

# Smalltalk - Pure OOP

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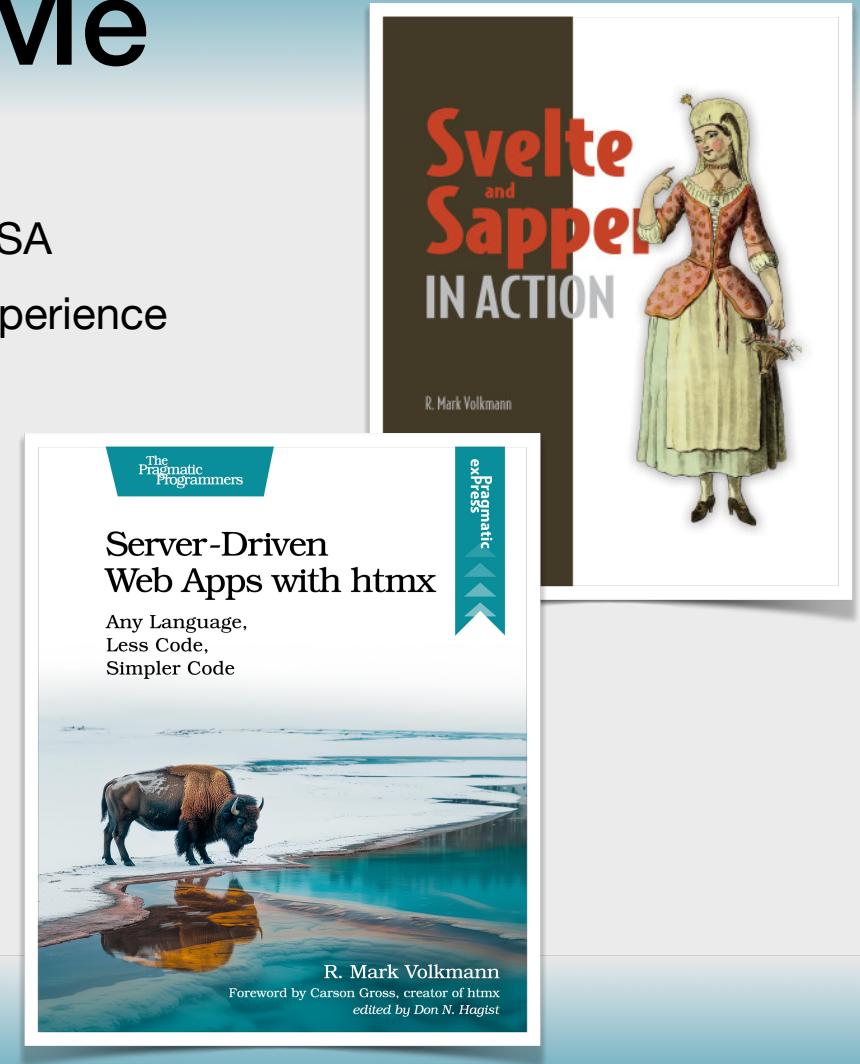
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Slides at <https://github.com/mvolkmann/talks/>



# About Me

- Partner and Distinguished Software Engineer at Object Computing, Inc. in St. Louis, Missouri USA
- 44 years of professional software development experience
- Writer and speaker
- Blog at <https://mvolkmann.github.io/blog/>
- Author of Manning book “Svelte ... in Action”
- Author of Pragmatic Bookshelf book “Server-Driven Web Apps with htmx”



# Some Applicable Quotes

- “The further backward you can look,  
the further forward you are likely to see.”
  - Winston Churchill
- “Simplicity is the ultimate sophistication.”
  - Leonardo Da Vinci
- “The single most important thing I have learned  
about software development over my career  
is that if you do not aggressively fight complexity,  
it will eat you alive.”
  - Vicki Boykis

# Why Learn Smalltalk?

- Beautifully minimal syntax
- Excellent development environment
- Gain understanding of pros and cons compared to other languages
- Get ideas for features that can be added to other languages and their development environments
- Actually use it as an alternative to other languages
- Have fun!



# Smalltalk Cons



- **Small community**, so it can be difficult to get answers to questions
- **Attitude** in community that because all the code is easily accessible, you can find answers to any questions on your own
- **Documentation** on some topics is lacking
  - how to package applications for use by non-developers
  - how to implement HTTP API endpoints (web servers) my package WebClientPlus addresses this
  - how to deploy to cloud environments (use Docker)

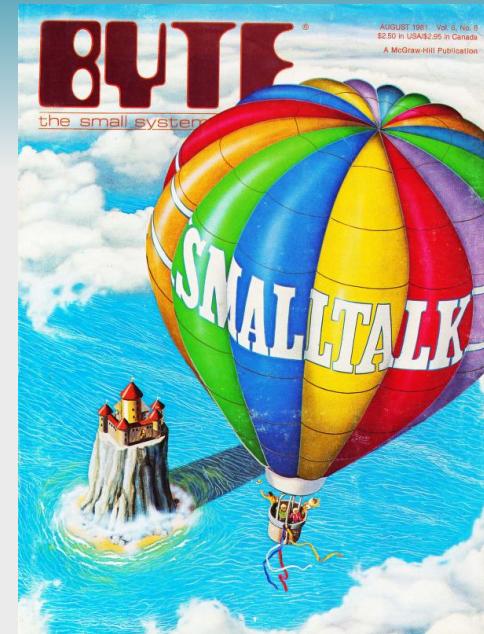
# Smalltalk Overview



- **Purely object-oriented, dynamically typed programming language**
  - first popular OOP
  - everything is represented by an object that is an instance of some class
  - includes classes themselves and all development environment GUI elements
- **Everything happens by sending messages to objects**
  - objects decide whether and how to act on messages
- **Duck typing**
  - types of variables, method parameters, and method return types are never specified
  - use any object as long as it responds to all messages sent to it
    - determined at run-time (late binding)

# Origin

- Invented at Xerox Palo Alto Research Center (PARC)
  - by Alan Kay, Dan Ingalls, Adele Goldberg, and others in 1970's
- First version in 1972
- Gained popularity in 1981 due to Byte magazine cover
- Was popular alternative to C++ in early 1990's
- But there were no free, open source implementations and licenses for commercials versions were expensive
- The free Java language was released in 1995 and the wind was removed from Smalltalk sails



# Current Implementations

- **Free, Open-Source**

- Squeak (1996) - fork of Smalltalk-80
- Pharo (2008) - fork of Squeak
  - aims to provide a more comprehensive feature set
- Cuis (2009) - fork of Squeak
  - aims to remain small and easy to learn

Pharo and Cuis  
use Squeak VM

**Notable ways in which Cuis differs from Squeak and Pharo:**

- ships with **minimal** set of Smalltalk-80-inspired classes for simplicity
- supports **Unicode**
- supports **TrueType fonts**
- supports high-quality **vector graphics**, including SVG

- **Commercial**

- Cincom Smalltalk - VisualWorks and ObjectStudio
- Instantiations VA Smalltalk - VAST Platform
- GemTalk Systems - GemStone/S
- Dolphin Smalltalk



# Just-in-Time Compilation



- Not interpreted
- First programming language to use just-in-time (JIT) compilation
- Code is compiled to optimized bytecode that is executed by a virtual machine (VM)
- Compilation occurs when method code is saved
- Results in better performance than interpreting code

# VMs and Images



- Running Smalltalk programs requires **two parts, VM and image file**
  - VM reads and executes Smalltalk code found in image file
  - VM is specific to operating system and CPU architecture being used
- Image files are snapshots of current environment state
  - describes collection of all active objects
  - during development, changes can be saved to current image or a new image
- Image files can be moved between operating systems on different CPU architectures
  - displays same (pixel for pixel) across Windows, Linux, and MacOS, only differing based on screen size
  - no need to recompile code for different environments; makes code highly portable



# Installing Cuis Smalltalk



- Browse <https://cuis.st>
- Click Download link
- Click “Cuis Stable Release” or “Cuis Rolling Release” (preferred)
- Click Code button and copy GitHub repository URL
- Clone repository



# Starting, Saving, Quitting



- To start an image, double-click it
  - in a file like `Cuis-Smalltalk-Dev/CuisImage/Cuis7.1-6713.image`
- To save changes to an image, open World menu and select **Save Image**, **Save Image as...**, or **Save Image and Quit**
  - avoid saving changes to base image
- To quit an image, open World menu and select **Save Image and Quit** or **Quit Without Saving**



# Updating Cuis Image

- To install latest updates
  - `git pull` the repository
  - open World menu and select **Changes ... Install New Updates**

# Delimiters

- **Single quote** - surrounds literal String instances
  - 'Hello, World!'
- **Double quote** - surrounds comments
  - "Answer largest number in collection"
- **Vertical bars** - surrounds list of temporary (local) variables in a method or block
  - | color price size |
- **Square brackets** - surrounds a block (anonymous function)
  - [:a :b | a + b] vertical bar separates parameter list from expressions
- **Period** - separates expressions
  - a := 2. b := 3. c := a \* b. c print typically also separated by newline characters

# Message Syntax ...



- Three kinds
  - unary - **receiver unaryMsg**
    - example: `'Hello, World!' print`
  - binary - **receiver binaryMsg argument**
    - example: `width * height`
  - keyword - **receiver kw1: arg1 kw2: arg2 kw3: arg3**
    - example: `dogs at: 'Comet' put: 'Whippet'`
- Precedence is unary, binary, then keyword
- Evaluated left to right
- Parentheses change evaluation order

Binary message names can only contain one or more of the following characters:  
+ - \* / \ ~ < > = @ % | & ? ,

assume dogs is a Dictionary

# ... Message Syntax

- Use `self` as receiver to send message to current object
- Expressions in method bodies are separated by periods
- Message cascade (;)
  - sends multiple messages to same receiver
  - ex. `Transcript show: 'Hello'; newLine; show: 'World!'`
- Message chain (::)
  - sends message to result of previous message
  - removes need to surround previous expression with parentheses

```
1 + 2 squared -> 5
(1 + 2) squared -> 9
1 + 2 :: squared -> 9
```



# Blocks ...



- Deferred set of message sends that are not evaluated until block value is requested
- Value is that of last expression

```
[1 + 2] value 3
```

- Can take arguments

```
[:a :b | a + b] value: 1 value: 2 3 up to four  
of these
```

OR

```
[:a :b | a + b] valueWithArguments: #(1 2) 3
```

syntax for a  
compile-time  
literal array

# ... Blocks

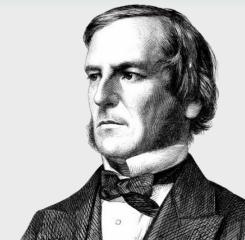
- First class
  - can be assigned to variables
  - can be passed to methods
  - can be returned from methods
- Can declare temporary (local) variables
- Can contain multiple expressions
- Are closures, so can access in-scope variables

```
average := [:a :b |  
  sum |  
  sum := a + b.  
  sum / 2.0  
]
```



# Booleans

- Boolean values `true` and `false` are singleton instances of `True` and `False` classes which are the only subclasses of `Boolean`



George Boole

```
size = #large and: [color = #yellow] :: ifTrue: [
    "Buy the item."
    ...
]
```

## Methods in True class

```
and: alternativeBlock
  ^alternativeBlock value

or: alternativeBlock
  ^self true
```

## Methods in False class

```
and: alternativeBlock
  ^self false

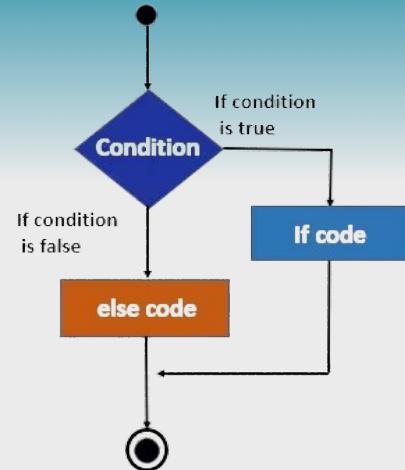
or: alternativeBlock
  ^alternativeBlock value
```

# Conditional Logic

- Implemented as methods in **Boolean** class
- Examples

```
result := a < b ifTrue: ['less'] ifFalse: ['more'].

color := 'blue'.
assessment := color caseOf: { [ start of dynamic array
    ['red'] -> ['hot'].
    ['green'] -> ['warm']. associations between blocks
    ['blue'] -> ['cold']
}
```

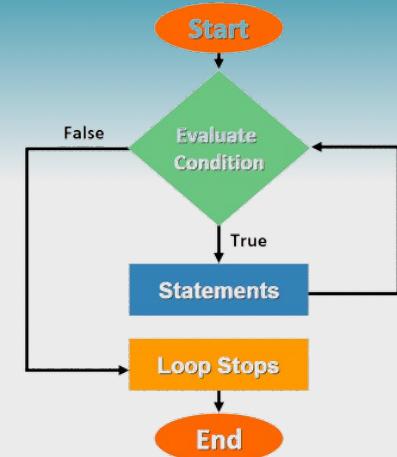


# Iteration

- Many methods in provided classes support iteration
  - such as `Integer`, `Interval`, and `BlockClosure`
- Examples

```
3 timesRepeat: ['Ho' print].  
  
interval := 1 to: 10 by: 2.  
interval do: [:n | n print].  
  
1 to: 10 by: 2 do: [:n | n print]
```

```
n := 0.  
[n = 10] whileFalse: [  
  n := 10 atRandom.  
  n print.  
]
```



- Also see `Collection` method `do:` on next slide

# Collections

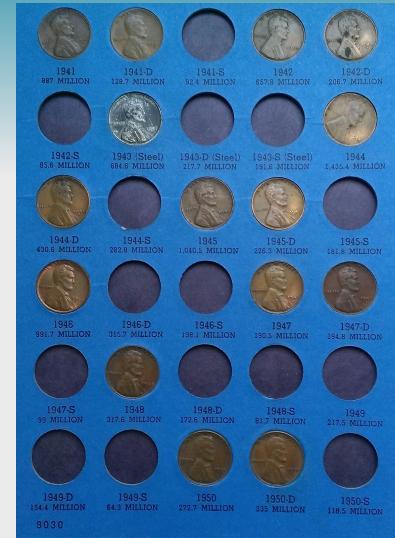
- Many provided collection classes in a class hierarchy (some shown here)
- **Collection** (abstract)
  - **SequenceableCollection** (abstract)
    - **ArrayedCollection** (abstract)
      - **Array**
      - **Heap**
      - **Interval**
      - **LinkedList**
    - **OrderedCollection**
      - **SortedCollection**
  - **Bag**
  - **Set**
    - **Dictionary**
    - **OrderedDictionary**

**OrderedCollection** is used frequently because **Array** instances have fixed length.

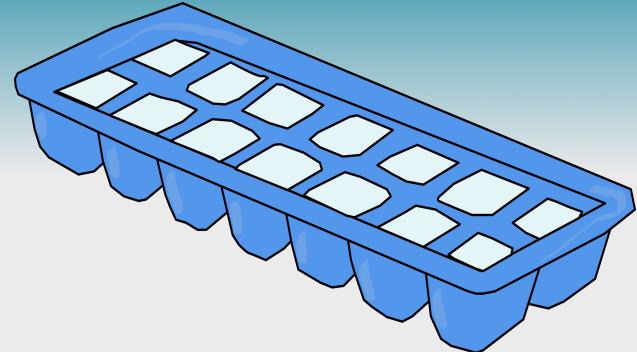
```
coll := OrderedCollection newFrom: #(1 2).  
coll add: 3.  
coll do: [ :n | (n * 2) print ]
```

2  
4  
6

**Dictionary** is like **Map** or **HashMap** in other languages.



# Arrays



- **Fixed length**
  - use `OrderedCollection` for variable length
- **Two literal syntaxes**
  - **compile-time array**
    - list of compile-time literal values separated by spaces
    - `#(1 4 8)`
  - **dynamic array**
    - list of run-time expressions separated by periods
    - `{score1. score2. score3}`
- Indexed from **1** rather than **0**



# Map, Filter, Reduce

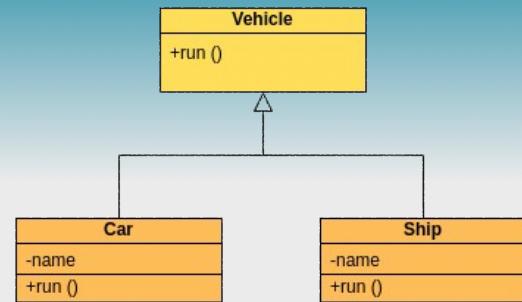
- **Map** creates new collection with same size as original
  - `collect` in Smalltalk
- **Filter** creates new collection containing subset of original
  - `select` in Smalltalk
- **Reduce** creates single value from elements of collection
  - `inject` in Smalltalk

```
numbers := #(1 2 3 4).
numbers collect: [:n | n * 2]. "#(2 4 6 8)"
numbers select: [:n | n odd]. "#(1 3)"
numbers inject: 0 into: [:acc :n | acc + n]. "10"
```

# Class Definitions

- Must be a subclass of some existing class
- Class name is a symbol
  - an interned **String**
- 3 space-separated lists
  - instance variable names
  - class variable names
  - pool dictionary names rarely used
- Category name
  - organizes classes

```
Object subclass: #Todo
instanceVariableNames: 'done text'
classVariableNames: ''
poolDictionaries: ''
category: 'TodoApp'
```



# Instance Variables

- Always private
- To expose, define accessor methods

```
text
```

```
^text
```

```
text: aString
```

```
text := aString
```

^ returns an object from a method  
and is typically rendered as ↑

:= assigns a value to a variable  
and is typically rendered as ←



# Methods

- Always public
- Always return an object
  - if none specified, `self` is returned to support chaining
- Organized by category inside each class
- Methods that should only be used by others in the same class, should be in a method category whose name begins with “**private**”
  - ex. method `emptyCheck` in `Collection` class is in **private** method category

# Method Arguments

- Follow convention for argument names that describes expected type

```
findFirst: aBlock startingAt: aNumber  
...  
  
from: fromNumber to: toNumber do: aBlock  
...
```

- No such thing as passing wrong type,  
only passing an object that doesn't respond  
to all the messages that will be sent to it

# doesNotUnderstand ...

- Special method **doesNotUnderstand** is invoked when a message is sent to an object and there is no corresponding method
- Examples
  - can be used in an Active Record implementation for database table column accessors
  - next slide shows using to remove need to implement accessor methods for instance variables
    - not recommending this, just showing an interesting approach

equivalent to Ruby's  
`method_missing`

# ... doesNotUnderstand

```
doesNotUnderstand: aMessage
    "Handle requests to get or set an instance variable"
    | keyword keywords |

    keywords := aMessage keywords.

    "Only handle messages with a single keyword."
    keywords size > 1 ifTrue: [^super doesNotUnderstand: aMessage].

    keyword := keywords first.
    keyword endsWith: '::' :::
        ifTrue: [
            | arg instVarName |
            instVarName := keyword allButLast asSymbol.
            arg := aMessage arguments first.
            self instVarNamed: instVarName put: arg.
        ]
        ifFalse: [
            ^ self instVarNamed: keyword.
        ].
```

```
Object subclass: #Book
instanceVariableNames:
    'author pages title year'
classVariableNames: ''
poolDictionaries: ''
category: 'Experiments'
```

```
b := Book new.
b title: 'Server-Driver Web Apps with htmx'.
b author: 'R. Mark Volkmann'.
b pages: 160.
b year: 2024.

b title. 'Server-Driver Web Apps with htmx' .
```



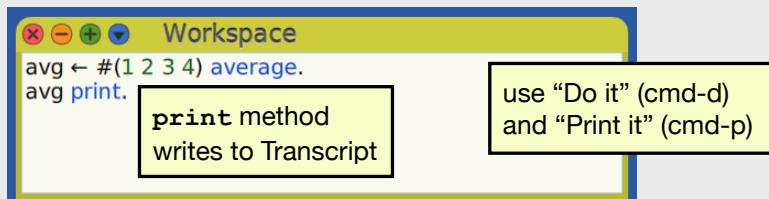
# Pseudo Variables

- Reserved words whose value is provided automatically and cannot be modified
- Six of them: **true**, **false**, **nil**, **self**, **super**, and **thisContext**
- **true** and **false** represent Boolean values
  - refer to singleton instances of **True** and **False** classes
- **nil** represents lack of a real value
- **self** is used in instance methods to refer to current object
  - also in class methods to refer to current class
- **super** is used in instance methods to refer to superclass of current object
  - also in class methods to refer to superclass
- **thisContext** represents top frame of run-time stack
  - used to implement development tools like Debugger

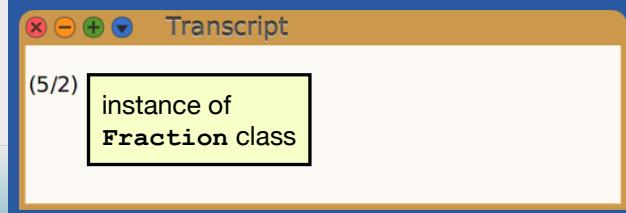
**self** and **super** are often used as the receiver of messages

# Development Environment

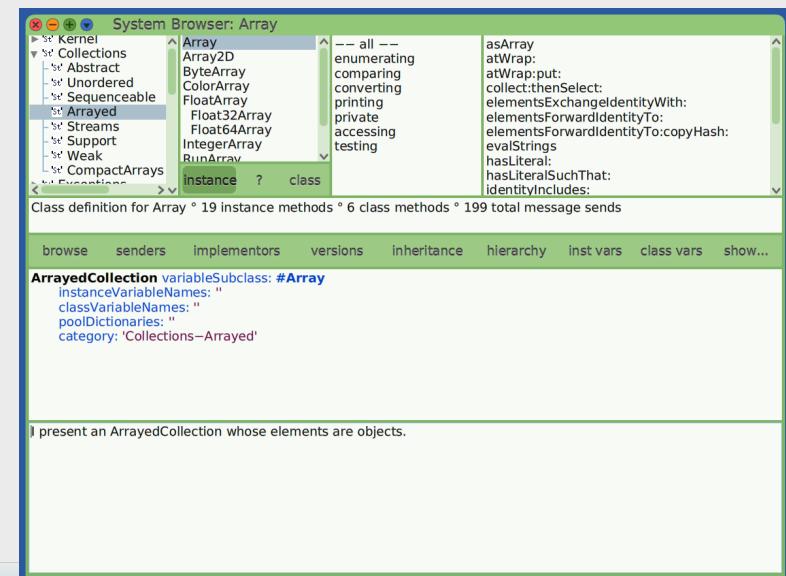
- Many kinds of windows
- Main ones are
  - **System Browser** - for reading, writing, and modifying code
    - see next slide
  - **Workspace** - for experimenting with message sends



- **Transcript** - for displaying output



By default, focus moves with cursor position.



# System Browser

class categories    classes in selected category    method categories    methods in selected category

System Browser: Array

Kernel  
Collections  
Abstract  
Unordered  
Sequenceable  
Arrayed  
Streams  
Support  
Weak  
CompactArrays  
Exceptions

Array  
Array2D  
ByteArray  
ColorArray  
FloatArray  
Float32Array  
Float64Array  
IntegerArray  
RunArray

-- all --  
enumerating  
comparing  
converting  
printing  
private  
accessing  
testing

asArray  
atWrap:  
atWrap:put:  
collect:thenSelect:  
elementsExchangeIdentityWith:  
elementsForwardIdentityTo:  
elementsForwardIdentityTo:copyHash:  
evalStrings  
hasLiteral:  
hasLiteralSuchThat:  
identityIncludes:

instance ? class

Class definition for Array ° 19 instance methods ° 6 class methods ° 199 total message sends

browse senders implementors versions inheritance hierarchy inst vars class vars show...

**ArrayedCollection** variableSubclass: #Array  
instanceVariableNames: ""  
classVariableNames: ""  
poolDictionaries: ""  
category: 'Collections-Arrayed'

I present an ArrayedCollection whose elements are objects.

Code is written and read one method at a time, not in one source file per class.

# Saving and Sharing Code

- Three options
  - in an **image**
    - from World menu, select **Save Image**, **Save Image as...**, or **Save Image and Quit**
  - in a **package**
    - from Installed Packages window, select a modified package and click “save” button
    - for packages with an associated GitHub repository, push changes
    - can install in other images
  - in a **fileOut**
    - from a Browser window, select a class category, class, or method, right click, and select **fileOut**
    - uses “chunk” format described on next slide
    - can **fileIn** from a File List window



# Chunked Format

- **.st** files are human-readable text file that contain “chunks”
- Each chunk is delimited by exclamation marks (bang)
- A chunk can contain
  - **From** line that gives version of Smalltalk that created the file and creation date/time
  - **classDefinition** that associates a class with a class category
  - **subclass**: message send that creates a class
  - **methodsFor** which states that the method definitions that follow are in a given method category
  - method definition
  - message send that creates an object
  - message send that executes code for its side effects



# File List

- Can navigate file system
- Can create, rename, view contents, and delete directories
- Can create, rename, view contents, edit (text files), and delete files
- For **.st** files
  - can open “code changes” window to view contents one class definition or method at a time
  - can “fileIn” to load into current image

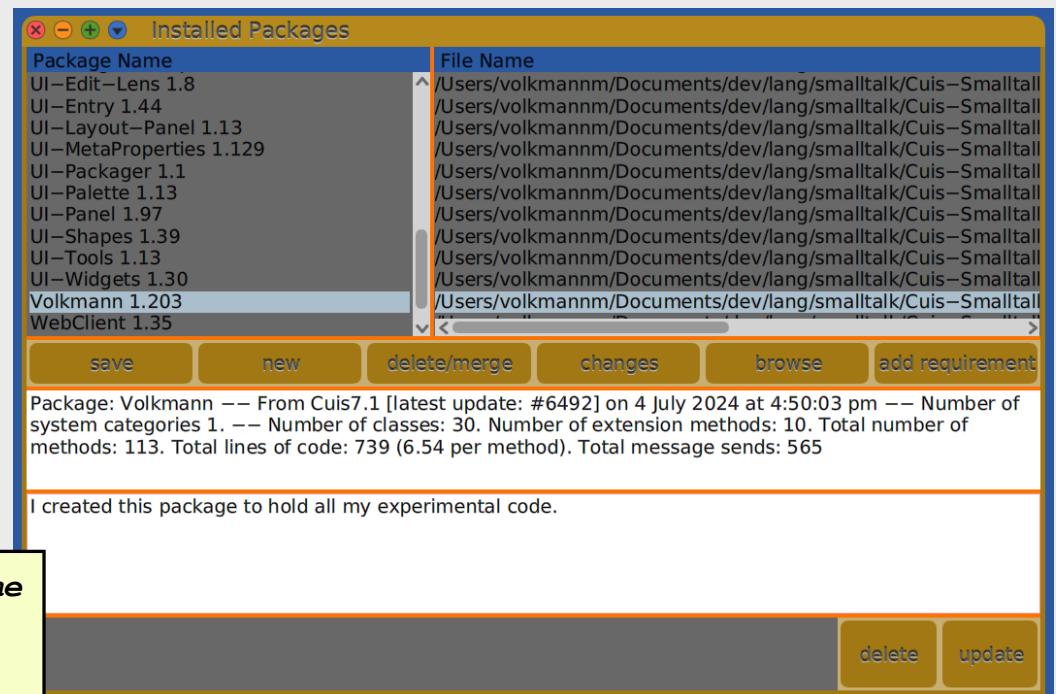
		name	[v] – date	size
		UserPrefs.txt	( 2024/10/03 12:23:36	142 )
		hello	( 2024/09/28 13:49:07	33,432 )
		hello.c	( 2024/09/28 13:48:31	138 )
		pets.db	( 2024/09/23 13:40:56	12,288 )
		LayoutMorph.st	( 2024/08/18 20:12:38	53,354 )
		todo-app-workspace	( 2024/08/18 07:00:52	244 )
		my-workspace.st	( 2024/08/17 16:45:07	984 )
		layout-issue	( 2024/08/12 18:57:53	559 )
		BeverlyHillbillies.txt	( 2024/05/31 10:44:09	797 )
NO FILE SELECTED				
-- Folder Summary --				
		UserPrefs.txt	( 2024/10/03 12:23:36	142 )
		hello	( 2024/09/28 13:49:07	33,432 )
		hello.c	( 2024/09/28 13:48:31	138 )
		pets.db	( 2024/09/23 13:40:56	12,288 )
		LayoutMorph.st	( 2024/08/18 20:12:38	53,354 )
		todo-app-workspace	( 2024/08/18 07:00:52	244 )
		my-workspace.st	( 2024/08/17 16:45:07	984 )
		layout-issue	( 2024/08/12 18:57:53	559 )



# Installed Packages

- Displays list of installed package
- Can create, browse, uninstall, and delete packages
- Can view changes to a package and save them
- Can add dependencies to a package

Packages in directories named **Cuis-Smalltalk-Name** can also be installed from a Workspace with **Feature require: 'Name'**



# DEMO #1

- Open a Browser
- Hover over class categories pane
- Press cmd-f and enter “**Stri**”
- Select “**String**” class
- Hover over methods pane
- Press “**i**” to scroll to first entry that begins with that
- Select “**isEmpty**” method
- Note that it sends the message “**size**” to **self**
- Click **size** method and discuss primitives (62 returns collection size)
- Click “?” button to see class comment
- Click “class” button to see list of class methods

# DEMO #2

- Open Browser
- Right-click in class categories pane and select “add item...”
- Enter “**Demo**”
- In bottom code pane, change “**NameOfSubclass**” to “**Greeter**”
- Press cmd-s to save new class
- Add “**message**” to **instanceVariableNames** list
- In message categories pane, select “**as yet unclassified**”
- Add these methods
- Place first two methods in method category “accessing” and last one in “printing”
- Open Workspace
- Enter following lines, select them, and press cmd-d to “Do it”

```
g := Greeter new message: 'Hello, World!'.
g greet
```

```
message
^message

message: aString
message := aString

greet
message print
```

# Inspect/Explore Windows



- Inspect windows examine a single object
- Explore windows examine a tree of objects starting from one
- Both can send messages to selected object in bottom pane

**Inspect: a Dog**

self	breed: 'Whippet'
all inst vars	name: 'Comet'
breed	
name	

inspect window

```
self speak 'bark' .
```

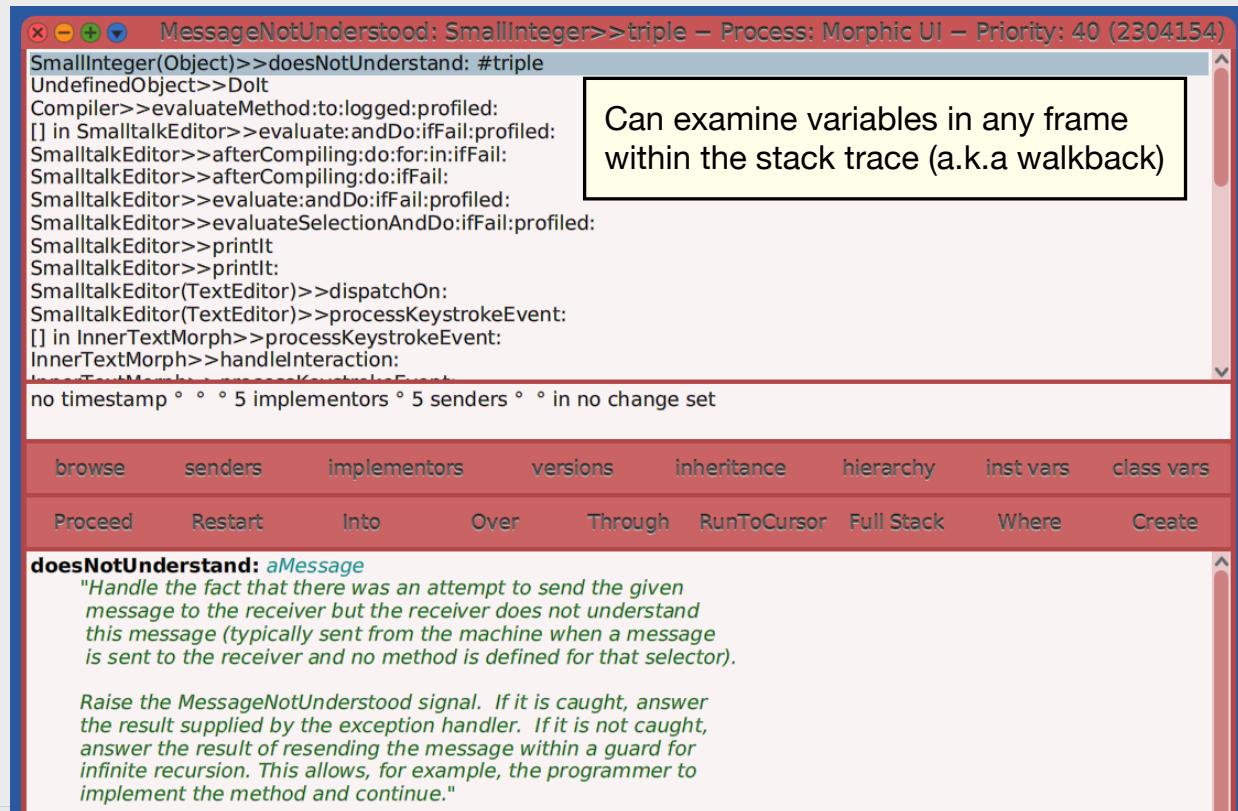
**a Dog**

root: a Dog
▶ breed: 'Whippet'
▶ name: 'Comet'
└ 1: \$C
└ 2: \$o
└ 3: \$m
└ 4: \$e
└ 5: \$t

explore window

```
self speak 'bark' .
```

# Most Common Error





# DEMO #3

- In the Workspace, enter “g” (variable name)
- Press cmd-i to “Inspect it”
- Press cmd-l to “Explore it”
- In bottom pane of either window, enter `self message asUppercase`
- Press cmd-p to “Print it”



# DEMO #4

- Open a “Message Names” window
- Enter “`at:put:`”
- Select “`Dictionary at:put:`”
- Study signature, method comment, and method body
  - `findElementOrNil` is implemented in `Set` which is the superclass of `Dictionary`
  - `ifNil:ifNotNil:` is implemented in `ProtoObject` which is the superclass of `Object` which is a superclass of every class



# Morphic

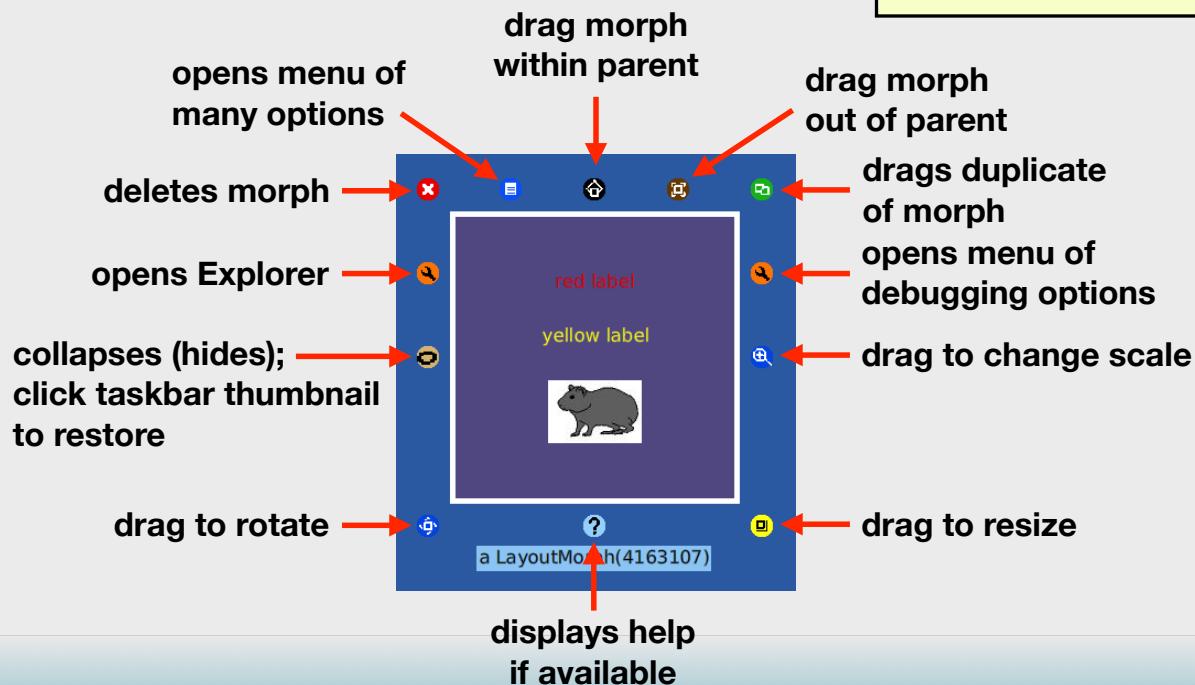
- GUI framework included in popular Smalltalk images such as Squeak, Pharo, and Cuis
- Defines user interfaces with “morphs”
  - objects that know how to render themselves in Smalltalk environment
  - referred to as widgets or components in other GUI frameworks
- Examples
  - `CheckButtonMorph`, `ImageMorph`, `LabelMorph`, `LayoutMorph`, `RadioButtonMorph`, `TextEntryMorph`, `TextModelMorph`



# Halos

- cmd-click a morph to display its halo which is a collection of “handles” around its perimeter

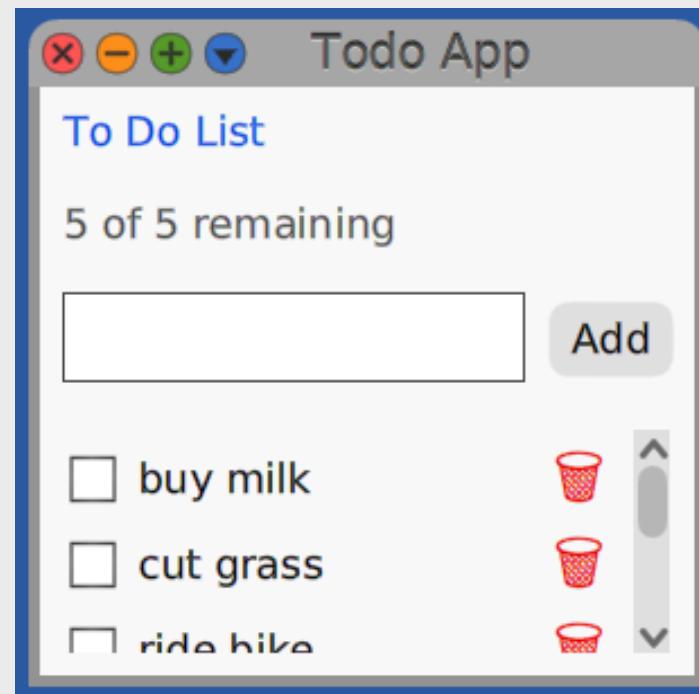
Hover over any handle to see a tooltip that describes it.





# Todo App

- Demonstrate app in Cuis
- Walk through code in Cuis





# Class Names

- Class names must be unique within an image
- Issue if
  - two installed packages define a class with same name
  - you create a class with same name as an installed package
- Seems like a serious restriction, but rarely happens
- When it does, options include
  - combine functionality of classes into one
  - rename one of the classes and update all references to it

Will be asked to confirm with  
“Name is an existing class in this system.  
Redefining it might cause serious problems.  
Is this really what you want to do?”



# Primitives ...

- Primitive methods are implemented in the VM for more efficiency than can be achieved in Smalltalk code
- Examples of messages that invoke primitives include
  - `+ message` to small integers
  - `at:` message to objects with indexed instance variables
  - `new` and `new:` messages to classes



# ... Primitives

- Methods that are implemented with primitives begin with `<primitive #>` where # is an integer indicating the primitive method to invoke
- If this succeeds, the containing Smalltalk method will return its value and expressions that follow are not evaluated
- If this fails, execution continues in the Smalltalk method
- Example
  - `SmallInteger + method`
- Functionality of specific numbered primitives can differ between VM implementations

```
+ aNumber  
<primitive: 1> ←  
^ super + aNumber
```

This is provided with the receiver and the argument and returns their sum.

# Resources

- **My Blog**
  - <https://mvolkmann.github.io/blog/> - click Smalltalk in left nav
- **Smalltalk Wikipedia page**
  - <https://en.wikipedia.org/wiki/Smalltalk>
- **Cuis Smalltalk**
  - <https://cuis.st/>
- **Pharo Smalltalk**
  - <https://pharo.org/>
- **Squeak Smalltalk**
  - <https://squeak.org/>
- **Byte Magazine issue on Smalltalk**
  - <https://archive.org/details/byte-magazine-1981-08>



# Wrap Up

- For me, Smalltalk has the most elegant syntax of any programming language
- Even if you choose not to use Smalltalk, there are many ideas from it that can be applied to other programming languages
  - especially in its development environment
- Todo App code at  
<https://github.com/mvolkmann/Cuis-Smalltalk-TodoApp>