Object Oriented Languages

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- classes (first-class or not first-class)
- instances of those classes
- methods attached to classes or generic functions (see later), shared by instances
- attributes/slots/values defined in classes, attached to instances (or shared within classes)
- single or multiple inheritance defined through the relationships between the classes

Object Oriented Languages

Class Centred

And, of course, there are languages that don’t fit this simple view

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Exercise Ruby first looks for methods in the object; then the class; then parent classes. Read about this

Object Oriented Languages

Brief aside

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- For data: attribute, state, slot, member, value, element, variant, structure
- For code: method, behaviour, action, message

Be aware of these variations!

Object Oriented Languages

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- object receiver: Java, C++, ...
- generic functions: Lisp, ...

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(We ignore the extra complications of overloading here)

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(We ignore the extra complications of overloading here)

This is the familiar “object dot method name” syntax

On the other hand, *generic functions* look more like normal functions: `plus(x,y)` or `(plus x y)`, and they choose a method depending on the types of both `x` *and* `y`

Object Oriented Languages

Class Centred

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They are sometimes called *multimethods*

Note this is syntactic convenience. We might write

```
(x,y).plus()
```

to emphasise the messaging, but it's simpler to use the function notation for the "multiple receiver" case: as long as you remember it's a *method call*, not a *function call*

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Exercise Compare with *pair types* and, more generally, *product types*

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For example, a multimethod `wombat` with methods defined on (`int`, `String`) and (`double`, `int`) — which class would it be defined on?

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As there may be more than one class involved

For example, a multimethod `wombat` with methods defined on (`int`, `String`) and (`double`, `int`) — which class would it be defined on?

That doesn’t make sense, so we put them elsewhere, in the generic function named `wombat`, and not worry about attaching them to classes

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Class Centred

And when defining new methods we will refer to the generic function, not to a class or classes

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Saying “method in a class” is OK for Java, not for Lisp

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Object receiver collects them by the (single) class

Generic functions collect them by the name

A choice of approach, but not symmetric, as a method only has one name, but can depend on more than one class

Object Oriented Languages

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Generic functions *dispatch* (choose a method) on the type of one or more objects

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In use, generic functions look a lot like normal functions, but are actually *collections* of methods

Object Oriented Languages

Class Centred

```
(defgeneric foo (x y))

(defmethod foo ((x <number>) (y <number>)) ...)

(defmethod foo ((x <integer>) (y <integer>)) ...)

(defmethod foo ((x <number>) (y <float>)) ...)

(defmethod foo ((x <float>) (y <integer>)) ...)

...
```

Object Oriented Languages

Class Centred

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(defmethod foo ((x <integer>) (y <integer>)) ...)

(defmethod foo ((x <number>) (y <float>)) ...)

(defmethod foo ((x <float>) (y <integer>)) ...)

...
```

Choosing the applicable method is more involved, but typically is the closest match, taking arguments left-to-right to break ties (more on this later)

General Remark

Methods, functions and generic functions are different things

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Functions and methods are different things

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They both execute code, but they do it in very different ways

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You can’t use a function a like a method

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You may have also seen *closures*, which are different again

General Remark

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- method: code plus reference to the object
- generic function: collection of methods
- closure: code plus captured environment

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- method: code plus reference to the object
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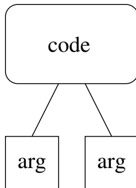
Confusing these concepts will ensure loss of marks!

General Remark

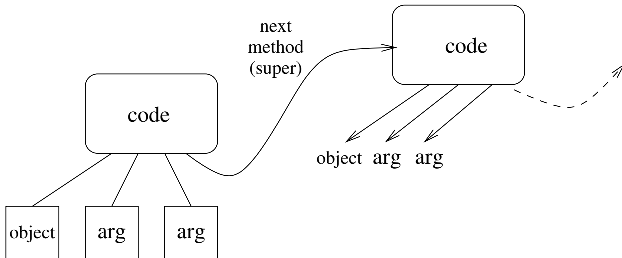
Functions just have code and data (arguments)



Function are code

General Remark

Methods have code, arguments, the object and often a *next method list*



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Within the body of the code the object is often referred to as a special argument named `self` or `this`; or it can be implicit, such as referring to a slot as simply “`x`” rather than “`this.x`” or “`self.x`”

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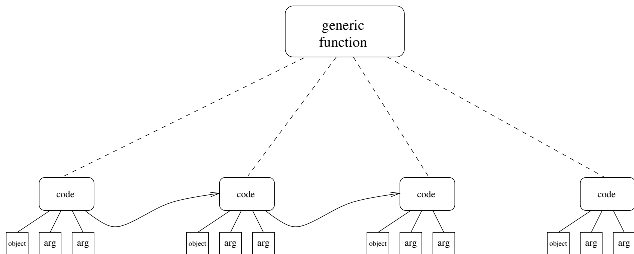
In a generic function it is more complicated

General Remark



Generic functions are a collection of methods

Aside

For those interested in the mechanisms: a method call `obj.meth(x,y)` is often compiled into the equivalent of a normal function call with extra "hidden" arguments

```
meth_class_of_obj(obj, next_method_list, x, y)
```

and `obj` is accessible within the body of the function as the function parameter `this` or `self` or similar

Any `super` methods are contained in the `next_method_list`

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So this is more name mangling

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Hint: if you write
`x.foo()`
it's probably a method call

If you write
`foo(x)`
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More on this later, but we need to introduce the other kinds of OO

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- slots attached to objects
- direct construction and *cloning* to make instances
- **no inheritance**

Object Oriented Languages

List Constructor in JavaScript

```
function list() {
  this.size = 0
  this.node = {next: 0, prev: 0, data: 0}
  this.node.next = this.node
  this.node.prev = this.node
  this.push_back = function (x) {
                     var tmp = {next: this.node,
                                prev: this.node.prev,
                                data: x}
                     this.node.prev.next = tmp
                     this.node.prev = tmp
                     this.size += 1
                     return x
                   }
  this.toString = list_toString
  for (var i = 0; i < arguments.length; i++) {
    this.push_back(arguments[i])
  }
}
```

Object Oriented Languages

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- `this.toString = list_toString`: another method with code defined elsewhere
- `for ...`: more code to execute when making an object

Object Oriented Languages

List Constructor in JavaScript

This would be used like

```
var l = new list("hello", 1, "world");
l.push_back(2);
var len = l.size;
```

Object Oriented Languages

List Constructor in JavaScript

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var l = new list("hello", 1, "world");
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Note: no class definition, only how to make an object

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Some class centred languages are dynamic, e.g., Common Lisp can redefine its classes while it is running

Object Oriented Languages

Class centred OO could be thought of as

two kinds of object, two kinds of link

Object Oriented Languages

Class centred OO could be thought of as

two kinds of object, two kinds of link

Namely classes and non-classes, inheritance and instance

Prototyping is then

one kind of object, no links

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JavaScript is an example of a *prototyping* language

Prototyping is then

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JavaScript is an example of a *prototyping* language

NB: don’t confuse this usage with languages that are used for prototyping!

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Prototyping

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- an object contains its own attributes (slots) and behaviours (methods)
- attribute and behaviour lookup are both by interrogating the object
- no inheritance in the class-centred sense, but an object can itself call other methods as it sees fit: an object could contain an object of another type and treat that as its “parent”, calling its methods explicitly

Object Oriented Languages

Prototyping

Though not a defining feature of prototyping, these languages often allow dynamic addition of attributes and behaviours to objects:

```
function obj() { this.one = 1; this.two = 2; }
var a = new obj(), b = new obj();
a.three = 3;
// b.three is undefined
```

- used in *differential inheritance*: clone an object then add a new behaviour or modify an existing behaviour (or attribute)

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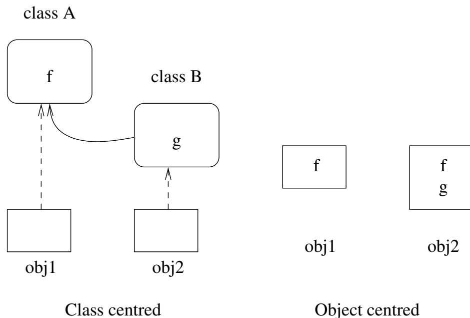
- used in *differential inheritance*: clone an object then add a new behaviour or modify an existing behaviour (or attribute)
- again, different from class-centred inheritance as the cloned object contains all its own methods and attributes

Object Oriented Languages

Prototyping



Class vs. object centred methods

In class-centred, `obj2` gets `f` and `g` from its classes

In object centred, they are self-contained

Object Oriented Languages

Prototyping

- Prototyping gives less efficient code (requires runtime lookups) but more flexible programming

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Prototyping

- Prototyping gives less efficient code (requires runtime lookups) but more flexible programming
- it was developed as real code is never as simple as a tidy class hierarchy might provide: we might want some behaviour of a parent (or parents) but not all their behaviours. Prototyping allows us to gather together whatever we need from wherever we want without constraint