

Object Orientation

Concepts & Principles

Object Oriented Paradigm

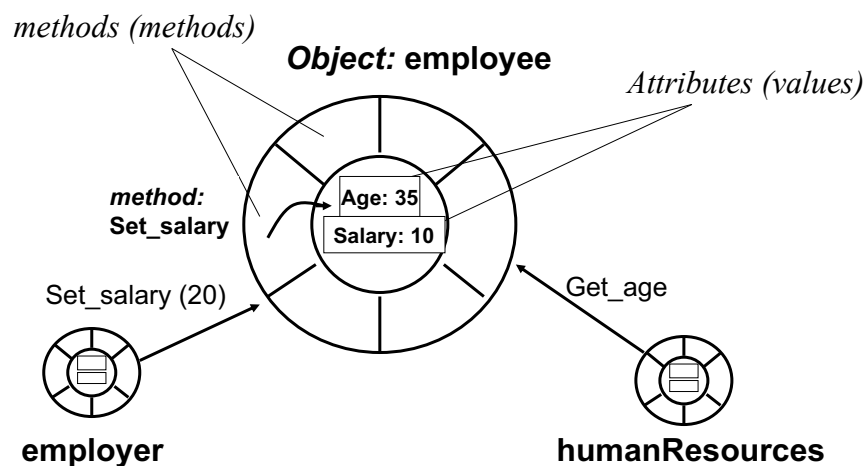
(Paradigm: a way of seeing and doing things)

- Object - Oriented (OO) Programming:
 - Organizing software as a collection of objects with a certain state and behavior.
- Object Oriented Design:
 - Based on the identification & organization of objects.
- OO Methodology
 - Construction of models
 - The development of SW is a modeling process
- OO Modeling and Design
 - Modeling objects based on the real world
 - Using models to design independently of a programming language

Objects

- Object: Complex data type that has an **identity**, contains other data types called **attributes** and modules of code called **operations** or **methods**
- Attributes and associated values are **hidden** inside the object.
- Any object that wants to obtain or change a value associated with other object, must do so by sending a **message** to one of the objects (invoking a method)

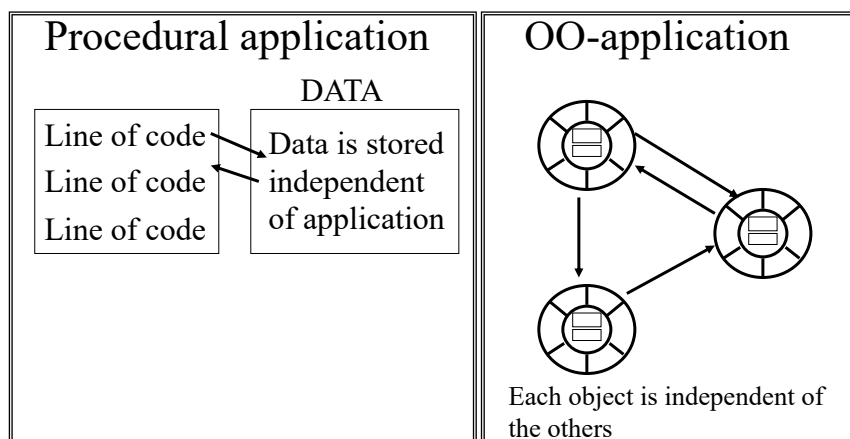
Objects



Encapsulation

- Each objects methods manage it's own attributes.
- This is also known as *hiding*.
- An object A can learn about the values of attributes of another object B, only by invoking the corresponding method (message) associated to the object B.
- Example:
 - Class: Lady
 - Attributes: Age, salary
 - Methods: get_age, set_salary

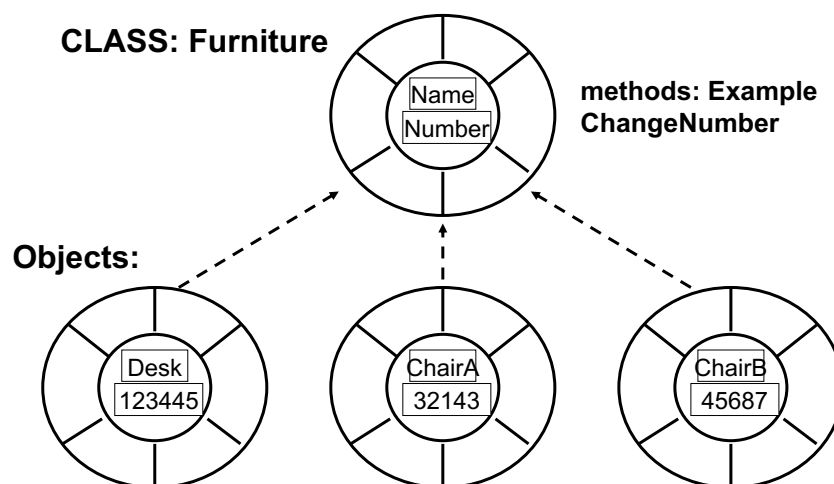
Procedural vs. Object-Oriented



Classes

- Classes are **templates** that have methods and attribute names and type information, but no actual values!
- Objects are generated by these classes and they actually contain values.
- We design an application at the class level.
- When the system is running objects are created by classes as they are needed to contain state information.
- When objects are no longer needed by the application, they are eliminated.

Class & Objects

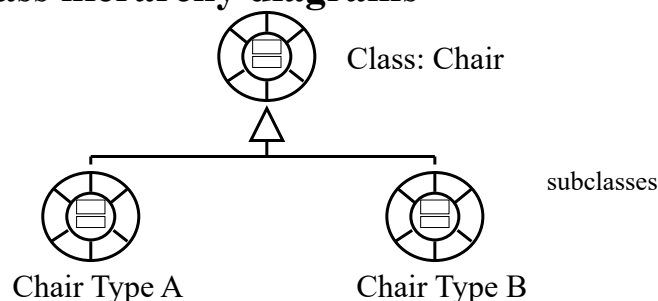


Message Passing & Associations

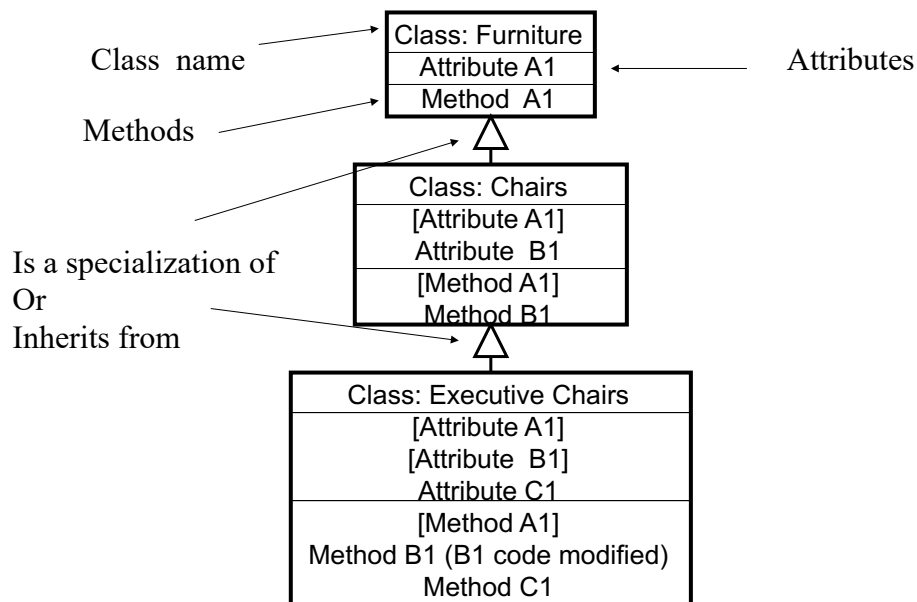
- Methods are associated with classes but classes don't send messages to each other.
- Objects send messages.
- A **class diagram** shows classes and the logical associations between classes, it doesn't show the movement of messages.
- An **association** between two classes means that the objects of the two classes can send messages to each other.
- **Aggregation**: when an object contains other objects (a part-whole relationship)

Class Hierarchies & Inheritance

- Classes can be arranged in hierarchies so that more classes inherit attributes and methods from more abstract classes
- **Class hierarchy diagrams**



Class Inheritance & Specialization



Polimorphism

- Means that the same method will behave differently when it is applied to the objects of different classes
- It also means that different methods associated with different classes can interpret the same message in different ways.
- Example: an object can send a message PRINT to several objects, and each one will use it's own PRINT method to execute the message.

Real life example of polymorphism

Suppose if you are in class room that time you behave like a student, when you are in market at that time you behave like a customer, when you at your home at that time you behave like a son or daughter, Here one person present in different-different behaviors.



Data types

- A data type is characterized by:
 - a set of *values*
 - a *data representation*, which is common to all these values, and
 - a set of *operations*, which can be applied uniformly to all these values

Abstract Data Types

- An Abstract Data Type (ADT) is:
 - a set of *values*
 - a set of *operations*, which can be applied uniformly to all these values
- To *abstract* is to leave out information, keeping (hopefully) the more important parts
 - What part of a Data Type does an ADT leave out?

Class defines a data type

- A class defines a *data type*
 - The possible *values* of a class are called objects
 - The *operations* on the objects are called methods
 - The *data representation* is all the fields that are contained within the object
- If there is no external access to the data representation, you have an *abstract data type*
- Sun's Java classes are (almost all) abstract data types

ADTs are better than DTs

- It is the responsibility of a class to protect its own data, so that objects are always in a valid state
 - Invalid objects cause program bugs
 - By keeping the responsibility in one place, it is easier to debug when invalid objects are present
- The less the user has to know about the implementation, the easier it is to use the class
- The less the user *does* know about the implementation, the less likely s\he is to write code that depends on it
- “Less is more”

Abstract Data Types

- **Data type**: set of values and operations on those values.
- Ex: int, String, ComplexNumber, BigNumber, Card, Deck, Wave, Tour, . . .
- **Abstract data type** is a **data type** whose internal representation is hidden. They are language independent.
- Separate implementation from design specification.
- CLASS: provides data representation and code for operations.
- CLIENT: uses data type as black box.
- INTERFACE: contract between client and class.

Intuition



Client



Interface

- volume
- change channel
- adjust picture
- decode NTSC, PAL signals



Implementation

- cathode ray tube
- electron gun
- Sony Wega 36XBR250
- 241 pounds, \$2,699

client needs to know how to use interface

implementation needs to know what interface to implement

Implementation and client need to agree on interface ahead of time.

Intuition



Client



Interface

- volume
- change channel
- adjust picture
- decode NTSC, PAL signals



Implementation

- gas plasma monitor
- Pioneer PDP-502MX
- wall mountable
- 4 inches deep
- \$19,995

client needs to know how to use interface

implementation needs to know what interface to implement

Can substitute better implementation without changing the client.

ADT Implementation in Java

Java ADTs.

- Keep data representation hidden with `private` access modifier.
- Define interface as operations having `public` access modifier.

```
public class Complex {  
    private double re;  
    private double im;  
  
    public Complex(double re, double im) { . . . }  
    public double abs() { . . . }  
    public String toString() { . . . }  
    public Complex conjugate() { . . . }  
    public Complex plus(Complex b) { . . . }  
    public Complex times(Complex b) { . . . }  
}
```

Advantage: can switch to polar representation without changing client.

Note: all of the data types we have created are actually ADTs!

Modular Programming and Encapsulation

ADTs enable modular programming.

- Split program into smaller modules.
- Separate compilation.
- Different clients can share the same ADT.

ADTs enable encapsulation.

- Keep modules independent (include `main` in each class for testing).
- Can substitute different classes that implement same interface.
- No need to change client.

Classes in Java

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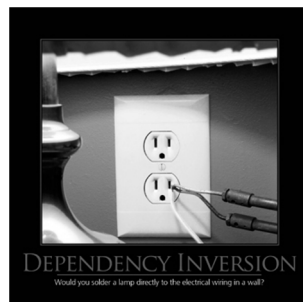
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ADTs are better than DTs

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Data representation in an ADT

- An ADT must obviously have *some* kind of representation for its data
 - The user need not know the representation
 - The user should not be allowed to tamper with the representation
 - Solution: Make all data **private**
- But what if it's really more convenient for the user to have direct access to the data?
 - Solution: Use *setters* and *getters*

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Example of setters and getters

```
class Pair {  
    private int first, last;  
  
    public getFirst() { return first; }  
    public setFirst(int first) { this.first = first; }  
  
    public getLast() { return last; }  
    public setLast(int last) { this.last = last; }  
}
```

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Aside: Naming setters and getters

- Setters and getters should be named by:
 - Capitalizing the first letter of the variable (**first** becomes **First**), and
 - Prefixing the name with **get** or **set** (**setFirst**)
 - For boolean variables, you can replace **get** with **is** (for example, **isRunning**)

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What's the point?

- We can *claim* that a class is an abstract data type if we make all data private
- However, if we then provide unlimited access by providing simple getters and setters for everything, we are only fooling ourselves

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What's the point?

Rules:

- Only supply getters and setters if there is a clear use for them
- Do not supply getters and setters that depend on the particular implementation you are using
- Never, *never* write a setter that could be used to create an invalid object!
 - Your setters should do all possible error checking before they change the object

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And another thing...

- Setters and getters allow you to keep control of your implementation
- For example, you decide to define a `Point` in a plane by its x-y coordinates:
 - `class Point { public int x; public int y; }`
- Later on, as you gradually add methods to this class, you decide that it's more efficient to represent a point by its angle and distance from the origin, θ and ρ
- Sorry, you can't do that—you'll break too much code that accesses `x` and `y` directly
- If you had used setters and getters, you could redefine them to *compute* `x` and `y` from θ and ρ

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Contracts

Every ADT should have a contract (or specification) that:

- Specifies the set of valid values of the ADT
- Specifies, for each operation of the ADT:
 - Its name
 - Its parameter types
 - Its result type, if any
 - Its observable behavior
- Does *not* specify:
 - The data representation
 - The algorithms used to implement the operations

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Importance of the contract

- A contract is an agreement between two parties; in this case
 - The implementer of the ADT, who is concerned with making the operations correct and efficient, *and also* with preserving the flexibility to make changes later
 - The applications programmer, who just wants to *use* the ADT to get a job done
- It does not matter if you are *both* of these parties; the contract is *still essential* for good code
- This separation of concerns is essential in any large project

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Promise no more than necessary

- For a general API, the implementer should provide as much generality as feasible
 - This is the way Sun's classes are (mostly) written
- But for a specific program, the class author should provide only what is essential at the moment
 - In Extreme Programming terms, “You ain't gonna need it!”
 - Your documentation should not expose anything that the application programmer does not need to know
- If you design for generality, it's easy to add functionality later—but removing it may have serious consequences

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Implementing an ADT

To implement an ADT, you need to choose:

- a data representation that
 - must be able to represent all possible values of the ADT
 - should be private
- a set of methods that support normal use of the ADT
 - The user must be able to create, possibly modify, and examine the values of the ADT
- an algorithm for each of the possible operations that
 - must be consistent with the chosen representation
 - all auxiliary (helper) operations that are not in the contract should be private

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Writing the contract

- In most cases, the Javadoc for a class *is* the contract
- This means:
 - The Javadoc documentation should describe what the class is for and how it should be used
 - The Javadoc documentation should ***not*** describe implementation details
 - Also, now is a good time to read **Documentation Comments** (rules 38 to 58) in *The Elements of Java Style*

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Writing the contract

- Sometimes, however...
 - The particular implementation makes certain operations efficient at the cost of making others inefficient
 - For example, Java provides both **ArrayList** (fast random access) and **LinkedList** (fast insertions and deletions)
 - The user needs to know this information, but doesn't need detailed implementation information

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Interfaces

- In many cases, an **interface** makes a better contract than a concrete implementation
- Why? Because the interface can only describe what the ADT does
 - It cannot describe variables
 - It cannot provide an implementation
 - Unfortunately, Java interfaces are not allowed to have constructors, but (as of Java 8) they are allowed to contain static methods. So we can implement creator operations as static methods. This design pattern, using a static method as a creator instead of a constructor, is called a factory method.

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Interfaces

simplified version of the Set interface:

```
public interface Set<E> {  
  
    // example of creator method  
  
    /** Make an empty set.  
     * @return a new set instance, initially empty  
     */  
    public static Set<E> make() { ... }  
}
```

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Interfaces

```
// examples of observer methods  
  
/** Get size of the set.  
 * @return the number of elements in this set. */  
public int size();  
  
/** Test for membership.  
 * @param e an element  
 * @return true iff this set contains e. */  
public boolean contains(E e);
```

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Interfaces

// examples of mutator methods

/** Modifies this set by adding e to the set.

* @param e element to add. */

public void add(E e);

/** Modifies this set by removing e, if found.

* If e is not found in the set, has no effect.

* @param e element to remove.*/

public void remove(E e);

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Interfaces

- Design principle: “Program to an interface, not an implementation”
 - Always avoid getting locked in to a specific implementation
 - Example: You need a list?
 - List myList = new ArrayList(); is better than ArrayList myList = new ArrayList();
 - This makes it much easier if you later decide a LinkedList is better, because it prevents you from using implementation-specific methods

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