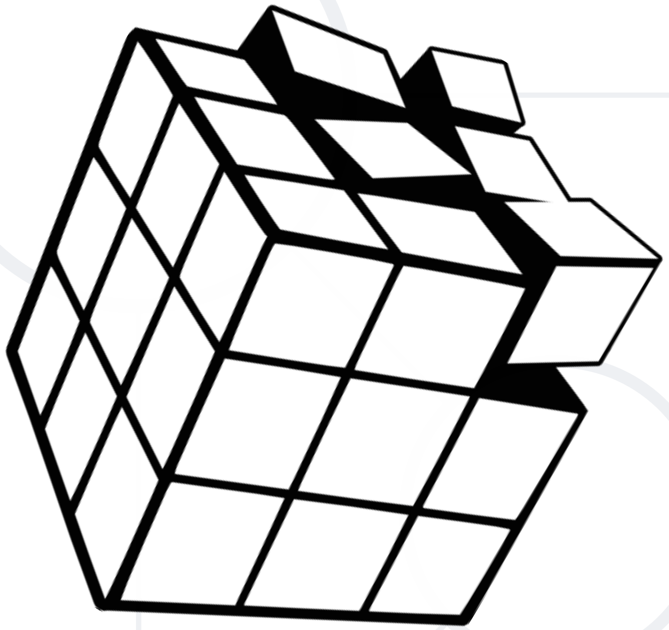
Multidimensional Arrays

Processing Matrices and Jagged Arrays



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Multidimensional Arrays

Definition and Usage

What is a Multidimensional Array?

- **Array** is a systematic arrangement of similar objects
- **Multidimensional arrays** have more than one dimension
  - The most used multidimensional arrays are the 2-dimensional, also called **matrices**

R	COLS				
O	[0, 0]	[0, 1]	[0, 2]	[0, 3]	[0, 4]
W	[1, 0]	[1, 1]	[1, 2]	[1, 3]	[1, 4]
S	[2, 0]	[2, 1]	[2, 2]	[2, 3]	[2, 4]

Col Index

Row Index

Creating Multidimensional Arrays

- Creating a **multidimensional** array in C#
  - Use the **new** keyword
  - Must specify the size of each dimension

```
int[,] intMatrix = new int[3, 4];
float[,] floatMatrix = new float[8, 2];
string[,,] stringCube = new string[5, 5, 5];
```

Initializing Multidimensional Arrays

- Initializing with values:

```
int[,] matrix = {
    {1, 2, 3, 4}, // row 0 values
    {5, 6, 7, 8}  // row 1 values
};
```

- Two-dimensional arrays represent **rows with values**
- The **rows** represent the first dimension and the **columns** – the second (**the one inside the first**)

Accessing Elements

- Accessing N-dimensional array element:

```
nDimensionalArray[index_1, … , index_n]
```

- Getting element value:

```
int[,] array = {{10, 20, 30}, {40, 50, 60}};
int element11 = array[1, 0]; // element10 = 40
```

0	1	2	
10	20	30	row 0
40	50	60	row 1

- Setting element value:

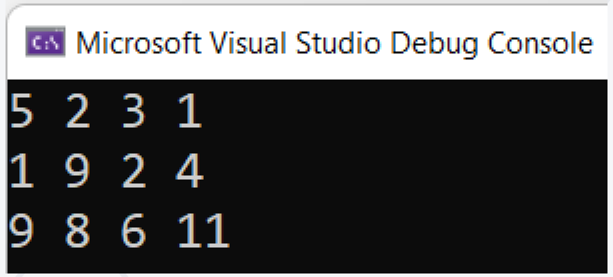
```
int[,] array = new int[3, 4];
for (int row = 0; row < array.GetLength(0); row++)
  for (int col = 0; col < array.GetLength(1); col++)
    array[row, col] = row + col;
```

Returns the size of the dimension

Printing a Matrix – Example (1)

```
int[,] matrix =
    {  { 5, 2, 3, 1 },
       { 1, 9, 2, 4 },
       { 9, 8, 6, 11 }  };
for (int row = 0; row < matrix.GetLength(0); row++)
{
  for (int col = 0; col < matrix.GetLength(1); col++)
  {
    Console.Write("{0} ", matrix[row, col]);
  }

  Console.WriteLine();
}
```


Microsoft Visual Studio Debug Console

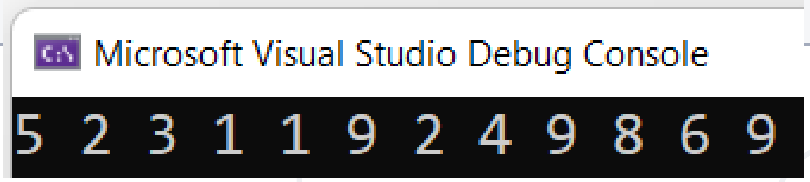
```
5 2 3 1
1 9 2 4
9 8 6 11
```

Printing Matrix – Example (2)

- Foreach iterates through all the elements in the matrix

```
int[,] matrix = {
  { 5, 2, 3, 1 },
  { 1, 9, 2, 4 },
  { 9, 8, 6, 9 }
};

foreach (int element in matrix)
{
  Console.WriteLine(element + " ");
}
```



Microsoft Visual Studio Debug Console

```
5 2 3 1 1 9 2 4 9 8 6 9
```

Problem: Sum Matrix Elements

- Read a matrix from the console
- Print the number of rows
- Print the number of columns
- Print the **sum of all numbers** in the matrix

```
3, 6
7, 1, 3, 3, 2, 1
1, 3, 9, 8, 5, 6
4, 6, 7, 9, 1, 0
```

$\rightarrow$

```
3
6
76
```

```
3, 4
1, 2, 3, 1
1, 2, 2, 4
2, 2, 2, 2
```

$\rightarrow$

```
3
4
24
```

Check your solution here: https://judge.softuni.org/Contests/Practice/Index/1452#0

Solution: Sum Matrix Elements (1)

```
int[] sizes = Console.ReadLine().Split(", ")
  .Select(int.Parse).ToArray();
int[,] matrix = new int[sizes[0], sizes[1]];
for (int row = 0; row < matrix.GetLength(0); row++) {
  int[] colElements = Console.ReadLine().Split(", ")
    .Select(int.Parse).ToArray();
  for (int col = 0; col < matrix.GetLength(1); col++)
    matrix[row, col] = colElements[col];
}
```

Gets length of 0th dimension (rows)

Gets length of 1st dimension (cols)

Solution: Sum Matrix Elements (2)

```
int sum = 0;
for (int row = 0; row < matrix.GetLength(0); row++)
{
  for (int col = 0; col < matrix.GetLength(1); col++)
    sum += matrix[row, col];
}
Console.WriteLine(matrix.GetLength(0));
Console.WriteLine(matrix.GetLength(1));
Console.WriteLine(sum);
```

Problem: Sum Matrix Columns

- Read matrix sizes
- Read a matrix from the console
- Print the **sum of all numbers** in matrix columns

```
3, 6
7 1 3 3 2 1
1 3 9 8 5 6
4 6 7 9 1 0
```

```
12
10
19
20
8
7
```

```
3, 3
1 2 3
4 5 6
7 8 9
```

```
12
15
18
```

Check your solution here: https://judge.softuni.org/Contests/Practice/Index/1452#1

Solution: Sum Matrix Columns (1)

```
var sizes = Console.ReadLine()
  .Split(", ").Select(int.Parse).ToArray();
int[,] matrix = new int[sizes[0], sizes[1]];
for (int r = 0; r < matrix.GetLength(0); r++) {
  var col = Console.ReadLine().Split().Select(int.Parse).ToArray();
  for (int c = 0; c < matrix.GetLength(1); c++) {
    matrix[r, c] = col[c];
  }
}
```

Solution: Sum Matrix Columns (2)

```
for (int c = 0; c < matrix.GetLength(1); c++) {
  int sum = 0;
  for (int r = 0; r < matrix.GetLength(0); r++) {
    sum += matrix[r, c];
  }
  Console.WriteLine(sum);
}
```

Problem: Square with Maximum Sum

- Find **2x2 square** with max sum in given matrix
  - Read matrix from the console
  - Find **biggest sum** of 2x2 submatrix
  - Print the result as a **new matrix**, followed by **the sum**

```
3, 6
7, 1, 3, 3, 2, 1
1, 3, 9, 8, 5, 6
4, 6, 7, 9, 1, 0
```

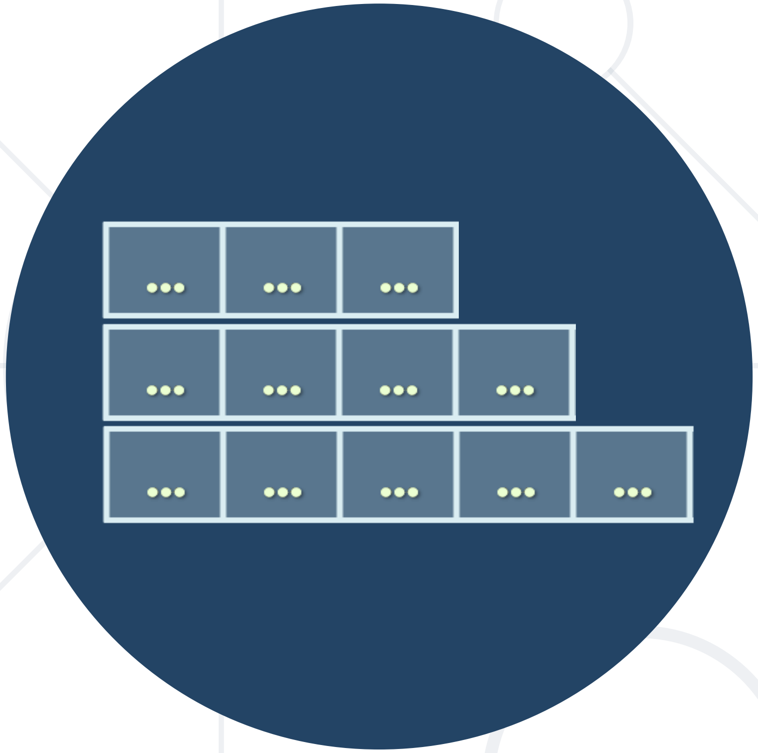
$\Rightarrow$

```
9 8
7 9
33
```

Check your solution here: https://judge.softuni.org/Contests/Practice/Index/1452#4

Solution: Square with Maximum Sum

```
// TODO: Read the input from the console
for (int row = 0; row < matrix.GetLength(0) - 1; row++) {
  for (int col = 0; col < matrix.GetLength(1) - 1; col++) {
    var newSquareSum = matrix[row, col] +
                       matrix[row + 1, col] +
                       matrix[row, col + 1] +
                       matrix[row + 1, col + 1];
    // TODO: Check if the sum is bigger
    // → remember the best sum, row and col
  }
}
// TODO: Print the square with the max sum
```



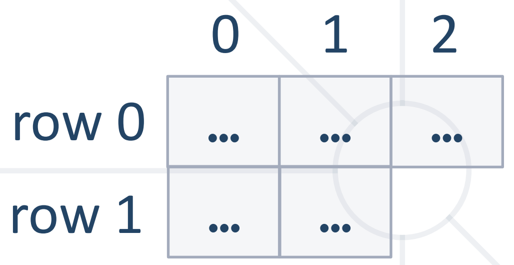
Jagged Arrays

Definition and Usage

What is Jagged Array

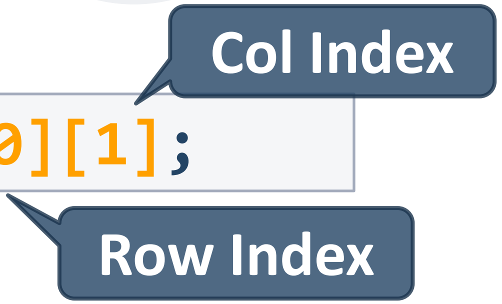
- **Jagged arrays** are multidimensional arrays
  - But each dimension may have a different size
  - A jagged array is an **array of arrays**
  - Each of the arrays has **different length**

```
int[][] jagged = new int[2][];
jagged[0] = new int[3];
jagged[1] = new int[2];
```



- **Accessing elements**

```
int element = jagged[0][1];
```



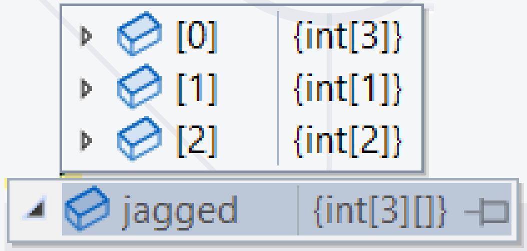
Reading a Jagged Array

```
int rowsCount = int.Parse(Console.ReadLine());
int[][] jagged = new int[rowsCount][];

for (int row = 0; row < jagged.Length; row++)
{
  string[] nums = Console.ReadLine().Split(' ');
  jagged[row] = new int[nums.Length];

  for (int col = 0; col < jagged[row].Length; col++)
  {
    jagged[row][col] = int.Parse(nums[col]);
  }
}
```

```
3
10 20 30
40
50 60
```



```
[0]     {int[3]}
[1]     {int[1]}
[2]     {int[2]}
jagged  {int[3][]}
```

Printing a Jagged Array – Example

- Using a **for** loop

```
int[][] matrix = ReadJaggedArray();
for (int row = 0; row < matrix.Length; row++)
{
  for (int col = 0; col < matrix[row].Length; col++)
    Console.Write("{0} ", matrix[row][col]);
  Console.WriteLine();
}
```

Implement your custom method

- Using a **foreach** loop

```
int[][] matrix = ReadJaggedArray();
foreach (int[] row in matrix)
  Console.WriteLine(string.Join(" ", row));
```

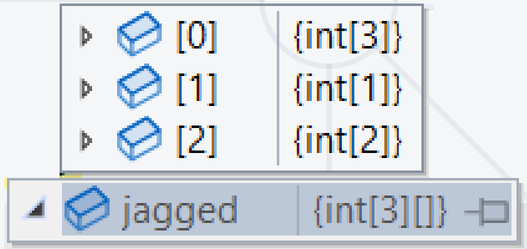
Read and Print a Jagged Array (Short Version)

```
// Allocate the array rows
int rows = int.Parse(Console.ReadLine());
int[][] jagged = new int[rows][];

// Read the jagged array
for (int row = 0; row < jagged.Length; row++)
    jagged[row] = Console.ReadLine().Split(' ')
        .Select(int.Parse).ToArray();

// Print the jagged array
foreach (int[] row in jagged)
    Console.WriteLine(string.Join(" ", row));
```

```
3
10 20 30
40
50 60
```



```
[0]  {int[3]}
[1]  {int[1]}
[2]  {int[2]}
jagged  {int[3][]}
```

Problem: Jagged-Array Modification

- On the first line you will get the number **rows**
- On the next lines you will get the **elements for each row**
- Until you receive "**END**", read commands
  - **`Add {row} {col} {value}`**
  - **`Subtract {row} {col} {value}`**
- If the coordinates are invalid, print "**`Invalid coordinates`**"
- When you receive "**END**", print the jagged array

Check your solution here: https://judge.softuni.org/Contests/Practice/Index/1452#5

Jagged-Array Modification – Example

```
3
1 2 3
4 5 6 7
8 9 10
Add 0 0 5
Subtract 1 2 2
Subtract 1 4 7
END
```

```
Invalid coordinates
6 2 3
4 5 4 7
8 9 10
```

	0	1	2	
row 0	1	2	3	
row 1	4	5	6	7
row 2	8	9	10	

Solution: Jagged-Array Modification (1)

```
int rowSize = int.Parse(Console.ReadLine());
int[][] matrix = new int[rowSize][];

for (int row = 0; row < rowSize; row++)
{
  int[] columns = Console.ReadLine()
    .Split()
    .Select(int.Parse)
    .ToArray();
  matrix[row] = columns;
}
// continues on the next slide…
```

Solution: Jagged-Array Modification (2)

```
string line;
while ((line = Console.ReadLine()) != "END") {
  string[] tokens = line.Split();
  string command = tokens[0];
  int row = int.Parse(tokens[1]);
  int col = int.Parse(tokens[2]);
  int value = int.Parse(tokens[3]);
  if (row < 0 || row >= matrix.Length || … )
    Console.WriteLine("Invalid coordinates");
  else
    { // TODO: Execute the command }
}
// TODO: Print the matrix
```

Check the row and col ranges

Problem: Pascal Triangle

- Write a program to prints on the console the Pascal's Triangle

```
6
```

```
1
1 1
1 2 1
1 3 3 1
1 4 6 4 1
1 5 10 10 5 1
```

```
4
```

```
1
1 1
1 2 1
1 3 3 1
```

```
2
```

```
1
1 1
```

Check your solution here: https://judge.softuni.org/Contests/Practice/Index/1452#6

Solution: Pascal Triangle (1)

```
int height = int.Parse(Console.ReadLine());
long[][] triangle = new long[height][];
int currentWidth = 1;

for (long row = 0; row < height; row++)
{
  triangle[row] = new long[currentWidth];
  long[] currentRow = triangle[row];
  currentRow[0] = 1;
  currentRow[currentRow.Length - 1] = 1;
  currentWidth++;
  // TODO: Fill elements for each row (next slide)
}
```

Solution: Pascal Triangle (2)

```
if (currentRow.Length > 2)
{
  for (int i = 1; i < currentRow.Length - 1; i++)
  {
    long[] previousRow = triangle[row - 1];
    long prevoiousRowSum = previousRow[i] + previousRow[i - 1];
    currentRow[i] = prevoiousRowSum;
  }
}
// TODO: Print triangle
foreach (long[] row in triangle)
  Console.WriteLine(string.Join(" ", row));
```

Summary

- Multidimensional arrays
  - Have **more than one** dimension
  - Two-dimensional arrays are like tables with **rows** and **columns**
- Jagged arrays
  - Arrays of arrays
  - Each **element** is an array **itself**

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