Inheritance 1

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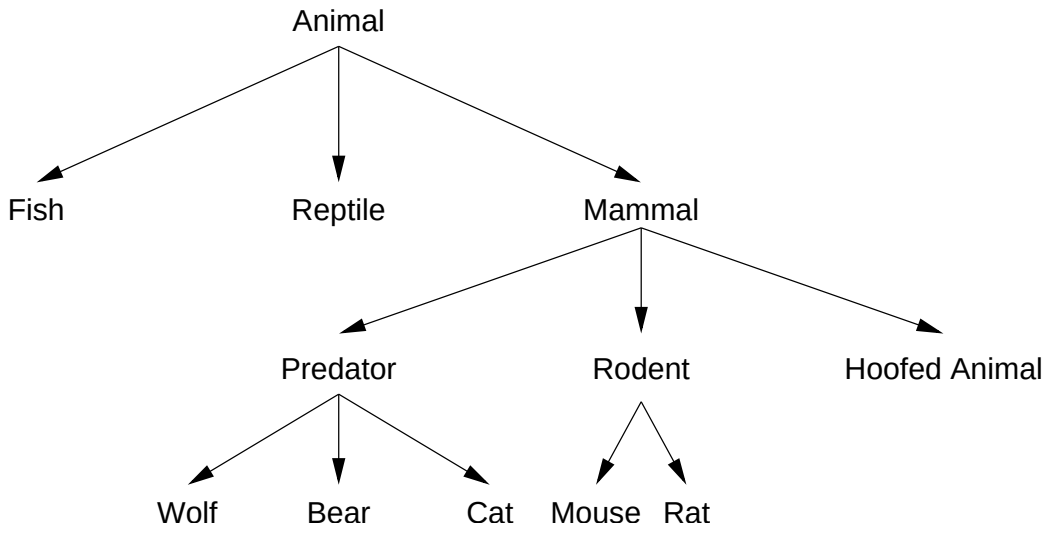
Fundamental Ideas

Classes

Classes represent collections of uniform objects.

- In reality, objects come in variants.
  - Often the variants can be hierarchically classified.



Fishes and mammals are both animals.

Common and Distinguishing Properties

Whether two objects belong to a class depends on how close we look.

- "A wolf and a mouse are both mammals."
  - Common characteristics: both breastfeed their offspring.
- "A wolf is a predator while a mouse is a rodent."
  - A wolf eats other animals.
  - A mouse eats corn.
- "Predator" and "mouse" have a common ancestor "mammal".
  - The classes share some properties but differ in other properties.

Java offers a similar organization of classes.

Shop Example

An internet shop offers books and CDs.

- Books:
  - Article number, title, price.
  - Author, publisher, ISBN number.
- CDs:
  - Article number, title, price.
  - Interpreter, list of songs.

A shopping cart shall list number, title, and price of articles.

Common Functionality

The common functionality may be extracted to a class.

```
public class Article
{
  public int number;
  public String title;
  public int price;

  public Article (...) { ... }

  public int getNumber() { ... }
  public String getTitle() { ... }
  public int getPrice() { ... }
}
```

Books and CDs are special cases of articles.

Inheritance

Special functionality may be added to the common functionality.

```
public class Book extends Article
{
  public String author;
  public String publisher;
  public String ISBN;

  public Book(...) { ... }

  public String getAuthor() { ... }
  public String getPublisher() { ... }
  public String getISBN() { ... }
}
```

Class `Book` inherits fields and methods of class `Article`.

Inheritance

Child classes inherit from parent classes.

```
public class Subclass extends Superclass implements Interface, ...
{
  ...
}
```

- *Subclass* is the child of *Superclass*.
  - *Superclass* is the parent of *Subclass* .
  - Single inheritance: a child class may have only one parent.
    - A class may implement multiple interfaces.
- *Subclass* inherits all fields and methods of *Superclass*.
  - Fields and methods can be used as if they were defined locally within *Subclass*.
  - *Subclass* may add additional fields and methods.

Inheritance

A class may have multiple children.

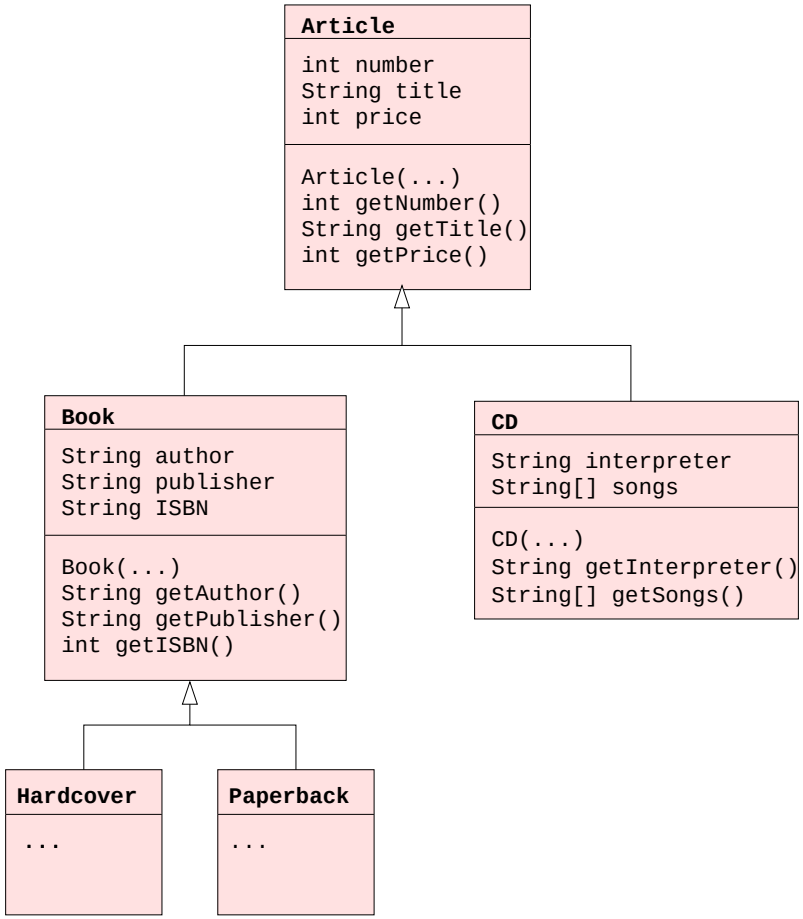
```
public class CD extends Article
{
  public String interpreter;
  public String[] songs;

  public CD(...) { ... }

  public String getInterpreter() { ... }
  public String[] getSongs() { ... }
}
```

Class `CD` inherits fields and methods of class `Article`.

Inheritance Hierarchy



Interface Inheritance

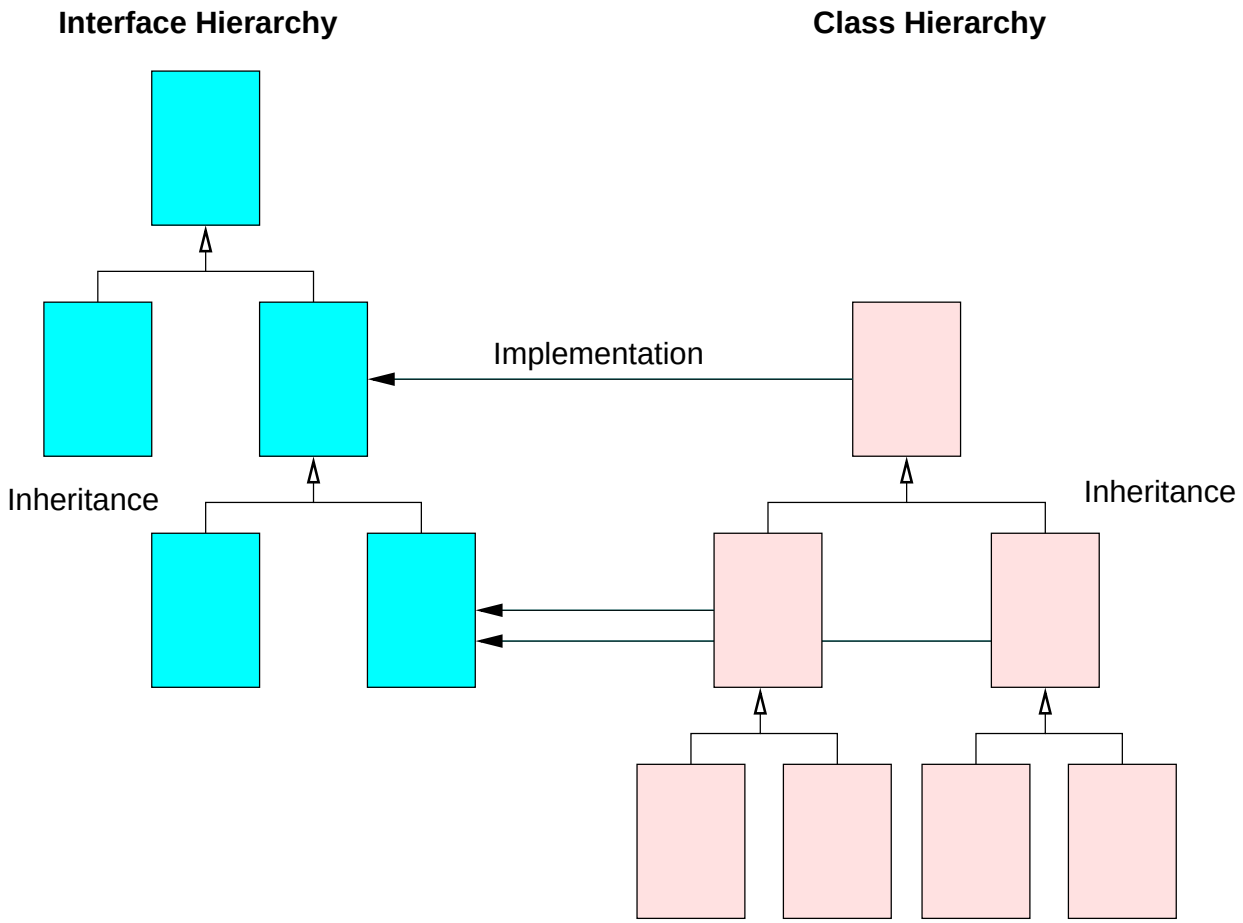
Also an interface may inherit from another interface.

```
public interface I extends J
{
  ...
}
```

- Interface *I* inherits methods and constants of interface *J*.
  - An interface cannot inherit from a class.
  - A class cannot inherit from an interface.

Classes and interfaces form separate inheritance hierarchies.

Interface and Class Inheritance



Constructors in Parent Classes

```
public class Article
{
  public int number;
  public String title;
  public int price;

  public Article(int n, String t, int p)
  {
     number = n;
     title = t;
     price = p;
  }
}
```

A parent class may have constructors.

Constructors in Child Classes

```
public class Book extends Article
{
  public String author;
  public String publisher;
  public String ISBN;

  public Book(int n, String t, int p, String a, String pb, String i)
  {
     number = n; title = t; price = p;
     author = a;
     publisher = pb;
     ISBN = i;
  }
}
```

A child class has its own constructors.

Calls of Constructors of Parent Classes

```
public class Book extends Article
{
  public String author;
  public String publisher;
  public String ISBN;

  public Book(int n, String t, int p, String a, String pb, String i)
  {
     super(n, t, p);
     author = a;
     publisher = pb;
     ISBN = i;
  }
}
```

A constructor may call with `super` a parent constructor.

Code Sharing

Inheritance reduces the amount of code to be written.

- Multiple subclasses inherit from the same superclass.
  - Common functionality is defined only once in the superclass.
- General rule:

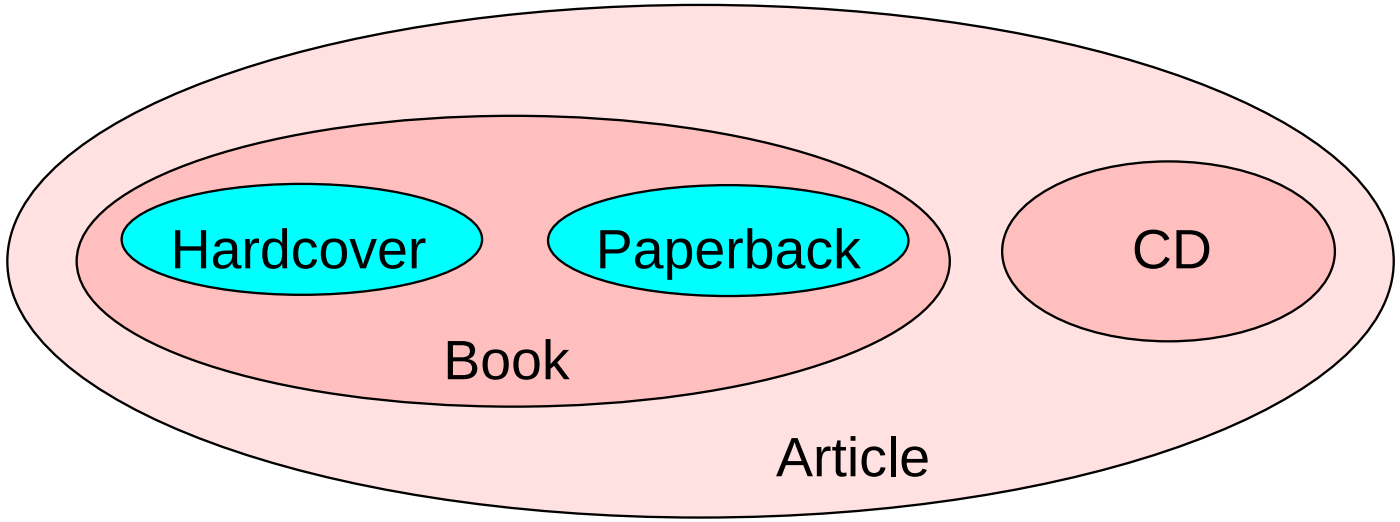
  Whenever there are two or more classes that share common functionality, this functionality should be put in a separate class; from this class, the other classes can be derived by inheritance.

Avoid code duplication by inheritance.

Dynamic Types and Genericicity

Is-Relationship

Every object of a subclass is also an object of the superclass.



An object of type `Book` is also an object of type `Article`.

Type Compatibility

A subclass is compatible with the super class.

- General rule:

  Every program that is able to work with objects of the superclass can automatically also work with objects of the subclass.

- Example: internet shop.
  - Write program that works with objects of type `Article`.
    - Place articles in shopping cart, print contents of cart, compute total price of order.
  - Later implement concrete articles as subclasses of `Article`.
    - `Book`, `CD`, `Video`, ...
  - Program can immediately work with these articles.
    - Program need not be modified.

First write the general functionality, then the more special one.

Object Assigments

A variable whose type is a class may refer to an object of a subclass.

- A `Book` is an `Article` and a `CD` is an `Article`.

```
Article a = new Book(...);
a = new CD(...);
```

- A `Article` variable may hold a `Book` or a `CD`.
  - Can only refer to the `Article` fields and methods.

```
String t = a.getTitle();
int p = a.getPrice();
```

  - May check the actual type with `instanceof`:

```
if (a instanceof Book)
{
  Book b = (Book)a;
  ...
}
```

Object Assigments

```
public class D extends C
{
  ...
}

D d = ...
C c = d;

C c = ...;
if (c instanceof D)
{
  D d = (D)c;
  ...
}
```

Static Types and Dynamic Types

An object variable has two kinds of types.

1. The static type:
   - The type with which the variable has been declared.
   - Determines to which fields and methods we can refer.
   - `Article a = new Book(...);`
2. The dynamic type:
   - The type of the object to which the variable refers.
   - Determines which methods are actually called (see later).
   - `Article a = new Book(...);`

The dynamic type is always a subtype of the static type.

Generic Methods

An object variable or parameter can refer to objects of different types.

```
public static void printInfo(Article a)
{
  int number = a.getNumber();
  String title = a.getTitle();
  int price = a.getPrice();
  System.out.print("Article '" + title);
  System.out.print( "' (" + number + ") costs ");
  System.out.println(price/100 + "." + price%100 + " Euro.");
}
```

A generic method may operate on objects of different types.

Generic Methods

A generic method may be invoked with objects of different types.

```
public class Book extends Article { ... }
public class CD extends Article { ... }

Book book = new Book(...);
CD cd = new CD(...);
printInfo(book);
printInfo(cd);
```

The argument may be any subtype of the parameter type.

The `Object` Class

Every class is a (direct or indirect) subclass of `Object`.

```
public class Class
{
  ...
}

public class Class extends Object
{
  ...
}
```

`Object` is a class of package `java.lang`.

A Generic Collection Class

`Object` may serve as a placeholder for any class.

```
public class Stack
{
  public int N = 100;
  public Object[] stack = new Object[N];
  public int n = 0;

  public void push(Object o)
  { if (n == N) resize();
    stack[n] = o;
    n++;
  }

  public Object pop() { n--; return stack[n]; }
}
```

Application

Any object type may be stored in the generic collection class.

```
Stack s = new Stack();
s.push(new Integer(2));
s.push(new Integer(3));
Integer i = (Integer)(s.pop());
```

The result of a selector function is `Object` as well.

Application

Different object types may be stored in a generic collection.

```
Stack s = new Stack();
s.push(new Integer(2)); s.push("hello");
Object o = s.pop();
if (o instanceof Integer)
{
  Integer i = (Integer)o;
  ...
}
else if (o instanceof String)
{
  String s = (String)o;
  ...
}
```

See the Java standard class `Stack`.