CS 4120
Introduction to Compilers

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Lecture 20: Object layout and method dispatch

How the [illegible] . operator works?

Class Components

- fields/instance variables
  - values may differ from object to object
  - usually mutable
- methods
  - values shared by all objects of a class
  - usually immutable
  - usually functions with implicit argument
    - object itself (this/self)
- all components have visibility
  - e.g. public, private, protected

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Code generation for objects

- Methods
  - Generating method body
  - Generating method calls (dispatching)
- Fields
  - Memory layout
    - Packing and alignment
  - Generating accessor code

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Compiling methods

- Methods look like functions, are type-checked like functions...what is different?
- Argument list: implicit receiver argument
- Calling sequence: use *dispatch vector* instead of jumping to absolute address

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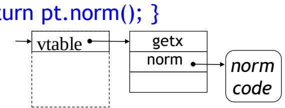
The need for dispatching

- Problem: compiler can't tell what code to run when method is called

```
abstract class Point { int getx(); float norm(); }
class CartesianPoint implements Point { ...
      float norm() { return sqrt(x*x+y*y); }
class RadialPoint implements Point { ...
      float norm() { return r; }
float dist(Point pt) { return pt.norm(); }
```

- Solution: dispatch table (dispatch vector, selector table...)



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Method dispatch

- Idea: every method has its own small integer index
- Index is used to look up method in dispatch vector

```
abstract class A {
   void foo();          0
}
abstract class B extends A {
   void bar();          1
   void baz();          2
}
```

```
class C implements B {
      void foo() {...}
      void bar() {...}
      void baz() {...}
      void quux() {...} 3
}
```

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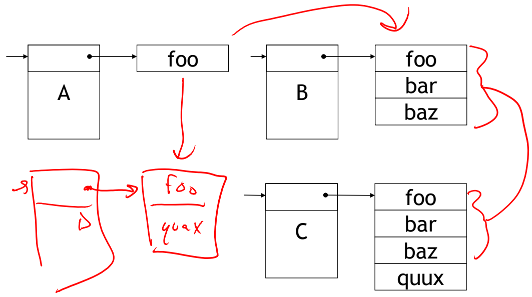
V-Table layouts



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Method arguments

- Methods have a special variable (in Java, "this") called the *receiver object* or *context object*
- Historically (Smalltalk): method calls thought of as *messages* sent to *receivers*
- Receiver object is (implicit) argument to method

```
class Shape {
    int setCorner(int which, Point p) { … }
}
```

compiled like

```
int setCorner(Shape this, int which, Point p) { … }
```

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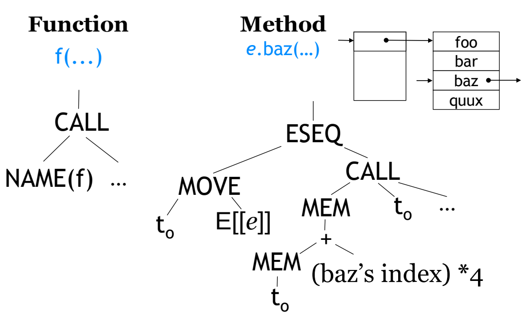
Calling sequence



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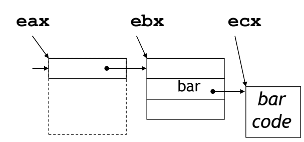
Example

A	foo
B	bar, baz
C	quux

b.bar(3);

```
push 3
push eax
mov ebx, [eax]
mov ecx, [ebx + 4]
call ecx
```

(bar's index = *1*)



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Inheritance

Three traditional components of object-oriented languages

- abstraction/encapsulation/information hiding
- subtyping/interface inheritance -- interfaces inherit method signatures from supertypes
- inheritance/implementation inheritance -- a class inherits signatures *and* code from a superclass (possibly "abstract")

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Inheritance

- Method code copied down from superclass if not *overridden* by subclass
- Fields also inherited (needed by inherited code in general)

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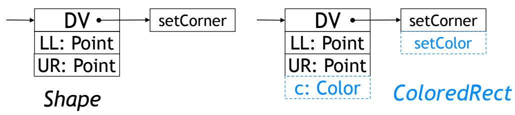
Object Layout

```
class Shape {
  Point LL, UR;
  void setCorner(int which, Point p);
}
class ColoredRect extends Shape {
  Color c;
  void setColor(Color c_);
}
```



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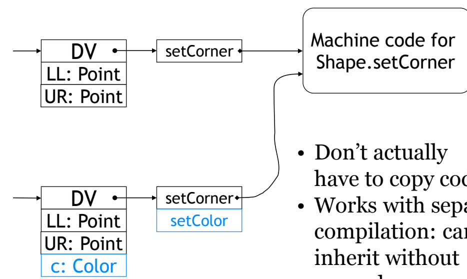
Code Sharing



- Don't actually have to copy code!
- Works with separate compilation: can inherit without superclass source

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Interfaces, abstract classes

- Classes define a type *and* some values (methods)
- Interfaces are pure object types : no implementation
  - no V-Table: only an IM-Table layout
- Abstract classes are halfway:
  - define some methods
  - leave others unimplemented
  - no objects (instances) of abstract class
- V-Table only for (abstract) classes

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Static methods

- In Java, can declare methods *static* -- they have no receiver object
- Called exactly like normal functions
  - don't need to enter into dispatch vector
  - don't need implicit extra argument for receiver
- Treated as methods as way of getting functions inside the class scope (access to module internals for semantic analysis)
- Not really methods

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Constructors

- Java, C++: classes can declare *object constructors* that create new objects:
  class C { public C(x, y, z) { initialize C } …}
- Scala, CubeX: one constructor
  class C(x,y,z) { initialize C in body }

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Compiling constructors

- Compiled just like static methods except:
  - pseudo-variable "this" is in scope as in methods
  - this is initialized with newly allocated memory
  - first word in memory initialized to point to v-table
  - value of this is return value of code
- For CubeX
  - Where "new C" is called
    - allocate memory for C instance
    - set first word of instance to point to C's v-table
    - call C's constructor passing the pointer
  - Inside C's constructor
    - initialize fields of C using initialization statements
    - use super's constructor to initialize super's fields

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