Exception Handling

Objectives

- At the end of the lesson, the student should be able to:
  - Define exceptions
  - Handle exceptions using a simple try-catch-finally block
  - Use throw and throws clause
  - create and use user Defined Exception

Exceptions

- An exception
  - is an event that interrupts the normal processing flow of a program. This event is usually some error of some sort.
  - This causes our program to terminate abnormally.

Exceptions

- The term *exception* is shorthand for the phrase “exceptional event “
- **Definition:**
  - “ An *exception* is an event that occurs during the execution of a program that disrupts the normal flow of instructions.”
  - A Java exception is an object that describes an exceptional (that is, error) condition that has occurred in a piece of code.

Exceptions

- Many kinds of errors can cause exceptions
- problems ranging from serious hardware errors, such as a hard disk crash to simple programming errors, such as trying to access an out-of-bounds array element

Examples

- Some examples of exceptions:
  - **`ArrayIndexOutOfBounds`** exceptions, which occurs if we try to access a non-existent array element
  - **`NumberFormatException`**, which occurs when we try to pass as a parameter a non-number in the Integer.parseInt() method.

Throwing an Exception

- When an exception occurs within a Java method, the method creates an **exception object** and hands it off to the runtime system.
- The exception object contains information about the exception, including its type and the state of the program when the error occurred.
- Creating an exception object and handing it to the runtime system is called ***throwing an exception***.

Catching an Exception

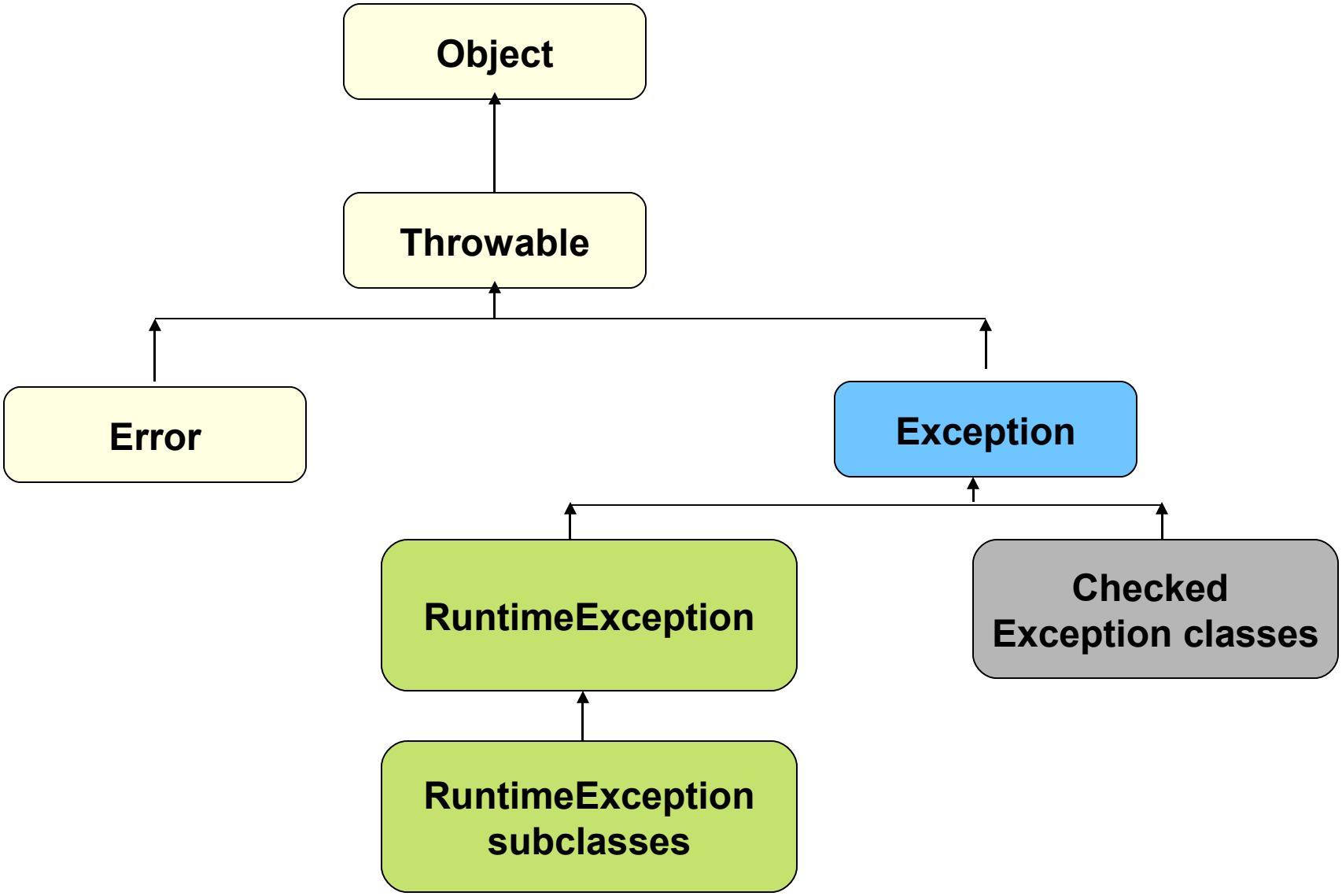
- After a method throws an exception, the runtime for an appropriate exception handler
- An exception handler is considered appropriate if the type of the exception thrown is the same as the type of exception handled by the handler
- Handling the Exception by the handler is called ***"catching an exception"***
- In case the runtime system does not find an exception handler, the runtime system (and consequently the Java program) terminates.

Why to handle Exception?

- By using exceptions to manage errors, Java programs have the following advantages over traditional error management techniques:

  - **Advantage 1:** Separating Error Handling Code from "Regular" Code
  - **Advantage 2:** Propagating Errors Up the Call Stack
  - **Advantage 3:** Grouping Error Types and Error Differentiation

Java Exception Class hierarchy



Types of Exception

- Java Exceptions can be categorized into two broad categories
  - Checked Exceptions
  - Unchecked Exceptions (runtime exceptions)

Runtime exceptions
(Unchecked Exception)

- Runtime exceptions are those exceptions that occur within the Java runtime system.
- Examples:
  - `ArithmeticExceptions`
  - `NullpointerExceptions`
  - `ArrayIndexOutOfBoundsException`
- Such type of exceptions cannot be checked/detected by the compiler and hence are also called unchecked exceptions.

Checked Exceptions

- *Checked exceptions* are not runtime exceptions and are checked by the compiler
- the compiler checks that these exceptions are caught or specified.
- Checked exceptions do ***not*** extend the **RuntimeException** class.
- Checked exceptions ***must*** be *handled* by the programmer to avoid a compile-time error.
- Example
  - **IOException**

Handling exceptions in Java

- Java exception handling is managed via five keywords:
  - **try**
  - **catch**
  - **finally**
  - **throw**
  - **throws**,

try-catch-finally block

- To handle exceptions in Java, we use a try-catch-finally block
  - What we do in our programs is that we place the statements that can possibly generate an exception inside this block.

try-catch-finally block

- The general form of a try-catch-finally block is,

```
try {
        // write the statements that can generate an exception in the
        // block
   }
catch(<exceptionType> <varName>) {
        //write the action your program will do if an exception
        // of a certain type occurs
        }
.............
catch(<exceptionType> <varName>) {
        //write the action your program will do if an exception
        // of a certain type occurs
        }
finally {
        // add more cleanup code here
        }
```

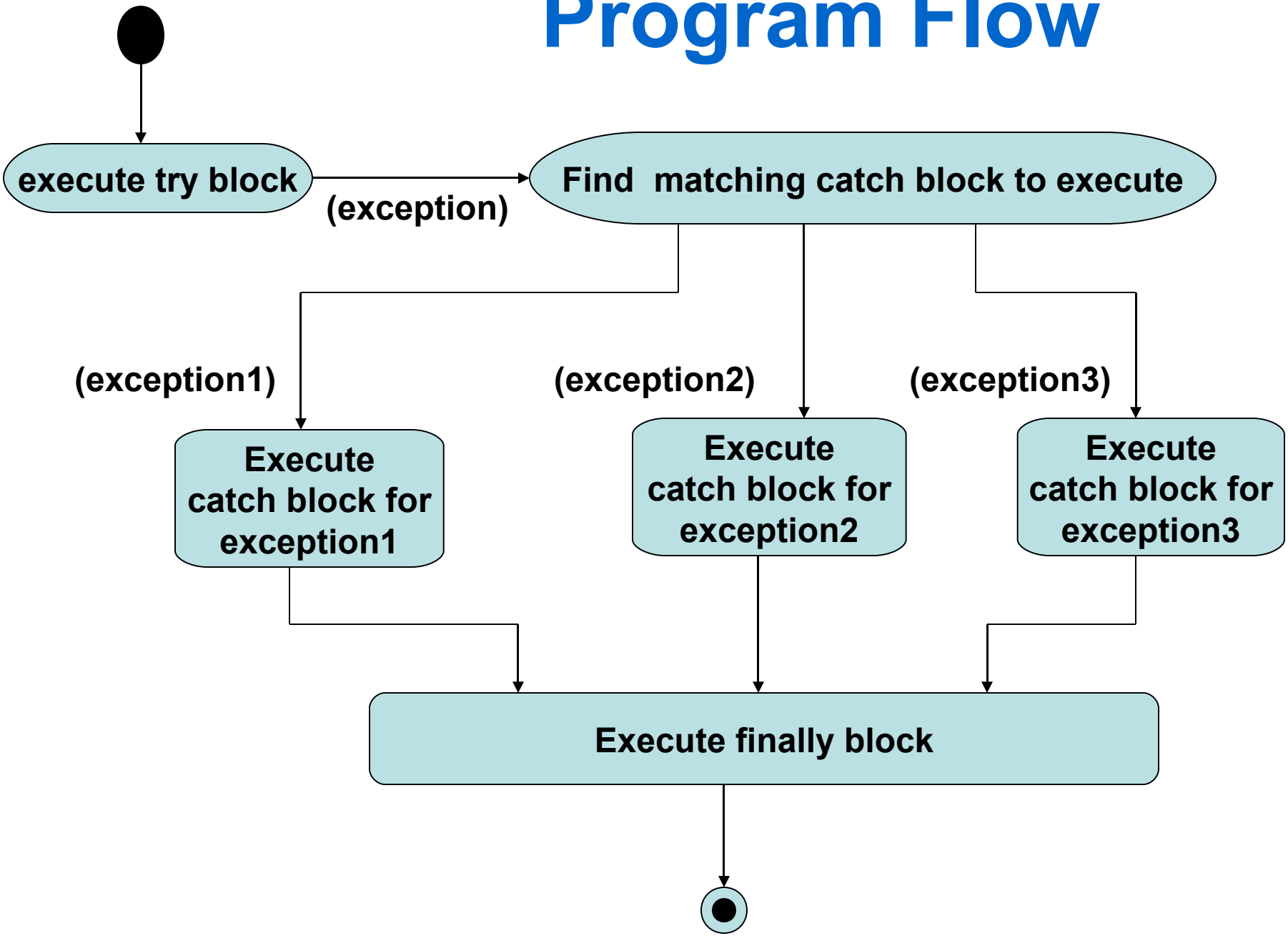
try-catch-finally block

- **Key aspects about the syntax of the try-catch-finally construct**:
  - For each try block, there can be one or more catch blocks, but only one finally block.
  - The catch blocks and finally blocks must always appear in conjunction with the try block, and in the above order.
  - A try block must be followed by AT LEAST one catch block OR one finally block, or both.
  - Each catch block defines an exception handle. The header of the catch block takes exactly one argument, which is the
  - exception its block is willing to handle. The exception must be of the Throwable class or one of its subclasses.

try-catch-finally block

- A single try block may have more than one catch block
- A try -catch block can be nested inside a try block.
- A catch block handles only the exception for which it is meant for.
- If an exception occurs in a inner try block and is not handled by the inner catch blocks the exception cab be handled by the outer catch block(s)
- Whether an exception occurs in a try block or not the finally block always executes.

Program Flow



Example: try-catch

```
public class ExceptionExample {
    public static void main( String[] args ){
        try{
                System.out.println( args[1] );
            }
        catch( ArrayIndexOutOfBoundsException exp ){
                System.out.println("Exception caught!");
                }
         }
}
```

throw

- Using the “throw” clause the programmer can throw an exception depending upon a certain condition desired by the programmer.
- The “throw” clause can also be used to throw user defined exceptions.

```
throw new ExceptionType();
```

throw - An Example

```
class  ThrowDemo
{
        public static void main(String[] args)
        {
                double balance = 3000;
                try
                {
                        double amount = Double.parseDouble(args[0]);
                        if (balance<amount)
                                throw new BalanceException();

                }
                catch (BalanceException e)
                {
                        System.out.println( "You do not have
                                                sufficient balance");
                }
                System.out.println( "Hello World!");
        }
}
```

throws

- If a method is capable of causing an exception that it does not handle, it must specify this behavior so that callers of the method can guard themselves against that exception.
- This is done by including a **throws** clause in the method's declaration.
- The general form of a method declaration that includes a **throws** clause:

```
type method-name (parameter-list) throws exception-list
{
// body of method
}
```

- *exception-list* is a comma-separated list of the exceptions that a method can throw.

throws

- A **throws** clause lists the types of exceptions that a method might throw. This is necessary for all exceptions, except those of type **Error** or **RuntimeException**, or any of their subclasses.
- All other exceptions that a method can throw must be declared in the **throws** clause. If they are not, a compile-time error will result.

throws – An Example

```
class  ReadFileDemo{
public static void main(String[] args) throws
    IOException,FileNotFoundException
  {
    FileInputStream fis = new FileInputStream( "note.txt");
    int i;
    while ((i=fis.read())!=-1)
    {
          System.out.print((char)i);
    }
  }
}
```

The method read() throws IOException and FileInputStream() throws FileNotFoundException

User Defined Exceptions

- Java's built-in Exceptions handle most of the Exceptions
- we can also define our own exception class
- To create a user defined Exception we need to create a subclass of Exception
- In-turn which automatically becomes subclass of Throwable also

Methods Inherited by User Defined Exception class

- The **Exception** class does not define any methods of its own.
- It inherits those methods provided by **Throwable class**
- all exceptions, including those we create, have the methods defined by **Throwable** class

Methods of Throwable class

Method Summary	
Throwable	**getCause()** Returns the cause of this throwable or null if the cause is nonexistent or unknown.
String	**getMessage()** Returns the detail message string of this throwable.
Throwable	**initCause(**Throwable cause) Initializes the *cause* of this throwable to the specified value.
void	**printStackTrace()** Prints this throwable and its backtrace to the standard error stream.
void	**printStackTrace(**PrintStream s) Prints this throwable and its backtrace to the specified print stream.
void	**printStackTrace(**PrintWriter s) Prints this throwable and its backtrace to the specified print writer.
String	**toString()** Returns a short description of this throwable

Example: User defined Exception(1)

```
class InsufficientBalanceException extends Exception{

InsufficientBalanceException( String message){
                    super(name);
                    }

};
```

Example: User defined Exception(2)

```
class Withdraw {
double balance=500;
public void withdraw( double amount){
    try   {
          if (balance<amount)
          throw new InsufficientBalanceException(
                              "Insufficient balance");
    System.out.println (" Transaction Successful!!");
          }
    catch (InsufficientBalanceException e){
          System.out.println (e.getMessage());

          }
    }
};
```

Example: User defined Exception(3)

```
class MyCustomException{
    public static void main( String[] args){

            Withdraw w= new Withdraw();
            w.withdraw(700);
            w.withdraw(300);
            w.withdraw(600);
            }
};
```

Output:

Insufficient Balance
transaction Succesfull
Insufficient Balance

Source of Exceptions

- Exceptions can be thrown by
  - JVM
    - JVM exceptions
    - Those exceptions and errors exclusively or most logically thrown by JVM
      - NullPointerException, StackOverflowError
  - Programmatically
    - Exceptions that are thrown by application and/or API Programmers
      - NumberFormatException

Sources of Common Exception

- ArrayIndexOutOfBoundsException
  - Thrown when attempting to access an with an invalid index
  - Thrown by JVM
- ClassCastException
  - Thrown when Attempting to cast a reference variable to type that fails Is-A test
  - Thrown by JVM
- IlligalArgumentException
  - Thrown when a method receives an argument formatted differently than the method expects
  - Thrown Programatically

Sources of Common Exception

- IlligalStateException
  - Thrown when the state of the environment does not match the operation being attempted
    - E.g. using a Scanner which is closed
  - Thrown programmatically
- NullPointerException
  - Thrown when attempting to access an object with a reference variable whose current value is null
  - Thrown by JVM
- NumberFormatException
  - Thrown when a method that converts a String to a number receives a number that it cannot convert
  - Thrown programmatically

Sources of Common Exception

- AssertionError
  - Thrown when a statements boolean test fails
  - Thrown programmatically
- ExceptionInitializerError
  - Thrown when attempting to initialize a static variable or initialization block
  - Thrown by JVM
- StackOverflowError
  - Typically thrown when a method recurses deeply
  - Thrown by JVM
- NoClassDefFoundError
  - Thrown when JVM cannot find a class it needs, because of a commandline error, a classpath issue or a missing .class file
  - Thrown by JVM

Summary

- Defined what exceptions are and some sample exceptions we encountered along the way.
- How to handle exceptions by using the try-catch-finally block.