Lecture Set #7: Exceptions & Mutability Issues

1. Break and Continue for Loops
2. Exceptions
3. Mutability/Immutability
4. StringBuffer class

“this” – when in an instance method: always represents the current object

optional to indicate an instance method or an instance data member is of the current object
when you have a local variable or a parameter named the same as a instance data member of the same class, use “this” to override the default
when you need to pass the whole current object as the argument to another method
when you are writing a constructor and want to call a different constructor to construct the current object

`break` from loops

`break` can also be used to exit immediately from any loop

- `while`
- `do-while`
- `for`

e.g. "Read numbers from input until negative number encountered"

```
Scanner sc = new Scanner (System.in);
int n;
while (true) {
    n = sc.nextInt ();
    if (n < 0) {
    break;
    } else {
    <process n>;
   }
}
```

- Loop only terminates when `break` executed
- This only happens when `n < 0`
- "breaks past" if statements
- Always breaks to first enclosing loop

Warning about `break`

Undisciplined use of `break` can make loops impossible to understand

- Termination of loops without `break` can be understood purely by looking `while`, `for` parts
- When break included, arbitrary termination behavior can be introduced

Rule of thumb: use `break` only when loop condition is always true (i.e. `break` is only way to terminate loop)
When you use it, make sure it has a good comment explaining what is happening

`continue` Statement

`continue` can also be used to affect loops

- `break` halts loops
- `continue` jumps to bottom of loop body

Following prints even numbers between 0 and 10

```
for (int i = 0; i <= 10; i++){
    if (i % 2 == 1) {
      continue;
   }
    System.out.println (i);
}
```

- Effect of `continue` statement is to jump to bottom of loop immediately when `i` is odd
- This bypasses `println`!

`continue` should be avoided

- Confusing
- Easy equivalents exist (e.g. `if-else`)
- Included in Java mainly for historical reasons

When you use it, make sure it has a good comment explaining what is happening

Exceptions

Programs can generate errors

- Arithmetic
  - Divide by zero, overflows, …
- Object / Array
  - Using a null reference, illegal array index, …
- File and I/O
  - Nonexistent file, attempt to read past the end of the file, (we'll see more about file I/O later in course), …
- Application-specific
  - Errors particular to application (e.g., attempt to remove a nonexistent customer from a database)

In Java: something that is outside the norm = exception

What to do when an error occurs?

1. Basically ignore it: Print an error message and terminate?
2. Have the method handle it internally: Handle error in the code where the problem lies as best you can.
3. Have the method pass it off to someone else to handle: Return "error code" so that whoever called this function can handle it.
4. Modern language approach: Cause "exception" to be thrown (and caught (or processed) by any function up the stack trace)

Exception Behavior

If program generates ("throws") exception then default behavior is:

- Java clobbers ("aborts") the program
- Stack trace is printed showing where exception was generated (red and blue in Eclipse window)

Example

```
public int mpg(int miles, int gallons) {
   return miles/gallons;
}
```

Throws an exception and terminates the program.

Throwing Exceptions Yourself

To throw an exception, use throw command:

```
throw e;
```

e must evaluate to an exception object

You can create exceptions just like other objects, e.g.:

```
RuntimeException e = new RuntimeException("Uh oh");
```

`RuntimeException` is a class

Calling new this way invokes constructor for this class

`RuntimeException` generalizes other kinds of exceptions (e.g. `ArithmeticException`)

Exceptions, Classes and Types

Exceptions are objects
Some examples from the Java class library (mostly java.lang):

- `ArithmeticException`: Used e.g. for divide by zero
- `NullPointerException`: attempt to access an object with a null reference
- `IndexOutOfBoundsException`: array or string index out of range
- `ArrayStoreException`: attempting to store wrong type of object in array
- `EmptyStackException`: attempt to pop an empty Stack (java.util)
- `IOException`: attempt to perform an illegal input/output operation (java.io)
- `NumberFormatException`: attempt to convert an invalid string into a number (e.g., when calling Integer.parseInt( ))
- `RuntimeException`: general run-time error (subsumes above)
- `Exception`: The most generic type of exception

Throw Example

```
public int mpg(int miles, int gallons) {
  if (gallons == 0) {
    throw new NullPointerException();
  } else {
    return miles/gallons;
  }
}
```

Java Exceptions in Detail

Exceptions are (special) objects in Java

They are created from classes

The classes are derived ("inherit") from a special class, Throwable

We will learn more about inheritance, etc., later

Every exception object / class has:

`Exception(String message)`

- Constructor taking an explanation as an argument

`String getMessage()`

- Method returning the embedded message of the exception

`void printStackTrace()`

- Method printing the call stack when the exception was thrown

Handling Exceptions

Aborting program not always a good idea

E-mail: can't lose messages

E-commerce: must ensure correct handling of private info in case of crash

Antilock braking, air-traffic control: must recover and keep working

Java provides the programmer with mechanisms for recovering from exceptions

Java Exception Terminology

When an anomaly is detected during program execution, the JVM throws a particular type of exception

- There are built-in exceptions
- Users can also define their own (more later)

To avoid crashing, a program can catch a thrown exception (if it isn't caught – you see the red and blue messages – stack trace)
An exception generated by a piece of code can only be caught if the program is alerted. This process is called trying the piece of code.

Catch Example

```
try {
  System.out.println(“Start”);
  mpg(5, 0);
  System.out.println(“Finish”);
} catch (Exception e) {
  System.out.println("e = " + e);
}
```

Exception Propagation

Goes out to caller if not handled:

Exception thrown in one method …

… but caught in another

Java uses exception propagation to look for exception handlers

When an exception occurs, Java pops back up the call stack to each of the calling methods to see whether the exception is being handled (by a try-catch block). This is exception propagation

The first method it finds that catches the exception will have its catch block executed. Execution resumes normally in the method after this catch block

If we get all the way back to main and no method catches this exception, Java catches it and aborts your program

Finally Block

Always run:

- When no exception has been thrown
- When an exception has been thrown but the exception was handled before that point in time
- When an exception has been thrown but the exception was NOT handled before that point in time

finally = ALWAYS

Exception Handling: Example

`DateReader.java`

Prompts user for a date in mm/dd/yyyy format

Prints year

Program uses:

`substring` method

- May throw `IndexOutOfBoundsException`

`Integer.parseInt` method

- May throw `NumberFormatException`

`getYear` method (if d is null)

- May throw NullPointerException

How do we know about these exceptions? Javadoc!

`http://java.sun.com/j2se/1.5.0/docs/api/java/lang/package-summary.html`

What about Strings and Aliasing?

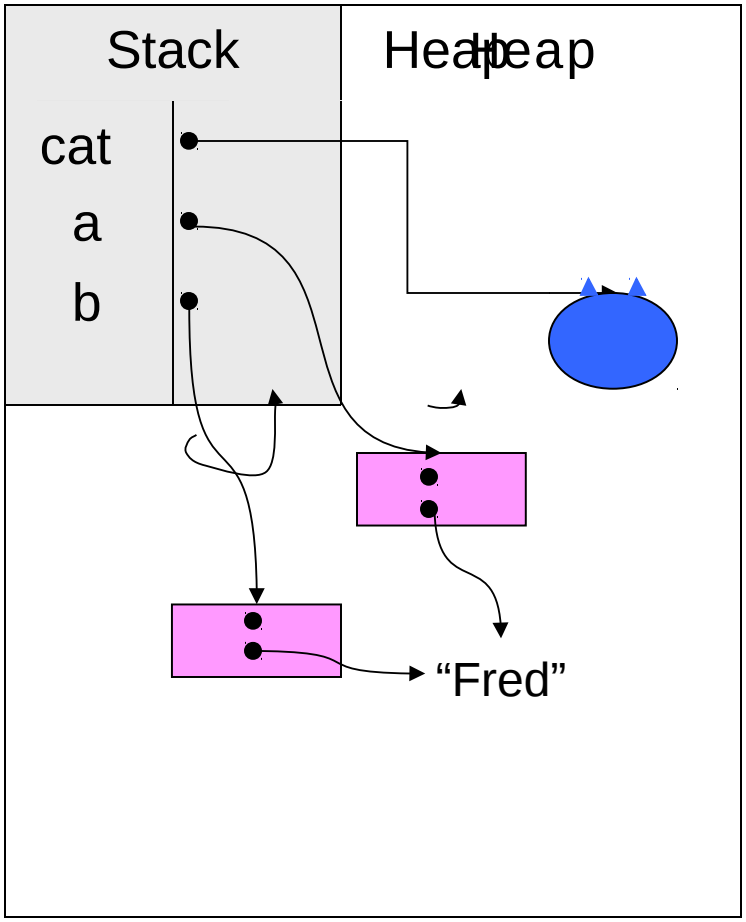
`String` objects are *immutable*; fields cannot be changed once created

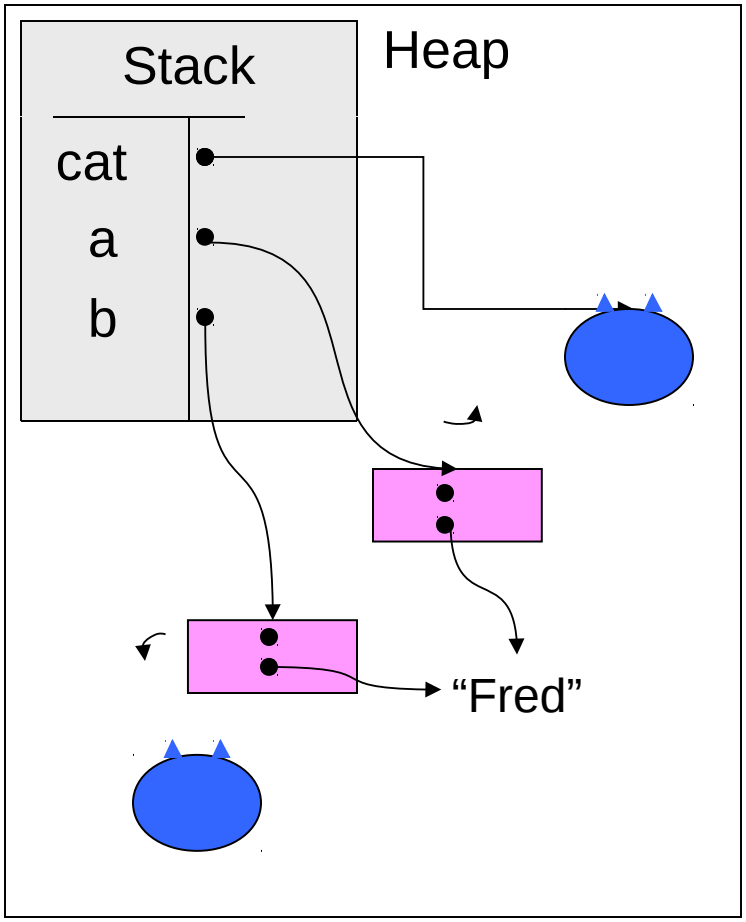
- Mutable objects: fields (values of instance variables) can be changed by a call to some function (e.g. Cat, Student, etc.)
- Immutable objects: fields (values of instance variables) cannot be changed by any call to any function
- See `String` API: http://java.sun.com/j2se/1.3/docs/api/java/lang/package-summary.h

In the Cat and CatOwner example:

- when one object is assigned to another, an alias is created
- Cat a = new Cat("Fluffy");
- Cat b = a;

Which picture represents the current status of memory?





Mutable Strings

`Strings` are immutable

- Once a String object is created, it cannot be altered

Sometimes mutable strings would be handy

- Sometimes a small change needs to be made to a string (e.g. misspelled name)
- Don't want to create a whole new `String` object in this case

`StringBuffer`: Java's class for mutable `Strings`

StringBuffer Basics

See documentation at:
http://java.sun.com/j2se/1.5.0/docs/api/java/lang/StringBuffer.html

Main methods

- `append`: add characters to end
- `insert`: add characters in middle
- `delete`: remove characters

Note

- `append`, `insert` return object of type `StringBuffer`
- This is alias to object that the methods belong to!

See `StringBufferExample.java`