Nested Loops

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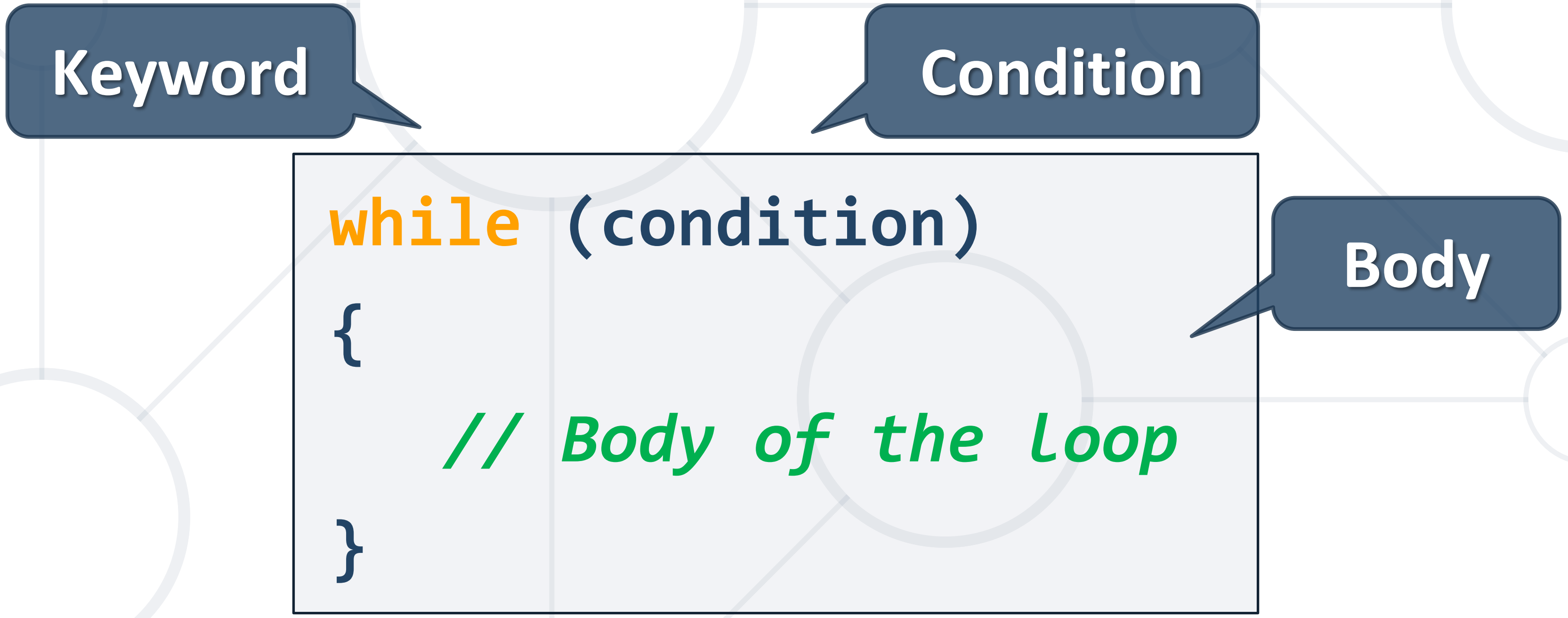
Review

While Loops

While Loop

- Control flow **statement**
  - Executes code repeatedly while a condition is **true**



```
while (condition)
{
    // Body of the loop
}
```

Example: While Loop

- Print the numbers from **1 to 5**

```
int i = 1;
while (i <= 5)
{
    Console.WriteLine(i);
    i++;
}
```

1 … 5

While or For?

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- `while` and `for` loops repeat blocks of code
- Use `for` when you know in advance the number of repetitions
  - For example, repeat exactly 10 times
- Use `while` when you don't know when the exit condition will be met
  - For example, repeat until `0` is reached

The "break" Operator

- Used for **prematurely exiting** the loop
- Can only be executed from the **body**, during **an iteration** of the loop
- **break** immediately exits from the loop
  - The rest of the loop body **is skipped**

```
int i = 1;
while (true)
{
  if (i > 10)
    break;
  i++;
}
```

Complex Loops

Loops with a Special Step

Complex Loops

- For-loops may have different **steps**

```
for (int i = n; i >= 1; i--) …
```

Step -1

```
for (int j = 1; j <= n; j += 2) …
```

Step +2

```
for (int k = 1; k <= n; k *= 2) …
```

Step *2

```
for (int d = n; d > 0; d /= 2) …
```

Step /2

Do...While Loops

- The **do … while (…)** loop repeats a block of code until an **exit condition** is met
  - The loop body is always executed at least **once**
- **while (…)** loop uses an exit condition at the **start**
- **do … while (…)** loop uses an exit condition at the **end**

```
int i = 1;
do {
  Console.WriteLine(i);
  i++;
} while (i <= 10);
```

Nested Loops

Introduction

Real Life Example: Clock

- Imagine **how the clock works**
  - A sequence of **iterations**
  - At each iteration, **the rightmost digit is increased**
  - When a digit **overflows** (reaches 10), it starts from **0** and the digit on its left is increased

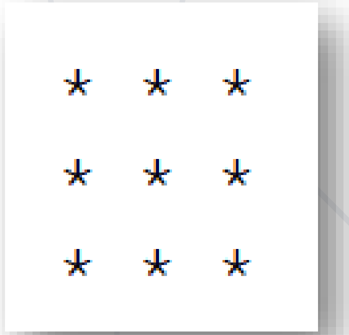
0 0 1 0

Loops Inside Other Loops

Nested Loops

- We can nest a **loop inside another loop**:

```
int n = 3;
for (int row = 1; row <= n; row++)
{
  for (int col = 1; col <= n; col++)
  {
    Console.Write(" *");
  }
  Console.WriteLine();
}
```



```
 * * *
 * * *
 * * *
```

Nested Loops

- Nested loops == several **loops** placed **inside each other**
- **Nested loops** are used:
  - To execute multiple times an **action**, which **executes** multiple **actions**
  - To implement more **complex** calculations and program logic

Multiple Levels of Nested Loops

```
for (int floor = 1; floor <= n; floor++)
{
  for (int row = 1; row <= n; row++)
   {
    for (int col = 1; col <= n; col++)
    {
      // …
    }
  }
}
```

The loop variable names must be different

Nested For-Loops

Nested For Loops

- The syntax for a **nested for loop** in C# is as follows:

```
// Outer Loop
for (init; condition; increment)
{
  // Inner Loop
  for (init; condition; increment)
  {
      // Commands
  }
}
```

Example: Nested For Loops

```
int rows = 3;
int columns = 2;
for (int r = 1; r <= rows; r++)
{
  Console.WriteLine("row = " + r);
  for (int c = 1; c <= columns; c++)
   {
     Console.WriteLine("  column = " + c);
   }
}
```

```
// Output
row = 1
   column = 1
   column = 2
row = 2
   column = 1
   column = 2
row = 3
   column = 1
   column = 2
```

Problem: Triangle of Stars

- Write a program to print a **triangle of stars** like shown below:
  - Read the **size** of a triangle from the console
  - Print a **triangle of stars**

```
5
```

```
*
**
***
****
*****
```

```
7
```

```
*
**
***
****
*****
******
*******
```

Solution: Triangle of Stars

```
int size = int.Parse(Console.ReadLine());
for (int row = 1; row <= size; row++)
{
  for (int col = 1; col <= row; col++)
  {
    Console.Write("*");
  }
 Console.WriteLine();
}
```

Problem: Building

- Write a program to **print a table**, representing a **building**:
  - **Odd** floors hold **apartments** (type **A**), e.g. **A10**, **A11**, **A12**, …
  - **Even** floors hold **offices** (type **O**), e.g. **O20**, **O21**, **O22**, …
  - The **last floor** holds large apartments (type **L**), e.g. **L60**, **L61**, **L62**
  - Identifiers consist of: **{type}{floor}{number}**, e.g. **L65**, **A12**, **O24**
  - Example:

```
L60 L61 L62 L63 L64 L65
A30 A31 A32 A33 A34 A35
O20 O21 O22 O23 O24 O25
A10 A11 A12 A13 A14 A15
```

Example: Building

- **Input**: the **count of floors** and the **count of estates per floor**
- **Output**: the building plan (rectangular table of estates)

```
6
4
```

```
L60 L61 L62 L63
A50 A51 A52 A53
O40 O41 O42 O43
A30 A31 A32 A33
O20 O21 O22 O23
A10 A11 A12 A13
```

Solution: Building

```
int floors = int.Parse(Console.ReadLine());
int rooms = int.Parse(Console.ReadLine());
for (int f = floors; f >= 1; f--)
{
  for (int r = 0; r < rooms; r++)
  {
    if (f == floors) // Print last floor: L{f}{r}
    else if (f % 2 == 0) // Print office: O{f}{r}
    else // Print apartment: A{f}{r}
  }
  Console.WriteLine();
}
```

The outer loop iterates through the floors

The inner loop iterates through the rooms

Nested While Loops

Nested While Loops

```
// Outer Loop
while (condition)
{
    // Inner Loop
    while (condition)
    {
        // Statements
    }
}
```

Example: Nested While Loops

```
int row = 1;
while (row <= 2)
{
  Console.WriteLine($"Row: {row}");
  int col = 1;
  while (col <= 3)
  {
    Console.WriteLine($"  Column: {col}");
    col++;
  }
  row++;
}
```

```
// Output
Row: 1
  Column: 1
  Column: 2
  Column: 3
Row: 2
  Column: 1
  Column: 2
  Column: 3
```

Problem: Travel Savings

- Calculate the **money collection** for multiple travel destinations:
  - Read **destination** and **needed budget** for destination
  - Read many times amounts of collected money, until they are **enough** for the destination (starting from 0)
    - Print "`Collected: {sum}`" where sum is formatted to 2nd digit or "`Going to {destination}`"
  - Read another destination and budget and collect money again
  - A destination "`End`" ends the program

Example: Travel Savings

```
Bali
3500
800
1800
1000
Brazil
4600
5000
End
```

```
Collected: 800.00
Collected: 2600.00
Collected: 3600.00
Going to Bali!
Collected: 5000.00
Going to Brazil!
```

Solution: Travel Savings

```
string destination = Console.ReadLine();
while (destination != "End")
{
  double neededSum = double.Parse(Console.ReadLine());
  double collectedSum = 0;
  while (collectedSum < neededSum)
  {
    collectedSum += double.Parse(Console.ReadLine());
    Console.WriteLine($"Collected: {collectedSum:F2}");
  }
 Console.WriteLine($"Going to {destination}!");

  destination = Console.ReadLine();
}
```

Summary

- For-loops can use different **steps**
- **Nested loops** are loops **within another loop**
  - Nested `for` loops, e.g. process data by rows and columns
  - Nested `while` loops, e.g. nested repeating logic with exit conditions

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