1.1 ./csharp/Platform.Collections/Arrays/ArrayFiller[TElement, TReturnConstant].cs

```
1  using System.Collections.Generic;
2  using System.Runtime.CompilerServices;
3
4  namespace Platform.Collections.Arrays
5  {
6      /// <summary>
7      /// <para>Represents <see cref="T:TElement[]"/> array filler with additional methods that
       ↪  return a given constant of type <typeparamref cref="TReturnConstant"/>.</para>
8      /// <para>Представляет заполнитель массива <see cref="T:TElement[]"/> с дополнительными
       ↪  методами, возвращающими заданную константу типа <typeparamref
       ↪  cref="TReturnConstant"/>.</para>
9      /// </summary>
10     /// <typeparam name="TElement"><para>The elements' type.</para><para>Тип элементов
       ↪  массива.</para></typeparam>
11     /// <typeparam name="TReturnConstant"><para>The return constant's type.</para><para>Тип
       ↪  возвращаемой константы.</para></typeparam>
12     public class ArrayFiller<TElement, TReturnConstant> : ArrayFiller<TElement>
13     {
14         protected readonly TReturnConstant _returnConstant;
15
16         /// <summary>
17         /// <para>Initializes a new instance of the <see cref="ArrayFiller"/> class using the
           ↪  specified array, the offset from which filling will start and the constant returned
           ↪  when elements are being filled.</para>
18         /// <para>Инициализирует новый экземпляр класса <see cref="ArrayFiller"/>, используя
           ↪  указанный массив, смещение с которого начнётся заполнение и константу возвращаемую
           ↪  при заполнении элементов.</para>
19         /// </summary>
20         /// <param name="array"><para>The array to fill.</para><para>Массив для
           ↪  заполнения.</para></param>
21         /// <param name="offset"><para>The offset from which to start the array
           ↪  filling.</para><para>Смещение с которого начнётся заполнение массива.</para></param>
22         /// <param name="returnConstant"><para>The constant's value.</para><para>Значение
           ↪  константы.</para></param>
23         [MethodImpl(MethodImplOptions.AggressiveInlining)]
24         public ArrayFiller(TElement[] array, long offset, TReturnConstant returnConstant) :
           ↪  base(array, offset) => _returnConstant = returnConstant;
25
26         /// <summary>
27         /// <para>Initializes a new instance of the <see cref="ArrayFiller"/> class using the
           ↪  specified array and the constant returned when elements are being filled. Filling
           ↪  will start from the beginning of the array.</para>
28         /// <para>Инициализирует новый экземпляр класса <see cref="ArrayFiller"/>, используя
           ↪  указанный массив и константу возвращаемую при заполнении элементов. Заполнение
           ↪  начнётся с начала массива.</para>
29         /// </summary>
30         /// <param name="array"><para>The array to fill.</para><para>Массив для
           ↪  заполнения.</para></param>
31         /// <param name="returnConstant"><para>The constant's value.</para><para>Значение
           ↪  константы.</para></param>
32         [MethodImpl(MethodImplOptions.AggressiveInlining)]
33         public ArrayFiller(TElement[] array, TReturnConstant returnConstant) : this(array, 0,
           ↪  returnConstant) { }
34
35         /// <summary>
36         /// <para>Adds an item into the array and returns the constant.</para>
37         /// <para>Добавляет элемент в массив и возвращает константу.</para>
38         /// </summary>
39         /// <param name="element"><para>The element to add.</para><para>Добавляемый
           ↪  элемент.</para></param>
40         /// <returns>
41         /// <para>The constant's value.</para>
42         /// <para>Значение константы.</para>
43         /// </returns>
44         [MethodImpl(MethodImplOptions.AggressiveInlining)]
45         public TReturnConstant AddAndReturnConstant(TElement element) =>
           ↪  _array.AddAndReturnConstant(ref _position, element, _returnConstant);
46
47         /// <summary>
48         /// <para>Adds the first element from the specified list to the filled array and returns
           ↪  the constant.</para>
49         /// <para>Добавляет первый элемент из указанного списка в заполняемый массив и
           ↪  возвращает константу.</para>
50         /// </summary>
```

```
        /// <param name="element"><para>The list from which the first item will be added.</para><para>Список из которого будет добавлен первый элемент.</para></param>
        /// <returns>
        /// <para>The constant's value.</para>
        /// <para>Значение константы.</para>
        /// <returns>
        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public TReturnConstant AddFirstAndReturnConstant(IList<TElement> elements) => _array.AddFirstAndReturnConstant(ref _position, elements, _returnConstant);

        /// <summary>
        /// <para>Adds all elements from the specified list to the filled array and returns the constant.</para>
        /// <para>Добавляет все элементы из указанного списка в заполняемый массив и возвращает константу.</para>
        /// </summary>
        /// <param name="elements"><para>The list of values to add.</para><para>Список значений для добавления.</para></param>
        /// <returns>
        /// <para>The constant's value.</para>
        /// <para>Значение константы.</para>
        /// <returns>
        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public TReturnConstant AddAllAndReturnConstant(IList<TElement> elements) => _array.AddAllAndReturnConstant(ref _position, elements, _returnConstant);

        /// <summary>
        /// <para>Adds the elements of the list to the array, skipping the first element and returns the constant.</para>
        /// <para>Добавляет элементы списка в массив пропуская первый элемент и возвращает константу.</para>
        /// </summary>
        /// <param name="elements"><para>The list of values to add.</para><para>Список значений для добавления.</para></param>
        /// <returns>
        /// <para>The constant's value.</para>
        /// <para>Значение константы.</para>
        /// </returns>
        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public TReturnConstant AddSkipFirstAndReturnConstant(IList<TElement> elements) => _array.AddSkipFirstAndReturnConstant(ref _position, elements, _returnConstant);
    }
}
```

1.2 ./csharp/Platform.Collections/Arrays/ArrayFiller[TElement].cs

```
using System.Collections.Generic;
using System.Runtime.CompilerServices;

namespace Platform.Collections.Arrays
{
    /// <summary>
    /// <para>Represents an <see cref="T:TElement[]"/> array filler.</para>
    /// <para>Представляет заполнитель массива <see cref="T:TElement[]"/>.</para>
    /// </summary>
    /// <typeparam name="TElement"><para>The elements' type.</para><para>Тип элементов массива.</para></typeparam>
    public class ArrayFiller<TElement>
    {
        protected readonly TElement[] _array;
        protected long _position;

        /// <summary>
        /// <para>Initializes a new instance of the <see cref="ArrayFiller"/> class using the specified array as the array to fill and the offset from which to start filling.</para></para>
        /// <para>Инициализирует новый экземпляр класса <see cref="ArrayFiller"/>, используя указанный массив в качестве заполняемого и смещение с которого начнётся заполнение.</para>
        /// </summary>
        /// <param name="array"><para>The array to fill.</para><para>Массив для заполнения.</para></param>
        /// <param name="offset"><para>The offset from which to start filling the array.</para><para>Смещение с которого начнётся заполнение массива.</para></param>
        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public ArrayFiller(TElement[] array, long offset)
        {
            _array = array;
```

```
26              _position = offset;
27          }
28
29          /// <summary>
30          /// <para>Initializes a new instance of the <see cref="ArrayFiller"/> class using the
            ↪  specified array. Filling will start from the beginning of the array.</para>
31          /// <para>Инициализирует новый экземпляр класса <see cref="ArrayFiller"/>, используя
            ↪  указанный массив. Заполнение начнётся с начала массива.</para>
32          /// </summary>
33          /// <param name="array"><para>The array to fill.</para><para>Массив для
            ↪  заполнения.</para></param>
34          [MethodImpl(MethodImplOptions.AggressiveInlining)]
35          public ArrayFiller(TElement[] array) : this(array, 0) { }
36
37          /// <summary>
38          /// <para>Adds an item into the array.</para>
39          /// <para>Добавляет элемент в массив.</para>
40          /// </summary>
41          /// <param name="element"><para>The element to add.</para><para>Добавляемый
            ↪  элемент.</para></param>
42          [MethodImpl(MethodImplOptions.AggressiveInlining)]
43          public void Add(TElement element) => _array[_position++] = element;
44
45          /// <summary>
46          /// <para>Adds an item into the array and returns <see langword="true"/>.</para>
47          /// <para>Добавляет элемент в массив и возвращает <see langword="true"/>.</para>
48          /// </summary>
49          /// <param name="element"><para>The element to add.</para><para>Добавляемый
            ↪  элемент.</para></param>
50          /// <returns>
51          /// <para>The <see langword="true"/> value.</para>
52          /// <para>Значение <see langword="true"/>.</para>
53          /// </returns>
54          [MethodImpl(MethodImplOptions.AggressiveInlining)]
55          public bool AddAndReturnTrue(TElement element) => _array.AddAndReturnConstant(ref
            ↪  _position, element, true);
56
57          /// <summary>
58          /// <para>Adds the first element from the specified list to the array to fill and
            ↪  returns <see langword="true"/>.</para>
59          /// <para>Добавляет первый элемент из указанного списка в заполняемый массив и
            ↪  возвращает <see langword="true"/>.</para>
60          /// </summary>
61          /// <param name="element"><para>The list from which the first item will be
            ↪  added.</para><para>Список из которого будет добавлен первый элемент.</para></param>
62          /// <returns>
63          /// <para>The <see langword="true"/> value.</para>
64          /// <para>Значение <see langword="true"/>.</para>
65          /// </returns>
66          [MethodImpl(MethodImplOptions.AggressiveInlining)]
67          public bool AddFirstAndReturnTrue(IList<TElement> elements) =>
            ↪  _array.AddFirstAndReturnConstant(ref _position, elements, true);
68
69          /// <summary>
70          /// <para>Adds all elements from the specified list to the array to fill and returns
            ↪  <see langword="true"/>.</para>
71          /// <para>Добавляет все элементы из указанного списка в заполняемый массив и возвращает
            ↪  <see langword="true"/>.</para>
72          /// </summary>
73          /// <param name="elements"><para>The list of values to add.</para><para>Список значений
            ↪  которые необходимо добавить.</para></param>
74          /// <returns>
75          /// <para>The <see langword="true"/> value.</para>
76          /// <para>Значение <see langword="true"/>.</para>
77          /// </returns>
78          [MethodImpl(MethodImplOptions.AggressiveInlining)]
79          public bool AddAllAndReturnTrue(IList<TElement> elements) =>
            ↪  _array.AddAllAndReturnConstant(ref _position, elements, true);
80
81          /// <summary>
82          /// <para>Adds values to the array skipping the first element and returns <see
            ↪  langword="true"/>.</para>
83          /// <para>Добавляет значения в массив пропуская первый элемент и возвращает <see
            ↪  langword="true"/>.</para>
84          /// </summary>
```

```
85          /// <param name="elements"><para>A list from which elements will be added except the
            ↪  first.</para><para>Список из которого будут добавлены элементы кроме
            ↪  первого.</para></param>
86          /// <returns>
87          /// <para>The <see langword="true"/> value.</para>
88          /// <para>Значение <see langword="true"/>.</para>
89          /// </returns>
90          [MethodImpl(MethodImplOptions.AggressiveInlining)]
91          public bool AddSkipFirstAndReturnTrue(IList<TElement> elements) =>
            ↪  _array.AddSkipFirstAndReturnConstant(ref _position, elements, true);
92      }
93  }
```

1.3 ./csharp/Platform.Collections/Arrays/ArrayPool.cs

```
1   using System.Runtime.CompilerServices;
2
3   namespace Platform.Collections.Arrays
4   {
5       /// <summary>
6       /// <para>Represents a set of wrapper methods over <see cref="ArrayPool{T}"/> class methods
        ↪  to simplify access to them.</para>
7       /// <para>Представляет набор методов обёрток над методами класса <see cref="ArrayPool{T}">
        ↪  для упрощения доступа к ним.</para>
8       /// </summary>
9       public static class ArrayPool
10      {
11          public static readonly int DefaultSizesAmount = 512;
12          public static readonly int DefaultMaxArraysPerSize = 32;
13
14          /// <summary>
15          /// <para>Allocation of an array of a specified size from the array pool.</para>
16          /// <para>Выделение массива указанного размера из пула массивов.</para>
17          /// </summary>
18          /// <typeparam name="T"><para>The array elements type.</para><para>Тип элементов
            ↪  массива.</para></typeparam>
19          /// <param name="size"><para>The allocated array size.</para><para>Размер выделяемого
            ↪  массива.</para></param>
20          /// <returns>
21          /// <para>The array from a pool of arrays.</para>
22          /// <para>Массив из пулла массивов.</para>
23          /// </returns>
24          [MethodImpl(MethodImplOptions.AggressiveInlining)]
25          public static T[] Allocate<T>(long size) => ArrayPool<T>.ThreadInstance.Allocate(size);
26
27          /// <summary>
28          /// <para>Freeing an array into an array pool.</para>
29          /// <para>Освобождение массива в пул массивов.</para>
30          /// </summary>
31          /// <typeparam name="T"><para>The array elements type.</para><para>Тип элементов
            ↪  массива.</para></typeparam>
32          /// <param name="array"><para>The array to be freed into the pull.</para><para>Массив
            ↪  который нужно освободить в пулл.</para></param>
33          [MethodImpl(MethodImplOptions.AggressiveInlining)]
34          public static void Free<T>(T[] array) => ArrayPool<T>.ThreadInstance.Free(array);
35      }
36  }
```

1.4 ./csharp/Platform.Collections/Arrays/ArrayPool[T].cs

```
1   using System;
2   using System.Collections.Generic;
3   using System.Runtime.CompilerServices;
4   using Platform.Disposables;
5   using Platform.Collections.Stacks;
6
7   namespace Platform.Collections.Arrays
8   {
9       /// <summary>
10      /// <para>Represents a set of arrays ready for reuse.</para>
11      /// <para>Представляет собой набор массивов готовых к повторному использованию.</para>
12      /// </summary>
13      /// <typeparam name="T"><para>The array elements type.</para><para>Тип элементов
        ↪  массива.</para></typeparam>
14      /// <remarks>
15      /// Original idea from
        ↪  http://geekswithblogs.net/blackrob/archive/2014/12/18/array-pooling-in-csharp.aspx
16      /// </remarks>
17      public class ArrayPool<T>
18      {
```

```
        // May be use Default class for that later.
        [ThreadStatic]
        private static ArrayPool<T> _threadInstance;
        internal static ArrayPool<T> ThreadInstance => _threadInstance ?? (_threadInstance = new ArrayPool<T>());

        private readonly int _maxArraysPerSize;
        private readonly Dictionary<long, Stack<T[]>> _pool = new Dictionary<long, Stack<T[]>>(ArrayPool.DefaultSizesAmount);

        /// <summary>
        /// <para>Initializes a new instance of the ArrayPool class using the specified maximum number of arrays per size.</para>
        /// <para>Инициализирует новый экземпляр класса ArrayPool, используя указанное максимальное количество массивов на каждый размер.</para>
        /// </summary>
        /// <param name="maxArraysPerSize"><para>The maximum number of arrays in the pool per size.</para><para>Максимальное количество массивов в пуле на каждый размер.</para></param>
        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public ArrayPool(int maxArraysPerSize) => _maxArraysPerSize = maxArraysPerSize;

        /// <summary>
        /// <para>Initializes a new instance of the ArrayPool class using the default maximum number of arrays per size.</para>
        /// <para>Инициализирует новый экземпляр класса ArrayPool, используя максимальное количество массивов на каждый размер по умолчанию.</para>
        /// </summary>
        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public ArrayPool() : this(ArrayPool.DefaultMaxArraysPerSize) { }

        /// <summary>
        /// <para>Retrieves an array from the pool, which will automatically return to the pool when the container is disposed.</para>
        /// <para>Извлекает из пула массив, который автоматически вернётся в пул при высвобождении контейнера.</para>
        /// </summary>
        /// <param name="size"><para>The allocated array size.</para><para>Размер выделяемого массива.</para></param>
        /// <returns>
        /// <para>The disposable container containing either a new array or an array from the pool.</para>
        /// <para>Высвобождаемый контейнер содержащий либо новый массив, либо массив из пула.</para>
        /// </returns>
        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public Disposable<T[]> AllocateDisposable(long size) => (Allocate(size), Free);

        /// <summary>
        /// <para>Replaces the array with another array from the pool with the specified size.</para>
        /// <para>Заменяет массив на другой массив из пула с указанным размером.</para>
        /// </summary>
        /// <param name="source"><para>The source array.</para><para>Исходный массив.</para></param>
        /// <param name="size"><para>A new array size.</para><para>Новый размер массива.</para></param>
        /// <returns>
        /// <para>An array with a new size.</para>
        /// <para>Массив с новым размером.</para>
        /// </returns>
        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public Disposable<T[]> Resize(Disposable<T[]> source, long size)
        {
            var destination = AllocateDisposable(size);
            T[] sourceArray = source;
            if (!sourceArray.IsNullOrEmpty())
            {
                T[] destinationArray = destination;
                Array.Copy(sourceArray, destinationArray, size < sourceArray.LongLength ? size : sourceArray.LongLength);
                source.Dispose();
            }
            return destination;
        }

        /// <summary>
```

```
79          /// <para>Clears the pool.</para>
80          /// <para>Очищает пул.</para>
81          /// </summary>
82          [MethodImpl(MethodImplOptions.AggressiveInlining)]
83          public virtual void Clear() => _pool.Clear();
84
85          /// <summary>
86          /// <para>Retrieves an array with the specified size from the pool.</para>
87          /// <para>Извлекает из пула массив с указанным размером.</para>
88          /// </summary>
89          /// <param name="size"><para>The allocated array size.</para><para>Размер выделяемого
            ↪  массива.</para></param>
90          /// <returns>
91          /// <para>An array from the pool or a new array.</para>
92          /// <para>Массив из пула или новый массив.</para>
93          /// </returns>
94          [MethodImpl(MethodImplOptions.AggressiveInlining)]
95          public virtual T[] Allocate(long size) => size <= 0L ? Array.Empty<T>() :
            ↪  _pool.GetOrDefault(size)?.PopOrDefault() ?? new T[size];
96
97          /// <summary>
98          /// <para>Frees the array to the pool for later reuse.</para>
99          /// <para>Освобождает массив в пул для последующего повторного использования.</para>
100         /// </summary>
101         /// <param name="array"><para>The array to be freed into the pool.</para><para>Массив
            ↪  который нужно освободить в пул.</para></param>
102         [MethodImpl(MethodImplOptions.AggressiveInlining)]
103         public virtual void Free(T[] array)
104         {
105             if (array.IsNullOrEmpty())
106             {
107                 return;
108             }
109             var stack = _pool.GetOrAdd(array.LongLength, size => new
                ↪  Stack<T[]>(_maxArraysPerSize));
110             if (stack.Count == _maxArraysPerSize) // Stack is full
111             {
112                 return;
113             }
114             stack.Push(array);
115         }
116     }
117 }
```

1.5 ./csharp/Platform.Collections/Arrays/ArrayString.cs

```
1  using System.Runtime.CompilerServices;
2  using Platform.Collections.Segments;
3
4  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
5
6  namespace Platform.Collections.Arrays
7  {
8      public class ArrayString<T> : Segment<T>
9      {
10         [MethodImpl(MethodImplOptions.AggressiveInlining)]
11         public ArrayString(int length) : base(new T[length], 0, length) { }
12
13         [MethodImpl(MethodImplOptions.AggressiveInlining)]
14         public ArrayString(T[] array) : base(array, 0, array.Length) { }
15
16         [MethodImpl(MethodImplOptions.AggressiveInlining)]
17         public ArrayString(T[] array, int length) : base(array, 0, length) { }
18     }
19 }
```

1.6 ./csharp/Platform.Collections/Arrays/CharArrayExtensions.cs

```
1  using System.Runtime.CompilerServices;
2
3  namespace Platform.Collections.Arrays
4  {
5      public static unsafe class CharArrayExtensions
6      {
7          /// <summary>
8          /// <para>Generates a hash code for an array segment with the specified offset and
               ↪  length. The hash code is generated based on the values of the array elements
               ↪  included in the specified segment.</para>
9          /// <para>Генерирует хэш-код сегмента массива с указанным смещением и длиной. Хэш-код
               ↪  генерируется на основе значений элементов массива входящих в указанный
               ↪  сегмент.</para>
```

```
        /// </summary>
        /// <param name="array"><para>The array to hash.</para><para>Массив для
        ↪  хеширования.</para></param>
        /// <param name="offset"><para>The offset from which reading of the specified number of
        ↪  elements in the array starts.</para><para>Смещение, с которого начинается чтение
        ↪  указанного количества элементов в массиве.</para></param>
        /// <param name="length"><para>The number of array elements used to calculate the
        ↪  hash.</para><para>Количество элементов массива, на основе которых будет вычислен
        ↪  хэш.</para></param>
        /// <returns>
        /// <para>The hash code of the segment in the array.</para>
        /// <para>Хэш-код сегмента в массиве.</para>
        /// </returns>
        /// <remarks>
        /// Based on https://github.com/Microsoft/referencesource/blob/3b1eaf5203992df69de44c783
        ↪  a3eda37d3d4cd10/mscorlib/system/string.cs#L833
        /// </remarks>
        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public static int GenerateHashCode(this char[] array, int offset, int length)
        {
            var hashSeed = 5381;
            var hashAccumulator = hashSeed;
            fixed (char* arrayPointer = &array[offset])
            {
                for (char* charPointer = arrayPointer, last = charPointer + length; charPointer
                ↪  < last; charPointer++)
                {
                    hashAccumulator = (hashAccumulator << 5) + hashAccumulator ^ *charPointer;
                }
            }
            return hashAccumulator + (hashSeed * 1566083941);
        }

        /// <summary>
        /// <para>Checks if all elements of two lists are equal.</para>
        /// <para>Проверяет равны ли все элементы двух списков.</para>
        /// </summary>
        /// <param name="left"><para>The first compared array.</para><para>Первый массив для
        ↪  сравнения.</para></param>
        /// <param name="leftOffset"><para>The offset from which reading of the specified number
        ↪  of elements in the first array starts.</para><para>Смещение, с которого начинается
        ↪  чтение элементов в первом массиве.</para></param>
        /// <param name="length"><para>The number of checked elements.</para><para>Количество
        ↪  проверяемых элементов.</para></param>
        /// <param name="right"><para>The second compared array.</para><para>Второй массив для
        ↪  сравнения.</para></param>
        /// <param name="rightOffset"><para>The offset from which reading of the specified
        ↪  number of elements in the second array starts.</para><para>Смещение, с которого
        ↪  начинается чтение элементов в втором массиве.</para></param>
        /// <returns>
        /// <para><see langword="true"/> if the segments of the passed arrays are equal to each
        ↪  other otherwise <see langword="false"/>.</para>
        /// <para><see langword="true"/>, если сегменты переданных массивов равны друг другу,
        ↪  иначе же <see langword="false"/>.</para>
        /// </returns>
        /// <remarks>
        /// Based on https://github.com/Microsoft/referencesource/blob/3b1eaf5203992df69de44c783
        ↪  a3eda37d3d4cd10/mscorlib/system/string.cs#L364
        /// </remarks>
        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public static bool ContentEqualTo(this char[] left, int leftOffset, int length, char[]
        ↪  right, int rightOffset)
        {
            fixed (char* leftPointer = &left[leftOffset])
            {
                fixed (char* rightPointer = &right[rightOffset])
                {
                    char* leftPointerCopy = leftPointer, rightPointerCopy = rightPointer;
                    if (!CheckArraysMainPartForEquality(ref leftPointerCopy, ref
                    ↪  rightPointerCopy, ref length))
                    {
                        return false;
                    }
                    CheckArraysRemainderForEquality(ref leftPointerCopy, ref rightPointerCopy,
                    ↪  ref length);
                    return length <= 0;
```

```
                }
            }
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        private static bool CheckArraysMainPartForEquality(ref char* left, ref char* right, ref int length)
        {
            while (length >= 10)
            {
                if ((*(int*)left != *(int*)right)
                 || (*(int*)(left + 2) != *(int*)(right + 2))
                 || (*(int*)(left + 4) != *(int*)(right + 4))
                 || (*(int*)(left + 6) != *(int*)(right + 6))
                 || (*(int*)(left + 8) != *(int*)(right + 8)))
                {
                    return false;
                }
                left += 10;
                right += 10;
                length -= 10;
            }
            return true;
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        private static void CheckArraysRemainderForEquality(ref char* left, ref char* right, ref int length)
        {
            // This depends on the fact that the String objects are
            // always zero terminated and that the terminating zero is not included
            // in the length. For odd string sizes, the last compare will include
            // the zero terminator.
            while (length > 0)
            {
                if (*(int*)left != *(int*)right)
                {
                    break;
                }
                left += 2;
                right += 2;
                length -= 2;
            }
        }
    }
}
```

1.7 ./csharp/Platform.Collections/Arrays/GenericArrayExtensions.cs

```
using System;
using System.Collections.Generic;
using System.Runtime.CompilerServices;

namespace Platform.Collections.Arrays
{
    /// <summary>
    /// <para>Represents a set of extension methods for a <see cref="T:T[]"/> array.</para>
    /// <para>Представляет набор методов расширения для массива <see cref="T:T[]"/>.</para>
    /// </summary>
    public static class GenericArrayExtensions
    {
        /// <summary>
        /// <para>Checks if an array exists, if so,  checks the array length using the  index variable type int, and if the array length is greater than the index - return array[index], otherwise - default value.</para>
        /// <para>Проверяет, существует ли массив, если да - идет проверка длины массива с помощью переменной index, и если длина массива больше индекса - возвращает array[index], иначе - значение по умолчанию.</para>
        /// </summary>
        /// <typeparam name="T"><para>Array elements type.</para><para>Тип элементов массива.</para></typeparam>
        /// <param name="array"><para>Array that will participate in verification.</para><para>Массив который будет учавствовать в проверке.</para></param>
        /// <param name="index"><para>Number type int to compare.</para><para>Число типа int для сравнения.</para></param>
        /// <returns><para>Array element or default value.</para><para>Элемент массива или же значение по умолчанию.</para></returns>
        [MethodImpl(MethodImplOptions.AggressiveInlining)]
```

```
22          public static T GetElementOrDefault<T>(this T[] array, int index) => array != null &&
            ↪  array.Length > index ? array[index] : default;
23
24          /// <summary>
25          /// <para>Checks whether the array exists, if so, checks the array length using the
            ↪  index variable type long, and if the array length is greater than the index - return
            ↪  array[index], otherwise - default value.</para>
26          /// <para>Проверяет, существует ли массив, если да - идет проверка длины массива с
            ↪  помощью переменной index, и если длина массива больше индекса - возвращает
            ↪  array[index], иначе - значение по умолчанию.</para>
27          /// </summary>
28          /// <typeparam name="T"><para>Array elements type.</para><para>Тип элементов
            ↪  массива.</para></typeparam>
29          /// <param name="array"><para>Array that will participate in
            ↪  verification.</para><para>Массив который будет учавствовать в
            ↪  проверке.</para></param>
30          /// <param name="index"><para>Number type long to compare.</para><para>Число типа long
            ↪  для сравнения.</para></param>
31          /// <returns><para>Array element or default value.</para><para>Элемент массива или же
            ↪  значение по умолчанию.</para></returns>
32          [MethodImpl(MethodImplOptions.AggressiveInlining)]
33          public static T GetElementOrDefault<T>(this T[] array, long index) => array != null &&
            ↪  array.LongLength > index ? array[index] : default;
34
35          /// <summary>
36          /// <para>Checks whether the array exist, if so, checks the array length using the index
            ↪  varible type int, and if the array length is greater than the index, set the element
            ↪  variable to array[index] and return <see langword="true"/>.</para>
37          /// <para>Проверяет, существует ли массив, если да, то  идет проверка  длины массива с
            ↪  помощью переменной index  типа int, и если длина массива больше значения index,
            ↪  устанавливает значение переменной element - array[index] и возвращает <see
            ↪  langword="true"/>.</para>
38          /// </summary>
39          /// <typeparam name="T"><para>Array elements type.</para><para>Тип элементов
            ↪  массива.</para></typeparam>
40          /// <param name="array"><para>Array that will participate in
            ↪  verification.</para><para>Массив который будет учавствовать в
            ↪  проверке.</para></param>
41          /// <param name="index"><para>Number type int to compare.</para><para>Число типа int для
            ↪  сравнения.</para></param>
42          /// <param name="element"><para>Passing the argument by reference, if successful, it
            ↪  will take the value array[index] otherwise default value.</para><para>Передает
            ↪  аргумент по ссылке, в случае успеха он примет значение array[index] в противном
            ↪  случае значение по умолчанию.</para></param>
43          /// <returns><para><see langword="true"/> if successful otherwise <see
            ↪  langword="false"/>.</para><para><see langword="true"/> в случае успеха, в противном
            ↪  случае <see langword="false"/>.</para></returns>
44          [MethodImpl(MethodImplOptions.AggressiveInlining)]
45          public static bool TryGetElement<T>(this T[] array, int index, out T element)
46          {
47              if (array != null && array.Length > index)
48              {
49                  element = array[index];
50                  return true;
51              }
52              else
53              {
54                  element = default;
55                  return false;
56              }
57          }
58
59          /// <summary>
60          /// <para>Checks whether the array exist, if so,  checks the array length using the
            ↪  index varible type long, and if the array length is greater than the index,  set the
            ↪  element variable to array[index] and return <see langword="true"/>.</para>
61          /// <para>Проверяет, существует ли массив, если да, то идет проверка длины массива с
            ↪  помощью переменной index  типа long, и если длина массива больше значения index,
            ↪  устанавливает значение переменной element - array[index] и возвращает <see
            ↪  langword="true"/>.</para>
62          /// </summary>
63          /// <typeparam name="T"><para>Array elements type.</para><para>Тип элементов
            ↪  массива.</para></typeparam>
64          /// <param name="array"><para>Array that will participate in
            ↪  verification.</para><para>Массив который будет учавствовать в
            ↪  проверке.</para></param>
```

```
65          /// <param name="index"><para>Number type long to compare.</para><para>Число типа long
            ↪ для сравнения.</para></param>
66          /// <param name="element"><para>Passing the argument by reference, if successful, it
            ↪ will take the value array[index] otherwise default value.</para><para>Передает
            ↪ аргумент по ссылке, в случае успеха он примет значение array[index] в противном
            ↪ случае значение по умолчанию.</para></param>
67          /// <returns><para><see langword="true"/> if successful otherwise <see
            ↪ langword="false"/>.</para><para><see langword="true"/> в случае успеха, в противном
            ↪ случае <see langword="false"/></para></returns>
68          [MethodImpl(MethodImplOptions.AggressiveInlining)]
69          public static bool TryGetElement<T>(this T[] array, long index, out T element)
70          {
71              if (array != null && array.LongLength > index)
72              {
73                  element = array[index];
74                  return true;
75              }
76              else
77              {
78                  element = default;
79                  return false;
80              }
81          }
82
83          /// <summary>
84          /// <para>Copying of elements from one array to another array.</para>
85          /// <para>Копирует элементы из одного массива в другой массив.</para>
86          /// </summary>
87          /// <typeparam name="T"><para>Array elements type.</para><para>Тип элементов
            ↪ массива.</para></typeparam>
88          /// <param name="array"><para>The array  to copy.</para><para>Массив который необходимо
            ↪ скопировать.</para></param>
89          /// <returns><para>Copy of the array.</para><para>Копию массива.</para></returns>
90          [MethodImpl(MethodImplOptions.AggressiveInlining)]
91          public static T[] Clone<T>(this T[] array)
92          {
93              var copy = new T[array.LongLength];
94              Array.Copy(array, 0L, copy, 0L, array.LongLength);
95              return copy;
96          }
97
98          /// <summary>
99          /// <para>Shifts all the elements of the array by one position to the right.</para>
100         /// <para>Сдвигает вправо все элементы массива на одну позицию.</para>
101         /// </summary>
102         /// <typeparam name="T"><para>The array item type.</para><para>Тип элементов
            ↪ массива.</para></typeparam>
103         /// <param name="array"><para>The array to copy from.</para><para>Массив для
            ↪ копирования.</para></param>
104         /// <returns>
105         /// <para>Array with a shift of elements by one position.</para>
106         /// <para>Массив со сдвигом элементов на одну позицию.</para>
107         /// </returns>
108         [MethodImpl(MethodImplOptions.AggressiveInlining)]
109         public static IList<T> ShiftRight<T>(this T[] array) => array.ShiftRight(1L);
110
111         /// <summary>
112         /// <para>Shifts all elements of the array to the right by the specified number of
            ↪ elements.</para>
113         /// <para>Сдвигает вправо все элементы массива на указанное количество элементов.</para>
114         /// </summary>
115         /// <typeparam name="T"><para>The array item type.</para><para>Тип элементов
            ↪ массива.</para></typeparam>
116         /// <param name="array"><para>The array to copy from.</para><para>Массив для
            ↪ копирования.</para></param>
117         /// <param name="skip"><para>The number of items to shift.</para><para>Количество
            ↪ сдвигаемых элементов.</para></param>
118         /// <returns>
119         /// <para>If the value of the shift variable is less than zero - an <see
            ↪ cref="NotImplementedException"/> exception is thrown, but if the value of the shift
            ↪ variable is 0 - an exact copy of the array is returned. Otherwise, an array is
            ↪ returned with the shift of the elements.</para>
120         /// <para>Если значение переменной shift меньше нуля - выбрасывается исключение <see
            ↪ cref="NotImplementedException"/>, если же значение переменной shift равно 0 -
            ↪ возвращается точная копия массива. Иначе возвращается массив со сдвигом
            ↪ элементов.</para>
121         /// </returns>
```

```
122         [MethodImpl(MethodImplOptions.AggressiveInlining)]
123         public static IList<T> ShiftRight<T>(this T[] array, long shift)
124         {
125             if (shift < 0)
126             {
127                 throw new NotImplementedException();
128             }
129             if (shift == 0)
130             {
131                 return array.Clone<T>();
132             }
133             else
134             {
135                 var restrictions = new T[array.LongLength + shift];
136                 Array.Copy(array, 0L, restrictions, shift, array.LongLength);
137                 return restrictions;
138             }
139         }
140 
141         /// <summary>
142         /// <para>Adding in array the passed element at the specified position and increments
            ↪  position value by one.</para>
143         /// <para>Добавляет в массив переданный элемент на указанную позицию и увеличивает
            ↪  значение position на единицу.</para>
144         /// </summary>
145         /// <typeparam name="T"><para>Array elements type.</para>Тип элементов
            ↪  массива.<para></typeparam>
146         /// <param name="array"><para>The array to add the element to.</para><para>Массив в
            ↪  который необходимо добавить элемент.</para></param>
147         /// <param name="position"><para>A reference to the position of type int where the
            ↪  element will be added.</para><para>Ссылка на позицию типа int, в которую будет
            ↪  добавлен элемент.</para></param>
148         /// <param name="element"><para>The element to add to the array.</para><para>Элемент,
            ↪  который нужно добавить в массив.</para></param>
149         [MethodImpl(MethodImplOptions.AggressiveInlining)]
150         public static void Add<T>(this T[] array, ref int position, T element) =>
            ↪  array[position++] = element;
151 
152         /// <summary>
153         /// <para>Adding in array the passed element at the specified position and increments
            ↪  position value by one.</para>
154         /// <para>Добавляет в массив переданный элемент на указанную позицию и увеличивает
            ↪  значение position на единицу.</para>
155         /// </summary>
156         /// <typeparam name="T"><para>Array elements type.</para>Тип элементов
            ↪  массива.<para></typeparam>
157         /// <param name="array"><para>The array to add the element to.</para><para>Массив в
            ↪  который необходимо добавить элемент.</para></param>
158         /// <param name="position"><para>A reference to the position of type long where the
            ↪  element will be added.</para><para>Ссылка на позицию типа long, в которую будет
            ↪  добавлен элемент.</para></param>
159         /// <param name="element"><para>The element to add to the array</para><para>Элемент
            ↪  который необходимо добавить в массив.</para></param>
160         [MethodImpl(MethodImplOptions.AggressiveInlining)]
161         public static void Add<T>(this T[] array, ref long position, T element) =>
            ↪  array[position++] = element;
162 
163         /// <summary>
164         /// <para>Adding in array the passed element, at the specified position, increments
            ↪  position value by one and returns the value of the passed constant.</para>
165         /// <para>Добавляет в массив переданный элемент на указанную позицию, увеличивает
            ↪  значение position на единицу и возвращает значение переданной константы.</para>
166         /// </summary>
167         /// <typeparam name="TElement"><para>The array element type.</para><para>Тип элемента
            ↪  массива.</para></typeparam>
168         /// <typeparam name="TReturnConstant"><para>Type of return constant.</para><para>Тип
            ↪  возвращаемой константы.</para></typeparam>
169         /// <param name="array"><para>The array to add the element to.</para><para>Массив в
            ↪  который необходимо добавить элемент.</para></param>
170         /// <param name="position"><para>Reference to the position to which the element will be
            ↪  added.</para><para>Ссылка на позицию, в которую будет добавлен
            ↪  элемент.</para></param>
171         /// <param name="element"><para>The element to add to the array.</para><para>Элемент
            ↪  который необходимо добавить в массив.</para></param>
172         /// <param name="returnConstant"><para>The constant value that will be
            ↪  returned.</para><para>Значение константы, которое будет возвращено.</para></param>
```

```
173         /// <returns>
174         /// <para>The constant value passed as an argument.</para>
175         /// <para>Значение константы, переданное в качестве аргумента.</para>
176         /// </returns>
177         [MethodImpl(MethodImplOptions.AggressiveInlining)]
178         public static TReturnConstant AddAndReturnConstant<TElement, TReturnConstant>(this
            ↪ TElement[] array, ref long position, TElement element, TReturnConstant
            ↪ returnConstant)
179         {
180             array.Add(ref position, element);
181             return returnConstant;
182         }
183 
184         /// <summary>
185         /// <para>Adds the first element from the passed collection to the array, at the
            ↪ specified position and increments position value by one.</para>
186         /// <para>Добавляет в массив первый элемент из переданной коллекции, на указанную
            ↪ позицию и увеличивает значение position на единицу.</para>
187         /// </summary>
188         /// <typeparam name="T"><para>Array element type.</para><para>Тип элементов
            ↪ массива.</para></typeparam>
189         /// <param name="array"><para>The array to add the element to.</para><para>Массив в
            ↪ который необходимо добавить элемент.</para></param>
190         /// <param name="position"><para>Reference to the position to which the element will be
            ↪ added.</para><para>Ссылка на позицию, в которую будет добавлен
            ↪ элемент.</para></param>
191         /// <param name="elements"><para>List, the first element of which will be added to the
            ↪ array.</para><para>Список, первый элемент которого будет добавлен в
            ↪ массив.</para></param>
192         [MethodImpl(MethodImplOptions.AggressiveInlining)]
193         public static void AddFirst<T>(this T[] array, ref long position, IList<T> elements) =>
            ↪ array[position++] = elements[0];
194 
195         /// <summary>
196         /// <para>Adds the first element from the passed collection to the array, at the
            ↪ specified position, increments position value by one and returns the value of the
            ↪ passed constant.</para>
197         /// <para>Добавляет в массив первый элемент из переданной коллекции, на указанную
            ↪ позицию, увеличивает значение position на единицу и возвращает значение переданной
            ↪ константы.</para>
198         /// </summary>
199         /// <typeparam name="TElement"><para>The array element type.</para><para>Тип элемента
            ↪ массива.</para></typeparam>
200         /// <typeparam name="TReturnConstant"><para>Type of return constant.</para><para>Тип
            ↪ возвращаемой константы.</para></typeparam>
201         /// <param name="array"><para>The array to add the element to.</para><para>Массив в
            ↪ который необходимо добавить элемент.</para></param>
202         /// <param name="position"><para>Reference to the position to which the element will be
            ↪ added.</para><para>Ссылка на позицию, в которую будет добавлен
            ↪ элемент.</para></param>
203         /// <param name="elements"><para>List, the first element of which will be added to the
            ↪ array.</para><para>Список, первый элемент которого будет добавлен в
            ↪ массив.</para></param>
204         /// <param name="returnConstant"><para>The constant value that will be
            ↪ returned.</para><para>Значение константы, которое будет возвращено.</para></param>
205         /// <returns>
206         /// <para>The constant value passed as an argument.</para>
207         /// <para>Значение константы, переданное в качестве аргумента.</para>
208         /// </returns>
209         [MethodImpl(MethodImplOptions.AggressiveInlining)]
210         public static TReturnConstant AddFirstAndReturnConstant<TElement, TReturnConstant>(this
            ↪ TElement[] array, ref long position, IList<TElement> elements, TReturnConstant
            ↪ returnConstant)
211         {
212             array.AddFirst(ref position, elements);
213             return returnConstant;
214         }
215 
216         /// <summary>
217         /// <para>Adding in array all elements from the passed collection, at the specified
            ↪ position, increases the position value by the number of elements added and returns
            ↪ the value of the passed constant.</para>
218         /// <para>Добавляет в массив все элементы из переданной коллекции, на указанную позицию,
            ↪ увеличивает значение position на количество добавленных элементов и возвращает
            ↪ значение переданной константы.</para>
219         /// </summary>
```

```
220         /// <typeparam name="TElement"><para>The array element type.</para><para>Тип элемента
            ↪ массива.</para></typeparam>
221         /// <typeparam name="TReturnConstant"><para>Type of return constant.</para><para>Тип
            ↪ возвращаемой константы.</para></typeparam>
222         /// <param name="array"><para>The array to add the element to.</para><para>Массив в
            ↪ который необходимо добавить элементы.</para></param>
223         /// <param name="position"><para>Reference to the position from which elements will be
            ↪ added to the array.</para><para>Ссылка на позицию, начиная с которой будут
            ↪ добавляться элементы в массив.</para></param>
224         /// <param name="elements"><para>List, whose elements will be added to the
            ↪ array.</para><para>Список, элементы которого будут добавленны в
            ↪ массив.</para></param>
225         /// <param name="returnConstant"><para>The constant value that will be
            ↪ returned.</para><para>Значение константы, которое будет возвращено.</para></param>
226         /// <returns>
227         /// <para>The constant value passed as an argument.</para>
228         /// <para>Значение константы, переданное в качестве аргумента.</para>
229         /// </returns>
230         [MethodImpl(MethodImplOptions.AggressiveInlining)]
231         public static TReturnConstant AddAllAndReturnConstant<TElement, TReturnConstant>(this
            ↪ TElement[] array, ref long position, IList<TElement> elements, TReturnConstant
            ↪ returnConstant)
232         {
233             array.AddAll(ref position, elements);
234             return returnConstant;
235         }
236
237         /// <summary>
238         /// <para>Adding in array a collection of elements, starting from a specific position
            ↪ and increases the position value by the number of elements added.</para>
239         /// <para>Добавляет в массив все элементы коллекции, начиная с определенной позиции и
            ↪ увеличивает значение position на количество добавленных элементов.</para>
240         /// </summary>
241         /// <typeparam name="T"><para>Array elements type.</para><para>Тип элементов
            ↪ массива.</para></typeparam>
242         /// <param name="array"><para>The array to add the element to.</para><para>Массив в
            ↪ который необходимо добавить элементы.</para></param>
243         /// <param name="position"><para>Reference to the position from which elements will be
            ↪ added to the array.</para><para>Ссылка на позицию, начиная с которой будут
            ↪ добавляться элементы в массив.</para></param>
244         /// <param name="elements"><para>List, whose elements will be added to the
            ↪ array.</para><para>Список, элементы которого будут добавленны в
            ↪ массив.</para></param>
245         [MethodImpl(MethodImplOptions.AggressiveInlining)]
246         public static void AddAll<T>(this T[] array, ref long position, IList<T> elements)
247         {
248             for (var i = 0; i < elements.Count; i++)
249             {
250                 array.Add(ref position, elements[i]);
251             }
252         }
253
254         /// <summary>
255         /// <para>Adding in array all elements of the collection, skipping the first position,
            ↪ increments position value by one and returns the value of the passed constant.</para>
256         /// <para>Добавляет в массив все элементы коллекции, пропуская первую позицию,
            ↪ увеличивает значение position на единицу и возвращает значение переданной
            ↪ константы.</para>
257         /// </summary>
258         /// <typeparam name="TElement"><para>The array element type.</para><para>Тип элемента
            ↪ массива.</para></typeparam>
259         /// <typeparam name="TReturnConstant"><para>Type of return constant.</para><para>Тип
            ↪ возвращаемой константы.</para></typeparam>
260         /// <param name="array"><para>The array to add items to.</para><para>Массив в который
            ↪ необходимо добавить элементы.</para></param>
261         /// <param name="position"><para>Reference to the position from which to start adding
            ↪ elements.</para><para>Ссылка на позицию, с которой начинается добавление
            ↪ элементов.</para></param>
262         /// <param name="elements"><para>List, whose elements will be added to the
            ↪ array.</para><para>Список, элементы которого будут добавленны в
            ↪ массив.</para></param>
263         /// <param name="returnConstant"><para>The constant value that will be
            ↪ returned.</para><para>Значение константы, которое будет возвращено.</para></param>
264         /// <returns>
265         /// <para>The constant value passed as an argument.</para>
```

```
266         /// <para>Значение константы, переданное в качестве аргумента.</para>
267         /// </returns>
268         [MethodImpl(MethodImplOptions.AggressiveInlining)]
269         public static TReturnConstant AddSkipFirstAndReturnConstant<TElement,
            ↪ TReturnConstant>(this TElement[] array, ref long position, IList<TElement> elements,
            ↪ TReturnConstant returnConstant)
270         {
271             array.AddSkipFirst(ref position, elements);
272             return returnConstant;
273         }
274 
275         /// <summary>
276         /// <para>Adding in array all elements of the collection, skipping the first position
            ↪ and increments position value by one.</para>
277         /// <para>Добавляет в массив все элементы коллекции, пропуская первую позицию и
            ↪ увеличивает значение position на единицу.</para>
278         /// </summary>
279         /// <typeparam name="T"><para>Array elements type.</para><para>Тип элементов
            ↪ массива.</para></typeparam>
280         /// <param name="array"><para>The array to add items to.</para><para>Массив в который
            ↪ необходимо добавить элементы.</para></param>
281         /// <param name="position"><para>Reference to the position from which to start adding
            ↪ elements.</para><para>Ссылка на позицию, с которой начинается добавление
            ↪ элементов.</para></param>
282         /// <param name="elements"><para>List, whose elements will be added to the
            ↪ array.</para><para>Список, элементы которого будут добавленны в
            ↪ массив.</para></param>
283         [MethodImpl(MethodImplOptions.AggressiveInlining)]
284         public static void AddSkipFirst<T>(this T[] array, ref long position, IList<T> elements)
            ↪ => array.AddSkipFirst(ref position, elements, 1);
285 
286         /// <summary>
287         /// <para>Adding in array all but the first element, skipping a specified number of
            ↪ positions and increments position value by one.</para>
288         /// <para>Добавляет в массив все элементы коллекции, кроме первого, пропуская
            ↪ определенное количество позиций и увеличивает значение position на единицу.</para>
289         /// </summary>
290         /// <typeparam name="T"><para>Array elements type.</para><para>Тип элементов
            ↪ массива.</para></typeparam>
291         /// <param name="array"><para>The array to add items to.</para><para>Массив в который
            ↪ необходимо добавить элементы.</para></param>
292         /// <param name="position"><para>Reference to the position from which to start adding
            ↪ elements.</para><para>Ссылка на позицию, с которой начинается добавление
            ↪ элементов.</para></param>
293         /// <param name="elements"><para>List, whose elements will be added to the
            ↪ array.</para><para>Список, элементы которого будут добавленны в
            ↪ массив.</para></param>
294         /// <param name="skip"><para>Number of elements to skip.</para><para>Количество
            ↪ пропускаемых элементов.</para></param>
295         [MethodImpl(MethodImplOptions.AggressiveInlining)]
296         public static void AddSkipFirst<T>(this T[] array, ref long position, IList<T> elements,
            ↪ int skip)
297         {
298             for (var i = skip; i < elements.Count; i++)
299             {
300                 array.Add(ref position, elements[i]);
301             }
302         }
303     }
304 }
```

1.8 ./csharp/Platform.Collections/BitString.cs

```
1  using System;
2  using System.Collections.Concurrent;
3  using System.Collections.Generic;
4  using System.Numerics;
5  using System.Runtime.CompilerServices;
6  using System.Threading.Tasks;
7  using Platform.Exceptions;
8  using Platform.Ranges;
9 
10 // ReSharper disable ForCanBeConvertedToForeach
11 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
12 
13 namespace Platform.Collections
14 {
15     /// <remarks>
```

```
    /// А что если хранить карту значений, где каждый бит будет означать присутствует ли блок в 64 бит в массиве значений.
    /// 64 бита по 0 бит, будут означать отсутствие 64-х блоков по 64 бита. Т.е. упаковка 512 байт в 8 байт.
    /// Подобный принцип можно применять и к 64-ём блокам и т.п. По сути это карта значений. С помощью которой можно быстро
    /// проверять есть ли значения непосредственно далее (ниже по уровню).
    /// Или как таблица виртуальной памяти где номер блока означает его присутствие и адрес.
    /// </remarks>
    public class BitString : IEquatable<BitString>
    {
        private static readonly byte[][] _bitsSetIn16Bits;
        private long[] _array;
        private long _length;
        private long _minPositiveWord;
        private long _maxPositiveWord;

        public bool this[long index]
        {
            [MethodImpl(MethodImplOptions.AggressiveInlining)]
            get => Get(index);
            [MethodImpl(MethodImplOptions.AggressiveInlining)]
            set => Set(index, value);
        }

        public long Length
        {
            [MethodImpl(MethodImplOptions.AggressiveInlining)]
            get => _length;
            [MethodImpl(MethodImplOptions.AggressiveInlining)]
            set
            {
                if (_length == value)
                {
                    return;
                }
                Ensure.Always.ArgumentInRange(value, GetValidLengthRange(), nameof(Length));
                // Currently we never shrink the array
                if (value > _length)
                {
                    var words = GetWordsCountFromIndex(value);
                    var oldWords = GetWordsCountFromIndex(_length);
                    if (words > _array.LongLength)
                    {
                        var copy = new long[words];
                        Array.Copy(_array, copy, _array.LongLength);
                        _array = copy;
                    }
                    else
                    {
                        // What is going on here?
                        Array.Clear(_array, (int)oldWords, (int)(words - oldWords));
                    }
                    // What is going on here?
                    var mask = (int)(_length % 64);
                    if (mask > 0)
                    {
                        _array[oldWords - 1] &= (1L << mask) - 1;
                    }
                }
                else
                {
                    // Looks like minimum and maximum positive words are not updated
                    throw new NotImplementedException();
                }
                _length = value;
            }
        }

        #region Constructors

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        static BitString()
        {
            _bitsSetIn16Bits = new byte[65536][];
            int i, c, k;
            byte bitIndex;
            for (i = 0; i < 65536; i++)
            {
```

```
                // Calculating size of array (number of positive bits)
                for (c = 0, k = 1; k <= 65536; k <<= 1)
                {
                    if ((i & k) == k)
                    {
                        c++;
                    }
                }
                var array = new byte[c];
                // Adding positive bits indices into array
                for (bitIndex = 0, c = 0, k = 1; k <= 65536; k <<= 1)
                {
                    if ((i & k) == k)
                    {
                        array[c++] = bitIndex;
                    }
                    bitIndex++;
                }
                _bitsSetIn16Bits[i] = array;
            }
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public BitString(BitString other)
        {
            Ensure.Always.ArgumentNotNull(other, nameof(other));
            _length = other._length;
            _array = new long[GetWordsCountFromIndex(_length)];
            _minPositiveWord = other._minPositiveWord;
            _maxPositiveWord = other._maxPositiveWord;
            Array.Copy(other._array, _array, _array.LongLength);
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public BitString(long length)
        {
            Ensure.Always.ArgumentInRange(length, GetValidLengthRange(), nameof(length));
            _length = length;
            _array = new long[GetWordsCountFromIndex(_length)];
            MarkBordersAsAllBitsReset();
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public BitString(long length, bool defaultValue)
            : this(length)
        {
            if (defaultValue)
            {
                SetAll();
            }
        }

        #endregion

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public BitString Not()
        {
            for (var i = 0L; i < _array.LongLength; i++)
            {
                _array[i] = ~_array[i];
                RefreshBordersByWord(i);
            }
            return this;
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public BitString ParallelNot()
        {
            var threads = Environment.ProcessorCount / 2;
            if (threads <= 1)
            {
                return Not();
            }
            var partitioner = Partitioner.Create(0L, _array.LongLength, _array.LongLength /
            ↪  threads);
            Parallel.ForEach(partitioner.GetDynamicPartitions(), new ParallelOptions {
            ↪  MaxDegreeOfParallelism = threads }, range =>
            {
                var maximum = range.Item2;
```

```
                for (var i = range.Item1; i < maximum; i++)
                {
                    _array[i] = ~_array[i];
                }
            });
            MarkBordersAsAllBitsSet();
            TryShrinkBorders();
            return this;
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public BitString VectorNot()
        {
            if (!Vector.IsHardwareAccelerated || _array.LongLength >= int.MaxValue)
            {
                return Not();
            }
            var step = Vector<long>.Count;
            if (_array.Length < step)
            {
                return Not();
            }
            VectorNotLoop(_array, step, 0, _array.Length);
            MarkBordersAsAllBitsSet();
            TryShrinkBorders();
            return this;
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public BitString ParallelVectorNot()
        {
            var threads = Environment.ProcessorCount / 2;
            if (threads <= 1)
            {
                return VectorNot();
            }
            if (!Vector.IsHardwareAccelerated)
            {
                return ParallelNot();
            }
            var step = Vector<long>.Count;
            if (_array.Length < (step * threads))
            {
                return VectorNot();
            }
            var partitioner = Partitioner.Create(0, _array.Length, _array.Length / threads);
            Parallel.ForEach(partitioner.GetDynamicPartitions(), new ParallelOptions {
            ↪  MaxDegreeOfParallelism = threads }, range => VectorNotLoop(_array, step,
            ↪  range.Item1, range.Item2));
            MarkBordersAsAllBitsSet();
            TryShrinkBorders();
            return this;
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        static private void VectorNotLoop(long[] array, int step, int start, int maximum)
        {
            var i = start;
            var range = maximum - start - 1;
            var stop = range - (range % step);
            for (; i < stop; i += step)
            {
                (~new Vector<long>(array, i)).CopyTo(array, i);
            }
            for (; i < maximum; i++)
            {
                array[i] = ~array[i];
            }
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public BitString And(BitString other)
        {
            EnsureBitStringHasTheSameSize(other, nameof(other));
            GetCommonOuterBorders(this, other, out long from, out long to);
            var otherArray = other._array;
            for (var i = from; i <= to; i++)
            {
```

```
                _array[i] &= otherArray[i];
                RefreshBordersByWord(i);
            }
            return this;
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public BitString ParallelAnd(BitString other)
        {
            var threads = Environment.ProcessorCount / 2;
            if (threads <= 1)
            {
                return And(other);
            }
            EnsureBitStringHasTheSameSize(other, nameof(other));
            GetCommonOuterBorders(this, other, out long from, out long to);
            var partitioner = Partitioner.Create(from, to + 1, (to - from) / threads);
            Parallel.ForEach(partitioner.GetDynamicPartitions(), new ParallelOptions {
            ↪  MaxDegreeOfParallelism = threads }, range =>
            {
                var maximum = range.Item2;
                for (var i = range.Item1; i < maximum; i++)
                {
                    _array[i] &= other._array[i];
                }
            });
            MarkBordersAsAllBitsSet();
            TryShrinkBorders();
            return this;
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public BitString VectorAnd(BitString other)
        {
            if (!Vector.IsHardwareAccelerated || _array.LongLength >= int.MaxValue)
            {
                return And(other);
            }
            var step = Vector<long>.Count;
            if (_array.Length < step)
            {
                return And(other);
            }
            EnsureBitStringHasTheSameSize(other, nameof(other));
            GetCommonOuterBorders(this, other, out int from, out int to);
            VectorAndLoop(_array, other._array, step, from, to + 1);
            MarkBordersAsAllBitsSet();
            TryShrinkBorders();
            return this;
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public BitString ParallelVectorAnd(BitString other)
        {
            var threads = Environment.ProcessorCount / 2;
            if (threads <= 1)
            {
                return VectorAnd(other);
            }
            if (!Vector.IsHardwareAccelerated)
            {
                return ParallelAnd(other);
            }
            var step = Vector<long>.Count;
            if (_array.Length < (step * threads))
            {
                return VectorAnd(other);
            }
            EnsureBitStringHasTheSameSize(other, nameof(other));
            GetCommonOuterBorders(this, other, out int from, out int to);
            var partitioner = Partitioner.Create(from, to + 1, (to - from) / threads);
            Parallel.ForEach(partitioner.GetDynamicPartitions(), new ParallelOptions {
            ↪  MaxDegreeOfParallelism = threads }, range => VectorAndLoop(_array, other._array,
            ↪  step, range.Item1, range.Item2));
            MarkBordersAsAllBitsSet();
            TryShrinkBorders();
            return this;
        }
```

```
320
321         [MethodImpl(MethodImplOptions.AggressiveInlining)]
322         static private void VectorAndLoop(long[] array, long[] otherArray, int step, int start,
            ↪ int maximum)
323         {
324             var i = start;
325             var range = maximum - start - 1;
326             var stop = range - (range % step);
327             for (; i < stop; i += step)
328             {
329                 (new Vector<long>(array, i) & new Vector<long>(otherArray, i)).CopyTo(array, i);
330             }
331             for (; i < maximum; i++)
332             {
333                 array[i] &= otherArray[i];
334             }
335         }
336
337         [MethodImpl(MethodImplOptions.AggressiveInlining)]
338         public BitString Or(BitString other)
339         {
340             EnsureBitStringHasTheSameSize(other, nameof(other));
341             GetCommonOuterBorders(this, other, out long from, out long to);
342             for (var i = from; i <= to; i++)
343             {
344                 _array[i] |= other._array[i];
345                 RefreshBordersByWord(i);
346             }
347             return this;
348         }
349
350         [MethodImpl(MethodImplOptions.AggressiveInlining)]
351         public BitString ParallelOr(BitString other)
352         {
353             var threads = Environment.ProcessorCount / 2;
354             if (threads <= 1)
355             {
356                 return Or(other);
357             }
358             EnsureBitStringHasTheSameSize(other, nameof(other));
359             GetCommonOuterBorders(this, other, out long from, out long to);
360             var partitioner = Partitioner.Create(from, to + 1, (to - from) / threads);
361             Parallel.ForEach(partitioner.GetDynamicPartitions(), new ParallelOptions {
                ↪ MaxDegreeOfParallelism = threads }, range =>
362             {
363                 var maximum = range.Item2;
364                 for (var i = range.Item1; i < maximum; i++)
365                 {
366                     _array[i] |= other._array[i];
367                 }
368             });
369             MarkBordersAsAllBitsSet();
370             TryShrinkBorders();
371             return this;
372         }
373
374         [MethodImpl(MethodImplOptions.AggressiveInlining)]
375         public BitString VectorOr(BitString other)
376         {
377             if (!Vector.IsHardwareAccelerated || _array.LongLength >= int.MaxValue)
378             {
379                 return Or(other);
380             }
381             var step = Vector<long>.Count;
382             if (_array.Length < step)
383             {
384                 return Or(other);
385             }
386             EnsureBitStringHasTheSameSize(other, nameof(other));
387             GetCommonOuterBorders(this, other, out int from, out int to);
388             VectorOrLoop(_array, other._array, step, from, to + 1);
389             MarkBordersAsAllBitsSet();
390             TryShrinkBorders();
391             return this;
392         }
393
394         [MethodImpl(MethodImplOptions.AggressiveInlining)]
395         public BitString ParallelVectorOr(BitString other)
```

```
        {
            var threads = Environment.ProcessorCount / 2;
            if (threads <= 1)
            {
                return VectorOr(other);
            }
            if (!Vector.IsHardwareAccelerated)
            {
                return ParallelOr(other);
            }
            var step = Vector<long>.Count;
            if (_array.Length < (step * threads))
            {
                return VectorOr(other);
            }
            EnsureBitStringHasTheSameSize(other, nameof(other));
            GetCommonOuterBorders(this, other, out int from, out int to);
            var partitioner = Partitioner.Create(from, to + 1, (to - from) / threads);
            Parallel.ForEach(partitioner.GetDynamicPartitions(), new ParallelOptions {
            ↪  MaxDegreeOfParallelism = threads }, range => VectorOrLoop(_array, other._array,
            ↪  step, range.Item1, range.Item2));
            MarkBordersAsAllBitsSet();
            TryShrinkBorders();
            return this;
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        static private void VectorOrLoop(long[] array, long[] otherArray, int step, int start,
        ↪  int maximum)
        {
            var i = start;
            var range = maximum - start - 1;
            var stop = range - (range % step);
            for (; i < stop; i += step)
            {
                (new Vector<long>(array, i) | new Vector<long>(otherArray, i)).CopyTo(array, i);
            }
            for (; i < maximum; i++)
            {
                array[i] |= otherArray[i];
            }
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public BitString Xor(BitString other)
        {
            EnsureBitStringHasTheSameSize(other, nameof(other));
            GetCommonOuterBorders(this, other, out long from, out long to);
            for (var i = from; i <= to; i++)
            {
                _array[i] ^= other._array[i];
                RefreshBordersByWord(i);
            }
            return this;
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public BitString ParallelXor(BitString other)
        {
            var threads = Environment.ProcessorCount / 2;
            if (threads <= 1)
            {
                return Xor(other);
            }
            EnsureBitStringHasTheSameSize(other, nameof(other));
            GetCommonOuterBorders(this, other, out long from, out long to);
            var partitioner = Partitioner.Create(from, to + 1, (to - from) / threads);
            Parallel.ForEach(partitioner.GetDynamicPartitions(), new ParallelOptions {
            ↪  MaxDegreeOfParallelism = threads }, range =>
            {
                var maximum = range.Item2;
                for (var i = range.Item1; i < maximum; i++)
                {
                    _array[i] ^= other._array[i];
                }
            });
            MarkBordersAsAllBitsSet();
            TryShrinkBorders();
```

```
            return this;
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public BitString VectorXor(BitString other)
        {
            if (!Vector.IsHardwareAccelerated || _array.LongLength >= int.MaxValue)
            {
                return Xor(other);
            }
            var step = Vector<long>.Count;
            if (_array.Length < step)
            {
                return Xor(other);
            }
            EnsureBitStringHasTheSameSize(other, nameof(other));
            GetCommonOuterBorders(this, other, out int from, out int to);
            VectorXorLoop(_array, other._array, step, from, to + 1);
            MarkBordersAsAllBitsSet();
            TryShrinkBorders();
            return this;
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public BitString ParallelVectorXor(BitString other)
        {
            var threads = Environment.ProcessorCount / 2;
            if (threads <= 1)
            {
                return VectorXor(other);
            }
            if (!Vector.IsHardwareAccelerated)
            {
                return ParallelXor(other);
            }
            var step = Vector<long>.Count;
            if (_array.Length < (step * threads))
            {
                return VectorXor(other);
            }
            EnsureBitStringHasTheSameSize(other, nameof(other));
            GetCommonOuterBorders(this, other, out int from, out int to);
            var partitioner = Partitioner.Create(from, to + 1, (to - from) / threads);
            Parallel.ForEach(partitioner.GetDynamicPartitions(), new ParallelOptions {
            ↪  MaxDegreeOfParallelism = threads }, range => VectorXorLoop(_array, other._array,
            ↪  step, range.Item1, range.Item2));
            MarkBordersAsAllBitsSet();
            TryShrinkBorders();
            return this;
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        static private void VectorXorLoop(long[] array, long[] otherArray, int step, int start,
        ↪  int maximum)
        {
            var i = start;
            var range = maximum - start - 1;
            var stop = range - (range % step);
            for (; i < stop; i += step)
            {
                (new Vector<long>(array, i) ^ new Vector<long>(otherArray, i)).CopyTo(array, i);
            }
            for (; i < maximum; i++)
            {
                array[i] ^= otherArray[i];
            }
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        private void RefreshBordersByWord(long wordIndex)
        {
            if (_array[wordIndex] == 0)
            {
                if (wordIndex == _minPositiveWord && wordIndex != _array.LongLength - 1)
                {
                    _minPositiveWord++;
                }
                if (wordIndex == _maxPositiveWord && wordIndex != 0)
```

```
                {
                    _maxPositiveWord--;
                }
            }
            else
            {
                if (wordIndex < _minPositiveWord)
                {
                    _minPositiveWord = wordIndex;
                }
                if (wordIndex > _maxPositiveWord)
                {
                    _maxPositiveWord = wordIndex;
                }
            }
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public bool TryShrinkBorders()
        {
            GetBorders(out long from, out long to);
            while (from <= to && _array[from] == 0)
            {
                from++;
            }
            if (from > to)
            {
                MarkBordersAsAllBitsReset();
                return true;
            }
            while (to >= from && _array[to] == 0)
            {
                to--;
            }
            if (to < from)
            {
                MarkBordersAsAllBitsReset();
                return true;
            }
            var bordersUpdated = from != _minPositiveWord || to != _maxPositiveWord;
            if (bordersUpdated)
            {
                SetBorders(from, to);
            }
            return bordersUpdated;
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public bool Get(long index)
        {
            Ensure.Always.ArgumentInRange(index, GetValidIndexRange(), nameof(index));
            return (_array[GetWordIndexFromIndex(index)] & GetBitMaskFromIndex(index)) != 0;
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public void Set(long index, bool value)
        {
            if (value)
            {
                Set(index);
            }
            else
            {
                Reset(index);
            }
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public void Set(long index)
        {
            Ensure.Always.ArgumentInRange(index, GetValidIndexRange(), nameof(index));
            var wordIndex = GetWordIndexFromIndex(index);
            var mask = GetBitMaskFromIndex(index);
            _array[wordIndex] |= mask;
            RefreshBordersByWord(wordIndex);
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public void Reset(long index)
```

```
        {
            Ensure.Always.ArgumentInRange(index, GetValidIndexRange(), nameof(index));
            var wordIndex = GetWordIndexFromIndex(index);
            var mask = GetBitMaskFromIndex(index);
            _array[wordIndex] &= ~mask;
            RefreshBordersByWord(wordIndex);
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public bool Add(long index)
        {
            var wordIndex = GetWordIndexFromIndex(index);
            var mask = GetBitMaskFromIndex(index);
            if ((_array[wordIndex] & mask) == 0)
            {
                _array[wordIndex] |= mask;
                RefreshBordersByWord(wordIndex);
                return true;
            }
            else
            {
                return false;
            }
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public void SetAll(bool value)
        {
            if (value)
            {
                SetAll();
            }
            else
            {
                ResetAll();
            }
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public void SetAll()
        {
            const long fillValue = unchecked((long)0xffffffffffffffff);
            var words = GetWordsCountFromIndex(_length);
            for (var i = 0; i < words; i++)
            {
                _array[i] = fillValue;
            }
            MarkBordersAsAllBitsSet();
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public void ResetAll()
        {
            const long fillValue = 0;
            GetBorders(out long from, out long to);
            for (var i = from; i <= to; i++)
            {
                _array[i] = fillValue;
            }
            MarkBordersAsAllBitsReset();
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public List<long> GetSetIndices()
        {
            var result = new List<long>();
            GetBorders(out long from, out long to);
            for (var i = from; i <= to; i++)
            {
                var word = _array[i];
                if (word != 0)
                {
                    AppendAllSetBitIndices(result, i, word);
                }
            }
            return result;
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
```

```
703         public List<ulong> GetSetUInt64Indices()
704         {
705             var result = new List<ulong>();
706             GetBorders(out ulong from, out ulong to);
707             for (var i = from; i <= to; i++)
708             {
709                 var word = _array[i];
710                 if (word != 0)
711                 {
712                     AppendAllSetBitIndices(result, i, word);
713                 }
714             }
715             return result;
716         }
717 
718         [MethodImpl(MethodImplOptions.AggressiveInlining)]
719         public long GetFirstSetBitIndex()
720         {
721             var i = _minPositiveWord;
722             var word = _array[i];
723             if (word != 0)
724             {
725                 return GetFirstSetBitForWord(i, word);
726             }
727             return -1;
728         }
729 
730         [MethodImpl(MethodImplOptions.AggressiveInlining)]
731         public long GetLastSetBitIndex()
732         {
733             var i = _maxPositiveWord;
734             var word = _array[i];
735             if (word != 0)
736             {
737                 return GetLastSetBitForWord(i, word);
738             }
739             return -1;
740         }
741 
742         [MethodImpl(MethodImplOptions.AggressiveInlining)]
743         public long CountSetBits()
744         {
745             var total = 0L;
746             GetBorders(out long from, out long to);
747             for (var i = from; i <= to; i++)
748             {
749                 var word = _array[i];
750                 if (word != 0)
751                 {
752                     total += CountSetBitsForWord(word);
753                 }
754             }
755             return total;
756         }
757 
758         [MethodImpl(MethodImplOptions.AggressiveInlining)]
759         public bool HaveCommonBits(BitString other)
760         {
761             EnsureBitStringHasTheSameSize(other, nameof(other));
762             GetCommonInnerBorders(this, other, out long from, out long to);
763             var otherArray = other._array;
764             for (var i = from; i <= to; i++)
765             {
766                 var left = _array[i];
767                 var right = otherArray[i];
768                 if (left != 0 && right != 0 && (left & right) != 0)
769                 {
770                     return true;
771                 }
772             }
773             return false;
774         }
775 
776         [MethodImpl(MethodImplOptions.AggressiveInlining)]
777         public long CountCommonBits(BitString other)
778         {
779             EnsureBitStringHasTheSameSize(other, nameof(other));
780             GetCommonInnerBorders(this, other, out long from, out long to);
781             var total = 0L;
```

```
            var otherArray = other._array;
            for (var i = from; i <= to; i++)
            {
                var left = _array[i];
                var right = otherArray[i];
                var combined = left & right;
                if (combined != 0)
                {
                    total += CountSetBitsForWord(combined);
                }
            }
            return total;
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public List<long> GetCommonIndices(BitString other)
        {
            EnsureBitStringHasTheSameSize(other, nameof(other));
            GetCommonInnerBorders(this, other, out long from, out long to);
            var result = new List<long>();
            var otherArray = other._array;
            for (var i = from; i <= to; i++)
            {
                var left = _array[i];
                var right = otherArray[i];
                var combined = left & right;
                if (combined != 0)
                {
                    AppendAllSetBitIndices(result, i, combined);
                }
            }
            return result;
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public List<ulong> GetCommonUInt64Indices(BitString other)
        {
            EnsureBitStringHasTheSameSize(other, nameof(other));
            GetCommonBorders(this, other, out ulong from, out ulong to);
            var result = new List<ulong>();
            var otherArray = other._array;
            for (var i = from; i <= to; i++)
            {
                var left = _array[i];
                var right = otherArray[i];
                var combined = left & right;
                if (combined != 0)
                {
                    AppendAllSetBitIndices(result, i, combined);
                }
            }
            return result;
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public long GetFirstCommonBitIndex(BitString other)
        {
            EnsureBitStringHasTheSameSize(other, nameof(other));
            GetCommonInnerBorders(this, other, out long from, out long to);
            var otherArray = other._array;
            for (var i = from; i <= to; i++)
            {
                var left = _array[i];
                var right = otherArray[i];
                var combined = left & right;
                if (combined != 0)
                {
                    return GetFirstSetBitForWord(i, combined);
                }
            }
            return -1;
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public long GetLastCommonBitIndex(BitString other)
        {
            EnsureBitStringHasTheSameSize(other, nameof(other));
            GetCommonInnerBorders(this, other, out long from, out long to);
            var otherArray = other._array;
```

```
            for (var i = to; i >= from; i--)
            {
                var left = _array[i];
                var right = otherArray[i];
                var combined = left & right;
                if (combined != 0)
                {
                    return GetLastSetBitForWord(i, combined);
                }
            }
            return -1;
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public override bool Equals(object obj) => obj is BitString @string ? Equals(@string) :
        ↪  false;

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public bool Equals(BitString other)
        {
            if (_length != other._length)
            {
                return false;
            }
            var otherArray = other._array;
            if (_array.Length != otherArray.Length)
            {
                return false;
            }
            if (_minPositiveWord != other._minPositiveWord)
            {
                return false;
            }
            if (_maxPositiveWord != other._maxPositiveWord)
            {
                return false;
            }
            GetCommonBorders(this, other, out ulong from, out ulong to);
            for (var i = from; i <= to; i++)
            {
                if (_array[i] != otherArray[i])
                {
                    return false;
                }
            }
            return true;
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        private void EnsureBitStringHasTheSameSize(BitString other, string argumentName)
        {
            Ensure.Always.ArgumentNotNull(other, argumentName);
            if (_length != other._length)
            {
                throw new ArgumentException("Bit string must be the same size.", argumentName);
            }
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        private void MarkBordersAsAllBitsReset() => SetBorders(_array.LongLength - 1, 0);

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        private void MarkBordersAsAllBitsSet() => SetBorders(0, _array.LongLength - 1);

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        private void GetBorders(out long from, out long to)
        {
            from = _minPositiveWord;
            to = _maxPositiveWord;
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        private void GetBorders(out ulong from, out ulong to)
        {
            from = (ulong)_minPositiveWord;
            to = (ulong)_maxPositiveWord;
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
```

```
939             private void SetBorders(long from, long to)
940             {
941                 _minPositiveWord = from;
942                 _maxPositiveWord = to;
943             }
944 
945             [MethodImpl(MethodImplOptions.AggressiveInlining)]
946             private Range<long> GetValidIndexRange() => (0, _length - 1);
947 
948             [MethodImpl(MethodImplOptions.AggressiveInlining)]
949             private static Range<long> GetValidLengthRange() => (0, long.MaxValue);
950 
951             [MethodImpl(MethodImplOptions.AggressiveInlining)]
952             private static void AppendAllSetBitIndices(List<ulong> result, ulong wordIndex, long
                ↪  wordValue)
953             {
954                 GetBits(wordValue, out byte[] bits00to15, out byte[] bits16to31, out byte[]
                    ↪  bits32to47, out byte[] bits48to63);
955                 AppendAllSetIndices(result, wordIndex, bits00to15, bits16to31, bits32to47,
                    ↪  bits48to63);
956             }
957 
958             [MethodImpl(MethodImplOptions.AggressiveInlining)]
959             private static void AppendAllSetBitIndices(List<long> result, long wordIndex, long
                ↪  wordValue)
960             {
961                 GetBits(wordValue, out byte[] bits00to15, out byte[] bits16to31, out byte[]
                    ↪  bits32to47, out byte[] bits48to63);
962                 AppendAllSetBitIndices(result, wordIndex, bits00to15, bits16to31, bits32to47,
                    ↪  bits48to63);
963             }
964 
965             [MethodImpl(MethodImplOptions.AggressiveInlining)]
966             private static long CountSetBitsForWord(long word)
967             {
968                 GetBits(word, out byte[] bits00to15, out byte[] bits16to31, out byte[] bits32to47,
                    ↪  out byte[] bits48to63);
969                 return bits00to15.LongLength + bits16to31.LongLength + bits32to47.LongLength +
                    ↪  bits48to63.LongLength;
970             }
971 
972             [MethodImpl(MethodImplOptions.AggressiveInlining)]
973             private static long GetFirstSetBitForWord(long wordIndex, long wordValue)
974             {
975                 GetBits(wordValue, out byte[] bits00to15, out byte[] bits16to31, out byte[]
                    ↪  bits32to47, out byte[] bits48to63);
976                 return GetFirstSetBit(wordIndex, bits00to15, bits16to31, bits32to47, bits48to63);
977             }
978 
979             [MethodImpl(MethodImplOptions.AggressiveInlining)]
980             private static long GetLastSetBitForWord(long wordIndex, long wordValue)
981             {
982                 GetBits(wordValue, out byte[] bits00to15, out byte[] bits16to31, out byte[]
                    ↪  bits32to47, out byte[] bits48to63);
983                 return GetLastSetBit(wordIndex, bits00to15, bits16to31, bits32to47, bits48to63);
984             }
985 
986             [MethodImpl(MethodImplOptions.AggressiveInlining)]
987             private static void AppendAllSetBitIndices(List<long> result, long i, byte[] bits00to15,
                ↪  byte[] bits16to31, byte[] bits32to47, byte[] bits48to63)
988             {
989                 for (var j = 0; j < bits00to15.Length; j++)
990                 {
991                     result.Add(bits00to15[j] + (i * 64));
992                 }
993                 for (var j = 0; j < bits16to31.Length; j++)
994                 {
995                     result.Add(bits16to31[j] + 16 + (i * 64));
996                 }
997                 for (var j = 0; j < bits32to47.Length; j++)
998                 {
999                     result.Add(bits32to47[j] + 32 + (i * 64));
1000                }
1001                for (var j = 0; j < bits48to63.Length; j++)
1002                {
1003                    result.Add(bits48to63[j] + 48 + (i * 64));
1004                }
1005            }
```

```
1006
1007            [MethodImpl(MethodImplOptions.AggressiveInlining)]
1008            private static void AppendAllSetIndices(List<ulong> result, ulong i, byte[] bits00to15,
                ↪ byte[] bits16to31, byte[] bits32to47, byte[] bits48to63)
1009            {
1010                for (var j = 0; j < bits00to15.Length; j++)
1011                {
1012                    result.Add(bits00to15[j] + (i * 64));
1013                }
1014                for (var j = 0; j < bits16to31.Length; j++)
1015                {
1016                    result.Add(bits16to31[j] + 16UL + (i * 64));
1017                }
1018                for (var j = 0; j < bits32to47.Length; j++)
1019                {
1020                    result.Add(bits32to47[j] + 32UL + (i * 64));
1021                }
1022                for (var j = 0; j < bits48to63.Length; j++)
1023                {
1024                    result.Add(bits48to63[j] + 48UL + (i * 64));
1025                }
1026            }
1027
1028            [MethodImpl(MethodImplOptions.AggressiveInlining)]
1029            private static long GetFirstSetBit(long i, byte[] bits00to15, byte[] bits16to31, byte[]
                ↪ bits32to47, byte[] bits48to63)
1030            {
1031                if (bits00to15.Length > 0)
1032                {
1033                    return bits00to15[0] + (i * 64);
1034                }
1035                if (bits16to31.Length > 0)
1036                {
1037                    return bits16to31[0] + 16 + (i * 64);
1038                }
1039                if (bits32to47.Length > 0)
1040                {
1041                    return bits32to47[0] + 32 + (i * 64);
1042                }
1043                return bits48to63[0] + 48 + (i * 64);
1044            }
1045
1046            [MethodImpl(MethodImplOptions.AggressiveInlining)]
1047            private static long GetLastSetBit(long i, byte[] bits00to15, byte[] bits16to31, byte[]
                ↪ bits32to47, byte[] bits48to63)
1048            {
1049                if (bits48to63.Length > 0)
1050                {
1051                    return bits48to63[bits48to63.Length - 1] + 48 + (i * 64);
1052                }
1053                if (bits32to47.Length > 0)
1054                {
1055                    return bits32to47[bits32to47.Length - 1] + 32 + (i * 64);
1056                }
1057                if (bits16to31.Length > 0)
1058                {
1059                    return bits16to31[bits16to31.Length - 1] + 16 + (i * 64);
1060                }
1061                return bits00to15[bits00to15.Length - 1] + (i * 64);
1062            }
1063
1064            [MethodImpl(MethodImplOptions.AggressiveInlining)]
1065            private static void GetBits(long word, out byte[] bits00to15, out byte[] bits16to31, out
                ↪ byte[] bits32to47, out byte[] bits48to63)
1066            {
1067                bits00to15 = _bitsSetIn16Bits[word & 0xffffu];
1068                bits16to31 = _bitsSetIn16Bits[(word >> 16) & 0xffffu];
1069                bits32to47 = _bitsSetIn16Bits[(word >> 32) & 0xffffu];
1070                bits48to63 = _bitsSetIn16Bits[(word >> 48) & 0xffffu];
1071            }
1072
1073            [MethodImpl(MethodImplOptions.AggressiveInlining)]
1074            public static void GetCommonInnerBorders(BitString left, BitString right, out long from,
                ↪ out long to)
1075            {
1076                from = Math.Max(left._minPositiveWord, right._minPositiveWord);
1077                to = Math.Min(left._maxPositiveWord, right._maxPositiveWord);
```

```
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public static void GetCommonOuterBorders(BitString left, BitString right, out long from,
        ↪  out long to)
        {
            from = Math.Min(left._minPositiveWord, right._minPositiveWord);
            to = Math.Max(left._maxPositiveWord, right._maxPositiveWord);
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public static void GetCommonOuterBorders(BitString left, BitString right, out int from,
        ↪  out int to)
        {
            from = (int)Math.Min(left._minPositiveWord, right._minPositiveWord);
            to = (int)Math.Max(left._maxPositiveWord, right._maxPositiveWord);
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public static void GetCommonBorders(BitString left, BitString right, out ulong from, out
        ↪  ulong to)
        {
            from = (ulong)Math.Max(left._minPositiveWord, right._minPositiveWord);
            to = (ulong)Math.Min(left._maxPositiveWord, right._maxPositiveWord);
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public static long GetWordsCountFromIndex(long index) => (index + 63) / 64;

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public static long GetWordIndexFromIndex(long index) => index >> 6;

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public static long GetBitMaskFromIndex(long index) => 1L << (int)(index & 63);

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public override int GetHashCode() => base.GetHashCode();

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public override string ToString() => base.ToString();
    }
}
```

1.9 ./csharp/Platform.Collections/BitStringExtensions.cs

```
using System.Runtime.CompilerServices;
using Platform.Random;

#pragma warning disable CS1591 // Missing XML comment for publicly visible type or member

namespace Platform.Collections
{
    public static class BitStringExtensions
    {
        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public static void SetRandomBits(this BitString @string)
        {
            for (var i = 0; i < @string.Length; i++)
            {
                var value = RandomHelpers.Default.NextBoolean();
                @string.Set(i, value);
            }
        }
    }
}
```

1.10 ./csharp/Platform.Collections/Concurrent/ConcurrentQueueExtensions.cs

```
using System.Collections.Concurrent;
using System.Collections.Generic;
using System.Runtime.CompilerServices;

#pragma warning disable CS1591 // Missing XML comment for publicly visible type or member

namespace Platform.Collections.Concurrent
{
    public static class ConcurrentQueueExtensions
    {
        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public static IEnumerable<T> DequeueAll<T>(this ConcurrentQueue<T> queue)
        {
```

```
            while (queue.TryDequeue(out T item))
            {
                yield return item;
            }
        }
    }
}
```

1.11 ./csharp/Platform.Collections/Concurrent/ConcurrentStackExtensions.cs

```
using System.Collections.Concurrent;
using System.Runtime.CompilerServices;

#pragma warning disable CS1591 // Missing XML comment for publicly visible type or member

namespace Platform.Collections.Concurrent
{
    public static class ConcurrentStackExtensions
    {
        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public static T PopOrDefault<T>(this ConcurrentStack<T> stack) => stack.TryPop(out T
        ↪  value) ? value : default;

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public static T PeekOrDefault<T>(this ConcurrentStack<T> stack) => stack.TryPeek(out T
        ↪  value) ? value : default;
    }
}
```

1.12 ./csharp/Platform.Collections/EnsureExtensions.cs

```
using System;
using System.Collections.Generic;
using System.Diagnostics;
using System.Runtime.CompilerServices;
using Platform.Exceptions;
using Platform.Exceptions.ExtensionRoots;

#pragma warning disable IDE0060 // Remove unused parameter
#pragma warning disable CS1591 // Missing XML comment for publicly visible type or member

namespace Platform.Collections
{
    public static class EnsureExtensions
    {
        #region Always

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public static void ArgumentNotEmpty<T>(this EnsureAlwaysExtensionRoot root,
        ↪  ICollection<T> argument, string argumentName, string message)
        {
            if (argument.IsNullOrEmpty())
            {
                throw new ArgumentException(message, argumentName);
            }
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public static void ArgumentNotEmpty<T>(this EnsureAlwaysExtensionRoot root,
        ↪  ICollection<T> argument, string argumentName) => ArgumentNotEmpty(root, argument,
        ↪  argumentName, null);

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public static void ArgumentNotEmpty<T>(this EnsureAlwaysExtensionRoot root,
        ↪  ICollection<T> argument) => ArgumentNotEmpty(root, argument, null, null);

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public static void ArgumentNotEmptyAndNotWhiteSpace(this EnsureAlwaysExtensionRoot root,
        ↪  string argument, string argumentName, string message)
        {
            if (string.IsNullOrWhiteSpace(argument))
            {
                throw new ArgumentException(message, argumentName);
            }
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public static void ArgumentNotEmptyAndNotWhiteSpace(this EnsureAlwaysExtensionRoot root,
        ↪  string argument, string argumentName) => ArgumentNotEmptyAndNotWhiteSpace(root,
        ↪  argument, argumentName, null);

```

```
        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public static void ArgumentNotEmptyAndNotWhiteSpace(this EnsureAlwaysExtensionRoot root,
        ↪  string argument) => ArgumentNotEmptyAndNotWhiteSpace(root, argument, null, null);

        #endregion

        #region OnDebug

        [Conditional("DEBUG")]
        public static void ArgumentNotEmpty<T>(this EnsureOnDebugExtensionRoot root,
        ↪  ICollection<T> argument, string argumentName, string message) =>
        ↪  Ensure.Always.ArgumentNotEmpty(argument, argumentName, message);

        [Conditional("DEBUG")]
        public static void ArgumentNotEmpty<T>(this EnsureOnDebugExtensionRoot root,
        ↪  ICollection<T> argument, string argumentName) =>
        ↪  Ensure.Always.ArgumentNotEmpty(argument, argumentName, null);

        [Conditional("DEBUG")]
        public static void ArgumentNotEmpty<T>(this EnsureOnDebugExtensionRoot root,
        ↪  ICollection<T> argument) => Ensure.Always.ArgumentNotEmpty(argument, null, null);

        [Conditional("DEBUG")]
        public static void ArgumentNotEmptyAndNotWhiteSpace(this EnsureOnDebugExtensionRoot
        ↪  root, string argument, string argumentName, string message) =>
        ↪  Ensure.Always.ArgumentNotEmptyAndNotWhiteSpace(argument, argumentName, message);

        [Conditional("DEBUG")]
        public static void ArgumentNotEmptyAndNotWhiteSpace(this EnsureOnDebugExtensionRoot
        ↪  root, string argument, string argumentName) =>
        ↪  Ensure.Always.ArgumentNotEmptyAndNotWhiteSpace(argument, argumentName, null);

        [Conditional("DEBUG")]
        public static void ArgumentNotEmptyAndNotWhiteSpace(this EnsureOnDebugExtensionRoot
        ↪  root, string argument) => Ensure.Always.ArgumentNotEmptyAndNotWhiteSpace(argument,
        ↪  null, null);

        #endregion
    }
}
```

1.13 ./csharp/Platform.Collections/ICollectionExtensions.cs

```
using System.Collections.Generic;
using System.Linq;
using System.Runtime.CompilerServices;

#pragma warning disable CS1591 // Missing XML comment for publicly visible type or member

namespace Platform.Collections
{
    public static class ICollectionExtensions
    {
        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public static bool IsNullOrEmpty<T>(this ICollection<T> collection) => collection ==
        ↪  null || collection.Count == 0;

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public static bool AllEqualToDefault<T>(this ICollection<T> collection)
        {
            var equalityComparer = EqualityComparer<T>.Default;
            return collection.All(item => equalityComparer.Equals(item, default));
        }
    }
}
```

1.14 ./csharp/Platform.Collections/IDictionaryExtensions.cs

```
using System;
using System.Collections.Generic;
using System.Runtime.CompilerServices;

#pragma warning disable CS1591 // Missing XML comment for publicly visible type or member

namespace Platform.Collections
{
    public static class IDictionaryExtensions
    {
        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public static TValue GetOrDefault<TKey, TValue>(this IDictionary<TKey, TValue>
        ↪  dictionary, TKey key)
```

```
        {
            dictionary.TryGetValue(key, out TValue value);
            return value;
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public static TValue GetOrAdd<TKey, TValue>(this IDictionary<TKey, TValue> dictionary,
        ↪  TKey key, Func<TKey, TValue> valueFactory)
        {
            if (!dictionary.TryGetValue(key, out TValue value))
            {
                value = valueFactory(key);
                dictionary.Add(key, value);
                return value;
            }
            return value;
        }
    }
}
```

1.15 ./csharp/Platform.Collections/Lists/CharIListExtensions.cs

```
using System.Collections.Generic;
using System.Runtime.CompilerServices;

namespace Platform.Collections.Lists
{
    public static class CharIListExtensions
    {
        /// <summary>
        /// <para>Generates a hash code for the entire list based on the values of its
        ↪  elements.</para>
        /// <para>Генерирует хэш-код всего списка, на основе значений его элементов.</para>
        /// </summary>
        /// <param name="list"><para>The list to be hashed.</para><para>Список для
        ↪  хеширования.</para></param>
        /// <returns>
        /// <para>The hash code of the list.</para>
        /// <para>Хэш-код списка.</para>
        /// </returns>
        /// <remarks>
        /// Based on https://github.com/Microsoft/referencesource/blob/3b1eaf5203992df69de44c783
        ↪  a3eda37d3d4cd10/mscorlib/system/string.cs#L833
        /// </remarks>
        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public static int GenerateHashCode(this IList<char> list)
        {
            var hashSeed = 5381;
            var hashAccumulator = hashSeed;
            for (var i = 0; i < list.Count; i++)
            {
                hashAccumulator = (hashAccumulator << 5) + hashAccumulator ^ list[i];
            }
            return hashAccumulator + (hashSeed * 1566083941);
        }

        /// <summary>
        /// <para>Compares two lists for equality.</para>
        /// <para>Сравнивает два списка на равенство.</para>
        /// </summary>
        /// <param name="left"><para>The first compared list.</para><para>Первый список для
        ↪  сравнения.</para></param>
        /// <param name="right"><para>The second compared list.</para><para>Второй список для
        ↪  сравнения.</para></param>
        /// <returns>
        /// <para>True, if the passed lists are equal to each other otherwise false.</para>
        /// <para>True, если переданные списки равны друг другу, иначе false.</para>
        /// </returns>
        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public static bool EqualTo(this IList<char> left, IList<char> right) =>
        ↪  left.EqualTo(right, ContentEqualTo);

        /// <summary>
        /// <para>Compares each element in the list for equality.</para>
        /// <para>Сравнивает на равенство каждый элемент списка.</para>
        /// </summary>
        /// <param name="left"><para>The first compared list.</para><para>Первый список для
        ↪  сравнения.</para></param>
```

```
50          /// <param name="right"><para>The second compared list.</para><para>Второй список для
            ↪  сравнения.</para></param>
51          /// <returns>
52          /// <para>If at least one element of one list is not equal to the corresponding element
            ↪  from another list returns false, otherwise - true.</para>
53          /// <para>Если как минимум один элемент одного списка не равен соответствующему элементу
            ↪  из другого списка возвращает false, иначе - true.</para>
54          /// </returns>
55          [MethodImpl(MethodImplOptions.AggressiveInlining)]
56          public static bool ContentEqualTo(this IList<char> left, IList<char> right)
57          {
58              for (var i = left.Count - 1; i >= 0; --i)
59              {
60                  if (left[i] != right[i])
61                  {
62                      return false;
63                  }
64              }
65              return true;
66          }
67      }
68  }
```

1.16 ./csharp/Platform.Collections/Lists/IListComparer.cs

```
1   using System.Collections.Generic;
2   using System.Runtime.CompilerServices;
3
4   namespace Platform.Collections.Lists
5   {
6       public class IListComparer<T> : IComparer<IList<T>>
7       {
8           /// <summary>
9           /// <para>Compares two lists.</para>
10          /// <para>Сравнивает два списка.<para>
11          /// </summary>
12          /// <typeparam name="T"><para>The list's item type.</para><para>Тип элементов
            ↪  списка.</para></typeparam>
13          /// <param name="left"><para>The first compared list.</para><para>Первый список для
            ↪  сравнения.</para></param>
14          /// <param name="right"><para>The second compared list.</para><para>Второй список для
            ↪  сравнения.</para></param>
15          /// <returns>
16          /// <para>
17          ///     A signed integer that indicates the relative values of <paramref name="left" />
            ↪  and <paramref name="right" /> lists' elements, as shown in the following table.
18          ///     <list type="table">
19          ///         <listheader>
20          ///             <term>Value</term>
21          ///             <description>Meaning</description>
22          ///         </listheader>
23          ///         <item>
24          ///             <term>Is less than zero</term>
25          ///             <description>First non equal element of <paramref name="left" /> list is
            ↪  less than first not equal element of <paramref name="right" /> list.</description>
26          ///         </item>
27          ///         <item>
28          ///             <term>Zero</term>
29          ///             <description>All elements of <paramref name="left" /> list equals to all
            ↪  elements of <paramref name="right" /> list.</description>
30          ///         </item>
31          ///         <item>
32          ///             <term>Is greater than zero</term>
33          ///             <description>First non equal element of <paramref name="left" /> list is
            ↪  greater than first not equal element of <paramref name="right" /> list.</description>
34          ///         </item>
35          ///     </list>
36          /// <para>
37          /// <para>
38          ///     Целое число со знаком, которое указывает относительные значения элементов
            ↪  списков <paramref name="left" /> и <paramref name="right" /> как показано в
            ↪  следующей таблице.
39          ///     <list type="table">
40          ///         <listheader>
41          ///             <term>Значение</term>
42          ///             <description>Смысл</description>
43          ///         </listheader>
44          ///         <item>
```

```
45          ///             <term>Меньше нуля</term>
46          ///             <description>Первый не равный элемент <paramref name="left" /> списка
            ↪  меньше первого неравного элемента <paramref name="right" /> списка.</description>
47          ///         </item>
48          ///         <item>
49          ///             <term>Ноль</term>
50          ///             <description>Все элементы <paramref name="left" /> списка равны всем
            ↪  элементам <paramref name="right" /> списка.</description>
51          ///         </item>
52          ///         <item>
53          ///             <term>Больше нуля</term>
54          ///             <description>Первый не равный элемент <paramref name="left" /> списка
            ↪  больше первого неравного элемента <paramref name="right" /> списка.</description>
55          ///         </item>
56          ///     </list>
57          /// </para>
58          /// </returns>
59          [MethodImpl(MethodImplOptions.AggressiveInlining)]
60          public int Compare(IList<T> left, IList<T> right) => left.CompareTo(right);
61      }
62  }
```

1.17 ./csharp/Platform.Collections/Lists/IListEqualityComparer.cs

```
1   using System.Collections.Generic;
2   using System.Runtime.CompilerServices;
3
4   namespace Platform.Collections.Lists
5   {
6       public class IListEqualityComparer<T> : IEqualityComparer<IList<T>>
7       {
8           /// <summary>
9           /// <para>Compares two lists for equality.</para>
10          /// <para>Сравнивает два списка на равенство.</para>
11          /// </summary>
12          /// <param name="left"><para>The first compared list.</para><para>Первый список для
            ↪  сравнения.</para></param>
13          /// <param name="right"><para>The second compared list.</para><para>Второй список для
            ↪  сравнения.</para></param>
14          /// <returns>
15          /// <para>If the passed lists are equal to each other, true is returned, otherwise
            ↪  false.</para>
16          /// <para>Если переданные списки равны друг другу, возвращается true, иначе же
            ↪  false.</para>
17          /// </returns>
18          [MethodImpl(MethodImplOptions.AggressiveInlining)]
19          public bool Equals(IList<T> left, IList<T> right) => left.EqualTo(right);
20
21          /// <summary>
22          /// <para>Generates a hash code for the entire list based on the values of its
            ↪  elements.</para>
23          /// <para>Генерирует хэш-код всего списка, на основе значений его элементов.</para>
24          /// </summary>
25          /// <param name="list"><para>Hash list.</para><para>Список для
            ↪  хеширования.</para></param>
26          /// <returns>
27          /// <para>The hash code of the list.</para>
28          /// <para>Хэш-код списка.</para>
29          /// </returns>
30          [MethodImpl(MethodImplOptions.AggressiveInlining)]
31          public int GetHashCode(IList<T> list) => list.GenerateHashCode();
32      }
33  }
```

1.18 ./csharp/Platform.Collections/Lists/IListExtensions.cs

```
1   using System;
2   using System.Collections.Generic;
3   using System.Runtime.CompilerServices;
4
5   namespace Platform.Collections.Lists
6   {
7       public static class IListExtensions
8       {
9           /// <summary>
10          /// <para>Gets the element from specified index if the list is not null and the index is
            ↪  within the list's boundaries, otherwise it returns default value of type T.</para>
11          /// <para>Получает элемент из указанного индекса, если список не является null и индекс
            ↪  находится в границах списка, в противном случае он возвращает значение по умолчанию
            ↪  типа T.</para>
```

```
12          /// </summary>
13          /// <typeparam name="T"><para>The list's item type.</para><para>Тип элементов
            ↪  списка.</typeparam>
14          /// <param name="list"><para>The checked list.</para><para>Проверяемый
            ↪  список.</para></param>
15          /// <param name="index"><para>The index of element.</para><para>Индекс
            ↪  элемента.</para></param>
16          /// <returns>
17          /// <para>If the specified index is within list's boundaries, then - list[index],
            ↪  otherwise the default value.</para>
18          /// <para>Если указанный индекс находится в пределах границ списка, тогда - list[index],
            ↪  иначе же значение по умолчанию.</para>
19          /// </returns>
20          [MethodImpl(MethodImplOptions.AggressiveInlining)]
21          public static T GetElementOrDefault<T>(this IList<T> list, int index) => list != null &&
            ↪  list.Count > index ? list[index] : default;
22
23          /// <summary>
24          /// <para>Checks if a list is passed, checks its length, and if successful, copies the
            ↪  value of list [index] into the element variable. Otherwise, the element variable has
            ↪  a default value.</para>
25          /// <para>Проверяет, передан ли список, сверяет его длину и в случае успеха копирует
            ↪  значение list[index] в переменную element. Иначе переменная element имеет значение
            ↪  по умолчанию.</para>
26          /// </summary>
27          /// <typeparam name="T"><para>The list's item type.</para><para>Тип элементов
            ↪  списка.</para></typeparam>
28          /// <param name="list"><para>The checked list.</para><para>Список для
            ↪  проверки.</para></param>
29          /// <param name="index"><para>The index of element..</para><para>Индекс
            ↪  элемента.</para></param>
30          /// <param name="element"><para>Variable for passing the index
            ↪  value.</para><para>Переменная для передачи значения индекса.</para></param>
31          /// <returns>
32          /// <para>True on success, false otherwise.</para>
33          /// <para>True в случае успеха, иначе false.</para>
34          /// </returns>
35          [MethodImpl(MethodImplOptions.AggressiveInlining)]
36          public static bool TryGetElement<T>(this IList<T> list, int index, out T element)
37          {
38              if (list != null && list.Count > index)
39              {
40                  element = list[index];
41                  return true;
42              }
43              else
44              {
45                  element = default;
46                  return false;
47              }
48          }
49
50          /// <summary>
51          /// <para>Adds a value to the list.</para>
52          /// <para>Добавляет значение в список.</para>
53          /// </summary>
54          /// <typeparam name="T"><para>The list's item type.</para><para>Тип элементов
            ↪  списка.</para></typeparam>
55          /// <param name="list"><para>The list to add the value to.</para><para>Список в который
            ↪  нужно добавить значение.</para></param>
56          /// <param name="element"><para>The item to add to the list.</para><para>Элемент который
            ↪  нужно добавить в список.</para></param>
57          /// <returns>
58          /// <para>True value in any case.</para>
59          /// <para>Значение true в любом случае.</para>
60          /// </returns>
61          [MethodImpl(MethodImplOptions.AggressiveInlining)]
62          public static bool AddAndReturnTrue<T>(this IList<T> list, T element)
63          {
64              list.Add(element);
65              return true;
66          }
67
68          /// <summary>
69          /// <para>Adds the value with first index from other list to this list.</para>
70          /// <para>Добавляет в этот список значение с первым индексом из другого списка.</para>
71          /// </summary>
```

```
72          /// <typeparam name="T"><para>The list's item type.</para><para>Тип элементов
            ↪  списка.</para></typeparam>
73          /// <param name="list"><para>The list to add the value to.</para><para>Список в который
            ↪  нужно добавить значение.</para></param>
74          /// <param name="elements"><para>The item to add to the list.</para><para>Элемент
            ↪  который нужно добавить в список</para></param>
75          /// <returns>
76          /// <para>True value in any case.</para>
77          /// <para>Значение true в любом случае.</para>
78          /// </returns>
79          [MethodImpl(MethodImplOptions.AggressiveInlining)]
80          public static bool AddFirstAndReturnTrue<T>(this IList<T> list, IList<T> elements)
81          {
82              list.AddFirst(elements);
83              return true;
84          }
85
86          /// <summary>
87          /// <para>Adds a value to the list at the first index.</para>
88          /// <para>Добавляет значение в список по первому индексу.</para>
89          /// </summary>
90          /// <typeparam name="T"><para>The list's item type.</para><para>Тип элементов
            ↪  списка.</para></typeparam>
91          /// <param name="list"><para>The list to add the value to.</para><para>Список в который
            ↪  нужно добавить значение.</para></param>
92          /// <param name="elements"><para>The item to add to the list.</para><para>Элемент
            ↪  который нужно добавить в список</para></param>
93          [MethodImpl(MethodImplOptions.AggressiveInlining)]
94          public static void AddFirst<T>(this IList<T> list, IList<T> elements) =>
            ↪  list.Add(elements[0]);
95
96          /// <summary>
97          /// <para>Adds all elements from other list to this list and returns true.</para>
98          /// <para>Добавляет все элементы из другого списка в этот список и возвращает
            ↪  true.</para>
99          /// </summary>
100         /// <typeparam name="T"><para>The list's item type.</para><para>Тип элементов
            ↪  списка.</para></typeparam>
101         /// <param name="list"><para>The list to add the values to.</para><para>Список в который
            ↪  нужно добавить значения.</para></param>
102         /// <param name="elements"><para>List of values to add.</para><para>Список значений
            ↪  которые необходимо добавить.</para></param>
103         /// <returns>
104         /// <para>True value in any case.</para>
105         /// <para>Значение true в любом случае.</para>
106         /// </returns>
107         [MethodImpl(MethodImplOptions.AggressiveInlining)]
108         public static bool AddAllAndReturnTrue<T>(this IList<T> list, IList<T> elements)
109         {
110             list.AddAll(elements);
111             return true;
112         }
113
114         /// <summary>
115         /// <para>Adds all elements from other list to this list.</para>
116         /// <para>Добавляет все элементы из другого списка в этот список.</para>
117         /// </summary>
118         /// <typeparam name="T"><para>The list's item type.</para><para>Тип элементов
            ↪  списка.</para></typeparam>
119         /// <param name="list"><para>The list to add the values to.</para><para>Список в который
            ↪  нужно добавить значения.</para></param>
120         /// <param name="elements"><para>The list of values to add.</para><para>Список значений
            ↪  которые необходимо добавить.</para></param>
121         [MethodImpl(MethodImplOptions.AggressiveInlining)]
122         public static void AddAll<T>(this IList<T> list, IList<T> elements)
123         {
124             for (var i = 0; i < elements.Count; i++)
125             {
126                 list.Add(elements[i]);
127             }
128         }
129
130         /// <summary>
131         /// <para>Adds values to the list skipping the first element.</para>
132         /// <para>Добавляет значения в список пропуская первый элемент.</para>
133         /// </summary>
```

```
134         /// <typeparam name="T"><para>The list's item type.</para><para>Тип элементов
            ↪  списка.</para></typeparam>
135         /// <param name="list"><para>The list to add the values to.</para><para>Список в который
            ↪  нужно добавить значения.</para></param>
136         /// <param name="elements"><para>The list of values to add.</para><para>Список значений
            ↪  которые необходимо добавить.</para></param>
137         /// <returns>
138         /// <para>True value in any case.</para>
139         /// <para>Значение true в любом случае.</para>
140         /// </returns>
141         [MethodImpl(MethodImplOptions.AggressiveInlining)]
142         public static bool AddSkipFirstAndReturnTrue<T>(this IList<T> list, IList<T> elements)
143         {
144             list.AddSkipFirst(elements);
145             return true;
146         }
147
148         /// <summary>
149         /// <para>Adds values to the list skipping the first element.</para>
150         /// <para>Добавляет значения в список пропуская первый элемент.</para>
151         /// </summary>
152         /// <typeparam name="T"><para>The list's item type.</para><para>Тип элементов
            ↪  списка.</para></typeparam>
153         /// <param name="list"><para>The list to add the values to.</para><para>Список в который
            ↪  нужно добавить значения.</para></param>
154         /// <param name="elements"><para>List of values to add.</para><para>Список значений
            ↪  которые необходимо добавить.</para></param>
155         [MethodImpl(MethodImplOptions.AggressiveInlining)]
156         public static void AddSkipFirst<T>(this IList<T> list, IList<T> elements) =>
            ↪  list.AddSkipFirst(elements, 1);
157
158         /// <summary>
159         /// <para>Adds values to the list skipping a specified number of first elements.</para>
160         /// <para>Добавляет в список значения пропуская определенное количество первых
            ↪  элементов.</para>
161         /// </summary>
162         /// <typeparam name="T"><para>The list's item type.</para><para>Тип элементов
            ↪  списка.</para></typeparam>
163         /// <param name="list"><para>The list to add the values to.</para><para>Список в который
            ↪  нужно добавить значения.</para></param>
164         /// <param name="elements"><para>List of values to add.</para><para>Список значений
            ↪  которые необходимо добавить.</para></param>
165         /// <param name="skip"><para>Number of elements to skip.</para><para>Количество
            ↪  пропускаемых элементов.</para></param>
166         [MethodImpl(MethodImplOptions.AggressiveInlining)]
167         public static void AddSkipFirst<T>(this IList<T> list, IList<T> elements, int skip)
168         {
169             for (var i = skip; i < elements.Count; i++)
170             {
171                 list.Add(elements[i]);
172             }
173         }
174
175         /// <summary>
176         /// <para>Reads the number of elements in the list.</para>
177         /// <para>Считывает число элементов списка.</para>
178         /// </summary>
179         /// <typeparam name="T"><para>The list's item type.</para><para>Тип элементов
            ↪  списка.</para></typeparam>
180         /// <param name="list"><para>The checked list.</para><para>Список для
            ↪  проверки.</para></param>
181         /// <returns>
182         /// <para>The number of items contained in the list or 0.</para>
183         /// <para>Число элементов содержащихся в списке или же 0.</para>
184         /// </returns>
185         [MethodImpl(MethodImplOptions.AggressiveInlining)]
186         public static int GetCountOrZero<T>(this IList<T> list) => list?.Count ?? 0;
187
188         /// <summary>
189         /// <para>Compares two lists for equality.</para>
190         /// <para>Сравнивает два списка на равенство.</para>
191         /// </summary>
192         /// <typeparam name="T"><para>The list's item type.</para><para>Тип элементов
            ↪  списка.</para></typeparam>
193         /// <param name="left"><para>The first compared list.</para><para>Первый список для
            ↪  сравнения.</para></param>
```

```
194         /// <param name="right"><para>The second compared list.</para><para>Второй список для
            ↪ сравнения.</para></param>
195         /// <returns>
196         /// <para>If the passed lists are equal to each other, true is returned, otherwise
            ↪ false.</para>
197         /// <para>Если переданные списки равны друг другу, возвращается true, иначе же
            ↪ false.</para>
198         /// </returns>
199         [MethodImpl(MethodImplOptions.AggressiveInlining)]
200         public static bool EqualTo<T>(this IList<T> left, IList<T> right) => EqualTo(left,
            ↪ right, ContentEqualTo);
201
202         /// <summary>
203         /// <para>Compares two lists for equality.</para>
204         /// <para>Сравнивает два списка на равенство.</para>
205         /// </summary>
206         /// <typeparam name="T"><para>The list's item type.</para><para>Тип элементов
            ↪ списка.</para></typeparam>
207         /// <param name="left"><para>The first compared list.</para><para>Первый список для
            ↪ проверки.</para></param>
208         /// <param name="right"><para>The second compared list.</para><para>Второй список для
            ↪ сравнения.</para></param>
209         /// <param name="contentEqualityComparer"><para>Function to test two lists for their
            ↪ content equality.</para><para>Функция для проверки двух списков на равенство их
            ↪ содержимого.</para></param>
210         /// <returns>
211         /// <para>If the passed lists are equal to each other, true is returned, otherwise
            ↪ false.</para>
212         /// <para>Если переданные списки равны друг другу, возвращается true, иначе же
            ↪ false.</para>
213         /// </returns>
214         [MethodImpl(MethodImplOptions.AggressiveInlining)]
215         public static bool EqualTo<T>(this IList<T> left, IList<T> right, Func<IList<T>,
            ↪ IList<T>, bool> contentEqualityComparer)
216         {
217             if (ReferenceEquals(left, right))
218             {
219                 return true;
220             }
221             var leftCount = left.GetCountOrZero();
222             var rightCount = right.GetCountOrZero();
223             if (leftCount == 0 && rightCount == 0)
224             {
225                 return true;
226             }
227             if (leftCount == 0 || rightCount == 0 || leftCount != rightCount)
228             {
229                 return false;
230             }
231             return contentEqualityComparer(left, right);
232         }
233
234         /// <summary>
235         /// <para>Compares each element in the list for identity.</para>
236         /// <para>Сравнивает на равенство каждый элемент списка.</para>
237         /// </summary>
238         /// <typeparam name="T"><para>The list's item type.</para><para>Тип элементов
            ↪ списка.</para></typeparam>
239         /// <param name="left"><para>The first compared list.</para><para>Первый список для
            ↪ сравнения.</para></param>
240         /// <param name="right"><para>The second compared list.</para><para>Второй список для
            ↪ сравнения.</para></param>
241         /// <returns>
242         /// <para>If at least one element of one list is not equal to the corresponding element
            ↪ from another list returns false, otherwise - true.</para>
243         /// <para>Если как минимум один элемент одного списка не равен соответствующему элементу
            ↪ из другого списка возвращает false, иначе - true.</para>
244         /// </returns>
245         [MethodImpl(MethodImplOptions.AggressiveInlining)]
246         public static bool ContentEqualTo<T>(this IList<T> left, IList<T> right)
247         {
248             var equalityComparer = EqualityComparer<T>.Default;
249             for (var i = left.Count - 1; i >= 0; --i)
250             {
251                 if (!equalityComparer.Equals(left[i], right[i]))
252                 {
253                     return false;
```

```
254                 }
255             }
256             return true;
257         }
258 
259         /// <summary>
260         /// <para>Creates an array by copying all elements from the list that satisfy the
        ↪  predicate. If no list is passed, null is returned.</para>
261         /// <para>Создаёт массив, копируя из списка все элементы которые удовлетворяют
        ↪  предикату. Если список не передан, возвращается null.</para>
262         /// </summary>
263         /// <typeparam name="T"><para>The list's item type.</para><para>Тип элементов
        ↪  списка.</para></typeparam>
264         /// <param name="list">The list to copy from.<para>Список для копирования.</para></param>
265         /// <param name="predicate"><para>A function that determines whether an element should
        ↪  be copied.</para><para>Функция определяющая должен ли копироваться
        ↪  элемент.</para></param>
266         /// <returns>
267         /// <para>An array with copied elements from the list.</para>
268         /// <para>Массив с скопированными элементами из списка.</para>
269         /// </returns>
270         [MethodImpl(MethodImplOptions.AggressiveInlining)]
271         public static T[] ToArray<T>(this IList<T> list, Func<T, bool> predicate)
272         {
273             if (list == null)
274             {
275                 return null;
276             }
277             var result = new List<T>(list.Count);
278             for (var i = 0; i < list.Count; i++)
279             {
280                 if (predicate(list[i]))
281                 {
282                     result.Add(list[i]);
283                 }
284             }
285             return result.ToArray();
286         }
287 
288         /// <summary>
289         /// <para>Copies all the elements of the list into an array and returns it.</para>
290         /// <para>Копирует все элементы списка в массив и возвращает его.</para>
291         /// </summary>
292         /// <typeparam name="T"><para>The list's item type.</para><para>Тип элементов
        ↪  списка.</para></typeparam>
293         /// <param name="list"><para>The list to copy from.</para><para>Список для
        ↪  копирования.</para></param>
294         /// <returns>
295         /// <para>An array with all the elements of the passed list.</para>
296         /// <para>Массив со всеми элементами переданного списка.</para>
297         /// </returns>
298         [MethodImpl(MethodImplOptions.AggressiveInlining)]
299         public static T[] ToArray<T>(this IList<T> list)
300         {
301             var array = new T[list.Count];
302             list.CopyTo(array, 0);
303             return array;
304         }
305 
306         /// <summary>
307         /// <para>Executes the passed action for each item in the list.</para>
308         /// <para>Выполняет переданное действие для каждого элемента в списке.</para>
309         /// </summary>
310         /// <typeparam name="T"><para>The list's item type.</para><para>Тип элементов
        ↪  списка.</para></typeparam>
311         /// <param name="list"><para>The list of elements for which the action will be
        ↪  executed.</para><para>Список элементов для которых будет выполняться
        ↪  действие.</para></param>
312         /// <param name="action"><para>A function that will be called for each element of the
        ↪  list.</para><para>Функция которая будет вызываться для каждого элемента
        ↪  списка.</para></param>
313         [MethodImpl(MethodImplOptions.AggressiveInlining)]
314         public static void ForEach<T>(this IList<T> list, Action<T> action)
315         {
316             for (var i = 0; i < list.Count; i++)
317             {
318                 action(list[i]);
```

```
319             }
320         }
321 
322         /// <summary>
323         /// <para>Generates a hash code for the entire list based on the values of its
            ↪  elements.</para>
324         /// <para>Генерирует хэш-код всего списка, на основе значений его элементов.</para>
325         /// </summary>
326         /// <typeparam name="T"><para>The list's item type.</para><para>Тип элементов
            ↪  списка.</para></typeparam>
327         /// <param name="list"><para>Hash list.</para><para>Список для
            ↪  хеширования.</para></param>
328         /// <returns>
329         /// <para>The hash code of the list.</para>
330         /// <para>Хэш-код списка.</para>
331         /// </returns>
332         /// <remarks>
333         /// Based on http://stackoverflow.com/questions/263400/what-is-the-best-algorithm-for-an
            ↪  -overridden-system-object-gethashcode
334         /// </remarks>
335         [MethodImpl(MethodImplOptions.AggressiveInlining)]
336         public static int GenerateHashCode<T>(this IList<T> list)
337         {
338             var hashAccumulator = 17;
339             for (var i = 0; i < list.Count; i++)
340             {
341                 hashAccumulator = unchecked((hashAccumulator * 23) + list[i].GetHashCode());
342             }
343             return hashAccumulator;
344         }
345 
346         /// <summary>
347         /// <para>Compares two lists.</para>
348         /// <para>Сравнивает два списка.</para>
349         /// </summary>
350         /// <typeparam name="T"><para>The list's item type.</para><para>Тип элементов
            ↪  списка.</para></typeparam>
351         /// <param name="left"><para>The first compared list.</para><para>Первый список для
            ↪  сравнения.</para></param>
352         /// <param name="right"><para>The second compared list.</para><para>Второй список для
            ↪  сравнения.</para></param>
353         /// <returns>
354         /// <para>
355         ///     A signed integer that indicates the relative values of <paramref name="left" />
            ↪  and <paramref name="right" /> lists' elements, as shown in the following table.
356         ///     <list type="table">
357         ///         <listheader>
358         ///             <term>Value</term>
359         ///             <description>Meaning</description>
360         ///         </listheader>
361         ///         <item>
362         ///             <term>Is less than zero</term>
363         ///             <description>First non equal element of <paramref name="left" /> list is
            ↪  less than first not equal element of <paramref name="right" /> list.</description>
364         ///         </item>
365         ///         <item>
366         ///             <term>Zero</term>
367         ///             <description>All elements of <paramref name="left" /> list equals to all
            ↪  elements of <paramref name="right" /> list.</description>
368         ///         </item>
369         ///         <item>
370         ///             <term>Is greater than zero</term>
371         ///             <description>First non equal element of <paramref name="left" /> list is
            ↪  greater than first not equal element of <paramref name="right" /> list.</description>
372         ///         </item>
373         ///     </list>
374         /// </para>
375         /// <para>
376         ///     Целое число со знаком, которое указывает относительные значения элементов
            ↪  списков <paramref name="left" /> и <paramref name="right" /> как показано в
            ↪  следующей таблице.
377         ///     <list type="table">
378         ///         <listheader>
379         ///             <term>Значение</term>
380         ///             <description>Смысл</description>
381         ///         </listheader>
382         ///         <item>
```

```
383             ///             <term>Меньше нуля</term>
384             ///             <description>Первый не равный элемент <paramref name="left" /> списка
                ↪  меньше первого неравного элемента <paramref name="right" /> списка.</description>
385             ///         </item>
386             ///         <item>
387             ///             <term>Ноль</term>
388             ///             <description>Все элементы <paramref name="left" /> списка равны всем
                ↪  элементам <paramref name="right" /> списка.</description>
389             ///         </item>
390             ///         <item>
391             ///             <term>Больше нуля</term>
392             ///             <description>Первый не равный элемент <paramref name="left" /> списка
                ↪  больше первого неравного элемента <paramref name="right" /> списка.</description>
393             ///         </item>
394             ///     </list>
395             /// </para>
396             /// </returns>
397             [MethodImpl(MethodImplOptions.AggressiveInlining)]
398             public static int CompareTo<T>(this IList<T> left, IList<T> right)
399             {
400                 var comparer = Comparer<T>.Default;
401                 var leftCount = left.GetCountOrZero();
402                 var rightCount = right.GetCountOrZero();
403                 var intermediateResult = leftCount.CompareTo(rightCount);
404                 for (var i = 0; intermediateResult == 0 && i < leftCount; i++)
405                 {
406                     intermediateResult = comparer.Compare(left[i], right[i]);
407                 }
408                 return intermediateResult;
409             }
410 
411             /// <summary>
412             /// <para>Skips one element in the list and builds an array from the remaining
                ↪  elements.</para>
413             /// <para>Пропускает один элемент списка и составляет из оставшихся элементов
                ↪  массив.</para>
414             /// </summary>
415             /// <typeparam name="T"><para>The list's item type.</para><para>Тип элементов
                ↪  списка.</para></typeparam>
416             /// <param name="list"><para>The list to copy from.</para><para>Список для
                ↪  копирования.</para></param>
417             /// <returns>
418             /// <para>If the list is empty, returns an empty array, otherwise - an array with a
                ↪  missing first element.</para>
419             /// <para>Если список пуст, возвращает пустой массив, иначе - массив с пропущенным
                ↪  первым элементом.</para>
420             /// </returns>
421             [MethodImpl(MethodImplOptions.AggressiveInlining)]
422             public static T[] SkipFirst<T>(this IList<T> list) => list.SkipFirst(1);
423 
424             /// <summary>
425             /// <para>Skips the specified number of elements in the list and builds an array from
                ↪  the remaining elements.</para>
426             /// <para>Пропускает указанное количество элементов списка и составляет из оставшихся
                ↪  элементов массив.</para>
427             /// </summary>
428             /// <typeparam name="T"><para>The list's item type.</para><para>Тип элементов
                ↪  списка.</para></typeparam>
429             /// <param name="list"><para>The list to copy from.</para><para>Список для
                ↪  копирования.</para></param>
430             /// <param name="skip"><para>The number of items to skip.</para><para>Количество
                ↪  пропускаемых элементов.</para></param>
431             /// <returns>
432             /// <para>If the list is empty, or the number of skipped elements is greater than the
                ↪  list, returns an empty array, otherwise - an array with the specified number of
                ↪  missing elements.</para>
433             /// <para>Если список пуст, или количество пропускаемых элементов больше списка -
                ↪  возвращает пустой массив, иначе - массив с указанным количеством пропущенных
                ↪  элементов.</para>
434             /// </returns>
435             [MethodImpl(MethodImplOptions.AggressiveInlining)]
436             public static T[] SkipFirst<T>(this IList<T> list, int skip)
437             {
438                 if (list.IsNullOrEmpty() || list.Count <= skip)
439                 {
440                     return Array.Empty<T>();
```

```
            }
            var result = new T[list.Count - skip];
            for (int r = skip, w = 0; r < list.Count; r++, w++)
            {
                result[w] = list[r];
            }
            return result;
        }

        /// <summary>
        /// <para>Shifts all the elements of the list by one position to the right.</para>
        /// <para>Сдвигает вправо все элементы списка на одну позицию.</para>
        /// </summary>
        /// <typeparam name="T"><para>The list's item type.</para><para>Тип элементов
        ↪  списка.</para></typeparam>
        /// <param name="list"><para>The list to copy from.</para><para>Список для
        ↪  копирования.</para></param>
        /// <returns>
        /// <para>Array with a shift of elements by one position.</para>
        /// <para>Массив со сдвигом элементов на одну позицию.</para>
        /// </returns>
        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public static IList<T> ShiftRight<T>(this IList<T> list) => list.ShiftRight(1);

        /// <summary>
        /// <para>Shifts all elements of the list to the right by the specified number of
        ↪  elements.</para>
        /// <para>Сдвигает вправо все элементы списка на указанное количество элементов.</para>
        /// </summary>
        /// <typeparam name="T"><para>The list's item type.</para><para>Тип элементов
        ↪  списка.</para></typeparam>
        /// <param name="list"><para>The list to copy from.</para><para>Список для
        ↪  копирования.</para></param>
        /// <param name="skip"><para>The number of items to shift.</para><para>Количество
        ↪  сдвигаемых элементов.</para></param>
        /// <returns>
        /// <para>If the value of the shift variable is less than zero - an <see
        ↪  cref="NotImplementedException"/> exception is thrown, but if the value of the shift
        ↪  variable is 0 - an exact copy of the array is returned. Otherwise, an array is
        ↪  returned with the shift of the elements.</para>
        /// <para>Если значение переменной shift меньше нуля - выбрасывается исключение <see
        ↪  cref="NotImplementedException"/>, если же значение переменной shift равно 0 -
        ↪  возвращается точная копия массива. Иначе возвращается массив со сдвигом
        ↪  элементов.</para>
        /// </returns>
        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public static IList<T> ShiftRight<T>(this IList<T> list, int shift)
        {
            if (shift < 0)
            {
                throw new NotImplementedException();
            }
            if (shift == 0)
            {
                return list.ToArray();
            }
            else
            {
                var result = new T[list.Count + shift];
                for (int r = 0, w = shift; r < list.Count; r++, w++)
                {
                    result[w] = list[r];
                }
                return result;
            }
        }
    }
}
```

1.19 ./csharp/Platform.Collections/Lists/ListFiller.cs

```
using System.Collections.Generic;
using System.Runtime.CompilerServices;

namespace Platform.Collections.Lists
{
    public class ListFiller<TElement, TReturnConstant>
    {
        protected readonly List<TElement> _list;
```

```
        protected readonly TReturnConstant _returnConstant;

        /// <summary>
        /// <para>Initializes a new instance of the ListFiller class.</para>
        /// <para>Инициализирует новый экземпляр класса ListFiller.</para>
        /// </summary>
        /// <param name="list"><para>The list to be filled.</para><para>Список который будет
        ↪  заполняться.</para></param>
        /// <param name="returnConstant"><para>The value for the constant returned by
        ↪  corresponding methods.</para><para>Значение для константы возвращаемой
        ↪  соответствующими методами.</para></param>
        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public ListFiller(List<TElement> list, TReturnConstant returnConstant)
        {
            _list = list;
            _returnConstant = returnConstant;
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public ListFiller(List<TElement> list) : this(list, default) { }

        /// <summary>
        /// <para>Adds an item to the end of the list.</para>
        /// <para>Добавляет элемент в конец списка.</para>
        /// </summary>
        /// <param name="element"><para>Element to add.</para><para>Добавляемый
        ↪  элемент.</para></param>
        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public void Add(TElement element) => _list.Add(element);

        /// <summary>
        /// <para>Adds an item to the end of the list and return true.</para>
        /// <para>Добавляет элемент в конец списка и возвращает true.</para>
        /// </summary>
        /// <param name="element"><para>Element to add.</para><para>Добавляемый
        ↪  элемент.</para></param>
        /// <returns>
        /// <para>True value in any case.</para>
        /// <para>Значение true в любом случае.</para>
        /// </returns>
        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public bool AddAndReturnTrue(TElement element) => _list.AddAndReturnTrue(element);

        /// <summary>
        /// <para>Adds a value to the list at the first index and return true.</para>
        /// <para>Добавляет значение в список по первому индексу и возвращает true.</para>
        /// </summary>
        /// <param name="element"><para>Element to add.</para><para>Добавляемый
        ↪  элемент.</para></param>
        /// <returns>
        /// <para>True value in any case.</para>
        /// <para>Значение true в любом случае.</para>
        /// </returns>
        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public bool AddFirstAndReturnTrue(IList<TElement> elements) =>
        ↪  _list.AddFirstAndReturnTrue(elements);

        /// <summary>
        /// <para>Adds all elements from other list to this list and returns true.</para>
        /// <para>Добавляет все элементы из другого списка в этот список и возвращает
        ↪  true.</para>
        /// </summary>
        /// <param name="elements"><para>List of values to add.</para><para>Список значений
        ↪  которые необходимо добавить.</para></param>
        /// <returns>
        /// <para>True value in any case.</para>
        /// <para>Значение true в любом случае.</para>
        /// </returns>
        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public bool AddAllAndReturnTrue(IList<TElement> elements) =>
        ↪  _list.AddAllAndReturnTrue(elements);

        /// <summary>
        /// <para>Adds values to the list skipping the first element.</para>
        /// <para>Добавляет значения в список пропуская первый элемент.</para>
        /// </summary>
        /// <param name="elements"><para>The list of values to add.</para><para>Список значений
        ↪  которые необходимо добавить.</para></param>
```

```
        /// <returns>
        /// <para>True value in any case.</para>
        /// <para>Значение true в любом случае.</para>
        /// </returns>
        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public bool AddSkipFirstAndReturnTrue(IList<TElement> elements) =>
        ↪  _list.AddSkipFirstAndReturnTrue(elements);

        /// <summary>
        /// <para>Adds an item to the end of the list and return constant.</para>
        /// <para>Добавляет элемент в конец списка и возвращает константу.</para>
        /// </summary>
        /// <param name="element"><para>Element to add.</para><para>Добавляемый
        ↪  элемент.</para></param>
        /// <returns>
        /// <para>Constant value in any case.</para>
        /// <para>Значение константы в любом случае.</para>
        /// </returns>
        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public TReturnConstant AddAndReturnConstant(TElement element)
        {
            _list.Add(element);
            return _returnConstant;
        }

        /// <summary>
        /// <para>Adds a value to the list at the first index and return constant.</para>
        /// <para>Добавляет значение в список по первому индексу и возвращает константу.</para>
        /// </summary>
        /// <param name="element"><para>Element to add.</para><para>Добавляемый
        ↪  элемент.</para></param>
        /// <returns>
        /// <para>Constant value in any case.</para>
        /// <para>Значение константы в любом случае.</para>
        /// <returns></returns>
        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public TReturnConstant AddFirstAndReturnConstant(IList<TElement> elements)
        {
            _list.AddFirst(elements);
            return _returnConstant;
        }

        /// <summary>
        /// <para>Adds all elements from other list to this list and returns constant.</para>
        /// <para>Добавляет все элементы из другого списка в этот список и возвращает
        ↪  константу.</para>
        /// </summary>
        /// <param name="elements"><para>List of values to add.</para><para>Список значений
        ↪  которые необходимо добавить.</para></param>
        /// <returns>
        /// <para>Constant value in any case.</para>
        /// <para>Значение константы в любом случае.</para>
        /// <returns>
        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public TReturnConstant AddAllAndReturnConstant(IList<TElement> elements)
        {
            _list.AddAll(elements);
            return _returnConstant;
        }

        /// <summary>
        /// <para>Adds values to the list skipping the first element and return constant
        ↪  value.</para>
        /// <para>Добавляет значения в список пропуская первый элемент и возвращает значение
        ↪  константы.</para>
        /// </summary>
        /// <param name="elements"><para>The list of values to add.</para><para>Список значений
        ↪  которые необходимо добавить.</para></param>
        /// <returns>
        /// <para>constant value in any case.</para>
        /// <para>Значение константы в любом случае.</para>
        /// </returns>
        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public TReturnConstant AddSkipFirstAndReturnConstant(IList<TElement> elements)
        {
            _list.AddSkipFirst(elements);
            return _returnConstant;
```

```
        }
    }
}
```

1.20 ./csharp/Platform.Collections/Segments/CharSegment.cs

```
using System.Linq;
using System.Collections.Generic;
using System.Runtime.CompilerServices;
using Platform.Collections.Arrays;
using Platform.Collections.Lists;

#pragma warning disable CS1591 // Missing XML comment for publicly visible type or member

namespace Platform.Collections.Segments
{
    public class CharSegment : Segment<char>
    {
        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public CharSegment(IList<char> @base, int offset, int length) : base(@base, offset, length) { }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public override int GetHashCode()
        {
            // Base can be not an array, but still IList<char>
            if (Base is char[] baseArray)
            {
                return baseArray.GenerateHashCode(Offset, Length);
            }
            else
            {
                return this.GenerateHashCode();
            }
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public override bool Equals(Segment<char> other)
        {
            bool contentEqualityComparer(IList<char> left, IList<char> right)
            {
                // Base can be not an array, but still IList<char>
                if (Base is char[] baseArray && other.Base is char[] otherArray)
                {
                    return baseArray.ContentEqualTo(Offset, Length, otherArray, other.Offset);
                }
                else
                {
                    return left.ContentEqualTo(right);
                }
            }
            return this.EqualTo(other, contentEqualityComparer);
        }

        public override bool Equals(object obj) => obj is Segment<char> charSegment ? Equals(charSegment) : false;

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public static implicit operator string(CharSegment segment)
        {
            if (!(segment.Base is char[] array))
            {
                array = segment.Base.ToArray();
            }
            return new string(array, segment.Offset, segment.Length);
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public override string ToString() => this;
    }
}
```

1.21 ./csharp/Platform.Collections/Segments/Segment.cs

```
using System;
using System.Collections;
using System.Collections.Generic;
using System.Runtime.CompilerServices;
using Platform.Collections.Arrays;
using Platform.Collections.Lists;

```

```
#pragma warning disable CS1591 // Missing XML comment for publicly visible type or member

namespace Platform.Collections.Segments
{
    public class Segment<T> : IEquatable<Segment<T>>, IList<T>
    {
        public IList<T> Base
        {
            [MethodImpl(MethodImplOptions.AggressiveInlining)]
            get;
        }
        public int Offset
        {
            [MethodImpl(MethodImplOptions.AggressiveInlining)]
            get;
        }
        public int Length
        {
            [MethodImpl(MethodImplOptions.AggressiveInlining)]
            get;
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public Segment(IList<T> @base, int offset, int length)
        {
            Base = @base;
            Offset = offset;
            Length = length;
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public override int GetHashCode() => this.GenerateHashCode();

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public virtual bool Equals(Segment<T> other) => this.EqualTo(other);

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public override bool Equals(object obj) => obj is Segment<T> other ? Equals(other) :
        ↪  false;

        #region IList

        public T this[int i]
        {
            [MethodImpl(MethodImplOptions.AggressiveInlining)]
            get => Base[Offset + i];
            [MethodImpl(MethodImplOptions.AggressiveInlining)]
            set => Base[Offset + i] = value;
        }

        public int Count
        {
            [MethodImpl(MethodImplOptions.AggressiveInlining)]
            get => Length;
        }

        public bool IsReadOnly
        {
            [MethodImpl(MethodImplOptions.AggressiveInlining)]
            get => true;
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public int IndexOf(T item)
        {
            var index = Base.IndexOf(item);
            if (index >= Offset)
            {
                var actualIndex = index - Offset;
                if (actualIndex < Length)
                {
                    return actualIndex;
                }
            }
            return -1;
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public void Insert(int index, T item) => throw new NotSupportedException();

```

```
        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public void RemoveAt(int index) => throw new NotSupportedException();

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public void Add(T item) => throw new NotSupportedException();

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public void Clear() => throw new NotSupportedException();

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public bool Contains(T item) => IndexOf(item) >= 0;

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public void CopyTo(T[] array, int arrayIndex)
        {
            for (var i = 0; i < Length; i++)
            {
                array.Add(ref arrayIndex, this[i]);
            }
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public bool Remove(T item) => throw new NotSupportedException();

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public IEnumerator<T> GetEnumerator()
        {
            for (var i = 0; i < Length; i++)
            {
                yield return this[i];
            }
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        IEnumerator IEnumerable.GetEnumerator() => GetEnumerator();

        #endregion
    }
}
```

1.22 ./csharp/Platform.Collections/Segments/Walkers/AllSegmentsWalkerBase.cs

```
#pragma warning disable CS1591 // Missing XML comment for publicly visible type or member

namespace Platform.Collections.Segments.Walkers
{
    public abstract class AllSegmentsWalkerBase
    {
        public static readonly int DefaultMinimumStringSegmentLength = 2;
    }
}
```

1.23 ./csharp/Platform.Collections/Segments/Walkers/AllSegmentsWalkerBase[T, TSegment].cs

```
using System.Collections.Generic;
using System.Runtime.CompilerServices;

#pragma warning disable CS1591 // Missing XML comment for publicly visible type or member

namespace Platform.Collections.Segments.Walkers
{
    public abstract class AllSegmentsWalkerBase<T, TSegment> : AllSegmentsWalkerBase
        where TSegment : Segment<T>
    {
        private readonly int _minimumStringSegmentLength;

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        protected AllSegmentsWalkerBase(int minimumStringSegmentLength) =>
        ↪  _minimumStringSegmentLength = minimumStringSegmentLength;

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        protected AllSegmentsWalkerBase() : this(DefaultMinimumStringSegmentLength) { }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public virtual void WalkAll(IList<T> elements)
        {
            for (int offset = 0, maxOffset = elements.Count - _minimumStringSegmentLength;
            ↪  offset <= maxOffset; offset++)
            {
                for (int length = _minimumStringSegmentLength, maxLength = elements.Count -
                ↪  offset; length <= maxLength; length++)
```

```
                {
                    Iteration(CreateSegment(elements, offset, length));
                }
            }
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        protected abstract TSegment CreateSegment(IList<T> elements, int offset, int length);

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        protected abstract void Iteration(TSegment segment);
    }
}
```

1.24 ./csharp/Platform.Collections/Segments/Walkers/AllSegmentsWalkerBase[T].cs

```
using System.Collections.Generic;
using System.Runtime.CompilerServices;

#pragma warning disable CS1591 // Missing XML comment for publicly visible type or member

namespace Platform.Collections.Segments.Walkers
{
    public abstract class AllSegmentsWalkerBase<T> : AllSegmentsWalkerBase<T, Segment<T>>
    {
        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        protected override Segment<T> CreateSegment(IList<T> elements, int offset, int length)
        ↪  => new Segment<T>(elements, offset, length);
    }
}
```

1.25 ./csharp/Platform.Collections/Segments/Walkers/AllSegmentsWalkerExtensions.cs

```
using System.Runtime.CompilerServices;

#pragma warning disable CS1591 // Missing XML comment for publicly visible type or member

namespace Platform.Collections.Segments.Walkers
{
    public static class AllSegmentsWalkerExtensions
    {
        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public static void WalkAll(this AllSegmentsWalkerBase<char> walker, string @string) =>
        ↪  walker.WalkAll(@string.ToCharArray());

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public static void WalkAll<TSegment>(this AllSegmentsWalkerBase<char, TSegment> walker,
        ↪  string @string) where TSegment : Segment<char> =>
        ↪  walker.WalkAll(@string.ToCharArray());
    }
}
```

1.26 ./csharp/Platform.Collections/Segments/Walkers/DictionaryBasedDuplicateSegmentsWalkerBase[T, Segment

```
using System;
using System.Collections.Generic;
using System.Runtime.CompilerServices;

#pragma warning disable CS1591 // Missing XML comment for publicly visible type or member

namespace Platform.Collections.Segments.Walkers
{
    public abstract class DictionaryBasedDuplicateSegmentsWalkerBase<T, TSegment> :
    ↪  DuplicateSegmentsWalkerBase<T, TSegment>
        where TSegment : Segment<T>
    {
        public static readonly bool DefaultResetDictionaryOnEachWalk;

        private readonly bool _resetDictionaryOnEachWalk;
        protected IDictionary<TSegment, long> Dictionary;

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        protected DictionaryBasedDuplicateSegmentsWalkerBase(IDictionary<TSegment, long>
        ↪  dictionary, int minimumStringSegmentLength, bool resetDictionaryOnEachWalk)
            : base(minimumStringSegmentLength)
        {
            Dictionary = dictionary;
            _resetDictionaryOnEachWalk = resetDictionaryOnEachWalk;
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
```

```
        protected DictionaryBasedDuplicateSegmentsWalkerBase(IDictionary<TSegment, long>
        ↪  dictionary, int minimumStringSegmentLength) : this(dictionary,
        ↪  minimumStringSegmentLength, DefaultResetDictionaryOnEachWalk) { }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        protected DictionaryBasedDuplicateSegmentsWalkerBase(IDictionary<TSegment, long>
        ↪  dictionary) : this(dictionary, DefaultMinimumStringSegmentLength,
        ↪  DefaultResetDictionaryOnEachWalk) { }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        protected DictionaryBasedDuplicateSegmentsWalkerBase(int minimumStringSegmentLength,
        ↪  bool resetDictionaryOnEachWalk) : this(resetDictionaryOnEachWalk ? null : new
        ↪  Dictionary<TSegment, long>(), minimumStringSegmentLength, resetDictionaryOnEachWalk)
        ↪  { }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        protected DictionaryBasedDuplicateSegmentsWalkerBase(int minimumStringSegmentLength) :
        ↪  this(minimumStringSegmentLength, DefaultResetDictionaryOnEachWalk) { }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        protected DictionaryBasedDuplicateSegmentsWalkerBase() :
        ↪  this(DefaultMinimumStringSegmentLength, DefaultResetDictionaryOnEachWalk) { }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public override void WalkAll(IList<T> elements)
        {
            if (_resetDictionaryOnEachWalk)
            {
                var capacity = Math.Ceiling(Math.Pow(elements.Count, 2) / 2);
                Dictionary = new Dictionary<TSegment, long>((int)capacity);
            }
            base.WalkAll(elements);
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        protected override long GetSegmentFrequency(TSegment segment) =>
        ↪  Dictionary.GetOrDefault(segment);

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        protected override void SetSegmentFrequency(TSegment segment, long frequency) =>
        ↪  Dictionary[segment] = frequency;
    }
}
```

1.27 ./csharp/Platform.Collections/Segments/Walkers/DictionaryBasedDuplicateSegmentsWalkerBase[T].cs

```
using System.Collections.Generic;
using System.Runtime.CompilerServices;

#pragma warning disable CS1591 // Missing XML comment for publicly visible type or member

namespace Platform.Collections.Segments.Walkers
{
    public abstract class DictionaryBasedDuplicateSegmentsWalkerBase<T> :
    ↪  DictionaryBasedDuplicateSegmentsWalkerBase<T, Segment<T>>
    {
        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        protected DictionaryBasedDuplicateSegmentsWalkerBase(IDictionary<Segment<T>, long>
        ↪  dictionary, int minimumStringSegmentLength, bool resetDictionaryOnEachWalk) :
        ↪  base(dictionary, minimumStringSegmentLength, resetDictionaryOnEachWalk) { }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        protected DictionaryBasedDuplicateSegmentsWalkerBase(IDictionary<Segment<T>, long>
        ↪  dictionary, int minimumStringSegmentLength) : base(dictionary,
        ↪  minimumStringSegmentLength, DefaultResetDictionaryOnEachWalk) { }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        protected DictionaryBasedDuplicateSegmentsWalkerBase(IDictionary<Segment<T>, long>
        ↪  dictionary) : base(dictionary, DefaultMinimumStringSegmentLength,
        ↪  DefaultResetDictionaryOnEachWalk) { }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        protected DictionaryBasedDuplicateSegmentsWalkerBase(int minimumStringSegmentLength,
        ↪  bool resetDictionaryOnEachWalk) : base(minimumStringSegmentLength,
        ↪  resetDictionaryOnEachWalk) { }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        protected DictionaryBasedDuplicateSegmentsWalkerBase(int minimumStringSegmentLength) :
        ↪  base(minimumStringSegmentLength, DefaultResetDictionaryOnEachWalk) { }
```

```

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        protected DictionaryBasedDuplicateSegmentsWalkerBase() :
        ↪ base(DefaultMinimumStringSegmentLength, DefaultResetDictionaryOnEachWalk) { }
    }
}
```

1.28 ./csharp/Platform.Collections/Segments/Walkers/DuplicateSegmentsWalkerBase[T, TSegment].cs

```
using System.Runtime.CompilerServices;

#pragma warning disable CS1591 // Missing XML comment for publicly visible type or member

namespace Platform.Collections.Segments.Walkers
{
    public abstract class DuplicateSegmentsWalkerBase<T, TSegment> : AllSegmentsWalkerBase<T,
    ↪ TSegment>
        where TSegment : Segment<T>
    {
        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        protected DuplicateSegmentsWalkerBase(int minimumStringSegmentLength) :
        ↪ base(minimumStringSegmentLength) { }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        protected DuplicateSegmentsWalkerBase() : base(DefaultMinimumStringSegmentLength) { }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        protected override void Iteration(TSegment segment)
        {
            var frequency = GetSegmentFrequency(segment);
            if (frequency == 1)
            {
                OnDublicateFound(segment);
            }
            SetSegmentFrequency(segment, frequency + 1);
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        protected abstract void OnDublicateFound(TSegment segment);

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        protected abstract long GetSegmentFrequency(TSegment segment);

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        protected abstract void SetSegmentFrequency(TSegment segment, long frequency);
    }
}
```

1.29 ./csharp/Platform.Collections/Segments/Walkers/DuplicateSegmentsWalkerBase[T].cs

```
#pragma warning disable CS1591 // Missing XML comment for publicly visible type or member

namespace Platform.Collections.Segments.Walkers
{
    public abstract class DuplicateSegmentsWalkerBase<T> : DuplicateSegmentsWalkerBase<T,
    ↪ Segment<T>>
    {
    }
}
```

1.30 ./csharp/Platform.Collections/Sets/ISetExtensions.cs

```
using System.Collections.Generic;
using System.Runtime.CompilerServices;

#pragma warning disable CS1591 // Missing XML comment for publicly visible type or member

namespace Platform.Collections.Sets
{
    public static class ISetExtensions
    {
        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public static void AddAndReturnVoid<T>(this ISet<T> set, T element) => set.Add(element);

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public static void RemoveAndReturnVoid<T>(this ISet<T> set, T element) =>
        ↪ set.Remove(element);

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public static bool AddAndReturnTrue<T>(this ISet<T> set, T element)
        {
```

```
            set.Add(element);
            return true;
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public static bool AddFirstAndReturnTrue<T>(this ISet<T> set, IList<T> elements)
        {
            AddFirst(set, elements);
            return true;
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public static void AddFirst<T>(this ISet<T> set, IList<T> elements) =>
        ↪  set.Add(elements[0]);

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public static bool AddAllAndReturnTrue<T>(this ISet<T> set, IList<T> elements)
        {
            set.AddAll(elements);
            return true;
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public static void AddAll<T>(this ISet<T> set, IList<T> elements)
        {
            for (var i = 0; i < elements.Count; i++)
            {
                set.Add(elements[i]);
            }
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public static bool AddSkipFirstAndReturnTrue<T>(this ISet<T> set, IList<T> elements)
        {
            set.AddSkipFirst(elements);
            return true;
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public static void AddSkipFirst<T>(this ISet<T> set, IList<T> elements) =>
        ↪  set.AddSkipFirst(elements, 1);

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public static void AddSkipFirst<T>(this ISet<T> set, IList<T> elements, int skip)
        {
            for (var i = skip; i < elements.Count; i++)
            {
                set.Add(elements[i]);
            }
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public static bool DoNotContains<T>(this ISet<T> set, T element) =>
        ↪  !set.Contains(element);
    }
}
```

1.31 ./csharp/Platform.Collections/Sets/SetFiller.cs

```
using System.Collections.Generic;
using System.Runtime.CompilerServices;

#pragma warning disable CS1591 // Missing XML comment for publicly visible type or member

namespace Platform.Collections.Sets
{
    public class SetFiller<TElement, TReturnConstant>
    {
        protected readonly ISet<TElement> _set;
        protected readonly TReturnConstant _returnConstant;

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public SetFiller(ISet<TElement> set, TReturnConstant returnConstant)
        {
            _set = set;
            _returnConstant = returnConstant;
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public SetFiller(ISet<TElement> set) : this(set, default) { }

```

```
        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public void Add(TElement element) => _set.Add(element);

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public bool AddAndReturnTrue(TElement element) => _set.AddAndReturnTrue(element);

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public bool AddFirstAndReturnTrue(IList<TElement> elements) =>
        ↪  _set.AddFirstAndReturnTrue(elements);

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public bool AddAllAndReturnTrue(IList<TElement> elements) =>
        ↪  _set.AddAllAndReturnTrue(elements);

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public bool AddSkipFirstAndReturnTrue(IList<TElement> elements) =>
        ↪  _set.AddSkipFirstAndReturnTrue(elements);

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public TReturnConstant AddAndReturnConstant(TElement element)
        {
            _set.Add(element);
            return _returnConstant;
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public TReturnConstant AddFirstAndReturnConstant(IList<TElement> elements)
        {
            _set.AddFirst(elements);
            return _returnConstant;
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public TReturnConstant AddAllAndReturnConstant(IList<TElement> elements)
        {
            _set.AddAll(elements);
            return _returnConstant;
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public TReturnConstant AddSkipFirstAndReturnConstant(IList<TElement> elements)
        {
            _set.AddSkipFirst(elements);
            return _returnConstant;
        }
    }
}
```

1.32 ./csharp/Platform.Collections/Stacks/DefaultStack.cs

```
using System.Collections.Generic;
using System.Runtime.CompilerServices;

#pragma warning disable CS1591 // Missing XML comment for publicly visible type or member

namespace Platform.Collections.Stacks
{
    public class DefaultStack<TElement> : Stack<TElement>, IStack<TElement>
    {
        public bool IsEmpty
        {
            [MethodImpl(MethodImplOptions.AggressiveInlining)]
            get => Count <= 0;
        }
    }
}
```

1.33 ./csharp/Platform.Collections/Stacks/IStack.cs

```
using System.Runtime.CompilerServices;

#pragma warning disable CS1591 // Missing XML comment for publicly visible type or member

namespace Platform.Collections.Stacks
{
    public interface IStack<TElement>
    {
        bool IsEmpty
        {
            [MethodImpl(MethodImplOptions.AggressiveInlining)]
            get;
```

```
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        void Push(TElement element);

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        TElement Pop();

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        TElement Peek();
    }
}
```

1.34 ./csharp/Platform.Collections/Stacks/IStackExtensions.cs

```
using System.Runtime.CompilerServices;

#pragma warning disable CS1591 // Missing XML comment for publicly visible type or member

namespace Platform.Collections.Stacks
{
    public static class IStackExtensions
    {
        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public static void Clear<T>(this IStack<T> stack)
        {
            while (!stack.IsEmpty)
            {
                _ = stack.Pop();
            }
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public static T PopOrDefault<T>(this IStack<T> stack) => stack.IsEmpty ? default : stack.Pop();

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public static T PeekOrDefault<T>(this IStack<T> stack) => stack.IsEmpty ? default : stack.Peek();
    }
}
```

1.35 ./csharp/Platform.Collections/Stacks/IStackFactory.cs

```
using Platform.Interfaces;

#pragma warning disable CS1591 // Missing XML comment for publicly visible type or member

namespace Platform.Collections.Stacks
{
    public interface IStackFactory<TElement> : IFactory<IStack<TElement>>
    {
    }
}
```

1.36 ./csharp/Platform.Collections/Stacks/StackExtensions.cs

```
using System.Collections.Generic;
using System.Runtime.CompilerServices;

#pragma warning disable CS1591 // Missing XML comment for publicly visible type or member

namespace Platform.Collections.Stacks
{
    public static class StackExtensions
    {
        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public static T PopOrDefault<T>(this Stack<T> stack) => stack.Count > 0 ? stack.Pop() : default;

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public static T PeekOrDefault<T>(this Stack<T> stack) => stack.Count > 0 ? stack.Peek() : default;
    }
}
```

1.37 ./csharp/Platform.Collections/StringExtensions.cs

```
using System;
using System.Globalization;
using System.Runtime.CompilerServices;

#pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
```

```

namespace Platform.Collections
{
    public static class StringExtensions
    {
        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public static string CapitalizeFirstLetter(this string @string)
        {
            if (string.IsNullOrWhiteSpace(@string))
            {
                return @string;
            }
            var chars = @string.ToCharArray();
            for (var i = 0; i < chars.Length; i++)
            {
                var category = char.GetUnicodeCategory(chars[i]);
                if (category == UnicodeCategory.UppercaseLetter)
                {
                    return @string;
                }
                if (category == UnicodeCategory.LowercaseLetter)
                {
                    chars[i] = char.ToUpper(chars[i]);
                    return new string(chars);
                }
            }
            return @string;
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public static string Truncate(this string @string, int maxLength) =>
        ↪ string.IsNullOrEmpty(@string) ? @string : @string.Substring(0,
        ↪ Math.Min(@string.Length, maxLength));

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public static string TrimSingle(this string @string, char charToTrim)
        {
            if (!string.IsNullOrEmpty(@string))
            {
                if (@string.Length == 1)
                {
                    if (@string[0] == charToTrim)
                    {
                        return "";
                    }
                    else
                    {
                        return @string;
                    }
                }
                else
                {
                    var left = 0;
                    var right = @string.Length - 1;
                    if (@string[left] == charToTrim)
                    {
                        left++;
                    }
                    if (@string[right] == charToTrim)
                    {
                        right--;
                    }
                    return @string.Substring(left, right - left + 1);
                }
            }
            else
            {
                return @string;
            }
        }
    }
}
```

1.38 ./csharp/Platform.Collections/Trees/Node.cs

```
using System.Collections.Generic;
using System.Runtime.CompilerServices;

// ReSharper disable ForCanBeConvertedToForeach
#pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
```

```
namespace Platform.Collections.Trees
{
    public class Node
    {
        private Dictionary<object, Node> _childNodes;

        public object Value
        {
            [MethodImpl(MethodImplOptions.AggressiveInlining)]
            get;
            [MethodImpl(MethodImplOptions.AggressiveInlining)]
            set;
        }

        public Dictionary<object, Node> ChildNodes
        {
            [MethodImpl(MethodImplOptions.AggressiveInlining)]
            get => _childNodes ?? (_childNodes = new Dictionary<object, Node>());
        }

        public Node this[object key]
        {
            [MethodImpl(MethodImplOptions.AggressiveInlining)]
            get => GetChild(key) ?? AddChild(key);
            [MethodImpl(MethodImplOptions.AggressiveInlining)]
            set => SetChildValue(value, key);
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public Node(object value) => Value = value;

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public Node() : this(null) { }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public bool ContainsChild(params object[] keys) => GetChild(keys) != null;

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public Node GetChild(params object[] keys)
        {
            var node = this;
            for (var i = 0; i < keys.Length; i++)
            {
                node.ChildNodes.TryGetValue(keys[i], out node);
                if (node == null)
                {
                    return null;
                }
            }
            return node;
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public object GetChildValue(params object[] keys) => GetChild(keys)?.Value;

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public Node AddChild(object key) => AddChild(key, new Node(null));

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public Node AddChild(object key, object value) => AddChild(key, new Node(value));

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public Node AddChild(object key, Node child)
        {
            ChildNodes.Add(key, child);
            return child;
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public Node SetChild(params object[] keys) => SetChildValue(null, keys);

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public Node SetChild(object key) => SetChildValue(null, key);

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public Node SetChildValue(object value, params object[] keys)
        {
            var node = this;
            for (var i = 0; i < keys.Length; i++)
```

```
            {
                node = SetChildValue(value, keys[i]);
            }
            node.Value = value;
            return node;
        }

        [MethodImpl(MethodImplOptions.AggressiveInlining)]
        public Node SetChildValue(object value, object key)
        {
            if (!ChildNodes.TryGetValue(key, out Node child))
            {
                child = AddChild(key, value);
            }
            child.Value = value;
            return child;
        }
    }
}
```

1.39 ./csharp/Platform.Collections.Tests/ArrayTests.cs

```
using Xunit;
using Platform.Collections.Arrays;

namespace Platform.Collections.Tests
{
    public class ArrayTests
    {
        [Fact]
        public void GetElementTest()
        {
            var nullArray = (int[])null;
            Assert.Equal(0, nullArray.GetElementOrDefault(1));
            Assert.False(nullArray.TryGetElement(1, out int element));
            Assert.Equal(0, element);
            var array = new int[] { 1, 2, 3 };
            Assert.Equal(3, array.GetElementOrDefault(2));
            Assert.True(array.TryGetElement(2, out element));
            Assert.Equal(3, element);
            Assert.Equal(0, array.GetElementOrDefault(10));
            Assert.False(array.TryGetElement(10, out element));
            Assert.Equal(0, element);
        }
    }
}
```

1.40 ./csharp/Platform.Collections.Tests/BitStringTests.cs

```
using System;
using System.Collections;
using Xunit;
using Platform.Random;

namespace Platform.Collections.Tests
{
    public static class BitStringTests
    {
        [Fact]
        public static void BitGetSetTest()
        {
            const int n = 250;
            var bitArray = new BitArray(n);
            var bitString = new BitString(n);
            for (var i = 0; i < n; i++)
            {
                var value = RandomHelpers.Default.NextBoolean();
                bitArray.Set(i, value);
                bitString.Set(i, value);
                Assert.Equal(value, bitArray.Get(i));
                Assert.Equal(value, bitString.Get(i));
            }
        }

        [Fact]
        public static void BitVectorNotTest()
        {
            TestToOperationsWithSameMeaning((x, y, w, v) =>
            {
                x.VectorNot();
                w.Not();
```

```
        });
    }

    [Fact]
    public static void BitParallelNotTest()
    {
        TestToOperationsWithSameMeaning((x, y, w, v) =>
        {
            x.ParallelNot();
            w.Not();
        });
    }

    [Fact]
    public static void BitParallelVectorNotTest()
    {
        TestToOperationsWithSameMeaning((x, y, w, v) =>
        {
            x.ParallelVectorNot();
            w.Not();
        });
    }

    [Fact]
    public static void BitVectorAndTest()
    {
        TestToOperationsWithSameMeaning((x, y, w, v) =>
        {
            x.VectorAnd(y);
            w.And(v);
        });
    }

    [Fact]
    public static void BitParallelAndTest()
    {
        TestToOperationsWithSameMeaning((x, y, w, v) =>
        {
            x.ParallelAnd(y);
            w.And(v);
        });
    }

    [Fact]
    public static void BitParallelVectorAndTest()
    {
        TestToOperationsWithSameMeaning((x, y, w, v) =>
        {
            x.ParallelVectorAnd(y);
            w.And(v);
        });
    }

    [Fact]
    public static void BitVectorOrTest()
    {
        TestToOperationsWithSameMeaning((x, y, w, v) =>
        {
            x.VectorOr(y);
            w.Or(v);
        });
    }

    [Fact]
    public static void BitParallelOrTest()
    {
        TestToOperationsWithSameMeaning((x, y, w, v) =>
        {
            x.ParallelOr(y);
            w.Or(v);
        });
    }

    [Fact]
    public static void BitParallelVectorOrTest()
    {
        TestToOperationsWithSameMeaning((x, y, w, v) =>
        {
```

```
                x.ParallelVectorOr(y);
                w.Or(v);
            });
        }

        [Fact]
        public static void BitVectorXorTest()
        {
            TestToOperationsWithSameMeaning((x, y, w, v) =>
            {
                x.VectorXor(y);
                w.Xor(v);
            });
        }

        [Fact]
        public static void BitParallelXorTest()
        {
            TestToOperationsWithSameMeaning((x, y, w, v) =>
            {
                x.ParallelXor(y);
                w.Xor(v);
            });
        }

        [Fact]
        public static void BitParallelVectorXorTest()
        {
            TestToOperationsWithSameMeaning((x, y, w, v) =>
            {
                x.ParallelVectorXor(y);
                w.Xor(v);
            });
        }

        private static void TestToOperationsWithSameMeaning(Action<BitString, BitString,
        ↪  BitString, BitString> test)
        {
            const int n = 5654;
            var x = new BitString(n);
            var y = new BitString(n);
            while (x.Equals(y))
            {
                x.SetRandomBits();
                y.SetRandomBits();
            }
            var w = new BitString(x);
            var v = new BitString(y);
            Assert.False(x.Equals(y));
            Assert.False(w.Equals(v));
            Assert.True(x.Equals(w));
            Assert.True(y.Equals(v));
            test(x, y, w, v);
            Assert.True(x.Equals(w));
        }
    }
}
```

1.41 ./csharp/Platform.Collections.Tests/CharsSegmentTests.cs

```
using Xunit;
using Platform.Collections.Segments;

namespace Platform.Collections.Tests
{
    public static class CharsSegmentTests
    {
        [Fact]
        public static void GetHashCodeEqualsTest()
        {
            const string testString = "test test";
            var testArray = testString.ToCharArray();
            var firstHashCode = new CharSegment(testArray, 0, 4).GetHashCode();
            var secondHashCode = new CharSegment(testArray, 5, 4).GetHashCode();
            Assert.Equal(firstHashCode, secondHashCode);
        }

        [Fact]
        public static void EqualsTest()
        {
```

```
            const string testString = "test test";
            var testArray = testString.ToCharArray();
            var first = new CharSegment(testArray, 0, 4);
            var second = new CharSegment(testArray, 5, 4);
            Assert.True(first.Equals(second));
        }
    }
}
```

1.42 ./csharp/Platform.Collections.Tests/ListTests.cs

```
using System.Collections.Generic;
using Xunit;
using Platform.Collections.Lists;


namespace Platform.Collections.Tests
{
    public class ListTests
    {
        [Fact]
        public void GetElementTest()
        {
            var nullList = (IList<int>)null;
            Assert.Equal(0, nullList.GetElementOrDefault(1));
            Assert.False(nullList.TryGetElement(1, out int element));
            Assert.Equal(0, element);
            var list = new List<int>() { 1, 2, 3 };
            Assert.Equal(3, list.GetElementOrDefault(2));
            Assert.True(list.TryGetElement(2, out element));
            Assert.Equal(3, element);
            Assert.Equal(0, list.GetElementOrDefault(10));
            Assert.False(list.TryGetElement(10, out element));
            Assert.Equal(0, element);
        }
    }
}
```

1.43 ./csharp/Platform.Collections.Tests/StringTests.cs

```
using Xunit;

namespace Platform.Collections.Tests
{
    public static class StringTests
    {
        [Fact]
        public static void CapitalizeFirstLetterTest()
        {
            Assert.Equal("Hello", "hello".CapitalizeFirstLetter());
            Assert.Equal("Hello", "Hello".CapitalizeFirstLetter());
            Assert.Equal("  Hello", "  hello".CapitalizeFirstLetter());
        }

        [Fact]
        public static void TrimSingleTest()
        {
            Assert.Equal("", "''".TrimSingle('\''));
            Assert.Equal("", "'''".TrimSingle('\''));
            Assert.Equal("hello", "'hello'".TrimSingle('\''));
            Assert.Equal("hello", "hello'".TrimSingle('\''));
            Assert.Equal("hello", "'hello".TrimSingle('\''));
        }
    }
}
```

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