

## The String Class

- Represents a character string (e.g. "Hi")
- **Implicit constructor:**

```
String quote = "Hello World";
```

string literal

- All string literals are String instances
- Object has a toString() method
- More details in JDK 5.0 documentation  
<http://java.sun.com/j2se/1.5.0/docs/>



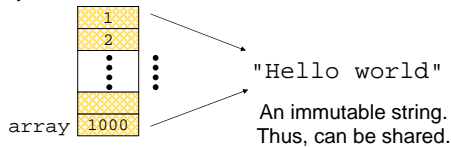
## Advanced Programming with Java

Strings and Arrays  
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## String Interning

- Avoids duplicate strings

```
String[] array = new String[1000];  
for (int i=0 ; i<1000 ; i++) {  
    array[i] = "Hello world";  
}
```



## String Immutability

- Strings are constants

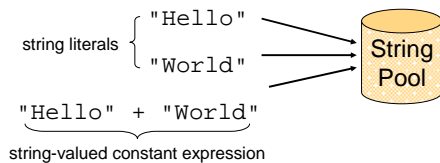
```
String s = " Tea ";  
s = s.trim();  
s = s.replace('T', 'S');
```

- A string reference may be set:

```
String s = "Tea";  
s = "Sea";
```

## String Interning (cont.)

- All string literals and string-valued constant expressions are interned.



## String Interning (cont.)

- The String class has a static private **pool** of internal strings.
- myString.intern() implementation:

```
if  $\exists s \in \text{pool} : \text{myString.equals}(s) == \text{true}$   
    return s;  
else  
    add myString to the pool  
    return myString;
```

equals:  
compares  
characters  
==,  
compares  
references

## String Constructors

- Use implicit constructor:

```
String s = "Hello";  
(string literals are interned)
```

Instead of:

```
String s = new String("Hello");  
(causes extra memory allocation)
```

## String Interning (cont.)

If:

```
String s1 = "ab";  
String s2 = "ab" + "ab";  
String s3 = "aba" + "b";  
String s4 = s1 + s1;  
String s5 = s1 + s1;  
String s6 = s1 + "ab";
```

Then:

```
s4.equals(s2) is true  
(s4 == s2) is false  
(s4 == s5) is false  
(s2 == s3) is true  
(s2 == s6) is false  
(s4.intern() == s2) is true  
(s4.intern() == s5.intern()) is true
```



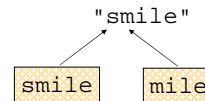
## The StringBuffer Class

- Represents a mutable character string
- Main methods: `append()` & `insert()`
  - accept data of any type
  - If: `sb = new StringBuffer("123")`  
Then: `sb.append(4)`  
is equivalent to  
`sb.insert(sb.length(), 4)`.  
Both yields "1234"

## Substrings

- Substrings are created without copying
- `String.substring()` is very efficient

```
String smile = "smile";  
String mile = "smile".substring(1,4);
```



## StringBuffer vs. String

- Inefficient version using String:

```
public static String  
duplicate(String s, int times) {  
    String result = s;  
    for (int i=1; i<times; i++) {  
        result = result + s;  
    }  
    return result;  
}
```

## The Concatenation Operator (+)

- String conversion and concatenation:

- "Hello " + "World" is "Hello World"
- "19" + 8 + 9 is "1989"

- Conversion by `toString()`
- Concatenation by `StringBuffer`
- `String x = "19" + 8 + 9;`

is compiled to the equivalent of:

```
String X = new StringBuffer().append("19").  
append(8).append(9).toString();
```

## StringBuffer vs. String (cont.)

- Much more efficient version:

```
public static String
duplicate(String s, int times) {
    StringBuffer result = new
        StringBuffer(s.length() * times);
    for (int i=0; i<times; i++) {
        result.append(s);
    }
    return result.toString();
}
```

## StringBuffer vs. String (cont.)

- More efficient version with StringBuffer:

```
public static String
duplicate(String s, int times) {
    StringBuffer result = new StringBuffer(s);
    for (int i=1; i<times; i++) {
        result.append(s);
    }
    return result.toString();
}
```

## Arrays

- **Array:** A fixed-length data structure for storing multiple values of the same type
- **Example:** An array of odd numbers:

Indices (start from 0) → 0 1 2 3 4 5 6 7  
odds: 

1	3	5	7	9	11	13	15
---	---	---	---	---	----	----	----

  
odds.length = 8

The type of all elements is int

The value of the element at index 4 is 9: odds[4] == 9

## StringBuffer vs. StringBuilder

- **StringBuilder** class provides an API compatible with **StringBuffer**, but with no guarantee of synchronization.
- This class is designed for use as a drop-in replacement for **StringBuffer** in places where the string buffer was being used by a single thread (as is generally the case).
- Where possible, it is recommended that this class be used in preference to **StringBuffer** as it will be faster under most implementations.

## Array Creation and Initialization

- What is the output of the following code:

```
int[] odds = new int[8];
for (int i=0 ; i < odds.length ; i++) {
    System.out.print(odds[i] + " ");
    odds[i] = 2*i+1;
    System.out.print(odds[i] + " ");
}
```

**Array creation:** all elements get the default value for their type (0 for int)

- **Output:**

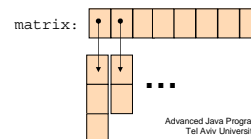
0 1 0 3 0 5 0 7 0 9 0 11 0 13 0 15

## Array Declaration

- An array is denoted by the [] notation

- **Examples:**

- int[] odds;
- int odds[]; // legal but discouraged
- String[] names;
- int[][] matrix; // an array of arrays



## Loop through Arrays

- By promoting the array's index:

```
for (int i=0 ; i < months.length ; i++) {  
    System.out.println(months[i]);  
}
```

The variable month is assigned the next element in each iteration

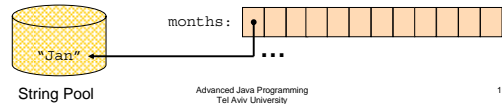
- In Java 5.0:

```
for (String month: months) {  
    System.out.println(month);  
}
```

## Array Creation and Initialization

- Creating and initializing small arrays with *a-priori* known values:

- `int[] odds = {1,3,5,7,9,11,13,15};`
- `String months[] =  
 {"Jan", "Feb", "Mar", "Apr",  
 "May", "Jun", "July", "Aug",  
 "Sep", "Oct", "Nov", "Dec"};`



## Copying Arrays

- Naïve copy:

```
int vec1[] = {1,2,3};  
int vec2[] = {8,7,6,5};  
vec1 = vec2;
```

- Doing it "by hand" is inefficient

- `arraycopy(vec2, 0, vec1, 0, 3);`  
will replace 1,2,3 in vec1 with 8,7,6

## Manipulating arrays

- The `java.util.Arrays` class has methods for sorting and searching arrays e.g.

- `public static void sort(int[] a)`
- `public static int binarySearch(int[] a, int key)`

- In the `java.lang.System` class:

- `public static void arraycopy(Object src, int srcPos, Object dest, int destPos, int length)`

## Reading command line arguments

```
class CommandLineDemo  
{  
    public static void main(String args[])  
    {  
        for (int i=0; i<args.length; i++)  
            System.out.println("Argument number " + (i+1)  
                               + " is : " + args[i]);  
    }  
}
```

```
> java CommandLineDemo Apple    Box Car  
Argument number 1 is : Apple  
Argument number 2 is : Box  
Argument number 3 is : Car
```

## Manipulating arrays (cont.)

- What is the output of the following code:

```
int[] odds = {1,3,5,7,9,11,13,15};  
int[] newOdds = new int[8];  
System.arraycopy(odds, 1, newOdds, 1, 7);  
for (int odd: odds) {  
    System.out.print(odd + " ");  
}
```

- Output:

```
0 3 5 7 9 11 13 15
```

## 2 Dimensional Arrays (con't)

Building a Tic-Tac-Toe board:

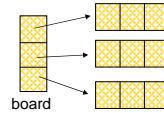
```
for (int i = 0; i < 3; i++)
    for (int j = 0; j < 3; j++)
        board[i][j] = (i + j) % 2 == 0 ? 'x' : 'o';

for (int i = 0; i < 3; i++) {
    for (int j = 0; j < 3; j++) {
        System.out.print(board[i][j] + " ");
    }
    System.out.println(" ");
}
```

## 2 Dimensional Arrays

- There are no 2D arrays in Java but you can build array of arrays:

```
char[] board[] = new char[3][];
for (int i = 0; i < 3; i++)
    board[i] = new char[3];
```



Or equivalently:

```
char[] board[] = new char[3][3];
```