

Java Exception Handling

Handling errors using Java's exception handling mechanism

James Tam

Approaches For Dealing With Error Conditions

- Use branches/decision making and return values
- Use Java's exception handling mechanism

James Tam

Class Inventory: An Earlier Example

```
public class Inventory
{
    public final int MIN = 0;
    public final int MAX = 100;
    public final int CRITICAL = 10;
    public boolean addToInventory (int amount)
    {
        int temp;
        temp = stockLevel + amount;
        if (temp > MAX)
        {
            System.out.print("Adding " + amount + " item will cause stock ");
            System.out.println("to become greater than " + MAX + " units
                (overstock)");
            return false;
        }
    }
}
```

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Class Inventory: An Earlier Example (2)

```
    else
    {
        stockLevel = stockLevel + amount;
        return true;
    }
} // End of method addToInventory
:
```

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Some Hypothetical Method Calls: Condition/Return

```
reference1.method1 ()
```

```
  if (reference2.method2() == false)  
    return false;
```

```
reference2.method2 ()
```

```
  if (store.addToInventory(amt) == false)  
    return false;
```

```
store.addToInventory (int amt)
```

```
  if (temp > MAX)  
    return false;
```

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Some Hypothetical Method Calls: Condition/Return

```
reference1.method1 ()
```

```
  if (reference2.method2() == false)  
    return false;
```

Problem 1: The calling method may forget to check the return value

```
reference2.method2 ()
```

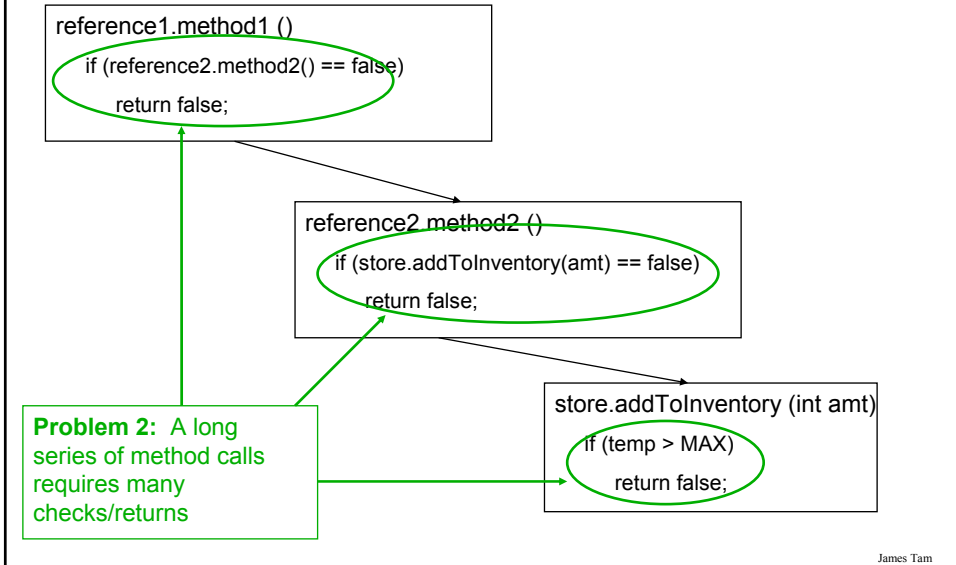
```
  if (store.addToInventory(amt) == false)  
    return false;
```

```
store.addToInventory (int amt)
```

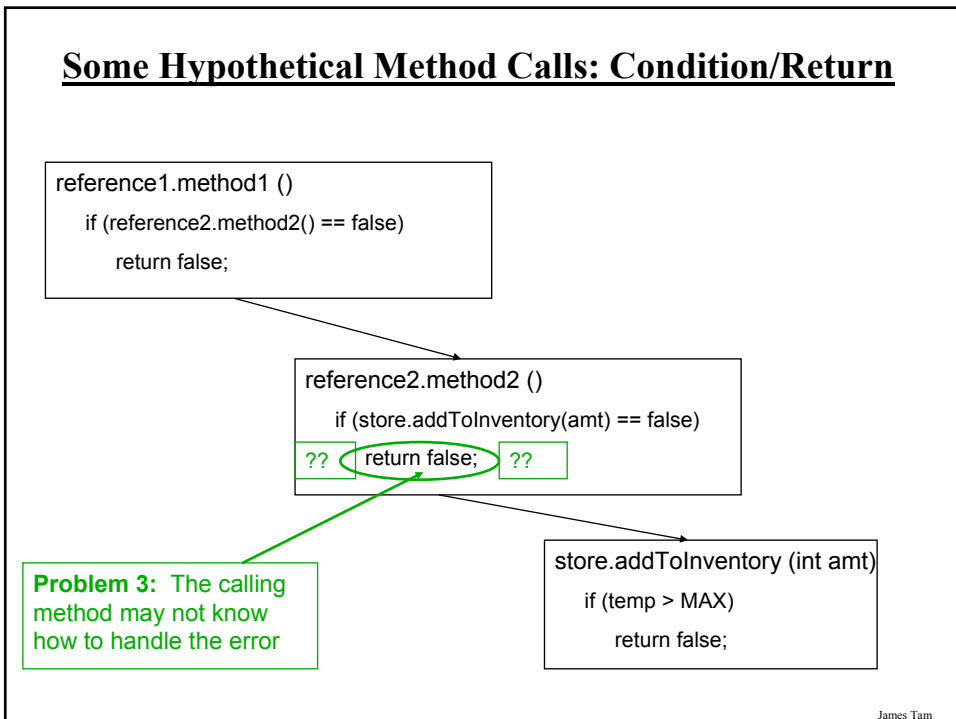
```
  if (temp > MAX)  
    return false;
```

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Some Hypothetical Method Calls: Condition/Return



Some Hypothetical Method Calls: Condition/Return



Approaches For Dealing With Error Conditions

- Use branches/decision making constructs and return values
- Use Java's exception handling mechanism

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Handling Exceptions

Format:

```
try
{
    // Code that may cause an error/exception to occur
}
catch (ExceptionType identifier)
{
    // Code to handle the exception
}
```

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Handling Exceptions: Reading Input

The complete program can be found in the directory:

- /home/courses/219/examples/exceptions/handlingExceptions/inputExample

```
import java.io.*;

public class Driver
{
    public static void main (String [] args)
    {
        BufferedReader stringInput;
        InputStreamReader characterInput;
        String s;
        int num;
        characterInput = new InputStreamReader(System.in);
        stringInput = new BufferedReader(characterInput);
```

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Handling Exceptions: Reading Input (2)

```
try
{
    System.out.print("Type an integer: ");
    s = stringInput.readLine();
    System.out.println("You typed in..." + s);
    num = Integer.parseInt (s);
    System.out.println("Converted to an integer..." + num);
}
catch (IOException e)
{
    System.out.println(e);
}
catch (NumberFormatException e)
{
    :      :      :
}
}
```

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Handling Exceptions: Where The Exceptions Occur

```
try
{
    System.out.print("Type an integer: ");
    s = stringInput.readLine();
    System.out.println("You typed in..." + s);
    num = Integer.parseInt (s);
    System.out.println("Converted to an integer..." + num);
}
```

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Handling Exceptions: Result Of Calling ReadLine ()

```
try
{
    System.out.print("Type an integer: ");
    s = stringInput.readLine();
    System.out.println("You typed in..." + s);
    num = Integer.parseInt (s);
    System.out.println("Converted to an integer..." + num);
}
```

The first exception can occur here

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Where The Exceptions Occur In Class BufferedReader

- For online documentation for this class go to:
- <http://java.sun.com/javase/7/docs/api/>

```
public class BufferedReader
{
    public BufferedReader (Reader in);
    public BufferedReader (Reader in, int sz);
    public String readLine () throws IOException;
    :
}
```

James Tam

Handling Exceptions: Result Of Calling parseInt ()

```
try
{
    System.out.print("Type an integer: ");
    s = stringInput.readLine();
    System.out.println("You typed in..." + s);
    num = Integer.parseInt (s);
    System.out.println("Converted to an integer..." + num);
}
```

The second exception can occur here

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Where The Exceptions Occur In Class Integer

- For online documentation for this class go to:
- <http://java.sun.com/javase/7/docs/api/>

```
public class Integer
{
    public Integer (int value);
    public Integer (String s) throws NumberFormatException;
        :
        :
    public static int parseInt (String s) throws NumberFormatException;
        :
        :
}
```

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Handling Exceptions: The Details

```
try
{
    System.out.print("Type an integer: ");
    s = stringInput.readLine();
    System.out.println("You typed in..." + s);
    num = Integer.parseInt (s);
    System.out.println("Converted to an integer..." + num);
}
catch (IOException e)
{
    System.out.println(e);
}
catch (NumberFormatException e)
{
    :
    :
    :
}
}
```

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Handling Exceptions: Tracing The Example

```
Driver.main ()
try
{
  num = Integer.parseInt (s);
}
:
catch (NumberFormatException e)
{
  :
}
```

```
Integer.parseInt (String s)
{
  :
  :
}
```

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Handling Exceptions: Tracing The Example

```
Driver.main ()
try
{
  num = Integer.parseInt (s);
}
:
catch (NumberFormatException e)
{
  :
}
```

```
Integer.parseInt (String s)
{
  Oops!
  The user didn't enter an integer
}
```

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Handling Exceptions: Tracing The Example

```
Driver.main ()
try
{
  num = Integer.parseInt (s);
}
:
catch (NumberFormatException e)
{
  :
}
```

```
Integer.parseInt (String s)
{
  NumberFormatException e =
  new NumberFormatException ();
}
```

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Handling Exceptions: Tracing The Example

```
Driver.main ()
try
{
  num = Integer.parseInt (s);
}
:
catch (NumberFormatException e)
{
  :
}
```

```
Integer.parseInt (String s)
{
  NumberFormatException e =
  new NumberFormatException ();
}
```

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Handling Exceptions: Tracing The Example

```
Driver.main ()
try
{
    num = Integer.parseInt (s);
}
:
catch (NumberFormatException e)
{
    Exception must be dealt with here
}
```

```
Integer.parseInt (String s)
{
}
}
```

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Handling Exceptions: Catching The Exception

```
catch (NumberFormatException e)
{
    :      :      :
}
}
}
```

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Catching The Exception: Error Messages

```
catch (NumberFormatException e)
{
    System.out.println("You entered a non-integer value.");
    System.out.println(e.getMessage());
    System.out.println(e);
    e.printStackTrace();
}
}
```

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Catching The Exception: Error Messages

```
catch (NumberFormatException e)
{
    System.out.println("You entered a non-integer value.");
    System.out.println(e.getMessage());
    System.out.println(e);
    e.printStackTrace();
}
}
```

For input string: "james tam"

java.lang.NumberFormatException:
For input string: "james tam"

java.lang.NumberFormatException: For input string: "james tam"
at java.lang.NumberFormatException.forInputString(NumberFormatException.java:48)
at java.lang.Integer.parseInt(Integer.java:426)
at java.lang.Integer.parseInt(Integer.java:476)
at Driver.main(Driver.java:39)

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Categories Of Exceptions

- Unchecked exceptions
- Checked exceptions

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Characteristics Of Unchecked Exceptions

- The compiler doesn't require you to catch them if they are thrown.
 - *No try-catch block required by the compiler*
- They can occur at any time in the program (not just for a specific method)
- Typically they are fatal runtime errors that are beyond the programmer's control
- Use branches/decision making statements rather than the exception handling model.
- Examples:
 - `NullPointerException`, `IndexOutOfBoundsException`, `ArithmeticException`...

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Common Unchecked Exceptions: NullPointerException

```
int [] arr = null;
```

```
arr[0] = 1; ← NullPointerException
```

```
arr = new int [4];
```

```
int i;
```

```
for (i = 0; i <= 4; i++)
```

```
    arr[i] = i;
```

```
arr[i-1] = arr[i-1] / 0;
```

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Common Unchecked Exceptions: ArrayIndexOutOfBoundsException

```
int [] arr = null;
```

```
arr[0] = 1;
```

```
arr = new int [4];
```

```
int i;
```

```
for (i = 0; i <= 4; i++)
```

```
    arr[i] = i; ← ArrayIndexOutOfBoundsException
```

(when i = 4)

```
arr[i-1] = arr[i-1] / 0;
```

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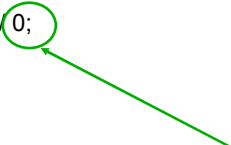
Common Unchecked Exceptions: ArithmeticExceptions

```
int [] arr = null;  
arr[0] = 1;
```

```
arr = new int [4];  
int i;  
for (i = 0; i <= 4; i++)  
    arr[i] = i;
```

```
arr[i-1] = arr[i-1] / 0;
```

ArithmeticException
(Division by zero)



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Checked Exceptions

- Must be handled if the potential for an error exists
 - You must use a try-catch block
- Deal with problems that occur in a specific place
 - When a particular method is invoked you must enclose it within a try-catch block
- Example:
 - NumberFormatException, IOException

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Avoid Squelching Your Exceptions

```
try
{
    s = stringInput.readLine();
    num = Integer.parseInt (s);
}
catch (IOException e)
{
    System.out.println(e);
}
catch (NumberFormatException e)
{
    // Do nothing here but set up the try-catch block to bypass the
    // "annoying" compiler error
}
```

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Avoid Squelching Your Exceptions

```
try
{
    s = stringInput.readLine();
    num = Integer.parseInt (s);
}
catch (IOException e)
{
    System.out.println(e);
}
catch (NumberFormatException e)
{
    // Do nothing here but set up the try-catch block to bypass the
    // "annoying" compiler error
}
```

NO!

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Avoid Squelching Your Exceptions

```
try
{
    s = stringInput.readLine();
    num = Integer.parseInt(s);
}
catch (IOException e)
{
    System.out.println(e);
}
catch (NumberFormatException e)
{
    // Minimal but still somewhat useful response
    System.out.println("A non integer value entered instead of an
integer");
}
```

James Tam

The Finally Clause

- An additional part of Java's exception handling model (try-catch-*finally*).
- Used to enclose statements that must always be executed whether or not an exception occurs.

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The Finally Clause: Exception Thrown

```
try  
{  
    f.method();  
}
```

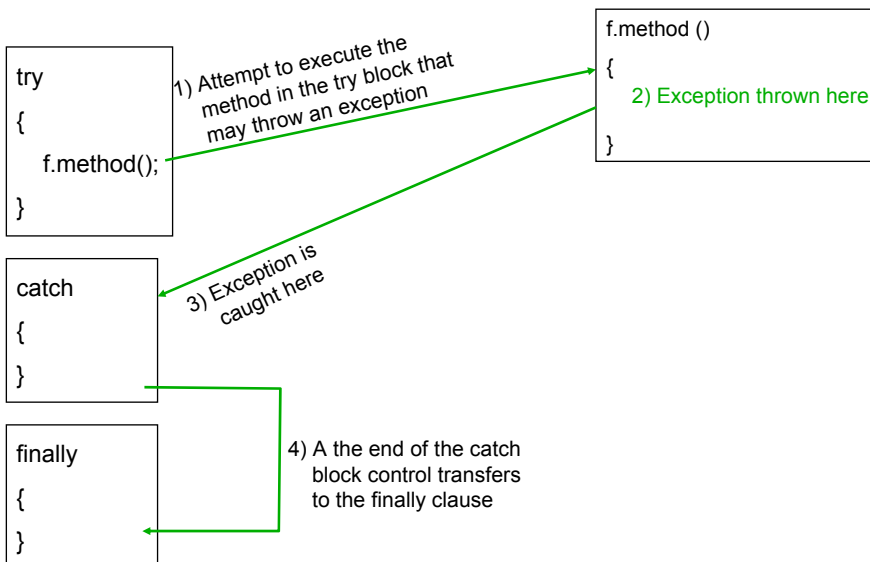
```
catch  
{  
}
```

```
finally  
{  
}
```

```
f.method ()  
{  
  
}
```

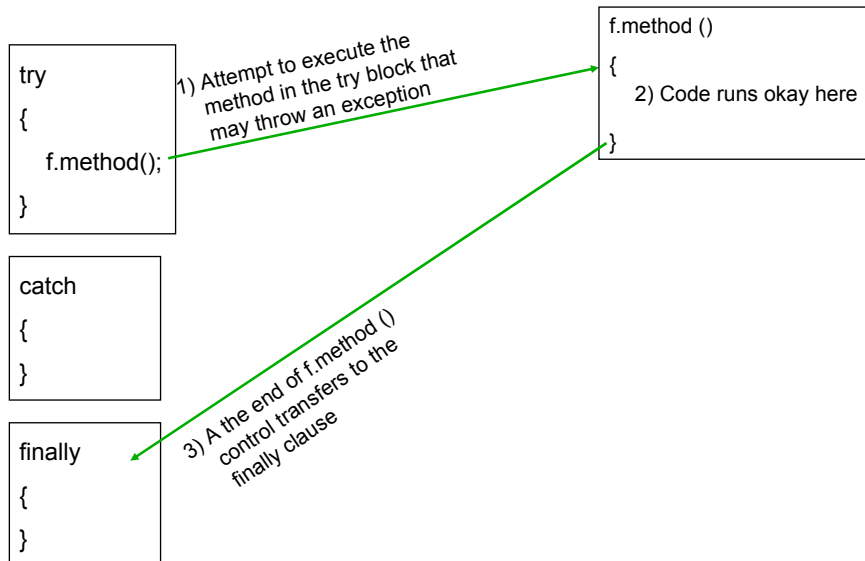
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The Finally Clause: Exception Thrown



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The Finally Clause: No Exception Thrown



Try-Catch-Finally: An Example

- The complete program can be found in the directory:
`/home/courses/219/examples/exceptions/handlingExceptions/
tryCatchFinallyExample`

```
public class Driver
{
    public static void main (String [] args)
    {
        TCFExample eg = new TCFExample ();
        eg.method();
    }
}
```

Try-Catch-Finally: An Example (2)

```
public class TCExample
{
    public void method ()
    {
        BufferedReader br;
        String s;
        int num;
        try
        {
            System.out.print("Type in an integer: ");
            br = new BufferedReader(new InputStreamReader(System.in));
            s = br.readLine();
            num = Integer.parseInt(s);
            return;
        }
    }
}
```

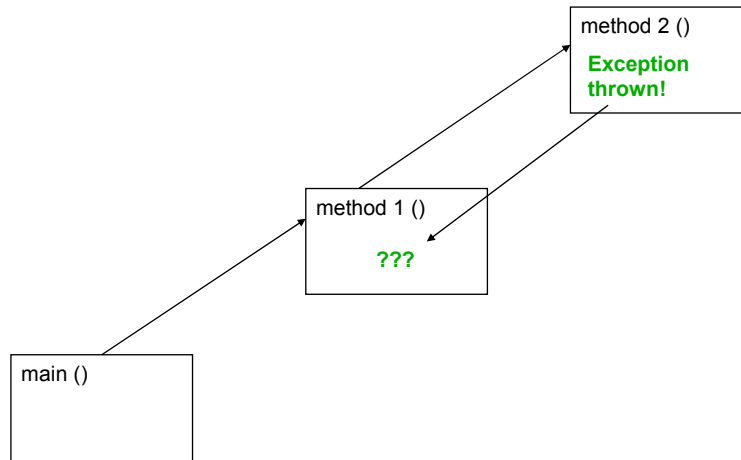
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Try-Catch-Finally: An Example (3)

```
        catch (IOException e)
        {
            e.printStackTrace();
            return;
        }
        catch (NumberFormatException e)
        {
            e.printStackTrace ();
            return;
        }
        finally
        {
            System.out.println("<<<This code will always execute>>>");
            return;
        }
    }
}
```

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When The Caller Can't Handle The Exceptions



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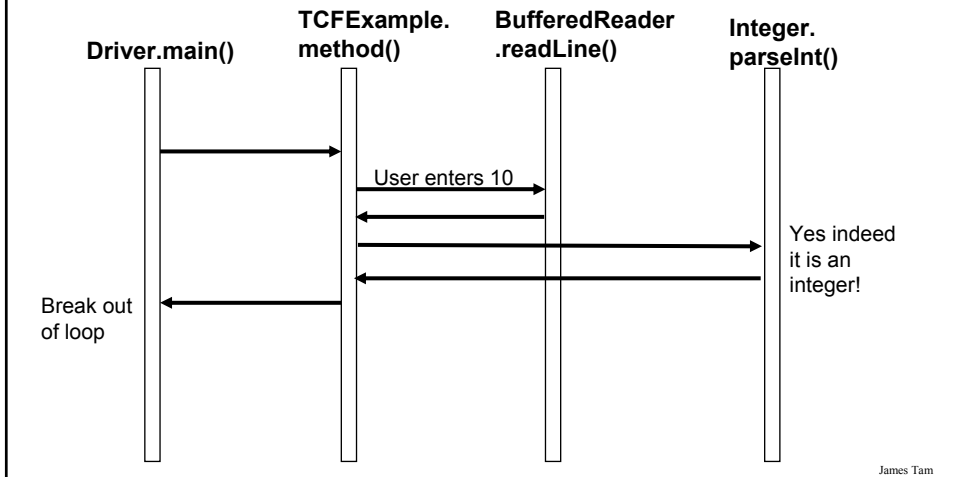
When The Caller Can't Handle The Exceptions: An Example

- The complete program can be found in the directory:
`/home/233/examples/exceptions/handlingExceptions/
delegatingExceptions`

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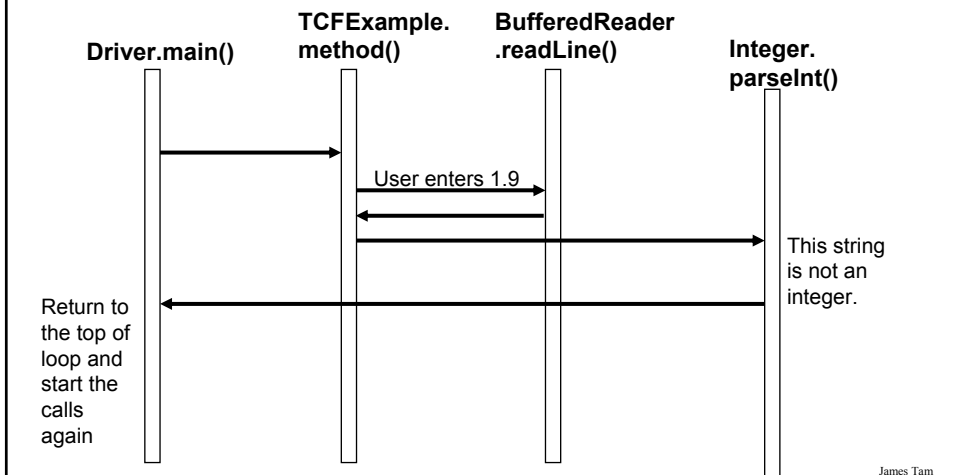
When The Caller Can't Handle The Exceptions: An Example (2)

- Tracing the method calls when *no exception occurs*:



When The Caller Can't Handle The Exceptions: An Example (3)

- Tracing the method calls when an *exception does occur*:



When The Caller Can't Handle The Exceptions: An Example (4)

```
public class Driver
{
    public static void main (String [] args)
    {
        TCEXample eg = new TCEXample ();
        boolean inputOkay = true;
```

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When The Caller Can't Handle The Exceptions: An Example (5)

```
do
{
    try
    {
        eg.method();
        inputOkay = true;
    }
    catch (IOException e)
    {
        e.printStackTrace();
    }
    catch (NumberFormatException e)
    {
        inputOkay = false;
        System.out.println("Please enter a whole number.");
    }
} while (inputOkay == false);
} // End of main
} // End of Driver class
```

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When The Caller Can't Handle The Exceptions: An Example (6)

```
import java.io.*;

public class TCExample
{

    public void method () throws IOException, NumberFormatException
    {
        BufferedReader br;
        String s;
        int num;

        System.out.print("Type in an integer: ");
        br = new BufferedReader(new InputStreamReader(System.in));
        s = br.readLine();
        num = Integer.parseInt(s);
    }
}
```

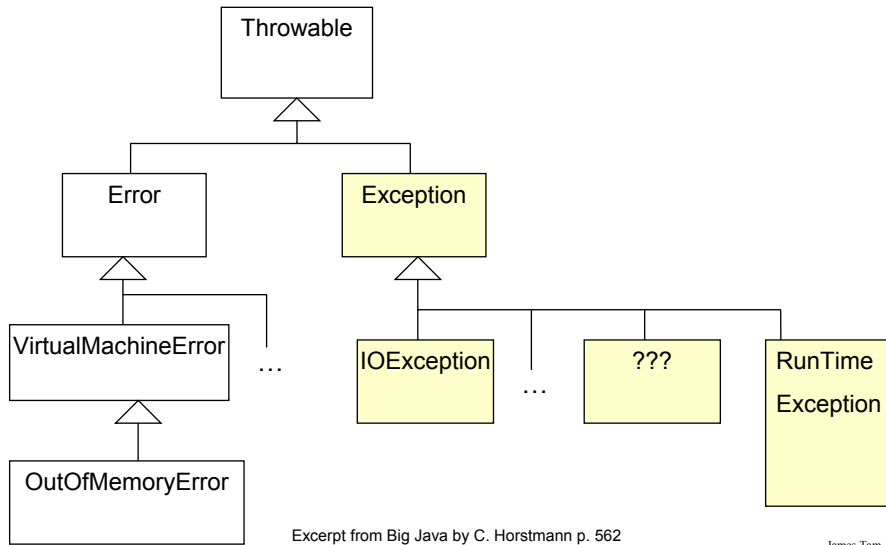
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When The Main () Method Can't Handle The Exception

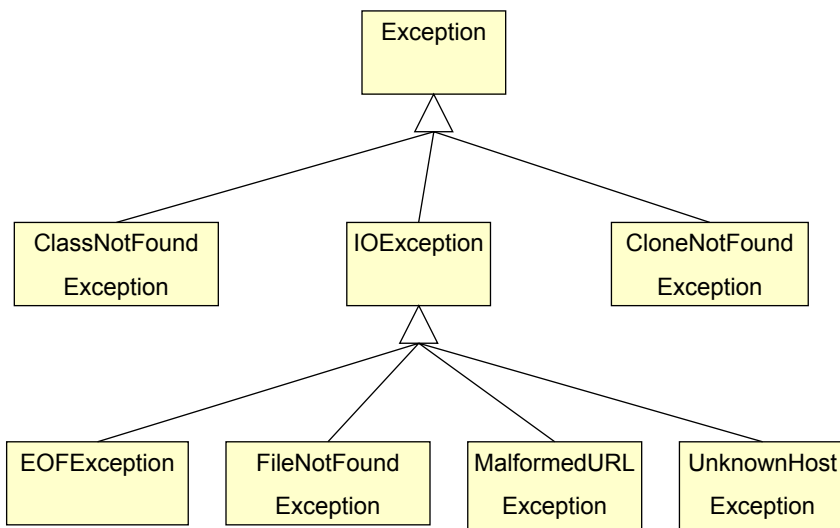
```
class Driver
{
    public static void main (String [] args) throws IOException,
        NumberFormatException
    {
        TCExample eg = new TCExample ();
        eg.method();
    }
}
```

James Tam

Creating Your Own Exceptions



Class Exception: The Local Inheritance Hierarchy



Writing New Exceptions: An Example

- The full example can be found in the directory:
/home/courses/219/examples/exceptions/writingExceptions/inventoryExample

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Writing New Exceptions: The Driver Class

```
class Driver
{
    public static void main (String [] argv)
    {
        Inventory chinookInventory = new Inventory ();
        CommandProcessor userInterface = new CommandProcessor
            (chinookInventory);
        userInterface.startProcessingInput ();
    }
}
```

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Writing New Exceptions: Class CommandProcessor

```
class CommandProcessor
{
    private String menuOption;
    private Inventory storeInventory;

    public CommandProcessor (Inventory storeToTrack)
    {
        menuOption = "q";
        storeInventory = storeToTrack;
    }
}
```

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Writing New Exceptions: Class CommandProcessor (2)

```
public void startProcessingInput ()
{
    do {
        displayMenu();
        readMenuOption();
        if ((menuOption.equals("a") || (menuOption.equals("A"))))
            storeInventory.getAmountToAdd();
        else if ((menuOption.equals("r") || (menuOption.equals("R"))))
            storeInventory.getAmountToRemove();
        else if ((menuOption.equals("d") || (menuOption.equals("D"))))
            storeInventory.displayInventoryLevel();
        else if ((menuOption.equals("c") || (menuOption.equals("C"))))
        {
            if (storeInventory.inventoryTooLow())
                System.out.println("Stock levels critical!");
            else
                System.out.println("Stock levels okay");
            storeInventory.displayInventoryLevel();
        }
    }
}
```

James Tam

Writing New Exceptions: Class CommandProcessor (3)

```
else if ((menuOption.equals("q")) || (menuOption.equals("Q")))
    System.out.println("Quitting program");
else
    System.out.println("Enter one of a, r, d, c or q");
} while (!menuOption.equals("Q") && !menuOption.equals("q"));
}

protected void displayMenu ()
{
    System.out.println("\n\nINVENTORY PROGRAM: OPTIONS");
    System.out.println("\t(a)dd new stock to inventory");
    System.out.println("\t(r)emove stock from inventory");
    System.out.println("\t(d)isplay stock level");
    System.out.println("\t(c)heck if stock level is critical");
    System.out.print("\t(q)uit program");
    System.out.println();
    System.out.print("Selection: ");
}
}
```

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Writing New Exceptions: Class CommandProcessor (4)

```
protected void readMenuOption ()
{
    Scanner in = new Scanner (System.in);
    menuOption = in.nextLine ();
    System.out.println();
}
}
```

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Writing New Exceptions: Class Inventory

```
class Inventory
{
    public final static int CRITICAL = 10;
    public final static int MIN = 0;
    public final static int MAX = 100;

    private int stockLevel;
    private boolean amountInvalid;

    public void getAmountToAdd ()
    {
        int amount;
        Scanner in = new Scanner (System.in);
```

James Tam

Writing New Exceptions: Class Inventory (2)

```
do
{
    System.out.print("No. items to add: ");
    amount = in.nextInt();
    try
    {
        addToInventory(amount);
        amountInvalid = false;
    }
    catch (InventoryOverMaxException e)
    {
        System.out.println(e);
        System.out.println("Enter another value.");
        System.out.println();
        amountInvalid = true;
    }
}
```

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Writing New Exceptions: Class Inventory (3)

```
finally
{
    displayInventoryLevel();
}
} while (amountInvalid == true);
}

public void getAmountToRemove ()
{
    int amount;
    Scanner in = new Scanner (System.in);
    do
    {
        System.out.print("No. items to remove: ");
        amount = in.nextInt ();
    }
```

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Writing New Exceptions: Class Inventory (4)

```
try
{
    removeFromInventory(amount);
    amountInvalid = false;
}
catch (InventoryBelowMinException e)
{
    System.out.println(e);
    System.out.println("Enter another value.");
    System.out.println();
    amountInvalid = true;
}
finally
{
    displayInventoryLevel();
}
} while (amountInvalid == true);
}
```

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Writing New Exceptions: Class Inventory (5)

```
private void addToInventory (int amount) throws
    InventoryOverMaxException
{
    int temp;
    temp = stockLevel + amount;
    if (temp > MAX)
    {
        throw new InventoryOverMaxException ("Adding " + amount + " item
            will cause stock to become greater than " + MAX + " units");
    }
    else
        stockLevel = stockLevel + amount;
}
```

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Writing New Exceptions: Class Inventory (6)

```
private void removeFromInventory (int amount) throws
    InventoryBelowMinException
{
    int temp;
    temp = stockLevel - amount;
    if (temp < MIN)
    {
        throw new InventoryBelowMinException ("Removing " + amount + "
            item will cause stock to become less than " + MIN + " units");
    }
    else
        stockLevel = temp;
}
```

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Writing New Exceptions: Class Inventory (7)

```
public boolean inventoryTooLow ()
{
    if (stockLevel < CRITICAL)
        return true;
    else
        return false;
}

public void displayInventoryLevel ()
{
    System.out.println("No. items in stock: " + stockLevel);
}
}
```

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Writing New Exceptions: Class InventoryOverMaxException

```
public class InventoryOverMaxException extends Exception
{
    public InventoryOverMaxException ()
    {
        super ();
    }

    public InventoryOverMaxException (String s)
    {
        super (s);
    }
}
```

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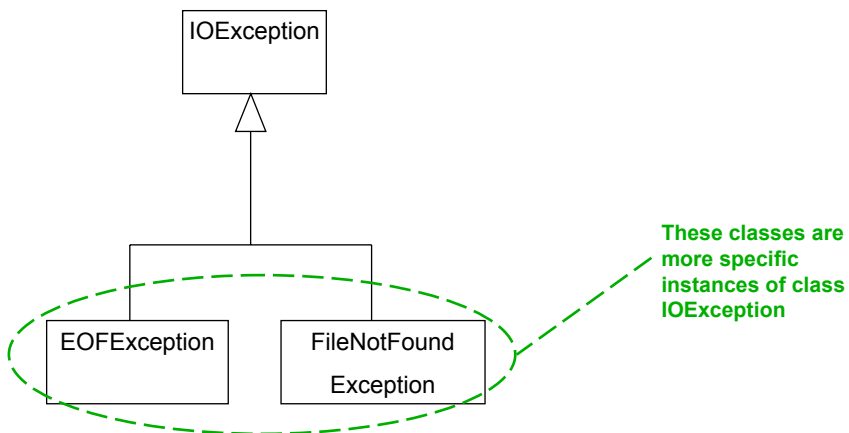
Writing New Exceptions: Class InventoryUnderMinException

```
public class InventoryUnderMinException extends Exception
{
    public InventoryUnderMinException ()
    {
        super();
    }

    public InventoryUnderMinException (String s)
    {
        super(s);
    }
}
```

James Tam

Inheritance Hierarchy For IOException



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Inheritance And Catching Exceptions

- If you are catching a sequence of exceptions then make sure that you catch the exceptions for the child classes before you catch the exceptions for the parent classes
- Deal with the more specific case before handling the more general case

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Inheritance And Catching Exceptions (2)

Correct

```
try
{

}
catch (EOFException e)
{

}
catch (IOException e)
{

}
```

Incorrect

```
try
{

}
catch (IOException e)
{

}
catch (EOFException e)
{

}
```

James Tam

You Should Now Know

- The benefits of handling errors with an exception handler rather than employing a series of return values and conditional statements/branches.
- How to handle exceptions
 - Being able to call a method that may throw an exception by using a try-catch block
 - What to do if the caller cannot properly handle the exception
 - What is the finally clause, how does it work and when should it be used
- What is the difference between a checked and an unchecked exception
- How to write your classes of exceptions
- The effect of the inheritance hierarchy when catching exceptions