

Programming Language Concepts: Lecture 3

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Subclasses

- A class `Employee` for employee data

```
class Employee{
    private String name;
    private double salary;

    // Some Constructors ...

    // "mutator" methods
    public boolean setName(String s){ ... }
    public boolean setSalary(double x){ ... }

    // "accessor" methods
    public String getName(){ ... }
    public double getSalary(){ ... }

    // other methods
    double bonus(float percent){
        return (percent/100.0)*salary;
    }
}
```

Subclasses

- ▶ Managers are special types of employees with extra features

```
class Manager extends Employee{  
    private String secretary;  
    public boolean setSecretary(name s){ ... }  
    public String getSecretary(){ ... }  
}
```

- ▶ **Manager** objects inherit other fields and methods from **Employee**
 - ▶ Every **Manager** has a **name**, **salary** and methods to access and manipulate these.
- ▶ **Manager** is a **subclass** of **Employee**
 - ▶ Think of subset

Subclasses

- ▶ **Manager** objects do not automatically have access to private data of parent class.
- ▶ Common to extend a parent class written by someone else

Subclasses

- Can use parent class's constructor using `super`

```
class Employee{  
    ...  
    public Employee(String n, double s){  
        name = n; salary = s;  
    }  
    public Employee(String n){  
        this(n,500.00);  
    }  
}
```

- In `Manager`

```
public Manager(String n, double s, String sn){  
    super(n,s);    /* super calls  
                    Employee constructor */  
    secretary = sn;  
}
```

Subclasses

- ▶ Subclass can override methods of super class

```
double bonus(float percent){  
    return 1.5*super.bonus(percent);  
}
```

- ▶ In general, subclass has more features than parent class
- ▶ Can use a subclass in place of a superclass

```
Employee e = new Manager(...)
```

- ▶ Every `Manager` is an `Employee`, but not vice versa!
- ▶ Recall

- ▶ `int[] a = new int[100];`
- ▶ **Aside:** Why the seemingly redundant reference to `int` in `new`?

- ▶ One can now presumably write

```
Employee[] e = new Manager(...)[100]
```

Subclasses

```
Employee e = new Manager(...)
```

- Can we invoke `e.setSecretary`?

Subclasses

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Employee e = new Manager(...)
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- ▶ Can we invoke `e.setSecretary`?
 - ▶ `e` is declared to be an `Employee`
 - ▶ Static typechecking — `e` can only refer to methods in `Employee`

Subclasses

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- ▶ Can we invoke `e.setSecretary`?
 - ▶ `e` is declared to be an `Employee`
 - ▶ Static typechecking — `e` can only refer to methods in `Employee`
- ▶ What about `e.bonus(p)`? Which `bonus` do we use?
 - ▶ **Static**: Use `Employee.bonus`
 - ▶ **Dynamic**: Use `Manager.bonus`

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Employee e = new Manager(...)
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 - ▶ `e` is declared to be an `Employee`
 - ▶ Static typechecking — `e` can only refer to methods in `Employee`
- ▶ What about `e.bonus(p)`? Which `bonus` do we use?
 - ▶ **Static**: Use `Employee.bonus`
 - ▶ **Dynamic**: Use `Manager.bonus`
- ▶ **Dynamic dispatch** (dynamic binding, late method binding, ...) turns out to be more useful
 - ▶ Default in Java, optional in C++ (use `virtual`)

Dynamic dispatch

```
Employee[] emparray = new Employee[2];  
Employee e = new Employee(...);  
Manager m = new Manager(...);  
  
emparray[0] = e;  
emparray[1] = m;  
  
for (i = 0; i < emparray.length; i++){  
    System.out.println(emparray[i].bonus(5.0);  
}
```

Dynamic dispatch

```
Employee[] emparray = new Employee[2];  
Employee e = new Employee(...);  
Manager m = new Manager(...);  
  
emparray[0] = e;  
emparray[1] = m;  
  
for (i = 0; i < emparray.length; i++){  
    System.out.println(emparray[i].bonus(5.0));  
}
```

- ▶ Every `Employee` in `emparray` “knows” how to calculate its `bonus` correctly!
- ▶ Also referred to as **runtime polymorphism** or **inheritance polymorphism**

Functions, signatures and overloading

- ▶ Signature of a function is its name and the list of argument types
- ▶ Can have different functions with the same name and different signatures
 - ▶ For example, multiple constructors

Functions, signatures and overloading ...

- ▶ Java class `Arrays`: method `sort` to sort arbitrary scalar arrays

```
double[] darr = new double[100];  
int[] iarr = new int[500];  
...  
Arrays.sort(darr); // sorts contents of darr  
Arrays.sort(iarr); // sorts contents of iarr
```

Functions, signatures and overloading ...

- ▶ Java class `Arrays`: method `sort` to sort arbitrary scalar arrays

```
double[] darr = new double[100];  
int[] iarr = new int[500];  
...  
Arrays.sort(darr); // sorts contents of darr  
Arrays.sort(iarr); // sorts contents of iarr
```

- ▶ Methods defined in class `Arrays`

```
class Arrays{  
    ...  
    public static void sort(double[] a){..  
        // sorts arrays of double[]  
    public static void sort(int[] a){..  
        // sorts arrays of int[]  
    ...  
}
```

Functions, signatures and overloading ...

- ▶ **Overloading**: multiple methods, different signatures, choice is static
- ▶ **Overriding**: multiple methods, same signature, choice is static
 - ▶ `Employee.bonus`
 - ▶ `Manager.bonus`
- ▶ **Dynamic dispatch**: multiple methods, same signature, choice made at run-time

Inheritance

```
Employee e = new Manager(...)
```

- ▶ Can we force `e.setSecretary` to work?

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- ▶ Type casting

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((Manager) e).setSecretary(s)
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((Manager) e).setSecretary(s)
```

- ▶ Cast fails (error) if `e` is not a `Manager`
- ▶ Can test if `e` is a `Manager`

```
if (e instanceof Manager){  
    ((Manager) e).setSecretary(s);  
}
```

Inheritance

```
Employee e = new Manager(...)
```

- ▶ Can we force `e.setSecretary` to work?
- ▶ Type casting

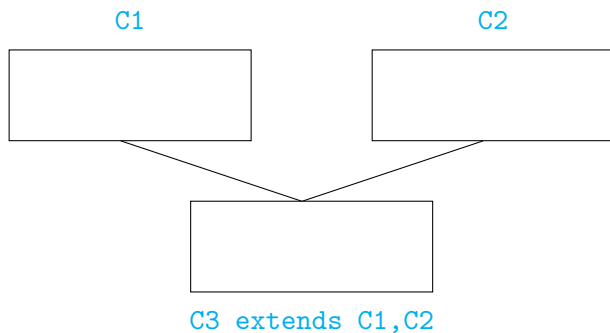
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((Manager) e).setSecretary(s)
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- ▶ Cast fails (error) if `e` is not a `Manager`
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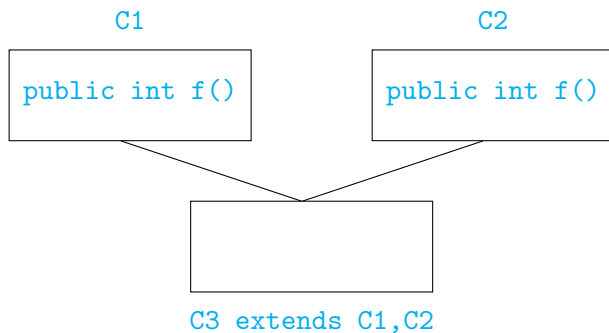
```
if (e instanceof Manager){  
    ((Manager) e).setSecretary(s);  
}
```

- ▶ **Reflection** — “think about oneself”

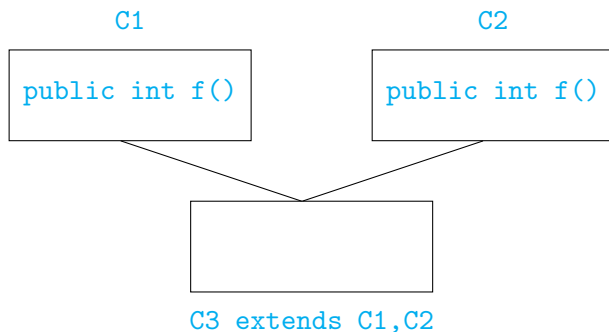
Multiple inheritance



Multiple inheritance



Multiple inheritance



- ▶ Which `f` do we use in C3 (assuming `f` is not redefined)?
 - ▶ Java does not allow multiple inheritance
 - ▶ C++ allows this if C1 and C2 have no conflict

Java class hierarchy

- ▶ No multiple inheritance — tree-like
- ▶ In fact, there is a universal superclass `Object`
- ▶ Useful methods defined in `Object`

```
boolean equals(Object o) // defaults to pointer equality
```

```
String toString() // converts the values of the  
// instance variable to String
```

- ▶ To print `o`, use `System.out.println(o+"");`

Java class hierarchy

```
public int find (Object[] objarr, Object o){  
    int i;  
    for (i = 0; i < objarr.length(); i++){  
        if (objarr[i] == o) {return i};  
    }  
    return (-1);  
}
```

Java class hierarchy

```
public int find (Object[] objarr, Object o){  
    int i;  
    for (i = 0; i < objarr.length(); i++){  
        if (objarr[i] == o) {return i};  
    }  
    return (-1);  
}
```

- Recall that `==` is pointer equality

Java class hierarchy

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public int find (Object[] objarr, Object o){  
    int i;  
    for (i = 0; i < objarr.length(); i++){  
        if (objarr[i] == o) {return i};  
    }  
    return (-1);  
}
```

- ▶ Recall that `==` is pointer equality
- ▶ Redefine `equals`

```
boolean equals(Date d){  
    return ((this.day == d.day) &&  
            (this.month == d.month) &&  
            (this.year == d.year));  
}
```

Java class hierarchy

- ▶ `boolean equals(Date d)` does not override `boolean equals(Object o)`!

Java class hierarchy

- ▶ `boolean equals(Date d)` does not override `boolean equals(Object o)`!
- ▶ Should write

```
boolean equals(Object d){  
    if (d instanceof Date){  
        return ((this.day == d.day) &&  
                (this.month == d.month) &&  
                (this.year == d.year));  
    }  
    return(false);  
}
```

Java class hierarchy

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Suppose `boolean equals(Employee e)` but no `equals` in `Manager`

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- Overriding looks for “closest” match

Suppose `boolean equals(Employee e)` but no `equals` in `Manager`

```
Manager m1 = new Manager(...);  
Manager m2 = new Manager(...);  
...  
if (m1.equals(m2)){ ... }
```

Java class hierarchy

- Overriding looks for “closest” match

Suppose `boolean equals(Employee e)` but no `equals` in `Manager`

```
Manager m1 = new Manager(...);  
Manager m2 = new Manager(...);  
...  
if (m1.equals(m2)){ ... }
```

`boolean equals(Manager m)` compatible with both
`boolean equals(Employee e)` and
`boolean equals(Object o)`

Java class hierarchy

- Overriding looks for “closest” match

Suppose `boolean equals(Employee e)` but no `equals` in `Manager`

```
Manager m1 = new Manager(...);  
Manager m2 = new Manager(...);  
...  
if (m1.equals(m2)){ ... }
```

`boolean equals(Manager m)` compatible with both
`boolean equals(Employee e)` and
`boolean equals(Object o)`

Use `boolean equals(Employee e)`