Language Design. Overview of COOL

CS164

Lecture 2

Course Administration

- If you drop the course, please make it official
- Questions about course policies?

Lecture Outline

- Introduction to Cool
- The Course Project

Cool Overview

- Classroom Object Oriented Language
- Designed to
  - Be implementable in one semester
  - Give a taste of implementation of modern features
    - Abstraction
    - Static typing
    - Reuse (inheritance)
    - Memory management
    - And more …
- But many things are left out

Getting Started

- Examples; ~cs164/examples
- Compiler: ~cs164/bin/coolc
  - coolc [-o outfile] file1.cl file2.cl … filen.cl
  - Generates MIPS assembly code
- Execute: ~cs164/bin/spim
  - MIPS simulator
  - spim –f file.s

A Simple Example

```
class Point {
        x : Int ← 0;
        y : Int ← 0;
};
```

- Cool programs are sets of class definitions
  - A special class **Main** with a special method **main**
  - No separate notion of subroutine
  - Class definition in a single source file (many source files)
- class = a collection of attributes and methods
- Instances of a class are objects

Cool Objects

```
class Point {
        x : Int ← 0;
        y : Int; (* use default value *)
};
```

- The expression "new Point" creates a new object of class Point
- An object can be thought of as a record with a slot for each attribute

Object as Record

Methods

- A class can also define methods for manipulating the attributes

```
class Point {
        x : Int ← 0;
        y : Int ← 0;
        movePoint(newx : Int, newy : Int): Point {
            { x ← newx;
              y ← newy;
              self;
            } -- close block expression
        }; -- close method
};  -- close class
```

- Methods can refer to the current object using self

Information Hiding in Cool

- Methods are global
- Attributes are local to a class
  - They can only be accessed by the class's methods
- Example:

```
class Point {
      . . .
      x () : Int { x };
      setx (newx : Int) : Int { x ← newx };
};
```

Methods

- Each object knows how to access the code of a method
- As if the object contains a slot pointing to the code

- In reality implementations save space by sharing these pointers among instances of the same class

Inheritance

- We can extend points to colored points using subclassing => class hierarchy

```
class ColorPoint inherits Point {
    color : Int ← 0;
    movePoint(newx : Int, newy : Int): Point {
      { color ← 0;
        x ← newx; y ← newy;
        self;
      }
    };
};
```

Initialization

Redefinition of attributes and methods

Cool Types

- Every class is a type
- Base classes:
  - Int for integers
  - Bool for boolean values: true, false
  - String for strings
  - Object root of the class hierarchy
- All variables must be declared (with their type)
  - compiler infers types for expressions

Type tree and type conformance

Cool Type Checking

```
x : P;
x ← new C;
```

- Is well typed if P is an ancestor of C in the class hierarchy
  - Anywhere an P is expected a C can be used
- Type safety:
  - A well-typed program cannot result in runtime type errors

Method Invocation and Inheritance

- Methods are invoked by dispatch
- Understanding dispatch in the presence of inheritance is a subtle aspect of OO languages

```
p : Point;
p ← new ColorPoint;
p.movePoint(1,2);
```

  - p has static type Point
  - p has dynamic type ColorPoint
  - p.movePoint must invoke the ColorPoint version

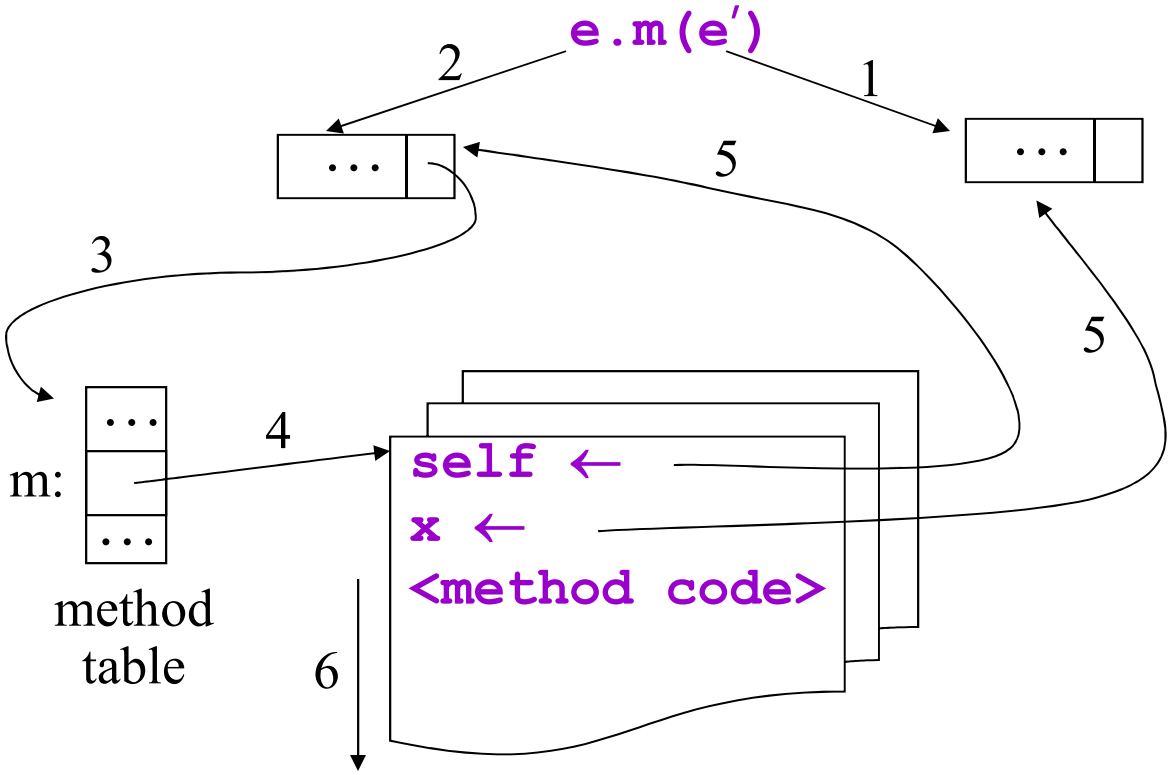
Method Invocation

- Example: invoke two-argument method m

```
e.m(e1, e2)
```

Method Invocation

- Example: invoke one-argument method m



1. Eval. argum e′
2. Eval. e
3. Find class of e
4. Find code of m
5. Bind self and x
6. Run method

Void

Other Expressions

- Expression language (every expression has a type and a value)
  - Conditionals — if E then E else E fi
  - Loops: — while E loop E pool
  - Case statement — case E of x : Type ⇒ E; … esac
  - Arithmetic, logical operations
  - Assignment — x ← E
  - Primitive I/O — out_string(s), in_string(), …
- Missing features:
  - Arrays, Floating point operations, Interfaces, Exceptions,…

Cool Memory Management

- Memory is allocated every time new is invoked
- Memory is deallocated automatically when an object is not reachable anymore
  - Done by the garbage collector (GC)
  - There is a Cool GC

Course Project

- A complete compiler
  - Cool ==> MIPS assembly language
  - No optimizations
- Split in 5 programming assignments (PAs)
- There is adequate time to complete assignments
  - But start early and please follow directions
  - Turn in early to test the turn-in procedure
- Individual or team (max. 2 students)

Programming Assignment I

- Write an interpreter for a stack machine …
- … in Cool
- Due in 1 week
- Must be completed individually