REVERSE ENGINEERING

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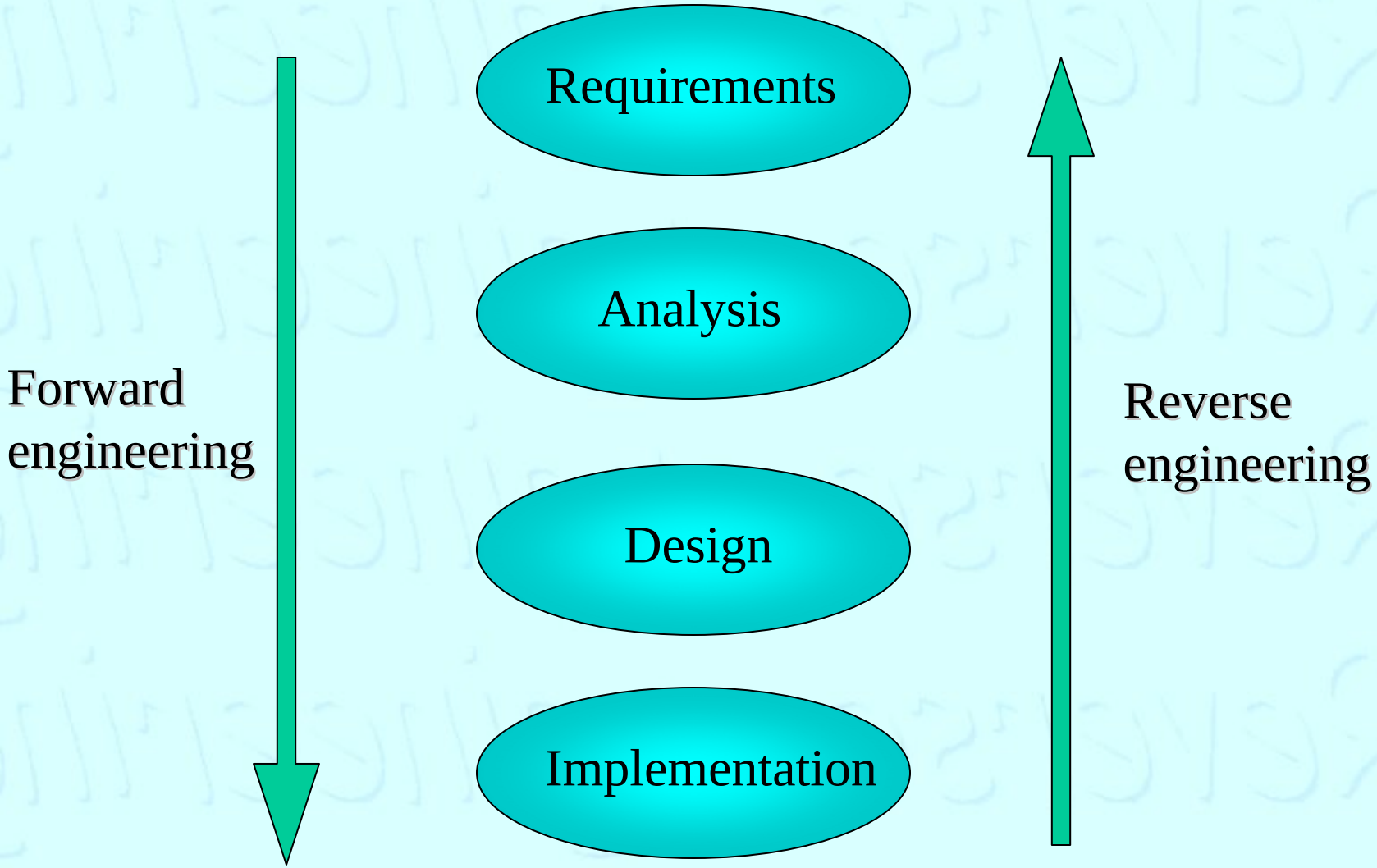
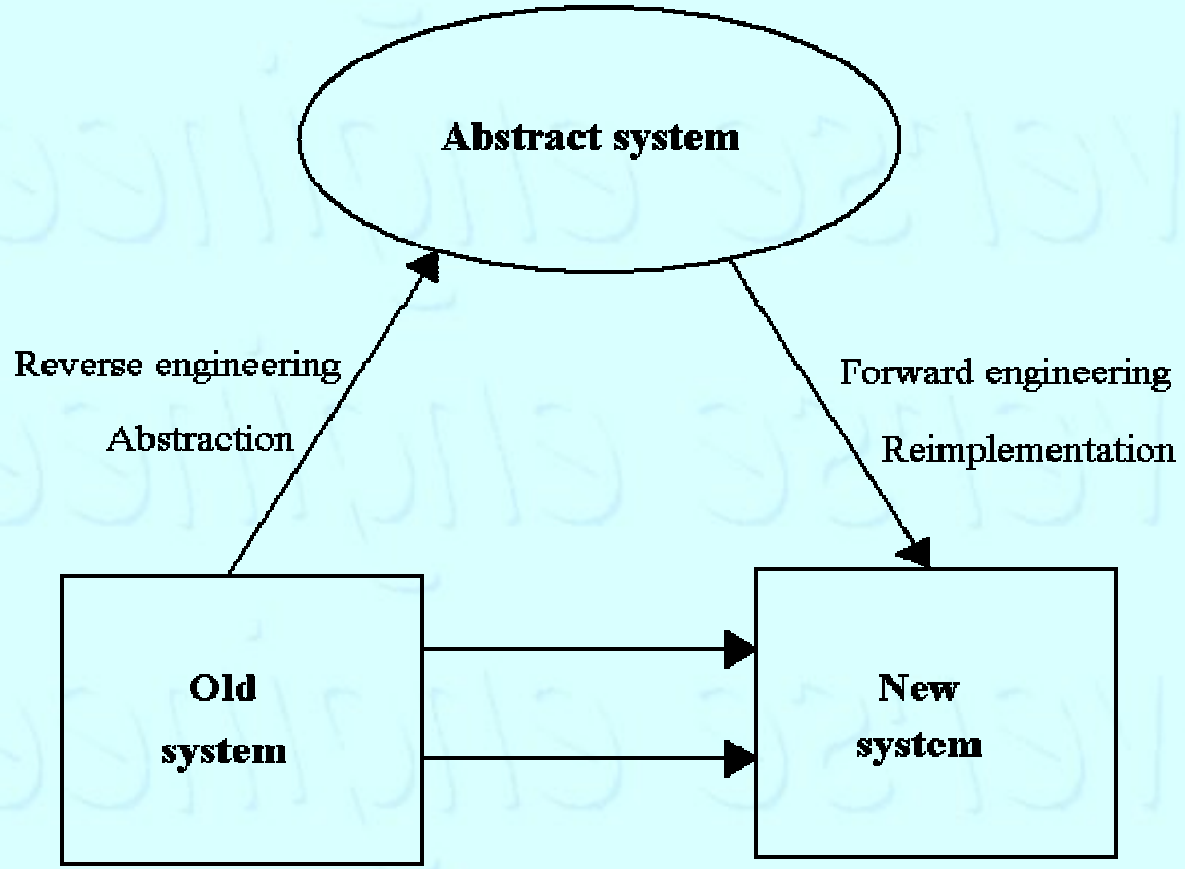
Reverse Engineering

- ‘Trying to figure out the structure and behaviour of existing software by building general-level static and dynamic models’
- Links:
  - **http://www.rigi.csc.uvic.ca/UVicRevTut/F4rev.html**
    - Compact information on reverse engineering
  - **http://users.ece.gatech.edu/~linda/revengr/revrepos.html**
    - Reengineering Resource Repository
    - Listings of tools, literature, …



Software engineering



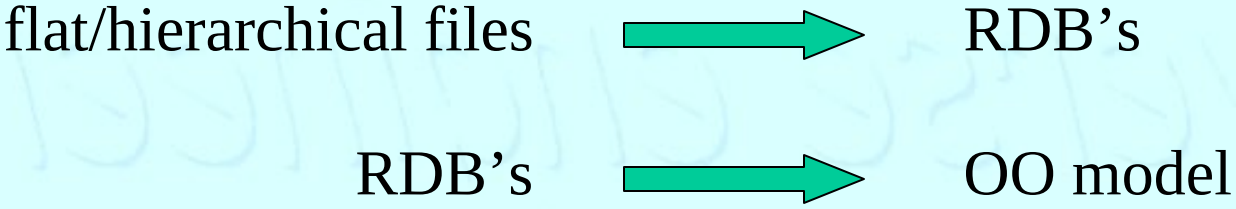
(Hausi A. Muller, 1997)

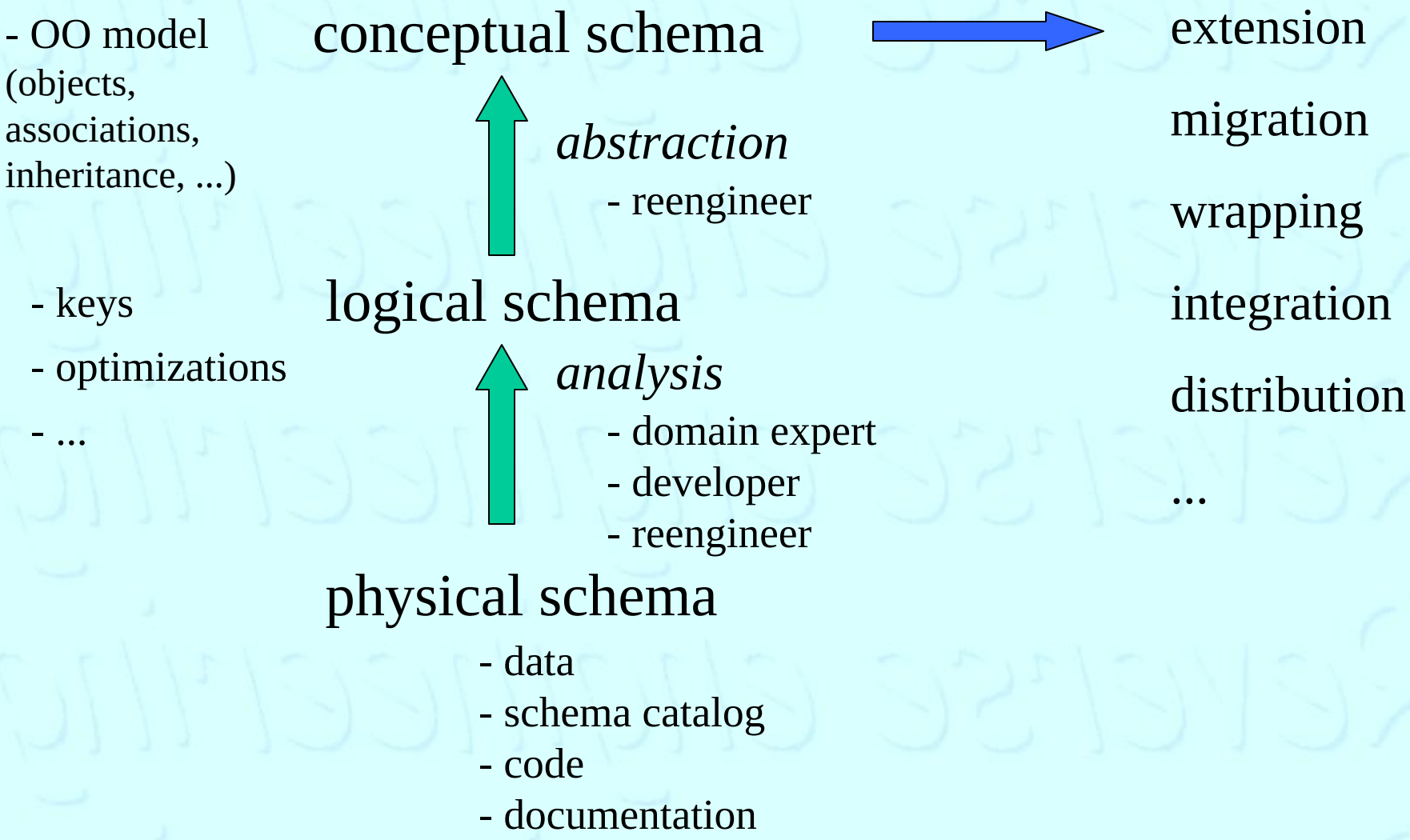
Applications

- Modifying software
  - Change of environment (software migration)
  - Re-designing software (re-engineering)
    - E.g. Y2K, €, e-commerce
- Design and implementation in forward engineering, e.g. debugging
- Program understanding/comprehension
- Program visualisation
- Software re-use

Data reverse engineering

- ” Data reverse engineering focuses on data and data-relationships both among data structures within programs and data bases”
- For example: relational data bases (RDBs):





Data reverse engineering

Other ’Re’ terms

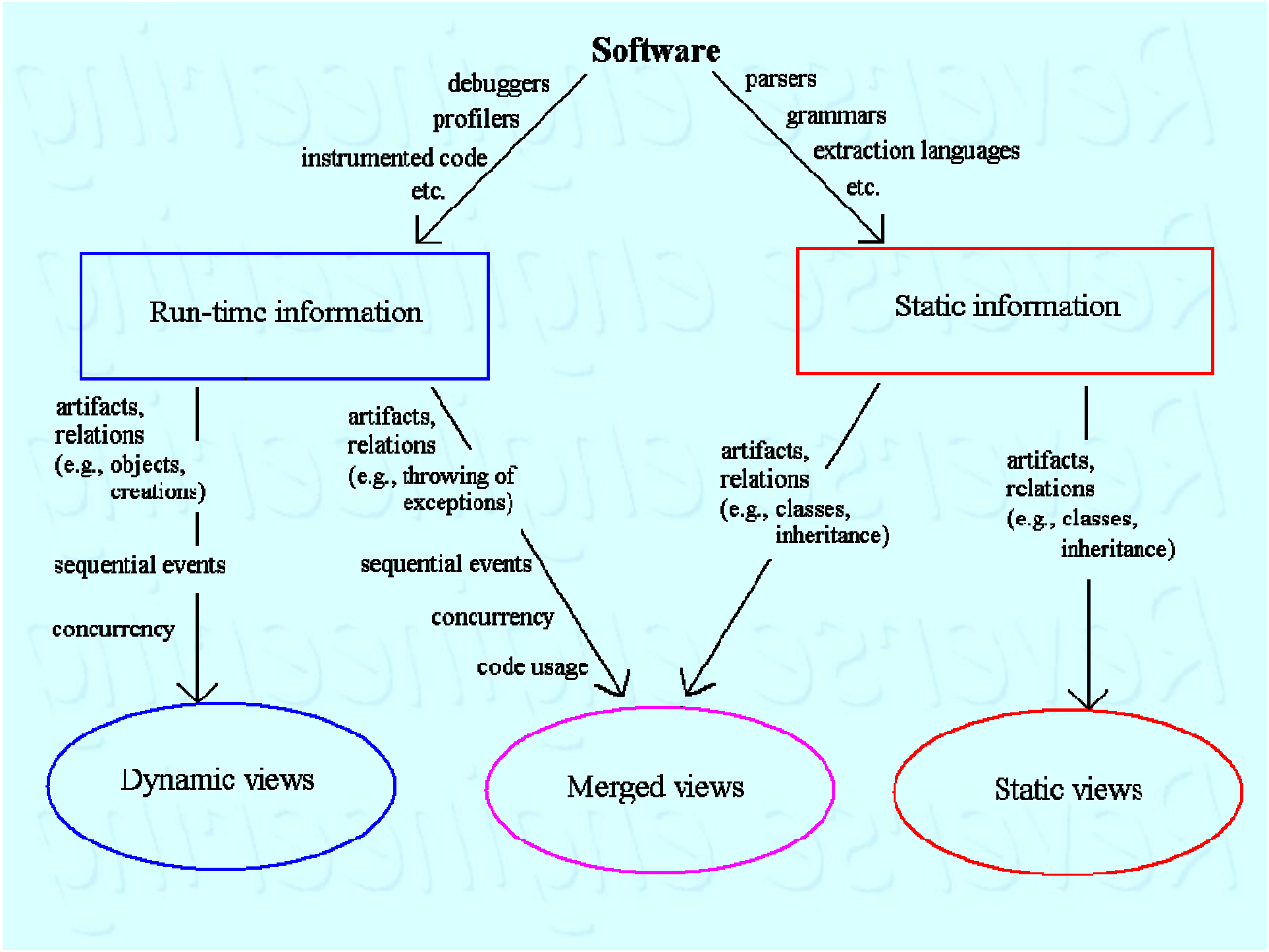
- Redocumentation
- Restructuring
  - transforming a system from one representation to another, while preserving its external functional behavior
- Retargeting
  - transforming and hosting or porting the existing system in a new configuration

More ’Re’ terms

- Business Process Reengineering
  - radical redesign of business processes to increase performance, such as cost, quality, service, and speed
  - reoptimization of organizational processes and structures
- Reverse specification
  - extracting a description of what the examined system does in terms of the application domain
  - a specification is abstracted from the source code or design description

Software reverse engineering

- Chikofsky & Cross: two-phase process
  - Collecting information
    - parsers, debuggers, profilers, event recorders
  - Abstracting information
    - Making understandable, high-level models
- *"Programmers have become part historian, part detective, and part clairvoyant" (T.A.Corbi 1989)*


Software
debuggers
profilers
instrumented code
etc.
parsers
grammars
extraction languages
etc.
Run-time information
Static information
artifacts,
relations
(e.g., objects,
creations)
artifacts,
relations
(e.g., throwing of
exceptions)
artifacts,
relations
(e.g., classes,
inheritance)
artifacts,
relations
(e.g., classes,
inheritance)
sequential events
sequential events
concurrency
concurrency
code usage
Dynamic views
Merged views
Static views

Source code vs. binaries

- Source code
  - better form of representation
  - not always possible
  - result depends on the parser (notable differencies)
- Binaries
  - faster information collection (e.g. Java byte code)
  - legality issues

Usage of binaries

(reverse engineering, decompilation, disassembly)

- Recovery of lost source code
- Migration of applications to a new hardware platform
- Translation of code written in obsolete languages not supported by compiler tools nowadays
- Determination of the existence of viruses or malicious code in the program
- Recovery of someone else's source code (to determine an algorithm for example)

Binary copyrights
(decompilation, disassembly)

- Not all countries implement the same laws !
- Commonly allowed by law
  - for the purposes of interoperability
  - for the purposes of error correction where the owner of the copyright is not available to make the correction
  - to determine parts of the program that are not protected by copyright (e.g. algorithms), without breach of other forms of protection (e.g. patents or trade secrets)
- The decompilation page: **http://archive.csee.uq.edu.au/~csmweb/decompilation/home.html**

Copyrights cont.

- EU: 1991 EC Copyright Directive on Legal Protection of Computer Programs provided extensions to copyright to permit decompilation in limited circumstances
- An example: Sony sued Connectix Corp (1999) for developing of its Virtual Game Station emulator, and emulator of the Sony developed PlayStation (Mac)
  -> a long fight over emulation rights and extent of copyright protection on computer programs

A decompilation example / 1

```
public class MyTest {
   / / This is a silly program.
   public static void main(String[] args) {
    int myInt1=1;
    int myInt2=2;
    for (int i=1;i<10;i++) {
       for (int j=2;j<8;j++)
           myInt1++;
       myInt2=myInt2+myInt1;
    }
    System.out.println("myInt1 is " + myInt1 + " and myInt2 is " +
    myInt2);
   }
}
```

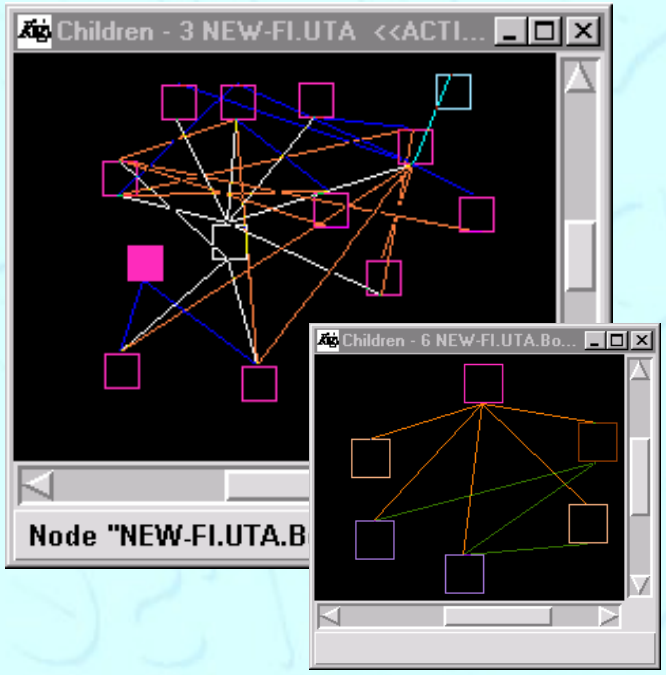
-> Compiled with Sun's javac compiler and decompiled with DJ Java Decompiler, let's see what we got:

A decompilation example / 2

```
import java.io.PrintStream;

public class MyTest
{

   public MyTest()
   {
   }

   public static void main(String args[])
   {
      int i = 1;
      int j = 2;
      for(int k = 1; k < 10; k++)
      {
         for(int l = 2; l < 8; l++)
            i++;

         j += i;
      }

      System.out.println("myInt1 is " + i + " and myInt2 is " + j);
   }
}
```

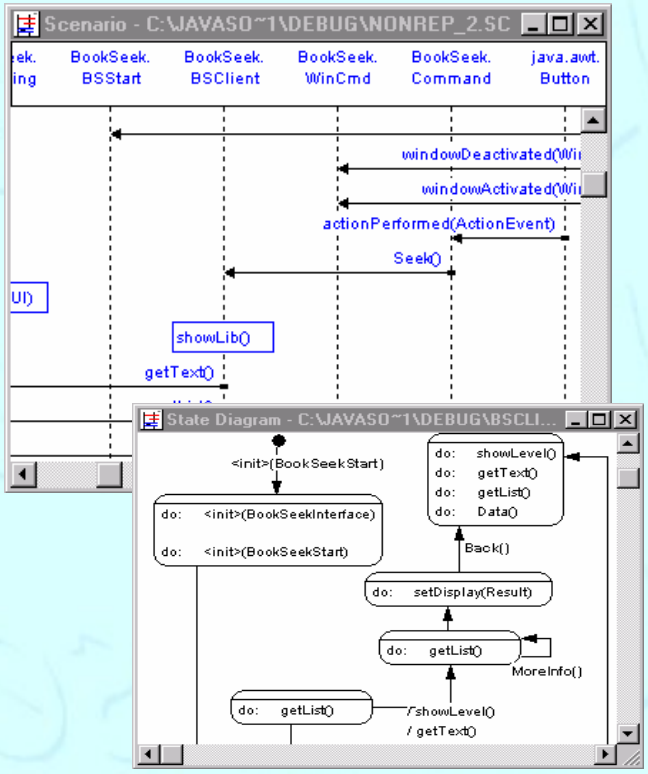
Static models

- Finding out the static structure, architecture
  - code (using a parser)
  - documents
  - interviews
- Visualisation:
  - class diagrams
  - (hierarchical) graphs



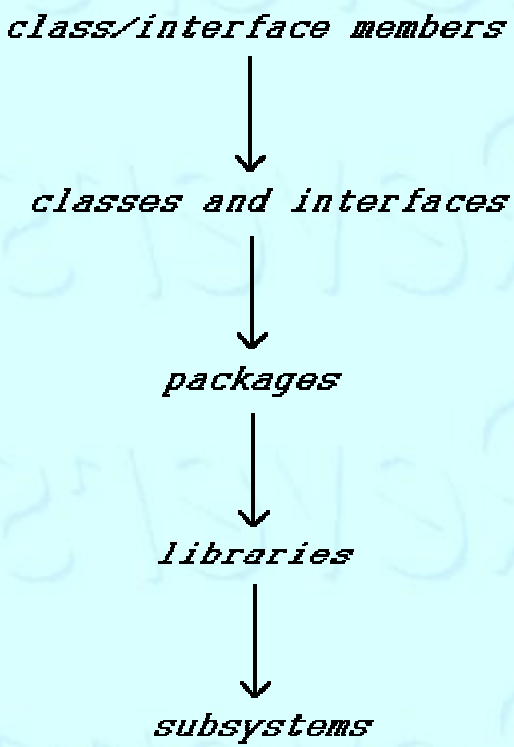
Dynamic models

- Finding out the run-time behaviour of software
  - debugger, profiler, source code instrumentation
- Visualisation:
  - scenarios (sequence diagrams)
  - State diagrams
  - (hierarchical) graphs



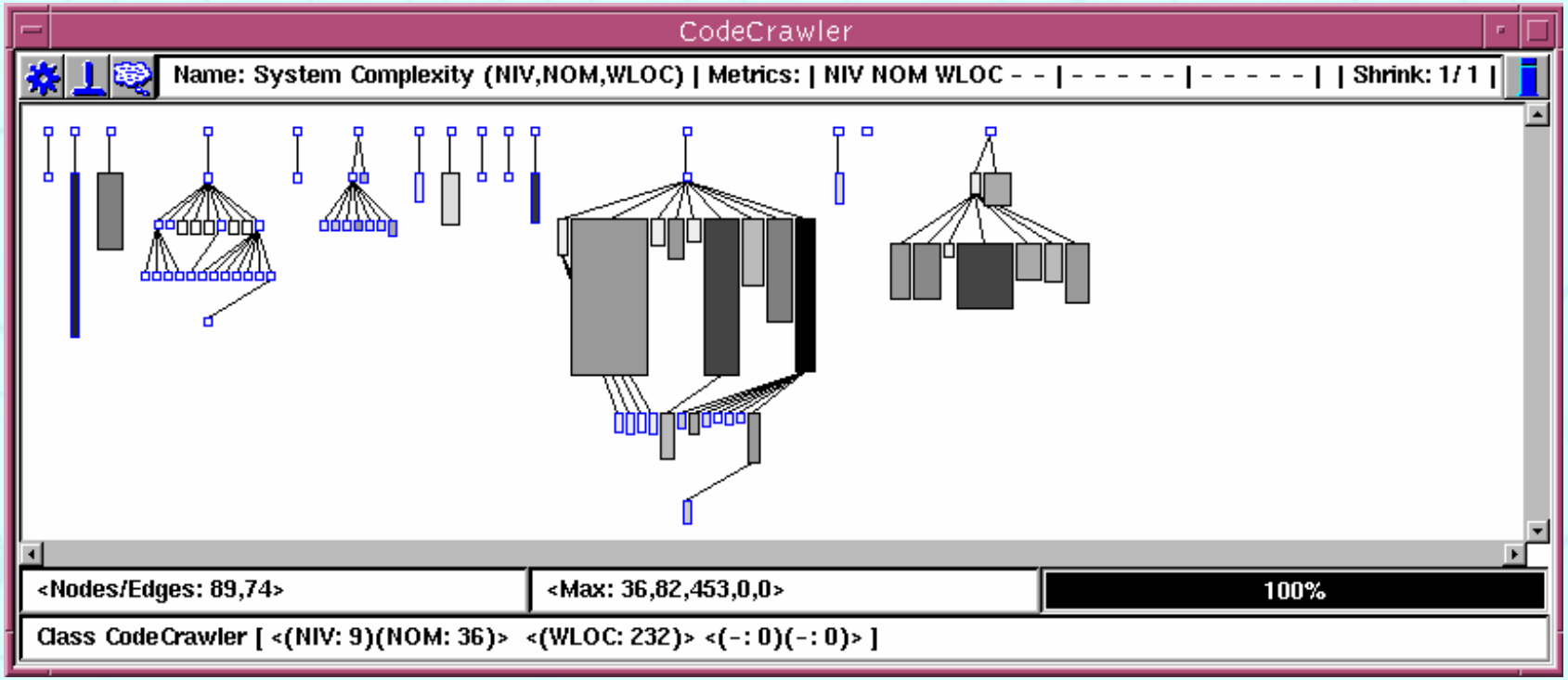
Abstracting the static model

- Abstracting the high-level components (like subsystems)
- The process can be made partly automatic
  - Automatic abstraction
    - Using the structure of the language
    - Using measurements
  - Manual abstraction



Metrics

- Numeric measurements from software (or software projects)
- *More on these later in this course*



CodeCrawler:

* a reverse engineering tool that combines metrics and graphs to visualize OO systems
* **http://www.iam.unibe.ch/~lanza/codecrawler/codecrawler.html**

Abstracting the dynamic model

- Finding behaviour patterns, repeating sequences of events
  - E.g. initialising a dialogue
- Using static abstractions
  - E.g. representing interactions between high-level software elements in sequence diagrams
- Dynamic information is combined with the high-level static model

Merging static and dynamic information to a single view	Dynamic and static views
+ Directly illustrates connections between static and dynamic info + Ensuring the quality of the view -polymorfism (OO) may cause confusion - building abstractions becomes combersome and/or requires trade offs: bahavioral patterns <-> subsystems - sequential information is difficult to merge to a static view - the more informatin a view contains, the less readable it gets !	- connections and correspondencies between the views need to be defined + both static and dynamic abstractions can be built + static and dynamic views are separated also in forward engineering: support for re-engineering and roun-trip engineering + more informatin can be viewed

Analysing the static model

- Syntax, type checking, interfaces
- Control and data flow analysis
- Structure analysis
- Slicing and dicing (different ways to partition the software)
- Measuring the complexity
- Navigation

Analysing the dynamic model

- Object creation and related dependencies
- Dynamic binding, polymorphism
- Method calls
- Looking for dead code/reachability analysis
- Memory management
- Performance and related problems
- Concurrency

Reverse engineering for OO software

- Dynamic behavior may be hard to detect from static model (creating and deleting objects, garbage collection, dynamic binding,…)

  -> **this emphasises dynamic modelling**

- Pure object languages support encapsulation (classes, packages,…)

  -> **helps in static reverse engineering**

  -> increases usability of metrics

- OO paradigm supports the use of design patterns

  -> **reusability applications (pattern recognition)**

Round-trip engineering

- Forward and backword (reverse) engineering combined
- Most typical OO example: producing source code from class diagrams and class diagrams from source code.
- As another example, a design tool may support automatic (or mostly automatic) translation from ER-model to relational model and back.

Why round-trip engineering? / 2

- Assume that you first model your software using UML.
- Typically, it is possible to automatically generate source code files (say, Java) from a class diagram.
- Eventually someone will touch the source code in such a way that the class diagram is no longer valid and the classes are not to be re-generated from the class diagram.
- After that, you will just spend the rest of project hoping that no-one will have a look at the class diagrams ☹
- Of course, you may manually update your class diagrams ☹ ☹

Why round-trip engineering? / 3

- Some software development tools automatically generate source code.
- However, it may be that they do not generate the UML diagrams.
- Or, if they do, they may be in a format, which your UML design tools do not know how to read.
- Again, of course, you may manually update your class diagrams ☹

Tools

- Tools supporting creation of high-level models
- Tools supporting metrics
- Forward & reverse engineering
  - re-engineering & round-trip-engineering &testing
- Other tools
  - parser generators
  - design pattern recognition

Tools

- Rigi (University of Victoria, Canada)
  - **http://www.rigi.csc.uvic.ca/**
  - a research prototype that represents an open and public domain reverse engineering tool
  - user programmable
  - analysis for: C, C++, COBOL, PL/AS, LaTeX
- SNIFF+ (TakeFive Software)
  - a software development environment that also provides reverse engineering capabilities

Tools

- McCabe's Visual Reengineering Toolset and Visual Quality Toolset
  - various views
  - software metrics (complexity and structuredness)
    - shown as specific colors on the views
- Logiscope (CS Verilog)
  - reverse eng, code testing, static and dynamic testing, metrics
  - analysis for: C, C++, Java, ADA
- ESW (Viasoft Inc.)
  - forward and reverse engineering (maintenance), metrics, testing

Tools

- Refine (Reasoning Systems Inc.)
  - an open and programmable tool that works in the Refinery environment
    - tools for generating source code parsing and conversion tools
  - features for analyzing and re-engineering code
  - analysis for: Ada, C, Cobol
- Imagix4D (Imagix Corp.)
  - **http://www.powersoftware.com/english/im/index.html**
  - a closed tool that provides a large set of built-in functionalities
  - several views (also 3D)
  - analysis for: C/C++

Tools for OO languages

- Produce a class diagram from code
  - Rational Rose (Rational Software Corp.)
  - Paradigm Plus (Computer Associates International)
  - OEW (Innovative Software GmbH)
  - Graphical Designer (Advanced Software Technologies Inc.)
  - Domain Objects (Domain Objects Inc.)
  - COOL:Jex (Sterling Software Inc.)
  - Fujaba (Paderborn University)
  - ...