

# Inheritance

Polymorphism, Subtyping, Reuse

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Lecture #8 out of 8  
80 minutes

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Polymorphism

Implementation Inheritance

Chapter #1:

# Polymorphism

[ LSP SOLID Subtyping Generics Overloading ]

## Liskov Substitution Principle



“If for each object  $o_1$  of type  $S$  there is an object  $o_2$  of type  $T$  such that for all programs  $P$  defined in terms of  $T$ , the behavior of  $P$  is unchanged when  $o_1$  is substituted for  $o_2$ , then  $S$  is a subtype of  $T$ .”

— Barbara Liskov. Keynote Address — Data Abstraction and Hierarchy, 1987

[ LSP SOLID Subtyping Generics Overloading ]

## SOLID (the “L” part)



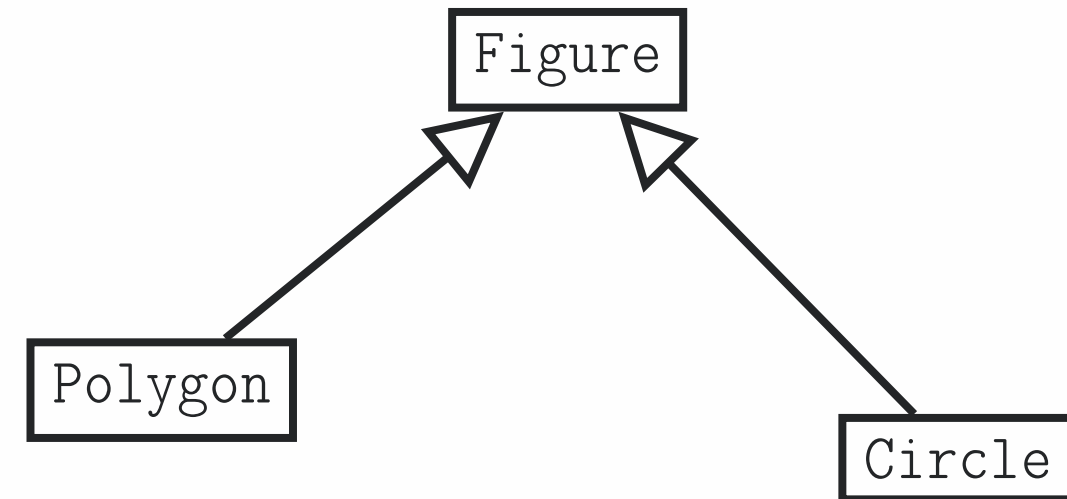
“Functions that use pointers or references to base classes must be able to use objects of derived classes without knowing it.”

— Robert C. Martin. *Clean Code: A Handbook of Agile Software Craftsmanship*. Pearson Education, 2008. doi:[10.5555/1388398](https://doi.org/10.5555/1388398)

[ LSP SOLID [Subtyping](#) Generics Overloading ]

## Subtyping

```
1 interface Figure
2     float area();
3
4 interface Circle extends Figure
5     float perimeter();
6
7 interface Polygon extends Figure
8     int sides();
9
10 void paint(Figure f)
11     float s = f.area();
12     // ...
```



Circle  $\sqsubseteq$  Figure

Circle <: Figure

[ LSP SOLID Subtyping Generics Overloading ]

## Parametric Polymorphism (Generics)

```
1 class StackOfStrings {  
2     void push(String str) // ...  
3     String pop() // ...  
4  
5 class StackOfIntegers {  
6     void push(Integer num) // ...  
7     Integer pop() // ...  
8  
9 var s1 = new StackOfStrings();  
10 s1.push("Hello, world!");  
11  
12 var s2 = new StackOfIntegers();  
13 s2.push(42);
```

```
1 class <T> Stack<T> {  
2     void push(T item) // ...  
3     T pop() // ...  
4 }  
5  
6 var s1 = new Stack<String>();  
7 s1.push("Hello, world!");  
8  
9 var s2 = new Stack<Integer>();  
10 s2.push(42);
```

[ LSP SOLID Subtyping Generics [Overloading](#) ]

## Ad Hoc Polymorphism (Method Overloading)

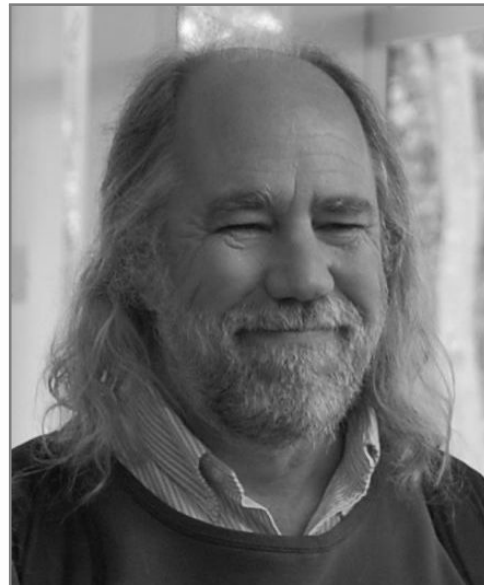
```
1 class Cart {
2     void add(int pid) // ...
3     void addString(String pid) {
4         this.add(Integer.parseInt(pid));
5     }
6 }
7
8 var c = new Cart();
9 c.add(42);
10 c.addString("17");
11 c.addString("Hello, world!");
```

```
1 class Cart {
2     void add(int pid) // ...
3     void add(String pid) {
4         this.add(Integer.parseInt(pid));
5     }
6 }
7
8 var c = new Cart();
9 c.add(42);
10 c.add("17");
11 c.add("Hello, world!");
```



Chapter #2:

# Implementation Inheritance



GRADY BOOCH

“However, there is tension between the concepts of coupling and inheritance because inheritance introduces significant coupling. On the one hand, weakly coupled classes are desirable; on the other hand, inheritance—which tightly couples superclasses and their subclasses—helps us to exploit the commonality among abstractions.”

— Grady Booch, Robert A. Maksimchuk, Michael W. Engle, Bobbi J. Young, Jim Connallen, and Kelli A. Houston. *Object-Oriented Analysis and Design With Applications*. Addison-Wesley, 1994. doi:[10.5555/1407387](https://doi.org/10.5555/1407387)



“The `|extends|` keyword is evil; maybe not at the Charles Manson level, but bad enough that it should be shunned whenever possible.”

— Allen Holub. Why Extends Is Evil. <https://jttu.net/holub2003extends>, 9 2003. [Online; accessed 12-09-2024]



“Someone asked him: “If you could do Java over again, what would you change?” “I’d leave out classes,” he replied.”

— Allen Holub. Why Extends Is Evil. <https://jttu.net/holub2003extends>, 9 2003. [Online; accessed 12-09-2024]

[ Reuse Composition Multiple Parents ]**Code reuse**

```
1 class Square
2     private float width;
3     float area()
4         return width * width;
5
6 class Circle extends Square
7     Circle(float radius)
8         super(radius);
9     @Override float area()
10         return 3.14 * super.area();
```



Here, the `|Circle|` is not a `|Square|`. It merely reuses the code that was negligently left open in the `|Square|`.

Inheriting means “receive (money, property, or a title) as an heir at the death of the previous holder.” Who is dead, you ask? An object is dead if it allows other objects to inherit its encapsulated code and data.

[ Reuse [Composition](#) Multiple Parents ]

## Composition over inheritance

### Implementation Inheritance:

```
1 class Square
2     private float width;
3     float area()
4         return width * width;
5
6 class Circle extends Square
7     Circle(float radius)
8         super(radius);
9     @Override float area()
10         return 3.14 * super.area();
```

### Composition:

```
1 final class Square
2     private float width;
3     float area()
4         return width * width;
5
6 final class Circle
7     private Square s;
8     Circle(float radius)
9         this.s = new Square(radius);
10    float area()
11        return 3.14 * s.area();
```

[ Reuse [Composition](#) Multiple Parents ]

All classes, without exceptions, should be either `final` or `abstract`



[ Reuse Composition Multiple Parents ]

## Multiple inheritance

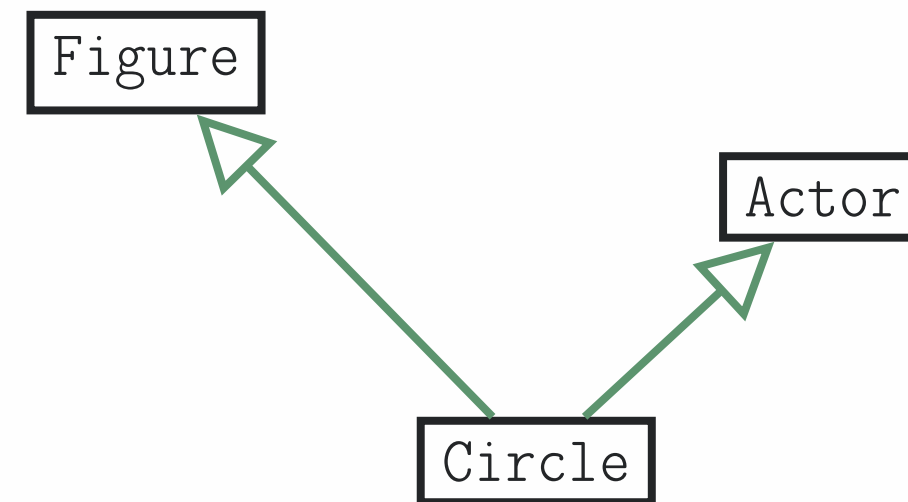
```
1 class Pi
2     float value()
3         return 3.1415926;
4
5 class Square
6     private float width;
7     float area()
8         return width * width;
9
10 class Circle extends Square, Pi
11     Circle(float r): Square(r), Pi() {}
12     virtual float area()
13         return Pi.value() * Square.area();
```



[ Reuse Composition Multiple Parents ]

## Multiple super types

```
1 interface Actor
2     void move(int dx, int dy);
3
4 interface Figure
5     float area();
6
7 class Circle implements Figure, Actor
8     Circle(float r)
9     @Override float area()
10         // ...
11     @Override void move(int dx, int dy)
12         // ...
```



[ Reuse Composition Multiple [Parents](#) ]

# Bibliography

Grady Booch, Robert A. Maksimchuk, Michael W. Engle,  
Bobbi J. Young, Jim Connallen, and Kelli A. Houston.

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