Smalltalk

CSE 413: Programming Languages
Michael Ringenburg
miker@cs.washington.edu

Why Learn Smalltalk?

- A pure object-oriented language
  - All values are objects
  - All operations are message sends (the Smalltalk term for method calls)
- Historical context
  - One of the first object-oriented languages
  - Java was originally designed to provide "Smalltalk semantics in a C-like language".
- Still used today

Some History

- 1964: Kristen Nygaard and Ole-Johan Dahl develop Simula—the first object-oriented language.
- 1966: Alan Kay starts grad school at the University of Utah, and learns object-oriented programming from a pile of Simula code left on his desk.
- 1971: Alan Kay develops Smalltalk-71 as a programming language for the KiddiKomp.

Some History, continued …

- 1972: Smalltalk rewritten from scratch in response to a bet that Kay could define "the most powerful language in the world" in "a page of code".
- 1976: Smalltalk-76 developed.
- 1980: Smalltalk-80 (modern Smalltalk) released by Xerox.

Some History, continued …

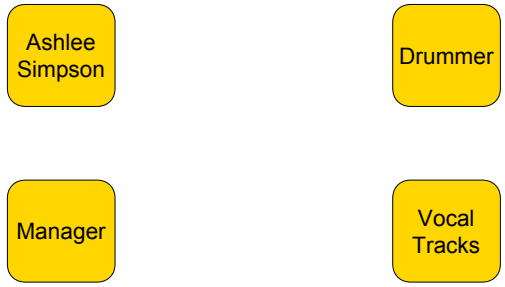
- 1979-80: Apple bases Lisa user interface on Xerox's SmallTalk Development environment. Lisa eventually evolved into the Macintosh.
- 1991: Bridge Systems develops a C-like language with SmallTalk semantics for Sun. This later evolves into Java.
- 1996: Kay and colleagues release Squeak - an open-source dialect of Smalltalk-80.
  - Try it out! Available at :

    `http://www.squeak.org/`

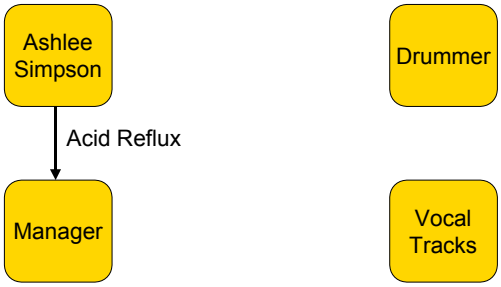
Smalltalk: A Pure Object-Oriented Language

- All values are objects:
  - `3`, `'hello world'`, `true`, etc …
- All operations (except assignment) are message sends:
  - `3 + 4`, `20 negated`, etc …
- Even control structures are sends:
  - `1 to: 5 do: [ :i | x := x+i ]`, etc …
- Classes are objects too!
  - `Point new` sends the `new` message to the `Point` class object

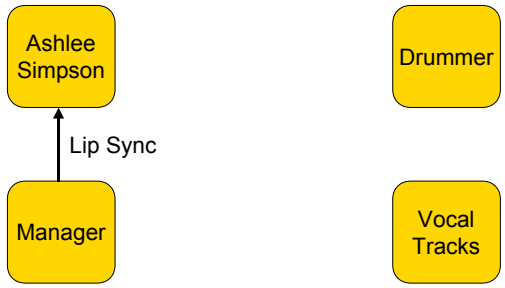
Smalltalk Model of the World



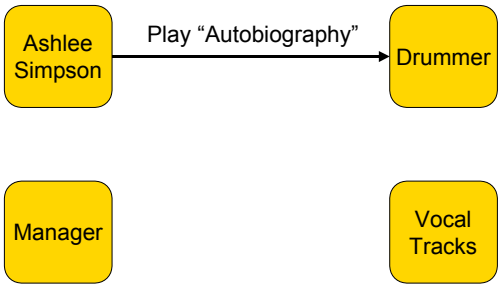
Smalltalk Model of the World



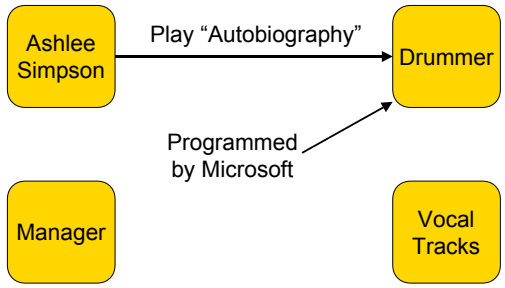
Smalltalk Model of the World



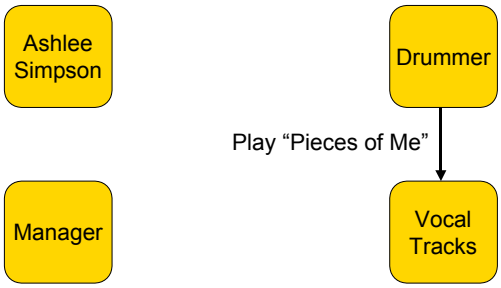
Smalltalk Model of the World



Smalltalk Model of the World



Smalltalk Model of the World



Basic Smalltalk Syntax

Comment	`"Your comment"`
String literal	`'hello world'`
Character literal	`$a`
Booleans	`true`, `false`
Arrays	`#(2 3 5 10)`
Assignment	`x := 5`
Return	`^ resultValue`
Statement Separater	`stmt1 . stmt2`

Messages

- All non-assignment operations in Smalltalk are message sends.
  - Like method calls in Java.
- Messages are sent to a receiver object
  - In Java, the receiver of `x.foo(y,z)` is `x`.
- Three types of messages: unary, infix binary, and keyword.
  - The main difference is how arguments are passed.

Unary Messages

- No arguments
- Syntax:

```
receiverObject methodName
```

- Example:
  - `20 negated`
  - `myQueue front`
  - `Point new`
  - `Date today`

Infix Binary Messages

- Consist of one or two non-alphabetic characters, like + or &&.
- Syntax:

```
receiver <binOp> argument
```

- Examples:
  - 3 + 4
  - (x < y) & (3 <= 4)

Keyword Messages

- Take one or more arguments separated by keywords.
- Syntax:

```
rcvr keyword1: arg1 keyw2: arg2
```

- Examples:
  - `x at: 5 put: $a`
  - `Array new: 10`
  - `4 printOn: Transcript base: 8`
  - `Point3D x: 4 y: 5 z: 10 negated`

Precedence of Messages

- Precedence of messages:
  - First, send unary messages
  - Then, infix binary messages.
  - Finally, send keyword messages.
- Multiple messages of the same type are sent in left to right order.
  - `5 negated squared`
- Only one keyword message is allowed per statement, unless we use parenthesis.
  - `x foo: 5 bar: 6`
  - `(x foo: 5) bar: 6.`

Class Exercise:

- How do the following expressions evaluate?
  - `5 + 3 * 2`
  - Answer:
  - `7 + 9 negated`
  - Answer:
  - `6 multipliedBy: 7 + 3 negated`
  - Answer:
  - `(5 multBy: (4 multBy: 3)) negated`
  - Answer:

Class Exercise:

- How do the following expressions evaluate?
  - `8 * 2`
  - Answer:
  - `7 + 9 negated`
  - Answer:
  - `6 multipliedBy: 7 + 3 negated`
  - Answer:
  - `(5 multBy: (4 multBy: 3)) negated`
  - Answer:

Class Exercise:

- How do the following expressions evaluate?
  - `16`
  - Answer: 16
  - `7 + 9 negated`
  - Answer:
  - `6 multipliedBy: 7 + 3 negated`
  - Answer:
  - `(5 multBy: (4 multBy: 3)) negated`
  - Answer:

Class Exercise:

- How do the following expressions evaluate?
  - `16`
  - Answer: 16
  - `7 + (-9)`
  - Answer:
  - `6 multipliedBy: 7 + 3 negated`
  - Answer:
  - `(5 multBy: (4 multBy: 3)) negated`
  - Answer:

Class Exercise:

- How do the following expressions evaluate?
  - `16`
  - Answer: 16
  - `-2`
  - Answer: -2
  - `6 multipliedBy: 7 + 3 negated`
  - Answer:
  - `(5 multBy: (4 multBy: 3)) negated`
  - Answer:

Class Exercise:

- How do the following expressions evaluate?
  - `16`
  - Answer: 16
  - `-2`
  - Answer: -2
  - `6 multipliedBy: 7 + (-3)`
  - Answer:
  - `(5 multBy: (4 multBy: 3)) negated`
  - Answer:

Class Exercise:

- How do the following expressions evaluate?
  - `16`
  - Answer: 16
  - `-2`
  - Answer: -2
  - `6 multipliedBy: 4`
  - Answer:
  - `(5 multBy: (4 multBy: 3)) negated`
  - Answer:

Class Exercise:

- How do the following expressions evaluate?
  - `16`
  - Answer: 16
  - `-2`
  - Answer: -2
  - `24`
  - Answer: 24
  - `(5 multBy: (4 multBy: 3)) negated`
  - Answer:

Class Exercise:

- How do the following expressions evaluate?
  - `16`
  - Answer: 16
  - `-2`
  - Answer: -2
  - `24`
  - Answer: 24
  - `(5 multBy: 12) negated`
  - Answer:

Class Exercise:

- How do the following expressions evaluate?
  - `16`
  - Answer: 16
  - `-2`
  - Answer: -2
  - `24`
  - Answer: 24
  - `60 negated`
  - Answer:

Class Exercise:

- How do the following expressions evaluate?
  - `16`
  - Answer: 16
  - `-2`
  - Answer: -2
  - `24`
  - Answer: 24
  - `-60`
  - Answer: -60

Defining a class

- In Smalltalk, every class has a superclass (except the Object class).
- Recall, classes are objects—thus, we can send them messages.
- To define a new class, we simply send a subclass keyword message to its superclass.
- All methods and variables of the superclass are inherited by the new subclass.

The Subclass Message

- The subclass message takes the following arguments:
  - `subclass:` The name of the new class.
  - `instanceVariableNames:` Whitespace-separated string listing the fields of the new class.
  - `classVariableNames:` List of variables that are shared by all instances (objects) of the new class.
  - `poolDictionaries:` List of dictionaries that this class has access to.
  - `category:` No semantic significance; helps the programmer organize classes.

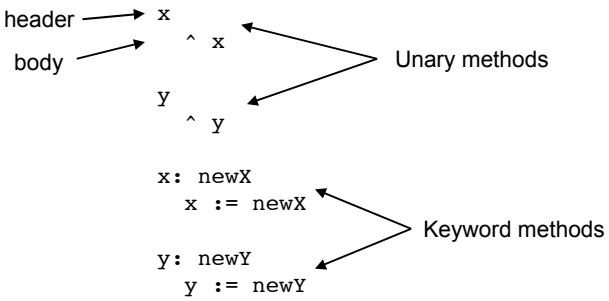
Example - Point Class

```
Object subclass: #Point
  instanceVariableNames: 'x y'
  classVariableNames: 'OriginX OriginY'
  poolDictionaries: ''
  category: 'CSE 413-Point Examples'
```

Defining Instance Methods

- Once we have defined a class, we can define the messages types that an object of that class can receive.
  - These are the "instance methods" of the class.
- If an incorrect message type is sent to an object, a runtime error is generated.
- Instance methods are entered by selecting the class, and clicking "Instance".
- Method declarations consist of three parts: the header line, the local variables declarations, and the method body.

Example - Point Methods



Example - Point Methods

An infix binary method:

```
+ anotherPoint
  | result |
  result := Point new.
  result x: x + anotherPoint x.
  result y: y + anotherPoint y.
  ^ result
```

local variables

Example - Point Methods

Shift the point:

```
xShift: xs yShift: ys
  x := x + xs.
  y := y + ys
```

Class Exercise: scaleBy

Define a `scaleBy` method that multiplies all coordinates by a fixed factor.

Class Exercise: scaleBy

Define a `scaleBy` method that multiplies all coordinates by a fixed factor.
Answer that returns a new point:

```
scaleBy: factor
  | result |
  result := Point new.
  result x: x * factor.
  result y: y * factor.
  ^ result
```

Class Exercise: scaleBy

Define a `scaleBy` method that multiplies all coordinates by a fixed factor.
Answer that modifies the receiver:

```
scaleBy: factor
  x := x * factor.
  y := y * factor
```

Defining Class Methods

- Recall that classes are objects too.
- Thus, we can also define the message types that a class object can receive.
  - These are the class methods.
- Common uses:
  - Constructors
  - Methods that have nothing to do with a specific instance (object) of the class.
- To enter a class method, select the class and click on “Class”.

Example - Point Constructor

```
x: xCoord y: yCoord
  | p |
  p := self new.
  p x: xCoord.
  p y: yCoord.
  ^ p
```

- I’ll explain why you should use `self new` rather than just `new` when we discuss dynamic dispatch.

Example:Changing the Origin

```
originX: newX y: newY
  OriginX := newX.
  OriginY := newY
```

Access Protection

- All messages/methods are public - anyone can send them.
- All variables are private - only methods of the class may access them.
- In fact, an object's variables are only added to the environment when a message to the object is evaluated.

Next Time

- How control structures are implemented in Smalltalk.
  - Hint: everything in Smalltalk is a message send!
- Self, Super, Inheritance and Dynamic Dispatch.
- A case study in object oriented design.