DEFENSIVE PROGRAMMING

CITS1001

Lecture Outline

- Why program defensively?
- Encapsulation
- Access Restrictions
- Unchecked Exceptions
- Checked Exceptions

"I was driving defensively, but it turned out that the other driver was more defensive than I was."

DEFENSIVE PROGRAMMING

Why Program Defensively?

- Normally, your classes will form part of a larger system
- So other programmers will be using and relying upon your classes
- Obviously, your classes should be *correct*, but equally importantly, your classes should be *robust* – that is, resistant to accidental misuse by other programmers
- You should aim to ensure that no errors in the final system can be attributed to the behaviour of your classes
- We use the terminology "*client code*" for the code written by other programmers that is using your classes

Encapsulation

- One of the most important features of OOP is that it facilitates *encapsulation* – a class encapsulates both the data it uses, and the methods to manipulate the data
- The external user *only* sees the public methods of the class, and interacts with the objects of that class purely by calling those methods
- This has several benefits
  - Users are insulated from needing to learn details outside their scope of competence
  - Programmers can alter or improve the implementation without affecting any client code

Access Restrictions

- Encapsulation is enforced by the correct use of the access modifiers, public, private, <default>, and protected
- If you omit the access modifier, then you get the default, sometimes known as “package”
- These latter two modifiers are only really relevant for multi-package programs that use inheritance, so we need only consider public and private at the moment

`public` and `private`

- If an **instance variable** is **public**, then
  - Any object can *access* it directly
  - Any object can *alter* it directly
- If an **instance variable** is **private**, then
  - Objects that belong to *the same class* can access and alter it
  - Notice that privacy is a per-class attribute not per-object
- If a **method** is public, then
  - Any object can call that method
- If a **method** is private, then
  - Objects that belong to *the same class* can call it

Public Methods

- The *public interface* of a class is its list of public methods, which details all of the services that this class provides
- Once a class is released (for example, as part of a library), then it is impossible or very difficult to change its public interface, because client code may use any of the public methods
- Public methods must be precisely documented and robust to incorrect input and accidental misuse
- Classes should make as *few* methods public as possible – limit them to just the methods needed for the class to perform its stated function

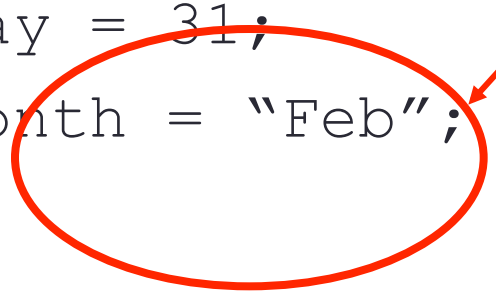
Public variables

- Normally instance variables should **not** be public, since if client code can alter the values of instance variables then the benefit of encapsulation is lost
- If client access to instance variables is desirable, then it should be provided by *accessor* and/or *mutator* methods (getters and setters)
- Advantages:
  - Maintenance of object integrity
  - Permits change of implementation

Simple Example

```
class MyDate {
  public int day;
  public String month;
  public int year;
}

MyDate md = new MyDate();
md.day = 31;
md.month = "Feb";
```



md is corrupt and so could cause problems elsewhere in the system

Use mutators instead

```
public void setDay(int day) {
  // Check that day is valid for this.month
  // before setting the variables
}
public int getDay() {
  return this.day;
}
```

Setter methods act as “gatekeepers” to protect the integrity of objects.

Setters reject values that would create a corrupt object.

Getters return a value for client code to use, but do not allow the object itself to be changed.

JAVA EXCEPTIONS

Dealing with Errors

- Even if your classes are well-protected, errors still occur
  - Client code attempts to use your methods incorrectly, by passing incorrect or invalid parameter values
  - Your code cannot perform the services it is meant to due to circumstances outside your control (such as an Internet site being unavailable)
  - Your own code behaves incorrectly and/or your objects become corrupted
- Java provides **exceptions** (checked and unchecked) to handle these situations

Invalid Parameters

- The `String` method `charAt(int index)`
  returns the character at position index in a String

- The only *valid* values for the parameter are numbers from 0 up to one less than the length of the String

- What happens if `charAt(-1)` is ever called?

The method “throws” an exception

- If a parameter is invalid, then the method cannot do anything sensible with the request and so it creates an object from an Exception class and “throws” it
- If an Exception is thrown, then the runtime environment immediately tries to deal with it
  - If it is an *unchecked* exception, it simply causes the runtime to halt with an error message
  - If it is a *checked* exception, then the runtime tries to find some object willing to deal with it
- The method `charAt` throws a `StringIndexOutOfBoundsException`

  which is unchecked and hence causes the program to cease execution (crash!)

Throw your own exceptions

- Your own methods and/or constructors can throw exceptions if clients attempt to call them incorrectly
- This is how your code can enforce rules about how methods should be used
- For example, we can insist that the deposit and withdraw methods from the BankAccount class are called with positive values for the amount
- The general mechanism is to check the parameters and if they are invalid in some way to then
  - *Create* an object from class IllegalArgumentException
  - *Throw* that object

Throw your own

```
Public BankAccount(int amount) {
  if (amount >= 0) {
    balance = amount;
  } else {
    throw new IllegalArgumentException(
        "Account opening balance " +
         amount + " must be >0”);
  }
}
```

- If the amount is negative then *declare* the variable ie, *create* the object and then *throw* it
- The constructor for IllegalArgumentException takes a String argument which is used for an error message that is returned to the user
- Throwing an exception is often used by **constructors** to prohibit the construction of invalid objects

“Predictable” errors

- **Unchecked** exceptions terminate program execution and are used when the client code must be seriously wrong
- However, there are error situations that do not necessarily mean that the client code is incorrect, but reflect either a transient, predictable or easily-correctable mistake – this is *particularly* common when handling end-user input, or dealing with the operating system
- For example, printers may be out of paper, disks may be full, Web sites may be inaccessible, filenames might be mistyped and so on.

Checked Exceptions

- Methods prone to such errors may elect to throw **checked** exceptions, rather than unchecked exceptions
- Using checked exceptions is more complicated than using unchecked exceptions in two ways:
  - The programmer must *declare* that the method might throw a checked exception, and
  - The client code using that method is *required* to provide code that will be run if the method *does* throw an exception

Client Perspective

- Many of the Java library classes declare that they *might* throw a checked exception

public **FileReader**(File file) throws FileNotFoundException

Creates a new FileReader, given the File to read from.

Parameters:

file - the File to read from

Throws:

FileNotFoundException - if the file does not exist, is a directory rather than a regular file, or for some other reason cannot be opened for reading.

try and catch

- If code *uses* a method that might throw a checked exception, then it *must* enclose it in a try/catch block

```
try {
  FileReader fr = new FileReader("lect.ppt");
   // code for when everything is OK
  } catch (java.io.FileNotFoundException e) {
   // code for when things go wrong
}
```

- *Try* to open and process this file, but *be prepared* to *catch* an exception if necessary

try and catch continued

- If everything goes smoothly, the code in the try block is executed, the code in the catch block is skipped
- Otherwise, if one of the statements in the try block causes an exception to be thrown, then execution immediately jumps to the catch block, which tries to recover from the problem
- What can the catch block do?
  - For human users: report the error and ask the user to change their request, or retype their password, or …
  - In all cases: Provide some feedback as to the likely cause of the error and how it may be overcome, even if it ultimately it just causes execution to cease

Using and Testing exceptions

```
@Test(expected =
 IllegalArgumentException.class)
 public void testIllegalDeposit() {
 BankAccount(-20);
}
```

- Java provides a many exception classes that cover most common possibilities
- Exceptions are simply objects in a Java program, so you can write your own classes of exceptions if desired

Some useful Java Exceptions

- IllegalArgumentException
- IndexOutOfBoundsException
- NullPointerException
- ArithmeticException
- IOException, FileNotFoundException

Exception vs RuntimeException

- Checked exceptions in Java extend the java.lang.Exception class
- Unchecked exceptions extend the java.lang.RuntimeException class

Programmer Perspective

- If you choose to write a method that throws a checked exception, then this must be *declared* in the source code, where you must specify the *type* of exception that might be thrown

```
public void printFile(String fileName) throws
  java.io.FileNotFoundException {
  // Code that attempts to print the file
}
```

- If you declare that your method might throw a checked exception, then the compiler will *force* any client code that uses your method to use a try/catch block
- This explicitly makes the client code responsible for these situations

Checked or Unchecked ?

- Unchecked Exceptions
  - Any method can throw them without declaring the possibility
  - No need for client code to use try/catch
  - Causes execution to cease
  - Used for fatal errors that are unexpected and unlikely to be recoverable
- Checked Exceptions
  - Methods must declare that they might throw them
  - Client code must use try/catch
  - Causes control flow to move to the catch block
  - Used for situations that are not entirely unexpected and from which clients may be able to recover
  - Use only if you think the client code might be able to do something about the problem

Summary

- Programming defensively means making your code **robust** to unexpected use.
- Use the **need to know** principle: Only expose the parts of your class that your client classes need to know
- Java exceptions provide a uniform way of handling errors
- Exceptions may be Unchecked or Checked