Polymorphism

Polymorphism literally means "many shapes". Inheritance allows you to define a base class and derive classes from the base class. Polymorphism allows you to make changes in the method definition for the derived classes and have those changes apply to the methods written in the base class. This all happens automatically in Java, but you must understand the process to use it correctly.

Consider the `Man` and `Woman` classes that we derived from `Person` in the inheritance lecture. Let's say that we have an array of people and we add several Man and Woman objects to it:

```
Person[] people = new Person[3];

people[0] = new Man(15, 125, 5, 9);
people[1] = new Woman(15, 125, 5, 9);
people[2] = new Man(30, 200, 6, 5);


for (int i = 0; i < people.length; i++)
{
      System.out.println("Person " + i +
            " should eat " + people[i].howManyTwix() +
            " twix bars.");
}
```

In this case we are assigning an object of a derived class (either Man or Woman) to a variable defined as an ancestor of the derived class (Person). This is valid because Person encompasses the derived classes. In other words, Man "is-a" Person and Woman "is-a" Person, so we can assign either one to a variable of type Person.

What will be the output of this program? It is logical to assume that the `howManyTwix` method defined in the `Person` object will be invoked, since the array is created of type `Person`. But that is not what happens! Instead, Java recognizes that an object of type `Man` is stored in `people[0]`. As a result, even though `people[0]` is declared to be of type `Person`, the method associated with the class used to create the object is invoked. This is called **dynamic binding** or **late binding**.

More precisely, when an overridden method is invoked, its action is the one defined in the class used to create the object using the new operator. It is not determined by the type of the variable naming the object. A variable of any ancestor class can reference an object of a descendant class, but the object always remembers which method actions to use for every method name. The type of the variable does not matter. What matters is the class name when the object was created.

The output in this case is:

```
Person 0 should eat 2.80555 twix bars ← Output for a 125 lb. 5'9 man
Person 1 should eat 2.51330 twix bars ← Output for a 125 lb. 5'9 woman
Person 2 should eat 3.49729 twix bars
```

Note that the method defined in `Person` is not invoked, otherwise the number returned would be 0.

One of the amazing things about polymorphism is it lets us invoke methods that might not even exist yet! For example, assume the program runs with only the `Person`, `Man`, and `Woman` classes defined. At some later date we could write a `Child` class that is also derived from `Person`. As long as each implements a `howManyTwix` method then we could add one of these objects to the array and its `howManyTwix` method would be invoked in the for loop. We wouldn't even need to recompile the class to invoke the new methods via dynamic binding.

Polymorphism Example – Guessing Game

Consider a guessing game where someone is thinking of a number from 0-99 and two other players try to guess the number. The players are told if the guess is too high or too low if they are not correct.

Here is the main game code with most of the logic in the `playRound` method:

```
public class Game
{
	// Return false if the game is over
	// True if it is not
	public static boolean playRound(Player p1, Player p2, int number)
	{
		// Get P1's guess
		System.out.println("Player 1: " + p1.getName()
			+ ", it is your turn.");
		int p1Guess = p1.getGuess();
		System.out.println(p1.getName() + " guessed " + p1Guess);
		if (p1Guess == number)
		{
			System.out.println("That is the correct number!");
			return false;
		}
		else if (p1Guess < number)
			System.out.println("The guess is too low.");
		else
			System.out.println("The guess is too high.");

		// Get P2's guess
		System.out.println("Player 2: " + p2.getName()
			+ ", it is your turn.");
		int p2Guess = p2.getGuess();
		System.out.println(p2.getName() + " guessed " + p2Guess);
		System.out.println("Player 2, " + p2.getName() +
				", guessed " + p2Guess);
```

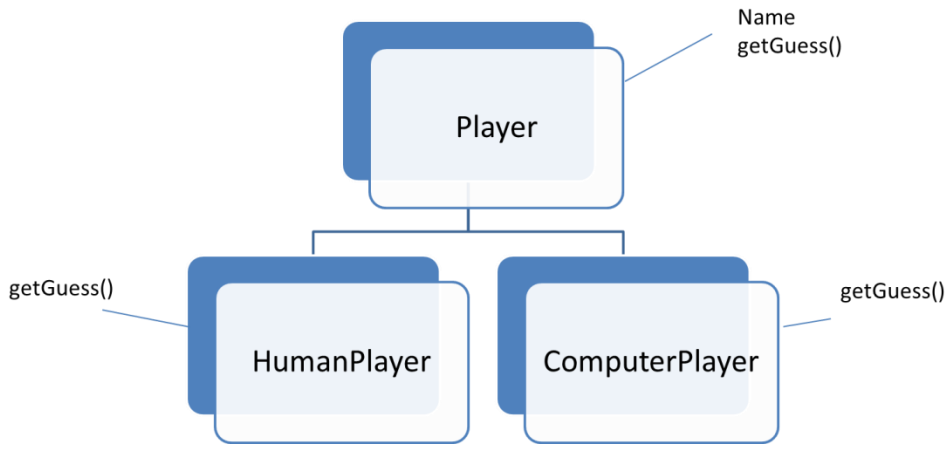
```
            if (p2Guess == number)
            {
                  System.out.println("That is the correct number!");
                  return false;
            }
            else if (p2Guess < number)
                  System.out.println("The guess is too low.");
            else
                  System.out.println("The guess is too high.");
            return true;
      }


      public static void main(String[] args)
      {
            HumanPlayer p1 = new HumanPlayer("Kenrick");
            ComputerPlayer p2 = new ComputerPlayer("Tobor");
            int numToGuess = (int) (Math.random() * 100);

            while (playRound(p1,p2,numToGuess))
            {
                  System.out.println();
                  System.out.println("Starting next round.");
            }
      }
}
```

The key part about this method is it takes two arbitrary `Player` objects and then invokes the `getGuess()` method to get the player's guess.

We can implement the `getGuess()` method different ways depending upon the player. The nice thing about polymorphism is that Java automatically uses the method defined for the Player object passed in. In our case we'll define a `Player` class and a `HumanPlayer` and a `ComputerPlayer` derived from it.



```
public class Player
{
	private String name;

	public Player()
	{
		name = "Unknown";
	}
	public Player(String theName)
	{
		this.name = theName;
	}

	public String getName()
	{
		return name;
	}

	public int getGuess()
	{
		return 0;
	}
}


import java.util.Scanner;
public class HumanPlayer extends Player
{
	public HumanPlayer()
	{
		super();
	}
	public HumanPlayer(String name)
	{
		super(name);
	}

	public int getGuess()
	{
		Scanner keyboard = new Scanner(System.in);
		System.out.println("Enter your guess.");
		int guess = keyboard.nextInt();
		return guess;
	}
}
```

```
public class ComputerPlayer extends Player
{
	public ComputerPlayer()
	{
		super();
	}
	public ComputerPlayer(String name)
	{
		super(name);
	}

	public int getGuess()
	{
		int guess = (int) (Math.random() * 100);
		return guess;
	}

}
```

We've made a really dumb implementation for `getGuess()` for the computer. It just guesses a random number. The human player just inputs a guess from the keyboard.

When this program is run it will alternate between inputting a guess from the human from the keyboard (for player 1) and randomly guessing a number for player 2. If we wanted to make two computer players we simply change p1 to an instance of `ComputerPlayer` and re-run the program. We could make a smarter AI program as well and plug it right in (although it would need additional methods to tell the AI if the guess was too high or too low).

Abstract Classes

Finally, you may have noticed that in our game example, we should never be creating an instance of `Player`. This is because this class is an abstract notions of generalized players, and don't actually exist. We should only be dealing with instances of `HumanPlayer` or `ComputerPlayer`. The situation was identical with our example using the `Man`/`Woman` classes that are instances of `Person`.

To address this issue, we could make `Player` class **abstract**. An abstract class behaves like a normal class, except we are not allowed to make instances of it. To make the class abstract, just add the keyword extract in front of the class name:

```
public abstract class Player
{
	…
}
```

We can also make a method abstract. This means that the method must be overridden and defined in any derived class. For an abstract method we don't define anything, e.g.

```
public abstract int getGuess();
```

Interfaces

Java also supports something called an **interface**. An interface is similar to an abstract class. It defines what methods a class must **implement**. A class can implement multiple interfaces. You will use interfaces quite a bit in CS A202.

An interface is something like the extreme case of an abstract class but an interface is not a class. It is, however, a type that can be satisfied by any class that implements the interface. An interface is a property of a class that says what methods it must have.

An interface specifies the headings for methods that must be defined in any class that implements the interface. For example, we can make an interface that specifies the methods that a class must have if it is driveable:

```
public interface Driveable
{
  public void start();
  public void stop();
  public void turn();
}
```

This says that anything that can be Driveable must have a method to Start, Stop, and Turn. We can't implement any code for these methods in the interface.

When we define a class that is Driveable then we say that the class **implements** the Driveable interface. Here is an example:

```
public class SportsCar implements Driveable
{
  public void start()
  {
    System.out.println("Step on the gas");
  }
  public void stop()
  {
    System.out.println("Step on the brake");
  }
  public void turn()
  {
    System.out.println("Turn steering wheel");
  }
  public void engineCheck()
  {
    System.out.println("Engine OK");
  }
}
```

```
public class Bicycle implements Driveable
{
  public void start()
  {
    System.out.println("Start pedaling");
  }
  public void stop()
  {
    System.out.println("Press hand brake");
  }
  public void turn()
  {
    System.out.println("Turn handlebars");
  }
  public void ringBell()
  {
    System.out.println("Ring Ring");
  }
}
```

Here is a class that shows how we might use the interface. Let's say we need to drive some kind of vehicle forward, but we want it to work with anything that is driveable, whether it is a Bicycle or Sportscar:

```
  public static void main(String[] args)
  {
    SportsCar s = new SportsCar();
    Bicycle b = new Bicycle();
    goForward(s);
    goForward(b);
  }

  public static void goForward(Driveable vehicle)
  {
    vehicle.start();
    System.out.println("Wait a few seconds");
    vehicle.stop();
    System.out.println();
  }
```

Here the GoForward method invokes the corresponding method for either the car or the bicycle. The output is:

```
Step on the gas
Wait a few seconds
Step on the brake

Start pedaling
Wait a few seconds
Press hand brake
```