STRING & ARRAY

20TH WEEK LECTURE

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Outline

- **String**
  - Overloading
  - Operations
  - Formatter Class
  - Scanner
- Array

Immutable Strings

- Objects of the **String** class are immutable.
- **String** class
  - every method in the class that appears to modify a **String** actually creates and returns a brand new **String** object containing the modification.
- The original **String** is left untouched.

```
import static net.mindview.util.Print.*;
public class Immutable {
    public static String upcase(String s) {
        return s.toUpperCase();
    }
    public static void main(String[] args) {
        String q = "howdy";
        print(q); // howdy
        String qq = upcase(q);
        print(qq); // HOWDY
        print(q); // howdy
    }
}
```

```
>>
howdy
HOWDY
howdy
```

Overloading ‘+’ vs. StringBuilder

- operator ‘**+**’ has been overloaded for **String** objects.
- Overloading
  - an operation has been given an extra meaning when used with a particular class.
  - (The ‘**+**’ and ‘**+=**‘ for **String** are the only operators that are overloaded in Java, and Java does not allow the programmer to overload any others.)
  - The’**+**’ operator allows you to concatenate **Strings**

```
public class Concatenation {
    public static void main(String[] args) {
    String mango = "mango";
    String s = "abc" + mango + "def" + 47;
    System.out.println(s);
    }
}
```

```
>>
abcmangodef47
```

Overloading '+' vs. StringBuilder Cont'd

```
public class UsingStringBuilder {
    public static Random rand = new Random(47);
    public String toString() {
        StringBuilder result = new StringBuilder("[");
        for(int i = 0; i < 25; i++) {
            result.append(rand.nextInt(100));
            result.append(", ");
        }
        result.delete(result.length()-2, result.length());
        result.append("]");
        return result.toString();
    }
    public static void main(String[] args) {
        UsingStringBuilder usb = new UsingStringBuilder();
        System.out.println(usb);
    }
}
```

```
>>
[58, 55, 93, 61, 61, 29,
68, 0, 22, 7, 88, 28, 51,
89, 9, 78, 98, 61, 20,
58, 16, 40, 11, 22, 4]
```

Overloading ‘+’ vs. StringBuilder

- **append(a + ": " + c)**
  - the compiler will jump in and start making more **StringBuilder** objects again.
- **StringBuilder** has a full complement of methods
  - **insert( )**, **replace( )**, **substring( )** and even **reverse( )**
- But the ones you will generally use are **append( )** and **toString( )**.
- Note the use of **delete( )** to remove the last comma and space before adding the closing square bracket.
- **StringBuilder**
  - introduced in Java SE5
  - Prior : **StringBuffer**, which ensured thread safety

Operations on Strings

Method	Arguments, Overloading	Use
Constructor	Overloaded: default, String, StringBuilder, StringBuffer, char arrays, byte arrays.	Creating String objects.
length( )		Number of characters in the String.
charAt( )	int Index	The char at a location in the String.
getChars( ), getBytes( )	The beginning and end from which to copy, the array to copy into, an index into the destination array.	Copy chars or bytes into an external array.
toCharArray( )		Produces a char[] containing the characters in the String.
equals( ), equals-IgnoreCase( )	A String to compare with.	An equality check on the contents of the two Strings.
compareTo( )	A String to compare with.	Result is negative, zero, or positive depending on the lexicographical ordering of the String and the argument. Uppercase and lowercase are not equal!
contains( )	A CharSequence to search for.	Result is true if the argument is contained in the String.

Operations on Strings Cont'd

Method	Arguments, Overloading	Use
contentEquals( )	A **CharSequence** or **StringBuffer** to compare to.	Result is **true** if there's an exact match with the argument.
equalsIgnoreCase( )	A **String** to compare with.	Result is **true** if the contents are equal, ignoring case.
regionMatches( )	Offset into this **String**, the other **String** and its offset and length to compare. Overload adds "ignore case."	**boolean** result indicates whether the region matches.
startsWith( )	**String** that it might start with. Overload adds offset into argument.	**boolean** result indicates whether the **String** starts with the argument.
endsWith( )	**String** that might be a suffix of this **String**.	**boolean** result indicates whether the argument is a suffix.
indexOf( ), lastIndexOf( )	Overloaded: **char**, **char** and starting index, **String**,	Returns -1 if the argument is not found within this **String**; otherwise, returns

Method	Arguments, Overloading	Use
	String and starting index.	the index where the argument starts. **lastIndexOf( )** searches backward from end.
substring( ) (also **subSequence( )**)	Overloaded: starting index; starting index + ending index.	Returns a new **String** object containing the specified character set.
concat( )	The **String** to concatenate.	Returns a new **String** object containing the original String's characters followed by the characters in the argument.
replace()	The old character to search for, the new character to replace it with. Can also replace a **CharSequence** with a **CharSequence**.	Returns a new **String** object with the replacements made. Uses the old **String** if no match is found.
toLowerCase( ) **toUpperCase( )**		Returns a new **String** object with the case of all letters changed. Uses the old **String** if no changes need to be made.
trim( )		Returns a new **String** object with the whitespace removed from each end. Uses the old **String** if no changes need to be made.
valueOf( )	Overloaded: **Object**, **char[]**, **char[]** and offset and count, **boolean**, **char**, **int**, **long**, **float**, **double**.	Returns a **String** containing a character representation of the argument.
intern( )		Produces one and only one **String** reference per unique character sequence.

System.out.format()

```
public class SimpleFormat {
    public static void main(String[] args) {
        int x = 5;
        double y = 5.332542;
        // The old way:
        System.out.println("Row 1: [" + x + " " + y + "]");
        // The new way:
        System.out.format("Row 1: [%d %f]\n", x, y);
        // or
        System.out.printf("Row 1: [%d %f]\n", x, y);
    }
}
```

```
>>
Row 1: [5 5.332542]
Row 1: [5 5.332542]
Row 1: [5 5.332542]
```

The Formatter class

```
%[argument_index$][flags][width][.precision]conversion
```

- Need to control the minimum size of a field.
  - This can be accomplished by specifying a *width*.
  - The **Formatter** guarantees that a field is at least a certain number of characters wide by padding it with spaces
  - By default
    - the data is right justified
    - this can be overridden by including a '-' in the flags section.

The Formatter class Cont'd

```
import java.util.*;
public class Receipt {
        private double total = 0;
        private Formatter f = new Formatter(System.out);
        public void printTitle() {
                f.format("%-15s %5s %10s\n", "Item", "Qty", "Price");
                f.format("%-15s %5s %10s\n", "----", "---", "-----");
        }
        public void print(String name, int qty, double price) {
                f.format("%-15.15s %5d %10.2f\n", name, qty, price);
                total += price;
        }
        public void printTotal() {
                f.format("%-15s %5s %10.2f\n", "Tax", "", total*0.06);
                f.format("%-15s %5s %10s\n", "", "", "-----");
                f.format("%-15s %5s %10.2f\n", "Total", "",
                total * 1.06);
        }
        public static void main(String[] args) {
                Receipt receipt = new
                Receipt();
                receipt.printTitle();
                receipt.print("Jack's Magic
                Beans", 4, 4.25);
                receipt.print("Princess Peas",
                3, 5.1);
                receipt.print("Three Bears
                Porridge", 1, 14.29);
                receipt.printTotal();
        }
}
```

```
>>
Item            Qty        Price
----            ---         -----
Jack's Magic Be  4          4.25
Princess Peas    3          5.10
Three Bears Por  1
14.29
Tax                          1.42
                            -----
Total
25.06
```

Formatter conversions

Conversion Characters	
d	Integral (as decimal)
c	Unicode character
b	Boolean value
s	String
f	Floating point (as decimal)
e	Floating point (in scientific notation)
x	Integral (as hex)
h	Hash code (as hex)
%	Literal "%"

String.format()

- **String.format( )**
  - a **static** method which takes all the same arguments as **For matter's format( )** but returns a **String**.
  - It can come in handy when you only need to call **format( )** once:

```
public class DatabaseException extends Exception {
    public DatabaseException(int transactionID, int queryID,
    String message) {
        super(String.format("(t%d, q%d) %s", transactionID,
        queryID, message));
    }
    public static void main(String[] args) {
        try {
            throw new DatabaseException(3, 7, "Write failed");
        } catch(Exception e) {
            System.out.println(e);
        }
    }
}
```

```
>>
DatabaseException: (t3,  q
7) Write failed
```

Creating regular expressions

Characters	
B	The specific character **B**
\xhh	Character with hex value **oxhh**
\uhhhh	The Unicode character with hex representation **oxhhhh**
\t	Tab
\n	Newline
\r	Carriage return
\f	Form feed
\e	Escape

Creating regular expressions Cont'd

Character Classes	
.	Any character
[abc]	Any of the characters **a**, **b**, or **c** (same as **a|b|c**)
[^abc]	Any character except **a**, **b**, and **c** (negation)
[a-zA-Z]	Any character **a** through **z** or **A** through **Z** (range)
[abc[hij]]	Any of **a**,**b**,**c**,**h**,**I**,**j** (same as **a|b|c|h|i|j)** (union)
[a-z&&[hij]]	Either **h**, **i**, or **j** (intersection)
\s	A whitespace character (space, tab, newline, form feed, carriage return)
\S	A non-whitespace character (**[^\s]**)
\d	A numeric digit **[0-9]**
\D	A non-digit **[^0-9]**
\w	A word character **[a-zA-Z_0-9]**
\W	A non-word character **[^\w]**

Creating regular expressions

Logical Operators	
XY	X followed by Y
X|Y	X or Y
(X)	A *capturing group*. You can refer to the *i*th captured group later in the expression with \i.

Boundary Matchers	
^	Beginning of a line
$	End of a line
\b	Word boundary
\B	Non-word boundary
\G	End of the previous match

Basics of Regular Expressions

- Regular expression backslash
  - \\
- Digit
  - \\d
- Literal backslash
  - \\\\
    - Cf., '\\' in other languages
- Number N possibly being preceded by a minus sign
  - -?N
- One or more of the preceding expression
  - +
- Possibly a minus sign, followed by one or more digits
  - -?\\d+

More Basics and Integer Match Example

- Grouping
  - ()
- OR
  - |
- Possibly starting with a + or a -
  - (-|\\+)?

```
public class IntegerMatch {
public static void main(String[] args) {
    System.out.println("-1234".matches("-? \\d+"));
    System.out.println("5678".matches("-? \\d+"));
    System.out.println("+911".matches("-? \\d+"));
    System.out.println("+911".matches("(-|\\+)? \\d+"));
}
}
```

```
true
true
false
true
```

Splitting Example

```
import java.util.*;
public class Splitting {
public static String knights =
    "Then, when you have found the shrubbery, you must " +
    "cut down the mightiest tree in the forest... " +
    "with... a herring!";
public static void split(String regex) {
    System.out.println(Arrays.toString(knights.split(regex)));
}
public static void main(String[] args) {
    split(" "); // Doesn't have to contain regex chars
    split("\\W+"); // Non-word characters
    split("n\\W+"); // 'n' followed by non-word characters
}
}
```

```
[Then,, when, you, have, found, the, shrubbery,, you, must, cut, down,
the, mightiest, tree, in, the, forest..., with..., a, herring!]
[Then, when, you, have, found, the, shrubbery, you, must, cut, down,
the, mightiest, tree, in, the, forest, with, a, herring]
[The, whe, you have found the shrubbery, you must cut dow, the
mightiest tree i, the forest... with... a herring!]
```

Replacing Example

```
public class Replacing {
static String s = Splitting.knights;
public static void main(String[] args) {
    System.out.println(s.replaceFirst("f\\w+", "located"));
    System.out.println(s.replaceAll("shrubbery|tree|herring","banana"));
}
```

Then, when you have located the shrubbery, you must cut down the mightiest tree in the forest... with... a herring!

Then, when you have found the banana, you must cut down the mightiest banana in the forest... with... a banana!

Character Match Example

```
public class Rudolph {
public static void main(String[] args) {
    for(String pattern : new String[]{ "Rudolph",
        "[rR]udolph", "[rR][aeiou][a-z]ol.*", "R.*" })
        System.out.println("Rudolph".matches(pattern));
}
}
```

```
true
true
true
true
```

Scanner

- The **Scanner** class
  - added in Java SE5
  - relieves much of the burden of scanning input
- The **Scanner** constructor
  - It can take just about any kind of input object, including a **File** object (which will also be covered in the *I/O* chapter), an **InputStream**, a **String**, or in this case a **Readable**
- With **Scanner,** the input, tokenizing, and parsing are all ensconced in various different kinds of "next" methods.
- A plain **next( )**
  - returns the next **String** token
  - there are "next" methods for all the primitive types (except **char**) as well as for **BigDecimal** and **BigInteger**.
- All of the "next" methods *block*
    - they will return only after a complete data token is available for input.

Scanning Input

```
import java.io.*;
public class SimpleRead {
public static BufferedReader input = new BufferedReader(
    new StringReader("Sir Robin of Camelot\n22 1.61803"));
public static void main(String[] args) {
    try {
        System.out.println("What is your name?");
        String name = input.readLine();
        System.out.println(name);
        System.out.println("How old are you? What is your favorite double?");
        System.out.println("(input: <age> <double>)");
        String numbers = input.readLine();
        System.out.println(numbers);
        String[] numArray = numbers.split(" ");
        int age = Integer.parseInt(numArray[0]);
        double favorite = Double.parseDouble(numArray[1]);
        System.out.format("Hi %s. \n", name);
        System.out.format("In 5 years you will be %d.₩n", age + 5);
        System.out.format("My favorite double is %f.", favorite / 2);
```

Scanning Input Cont'd

```
    } catch(IOException e) {
        System.err.println("I/O exception");
    }
}
}
```

```
What is your name?
Sir Robin of Camelot
How old are you? What is your favorite double?
(input: <age> <double>)
22 1.61803
Hi Sir Robin of Camelot.
In 5 years you will be 27.
My favorite double is 0.809015.
```

Scanner Example

```
import java.util.*;
public class BetterRead {
	public static void main(String[] args) {
		Scanner stdin = new Scanner(SimpleRead.input);
		System.out.println("What is your name?");
		String name = stdin.nextLine();
		System.out.println(name);
		System.out.println(
		"How old are you? What is your favorite double?");
		System.out.println("(input: <age> <double>)");
		int age = stdin.nextInt();
		double favorite = stdin.nextDouble();
		System.out.println(age);
		System.out.println(favorite);
		System.out.format("Hi %s.\n", name);
		System.out.format("In 5 years you will be %d.\n",
		age + 5);
		System.out.format("My favorite double is %f.",
		favorite / 2);
	}
}
```

```
>>
What is your name?
Sir Robin of Camelot
How old are you? What is
your favorite double?
(input: <age> <double>)
22
1.61803
Hi Sir Robin of Camelot.
In 5 years you will be 27.
My favorite double is
0.809015.
```

Scanner delimiters

```
import java.util.*;
	public class ScannerDelimiter {
	public static void main(String[] args) {
		Scanner scanner = new Scanner("12, 42, 78, 99, 42");
		scanner.useDelimiter("\\s*,\\s*");
		while(scanner.hasNextInt())
		System.out.println(scanner.nextInt());
	}
}
```

```
>>
12
42
78
99
42
```

StringTokenizer

- StringTokenizer
  - Before regular expressions (in J2SE1.4) or the **Scanner** class (in Java SE5)
  - the way to split a string into parts was to "tokenize"
  - But now it's much easier and more succinct to do the same thing with regular expressions or the **Scanner** class.

StringTokenizer

```
import java.util.*;
    public class ReplacingStringTokenizer {
        public static void main(String[] args) {
        String input = "But I'm not dead yet! I feel happy!";
        StringTokenizer stoke = new StringTokenizer(input);
        while(stoke.hasMoreElements())
        System.out.print(stoke.nextToken() + " ");
        System.out.println();
        System.out.println(Arrays.toString(input.split(" ")));
        Scanner scanner = new Scanner(input);
        while(scanner.hasNext())
        System.out.print(scanner.next() + " ");
    }
}
```

```
>>
But I'm not dead yet! I feel happy!
[But, I'm, not, dead, yet!, I, feel,  happy!]
But I'm not dead yet! I feel happy!
```

Arrays

- Most efficient way to hold references to objects
- Limitation: size of an array is fixed
- Benefits
  - Array knows what type it holds, compile-time type checking
  - Knows its size, you can ask

Returning an Array

- Returning Java array == returning a reference
  - Reference knows the type of the array
  - Doesn't matter where or how array is created
  - Array is around as long as needed, GC cleans up

Arrays of Primitives

- Arrays can hold primitive types directly
- Containers can only hold references
- Can use “wrapper” classes to put primitives into containers, but that’s read only

java.util.Arrays

- Algorithms for array processing:
  - **binarySearch( )**
  - **equals( )**
  - **fill( )**
    - The same object duplicated
  - **sort( )**
    - Unstable Quicksort for primitives
    - Stable merge sort for Objects
- Overloaded for **Object** and all primitives

Sorting

- No support for sorting in Java 1.0/1.1
  - Explain this one to me. They forgot??
- Your class must implement **Comparable**
- Single method, **compareTo(Object rv)**
- Negative value if the argument is less than the current object
- Zero if the argument is equal
- Positive if the argument is greater

Creating Arrays from Generators

```
import java.util.*;

public interface Generator<T> { T next(); }

public class CollectionData<T> extends ArrayList<T> {
public CollectionData(Generator<T> gen, int quantity) {
    for(int i = 0; i < quantity; i++)
        add(gen.next());
}
// A generic convenience method:
public static <T> CollectionData<T>
    list(Generator<T> gen, int quantity) {
    return new CollectionData<T>(gen, quantity);
}
}
```

Creating Arrays from Generators Cont'd

```
public class Generated {
// Fill an existing array:
public static <T> T[] array(T[] a, Generator<T> gen) {
    return new CollectionData<T>(gen, a.length).toArray(a);
}
// Create a new array:
public static <T> T[] array(Class<T> type, Generator<T> gen, int size) {
    T[] a = (T[])java.lang.reflect.Array.newInstance(type, size);
    return new CollectionData<T>(gen, size).toArray(a);
}
}
```

Array Element Comparisons

```
import java.util.*;
public class CompType implements Comparable<CompType> {
int i;
int j;
private static int count = 1;
public CompType(int n1, int n2) {
    i = n1;
    j = n2;
}
public String toString() {
    String result = "[i = " + i + ", j = " + j + "]";
    if(count++ % 3 == 0)
        result += "\n";
    return result;
}
public int compareTo(CompType rv) {
return (i < rv.i ? -1 : (i == rv.i ? 0 : 1));
}
```

Array Element Comparisons Cont'd

```
private static Random r = new Random(47);
public static Generator<CompType> generator() {
    return new Generator<CompType>() {
        public CompType next() {
            return new CompType(r.nextInt(100),r.nextInt(100));
        }
    };
}
public static void main(String[] args) {
    CompType[] a = Generated.array(new CompType[12], generator());
    System.out.println("before sorting:");
    System.out.println(Arrays.toString(a));
    Arrays.sort(a);
    System.out.println("after sorting:");
    System.out.println(Arrays.toString(a));
}
}
```

Array Element Comparisons Cont'd

```
before sorting:
[[i = 58, j = 55], [i = 93, j = 61], [i = 61, j = 29]
, [i = 68, j = 0], [i = 22, j = 7], [i = 88, j = 28]
, [i = 51, j = 89], [i = 9, j = 78], [i = 98, j = 61]
, [i = 20, j = 58], [i = 16, j = 40], [i = 11, j = 22]
]
after sorting:
[[i = 9, j = 78], [i = 11, j = 22], [i = 16, j = 40]
, [i = 20, j = 58], [i = 22, j = 7], [i = 51, j = 89]
, [i = 58, j = 55], [i = 61, j = 29], [i = 68, j = 0]
, [i = 88, j = 28], [i = 93, j = 61], [i = 98, j = 61]
]
```

Imposing a Different Order

- If a class doesn't implement **Comparable** or you'd like a different order
- Create a **Comparator** class
- Two methods, **compare( )** and **equals( )**
  - Don't have to implement **equals( )** except for special performance needs
  - Just use the default **Object equals( )**
- The **compare( )** method
  - must return a negative integer, zero, or a positive integer if the first argument is less than, equal to, or greater than the second, respectively
- Primitives can only sort in ascending order

Array Element Comparisons Cont'd

```
import java.util.*;
class CompTypeComparator implements Comparator<CompType> {
    public int compare(CompType o1, CompType o2) {
        return (o1.j < o2.j ? -1 : (o1.j == o2.j ? 0 : 1));
    }
}
public class ComparatorTest {
public static void main(String[] args) {
    CompType[] a = Generated.array(
        new CompType[12], CompType.generator());
    print("before sorting:");
    print(Arrays.toString(a));
    Arrays.sort(a, new CompTypeComparator());
   print("after sorting:");
    print(Arrays.toString(a));
}
}
```

Array Element Comparisons Cont'd

```
before sorting:
[[i = 58, j = 55], [i = 93, j = 61], [i = 61, j = 29]
, [i = 68, j = 0], [i = 22, j = 7], [i = 88, j = 28]
, [i = 51, j = 89], [i = 9, j = 78], [i = 98, j = 61]
, [i = 20, j = 58], [i = 16, j = 40], [i = 11, j = 22]
]
after sorting:
[[i = 68, j = 0], [i = 22, j = 7], [i = 11, j = 22]
, [i = 88, j = 28], [i = 61, j = 29], [i = 16, j = 40]
, [i = 58, j = 55], [i = 20, j = 58], [i = 93, j = 61]
, [i = 98, j = 61], [i = 9, j = 78], [i = 51, j = 89]
]
```

Summary

- Array associates numerical indices to objects
  - Holds objects of a known type
  - Fixed size