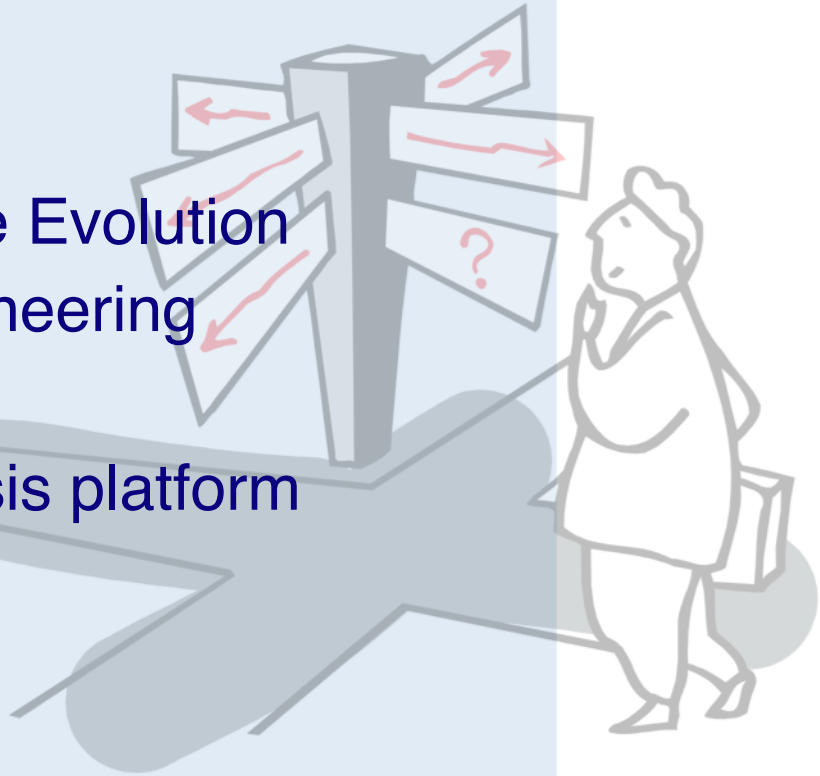
UNIVERSITÄT
BERN

Introduction to Software Engineering

13. Software Evolution

Roadmap

- Lehman's Laws of Software Evolution
- Forward and Reverse Engineering
- Reengineering Patterns
- The Moose software analysis platform



Literature

- Demeyer, Ducasse, and Nierstrasz. *Object-Oriented Reengineering Patterns*, Square Bracket Associates, 2008.

http://scg.unibe.ch/download/oorp/

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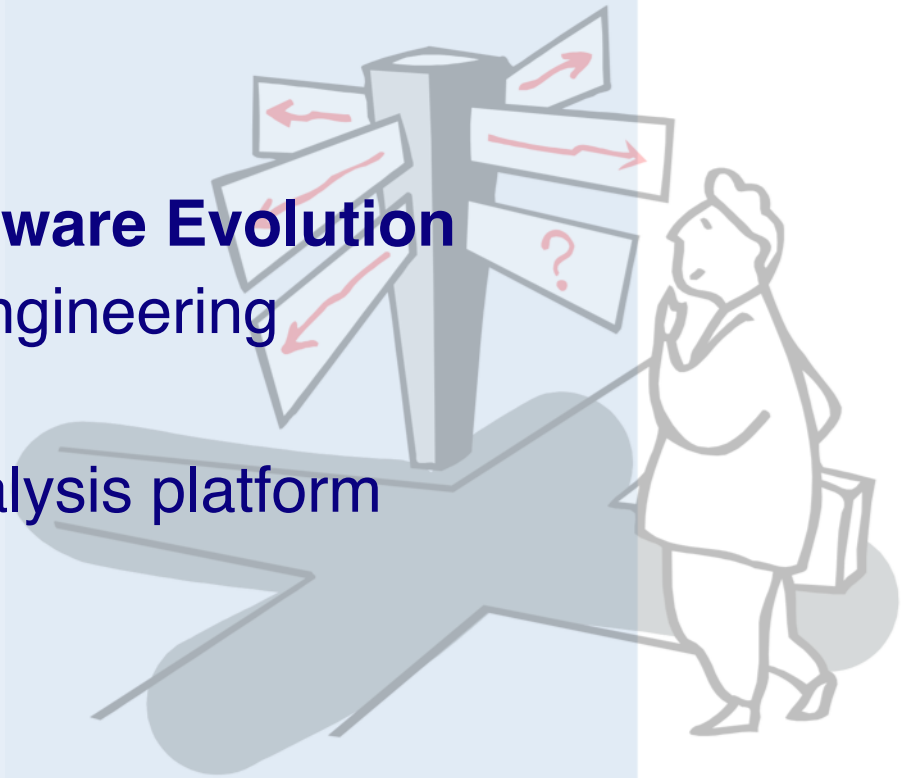
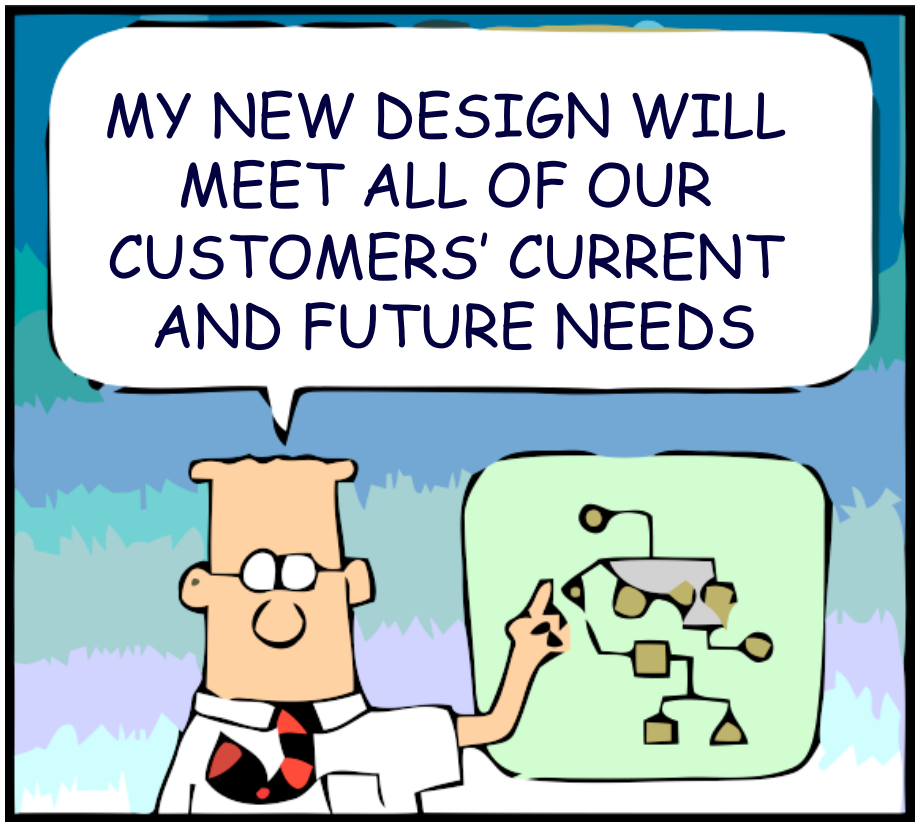




What is wrong with this picture?

Lehman's Laws

Continuing change

— A program that is used in a real-world environment *must change*, or become progressively less useful in that environment.

Increasing complexity

— As a program evolves, it becomes *more complex*, and extra resources are needed to preserve and simplify its structure.

Lehman, Belady. *Program Evolution: Processes of Software Change*, London Academic Press, London, 1985

The Dilemma of Legacy Software

A legacy system is a piece of software that:

- you have *inherited*, and
- is *valuable* to you.

You can't afford to throw it out, but it is too expensive to change

Symptoms

- Loss of *knowledge*
- Architecture & design *drift*
- Hard to make *changes*
- …

OO Legacy

- Object-oriented legacy systems are *successful* OO systems whose architecture and design *no longer respond to changing requirements*

Common Symptoms

Lack of Knowledge

- *obsolete* or no documentation
- *departure* of the original developers or users
- *disappearance of inside knowledge* about the system
- *limited understanding* of entire system

  ⇒ *missing tests*

Process symptoms

- *too long* to turn things over to production
- need for *constant bug fixes*
- *maintenance dependencies*
- *difficulties separating* products

  ⇒ *simple changes take too long*

Code symptoms

- *duplicated* code
- *code smells*

  ⇒ *big build times*

Common Problems

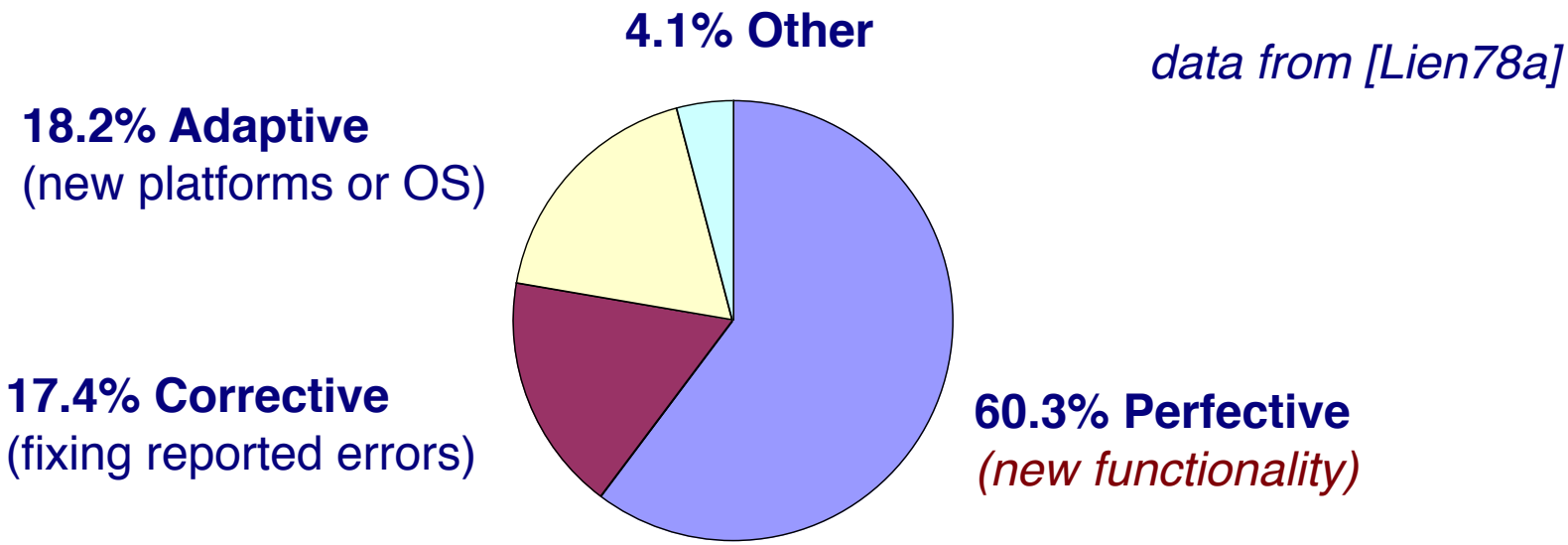
Architectural Problems

- insufficient *documentation*
  = non-existent or out-of-date
- improper *layering*
  = too few or too many layers
- lack of *modularity*
  = strong coupling
- *duplicated code*
  = copy, paste & edit code
- duplicated *functionality*
  = similar functionality
  by separate teams

Refactoring opportunities

- *misuse* of inheritance
  = code reuse vs polymorphism
- *missing* inheritance
  = duplication, case-statements
- *misplaced* operations
  = operations outside classes
- *violation* of encapsulation
  = type-casting; C++ "friends"
- *class abuse*
  = classes as namespaces

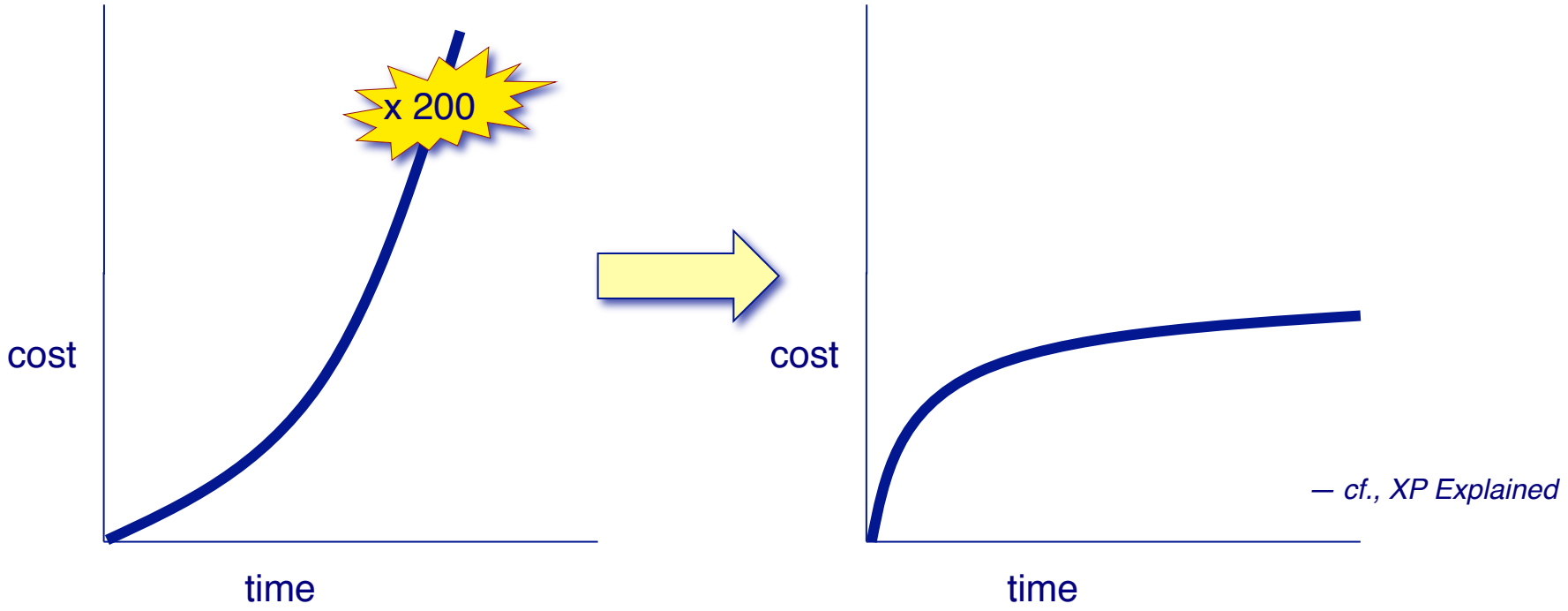
Continuous Development



The bulk of the maintenance cost is due to *new functionality*
⇒ even with better requirements, it is hard to predict new functions

The cost of change

We need to reduce the cost of change over time …



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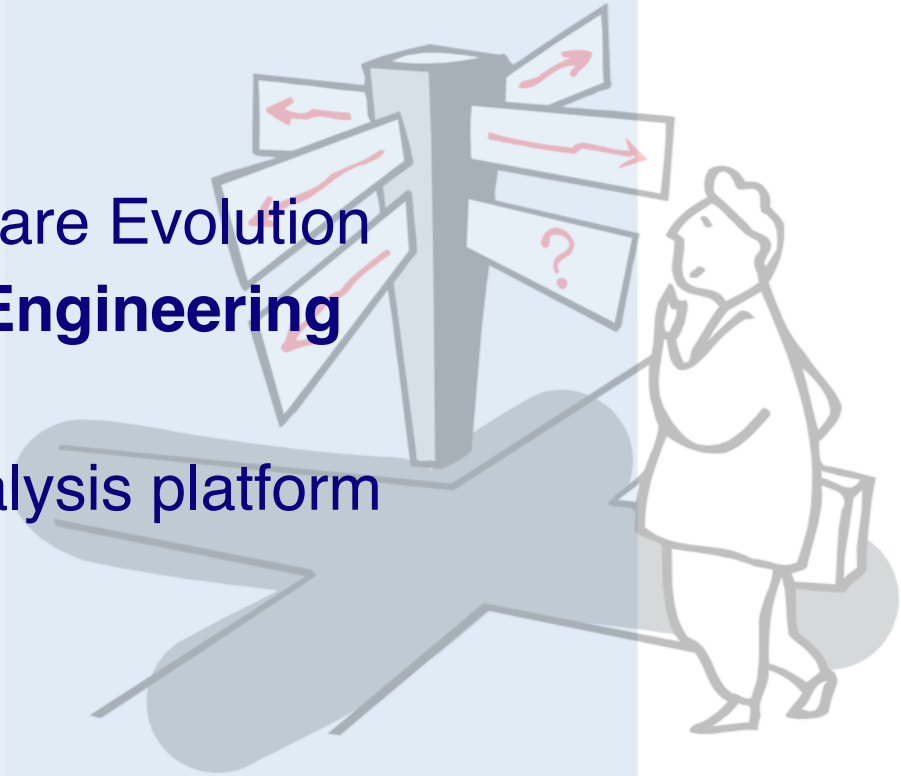

Some Terminology

"***Forward Engineering*** is the traditional process of moving from high-level abstractions and logical, implementation-independent designs to the physical implementation of a system."

"***Reverse Engineering*** is the process of analyzing a subject system to identify the system's components and their interrelationships and create representations of the system in another form or at a higher level of abstraction."

"***Reengineering*** ... is the examination and alteration of a subject system to reconstitute it in a new form and the subsequent implementation of the new form."

— *Chikofsky and Cross [in Arnold, 1993]*

Goals of Reverse Engineering

- Cope with *complexity*
  - need techniques to understand large, complex systems
- Generate *alternative views*
  - automatically generate different ways to view systems
- Recover *lost information*
  - extract what changes have been made and why
- Detect *side effects*
  - help understand ramifications of changes
- Synthesize *higher abstractions*
  - identify latent abstractions in software
- Facilitate *reuse*
  - detect candidate reusable artifacts and components

— Chikofsky and Cross [in Arnold, 1993]

Reverse Engineering Techniques

- *Redocumentation*
  - pretty printers
  - diagram generators
  - cross-reference listing generators
- *Design recovery*
  - software metrics
  - browsers, visualization tools
  - static analyzers
  - dynamic (trace) analyzers

Goals of Reengineering

- *Unbundling*
  - split a monolithic system into parts that can be separately marketed
- *Performance*
  - “first do it, then do it right, then do it fast” — experience shows this is the right sequence!
- *Port* to other Platform
  - the architecture must distinguish the platform dependent modules
- *Design extraction*
  - to improve maintainability, portability, etc.
- Exploitation of *New Technology*
  - i.e., new language features, standards, libraries, etc.

Reengineering Techniques

- *Restructuring*
  - automatic conversion from unstructured to structured code
  - source code translation

  — *Chikofsky and Cross*
- *Data reengineering*
  - integrating and centralizing multiple databases
  - unifying multiple, inconsistent representations
  - upgrading data models

  — *Sommerville, ch 32*
- *Refactoring*
  - renaming/moving methods/classes etc.

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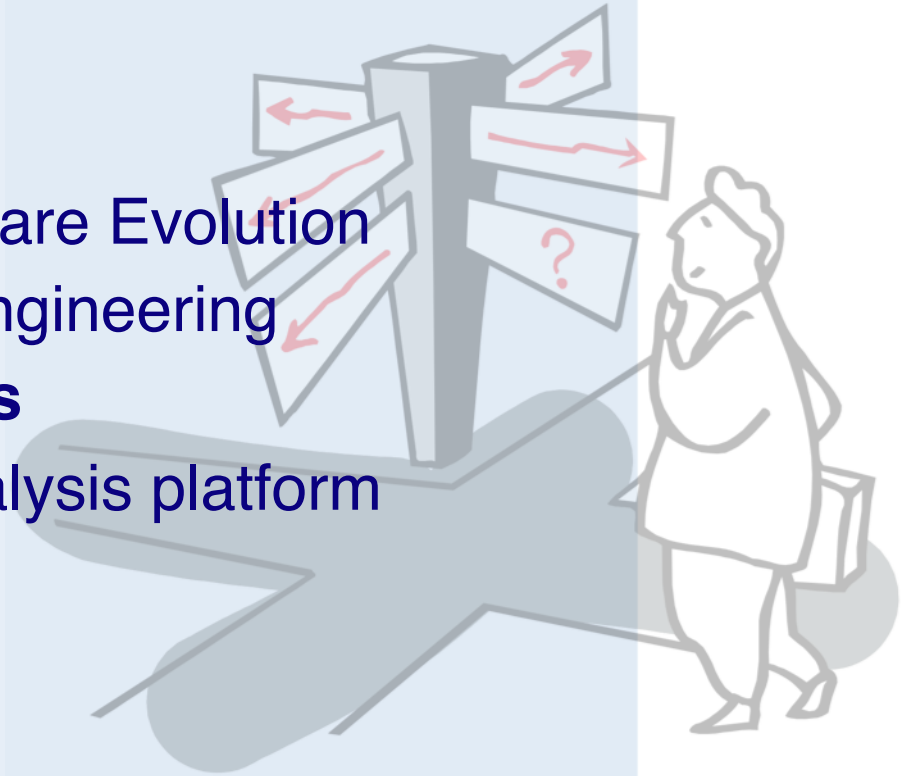
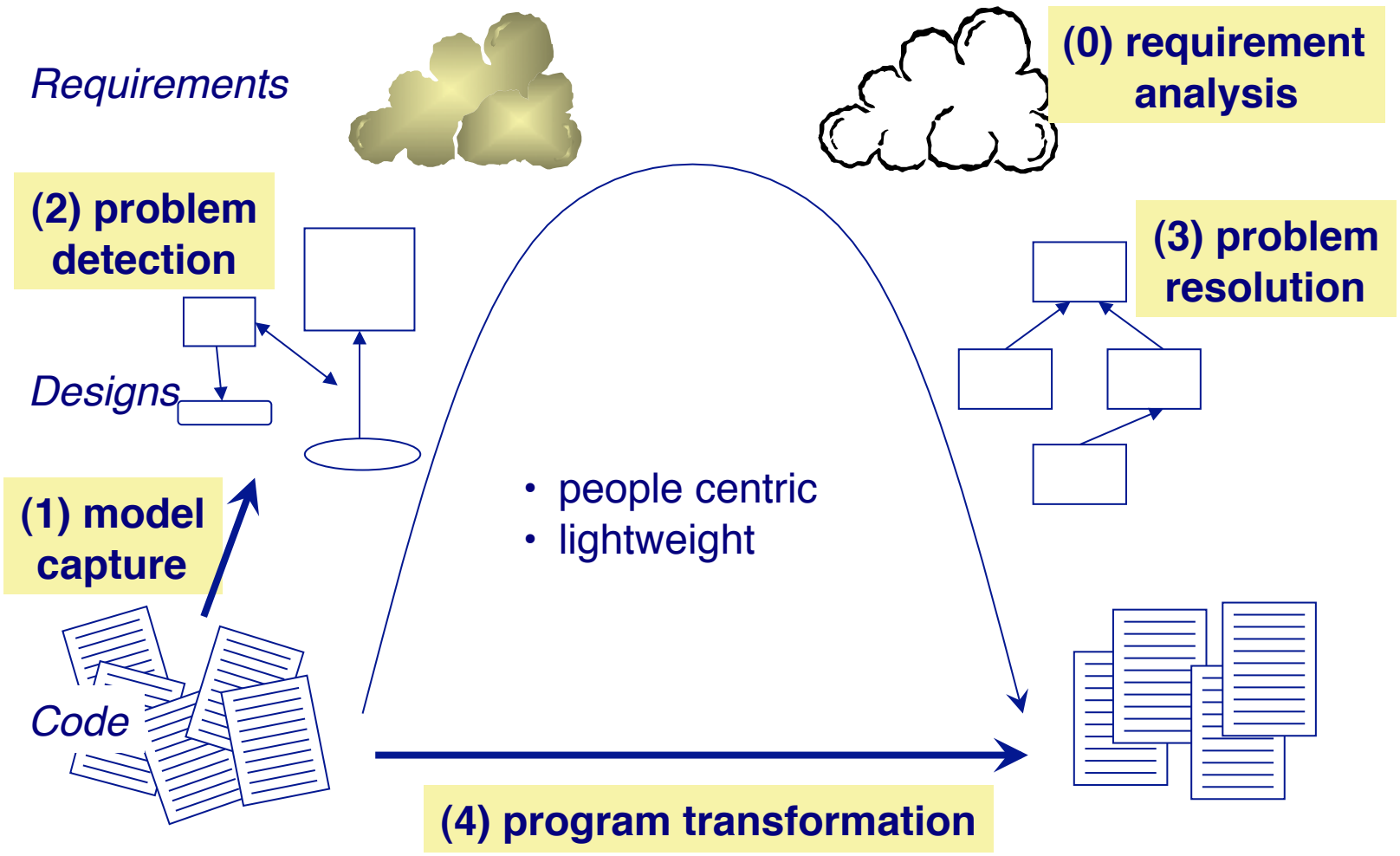


The Reengineering Life-Cycle



Reengineering Patterns

In software engineering, a **design pattern** is a general solution to a common problem in software design. *A design pattern isn't a finished design that can be transformed directly into code; it is a description or template for how to solve a problem that can be used in many different situations.*

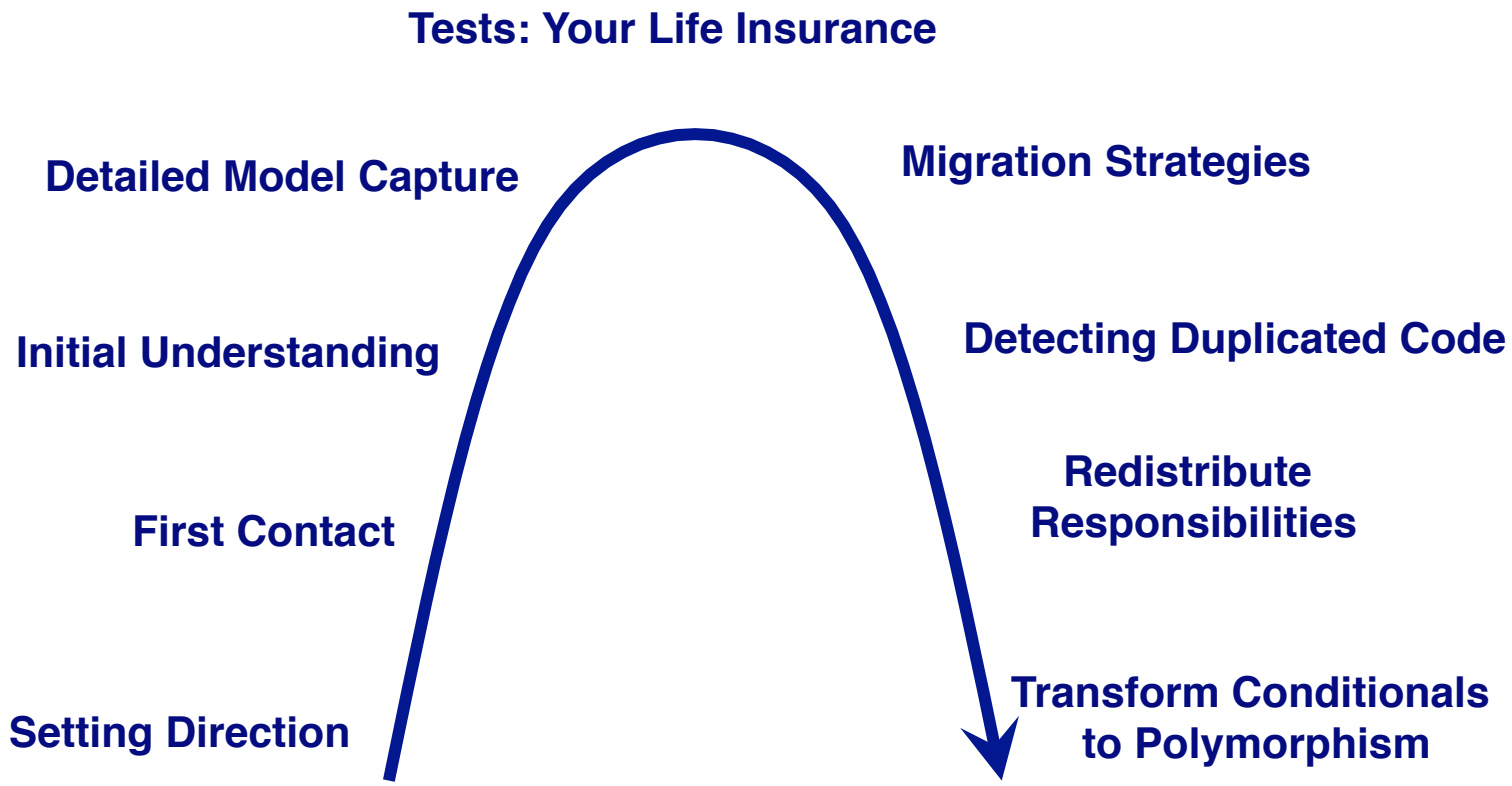
Reverse engineering patterns *encode expertise and trade-offs* in *extracting design* from source code, running systems and people.

—*Even if design documents exist, they are typically out of sync with reality.*

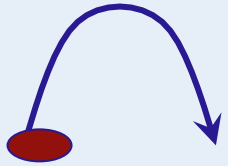
Reengineering patterns encode expertise and trade-offs in *transforming legacy code* to resolve problems that have emerged.

—*These problems are typically not apparent in original design but are due to architectural drift as requirements evolve*

A Map of Reengineering Patterns



Setting Direction



Set direction

Agree on Maxims

Maintain direction

Coordinate direction

Appoint a Navigator

Speak to the Round Table

Where to start

Most Valuable First

What to do

What not to do

Fix Problems, Not Symptoms

If It Ain't Broke Don't Fix It

How to do it

Keep it Simple

Principles & Guidelines *for Software project management especially relevant for reengineering projects*

Most Valuable First

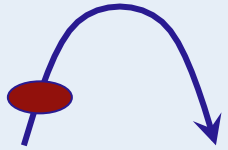
Problem: *Which problems should you focus on first?*

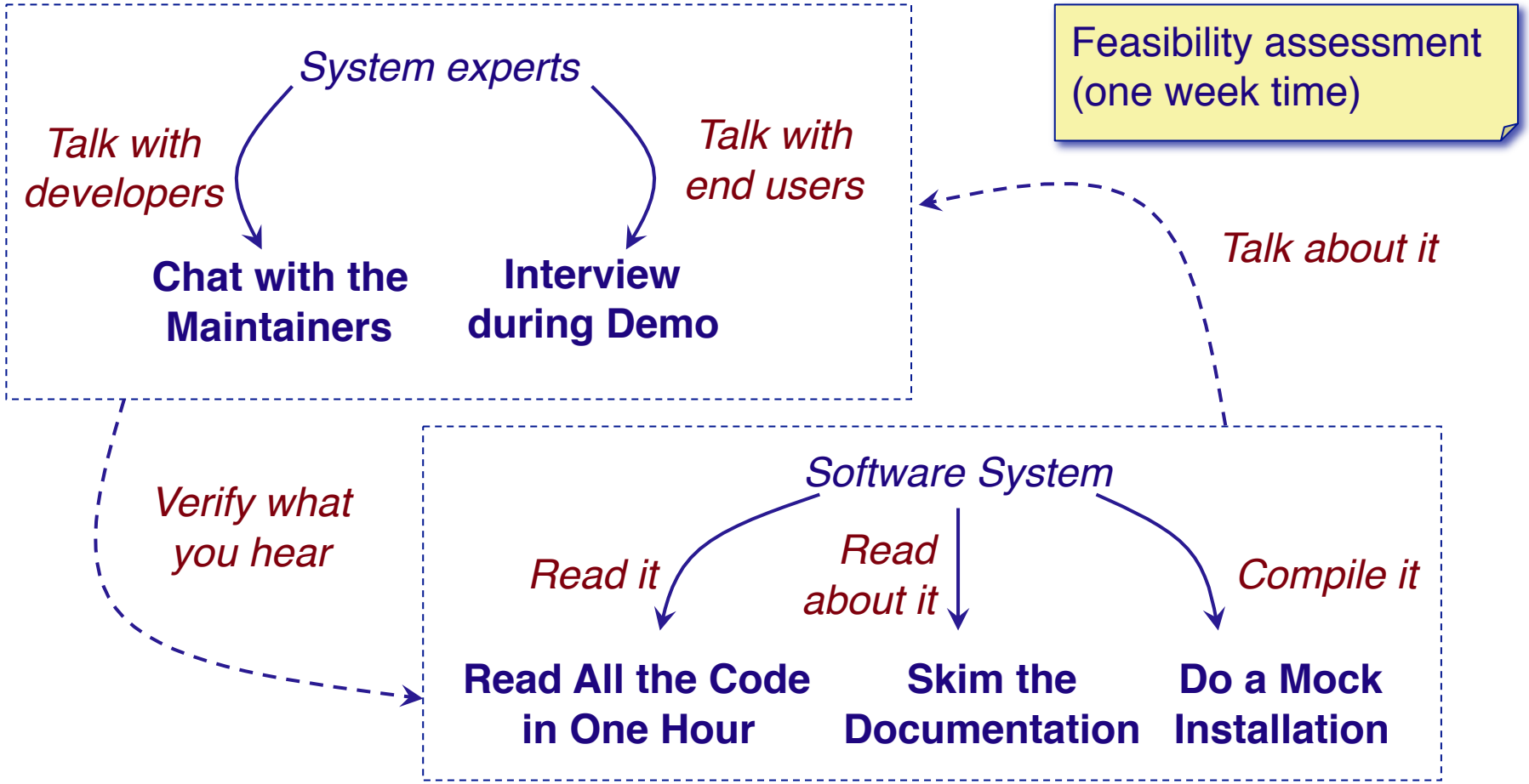
Solution: Work on aspects that are *most valuable* to your customer

- Maximize commitment, early results; build confidence
- Difficulties and hints:
  - Which *stakeholder* do you listen to?
  - What *measurable goal* to aim for?
  - Consult *change logs* for high activity
  - Play the *Planning Game*
  - Wrap, refactor or rewrite? — *Fix Problems, not Symptoms*

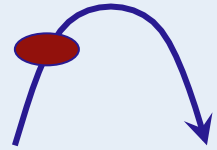
Vs. Fix the Buggiest First?

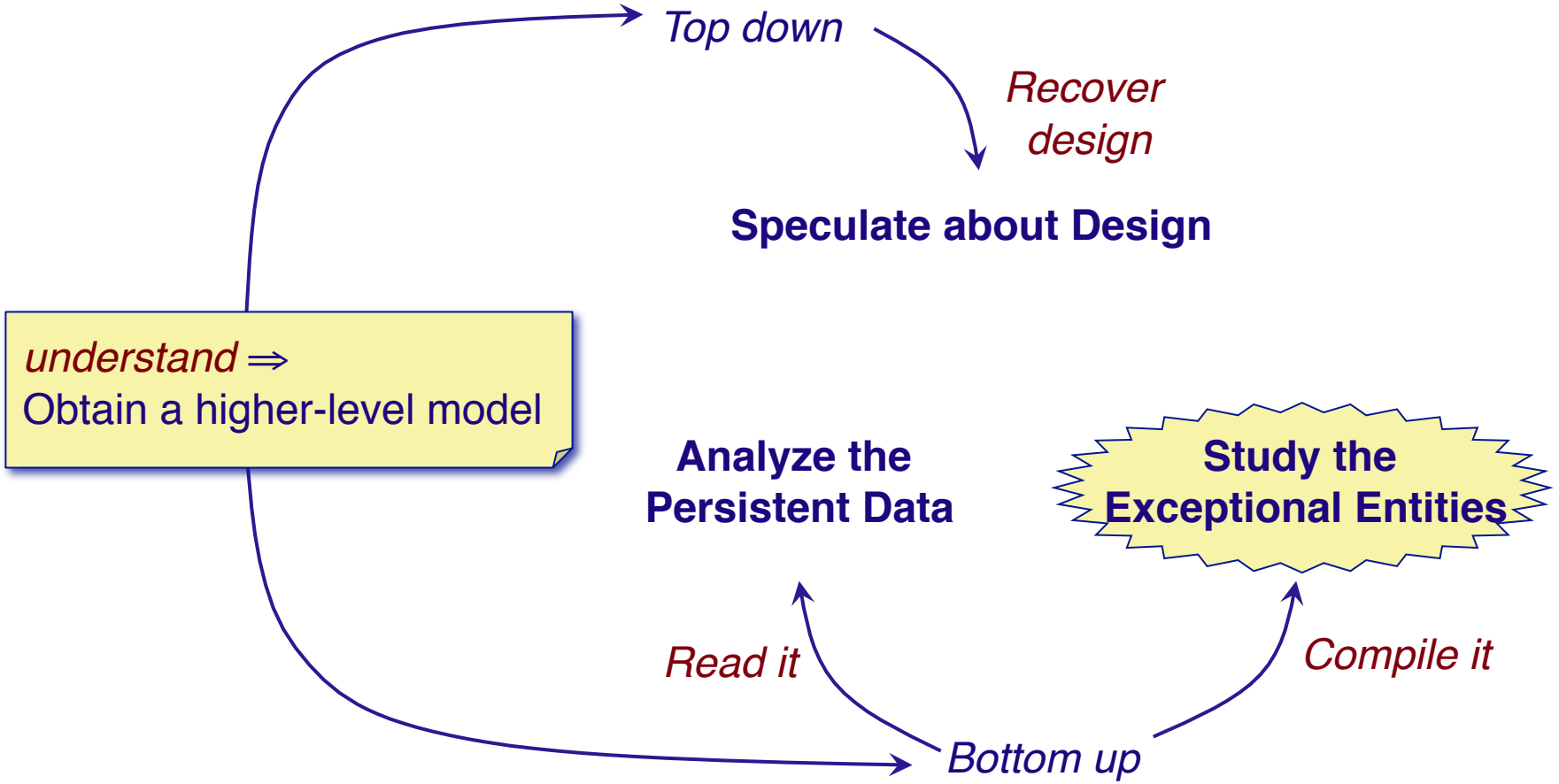
First Contact





Initial Understanding





Pattern: Study the Exceptional Entities

Problem

— **How can you quickly gain insight into complex software?**

Solution

— *Measure* software entities and *study the anomalous ones*

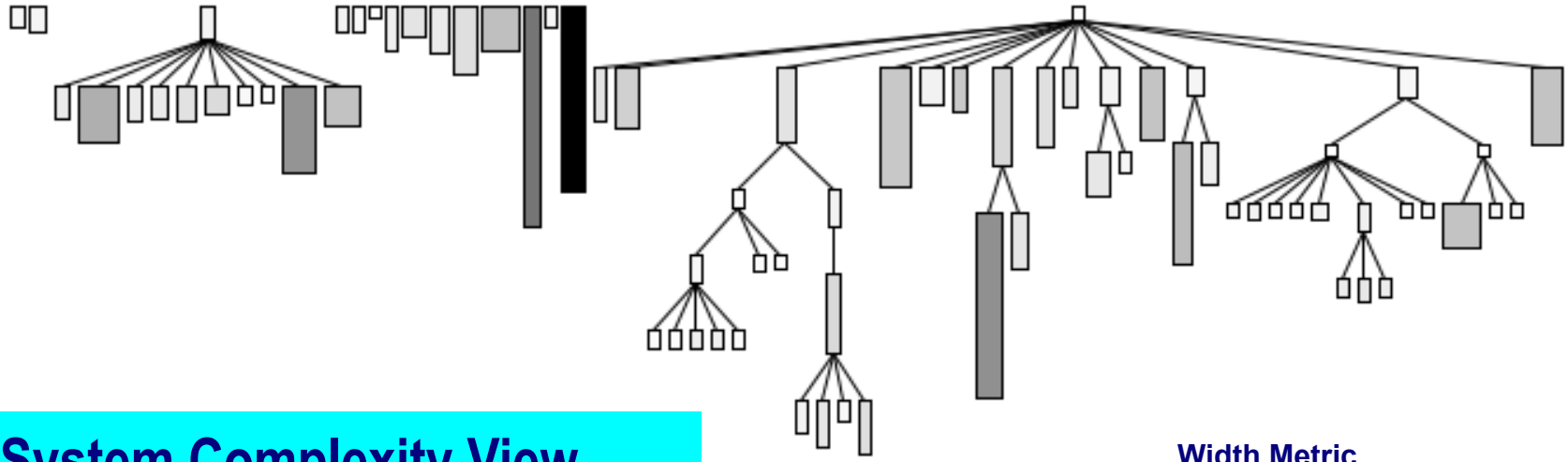
Steps

— Use simple metrics

— Visualize metrics to get an overview

— Browse the code to get insight into the anomalies

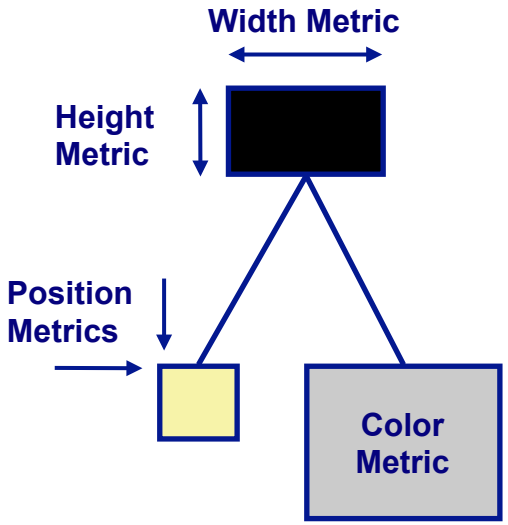
System Complexity View



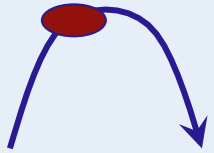
System Complexity View

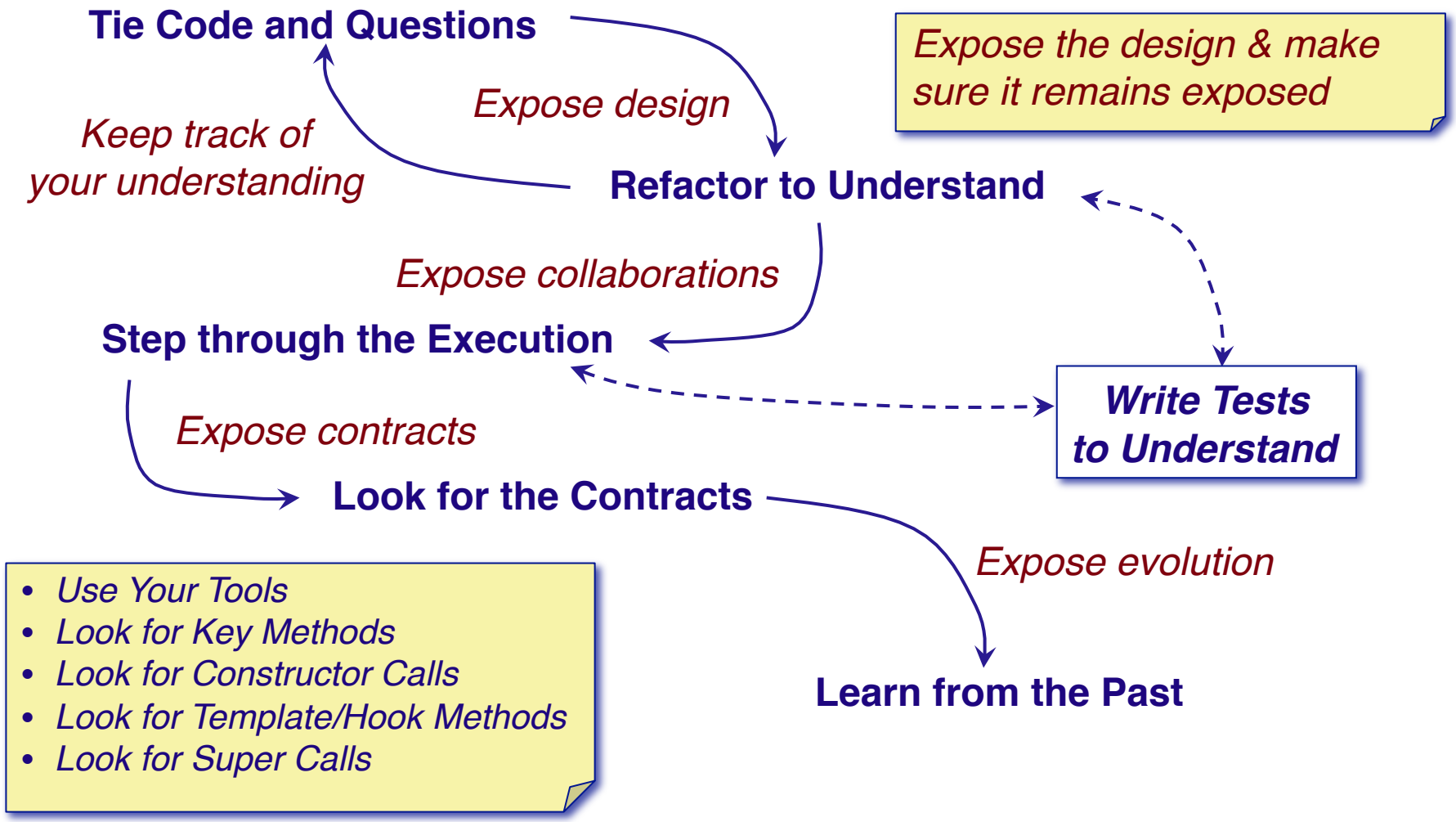
Nodes = Classes
Edges = Inheritance Relationships

Width = Number of Attributes
Height = Number of Methods
Color = Number of Lines of Code

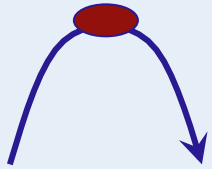


Detailed Model Capture





Tests: Your Life Insurance



Write Tests to Enable Evolution

Managing tests

Grow Your Test Base Incrementally

Write Tests to Understand

Use a Testing Framework

Designing tests

Test the Interface, Not the Implementation

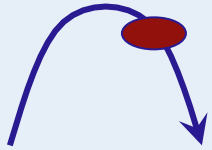
Record Business Rules as Tests

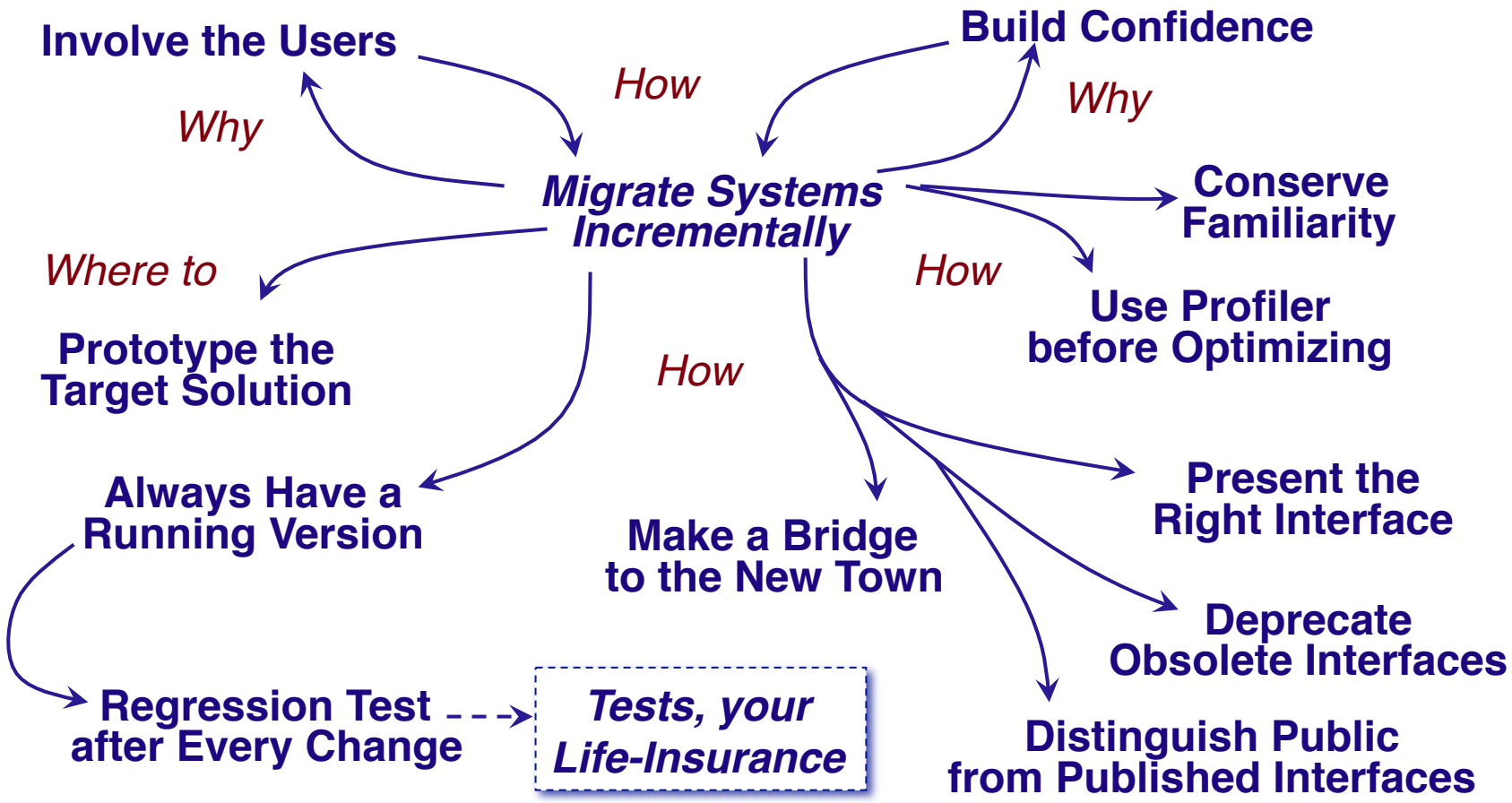
- *Test Fuzzy features*
- *Test Old Bugs*
- *Retest Persistent Problems*

Regression Test after Every Change

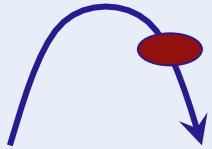
Migration Strategies

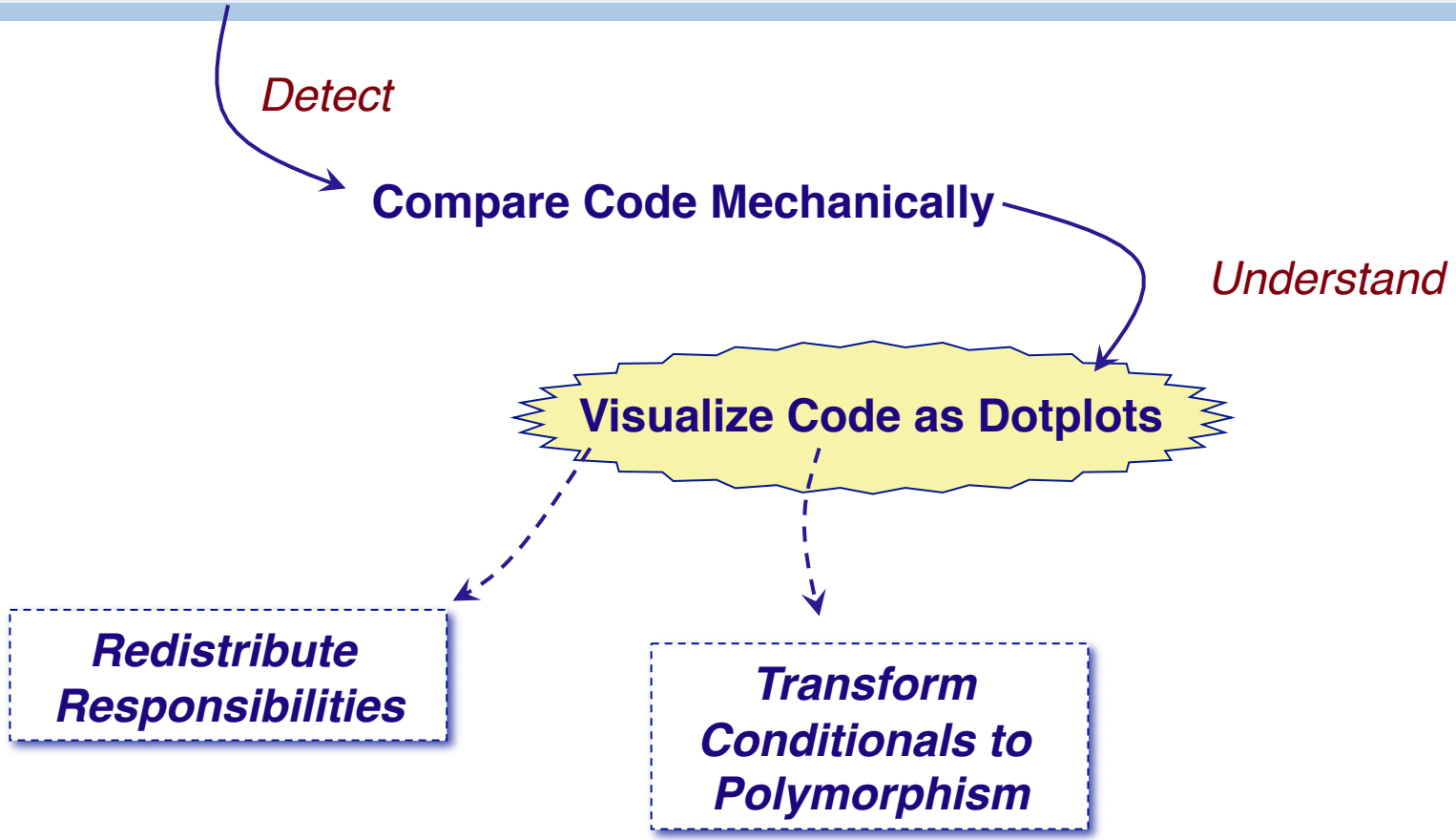
Migration





Detecting Duplicated Code





Pattern: Visualize Code as Dotplots

Problem

— **How can you effectively identify significant duplication in a complex software system?**

Solution

— Visualize the code as a *dotplot*, where dots represent duplication.

Steps

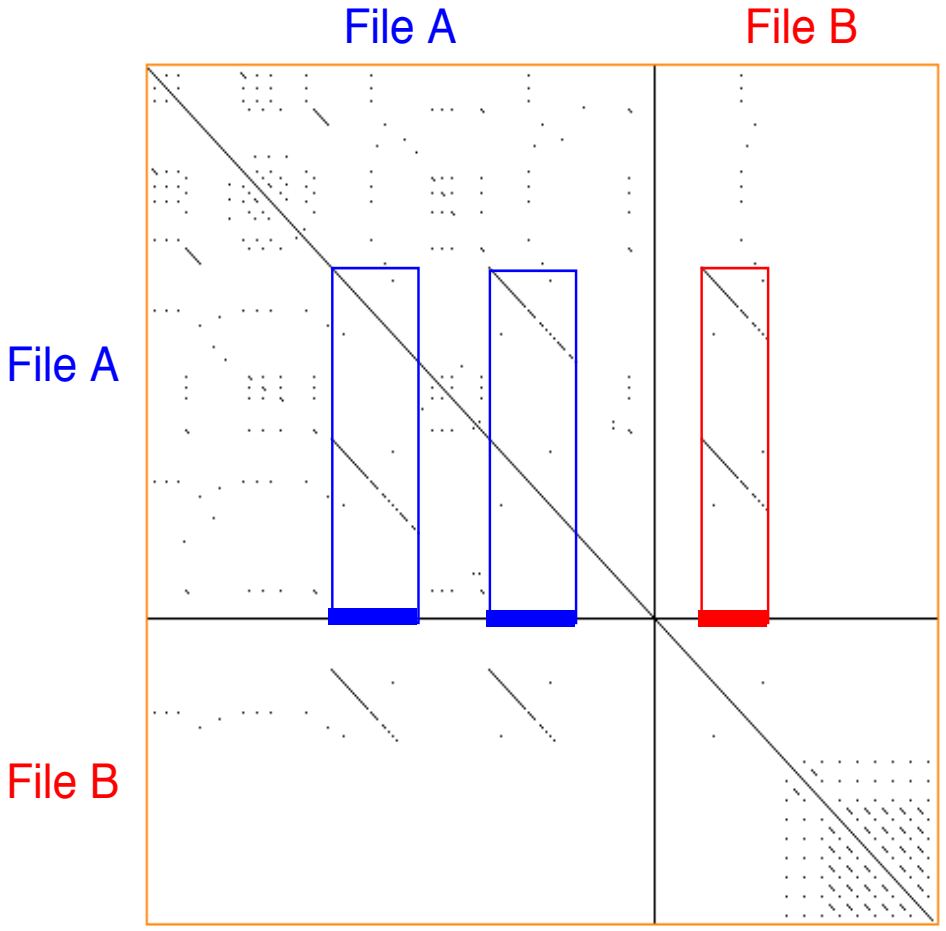
— Normalize the source files

— Compare files line-by-line

— Visualize and interpret the dotplots

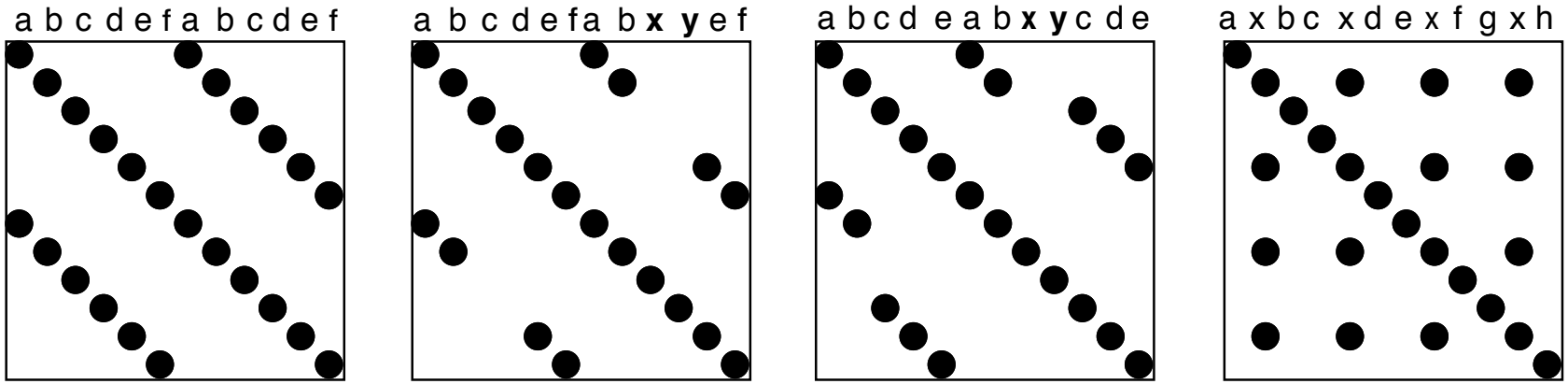
Clone detection by string-matching

Solid diagonals indicate significant duplication between or within source files.



Dotplot Visualization

Sample Dot Configurations:



Exact Copies

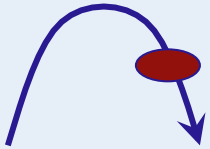
Copies with Variations

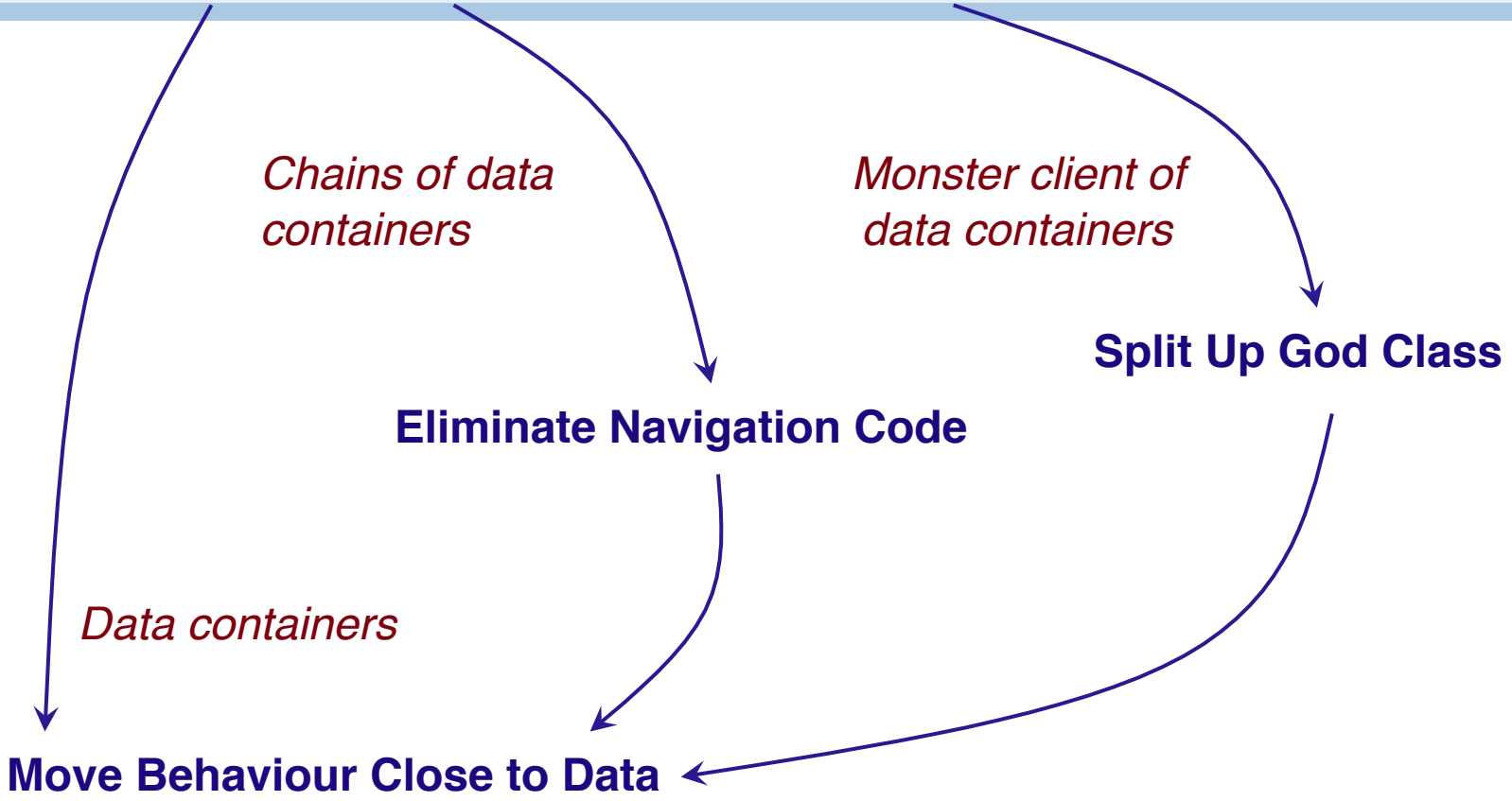
Inserts/Deletes

Repetitive Code Elements

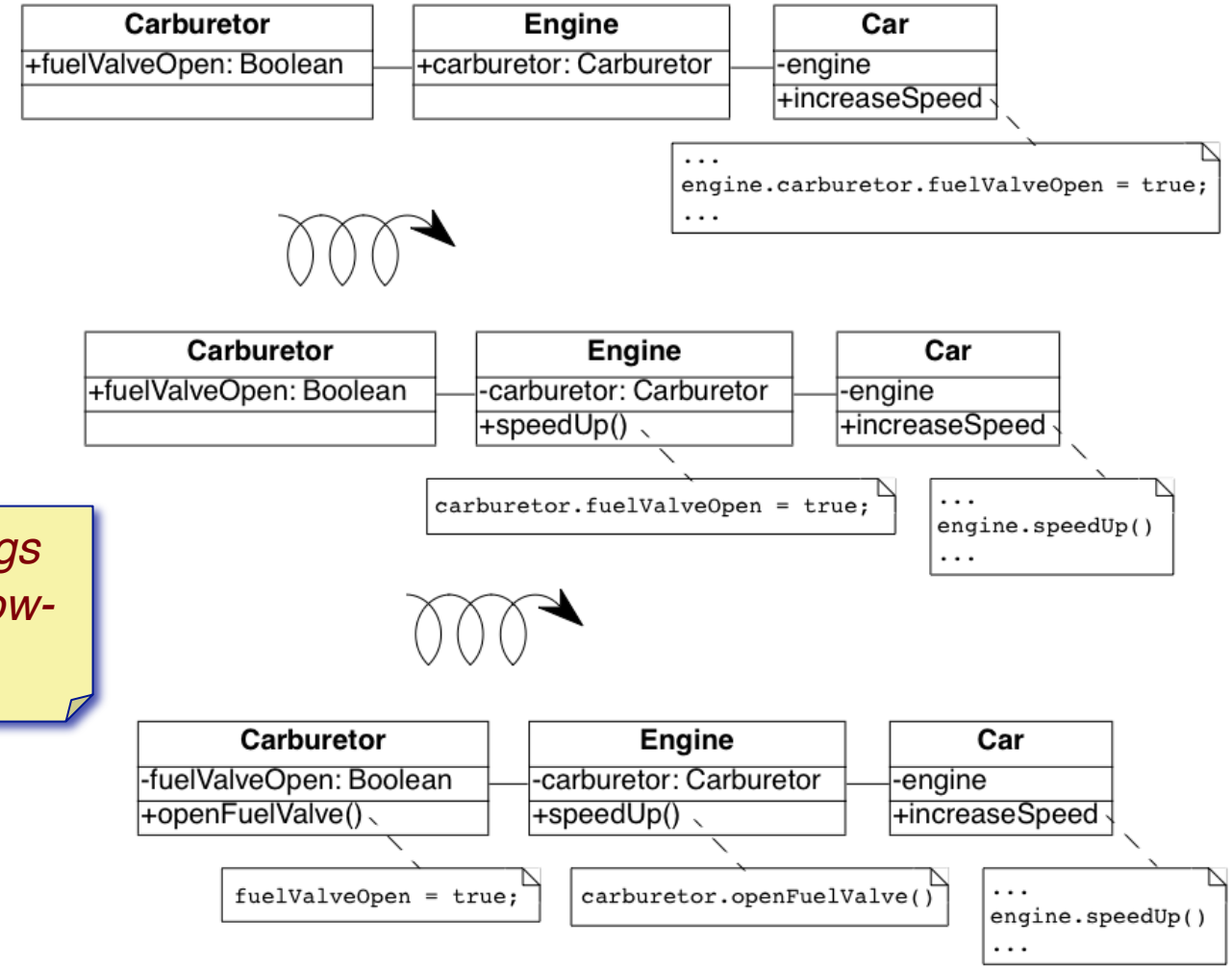
(Helfman, 1995)

Redistribute Responsibilities



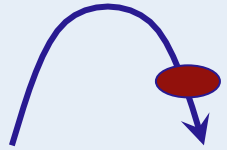


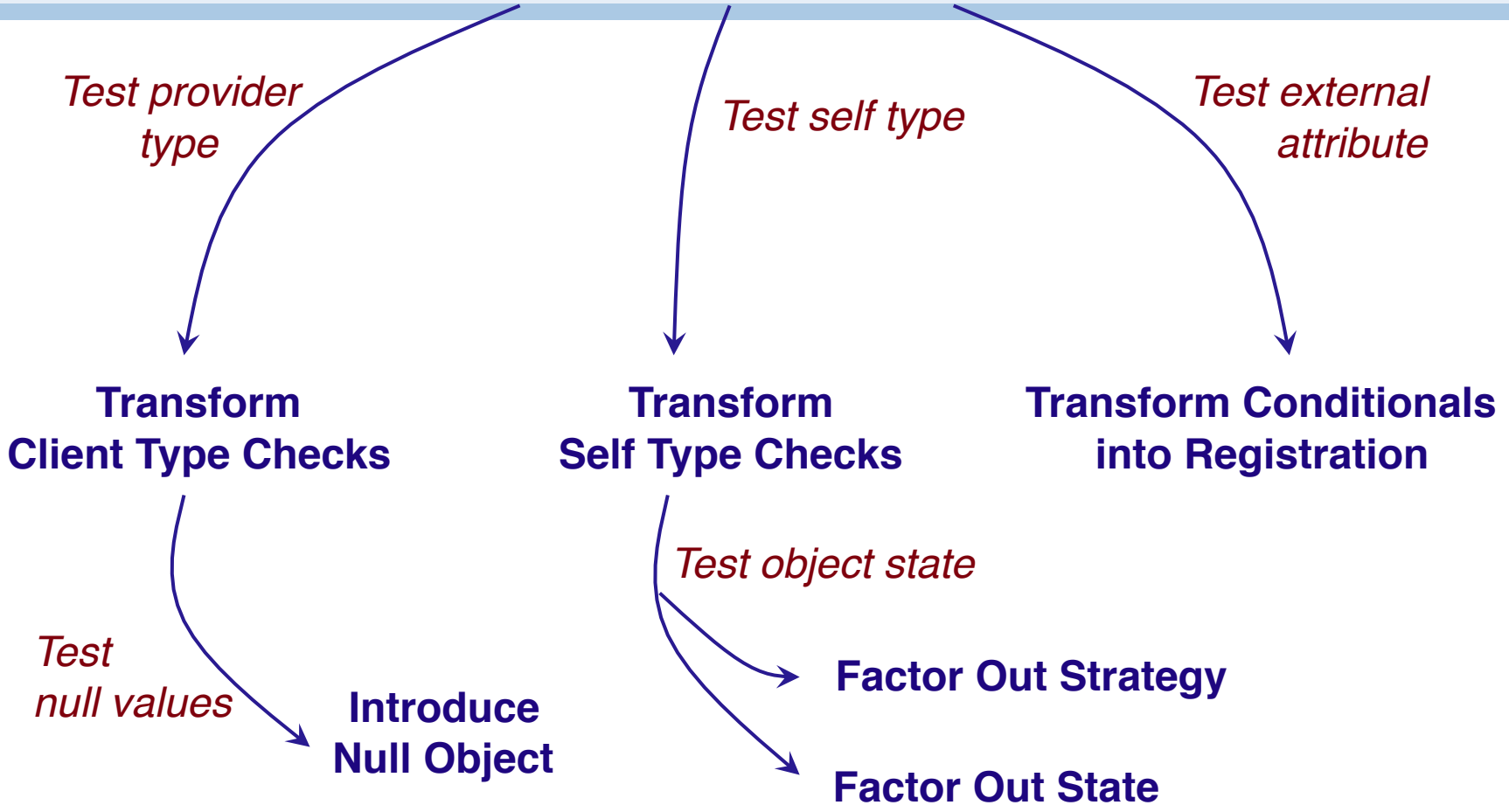
High-level refactorings



High-level refactorings make use of many low-level refactorings

Transform Conditionals to Polymorphism





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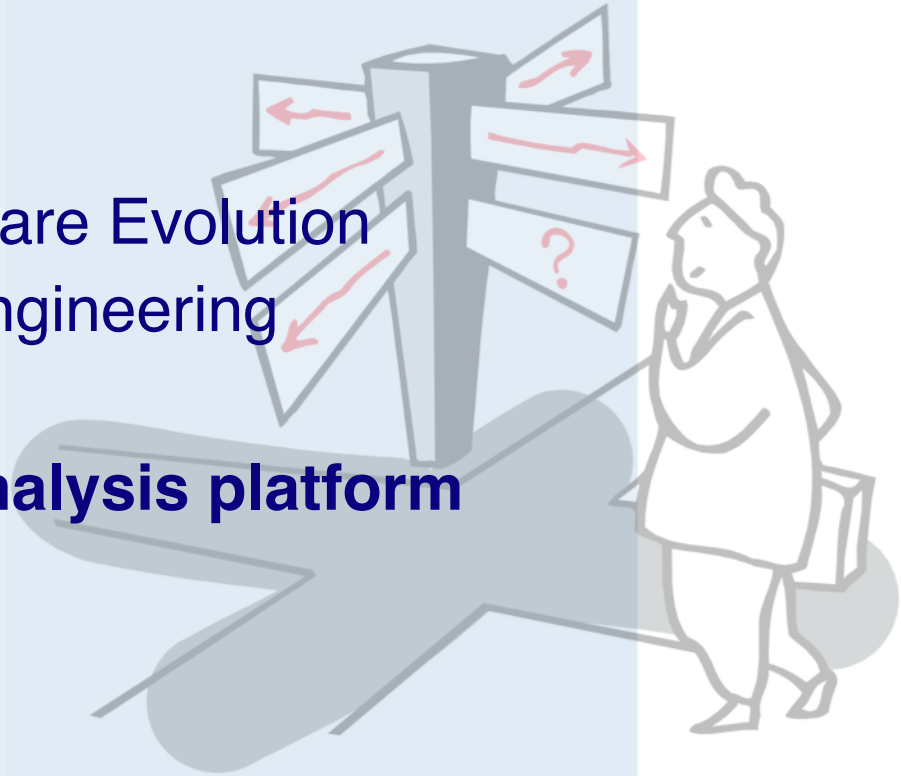
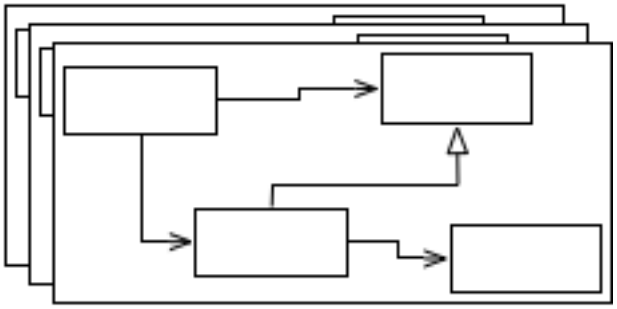
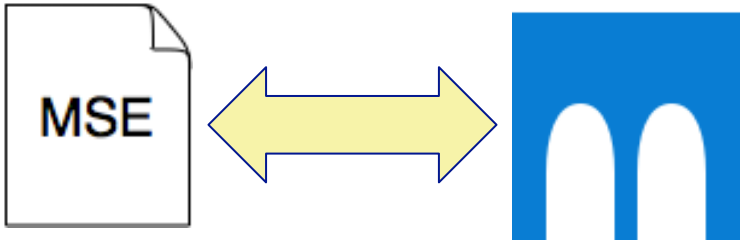


Moose — an extensible platform for software and data analysis



FAMIX meta-models family

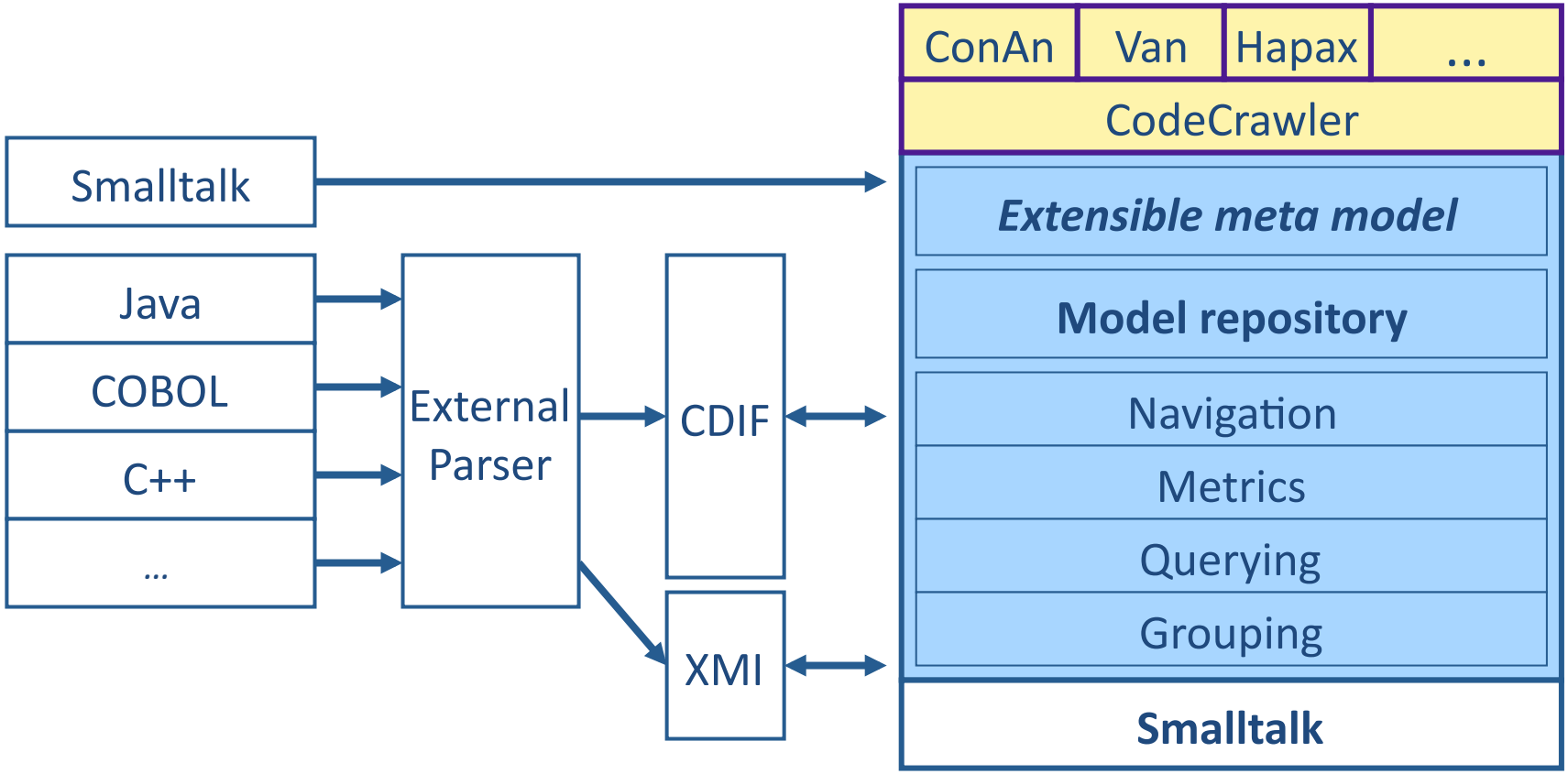


Import/export format for models

Data parsing support

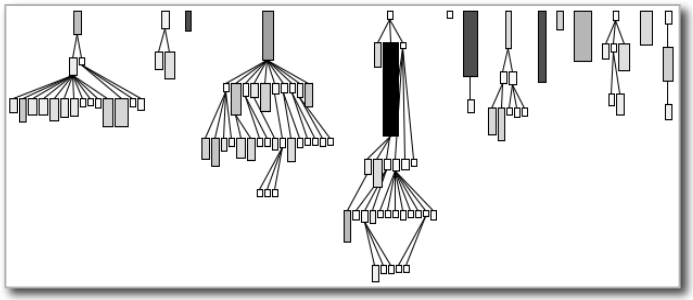
…more

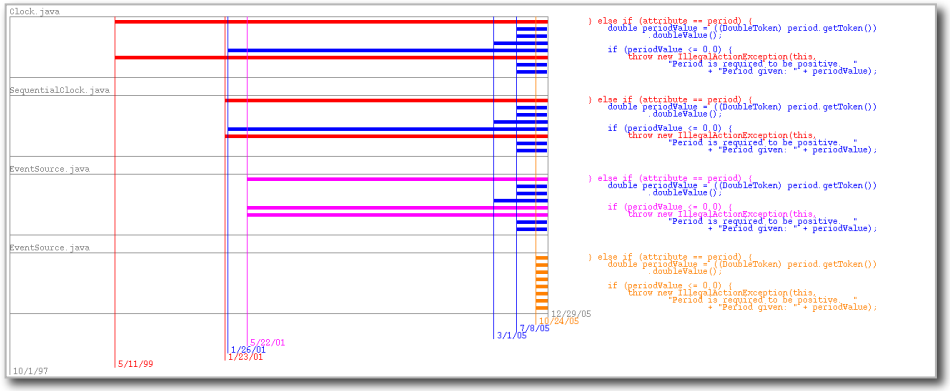
Explicit metamodels enable change

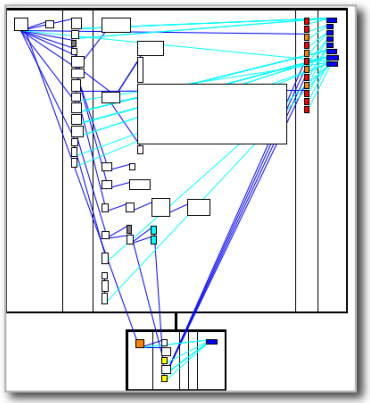


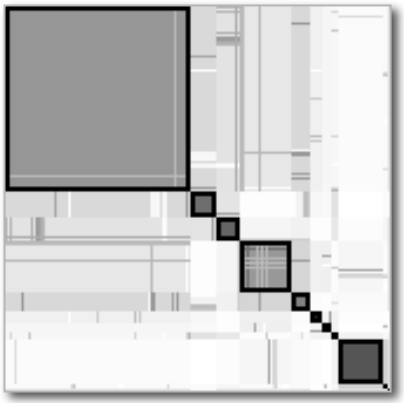
The Story of Moose: an Agile Reengineering Environment.
Nierstrasz, Ducasse, Gîrba. ESEC/FSE 2005

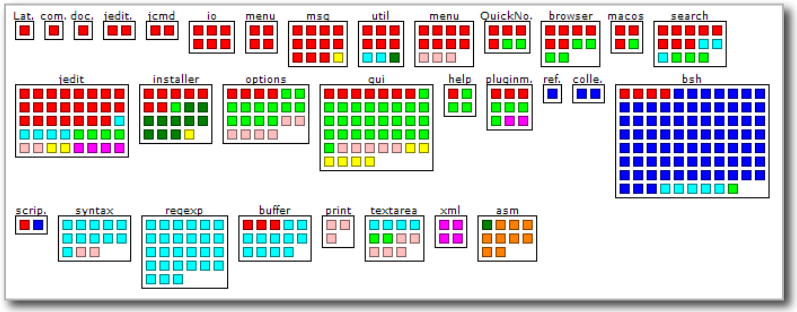
Moose visualizations

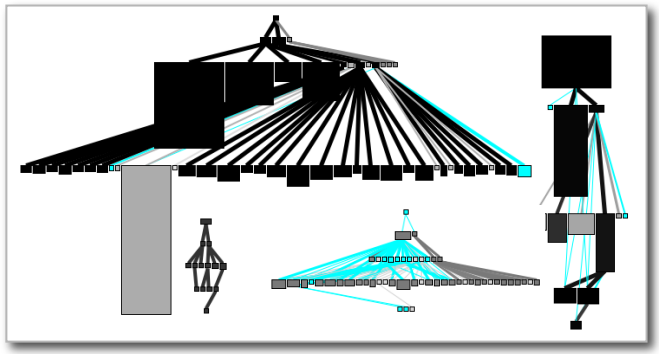


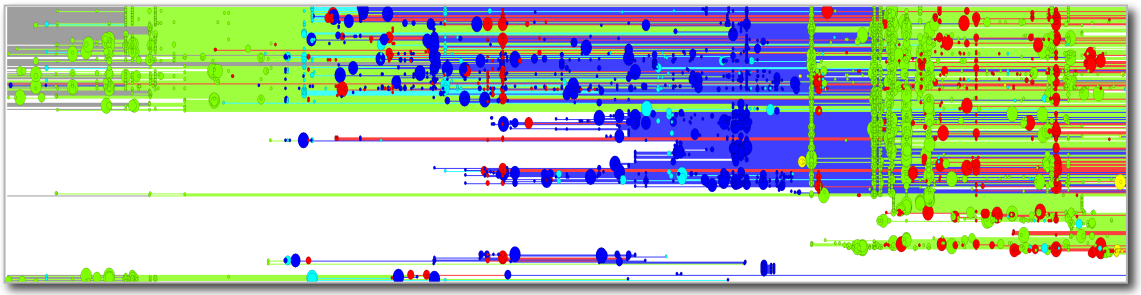




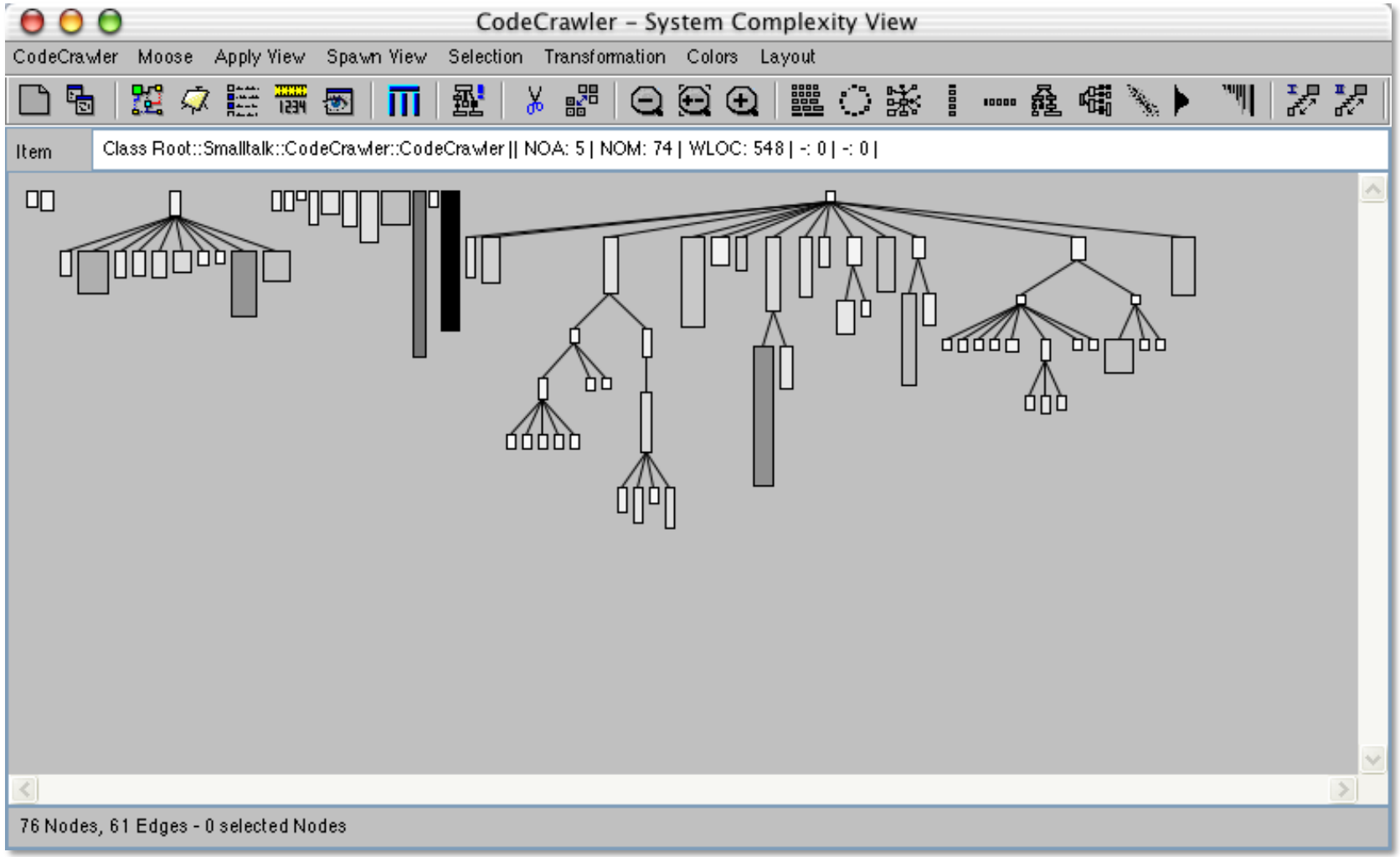




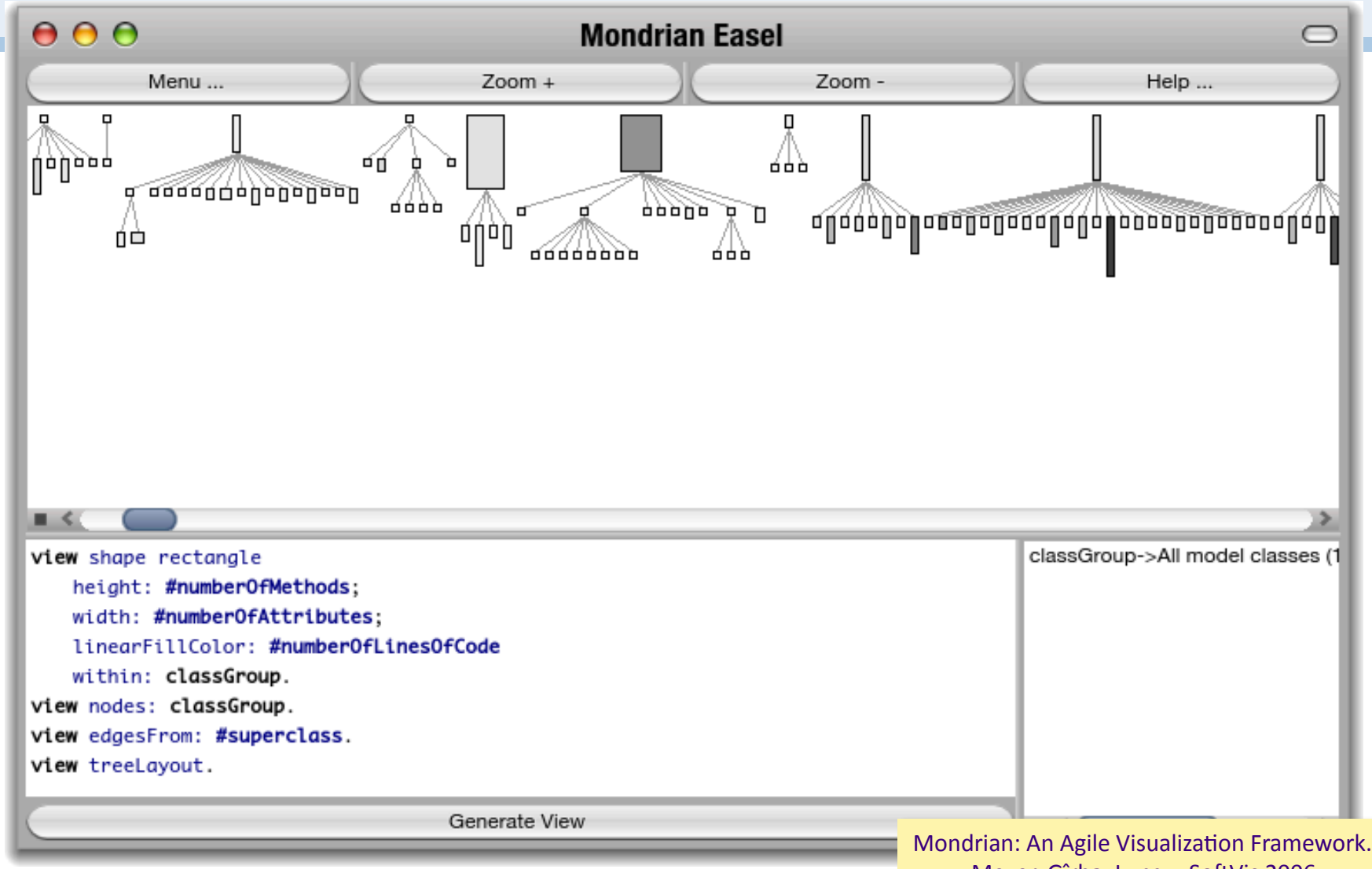




Programming visualizations with CodeCrawler

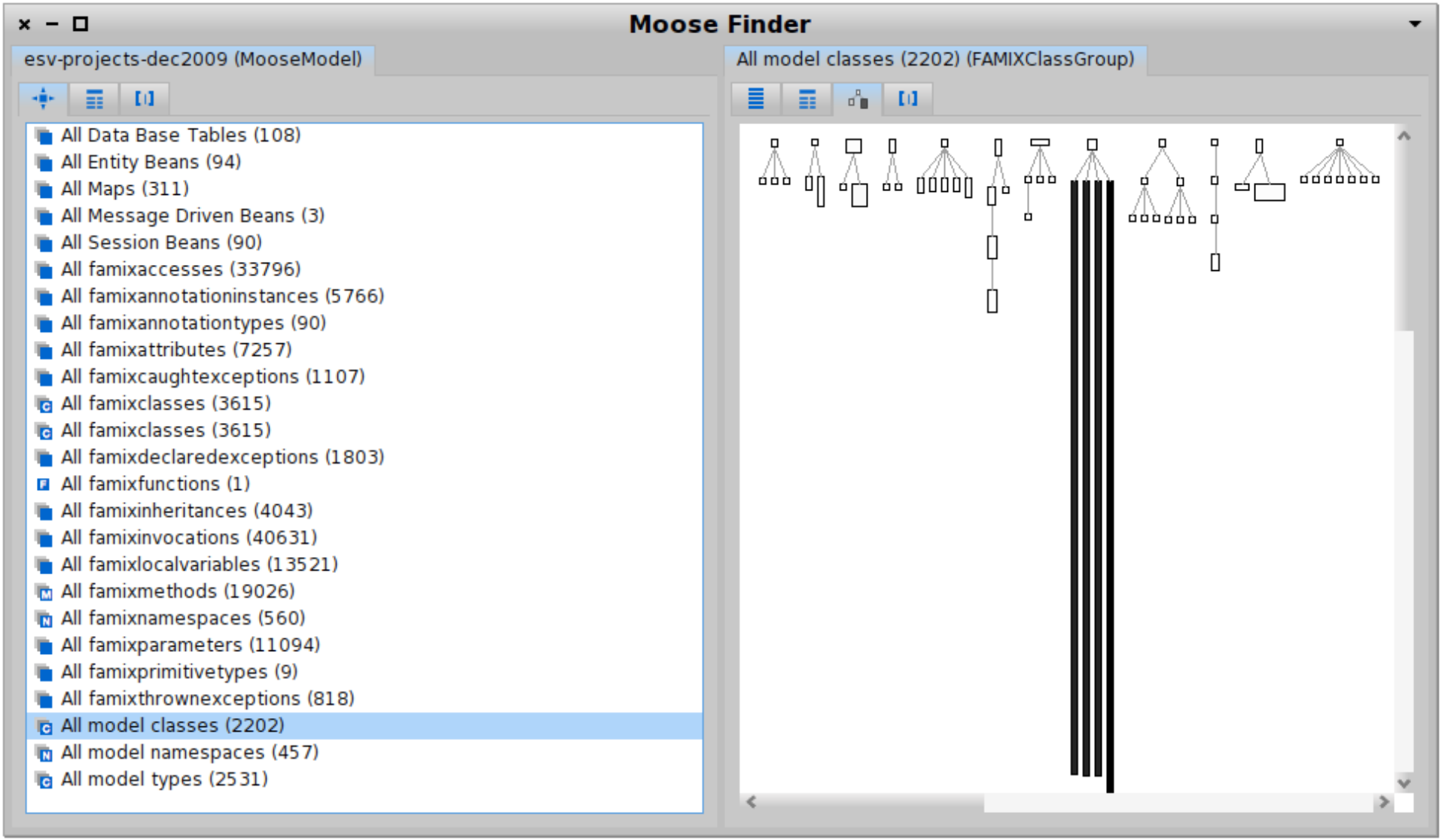


Scripting visualizations with Mondrian



Mondrian: An Agile Visualization Framework.
Meyer, Gîrba, Lungu. SoftVis 2006

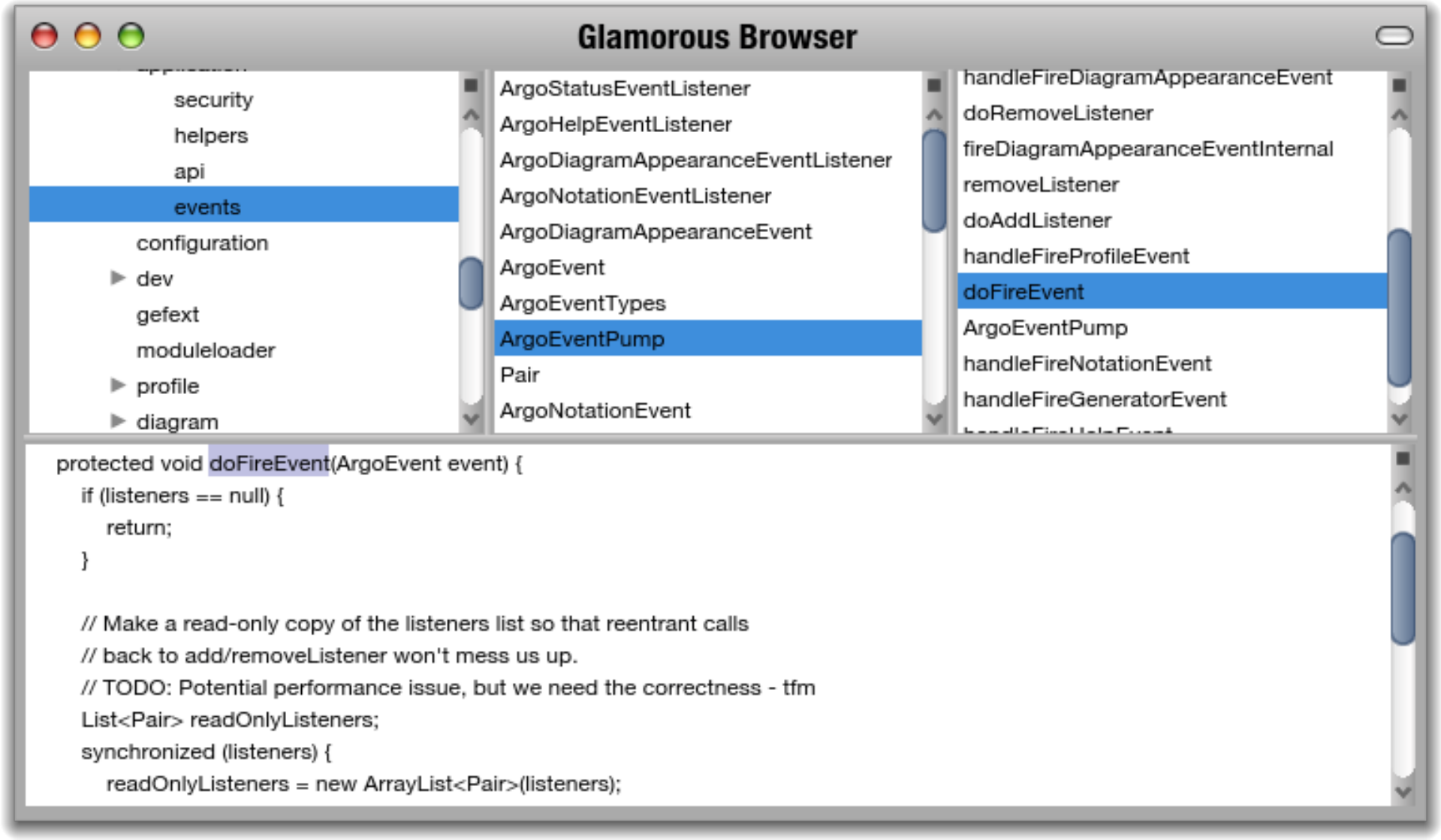
Data navigation through generic or dedicated browsers



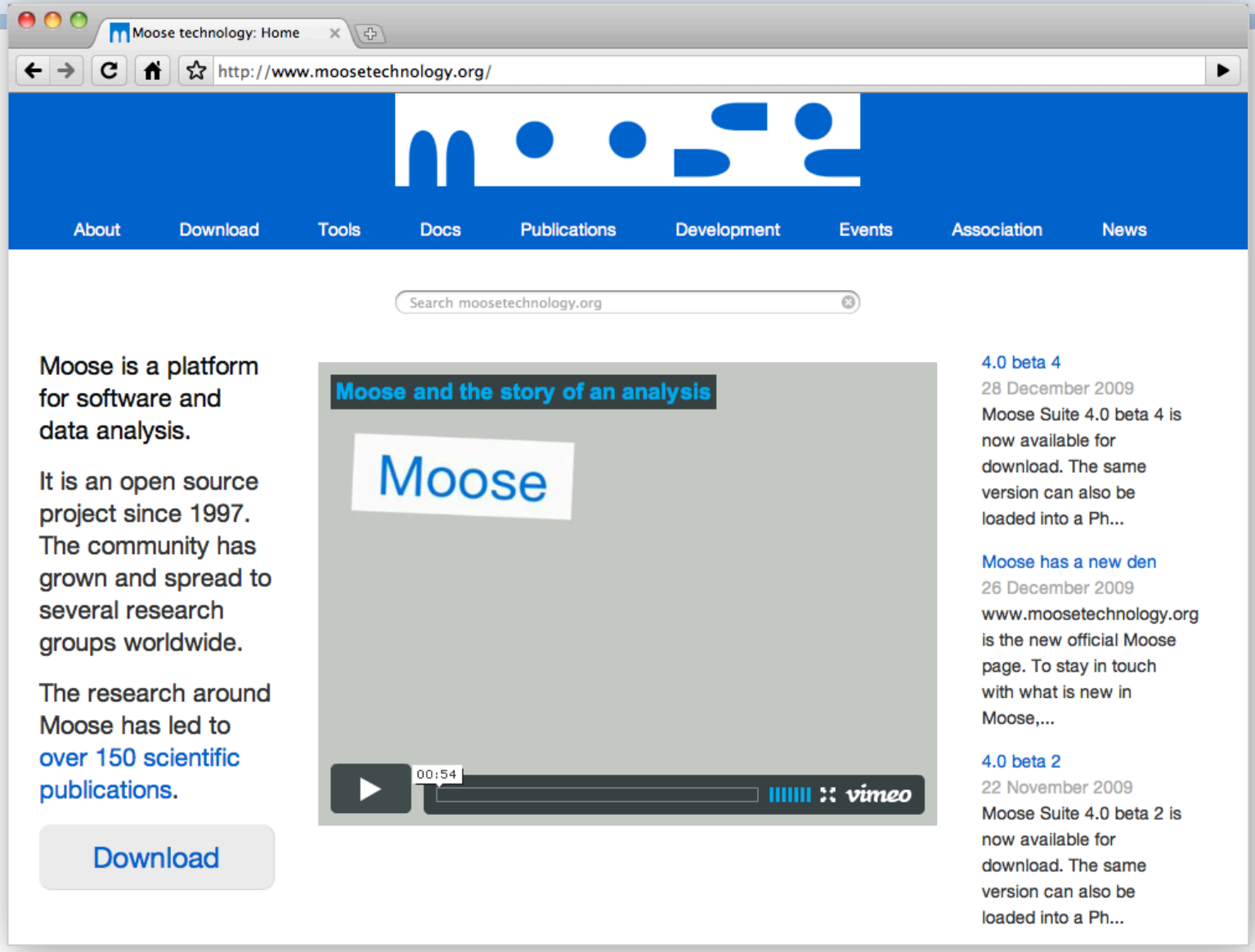
Scripting browsers with Glamour

```
| browser |

browser := GLMTabulator new.

browser
  row: [ :r | r column: #namespaces; column: #classes; column: #methods ];
  row: #details.

browser transmit to: #namespaces; andShow: [ :a |
  a tree
    display: [ :model | model allNamespaces select: [ :each | each isRoot ] ];
    children: [ :namespace | namespace childScopes ];
    format: [ :namespace | namespace stubFormattedName ] ].

browser transmit from: #namespaces; to: #classes; andShow: [ :a |
  a list
    display: [ :namespace | namespace classes ];
    format: [ :class | class stubFormattedName ] ].

browser transmit from: #classes; to: #methods; andShow: [ :a |
  a list
    display: [ :class | class methods ];
    format: [ :method | method stubFormattedName ] ].

browser transmit from: #methods; to: #details; andShow: [ :a |
  a text
    display: [ :method | method sourceText ] ].

browser openOn: MooseModel root allModels anyOne
```

Scripting browsers with Glamour

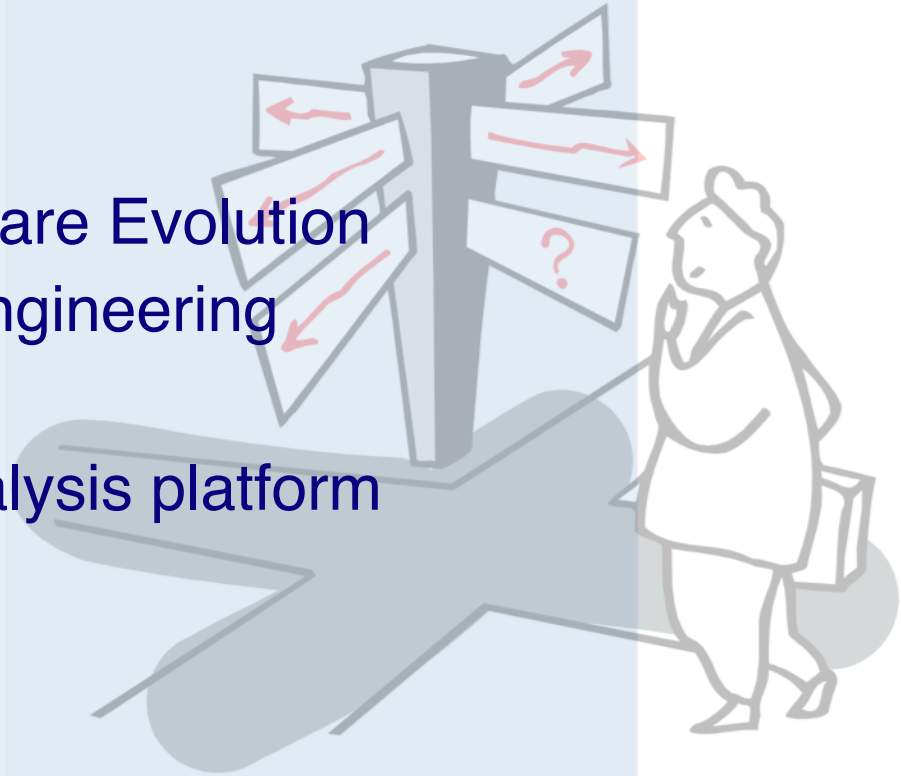


Moose — a platform for collaborative research



Roadmap

- Lehman's Laws of Software Evolution
- Forward and Reverse Engineering
- Reengineering Patterns
- The Moose software analysis platform



Conclusion

- Valuable software inevitably changes
- Reverse and reengineering are necessary activities throughout the lifecycle of a software system
- Simple techniques go a long way

What you should know!

- What is Lehman's Laws of Continuing Change?
- Why do software systems become more complex over time?
- Why is duplicated code considered to be a bad code smell?
- How can you reduce the cost of software maintenance?
- What is meant by "reverse engineering"?
- How can studying exceptional entities help you to understand a software system?

Can you answer the following questions?

- Is a legacy software system a good thing or a bad thing to have?
- How can you ensure that documentation stays in sync with implementation?
- When should you start a reengineering project?
- What are the dangers of trying to fix the buggiest code first?

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