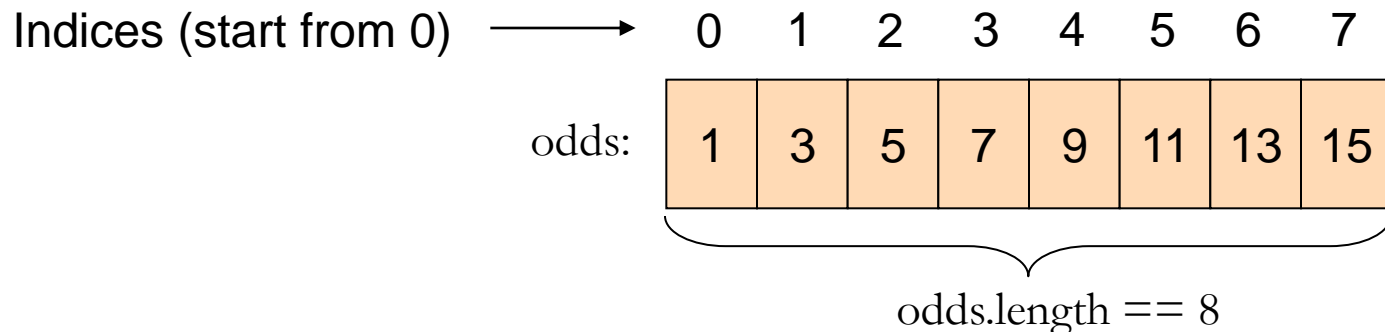


תוכנה 1

תרגול 2: מערכים, מבני בקרה ושגיאות
רובי בוים ומתי שמרת

מערכים

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



The type of all elements is `int`

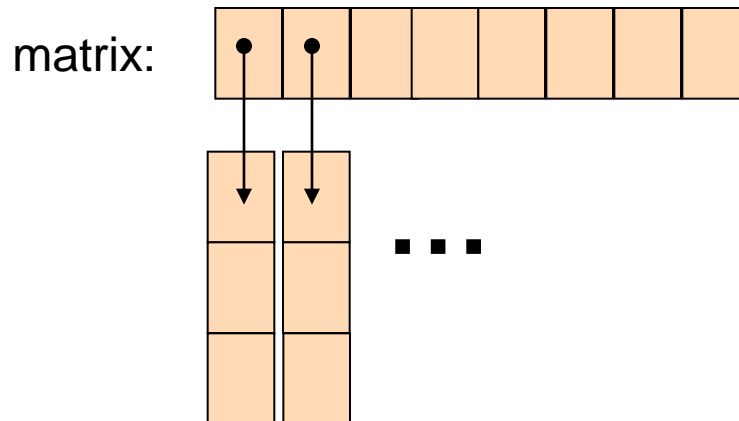
The value of the element at index 4 is 9: `odds[4] == 9`

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



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

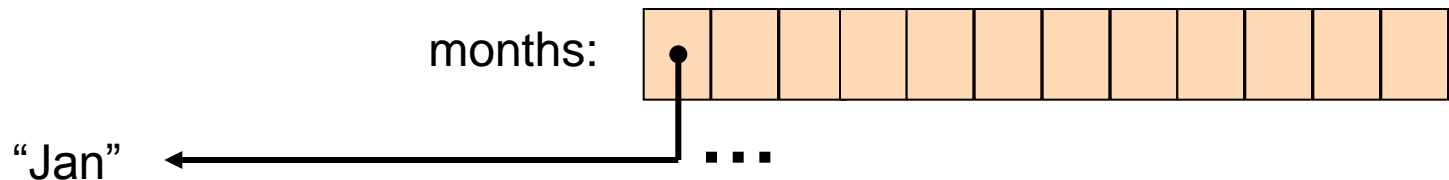
Array Creation and Initialization

- 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"};
```



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

- foreach (since Java 5.0):

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

Operations on arrays

- The class Arrays provide operations on array
 - Copy
 - Sort
 - Search
 - Fill
 - ...
- [java.util.Arrays](http://java.sun.com/javase/6/docs/api/java/util/Arrays.html)
<http://java.sun.com/javase/6/docs/api/java/util/Arrays.html>

Copying Arrays

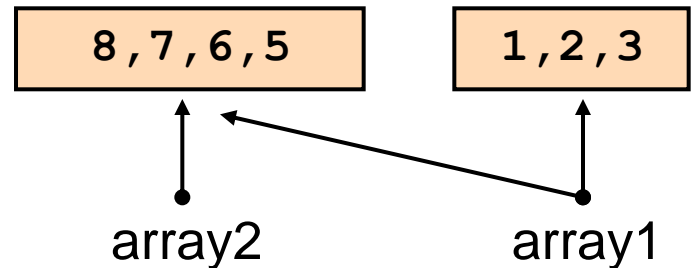
- Assume:

```
int[] array1 = {1,2,3};
```

```
int[] array2 = {8,7,6,5};
```

- Naïve copy:

```
array1 = array2;
```



- What's wrong with this solution?

Copying Arrays

■ `Arrays.copyOf`

- the original array
- the length of the copy

```
int[] arr1 = {1, 2, 3};  
int[] arr2 = Arrays.copyOf(arr1, arr1.length);
```

■ `Arrays.copyOfRange`

- the original array
- initial index of the range to be copied, inclusive
- final index of the range to be copied, exclusive

- What is the output of the following code:

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

Output: 3 5 7 9 11 13 15

Other Manipulations on Arrays

- The [java.util.Arrays](#) class has methods for sorting and searching, assigning arrays e.g.
 - public static void **sort**(int[] a)
 - public static int **binarySearch**(int[] a, int key)
 - public static void **fill**(long[] a, long val)
- More details in JDK 6.0 documentation
<http://java.sun.com/javase/6/docs/api/java/util/Arrays.html>

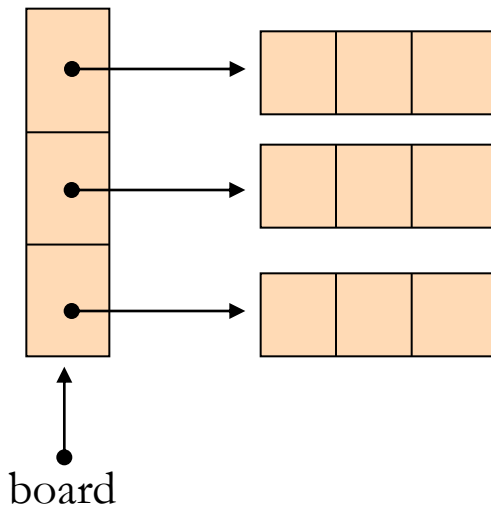
2D Arrays

- 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];
```

2D Arrays

- Building a multiplication table:

```
int[][] table = new int[10][10];
for (int i = 0 ;i < 10 ;i++) {
    for (int j = 0 ;j < 10; j++) {
        table[i][j] = (i+1) * (j+1);
    }
}
```

Fibonacci

- Fibonacci series

1, 1, 2, 3, 5, 8, 13, 21, 34

- Definition:

- $\text{fib}(0) = 1$
- $\text{fib}(1) = 1$
- $\text{fib}(n) = \text{fib}(n-1) + \text{fib}(n-2)$

en.wikipedia.org/wiki/Fibonacci_number



"Yes, you're right! We have increased our initial investment."

If-Else Statement

```
public class Fibonacci {  
    ...  
  
    /** Returns the n-th Fibonacci element */  
    public static int computeElement(int n) {  
        if (n==0)  
            return 1;  
        else if (n==1)  
            return 1;  
        else  
            return computeElement(n-1) + computeElement(n-2);  
    }  
}
```

Assumption:
 $n \geq 0$

Can be
removed

Switch Statement

```
public class Fibonacci {  
    ...  
  
    /** Returns the n-th Fibonacci element */  
    public static int computeElement(int n) {  
        switch(n) {  
            case 0:  
                return 1;  
            case 1:  
                return 1;  
            default:  
                return computeElement(n-1) + computeElement(n-2);  
        }  
    }  
}
```

Assumption:
 $n \geq 0$

can be placed
outside the switch

Switch Statement

```
public class Fibonacci {  
    ...  
  
    /** Returns the n-th Fibonacci element */  
    public static int computeElement(int n) {  
        switch(n) {  
            case 0:  
                return 1;  
            case 1:  
                return 1;  
                break;  
            default:  
                return computeElement(n-1) + computeElement(n-2);  
        }  
    }  
}
```

Assumption:
 $n \geq 0$

Compilation Error:
Unreachable Code

Iterative Fibonacci

- A loop instead of a recursion

```
static int computeElement(int n) {  
    if (n == 0 || n == 1)  
        return 1;  
  
    int prev = 1;  
    int prevPrev = 1;  
    int curr;  
  
    for (int i = 2 ; i < n ; i++) {  
        curr = prev + prevPrev;  
        prevPrev = prev;  
        prev = curr;  
    }  
  
    curr = prev + prevPrev;  
    return curr;  
}
```

Assumption:
 $n \geq 0$

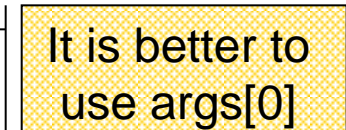
נתונים במקום חישוב

- בתרגום רקורסיה ללולאה אנו משתמשים במשתני עזר לשמירת המצב `curr, prev` ו-`prevPrev`
- הלולאה "זוכרת" את הנקודה שבה אנו נמצאים בתהליך החישוב
- דין: יעילות לעומת פשטות.
- עיקרון ה-KISS (**keep it simple stupid**)
- תרגיל: כתבו את השירות `computeElement` בעזרת `prev` ו-`prevPrev` בלבד (ללא `curr`)

For Loop

- Printing the first n elements:

```
public class Fibonacci {  
    public static int computeElement(int n) {  
        ...  
    }  
  
    public static void main(String[] args) {  
        for(int i = 0 ; i < 10 ; i++)  
            System.out.println(computeElement(i));  
    }  
}
```



It is better to use args[0]

מודולריות, שכפול קוד ויעילות

- יש כאן חוסר יעילות מסוים:
 - לולאת ה-`for` חוזרת גם ב-`main` וגם ב-`computeElement`. לכאורה, במעבר אחד ניתן גם לחשב את האברים וגם להדפיס אותם
- כמו כן כדי לחשב איבר בסדרה איננו משתמשים בתוצאות שכבר חישבנו (של אברים קודמים) ומתחילים כל חישוב מתחילתו

מודולריות, שכפול קוד ויעילות

- מתודה (פונקציה) צריכה לעשות דבר אחד בדיוק!
 - ערוב של חישוב והדפסה פוגע במודולריות (מדוע?)
- היזהרו משכפול קוד!
 - קטע קוד דומה המופיע בשתי פונקציות שונות יגרום במוקדם או במאוחר לבאג בתוכנית (מדוע?)
- את בעיית היעילות (הוספת מנגנון memoization) אפשר לפתור בעזרת מערכים (תרגיל)

for vs. while

- The following two statements are almost equivalent:

Variable `i` is not defined outside the for block

```
for(int i = 0 ; i < n ; i++)  
    System.out.println(computeElement(i));
```

```
int i=0;  
while (i < n) {  
    System.out.println(computeElement(i));  
    i++;  
}
```

while vs. do while

- The following two statements are equivalent if and only if $n > 0$:

```
int i=0;
while (i < n) {
    System.out.println(computeElement(i));
    i++;
}
```

```
int i=0;
do {
    System.out.println(computeElement(i));
    i++;
} while (i < n);
```

works since $n \geq 1$

הסוף...