CS2030 Lecture 6

SOLID Principles
Packaging and Exception Handling

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Outline and Learning Outcome

- Understand the SOLID principles and their application in the design of object-oriented software
- Be able to create packages and use the appropriate access modifiers
- Be able to employ exception handling to deal with "exceptional" events
 - Understand the use of try-catch-finally clauses
 - Able to distinguish the different types of exceptions
 - Able to appreciate exception control flow

Single responsibility principle:

a class should have only one reason to change

— Robert C. Martin (Uncle Bob)

Liskov substitution principle:

Let $\phi(x)$ be a property provable about objects x of type T. Then $\phi(y)$ should be true for objects y of type S where S is a subtype of T.

— Barbara Liskov

- If S is a *subtype* of T (denoted S <: T), then an object of type T can be replaced by that of type S without changing the desirable property of the program

Open-closed principle:

classes should be *open for extension, but closed for modification*— Bertrand Meyer

```
jshell> class A { void foo() { } }
| created class A

jshell> void client(A a) { a.foo(); }
| created method client(A)

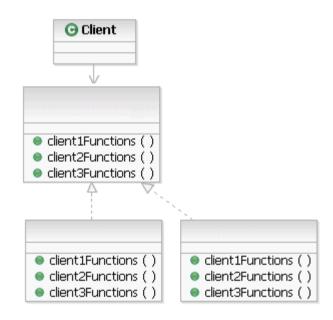
jshell> client(new A())

jshell> class B extends A { }
| created class B

jshell> class C extends A { @Override void foo() { } }
| created class C

jshell> class D extends B { @Override void foo() { } }
| created class D

jshell> client(new B()) // client does not need modification
jshell> client(new C()) // C:foo() invoked
```

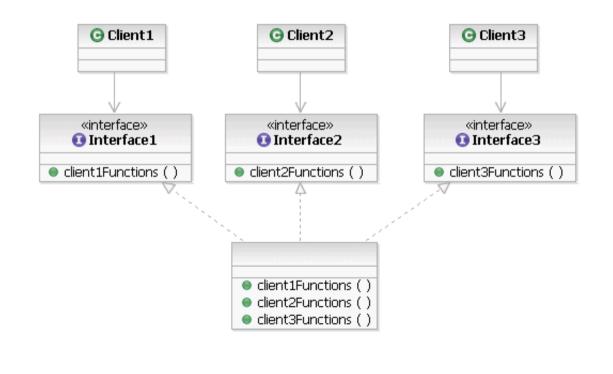


Interface segregation principle:

no client should be forced to depend on methods it does not use.

— Uncle Bob

```
jshell> Circle circle = new Circle(1)
circle ==> Circle with radius 1
jshell> void client1(Shape s) {
            s.getArea();
   . . .>
   ...> }
   created method client1(Shape)
ishell> void client2(Scalable k) {
            k.scale(2);
   ...>
   ...> }
   created method client2(Scalable)
jshell> client1(circle)
jshell> client2(circle)
jshell> void client3(Scalable k) {
            k.getArea(); // ???
   ...> }
```



Dependency inversion principle:

Program to an interface, not an implementation.

```
ishell> /list Shape
   1 : interface Shape { // Shape is the contract
           double getArea();
ishell> Shape s = new Circle(1)
s ==> Area 3.14 and perimeter 6.28
ishell> class Circle implements Shape { // Circle follows contract specs
         private final int radius;
   . . .>
         public double getArea() {
              return Math.PI * this.radius * this.radius;
   . . .>
   ...>
   ...> }
   created class Circle
jshell> void client(Shape s) { // client codes according to contract
            double area = s.getArea();
   . . . >
   ...> }
   created method client(Shape)
ishell> client(circle)
```

Creating Packages

Include the package statement at the top of all source files that reside within the package, e.g.

```
package cs2030.test;
```

- Include the import statement to source files outside the package, e.g. import cs2030.test.SomeClass;
- □ Compile the Java files using\$ javac -d . *.java

Most Restrictive

□ cs2030/test directory created with same-package class files stored within

Wiose Restrictive			Least Restrictive	
Access Modifiers ->	private	Default/no-access	protected	public
Inside class	Υ	Υ	Υ	Υ
Same Package Class	N	Υ	Υ	Υ
Same Package Sub-Class	N	Υ	Υ	Υ
Other Package Class	N	N	N	Υ
Other Package Sub-Class	N	N	Υ	Υ

Least Restrictive

Access Modifiers and Their Accessibility

```
==> Base.java <==
package cs2030.test;
public class Base {
    private void foo() { } // -
    protected void bar() { } // #
    void baz() { } // ~
    public void qux() { } // +
    private void test() {
        this.foo();
        this.bar();
        this.baz();
        this.qux();
==> InsidePackageClient.java <==</pre>
package cs2030.test;
class InsidePackageClient {
    private void test() {
        Base b = new Base();
        b.bar();
        b.baz();
        b.qux();
```

```
==> InsidePackageSubClass.java <==</pre>
package cs2030.test;
class InsidePackageSubClass extends Base {
    private void test() {
        super.bar();
        super.baz();
        super.qux();
==> OutsidePackageClient.java <==</pre>
import cs2030.test.Base;
class OutsidePackageClient {
    private void test() {
        Base b = new Base();
        b.qux();
    }
==> OutsidePackageSubClass.java <==</pre>
import cs2030.test.Base;
class OutsidePackageSubClass extends Base {
    private void test() {
        super.bar();
        super.qux();
```

Preventing Inheritance and Overriding

- □ The **final** keyword can be applied to methods or classes
 - Use the final keyword to explicitly prevent inheritance final class Circle {

To allow inheritance but prevent overriding

Error Handling

 \supset Use exceptions to track reasons for program failure, e.g.

```
public static void main(String[] args) {
    FileReader file = new FileReader(args[0]);
    Scanner sc = new Scanner(file);
    List<Point> points = new ArrayList<Point>();
    while (sc.hasNext()) {
        points.add(new Point(sc.nextDouble(), sc.nextDouble()));
    }
    DiscCoverage maxCoverage = new DiscCoverage(points);
    System.out.println(maxCoverage);
}
```

- Filename missing or misspelt
- The file contains a non-numerical value
- The file provided contains insufficient numerical values
- Compiling the above gives the following compilation error:

Handling Exceptions

- Method #1: throws the exception out of the method public static void main(String[] args) throws FileNotFoundException {
- \Box Method #2: **handle** the exception within the method

```
try {
    FileReader file = new FileReader(args[0]);
    Scanner sc = new Scanner(file);
    List<Point> points = new ArrayList<Point>();
    while (sc.hasNext()) {
        points.add(new Point(sc.nextDouble(), sc.nextDouble()));
    }
    DiscCoverage maxCoverage = new DiscCoverage(points);
    System.out.println(maxCoverage);
} catch (FileNotFoundException ex) {
    System.err.println("Unable to open file " + args[0] + "\n" + ex);
}
```

- try block encompasses the business logic
- catch block encompasses exception handling logic

Catching Multiple Exceptions

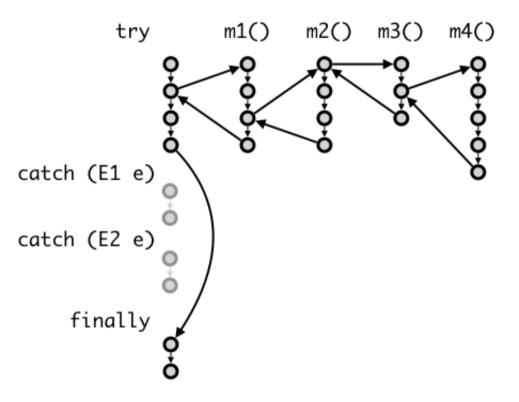
Multiple catch blocks ordered by most specific exceptions first

```
try {
    FileReader file = new FileReader(args[0]);
    Scanner sc = new Scanner(file);
    List<Point> points = new ArrayList<Point>();
    while (sc.hasNext()) {
        points.add(new Point(sc.nextDouble(), sc.nextDouble()));
   DiscCoverage maxCoverage = new DiscCoverage(points);
    System.out.println(maxCoverage);
} catch (FileNotFoundException ex) {
    System.err.println("Unable to open file " + args[0] + "\n" + ex);
} catch (ArrayIndexOutOfBoundsException ex) {
    System.err.println("Missing filename");
} catch (NoSuchElementException ex) { // includes InputMismatchException
    System.err.println("Incorrect file format\n");
} finally {
    System.out.println("Program Terminated\n");
```

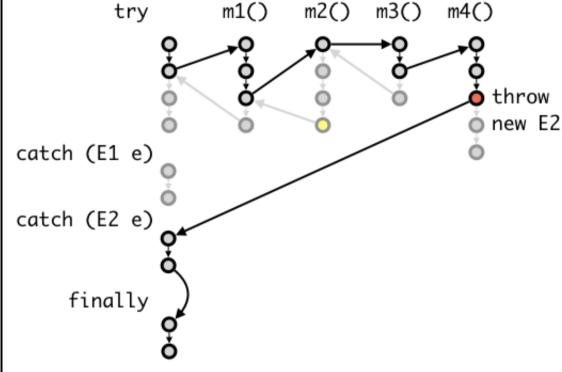
- Optional finally block used for house-keeping tasks
- ${\scriptscriptstyle \square}$ ${}$ Multiple exceptions (no sub-classing) in a single catch using [

Normal vs Exception Control Flow

□ E.g. **try**-**catch**-**finally** block (**m1** is called, **m1** calls **m2**, **m2** calls **m3**, **m3** calls **m4**), and catching two exceptions **E1**, **E2**



Normal Control Flow



Exception Control Flow

Throwing an Exception

☐ An exception can be created and thrown using throw

```
Circle createUnitCircle(Point p, Point q) {
    double distPQ = p.distanceTo(q);
    if (distPQ < EPSILON || distPQ > 2.0 + EPSILON) {
        throw new IllegalArgumentException("Distance pq not within (0, 2]");
    }
    ...
    return new Circle(...);
}
```

□ Creating a user defined exception to be thrown

```
class IllegalCircleException extends IllegalArgumentException {
    IllegalCircleException(String message) {
        super(message);
    }
    @Override
    public String toString() {
        return "IllegalCircleException:" + getMessage();
    }
}
```

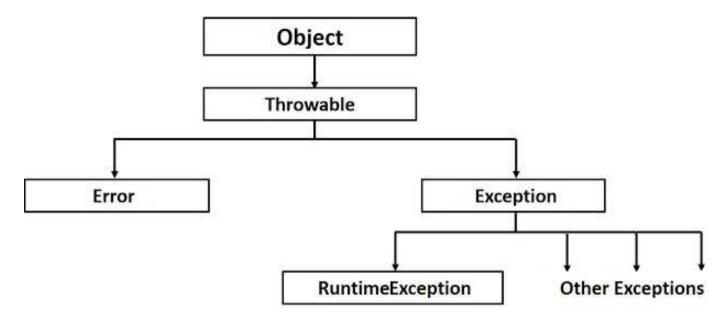
 Only create your own exceptions if there is a good reason to do so, else just find one that suits your needs

Types of Exceptions

- There are two types of exceptions:
 - A checked exception is one that the programmer is expected to actively anticipate and handle
 - all checked exceptions should be caught (catch) or propagated (throw)
 - e.g. when opening a file, FileNotFoundException should be explicitly handled
 - An unchecked exception is one that is unanticipated, usually the result of a bug in the program
 - e.g. ArithmeticException surfaces when trying to divide by zero

Exception Hierarchy

Unchecked exceptions are sub-classes of RuntimeException



- When overriding a method that throws a checked exception, the overriding method cannot throw a more general exception
- \square Avoid *Pokemon Exception Handling*, **catch** (Exception ex)
- Handle exceptions at the appropriate abstraction level, do not just throw and break the abstraction barrier