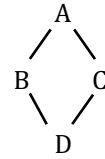


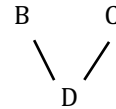
The diamond problem: multiple inheritance

Google “diamond problem” and you will get a bunch of websites that talk about the diamond problem in OO languages, showing a diamond like that drawn to the right. It shows classes or interfaces (Java terminology) A, B, C, and D, with (1) B and C extending or implementing A and (2) D extending or implementing both B and C. The diamond problem has to do with multiple inheritance. If both B and C declare a method *m* and D calls *m*, which method *m* should be called, the one in B or the one in C? This question has to be answered in some unambiguous way.



Multiple inheritance is an issue not just in Java but in many OO languages like C++, Common Lisp, C#, Eiffel, Go, OCaml, Perl, Python, Ruby, and Scala. Each OO language solves the ambiguity in some way.

We show you the solution to the diamond problem in Java, talking a bit about its history. But in Java, at least, it's not a *diamond* problem, it's a *Vee* problem. Class or interface A is a red herring, it has nothing to do with the problem and can be removed from the discussion. Only B, C, and D are needed to explain the problem and its solutions. Here is how Java handles the multiple inheritance problem.



1. B, C, and D are classes

The program to the right is not a legal Java program because class D may extend only one class, and here it extends both B and C. But if it were legal, it would be ambiguous because in class D, it is not known which method *m* to call, the one inherited from class B or the one inherited from class C. Java avoids the multiple inheritance problem for classes by allowing a class to extend only one other class.

```
class B { int m() {return 0;} }
class C { int m() {return 1;} }
class D extends B, C {
    void p() {System.out.println(m());}
}. // not legal Java
```

2. B, C are interfaces and D is a class, in version 7 or less

Class D can implement many interfaces. To the right, it implements both B and C. Further, in Java 7 and earlier, all methods in an interface are abstract, and method had to be overridden in any class that implements the interface. The interface defines only the *syntax* of calls on a method, so there is no ambiguity.

```
interface B { int m(); }
interface C { int m(); }
class D implements B, C {
    void p() {System.out.println(m());}
    public int m() {return 5;}
}
```

3. B and D are classes and C is an interface, in version 7 or less

To the right, class B declares method *m* and interface C declares abstract *m*. Since D inherits *m* from B, D need not declare *m* again; it is already available. There is no ambiguity here because interface C defines only the syntax of calls on *m*.

Suppose B does not declare *m* to be public. Then there is a syntax error: inherited method *m* cannot hide public abstract method *m* in C. There is a choice here: either have *m* in B be public or declare public method *m* in D.

```
class B { public int m() {return 0;} }
interface C { int m(); }
class D extends B implements C {
    void p() {System.out.println(m());}
}
```

4. Default interface methods in Java version 8

Version 8 of Java, released in Spring 2014, allowed default methods in interfaces, as shown to the right. Since interface C has a default method *m*, class D does not have to override *m*; if it doesn't, the default method is used.

Ah, but now we have a problem. With the classes and interfaces shown to the right, what method *m* will be called in method *D.p*? The one in class B or the one in interface C?

For backward compatibility (a Java 7 program should run in Java 8) the Java designers ruled that the method in B should be called: the superclass has precedence over the interface.

```
interface C { default int m() {return 1;}}
class D implements C {
    void p() {System.out.println(m());}
}
```

```
class B { public int m() {return 0;} }
interface C { default int m() {return 1;}}
class D extends B implements C {
    void p() {System.out.println(m());}
}
```

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5. How does one call the interface default method?

In method `D.p`, how does one call inherited default method `C.m`? Use something you may not have seen before: use `C.super`... to designate the implemented interface `C` whose method is to be called:

```
C.super.m();
```

Here, there is no ambiguity. In method `p`, a call `m()` calls method `m` in inherited from class `B`, and a call `C.super.m()` calls default method `m` inherited from interface `C`.

```
class B { public int m() {return 0;} }  
interface C { default int m() {return 1;}}  
class D extends B implements C {  
    void p() {  
        System.out.println(C.super.m());  
    }  
}
```

6. No class extension, no multiple interfaces with a default

If class `D` does not extend a class and implements two interfaces that both have a default method `m`, as shown to the right, the program has a syntax error and won't compile. Even if method `m` in one of the interfaces is abstract, it's still a syntax error.

```
interface C1 { default int m() {return 1;}}  
interface C2 { default int m() {return 2;}}  
class D implements C1, C2 {  
    ...  
} // syntax error: won't compile
```

7. With a class extension, multiple interfaces with defaults are OK

In the program to the right, `D` extends class `B` and implements interfaces `C1` and `C2`. All three of them —`B`, `C1`, and `C2`— declare method `m`. The return statement in method `D.p` shows how to call all three of the inherited methods.

```
class B { public int m() {return 0;} }  
interface C1 {default int m() {return 1;}}  
interface C2 {default int m() {return 2;}}  
class D extends B implements C1, C2 {  
    public int p() {  
        return m() + C1.super.m() + C2.super.m();  
    }  
}
```

Example of backward compatibility

We said earlier that the choice of a method in the superclass instead of the default method in the interface was made to maintain backward compatibility. Here's one of many examples of why this choice was made. In Java 7, interface `java.util.List` had no abstract method to sort a list. In Java 8, they wanted to make life easier for programmers by adding this default method to interface `List`:

```
default void sort(Comparator<? super E> c)
```

It can be used to sort any `List`. For the Java 7 program shown on the right to work as it did in Java 7, `B.sort` had to be called from method `p`, even though `List` has a default method `sort`.

```
class B {  
    ...  
    public void sort(...) {...}  
    ...  
}  
class D extends B implements List {  
    void p() {... sort(...); ... }  
}
```