GC01 Introductory Programming

Week 2 – Lecture

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Basic Object-Oriented concepts

Programming paradigms

- Different methodologies are more suitable for solving certain kinds of problems or applications domains.
- Same for programming languages and paradigms.
- Programming paradigms differ in:
  - the concepts and abstractions used to represent the elements of a program (such as objects, functions, variables, constraints, etc.)
  - the steps that compose a computation (assignation, evaluation, data flow, control flow, etc.).

Programming paradigms

- In **object-oriented programming**, programmers can think of a program as a collection of interacting objects, while in **functional programming** a program can be thought of as a sequence of stateless function evaluations.

- In **process-oriented programming,** programmers think about applications as sets of concurrent processes acting upon shared data structures.

Programming paradigms

- Some languages are designed to support one particular paradigm
  - Smalltalk supports object-oriented programming
  - Haskell supports functional programming

- Other programming languages support multiple paradigms
  - Object Pascal, C++, C#, Visual Basic, Common Lisp, Scheme, Perl, Python, Ruby, Oz and F#.

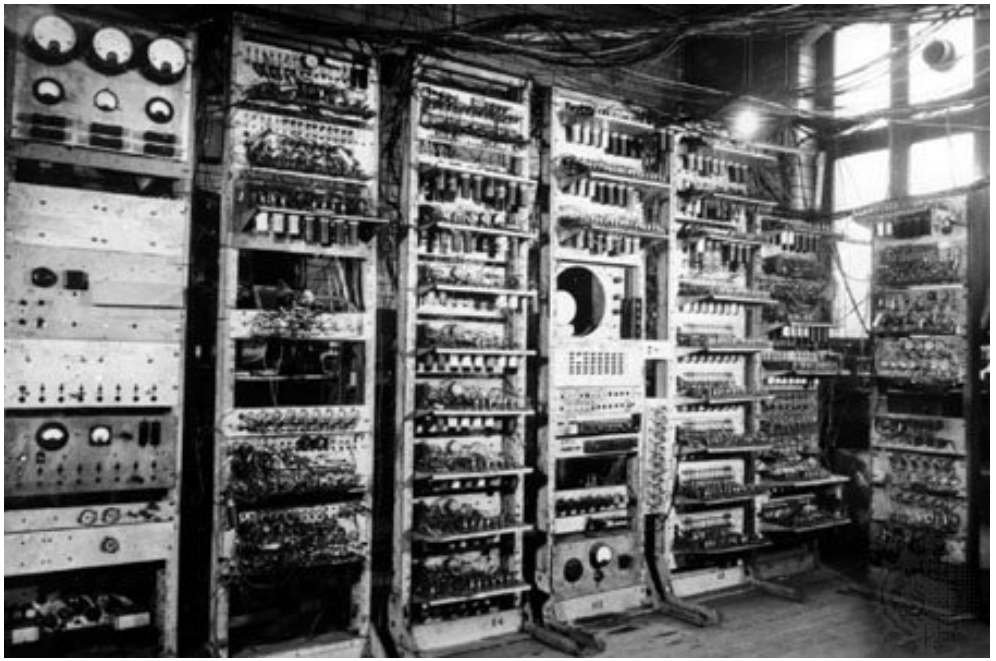
- The design goal of multi-paradigm languages is to allow programmers to use the best tool for a job, admitting that no one paradigm solves all problems in the easiest or most efficient way.

Evolution of programming languages

Low level - Genesis

- Initially, computers were **hard-wired** or **soft-wired** and then later programmed using **binary code** that represented control sequences fed to the computer CPU.

- This was difficult and error-prone. Programs written in binary are said to be written in machine code, which is a very low-level programming paradigm. Hard-wired, soft-wired, and binary programming are considered **first generation** languages.



```
01010101 01101110 01100100 01100101 01110010 01110011 01110100 01100001
01101110 01100100 01101001 01101110 01100111 00100000 01110100 01101000
01100101 00100000 01100010 01101001 01101110 01100001 01110010 01111001
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01110011 00100000 01100001 00100000 01110101 01110011 01100101 01100110
01110101 01101100 00100000 01110011 01101011 01101001 01101100 01101100
```

Low level – Assembly language

- To make programming easier, assembly languages were developed.
- These replaced machine code functions with **mnemonics** and memory addresses with **symbolic labels**.
- Assembly language programming is considered a low-level paradigm although it is a '**second generation**' paradigm.
- Assembly languages of the 1960s eventually supported **libraries** and quite sophisticated conditional **macro** generation.

```
fib:
    mov edx, [esp+8]
    cmp edx, 0
    ja @f
    mov eax, 0
    ret

    @@:
    cmp edx, 2
    ja @f
    mov eax, 1
    ret

    @@:
    push ebx
    mov ebx, 1
    mov ecx, 1

    @@:
        lea eax, [ebx+ecx]
        cmp edx, 3
        jbe @f
        mov ebx, ecx
        mov ecx, eax
        dec edx
    jmp @b

    @@:
    pop ebx
    ret
```

Assembly language still relevant

- Assembly was, and still is, used for **time-critical** systems and frequently in **embedded systems**.
- Assembly programming can directly take advantage of a specific computer architecture and, when written properly, leads to **highly optimized code**.
- However, it is bound to this architecture or processor and thus suffers from **lack of portability**.
- Assembly languages have **limited abstraction capabilities**, which makes them unsuitable to develop large/complex software.

High level

- A programming language that enables a programmer to write programs that are more or less independent of a particular type of computer.
- Such languages are considered high-level because they are **closer to human languages** and further from machine languages. Easier to read, write, and maintain.
- Must be translated into machine language by a compiler or interpreter.
- Ada, Algol, BASIC, COBOL, C, C++, FORTRAN, LISP, Pascal, and Java.

```
unsigned int fib(unsigned int n)
{
    if (n <= 0)
        return 0;
    else if (n <= 2)
        return 1;
    else {
        int a,b,c;
        a = 1;
        b = 1;
        while (1) {
            c = a + b;
            if (n <= 3) return c;
            a = b;
            b = c;
            n--;
        }
    }
}
```

Object-oriented programming

- Object-oriented programming (OOP) is a programming paradigm that uses "**objects**" – data structures encapsulating data fields and procedures together with their interactions – to design applications and computer programs.

- Four fundamental OOP concepts: **abstraction**, **encapsulation**, **polymorphism**, and **inheritance**.

- Though it was invented with the creation of the **Simula** language in 1965, and further developed in **Smalltalk** in the 1970s, it was not commonly used in mainstream software application development until the early 1990s.

- Many modern programming languages now support **OOP**.

Why object-oriented design?

- Software is complex (too many people is doing too many things – the mess is inevitable ☺)
- One of the main goals in programming is to avoid the redundancy and objects can help to do this (**inheritance**)
- Objects can help increase modularity through data hiding (**encapsulation** or **data hiding**)

Class and Object

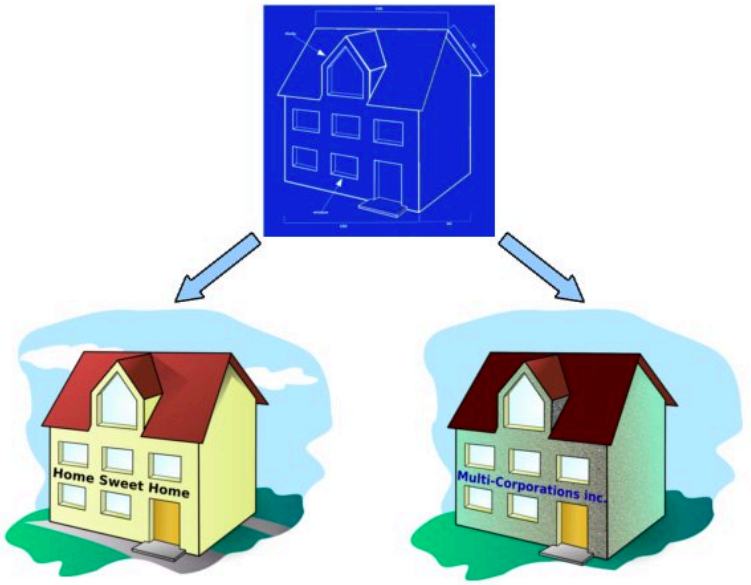
- "Class" refers to a blueprint. It defines the *variables* and *methods* the objects support.

- "Object" is an *instance* of a class. Each object has a class which defines its *data* and *behavior*.

- *Explanation…*

Class and Object

- *A class is to an Object what a blueprint is to a house*
- A class establishes the characteristics and the behaviors of the object
- *Classes* are the plan; *objects* are the embodiment of that plan
- Many houses can be built from the same blueprint



Anatomy of a class

In the Java language, the general form of a class definition is:

```
accessModifier class Classname{
    // field, constructor, and
    // method declarations
}
```

Class body

- The keyword **class** begins the class definition for a class named ***Classname***.
- *Access modifiers* such as ***public***, ***private***, and a number of others that you will encounter later.
- The *className*, with the initial letter capitalized by convention.
- The variables and methods of the class are embraced by the curly brackets that begin and end the class definition block.
- Anything included between the two curly brackets is called the *class body*

Class example: Minimal form

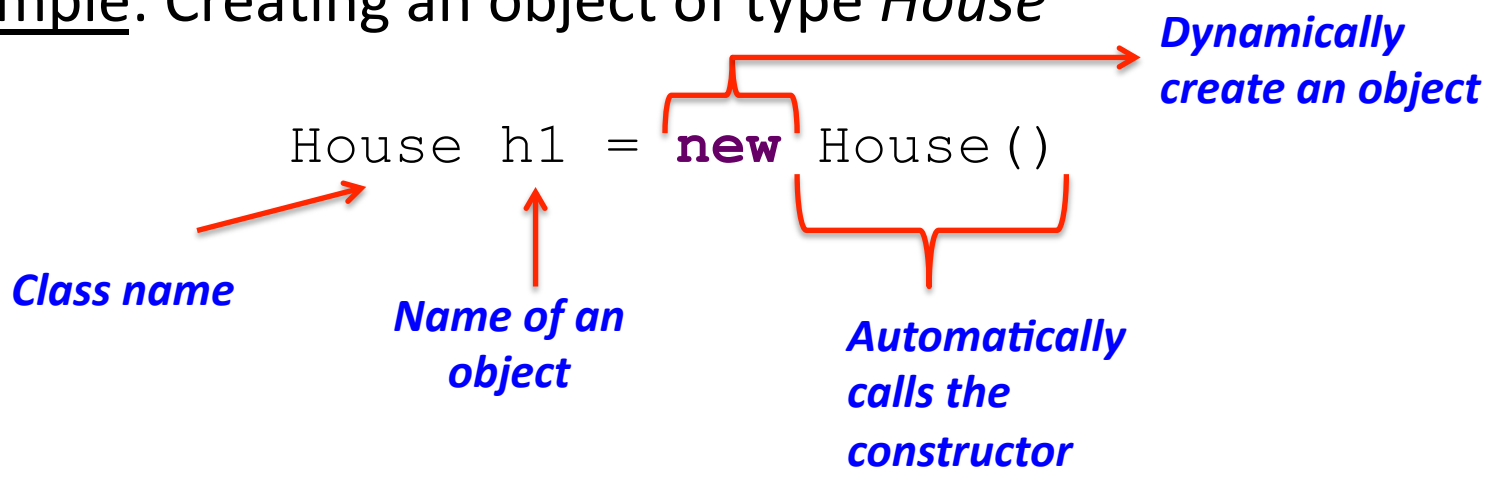
```
public class House{

}
```

instantiating a class = Creating an object

- The **`new`** operator instantiates a class by allocating memory for a new object and returning a reference to that memory.

- ***Note***: The phrase "instantiating a class" means the same thing as "creating an object." When you create an object, you are creating an "instance" of a class, therefore "instantiating" a class.

- Example: Creating an object of type *House*



instantiating a class = Creating an object

```
House h1 = new House()
```

- Memory is allocated for an object after executing this statement.
- This Statement will create instance of the class *House* and name of instance is nothing but actual object *h1*.

Driver class or Main class

```
/* This is a driver class also known as
main class or entry point */
public class HouseApp {

public static void main(String[] args) {

     House h1 = new House();
   }
}
```

Class and Object

- “Class” refers to a blueprint. It defines the *variables* and *methods* the objects support.

- “Object” is an *instance* of a class. Each object has a class which defines its *data* and behavior.

Anatomy of a class: Instance variables

```
public class Classname{

    type instance-variable1;
    type instance-variable2;

    // ..

    type instance-variableN;
}
```

instance-variable1, *instance-variable2*, etc… are called *instance variables*, *fields* or *member variables* (more general definition).

Anatomy of a class: Instance variables

```
public class House{

// These are all instance variables
   int propertyNumber;
   int nbBedrooms;
   boolean bathroomIsClean;
}
```

- `int, boolean`, etc… are the variables types.
- A variable can be of a primitive type or reference/object data Type.

Driver class

```
/* This is a driver class also known as main class
or entry point */
public class HouseApp {
   public static void main(String[] args) {

      House h1 = new House();

      System.out.println("House number: " +
h1.propertyNumber + " has " + h1.nbBedrooms + "
bedrooms. The bathroom is  clean? " +
h1.bathroomIsClean);
   }
}
```

Initialisation of instance variables (1)

- You can often provide an initial value for an instance variable in its declaration.

```
public class House{
// These are all instance variables
   int propertyNumber;
   int nbBedrooms = 5;
   boolean bathroomIsClean;
}
```

Driver class

```
/* This is a driver class also known as main class
or entry point */
public class HouseApp {
   public static void main(String[] args) {

      House h1 = new House();

      System.out.println("House number: " +
h1.propertyNumber + " has " + h1.nbBedrooms + "
bedrooms. The bathroom is  clean? " +
h1.bathroomIsClean);
   }
}
```

Initialisation of instance variables (2)

- You can also provide an initial value for an instance variable in the newly created object (instance).
- We use the *dot notation* and the *assignment operator.*

```
public class HouseApp{
…
House h1 = new House();
      /* accessing h1's copy of instance variable
         using the dot notation */
      h1.nbBedrooms = 7; // assignment
…
}
```

Driver class

```
/* This is a driver class also known as main class
or entry point */
public class HouseApp {
   public static void main(String[] args) {
      House h1 = new House();
      /* accessing h1's copy of instance variable
         using the dot notation */
      h1.nbBedrooms = 7; // assignment
      h1.propertyNumber = 25;
      h1.bathroomIsClean = true;

      System.out.println("House number: " +
h1.propertyNumber + " has " + h1.nbBedrooms + "
bedrooms. The bathroom is  clean? " +
h1.bathroomIsClean);
   }
}
```

Class and Object

- “Class” refers to a blueprint. It defines the variables and *methods* the objects support.

- “Object” is an *instance* of a class. Each object has a class which defines its data and *behavior.*

Methods

- A class with only instance variables has no life. Objects created by such a class cannot *respond to any messages.*

- Methods are declared inside the body of the class but immediately *after the declaration of instance variables.*

Methods: General form

The general form of a method declaration is:

```
modifier returnType nameOfMethod (Parameter List) {
 // Method-body
}
```

- *modifier*: It defines the access type of the method and it is optional to use.
- *returnType*: Method may return a value.
- *nameOfMethod:* Choose meaningful names.
- *Parameter List*: The list of parameters, it is the type, order, and number of parameters of a method. A method may contain zero parameters.
- *method body*: The method body defines what the method does.

Example

```
public class House{
    int propertyNumber;
    int nbBedrooms = 5;
    boolean bathroomIsClean;

    // return the house type
    public String getOfficeType(){
        if (propertyNumber == 11){
            return "Police Station";
        }else if ( propertyNumber == 20){
            return "Community center";
        }else {
            return "Family house";
       }
    }
}
```

Note: The use of the **return** keyword.

Method calling

```
public class HouseApp {
    public static void main(String[] args) {
        House h1 = new House();
        h1.propertyNumber = 23344;

        // method calling
        String type = h1.getHouseType();

        System.out.println("h1 is of type: " + type);

    }
}
```

The **`void`** keyword

- The void keyword allows us to create methods which *do not return a value*.

- Example:

```
public void getInfo(){
    System.out.println("Any question please call: 890
                        980 980");
}
```

- Call to a void method must be a statement i.e.

```
h1.getInfo();
```

Class constructors

- A constructor initializes an object when it is created. It has the same name as its class and is syntactically similar to a method. However, constructors have no explicit return type.

- Typically, you will use a constructor to give initial values to the instance variables defined by the class, or to perform any other startup procedures required to create a fully formed object.

- All classes have constructors, whether you define one or not, because Java automatically provides a default constructor that initializes all member variables to default values. However, once you define your own constructor, the default constructor is no longer used.

Class constructors

```
// constructor
public House(){
        propertyNumber = 12;//see slide on 'this' keyword
        bathroomIsClean = true;

        System.out.println("Constructor called.")

    }
```

Parameterised constructors

- Most often, you will need a constructor that accepts one or more parameters. Parameters are added to a constructor in the same way that they are added to a method, just declare them inside the parentheses after the constructor's name.

```
// parameterised constructor
public House(int c){
        propertyNumber = c;
        System.out.println("Constructor called." )
    }
```

The `this` keyword

```
// parameterised constructor
public House(int propertyNumber, boolean
                    bathroomClean){

this.propertyNumber = propertyNumber;
this.bathroomClean = bathroomClean;
      }
```

- `this` is a keyword in Java which is used as a reference to the object of the current class, with in an instance method or a constructor.
- The keyword `this` is used to differentiate the instance variables from local variables if they have same names, within a constructor or a method.

Multiple constructors

- A class can have multiple constructors.
- Each one must accept a unique set of parameters.
- (See previous slides)

Common constructor bugs

- Accidentally writing a return type such as `void`:

```
public void House(int number) {
    this.propertyNumber = number;
}
```

  - This is not a constructor at all, but a method!

  - Storing into local variables instead of fields ("shadowing"):

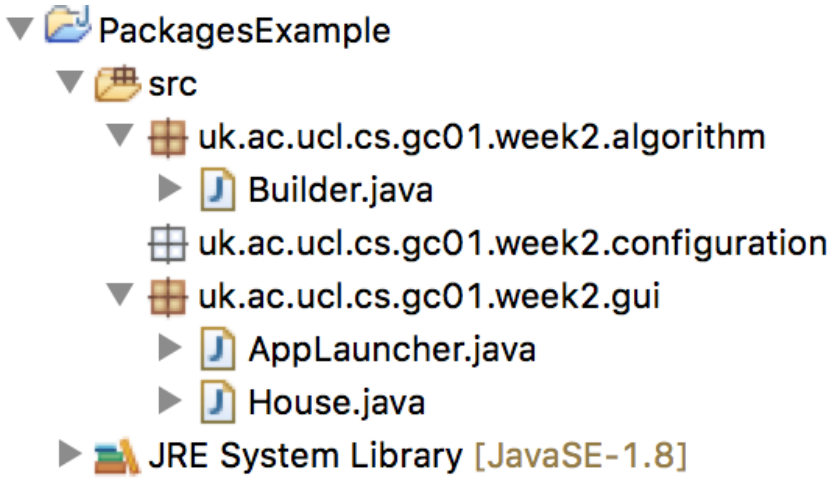
```
public House (int number) {
    int propertyName = number;
}
```

  - This declares a local variable with the same name as the fields, rather than storing values into the fields. The fields remain with their default values.

Java packages

- Packages are nothing more than the way we organize files into different directories according to their functionality, usability as well as category they should belong to.

- A Java package is a Java programming language mechanism for organizing classes into namespaces.



Package Naming Conventions

- Package names should be all lowercase characters whenever possible.
- Frequently a package name begins with the top level domain name of the organization and then the organization's domain and then any subdomains listed in *reverse order*.
- The developer can then choose a specific name for their package..

```
uk.ac.ucl.cs.gc01
```

Using packages

- If class is contained in a given package, at the top of its source file (before any imports or anything else other than comments), you should have a package declaration.

```
package uk.ac.ucl.cs.gc01.week2.gui;
```

- To use a package inside a Java source file, it is convenient to import the classes from the package with an import statement.

```
import uk.ac.ucl.cs.gc01.week2.algorithm.*;
```

Controlling access to members of a class

An access modifier determines whether other classes can use a particular *member variable* or call a particular *method.*

- **public**
  - Accessible to everyone, both designer and users of the class
- **private**
  - Accessible only within class implementation, only class designer
- **protected**
  - Accessible to the package and all subclasses (classes that are designed based on this one). We will cover it when we study inheritance.
- default (when you list no keyword)
  - Accessible to the package.

Java access modifiers: Summary

Modifier	Class	Package	Subclass	World
public	Y	Y	Y	Y
protected	Y	Y	Y	N
default	Y	Y	N	N
private	Y	N	N	N