

Exceptions/Debugging/ Annotations/RegEx in Java

Exceptions Overview

- A prescription for handling errors in the Java language
- Not meant as flow control for normal execution; these are exceptions after all.
- There are two types of exceptions in Java
 - “Checked” exceptions
 - “Unchecked” exceptions

How not to handle exceptions when coding (in any language)

- Returning a “special” value
 - Returning `null` or `-1`
 - Can be confusing - type does not document the exception
 - Can be restrictive - what if the value you need to return is actually `-1`?
- Instead use exceptions (most languages have a notion of exceptions) but only if the case is indeed exceptional (not simply for flow-control)
- If an exception does not make sense, return a type (or wrapper type) detailing the issue

Exception Example

```
1  public class ExceptionsExample {
2
3      public static void main(String[] args) {
4          if ((args == null) || (args.length != 1) || (args[0] == null)) {
5              1 throw new IllegalArgumentException("Expecting 1 argument which is a path to a file");
6          }
7          2 try {
8              ExceptionsExample example = new ExceptionsExample(args[0]);
9          } catch (IOException ioe) {
10             System.out.printf("Invalid file-name given to ExceptionsExample%n");
11         }
12     }
13
14     private final File file;
15
16     3 public ExceptionsExample(String fileName) throws IOException {
17         if (fileName == null) {
18             throw new IllegalArgumentException();
19         }
20         this.file = new File(fileName);
21     }
22 }
```

checked exception

a different exception
(unchecked, do not need to
put in the method signature)

Checked Exceptions

- Must be caught or rethrown
- Catching or re-throwing is statically “checked” by the compiler
- In general, only use if the program can recover from this failure. Does this exception have a graceful route to recovery.
 - Otherwise, code becomes bloated with exception handling that isn't aiding in recovery but simply appeasing the compiler.

Checked Exception Example

```
1 public class CheckedExceptionExample {
2
3     public void printJson(byte[] json) {
4         try {
5             String parsed = parseJson(json);
6             System.out.printf("%s\n", parsed);
7         } catch (IOException ioe) {
8             System.out.printf("Could not parse JSON - %s\n", ioe.getMessage());
9         }
10    }
11
12    public String parseJson(byte[] json) throws IOException {
13        StringBuilder buffer = new StringBuilder();
14        for (byte data : json) {
15            if (data > 0x20) {
16                throw new IOException();
17            }
18            buffer.append((char) data);
19        }
20        return buffer.toString();
21    }
22
23 }
```

Unchecked Exceptions

- Need not be caught, rethrown or declared
- In general, only use when the program cannot be expected to recover from the failure.
- Callers can choose to catch these exceptions (and recover) they're just not required by the compiler.

Unchecked Exceptions Example

```
1 public class UncheckedExceptionExample {
2
3     public void printJson(byte[] json) {
4         String parsed = parseJson(json);
5         System.out.printf("%s%n", parsed);
6     }
7
8     public String parseJson(byte[] json) {
9         StringBuilder buffer = new StringBuilder();
10        for (byte data : json) {
11            if (data > 0x20) {
12                throw new IllegalArgumentException();
13            }
14            buffer.append((char) data);
15        }
16        return buffer.toString();
17    }
18
19 }
```

if invoked, jump out of everything

Throwing Exceptions

- Done by using keyword throw (i.e., `throw new IllegalArgumentException()`)
- Must declare checked exceptions as being 'thrown'
- Do not have to but can declare unchecked exceptions
 - Not often done. If you do this it does not mean the caller must catch the exception
- Cannot override a method and throw a more generic exception
 - But can override and throw a more specific exception
- If overriding a method without a declared checked exception, cannot add one

Catching Exceptions

- Use the try/catch mechanism provided by Java
- If you do not catch the type thrown it is handled by the caller
 - If the exception is checked you must either catch it or declare your method as throwing it
 - If the exception is unchecked and not handled up the call-stack, then the JVM stops because of the “uncaught” exception
- If no exception is thrown within the try block then the catch block is not executed. Additionally, if the type of the catch block does not match the thrown exception then the catch block is not executed.
- Multiple catch blocks are handled in order of declaration
- Cannot catch checked exceptions which are not thrown.

Exceptions are Throwables are Objects

- “Exceptions” in Java are actually a subtype of Throwable
- There are two main types that extend Throwable
 - Exception
 - Includes checked and unchecked exceptions.
 - Unchecked exceptions should extend from RuntimeException
 - Error
 - An exception indicating a system failure (i.e., no more memory).
 - In general, should not extend this class and very rarely throw it yourself

Hierarchy When Catching

- More generic exception in hierarchy can handle more specific.
 - I.e., parent types can catch all of their children
 - Because of this, order matters. What does the following print?

```
1 public void readFile(String fileName) {  
2     try {  
3         if (true) {  
4             throw new FileNotFoundException();  
5         }  
6     } catch (IOException ioe) {  
7         System.out.printf("IOException thrown and caught");  
8     } catch (FileNotFoundException fnfe) {  
9         System.out.printf("FileNotFoundException thrown and caught");  
10    }  
11 }
```

Multiple Exception Types in Catch

- Java 1.7 added ability to handle disparate exception types in the same catch statement.

```
1 public class MultipleTypeInCatch {
2
3     public void multipleCatch() {
4
5         try {
6             // do something
7         } catch (IllegalArgumentException | NullPointerException e) {
8             System.out.printf("Something bad happened %s%n", e.getMessage());
9         }
10
11     }
12
13 }
```

catch different exceptions and handle then in the same way

type of e: least common parent -> Exception

Custom Exceptions

- You can extend `Throwable` / `Exception` / `RuntimeException` / etc to create your own exception type.

```
1  public class ParsingException extends Exception {  
2  
3      public ParsingException(Throwable cause) {  
4          super(cause);  
5      }  
6  
7  }
```

```
public ParsingException(String message){  
    super(message);  
}  
  
public ParsingException(String message, Throwable cause){  
    super(message, cause);  
}
```

- Not often necessary. Prefer existing exceptions (`NullPointerException`, `IllegalArgumentException`, `IOException`, etc)

Rethrowing / Chaining Pattern

- To simplify your method signature (i.e., API) only throw one checked exception. Catch others and rethrow as one type.
 - Not always necessary, use discretion.

```
1 public class RethrowChainingExample {  
2  
3     public void read(String filePath) {  
4         try {  
5             FileInputStream stream = new FileInputStream(filePath);  
6             int read;  
7             while ((read = stream.read()) != -1) {  
8                 if (read > 0xFF) {  
9                     throw new ParsingException();  
10                }  
11                System.out.printf("%d", read);  
12            }  
13        } catch (IOException fnfe) {  
14            throw new ParsingException(fnfe);  
15        }  
16    }  
17 }  
18  
19 }
```

Finally Clause

- Used in conjunction with the try block, to allow code to be executed no matter whether an exception is thrown or not

```
1 public class FinallyClause {
2
3     public void finallyClause(String path) {
4         InputStream stream = null;
5         try {
6             stream = new FileInputStream(path);
7         } catch (IOException ioe) {
8             throw new RuntimeException(ioe);
9         } finally {
10             if (stream != null) {
11                 try {
12                     stream.close();
13                 } catch (IOException ioe) {
14                     // ignore; trying to close anyway
15                 }
16             }
17         }
18     }
19 }
20 }
```

open a stream and close it

always execute the finally block even the IOException is caught

Finally Clause Gotcha

```
1 public class FinallyGotcha {  
2  
3     public static void main(String[] args) {  
4         FinallyGotcha gotcha = new FinallyGotcha();  
5         int result = gotcha.finallyGotcha();  
6         System.out.printf("%d\n", result);  
7     }  
8  
9     public int finallyGotcha() {  
10        try {  
11            if (true) {  
12                throw new RuntimeException();  
13            }  
14            return 1;  
15        } catch (RuntimeException re) {  
16            return 2;  
17        } finally {  
18            return 3;  
19        }  
20    }  
21 }
```

return 3
because finally always run
(override return 2)
if print: print 2 3

22 }

Try With Resources (Java 1.7)

- Introduced in Java 1.7 - handy way to close resources.
 - Avoids the boilerplate code seen two slides previously
 - Can create your own using AutoCloseable interface

```
1  public class FinallyClause {  
2  
3      public void finallyClause(String path) {  
4          try (InputStream stream = new FileInputStream(path)) {  
5              // TODO  
6          } catch (IOException ioe) {  
7              throw new RuntimeException(ioe);  
8          }  
9      }  
10  
11 }
```

Exceptions and Logging

- **Never** print the exception stack-trace using `e.printStackTrace()`;
 - As this often simply squashes the exception handling.
- Instead prefer a Logging implementation
 - Java provides a common API - **java.util.logger**
 - **log4j** is a popular library but outdated
 - Latest/best is **slf4j**

```
1 public class ExceptionLogging {
2
3     private final static Logger LOG = Logger.getLogger(ExceptionLogging.class.getSimpleName());
4
5     public InputStream open(String file) {
6         try {
7             return new FileInputStream(file);
8         } catch (IOException ioe) {
9             LOG.log(Level.SEVERE, ioe.getMessage(), ioe);
10            return null;
11        }
12    }
13 }
```

Debugging!

- Do early and often.
- Do not litter log statements into your program, instead use the debugger (jdb or an IDE).
- Always compile your code with **-Xlint:all**
- Do not debug code by adding a **main** method for testing. Test your code using unit-tests instead. Debugging by **main** methods pollutes your code and adds unnecessary dependencies

Annotations

- Form of meta programming
 - I.e., annotates your code with metadata which can be used.
- Adds metadata to your code which can be used by programmers for clarity as well as compilers/tooling to do static code analysis
 - We've already seen this with **@Override**

```
21      @Override public int hashCode() {  
22          return variable != null ? variable.hashCode() : 0;  
23      }
```

Creating Your Own

```
1 @Target(ElementType.METHOD)
2 @Retention(RetentionPolicy.RUNTIME)
3 public @interface Authorized {
4     String headerKey() default "Bearer";
5 }
6
7
```

defining your own annotation named
Authorized

method

@Authorized (bearerKey = "foo")

Regular Expressions

- Encourage you to read the Java tutorial
 - <http://docs.oracle.com/javase/tutorial/essential/regex/>
- Similar to *Perl* in syntax
- Two main classes
 - `java.util.regex.Pattern`
 - `java.util.regex.Matcher`

```
1 public class RegexExample {
2
3     private static final Pattern REG_EX = Pattern.compile("\\d\\d");
4
5     public static void main(String[] args) {
6         RegexExample example = new RegexExample();
7         example.match("Foo 01 Bar");
8
9     }
10
11     private void match(String input) {
12         Matcher matcher = REG_EX.matcher(input);
13         while (matcher.find()) {
14             String match = matcher.group();
15             System.out.printf("%s%n", match);
16         }
17     }
18
19 }
```

print 01

Read Chapter 8

All sections except 8.9

Homework 6

<https://github.com/NYU-CS9053/Fall-2019-II/homework/week6>