

## LinksPlatform's Platform.Collections Class Library

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

```
1 using System.Collections.Generic;
2 using System.Runtime.CompilerServices;
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 ArrayFiller<TElement, TReturnConstant> : ArrayFiller<TElement>
9     {
10         protected readonly TReturnConstant _returnConstant;
11
12         [MethodImpl(MethodImplOptions.AggressiveInlining)]
13         public ArrayFiller(TElement[] array, long offset, TReturnConstant returnConstant) :
14             ↪ base(array, offset) => _returnConstant = returnConstant;
15
16         [MethodImpl(MethodImplOptions.AggressiveInlining)]
17         public ArrayFiller(TElement[] array, TReturnConstant returnConstant) : this(array, 0,
18             ↪ returnConstant) { }
19
20         [MethodImpl(MethodImplOptions.AggressiveInlining)]
21         public TReturnConstant AddAndReturnConstant(TElement element) =>
22             ↪ _array.AddAndReturnConstant(ref _position, element, _returnConstant);
23
24         [MethodImpl(MethodImplOptions.AggressiveInlining)]
25         public TReturnConstant AddFirstAndReturnConstant(ICollection<TElement> elements) =>
26             ↪ _array.AddFirstAndReturnConstant(ref _position, elements, _returnConstant);
27
28         [MethodImpl(MethodImplOptions.AggressiveInlining)]
29         public TReturnConstant AddAllAndReturnConstant(ICollection<TElement> elements) =>
30             ↪ _array.AddAllAndReturnConstant(ref _position, elements, _returnConstant);
31
32         [MethodImpl(MethodImplOptions.AggressiveInlining)]
33         public TReturnConstant AddSkipFirstAndReturnConstant(ICollection<TElement> elements) =>
34             ↪ _array.AddSkipFirstAndReturnConstant(ref _position, elements, _returnConstant);
35     }
36 }
```

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

```
1 using System.Collections.Generic;
2 using System.Runtime.CompilerServices;
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 ArrayFiller<TElement>
9     {
10         protected readonly TElement[] _array;
11         protected long _position;
12
13         [MethodImpl(MethodImplOptions.AggressiveInlining)]
14         public ArrayFiller(TElement[] array, long offset)
15         {
16             _array = array;
17             _position = offset;
18         }
19
20         [MethodImpl(MethodImplOptions.AggressiveInlining)]
21         public ArrayFiller(TElement[] array) : this(array, 0) { }
22
23         [MethodImpl(MethodImplOptions.AggressiveInlining)]
24         public void Add(TElement element) => _array[_position++] = element;
25
26         [MethodImpl(MethodImplOptions.AggressiveInlining)]
27         public bool AddAndReturnTrue(TElement element) => _array.AddAndReturnConstant(ref
28             ↪ _position, element, true);
29
30         [MethodImpl(MethodImplOptions.AggressiveInlining)]
31         public bool AddFirstAndReturnTrue(ICollection<TElement> elements) =>
32             ↪ _array.AddFirstAndReturnConstant(ref _position, elements, true);
33
34         [MethodImpl(MethodImplOptions.AggressiveInlining)]
35         public bool AddAllAndReturnTrue(ICollection<TElement> elements) =>
36             ↪ _array.AddAllAndReturnConstant(ref _position, elements, true);
37
38         [MethodImpl(MethodImplOptions.AggressiveInlining)]
39         public bool AddSkipFirstAndReturnTrue(ICollection<TElement> elements) =>
40             ↪ _array.AddSkipFirstAndReturnConstant(ref _position, elements, true);
41     }
42 }
```

```

36         public bool AddSkipFirstAndReturnTrue(ICollection<TElement> elements) =>
           ↪ _array.AddSkipFirstAndReturnConstant(ref _position, elements, true);
37     }
38 }

```

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

```

1  using System.Runtime.CompilerServices;
2
3  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
4
5  namespace Platform.Collections.Arrays
6  {
7      public static class ArrayPool
8      {
9          public static readonly int DefaultSizesAmount = 512;
10         public static readonly int DefaultMaxArraysPerSize = 32;
11
12         [MethodImpl(MethodImplOptions.AggressiveInlining)]
13         public static T[] Allocate<T>(long size) => ArrayPool<T>.ThreadInstance.Allocate(size);
14
15         [MethodImpl(MethodImplOptions.AggressiveInlining)]
16         public static void Free<T>(T[] array) => ArrayPool<T>.ThreadInstance.Free(array);
17     }
18 }

```

### 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  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
8
9  namespace Platform.Collections.Arrays
10 {
11     /// <remarks>
12     /// Original idea from
13     ↪ http://geekswithblogs.net/blackrob/archive/2014/12/18/array-pooling-in-csharp.aspx
14     /// </remarks>
15     public class ArrayPool<T>
16     {
17         // May be use Default class for that later.
18         [ThreadStatic]
19         private static ArrayPool<T> _threadInstance;
20         internal static ArrayPool<T> ThreadInstance => _threadInstance ?? (_threadInstance = new
           ↪ ArrayPool<T>());
21
22         private readonly int _maxArraysPerSize;
23         private readonly Dictionary<long, Stack<T[]>> _pool = new Dictionary<long,
           ↪ Stack<T[]>>(ArrayPool.DefaultSizesAmount);
24
25         [MethodImpl(MethodImplOptions.AggressiveInlining)]
26         public ArrayPool(int maxArraysPerSize) => _maxArraysPerSize = maxArraysPerSize;
27
28         [MethodImpl(MethodImplOptions.AggressiveInlining)]
29         public ArrayPool() : this(ArrayPool.DefaultMaxArraysPerSize) { }
30
31         [MethodImpl(MethodImplOptions.AggressiveInlining)]
32         public Disposable<T[]> AllocateDisposable(long size) => (Allocate(size), Free);
33
34         [MethodImpl(MethodImplOptions.AggressiveInlining)]
35         public Disposable<T[]> Resize(Disposable<T[]> source, long size)
36         {
37             var destination = AllocateDisposable(size);
38             T[] sourceArray = source;
39             if (!sourceArray.IsNullOrEmpty())
40             {
41                 T[] destinationArray = destination;
42                 Array.Copy(sourceArray, destinationArray, size < sourceArray.LongLength ? size :
                   ↪ sourceArray.LongLength);
43                 source.Dispose();
44             }
45             return destination;
46         }
47
48         [MethodImpl(MethodImplOptions.AggressiveInlining)]
49         public virtual void Clear() => _pool.Clear();
50     }
51 }

```

```

50     [MethodImpl(MethodImplOptions.AggressiveInlining)]
51     public virtual T[] Allocate(long size) => size <= 0L ? Array.Empty<T>() :
    ↪     _pool.GetOrDefault(size)?.PopOrDefault() ?? new T[size];
52
53     [MethodImpl(MethodImplOptions.AggressiveInlining)]
54     public virtual void Free(T[] array)
55     {
56         if (array.IsNullOrEmpty())
57         {
58             return;
59         }
60         var stack = _pool.GetOrAdd(array.LongLength, size => new
    ↪         Stack<T[]>(_maxArraysPerSize));
61         if (stack.Count == _maxArraysPerSize) // Stack is full
62         {
63             return;
64         }
65         stack.Push(array);
66     }
67 }
68 }

```

### 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  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
4
5  namespace Platform.Collections.Arrays
6  {
7      public static unsafe class CharArrayExtensions
8      {
9          /// <remarks>
10         /// Based on https://github.com/Microsoft/referencesource/blob/3b1eaf5203992df69de44c783\_a3eda37d3d4cd10/mscorlib/system/string.cs#L833
11         ↪
12         /// </remarks>
13         [MethodImpl(MethodImplOptions.AggressiveInlining)]
14         public static int GenerateHashCode(this char[] array, int offset, int length)
15         {
16             var hashSeed = 5381;
17             var hashAccumulator = hashSeed;
18             fixed (char* arrayPointer = &array[offset])
19             {
20                 for (char* charPointer = arrayPointer, last = charPointer + length; charPointer
21                     ↪ < last; charPointer++)
22                 {
23                     hashAccumulator = (hashAccumulator << 5) + hashAccumulator ^ *charPointer;
24                 }
25             }
26             return hashAccumulator + (hashSeed * 1566083941);
27         }
28
29         /// <remarks>
30         /// Based on https://github.com/Microsoft/referencesource/blob/3b1eaf5203992df69de44c783\_a3eda37d3d4cd10/mscorlib/system/string.cs#L364
31         ↪
32         /// </remarks>
33         [MethodImpl(MethodImplOptions.AggressiveInlining)]
34         public static bool ContentEqualTo(this char[] left, int leftOffset, int length, char[]
35             ↪ right, int rightOffset)

```

```

32 {
33     fixed (char* leftPointer = &left[leftOffset])
34     {
35         fixed (char* rightPointer = &right[rightOffset])
36         {
37             char* leftPointerCopy = leftPointer, rightPointerCopy = rightPointer;
38             if (!CheckArraysMainPartForEquality(ref leftPointerCopy, ref
39                 ↪ rightPointerCopy, ref length))
40             {
41                 return false;
42             }
43             CheckArraysRemainderForEquality(ref leftPointerCopy, ref rightPointerCopy,
44                 ↪ ref length);
45             return length <= 0;
46         }
47     }
48 }
49 [MethodImpl(MethodImplOptions.AggressiveInlining)]
50 private static bool CheckArraysMainPartForEquality(ref char* left, ref char* right, ref
51     ↪ int length)
52 {
53     while (length >= 10)
54     {
55         if ((* (int*)left != *(int*)right)
56             || (*(int*)(left + 2) != *(int*)(right + 2))
57             || (*(int*)(left + 4) != *(int*)(right + 4))
58             || (*(int*)(left + 6) != *(int*)(right + 6))
59             || (*(int*)(left + 8) != *(int*)(right + 8)))
60         {
61             return false;
62         }
63         left += 10;
64         right += 10;
65         length -= 10;
66     }
67     return true;
68 }
69 [MethodImpl(MethodImplOptions.AggressiveInlining)]
70 private static void CheckArraysRemainderForEquality(ref char* left, ref char* right, ref
71     ↪ int length)
72 {
73     // This depends on the fact that the String objects are
74     // always zero terminated and that the terminating zero is not included
75     // in the length. For odd string sizes, the last compare will include
76     // the zero terminator.
77     while (length > 0)
78     {
79         if ((* (int*)left != *(int*)right)
80             {
81                 break;
82             }
83         left += 2;
84         right += 2;
85         length -= 2;
86     }
87 }

```

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

```

1 using System;
2 using System.Collections.Generic;
3 using System.Runtime.CompilerServices;
4
5 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
6
7 namespace Platform.Collections.Arrays
8 {
9     public static class GenericArrayExtensions
10     {
11         [MethodImpl(MethodImplOptions.AggressiveInlining)]
12         public static T GetElementOrDefault<T>(this T[] array, int index) => array != null &&
13             ↪ array.Length > index ? array[index] : default;
14
15         [MethodImpl(MethodImplOptions.AggressiveInlining)]
16         public static T GetElementOrDefault<T>(this T[] array, long index) => array != null &&
17             ↪ array.LongLength > index ? array[index] : default;
18     }
19 }

```

```

16 [MethodImpl(MethodImplOptions.AggressiveInlining)]
17 public static bool TryGetElement<T>(this T[] array, int index, out T element)
18 {
19     if (array != null && array.Length > index)
20     {
21         element = array[index];
22         return true;
23     }
24     else
25     {
26         element = default;
27         return false;
28     }
29 }
30
31 [MethodImpl(MethodImplOptions.AggressiveInlining)]
32 public static bool TryGetElement<T>(this T[] array, long index, out T element)
33 {
34     if (array != null && array.LongLength > index)
35     {
36         element = array[index];
37         return true;
38     }
39     else
40     {
41         element = default;
42         return false;
43     }
44 }
45
46 [MethodImpl(MethodImplOptions.AggressiveInlining)]
47 public static T[] Clone<T>(this T[] array)
48 {
49     var copy = new T[array.LongLength];
50     Array.Copy(array, 0L, copy, 0L, array.LongLength);
51     return copy;
52 }
53
54 [MethodImpl(MethodImplOptions.AggressiveInlining)]
55 public static IList<T> ShiftRight<T>(this T[] array) => array.ShiftRight(1L);
56
57 [MethodImpl(MethodImplOptions.AggressiveInlining)]
58 public static IList<T> ShiftRight<T>(this T[] array, long shift)
59 {
60     if (shift < 0)
61     {
62         throw new NotImplementedException();
63     }
64     if (shift == 0)
65     {
66         return array.Clone<T>();
67     }
68     else
69     {
70         var restrictions = new T[array.LongLength + shift];
71         Array.Copy(array, 0L, restrictions, shift, array.LongLength);
72         return restrictions;
73     }
74 }
75
76 [MethodImpl(MethodImplOptions.AggressiveInlining)]
77 public static void Add<T>(this T[] array, ref int position, T element) =>
78     ↪ array[position++] = element;
79
80 [MethodImpl(MethodImplOptions.AggressiveInlining)]
81 public static void Add<T>(this T[] array, ref long position, T element) =>
82     ↪ array[position++] = element;
83
84 [MethodImpl(MethodImplOptions.AggressiveInlining)]
85 public static TReturnConstant AddAndReturnConstant<TElement, TReturnConstant>(this
86     ↪ TElement[] array, ref long position, TElement element, TReturnConstant
87     ↪ returnConstant)
88 {
89     array.Add(ref position, element);
90     return returnConstant;
91 }
92
93 [MethodImpl(MethodImplOptions.AggressiveInlining)]

```

```

91     public static void AddFirst<T>(this T[] array, ref long position, IList<T> elements) =>
92         ↪ array[position++] = elements[0];
93
94     [MethodImpl(MethodImplOptions.AggressiveInlining)]
95     public static TReturnConstant AddFirstAndReturnConstant<TElement, TReturnConstant>(this
96         ↪ TElement[] array, ref long position, IList<TElement> elements, TReturnConstant
97         ↪ returnConstant)
98     {
99         array.AddFirst(ref position, elements);
100         return returnConstant;
101     }
102
103     [MethodImpl(MethodImplOptions.AggressiveInlining)]
104     public static TReturnConstant AddAllAndReturnConstant<TElement, TReturnConstant>(this
105         ↪ TElement[] array, ref long position, IList<TElement> elements, TReturnConstant
106         ↪ returnConstant)
107     {
108         array.AddAll(ref position, elements);
109         return returnConstant;
110     }
111
112     [MethodImpl(MethodImplOptions.AggressiveInlining)]
113     public static void AddAll<T>(this T[] array, ref long position, IList<T> elements)
114     {
115         for (var i = 0; i < elements.Count; i++)
116         {
117             array.Add(ref position, elements[i]);
118         }
119     }
120
121     [MethodImpl(MethodImplOptions.AggressiveInlining)]
122     public static TReturnConstant AddSkipFirstAndReturnConstant<TElement,
123         ↪ TReturnConstant>(this TElement[] array, ref long position, IList<TElement> elements,
124         ↪ TReturnConstant returnConstant)
125     {
126         array.AddSkipFirst(ref position, elements);
127         return returnConstant;
128     }
129
130     [MethodImpl(MethodImplOptions.AggressiveInlining)]
131     public static void AddSkipFirst<T>(this T[] array, ref long position, IList<T> elements)
132         ↪ => array.AddSkipFirst(ref position, elements, 1);
133
134     [MethodImpl(MethodImplOptions.AggressiveInlining)]
135     public static void AddSkipFirst<T>(this T[] array, ref long position, IList<T> elements,
136         ↪ int skip)
137     {
138         for (var i = skip; i < elements.Count; i++)
139         {
140             array.Add(ref position, elements[i]);
141         }
142     }
143 }
144 }
145 }

```

## 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>
16     /// А что если хранить карту значений, где каждый бит будет означать присутствует ли блок в
17     ↪ 64 бит в массиве значений.
18     /// 64 бита по 0 бит, будут означать отсутствие 64-х блоков по 64 бита. Т.е. упаковка 512
19     ↪ байт в 8 байт.
20     /// Подобный принцип можно применять и к 64-ём блокам и т.п. По сути это карта значений. С
21     ↪ помощью которой можно быстро
22     /// проверять есть ли значения непосредственно далее (ниже по уровню).
23     /// Или как таблица виртуальной памяти где номер блока означает его присутствие и адрес.

```

```

21 /// </remarks>
22 public class BitString : IEquatable<BitString>
23 {
24     private static readonly byte[] [] _bitsSetIn16Bits;
25     private long[] _array;
26     private long _length;
27     private long _minPositiveWord;
28     private long _maxPositiveWord;
29
30     public bool this[long index]
31     {
32         [MethodImpl(MethodImplOptions.AggressiveInlining)]
33         get => Get(index);
34         [MethodImpl(MethodImplOptions.AggressiveInlining)]
35         set => Set(index, value);
36     }
37
38     public long Length
39     {
40         [MethodImpl(MethodImplOptions.AggressiveInlining)]
41         get => _length;
42         [MethodImpl(MethodImplOptions.AggressiveInlining)]
43         set
44         {
45             if (_length == value)
46             {
47                 return;
48             }
49             Ensure.Always.ArgumentInRange(value, GetValidLengthRange(), nameof(Length));
50             // Currently we never shrink the array
51             if (value > _length)
52             {
53                 var words = GetWordsCountFromIndex(value);
54                 var oldWords = GetWordsCountFromIndex(_length);
55                 if (words > _array.LongLength)
56                 {
57                     var copy = new long[words];
58                     Array.Copy(_array, copy, _array.LongLength);
59                     _array = copy;
60                 }
61                 else
62                 {
63                     // What is going on here?
64                     Array.Clear(_array, (int)oldWords, (int)(words - oldWords));
65                 }
66                 // What is going on here?
67                 var mask = (int)(_length % 64);
68                 if (mask > 0)
69                 {
70                     _array[oldWords - 1] &= (1L << mask) - 1;
71                 }
72             }
73             else
74             {
75                 // Looks like minimum and maximum positive words are not updated
76                 throw new NotImplementedException();
77             }
78             _length = value;
79         }
80     }
81
82     #region Constructors
83
84     [MethodImpl(MethodImplOptions.AggressiveInlining)]
85     static BitString()
86     {
87         _bitsSetIn16Bits = new byte[65536] [];
88         int i, c, k;
89         byte bitIndex;
90         for (i = 0; i < 65536; i++)
91         {
92             // Calculating size of array (number of positive bits)
93             for (c = 0, k = 1; k <= 65536; k <= 1)
94             {
95                 if ((i & k) == k)
96                 {
97                     c++;
98                 }
99             }

```

```

100     var array = new byte[c];
101     // Adding positive bits indices into array
102     for (bitIndex = 0, c = 0, k = 1; k <= 65536; k <= 1)
103     {
104         if ((i & k) == k)
105         {
106             array[c++] = bitIndex;
107         }
108         bitIndex++;
109     }
110     _bitsSetIn16Bits[i] = array;
111 }
112 }
113
114 [MethodImpl(MethodImplOptions.AggressiveInlining)]
115 public BitString(BitString other)
116 {
117     Ensure.Always.ArgumentNotNull(other, nameof(other));
118     _length = other._length;
119     _array = new long[GetWordsCountFromIndex(_length)];
120     _minPositiveWord = other._minPositiveWord;
121     _maxPositiveWord = other._maxPositiveWord;
122     Array.Copy(other._array, _array, _array.LongLength);
123 }
124
125 [MethodImpl(MethodImplOptions.AggressiveInlining)]
126 public BitString(long length)
127 {
128     Ensure.Always.ArgumentInRange(length, GetValidLengthRange(), nameof(length));
129     _length = length;
130     _array = new long[GetWordsCountFromIndex(_length)];
131     MarkBordersAsAllBitsReset();
132 }
133
134 [MethodImpl(MethodImplOptions.AggressiveInlining)]
135 public BitString(long length, bool defaultValue)
136     : this(length)
137 {
138     if (defaultValue)
139     {
140         SetAll();
141     }
142 }
143
144 #endregion
145
146 [MethodImpl(MethodImplOptions.AggressiveInlining)]
147 public BitString Not()
148 {
149     for (var i = 0L; i < _array.LongLength; i++)
150     {
151         _array[i] = ~_array[i];
152         RefreshBordersByWord(i);
153     }
154     return this;
155 }
156
157 [MethodImpl(MethodImplOptions.AggressiveInlining)]
158 public BitString ParallelNot()
159 {
160     var threads = Environment.ProcessorCount / 2;
161     if (threads <= 1)
162     {
163         return Not();
164     }
165     var partitioner = Partitioner.Create(0L, _array.LongLength, _array.LongLength /
166 ↪ threads);
167     Parallel.ForEach(partitioner.GetDynamicPartitions(), new ParallelOptions {
168 ↪ MaxDegreeOfParallelism = threads }, range =>
169     {
170         var maximum = range.Item2;
171         for (var i = range.Item1; i < maximum; i++)
172         {
173             _array[i] = ~_array[i];
174         }
175     });
176     MarkBordersAsAllBitsSet();
177     TryShrinkBorders();
178     return this;

```



```

177     }
178
179     [MethodImpl(MethodImplOptions.AggressiveInlining)]
180     public BitString VectorNot()
181     {
182         if (!Vector.IsHardwareAccelerated || _array.LongLength >= int.MaxValue)
183         {
184             return Not();
185         }
186         var step = Vector<long>.Count;
187         if (_array.Length < step)
188         {
189             return Not();
190         }
191         VectorNotLoop(_array, step, 0, _array.Length);
192         MarkBordersAsAllBitsSet();
193         TryShrinkBorders();
194         return this;
195     }
196
197     [MethodImpl(MethodImplOptions.AggressiveInlining)]
198     public BitString ParallelVectorNot()
199     {
200         var threads = Environment.ProcessorCount / 2;
201         if (threads <= 1)
202         {
203             return VectorNot();
204         }
205         if (!Vector.IsHardwareAccelerated)
206         {
207             return ParallelNot();
208         }
209         var step = Vector<long>.Count;
210         if (_array.Length < (step * threads))
211         {
212             return VectorNot();
213         }
214         var partitioner = Partitioner.Create(0, _array.Length, _array.Length / threads);
215         Parallel.ForEach(partitioner.GetDynamicPartitions(), new ParallelOptions {
216             ↪ MaxDegreeOfParallelism = threads }, range => VectorNotLoop(_array, step,
217             ↪ range.Item1, range.Item2));
218         MarkBordersAsAllBitsSet();
219         TryShrinkBorders();
220         return this;
221     }
222
223     [MethodImpl(MethodImplOptions.AggressiveInlining)]
224     static private void VectorNotLoop(long[] array, int step, int start, int maximum)
225     {
226         var i = start;
227         var range = maximum - start - 1;
228         var stop = range - (range % step);
229         for (; i < stop; i += step)
230         {
231             (~new Vector<long>(array, i)).CopyTo(array, i);
232         }
233         for (; i < maximum; i++)
234         {
235             array[i] = ~array[i];
236         }
237     }
238
239     [MethodImpl(MethodImplOptions.AggressiveInlining)]
240     public BitString And(BitString other)
241     {
242         EnsureBitStringHasTheSameSize(other, nameof(other));
243         GetCommonOuterBorders(this, other, out long from, out long to);
244         var otherArray = other._array;
245         for (var i = from; i <= to; i++)
246         {
247             _array[i] &= otherArray[i];
248             RefreshBordersByWord(i);
249         }
250         return this;
251     }
252
253     [MethodImpl(MethodImplOptions.AggressiveInlining)]
254     public BitString ParallelAnd(BitString other)
255     {

```

```

254     var threads = Environment.ProcessorCount / 2;
255     if (threads <= 1)
256     {
257         return And(other);
258     }
259     EnsureBitStringHasTheSameSize(other, nameof(other));
260     GetCommonOuterBorders(this, other, out long from, out long to);
261     var partitioner = Partitioner.Create(from, to + 1, (to - from) / threads);
262     Parallel.ForEach(partitioner.GetDynamicPartitions(), new ParallelOptions {
        ↪ MaxDegreeOfParallelism = threads }, range =>
    {
263         var maximum = range.Item2;
264         for (var i = range.Item1; i < maximum; i++)
265         {
266             _array[i] &= other._array[i];
267         }
268     });
269     MarkBordersAsAllBitsSet();
270     TryShrinkBorders();
271     return this;
272 }
273
274 [MethodImpl(MethodImplOptions.AggressiveInlining)]
275 public BitString VectorAnd(BitString other)
276 {
277     if (!Vector.IsHardwareAccelerated || _array.LongLength >= int.MaxValue)
278     {
279         return And(other);
280     }
281     var step = Vector<long>.Count;
282     if (_array.Length < step)
283     {
284         return And(other);
285     }
286     EnsureBitStringHasTheSameSize(other, nameof(other));
287     GetCommonOuterBorders(this, other, out int from, out int to);
288     VectorAndLoop(_array, other._array, step, from, to + 1);
289     MarkBordersAsAllBitsSet();
290     TryShrinkBorders();
291     return this;
292 }
293
294 [MethodImpl(MethodImplOptions.AggressiveInlining)]
295 public BitString ParallelVectorAnd(BitString other)
296 {
297     var threads = Environment.ProcessorCount / 2;
298     if (threads <= 1)
299     {
300         return VectorAnd(other);
301     }
302     if (!Vector.IsHardwareAccelerated)
303     {
304         return ParallelAnd(other);
305     }
306     var step = Vector<long>.Count;
307     if (_array.Length < (step * threads))
308     {
309         return VectorAnd(other);
310     }
311     EnsureBitStringHasTheSameSize(other, nameof(other));
312     GetCommonOuterBorders(this, other, out int from, out int to);
313     var partitioner = Partitioner.Create(from, to + 1, (to - from) / threads);
314     Parallel.ForEach(partitioner.GetDynamicPartitions(), new ParallelOptions {
        ↪ MaxDegreeOfParallelism = threads }, range => VectorAndLoop(_array, other._array,
        ↪ step, range.Item1, range.Item2));
315     MarkBordersAsAllBitsSet();
316     TryShrinkBorders();
317     return this;
318 }
319
320 [MethodImpl(MethodImplOptions.AggressiveInlining)]
321 static private void VectorAndLoop(long[] array, long[] otherArray, int step, int start,
        ↪ int maximum)
322 {
323     var i = start;
324     var range = maximum - start - 1;
325     var stop = range - (range % step);
326     for (; i < stop; i += step)
327 
```

```

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 {
362             ↪ MaxDegreeOfParallelism = threads }, range =>
363         {
364             var maximum = range.Item2;
365             for (var i = range.Item1; i < maximum; i++)
366             {
367                 _array[i] |= other._array[i];
368             }
369         });
370         MarkBordersAsAllBitsSet();
371         TryShrinkBorders();
372         return this;
373     }
374
375     [MethodImpl(MethodImplOptions.AggressiveInlining)]
376     public BitString VectorOr(BitString other)
377     {
378         if (!Vector.IsHardwareAccelerated || _array.LongLength >= int.MaxValue)
379         {
380             return Or(other);
381         }
382         var step = Vector<long>.Count;
383         if (_array.Length < step)
384         {
385             return Or(other);
386         }
387         EnsureBitStringHasTheSameSize(other, nameof(other));
388         GetCommonOuterBorders(this, other, out int from, out int to);
389         VectorOrLoop(_array, other._array, step, from, to + 1);
390         MarkBordersAsAllBitsSet();
391         TryShrinkBorders();
392         return this;
393     }
394
395     [MethodImpl(MethodImplOptions.AggressiveInlining)]
396     public BitString ParallelVectorOr(BitString other)
397     {
398         var threads = Environment.ProcessorCount / 2;
399         if (threads <= 1)
400         {
401             return VectorOr(other);
402         }
403         if (!Vector.IsHardwareAccelerated)
404         {
405             return ParallelOr(other);
406         }

```

```

405     }
406     var step = Vector<long>.Count;
407     if (_array.Length < (step * threads))
408     {
409         return VectorOr(other);
410     }
411     EnsureBitStringHasTheSameSize(other, nameof(other));
412     GetCommonOuterBorders(this, other, out int from, out int to);
413     var partitioner = Partitioner.Create(from, to + 1, (to - from) / threads);
414     Parallel.ForEach(partitioner.GetDynamicPartitions(), new ParallelOptions {
415         ↪ MaxDegreeOfParallelism = threads }, range => VectorOrLoop(_array, other._array,
416         ↪ step, range.Item1, range.Item2));
417     MarkBordersAsAllBitsSet();
418     TryShrinkBorders();
419     return this;
420 }
421
422 [MethodImpl(MethodImplOptions.AggressiveInlining)]
423 static private void VectorOrLoop(long[] array, long[] otherArray, int step, int start,
424 ↪ int maximum)
425 {
426     var i = start;
427     var range = maximum - start - 1;
428     var stop = range - (range % step);
429     for (; i < stop; i += step)
430     {
431         (new Vector<long>(array, i) | new Vector<long>(otherArray, i)).CopyTo(array, i);
432     }
433     for (; i < maximum; i++)
434     {
435         array[i] |= otherArray[i];
436     }
437 }
438
439 [MethodImpl(MethodImplOptions.AggressiveInlining)]
440 public BitString Xor(BitString other)
441 {
442     EnsureBitStringHasTheSameSize(other, nameof(other));
443     GetCommonOuterBorders(this, other, out long from, out long to);
444     for (var i = from; i <= to; i++)
445     {
446         _array[i] ^= other._array[i];
447         RefreshBordersByWord(i);
448     }
449     return this;
450 }
451
452 [MethodImpl(MethodImplOptions.AggressiveInlining)]
453 public BitString ParallelXor(BitString other)
454 {
455     var threads = Environment.ProcessorCount / 2;
456     if (threads <= 1)
457     {
458         return Xor(other);
459     }
460     EnsureBitStringHasTheSameSize(other, nameof(other));
461     GetCommonOuterBorders(this, other, out long from, out long to);
462     var partitioner = Partitioner.Create(from, to + 1, (to - from) / threads);
463     Parallel.ForEach(partitioner.GetDynamicPartitions(), new ParallelOptions {
464         ↪ MaxDegreeOfParallelism = threads }, range =>
465     {
466         var maximum = range.Item2;
467         for (var i = range.Item1; i < maximum; i++)
468         {
469             _array[i] ^= other._array[i];
470         }
471     });
472     MarkBordersAsAllBitsSet();
473     TryShrinkBorders();
474     return this;
475 }
476
477 [MethodImpl(MethodImplOptions.AggressiveInlining)]
478 public BitString VectorXor(BitString other)
479 {
480     if (!Vector.IsHardwareAccelerated || _array.LongLength >= int.MaxValue)
481     {
482         return Xor(other);
483     }

```

```

479     }
480     var step = Vector<long>.Count;
481     if (_array.Length < step)
482     {
483         return Xor(other);
484     }
485     EnsureBitStringHasTheSameSize(other, nameof(other));
486     GetCommonOuterBorders(this, other, out int from, out int to);
487     VectorXorLoop(_array, other._array, step, from, to + 1);
488     MarkBordersAsAllBitsSet();
489     TryShrinkBorders();
490     return this;
491 }
492
493 [MethodImpl(MethodImplOptions.AggressiveInlining)]
494 public BitString ParallelVectorXor(BitString other)
495 {
496     var threads = Environment.ProcessorCount / 2;
497     if (threads <= 1)
498     {
499         return VectorXor(other);
500     }
501     if (!Vector.IsHardwareAccelerated)
502     {
503         return ParallelXor(other);
504     }
505     var step = Vector<long>.Count;
506     if (_array.Length < (step * threads))
507     {
508         return VectorXor(other);
509     }
510     EnsureBitStringHasTheSameSize(other, nameof(other));
511     GetCommonOuterBorders(this, other, out int from, out int to);
512     var partitioner = Partitioner.Create(from, to + 1, (to - from) / threads);
513     Parallel.ForEach(partitioner.GetDynamicPartitions(), new ParallelOptions {
514         ↪ MaxDegreeOfParallelism = threads }, range => VectorXorLoop(_array, other._array,
515         ↪ step, range.Item1, range.Item2));
516     MarkBordersAsAllBitsSet();
517     TryShrinkBorders();
518     return this;
519 }
520
521 [MethodImpl(MethodImplOptions.AggressiveInlining)]
522 static private void VectorXorLoop(long[] array, long[] otherArray, int step, int start,
523 ↪ int maximum)
524 {
525     var i = start;
526     var range = maximum - start - 1;
527     var stop = range - (range % step);
528     for (; i < stop; i += step)
529     {
530         (new Vector<long>(array, i) ^ new Vector<long>(otherArray, i)).CopyTo(array, i);
531     }
532     for (; i < maximum; i++)
533     {
534         array[i] ^= otherArray[i];
535     }
536 }
537
538 [MethodImpl(MethodImplOptions.AggressiveInlining)]
539 private void RefreshBordersByWord(long wordIndex)
540 {
541     if (_array[wordIndex] == 0)
542     {
543         if (wordIndex == _minPositiveWord && wordIndex != _array.LongLength - 1)
544         {
545             _minPositiveWord++;
546         }
547         if (wordIndex == _maxPositiveWord && wordIndex != 0)
548         {
549             _maxPositiveWord--;
550         }
551     }
552     else
553     {
554         if (wordIndex < _minPositiveWord)
555         {
556             _minPositiveWord = wordIndex;
557         }
558     }
559 }

```

```

554     }
555     if (wordIndex > _maxPositiveWord)
556     {
557         _maxPositiveWord = wordIndex;
558     }
559 }
560
561 [MethodImpl(MethodImplOptions.AggressiveInlining)]
562 public bool TryShrinkBorders()
563 {
564     GetBorders(out long from, out long to);
565     while (from <= to && _array[from] == 0)
566     {
567         from++;
568     }
569     if (from > to)
570     {
571         MarkBordersAsAllBitsReset();
572         return true;
573     }
574     while (to >= from && _array[to] == 0)
575     {
576         to--;
577     }
578     if (to < from)
579     {
580         MarkBordersAsAllBitsReset();
581         return true;
582     }
583     var bordersUpdated = from != _minPositiveWord || to != _maxPositiveWord;
584     if (bordersUpdated)
585     {
586         SetBorders(from, to);
587     }
588     return bordersUpdated;
589 }
590
591 [MethodImpl(MethodImplOptions.AggressiveInlining)]
592 public bool Get(long index)
593 {
594     Ensure.Always.ArgumentInRange(index, GetValidIndexRange(), nameof(index));
595     return (_array[GetWordIndexFromIndex(index)] & GetBitMaskFromIndex(index)) != 0;
596 }
597
598 [MethodImpl(MethodImplOptions.AggressiveInlining)]
599 public void Set(long index, bool value)
600 {
601     if (value)
602     {
603         Set(index);
604     }
605     else
606     {
607         Reset(index);
608     }
609 }
610
611 [MethodImpl(MethodImplOptions.AggressiveInlining)]
612 public void Set(long index)
613 {
614     Ensure.Always.ArgumentInRange(index, GetValidIndexRange(), nameof(index));
615     var wordIndex = GetWordIndexFromIndex(index);
616     var mask = GetBitMaskFromIndex(index);
617     _array[wordIndex] |= mask;
618     RefreshBordersByWord(wordIndex);
619 }
620
621 [MethodImpl(MethodImplOptions.AggressiveInlining)]
622 public void Reset(long index)
623 {
624     Ensure.Always.ArgumentInRange(index, GetValidIndexRange(), nameof(index));
625     var wordIndex = GetWordIndexFromIndex(index);
626     var mask = GetBitMaskFromIndex(index);
627     _array[wordIndex] &= ~mask;
628     RefreshBordersByWord(wordIndex);
629 }
630
631 [MethodImpl(MethodImplOptions.AggressiveInlining)]
632

```

```

633 public bool Add(long index)
634 {
635     var wordIndex = GetWordIndexFromIndex(index);
636     var mask = GetBitMaskFromIndex(index);
637     if ((_array[wordIndex] & mask) == 0)
638     {
639         _array[wordIndex] |= mask;
640         RefreshBordersByWord(wordIndex);
641         return true;
642     }
643     else
644     {
645         return false;
646     }
647 }
648
649 [MethodImpl(MethodImplOptions.AggressiveInlining)]
650 public void SetAll(bool value)
651 {
652     if (value)
653     {
654         SetAll();
655     }
656     else
657     {
658         ResetAll();
659     }
660 }
661
662 [MethodImpl(MethodImplOptions.AggressiveInlining)]
663 public void SetAll()
664 {
665     const long fillValue = unchecked((long)0xffffffffffffffff);
666     var words = GetWordsCountFromIndex(_length);
667     for (var i = 0; i < words; i++)
668     {
669         _array[i] = fillValue;
670     }
671     MarkBordersAsAllBitsSet();
672 }
673
674 [MethodImpl(MethodImplOptions.AggressiveInlining)]
675 public void ResetAll()
676 {
677     const long fillValue = 0;
678     GetBorders(out long from, out long to);
679     for (var i = from; i <= to; i++)
680     {
681         _array[i] = fillValue;
682     }
683     MarkBordersAsAllBitsReset();
684 }
685
686 [MethodImpl(MethodImplOptions.AggressiveInlining)]
687 public List<long> GetSetIndices()
688 {
689     var result = new List<long>();
690     GetBorders(out long from, out long to);
691     for (var i = from; i <= to; i++)
692     {
693         var word = _array[i];
694         if (word != 0)
695         {
696             AppendAllSetBitIndices(result, i, word);
697         }
698     }
699     return result;
700 }
701
702 [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;
782     var otherArray = other._array;
783     for (var i = from; i <= to; i++)
784     {
785         var left = _array[i];
786         var right = otherArray[i];
787         var combined = left & right;
788         if (combined != 0)
789         {
790             total += CountSetBitsForWord(combined);
791         }
792     }
793 }

```



```

791     }
792 }
793 return total;
794 }
795
796 [MethodImpl(MethodImplOptions.AggressiveInlining)]
797 public List<long> GetCommonIndices(BitString other)
798 {
799     EnsureBitStringHasTheSameSize(other, nameof(other));
800     GetCommonInnerBorders(this, other, out long from, out long to);
801     var result = new List<long>();
802     var otherArray = other._array;
803     for (var i = from; i <= to; i++)
804     {
805         var left = _array[i];
806         var right = otherArray[i];
807         var combined = left & right;
808         if (combined != 0)
809         {
810             AppendAllSetBitIndices(result, i, combined);
811         }
812     }
813     return result;
814 }
815
816 [MethodImpl(MethodImplOptions.AggressiveInlining)]
817 public List<ulong> GetCommonUInt64Indices(BitString other)
818 {
819     EnsureBitStringHasTheSameSize(other, nameof(other));
820     GetCommonBorders(this, other, out ulong from, out ulong to);
821     var result = new List<ulong>();
822     var otherArray = other._array;
823     for (var i = from; i <= to; i++)
824     {
825         var left = _array[i];
826         var right = otherArray[i];
827         var combined = left & right;
828         if (combined != 0)
829         {
830             AppendAllSetBitIndices(result, i, combined);
831         }
832     }
833     return result;
834 }
835
836 [MethodImpl(MethodImplOptions.AggressiveInlining)]
837 public long GetFirstCommonBitIndex(BitString other)
838 {
839     EnsureBitStringHasTheSameSize(other, nameof(other));
840     GetCommonInnerBorders(this, other, out long from, out long to);
841     var otherArray = other._array;
842     for (var i = from; i <= to; i++)
843     {
844         var left = _array[i];
845         var right = otherArray[i];
846         var combined = left & right;
847         if (combined != 0)
848         {
849             return GetFirstSetBitForWord(i, combined);
850         }
851     }
852     return -1;
853 }
854
855 [MethodImpl(MethodImplOptions.AggressiveInlining)]
856 public long GetLastCommonBitIndex(BitString other)
857 {
858     EnsureBitStringHasTheSameSize(other, nameof(other));
859     GetCommonInnerBorders(this, other, out long from, out long to);
860     var otherArray = other._array;
861     for (var i = to; i >= from; i--)
862     {
863         var left = _array[i];
864         var right = otherArray[i];
865         var combined = left & right;
866         if (combined != 0)
867         {
868             return GetLastSetBitForWord(i, combined);
869         }

```

```

870     }
871     return -1;
872 }
873
874 [MethodImpl(MethodImplOptions.AggressiveInlining)]
875 public override bool Equals(object obj) => obj is BitString @string ? Equals(@string) :
    ↪ false;
876
877 [MethodImpl(MethodImplOptions.AggressiveInlining)]
878 public bool Equals(BitString other)
879 {
880     if (_length != other._length)
881     {
882         return false;
883     }
884     var otherArray = other._array;
885     if (_array.Length != otherArray.Length)
886     {
887         return false;
888     }
889     if (_minPositiveWord != other._minPositiveWord)
890     {
891         return false;
892     }
893     if (_maxPositiveWord != other._maxPositiveWord)
894     {
895         return false;
896     }
897     GetCommonBorders(this, other, out ulong from, out ulong to);
898     for (var i = from; i <= to; i++)
899     {
900         if (_array[i] != otherArray[i])
901         {
902             return false;
903         }
904     }
905     return true;
906 }
907
908 [MethodImpl(MethodImplOptions.AggressiveInlining)]
909 private void EnsureBitStringHasTheSameSize(BitString other, string argumentName)
910 {
911     Ensure.Always.ArgumentNotNull(other, argumentName);
912     if (_length != other._length)
913     {
914         throw new ArgumentException("Bit string must be the same size.", argumentName);
915     }
916 }
917
918 [MethodImpl(MethodImplOptions.AggressiveInlining)]
919 private void MarkBordersAsAllBitsReset() => SetBorders(_array.LongLength - 1, 0);
920
921 [MethodImpl(MethodImplOptions.AggressiveInlining)]
922 private void MarkBordersAsAllBitsSet() => SetBorders(0, _array.LongLength - 1);
923
924 [MethodImpl(MethodImplOptions.AggressiveInlining)]
925 private void GetBorders(out long from, out long to)
926 {
927     from = _minPositiveWord;
928     to = _maxPositiveWord;
929 }
930
931 [MethodImpl(MethodImplOptions.AggressiveInlining)]
932 private void GetBorders(out ulong from, out ulong to)
933 {
934     from = (ulong)_minPositiveWord;
935     to = (ulong)_maxPositiveWord;
936 }
937
938 [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);
1078 }
1079
1080 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1081 public static void GetCommonOuterBorders(BitString left, BitString right, out long from,
    ↪ out long to)
1082 {
1083     from = Math.Min(left._minPositiveWord, right._minPositiveWord);
1084     to = Math.Max(left._maxPositiveWord, right._maxPositiveWord);

```

```

1085     }
1086
1087     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1088     public static void GetCommonOuterBorders(BitString left, BitString right, out int from,
1089         ↪ out int to)
1089     {
1090         from = (int)Math.Min(left._minPositiveWord, right._minPositiveWord);
1091         to = (int)Math.Max(left._maxPositiveWord, right._maxPositiveWord);
1092     }
1093
1094     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1095     public static void GetCommonBorders(BitString left, BitString right, out ulong from, out
1096         ↪ ulong to)
1097     {
1098         from = (ulong)Math.Max(left._minPositiveWord, right._minPositiveWord);
1099         to = (ulong)Math.Min(left._maxPositiveWord, right._maxPositiveWord);
1100     }
1101
1102     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1103     public static long GetWordsCountFromIndex(long index) => (index + 63) / 64;
1104
1105     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1106     public static long GetWordIndexFromIndex(long index) => index >> 6;
1107
1108     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1109     public static long GetBitMaskFromIndex(long index) => 1L << (int)(index & 63);
1110
1111     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1112     public override int GetHashCode() => base.GetHashCode();
1113
1114     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1115     public override string ToString() => base.ToString();
1116 }

```

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

```

1  using System.Runtime.CompilerServices;
2  using Platform.Random;
3
4  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
5
6  namespace Platform.Collections
7  {
8      public static class BitStringExtensions
9      {
10         [MethodImpl(MethodImplOptions.AggressiveInlining)]
11         public static void SetRandomBits(this BitString @string)
12         {
13             for (var i = 0; i < @string.Length; i++)
14             {
15                 var value = RandomHelpers.Default.NextBoolean();
16                 @string.Set(i, value);
17             }
18         }
19     }
20 }

```

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

```

1  using System.Collections.Concurrent;
2  using System.Collections.Generic;
3  using System.Runtime.CompilerServices;
4
5  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
6
7  namespace Platform.Collections.Concurrent
8  {
9      public static class ConcurrentQueueExtensions
10     {
11         [MethodImpl(MethodImplOptions.AggressiveInlining)]
12         public static IEnumerable<T> DequeueAll<T>(this ConcurrentQueue<T> queue)
13         {
14             while (queue.TryDequeue(out T item))
15             {
16                 yield return item;
17             }
18         }
19     }
20 }

```

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

```
1 using System.Collections.Concurrent;
2 using System.Runtime.CompilerServices;
3
4 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
5
6 namespace Platform.Collections.Concurrent
7 {
8     public static class ConcurrentStackExtensions
9     {
10         [MethodImpl(MethodImplOptions.AggressiveInlining)]
11         public static T PopOrDefault<T>(this ConcurrentStack<T> stack) => stack.TryPop(out T
12             ↪ value) ? value : default;
13
14         [MethodImpl(MethodImplOptions.AggressiveInlining)]
15         public static T PeekOrDefault<T>(this ConcurrentStack<T> stack) => stack.TryPeek(out T
16             ↪ value) ? value : default;
17     }
18 }
```

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

```
1 using System;
2 using System.Collections.Generic;
3 using System.Diagnostics;
4 using System.Runtime.CompilerServices;
5 using Platform.Exceptions;
6 using Platform.Exceptions.ExtensionRoots;
7
8 #pragma warning disable IDE0060 // Remove unused parameter
9 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
10
11 namespace Platform.Collections
12 {
13     public static class EnsureExtensions
14     {
15         #region Always
16
17         [MethodImpl(MethodImplOptions.AggressiveInlining)]
18         public static void ArgumentNotEmpty<T>(this EnsureAlwaysExtensionRoot root,
19             ↪ ICollection<T> argument, string argumentName, string message)
20         {
21             if (argument.IsNullOrEmpty())
22             {
23                 throw new ArgumentException(message, argumentName);
24             }
25         }
26
27         [MethodImpl(MethodImplOptions.AggressiveInlining)]
28         public static void ArgumentNotEmpty<T>(this EnsureAlwaysExtensionRoot root,
29             ↪ ICollection<T> argument, string argumentName) => ArgumentNotEmpty(root, argument,
30             ↪ argumentName, null);
31
32         [MethodImpl(MethodImplOptions.AggressiveInlining)]
33         public static void ArgumentNotEmpty<T>(this EnsureAlwaysExtensionRoot root,
34             ↪ ICollection<T> argument) => ArgumentNotEmpty(root, argument, null, null);
35
36         [MethodImpl(MethodImplOptions.AggressiveInlining)]
37         public static void ArgumentNotEmptyAndNotWhiteSpace(this EnsureAlwaysExtensionRoot root,
38             ↪ string argument, string argumentName, string message)
39         {
40             if (string.IsNullOrEmpty(argument))
41             {
42                 throw new ArgumentException(message, argumentName);
43             }
44         }
45
46         [MethodImpl(MethodImplOptions.AggressiveInlining)]
47         public static void ArgumentNotEmptyAndNotWhiteSpace(this EnsureAlwaysExtensionRoot root,
48             ↪ string argument, string argumentName) => ArgumentNotEmptyAndNotWhiteSpace(root,
49             ↪ argument, argumentName, null);
50
51         [MethodImpl(MethodImplOptions.AggressiveInlining)]
52         public static void ArgumentNotEmptyAndNotWhiteSpace(this EnsureAlwaysExtensionRoot root,
53             ↪ string argument) => ArgumentNotEmptyAndNotWhiteSpace(root, argument, null, null);
54
55         #endregion
56
57         #region OnDebug
58
59         [MethodImpl(MethodImplOptions.AggressiveInlining)]
60         public static void ArgumentNotEmptyAndNotWhiteSpace(this EnsureAlwaysExtensionRoot root,
61             ↪ string argument, string argumentName, string message)
62         {
63             if (string.IsNullOrEmpty(argument))
64             {
65                 throw new ArgumentException(message, argumentName);
66             }
67         }
68
69         [MethodImpl(MethodImplOptions.AggressiveInlining)]
70         public static void ArgumentNotEmptyAndNotWhiteSpace(this EnsureAlwaysExtensionRoot root,
71             ↪ string argument, string argumentName) => ArgumentNotEmptyAndNotWhiteSpace(root,
72             ↪ argument, argumentName, null);
73
74         [MethodImpl(MethodImplOptions.AggressiveInlining)]
75         public static void ArgumentNotEmptyAndNotWhiteSpace(this EnsureAlwaysExtensionRoot root,
76             ↪ string argument) => ArgumentNotEmptyAndNotWhiteSpace(root, argument, null, null);
77
78         #endregion
79     }
80 }
```

```

51     [Conditional("DEBUG")]
52     public static void ArgumentNotEmpty<T>(this EnsureOnDebugExtensionRoot root,
    ↪     ICollection<T> argument, string argumentName, string message) =>
    ↪     Ensure.Always.ArgumentNotEmpty(argument, argumentName, message);
53
54     [Conditional("DEBUG")]
55     public static void ArgumentNotEmpty<T>(this EnsureOnDebugExtensionRoot root,
    ↪     ICollection<T> argument, string argumentName) =>
    ↪     Ensure.Always.ArgumentNotEmpty(argument, argumentName, null);
56
57     [Conditional("DEBUG")]
58     public static void ArgumentNotEmpty<T>(this EnsureOnDebugExtensionRoot root,
    ↪     ICollection<T> argument) => Ensure.Always.ArgumentNotEmpty(argument, null, null);
59
60     [Conditional("DEBUG")]
61     public static void ArgumentNotEmptyAndNotWhiteSpace(this EnsureOnDebugExtensionRoot
    ↪     root, string argument, string argumentName, string message) =>
    ↪     Ensure.Always.ArgumentNotEmptyAndNotWhiteSpace(argument, argumentName, message);
62
63     [Conditional("DEBUG")]
64     public static void ArgumentNotEmptyAndNotWhiteSpace(this EnsureOnDebugExtensionRoot
    ↪     root, string argument, string argumentName) =>
    ↪     Ensure.Always.ArgumentNotEmptyAndNotWhiteSpace(argument, argumentName, null);
65
66     [Conditional("DEBUG")]
67     public static void ArgumentNotEmptyAndNotWhiteSpace(this EnsureOnDebugExtensionRoot
    ↪     root, string argument) => Ensure.Always.ArgumentNotEmptyAndNotWhiteSpace(argument,
    ↪     null, null);
68
69     #endregion
70 }
71 }

```

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

```

1  using System.Collections.Generic;
2  using System.Linq;
3  using System.Runtime.CompilerServices;
4
5  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
6
7  namespace Platform.Collections
8  {
9      public static class ICollectionExtensions
10     {
11         [MethodImpl(MethodImplOptions.AggressiveInlining)]
12         public static bool IsNullOrEmpty<T>(this ICollection<T> collection) => collection ==
    ↪     null || collection.Count == 0;
13
14         [MethodImpl(MethodImplOptions.AggressiveInlining)]
15         public static bool AllEqualToDefault<T>(this ICollection<T> collection)
16         {
17             var equalityComparer = EqualityComparer<T>.Default;
18             return collection.All(item => equalityComparer.Equals(item, default));
19         }
20     }
21 }

```

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

```

1  using System;
2  using System.Collections.Generic;
3  using System.Runtime.CompilerServices;
4
5  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
6
7  namespace Platform.Collections
8  {
9      public static class IDictionaryExtensions
10     {
11         [MethodImpl(MethodImplOptions.AggressiveInlining)]
12         public static TValue GetOrDefault<TKey, TValue>(this IDictionary<TKey, TValue>
    ↪     dictionary, TKey key)
13         {
14             dictionary.TryGetValue(key, out TValue value);
15             return value;
16         }
17
18         [MethodImpl(MethodImplOptions.AggressiveInlining)]
19         public static TValue GetOrAdd<TKey, TValue>(this IDictionary<TKey, TValue> dictionary,
    ↪     TKey key, Func<TKey, TValue> valueFactory)

```

```

20     {
21         if (!dictionary.TryGetValue(key, out TValue value))
22         {
23             value = valueFactory(key);
24             dictionary.Add(key, value);
25             return value;
26         }
27         return value;
28     }
29 }
30 }

```

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

```

1  using System.Collections.Generic;
2  using System.Runtime.CompilerServices;
3
4  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
5
6  namespace Platform.Collections.Lists
7  {
8      public static class CharIListExtensions
9      {
10         /// <remarks>
11         /// Based on https://github.com/Microsoft/referencesource/blob/3b1eaf5203992df69de44c783a3eda37d3d4cd10/mscorlib/system/string.cs#L833
12         /// </remarks>
13         [MethodImpl(MethodImplOptions.AggressiveInlining)]
14         public static int GenerateHashCode(this IList<char> list)
15         {
16             var hashSeed = 5381;
17             var hashAccumulator = hashSeed;
18             for (var i = 0; i < list.Count; i++)
19             {
20                 hashAccumulator = (hashAccumulator << 5) + hashAccumulator ^ list[i];
21             }
22             return hashAccumulator + (hashSeed * 1566083941);
23         }
24
25         [MethodImpl(MethodImplOptions.AggressiveInlining)]
26         public static bool EqualTo(this IList<char> left, IList<char> right) =>
27             left.EqualTo(right, ContentEqualTo);
28
29         [MethodImpl(MethodImplOptions.AggressiveInlining)]
30         public static bool ContentEqualTo(this IList<char> left, IList<char> right)
31         {
32             for (var i = left.Count - 1; i >= 0; --i)
33             {
34                 if (left[i] != right[i])
35                 {
36                     return false;
37                 }
38             }
39             return true;
40         }
41     }

```

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

```

1  using System.Collections.Generic;
2  using System.Runtime.CompilerServices;
3
4  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
5
6  namespace Platform.Collections.Lists
7  {
8      public class IListComparer<T> : IComparer<IList<T>>
9      {
10         [MethodImpl(MethodImplOptions.AggressiveInlining)]
11         public int Compare(IList<T> left, IList<T> right) => left.CompareTo(right);
12     }
13 }

```

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

```

1  using System.Collections.Generic;
2  using System.Runtime.CompilerServices;
3
4  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
5
6  namespace Platform.Collections.Lists

```



```

7 {
8     public class IListEqualityComparer<T> : IEqualityComparer<IList<T>>
9     {
10         [MethodImpl(MethodImplOptions.AggressiveInlining)]
11         public bool Equals(IList<T> left, IList<T> right) => left.EqualTo(right);
12
13         [MethodImpl(MethodImplOptions.AggressiveInlining)]
14         public int GetHashCode(IList<T> list) => list.GenerateHashCode();
15     }
16 }

```

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

```

1 using System;
2 using System.Collections.Generic;
3 using System.Runtime.CompilerServices;
4
5 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
6
7 namespace Platform.Collections.Lists
8 {
9     public static class IListExtensions
10    {
11        [MethodImpl(MethodImplOptions.AggressiveInlining)]
12        public static T GetElementOrDefault<T>(this IList<T> list, int index) => list != null &&
13            ↪ list.Count > index ? list[index] : default;
14
15        [MethodImpl(MethodImplOptions.AggressiveInlining)]
16        public static bool TryGetElement<T>(this IList<T> list, int index, out T element)
17        {
18            if (list != null && list.Count > index)
19            {
20                element = list[index];
21                return true;
22            }
23            else
24            {
25                element = default;
26                return false;
27            }
28        }
29
30        [MethodImpl(MethodImplOptions.AggressiveInlining)]
31        public static bool AddAndReturnTrue<T>(this IList<T> list, T element)
32        {
33            list.Add(element);
34            return true;
35        }
36
37        [MethodImpl(MethodImplOptions.AggressiveInlining)]
38        public static bool AddFirstAndReturnTrue<T>(this IList<T> list, IList<T> elements)
39        {
40            list.AddFirst(elements);
41            return true;
42        }
43
44        [MethodImpl(MethodImplOptions.AggressiveInlining)]
45        public static void AddFirst<T>(this IList<T> list, IList<T> elements) =>
46            ↪ list.Add(elements[0]);
47
48        [MethodImpl(MethodImplOptions.AggressiveInlining)]
49        public static bool AddAllAndReturnTrue<T>(this IList<T> list, IList<T> elements)
50        {
51            list.AddAll(elements);
52            return true;
53        }
54
55        [MethodImpl(MethodImplOptions.AggressiveInlining)]
56        public static void AddAll<T>(this IList<T> list, IList<T> elements)
57        {
58            for (var i = 0; i < elements.Count; i++)
59            {
60                list.Add(elements[i]);
61            }
62        }
63
64        [MethodImpl(MethodImplOptions.AggressiveInlining)]
65        public static bool AddSkipFirstAndReturnTrue<T>(this IList<T> list, IList<T> elements)
66        {
67            list.AddSkipFirst(elements);
68            return true;
69        }
70    }
71 }

```

```

67     }
68
69     [MethodImpl(MethodImplOptions.AggressiveInlining)]
70     public static void AddSkipFirst<T>(this IList<T> list, IList<T> elements) =>
        ↪ list.AddSkipFirst(elements, 1);
71
72     [MethodImpl(MethodImplOptions.AggressiveInlining)]
73     public static void AddSkipFirst<T>(this IList<T> list, IList<T> elements, int skip)
74     {
75         for (var i = skip; i < elements.Count; i++)
76         {
77             list.Add(elements[i]);
78         }
79     }
80
81     [MethodImpl(MethodImplOptions.AggressiveInlining)]
82     public static int GetCountOrZero<T>(this IList<T> list) => list?.Count ?? 0;
83
84     [MethodImpl(MethodImplOptions.AggressiveInlining)]
85     public static bool EqualTo<T>(this IList<T> left, IList<T> right) => EqualTo(left,
        ↪ right, ContentEqualTo);
86
87     [MethodImpl(MethodImplOptions.AggressiveInlining)]
88     public static bool EqualTo<T>(this IList<T> left, IList<T> right, Func<IList<T>,
        ↪ IList<T>, bool> contentEqualityComparer)
89     {
90         if (ReferenceEquals(left, right))
91         {
92             return true;
93         }
94         var leftCount = left.GetCountOrZero();
95         var rightCount = right.GetCountOrZero();
96         if (leftCount == 0 && rightCount == 0)
97         {
98             return true;
99         }
100         if (leftCount == 0 || rightCount == 0 || leftCount != rightCount)
101         {
102             return false;
103         }
104         return contentEqualityComparer(left, right);
105     }
106
107     [MethodImpl(MethodImplOptions.AggressiveInlining)]
108     public static bool ContentEqualTo<T>(this IList<T> left, IList<T> right)
109     {
110         var equalityComparer = EqualityComparer<T>.Default;
111         for (var i = left.Count - 1; i >= 0; --i)
112         {
113             if (!equalityComparer.Equals(left[i], right[i]))
114             {
115                 return false;
116             }
117         }
118         return true;
119     }
120
121     [MethodImpl(MethodImplOptions.AggressiveInlining)]
122     public static T[] ToArray<T>(this IList<T> list, Func<T, bool> predicate)
123     {
124         if (list == null)
125         {
126             return null;
127         }
128         var result = new List<T>(list.Count);
129         for (var i = 0; i < list.Count; i++)
130         {
131             if (predicate(list[i]))
132             {
133                 result.Add(list[i]);
134             }
135         }
136         return result.ToArray();
137     }
138
139     [MethodImpl(MethodImplOptions.AggressiveInlining)]
140     public static T[] ToArray<T>(this IList<T> list)
141     {
142         var array = new T[list.Count];

```

```

143         list.CopyTo(array, 0);
144         return array;
145     }
146
147     [MethodImpl(MethodImplOptions.AggressiveInlining)]
148     public static void ForEach<T>(this IList<T> list, Action<T> action)
149     {
150         for (var i = 0; i < list.Count; i++)
151         {
152             action(list[i]);
153         }
154     }
155
156     /// <remarks>
157     /// Based on http://stackoverflow.com/questions/263400/what-is-the-best-algorithm-for-an\_
158     /// ↪ -overridden-system-object-gethashcode
159     /// </remarks>
160     [MethodImpl(MethodImplOptions.AggressiveInlining)]
161     public static int GenerateHashCode<T>(this IList<T> list)
162     {
163         var hashAccumulator = 17;
164         for (var i = 0; i < list.Count; i++)
165         {
166             hashAccumulator = unchecked((hashAccumulator * 23) + list[i].GetHashCode());
167         }
168         return hashAccumulator;
169     }
170
171     [MethodImpl(MethodImplOptions.AggressiveInlining)]
172     public static int CompareTo<T>(this IList<T> left, IList<T> right)
173     {
174         var comparer = Comparer<T>.Default;
175         var leftCount = left.GetCountOrZero();
176         var rightCount = right.GetCountOrZero();
177         var intermediateResult = leftCount.CompareTo(rightCount);
178         for (var i = 0; intermediateResult == 0 && i < leftCount; i++)
179         {
180             intermediateResult = comparer.Compare(left[i], right[i]);
181         }
182         return intermediateResult;
183     }
184
185     [MethodImpl(MethodImplOptions.AggressiveInlining)]
186     public static T[] SkipFirst<T>(this IList<T> list) => list.SkipFirst(1);
187
188     [MethodImpl(MethodImplOptions.AggressiveInlining)]
189     public static T[] SkipFirst<T>(this IList<T> list, int skip)
190     {
191         if (list.IsNullOrEmpty() || list.Count <= skip)
192         {
193             return Array.Empty<T>();
194         }
195         var result = new T[list.Count - skip];
196         for (int r = skip, w = 0; r < list.Count; r++, w++)
197         {
198             result[w] = list[r];
199         }
200         return result;
201     }
202
203     [MethodImpl(MethodImplOptions.AggressiveInlining)]
204     public static IList<T> ShiftRight<T>(this IList<T> list) => list.ShiftRight(1);
205
206     [MethodImpl(MethodImplOptions.AggressiveInlining)]
207     public static IList<T> ShiftRight<T>(this IList<T> list, int shift)
208     {
209         if (shift < 0)
210         {
211             throw new NotImplementedException();
212         }
213         if (shift == 0)
214         {
215             return list.ToArray();
216         }
217         else
218         {
219             var result = new T[list.Count + shift];
220             for (int r = 0, w = shift; r < list.Count; r++, w++)
221             {

```

```

221         result[w] = list[r];
222     }
223     return result;
224 }
225 }
226 }
227 }

```

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

```

1  using System.Collections.Generic;
2  using System.Runtime.CompilerServices;
3
4  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
5
6  namespace Platform.Collections.Lists
7  {
8      public class ListFiller<TElement, TReturnConstant>
9      {
10         protected readonly List<TElement> _list;
11         protected readonly TReturnConstant _returnConstant;
12
13         [MethodImpl(MethodImplOptions.AggressiveInlining)]
14         public ListFiller(List<TElement> list, TReturnConstant returnConstant)
15         {
16             _list = list;
17             _returnConstant = returnConstant;
18         }
19
20         [MethodImpl(MethodImplOptions.AggressiveInlining)]
21         public ListFiller(List<TElement> list) : this(list, default) { }
22
23         [MethodImpl(MethodImplOptions.AggressiveInlining)]
24         public void Add(TElement element) => _list.Add(element);
25
26         [MethodImpl(MethodImplOptions.AggressiveInlining)]
27         public bool AddAndReturnTrue(TElement element) => _list.AddAndReturnTrue(element);
28
29         [MethodImpl(MethodImplOptions.AggressiveInlining)]
30         public bool AddFirstAndReturnTrue(IList<TElement> elements) =>
31             ↪ _list.AddFirstAndReturnTrue(elements);
32
33         [MethodImpl(MethodImplOptions.AggressiveInlining)]
34         public bool AddAllAndReturnTrue(IList<TElement> elements) =>
35             ↪ _list.AddAllAndReturnTrue(elements);
36
37         [MethodImpl(MethodImplOptions.AggressiveInlining)]
38         public bool AddSkipFirstAndReturnTrue(IList<TElement> elements) =>
39             ↪ _list.AddSkipFirstAndReturnTrue(elements);
40
41         [MethodImpl(MethodImplOptions.AggressiveInlining)]
42         public TReturnConstant AddAndReturnConstant(TElement element)
43         {
44             _list.Add(element);
45             return _returnConstant;
46         }
47
48         [MethodImpl(MethodImplOptions.AggressiveInlining)]
49         public TReturnConstant AddFirstAndReturnConstant(IList<TElement> elements)
50         {
51             _list.AddFirst(elements);
52             return _returnConstant;
53         }
54
55         [MethodImpl(MethodImplOptions.AggressiveInlining)]
56         public TReturnConstant AddAllAndReturnConstant(IList<TElement> elements)
57         {
58             _list.AddAll(elements);
59             return _returnConstant;
60         }
61
62         [MethodImpl(MethodImplOptions.AggressiveInlining)]
63         public TReturnConstant AddSkipFirstAndReturnConstant(IList<TElement> elements)
64         {
65             _list.AddSkipFirst(elements);
66             return _returnConstant;
67         }
68     }
69 }

```

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

```

1  using System.Linq;
2  using System.Collections.Generic;
3  using System.Runtime.CompilerServices;
4  using Platform.Collections.Arrays;
5  using Platform.Collections.Lists;
6
7  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
8
9  namespace Platform.Collections.Segments
10 {
11     public class CharSegment : Segment<char>
12     {
13         [MethodImpl(MethodImplOptions.AggressiveInlining)]
14         public CharSegment(IList<char> @base, int offset, int length) : base(@base, offset,
15             ↪ length) { }
16
17         [MethodImpl(MethodImplOptions.AggressiveInlining)]
18         public override int GetHashCode()
19         {
20             // Base can be not an array, but still IList<char>
21             if (Base is char[] baseArray)
22             {
23                 return baseArray.GenerateHashCode(Offset, Length);
24             }
25             else
26             {
27                 return this.GenerateHashCode();
28             }
29         }
30
31         [MethodImpl(MethodImplOptions.AggressiveInlining)]
32         public override bool Equals(Segment<char> other)
33         {
34             bool contentEqualityComparer(IList<char> left, IList<char> right)
35             {
36                 // Base can be not an array, but still IList<char>
37                 if (Base is char[] baseArray && other.Base is char[] otherArray)
38                 {
39                     return baseArray.ContentEqualTo(Offset, Length, otherArray, other.Offset);
40                 }
41                 else
42                 {
43                     return left.ContentEqualTo(right);
44                 }
45             }
46             return this.EqualTo(other, contentEqualityComparer);
47         }
48
49         public override bool Equals(object obj) => obj is Segment<char> charSegment ?
50             ↪ Equals(charSegment) : false;
51
52         [MethodImpl(MethodImplOptions.AggressiveInlining)]
53         public static implicit operator string(CharSegment segment)
54         {
55             if (!(segment.Base is char[] array))
56             {
57                 array = segment.Base.ToArray();
58             }
59             return new string(array, segment.Offset, segment.Length);
60         }
61
62         [MethodImpl(MethodImplOptions.AggressiveInlining)]
63         public override string ToString() => this;
64     }
65 }

```

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

```

1  using System;
2  using System.Collections;
3  using System.Collections.Generic;
4  using System.Runtime.CompilerServices;
5  using Platform.Collections.Arrays;
6  using Platform.Collections.Lists;
7
8  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
9
10 namespace Platform.Collections.Segments
11 {
12     public class Segment<T> : IEquatable<Segment<T>>, IList<T>

```

```

13 {
14     public IList<T> Base
15     {
16         [MethodImpl(MethodImplOptions.AggressiveInlining)]
17         get;
18     }
19     public int Offset
20     {
21         [MethodImpl(MethodImplOptions.AggressiveInlining)]
22         get;
23     }
24     public int Length
25     {
26         [MethodImpl(MethodImplOptions.AggressiveInlining)]
27         get;
28     }
29
30     [MethodImpl(MethodImplOptions.AggressiveInlining)]
31     public Segment(IList<T> @base, int offset, int length)
32     {
33         Base = @base;
34         Offset = offset;
35         Length = length;
36     }
37
38     [MethodImpl(MethodImplOptions.AggressiveInlining)]
39     public override int GetHashCode() => this.GenerateHashCode();
40
41     [MethodImpl(MethodImplOptions.AggressiveInlining)]
42     public virtual bool Equals(Segment<T> other) => this.EqualTo(other);
43
44     [MethodImpl(MethodImplOptions.AggressiveInlining)]
45     public override bool Equals(object obj) => obj is Segment<T> other ? Equals(other) :
46         ↪ false;
47
48     #region IList
49     public T this[int i]
50     {
51         [MethodImpl(MethodImplOptions.AggressiveInlining)]
52         get => Base[Offset + i];
53         [MethodImpl(MethodImplOptions.AggressiveInlining)]
54         set => Base[Offset + i] = value;
55     }
56
57     public int Count
58     {
59         [MethodImpl(MethodImplOptions.AggressiveInlining)]
60         get => Length;
61     }
62
63     public bool IsReadOnly
64     {
65         [MethodImpl(MethodImplOptions.AggressiveInlining)]
66         get => true;
67     }
68
69     [MethodImpl(MethodImplOptions.AggressiveInlining)]
70     public int IndexOf(T item)
71     {
72         var index = Base.IndexOf(item);
73         if (index >= Offset)
74         {
75             var actualIndex = index - Offset;
76             if (actualIndex < Length)
77             {
78                 return actualIndex;
79             }
80         }
81         return -1;
82     }
83
84     [MethodImpl(MethodImplOptions.AggressiveInlining)]
85     public void Insert(int index, T item) => throw new NotSupportedException();
86
87     [MethodImpl(MethodImplOptions.AggressiveInlining)]
88     public void RemoveAt(int index) => throw new NotSupportedException();
89
90     [MethodImpl(MethodImplOptions.AggressiveInlining)]
91     public void Add(T item) => throw new NotSupportedException();

```

```

92     [MethodImpl(MethodImplOptions.AggressiveInlining)]
93     public void Clear() => throw new NotSupportedException();
94
95     [MethodImpl(MethodImplOptions.AggressiveInlining)]
96     public bool Contains(T item) => IndexOf(item) >= 0;
97
98     [MethodImpl(MethodImplOptions.AggressiveInlining)]
99     public void CopyTo(T[] array, int arrayIndex)
100     {
101         for (var i = 0; i < Length; i++)
102         {
103             array.Add(ref arrayIndex, this[i]);
104         }
105     }
106
107     [MethodImpl(MethodImplOptions.AggressiveInlining)]
108     public bool Remove(T item) => throw new NotSupportedException();
109
110     [MethodImpl(MethodImplOptions.AggressiveInlining)]
111     public IEnumerator<T> GetEnumerator()
112     {
113         for (var i = 0; i < Length; i++)
114         {
115             yield return this[i];
116         }
117     }
118
119     [MethodImpl(MethodImplOptions.AggressiveInlining)]
120     IEnumerator IEnumerable.GetEnumerator() => GetEnumerator();
121
122     #endregion
123 }
124
125 }

```

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

```

1  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
2
3  namespace Platform.Collections.Segments.Walkers
4  {
5      public abstract class AllSegmentsWalkerBase
6      {
7          public static readonly int DefaultMinimumStringSegmentLength = 2;
8      }
9  }

```

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

```

1  using System.Collections.Generic;
2  using System.Runtime.CompilerServices;
3
4  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
5
6  namespace Platform.Collections.Segments.Walkers
7  {
8      public abstract class AllSegmentsWalkerBase<T, TSegment> : AllSegmentsWalkerBase
9          where TSegment : Segment<T>
10     {
11         private readonly int _minimumStringSegmentLength;
12
13         [MethodImpl(MethodImplOptions.AggressiveInlining)]
14         protected AllSegmentsWalkerBase(int minimumStringSegmentLength) =>
15             ↪ _minimumStringSegmentLength = minimumStringSegmentLength;
16
17         [MethodImpl(MethodImplOptions.AggressiveInlining)]
18         protected AllSegmentsWalkerBase() : this(DefaultMinimumStringSegmentLength) { }
19
20         [MethodImpl(MethodImplOptions.AggressiveInlining)]
21         public virtual void WalkAll(ICollection<T> elements)
22         {
23             for (int offset = 0, maxOffset = elements.Count - _minimumStringSegmentLength;
24                 ↪ offset <= maxOffset; offset++)
25             {
26                 for (int length = _minimumStringSegmentLength, maxLength = elements.Count -
27                     ↪ offset; length <= maxLength; length++)
28                 {
29                     Iteration(CreateSegment(elements, offset, length));
30                 }
31             }
32         }
33     }
34 }

```

```

30
31     [MethodImpl(MethodImplOptions.AggressiveInlining)]
32     protected abstract TSegment CreateSegment(IList<T> elements, int offset, int length);
33
34     [MethodImpl(MethodImplOptions.AggressiveInlining)]
35     protected abstract void Iteration(TSegment segment);
36 }
37 }

```

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

```

1 using System.Collections.Generic;
2 using System.Runtime.CompilerServices;
3
4 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
5
6 namespace Platform.Collections.Segments.Walkers
7 {
8     public abstract class AllSegmentsWalkerBase<T> : AllSegmentsWalkerBase<T, Segment<T>>
9     {
10         [MethodImpl(MethodImplOptions.AggressiveInlining)]
11         protected override Segment<T> CreateSegment(IList<T> elements, int offset, int length)
12             => new Segment<T>(elements, offset, length);
13     }
14 }

```

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

```

1 using System.Runtime.CompilerServices;
2
3 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
4
5 namespace Platform.Collections.Segments.Walkers
6 {
7     public static class AllSegmentsWalkerExtensions
8     {
9         [MethodImpl(MethodImplOptions.AggressiveInlining)]
10        public static void WalkAll(this AllSegmentsWalkerBase<char> walker, string @string) =>
11            walker.WalkAll(@string.ToCharArray());
12
13        [MethodImpl(MethodImplOptions.AggressiveInlining)]
14        public static void WalkAll<TSegment>(this AllSegmentsWalkerBase<char, TSegment> walker,
15            string @string) where TSegment : Segment<char> =>
16            walker.WalkAll(@string.ToCharArray());
17    }
18 }

```

#### 1.26 ./csharp/Platform.Collections.Segments.Walkers/DictionaryBasedDuplicateSegmentsWalkerBase[T, Segment<T>].cs

```

1 using System;
2 using System.Collections.Generic;
3 using System.Runtime.CompilerServices;
4
5 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
6
7 namespace Platform.Collections.Segments.Walkers
8 {
9     public abstract class DictionaryBasedDuplicateSegmentsWalkerBase<T, TSegment> :
10        DuplicateSegmentsWalkerBase<T, TSegment>
11        where TSegment : Segment<T>
12     {
13         public static readonly bool DefaultResetDictionaryOnEachWalk;
14
15         private readonly bool _resetDictionaryOnEachWalk;
16         protected IDictionary<TSegment, long> Dictionary;
17
18         [MethodImpl(MethodImplOptions.AggressiveInlining)]
19         protected DictionaryBasedDuplicateSegmentsWalkerBase(IDictionary<TSegment, long>
20             dictionary, int minimumStringSegmentLength, bool resetDictionaryOnEachWalk)
21             : base(minimumStringSegmentLength)
22         {
23             Dictionary = dictionary;
24             _resetDictionaryOnEachWalk = resetDictionaryOnEachWalk;
25         }
26
27         [MethodImpl(MethodImplOptions.AggressiveInlining)]
28         protected DictionaryBasedDuplicateSegmentsWalkerBase(IDictionary<TSegment, long>
29             dictionary, int minimumStringSegmentLength) : this(dictionary,
30             minimumStringSegmentLength, DefaultResetDictionaryOnEachWalk) { }
31
32         [MethodImpl(MethodImplOptions.AggressiveInlining)]
33     }
34 }

```



```

29     protected DictionaryBasedDuplicateSegmentsWalkerBase(IDictionary<TSegment, long>
        ↪ dictionary) : this(dictionary, DefaultMinimumStringSegmentLength,
        ↪ DefaultResetDictionaryOnEachWalk) { }
30
31     [MethodImpl(MethodImplOptions.AggressiveInlining)]
32     protected DictionaryBasedDuplicateSegmentsWalkerBase(int minimumStringSegmentLength,
        ↪ bool resetDictionaryOnEachWalk) : this(resetDictionaryOnEachWalk ? null : new
        ↪ Dictionary<TSegment, long>(), minimumStringSegmentLength, resetDictionaryOnEachWalk)
        ↪ { }
33
34     [MethodImpl(MethodImplOptions.AggressiveInlining)]
35     protected DictionaryBasedDuplicateSegmentsWalkerBase(int minimumStringSegmentLength) :
        ↪ this(minimumStringSegmentLength, DefaultResetDictionaryOnEachWalk) { }
36
37     [MethodImpl(MethodImplOptions.AggressiveInlining)]
38     protected DictionaryBasedDuplicateSegmentsWalkerBase() :
        ↪ this(DefaultMinimumStringSegmentLength, DefaultResetDictionaryOnEachWalk) { }
39
40     [MethodImpl(MethodImplOptions.AggressiveInlining)]
41     public override void WalkAll(ICollection<T> elements)
42     {
43         if (_resetDictionaryOnEachWalk)
44         {
45             var capacity = Math.Ceiling(Math.Pow(elements.Count, 2) / 2);
46             Dictionary = new Dictionary<TSegment, long>((int)capacity);
47         }
48         base.WalkAll(elements);
49     }
50
51     [MethodImpl(MethodImplOptions.AggressiveInlining)]
52     protected override long GetSegmentFrequency(TSegment segment) =>
        ↪ Dictionary.GetOrDefault(segment);
53
54     [MethodImpl(MethodImplOptions.AggressiveInlining)]
55     protected override void SetSegmentFrequency(TSegment segment, long frequency) =>
        ↪ Dictionary[segment] = frequency;
56 }
57 }

```

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

```

1  using System.Collections.Generic;
2  using System.Runtime.CompilerServices;
3
4  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
5
6  namespace Platform.Collections.Segments.Walkers
7  {
8      public abstract class DictionaryBasedDuplicateSegmentsWalkerBase<T> :
        ↪ DictionaryBasedDuplicateSegmentsWalkerBase<T, Segment<T>>
9      {
10         [MethodImpl(MethodImplOptions.AggressiveInlining)]
11         protected DictionaryBasedDuplicateSegmentsWalkerBase(IDictionary<Segment<T>, long>
            ↪ dictionary, int minimumStringSegmentLength, bool resetDictionaryOnEachWalk) :
            ↪ base(dictionary, minimumStringSegmentLength, resetDictionaryOnEachWalk) { }
12
13         [MethodImpl(MethodImplOptions.AggressiveInlining)]
14         protected DictionaryBasedDuplicateSegmentsWalkerBase(IDictionary<Segment<T>, long>
            ↪ dictionary, int minimumStringSegmentLength) : base(dictionary,
            ↪ minimumStringSegmentLength, DefaultResetDictionaryOnEachWalk) { }
15
16         [MethodImpl(MethodImplOptions.AggressiveInlining)]
17         protected DictionaryBasedDuplicateSegmentsWalkerBase(IDictionary<Segment<T>, long>
            ↪ dictionary) : base(dictionary, DefaultMinimumStringSegmentLength,
            ↪ DefaultResetDictionaryOnEachWalk) { }
18
19         [MethodImpl(MethodImplOptions.AggressiveInlining)]
20         protected DictionaryBasedDuplicateSegmentsWalkerBase(int minimumStringSegmentLength,
            ↪ bool resetDictionaryOnEachWalk) : base(minimumStringSegmentLength,
            ↪ resetDictionaryOnEachWalk) { }
21
22         [MethodImpl(MethodImplOptions.AggressiveInlining)]
23         protected DictionaryBasedDuplicateSegmentsWalkerBase(int minimumStringSegmentLength) :
            ↪ base(minimumStringSegmentLength, DefaultResetDictionaryOnEachWalk) { }
24
25         [MethodImpl(MethodImplOptions.AggressiveInlining)]
26         protected DictionaryBasedDuplicateSegmentsWalkerBase() :
            ↪ base(DefaultMinimumStringSegmentLength, DefaultResetDictionaryOnEachWalk) { }
27     }

```

```
28 }
```

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

```
1 using System.Runtime.CompilerServices;
2
3 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
4
5 namespace Platform.Collections.Segments.Walkers
6 {
7     public abstract class DuplicateSegmentsWalkerBase<T, TSegment> : AllSegmentsWalkerBase<T,
8         ↪ TSegment>
9         where TSegment : Segment<T>
10     {
11         [MethodImpl(MethodImplOptions.AggressiveInlining)]
12         protected DuplicateSegmentsWalkerBase(int minimumStringSegmentLength) :
13             ↪ base(minimumStringSegmentLength) { }
14
15         [MethodImpl(MethodImplOptions.AggressiveInlining)]
16         protected DuplicateSegmentsWalkerBase() : base(DefaultMinimumStringSegmentLength) { }
17
18         [MethodImpl(MethodImplOptions.AggressiveInlining)]
19         protected override void Iteration(TSegment segment)
20         {
21             var frequency = GetSegmentFrequency(segment);
22             if (frequency == 1)
23             {
24                 OnDuplicateFound(segment);
25             }
26             SetSegmentFrequency(segment, frequency + 1);
27         }
28
29         [MethodImpl(MethodImplOptions.AggressiveInlining)]
30         protected abstract void OnDuplicateFound(TSegment segment);
31
32         [MethodImpl(MethodImplOptions.AggressiveInlining)]
33         protected abstract long GetSegmentFrequency(TSegment segment);
34
35         [MethodImpl(MethodImplOptions.AggressiveInlining)]
36         protected abstract void SetSegmentFrequency(TSegment segment, long frequency);
37     }
38 }
```

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

```
1 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
2
3 namespace Platform.Collections.Segments.Walkers
4 {
5     public abstract class DuplicateSegmentsWalkerBase<T> : DuplicateSegmentsWalkerBase<T,
6         ↪ Segment<T>>
7     {
8     }
9 }
```

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

```
1 using System.Collections.Generic;
2 using System.Runtime.CompilerServices;
3
4 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
5
6 namespace Platform.Collections.Sets
7 {
8     public static class ISetExtensions
9     {
10         [MethodImpl(MethodImplOptions.AggressiveInlining)]
11         public static void AddAndReturnVoid<T>(this ISet<T> set, T element) => set.Add(element);
12
13         [MethodImpl(MethodImplOptions.AggressiveInlining)]
14         public static void RemoveAndReturnVoid<T>(this ISet<T> set, T element) =>
15             ↪ set.Remove(element);
16
17         [MethodImpl(MethodImplOptions.AggressiveInlining)]
18         public static bool AddAndReturnTrue<T>(this ISet<T> set, T element)
19         {
20             set.Add(element);
21             return true;
22         }
23
24         [MethodImpl(MethodImplOptions.AggressiveInlining)]
25         public static bool AddFirstAndReturnTrue<T>(this ISet<T> set, IList<T> elements)
```

```

25     {
26         AddFirst(set, elements);
27         return true;
28     }
29
30     [MethodImpl(MethodImplOptions.AggressiveInlining)]
31     public static void AddFirst<T>(this ISet<T> set, IList<T> elements) =>
        ↪ set.Add(elements[0]);
32
33     [MethodImpl(MethodImplOptions.AggressiveInlining)]
34     public static bool AddAllAndReturnTrue<T>(this ISet<T> set, IList<T> elements)
35     {
36         set.AddAll(elements);
37         return true;
38     }
39
40     [MethodImpl(MethodImplOptions.AggressiveInlining)]
41     public static void AddAll<T>(this ISet<T> set, IList<T> elements)
42     {
43         for (var i = 0; i < elements.Count; i++)
44         {
45             set.Add(elements[i]);
46         }
47     }
48
49     [MethodImpl(MethodImplOptions.AggressiveInlining)]
50     public static bool AddSkipFirstAndReturnTrue<T>(this ISet<T> set, IList<T> elements)
51     {
52         set.AddSkipFirst(elements);
53         return true;
54     }
55
56     [MethodImpl(MethodImplOptions.AggressiveInlining)]
57     public static void AddSkipFirst<T>(this ISet<T> set, IList<T> elements) =>
        ↪ set.AddSkipFirst(elements, 1);
58
59     [MethodImpl(MethodImplOptions.AggressiveInlining)]
60     public static void AddSkipFirst<T>(this ISet<T> set, IList<T> elements, int skip)
61     {
62         for (var i = skip; i < elements.Count; i++)
63         {
64             set.Add(elements[i]);
65         }
66     }
67
68     [MethodImpl(MethodImplOptions.AggressiveInlining)]
69     public static bool DoNotContains<T>(this ISet<T> set, T element) =>
        ↪ !set.Contains(element);
70 }
71 }

```

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

```

1 using System.Collections.Generic;
2 using System.Runtime.CompilerServices;
3
4 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
5
6 namespace Platform.Collections.Sets
7 {
8     public class SetFiller<TElement, TReturnConstant>
9     {
10         protected readonly ISet<TElement> _set;
11         protected readonly TReturnConstant _returnConstant;
12
13         [MethodImpl(MethodImplOptions.AggressiveInlining)]
14         public SetFiller(ISet<TElement> set, TReturnConstant returnConstant)
15         {
16             _set = set;
17             _returnConstant = returnConstant;
18         }
19
20         [MethodImpl(MethodImplOptions.AggressiveInlining)]
21         public SetFiller(ISet<TElement> set) : this(set, default) { }
22
23         [MethodImpl(MethodImplOptions.AggressiveInlining)]
24         public void Add(TElement element) => _set.Add(element);
25
26         [MethodImpl(MethodImplOptions.AggressiveInlining)]
27         public bool AddAndReturnTrue(TElement element) => _set.AddAndReturnTrue(element);
28

```

```

29     [MethodImpl(MethodImplOptions.AggressiveInlining)]
30     public bool AddFirstAndReturnTrue(IList<TElement> elements) =>
        => _set.AddFirstAndReturnTrue(elements);
31
32     [MethodImpl(MethodImplOptions.AggressiveInlining)]
33     public bool AddAllAndReturnTrue(IList<TElement> elements) =>
        => _set.AddAllAndReturnTrue(elements);
34
35     [MethodImpl(MethodImplOptions.AggressiveInlining)]
36     public bool AddSkipFirstAndReturnTrue(IList<TElement> elements) =>
        => _set.AddSkipFirstAndReturnTrue(elements);
37
38     [MethodImpl(MethodImplOptions.AggressiveInlining)]
39     public TReturnConstant AddAndReturnConstant(TElement element)
40     {
41         _set.Add(element);
42         return _returnConstant;
43     }
44
45     [MethodImpl(MethodImplOptions.AggressiveInlining)]
46     public TReturnConstant AddFirstAndReturnConstant(IList<TElement> elements)
47     {
48         _set.AddFirst(elements);
49         return _returnConstant;
50     }
51
52     [MethodImpl(MethodImplOptions.AggressiveInlining)]
53     public TReturnConstant AddAllAndReturnConstant(IList<TElement> elements)
54     {
55         _set.AddAll(elements);
56         return _returnConstant;
57     }
58
59     [MethodImpl(MethodImplOptions.AggressiveInlining)]
60     public TReturnConstant AddSkipFirstAndReturnConstant(IList<TElement> elements)
61     {
62         _set.AddSkipFirst(elements);
63         return _returnConstant;
64     }
65 }
66 }

```

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

```

1 using System.Collections.Generic;
2 using System.Runtime.CompilerServices;
3
4 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
5
6 namespace Platform.Collections.Stacks
7 {
8     public class DefaultStack<TElement> : Stack<TElement>, IStack<TElement>
9     {
10         public bool IsEmpty
11         {
12             [MethodImpl(MethodImplOptions.AggressiveInlining)]
13             get => Count <= 0;
14         }
15     }
16 }

```

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

```

1 using System.Runtime.CompilerServices;
2
3 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
4
5 namespace Platform.Collections.Stacks
6 {
7     public interface IStack<TElement>
8     {
9         bool IsEmpty
10         {
11             [MethodImpl(MethodImplOptions.AggressiveInlining)]
12             get;
13         }
14
15         [MethodImpl(MethodImplOptions.AggressiveInlining)]
16         void Push(TElement element);
17
18         [MethodImpl(MethodImplOptions.AggressiveInlining)]

```

```

19         TElement Pop();
20
21         [MethodImpl(MethodImplOptions.AggressiveInlining)]
22         TElement Peek();
23     }
24 }

```

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

```

1 using System.Runtime.CompilerServices;
2
3 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
4
5 namespace Platform.Collections.Stacks
6 {
7     public static class IStackExtensions
8     {
9         [MethodImpl(MethodImplOptions.AggressiveInlining)]
10        public static void Clear<T>(this IStack<T> stack)
11        {
12            while (!stack.IsEmpty)
13            {
14                _ = stack.Pop();
15            }
16        }
17
18        [MethodImpl(MethodImplOptions.AggressiveInlining)]
19        public static T PopOrDefault<T>(this IStack<T> stack) => stack.IsEmpty ? default :
20            ↪ stack.Pop();
21
22        [MethodImpl(MethodImplOptions.AggressiveInlining)]
23        public static T PeekOrDefault<T>(this IStack<T> stack) => stack.IsEmpty ? default :
24            ↪ stack.Peek();
25    }
26 }

```

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

```

1 using Platform.Interfaces;
2
3 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
4
5 namespace Platform.Collections.Stacks
6 {
7     public interface IStackFactory<TElement> : IFactory<IStack<TElement>>
8     {
9     }
10 }

```

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

```

1 using System.Collections.Generic;
2 using System.Runtime.CompilerServices;
3
4 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
5
6 namespace Platform.Collections.Stacks
7 {
8     public static class StackExtensions
9     {
10        [MethodImpl(MethodImplOptions.AggressiveInlining)]
11        public static T PopOrDefault<T>(this Stack<T> stack) => stack.Count > 0 ? stack.Pop() :
12            ↪ default;
13
14        [MethodImpl(MethodImplOptions.AggressiveInlining)]
15        public static T PeekOrDefault<T>(this Stack<T> stack) => stack.Count > 0 ? stack.Peek()
16            ↪ : default;
17    }
18 }

```

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

```

1 using System;
2 using System.Globalization;
3 using System.Runtime.CompilerServices;
4
5 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
6
7 namespace Platform.Collections
8 {
9     public static class StringExtensions
10    {
11        [MethodImpl(MethodImplOptions.AggressiveInlining)]

```

```

12 public static string CapitalizeFirstLetter(this string @string)
13 {
14     if (@string.IsNullOrEmpty(@string))
15     {
16         return @string;
17     }
18     var chars = @string.ToCharArray();
19     for (var i = 0; i < chars.Length; i++)
20     {
21         var category = char.GetUnicodeCategory(chars[i]);
22         if (category == UnicodeCategory.UppercaseLetter)
23         {
24             return @string;
25         }
26         if (category == UnicodeCategory.LowercaseLetter)
27         {
28             chars[i] = char.ToUpper(chars[i]);
29             return new string(chars);
30         }
31     }
32     return @string;
33 }
34
35 [MethodImpl(MethodImplOptions.AggressiveInlining)]
36 public static string Truncate(this string @string, int maxLength) =>
    => @string.IsNullOrEmpty(@string) ? @string : @string.Substring(0,
    => Math.Min(@string.Length, maxLength));
37
38 [MethodImpl(MethodImplOptions.AggressiveInlining)]
39 public static string TrimSingle(this string @string, char charToTrim)
40 {
41     if (!@string.IsNullOrEmpty(@string))
42     {
43         if (@string.Length == 1)
44         {
45             if (@string[0] == charToTrim)
46             {
47                 return "";
48             }
49             else
50             {
51                 return @string;
52             }
53         }
54         else
55         {
56             var left = 0;
57             var right = @string.Length - 1;
58             if (@string[left] == charToTrim)
59             {
60                 left++;
61             }
62             if (@string[right] == charToTrim)
63             {
64                 right--;
65             }
66             return @string.Substring(left, right - left + 1);
67         }
68     }
69     else
70     {
71         return @string;
72     }
73 }
74 }
75 }

```

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

```

1 using System.Collections.Generic;
2 using System.Runtime.CompilerServices;
3
4 // ReSharper disable ForCanBeConvertedToForeach
5 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
6
7 namespace Platform.Collections.Trees
8 {
9     public class Node
10     {
11         private Dictionary<object, Node> _childNodes;

```

```

12
13 public object Value
14 {
15     [MethodImpl(MethodImplOptions.AggressiveInlining)]
16     get;
17     [MethodImpl(MethodImplOptions.AggressiveInlining)]
18     set;
19 }
20
21 public Dictionary<object, Node> ChildNodes
22 {
23     [MethodImpl(MethodImplOptions.AggressiveInlining)]
24     get => _childNodes ?? (_childNodes = new Dictionary<object, Node>());
25 }
26
27 public Node this[object key]
28 {
29     [MethodImpl(MethodImplOptions.AggressiveInlining)]
30     get => GetChild(key) ?? AddChild(key);
31     [MethodImpl(MethodImplOptions.AggressiveInlining)]
32     set => SetChildValue(value, key);
33 }
34
35 [MethodImpl(MethodImplOptions.AggressiveInlining)]
36 public Node(object value) => Value = value;
37
38 [MethodImpl(MethodImplOptions.AggressiveInlining)]
39 public Node() : this(null) { }
40
41 [MethodImpl(MethodImplOptions.AggressiveInlining)]
42 public bool ContainsChild(params object[] keys) => GetChild(keys) != null;
43
44 [MethodImpl(MethodImplOptions.AggressiveInlining)]
45 public Node GetChild(params object[] keys)
46 {
47     var node = this;
48     for (var i = 0; i < keys.Length; i++)
49     {
50         node.ChildNodes.TryGetValue(keys[i], out node);
51         if (node == null)
52         {
53             return null;
54         }
55     }
56     return node;
57 }
58
59 [MethodImpl(MethodImplOptions.AggressiveInlining)]
60 public object GetChildValue(params object[] keys) => GetChild(keys)?.Value;
61
62 [MethodImpl(MethodImplOptions.AggressiveInlining)]
63 public Node AddChild(object key) => AddChild(key, new Node(null));
64
65 [MethodImpl(MethodImplOptions.AggressiveInlining)]
66 public Node AddChild(object key, object value) => AddChild(key, new Node(value));
67
68 [MethodImpl(MethodImplOptions.AggressiveInlining)]
69 public Node AddChild(object key, Node child)
70 {
71     ChildNodes.Add(key, child);
72     return child;
73 }
74
75 [MethodImpl(MethodImplOptions.AggressiveInlining)]
76 public Node SetChild(params object[] keys) => SetChildValue(null, keys);
77
78 [MethodImpl(MethodImplOptions.AggressiveInlining)]
79 public Node SetChild(object key) => SetChildValue(null, key);
80
81 [MethodImpl(MethodImplOptions.AggressiveInlining)]
82 public Node SetChildValue(object value, params object[] keys)
83 {
84     var node = this;
85     for (var i = 0; i < keys.Length; i++)
86     {
87         node = SetChildValue(value, keys[i]);
88     }
89     node.Value = value;
90     return node;
91 }

```

```

92     [MethodImpl(MethodImplOptions.AggressiveInlining)]
93     public Node SetChildValue(object value, object key)
94     {
95         if (!ChildNodes.TryGetValue(key, out Node child))
96         {
97             child = AddChild(key, value);
98         }
99         child.Value = value;
100         return child;
101     }
102 }
103 }
104 }

```

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

```

1  using Xunit;
2  using Platform.Collections.Arrays;
3
4  namespace Platform.Collections.Tests
5  {
6      public class ArrayTests
7      {
8          [Fact]
9          public void GetElementTest()
10         {
11             var nullArray = (int[])null;
12             Assert.Equal(0, nullArray.GetElementOrDefault(1));
13             Assert.False(nullArray.TryGetElement(1, out int element));
14             Assert.Equal(0, element);
15             var array = new int[] { 1, 2, 3 };
16             Assert.Equal(3, array.GetElementOrDefault(2));
17             Assert.True(array.TryGetElement(2, out element));
18             Assert.Equal(3, element);
19             Assert.Equal(0, array.GetElementOrDefault(10));
20             Assert.False(array.TryGetElement(10, out element));
21             Assert.Equal(0, element);
22         }
23     }
24 }

```

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

```

1  using System;
2  using System.Collections;
3  using Xunit;
4  using Platform.Random;
5
6  namespace Platform.Collections.Tests
7  {
8      public static class BitStringTests
9      {
10         [Fact]
11         public static void BitGetSetTest()
12         {
13             const int n = 250;
14             var bitArray = new BitArray(n);
15             var bitString = new BitString(n);
16             for (var i = 0; i < n; i++)
17             {
18                 var value = RandomHelpers.Default.NextBoolean();
19                 bitArray.Set(i, value);
20                 bitString.Set(i, value);
21                 Assert.Equal(value, bitArray.Get(i));
22                 Assert.Equal(value, bitString.Get(i));
23             }
24         }
25
26         [Fact]
27         public static void BitVectorNotTest()
28         {
29             TestToOperationsWithSameMeaning((x, y, w, v) =>
30             {
31                 x.VectorNot();
32                 w.Not();
33             });
34         }
35
36         [Fact]
37         public static void BitParallelNotTest()
38         {

```



```

39     TestToOperationsWithSameMeaning((x, y, w, v) =>
40     {
41         x.ParallelNot();
42         w.Not();
43     });
44 }
45
46 [Fact]
47 public static void BitParallelVectorNotTest()
48 {
49     TestToOperationsWithSameMeaning((x, y, w, v) =>
50     {
51         x.ParallelVectorNot();
52         w.Not();
53     });
54 }
55
56 [Fact]
57 public static void BitVectorAndTest()
58 {
59     TestToOperationsWithSameMeaning((x, y, w, v) =>
60     {
61         x.VectorAnd(y);
62         w.And(v);
63     });
64 }
65
66 [Fact]
67 public static void BitParallelAndTest()
68 {
69     TestToOperationsWithSameMeaning((x, y, w, v) =>
70     {
71         x.ParallelAnd(y);
72         w.And(v);
73     });
74 }
75
76 [Fact]
77 public static void BitParallelVectorAndTest()
78 {
79     TestToOperationsWithSameMeaning((x, y, w, v) =>
80     {
81         x.ParallelVectorAnd(y);
82         w.And(v);
83     });
84 }
85
86 [Fact]
87 public static void BitVectorOrTest()
88 {
89     TestToOperationsWithSameMeaning((x, y, w, v) =>
90     {
91         x.VectorOr(y);
92         w.Or(v);
93     });
94 }
95
96 [Fact]
97 public static void BitParallelOrTest()
98 {
99     TestToOperationsWithSameMeaning((x, y, w, v) =>
100    {
101        x.ParallelOr(y);
102        w.Or(v);
103    });
104 }
105
106 [Fact]
107 public static void BitParallelVectorOrTest()
108 {
109     TestToOperationsWithSameMeaning((x, y, w, v) =>
110    {
111        x.ParallelVectorOr(y);
112        w.Or(v);
113    });
114 }
115
116 [Fact]

```

```

117 public static void BitVectorXorTest()
118 {
119     TestToOperationsWithSameMeaning((x, y, w, v) =>
120     {
121         x.VectorXor(y);
122         w.Xor(v);
123     });
124 }
125
126 [Fact]
127 public static void BitParallelXorTest()
128 {
129     TestToOperationsWithSameMeaning((x, y, w, v) =>
130     {
131         x.ParallelXor(y);
132         w.Xor(v);
133     });
134 }
135
136 [Fact]
137 public static void BitParallelVectorXorTest()
138 {
139     TestToOperationsWithSameMeaning((x, y, w, v) =>
140     {
141         x.ParallelVectorXor(y);
142         w.Xor(v);
143     });
144 }
145
146 private static void TestToOperationsWithSameMeaning(Action<BitString, BitString,
147     ↪ BitString, BitString> test)
148 {
149     const int n = 5654;
150     var x = new BitString(n);
151     var y = new BitString(n);
152     while (x.Equals(y))
153     {
154         x.SetRandomBits();
155         y.SetRandomBits();
156     }
157     var w = new BitString(x);
158     var v = new BitString(y);
159     Assert.False(x.Equals(y));
160     Assert.False(w.Equals(v));
161     Assert.True(x.Equals(w));
162     Assert.True(y.Equals(v));
163     test(x, y, w, v);
164     Assert.True(x.Equals(w));
165 }
166 }

```

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

```

1 using Xunit;
2 using Platform.Collections.Segments;
3
4 namespace Platform.Collections.Tests
5 {
6     public static class CharsSegmentTests
7     {
8         [Fact]
9         public static void GetHashCodeEqualsTest()
10         {
11             const string testString = "test test";
12             var testArray = testString.ToCharArray();
13             var firstHashCode = new CharSegment(testArray, 0, 4).GetHashCode();
14             var secondHashCode = new CharSegment(testArray, 5, 4).GetHashCode();
15             Assert.Equal(firstHashCode, secondHashCode);
16         }
17
18         [Fact]
19         public static void EqualsTest()
20         {
21             const string testString = "test test";
22             var testArray = testString.ToCharArray();
23             var first = new CharSegment(testArray, 0, 4);
24             var second = new CharSegment(testArray, 5, 4);
25             Assert.True(first.Equals(second));
26         }
27     }
28 }

```

```
27     }
28 }
```

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

```
1 using System.Collections.Generic;
2 using Xunit;
3 using Platform.Collections.Lists;
4
5
6 namespace Platform.Collections.Tests
7 {
8     public class ListTests
9     {
10         [Fact]
11         public void GetElementTest()
12         {
13             var nullList = (IList<int>)null;
14             Assert.Equal(0, nullList.GetElementOrDefault(1));
15             Assert.False(nullList.TryGetElement(1, out int element));
16             Assert.Equal(0, element);
17             var list = new List<int>() { 1, 2, 3 };
18             Assert.Equal(3, list.GetElementOrDefault(2));
19             Assert.True(list.TryGetElement(2, out element));
20             Assert.Equal(3, element);
21             Assert.Equal(0, list.GetElementOrDefault(10));
22             Assert.False(list.TryGetElement(10, out element));
23             Assert.Equal(0, element);
24         }
25     }
26 }
```

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

```
1 using Xunit;
2
3 namespace Platform.Collections.Tests
4 {
5     public static class StringTests
6     {
7         [Fact]
8         public static void CapitalizeFirstLetterTest()
9         {
10             Assert.Equal("Hello", "hello".CapitalizeFirstLetter());
11             Assert.Equal("Hello", "Hello".CapitalizeFirstLetter());
12             Assert.Equal(" Hello", " hello".CapitalizeFirstLetter());
13         }
14
15         [Fact]
16         public static void TrimSingleTest()
17         {
18             Assert.Equal("", "".TrimSingle('\\'));
19             Assert.Equal("", ""'.TrimSingle('\\'));
20             Assert.Equal("hello", "'hello".TrimSingle('\\'));
21             Assert.Equal("hello", "hello'".TrimSingle('\\'));
22             Assert.Equal("hello", "'hello".TrimSingle('\\'));
23         }
24     }
25 }
```

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