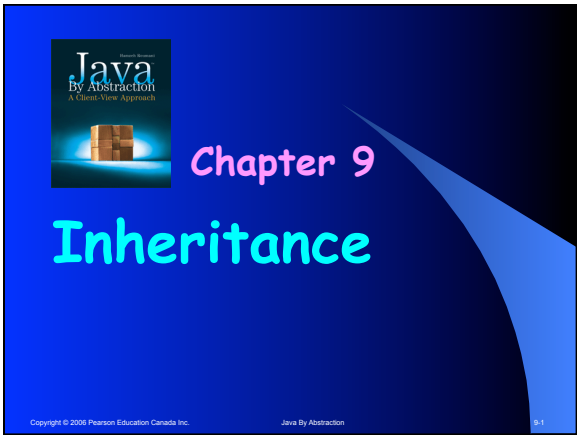


Outline

9.1 What is Inheritance?

For each pair, determine the relationship if any

- Camera, Film
- Vehicle, Car
- Library, Book
- Animal, Dog
- Car, Tree

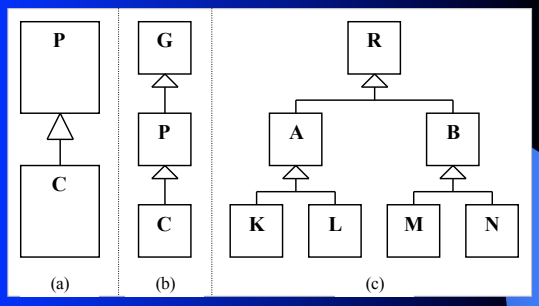
When can you say that the 2nd is a subclass of the 1st

9.1.1 Definition and Terminology

- The API of a class C may indicate that it extends some other class P
- Every feature of P is in C
- C inherits from P.
- Child-Parent, Subclass-Superclass
- Inheritance = is-a = Specialization
- Inheritance chain, hierarchy (root, descendents, ascendant)

 Java By Abstraction 9-4

UML



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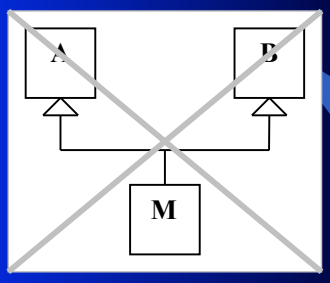
No Multiple Inheritance



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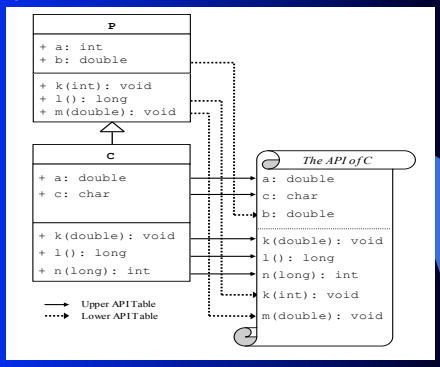
9.1.2 The Subclass API



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Feature Classification

- Inherited from parent
  Lower table
- Added as new by child
  Upper table
- Overriding by child (same signature)
  Upper table
- Shadowing by child (same name)
  Upper table

Note: a child cannot override with a diff return!

 Java By Abstraction 9-8

Feature Count

Is this correct?

- x = #of methods in parent's UML
- y = #of methods in child's UML
- The child's API shows x + y methods
  (upper plus lower)

Repeat for fields.

 Java By Abstraction 9-9

9.1.3 Case Study: CC-RW

Examine the API of CreditCard

- Issue a card #9 to Adam
- Charge $500 on it
- Pay back $300
- How many dollars does Adam owe?

RewardCard

- Issue a reward card #9 to Adam
- Charge $500 on it
- Pay back $300
- How many does Adam owe?
- How many reward points does he have?

Case Study, cont.

Examine the API of RewardCard

- Is the constructor inherited?
- How many fields does it have?
- How many methods does it have?
- Provide a rationale as to why certain methods were overridden, or added.

9.2 Working with Hierarchies

- Inheritance is no problem as long as client deals with one class at a time
- Just watch out for multiple tables in the API of that class
- What if the client uses several sub-classes on a chain?

 Java By Abstraction 9-13

Example

Write a program that prompts the user for a card type and then instantiate the desired card and charge $250 on it.

 Java By Abstraction 9-14

Example

```
output.println("Ordinary or Reward [O/R]?");
char type = input.nextChar();
if (type == 'O')
{
   CreditCard card;
   card = new CreditCard(9, "Adam");
} else
{
   RewardCard card;
   card = new RewardCard(9, "Adam");
}
// charge the card
```

 Java By Abstraction 9-15

Example

```
output.println("Ordinary or Reward [O/R]?");
char type = input.nextChar();
if (type == 'O')
{
   CreditCard card;
   card = new CreditCard(9, "Adam");
} else
{
   RewardCard card;
   card = new RewardCard(9, "Adam");
}
// charge the card
```

But it is out of scope here!

 Java By Abstraction 9-16

Example

```
output.println("Ordinary or Reward [O/R]?");
char type = input.nextChar();
if (type == 'O')
{
   CreditCard card;
   card = new CreditCard(9, "Adam");
} else
{
   RewardCard card;
   card = new RewardCard(9, "Adam");
}
// charge the card
```

 Java By Abstraction 9-17

9.2.1 The Substitutability Principle

When a parent is expected, a child is accepted

- Similar to substituting "man" or "woman" in The fare is $5 per person
- Similar to automatic promotion of primitive's.
- Compiler uses it in:
  - LHR / RHS of an assignment
  - Parameter passing

 Java By Abstraction 9-18

Substitutability Examples

Assigning RHS to LHS:

```
CreditCard card = new RewardCard(…);
```

Passing parameters:

```
CreditCard cc = new CreditCard(…);
RewardCard rc = new RewardCard(…);
if (cc.isSimilar(rc))
{   …
```

 Java By Abstraction 9-19

9.2.2 Early & Late Binding

How do you bind: `r.m(…)` ?

 Java By Abstraction 9-20

9.2.2 Early & Late Binding

How do you bind: `r.m(…)` ?

1. Search for m(…) in the declared class of r
2. If more than one, pick S, the most specific
3. If above failed, issue compile-time error

 Java By Abstraction 9-21

9.2.2 Early & Late Binding

How do you bind: `r.m(…)` ?

1. Search for m(…) in the declared class of r
2. If more than one, pick S, the most specific
3. If above failed, issue compile-time error

This is early binding. It is done at compile time and culminates in an error or a signature S.

 Java By Abstraction 9-22

9.2.2 Early & Late Binding

How do you bind: `r.m(…)` ?

This is late binding. It is done at runtime and culminates in an error or a binding.

1. If r is null, issue runtime error (NullPointer)
2. Search for S in actual class of r (the object)
3. You will find it … guaranteed!

 Java By Abstraction 9-23

9.2.2 Early & Late Binding

How do you bind: `r.m(…)` ?

1. Search for m(…) in the declared class of r
2. If more than one, pick S, the most specific
3. If above failed, issue compile-time error

1. If r is null, issue runtime error (NullPointer)
2. Search for S in actual class of r (the object)
3. You will find it!

 Java By Abstraction 9-24

Example

Bind all invocations:

```
CreditCard c1 = new RewardCard(9, "Jim");
CreditCard c2 = new RewardCard(9, "Eve");

c1.charge(500);
c1.pay(500);

output.println(c1.isSimilar(c2));
```

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9.2.3 Polymorphism

- An invocation of an overridden method, e.g. r.charge(500), is polymorphic
- The meaning changes (during late binding) based on the actual object type
- Polymorphism leads to elegant programs. No if statements and no redundancies.

 Java By Abstraction 9-26

9.2.3 Polymorphism

- For methods that are only present in the child, polymorphism cannot be used.
- Must have a cast (down the chain)
- In such cases, use instanceof before casting

 Java By Abstraction 9-27

Example 1

Given that `card` is declared as CreditCard, find its point balance if applicable.

Example 1

Given that `card` is declared as CreditCard, find its point balance if applicable.

First attempt:

```
if (card instanceof RewsrdCard)
{
   output.println(card.getPointBalance());
}
```


Example 1

Given that `card` is declared as CreditCard, find its point balance if applicable.

Correct solution:

```
if (card instanceof RewsrdCard)
{
     RewardCard rc = (RewardCard) card;
     output.println(rc.getPointBalance());
}
```

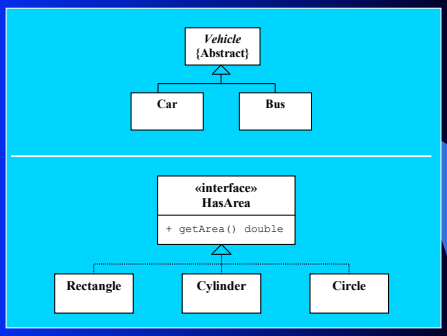

Example 2

Predict the output:

```
CreditCard c1 = new RewardCard(9, "Adam");
CreditCard c2 = new RewardCard(9, "Adam");
c1.charge(100);
c1.pay(100);
print(c1.isSimilar(c2));
print(c1.isSimilar((RewardCard) c2));
print(((RewardCard) c1).isSimilar(c2));
print(((RewardCard) c1).isSimilar((RewardCard) c2));
```

 Java By Abstraction 9-31

9.2.4 Abstract Classes & Interfaces



 Java By Abstraction 9-32

Abstract Classes & Interfaces, cont.

Key points to remember:

- How to recognize an abstract class or an interface given its API or UML diagram.
- Both can be used as types for declarations.
- An abstract class cannot be instantiated. Instead, look for a concrete class C that extends it (or for a factory method that returns an instance of C).
- An interface class cannot be instantiated. Instead, look for a class C that implements it.

Example: create an instance of `Calendar`.

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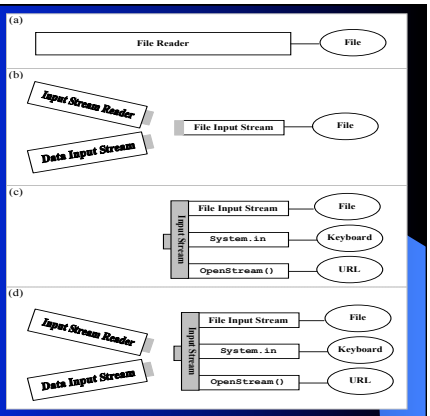
9.2.5 Revisiting Streams



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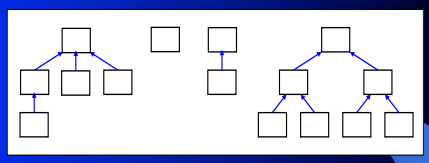
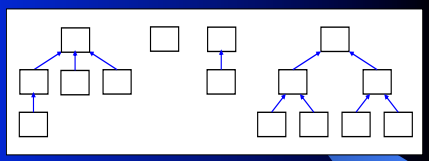
9.3 Obligatory Inheritance



 Java By Abstraction 9-35

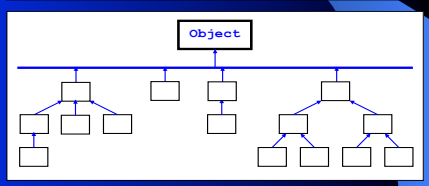
9.3 Obligatory Inheritance

Option #1



Option #2

Java uses this one.



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9.3.1 The Object Class

Conclusion:

All classes have the features present in Object (unless they overrode them). They include:

- toString()
- equals()
- getClass()

9.3.2 Case Study: Object Serialization

Serialize = Write the state of an object to a stream

1. Create an output stream connected to a file:
```
FileOutputStream fos;
fos = new FileOutputStream(filename);
```
2. Create an object output stream that feeds the file output stream:
```
ObjectOutputStream oos;
oos = new ObjectOutputStream(fos);
```
3. Serialize an object x: `oos.writeObject(x);`
4. Close the stream: `oos.close();`

Object Serialization, cont.

De-serialize = Reconstruct a serialized object

```
FileInputStream fis;
fis = new FileInputStream(filename);

ObjectInputStream ois;
ois = new ObjectInputStream(fis);

x = (cast*) ois.readObject();

ois.close();
```

*The cast is needed because `readObject` returns an Object