V - Polymorphism

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Overview

- **Definitions**
- **Static ("compile-time") Polymorphism**
- **Polymorphic references, Upcasting / Downcasting**
- **Runtime ("dynamic") Polymorphism**
- **Polymorphic Safety**
- **Polymorphism - Java vs. C++**

Polymorphism Defined

- Literally: from the Greek

  poly *("many")* + ***morphos*** *("forms")*

- Examples in nature:
  - Carbon: graphite or diamond
  - H_2O: water, ice, or steam
  - Honeybees: queen, drone, or worker

- Programming examples:
  - An operation that can be done on various types of objects
  - An operation that can be done in a variety of ways
  - A reference can be assigned to different types

"Static" Polymorphism

Detectable *during compilation.*

Example: Operator overloading:

```
int1 =  int2 + int3 ;

float1 =  float2 + float3 ;
```

- The "+" can perform on *different* types of objects
- "+" can therefore be thought of as a "*polymorphic operator*"

"Static" Polymorphism (cont.)

Another example: Method overloading:

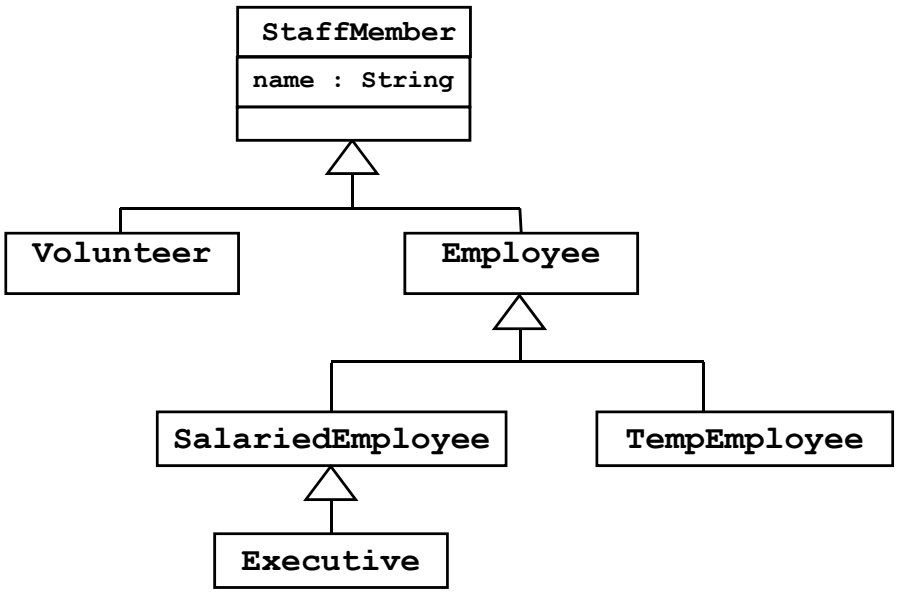
```
//return the distance to an origin
double distance (int x, int y) { . . . }

//return the distance between two points
double distance (Point p1, Point p2) { . . . }
```

- Same method name, for two different operations
- "**`distance`**" can therefore be thought of as a "*polymorphic method*"

Polymorphic References

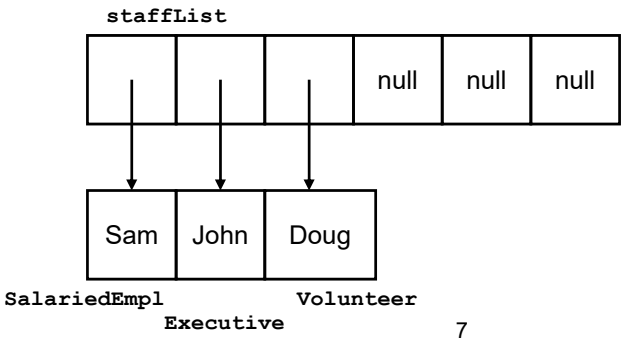
Consider the following class hierarchy:



Polymorphic References (cont.)

- A "polymorphic reference" can *refer to different object types at runtime*:

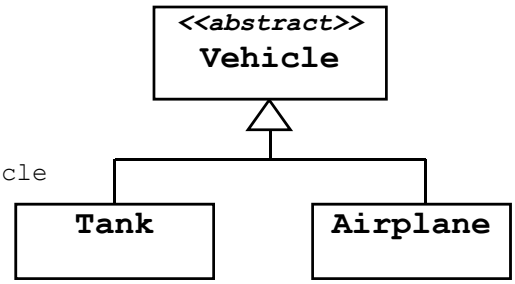
```
StaffMember [ ] staffList = new StaffMember[6];
. . .
staffList[0] = new SalariedEmployee ("Sam");
staffList[1] = new Executive ("John");
staffList[2] = new Volunteer ("Doug");
. . .
```



Upcasting and Downcasting

- "Upcasting" allowed in assignments:

```
Vehicle v ;
Airplane a = new Airplane();
Tank t = new Tank();
...
v = t ;   // a tank IS-A Vehicle
v = a;    // an airplane IS-A Vehicle
```

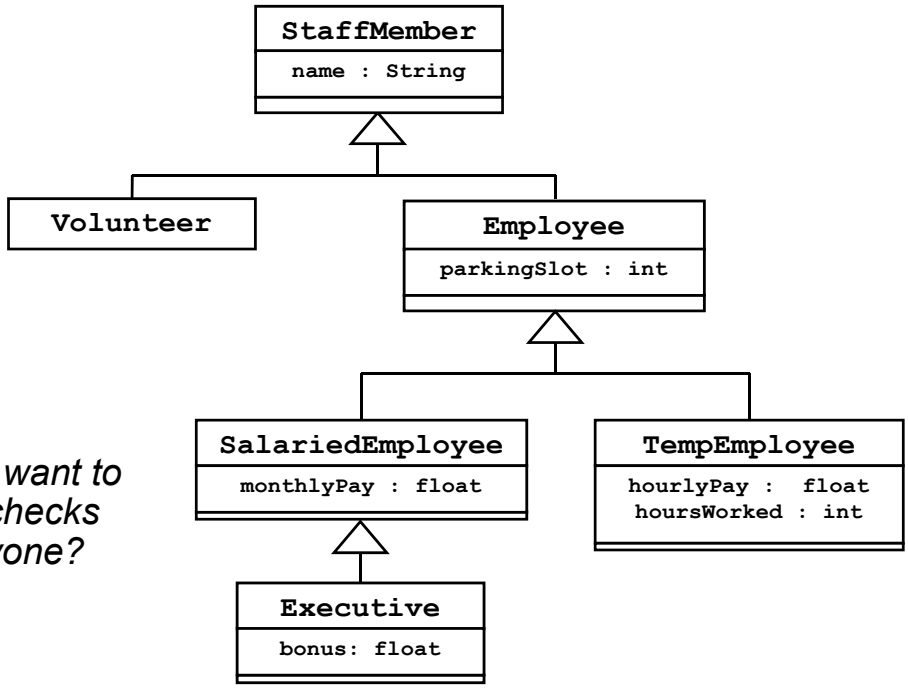


- "Downcasting" requires casting:

```
t = v ;          // compiler error - a Vehicle isn't a Tank
t = (Tank) v ;   // legal, but dangerous
```

Runtime Polymorphism

Consider this expanded version of the hierarchy shown earlier:



What if we want to print paychecks for everyone?

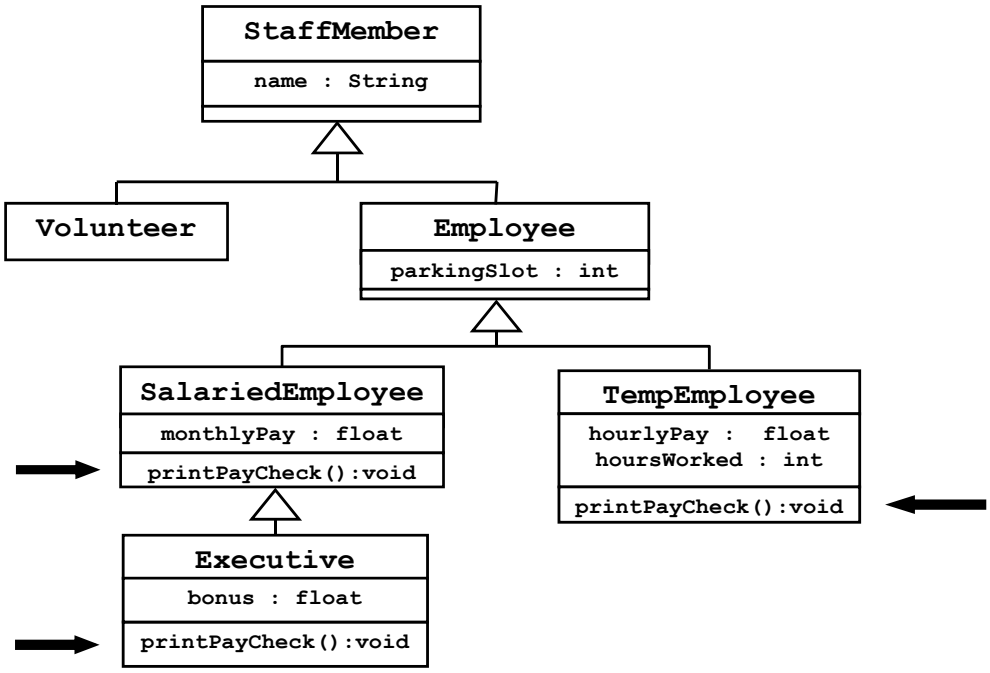
Runtime Polymorphism (cont.)

Printing Paychecks (traditional approach) :

```
for (int i=0; i<staffList.length; i++) {
  String name = staffList[i].getName();
  float amount = 0;
  if (staffList[i] instanceof SalariedEmployee) {
      SalariedEmployee curEmp = (SalariedEmployee) staffList[i];
      amount = curEmp.getMonthlyPay();
      printPayCheck (name, amount);
  } else if (staffList[i] instanceof Executive) {
      Executive curExec = (Executive) staffList[i] ;
      amount = curExec.getMonthlyPay() + curExec.getBonus());
      printPayCheck (name, amount);
  } else if (staffList[i] instanceof TempEmployee) {
      TempEmployee curTemp = (TempEmployee) staffList[i] ;
      amount = curTemp.getHoursWorked()*curTemp.getHourlyPay();
      printPayCheck (name, amount);
  }
}
. . .
private void printPayCheck (String name, float amt) {
  System.out.println ("Pay To The Order Of:" + name + " $" + amt);
}
```

Runtime Polymorphism (cont.)

First, paycheck computation should be "encapsulated":



Runtime Polymorphism (cont.)

Polymorphic solution:

```
...
for (int i=0; i<staffList.length; i++) {
     staffList[i].printPayCheck() ;
}
...
```

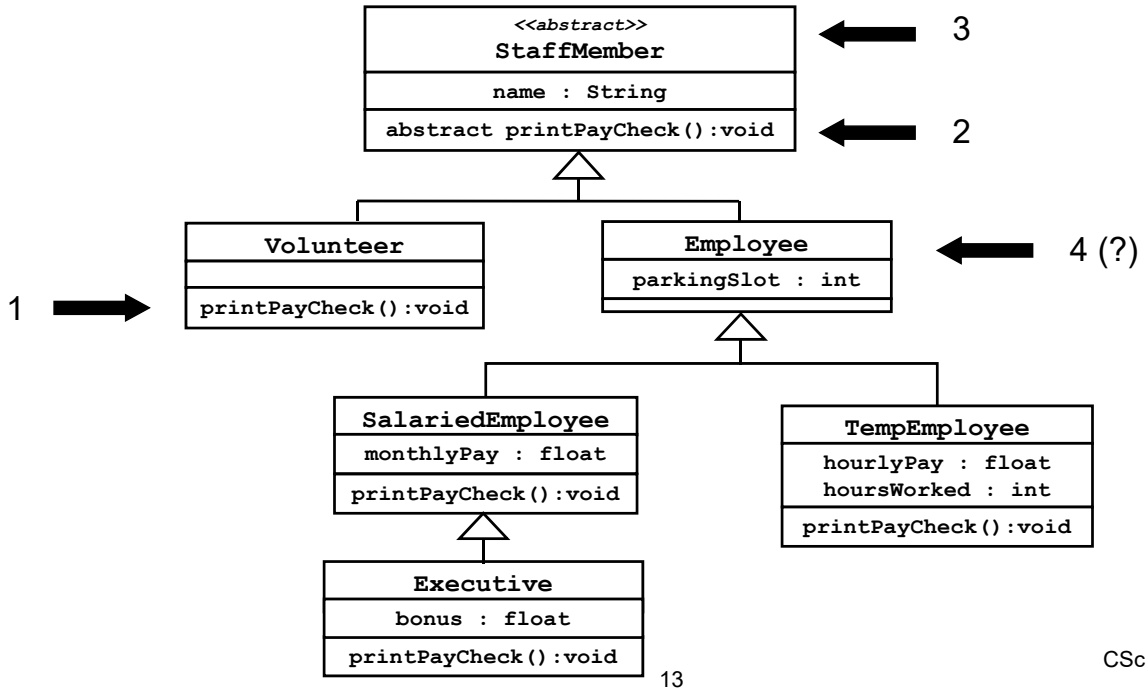
Now, the Print method which gets invoked is:

- *determined at runtime, and*
- *depends on subtype*

We still need to make sure it will compile, and that it is maintainable and extendable…

Polymorphic Safety

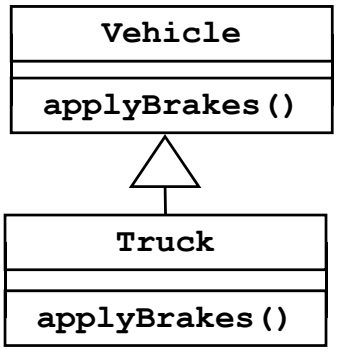
Ideally, *every* class should know how to deal with "**`printPayCheck`**" messages:



Polymorphism: Java vs. C++

- **Java**
  - Run-time (dynamic; late) binding is the default
    - Drawback: may be unnecessary (hence inefficient)
    - Programmer can force compile-time binding by declaring methods "**`static`**, **`final`**, and/or **`private`**"
- **C++**
  - Compile-time (static; early) binding is the default
    - Drawback: may be inappropriate, since it defaults to calling base-class methods in certain circumstances
    - Programmer can force late binding by declaring methods "**`virtual`**"

Java vs. C++ : Example



C++

```
class Vehicle {
  public:
    void applyBrakes() {
      printf ("Applying vehicle brakes...\n");
    }
};

class Truck : public Vehicle {
  public:
    void applyBrakes() {
      printf ("Applying truck brakes...\n");
    }
};
```

Java

```
class Vehicle {
  public void applyBrakes() {
    System.out.printf ("Applying vehicle brakes\n");
  }
}
class Truck extends Vehicle {
  public void applyBrakes() {
    System.out.printf("Applying truck brakes...\n");
  }
}
```


Java vs. C++ : Example (cont.)

C++

```
void main (int argc, char** argv){
  Vehicle * pV ;
  Truck * pT ;
  pT = new Truck();
  pT->applyBrakes();
  pV = pT;
  pV->applyBrakes();
}
```

Java

```
public static void main (String [] args){
  Vehicle v;
  Truck t;
  t = new Truck();
  t.applyBrakes();
  v = t ;
  v.applyBrakes();
}
```

Output

```
Applying truck brakes...
Applying vehicle brakes...
```

```
Applying truck brakes...
Applying truck brakes...
```