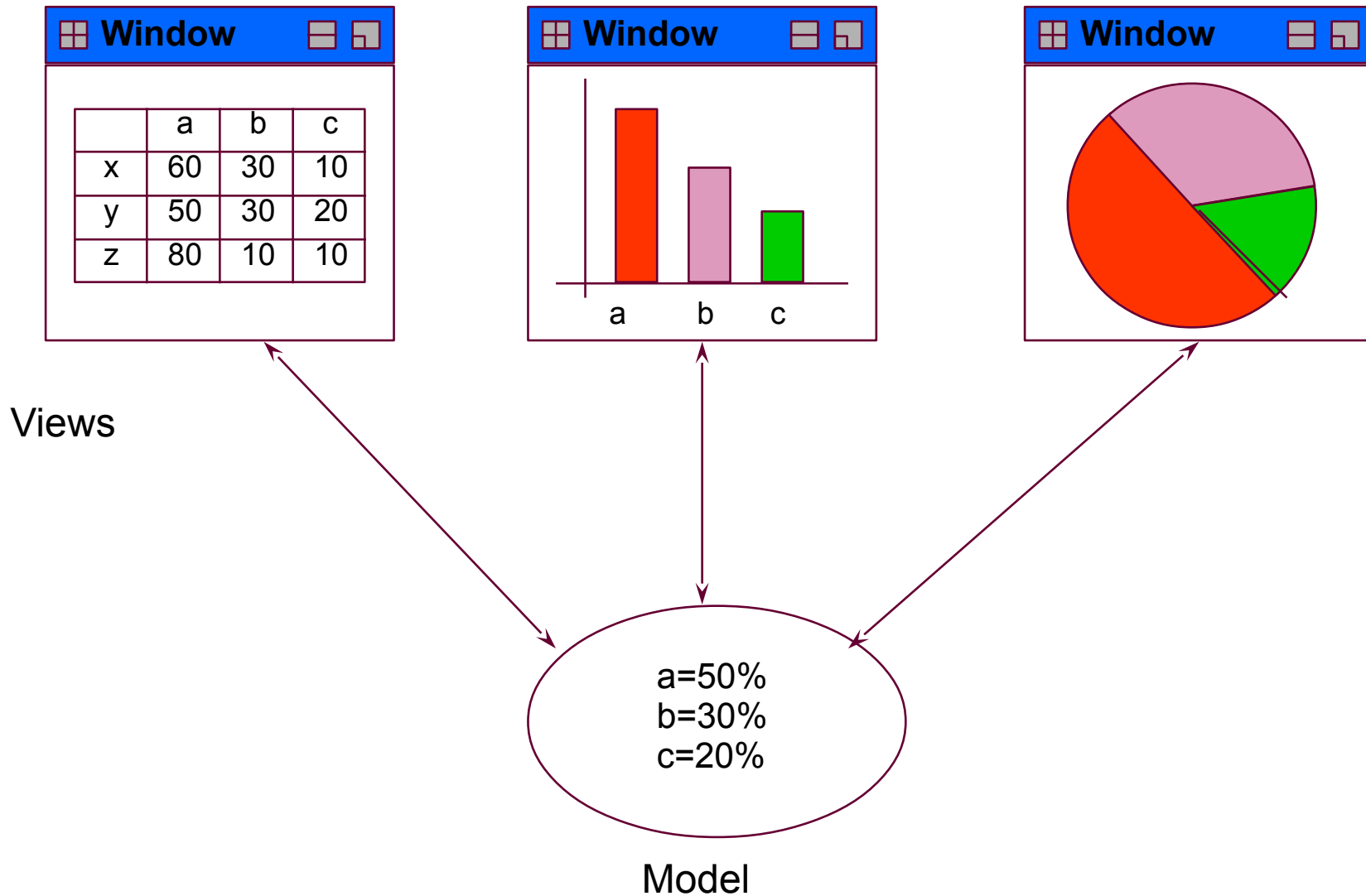
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- ▶ MVC is a agglomeration of classes to control a user interface and a data structure
 - Developed by Goldberg/Reenskaug 1978, for Smalltalk
- ▶ MVC is a complex design pattern and combines the simpler ones compositum, strategy, observer.
- ▶ Ingredients:
 - Model: Data structure or object, invisible
 - View: Representation(s) on the screen
 - Controller: Encapsulates reactions on inputs of users, couples model and views

Ex.: Views as Observer



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Patterns

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- ▶ Pattern 1: Observer. Grasps relation between model and controllers resp. views
 - Views may register at the model as observers. They are notified if the model changes. Then, every view updates itself by accessing the data of the model.
 - Observer decouples strongly. Views are independent of each other. The model does not know how views visualize it.
- ▶ 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)

Structure for Design Pattern Description (GOF Form)

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- ▶ **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

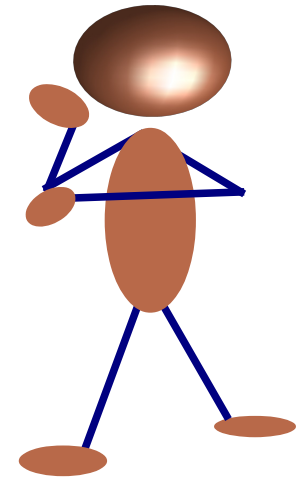
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- ▶ Design patterns create an “ontology of software design”
 - Improvement of the state of the art of software engineering
 - Fix a glossary for software engineering
 - A “software engineer” without the knowledge of patterns is a programmer
 - Prevent 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

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





1.2 Different Kinds of Patterns

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What is a Pattern?

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- ▶ 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

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- ▶ 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

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- ▶ “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

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- ▶ **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)

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- ▶ 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

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

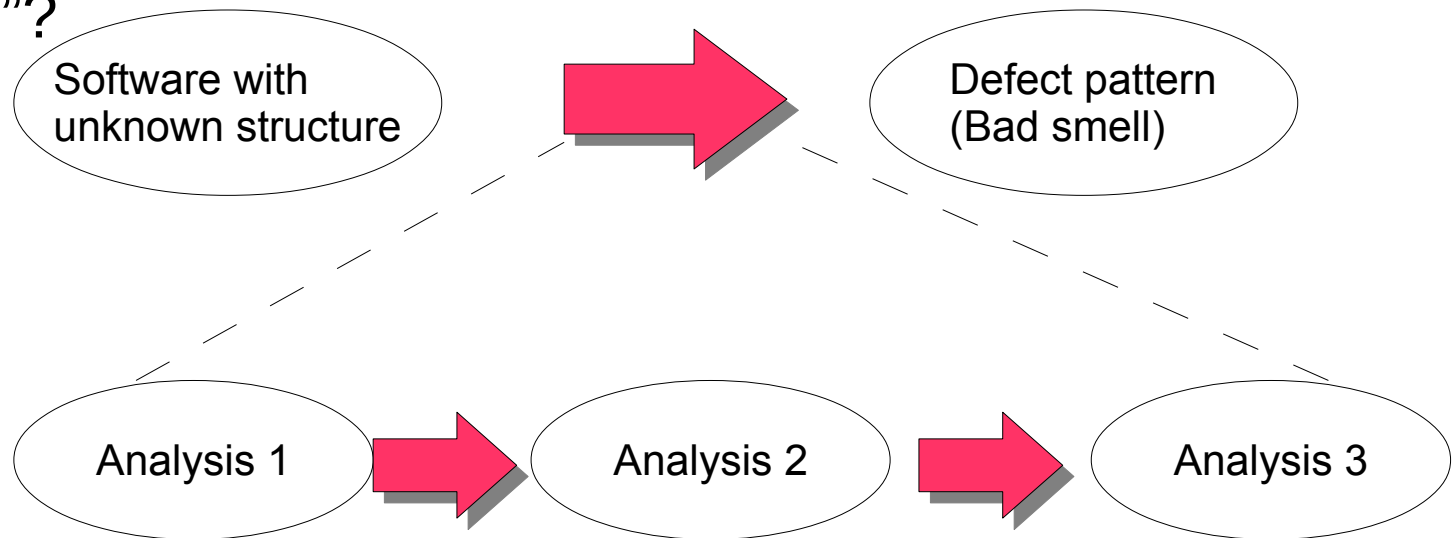
```
public void processIt (Document doc) {  
    // Analyze type of document  
    if (doc->type == Text)  
        processtext((Text)doc);  
    else if (doc->type == Figure)  
        processFigure((Figure)doc);  
    else  
        printf("unknown subtype of document");  
}
```

```
void processtext(Text t) {...}  
void processFigure(Figure f) {...}
```

Antipatterns (Defect Patterns)

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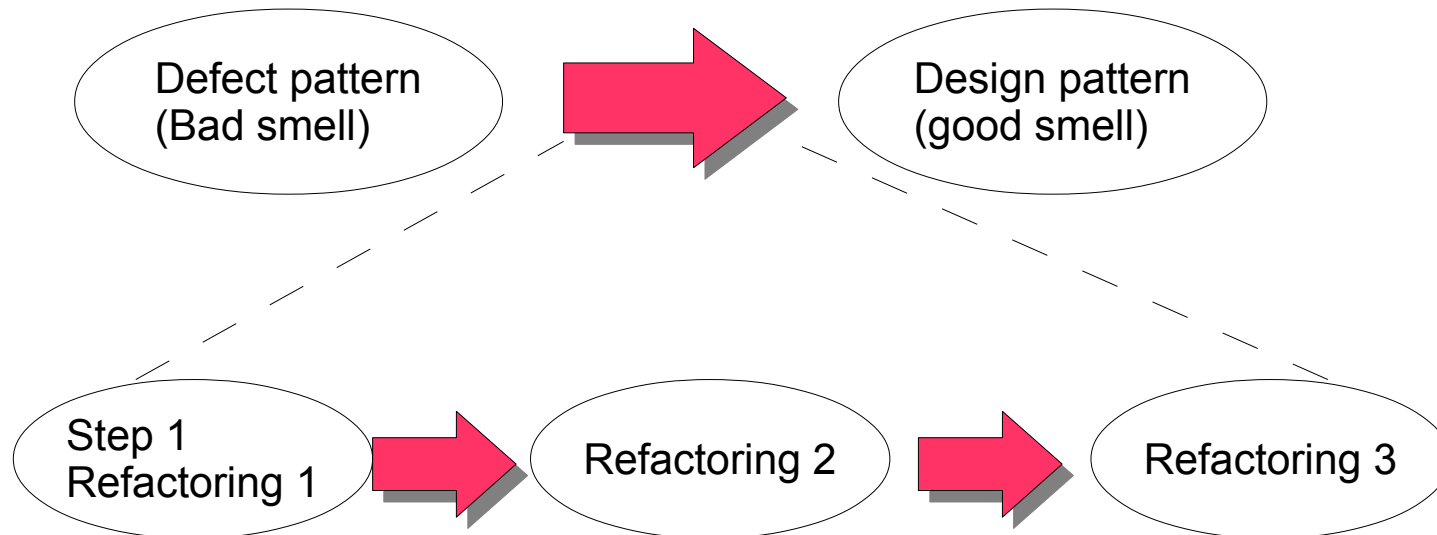
- ▶ Software can contain bad structure
 - No modular structure, only procedure calls
 - If-cascades instead of polymorphism
 - Casts everywhere
 - Spaghetti code (no reducible control flow graphs)
 - Cohesion vs Coupling (McCabe)
- ▶ Question: what is here the “abstraction from the concrete form”?



Refactorings Transform Antipatterns Into Design Patterns

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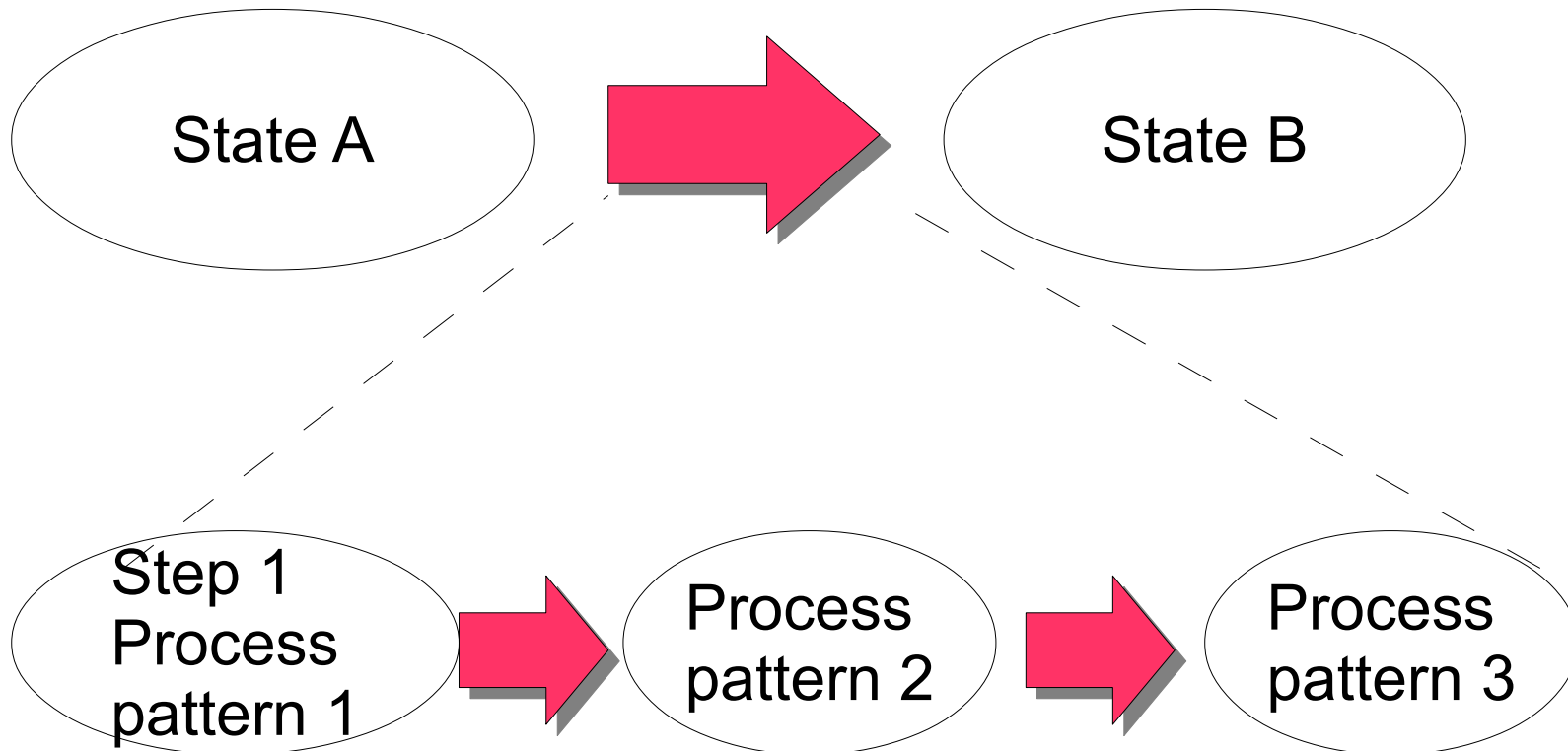
- ▶ A DP can be a goal of a refactoring
- ▶ Structurally, a **refactoring** is an operator on the code (a metaprogram)
 - Semi-formal: Fowler's book on refactorings uses graph rewrite rules to indicate what the refactorings do
 - Formal: Refactorings can be realized in program transformation and metaprogramming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



Process Patterns

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



Process Patterns

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- ▶ When process patterns are automatized, 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

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- ▶ 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

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- ▶ 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

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

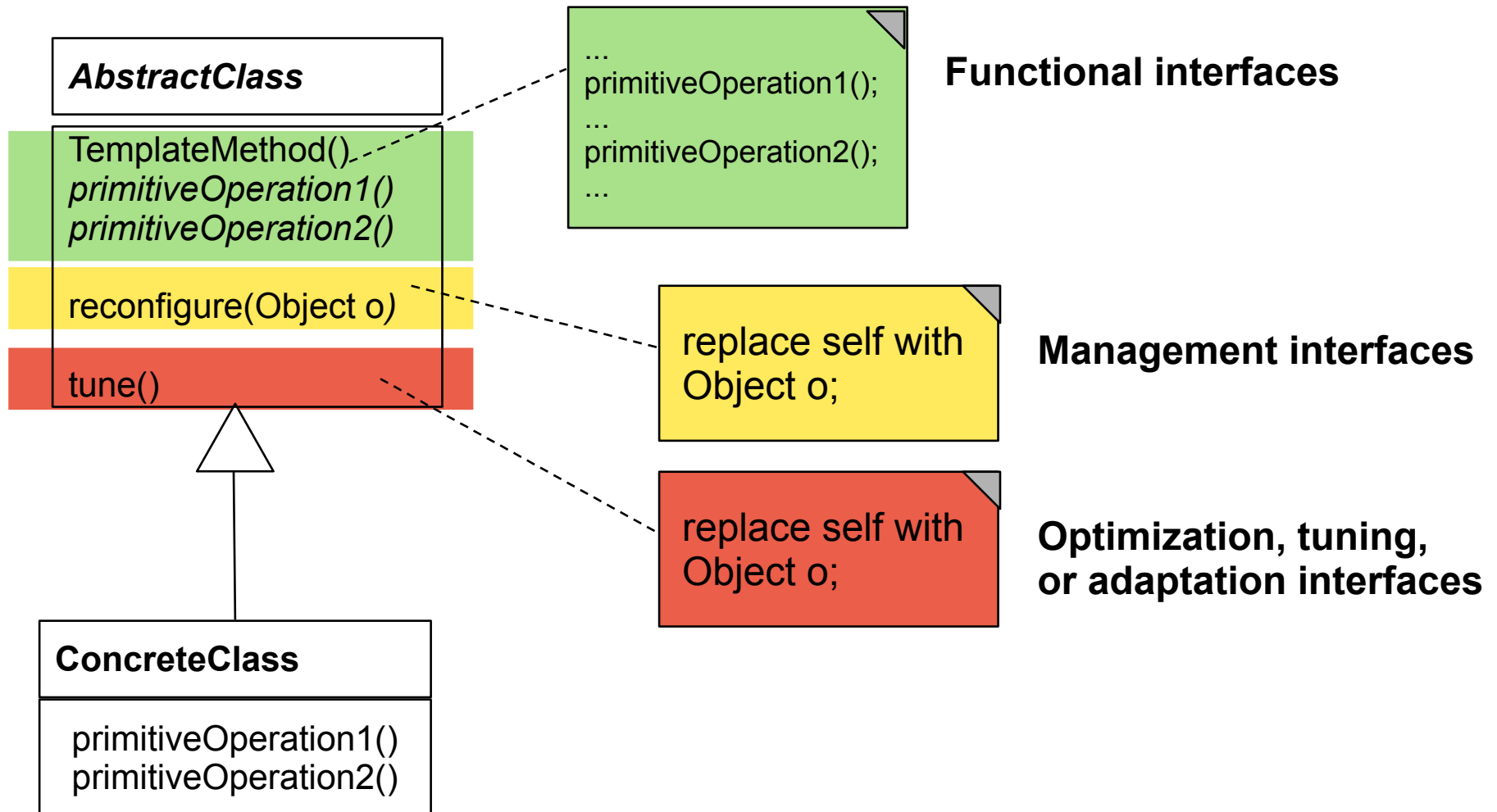
Pattern Languages: Patterns in Context

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- ▶ 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

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1.3 Where do Patterns Occur in Software Development?

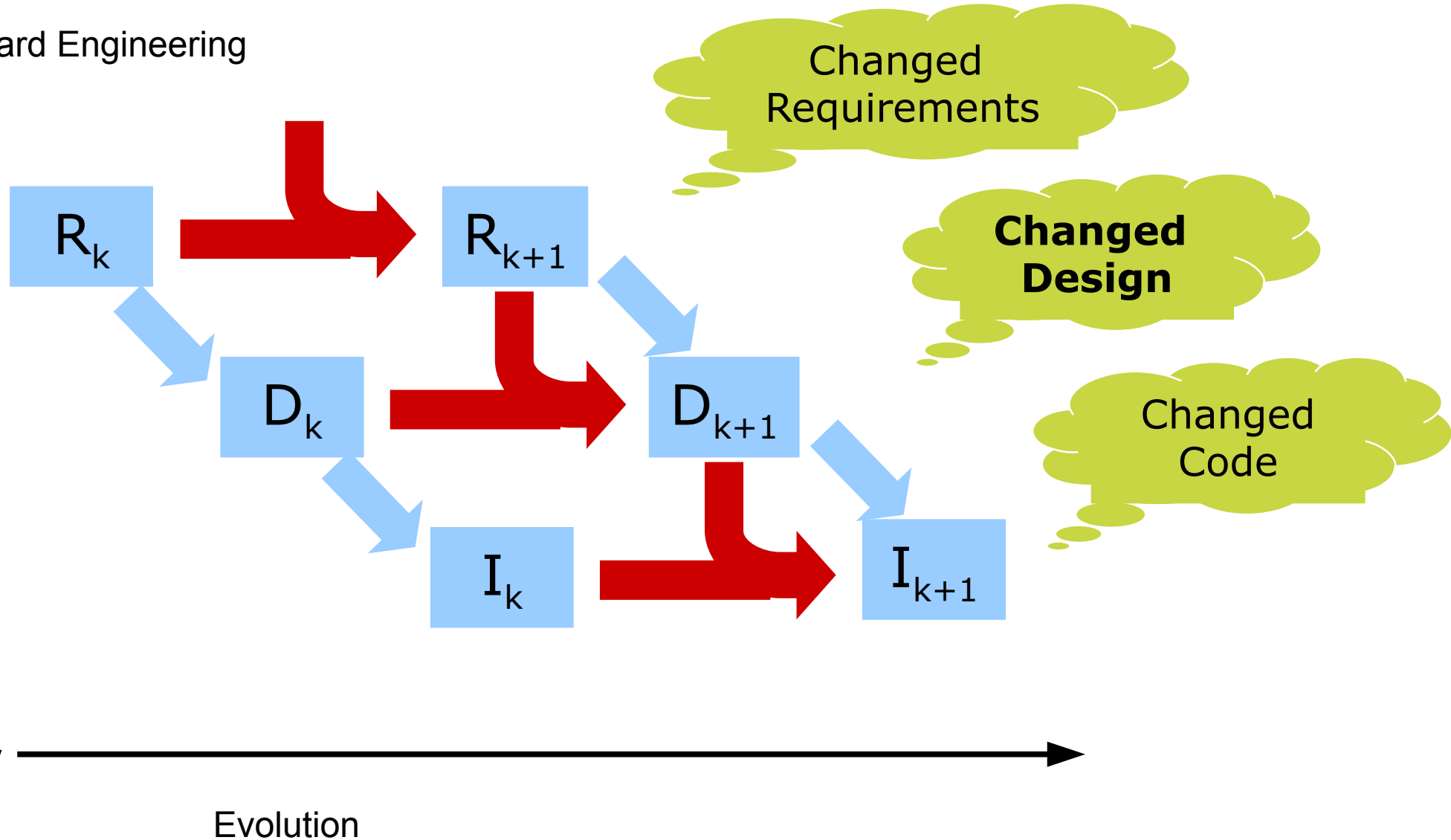
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Software Construction By Forward Engineering

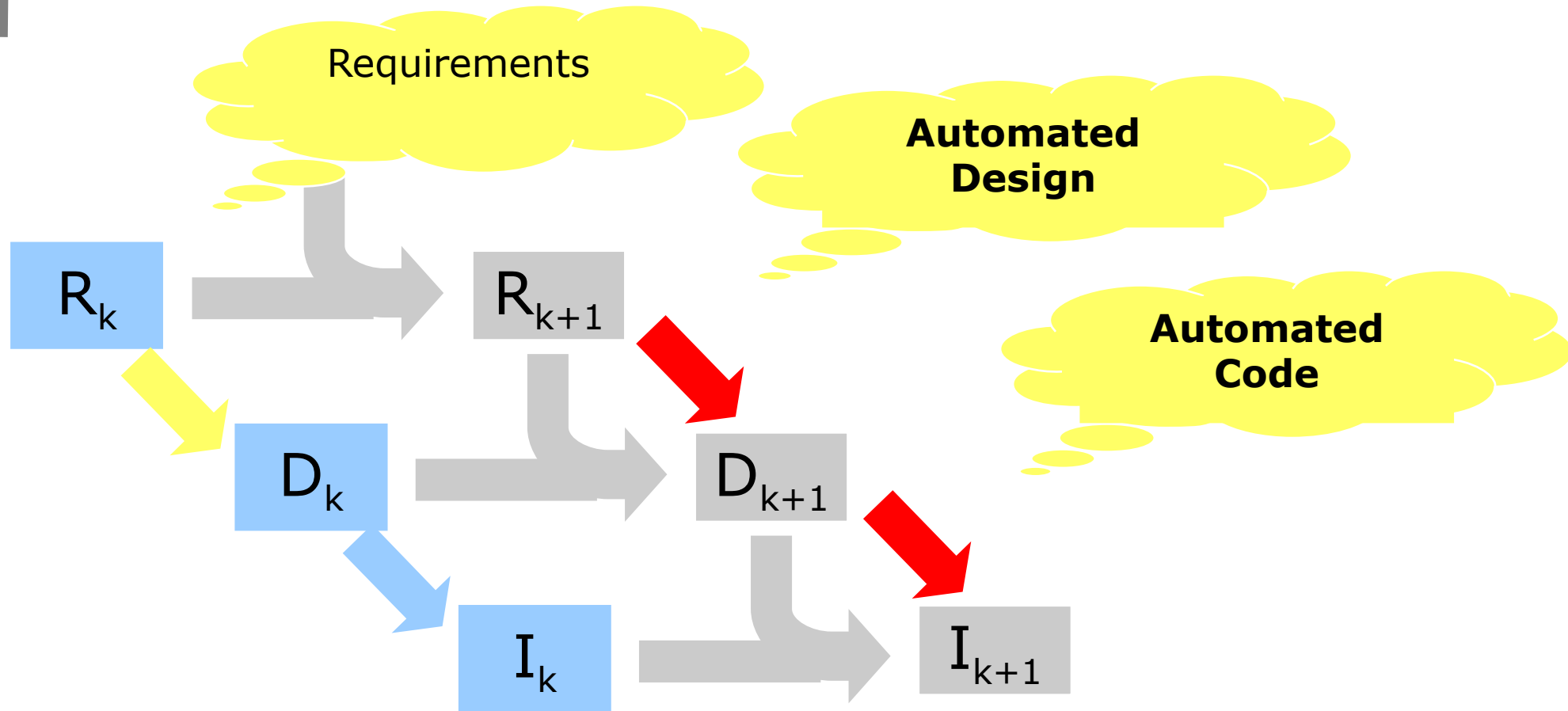
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Forward Engineering



Automated Design (Computer-Aided Software Engineering, CASE)

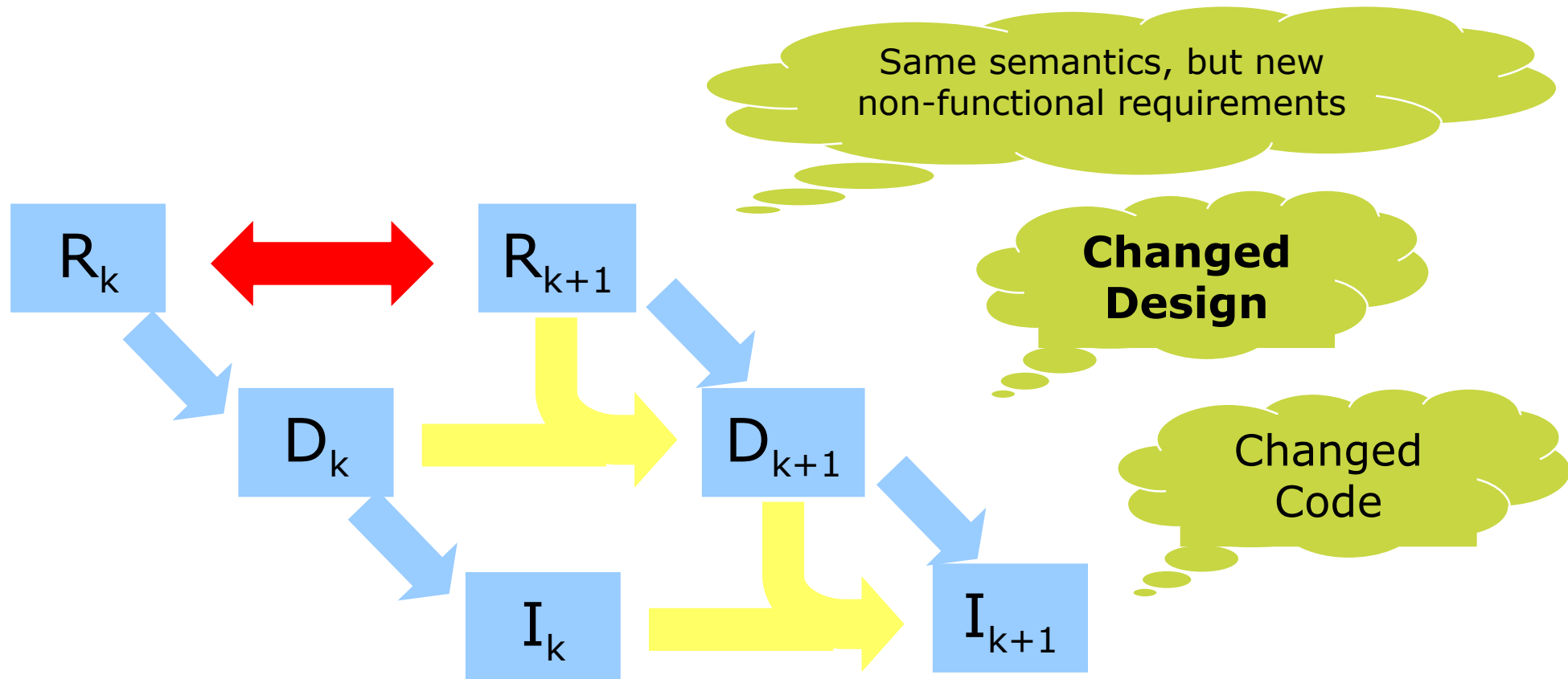
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Support by CASE tools to a limited extend possible
Tools generate structure of design patterns into the code
(see course Softwarewerkzeuge)

Program Refinement

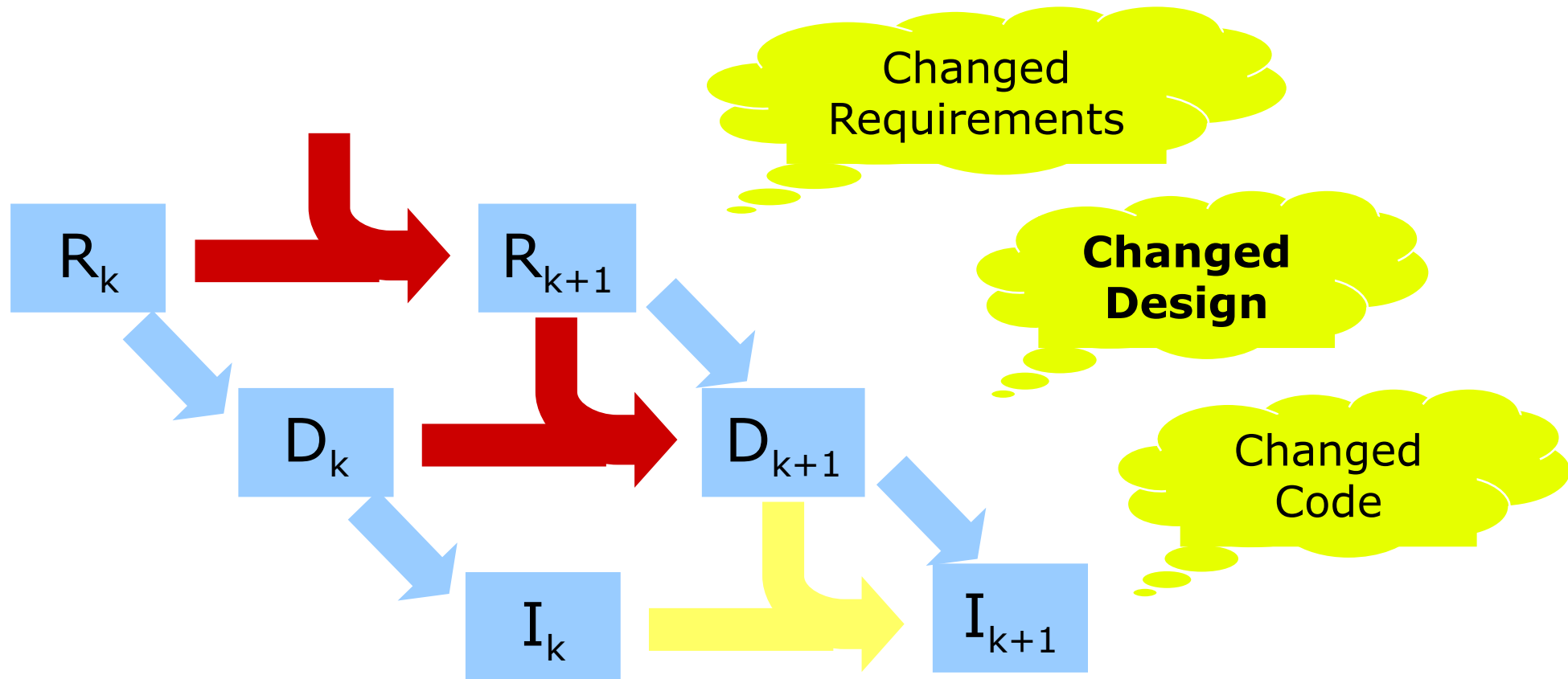
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Needs new non-functional requirements. For instance, optimization patterns speed applications up; adapters and bridges can be used for checking consistency

Automated Software Evolution (XP-like)

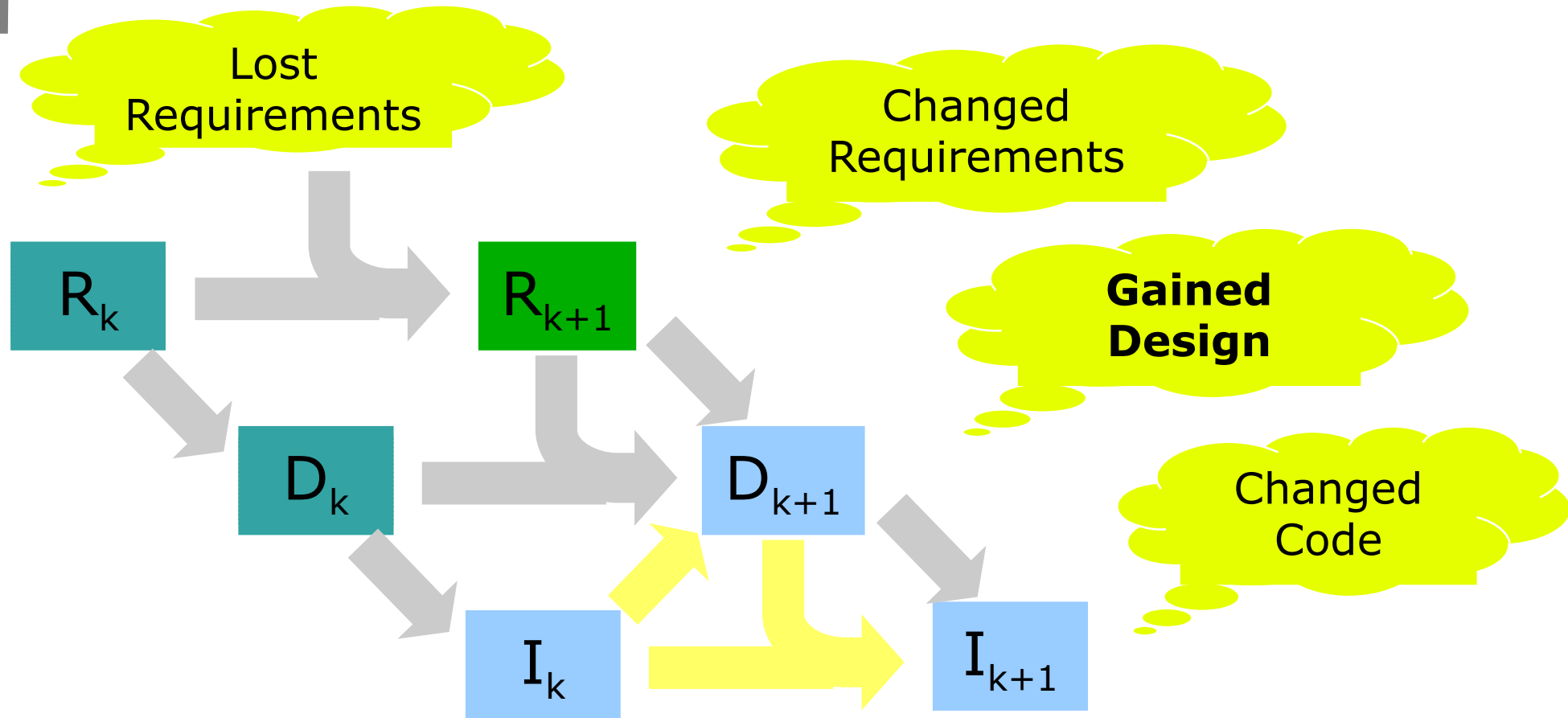
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In XP, many adaptations can be automated by employing refactoring tools

Reengineering

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

The End

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