

Multidimensional Arrays

CSE 114: Introduction to Object-Oriented Programming

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Multidimensional Arrays

- A two-dimensional array to represent a matrix or a table
 - Example: the following table that describes the distances between the cities can be represented using a two-dimensional array.

Distance Table (in miles)

	Chicago	Boston	New York	Atlanta	Miami	Dallas	Houston
Chicago	0	983	787	714	1375	967	1087
Boston	983	0	214	1102	1763	1723	1842
New York	787	214	0	888	1549	1548	1627
Atlanta	714	1102	888	0	661	781	810
Miami	1375	1763	1549	661	0	1426	1187
Dallas	967	1723	1548	781	1426	0	239
Houston	1087	1842	1627	810	1187	239	0

Declare Two-dimensional Arrays

```
// Declare array ref var  
elementType[][] refVar;
```

```
// Alternative syntax - Not preferred!
```

```
elementType refVar[][];  
elementType[] refVar[];
```

Create Two-dimensional Arrays

```
// Create array and assign its reference to variable  
refVar = new elementType[N][M];
```

- **Example: a matrix of 5 rows of 10 elements each:**

```
int[][] matrix;
```

```
matrix = new int[5][10];
```

Declare/Create

Two-dimensional Arrays

```
// Combine declaration and creation in one statement
```

```
elementType[][] refVar =  
    new elementType[N][M];
```

- **Example: a matrix of 5 rows of 10 elements each:**

```
int[][] matrix = new int[5][10];
```

Indexed Variables

- Indexed variables: 0-based index for first dimension first (row), then second dimension (column) second

- Examples:

```
int[][] matrix = new int[5][10];
```

```
matrix[0][0] = 3;
```

```
matrix[0][1] = matrix[0][0] + 3;
```

Default Values

- **Default values:**
 - numeric types get 0
 - boolean get false
 - char gets '\u0000'
 - reference types (e.g., String): null

Examples:

```
int[][] matrix = new int[5][10];  
System.out.print(matrix[0][0]); // 0  
System.out.print(matrix[0][1]); // 0  
System.out.print(matrix[0][2]); // 0
```


Declaring, Creating, and Initializing Using **Shorthand** Notations

You can also use an array **initializer** to declare, create and initialize a two-dimensional array. For example,

```
int[][] array = {  
    {1, 2, 3},  
    {4, 5, 6},  
    {7, 8, 9},  
    {10, 11, 12}  
};
```

Same as

```
int[][] array = new int[4][3];  
array[0][0] = 1; array[0][1] = 2; array[0][2] = 3;  
array[1][0] = 4; array[1][1] = 5; array[1][2] = 6;  
array[2][0] = 7; array[2][1] = 8; array[2][2] = 9;  
array[3][0] = 10; array[3][1] = 11; array[3][2] = 12;
```

Alternative syntax:

```
int[][] array = new int[4][];  
array[0] = new int[3];  
array[1] = new int[3];  
array[2] = new int[3];  
array[0][0] = 1;...
```

Lengths of a 2-dimensional array

- `matrix.length` is the size of the first dimension (number of rows)
- `matrix[i].length` is the size of the row `i` (i.e., the number of columns in row `i`)

Lengths of Two-dimensional Arrays

```
int[][] array = {  
    {1, 2, 3},  
    {4, 5, 6},  
    {7, 8, 9},  
    {10, 11, 12}  
}
```

`array.length` 4

`array[0].length` 3

`array[1].length` 3

`array[2].length` 3

`array[3].length` 3

	0	1	2
0	1	2	3
1	4	5	6
2	7	8	9
3	10	11	12

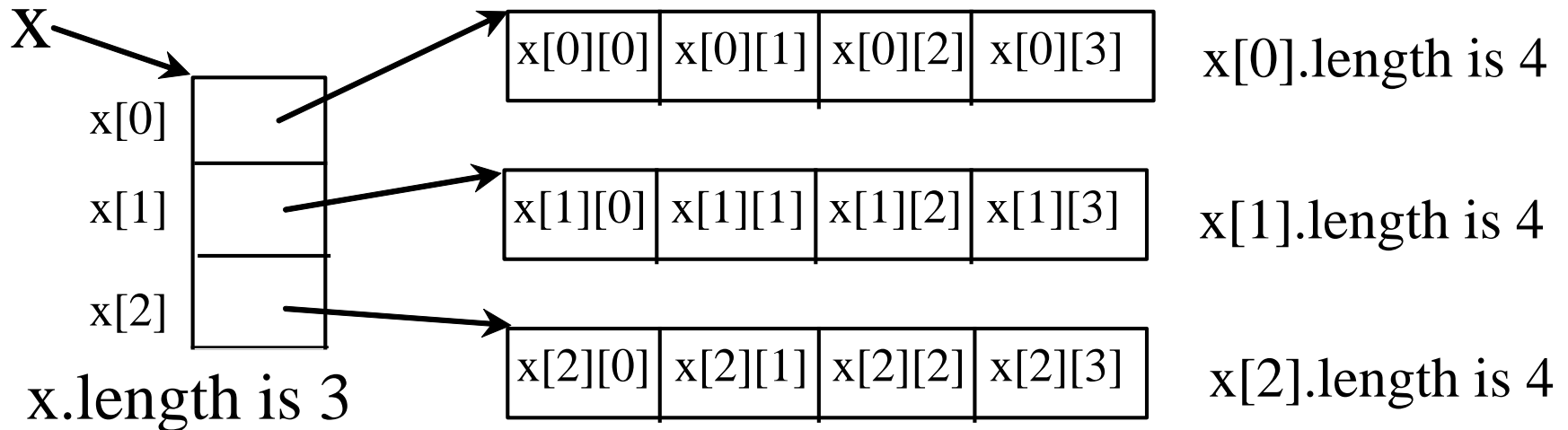
`array[4].length`

`ArrayIndexOutOfBoundsException`

Two-dimensional Arrays

Storage

```
int[][] x = new int[3][4];
```



Ragged Arrays

- A *ragged array* is an array where at least 2 rows have different lengths:

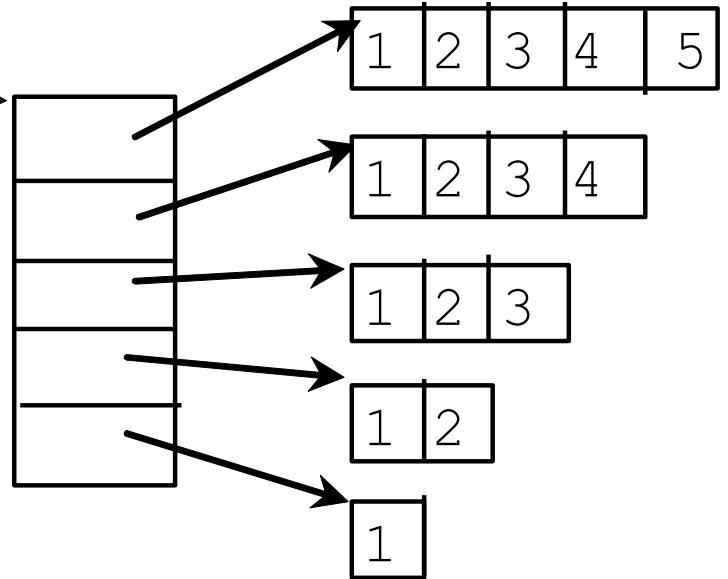
```
int[][] matrix = {  
    {1, 2, 3, 4, 5},  
    {2, 3, 4, 5},  
    {3, 4, 5, 6},  
    {4, 5},  
    {5, 4, 3, 2, 1}  
};
```

```
matrix.length is 5  
matrix[0].length is 5  
matrix[1].length is 4  
matrix[2].length is 4  
matrix[3].length is 2  
matrix[4].length is 5
```

Ragged Arrays

Storing a ragged array:

```
int[][] triangleArray = {  
    {1, 2, 3, 4, 5},  
    {1, 2, 3, 4},  
    {1, 2, 3},  
    {1, 2},  
    {1}  
};
```



Initializing 2D arrays with input values

```
int matrix[][] = new int[5][10];
java.util.Scanner input =
    new java.util.Scanner(System.in);
System.out.println("Enter " +
    matrix.length + " rows and "
    + matrix[0].length + " columns: ");
for (int row = 0; row < matrix.length; row++)
    for (int column = 0;
        column < matrix[row].length; column++)
        matrix[row][column] = input.nextInt();
```

Initializing 2D arrays with random values

- Initialize matrix with random values:

```
for (int i = 0; i < matrix.length; i++)  
    for (int j = 0; j < matrix[i].length; j++)  
        matrix[i][j] = (int) (Math.random() * 1000);
```


Printing 2D arrays

```
for(int row=0; row<matrix.length; row++){  
    for(int column = 0; column<matrix[row].length; column++){  
        System.out.print(matrix[row][column] + " ");  
        // new line after each row  
        System.out.println();  
    }  
}
```

Printing 2D arrays with **for-each**

```
for(int[] row:matrix){  
    for(int elem:row)  
        System.out.print(elem + " ");  
    // new line after each row  
    System.out.println();  
}
```

Summing all elements

```
int total = 0;
for(int row = 0; row < matrix.length; row++)
    for(int column = 0; column < matrix[row].length; column++)
        total += matrix[row][column];
```

Summing all elements with **for-each**

```
int total = 0;
for(int[] row:matrix)
    for(int elem:row)
        total += elem;
```

Summing elements by column

```
for(int column = 0; column < matrix[0].length; column++){  
    int total = 0;  
    for(int row=0; row<matrix.length; row++){  
        total += matrix[row][column];  
        System.out.println("Sum for column " + column + " is " + total);  
    }  
}
```

2D Random shuffling

```
for (int i = 0; i < matrix.length; i++)
    for (int j = 0; j < matrix[i].length; j++) {
        int i2 = (int) (Math.random() * matrix.length);
        int j2 = (int) (Math.random() * matrix[i2].length);
        // Swap matrix[i][j] with matrix[i2][j2]
        int temp = matrix[i][j];
        matrix[i][j] = matrix[i2][j2];
        matrix[i2][j2] = temp;
    }
```

Check Ragged

```
public class Test {
    public static boolean isRagged(int[][] m){
        int l0 = m[0].length;
        for(int i=1; i<m.length; i++)
            if(m[i].length != l0)
                return true;
        return false;
    }
    public static void main(String[] args) {
        int[][] a = {
            {1,2,3},
            {1,2},
            {1,2,3}
        };
        System.out.println(isRagged(a)); // true
    }
}
```

Check Ragged with for-each

```
public class Test {
    public static boolean isRagged(int[][] m){
        int l0 = m[0].length;
        for(int[] row)
            if(row.length != l0)
                return true;
        return false;
    }
    public static void main(String[] args) {
        int[][] a = {
            {1,2,3},
            {1,2},
            {1,2,3}
        };
        System.out.println(isRagged(a)); // true
    }
}
```


N-dimensional Arrays

- Not just only 2-dimensional arrays!!!
- N-dimensional data structures example:
 - grades on multiple dimensions (2 courses, 100 students each course, 25 lab grades):

```
int[][][] scores = new int[2][100][25];
```

```
scores[0][0][0] = 3;
```

N-dimensional Arrays

- Printing N-dimensional Arrays:

```
int[][][] m = new int[2][3][4];
for(int i=0; i<m.length; i++) {
    for(int j=0; j<m[i].length; j++) {
        for(int k=0; k<m[i][j].length; k++)
            System.out.print(m[i][j][k] + " ");
        System.out.println();
    }
    System.out.println();
}
```

N-dimensional Arrays

- Printing N-dimensional Arrays with for-each:

```
int[][] [] m = new int[2][3][4];
for(int[] [] slice:m) {
    for(int[] row:slice) {
        for(int e:row)
            System.out.print(e + " ");
        System.out.println();
    }
    System.out.println("\n");
}
```