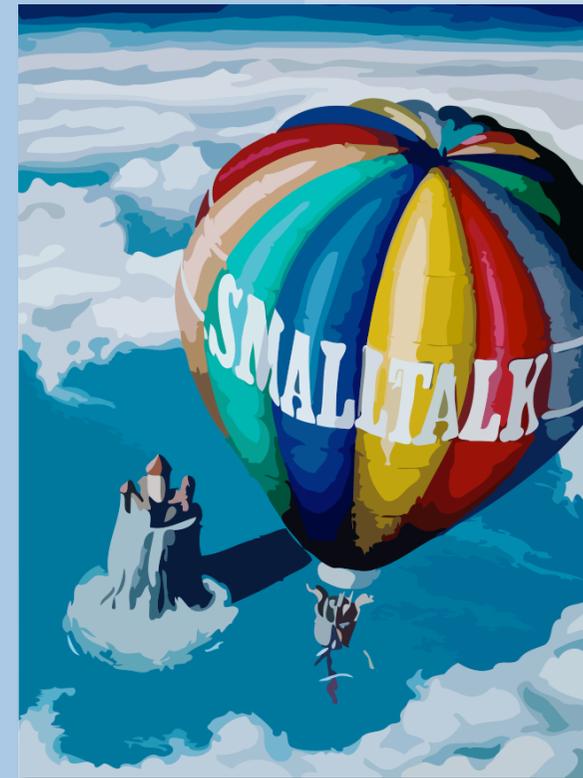


Dynamic Object-Oriented Programming with Smalltalk

1. Introduction

Prof. O. Nierstrasz
Autumn Semester 2009

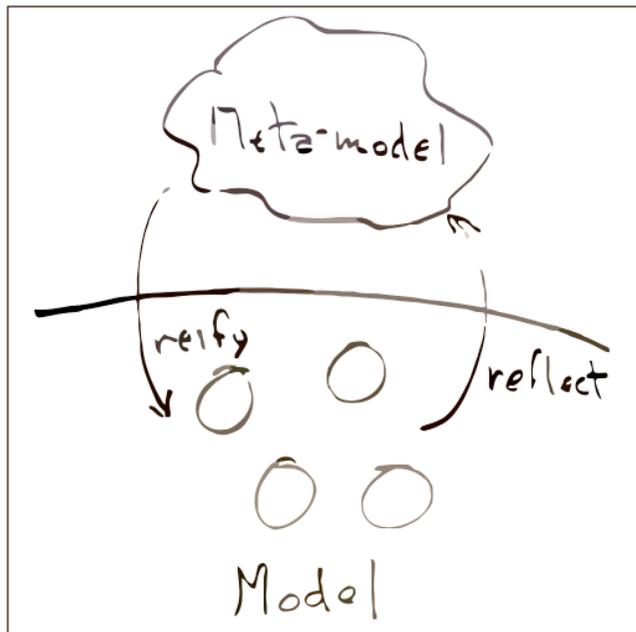


Smalltalk

<i>Lecturer</i>	Prof. Oscar Nierstrasz
<i>Assistants</i>	David Röthlisberger, Fabrizio Perin Timur Altun
<i>Lectures</i>	IWI 001, Wednesdays @ 10h15-12h00
<i>Exercises</i>	IWI 001, Wednesdays @ 12h00-13h00
<i>WWW</i>	http://scg.unibe.ch/teaching/smalltalk

Selected material courtesy Stéphane Ducasse

Birds-eye view

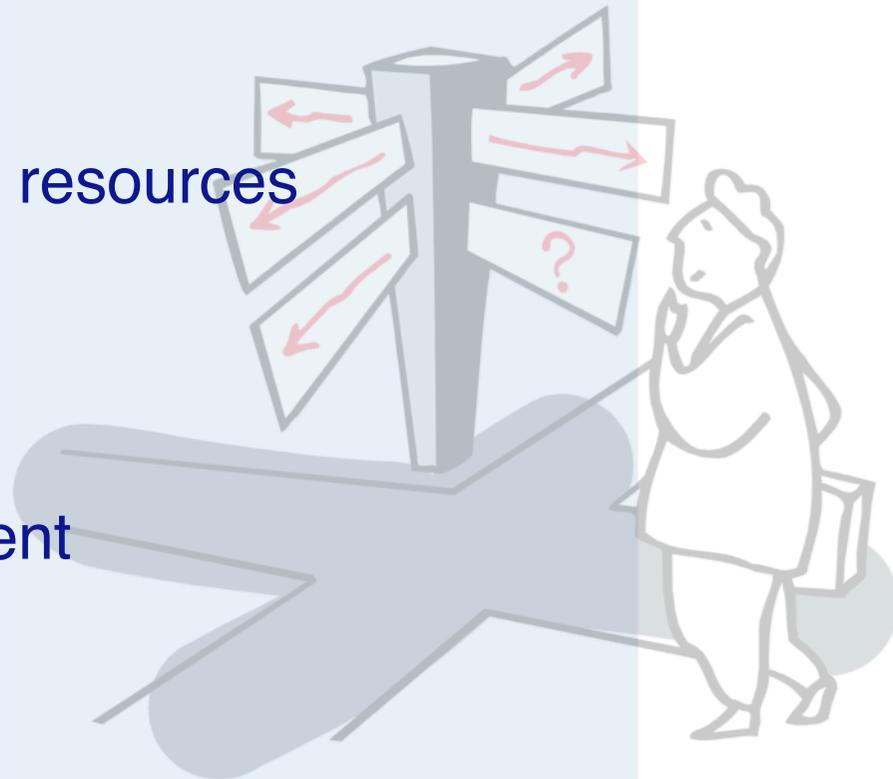


Smalltalk is still today one of the few fully reflective, fully dynamic, object-oriented development environments.

We will see how a simple, uniform object model enables live, dynamic, interactive software development.

Roadmap

- > Course schedule, goals, resources
- > What is Smalltalk?
- > Origins of Smalltalk
- > Smalltalk key concepts
- > The Smalltalk environment



Roadmap

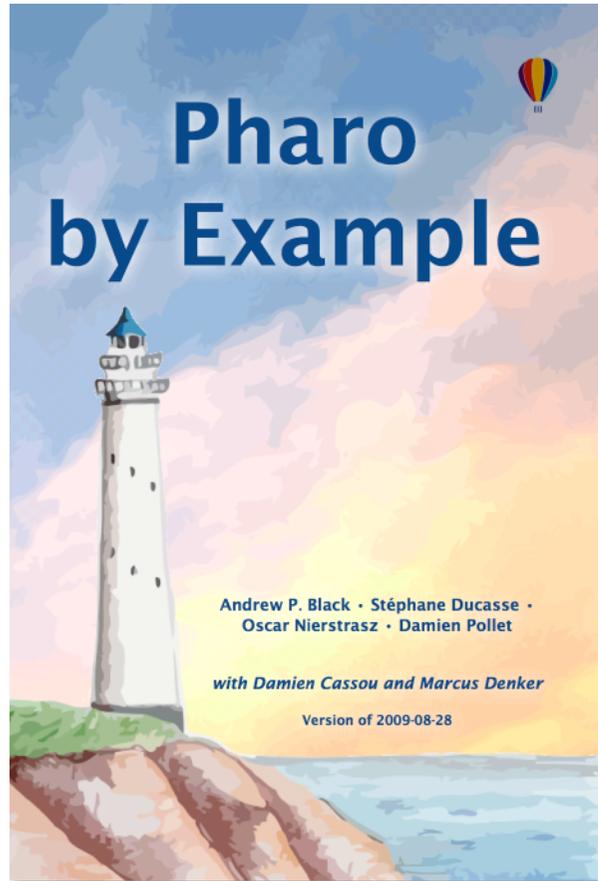
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Course Schedule

Week	Date	Lecture
1	16-Sep-09	Introduction
2	23-Sep-09	Smalltalk Basics
3	30-Sep-09	Standard Classes
4	07-Oct-09	Smalltalk Coding Idioms
5	14-Oct-09	Seaside
6	21-Oct-09	Debugging
7	04-Nov-09	Best Practice Patterns
8	28-Oct-09	Refactoring and Design Patterns
9	11-Nov-09	Understanding Classes and Metaclasses
10	18-Nov-09	Reflection
11	25-Nov-09	Working with ByteCode
12	02-Dec-09	Virtual Machines
13	09-Dec-09	Traits and Classboxes
14	16-Dec-09	Final Exam

Pharo by Example (preview)



Special preview
edition prepared
for this course

Goals of this Course

- > Some history
- > A pure object-oriented model
- > Classes and metaclasses
- > Reflection (not just introspection)
- > Design and implementation of dynamic languages
- > Advanced object-oriented design concepts

What is surprising about Smalltalk

- > Everything is an object
- > Everything happens by sending messages
- > All the source code is there all the time
- > You can't lose code
- > You can change everything
- > You can change things without restarting the system
- > The Debugger is your Friend

A Word of Advice

You do not have to know everything!!!

Try not to care — Beginning Smalltalk programmers often have trouble because they think they need to understand all the details of how a thing works before they can use it. This means it takes quite a while before they can master
Transcript show: 'Hello World'. One of the great leaps in OO is to be able to answer the question “*How does this work?*” with “*I don't care*”.

—*Alan Knight. Smalltalk Guru*

Resources

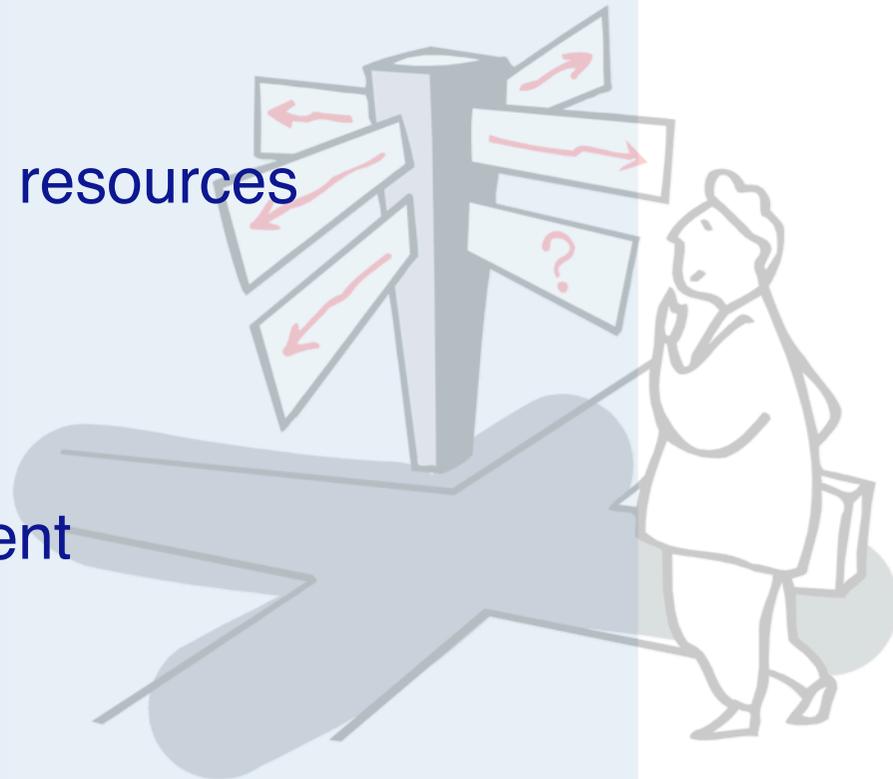
- > Pharo
 - www.pharo-project.org
- > History
 - en.wikipedia.org/wiki/Smalltalk
 - www.smalltalk.org/smalltalk/history.html
- > Free books
 - stephane.ducasse.free.fr/FreeBooks.html
- > European Smalltalk Users Group
 - www.esug.org

Recommended Books

- > Alec Sharp, *Smalltalk by Example*, McGraw-Hill, 1997.
- > Kent Beck, *Smalltalk Best Practice Patterns*, Prentice Hall, 1997.
- > Sherman Alpert et al., *The Smalltalk Design Pattern Companion*, Addison-Wesley, 1998

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Why Smalltalk?

- > *Pure* object-oriented language and environment
 - “Everything is an object”
- > Origin of *many innovations* in OO development
 - RDD, IDE, MVC, XUnit ...
- > Improves on many of its successors 
 - Fully interactive and dynamic

What is Smalltalk?

- > ***Pure OO language***
 - Single inheritance
 - Dynamically typed

- > ***Language and environment***
 - Guiding principle: *“Everything is an Object”*
 - Class browser, debugger, inspector, ...
 - Mature class library and tools

- > ***Virtual machine***
 - Objects exist in a persistent *image* [+ *changes*]
 - Incremental compilation

Smalltalk vs. C++ vs. Java

	<i>Smalltalk</i>	<i>C++</i>	<i>Java</i>
<i>Object model</i>	Pure	Hybrid	Hybrid
<i>Garbage collection</i>	Automatic	Manual	Automatic
<i>Inheritance</i>	Single	Multiple	Single
<i>Types</i>	Dynamic	Static	Static
<i>Reflection</i>	Fully reflective	Introspection	Introspection
<i>Concurrency</i>	Semaphores, Monitors	Some libraries	Monitors
<i>Modules</i>	Categories, namespaces	Namespaces	Packages

Smalltalk: a State of Mind

- > ***Small and uniform language***
 - Syntax fits on one sheet of paper

- > ***Large library of reusable classes***
 - Basic Data Structures, GUI classes, Database Access, Internet, Graphics

- > ***Advanced development tools***
 - Browsers, GUI Builders, Inspectors, Change Management Tools, Crash Recovery Tools, Project Management Tools

- > ***Interactive virtual machine technology***
 - Truly platform-independent

- > ***Team Working Environment***
 - Releasing, versioning, deploying

Smalltalk in industry

> **Worldwide:**

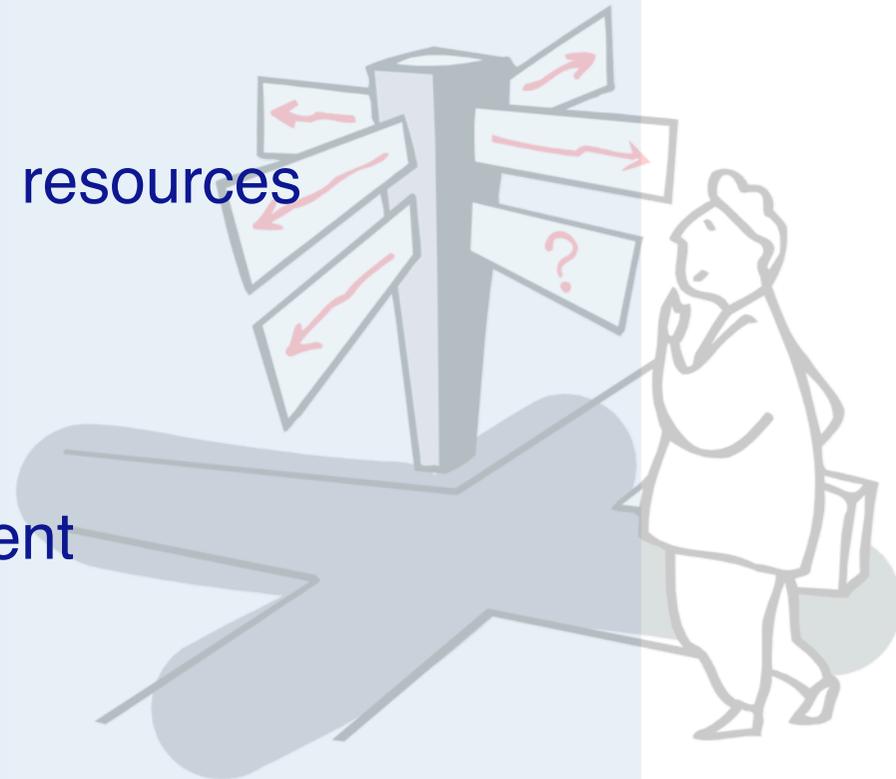
- <http://www.esug.org/companiesdevelopinginsmalltalk/>
- <http://www.whysmalltalk.com/production/index.htm>
- <http://www.stic.org/companies/companies.htm>
- <http://www.goodstart.com/whousesmalltalk.php>

> **In Bern:**

- Netstyle.ch
- DVBern AG
- Mobiliar (in-house)
- Pulinco

Roadmap

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Origins of Smalltalk

- > **Project at Xerox PARC in 1970s**
 - Language and environment for new generation of graphical workstations (target: “Dynabook”)

- > **In Smalltalk-72, every object was an independent entity**
 - Language was designed for children (!)
 - Evolved towards a meta-reflective architecture

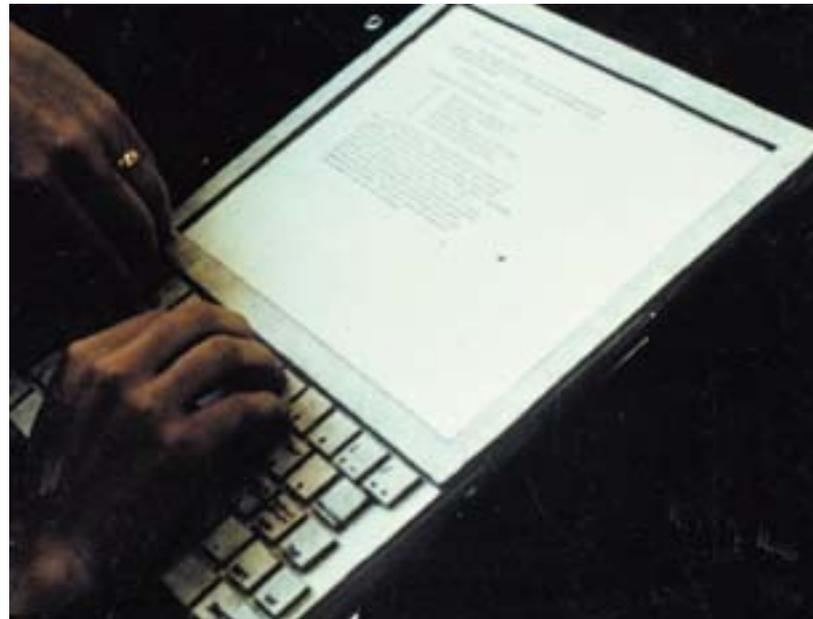
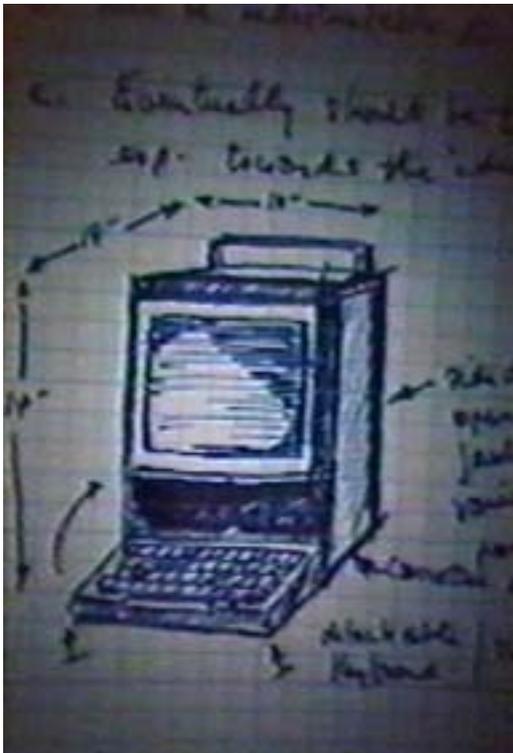
- > **Smalltalk-80 is the standard**

Smalltalk — The Inspiration

- > **Flex** (Alan Kay, 1969)
- > **Lisp** (Interpreter, Blocks, Garbage Collection)
- > Turtle graphics (The **Logo** Project, Programming for Children)
- > Direct Manipulation Interfaces (**Sketchpad**, Alan Sutherland, 1960)
- > **NLS**, (Doug Engelbart, 1968), “the augmentation of human intellect”
- > **Simula** (Classes and Message Sending)
- > Xerox PARC (Palo Alto Research Center)
- > **DynaBook**: a Laptop Computer for Children

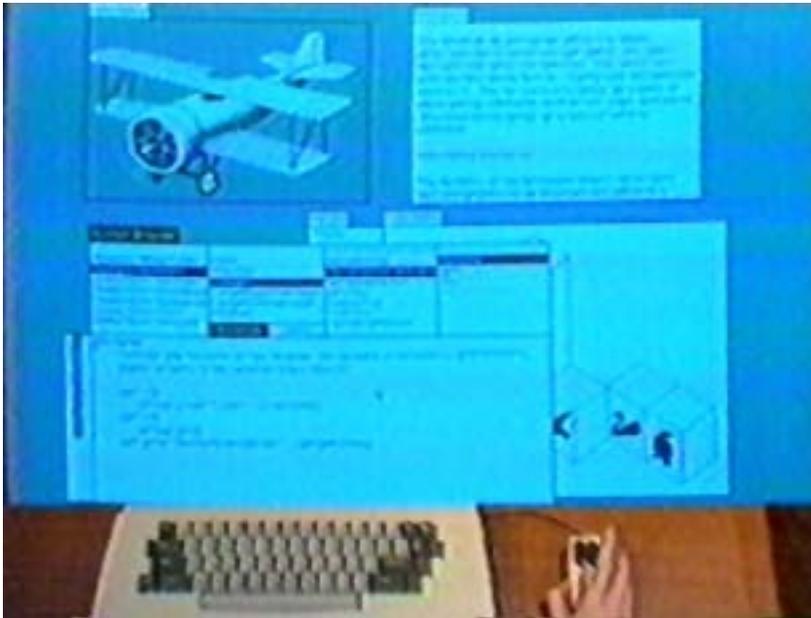
— www.smalltalk.org/smalltalk/TheEarlyHistoryOfSmalltalk_Abstract.html

Dynabook Mockup



www.artmuseum.net/w2vr/archives/Kay/01_Dynabook.html

Alto: a Machine to Run Smalltalk



Smalltalk on Alto III



Precursor, Innovator & Visionary

- > First to be based on Graphics
 - Multi-Windowing Environment (Overlapping Windows)
 - Integrated Development Environment: Debugger, Compiler, Text Editor, Browser
- > With a pointing device  *yes, a Mouse*
- > Ideas were taken over
 - Apple Lisa, Mac
 - Microsoft Windows 1.0
- > Platform-independent Virtual Machine
- > Garbage Collector
- > Just-in-time Compilation
- > Everything was there, the complete Source Code

History

1950

1960

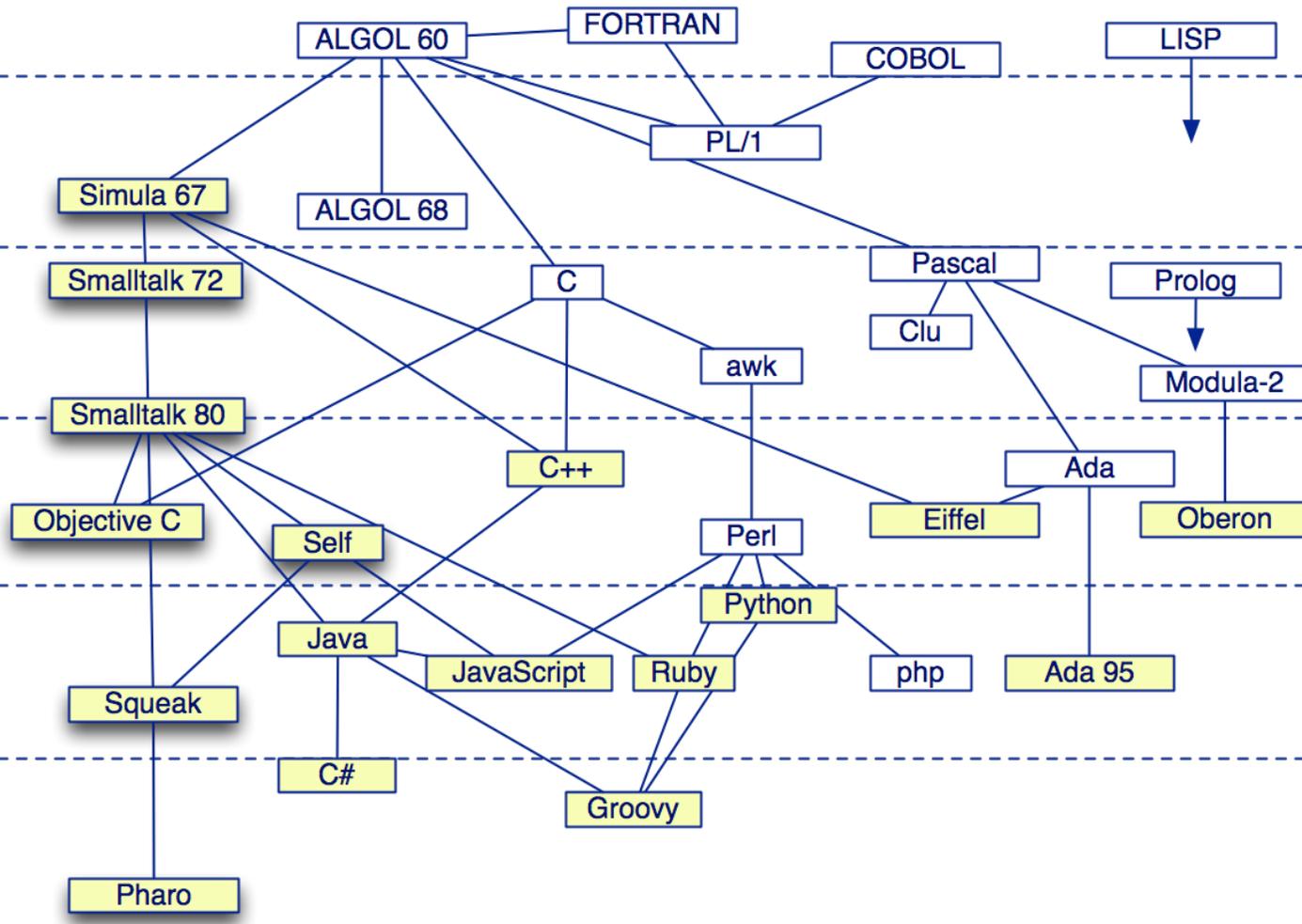
1970

1980

1990

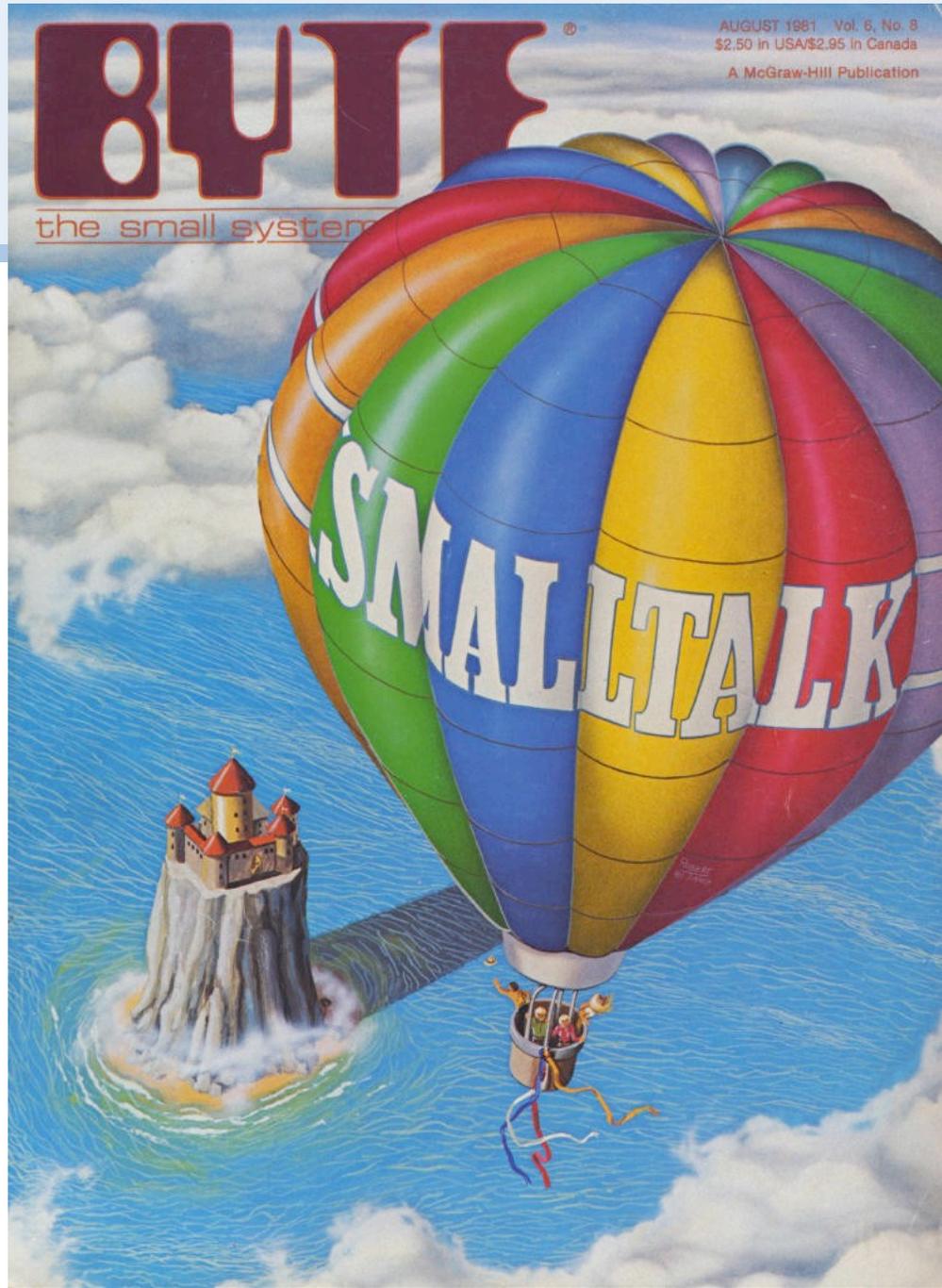
2000

2010



The History (Internal)

- > **1972 — First Interpreter**
 - More Agents than Objects
(every object could specify its own syntax!)
- > **1976 — Redesign**
 - A hierarchy of classes with a unique root, fixed syntax, compact bytecode, contexts, processes, semaphores, browsers, GUI library.
 - Projects: ThingLab, Visual Programming Environment, Programming by Rehearsal.
- > **1978 — NoteTaker Project**
 - Experimentation with 8086 Microprocessor with only 256 KB RAM.



The History (External)

- > **1980 — Smalltalk-80**
 - ASCII, cleaning primitives for portability, metaclasses, blocks as first-class objects, MVC.
 - Projects: Gallery Editor (mixing text, painting and animations) + Alternate Reality Kit (physics simulation)
- > **1981 — Books + 4 external virtual machines**
 - Dec, Apple, HP and Tektronix
 - GC by generation scavenging
- > **1988 — Creation of Parc Place Systems**
- > **1992 — ANSI Draft**
- > **1995 — New Smalltalk implementations**
 - MT, Dolphin, **Squeak**, Smalltalk/X, GNU Smalltalk
- > **2000 — Fscript, GNU Smalltalk, SmallScript**
- > **2002 — Smalltalk as OS: 128k ram**

What are Squeak and Pharo?

- > Squeak is a modern, open-source, highly portable, fast, full-featured Smalltalk implementation
 - Based on original Smalltalk-80 code



- > Pharo is a lean and clean fork of Squeak
 - www.pharo-project.org



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Smalltalk — Key Concepts

- > *Everything is an object*
 - numbers, files, editors, compilers, points, tools, booleans ...
- > Everything happens by *sending messages*
- > Every object is an instance of one class
 - which is also an object
 - A class defines the structure and the behavior of its instances.
- > Objects have private (protected) state
 - Encapsulation boundary is the object
- > Dynamic binding
 - Variables are dynamically typed and bound

Objects and Classes

- > *Every object is an instance of a class*
 - A class specifies the structure and the behaviour of all its instances
 - Instances of a class share the same behavior and have a specific state
 - *Classes are objects* that create other instances
 - Metaclasses are classes that create classes as instances
 - Metaclasses describe class behaviour and state (subclasses, method dictionary, instance variables...)

Messages and Methods

- > Message — which action to perform

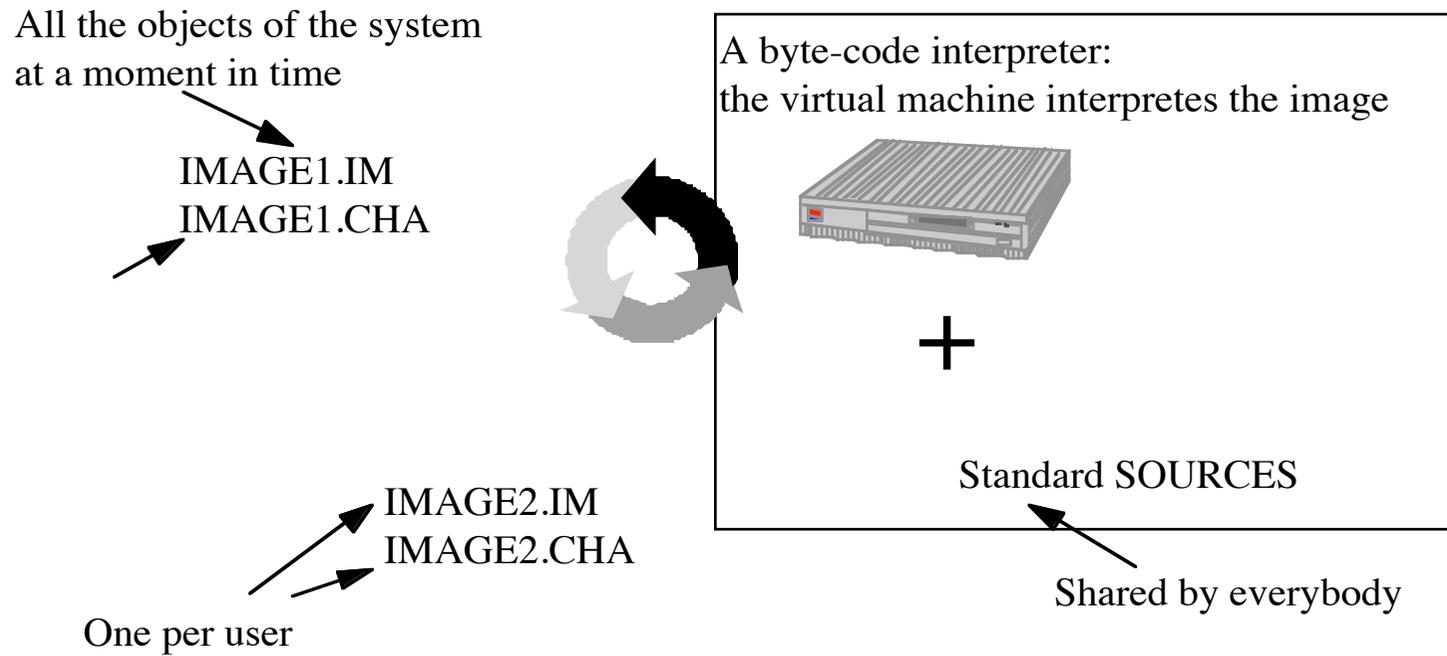
```
aWorkstation accept: aPacket  
aMonster eat: aCookie
```

- > Method — how to carry out the action

```
accept: aPacket  
  (aPacket isAddressedTo: self)  
    ifTrue:[  
      Transcript show:  
        'A packet is accepted by the Workstation ',  
        self name asString ]  
    ifFalse: [super accept: aPacket]
```

Smalltalk Run-Time Architecture

> Virtual Machine + Image + Changes and Sources



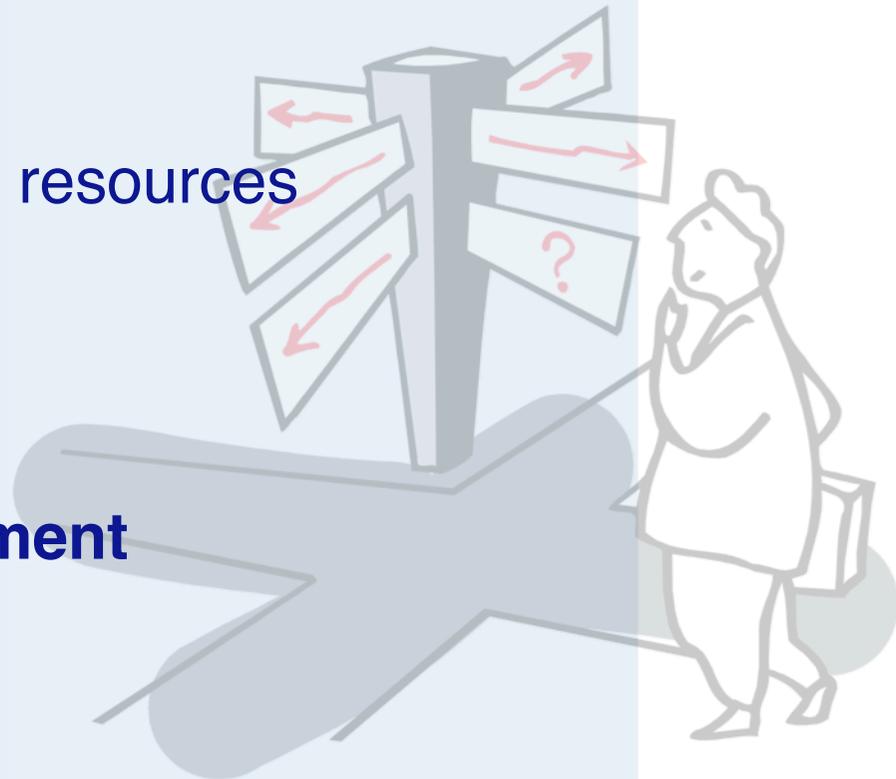
- > Image = bytecodes
- > Sources and changes = code (text)

Smalltalk Run-Time Architecture

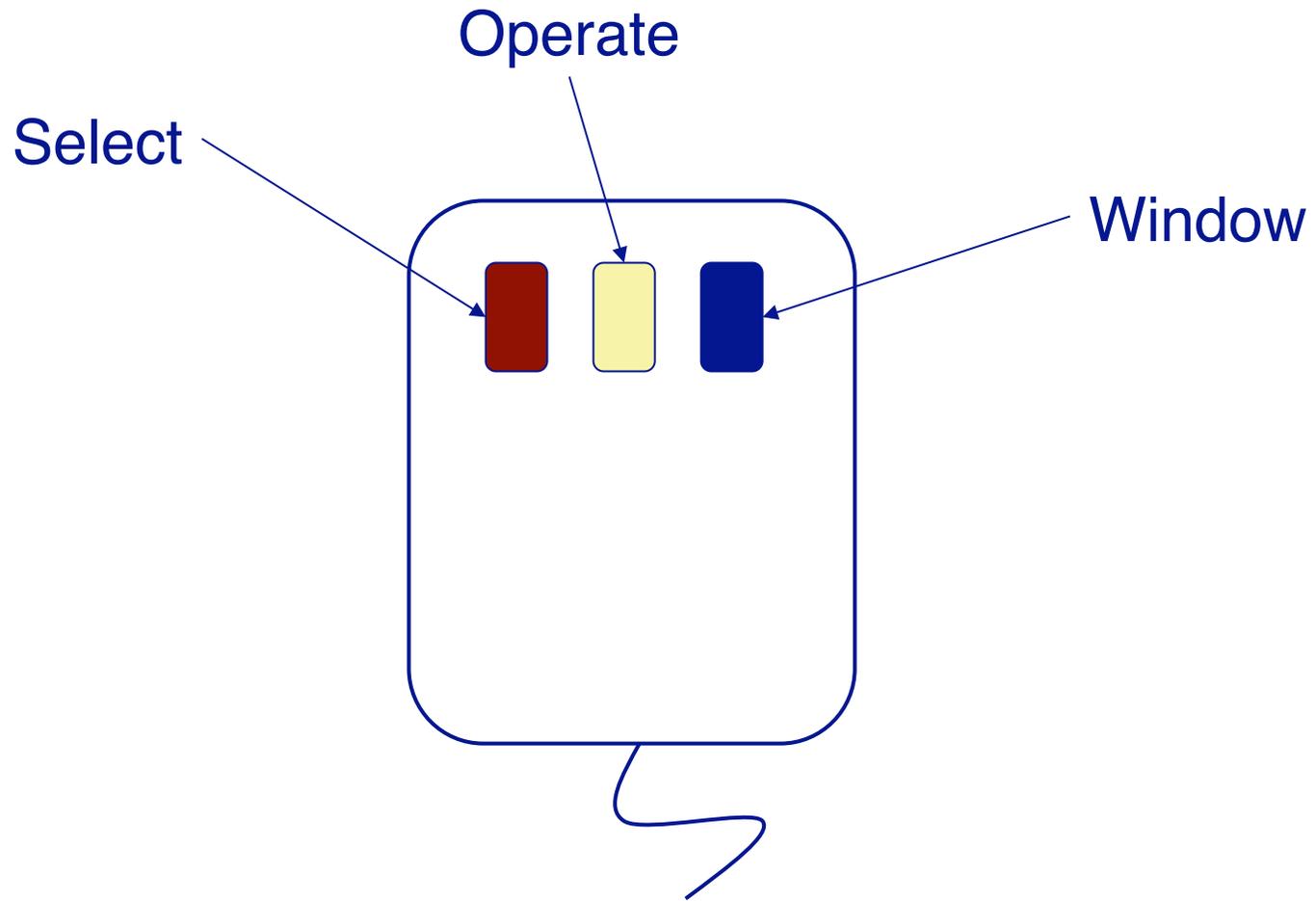
- > Byte-code is translated to native code by a just-in-time compiler
 - Some Smalltalks, but not Pharo
- > Source and changes are not needed to interpret the byte-code.
 - Just needed for development
 - Normally removed for deployment
- > An application can be delivered as byte-code files that will be executed with a VM.
 - The development image is stripped to remove the unnecessary development components.

Roadmap

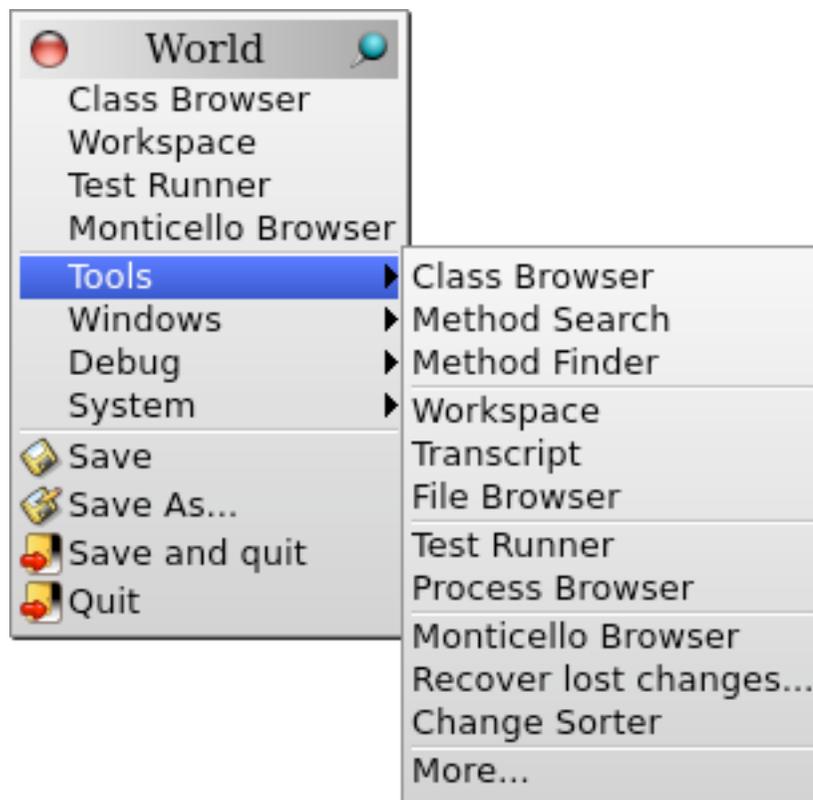
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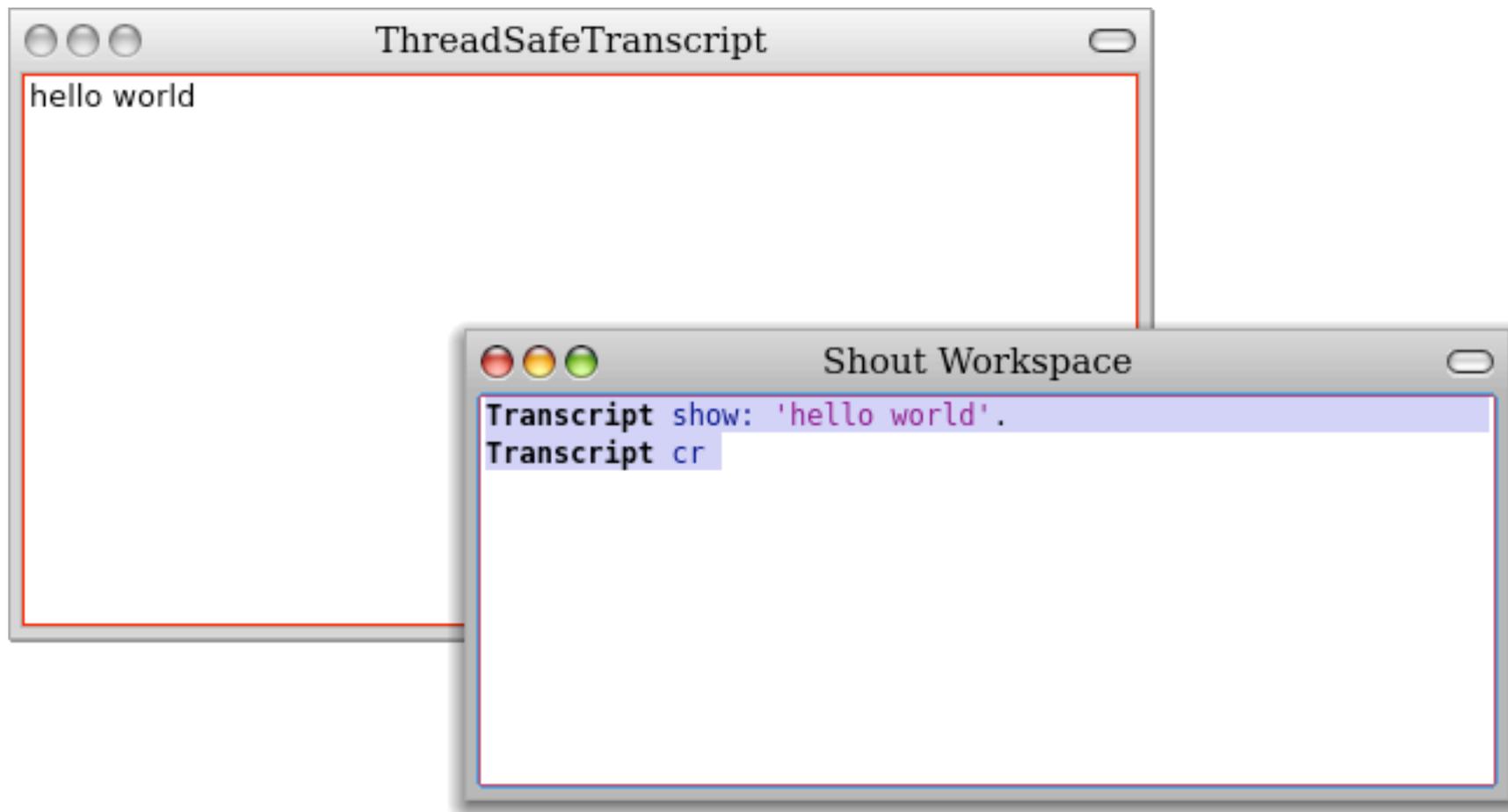
Mouse Semantics



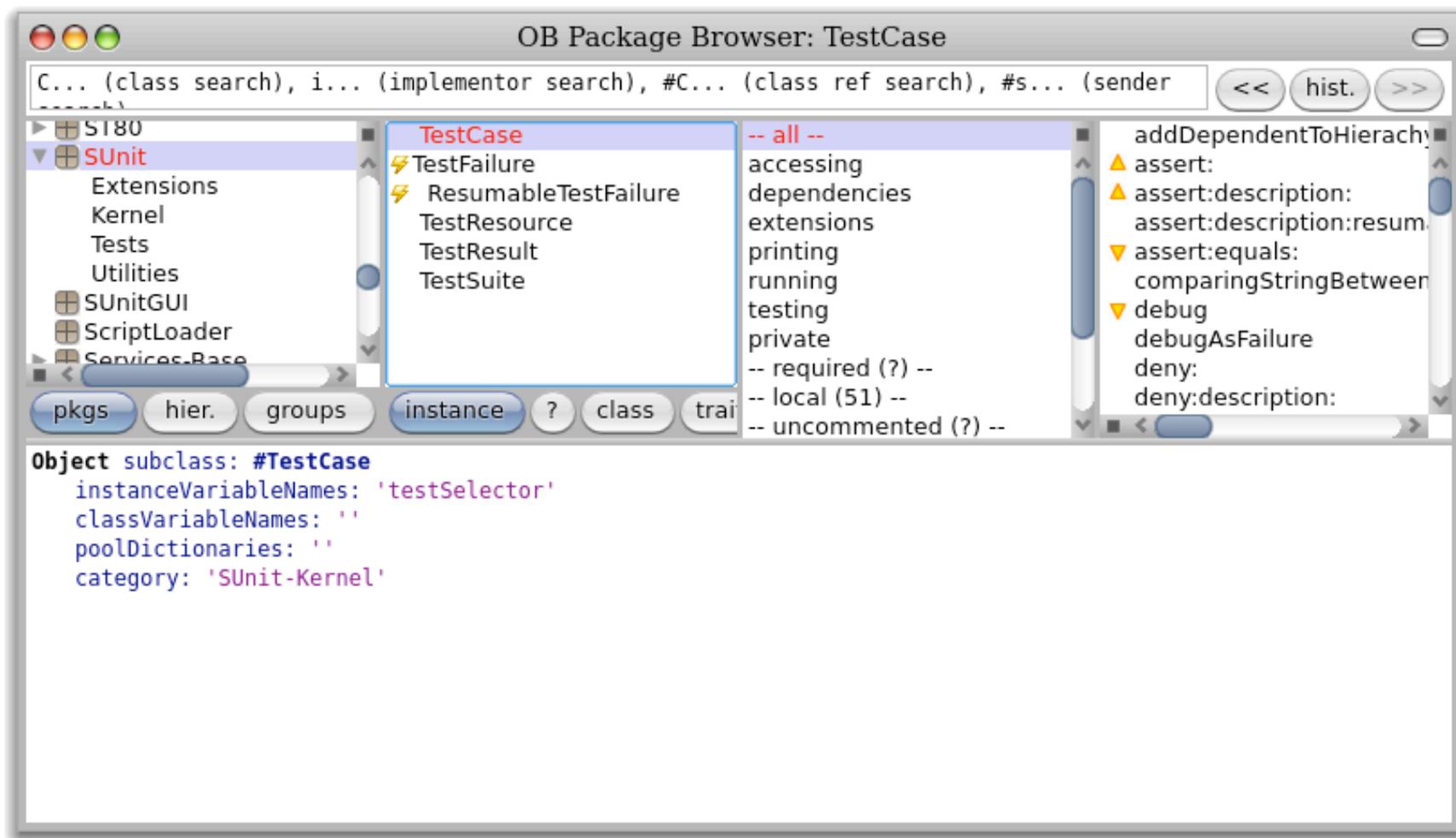
World Menu



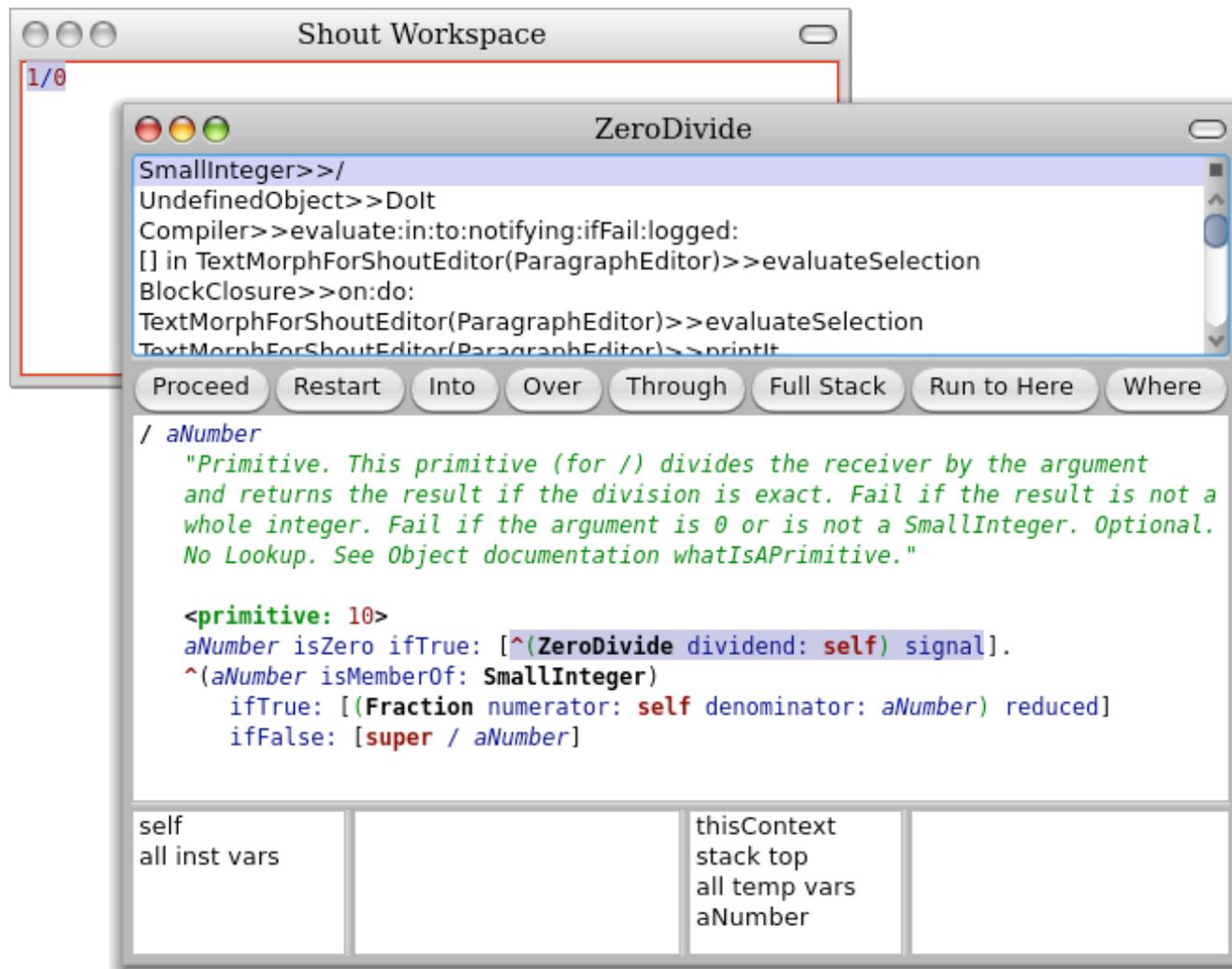
“Hello World”



The Smalltalk Browser



The Debugger

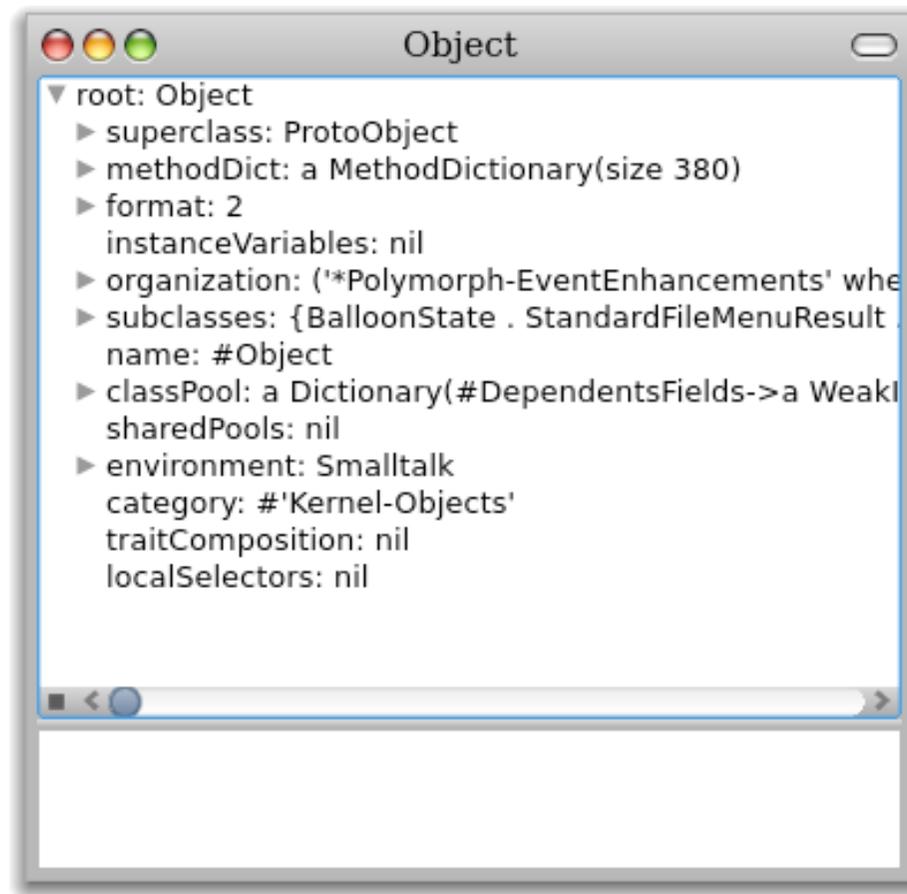


The Inspector

The screenshot displays three windows from a development environment:

- OB Package Browser: ThreadSafeTranscript**: This window shows a package browser on the left with 'Transcript' selected. The main area displays the class 'ThreadSafeTranscript' with a list of methods including 'color', 'initialize', 'printing', 'protected low level', 'streaming', 'ui building', and several debugging methods like '-- supersend (3) --', '-- long (?) --', '-- required (?) --', and '-- debugging (2) --'. A search bar at the top allows filtering by class search, implementor search, class reference search, or sender search.
- Transcript on NewInspector**: This window shows a detailed view of the 'Transcript' object. It lists the object's superclass as '#ThreadSafeTranscript' and shows instance variables: 'stream' (a WriteStream) and 'accessSemaphore' (a Mutex). It also indicates the class is 'ThreadSafeTranscript' and lists its methods.
- Shout Workspace**: This window shows a REPL prompt with the command 'Transcript inspect' entered, indicating the current object is being inspected.

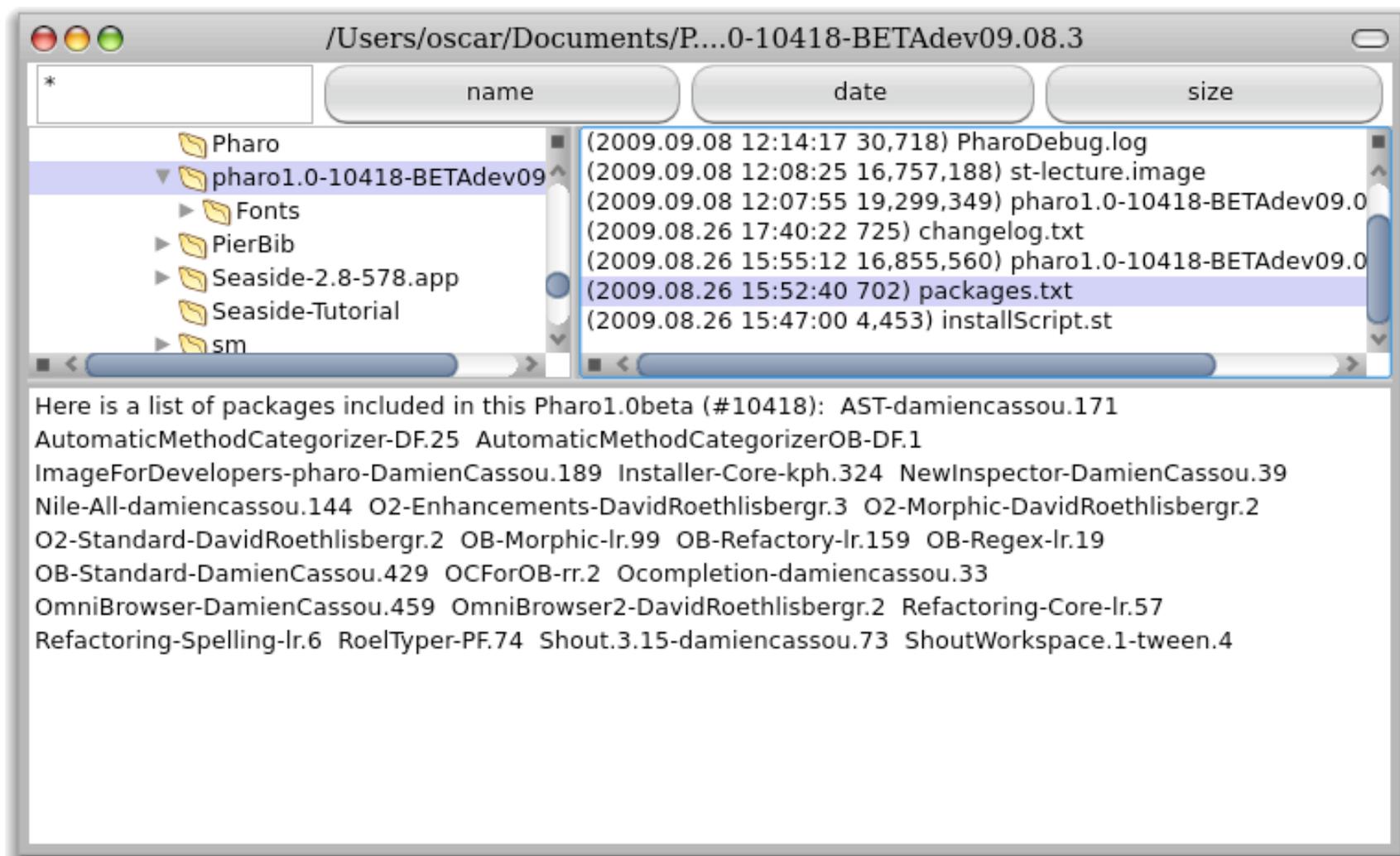
The Explorer



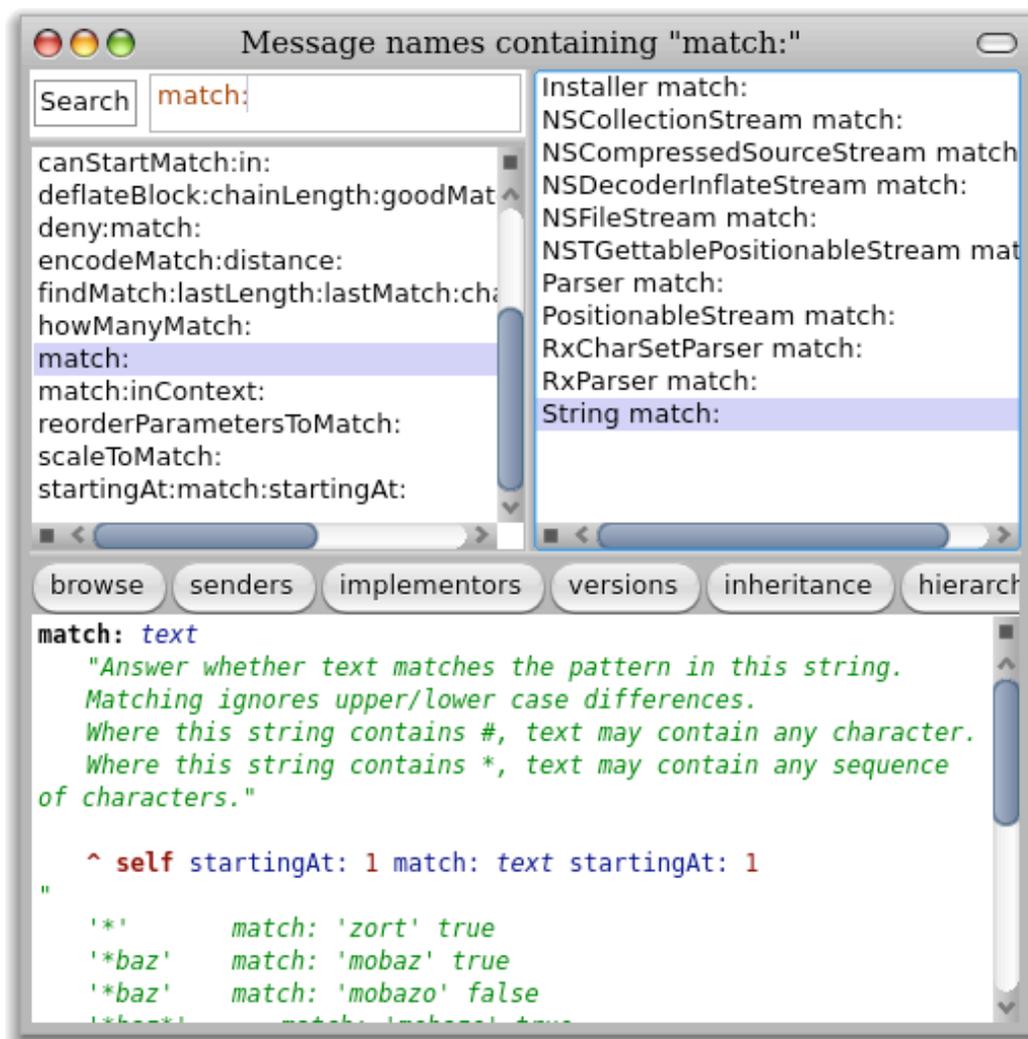
Other Tools

- > File Browser
 - *Browse, import, open files*
- > Method Finder, Message Name tool
 - *Find methods by name, behaviour*
- > Change Sorter
 - *Name, organize all source code changes*
- > SUnit Test Runner
 - *Manage & run unit tests*

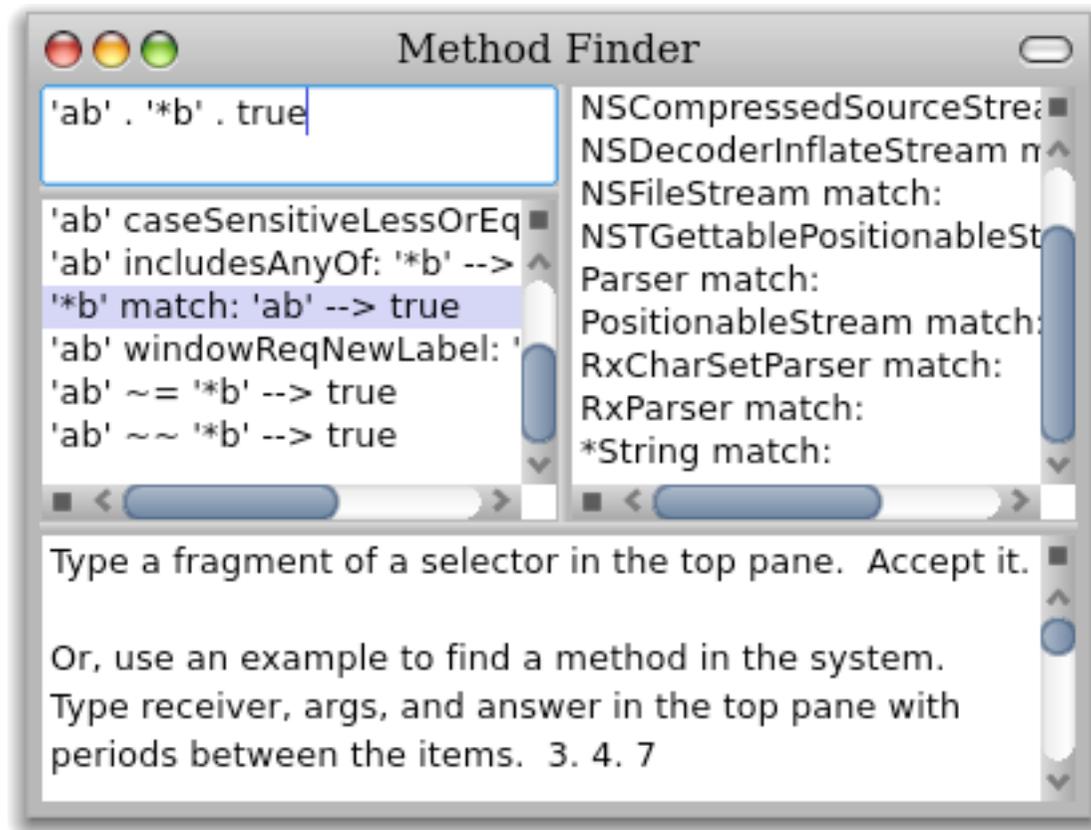
File Browser



Message Name Finder



Method Finder



Methods in ChangeSets & Versions

The screenshot shows an IDE window titled "Changes go to 'Unnamed'" with a file explorer on the left showing a project structure including "Money" and "TestMoney". A diff tool window titled "Money.2.cs log" is open, displaying a log of method calls and a diff of the code. The diff shows changes to the setup method, where variables chf2, chf8, and chf10 are assigned values and then used to create Money objects with 'CHF' currency.

```

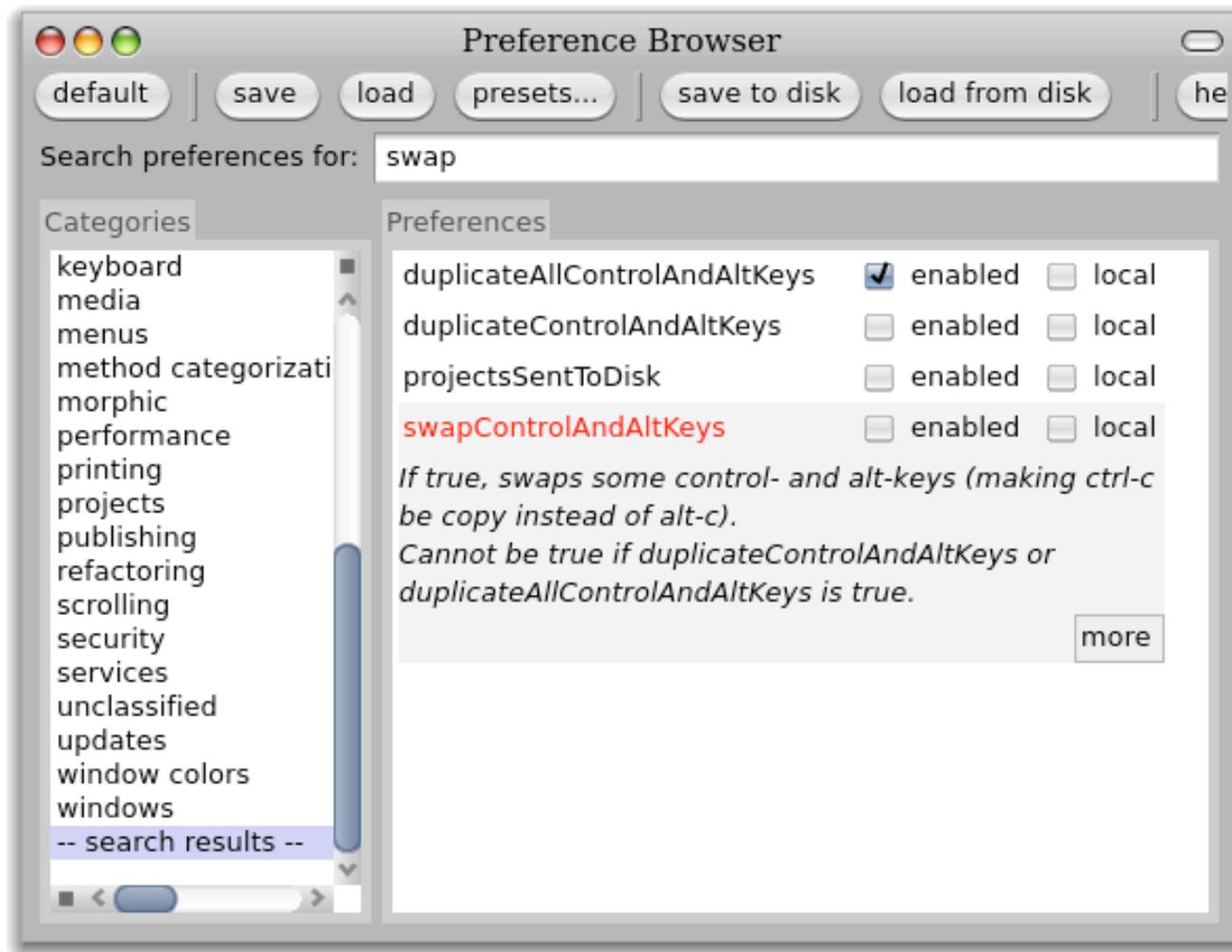
method: Money amount;; on 7/2/2007 13:18
method: Money currency; on 7/2/2007 13:17
method: Money currency;; on 7/2/2007 13:18
method: Money class currency:amount;; on 7/2/2007 13:23
method: Number chf; on 7/2/2007 13:30
method: TestMoney setUp; on 7/2/2007 13:28
method: TestMoney testAdd; on 7/2/2007 13:25
method: TestMoney testEquals; on 7/2/2007 13:17
preamble: Number reorganize
do it: ('arithmetic' * + - / //...onZero)/(('*Money' chf)/

select all  deselect all  select conflicts  file in selections  diffs  prettyDiffs

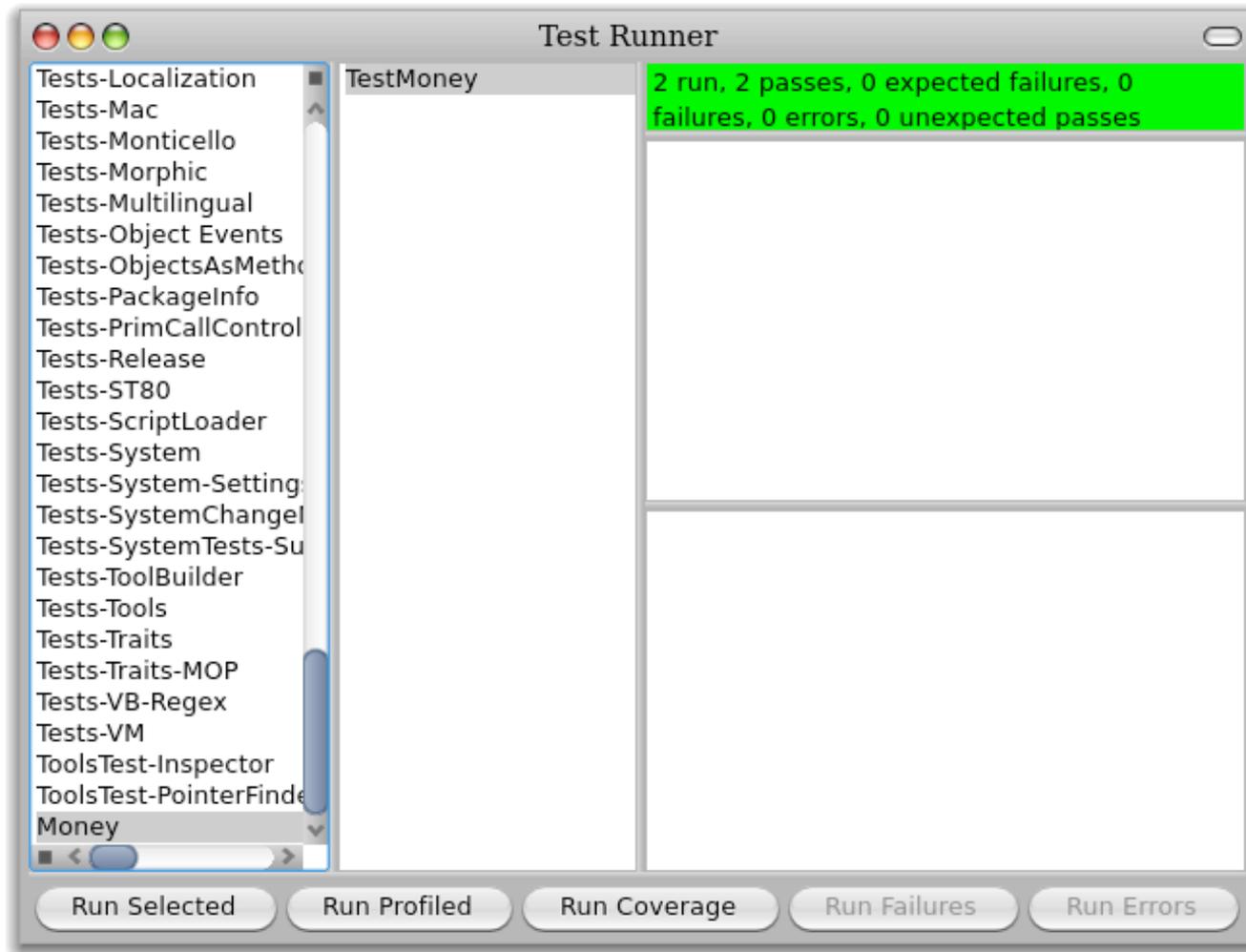
setUp
  chf2 := 2 chf.
  chf8 := 8 chf.
  chf10 := 10 chf.
  chf2 := Money currency: 'CHF' amount: 2.
  chf8 := Money new currency: 'CHF'; amount: 8.
  chf10 := Money new currency: 'CHF'; amount: 10.

```

Preferences



SUnit



Challenges of this Course

- > ***Mastering Smalltalk syntax***
 - Simple, but not Java-like
- > ***Pharo Programming Environment***
 - Requires some effort to learn at first, but worth the effort
- > ***Pharo Class Library***
 - Need time to learn what is there
- > ***Object-oriented thinking***
 - This is the hardest part!
- > ***Fully dynamic environment***
 - This is the most exciting part!
- > ***Smalltalk culture***
 - Best Practice Patterns (cf. book by Kent Beck)

What you should know!

-  *How does Smalltalk differ from Java or C++?*
-  *Where are Smalltalk programs stored?*
-  *Where are objects stored?*
-  *What was the Dynabook?*
-  *Is a class an object?*
-  *What is dynamic binding?*
-  *What is the difference between a message and a method?*

Can you answer these questions?

-  What ideas did Smalltalk take from Simula? From Lisp?*
-  Is there anything in Smalltalk which is not an object?*
-  What exactly is stored in the changes file?*
-  If objects have private state, then how can an Inspector get at that state?*
-  How do you create a new class?*
-  What is the root of the class hierarchy?*
-  If a class is an object, then what is its class? The class of its class? ...*
-  If you don't know, how would you find out?*

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