Object Oriented Languages

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Many people have the implicit assumption that if you know Java then you know all about OO

This is far from the truth: the Java way of doing OO is just one way of many

Object Oriented Languages

It is sometimes said that an OO language is typified by

> *“Abstraction, Encapsulation, Inheritance, Polymorphism”*

Object Oriented Languages

Abstraction: a high level view, where irrelevant details are hidden. Helps programming at a “higher” concept level. E.g., A `Dog` can `bark()` but you don’t need to know how it does that to use that code in your program

Object Oriented Languages

Abstraction: a high level view, where irrelevant details are hidden. Helps programming at a “higher” concept level. E.g., A `Dog` can `bark()` but you don’t need to know how it does that to use that code in your program

Encapsulation: structure and implementation kept hidden from the programmer behind a well-defined interface. Allows changing details of implementation at a lower level without affecting the higher levels. A way of enforcing abstraction

Object Oriented Languages

Inheritance: allowing properties to be shared in a hierarchy, thus avoiding re-implementation across related objects. Generally using classes to describe the hierarchy

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Polymorphism: treating different objects in different ways depending on their type/class. Allow the same “idea” to apply in different ways, e.g., a `Dog` and a `Cat` can both `eat()`, but in different ways

Object Oriented Languages

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Thus excluding a wide range of very useful languages!

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Classes are secondary, and sometimes not there at all!

And there are OO languages with classes, but no inheritance

Object Oriented Languages

> *OOP to me means only messaging, local retention and protection and hiding of state-process, and extreme late-binding of all things.*

Alan Kay (invented the term “object oriented”)

> *The notion of object oriented programming is completely misunderstood. It’s not about objects and classes, it’s all about messages.*

Alan Kay

Object Oriented Languages

From ISO/IEC 2382:2015 Information technology - Vocabulary

> *object-oriented:*
> *pertaining to a technique or a programming language that supports objects, classes, and inheritance*
>
> *Note 1 to entry: Some authorities list the following requirements for object-oriented programming: information hiding or encapsulation, data abstraction, message passing, polymorphism, dynamic binding, and inheritance.*

Object Oriented Languages

Exercise Another (better?) characterisation is

- Single Responsibility Principle
- Encapsulation
- Abstraction
- Minimal Coupling

Read about this

Object Oriented Languages

Exercise You will also find SOLID

- Single Responsibility Principle
- Open-Closed principle
- Liskov substitution principle
- Interface segregation principle
- dependency inversion principle

Read about this

Exercise For later. Come back and revisit SEAM and SOLID when we have gone though OO in detail

Object Oriented Languages

> *It was obvious to me 20-some years ago that OOP wasn't a panacea. That's the reason C++ supports several design and programming styles.*
>
> *In the first edition of "The C++ Programming Language," I didn't use the phrase "object-oriented programming" because I didn't want to feed the hype. One of the problems with OOP is exactly that unscrupulous people have hyped it as a panacea. Overselling something inevitably leads to disappointments.*

Bjarne Stroustrup, Feb 2000 (24 years ago!)

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Simula looks like a mixture of Pascal and Java, and has been described as “Algol plus classes”

Object Oriented Languages

Simula has constructs like objects, classes, subclasses and methods that eventually followed through C++ directly into Java

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However, it was with Smalltalk in 1972 that the OO concept really took off and influenced "modern" languages like C++ and Java

Object Oriented Languages

The original SmallTalk ideas of what defines OO were

- message passing
- isolation of objects
- polymorphism

Notice no mention of inheritance!

Object Oriented Languages

Feet

- Simula: ?

Object Oriented Languages

Feet

- Simula: ?
- Smalltalk: You send the message shoot to gun, with selectors bullet and myFoot. A window pops up saying Gunpowder doesNotUnderstand: spark. After several fruitless hours spent browsing the methods for Trigger, FiringPin and IdealGas, you take the easy way out and create ShotFoot, a subclass of Foot with an additional instance variable bulletHole

Object Oriented Languages

Reflection

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Self-modifying programs are dangerous and hard to understand or control

But metaobject programming as a way to implement reflection puts a framework on this which makes it safe to use

But still very powerful

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A related idea is *reification*

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Time permitting, we will look in more depth at these ideas later

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This is more like `2.plus(3)` in Java-like syntax

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And many different styles of OO were proposed including features called *prototyping* and *delegation*, and then Lisp-based languages featuring multiple inheritance and metaobject protocols

We shall be looking at these in turn, but we shall start with the most familiar kind of OO: that typified by having classes arranged in a hierarchy

Object Oriented Languages

Classes

Classes are things that gather together descriptions of the *structure* (how and which values are stored in the object, perhaps in memory, perhaps elsewhere) and the *behaviour* (the methods) of certain objects

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For code reuse, many languages allow classes to have subclasses that inherit and extend the structure and/or behaviour of the parent class

Object Oriented Languages

Class Hierarchy

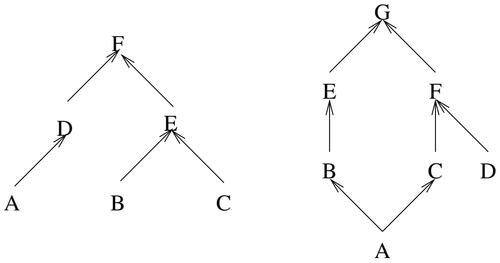
The *class hierarchy* is the relationship between classes

Object Oriented Languages

Class Hierarchy

The *class hierarchy* is the relationship between classes

This can be in a *tree*, where a class inherits from a single parent class (*single inheritance*); or a *directed acyclic graph* (DAG) when classes can inherit from more than one parent (*multiple inheritance*)



A Tree and a DAG

Object Oriented Languages

Class Hierarchy

Both trees and DAGs have an important property: no loops

Object Oriented Languages

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Object Oriented Languages

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Thus we do not allow loops in the class hierarchy

Object Oriented Languages

Class Hierarchy

In some languages, e.g., Lisp and Smalltalk, classes are first-class, being things that can be created and manipulated in the program

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Exercise But (later) look up `java.lang.reflect`

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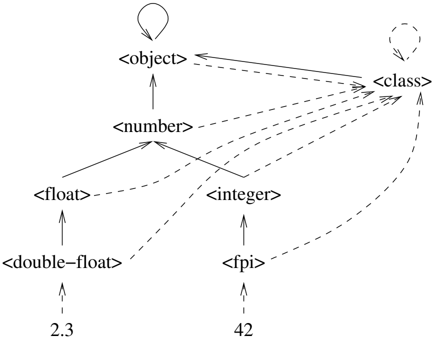
A language will have a default hierarchy of those classes that come with the language

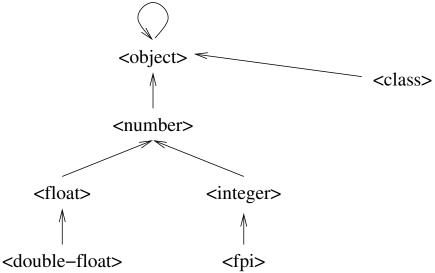
Object Oriented Languages



A Small Part of the EuLisp Class Hierarchy (simplified)

There are *two* hierarchies in this diagram

Object Oriented Languages

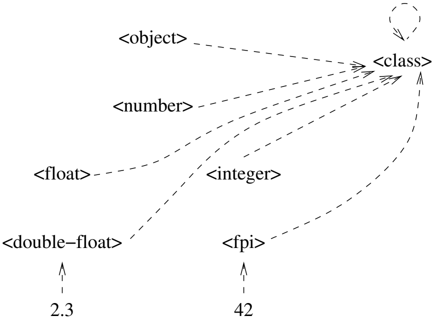


Inheritance hierarchy

Solid arrow is *inherits from*/*subclass*/*extends*/ *refines*/*specialises*/*subset*

This is the normal “class inheritance diagram”

Object Oriented Languages



Instance hierarchy

Dotted arrow is *instance of*/*member of*/*is a*;

Object Oriented Languages

Every object is an *instance* of a class (dotted arrow); sometimes called a *member* of that class.

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Exercise Think about the relationship between set theory and classes and objects: members and instances; subsets and subclasses

Object Oriented Languages

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It inherits both *structure*/*attributes* (how values in the instances are stored); and *behaviour* (the methods)

Of course, it may override or add to either: generally you add or override methods, but just add to attributes

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E.g., `<fpi>` inherits from `<integer>`

And `<class>` inherits from `<object>`

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Of course, the class `<class>` is an instance of itself

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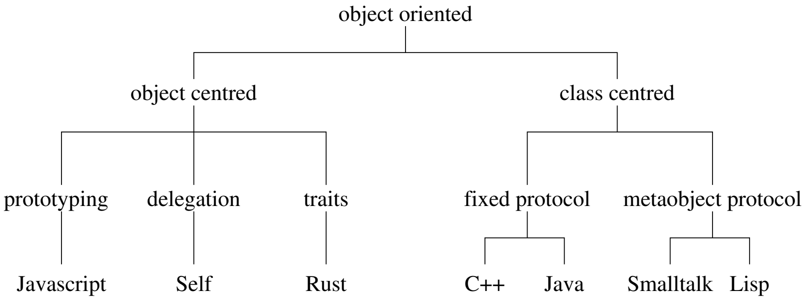
Or one of these kinds of object: the classes

Object Oriented Languages

Exercise For Java, C++, Common Lisp, EuLisp and any others determine their initial class hierarchy

Object Oriented Languages

Kinds of OO Language



A classification of OO languages

Note: non-exclusive properties

Object Oriented Languages

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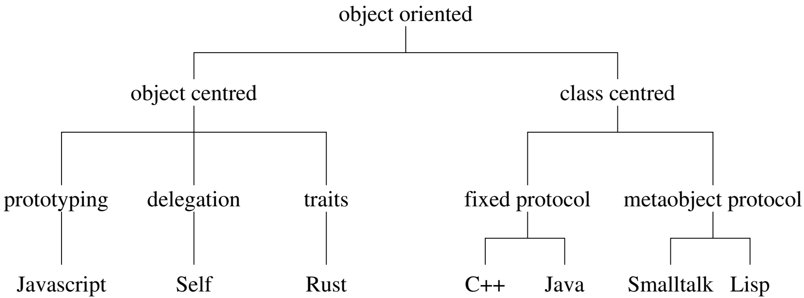

object oriented

object centred

class centred

prototyping

delegation

traits

fixed protocol

metaobject protocol

Javascript

Self

Rust

C++

Java

Smalltalk

Lisp

A classification of OO languages

Note: non-exclusive properties

Exercise In this picture, determine which are instance links and which are inheritance links!

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As always, it's not a case of what is *better*, more what is *better for the application in hand*