

## 12. A bit of Smalltalk

Oscar Nierstrasz



# Roadmap



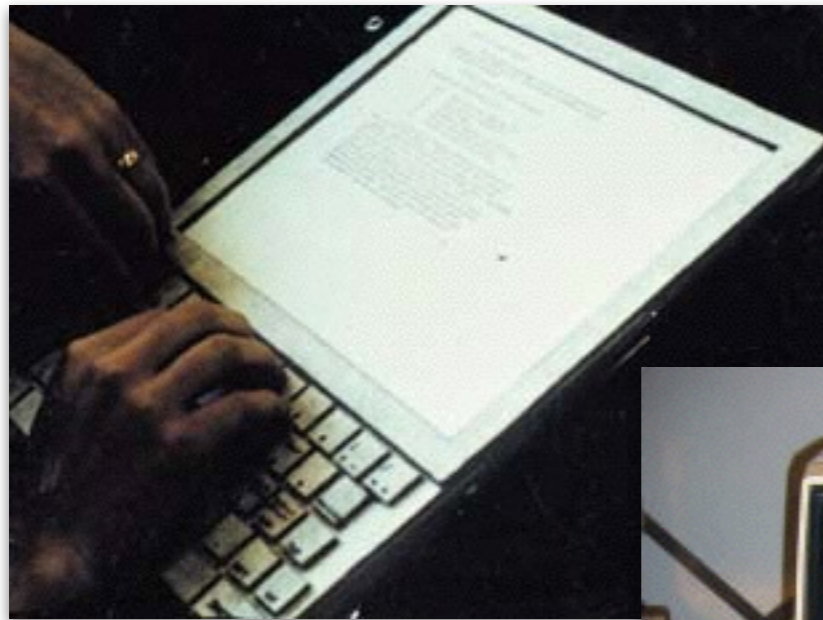
- > The origins of Smalltalk
- > What is Smalltalk?
- > Syntax in a nutshell
- > Seaside — web development with Smalltalk

# Roadmap

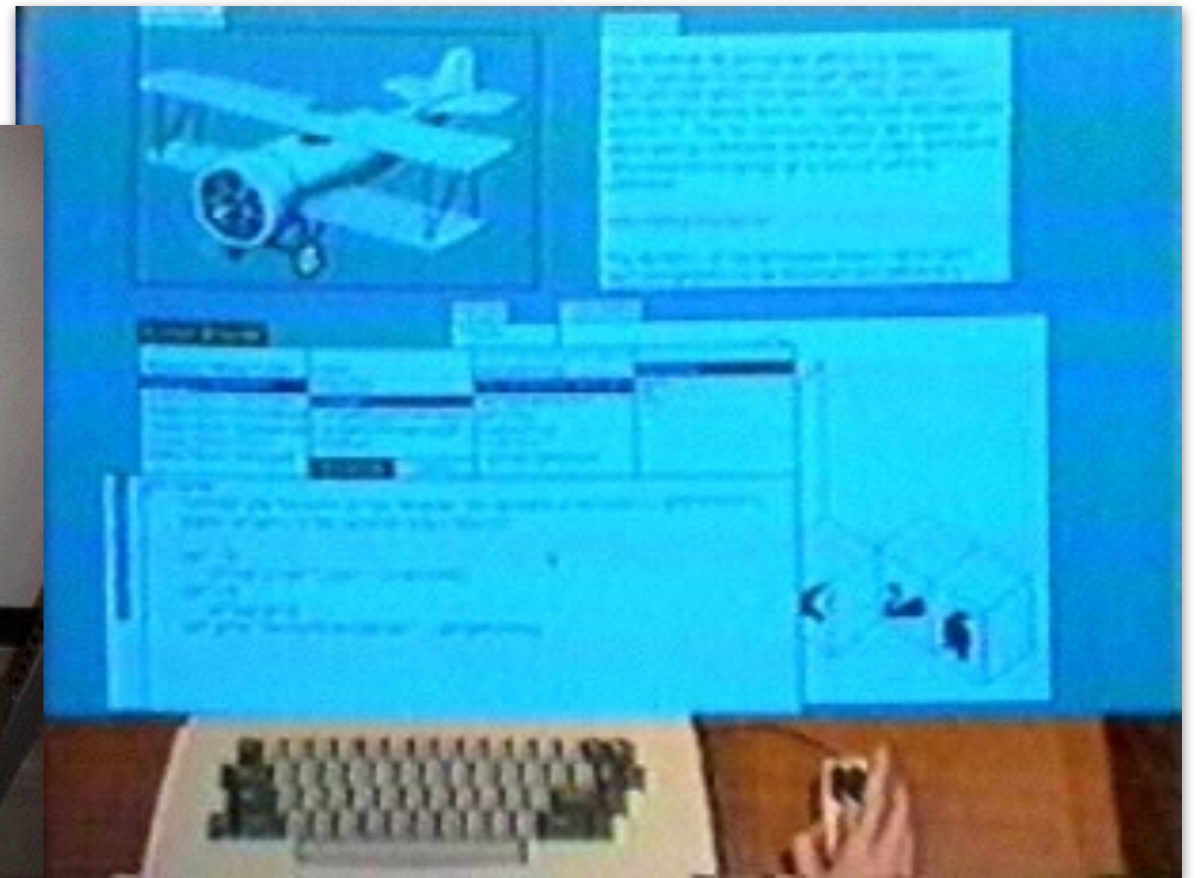


- > **The origins of Smalltalk**
- > What is Smalltalk?
- > Syntax in a nutshell
- > Seaside — web development with Smalltalk

# The origins of Smalltalk



Alan Kay's Dynabook project (1968)



Alto — Xerox PARC (1973)

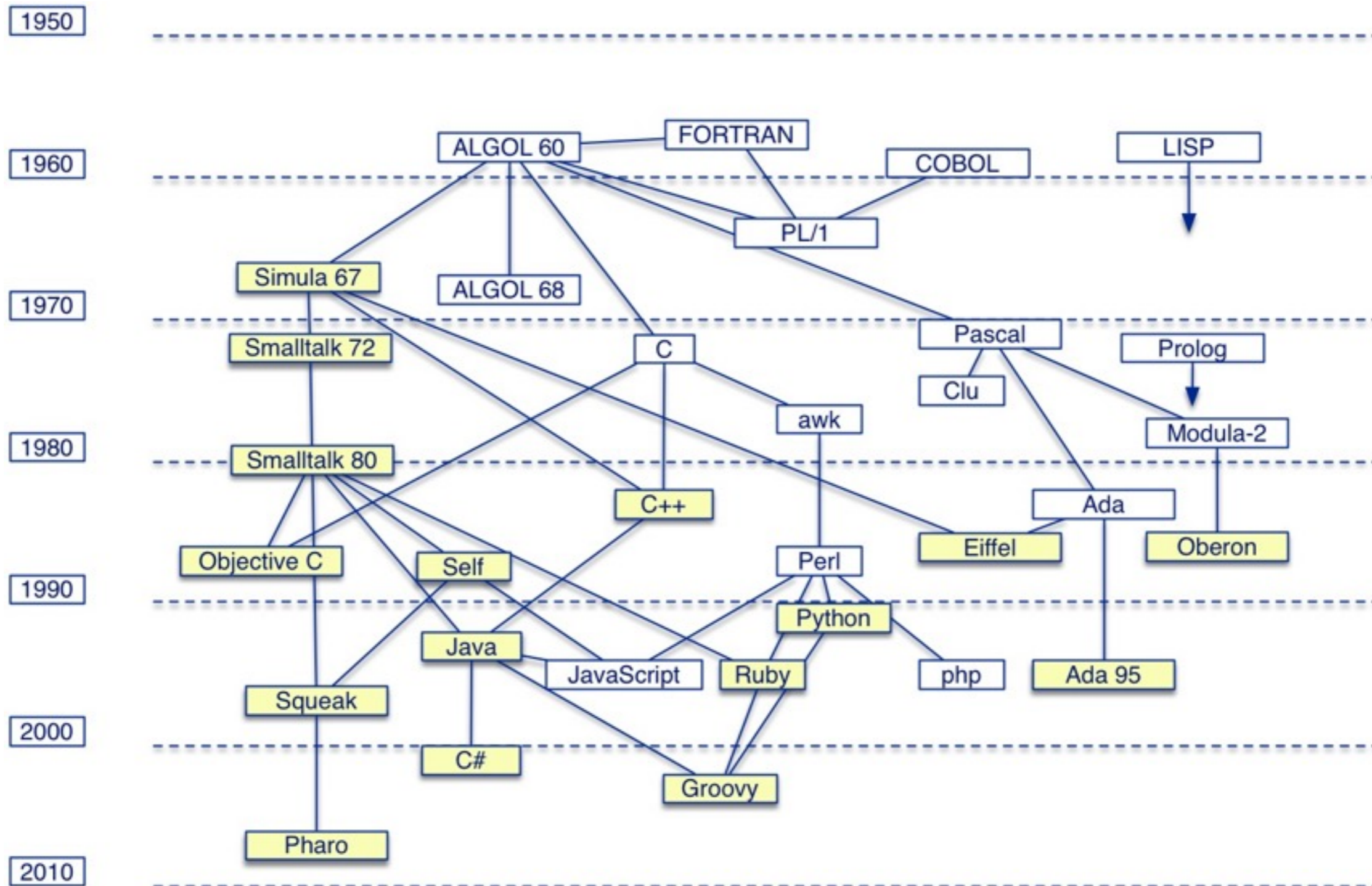
[gagne.homedns.org/~tgagne/contrib/EarlyHistoryST.html](http://gagne.homedns.org/~tgagne/contrib/EarlyHistoryST.html)



In the late 60s, Alan Kay predicted that in the foreseeable future handheld multimedia computers would become affordable. He called this a “Dynabook”. (The photo shows a mockup, not a real computer.)

He reasoned that such systems would need to be based on object from the ground up, so he set up a lab at the Xerox Palo Alto Research Center (PARC) to develop such a fully object-oriented system, including both software and hardware. They developed the first graphical workstations with windowing system and mouse.

# Object-oriented language genealogy



Simula was the first object-oriented language, designed by Kristen Nygaard and Ole Johan Dahl. Simula was designed in the early 60s, to support simulation programming, by adding classes and inheritance to Algol 60. The language was later standardized as Simula 67.

Programmers quickly discovered that these mechanisms were useful for general-purpose programming, not just simulations.

Smalltalk adopted the ideas of objects and message-passing as the core mechanisms, not just add-ons to a procedural language.

Stroustrup ported the ideas of Simula to C to support simulation programming. The resulting language was first called “C with classes”, and later C++.

Cox added Smalltalk-style message-passing syntax to C and called it “Objective-C”.

Java integrated implementation technology from Smalltalk and syntax from C++.

Squeak and Pharo are modern descendants of Smalltalk-80.

# Smalltalk vs. Java vs. C++

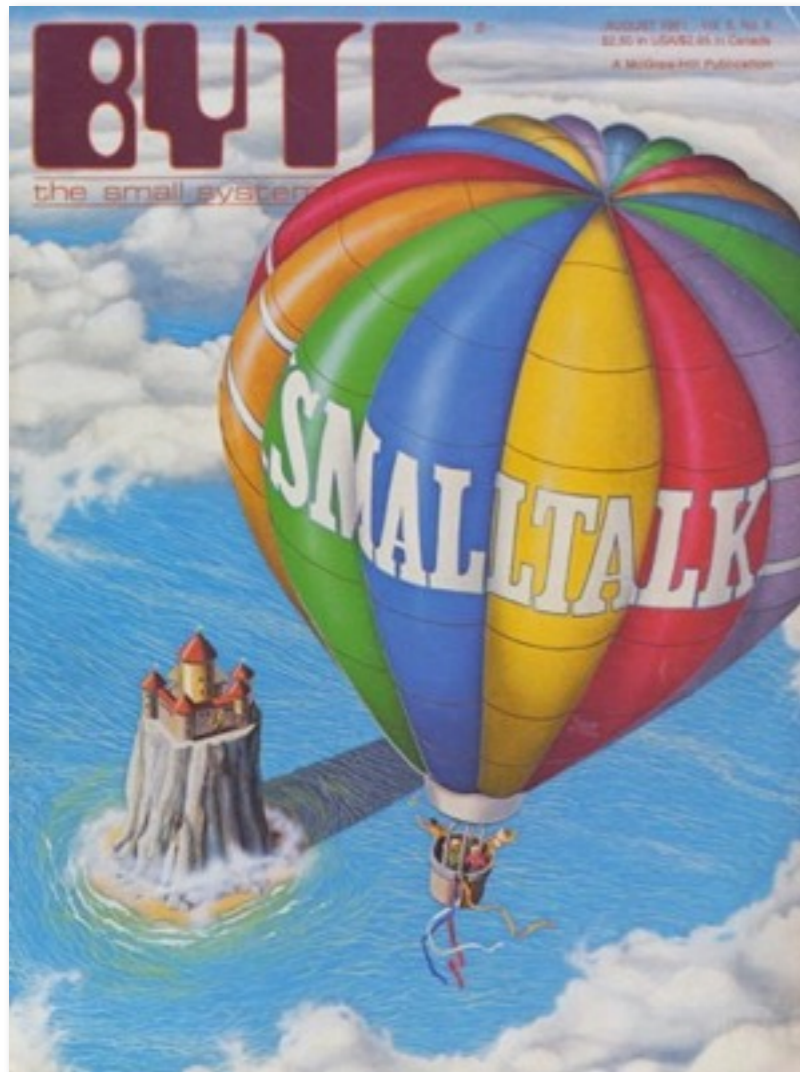
	<b><i>Smalltalk</i></b>	<b><i>Java</i></b>	<b><i>C++</i></b>
<i>Object model</i>	Pure	Hybrid	Hybrid
<i>Garbage collection</i>	Automatic	Automatic	Manual
<i>Inheritance</i>	Single	Single	Multiple
<i>Types</i>	Dynamic	Static	Static
<i>Reflection</i>	Fully reflective	Introspection	Introspection
<i>Concurrency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



The most important difference between Smalltalk, Java and C++, is that Smalltalk supports “live programming”. Whereas in Java and C++ you must first write source code and compile it before you run anything, in Smalltalk you are always programming in a live environment. You incrementally add classes and compile methods within a running system.

As a consequence, Smalltalk has to be fully reflective, allowing you to reify (“turn in objects”) all aspects of the system, and change them at run time. The only thing you cannot change from within Smalltalk is the virtual machine.

# Smalltalk-80 and Pharo



*Everything is an object.  
Everything is there, all the time.  
First windowing system with mouse.  
First graphical IDE.*

Smalltalk-80 was introduced to the world in 1981 in a now-famous issue of Byte Magazine. The “Smalltalk balloon” refers to this issue.

# 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
  - [pharo.org](http://pharo.org)





Squeak was developed by members of the original Smalltalk team, with the goal of supporting and experimenting with advanced multimedia systems. The Squeak image was ported from a Smalltalk-80 image.

Pharo is a modern descendent of Smalltalk-80, largely obeying the original syntax and design, but with numerous improvements to the language, the tools, and the environment. Whereas Squeak was developed with the goal to support experimentation, Pharo aspired to offer a clean and stable platform upon which both industrial and research projects can build.

# Pharo by Example



<http://pharobyexample.org/>

- Free download
- Open-Source
- Print-on-demand

Pharo by Example is a free book, originally published in 2009, to teach new users Pharo Smalltalk in an example-driven way. Since Pharo has advanced considerably since then, a revision of the book is underway. The old book nevertheless offers a good introduction.

Please read the beginning of this book for a quick introduction to Smalltalk.

A sequel, called “Deep into Pharo”, explains advanced details of the implementation and available tools. All the material is hosted on github:

[github.com/SquareBracketAssociates/](https://github.com/SquareBracketAssociates/)

# Don't panic!

*New Smalltalkers often think they need to understand all the details of a thing before they can use it.*

**Try to answer the question**

***“How does this work?”***

**with**

***“I don't care”.***

*Alan Knight. Smalltalk Guru*



This slide is a paraphrase of:

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”.

[alanknightsblog.blogspot.ch](http://alanknightsblog.blogspot.ch)

# Roadmap



- > The origins of Smalltalk
- > **What is Smalltalk?**
- > Syntax in a nutshell
- > Seaside — web development with Smalltalk

***Two rules to remember***

**Everything is an object**



(Nearly) everything in Smalltalk is an object, which means that you can “grab it” and talk to it. Everything that you see on the screen is an object, so you can interact with it programmatically.

The implementation of Smalltalk itself is build up of objects, so you can grab these objects and explore them. In particular, all the tools are objects, but also classes and methods are objects. This feature is extremely powerful and leads to a style of programming that is different from the usual edit/compile/run development cycle.

**Everything happens by  
sending messages**

The only way to make anything happen is by sending messages. To ask “what can I do with this object?” is the same as asking “what messages does it understand?”

The terminology of “message sending” is perhaps unfortunate, as those new to Smalltalk often assume it has something to do with network communication, but one should understand it as a metaphor: you do not “call an operation” of an object, but you politely ask it to do something by sending it a request (a “*message*”). The object then decides how to respond by checking to see if its class has a “*method*” for handling this request. If it does, it performs the method. If not, it asks its superclass if it has such a method, and so on. If this search fails, the object does not understand the message (but let’s not get into that now!).

# What is Smalltalk?

Image



+

Changes

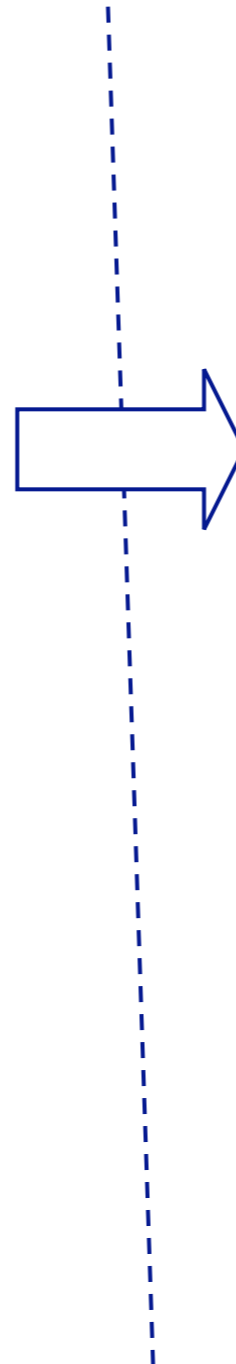
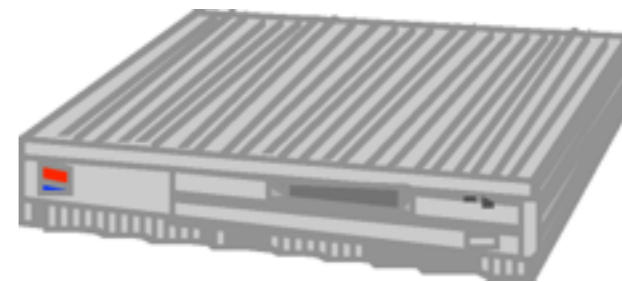


+

Sources



Virtual machine

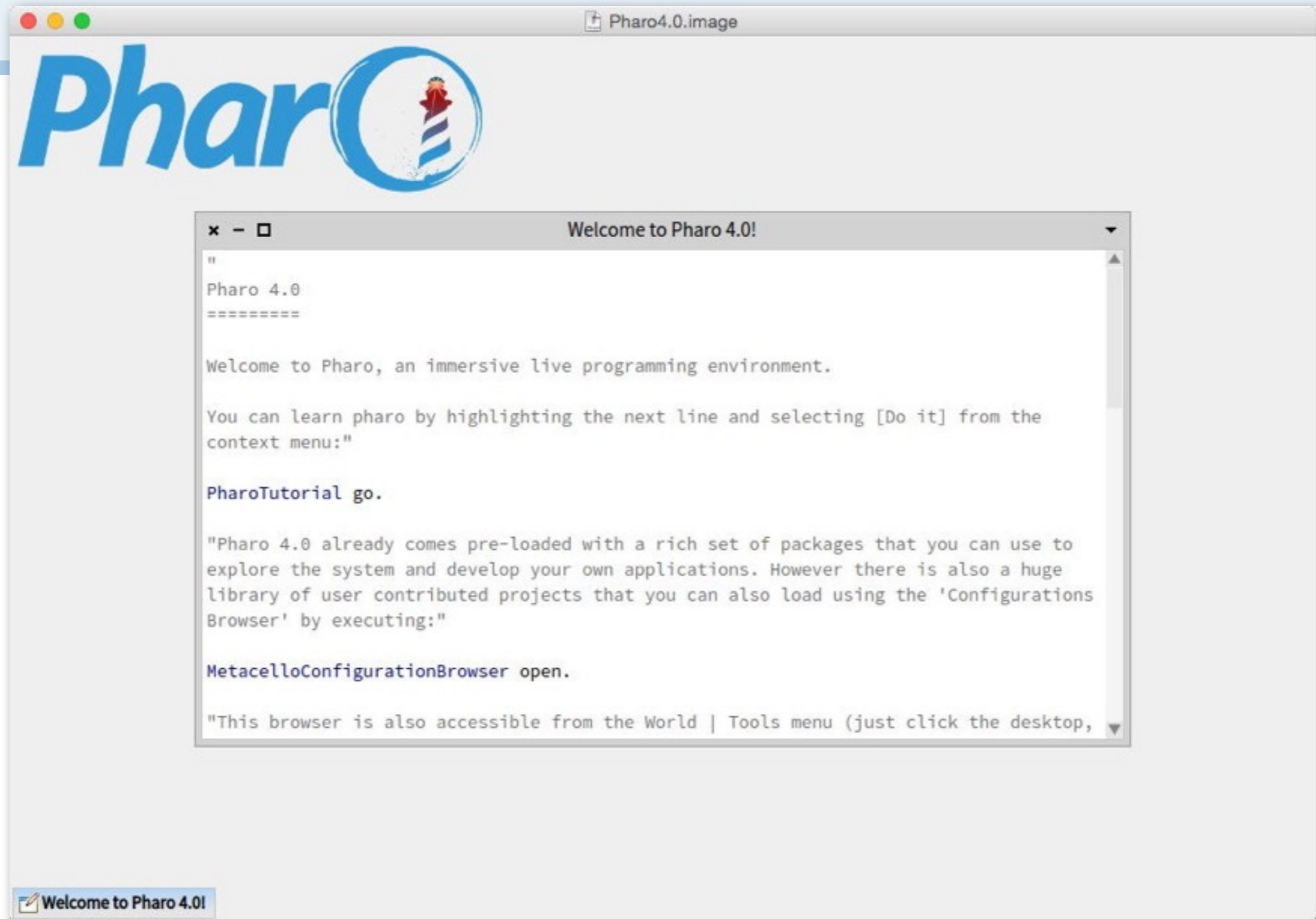


Smalltalk is often bundled into a single, “one-click” application, but there are actually four pieces that are important to understand.

Every user of Smalltalk can work with one or more Smalltalk images. The *image* file contains a snapshot of all the objects of the running system. Every time you quit Smalltalk, you can save and update this snapshot. In addition, the *changes* file consists of a log of all changes to the source code of that image, i.e., all new or changed classes and all compiled methods. If your image crashes (which is possible since Smalltalk allows you to do anything, even if that might be fatal), you can restart your image and *replay your changes*, so nothing is lost.

In addition, the virtual machine and sources files may be shared between users. The *VM* runs the bytecode of compiled methods and manages the image and changes file. Finally the *sources* file (optional) contains all the source code of objects in the base image (so you can not only explore this but modify it if you want).

# Demo: Running Pharo



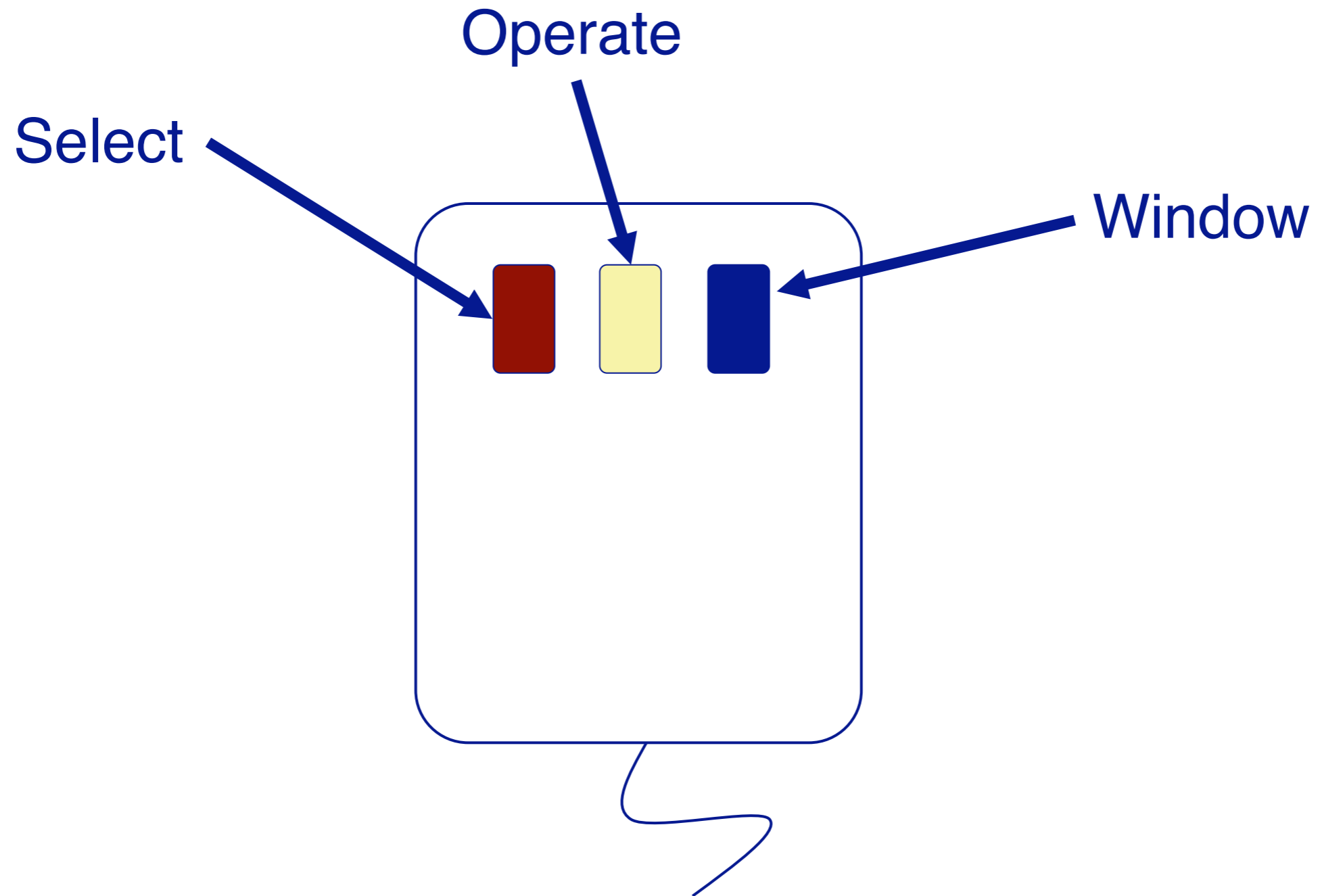
You can find the demo script in the p2-Smalltalk folder of the P2 examples repo:

```
git clone git://scg.unibe.ch/lectures-p2-examples
```

The demo illustrates: the workspace and basic tools, navigating between objects and their source code, inspection of live objects, test-driven development, debugging a live system ...



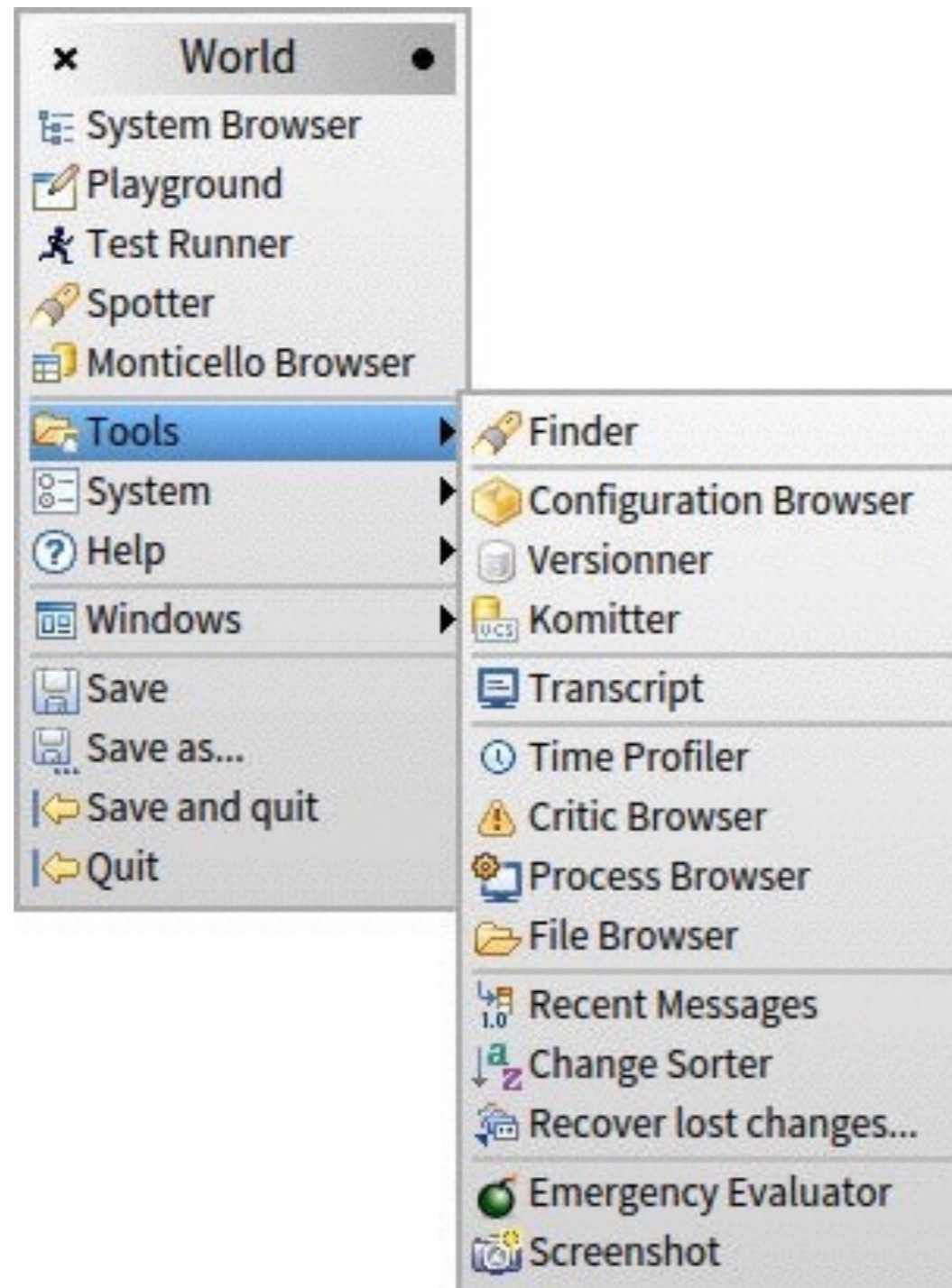
# Mouse Semantics



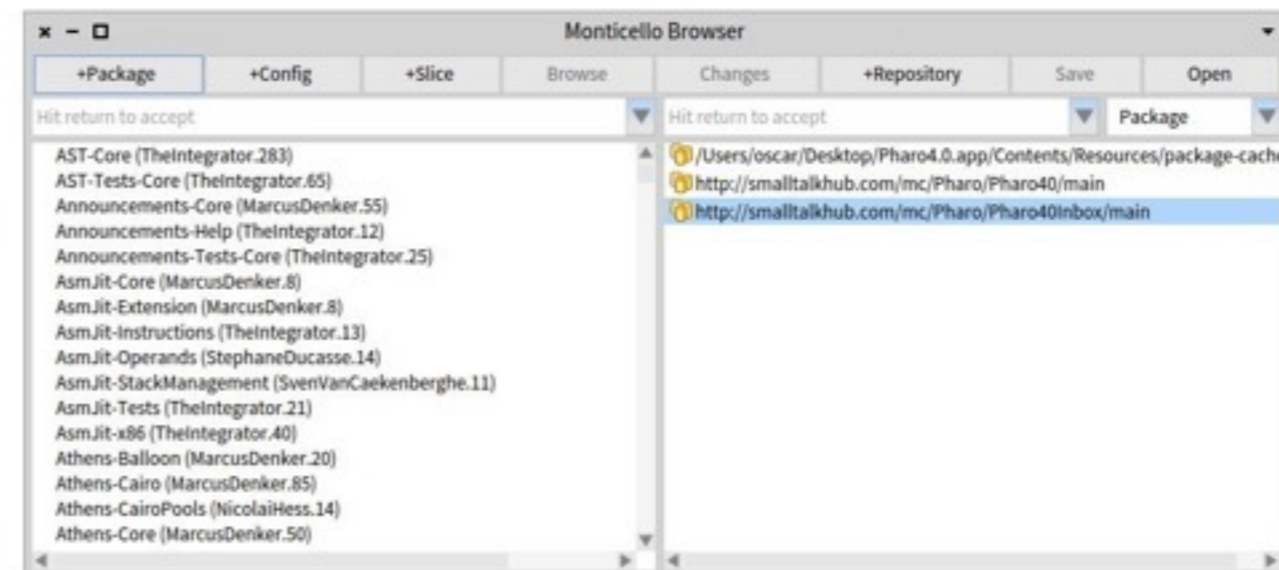
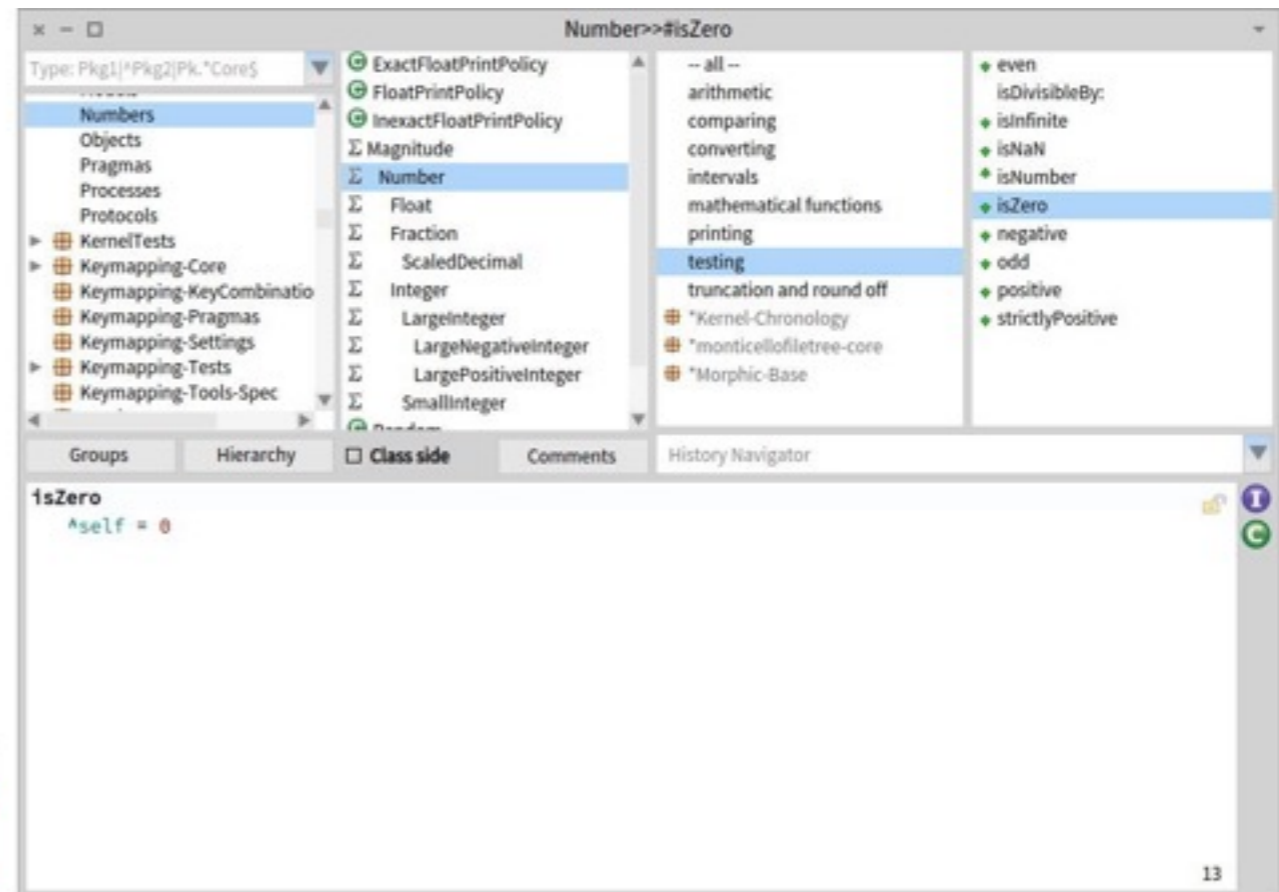
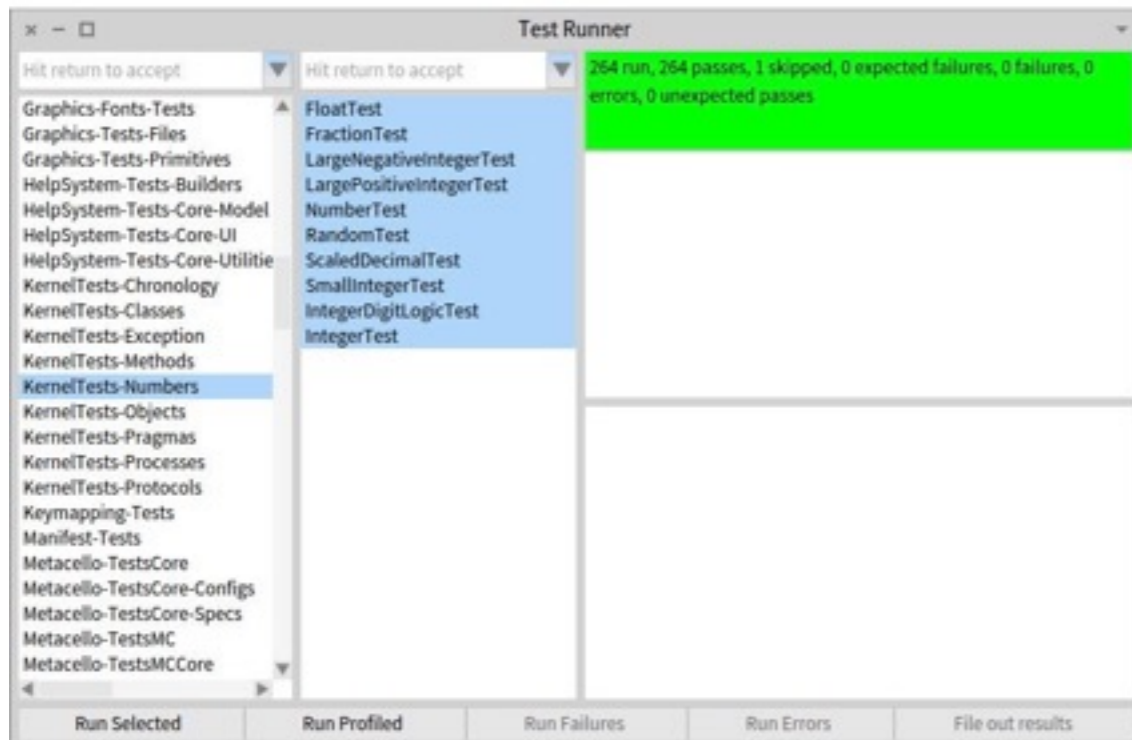
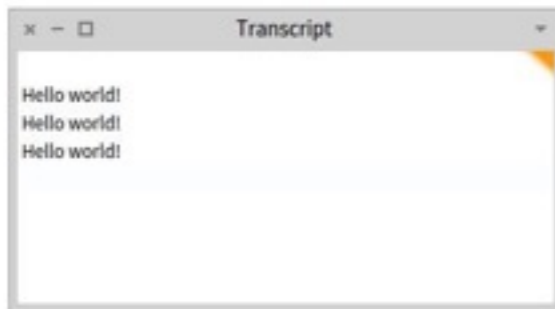
Smalltalk-80 assumes you have a “three-button mouse”. The “red button” allows you to select an object on the screen, the “yellow button” pops up a menu of things you can do with it, and the “blue button” offers a “meta menu” of system operations. (In Pharo, the “World menu”.)

Depending on the version of Smalltalk you are using and the platform you are on, the three buttons may be mapped to different modifier keys (e.g., <ALT>, <CTL> etc.)

# World Menu



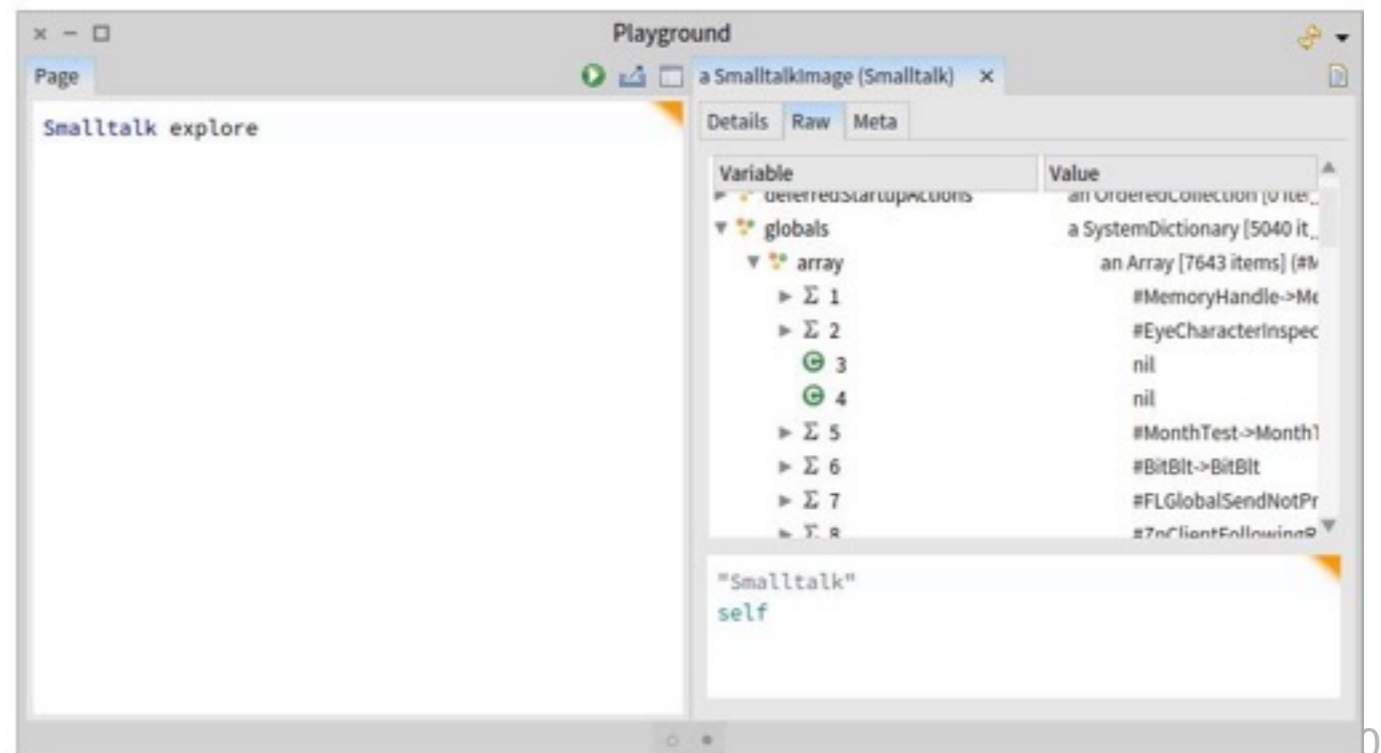
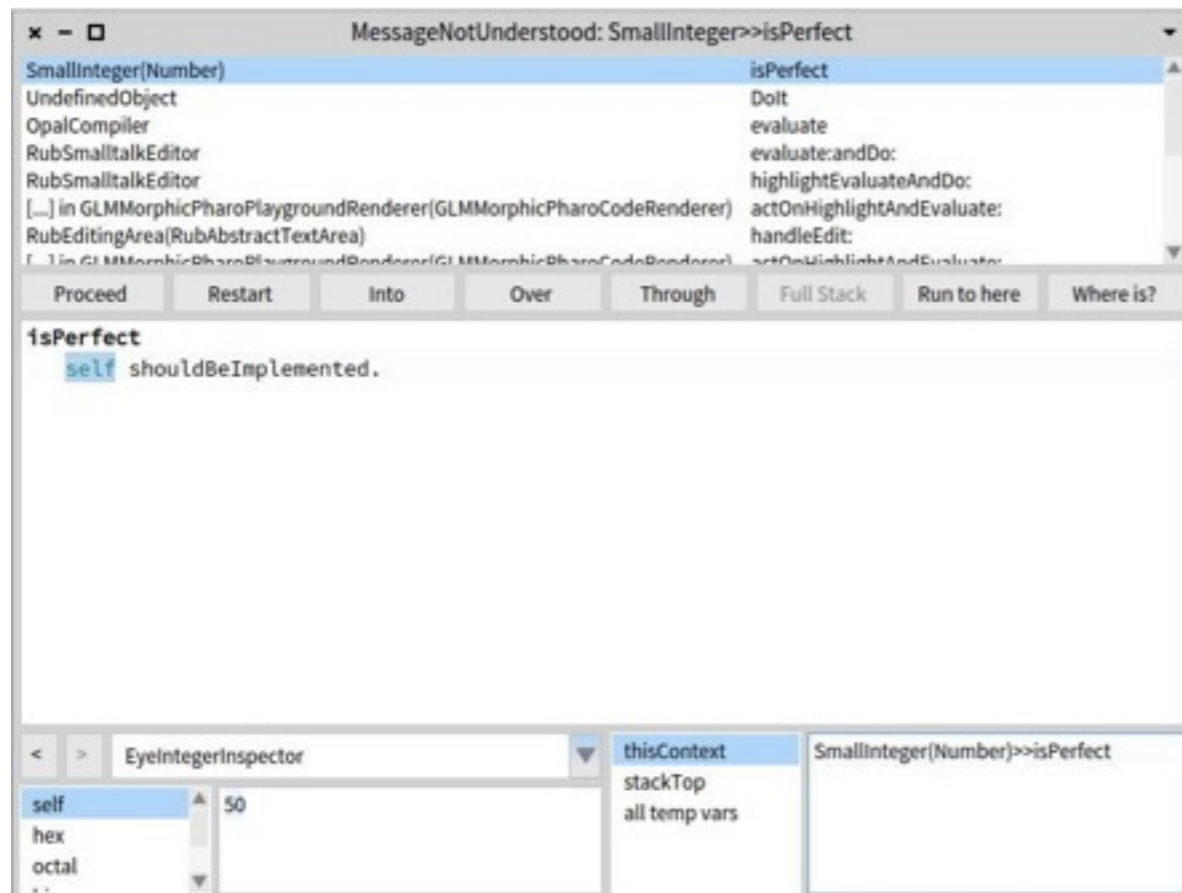
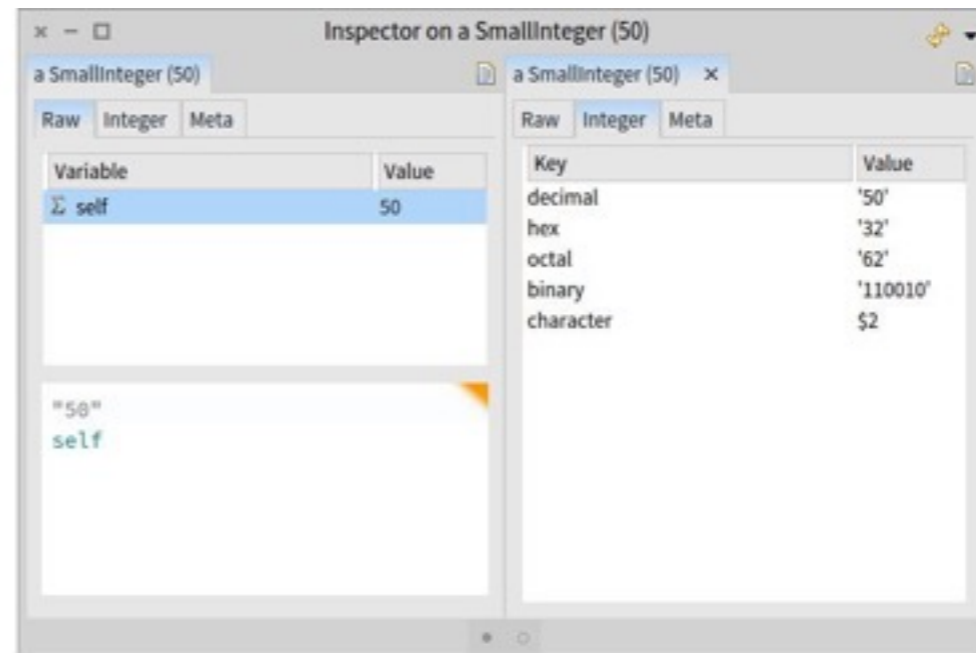
# Standard development tools



Here we see (clockwise from top left)

- the Playground, for executing arbitrary Smalltalk code
- the System Browser, for browsing (top) packages, classes, interfaces (or “protocols”), methods, and (bottom) source code
- the Monticello Browser, for connecting to a Monticello version repository
- the Test Runner, for (you guessed it!) running tests, and
- the Transcript, for displaying console messages.

# Debuggers, Inspectors, Explorers



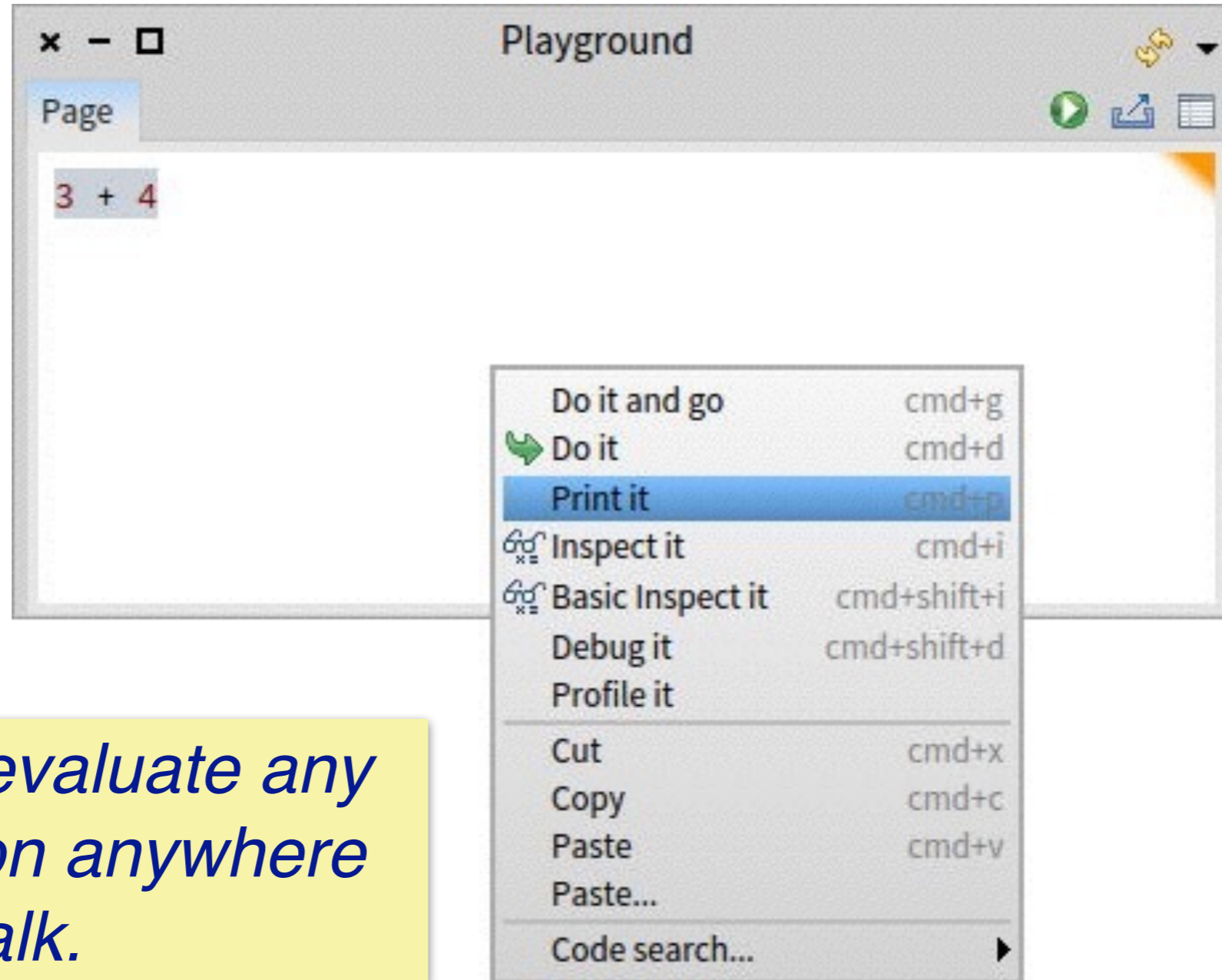


Here we see

- a Playground, where we inspect the expression  
`50 isPerfect`
- an object Inspector on the result of evaluating this expression
- another Playground where we evaluate and inspect Smalltalk explore in a separate tab
- a Debugger window showing us that the method `isPerfect` is just a stub to be implemented.



# Do it, Print it, ...



*You can evaluate any expression anywhere in Smalltalk.*

Here we have selected the text  $3+4$  in the Playground and clicked the “yellow” button to display a menu of operations we can perform.

- **do it** will evaluate it and discard the result
  - **print it** will display the result
  - **inspect it** will open an Inspector on the result
- and so on

# Roadmap



- > The origins of Smalltalk
- > What is Smalltalk?
- > **Syntax in a nutshell**
- > Seaside — web development with Smalltalk

# Three kinds of messages

> *Unary messages*

```
5 factorial  
Transcript cr
```

> *Binary messages*

```
3 + 4
```

> *Keyword messages*

```
3 raisedTo: 10 modulo: 5
```

```
Transcript show: 'hello world'
```

Smalltalk has a very simple syntax. There are just three kinds of messages:

1. *Unary messages* consist of a single word sent to an object (the result of an expression). Here we send `factorial` to the object `5` and `cr` (carriage return) to the object `Transcript`. (Aside: upper-case variables are global in Smalltalk, usually class names. `Transcript` is one of the few globals that is not a class.)
2. *Binary messages* are operators composed of the characters `+`, `-`, `*`, `/`, `&`, `=`, `>`, `|`, `<`, `~`, and `@`. Here we send the message `+ 4` to the object `3`.
3. *Keyword messages* take multiple arguments. Here we send `raisedTo: 10 modulo: 5` to `3` and `show: 'hello world'` to `Transcript`.

# Precedence

*First unary, then binary, then keyword:*

```
2 raisedTo: 1 + 3 factorial
```

128

*Same as:*

```
2 raisedTo: (1 + (3 factorial))
```

*Use parentheses to force order:*

```
1 + 2 * 3
```

```
1 + (2 * 3)
```

9 (!)

7

The precedence rules for Smalltalk are exceedingly simple: unary messages are sent first, then binary, and finally keyword messages. Use parentheses to force a different order.

Note that there is no difference in precedence between binary operators.



# A typical method in the class Point

Method name

Argument

Comment

```
<= aPoint
```

```
"Answer whether the receiver is neither  
below nor to the right of aPoint."
```

```
^ x <= aPoint x and: [y <= aPoint y]
```

Return

Instance variable

Binary message

Keyword message

Block

```
(2@3) <= (5@6)
```

```
true
```

The slide shows the `<=` method of the `Point` class as it appears in the IDE.

The first line lists the method name and its formal parameters. In this case we are defining the method for the `<=` selector. (In Smalltalk, method names are called “*selectors*”, because when a message is received, the selector is used to select the method to respond.)

*Comments* are enclosed in double quotation marks (*strings* are enclosed in single quotes).

The body of this method consists of a single expression. The caret (^) is a reserved symbol in Smalltalk and denotes a *return value*. A *block* is enclosed in square brackets and denotes an expression that may be evaluated. In this case, the Boolean `and:` method will only evaluate the block if its receiver (i.e., the subexpression to the left of the `and:`) evaluates to `true`.

# Statements and cascades

Temporary variables

Statement

Assignment

```
| p pen |  
p := 100@100.  
pen := Pen new.  
pen up.  
pen goto: p; down; goto: p+p
```

Cascade

This is a code snippet (not a method) that may be evaluated in the Playground.

Here we see that *statements* are expressions separated by periods (.).

Even though Smalltalk does not support type declarations, *local variables must still be declared*, appearing within or-bars (|).

A variable is bound to a value using the *assignment* operator (:=).

Smalltalk supports a special syntax, called a *cascade*, to send multiple messages to the same receiver. Messages in a cascade are separated by semi-colons (;). In this case we send the messages “goto: p”, “down”, and finally “goto: p+p” to the receiver p. (This draws a line from the Point 100@100 to 200@200.)

Note that 100@100 looks like special syntax for Point objects, but it is really just a Factory method of the Number class, which creates a new Point instance.

# Literals and constants

<i>Strings &amp; Characters</i>	'hello' \$a
<i>Numbers</i>	1 3.14159
<i>Symbols</i>	#yadayada
<i>Arrays</i>	#{1 2 3}
<i>Pseudo-variables</i>	self super
<i>Constants</i>	true false

Everything is an object in Smalltalk, including these literal and constant values.

Strings are just special kinds of ordered collections holding character values.

Smalltalk supports various kind of numbers, and also supports radix notation for numbers in different bases.

Symbols behave much like strings, but are guaranteed to be globally unique. They always start with a hash (#).

In addition to `self`, `super`, `true` and `false`, there are only two further reserved names in Smalltalk: `nil` and `thisContext`. (The latter is only needed for meta-programming!)

# Variables

- > *Local variables* are delimited by `| var |`  
*Block variables* by `: var |`

```
OrderedCollection>>collect: aBlock
  "Evaluate aBlock with each of my elements as the argument."
  | newCollection |
  newCollection := self species new: self size.
  firstIndex to: lastIndex do:
    [ :index |
      newCollection addLast: (aBlock value: (array at: index))].
  ^ newCollection
```

```
(OrderedCollection with: 10 with: 5) collect: [:each| each factorial ]
```

```
an OrderedCollection(3628800 120)
```



NB: Since source code for methods in the IDE does not show the class of the method, it is a common convention in documentation to add the missing class name, followed by two greater-than signs (>>), as in this example.

This example serves mainly to show that blocks can take arguments. The arguments are after the opening left square bracket, and each is preceded by a colon (:).

The block:

```
[ :each | each factorial ]
```

takes its arguments from the receiver of `collect:`, the collection holding 10 and 5.

# Control Structures

> *Every control structure is realized by message sends*

```
max: aNumber  
  ^ self < aNumber  
    ifTrue: [aNumber]  
    ifFalse: [self]
```

```
4 timesRepeat: [Beeper beep]
```

There are no built-in control constructs in Smalltalk. *Everything happens by sending messages!*

Even a simple if statement is achieved by sending a message to a boolean expression, which will then evaluate the block argument only if it boolean is true.

Here we see that the `max:` method is implemented by sending `ifTrue:ifFalse:` to the Boolean expression `self<aNumber`. The `ifTrue:ifFalse:` method is itself defined in the Boolean classes `True` and `False`.

(Try to imagine how it would be implemented, and then check in the image to see how it is done.)

# Creating objects

## > *Class methods*

```
OrderedCollection new  
Array with: 1 with: 2
```

## > *Factory methods*

```
1@2
```

```
1/2
```

```
a Point
```

```
a Fraction
```

Ultimately all objects (aside from literals) are created by sending the message `new` to a class. (The message `new:` is used to create arrays of a given length.) Further constructors may be defined as convenience methods on classes, for example,

```
Array with: 1 with: 2
```

will create an `Array` of length 2 using `new:`, and then initialize it with the two arguments.

Other instance creation methods may be defined on the classes of arguments used to create the objects. For example, to create a `Fraction`, we send the message `/` to an `Integer`, with the numerator as its argument. This method will then actually create a new `Fraction` for us.

# Creating classes

- > Send a message to a class (!)

```
Number subclass: #Complex
  instanceVariableNames: 'real imaginary'
  classVariableNames: ''
  poolDictionaries: ''
  category: 'ComplexNumbers'
```

Everything is an object, ergo *classes are objects too!*

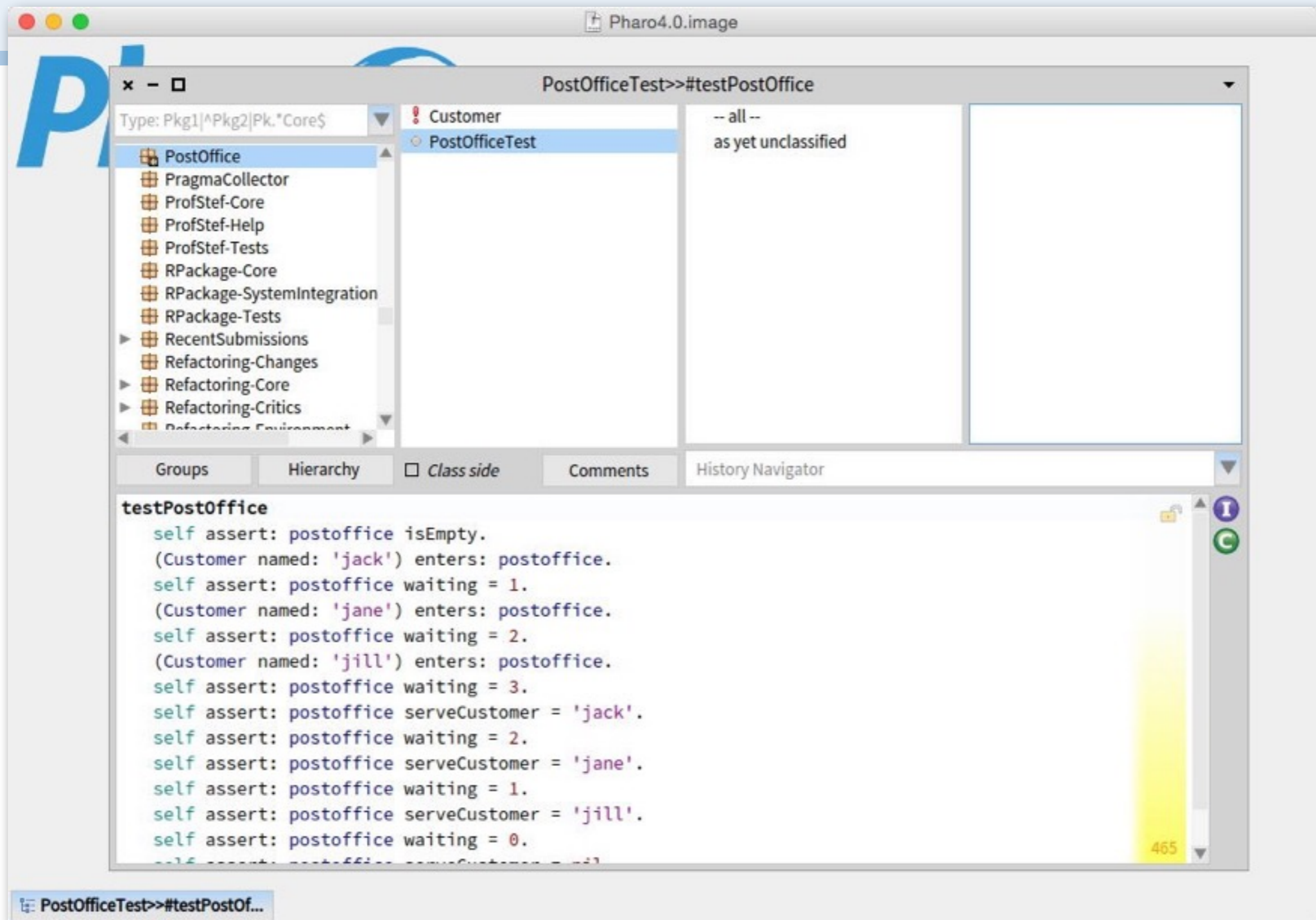
To create a new class, you must send a message to an existing class, asking it to create (or redefine) a subclass.

Since the class to be created probably does not yet exist, its name is not defined globally, so we must pass in the name as a symbol (here `#Complex`).

We can also provide the names of its instance variables (or we can update this later). Please ignore `classVariableNames` and `PoolDictionaries` — they are almost never needed. The “*category*” is the name of a related group of classes (something like a poor man's package).



# Demo: Defining classes and methods



The screenshot shows the Pharo IDE interface. The window title is "Pharo4.0.image". The main area is divided into several panes:

- Class Browser:** On the left, a list of packages is shown, with "PostOffice" selected. The right pane shows the class hierarchy for "PostOfficeTest", which is currently "as yet unclassified".
- Code Editor:** The bottom pane shows the source code for the `testPostOffice` method. The code is as follows:

```
testPostOffice
self assert: postoffice isEmpty.
(Customer named: 'jack') enters: postoffice.
self assert: postoffice waiting = 1.
(Customer named: 'jane') enters: postoffice.
self assert: postoffice waiting = 2.
(Customer named: 'jill') enters: postoffice.
self assert: postoffice waiting = 3.
self assert: postoffice serveCustomer = 'jack'.
self assert: postoffice waiting = 2.
self assert: postoffice serveCustomer = 'jane'.
self assert: postoffice waiting = 1.
self assert: postoffice serveCustomer = 'jill'.
self assert: postoffice waiting = 0.
```

The status bar at the bottom left shows the current context: "PostOfficeTest>>#testPostOf...".

This demo script can also be found in the same github repo listed earlier.

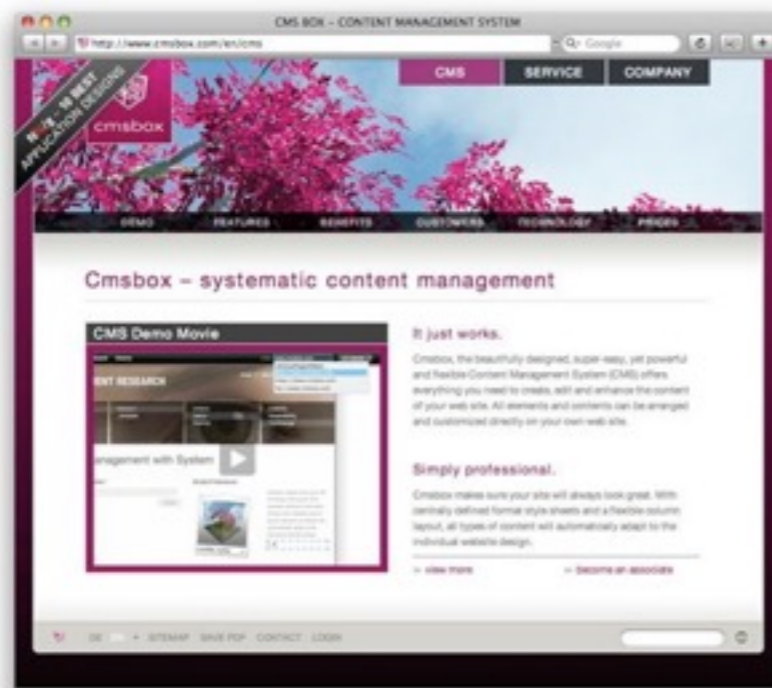
Here we apply test-driven development to simulate a Post Office serving customers.

# Roadmap



- > The origins of Smalltalk
- > What is Smalltalk?
- > Syntax in a nutshell
- > **Seaside – web development with Smalltalk**

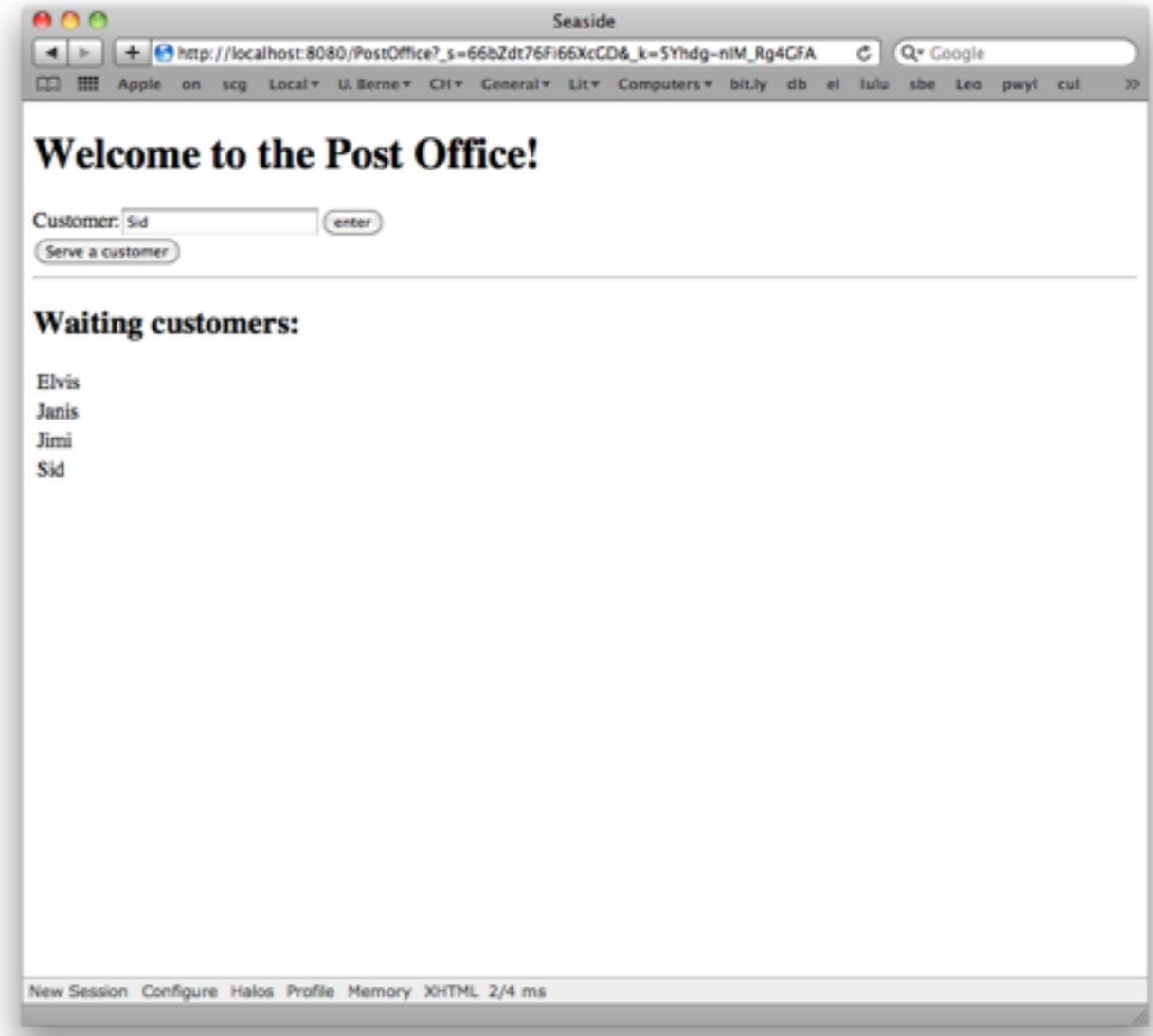
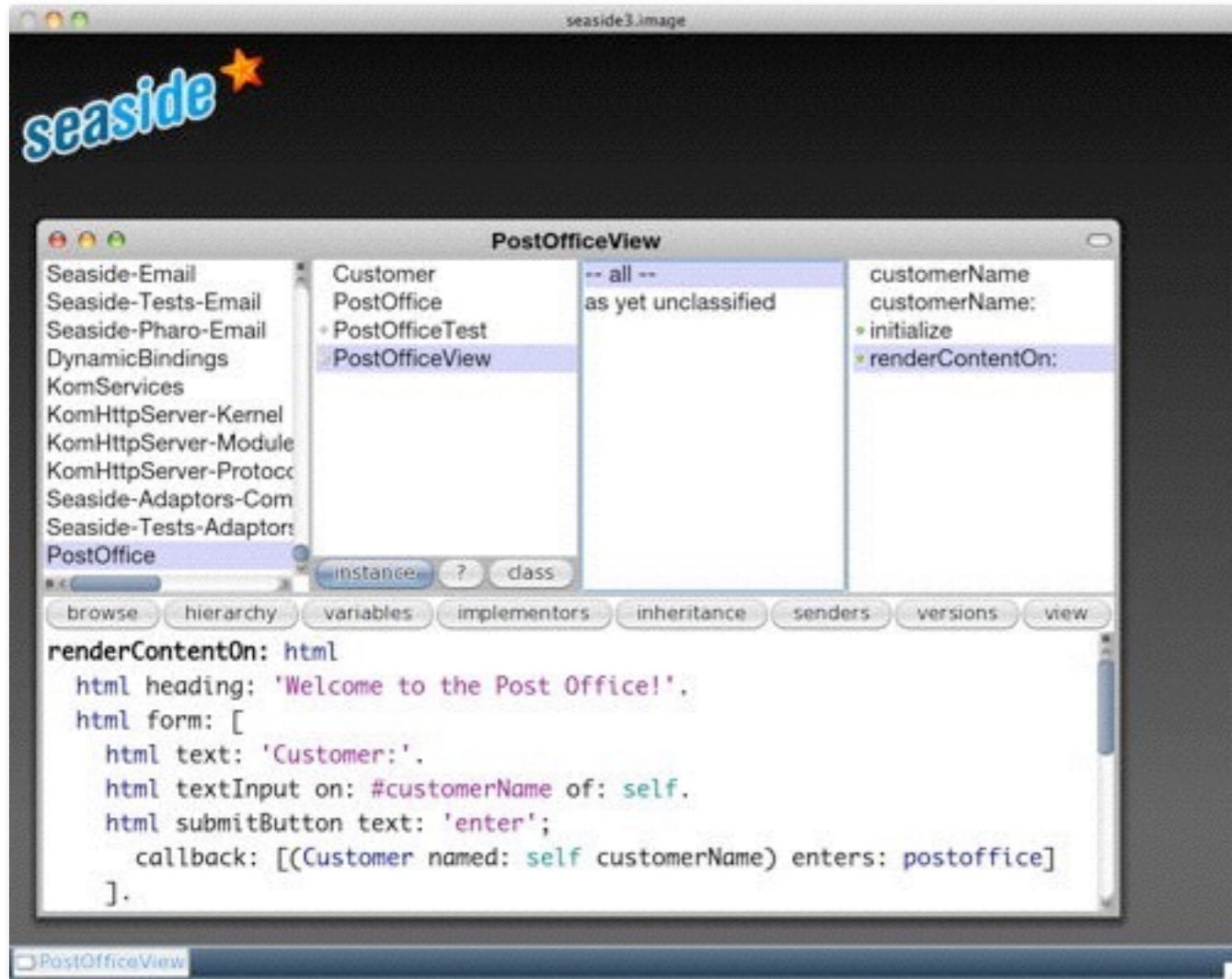
# Seaside — a Smalltalk web development platform



Seaside is a very successful web development platform built on top of Pharo Smalltalk. Like Pharo, it supports live programming.



# Demo: PostOffice in Seaside



The demo shows how we can quickly develop a simple web interface to the Post Office simulation.



# *What you should know!*

- ✎ What are the key differences between Smalltalk, C++ and Java?*
- ✎ What is at the root of the Smalltalk class hierarchy?*
- ✎ What kinds of messages can one send to objects?*
- ✎ What is a cascade?*
- ✎ Why does  $1+2/3 = 1$  in Smalltalk?*
- ✎ How are control structures realized?*
- ✎ How is a new class created?*
- ✎ What are categories for?*
- ✎ What are Factory methods? When are they useful?*

# *Can you answer these questions?*

- ✎ Which is faster, a program written in Smalltalk, C++ or Java?*
- ✎ Which is faster to develop & debug, a program written in Smalltalk, C++ or Java?*
- ✎ How are Booleans implemented?*
- ✎ Is a comment an Object? How would you check this?*
- ✎ What is the equivalent of a static method in Smalltalk?*
- ✎ How do you make methods private in Smalltalk?*
- ✎ What is the difference between = and ==?*
- ✎ If classes are objects too, what classes are they instances of?*



## Attribution-ShareAlike 4.0 International (CC BY-SA 4.0)

### You are free to:

**Share** — copy and redistribute the material in any medium or format

**Adapt** — remix, transform, and build upon the material for any purpose, even commercially.

The licensor cannot revoke these freedoms as long as you follow the license terms.

### Under the following terms:



**Attribution** — You must give appropriate credit, provide a link to the license, and indicate if changes were made. You may do so in any reasonable manner, but not in any way that suggests the licensor endorses you or your use.



**ShareAlike** — If you remix, transform, or build upon the material, you must distribute your contributions under the same license as the original.

**No additional restrictions** — You may not apply legal terms or technological measures that legally restrict others from doing anything the license permits.

<http://creativecommons.org/licenses/by-sa/4.0/>