Classes and Instances (Java)

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What We Have Done

- history/definition of Java
- basic OO needs (in various languages)
- `HelloWorld.java`, with a hint on the usage of `import`

Java towards Basic OOP Needs

- designing object (what variables? what methods?)
  —**[0] extended types**, **[1] method declaration/implementation**
- creating "first" object and calling its first action
  (done: `java ClassName` will call `main`)
- creating other objects —**[2] `new` and beyond**
- calling other objects (done: method invocation, will talk more in `[1]`)
- manipulating object status (done: instance variable assignments)
- deleting objects —**[3] object lifecycle**

[0] Types

Types (1/2)

- primitive (`int`, `double`, $\cdots$):
  - one single piece of data with literal support (e.g. `5.2`, `true`)
  - no extended actions except basic operations
- extended (classes):
  - one or many pieces of data (instance variables)
    —all instances with the same pieces, but (possibly) with different values
  - extended actions (instance methods)
    —all instances with the same capability, but (possibly) with different behavior depending on status
  - declared (designed) by you, or used (`new`, action call) by your code
- Java is **strongly typed** with static type checking like C
  —every (instance/local/...) variable must have a type in the first place, and compiler checks type compatibility

Types (2/2)

`class java.lang.String`

- one extended type with native support
- the same as any extended type you see
- literals `"abc"` recognized by the language
- native operation support (e.g. `+`)
  (roughly) `"abc" + "def"` is changed to
  `(new StringBuffer()).append("abc").append("def").toString()`
  by compiler
- some other special handling
  —can even be used in `switch` statements since Java 7

Type: Key Point

type: confining variable to **(internal data + external actions)**, where extended type corresponds to classes, the core of Java programming

[1] Methods

Method (1/2, Callee's View)

```
1 public class OOPStudent{
2     private int score;
3     private String name;
4     public void set_score(int new_score){ score = new_score; }
5     public String get_name(){ return name; }
6     public double get_adjusted(){ return (60 + score * 0.4); }
7 }
```

- method: what I (the instance) do
- **parameter**: what I get from the caller
- return value: what I want to tell the caller

Method (2/2, Caller's View)

```java
public class OOPStudent{
    private int score;
    private String name;
    public void set_score(int new_score){ score = new_score; }
    public String get_name(){ return name; }
    public double get_adjusted(){ return (60 + score * 0.4); }
}
```

```java
public class OOPStudentDemo{
    public static void main(String[] arg){
        OOPStudent CharlieL = new OOPStudent();
        CharlieL.set_score(80);
        System.out.println(CharlieL.get_adjusted());
        System.out.println(CharlieL.get_name());
    }
}
```

- method: what I (caller) want the instance to do
- **argument**: what I tell the callee
- return value: what I want to hear from the callee

Method: Key Point

method: meaning **action**, where information (message) is passed through argument/parameter and return values

Return Values (1/1)

```
1 public class OOPStudent{
2     private int score;
3     private String name;
4     public void set_score(int new_score){ score = new_score; }
5     public String get_name(){ return name; }
6     public double get_adjusted(){ return (60 + score * 0.4); }
7 }
```

```
1 public class OOPStudentDemo{
2     public static void main(String[] arg){
3         OOPStudent CharlieL = new OOPStudent();
4         CharlieL.set_score(80);
5         System.out.println(CharlieL.get_adjusted());
6         System.out.println(CharlieL.get_name());
7     }
8 }
```

- `void`: must-have to mean no return value
- primitive/extended return types possible

Return Values: Key Point

`void` for no return value, like C

Primitive Argument/Parameter (1/1)

```
1  public class Tool{
2    public void swap(int first, int second){
3      int tmp = first;
4      first = second;
5      second = tmp;
6      System.out.println(first);
7      System.out.println(second);
8    }
9  }
10 public class Demo{
11   public static void main(String[] arg){
12     Tool t = new Tool();
13     int i = 3; int j = 5;
14     t.swap(i, j);
15     System.out.println(i);
16     System.out.println(j);
17   }
18 }
```

- `first`, `second`: swapped
- `i`, `j`: didn't

Primitive Argument/Parameter: Key Point

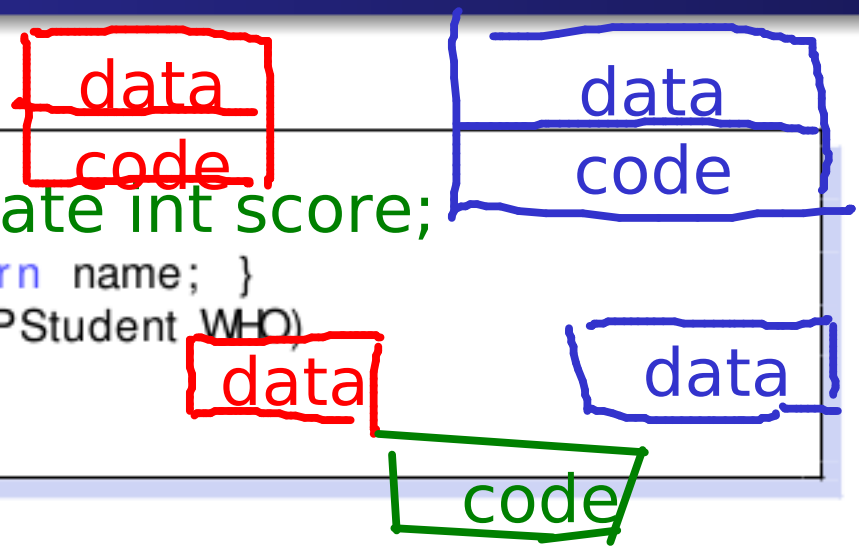
argument $\Rightarrow$ parameter: call by value (same as C)
—change in parameter does not change argument

Extended Argument/Parameter

to be discussed in Chapter 5

this (1/1)

```
1 public class OOPStudent{
2     private String name;
3     public String get_name(){ return name; }
4     public String get_the_name(OOPStudent WHO)
5         { return WHO.name; }
6 }
```



- `CharlieL.get_name()` returns `CharlieL.name`
- `Ptt.get_name()` returns `Ptt.name`
- how? a hidden parameter `WHO` can do

```
1     public String get_name(){ return this.name; }
2     public void set_score(int score){ this.score = score; }
```

s

this.score = s;

- when accessing instance variables or calling instance methods within, an implicit `this` is assumed by compiler

this: Key Point

this: a hidden parameter in the method to keep in touch with the instance

Method Overloading (1/2)

```
1  public class Printer{
2    public void printInteger(int a);
3    public void printDouble(double a);
4    public void printString(String a);
5  }
```

- "Integer" and "int" are basically saying the same thing
- lazy people don't want to type so many words

Method Overloading (2/2)

```
1  public class Printer{
2    public void print(int a);
3    public void print(double a);
4    public int print(String a);
5    public void print(int a, int b);
6  }
7  public class PrinterThatCompilerSees{
8    public void print_int(int a);
9    public void print_double(double a);
10   public int print_String(String a);
11   public void print_int_int(int a, int b);
12 }
```

- Java's (and many modern language's) solution: one method name, many possible argument types
- called **method overloading**
- Java "signature" of a method: include name and parameters (but **NO** return types)

coersion
no one catch
pass on to other methods

Method Overloading (2/2)

```
1  public class Printer{
2    public void print(int a);
3    public int print(int a);
4    public double print(int a);
5  }
6  public class PrinterDemo{
7    public static void main(String[] argv){
8      Printer p = new Printer();
9      p.print(P.print(3) + 5);
10     //which one do you want to call?
11   }
12 }
```

- determine programmer's intention from arguments: easy
- determine programmer's intention from return value: hard —can cast, can discard, etc.
- Java "signature" of a method: include name and parameters only
- compiler's job: from arguments (type), determine which method (name+parameters) to call
- cannot have two methods with the same signature

Method Overloading: Key Point

method overloading: a compiler's help by looking at "signature" rather than "name" in calling

Operator Overloading

```
1  public class Demo{
2    public static void main(String[] argv){
3      int a = 5;
4      System.out.println(3 + a); //plus(3, a)
5      System.out.println("" + a); //plus("", a)
6    }
7  }
```

new StringBuffer().append("").
append((new Integer(a)).toString())

- Java: a limited special case for String (actually, StringBuffer); the usual cases for primitive types; but not for other extended types
- C++: can overload almost "any" operator for any class
- double-sided sword: powerful, but easily misused

Operator Overloading: Key Point

operator overloading: very limited support in Java (up to now, and possibly will be)

int	java.lang.Integer
double	java.lang.Double

Local Variables (1/7)

```
1  public class FibCompute{
2      public int fib(int n){
3          int res;
4          String s = "fib(" + n + ")␣called";
               System.out.println(s);
5          if (n <= 1) res = 1;
6          else{   res = fib(n-1);   res = res + fib(n-2); }
7          return res;
8      }
9  }
```

```
1  public class FibDemo{
2      public static void main(String[] arg){
3          FibCompute f = new FibCompute();
4          System.out.println("res␣=␣" + f.fib(5));
5      }
6  }
```

- a so-called **recursive** method
- local primitive `n`: allocated, and assigned by argument ⇒ parameter

Local Variables (2/7)

```
1  public class FibCompute{
2      public int fib(int n){
3          int res;
4          String s = "fib(" + n + ") called";
               System.out.println(s);
5          if (n <= 1) res = 1;
6          else{   res = fib(n-1);   res = res + fib(n-2); }
7          return res;
8      }
9  }
```

```
1  public class FibDemo{
2      public static void main(String[] arg){
3          FibCompute f = new FibCompute();
4          System.out.println("res = " + f.fib(5));
5      }
6  }
```

- local extended `this`: allocated, and assigned by argument (f) $\Rightarrow$ parameter (this)

Local Variables (3/7)

```
1  public class FibCompute{
2      public int fib(int n){
3          int res;
4          String s = "fib(" + n + ") called";
               System.out.println(s);
5          if (n <= 1) res = 1;
6          else{   res = fib(n-1);   res = res + fib(n-2); }
7          return res;
8      }
9  }
```

```
1  public class FibDemo{
2      public static void main(String[] arg){
3          FibCompute f = new FibCompute();
4          System.out.println("res = " + f.fib(5));
5      }
6  }
```

- local primitive `res`: allocated, **not** initialized, assigned by ourselves

Local Variables (4/7)

```
1  public class FibCompute{
2      public int fib(int n){
3          int res;
4          String s = "fib(" + n + ") called";
               System.out.println(s);
5          if (n <= 1) res = 1;
6          else{   res = fib(n-1);   res = res + fib(n-2); }
7          return res;
8      }
9  }
```

```
1  public class FibDemo{
2      public static void main(String[] arg){
3          FibCompute f = new FibCompute();
4          System.out.println("res = " + f.fib(5));
5      }
6  }
```

- local extended `s`: allocated, **not** initialized, links to a valid instance by ourselves

Local Variables (5/7)

```
1  public class FibCompute{
2      public int fib(int n){
3          int res;
4          String s = "fib(" + n + ") called";
               System.out.println(s);
5          if (n <= 1) res = 1;
6          else{   res = fib(n-1);   res = res + fib(n-2); }
7          return res;
8      }
9  }
```

```
1  public class FibDemo{
2      public static void main(String[] arg){
3          FibCompute f = new FibCompute();
4          System.out.println("res = " + f.fib(5));
5      }
6  }
```

- some other local variables generated by compiler: allocated, **not** initialized, used internally

Local Variables (6/7)

```
1  public class FibCompute{
2      public int fib(int n){
3          int res;
4          String s = "fib(" + n + ") called";
               System.out.println(s);
5          if (n <= 1) res = 1;
6          else{   res = fib(n-1);   res = res + fib(n-2); }
7          return res;
8      }
9  }
```

```
1  public class FibDemo{
2      public static void main(String[] arg){
3          FibCompute f = new FibCompute();
4          System.out.println("res = " + f.fib(5));
5      }
6  }
```

- when call returns: the result is “copied” to the caller’s space-of-interest somewhere
- local variables: discarded

Local Variables (7/7, courtesy of Prof. Chuen-Liang Chen)

Category of Java Variables

	local variable	instance variable	class (static) variable
belong to	method invocation	instance	class
declaration	within method	within class	within class
modifier `static`	NO	NO	YES
allocation (when)	method invocation	instance creation	class loading
allocation (where)	stack memory	heap memory	heap memory
initial to 0	NO	YES	YES
de-allocation	method return	automatic garbage collection	NO
scope	usage range	direct access range	
	from declaration to end of block	whole class	whole class

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Local Variables: Key Point

local variables: the “status” of the current method frame
—by spec **not** necessarily initialized

[2] new and Beyond

Constructor (1/3)

```
1  public class Record{
2    private String name;
3    private int score;
4  }
5  //...
6  r = new Record();
```

- the new operator allocates memory for the instance
- often you will do this:

```
1  r = new Record();
2  r.set_name("HTLin");
3  r.set_score(99);
```

- out of laziness, you want to do this:

```
1  r = new Record("HTLin", 90);
```

How?

Constructor (2/3)

```
1  public class Record{
2    private String name;
3    private int score;
4    public Record(String init_name,
5                  int init_score){
6      name = init_name;
7      score = init_score;
8    }
9  }
10 //...
11 r = new Record("HTLin", 90);
```

Constructor (3/3)

- constructor: called by `new` to **initialize**
- name: same as class name
- default constructor (if you didn't write any code): same as

```
1    public Record(){
2    }
```

- constructor without argument ("replace" the default one):

```
1    public Record(){
2      score = 60;
3    }
```

Constructor: Key Point

a special method to initialize the instance during `new`

More on Constructors (1/3)

```
1  public class Record{
2    private String name;
3    private int score;
4    public int get_score() { return score; }
5  }
6  public class RecordDemo{
7    public static void main(String[] arg){
8      Record r1 = new Record();
9      System.out.println(r1.get_score());
10   }
11 }
```

- default value (when `new`): 0/false/null
- default constructor when no self-defined constructor

More on Constructors (2/3)

```
1  public class Record{
2    private String name;
3    private int score;
4    public int get_score() { return score; }
5    public Record(int init_score){ score = init_score; }
6  }
7  public class RecordDemo{
8    public static void main(String[] arg){
9      Record r1 = new Record(60);
10     Record r2 = new Record();
11     System.out.println(r1.get_score());
12     System.out.println(r2.get_score());
13   }
14 }
```

HAHAHA

- if there is self-defined constructor, no default one
- self-defined constructor: same-name, no return value (but not `void`)

More on Constructors (3/3)

```
1  class Record{
2    private int score;
3    public Record(int init_score){score = init_score;}
4    public Record(){ Record(40);}
5  }
6  public class RecordDemo{
7    public static void main(String[] arg){
8      Record r1 = new Record(60);
9      Record r2 = new Record();
10   }
11 }
```

- can **overload**: same name, different parameters
- can call other constructors to help initialize

More on Constructors: Key Point

often better to use self-defined and overloaded constructors to help initialize