

# Java By Abstraction: Chapter 11

## Exception Handling

Some examples and/or figures were borrowed (with permission)  
from slides prepared by Prof. H. Roumani

# What are Exceptions?

There are three sources that can lead to exceptions:

## The End User

Garbage-in, garbage-out

## The Programmer

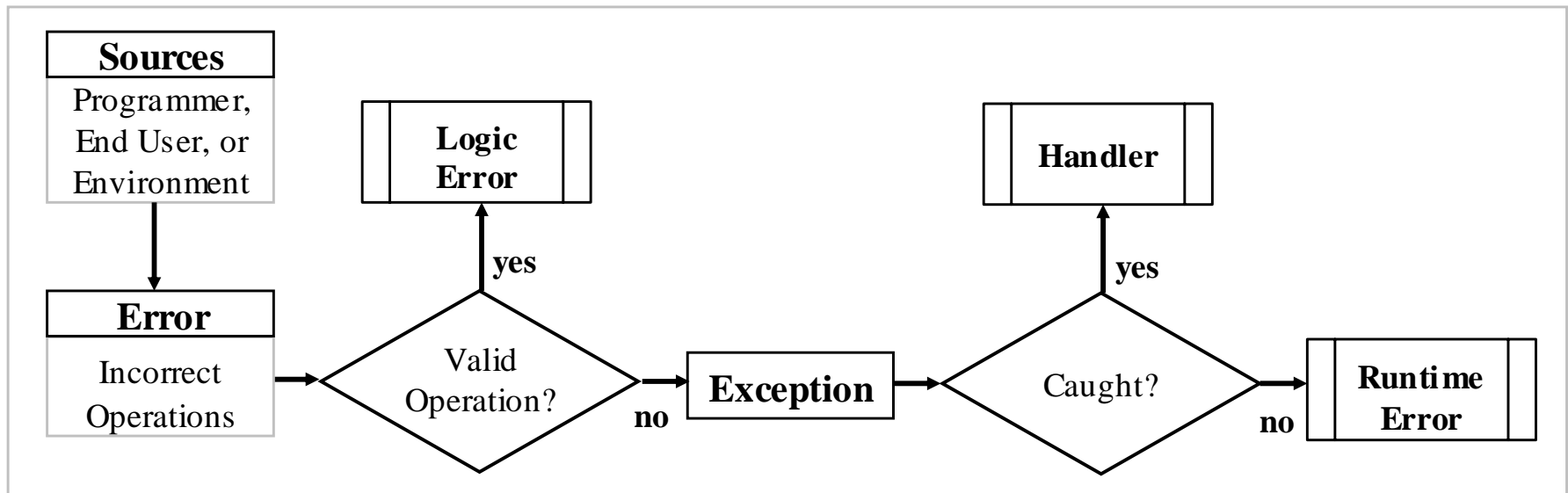
Misunderstanding requirements and/or contracts

## The Environment

The VM, the O/S, the H/W, or the network

# Exception Handling in General

- An error source can lead to an incorrect operation
- An incorrect operations may be valid or invalid
- An invalid operation throws an exception
- An exception becomes a runtime error unless caught



# Example One

Given two integers, write a program to compute and output their quotient.

```
output.println("Enter the first integer:");
int a = input.nextInt();
output.println("Enter the second:");
int b = input.nextInt();

int c = a / b;
output.println("Their quotient is: " + c);
```

# Example One

```
Enter the first integer:
```

```
8
```

```
Enter the second:
```

```
0
```

```
Exception in thread "main"
```

```
java.lang.ArithmeticException: / by zero
```

```
    at Quotient.main(Quotient.java:16)
```

**In this case:**

- The error source is the end user.
- The incorrect operation is invalid
- The exception was not caught

# Anatomy of an Error Message

```
Enter the first integer:
```

```
8
```

```
Enter the second:
```

```
0
```

```
Exception in thread "main"
```

```
java.lang.ArithmeticException: / by zero
```

```
at Quotient.main(Quotient.java:16)
```

**Type**

**Stack trace**

**Message**

# The Delegation Model

- We, the client, delegate to method A
- Method A delegates to method B
- An invalid operation is encountered in B
- If B handled it, no one would know
- Not even the API of B would document this
- If B didn't, it delegates the exception back to A
- If A handled it, we wouldn't know
- Otherwise, the exception is delegated to us
- We too can either handle or delegate (to VM)
- If we don't handle, the VM causes a runtime error

# The Delegation Model Policy

## Handle or Delegate Back

### Note:

- Applies to all (components and client)
- The API must document any back delegation
- It does so under the heading: "Throws"



# Example Two, Part 1

**Given a string containing two slash-delimited substrings, write a program that extracts and outputs the two substrings.**


```
int slash = str.indexOf("/");  
String left = str.substring(0, slash);  
String right = str.substring(slash + 1);  
output.println("Left substring: " + left);  
output.println("Right substring: " + right);
```

# Example Two, Part 1

Here is a sample run with `str = "14-9"`

```
int slash = str.indexOf("/");  
String left = str.substring(0, slash);  
String right = str.substring(slash + 1);  
output.println("Left substring: " + left);  
output.println("Right substring: " + right);
```

```
java.lang.IndexOutOfBoundsException:  
String index out of range: -1  
at java.lang.String.substring(String.java:1480)  
at Substring.main(Substring.java:14)
```



The trace follows the delegation from line 1480 within `substring` to line 14 within the client.

# Example Two, Part 1

Here is the *API* of substring:

```
String substring(int beginIndex, int endIndex)  
Returns a new string that...
```

**Parameters:**

**beginIndex** - the beginning index, inclusive.

**endIndex** - the ending index, exclusive.

**Returns:**

the specified substring.

**Throws:**

**IndexOutOfBoundsException** - if the **beginIndex** is negative, or **endIndex** is larger than the length of this **String** object, or **beginIndex** is larger than **endIndex**.

# Try-Catch Block

```
try
{
    ...
    code fragment
    ...
}
catch (SomeType e)
{
    ...
    exception handler
    ...
}
program continues
```

# Try-Catch Block Example

Redo the last example with exception handling

```
try
{
    int slash = str.indexOf("/");
    String left = str.substring(0, slash);
    String right = str.substring(slash + 1);
    output.println("Left substring: " + left);
    output.println("Right substring: " + right);
}
catch (IndexOutOfBoundsException e)
{
    output.println("No slash in input!");
}
output.println("Clean Exit."); // closing
```

# Try-Catch with Multiple Exceptions

```
try
{
    ...
}
catch (Type-1 e)
{
    ...
}
catch (Type-2 e)
{
    ...
}
...
catch (Type-n e)
{
    ...
}
program continues
```

## Example Two, Part 2

**Given a string containing two slash-delimited integers, write a program that outputs their quotient. Use exception handling to handle all possible input errors.**

**Note that when exception handling is used, do not code defensively; i.e. assume the world is perfect and then worry about problems. This separates the program logic from validation.**

## Example Two, Part 2

```
try
{
    int slash = str.indexOf("/");
    String left = str.substring(0, slash);
    String right = str.substring(slash + 1);
    int leftInt = Integer.parseInt(left);
    int rightInt = Integer.parseInt(right);
    int answer = leftInt / rightInt;
    output.println("Quotient = " + answer);
}
catch (?)
{

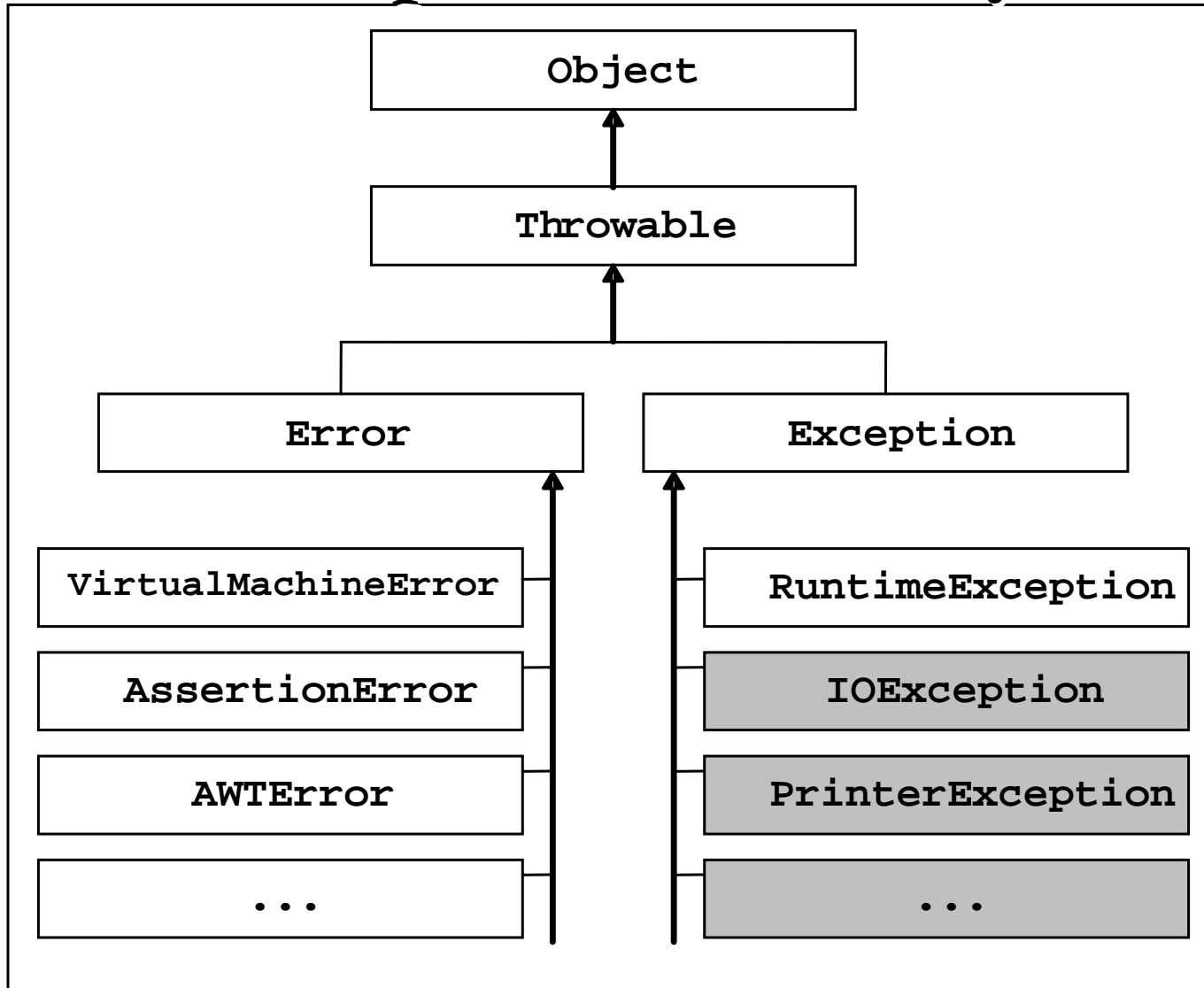
}
```



## Example Two, Part 2

```
catch (IndexOutOfBoundsException e)
{
    output.println("No slash in input!");
}
catch (NumberFormatException e)
{
    output.println("Non-integer operands!");
}
catch (ArithmeticException e)
{
    output.println("Cannot divide by zero!");
}
output.println("Clean Exit."); // closing
```

# Exception Hierarchy



# Exception Handling

- They all inherit the features in Throwable
- Can create them like any other object:  
`Exception e = new Exception();`
- And can invoke methods on them, e.g.  
`getMessage`, `printStackTrace`, etc.
- They all have a `toString`
- Creating one does not simulate an exception. For that, use the `throw` keyword:

```
Exception e = new Exception("test");  
throw e;
```

## Example Two, Part 3

Write an app that reads a string containing two slash-delimited integers, the first of which is positive, and outputs their quotient using exception handling. Allow the user to retry indefinitely if an input is found invalid.

As before but:

- What if the first integer is not positive?
- How do you allow retrying?

## Example Two, Part 3

```
for (boolean stay = true; stay;)
{
    try
    {
        // as before
        if (leftInt < 0) throw(??);
        ...
        output.println("Quotient = " + answer);
        stay = false;
    }
    // several catch blocks
}
```

# Checked Exceptions

- App programmers can avoid any `RuntimeException` through defensive validation
- Hence, we cannot force them to handle such exceptions
- Other exceptions, however, are "un-validatable", e.g. diskette not inserted; network not available...
- These are "checked" exceptions
- App programmers *must* acknowledge their existence
- How do we enforce that?
- The compiler ensures that the app either handles checked exceptions or use "throws" in its `main`.