CMPS 251

Read Chapter 11

Exception Handling

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Outline

- Exception handling using try-catch-finally
- Exception Types
- Throwing an Exception
- Custom Exceptions

try-catch-finally block

Back

Definition

- An exception is an event that occurs during the execution of a program that disrupts the normal flow of execution.
- Examples
  - A program is going to read a file, but *the file is missing*
  - A program is reading an array, but the *out of bound* case occurs
  - A program is receiving a file, but the network connection fails
- With **exception handling**, a program can continue executing (rather than terminating) after dealing with the exception.

Example of throwing an exception

```
1  // Fig. 8.1: Time1.java
2  // Time1 class declaration maintains the time in 24-hour format.
3
4  public class Time1
5  {
6     private int hour; // 0 - 23
7     private int minute; // 0 - 59
8     private int second; // 0 - 59
9
10    // set a new time value using universal time; throw an
11    // exception if the hour, minute or second is invalid
12    public void setTime( int h, int m, int s )
13    {
14       // validate hour, minute and second
15       if ( ( h >= 0 && h < 24 ) && ( m >= 0 && m < 60 ) &&
16          ( s >= 0 && s < 60 ) )
17       {
18          hour = h;
19          minute = m;
20          second = s;
21       } // end if
22       else
23          throw new IllegalArgumentException(
24             "hour, minute and/or second was out of range" );
25    } // end method setTime
```

throws an IllegalArgumentException if the data validation fails in set method

Example of catching and handling the Exception

```
25
26          // attempt to set time with invalid values
27          try
28          {
29             time.setTime( 99, 99, 99 ); // all values out of range
30          } // end try
31          catch ( IllegalArgumentException e )
32          {
33             System.out.printf( "Exception: %s\n\n", e.getMessage() );
34          } // end catch
```

Catch and handle the Exception

Method setTime() and Exception Handling

- For incorrect values, setTime throws an exception of type `IllegalArgumentException` (lines 23–24)
  - The **throw** statement (line 23) creates a new object of type **`IllegalArgumentException`** and pass a custom error message
  - The **throw** statement immediately terminates setTime() method and the exception is returned to the client code that attempted to set the time
  - The client can use `try...catch` to handle the exception

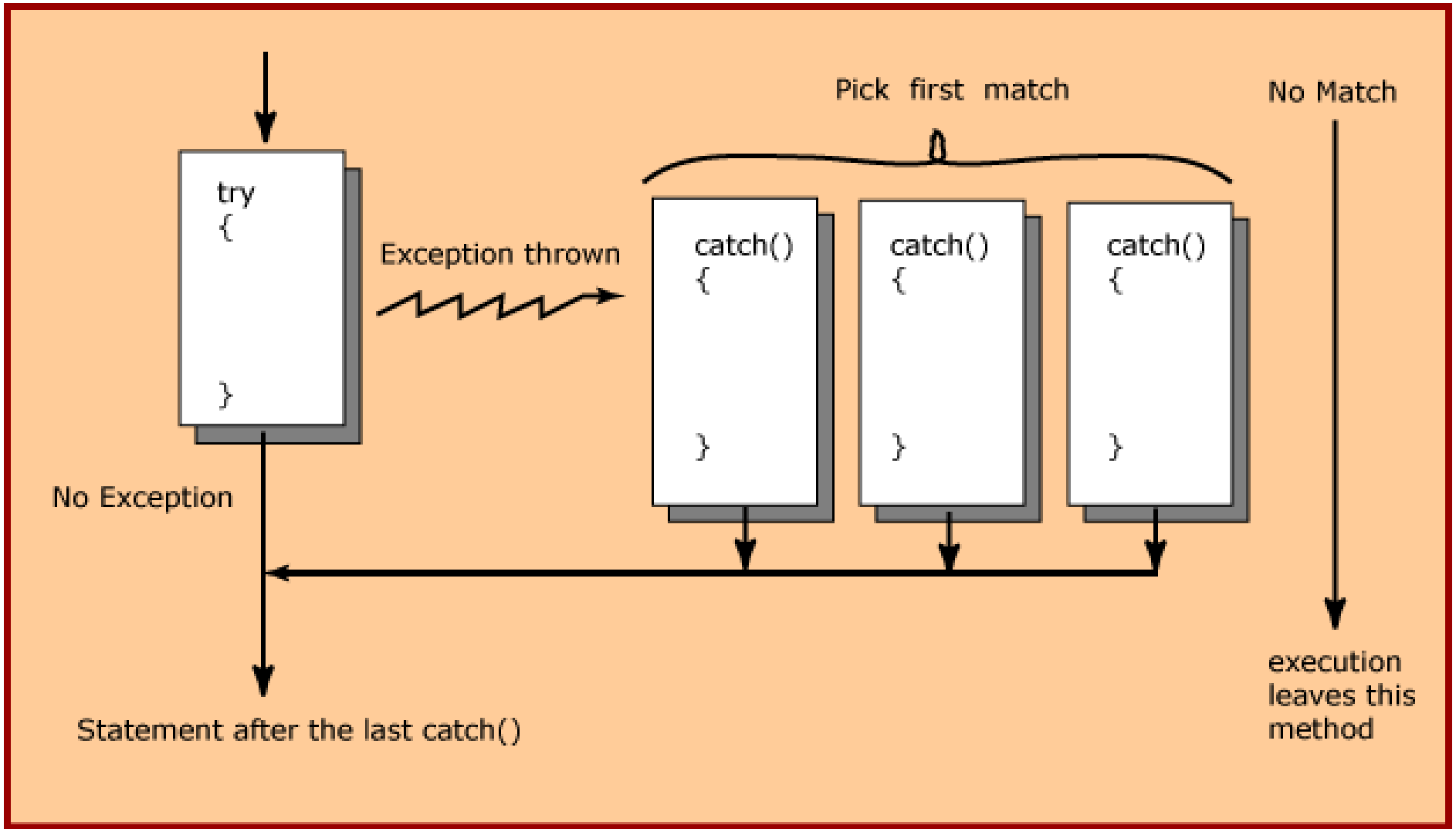
Some common exceptions …

- `ArrayIndexOutOfBoundsException` occurs when an attempt is made to access an element past either end of an array
- A `NullPointerException` occurs when a null reference is used where an object is expected
- `ClassCastException` occurs when an attempt is made to cast an object that does not have an *is-a* relationship with the type specified in the cast operator.
- `IOException` may occur when reading or writing to files

Exception Handling using try-catch-finally

```
try {
  //…something might have exception
}
catch (SomeExceptionClass e) {
  //handle the exception here
}
finally {
  //release resources
  //Perform any actions here common to
  whether or not an exception is thrown.
}
```

How try and catch Work



How try and catch Work (1 of 2)

- If an exception occurs in a try block, the try block terminates immediately and program control transfers to the first catch block whose type matches the type of the exception that occurred.
  - If there are remaining statements after the statement that causes the exception, those remaining statements won't be executed.
- After the exception is handled, any remaining catch blocks are ignored, and execution resumes at:
  - The finally block, if one is present
  - Or at the first line of code after the try…catch sequence
  - **Control does not return to the try block.**

How try and catch Work (2 of 2)

- If no catch{} block matches the exception, the **execution leaves this method**
  - The unhandled exception is passed to the caller
- If no exception occurs in the try block, the catch blocks are skipped and control continues with the first statement after the catch blocks
  - But, the finally block , if one is present, will execute whether or not an exception occurs in the corresponding try block.
  - The finally block is used to **release resources** acquired in the try block such as closing files and database/network connections.

When to Use Exceptions

- Use it if the event is truly exceptional and is an error
- Do not use it to deal with simple, expected situations
- Example:

```
try {
  System.out.println(refVar.toString());
}
catch (NullPointerException ex) {
  System.out.println("refVar is null");
}
```

Can be replaced by:

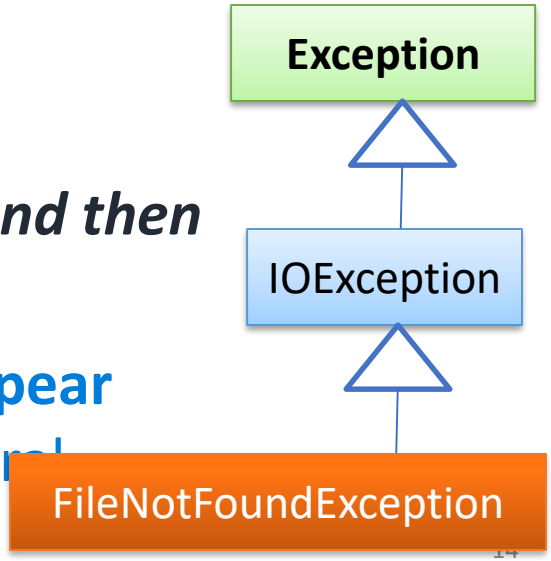
```
if (refVar != null)
  System.out.println(refVar.toString());
else
  System.out.println("refVar is null");
```

Try with multiple catch blocks

```
try {
    //maybe read a file or something…
}
catch (FileNotFoundException e) {
    System.out.println("FileNotFoundException: "  +
                       e.getMessage());
}
catch (IOException e) {
    System.out.println("Caught IOException: " +
                       e.getMessage());
}
```

- ***Why we catch FileNotFoundException first, and then IOException?***

=> The **most specific exception types should appear first** in the structure, followed by the more general exception types.



Multi-Catch

```
try {
...
} catch (ClassCastException e) {
  doSomethingClever(e);
  throw e;
} catch(InstantiationException |
    NoSuchMethodException |
    InvocationTargetException e) {
  // Useful if you do generic actions
  log(e);
  throw e;
}
```

Log the exception then rethrow it

try-with-resources

- The **try-with-resources** is a try statement that declares a *resource* (i.e., an object that must be closed after the try block)
  - Any object that implements **java.lang.AutoCloseable** can be used as a resource.
  - "**try-with-resources**" will auto-close the resource (e.g., an open file) that was created in the try

```
try (Scanner inputFile = new Scanner(new FileInputStream(filePath))) {
    String line;
    while (inputFile.hasNext()) {
        line = inputFile.nextLine();
        fileLines.add(line);
    }
} catch (IOException e) {
    System.out.println(e.getMessage());
}
```

inputFile will be closed automatically after try block. No need to add a finally block

Superclass/Subclass Exceptions

- A catch parameter of an exception can also catch **all** the exception subtypes.
  - Enables catch to handle related exceptions with a concise notation
  - E.g., **`catch (Exception e)`** can catch all exceptions that are subtypes of Exception class
- Catching related exceptions in one catch block makes sense only if the handling behavior is the same for **all** subclasses.
- You can also catch each subclass type individually if those exceptions require different processing.
- If multiple catch blocks match a particular exception type, only the **first** matching catch block executes.

When a called method throws an exception. The caller should either throw it or handle it.

```
public static void appendToFile(String filePath, String textToAppend)
        throws AlreadyExistsException {
    if (isLineExists(filePath, textToAppend)) {
        throw new AlreadyExistsException("The line to be add already exists
    }
    writeToFile(filePath, textToAppend, true);
}
```

Add throws declaration

Surround with try/catch

```
...
public static void appendToFile(String filePath, String
 textToAppend)
throws AlreadyExistsException, IOException {
if (isLineExists(filePath, textToAppend)) {
...
```

```
...
}
try {
writeToFile(filePath, textToAppend, true);
} catch (IOException e) {
// TODO Auto-generated catch block
e.printStackTrace();
}
}
...
```

When a called method throws an exception. The caller should either throw it or handle it.

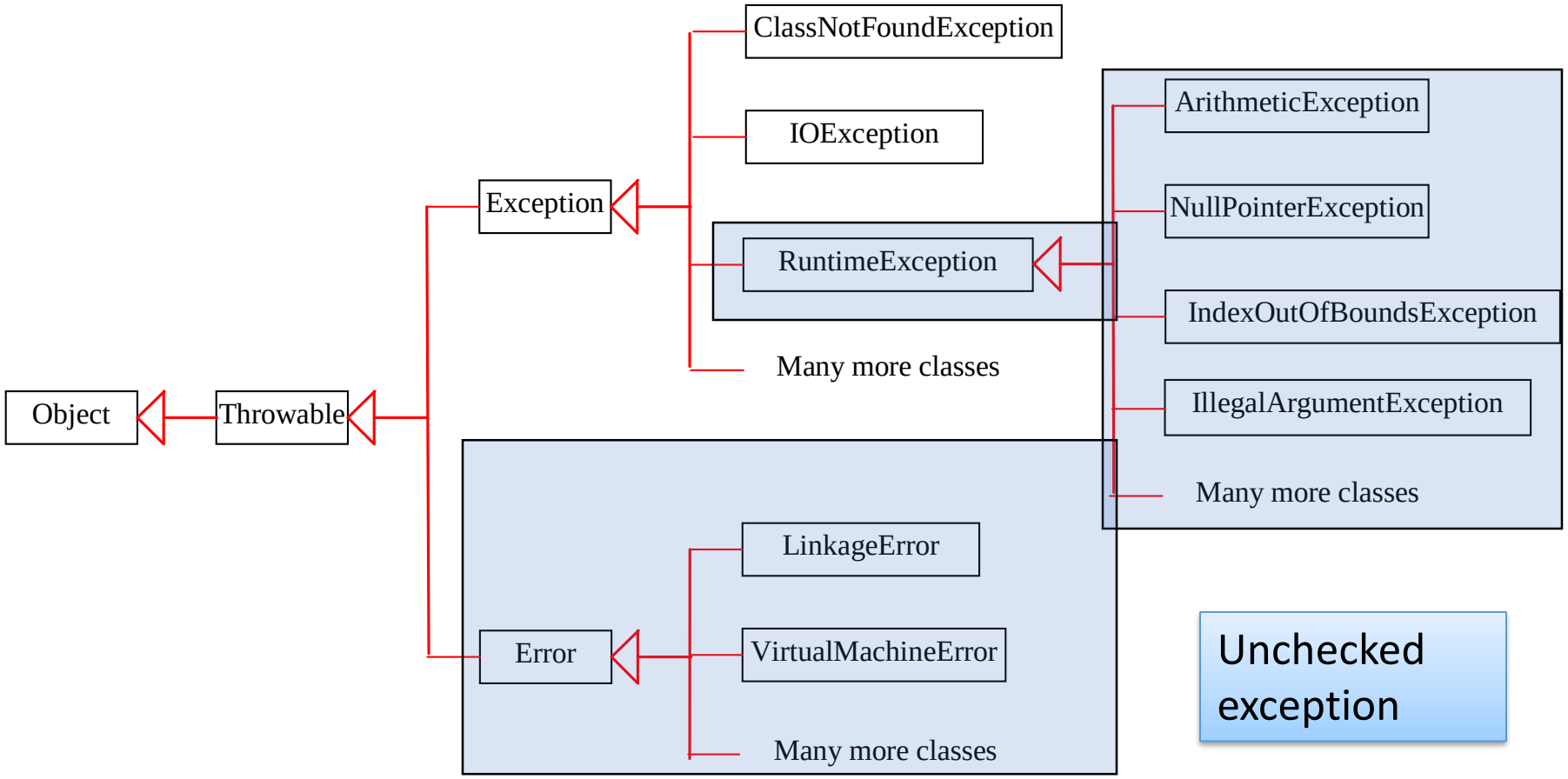
Uncaught exceptions that are still not handled in the ***main*** cause JVM default exception handler to run. This displays an error message then the application terminates.

Exception Types

Three kinds of exceptions

- ***Checked exception*** *(Java forces you to handle them)*
  - These are exceptional conditions that a well-written application should anticipate and recover from.
  - They occur usually interacting with outside resources/ network resources e.g. database problems, network connection errors, missing files. E.g., `FilNotFoundException`
- ***Unchecked exceptions*** *(Java does NOT force you to handle them)*
  - Error: Exceptional conditions that are external to the application and outside its control. The application usually cannot anticipate or recover from them. e.g., **Out of memory exception**
  - Runtime exception: caused by programming errors, such as accessing a null object, bad casting, accessing an out-of-bounds array, and arithmetic errors.

Unchecked vs. Checked Exceptions

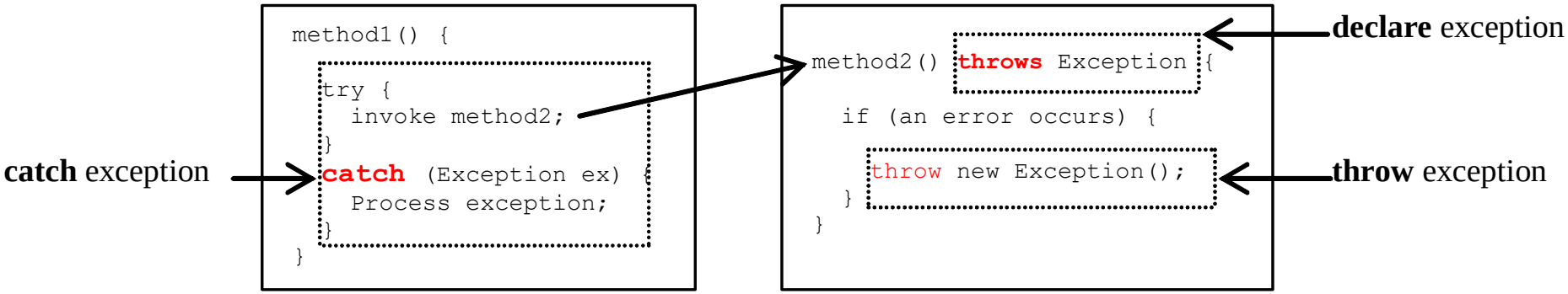


- Java does not mandate you to **write code to catch unchecked exceptions**.
- All other exceptions are ***checked exceptions***, meaning that the compiler forces the programmer to handle them.

Throwing an Exception

Declaring, Throwing, and Catching Exceptions

- Throw exceptions to indicate a problem
- Use catch blocks to specify exception handlers



Declaring Exceptions

- Specifies the exceptions a method may throw.

. E.g., `public void myMethod() throws IOException`

- Can declare a comma-separated list of the exceptions that the method will throw if various problems occur.
  - May be thrown by statements in the method's body or by methods called from the body.
- Method can throw exceptions listed in its throws clause or their subclasses.
  - e.g., `IOException` is a subclass of `Exception`
- Clients of a method with a throws clause are thus informed that the method may throw exceptions.

Throwing Exceptions

- A method can create an exception instance and throw it

```
public void setRadius(double radius)
      throws IllegalArgumentException {
    if (radius >= 0)
      radius =  radius;
    else
      throw new IllegalArgumentException(
        "Radius cannot be negative");
}
```

- A method can throw multiple exceptions

```
public static void appendToFile(String filePath, String textToAppend)
      throws IOException, AlreadyExistsException {
```

Custom Exceptions

Back

Declaring New Exception Types

- Sometimes it's useful to declare your own exception classes that are specific to the problems that can occur in your app
  - A new exception class **must** extend an existing exception class to ensure that the class can be used with the exception-handling mechanism
  - Before creating a custom exception try to first use one of Java's built-in *exception classes that might be suitable for the type of problems your methods need to indicate*

Examples

```java
public class InvalidLoginException extends Exception {
    //An example of throwing it could be:
    //throw new InvalidLoginException("Email and/or password are invalid");
    public InvalidLoginException(String message) {
        super(message);
    }

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

```java
public class AlreadyExistsException extends Exception {
    private String dataToAdd; //with getters and setters
    private String destination;
    public AlreadyExistsException(String message) {
        super(message);
    }

    public AlreadyExistsException(String message, String dataToAdd, String destination) {
        super(message);
        this.dataToAdd = dataToAdd;
        this.destination = destination;
    }

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

A custom Exception is a class that extends Exception. It can have extra attributes and methods.

Summary

- Exceptions are a powerful mechanism for separating Error-Handling Code from "Regular" Code => **this simplifies the normal flow code**.
- The ***try block*** identifies a block of code in which an exception can occur.
- The ***catch block*** defines as an exception handler that can handle a particular type of exception.
- The ***finally block*** is guaranteed to execute, and is the right place to release resources acquired in the try block such as closing files, database connections and network connections.