Essential OO Concepts

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Outline

- OOP
- Objects, classes
- Inheritance
- Composition
- Comparison

Object-Orientation

- Is a paradigm not a technology
- Reflects, simulates the real world
- Thinks in terms of organization
- Tries to
  - Handle complexity
  - Enhance reusability
  - Minimize maintenance cost

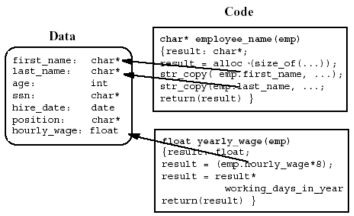
Evolution

- Procedures
- Structured Programming
- Fourth Generation Languages
- Object-Oriented Programming
- ???

Traditional Point of View

- Focuses upon procedures
- Functionality is vested in procedures
- Data exists solely to be operated upon by procedures
- Procedures know about the structure of data
- Requires large number of procedures and procedure names

Data and Procedures



Data

```
first_name:   char*
last_name:    char*
age:          int
ssn:          char*
hire_date:    date
position:     char*
hourly_wage:  float
```

Code

```
char* employee_name(emp)
{result: char*;
result = alloc (size_of(...));
str_copy( emp.first_name, ...);
str_copy(emp.last_name, ...;
return(result) }
```

```
float yearly_wage(emp)
{result: float;
result = (emp.hourly_wage*8);
result = result*
            working_days_in_year
return(result) }
```

Roadmap

- OOP
- Objects, classes
- Inheritance
- Composition
- Comparison

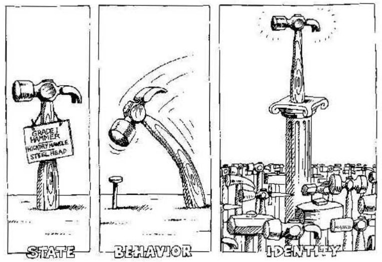
What is OOP?

- An application is a collection of interacting entities (objects)
- Objects are characterized by behavior and state
- Inter-object behavior needs to be coordinated
- Inter-object communication is the key to coordination

Object-Oriented Viewpoint

- An ***application*** is a set of ***objects*** interacting by sending ***messages***
- The functionality of an object is described by its ***methods***, its data are stored in private ***variables***
- An object's functionality can be invoked by sending a ***message***
- ***Everything*** is an object

State + Behavior + Identity



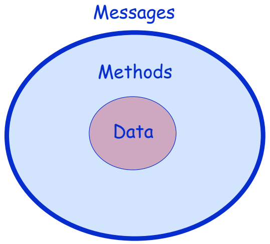
State + Behavior + Identity

- State: Objects it contains or refers to
  - Ex: point location
- Behavior: an object understands a given set of messages
- Identity: an object can be the same (of the same class) than another one but it has still a different identity (location in memory)

Equality and Identity

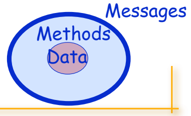
- I want to eat the pizza that you are eating
- Equality: I want to eat the "same" kind of pizza
- Identity: I eat your pizza

Data/Messages/Methods



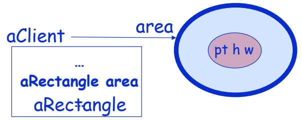
What vs. How

- What: Messages
  - Specify what behavior objects are to perform
  - Details of how are left up to the receiver
  - State information only accessed via messages
- How: Methods
  - Specify how operation is to be performed
  - Must have access to (contain or be passed) data
  - Need detailed knowledge of data
  - Can manipulate data directly



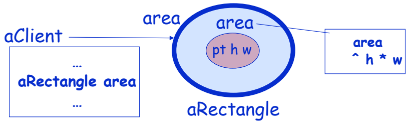
Message

- Sent to receiver object: receiver-object message
- A message may include parameters necessary for performing the action
- In Smalltalk, a message-send always returns a result (an object)
- Only way to communicate with an object and have it perform actions



Method

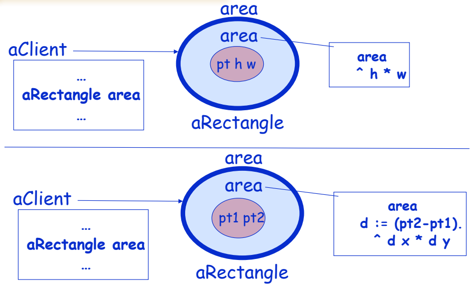
- Defines how to respond to a message
- Selected via method lookup technique
- Has name that is the same as message name
- Is a sequence of executable statements
- Returns an object as result of execution

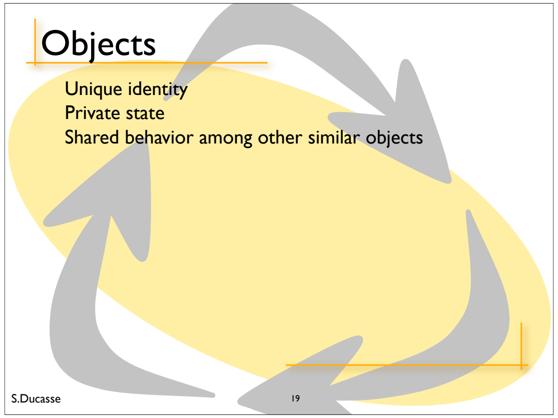


Object Encapsulation

- Technique for
  - Creating objects with encapsulated state/behaviour
  - Hiding implementation details
  - Protecting the state information of objects
  - Communicating/accessing via a uniform interface
- Puts objects in control
- Facilitates modularity, code reuse and maintenance
  - External perspective vs. Internal perspective
  - What vs. How
  - Message vs. Method

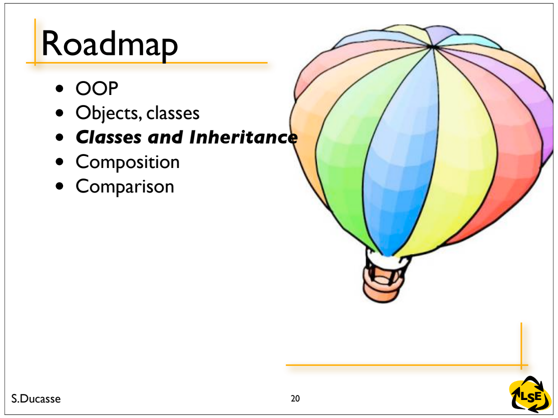
Encapsulation at Work





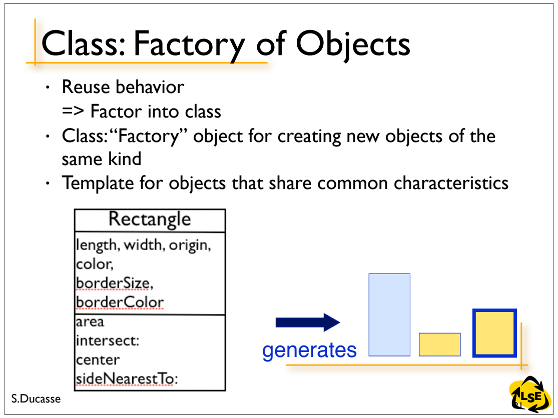
Objects

Unique identity
Private state
Shared behavior among other similar objects



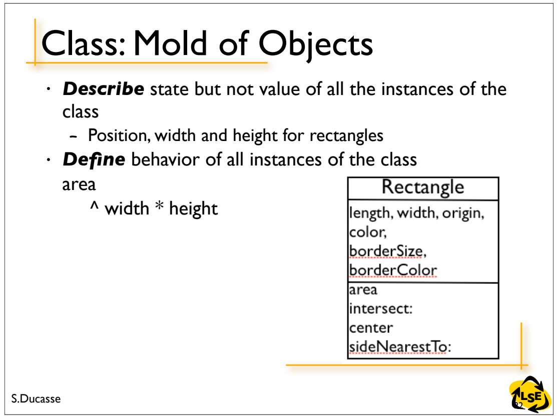
Roadmap

- OOP
- Objects, classes
- ***Classes and Inheritance***
- Composition
- Comparison



Class: Factory of Objects

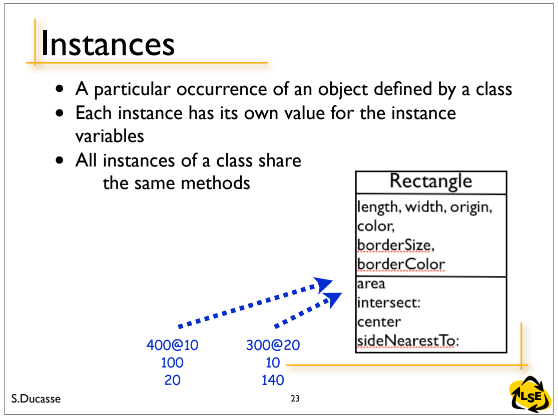
- Reuse behavior
  => Factor into class
- Class:"Factory" object for creating new objects of the same kind
- Template for objects that share common characteristics



Class: Mold of Objects

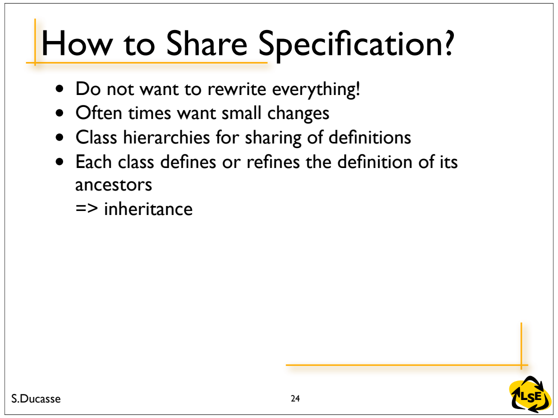
- ***Describe*** state but not value of all the instances of the class
  - Position, width and height for rectangles
- ***Define*** behavior of all instances of the class

area
    ^ width * height



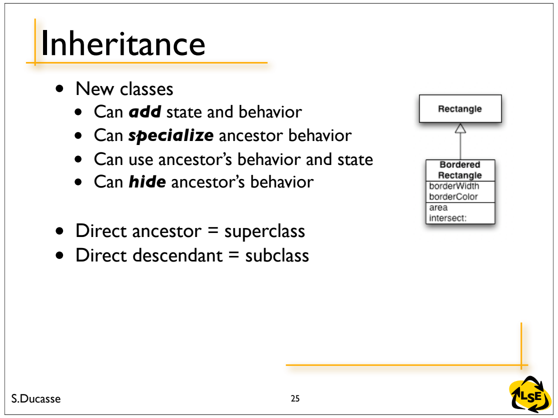
Instances

- A particular occurrence of an object defined by a class
- Each instance has its own value for the instance variables
- All instances of a class share
  the same methods



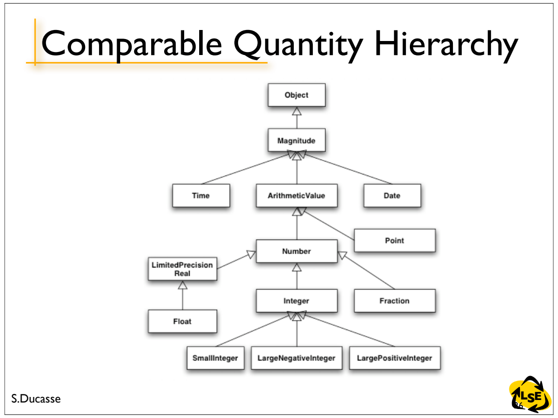
How to Share Specification?

- Do not want to rewrite everything!
- Often times want small changes
- Class hierarchies for sharing of definitions
- Each class defines or refines the definition of its ancestors
  => inheritance

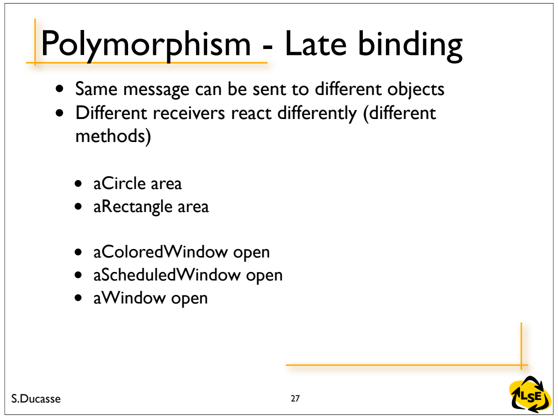


Inheritance

- New classes
  - Can ***add*** state and behavior
  - Can ***specialize*** ancestor behavior
  - Can use ancestor's behavior and state
  - Can ***hide*** ancestor's behavior
- Direct ancestor = superclass
- Direct descendant = subclass



Comparable Quantity Hierarchy



Polymorphism - Late binding

- Same message can be sent to different objects
- Different receivers react differently (different methods)
  - aCircle area
  - aRectangle area
  - aColoredWindow open
  - aScheduledWindow open
  - aWindow open

Late binding: "Let's the receiver decide"

Mapping of messages to methods deferred until run-time (dynamic binding)

Allows for rapid incremental development without the need to recompile the complete applications

Most traditional languages do this at compile time (static binding)

Roadmap

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- ***Composition***
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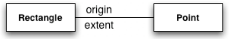
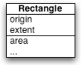
Composition

- An object is composed of other objects in a part-of relationship
- The object uses its parts to implement its behavior
- The object can delegate to its parts

Example

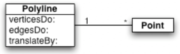
A rectangle can be composed of
  two points:
    to represent its origin and extent
    to represent its topleft and bottomleft corners
  or 4 numbers

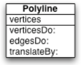




Example (2)

Polyline has a list of vertices





Composition vs. Inheritance

Inheritance supports extension: ColoredRectangle

But
  static, properties are difficult to change dynamically
  we have to change classes at run-time
  explosion of classes
  class with too much responsibilities

With composition
  run-time changes are easier: plug another objects (with the same interface)
  but lot of objects

Outline

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- Objects, classes
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- ***Comparison***

Graphical Editor

- Managing list of objects: square, rectangle, circle...
- Intersect, color, rotate translate….
- We want to know the total area of a list of figures

Procedural Solution

```
tArea
    element class = Circle
        then tArea := tArea + element.circleArea.
    element class= Rectangle
        then tArea := tArea + element.rectangleArea
    …
```

Same for ...
  intersect, color, rotate translate….

In Java for example

```
public static long sumShapes(Shape shapes[]) {
   long sum = 0;
   for (int i=0; i<shapes.length; i++) {
      switch (shapes[i].kind()) {
     //  a class constant
         case Shape.CIRCLE:
                sum += shapes[i].circleArea();
                break;
         case Shape.RECTANGLE:
                sum += shapes[i].rectangleArea();
                break;
           ... // more cases
             }
   }
 return sum;
}
```

Problems

- Adding a kind of graphical element
- Change all the methods area, intersect, rotate, translate…
- Always have to check what is the data I manipulate

Object-Oriented Solution

```
Circle>>area
  ^ Float pi * r * r

Rectangle>>area
  ^ width * height

XXX>>area
  elements do:
       [:each | tArea := tArea + each area]
```

Advantages

- Adding a new graphical object does not require to change the list operations
- I do not have know the kind of objects I'm manipulating as soon as they all share a common interface

Recap

OOP see the world as interacting objects

Objects
Have their ***own*** state
Share the behavior among similar objects
Classes: Factory of objects
Define behavior of objects
Describe the structure of objects
Share specification via hierarchies

Recap

- OOP is based on
  - Encapsulating data and procedures
  - Inheritance
  - Polymorphism
  - Late Binding
- OOP promotes
  - Modularity
  - Reuse