BETA and Newspeak

Seminar Module Systems, SS2015

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Overview

Introduction

- BETA: "A modern language in the Simula tradition"
  - Designed by Birger Møller-Pedersen and Kristen Nygaard (*Scandinavian School*)
  - Class = Method = Pattern
  - Nested Patterns
- Newspeak: "A new programming language in the tradition of Self and Smalltalk"
  - Designed by Gilad Bracha et al.
  - Nested Classes
  - No globals: all names are late bound

Overview

Patterns

- Classes and methods are patterns
- "Patterns [are] templates for generating objects (instances)."
- Objects are executable

```
Pattern: (#
  Declaration1; Declaration2; ...; DeclarationN
  enter InputArguments
  do Implementation
  exit OutputArguments
#)
```

Unification of Abstraction Mechanisms: The Pattern[7]

- Instances of a procedure are procedure activations
- Instances of a class are objects
- Instances of a function are function activations
- Instances of a type are values

Handout only: Similarities between Objects and Procedure Activations

- Procedure activation = Activation record + execution of code
- Activation record is similar to object: data items and local procedures (nested procedures in languages with block structure)

Example

```
(#
    Account: (#  balance: @integer;
        Deposit:
          (# amount: @integer
             enter amount
             do balance+amount->balance
             exit balance
          #);
        Withdraw: (# ... #);
    #);
   account: @Account;
   K1: @integer;
   do
     100->&account.Deposit;
     50->&account.Withdraw->K1;
#)
```

Handout only: Beta Syntax

- `(# ... #)` for block structure
- `@Type` for static references
- `^Type` for dynamic references
- `&Type` for instance creation
- `[]` aquires a references instead of object execution
- `&Account[]` returns a dynamic reference to a new account instance

Subpatterns

Specialization by Simple Inheritance

$$
\begin{aligned}
\textit{Resulting properties} &= \textit{inherited properties} + \textit{new properties} \\
\textit{Resulting behavior} &= \textit{inherited behavivor} + \textit{new behavior} \\
\textit{Resulting arguments} &= \textit{inherited arguments} + \textit{new arguments} \\
\textit{Resulting results} &= \textit{inherited results} + \textit{new results}
\end{aligned}
$$

- Method execution starts at base method: use `inner` to call specialized method

Handout only: Virtual Patterns and Pattern Variables

- Non-virtual pattern: entire type hierarchy has same pattern
- Virtual pattern: subtypes can have different patterns
- Pattern variables: every object can have a different pattern

Pattern (Design) Patterns

- **Procedure Pattern**: sequence of actions
- **Function Pattern**: sequence of actions with return value(s), does not change state
- **Class Pattern**: template for generating objects

Expected Benefits of Unification[6]

- Design goals
  - "The pattern mechanism should be the ultimate abstraction mechanism, subsuming all other known abstraction mechanisms."
  - "The unification should be more than just the union of existing mechanisms."
  - "All parts of a pattern should be meaningful, no matter how the pattern is applied."
- "Uniform treatment of all abstraction mechanisms. [...] It ensures orthogonality among class, procedure, etc."
- Functionality: subpatterns, virtual patterns, nested patterns, pattern variables

Overview

Nested Classes

What is it?

- Class defined inside another class
- Part-of relationship: nested classes belong to the enclosing class
- Access to enclosing class (lookup depends on programming language)

Nested Classes

Benefits

- **Namespace** for classes, avoiding name clashes
- Group together what belongs together: increase **understandability** and **readability**
- A form of **encapsulation**, promoting development towards an interfaces instead of an implementation (using visibility annotations)
- Support for more advanced features
  (e.g. Class Hierarchy Inheritance)

Nested Classes

Programming Languages

- Java: nested classes are non-virtual
- Ruby: inner classes/modules are non-virtual
- **BETA, Newspeak:** nested classes are virtual and can be overridden

BETA Nested Classes

- Virtual methods can be overridden in subclasses
- Virtual classes can be overridden in subclasses
- Virtual patterns can be overridden in subclasses

HPI

BETA Nested Classes

```
Reservation: (#
  date: @Date;
  Display:< (# do date.PrintToConsole; INNER; #)
#)

TrainReservation: Reservation (#
  seat: @Seat;
  Display::< (# do seat.PrintToConsole; INNER; #)
#)

(#
  reservation: ^Reservation;
  do
    &reservation.Display
#)
```

HPI

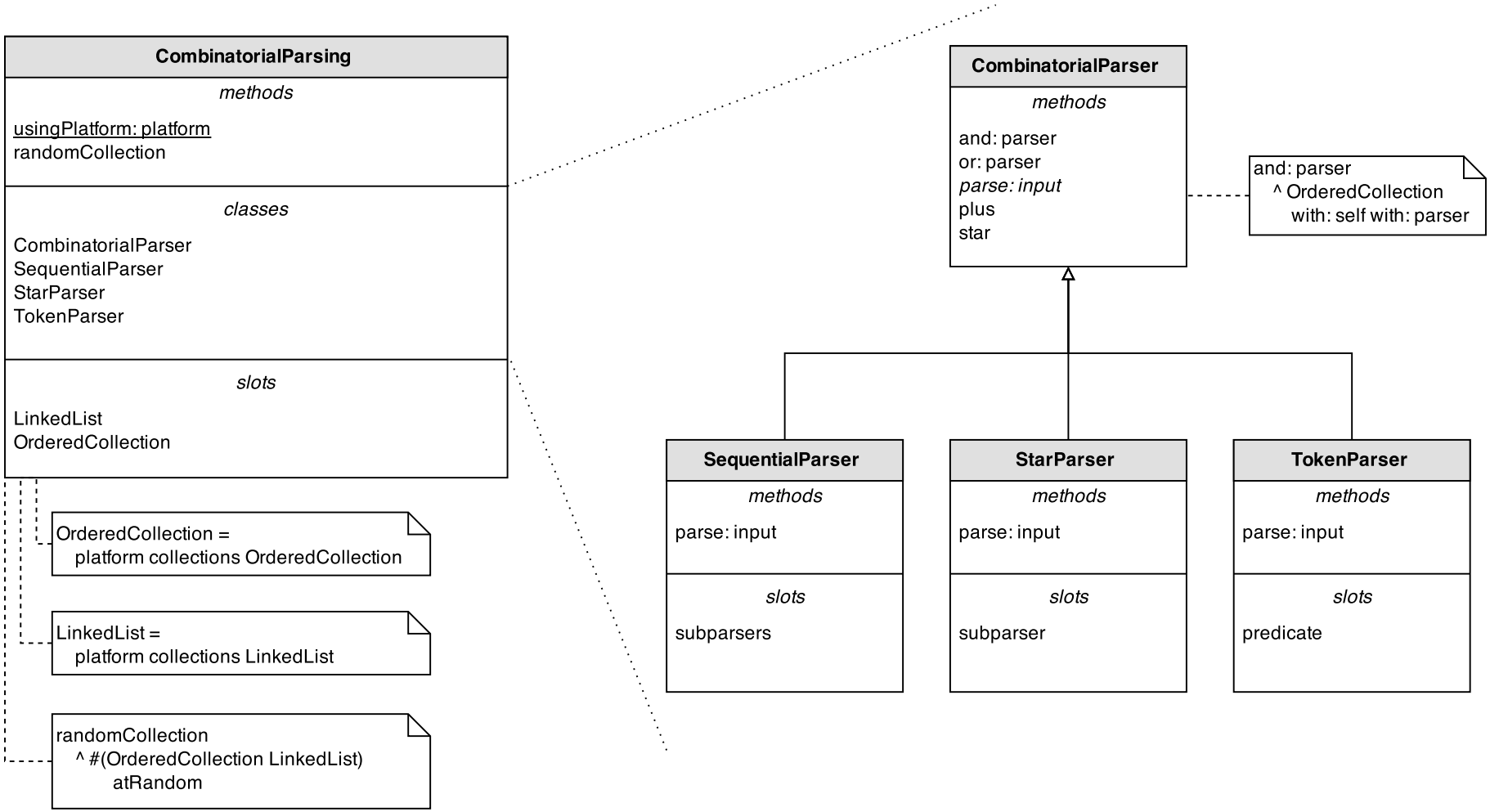
Handout only: BETA Nested Classes

```
Reservation: (#
  date: @Date;
  DisplayReservation: (# do date.PrintToConsole; INNER; #)
  Display:< DisplayReservation
#)

TrainReservation: Reservation (#
  seat: @Seat;
  DisplayTrainReservation: DisplayReservation (#
    do seat.PrintToConsole; #)
  Display::< DisplayTrainReservation
#)
```

Handout only: BETA Nested Classes

- Only virtual patterns can be overridden (denoted by `:<`)
- Overriding pattern must be a subpattern of superpattern
- Pattern execution starts with base pattern (`inner` instead of `super`)

Example: Nested Classes in Newspeak [2]



Handout only: Nested Classes in Newspeak [3]

- **Methods:** instance methods
- **Classes:** nested class definitions
- **Slots:** instance variables
- **Module Definition:** a class object that acts as a module
  - has to be a top-level class
  - has its own namespace which is represented by a `platform` object
  - is stateless
  - its external dependencies are listed at the top of the class
- **Module:** an instance of a module definition

`platform` Object instead of Global Namespace[8]

- `platform` contains references to top-level modules required by the application (mapping identifiers to top-level modules)
  - Provided by the system: collections, file system, drawing, kernel classes, ...
  - Provided by the developer: custom libraries
  - Contains all dependencies required for deployment
- Created using IDE support, then object graph serialization
- `Platform>>main:args:` is the application's entry point
- `platform` is similar to Squeak environments

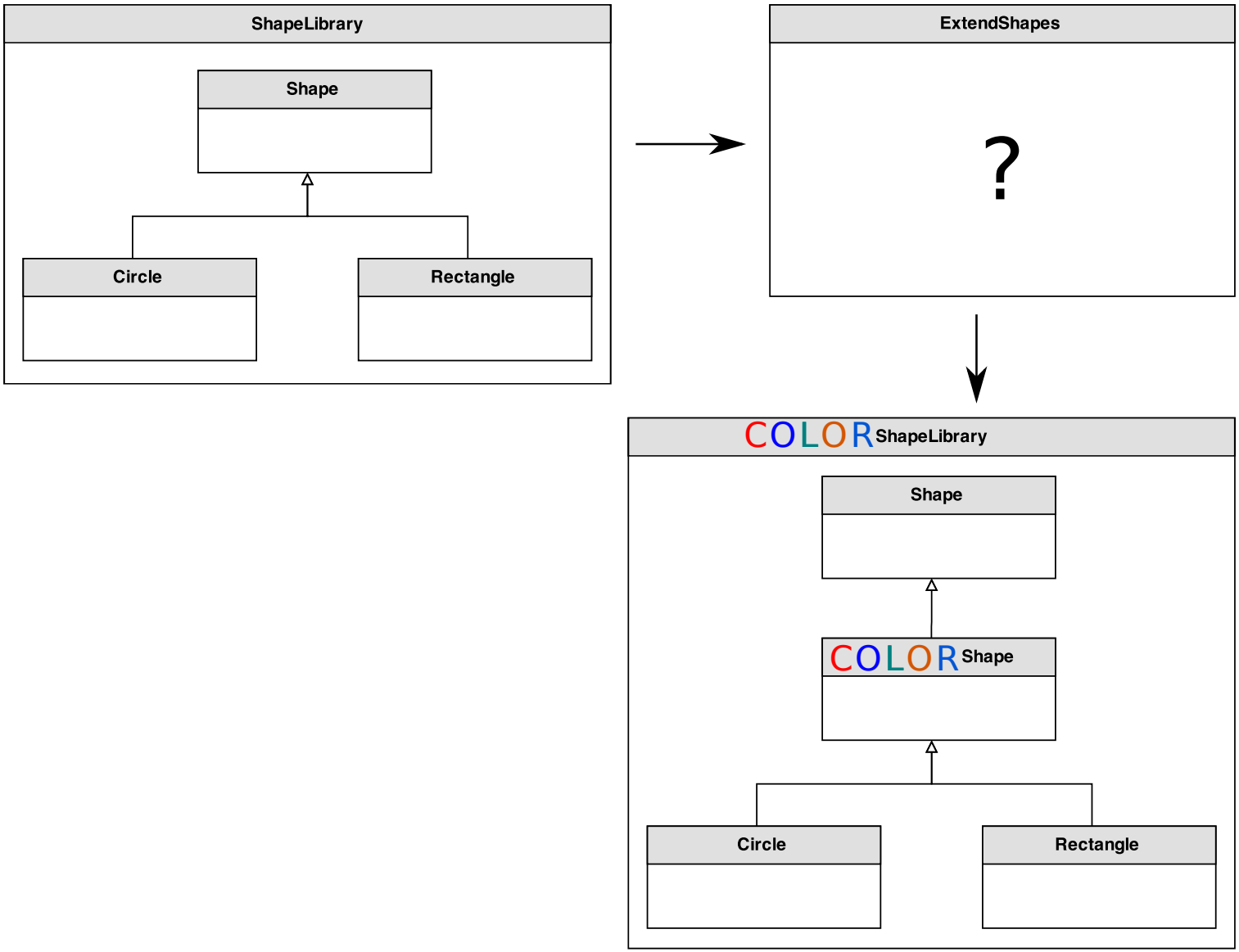
Instance Creation in Newspeak

Nested Classes in a Nutshell for Smalltalkers

1. Message send to class object: invoke factory method (e.g. `usingPlatform:` or `new`)
2. Execute factory method: might initialize some slots
3. Generate class objects for nested classes lazily (s.t. optimizations)

```
Object subclass: #CombinatorialParsing
    instanceVariableNames: 'CombinatorialParser SequentialParser
        ... OrderedCollection LinkedList parent platform'.

CombinatorialParser class>>usingPlatform: platform
  | inst | inst := self new.
  inst OrderedCollection: platform collections OrderedCollection.
  inst LinkedList: platform collections LinkedList.
  ^ inst

CombinatorialParsing>>StarParser
  | nested | "important: nested is cached"
  nested := self CombinatorialParser subclass: #StarParser
      instanceVariableNames: 'parent subparser'.
  nested compile: 'parse: input ^ ...'
  ^ nested
```

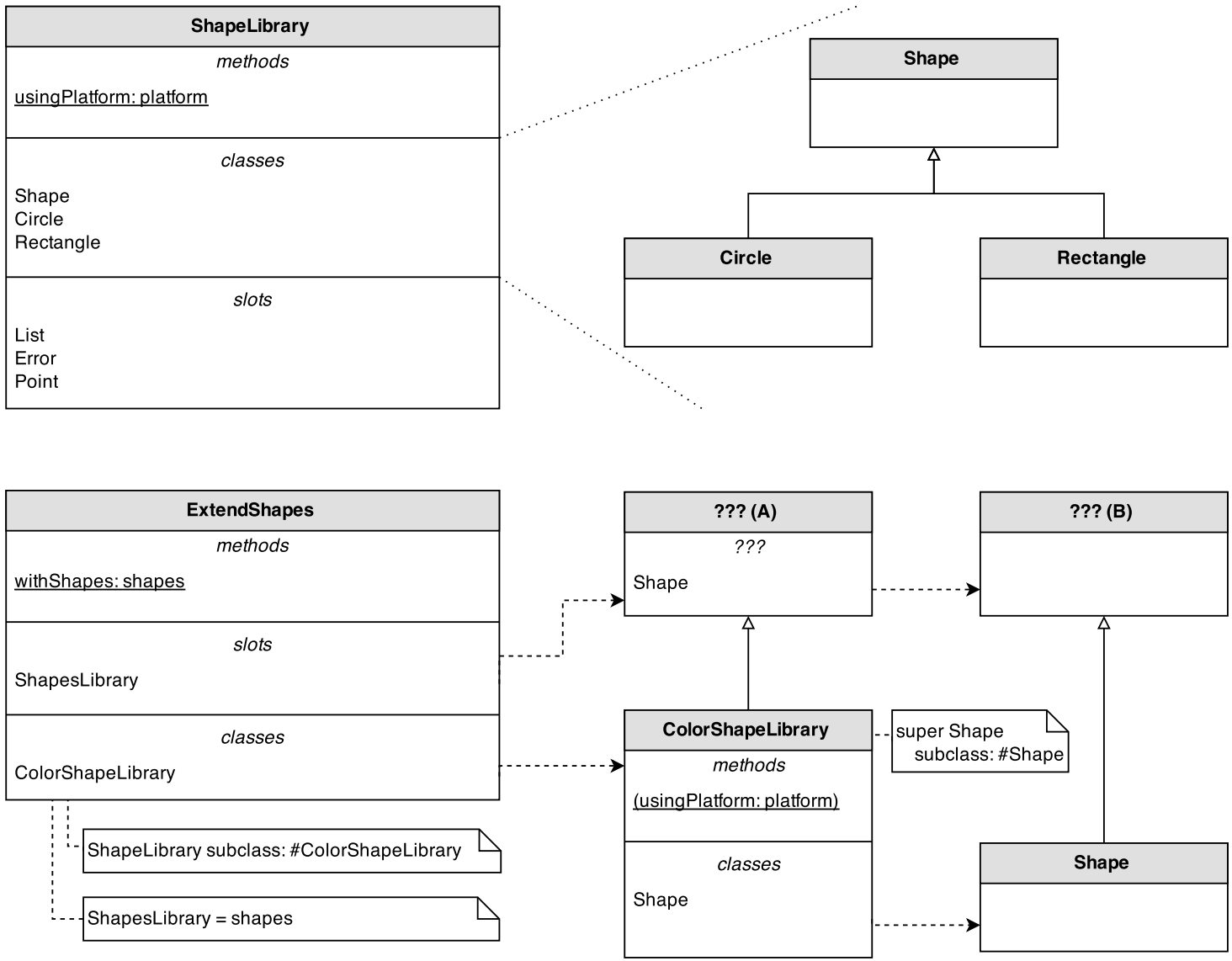
Example: Class Hierarchy Inheritance



Handout only: Example: Class Hierarchy Inheritance

- `ShapeLibrary`: a library for geometrical shapes, containing classes `Shape`, `Circle`, `Rectangle`
- `Shape` is superclass of `Circle` and `Rectangle`, and provides basic rendering functionality
- **Challenge:** provide a module `ExtendShapes` which takes as input *l* any `ShapeLibrary` and generates a modified `ColorShapeLibrary` where `ColorShapeLibrary.Shape` has additional behavior for drawing colors
  - *l* must have a nested class `Shape`
  - Override `ColorShapeLibrary.Shape` with a new class whose superclass is *l*`.Shape` (like method overriding)

Example: Class Hierarchy Inheritance in Newspeak [1]



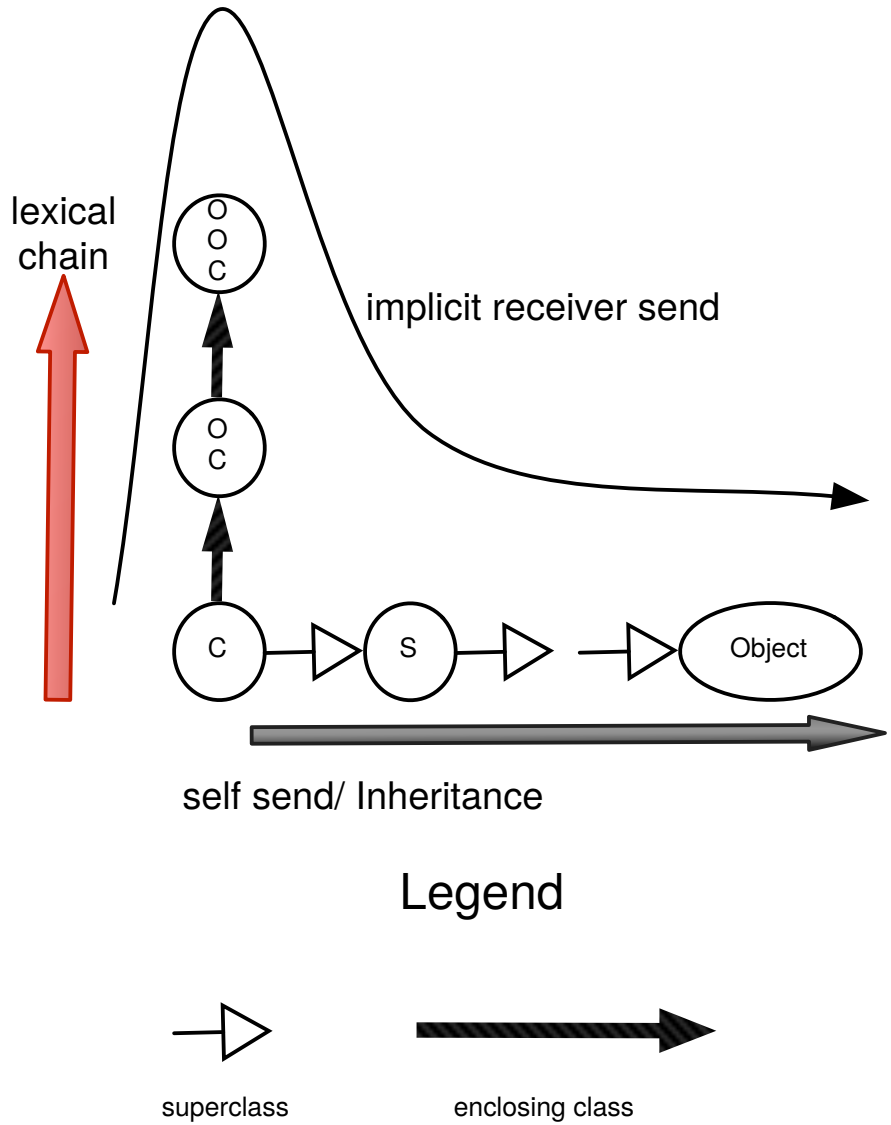
Handout only: Class Hierarchy Inheritance → Smalltalk

```
Object sublcass: #ShapeLibrary
  instanceVariableNames: 'Shape Circle Rectangle List Error Point'.

ShapeLibrary>>Rectangle
  | nested | "nested is cached"
  nested := self Shape subclass: #Rectangle ...
  ... ^ nested

Object subclass: #ExtendShapes
  instanceVariableNames: 'ShapesLibrary ColorShapeLibrary'.

ExtendShapes class>>withShapes: shapes
  | inst | inst := self new.
  inst ShapesLibrary: shapes.
  ^ inst

ExtendedShapes>>ColorShapeLibrary
  | nested | "nested is cached"
  nested := self ShapesLibrary subclass: #ColorShapeLibrary
      instanceVariableNames: 'Shape'.
  nested class compile: 'usingPlatform: platform ^ ...'.
  nested compile: 'Shape | nested | "nested is cached" nested :=
      super Shape subclass: #Shape. "add behavior to nested"'
  ^ nested
```

Handout only: Why Nested Classes are lazily initialized

- Consider nested classes are initialized in factory.
- `ExtendedShape>>ColorShapeLibrary class>>usingPlatform:` triggers `ShapeLibrary class>>usingPlatform:` (super constructor call).
- `ShapeLibrary class>>usingPlatform:` creates `Shape`, `Circle`, `Rectangle`.
- `ExtendedShape>>ColorShapeLibrary class>>usingPlatform:` creates (overrides) a new `Shape` class.
- **Problem:** `Circle` and `Rectangle` are still subclasses of the old `Shape` class.
- **Solution:** all names are late bound and method calls. The method call `Shape` creates the class on demand the superclass factory runs the subclass implementation (overridden).

Method Lookup in Newspeak [1]



Handout only: Method Lookup in Newspeak

- First enclosing classes (*lexical chain*)
- Then superclass hierarchy
- Never check superclass hierarchy of enclosing classes
- Different from BETA and Java: *comb semantics*
  - Check receiver class and superclass hierarchy
  - Check enclosing classes and superclass hierarchies

Newspeak Avoids Method Name Clashes by Superclasses

Example

```
class Super {
  //int m(){ return 42; }
}
class Outer {
  int m(){ return 91; }
  class Inner extends Super {
    int foo(){ return m(); }
  }
}

new Outer.Inner().foo()?
```

Poor Man's Nested Classes[4]

Classes as First Class Objects

- Scoping rules are different
- No convenient access to enclosing instance
- Hierarchy not reflected in the source code
- Bad tooling support
- No class hierarchy inheritance

Overview

Summary

- Pattern = Method = Class
- Nested patterns/classes: work like virtual methods in other programming languages
- More than Java nested classes: Java nested classes are not virtual
- Workaround for nested classes in other programming languages: factory
- No global namespace in Newspeak: `platform` object provides all dependencies
- Newspeak: all names are late bound

References

1. Gilad Bracha, Peter Ahe, Vassili Bykov, Yaron Kashai, William Maddox and Eliot Miranda. Modules as Objects in Newspeak.
2. Gilad Bracha, Peter Ahe and Vassili Bykov. Newspeak on Squeak: A Guide for the Perplexed.
3. Gilad Bracha, Peter Ahe, Vassili Bykov, Yaron Kashai and Eliot Miranda. The Newspeak Programming Platform.
4. `http://gbracha.blogspot.jp/2013/01/inheriting-class.html`
5. `http://www.cs.au.dk/~beta/Manuals/r5.2.2/beta-intro/Virtual.html`
6. Bent Bruun Kristensen, Ole Lehrmann Madsen, and Birger Møller-Pedersen. 2007. The when, why and why not of the BETA programming language.
7. Madsen, O. L.: Abstraction and Modularization in the BETA Programming Language.
8. `http://gbracha.blogspot.de/2008/12/living-without-global-namespaces.html`