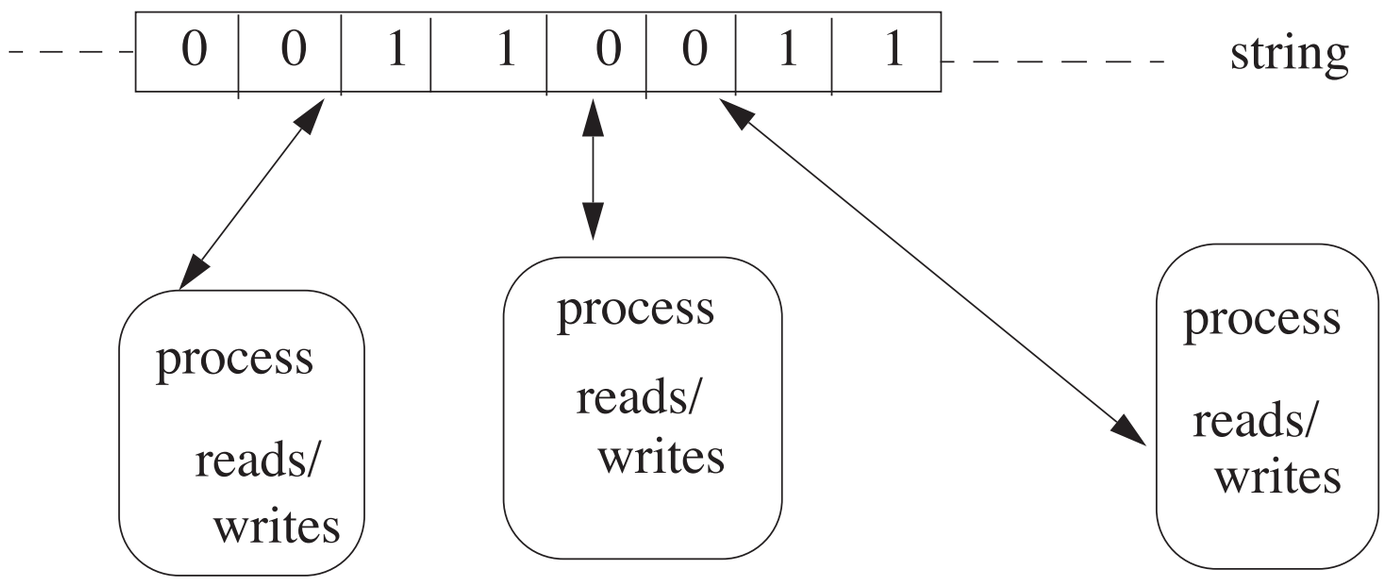
Introduction to Object-oriented Programming in Smalltalk

Objects are responsible for their own actions!

- In procedural programming, I write code that reaches into the internals of some data structure and twiddles with the bits



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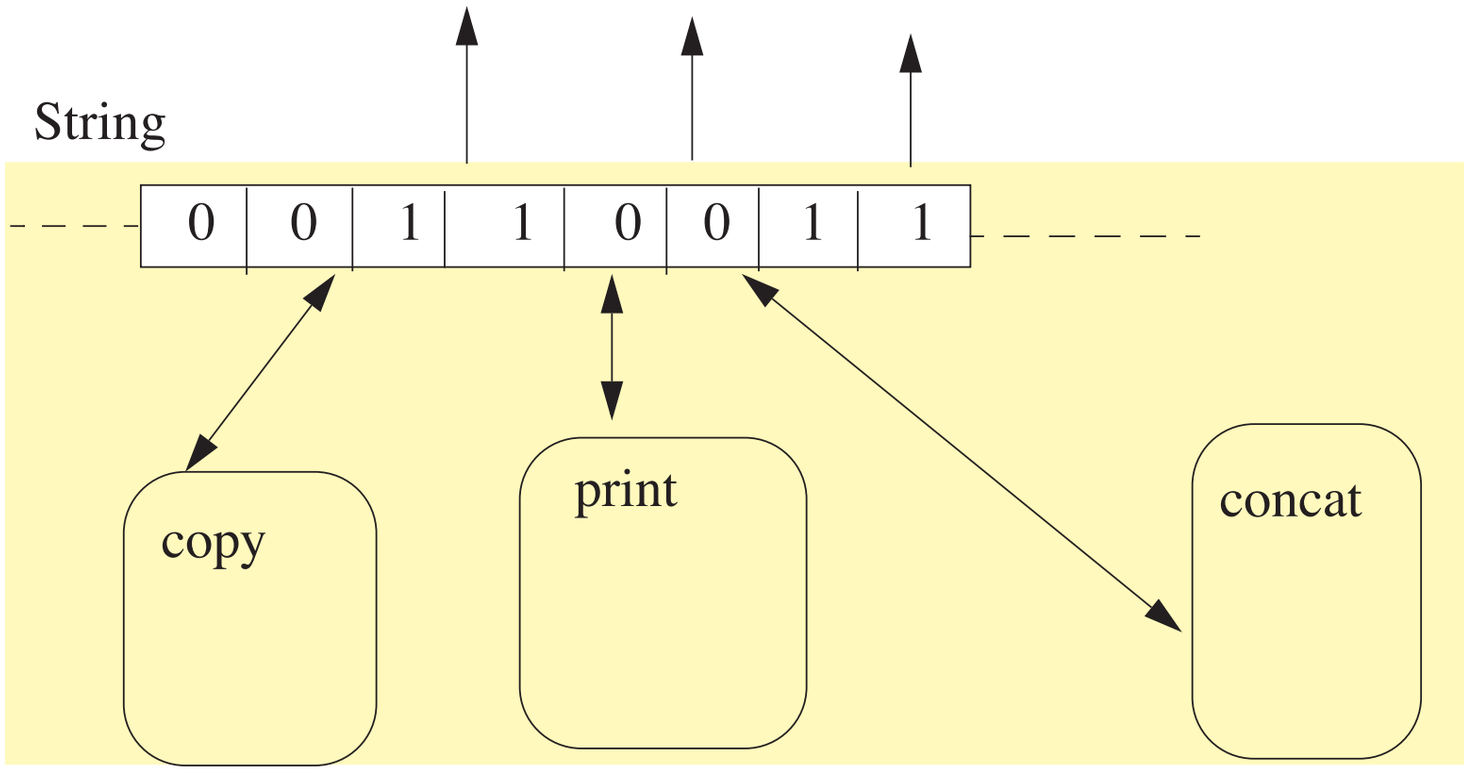

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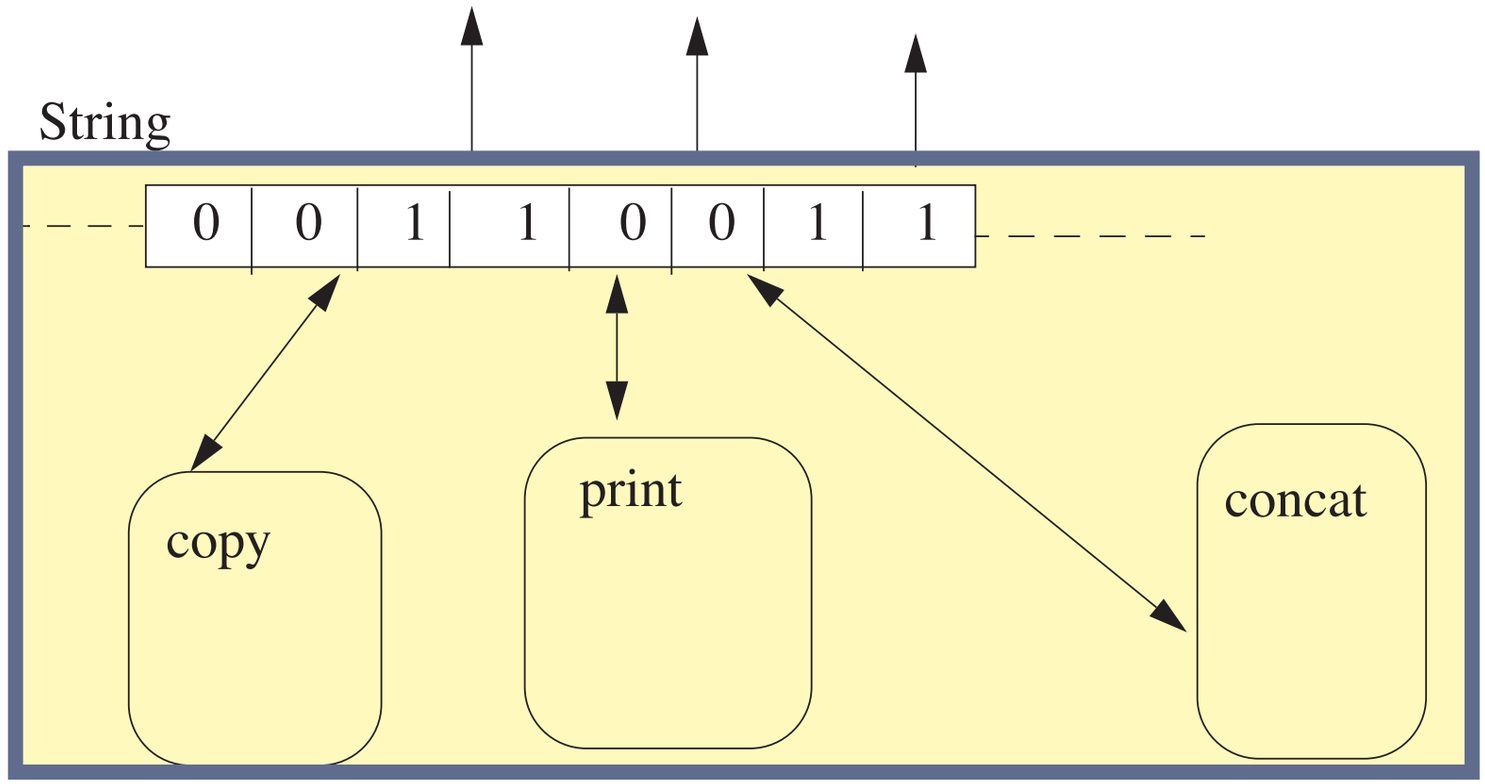

Encapsulation boundary

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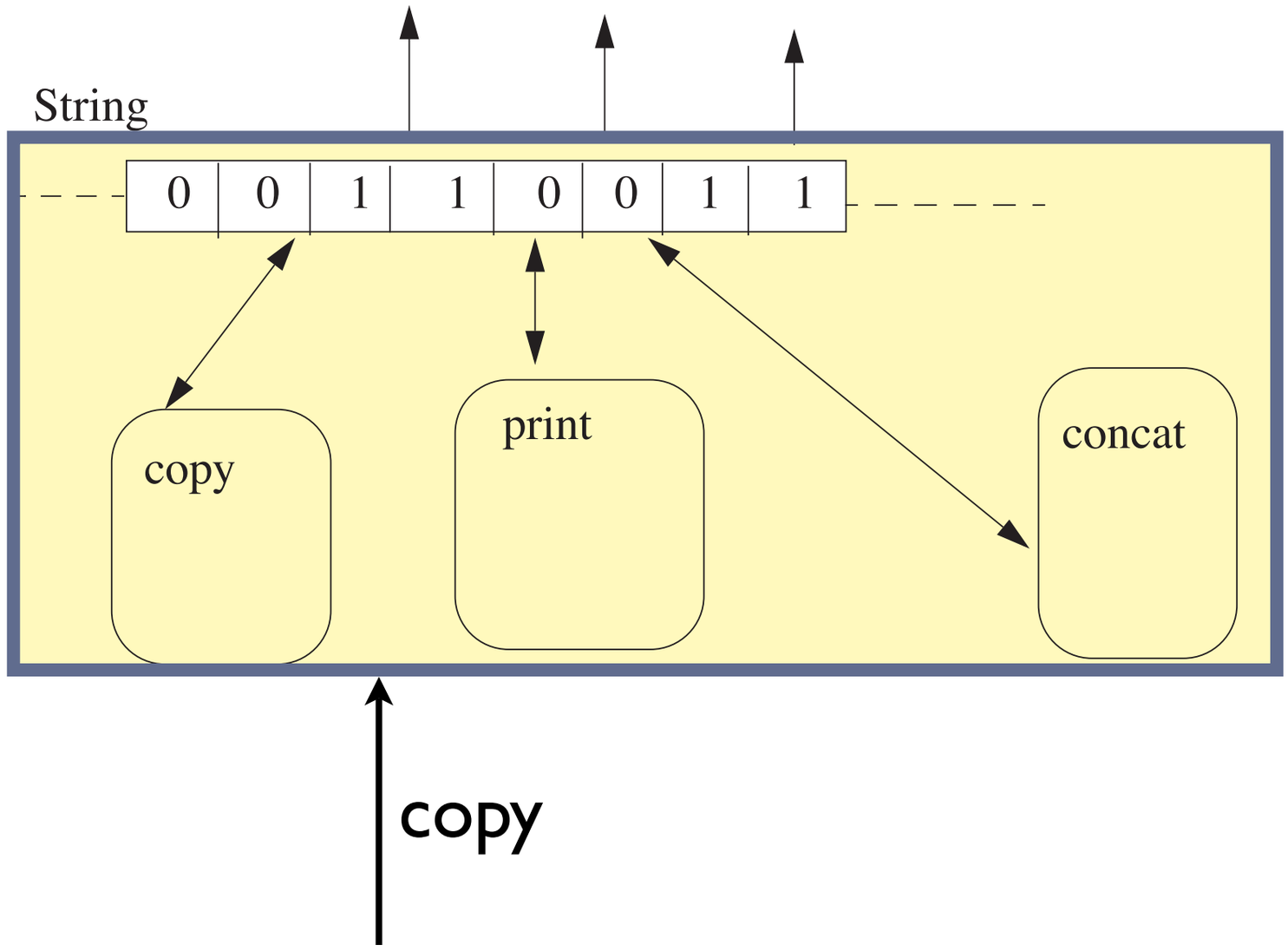

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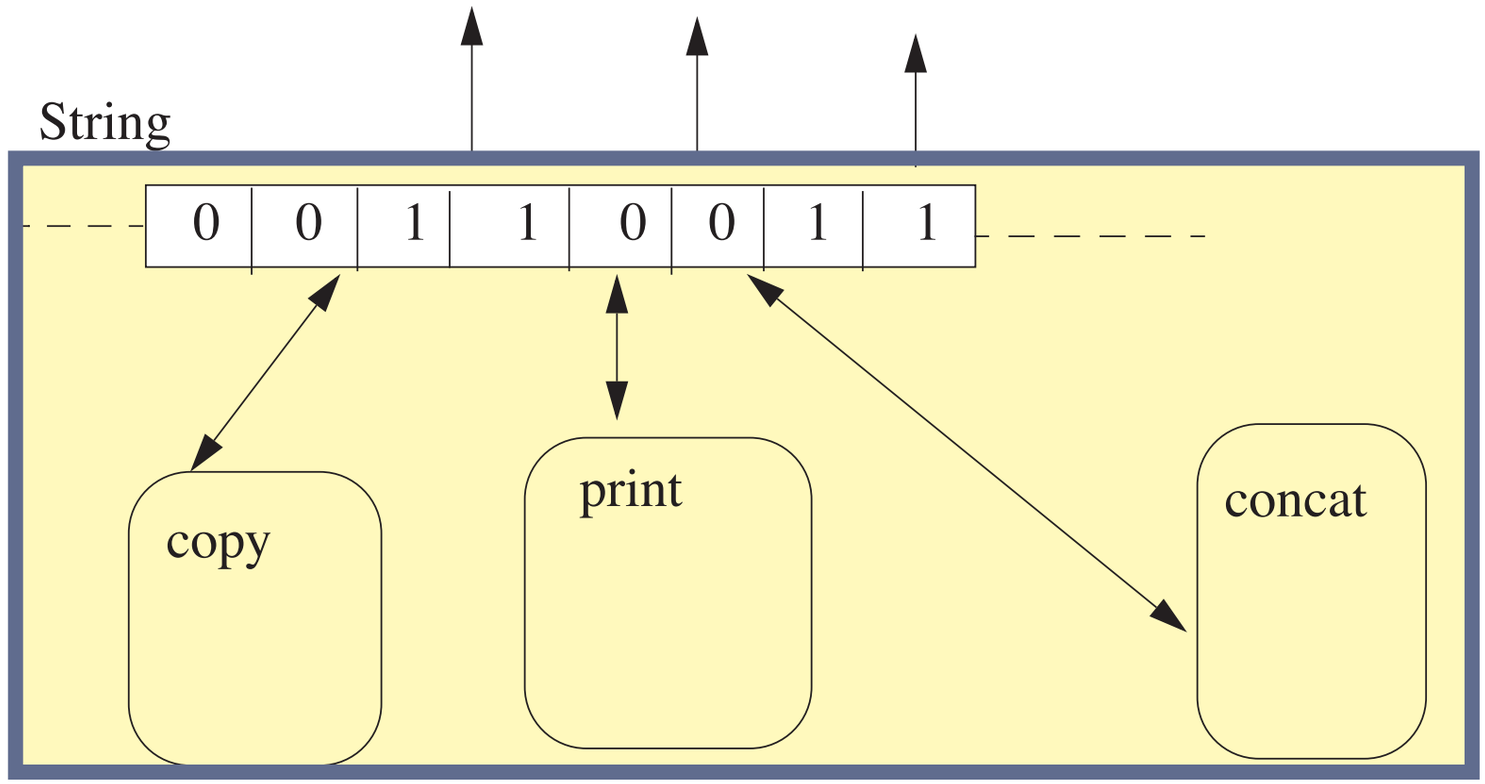

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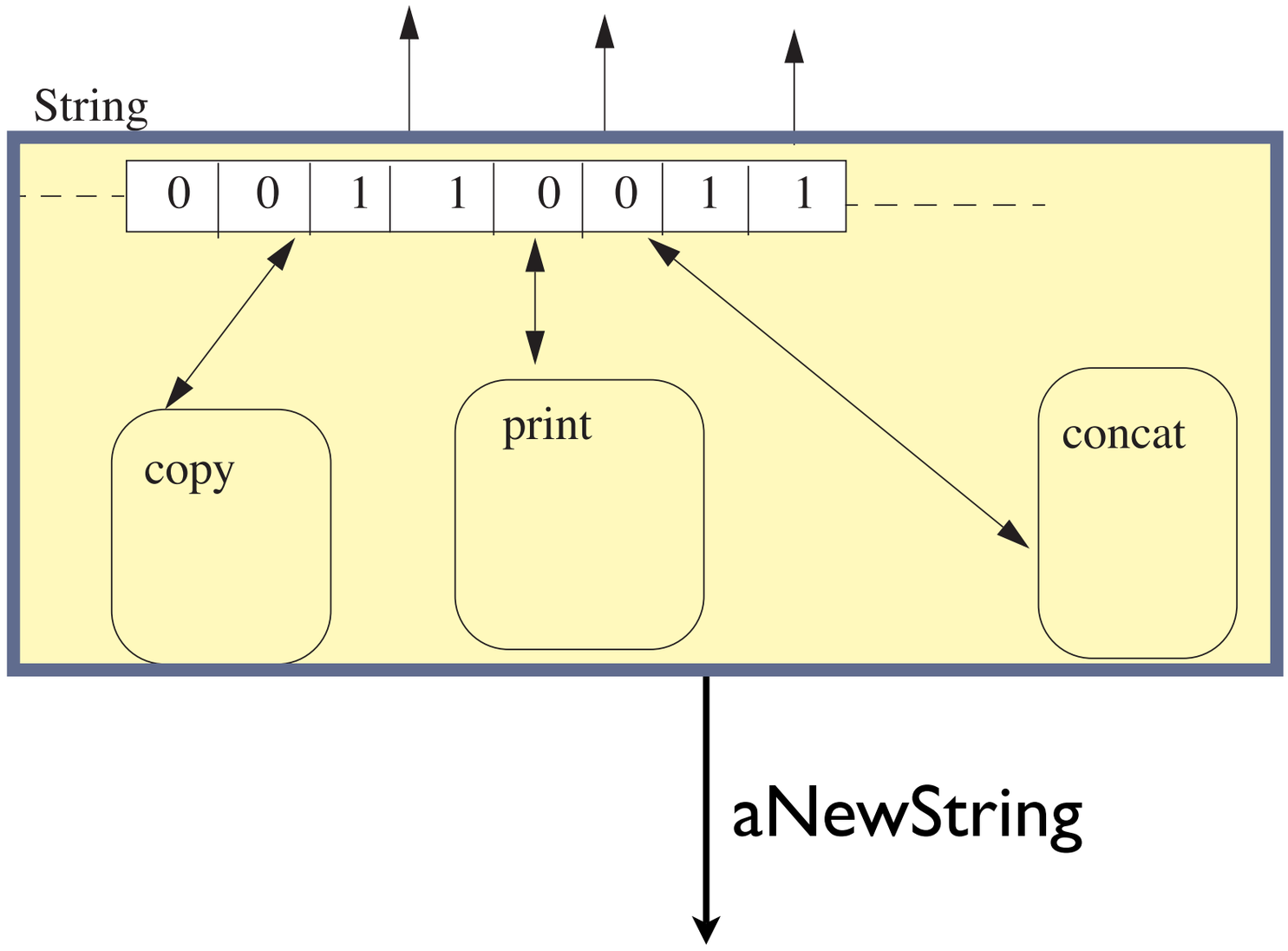

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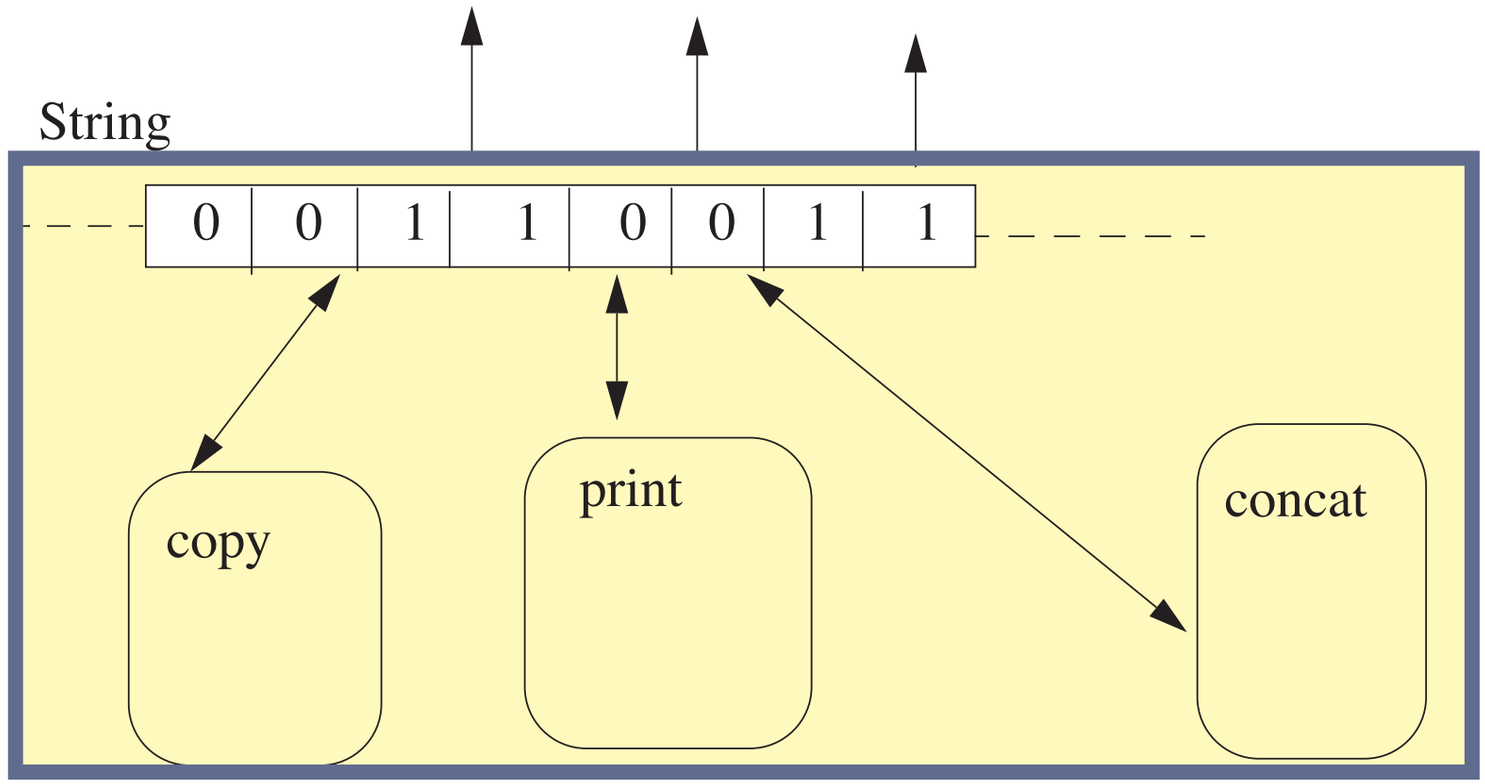


Encapsulation boundary

Computation as Simulation

- Encapsulation is key
- Autonomous objects in the program represent objects in the real world
  - just like discreet event simulation
- Antropomorphize!
  - It's OK to think about *this* object talking to *that* object…
  - in fact, it's recommended

Programming Philosophy

- Object-Oriented programming is programming by simulation.
  - The algorithm is less important than the structure of the solution.
- When requirements change:
  - If the structure represented the structure of some ‘reality’, then the new requirements will be consistent in that reality.
  - Object-oriented design is the search for this structure: uncover the structure rather than construct in isolation.

Shopping vs. Building

- Constructing an Object-oriented application is a process of shopping for the components that one needs
  - occasionally we add a new item to the shelf.
  - usually we can find a component that *almost* fits.
- The *openness* of an OO language allows the programmer to change the component that *almost* fits into one that is a *good* fit.
  - works only if we have a rich set of components on the shelf, and if they are open to change.

Is this the *only* view of OO Programming?

No! People disagree on the meaning and role of:

1. Encapsulation
2. Types
3. Inheritance
4. Polymorphism
5. Sets and classes

Smalltalk

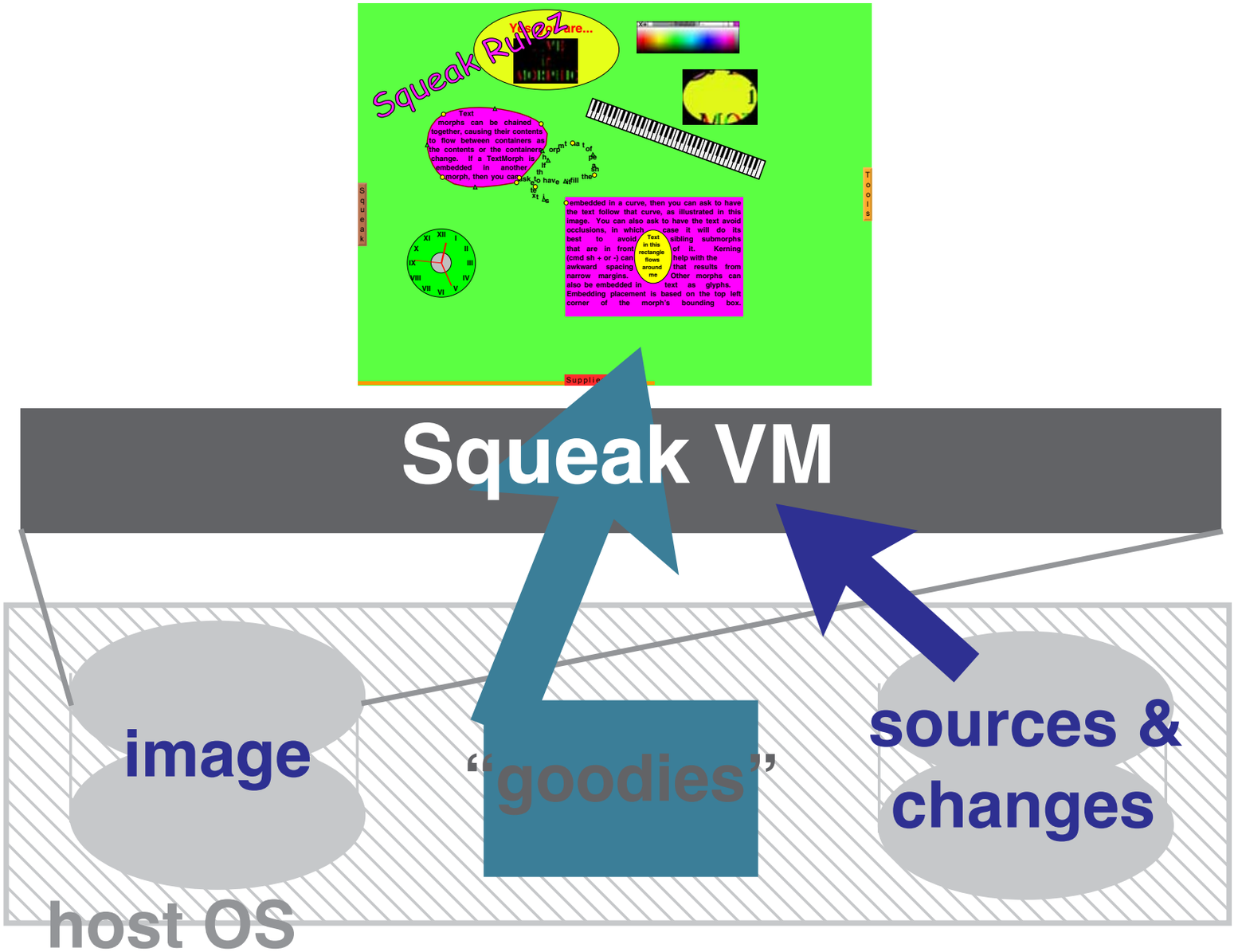
- Squeak is an open-source version of Smalltalk.
  - Smalltalk is still the best example of a Pure O-O language
  - The Squeak workspace is a place in which you can create and interact with objects.
- Large and active community of contributors
  - Runs “bit identical” on just about any platform, including many PDAs

The Squeak Environment

A “place” to experiment with objects

- Forget applications, files, compilers, data...
- Focus on objects

The Squeak World



Smalltalk Syntax

- No syntax for classes, packages, *etc.*
  - Class creation and method categorization are done *imperatively* using the development tools
- The method syntax is simple, but different

```
>= aString
        "Answer whether the receiver sorts after or equal to
        aString. The collation order is simple ascii (with case
        differences)."

        ^ (self compare: self with: aString collated: AsciiOrder) >= 2
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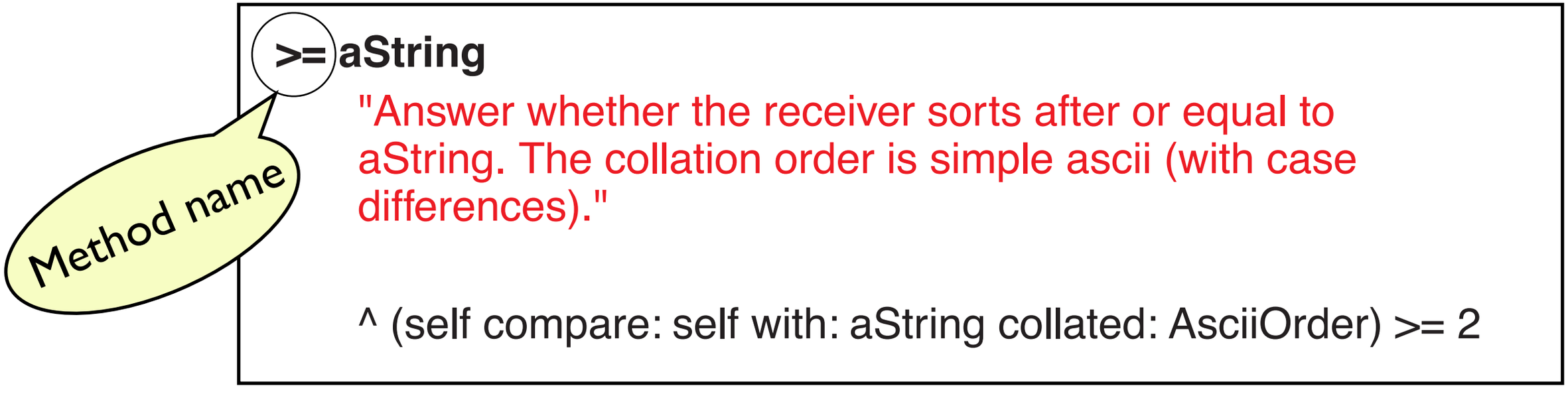

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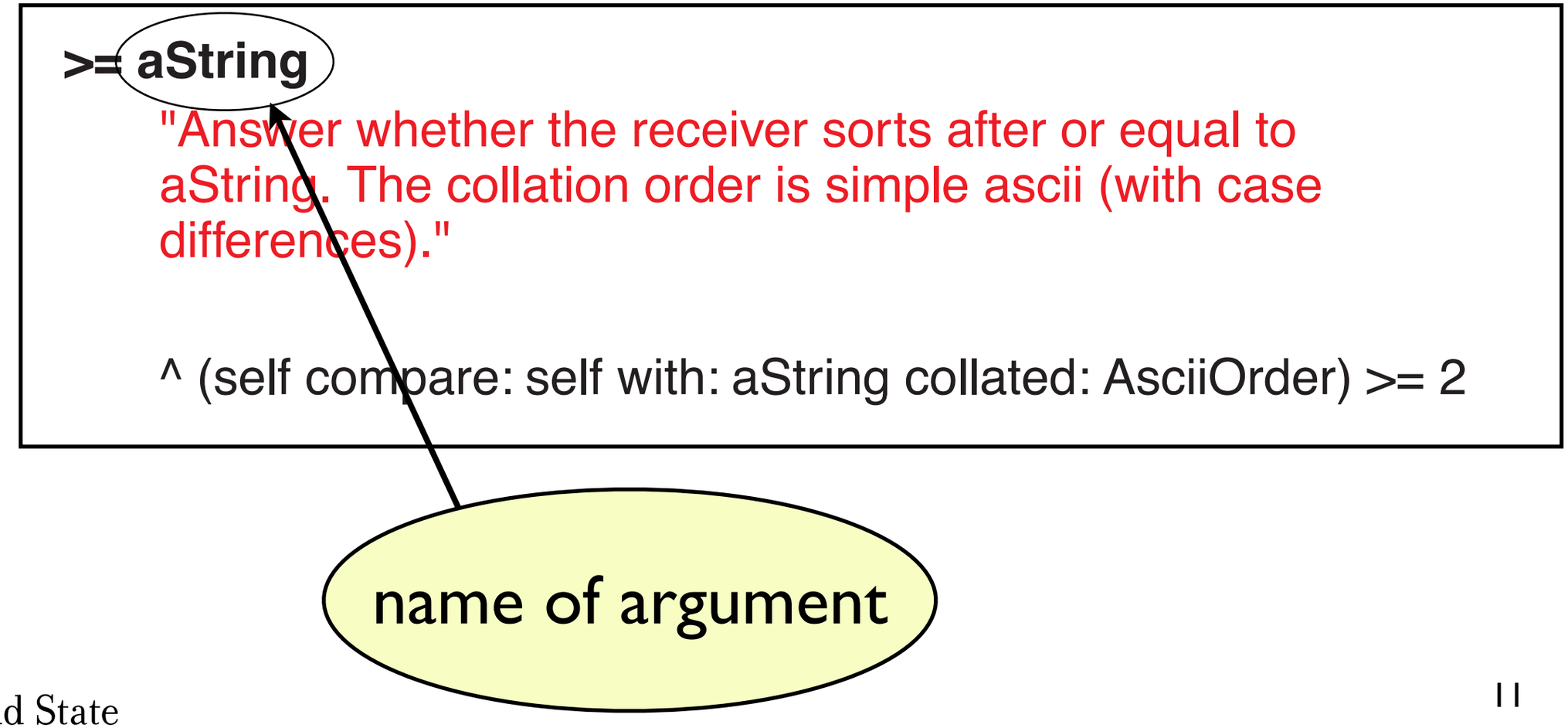

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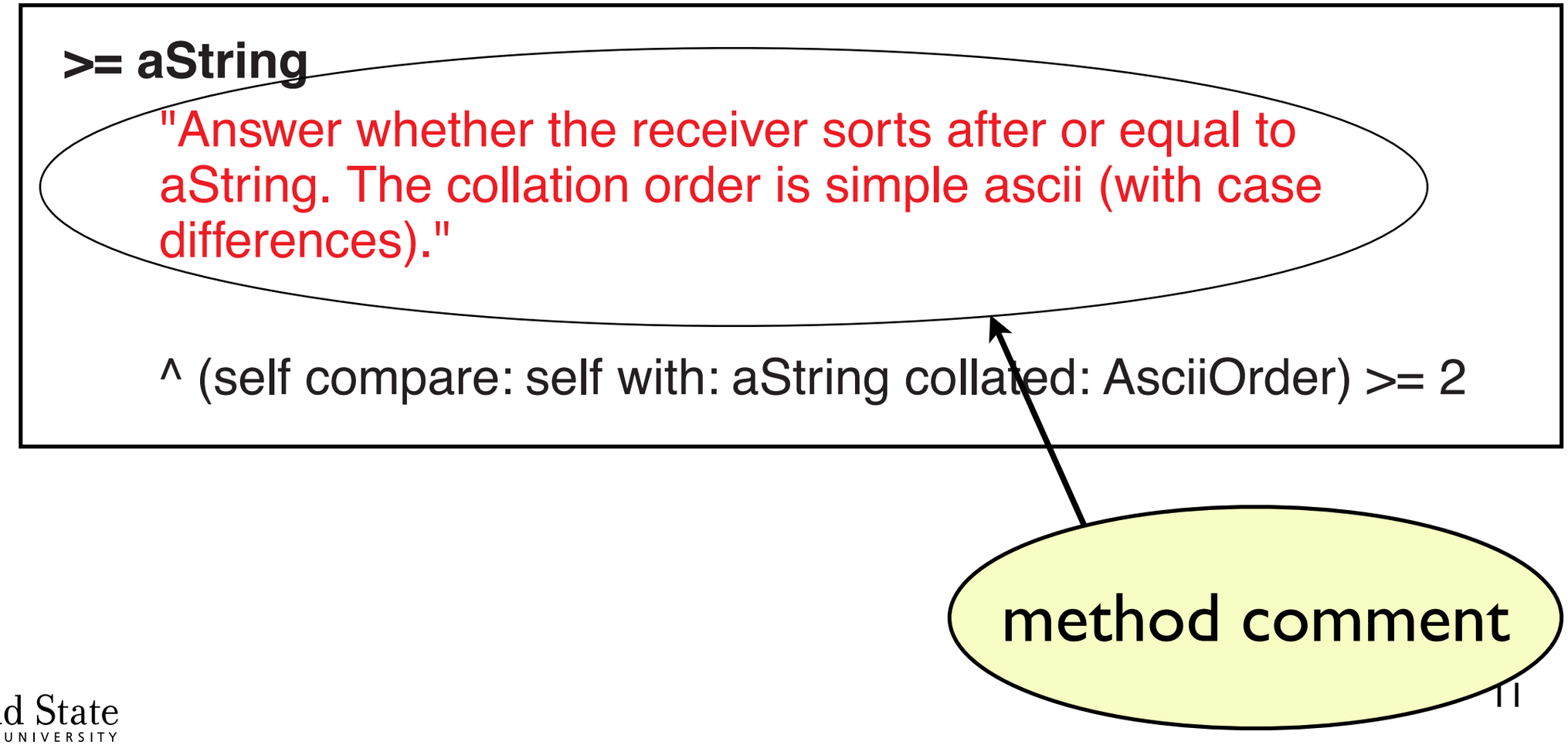

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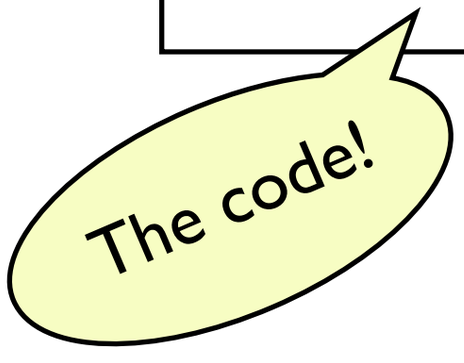


Read code

- The best way to become familiar with Smalltalk programming is to read the code in the image
- Expect to read 10 to 100 lines of code for each one that you write
  - If you find that you are writing long methods, you haven't “got it” yet.
  - Find a method in the image that does something like what you want, an learn from it

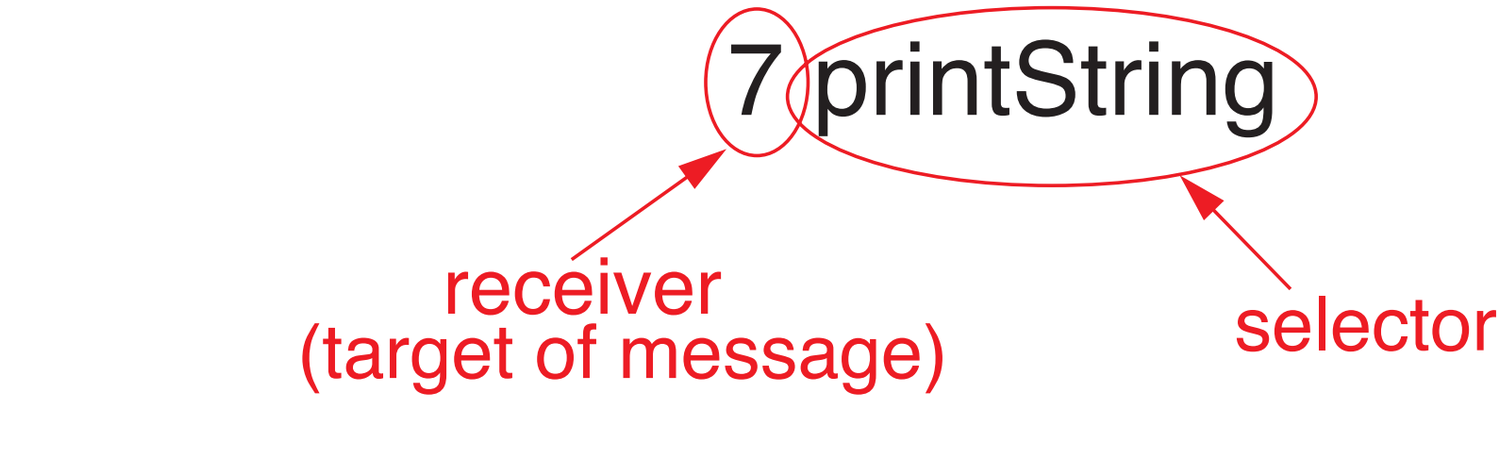
Smalltalk — The Language

Literal Objects

27	The unique object 27
18.5	The floating point number 18.5
1.85e1	same as above
'a string'	a string
#request	the symbol *request.* It is unique; two symbols with the same name denote the same object
$r	the single character *r*
#(3 2.7 'a string')	an array literal. This is a heterogeneous array containing an integer, a float, and a string

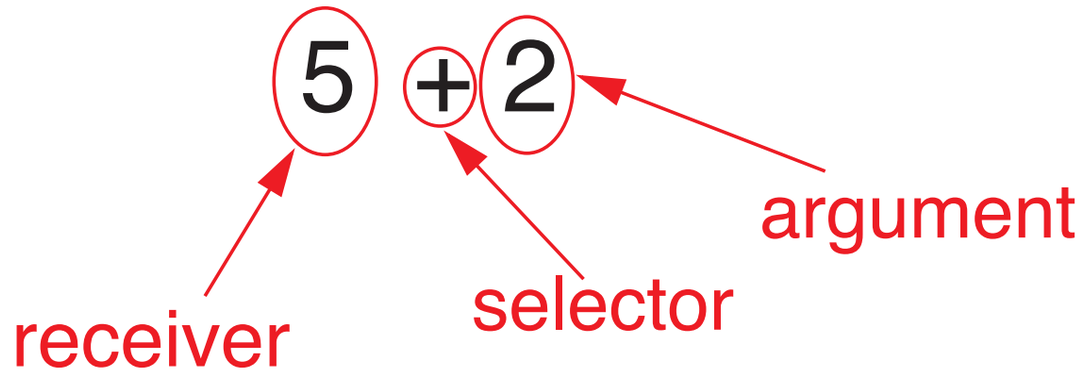
Sending Messages

Unary Message (no arguments)



- selector is a keyword-like *symbol*
  - examples: 3 factorial
    7 negated
    $c asInteger
  - note: no colon at the end of the symbol

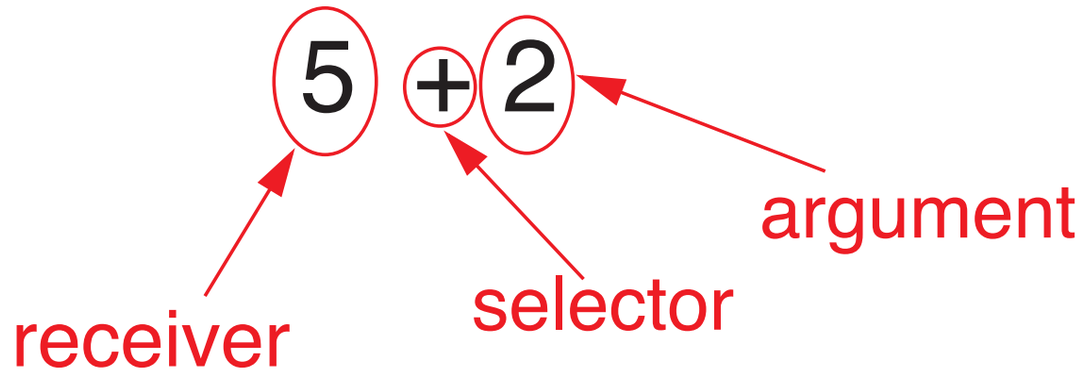
Binary Message (one argument!)



- selector is one or two special characters

7 = 5	message *= 5* sent to object 7
i + 3	message *+ 3* sent to object i
17 // 3	message *// 3* sent to integer object 17 (result is 5)
17 / 3	message */ 3* sent to integer object 17 (result is)

Binary Message (one argument!)



- selector is one or two special characte

Not exactly; *i* is not an object. It's a variable that's bound to an object

7 = 5	message = *5* sent to object 7
i + 3	message + *3* sent to object *i*
17 // 3	message // *3* sent to integer object 17 (result is 5)
17 / 3	message / *3* sent to integer object 17 (result is)

Keyword Messages

- one or more arguments
  - Examples:

    #(3 5 7 9 11) at: 2

    game movefrom: pinA to: pinB using: pinC

    5 between: 0 and: 9
- The colon ‘**:**’ indicates to the parser that an argument follows the keyword.

Order of Evaluation

- The receiver (or an argument) can be another invocation (message expression)
- Evaluation order is
  - parenthesized invocations
  - unary invocation, evaluated *left to right*
  - binary invocations, evaluated *left to right*
  - keyword invocations
- No “priorities” for particular operators
  - * does not bind more tightly than +

Cascaded Messages (syntactic sugar)

```
anArray at: 1 put: 9.
anArray at: 2 put: 11.
anArray at: 3 put: 13.
```

- This can be abbreviated as

```
anArray at: 1 put: 9; at: 2 put: 11; at: 3 put: 13
```

receiver for all 3 messages

"receiverless messages"

- Result is that of the last message send

```
Transcript show: 'Hello World'; cr
```

Variables

Instance Variables

- The names of the “slots” in an object, which make up its representation.
- declared in the class

```
instanceVariableNames: 'name1  name2'
```

Temporaries

- Names local to a method body or block

```
| student  professorAtOGI |
```

Assignment

x := 3 + 5

– make *x* name the object resulting from the evaluation of the expression *3 + 5*

y := Array new: 1000000

– make *y* name a new 1MB array

- Variables name objects
  - They do not provide storage for objects
- Assigning to a variable makes it name a different object
  - no object is created or copied by assignment

Learning More

- Finding Classes
  - By name or fragment of a name
    - command-f in the Class-category pane of a browser
  - By selecting a morph and choosing browse morph class from the debug menu

- Finding methods
  - By name fragment or by example — with the method finder
  - Smalltalk browseMethodsWhoseNamesContain: 'screen'
  - Smalltalk browseMethodsWithString: 'useful', or highlight the string and type *command-E*
  - highlight a selector, choose implementors of … (*command-m*) or senders of …(*command-n*)

Finding Answers

Some invaluable resources:

- The Squeak “Swiki”
  - a wiki is a website where anyone is free to contribute to editing and maintenance
  - http://minnow.cc.gatech.edu/squeak
    - snapshot at http://swikimirror.squeakspace.com/
- Squeak.org
  - Documentation, tutorials, swikis, other sites, books and papers, downloads, and information on …

- The Squeak mailing list
  - a friendly place where “newbies” are made welcome
  - squeak-request@cs.uiuc.edu
  - Archive of [FIX]es, [ENH]ancements, [GOODIE]s…

    http://swiki.gsug.org:8080/SQFIXES
  - Searchable archive of whole list

http://groups.yahoo.com/group/squeak

Creating Objects in Smalltalk

- Object are created by sending a message to some other (exisiting!) object called a *factory*
- *Usually,* the factory object is a class, *e.g.*

```
OrderedCollection new.
Array with: 'one' with: 'two' with: 'three'.
s := Bag new.
```

- The object will be deallocated automatically when it's no longer needed (garbage collected)

Blocks

- Blocks are Smalltalk objects that represent Smalltalk code

  ```
  [ 1 + 2 ]
  ```

  They can have arguments:

  ```
  [ :x | 1 + x ]
  ```
  compare with λ x. 1 + x

- Blocks understand messages in the value family:

  ```
  value
  value: value:
  ```

  ```
  value:
  value: value: value:
  ```

- The Block is *not* evaluated until it receives a value message

Examples of Blocks

- If-then-else is not a built-in control structure: it's a message

```
aBoolean ifTrue: trueBlock ifFalse: falseBlock

discountRate := (transactionValue > 100)
    ifFalse: [0.05] ifTrue: [0.10]
```

- You can build your own control structures:

```
( keyEvent controlKeyPressed )
        and: [keyEvent shiftKeyPressed]
```

Returning an Answer

↑ returns an answer from a method

- if there is no ↑, the method returns *self*
- ↑ is very useful to return from a block

```
color
    color ifNil: [↑ Color black].
    ↑ color
```

- ↑ in a block returns from the method in which the block is defined
  - *not* the method that evaluates the block!

Arrays

- Arrays in Smalltalk are Objects
  - They are “special” in 2 ways
    1. there is language syntax to create them

#(1 3.4 #symbol) an array literal

{4-3. 17/5 asFloat . ('sym','bol') asSymbol}

a dynamically constructed array

Array with: 4-3 with: 17.0/5 with: #symbol the same

2. there are ByteArrays, FloatArrays as well as Arrays

Characters & Strings

- Characters are also objects

  $H is the literal for the character H

  $H asciiValue is 72

  $H digitValue is 17, $3 digitValue is 3

- collect: creates a new array by applying a function to all elements of the receiver

```
'01234567890ABCDEF' asArray
        collect: [ :each | each digitValue]
```

evaluates to #(0 1 2 3 4 5 6 7 8 9 0 10 11 12 13 14 15)

Other enumeration methods

anArray do: aBlock

applies aBlock to each element of anArray, and answers anArray

anArray withIndexCollect: a2ArgumentBlock

answers the new array containing the results of applying a2ArgumentBlock to each element of anArray, together with its index.

anArray withIndexDo: a2ArgumentBlock

Examples

```
#(#one #two #three #four) withIndexCollect:
   [ :each :i |
      each,' = ', i asString]
```

evaluates to #('one = 1' 'two = 2' 'three = 3' 'four = 4')

```
#(#one #two #three #four) withIndexDo:
    [ :each :i |
       Transcript nextPutAll: each,' = '; show: i; cr]
```

evaluates to #(#one #two #three #four), i.e., the receiver

Indexing Arrays

- {#eins. #zwei. #drei} at: 1
- {#eins. #zwei. #drei} first
- {#eins. #zwei. #drei} third
- {#eins. #zwei. #drei} at: 2 put: #deux

modifies the receiver, and answers #deux

Assignment 1: Whole objects

- Parse numerals into numbers without using explicit loops or recursion
- Use the algorithm shown