Sets and Dictionaries Advanced

Sets and Multi-Dictionaries, Nested Dictionaries

SoftUni Team

Technical Trainers

Software University

SoftUni

Software University

https://about.softuni.bg/

Have a Question?

Software University

sli.do

#csharp-advanced

Table of Contents

Dictionary<K, V> Overview

Collection of Keys Mapped to Values

Associative Arrays (Maps, Dictionaries)

- Associative arrays are arrays indexed by keys
  - Not by the numbers 0, 1, 2, … (like arrays)
- Hold a set of pairs {**`key`** → **`value`**}

Key	Value
`John Smith`	`+1-555-8976`
`Lisa White`	`+1-555-1234`
`Sam Doe`	`+1-555-5030`

Dictionary

- **Dictionary<K, V>**: collection of {**key**, **value**} pairs
- Keys are **unique**, each mapping to a value
- **Dictionary<K, V>** keeps the keys in their **order of addition**

```
var fruits = new Dictionary<string, double>();
fruits["banana"] = 2.20;
fruits["apple"] = 1.40;
fruits["kiwi"] = 3.20;
Console.WriteLine(string.Join(", ", fruits.Keys));
```

Sorted Dictionary

- **SortedDictionary<K, V>**: collection of {**key**, **value**} pairs
  - Keeps its **keys** always **sorted**
  - Implemented internally by a balanced search tree

```
var fruits = new SortedDictionary<string, double>();
fruits["kiwi"] = 4.50;
fruits["orange"] = 2.50;
fruits["banana"] = 2.20;
Console.WriteLine(string.Join(", ", fruits.Keys));
```

Built-In Methods

- `Add(key, value)` method

```
var airplanes = new Dictionary<string, int>();
airplanes.Add("Boeing 737", 130);
airplanes.Add("Airbus A320", 150);
```

- `Remove(key)` method

```
var airplanes = new Dictionary<string, int>();
airplanes.Add("Boeing 737", 130);
airplanes.Remove("Boeing 737");
```

Built-In Methods

- ContainsKey(key) – fast!

```
var dictionary = new Dictionary<string, int>();
dictionary.Add("Airbus A320", 150);
if (dictionary.ContainsKey("Airbus A320"))
   Console.WriteLine($"Airbus A320 key exists");
```

- ContainsValue(value) – slow!

```
var dictionary = new Dictionary<string, int>();
dictionary.Add("Airbus A320", 150);
Console.WriteLine(airplanes.ContainsValue(150)); // True
Console.WriteLine(airplanes.ContainsValue(100)); // False
```

Problem: Count Same Values in Array

- Read a list of **real numbers** and print them along with their **number of occurrences**

```
8 2.5 2.5 8 2.5
```

```
8 - 2 times
2.5 - 3 times
```

```
1.5 5 1.5 3
```

```
1.5 - 2 times
5 - 1 times
3 - 1 times
```

Check your solution here: https://judge.softuni.org/Contests/Practice/Index/1465#0

Solution: Count Same Values in Array

```
double[] nums = Console.ReadLine().Split(' ')
  .Select(double.Parse).ToArray();
var counts = new Dictionary<double, int>();
foreach (var num in nums)
   if (counts.ContainsKey(num))
      counts[num]++;
   else
      counts[num] = 1;
foreach (var num in counts)
    Console.WriteLine($"{num.Key} - {num.Value} times");
```

counts[num] hold show many times num occurs in nums

Sorting Collections

- Using OrderBy() to sort collections:

```
List<int> nums = { 1, 5, 2, 4, 3 };
nums = nums
   .OrderBy(num => num)
   .ToList();
```

- Using OrderByDescending() to sort collections:

```
List<int> nums = { 1, 5, 2, 4, 3 };
nums = nums.OrderByDescending(num => num).ToList();
Console.WriteLine(String.Join(", ", nums));
```

Sorting Collections by Multiple Criteria

- Using ThenBy() to sort collections by multiple criteria:

```
var products = new Dictionary<int, string>();
Dictionary<int, string> sortedDict = products
  .OrderBy(pair => pair.Value)
  .ThenBy(pair => pair.Key)
  .ToDictionary(pair => pair.Key,
                pair => pair.Value);
```

Problem: Largest 3 Numbers

- Read a list of integers
- Print the **largest 3** of them (or less for shorter lists)
- Print them in **descending order**

```
10 30 15 20 50 5
```
$\downarrow$
```
50 30 20
```

```
1 2 3
```
$\downarrow$
```
3 2 1
```

```
20 30
```
$\downarrow$
```
30 20
```

Check your solution here: https://judge.softuni.org/Contests/Practice/Index/1465#2

Solution: Largest 3 Numbers

```
int[] numbers = Console.ReadLine()
  .Split()
  .Select(int.Parse)
  .OrderByDescending(n => n)
  .ToArray();
int count = numbers.Length >= 3 ? 3 : numbers.Length;
for (int i = 0; i < count; i++)
   Console.Write($"{numbers[i]} ");
```

Check your solution here: https://judge.softuni.org/Contests/Practice/Index/1465#2

Multi-Dictionaries

Dictionaries Holding a List of Values

Multi-Dictionaries

- A dictionary could hold a **set of values** by given key
  - Example: student may have multiple grades:
    - Peter → [5, 5, 6]
    - Kevin → [6, 6, 3, 4, 6]

```
var grades = new Dictionary<string, List<int>>();
grades["Peter"] = new List<int>();
grades["Peter"].Add(5);
grades["Kevin"] = new List<int>() { 6, 6, 3, 4, 6 };
Console.WriteLine(string.Join(" ", grades["Kevin"]));
```

Adding Elements to Multi-Dictionary

```
static void AddStudentGrade(
    Dictionary<string, List<double>> grades,
    string studentName, double grade)
{
   if (! grades.ContainsKey(studentName))
     grades.Add(studentName, new List<double>());
   grades[studentName].Add(grade);
}

AddStudentGrade(grades, "Peter", 6);
AddStudentGrade(grades, "Maria", 5);
```

Ensure that the list of grades exist for the target student

Problem: Average Student Grades

- Write a program to read student **names** + **grades**
- Print the **students** + **average grade** for each student

```
6
Barney 5.20
Melissa 5.50
Melissa 2.50
Ted 2.00
Melissa 3.46
Ted 3.00
```

```
Barney -> 5.20 (avg: 5.20)
Melissa -> 5.50 2.50 3.46 (avg: 3.82)
Ted -> 2.00 3.00 (avg: 2.50)
```

Check your solution here: https://judge.softuni.org/Contests/Practice/Index/1465#1

Solution: Average Student Grades

```
var grades = new Dictionary<string, List<decimal>>();
var n = int.Parse(Console.ReadLine());
for (int i = 0; i < n; i++) {
  var tokens = Console.ReadLine().Split();
  var name = tokens[0];
  var grade = decimal.Parse(tokens[1]);
  if (!grades.ContainsKey(name))
    grades[name] = new List<decimal>();
  grades[name].Add(grade);
}
// continues on next slide…
```

Make sure the list is initialized

Add the grade into the list

Solution: Average Student Grades

```
foreach (var (name, studentsGrades) in grades)
{
  var average = studentGrades.Average();
  Console.Write($"{name} -> ");
  foreach (var grade in studentGrades)
    Console.Write($"{grade:f2} ");
  Console.WriteLine($"(avg: {average:f2})");
}
```

Europe	{Bulgaria → Sofia}
	{France → Paris}
	{Germany → Berlin}
Asia	{China → Beijing}
	{India → New Delhi}
Africa	{Nigeria → Abuja}
	{Kenya → Nairobi}

Nested Dictionaries

Dictionaries Holding Other Dictionaries

Nested Dictionaries

- A dictionary may hold another **dictionary** as value
- Example: population by country and city

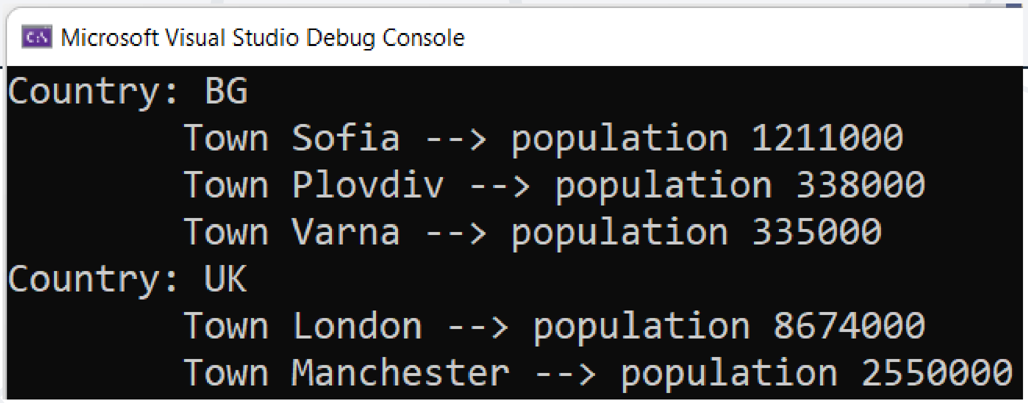
BG →	Sofia → 1,211,000 Plovdiv → 338,000 Varna → 335,000
UK →	London → 8,674,000 Manchester → 2,550,000
USA →	New York City → 8,406,000 Washington → 659,000

Nested Dictionaries: Initialization

```
var population = new Dictionary<string, Dictionary<string, int>> {
    {"BG",
        new Dictionary<string, int> {
            { "Sofia", 1_211_000 },
            { "Plovdiv", 338_000 },
            { "Varna", 335_000 },
        }
    },
    {"UK",
        new Dictionary<string, int> {
            { "London", 8_674_000 },
            { "Manchester", 2_550_000 },
        }
    }, …
};
```

Nested Dictionaries: Printing

```
foreach (var (countryName, towns) in population)
{
   Console.WriteLine("Country: " + countryName);
   foreach (var (townName, townPop) in towns)
      Console.WriteLine(
         $"\tTown {townName} --> population {townPop}");
}
```



Microsoft Visual Studio Debug Console

```
Country: BG
        Town Sofia --> population 1211000
        Town Plovdiv --> population 338000
        Town Varna --> population 335000
Country: UK
        Town London --> population 8674000
        Town Manchester --> population 2550000
```

Nested Dictionaries: Adding New Entry

```
AddPopulation("China", "Shanghai", 24_300_000);
AddPopulation("China", "Beijing", 18_800_000);
AddPopulation("China", "Shenzhen", 12_700_000);
AddPopulation("BG", "Stara Zagora", 250_000);

void AddPopulation(string country, string town, int townPop)
{
    if (! population.ContainsKey(country))
        population[country] = new Dictionary<string, int>();
    population[country][town] = townPop;
}
```

Problem: Product Shop

- Write a program to keep information about **food shops**
  - The input holds triples: **{shop, product, price}**
  - If you receive an existing {shop + product}, **replace the price**
- Your output must be **ordered by shop name**

```
lidl, juice, 2.30
kaufland, banana, 1.10
lidl, grape, 2.20
Revision
```

End command

```
kaufland->
Product: banana, Price: 1.1
lidl->
Product: juice, Price: 2.3
Product: grape, Price: 2.2
```

Check your solution here: https://judge.softuni.org/Contests/Practice/Index/1465#2

Solution: Product Shop

```
var shops = new Dictionary<string, Dictionary<string, double>>();
string line;
while ((line = Console.ReadLine()) != "Revision")
{
  string[] productsInfo = line.Split(", ");
  string shop = productsInfo[0];
  string product = productsInfo[1];
  double price = double.Parse(productsInfo[2]);
  // continues on next slide…
```

Solution: Product Shop

```
  if (!shops.ContainsKey(shop))
  {
    shops.Add(shop, new Dictionary<string, double>());
  }
  shops[shop].Add(product, price);
}
var orderedShops = shops.OrderBy(s => s.Key)
  .ToDictionary(x => x.Key, x => x.Value);
// TODO: Print the ordered dictionary
```

Make sure the inner dictionary is initialized

Problem: Cities by Continent and Country

- Write a program to read **continents**, **countries** and their **cities**, put them in a nested dictionary and print them

```
6
Europe Bulgaria Sofia
Asia China Beijing
Asia Japan Tokyo
Europe Poland Warsaw
Europe Germany Berlin
Europe Poland Poznan
```

```
Europe:
  Bulgaria -> Sofia
  Poland -> Warsaw, Poznan
  Germany -> Berlin
Asia:
  China -> Beijing
  Japan -> Tokyo
```

Check your solution here: https://judge.softuni.org/Contests/Practice/Index/1465#3

Solution: Cities by Continent and Country

```
var continentsData =
  new Dictionary<string, Dictionary<string, List<string>>>();
var n = int.Parse(Console.ReadLine());
for (int i = 0; i < n; i++) {
  var tokens = Console.ReadLine().Split();
  var continent = tokens[0];
  var country = tokens[1];
  var city = tokens[2];
  // continues on next slide…
```

Solution: Cities by Continent and Country

```
  if (!continentsData.ContainsKey(continent)) {
    continentsData[continent] = new Dictionary<string, List<string>>();
  }
  if (!continentsData[continent].ContainsKey(country)) {
    continentsData[continent][country] = new List<string>();
  }
  continentsData[continent][country].Add(city);
}
// continues on next slide…
```

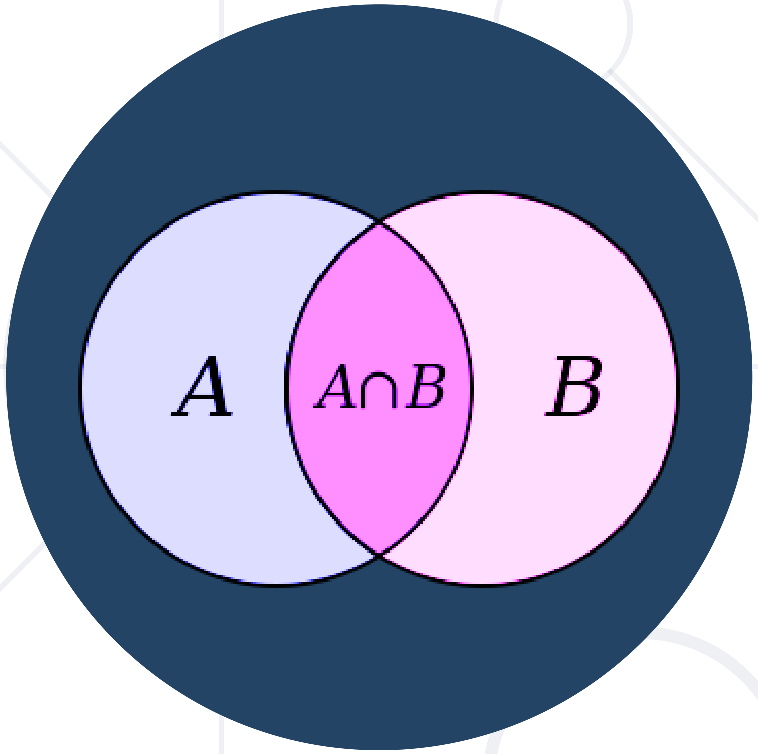
Initialize continent

Initialize cities

Append the city to the country

Solution: Cities by Continent and Country

```
foreach (var (continentName, countries) in continentsData)
{
  Console.WriteLine($"{continentName}:");
  foreach (var (countryName, cities) in countries)
  {
    // TODO: Print each country with its cities
  }
}
```



Set<T>

HashSet<T> and SortedSet<T>

Sets in C#

- A set keeps **unique elements**
  - Allows **add** / **remove** / **search** elements
  - Very **fast performance**
  - Example: Towns = {London, Tokyo, Paris, Rome}
- **HashSet<T>**
  - Keeps a set of elements in a **hash-table**
  - Elements are in **no particular order**
  - Similar to **List<T>**, but more efficient implementation

HashSet<T> – Example

```
HashSet<string> set = new HashSet<string>();
set.Add("Peter");
set.Add("Peter"); // Existing element → not added again
set.Add("George");
Console.WriteLine(string.Join(", ", set)); // Peter, George
Console.WriteLine(set.Contains("Maria")); // False
Console.WriteLine(set.Contains("Peter")); // True
set.Remove("Peter");
Console.WriteLine(set.Count); // 1
```

List<T> vs HashSet<T>

- List<T>
  - Fast "add", **slow** "search" and "remove" (pass through each element)
  - **Duplicates** are allowed
  - The insertion **order** is guaranteed

- HashSet<T>
  - **Fast** "add", "search" and "remove" thanks to **hash-table**
  - **No duplicates** are allowed
  - Does not guarantee the insertion **order**

Problem: Record Unique Names

- Read a sequence of names and print only the **unique ones**

```
8
Isabel
Patrick
Isabel
Steven
Patrick
Alice
Peter
Patrick
```

```
Isabel
Patrick
Steven
Alice
Peter
```

```
9
Lyle
Lyle
Bruce
Alice
Easton
Shawn
Alice
Shawn
Alice
```

```
Lyle
Bruce
Alice
Easton
Shawn
```

```
7
Roki
Roki
Roki
Roki
Roki
Roki
Roki
```

```
Roki
```

Check your solution here: https://judge.softuni.org/Contests/Practice/Index/1465#4

Solution: Record Unique Names

```
var names = new HashSet<string>();
var n = int.Parse(Console.ReadLine());
for (int i = 0; i < n; i++)
{
  var name = Console.ReadLine();
  names.Add(name);
}
foreach (var name in names)
  Console.WriteLine(name);
```

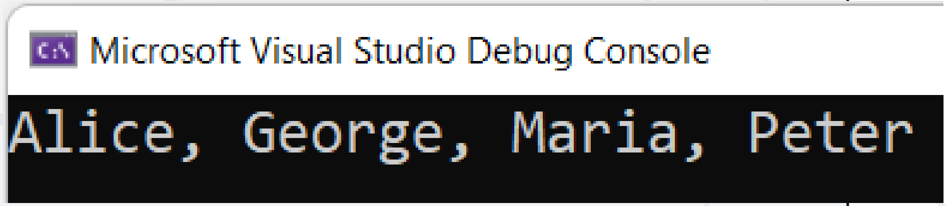
HashSet stores unique values

Adds non-existing names only

SortedSet<T>

- **SortedSet<T>**
  - The elements are **ordered incrementally**

```
var set = new SortedSet<string>();
set.Add("Peter");
set.Add("Peter");
set.Add("George");
set.Add("Maria");
set.Add("Alice");
Console.WriteLine(string.Join(", ", set));
```



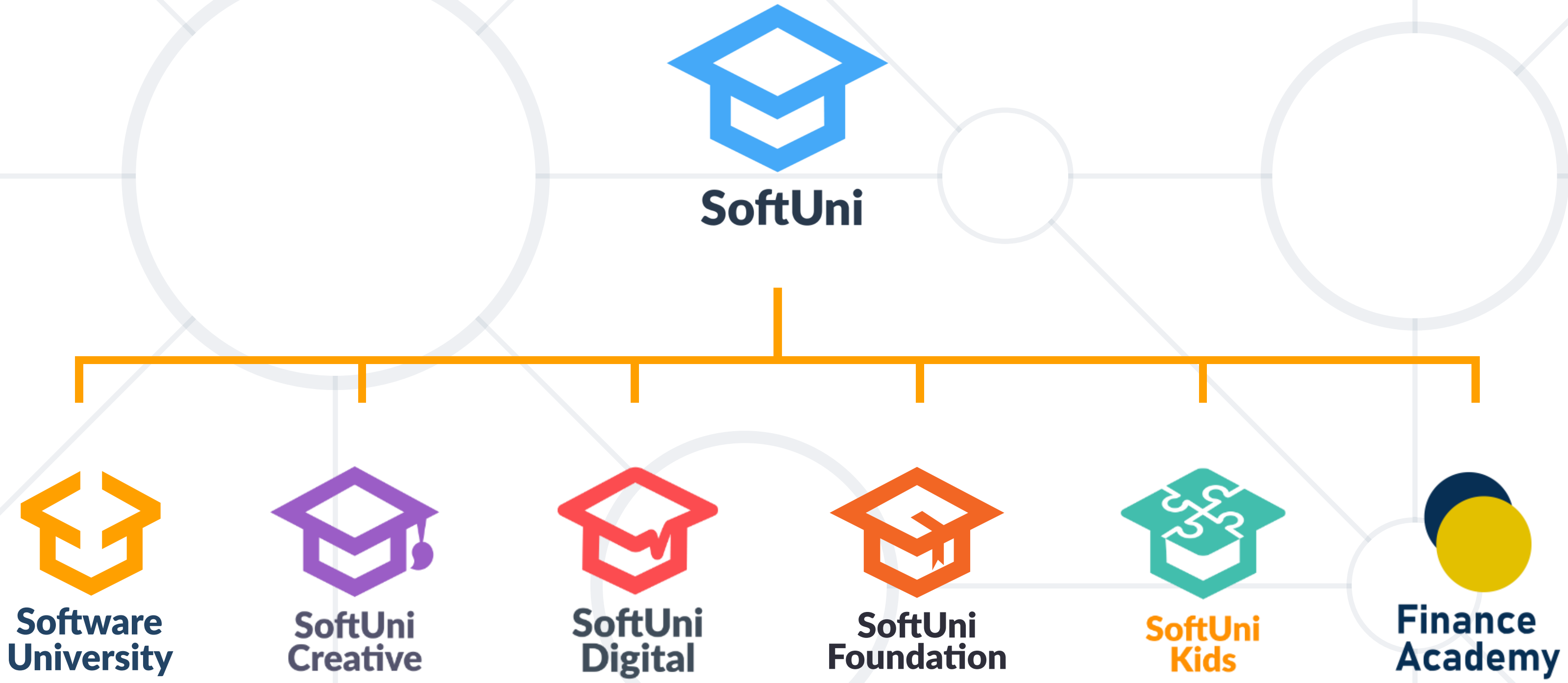
```
Alice, George, Maria, Peter
```

Summary

- Multi-dictionaries allow **keeping a collection** as a **dictionary value**
- Nested dictionaries **allow keeping a dictionary** as **dictionary value**
- Sets allow keeping **unique values** in **unspecified order**
  - No duplicates
  - Fast add, search & remove

Software University

Questions?



SoftUni Diamond Partners

Software University

SmartIT

Coca-Cola HBC Bulgaria

SOFTWARE GROUP

DXC TECHNOLOGY

createX

Postbank

Решения за твоето утре

SUPER HOSTING .BG

DRAFT KINGS

VIVACOM

INDEAVR

Serving the high achievers

AMBITIONED

PHAR VISION

Trainings @ Software University (SoftUni)

- Software University – High-Quality Education, Profession and Job for Software Developers
  - softuni.bg, about.softuni.bg
- Software University Foundation
  - softuni.foundation
- Software University @ Facebook
  - facebook.com/SoftwareUniversity
- Software University Forums
  - forum.softuni.bg

License