

# LinksPlatform's Platform.Data.Doublets.Sequences Class Library

## 1.1 ./csharp/Platform.Data.Doublets.Sequences/Converters/BalancedVariantConverter.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.Data.Doublets.Sequences.Converters
7 {
8     /// <summary>
9     /// <para>
10    /// Represents the balanced variant converter.
11    /// </para>
12    /// <para></para>
13    /// </summary>
14    /// <seealso cref="LinkedListToSequenceConverterBase{TLinkAddress}"/>
15    public class BalancedVariantConverter<TLinkAddress> :
16        ↳ LinkedListToSequenceConverterBase<TLinkAddress>
17    {
18        /// <summary>
19        /// <para>
20        /// Initializes a new <see cref="BalancedVariantConverter"/> instance.
21        /// </para>
22        /// <para></para>
23        /// </summary>
24        /// <param name="links">
25        /// <para>A links.</para>
26        /// </param>
27        [MethodImpl(MethodImplOptions.AggressiveInlining)]
28        public BalancedVariantConverter(ILinks<TLinkAddress> links) : base(links) { }
29
30        /// <summary>
31        /// <para>
32        /// Converts the sequence.
33        /// </para>
34        /// <para></para>
35        /// </summary>
36        /// <param name="sequence">
37        /// <para>The sequence.</para>
38        /// </param>
39        /// <returns>
40        /// <para>The link</para>
41        /// <para></para>
42        /// </returns>
43        [MethodImpl(MethodImplOptions.AggressiveInlining)]
44        public override TLinkAddress Convert(ICollection<TLinkAddress>? sequence)
45        {
46            var length = sequence.Count;
47            if (length < 1)
48            {
49                return default;
50            }
51            if (length == 1)
52            {
53                return sequence[0];
54            }
55            // Make copy of next layer
56            if (length > 2)
57            {
58                // TODO: Try to use stackalloc (which at the moment is not working with
59                ↳ generics) but will be possible with Sigil
60                var halvedSequence = new TLinkAddress[(length / 2) + (length % 2)];
61                HalveSequence(halvedSequence, sequence, length);
62                sequence = halvedSequence;
63                length = halvedSequence.Length;
64            }
65            // Keep creating layer after layer
66            while (length > 2)
67            {
68                HalveSequence(sequence, sequence, length);
69                length = (length / 2) + (length % 2);
70            }
71            return _links.GetOrCreate(sequence[0], sequence[1]);
72        }
73        [MethodImpl(MethodImplOptions.AggressiveInlining)]
```

```

74     private void HalveSequence(ICollection<TLinkAddress>? destination, ICollection<TLinkAddress>?
    ↪ source, int length)
75     {
76         var loopedLength = length - (length % 2);
77         for (var i = 0; i < loopedLength; i += 2)
78         {
79             destination[i / 2] = _links.GetOrCreate(source[i], source[i + 1]);
80         }
81         if (length > loopedLength)
82         {
83             destination[length / 2] = source[length - 1];
84         }
85     }
86 }
87 }

```

## 1.2 ./csharp/Platform.Data.Doublets.Sequences/Converters/CompressingConverter.cs

```

1  using System;
2  using System.Collections.Generic;
3  using System.Runtime.CompilerServices;
4  using Platform.Collections;
5  using Platform.Converters;
6  using Platform.Singletons;
7  using Platform.Numbers;
8  using Platform.Data.Doublets.Sequences.Frequencies.Cache;
9
10 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
11
12 namespace Platform.Data.Doublets.Sequences.Converters
13 {
14     /// <remarks>
15     /// TODO: Возможно будет лучше если алгоритм будет выполняться полностью изолированно от
    ↪ Links на этапе сжатия.
16     /// А именно будет создаваться временный список пар необходимых для выполнения сжатия, в
    ↪ таком случае тип значения элемента массива может быть любым, как char так и ulong.
17     /// Как только список/словарь пар был выявлен можно разом выполнить создание всех этих
    ↪ пар, а так же разом выполнить замену.
18     /// </remarks>
19     public class CompressingConverter<TLinkAddress> :
    ↪ LinkedListToSequenceConverterBase<TLinkAddress>
20     {
21         private static readonly LinkConstants<TLinkAddress> _constants =
    ↪ Default<LinkConstants<TLinkAddress>>.Instance;
22         private static readonly EqualityComparer<TLinkAddress> _equalityComparer =
    ↪ EqualityComparer<TLinkAddress>.Default;
23         private static readonly Comparer<TLinkAddress> _comparer =
    ↪ Comparer<TLinkAddress>.Default;
24         private static readonly TLinkAddress _zero = default;
25         private static readonly TLinkAddress _one = Arithmetic.Increment(_zero);
26         private readonly IConverter<ICollection<TLinkAddress>?, TLinkAddress> _baseConverter;
27         private readonly LinkFrequenciesCache<TLinkAddress> _doubletFrequenciesCache;
28         private readonly TLinkAddress _minFrequencyToCompress;
29         private readonly bool _doInitialFrequenciesIncrement;
30         private Doublet<TLinkAddress> _maxDoublet;
31         private LinkFrequency<TLinkAddress> _maxDoubletData;
32         private struct HalfDoublet
33         {
34             /// <summary>
35             /// <para>
36             /// The element.
37             /// </para>
38             /// <para></para>
39             /// </summary>
40             public TLinkAddress Element;
41             /// <summary>
42             /// <para>
43             /// The doublet data.
44             /// </para>
45             /// <para></para>
46             /// </summary>
47             public LinkFrequency<TLinkAddress> DoubletData;
48
49             /// <summary>
50             /// <para>
51             /// Initializes a new <see cref="HalfDoublet"/> instance.
52             /// </para>
53             /// <para></para>
54             /// </summary>
55             /// <param name="element">
56             /// <para>A element.</para>

```

```

57     /// <para></para>
58     /// </param>
59     /// <param name="doubletData">
60     /// <para>A doublet data.</para>
61     /// <para></para>
62     /// </param>
63     [MethodImpl(MethodImplOptions.AggressiveInlining)]
64     public HalfDoublet(TLinkAddress element, LinkFrequency<TLinkAddress> doubletData)
65     {
66         Element = element;
67         DoubletData = doubletData;
68     }
69
70     /// <summary>
71     /// <para>
72     /// Returns the string.
73     /// </para>
74     /// <para></para>
75     /// </summary>
76     /// <returns>
77     /// <para>The string</para>
78     /// <para></para>
79     /// </returns>
80     public override string ToString() => $"{Element}: ({DoubletData})";
81 }
82
83 /// <summary>
84 /// <para>
85 /// Initializes a new <see cref="CompressingConverter"/> instance.
86 /// </para>
87 /// <para></para>
88 /// </summary>
89 /// <param name="links">
90 /// <para>A links.</para>
91 /// <para></para>
92 /// </param>
93 /// <param name="baseConverter">
94 /// <para>A base converter.</para>
95 /// <para></para>
96 /// </param>
97 /// <param name="doubletFrequenciesCache">
98 /// <para>A doublet frequencies cache.</para>
99 /// <para></para>
100 /// </param>
101 [MethodImpl(MethodImplOptions.AggressiveInlining)]
102 public CompressingConverter(ILinks<TLinkAddress> links, IConverter<IList<TLinkAddress>?,
    ↪ TLinkAddress> baseConverter, LinkFrequenciesCache<TLinkAddress>
    ↪ doubletFrequenciesCache)
    : this(links, baseConverter, doubletFrequenciesCache, _one, true) { }
103
104 /// <summary>
105 /// <para>
106 /// Initializes a new <see cref="CompressingConverter"/> instance.
107 /// </para>
108 /// <para></para>
109 /// </summary>
110 /// <param name="links">
111 /// <para>A links.</para>
112 /// <para></para>
113 /// </param>
114 /// <param name="baseConverter">
115 /// <para>A base converter.</para>
116 /// <para></para>
117 /// </param>
118 /// <param name="doubletFrequenciesCache">
119 /// <para>A doublet frequencies cache.</para>
120 /// <para></para>
121 /// </param>
122 /// <param name="doInitialFrequenciesIncrement">
123 /// <para>A do initial frequencies increment.</para>
124 /// <para></para>
125 /// </param>
126 [MethodImpl(MethodImplOptions.AggressiveInlining)]
127 public CompressingConverter(ILinks<TLinkAddress> links, IConverter<IList<TLinkAddress>?,
    ↪ TLinkAddress> baseConverter, LinkFrequenciesCache<TLinkAddress>
    ↪ doubletFrequenciesCache, bool doInitialFrequenciesIncrement)
    : this(links, baseConverter, doubletFrequenciesCache, _one,
    ↪ doInitialFrequenciesIncrement) { }
128
129

```

```

130
131     /// <summary>
132     /// <para>
133     /// Initializes a new <see cref="CompressingConverter"/> instance.
134     /// </para>
135     /// </summary>
136     /// <param name="links">
137     /// <para>A links.</para>
138     /// </param>
139     /// <param name="baseConverter">
140     /// <para>A base converter.</para>
141     /// </param>
142     /// <param name="doubletFrequenciesCache">
143     /// <para>A doublet frequencies cache.</para>
144     /// </param>
145     /// <param name="minFrequencyToCompress">
146     /// <para>A min frequency to compress.</para>
147     /// </param>
148     /// <param name="doInitialFrequenciesIncrement">
149     /// <para>A do initial frequencies increment.</para>
150     /// </param>
151     [MethodImpl(MethodImplOptions.AggressiveInlining)]
152     public CompressingConverter(ILinks<TLinkAddress> links, IConverter<IList<TLinkAddress>?,
153     ↪ TLinkAddress> baseConverter, LinkFrequenciesCache<TLinkAddress>
154     ↪ doubletFrequenciesCache, TLinkAddress minFrequencyToCompress, bool
155     ↪ doInitialFrequenciesIncrement)
156     : base(links)
157     {
158         _baseConverter = baseConverter;
159         _doubletFrequenciesCache = doubletFrequenciesCache;
160         if (_comparer.Compare(minFrequencyToCompress, _one) < 0)
161         {
162             minFrequencyToCompress = _one;
163         }
164         _minFrequencyToCompress = minFrequencyToCompress;
165         _doInitialFrequenciesIncrement = doInitialFrequenciesIncrement;
166         ResetMaxDoublet();
167     }
168
169     /// <summary>
170     /// <para>
171     /// Converts the source.
172     /// </para>
173     /// </summary>
174     /// <param name="source">
175     /// <para>The source.</para>
176     /// </param>
177     /// <returns>
178     /// <para>The link</para>
179     /// </returns>
180     [MethodImpl(MethodImplOptions.AggressiveInlining)]
181     public override TLinkAddress Convert(IList<TLinkAddress>? source) =>
182     ↪ _baseConverter.Convert(Compress(source));
183     [MethodImpl(MethodImplOptions.AggressiveInlining)]
184     private IList<TLinkAddress>? Compress(IList<TLinkAddress>? sequence)
185     {
186         if (sequence.IsNullOrEmpty())
187         {
188             return null;
189         }
190         if (sequence.Count == 1)
191         {
192             return sequence;
193         }
194         if (sequence.Count == 2)
195         {
196             return new[] { _links.GetOrCreate(sequence[0], sequence[1]) };
197         }
198         // TODO: arraypool with min size (to improve cache locality) or stackalloc with Sigil

```

```

204 var copy = new HalfDoublet[sequence.Count];
205 Doublet<TLinkAddress> doublet = default;
206 for (var i = 1; i < sequence.Count; i++)
207 {
208     doublet = new Doublet<TLinkAddress>(sequence[i - 1], sequence[i]);
209     LinkFrequency<TLinkAddress> data;
210     if (_doInitialFrequenciesIncrement)
211     {
212         data = _doubletFrequenciesCache.IncrementFrequency(ref doublet);
213     }
214     else
215     {
216         data = _doubletFrequenciesCache.GetFrequency(ref doublet);
217         if (data == null)
218         {
219             throw new NotSupportedException("If you ask not to increment
220                 ↪ frequencies, it is expected that all frequencies for the sequence
221                 ↪ are prepared.");
222         }
223     }
224     copy[i - 1].Element = sequence[i - 1];
225     copy[i - 1].DoubletData = data;
226     UpdateMaxDoublet(ref doublet, data);
227 }
228 copy[sequence.Count - 1].Element = sequence[sequence.Count - 1];
229 copy[sequence.Count - 1].DoubletData = new LinkFrequency<TLinkAddress>();
230 if (_comparer.Compare(_maxDoubletData.Frequency, default) > 0)
231 {
232     var newLength = ReplaceDoublets(copy);
233     sequence = new TLinkAddress[newLength];
234     for (int i = 0; i < newLength; i++)
235     {
236         sequence[i] = copy[i].Element;
237     }
238 }
239 return sequence;
240 }
241 [MethodImpl(MethodImplOptions.AggressiveInlining)]
242 private int ReplaceDoublets(HalfDoublet[] copy)
243 {
244     var oldLength = copy.Length;
245     var newLength = copy.Length;
246     while (_comparer.Compare(_maxDoubletData.Frequency, default) > 0)
247     {
248         var maxDoubletSource = _maxDoublet.Source;
249         var maxDoubletTarget = _maxDoublet.Target;
250         if (_equalityComparer.Equals(_maxDoubletData.Link, _constants.Null))
251         {
252             _maxDoubletData.Link = _links.GetOrCreate(maxDoubletSource,
253                 ↪ maxDoubletTarget);
254         }
255         var maxDoubletReplacementLink = _maxDoubletData.Link;
256         oldLength--;
257         var oldLengthMinusTwo = oldLength - 1;
258         // Substitute all usages
259         int w = 0, r = 0; // (r == read, w == write)
260         for (; r < oldLength; r++)
261         {
262             if (_equalityComparer.Equals(copy[r].Element, maxDoubletSource) &&
263                 ↪ _equalityComparer.Equals(copy[r + 1].Element, maxDoubletTarget))
264             {
265                 if (r > 0)
266                 {
267                     var previous = copy[w - 1].Element;
268                     copy[w - 1].DoubletData.DecrementFrequency();
269                     copy[w - 1].DoubletData =
270                         ↪ _doubletFrequenciesCache.IncrementFrequency(previous,
271                         ↪ maxDoubletReplacementLink);
272                 }
273                 if (r < oldLengthMinusTwo)
274                 {
275                     var next = copy[r + 2].Element;
276                     copy[r + 1].DoubletData.DecrementFrequency();
277                     copy[w].DoubletData = _doubletFrequenciesCache.IncrementFrequency(max
278                         ↪ xDoubletReplacementLink,
279                         ↪ next);
280                 }
281                 copy[w++].Element = maxDoubletReplacementLink;

```

```

274         r++;
275         newLength--;
276     }
277     else
278     {
279         copy[w++] = copy[r];
280     }
281 }
282 if (w < newLength)
283 {
284     copy[w] = copy[r];
285 }
286 oldLength = newLength;
287 ResetMaxDoublet();
288 UpdateMaxDoublet(copy, newLength);
289 }
290 return newLength;
291 }
292 [MethodImpl(MethodImplOptions.AggressiveInlining)]
293 private void ResetMaxDoublet()
294 {
295     _maxDoublet = new Doublet<TLinkAddress>();
296     _maxDoubletData = new LinkFrequency<TLinkAddress>();
297 }
298 [MethodImpl(MethodImplOptions.AggressiveInlining)]
299 private void UpdateMaxDoublet(HalfDoublet[] copy, int length)
300 {
301     Doublet<TLinkAddress> doublet = default;
302     for (var i = 1; i < length; i++)
303     {
304         doublet = new Doublet<TLinkAddress>(copy[i - 1].Element, copy[i].Element);
305         UpdateMaxDoublet(ref doublet, copy[i - 1].DoubletData);
306     }
307 }
308 [MethodImpl(MethodImplOptions.AggressiveInlining)]
309 private void UpdateMaxDoublet(ref Doublet<TLinkAddress> doublet,
310     ↪ LinkFrequency<TLinkAddress> data)
311 {
312     var frequency = data.Frequency;
313     var maxFrequency = _maxDoubletData.Frequency;
314     //if (frequency > _minFrequencyToCompress && (maxFrequency < frequency ||
315     ↪ (maxFrequency == frequency && doublet.Source + doublet.Target < /* gives better
316     ↪ compression string data (and gives collisions quickly) */ _maxDoublet.Source +
317     ↪ _maxDoublet.Target)))
318     if (_comparer.Compare(frequency, _minFrequencyToCompress) > 0 &&
319     ↪ (_comparer.Compare(maxFrequency, frequency) < 0 ||
320     ↪ (_equalityComparer.Equals(maxFrequency, frequency) &&
321     ↪ _comparer.Compare(Arithmetic.Add(doublet.Source, doublet.Target),
322     ↪ Arithmetic.Add(_maxDoublet.Source, _maxDoublet.Target)) > 0))) /* gives
323     ↪ better stability and better compression on sequent data and even on random
324     ↪ numbers data (but gives collisions anyway) */
325     {
326         _maxDoublet = doublet;
327         _maxDoubletData = data;
328     }
329 }
330 }
331 }
332 }

```

### 1.3 ./csharp/Platform.Data.Doublets.Sequences/Converters/LinksListToSequenceConverterBase.cs

```

1 using System.Collections.Generic;
2 using System.Runtime.CompilerServices;
3 using Platform.Converters;
4
5 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
6
7 namespace Platform.Data.Doublets.Sequences.Converters
8 {
9     /// <summary>
10     /// <para>
11     /// Represents the links list to sequence converter base.
12     /// </para>
13     /// <para></para>
14     /// </summary>
15     /// <seealso cref="LinksOperatorBase{TLinkAddress}"/>
16     /// <seealso cref="IConverter{IList{TLinkAddress}, TLinkAddress}"/>
17     public abstract class LinksListToSequenceConverterBase<TLinkAddress> :
18     ↪ LinksOperatorBase<TLinkAddress>, IConverter<IList<TLinkAddress>?, TLinkAddress>
19     {

```

```

19     /// <summary>
20     /// <para>
21     /// Initializes a new <see cref="LinksListToSequenceConverterBase"/> instance.
22     /// </para>
23     /// <para></para>
24     /// </summary>
25     /// <param name="links">
26     /// <para>A links.</para>
27     /// <para></para>
28     /// </param>
29     [MethodImpl(MethodImplOptions.AggressiveInlining)]
30     protected LinksListToSequenceConverterBase(ILinks<TLinkAddress> links) : base(links) { }
31
32     /// <summary>
33     /// <para>
34     /// Converts the source.
35     /// </para>
36     /// <para></para>
37     /// </summary>
38     /// <param name="source">
39     /// <para>The source.</para>
40     /// <para></para>
41     /// </param>
42     /// <returns>
43     /// <para>The link</para>
44     /// <para></para>
45     /// </returns>
46     [MethodImpl(MethodImplOptions.AggressiveInlining)]
47     public abstract TLinkAddress Convert(IList<TLinkAddress>? source);
48 }
49 }

```

#### 1.4 ./csharp/Platform.Data.Doublets.Sequences/Converters/OptimalVariantConverter.cs

```

1  using System.Collections.Generic;
2  using System.Runtime.CompilerServices;
3  using Platform.Collections.Lists;
4  using Platform.Converters;
5  using Platform.Data.Doublets.Sequences.Frequencies.Cache;
6  using Platform.Data.Doublets.Sequences.Frequencies.Counters;
7
8  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
9
10 namespace Platform.Data.Doublets.Sequences.Converters
11 {
12     /// <summary>
13     /// <para>
14     /// Represents the optimal variant converter.
15     /// </para>
16     /// <para></para>
17     /// </summary>
18     /// <seealso cref="LinksListToSequenceConverterBase{TLinkAddress}"/>
19     public class OptimalVariantConverter<TLinkAddress> :
20         ↳ LinksListToSequenceConverterBase<TLinkAddress>
21     {
22         private static readonly EqualityComparer<TLinkAddress> _equalityComparer =
23             ↳ EqualityComparer<TLinkAddress>.Default;
24         private static readonly Comparer<TLinkAddress> _comparer =
25             ↳ Comparer<TLinkAddress>.Default;
26         private readonly IConverter<IList<TLinkAddress>??>
27             ↳ _sequenceToItsLocalElementLevelsConverter;
28
29         /// <summary>
30         /// <para>
31         /// Initializes a new <see cref="OptimalVariantConverter"/> instance.
32         /// </para>
33         /// <para></para>
34         /// </summary>
35         /// <param name="links">
36         /// <para>A links.</para>
37         /// <para></para>
38         /// </param>
39         /// <param name="sequenceToItsLocalElementLevelsConverter">
40         /// <para>A sequence to its local element levels converter.</para>
41         /// <para></para>
42         /// </param>
43         [MethodImpl(MethodImplOptions.AggressiveInlining)]
44         public OptimalVariantConverter(ILinks<TLinkAddress> links,
45             ↳ IConverter<IList<TLinkAddress>??> sequenceToItsLocalElementLevelsConverter) :
46             ↳ base(links)

```

```

41     => _sequenceToItsLocalElementLevelsConverter =
42         ↳ sequenceToItsLocalElementLevelsConverter;
43
44     /// <summary>
45     /// <para>
46     /// Initializes a new <see cref="OptimalVariantConverter"/> instance.
47     /// </para>
48     /// </summary>
49     /// <param name="links">
50     /// <para>A links.</para>
51     /// </param>
52     /// <param name="linkFrequenciesCache">
53     /// <para>A link frequencies cache.</para>
54     /// </param>
55     [MethodImpl(MethodImplOptions.AggressiveInlining)]
56     public OptimalVariantConverter(ILinks<TLinkAddress> links,
57         ↳ LinkFrequenciesCache<TLinkAddress> linkFrequenciesCache)
58         : this(links, new SequenceToItsLocalElementLevelsConverter<TLinkAddress>(links, new
59             ↳ FrequenciesCacheBasedLinkToItsFrequencyNumberConverter<TLinkAddress>(linkFrequen
60             ↳ ciesCache))) {
61
62     /// <summary>
63     /// <para>
64     /// Initializes a new <see cref="OptimalVariantConverter"/> instance.
65     /// </para>
66     /// </summary>
67     /// <param name="links">
68     /// <para>A links.</para>
69     /// </param>
70     [MethodImpl(MethodImplOptions.AggressiveInlining)]
71     public OptimalVariantConverter(ILinks<TLinkAddress> links)
72         : this(links, new LinkFrequenciesCache<TLinkAddress>(links, new
73             ↳ TotalSequenceSymbolFrequencyCounter<TLinkAddress>(links))) { }
74
75     /// <summary>
76     /// <para>
77     /// Converts the sequence.
78     /// </para>
79     /// </summary>
80     /// <param name="sequence">
81     /// <para>The sequence.</para>
82     /// </param>
83     /// <returns>
84     /// <para>The link</para>
85     /// </returns>
86     [MethodImpl(MethodImplOptions.AggressiveInlining)]
87     public override TLinkAddress Convert(IList<TLinkAddress>? sequence)
88     {
89         var length = sequence.Count;
90         if (length == 1)
91         {
92             return sequence[0];
93         }
94         if (length == 2)
95         {
96             return _links.GetOrCreate(sequence[0], sequence[1]);
97         }
98         sequence = sequence.ToArray();
99         var levels = _sequenceToItsLocalElementLevelsConverter.Convert(sequence);
100         while (length > 2)
101         {
102             var levelRepeat = 1;
103             var currentLevel = levels[0];
104             var previousLevel = levels[0];
105             var skipOnce = false;
106             var w = 0;
107             for (var i = 1; i < length; i++)
108             {
109                 if (_equalityComparer.Equals(currentLevel, levels[i]))
110

```



```

113     {
114         levelRepeat++;
115         skipOnce = false;
116         if (levelRepeat == 2)
117         {
118             sequence[w] = _links.GetOrCreate(sequence[i - 1], sequence[i]);
119             var newLevel = i >= length - 1 ?
120                 GetPreviousLowerThanCurrentOrCurrent(previousLevel,
121                     ↪ currentLevel) :
122                 i < 2 ?
123                 GetNextLowerThanCurrentOrCurrent(currentLevel, levels[i + 1]) :
124                 GetGreatestNeighbourLowerThanCurrentOrCurrent(previousLevel,
125                     ↪ currentLevel, levels[i + 1]);
126             levels[w] = newLevel;
127             previousLevel = currentLevel;
128             w++;
129             levelRepeat = 0;
130             skipOnce = true;
131         }
132         else if (i == length - 1)
133         {
134             sequence[w] = sequence[i];
135             levels[w] = levels[i];
136             w++;
137         }
138     }
139     else
140     {
141         currentLevel = levels[i];
142         levelRepeat = 1;
143         if (skipOnce)
144         {
145             skipOnce = false;
146         }
147         else
148         {
149             sequence[w] = sequence[i - 1];
150             levels[w] = levels[i - 1];
151             previousLevel = levels[w];
152             w++;
153         }
154         if (i == length - 1)
155         {
156             sequence[w] = sequence[i];
157             levels[w] = levels[i];
158             w++;
159         }
160     }
161     length = w;
162     return _links.GetOrCreate(sequence[0], sequence[1]);
163 }
164 [MethodImpl(MethodImplOptions.AggressiveInlining)]
165 private static TLinkAddress GetGreatestNeighbourLowerThanCurrentOrCurrent(TLinkAddress
    ↪ previous, TLinkAddress current, TLinkAddress next)
166 {
167     return _comparer.Compare(previous, next) > 0
168         ? _comparer.Compare(previous, current) < 0 ? previous : current
169         : _comparer.Compare(next, current) < 0 ? next : current;
170 }
171 [MethodImpl(MethodImplOptions.AggressiveInlining)]
172 private static TLinkAddress GetNextLowerThanCurrentOrCurrent(TLinkAddress current,
    ↪ TLinkAddress next) => _comparer.Compare(next, current) < 0 ? next : current;
173 [MethodImpl(MethodImplOptions.AggressiveInlining)]
174 private static TLinkAddress GetPreviousLowerThanCurrentOrCurrent(TLinkAddress previous,
    ↪ TLinkAddress current) => _comparer.Compare(previous, current) < 0 ? previous :
    ↪ current;
175 }
176 }

```

## 1.5 ./csharp/Platform.Data.Doublets.Sequences/Converters/SequenceToltsLocalElementLevelsConverter.cs

```

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

```

```

8 {
9     /// <summary>
10    /// <para>
11    /// Represents the sequence to its local element levels converter.
12    /// </para>
13    /// <para></para>
14    /// </summary>
15    /// <seealso cref="LinksOperatorBase{TLinkAddress}"/>
16    /// <seealso cref="IConverter{IList{TLinkAddress}}"/>
17    public class SequenceToItsLocalElementLevelsConverter<TLinkAddress> :
18    ↪ LinksOperatorBase<TLinkAddress>, IConverter<IList<TLinkAddress>?>
19    {
20        private static readonly Comparer<TLinkAddress> _comparer =
21        ↪ Comparer<TLinkAddress>.Default;
22        private readonly IConverter<Doublet<TLinkAddress>, TLinkAddress>
23        ↪ _linkToItsFrequencyToNumberConveter;
24
25        /// <summary>
26        /// <para>
27        /// Initializes a new <see cref="SequenceToItsLocalElementLevelsConverter"/> instance.
28        /// </para>
29        /// <para></para>
30        /// </summary>
31        /// <param name="links">
32        /// <para>A links.</para>
33        /// <para></para>
34        /// </param>
35        /// <param name="linkToItsFrequencyToNumberConveter">
36        /// <para>A link to its frequency to number conveter.</para>
37        /// <para></para>
38        /// </param>
39        [MethodImpl(MethodImplOptions.AggressiveInlining)]
40        public SequenceToItsLocalElementLevelsConverter(ILinks<TLinkAddress> links,
41        ↪ IConverter<Doublet<TLinkAddress>, TLinkAddress> linkToItsFrequencyToNumberConveter)
42        ↪ : base(links) => _linkToItsFrequencyToNumberConveter =
43        ↪ linkToItsFrequencyToNumberConveter;
44
45        /// <summary>
46        /// <para>
47        /// Converts the sequence.
48        /// </para>
49        /// <para></para>
50        /// </summary>
51        /// <param name="sequence">
52        /// <para>The sequence.</para>
53        /// <para></para>
54        /// </param>
55        /// <returns>
56        /// <para>The levels.</para>
57        /// <para></para>
58        /// </returns>
59        [MethodImpl(MethodImplOptions.AggressiveInlining)]
60        public IList<TLinkAddress>? Convert(IList<TLinkAddress>? sequence)
61        {
62            var levels = new TLinkAddress[sequence.Count];
63            levels[0] = GetFrequencyNumber(sequence[0], sequence[1]);
64            for (var i = 1; i < sequence.Count - 1; i++)
65            {
66                var previous = GetFrequencyNumber(sequence[i - 1], sequence[i]);
67                var next = GetFrequencyNumber(sequence[i], sequence[i + 1]);
68                levels[i] = _comparer.Compare(previous, next) > 0 ? previous : next;
69            }
70            levels[levels.Length - 1] = GetFrequencyNumber(sequence[sequence.Count - 2],
71            ↪ sequence[sequence.Count - 1]);
72            return levels;
73        }
74
75        /// <summary>
76        /// <para>
77        /// Gets the frequency number using the specified source.
78        /// </para>
79        /// <para></para>
80        /// </summary>
81        /// <param name="source">
82        /// <para>The source.</para>
83        /// <para></para>
84        /// </param>
85        /// <param name="target">

```

```

79     /// <para>The target.</para>
80     /// <para></para>
81     /// </param>
82     /// <returns>
83     /// <para>The link</para>
84     /// <para></para>
85     /// </returns>
86     [MethodImpl(MethodImplOptions.AggressiveInlining)]
87     public TLinkAddress GetFrequencyNumber(TLinkAddress source, TLinkAddress target) =>
88         ↪ _linkToItsFrequencyToNumberConveter.Convert(new Doublet<TLinkAddress>(source,
89         ↪ target));
88 }
89 }

```

## 1.6 ./csharp/Platform.Data.Doublets.Sequences/CriterionMatchers/DefaultSequenceElementCriterionMatcher.cs

```

1  using System.Runtime.CompilerServices;
2  using Platform.Interfaces;
3
4  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
5
6  namespace Platform.Data.Doublets.Sequences.CriterionMatchers
7  {
8      /// <summary>
9      /// <para>
10     /// Represents the default sequence element criterion matcher.
11     /// </para>
12     /// <para></para>
13     /// </summary>
14     /// <seealso cref="LinksOperatorBase{TLinkAddress}"/>
15     /// <seealso cref="ICriterionMatcher{TLinkAddress}"/>
16     public class DefaultSequenceElementCriterionMatcher<TLinkAddress> :
17         ↪ LinksOperatorBase<TLinkAddress>, ICriterionMatcher<TLinkAddress>
18     {
19         /// <summary>
20         /// <para>
21         /// Initializes a new <see cref="DefaultSequenceElementCriterionMatcher"/> instance.
22         /// </para>
23         /// <para></para>
24         /// </summary>
25         /// <param name="links">
26         /// <para>A links.</para>
27         /// <para></para>
28         /// </param>
29         [MethodImpl(MethodImplOptions.AggressiveInlining)]
30         public DefaultSequenceElementCriterionMatcher(ILinks<TLinkAddress> links) : base(links)
31             ↪ { }
32
33         /// <summary>
34         /// <para>
35         /// Determines whether this instance is matched.
36         /// </para>
37         /// <para></para>
38         /// </summary>
39         /// <param name="argument">
40         /// <para>The argument.</para>
41         /// <para></para>
42         /// </param>
43         /// <returns>
44         /// <para>The bool</para>
45         /// <para></para>
46         /// </returns>
47         [MethodImpl(MethodImplOptions.AggressiveInlining)]
48         public bool IsMatched(TLinkAddress argument) => _links.IsPartialPoint(argument);
49     }
50 }

```

## 1.7 ./csharp/Platform.Data.Doublets.Sequences/CriterionMatchers/MarkedSequenceCriterionMatcher.cs

```

1  using System.Collections.Generic;
2  using System.Runtime.CompilerServices;
3  using Platform.Interfaces;
4
5  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
6
7  namespace Platform.Data.Doublets.Sequences.CriterionMatchers
8  {
9      /// <summary>
10     /// <para>
11     /// Represents the marked sequence criterion matcher.

```

```

12  /// </para>
13  /// <para></para>
14  /// </summary>
15  /// <seealso cref="ICriterionMatcher{TLinkAddress}"/>
16  public class MarkedSequenceCriterionMatcher<TLinkAddress> : ICriterionMatcher<TLinkAddress>
17  {
18      private static readonly EqualityComparer<TLinkAddress> _equalityComparer =
19          ↪ EqualityComparer<TLinkAddress>.Default;
19      private readonly ILinks<TLinkAddress> _links;
20      private readonly TLinkAddress _sequenceMarkerLink;
21
22      /// <summary>
23      /// <para>
24      /// Initializes a new <see cref="MarkedSequenceCriterionMatcher"/> instance.
25      /// </para>
26      /// <para></para>
27      /// </summary>
28      /// <param name="links">
29      /// <para>A links.</para>
30      /// <para></para>
31      /// </param>
32      /// <param name="sequenceMarkerLink">
33      /// <para>A sequence marker link.</para>
34      /// <para></para>
35      /// </param>
36      [MethodImpl(MethodImplOptions.AggressiveInlining)]
37      public MarkedSequenceCriterionMatcher(ILinks<TLinkAddress> links, TLinkAddress
38          ↪ sequenceMarkerLink)
39      {
40          _links = links;
41          _sequenceMarkerLink = sequenceMarkerLink;
42      }
43
44      /// <summary>
45      /// <para>
46      /// Determines whether this instance is matched.
47      /// </para>
48      /// <para></para>
49      /// </summary>
50      /// <param name="sequenceCandidate">
51      /// <para>The sequence candidate.</para>
52      /// <para></para>
53      /// </param>
54      /// <returns>
55      /// <para>The bool</para>
56      /// <para></para>
57      /// </returns>
58      [MethodImpl(MethodImplOptions.AggressiveInlining)]
59      public bool IsMatched(TLinkAddress sequenceCandidate)
60      => _equalityComparer.Equals(_links.GetSource(sequenceCandidate), _sequenceMarkerLink)
61      || !_equalityComparer.Equals(_links.SearchOrDefault(_sequenceMarkerLink,
62          ↪ sequenceCandidate), _links.Constants.Null);
63  }
64  }

```

## 1.8 ./csharp/Platform.Data.Doublets.Sequences/DefaultSequenceAppender.cs

```

1  using System.Collections.Generic;
2  using System.Runtime.CompilerServices;
3  using Platform.Collections.Stacks;
4  using Platform.Data.Doublets.Sequences.HeightProviders;
5  using Platform.Data.Sequences;
6
7  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
8
9  namespace Platform.Data.Doublets.Sequences
10 {
11     /// <summary>
12     /// <para>
13     /// Represents the default sequence appender.
14     /// </para>
15     /// <para></para>
16     /// </summary>
17     /// <seealso cref="LinksOperatorBase{TLinkAddress}"/>
18     /// <seealso cref="ISequenceAppender{TLinkAddress}"/>
19     public class DefaultSequenceAppender<TLinkAddress> : LinksOperatorBase<TLinkAddress>,
20         ↪ ISequenceAppender<TLinkAddress>
21     {
22         private static readonly EqualityComparer<TLinkAddress> _equalityComparer =
23             ↪ EqualityComparer<TLinkAddress>.Default;

```

```

22 private readonly IStack<TLinkAddress> _stack;
23 private readonly ISequenceHeightProvider<TLinkAddress> _heightProvider;
24
25 /// <summary>
26 /// <para>
27 /// Initializes a new <see cref="DefaultSequenceAppender"/> instance.
28 /// </para>
29 /// <para></para>
30 /// </summary>
31 /// <param name="links">
32 /// <para>A links.</para>
33 /// <para></para>
34 /// </param>
35 /// <param name="stack">
36 /// <para>A stack.</para>
37 /// <para></para>
38 /// </param>
39 /// <param name="heightProvider">
40 /// <para>A height provider.</para>
41 /// <para></para>
42 /// </param>
43 [MethodImpl(MethodImplOptions.AggressiveInlining)]
44 public DefaultSequenceAppender(ILinks<TLinkAddress> links, IStack<TLinkAddress> stack,
45     ↪ ISequenceHeightProvider<TLinkAddress> heightProvider)
46     : base(links)
47 {
48     _stack = stack;
49     _heightProvider = heightProvider;
50 }
51
52 /// <summary>
53 /// <para>
54 /// Appends the sequence.
55 /// </para>
56 /// <para></para>
57 /// </summary>
58 /// <param name="sequence">
59 /// <para>The sequence.</para>
60 /// <para></para>
61 /// </param>
62 /// <param name="appendant">
63 /// <para>The appendant.</para>
64 /// <para></para>
65 /// </param>
66 /// <returns>
67 /// <para>The link</para>
68 /// <para></para>
69 /// </returns>
70 [MethodImpl(MethodImplOptions.AggressiveInlining)]
71 public TLinkAddress Append(TLinkAddress sequence, TLinkAddress appendant)
72 {
73     var cursor = sequence;
74     var links = _links;
75     while (!_equalityComparer.Equals(_heightProvider.Get(cursor), default))
76     {
77         var source = links.GetSource(cursor);
78         var target = links.GetTarget(cursor);
79         if (_equalityComparer.Equals(_heightProvider.Get(source),
80             ↪ _heightProvider.Get(target)))
81         {
82             break;
83         }
84         else
85         {
86             _stack.Push(source);
87             cursor = target;
88         }
89     }
90     var left = cursor;
91     var right = appendant;
92     while (!_equalityComparer.Equals(cursor = _stack.PopOrDefault(),
93         ↪ links.Constants.Null))
94     {
95         right = links.GetOrCreate(left, right);
96         left = cursor;
97     }
98     return links.GetOrCreate(left, right);
99 }

```

```

97     }
98 }

```

### 1.9 ./csharp/Platform.Data.Doublets.Sequences/DuplicateSegmentsCounter.cs

```

1  using System.Collections.Generic;
2  using System.Linq;
3  using System.Runtime.CompilerServices;
4  using Platform.Interfaces;
5
6  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
7
8  namespace Platform.Data.Doublets.Sequences
9  {
10     /// <summary>
11     /// <para>
12     /// Represents the duplicate segments counter.
13     /// </para>
14     /// <para></para>
15     /// </summary>
16     /// <seealso cref="ICounter{int}"/>
17     public class DuplicateSegmentsCounter<TLinkAddress> : ICounter<int>
18     {
19         private readonly IProvider<IList<KeyValuePair<IList<TLinkAddress>?>?,
20             ↳ IList<TLinkAddress>?>>> _duplicateFragmentsProvider;
21
22         /// <summary>
23         /// <para>
24         /// Initializes a new <see cref="DuplicateSegmentsCounter"/> instance.
25         /// </para>
26         /// <para></para>
27         /// </summary>
28         /// <param name="duplicateFragmentsProvider">
29         /// <para>A duplicate fragments provider.</para>
30         /// <para></para>
31         /// </param>
32         [MethodImpl(MethodImplOptions.AggressiveInlining)]
33         public DuplicateSegmentsCounter(IProvider<IList<KeyValuePair<IList<TLinkAddress>?>?,
34             ↳ IList<TLinkAddress>?>>> duplicateFragmentsProvider) => _duplicateFragmentsProvider =
35             ↳ duplicateFragmentsProvider;
36
37         /// <summary>
38         /// <para>
39         /// Counts this instance.
40         /// </para>
41         /// <para></para>
42         /// </summary>
43         /// <returns>
44         /// <para>The int</para>
45         /// <para></para>
46         /// </returns>
47         [MethodImpl(MethodImplOptions.AggressiveInlining)]
48         public int Count() => _duplicateFragmentsProvider.Get().Sum(x => x.Value.Count);
49     }
50 }

```

### 1.10 ./csharp/Platform.Data.Doublets.Sequences/DuplicateSegmentsProvider.cs

```

1  using System;
2  using System.Linq;
3  using System.Collections.Generic;
4  using System.Runtime.CompilerServices;
5  using Platform.Interfaces;
6  using Platform.Collections;
7  using Platform.Collections.Lists;
8  using Platform.Collections.Segments;
9  using Platform.Collections.Segments.Walkers;
10 using Platform.Singletons;
11 using Platform.Converters;
12 using Platform.Data.Doublets.Unicode;
13
14 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
15
16 namespace Platform.Data.Doublets.Sequences
17 {
18     /// <summary>
19     /// <para>
20     /// Represents the duplicate segments provider.
21     /// </para>
22     /// <para></para>
23     /// </summary>
24     /// <seealso cref="DictionaryBasedDuplicateSegmentsWalkerBase{TLinkAddress}"/>

```

```

25  /// <seealso cref="IProvider{IList{KeyValuePair{IList{TLinkAddress}},
    ↳ IList{TLinkAddress}}}" />
26 public class DuplicateSegmentsProvider<TLinkAddress> :
    ↳ DictionaryBasedDuplicateSegmentsWalkerBase<TLinkAddress>,
    ↳ IProvider<IList<KeyValuePair<IList<TLinkAddress>?, IList<TLinkAddress>?>>>
27 {
28     private static readonly UncheckedConverter<TLinkAddress, long> _addressToInt64Converter
    ↳ = UncheckedConverter<TLinkAddress, long>.Default;
29     private static readonly UncheckedConverter<TLinkAddress, ulong>
    ↳ _addressToUInt64Converter = UncheckedConverter<TLinkAddress, ulong>.Default;
30     private static readonly UncheckedConverter<ulong, TLinkAddress>
    ↳ _uInt64ToAddressConverter = UncheckedConverter<ulong, TLinkAddress>.Default;
31     private readonly IList<TLinkAddress> _links;
32     private readonly IList<TLinkAddress> _sequences;
33     private HashSet<KeyValuePair<IList<TLinkAddress>?, IList<TLinkAddress>?>> _groups;
34     private BitString _visited;
35     private class ItemEquilityComparer :
    ↳ IEqualityComparer<KeyValuePair<IList<TLinkAddress>?, IList<TLinkAddress>?>>
36     {
37         private readonly IListEqualityComparer<TLinkAddress> _listComparer;
38
39         /// <summary>
40         /// <para>
41         /// Initializes a new <see cref="ItemEquilityComparer" /> instance.
42         /// </para>
43         /// <para></para>
44         /// </summary>
45         public ItemEquilityComparer() => _listComparer =
    ↳ Default<IListEqualityComparer<TLinkAddress>>.Instance;
46
47         /// <summary>
48         /// <para>
49         /// Determines whether this instance equals.
50         /// </para>
51         /// <para></para>
52         /// </summary>
53         /// <param name="left">
54         /// <para>The left.</para>
55         /// <para></para>
56         /// </param>
57         /// <param name="right">
58         /// <para>The right.</para>
59         /// <para></para>
60         /// </param>
61         /// <returns>
62         /// <para>The bool</para>
63         /// <para></para>
64         /// </returns>
65         [MethodImpl(MethodImplOptions.AggressiveInlining)]
66         public bool Equals(KeyValuePair<IList<TLinkAddress>?, IList<TLinkAddress>?> left,
    ↳ KeyValuePair<IList<TLinkAddress>?, IList<TLinkAddress>?> right) =>
    ↳ _listComparer.Equals(left.Key, right.Key) && _listComparer.Equals(left.Value,
    ↳ right.Value);
67
68         /// <summary>
69         /// <para>
70         /// Gets the hash code using the specified pair.
71         /// </para>
72         /// <para></para>
73         /// </summary>
74         /// <param name="pair">
75         /// <para>The pair.</para>
76         /// <para></para>
77         /// </param>
78         /// <returns>
79         /// <para>The int</para>
80         /// <para></para>
81         /// </returns>
82         [MethodImpl(MethodImplOptions.AggressiveInlining)]
83         public int GetHashCode(KeyValuePair<IList<TLinkAddress>?, IList<TLinkAddress>?>
    ↳ pair) => (_listComparer.GetHashCode(pair.Key),
    ↳ _listComparer.GetHashCode(pair.Value)).GetHashCode();
84     }
85     private class ItemComparer : IComparer<KeyValuePair<IList<TLinkAddress>?,
    ↳ IList<TLinkAddress>?>>
86     {
87         private readonly IListComparer<TLinkAddress> _listComparer;
88
89         /// <summary>

```

```

90     /// <para>
91     /// Initializes a new <see cref="ItemComparer"/> instance.
92     /// </para>
93     /// <para></para>
94     /// </summary>
95     [MethodImpl(MethodImplOptions.AggressiveInlining)]
96     public ItemComparer() => _listComparer =
97         ↪ Default<IListComparer<TLinkAddress>>.Instance;
98
99     /// <summary>
100    /// <para>
101    /// Compares the left.
102    /// </para>
103    /// <para></para>
104    /// </summary>
105    /// <param name="left">
106    /// <para>The left.</para>
107    /// </param>
108    /// <param name="right">
109    /// <para>The right.</para>
110    /// </param>
111    /// </returns>
112    /// <para>The intermediate result.</para>
113    /// <para></para>
114    /// </returns>
115    [MethodImpl(MethodImplOptions.AggressiveInlining)]
116    public int Compare(KeyValuePair<IList<TLinkAddress>?, IList<TLinkAddress>?> left,
117        ↪ KeyValuePair<IList<TLinkAddress>?, IList<TLinkAddress>?> right)
118    {
119        var intermediateResult = _listComparer.Compare(left.Key, right.Key);
120        if (intermediateResult == 0)
121        {
122            intermediateResult = _listComparer.Compare(left.Value, right.Value);
123        }
124        return intermediateResult;
125    }
126 }
127
128 /// <summary>
129 /// <para>
130 /// Initializes a new <see cref="DuplicateSegmentsProvider"/> instance.
131 /// </para>
132 /// <para></para>
133 /// </summary>
134 /// <param name="links">
135 /// <para>A links.</para>
136 /// </param>
137 /// <param name="sequences">
138 /// <para>A sequences.</para>
139 /// </param>
140 /// </param>
141 [MethodImpl(MethodImplOptions.AggressiveInlining)]
142 public DuplicateSegmentsProvider(ILinks<TLinkAddress> links, ILinks<TLinkAddress>
143     ↪ sequences)
144     : base(minimumStringLength: 2)
145 {
146     _links = links;
147     _sequences = sequences;
148 }
149
150 /// <summary>
151 /// <para>
152 /// Gets this instance.
153 /// </para>
154 /// <para></para>
155 /// </summary>
156 /// <returns>
157 /// <para>The result list.</para>
158 /// <para></para>
159 /// </returns>
160 [MethodImpl(MethodImplOptions.AggressiveInlining)]
161 public IList<KeyValuePair<IList<TLinkAddress>?, IList<TLinkAddress>?>> Get()
162 {
163     _groups = new HashSet<KeyValuePair<IList<TLinkAddress>?,
164         ↪ IList<TLinkAddress>?>>(Default<ItemEquilityComparer>.Instance);

```



```

164     var links = _links;
165     var count = links.Count();
166     _visited = new BitString(_addressToInt64Converter.Convert(count) + 1L);
167     links.Each(link =>
168     {
169         var linkIndex = links.GetIndex(link);
170         var linkBitIndex = _addressToInt64Converter.Convert(linkIndex);
171         var constants = links.Constants;
172         if (!_visited.Get(linkBitIndex))
173         {
174             var sequenceElements = new List<TLinkAddress>();
175             var filler = new ListFiller<TLinkAddress, TLinkAddress>(sequenceElements,
176                 ↪ constants.Break);
177             _sequences.Each(filler.AddSkipFirstAndReturnConstant, new
178                 ↪ LinkAddress<TLinkAddress>(linkIndex));
179             if (sequenceElements.Count > 2)
180             {
181                 WalkAll(sequenceElements);
182             }
183         }
184         return constants.Continue;
185     });
186     var resultList = _groups.ToList();
187     var comparer = Default<ItemComparer>.Instance;
188     resultList.Sort(comparer);
189     #if DEBUG
190     foreach (var item in resultList)
191     {
192         PrintDuplicates(item);
193     }
194     #endif
195     return resultList;
196 }
197
198 /// <summary>
199 /// <para>
200 /// Creates the segment using the specified elements.
201 /// </para>
202 /// <para></para>
203 /// </summary>
204 /// <param name="elements">
205 /// <para>The elements.</para>
206 /// <para></para>
207 /// </param>
208 /// <param name="offset">
209 /// <para>The offset.</para>
210 /// <para></para>
211 /// </param>
212 /// <param name="length">
213 /// <para>The length.</para>
214 /// <para></para>
215 /// </param>
216 /// <returns>
217 /// <para>A segment of t link</para>
218 /// <para></para>
219 /// </returns>
220 [MethodImpl(MethodImplOptions.AggressiveInlining)]
221 protected override Segment<TLinkAddress> CreateSegment(ICollection<TLinkAddress>? elements,
222     ↪ int offset, int length) => new Segment<TLinkAddress>(elements, offset, length);
223
224 /// <summary>
225 /// <para>
226 /// On the duplicate found using the specified segment.
227 /// </para>
228 /// <para></para>
229 /// </summary>
230 /// <param name="segment">
231 /// <para>The segment.</para>
232 /// <para></para>
233 /// </param>
234 [MethodImpl(MethodImplOptions.AggressiveInlining)]
235 protected override void OnDuplicateFound(Segment<TLinkAddress> segment)
236 {
237     var duplicates = CollectDuplicatesForSegment(segment);
238     if (duplicates.Count > 1)
239     {
240         _groups.Add(new KeyValuePair<ICollection<TLinkAddress>?,
241             ↪ ICollection<TLinkAddress>?>(segment.ToArray(), duplicates));
242     }
243 }

```

```

238     }
239 }
240 [MethodImpl(MethodImplOptions.AggressiveInlining)]
241 private List<TLinkAddress> CollectDuplicatesForSegment(Segment<TLinkAddress> segment)
242 {
243     var duplicates = new List<TLinkAddress>();
244     var readAsElement = new HashSet<TLinkAddress>();
245     var restrictions = segment.ShiftRight();
246     var constants = _links.Constants;
247     restrictions[0] = constants.Any;
248     _sequences.Each(sequence =>
249     {
250         var sequenceIndex = sequence[constants.IndexPart];
251         duplicates.Add(sequenceIndex);
252         readAsElement.Add(sequenceIndex);
253         return constants.Continue;
254     }, restrictions);
255     if (duplicates.Any(x => _visited.Get(_addressToInt64Converter.Convert(x))))
256     {
257         return new List<TLinkAddress>();
258     }
259     foreach (var duplicate in duplicates)
260     {
261         var duplicateBitIndex = _addressToInt64Converter.Convert(duplicate);
262         _visited.Set(duplicateBitIndex);
263     }
264     if (_sequences is Sequences sequencesExperiments)
265     {
266         var partiallyMatched = sequencesExperiments.GetAllPartiallyMatchingSequences4((H
267             ↪ ashSet<ulong>)(object)readAsElement,
268             ↪ (IList<ulong>)segment);
269         foreach (var partiallyMatchedSequence in partiallyMatched)
270         {
271             var sequenceIndex =
272                 ↪ _uInt64ToAddressConverter.Convert(partiallyMatchedSequence);
273             duplicates.Add(sequenceIndex);
274         }
275     }
276     duplicates.Sort();
277     return duplicates;
278 }
279 [MethodImpl(MethodImplOptions.AggressiveInlining)]
280 private void PrintDuplicates(KeyValuePair<IList<TLinkAddress>?, IList<TLinkAddress>?>
281     ↪ duplicatesItem)
282 {
283     if (!(_links is ILinks<ulong> ulongLinks))
284     {
285         return;
286     }
287     var duplicatesKey = duplicatesItem.Key;
288     var keyString = UnicodeMap.FromLinksToString((IList<ulong>)duplicatesKey);
289     Console.WriteLine($"> {keyString} ({string.Join(", ", duplicatesKey)})");
290     var duplicatesList = duplicatesItem.Value;
291     for (int i = 0; i < duplicatesList.Count; i++)
292     {
293         var sequenceIndex = _addressToUInt64Converter.Convert(duplicatesList[i]);
294         var formattedSequenceStructure = ulongLinks.FormatStructure(sequenceIndex, x =>
295             ↪ Point<ulong>.IsPartialPoint(x), (sb, link) => _ =
296             ↪ UnicodeMap.IsCharLink(link.Index) ?
297             ↪ sb.Append(UnicodeMap.FromLinkToChar(link.Index)) : sb.Append(link.Index));
298         Console.WriteLine(formattedSequenceStructure);
299         var sequenceString = UnicodeMap.FromSequenceLinkToString(sequenceIndex,
300             ↪ ulongLinks);
301         Console.WriteLine(sequenceString);
302     }
303     Console.WriteLine();
304 }
305 }
306 }
307 }
308 }

```

## 1.11 ./csharp/Platform.Data.Doublets.Sequences/Frequencies/Cache/LinkFrequenciesCache.cs

```

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

```

```

8
9 namespace Platform.Data.Doublets.Sequences.Frequencies.Cache
10 {
11     /// <remarks>
12     /// Can be used to operate with many CompressingConverters (to keep global frequencies data
13     /// ↪ between them).
14     /// TODO: Extract interface to implement frequencies storage inside Links storage
15     /// </remarks>
16     public class LinkFrequenciesCache<TLinkAddress> : LinksOperatorBase<TLinkAddress>
17     {
18         private static readonly EqualityComparer<TLinkAddress> _equalityComparer =
19             ↪ EqualityComparer<TLinkAddress>.Default;
20         private static readonly Comparer<TLinkAddress> _comparer =
21             ↪ Comparer<TLinkAddress>.Default;
22         private static readonly TLinkAddress _zero = default;
23         private static readonly TLinkAddress _one = Arithmetic.Increment(_zero);
24         private readonly Dictionary<Doublet<TLinkAddress>, LinkFrequency<TLinkAddress>>
25             ↪ _doubletsCache;
26         private readonly ICounter<TLinkAddress, TLinkAddress> _frequencyCounter;
27
28         /// <summary>
29         /// <para>
30         /// Initializes a new <see cref="LinkFrequenciesCache"/> instance.
31         /// </para>
32         /// <para></para>
33         /// </summary>
34         /// <param name="links">
35         /// <para>A links.</para>
36         /// <para></para>
37         /// </param>
38         /// <param name="frequencyCounter">
39         /// <para>A frequency counter.</para>
40         /// <para></para>
41         /// </param>
42         [MethodImpl(MethodImplOptions.AggressiveInlining)]
43         public LinkFrequenciesCache(ILinks<TLinkAddress> links, ICounter<TLinkAddress,
44             ↪ TLinkAddress> frequencyCounter)
45             : base(links)
46         {
47             _doubletsCache = new Dictionary<Doublet<TLinkAddress>,
48                 ↪ LinkFrequency<TLinkAddress>>(4096, DoubletComparer<TLinkAddress>.Default);
49             _frequencyCounter = frequencyCounter;
50         }
51
52         /// <summary>
53         /// <para>
54         /// Gets the frequency using the specified source.
55         /// </para>
56         /// <para></para>
57         /// </summary>
58         /// <param name="source">
59         /// <para>The source.</para>
60         /// <para></para>
61         /// </param>
62         /// <param name="target">
63         /// <para>The target.</para>
64         /// <para></para>
65         /// </param>
66         /// <returns>
67         /// <para>A link frequency of t link</para>
68         /// <para></para>
69         /// </returns>
70         [MethodImpl(MethodImplOptions.AggressiveInlining)]
71         public LinkFrequency<TLinkAddress> GetFrequency(TLinkAddress source, TLinkAddress target)
72         {
73             var doublet = new Doublet<TLinkAddress>(source, target);
74             return GetFrequency(ref doublet);
75         }
76
77         /// <summary>
78         /// <para>
79         /// Gets the frequency using the specified doublet.
80         /// </para>
81         /// <para></para>
82         /// </summary>
83         /// <param name="doublet">
84         /// <para>The doublet.</para>
85         /// <para></para>
86         /// </param>

```

```

80    /// </param>
81    /// <returns>
82    /// <para>The data.</para>
83    /// <para></para>
84    /// </returns>
85    [MethodImpl(MethodImplOptions.AggressiveInlining)]
86    public LinkFrequency<TLinkAddress> GetFrequency(ref Doublet<TLinkAddress> doublet)
87    {
88        _doubletsCache.TryGetValue(doublet, out LinkFrequency<TLinkAddress> data);
89        return data;
90    }
91
92    /// <summary>
93    /// <para>
94    /// Increments the frequencies using the specified sequence.
95    /// </para>
96    /// <para></para>
97    /// </summary>
98    /// <param name="sequence">
99    /// <para>The sequence.</para>
100    /// <para></para>
101    /// </param>
102    [MethodImpl(MethodImplOptions.AggressiveInlining)]
103    public void IncrementFrequencies(ICollection<TLinkAddress>? sequence)
104    {
105        for (var i = 1; i < sequence.Count; i++)
106        {
107            IncrementFrequency(sequence[i - 1], sequence[i]);
108        }
109    }
110
111    /// <summary>
112    /// <para>
113    /// Increments the frequency using the specified source.
114    /// </para>
115    /// <para></para>
116    /// </summary>
117    /// <param name="source">
118    /// <para>The source.</para>
119    /// <para></para>
120    /// </param>
121    /// <param name="target">
122    /// <para>The target.</para>
123    /// <para></para>
124    /// </param>
125    /// <returns>
126    /// <para>A link frequency of t link</para>
127    /// <para></para>
128    /// </returns>
129    [MethodImpl(MethodImplOptions.AggressiveInlining)]
130    public LinkFrequency<TLinkAddress> IncrementFrequency(TLinkAddress source, TLinkAddress
131    ↪ target)
132    {
133        var doublet = new Doublet<TLinkAddress>(source, target);
134        return IncrementFrequency(ref doublet);
135    }
136
137    /// <summary>
138    /// <para>
139    /// Prints the frequencies using the specified sequence.
140    /// </para>
141    /// <para></para>
142    /// </summary>
143    /// <param name="sequence">
144    /// <para>The sequence.</para>
145    /// <para></para>
146    /// </param>
147    [MethodImpl(MethodImplOptions.AggressiveInlining)]
148    public void PrintFrequencies(ICollection<TLinkAddress>? sequence)
149    {
150        for (var i = 1; i < sequence.Count; i++)
151        {
152            PrintFrequency(sequence[i - 1], sequence[i]);
153        }
154    }
155
156    /// <summary>
157    /// <para>

```

```

157     /// Prints the frequency using the specified source.
158     /// </para>
159     /// <para></para>
160     /// </summary>
161     /// <param name="source">
162     /// <para>The source.</para>
163     /// <para></para>
164     /// </param>
165     /// <param name="target">
166     /// <para>The target.</para>
167     /// <para></para>
168     /// </param>
169     [MethodImpl(MethodImplOptions.AggressiveInlining)]
170     public void PrintFrequency(TLinkAddress source, TLinkAddress target)
171     {
172         var number = GetFrequency(source, target).Frequency;
173         Console.WriteLine("{0},{1} - {2}", source, target, number);
174     }
175
176     /// <summary>
177     /// <para>
178     /// Increments the frequency using the specified doublet.
179     /// </para>
180     /// <para></para>
181     /// </summary>
182     /// <param name="doublet">
183     /// <para>The doublet.</para>
184     /// <para></para>
185     /// </param>
186     /// <returns>
187     /// <para>The data.</para>
188     /// <para></para>
189     /// </returns>
190     [MethodImpl(MethodImplOptions.AggressiveInlining)]
191     public LinkFrequency<TLinkAddress> IncrementFrequency(ref Doublet<TLinkAddress> doublet)
192     {
193         if (_doubletsCache.TryGetValue(doublet, out LinkFrequency<TLinkAddress> data))
194         {
195             data.IncrementFrequency();
196         }
197         else
198         {
199             var link = _links.SearchOrDefault(doublet.Source, doublet.Target);
200             data = new LinkFrequency<TLinkAddress>(_one, link);
201             if (!_equalityComparer.Equals(link, default))
202             {
203                 data.Frequency = Arithmetic.Add(data.Frequency,
204                     ↪ _frequencyCounter.Count(link));
205             }
206             _doubletsCache.Add(doublet, data);
207         }
208         return data;
209     }
210
211     /// <summary>
212     /// <para>
213     /// Validates the frequencies.
214     /// </para>
215     /// <para></para>
216     /// </summary>
217     /// <exception cref="InvalidOperationException">
218     /// <para>Frequencies validation failed.</para>
219     /// <para></para>
220     /// </exception>
221     [MethodImpl(MethodImplOptions.AggressiveInlining)]
222     public void ValidateFrequencies()
223     {
224         foreach (var entry in _doubletsCache)
225         {
226             var value = entry.Value;
227             var linkIndex = value.Link;
228             if (!_equalityComparer.Equals(linkIndex, default))
229             {
230                 var frequency = value.Frequency;
231                 var count = _frequencyCounter.Count(linkIndex);
232                 // TODO: Why `frequency` always greater than `count` by 1?
233                 if (((_comparer.Compare(frequency, count) > 0) &&
234                     ↪ (_comparer.Compare(Arithmetic.Subtract(frequency, count), _one) > 0))

```

```

233         || (_comparer.Compare(count, frequency) > 0) &&
234         ⇨ (_comparer.Compare(Arithmetic.Subtract(count, frequency), _one) > 0)))
235     {
236         throw new InvalidOperationException("Frequencies validation failed.");
237     }
238     //else
239     //{
240     //    if (value.Frequency > 0)
241     //    {
242     //        var frequency = value.Frequency;
243     //        linkIndex = _createLink(entry.Key.Source, entry.Key.Target);
244     //        var count = _countLinkFrequency(linkIndex);
245     //
246     //        if ((frequency > count && frequency - count > 1) || (count > frequency
247     //        ⇨ && count - frequency > 1))
248     //        {
249     //            throw new InvalidOperationException("Frequencies validation
250     //            ⇨ failed.");
251     //        }
252     //    }
253 }

```

## 1.12 ./csharp/Platform.Data.Doublets.Sequences/Frequencies/Cache/LinkFrequency.cs

```

1  using System.Runtime.CompilerServices;
2  using Platform.Numbers;
3
4  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
5
6  namespace Platform.Data.Doublets.Sequences.Frequencies.Cache
7  {
8      /// <summary>
9      /// <para>
10     /// Represents the link frequency.
11     /// </para>
12     /// <para></para>
13     /// </summary>
14     public class LinkFrequency<TLinkAddress>
15     {
16         /// <summary>
17         /// <para>
18         /// Gets or sets the frequency value.
19         /// </para>
20         /// <para></para>
21         /// </summary>
22         public TLinkAddress Frequency { get; set; }
23         /// <summary>
24         /// <para>
25         /// Gets or sets the link value.
26         /// </para>
27         /// <para></para>
28         /// </summary>
29         public TLinkAddress Link { get; set; }
30
31         /// <summary>
32         /// <para>
33         /// Initializes a new <see cref="LinkFrequency"/> instance.
34         /// </para>
35         /// <para></para>
36         /// </summary>
37         /// <param name="frequency">
38         /// <para>A frequency.</para>
39         /// <para></para>
40         /// </param>
41         /// <param name="link">
42         /// <para>A link.</para>
43         /// <para></para>
44         /// </param>
45         [MethodImpl(MethodImplOptions.AggressiveInlining)]
46         public LinkFrequency(TLinkAddress frequency, TLinkAddress link)
47         {
48             Frequency = frequency;
49             Link = link;
50         }
51
52         /// <summary>

```

```

53     /// <para>
54     /// Initializes a new <see cref="LinkFrequency"/> instance.
55     /// </para>
56     /// <para></para>
57     /// </summary>
58     [MethodImpl(MethodImplOptions.AggressiveInlining)]
59     public LinkFrequency() { }
60
61     /// <summary>
62     /// <para>
63     /// Increments the frequency.
64     /// </para>
65     /// <para></para>
66     /// </summary>
67     [MethodImpl(MethodImplOptions.AggressiveInlining)]
68     public void IncrementFrequency() => Frequency =
        ↪ Arithmetic<TLinkAddress>.Increment(Frequency);
69
70     /// <summary>
71     /// <para>
72     /// Decrements the frequency.
73     /// </para>
74     /// <para></para>
75     /// </summary>
76     [MethodImpl(MethodImplOptions.AggressiveInlining)]
77     public void DecrementFrequency() => Frequency =
        ↪ Arithmetic<TLinkAddress>.Decrement(Frequency);
78
79     /// <summary>
80     /// <para>
81     /// Returns the string.
82     /// </para>
83     /// <para></para>
84     /// </summary>
85     /// <returns>
86     /// <para>The string</para>
87     /// <para></para>
88     /// </returns>
89     [MethodImpl(MethodImplOptions.AggressiveInlining)]
90     public override string ToString() => $"F: {Frequency}, L: {Link}";
91 }
92 }

```

### 1.13 ./csharp/Platform.Data.Doublets.Sequences/Frequencies/Cache/LinkToItsFrequencyValueConverter.cs

```

1  using System.Runtime.CompilerServices;
2  using Platform.Converters;
3
4  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
5
6  namespace Platform.Data.Doublets.Sequences.Frequencies.Cache
7  {
8      /// <summary>
9      /// <para>
10     /// Represents the frequencies cache based link to its frequency number converter.
11     /// </para>
12     /// <para></para>
13     /// </summary>
14     /// <seealso cref="IConverter{Doublet{TLinkAddress}, TLinkAddress}"/>
15     public class FrequenciesCacheBasedLinkToItsFrequencyNumberConverter<TLinkAddress> :
        ↪ IConverter<Doublet<TLinkAddress>, TLinkAddress>
16     {
17         private readonly LinkFrequenciesCache<TLinkAddress> _cache;
18
19         /// <summary>
20         /// <para>
21         /// Initializes a new <see
22         ↪ cref="FrequenciesCacheBasedLinkToItsFrequencyNumberConverter"/> instance.
23         /// </para>
24         /// <para></para>
25         /// </summary>
26         /// <param name="cache">
27         /// <para>A cache.</para>
28         /// </param>
29         [MethodImpl(MethodImplOptions.AggressiveInlining)]
30         public FrequenciesCacheBasedLinkToItsFrequencyNumberConverter(LinkFrequenciesCache<TLink_
        ↪ Address> cache) => _cache =
        ↪ cache;

```

```

31
32     /// <summary>
33     /// <para>
34     /// Converts the source.
35     /// </para>
36     /// <para></para>
37     /// </summary>
38     /// <param name="source">
39     /// <para>The source.</para>
40     /// <para></para>
41     /// </param>
42     /// <returns>
43     /// <para>The link</para>
44     /// <para></para>
45     /// </returns>
46     [MethodImpl(MethodImplOptions.AggressiveInlining)]
47     public TLinkAddress Convert(Doublet<TLinkAddress> source) => _cache.GetFrequency(ref
    ↪ source).Frequency;
48 }
49 }

```

#### 1.14 ./csharp/Platform.Data.Doublets.Sequences/Frequencies/Counters/MarkedSequenceSymbolFrequencyOneOff

```

1 using System.Runtime.CompilerServices;
2 using Platform.Interfaces;
3
4 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
5
6 namespace Platform.Data.Doublets.Sequences.Frequencies.Counters
7 {
8     /// <summary>
9     /// <para>
10    /// Represents the marked sequence symbol frequency one off counter.
11    /// </para>
12    /// <para></para>
13    /// </summary>
14    /// <seealso cref="SequenceSymbolFrequencyOneOffCounter{TLinkAddress}"/>
15    public class MarkedSequenceSymbolFrequencyOneOffCounter<TLinkAddress> :
    ↪ SequenceSymbolFrequencyOneOffCounter<TLinkAddress>
16    {
17        private readonly ICriterionMatcher<TLinkAddress> _markedSequenceMatcher;
18
19        /// <summary>
20        /// <para>
21        /// Initializes a new <see cref="MarkedSequenceSymbolFrequencyOneOffCounter"/> instance.
22        /// </para>
23        /// <para></para>
24        /// </summary>
25        /// <param name="links">
26        /// <para>A links.</para>
27        /// <para></para>
28        /// </param>
29        /// <param name="markedSequenceMatcher">
30        /// <para>A marked sequence matcher.</para>
31        /// <para></para>
32        /// </param>
33        /// <param name="sequenceLink">
34        /// <para>A sequence link.</para>
35        /// <para></para>
36        /// </param>
37        /// <param name="symbol">
38        /// <para>A symbol.</para>
39        /// <para></para>
40        /// </param>
41        [MethodImpl(MethodImplOptions.AggressiveInlining)]
42        public MarkedSequenceSymbolFrequencyOneOffCounter(ILinks<TLinkAddress> links,
    ↪ ICriterionMatcher<TLinkAddress> markedSequenceMatcher, TLinkAddress sequenceLink,
    ↪ TLinkAddress symbol)
43        : base(links, sequenceLink, symbol)
44        => _markedSequenceMatcher = markedSequenceMatcher;
45
46        /// <summary>
47        /// <para>
48        /// Counts this instance.
49        /// </para>
50        /// <para></para>
51        /// </summary>
52        /// <returns>
53        /// <para>The link</para>

```



```

54     /// <para></para>
55     /// </returns>
56     [MethodImpl(MethodImplOptions.AggressiveInlining)]
57     public override TLinkAddress Count()
58     {
59         if (!_markedSequenceMatcher.IsMatched(_sequenceLink))
60         {
61             return default;
62         }
63         return base.Count();
64     }
65 }
66 }

```

## 1.15 ./csharp/Platform.Data.Doublets.Sequences/Frequencies/Counters/SequenceSymbolFrequencyOneOffCounter

```

1  using System.Collections.Generic;
2  using System.Runtime.CompilerServices;
3  using Platform.Interfaces;
4  using Platform.Numbers;
5  using Platform.Data.Sequences;
6
7  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
8
9  namespace Platform.Data.Doublets.Sequences.Frequencies.Counters
10 {
11     /// <summary>
12     /// <para>
13     /// Represents the sequence symbol frequency one off counter.
14     /// </para>
15     /// <para></para>
16     /// </summary>
17     /// <seealso cref="ICounter{TLinkAddress}"/>
18     public class SequenceSymbolFrequencyOneOffCounter<TLinkAddress> : ICounter<TLinkAddress>
19     {
20         private static readonly EqualityComparer<TLinkAddress> _equalityComparer =
21             ↳ EqualityComparer<TLinkAddress>.Default;
22         private static readonly Comparer<TLinkAddress> _comparer =
23             ↳ Comparer<TLinkAddress>.Default;
24
25         /// <summary>
26         /// <para>
27         /// The links.
28         /// </para>
29         /// <para></para>
30         /// </summary>
31         protected readonly ILinks<TLinkAddress> _links;
32
33         /// <summary>
34         /// <para>
35         /// The sequence link.
36         /// </para>
37         /// <para></para>
38         /// </summary>
39         protected readonly TLinkAddress _sequenceLink;
40
41         /// <summary>
42         /// <para>
43         /// The symbol.
44         /// </para>
45         /// <para></para>
46         /// </summary>
47         protected readonly TLinkAddress _symbol;
48
49         /// <summary>
50         /// <para>
51         /// The total.
52         /// </para>
53         /// <para></para>
54         /// </summary>
55         protected TLinkAddress _total;
56
57         /// <summary>
58         /// <para>
59         /// Initializes a new <see cref="SequenceSymbolFrequencyOneOffCounter"/> instance.
60         /// </para>
61         /// <para></para>
62         /// </summary>
63         /// <param name="links">
64         /// <para>A links.</para>
65         /// <para></para>
66         /// </param>
67         /// <param name="sequenceLink">

```

```

63     /// <para>A sequence link.</para>
64     /// <para></para>
65     /// </param>
66     /// <param name="symbol">
67     /// <para>A symbol.</para>
68     /// <para></para>
69     /// </param>
70     [MethodImpl(MethodImplOptions.AggressiveInlining)]
71     public SequenceSymbolFrequencyOneOffCounter(ILinks<TLinkAddress> links, TLinkAddress
    ↪ sequenceLink, TLinkAddress symbol)
72     {
73         _links = links;
74         _sequenceLink = sequenceLink;
75         _symbol = symbol;
76         _total = default;
77     }
78
79     /// <summary>
80     /// <para>
81     /// Counts this instance.
82     /// </para>
83     /// <para></para>
84     /// </summary>
85     /// <returns>
86     /// <para>The total.</para>
87     /// <para></para>
88     /// </returns>
89     [MethodImpl(MethodImplOptions.AggressiveInlining)]
90     public virtual TLinkAddress Count()
91     {
92         if (_comparer.Compare(_total, default) > 0)
93         {
94             return _total;
95         }
96         StopableSequenceWalker.WalkRight(_sequenceLink, _links.GetSource, _links.GetTarget,
    ↪ IsElement, VisitElement);
97         return _total;
98     }
99     [MethodImpl(MethodImplOptions.AggressiveInlining)]
100    private bool IsElement(TLinkAddress x) => _equalityComparer.Equals(x, _symbol) ||
    ↪ _links.IsPartialPoint(x); // TODO: Use SequenceElementCriteriaMatcher instead of
    ↪ IsPartialPoint
101    [MethodImpl(MethodImplOptions.AggressiveInlining)]
102    private bool VisitElement(TLinkAddress element)
103    {
104        if (_equalityComparer.Equals(element, _symbol))
105        {
106            _total = Arithmetic.Increment(_total);
107        }
108        return true;
109    }
110 }
111 }

```

## 1.16 ./csharp/Platform.Data.Doublets.Sequences/Frequencies/Counters/TotalMarkedSequenceSymbolFrequencyCounter.cs

```

1  using System.Runtime.CompilerServices;
2  using Platform.Interfaces;
3
4  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
5
6  namespace Platform.Data.Doublets.Sequences.Frequencies.Counters
7  {
8      /// <summary>
9      /// <para>
10     /// Represents the total marked sequence symbol frequency counter.
11     /// </para>
12     /// <para></para>
13     /// </summary>
14     /// <seealso cref="ICounter{TLinkAddress, TLinkAddress}"/>
15     public class TotalMarkedSequenceSymbolFrequencyCounter<TLinkAddress> :
    ↪ ICounter<TLinkAddress, TLinkAddress>
16     {
17         private readonly ILinks<TLinkAddress> _links;
18         private readonly ICriterionMatcher<TLinkAddress> _markedSequenceMatcher;
19
20         /// <summary>
21         /// <para>
22         /// Initializes a new <see cref="TotalMarkedSequenceSymbolFrequencyCounter"/> instance.
23         /// </para>

```

```

24     /// <para></para>
25     /// </summary>
26     /// <param name="links">
27     /// <para>A links.</para>
28     /// <para></para>
29     /// </param>
30     /// <param name="markedSequenceMatcher">
31     /// <para>A marked sequence matcher.</para>
32     /// <para></para>
33     /// </param>
34     [MethodImpl(MethodImplOptions.AggressiveInlining)]
35     public TotalMarkedSequenceSymbolFrequencyCounter(ILinks<TLinkAddress> links,
36     ↪ ICriterionMatcher<TLinkAddress> markedSequenceMatcher)
37     {
38         _links = links;
39         _markedSequenceMatcher = markedSequenceMatcher;
40     }
41     /// <summary>
42     /// <para>
43     /// Counts the argument.
44     /// </para>
45     /// <para></para>
46     /// </summary>
47     /// <param name="argument">
48     /// <para>The argument.</para>
49     /// <para></para>
50     /// </param>
51     /// <returns>
52     /// <para>The link</para>
53     /// <para></para>
54     /// </returns>
55     [MethodImpl(MethodImplOptions.AggressiveInlining)]
56     public TLinkAddress Count(TLinkAddress argument) => new
57     ↪ TotalMarkedSequenceSymbolFrequencyOneOffCounter<TLinkAddress>(_links,
58     ↪ _markedSequenceMatcher, argument).Count();
59 }

```

## 1.17 ./csharp/Platform.Data.Doublets.Sequences/Frequencies/Counters/TotalMarkedSequenceSymbolFrequencyO

```

1  using System.Runtime.CompilerServices;
2  using Platform.Interfaces;
3  using Platform.Numbers;
4
5  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
6
7  namespace Platform.Data.Doublets.Sequences.Frequencies.Counters
8  {
9      /// <summary>
10     /// <para>
11     /// Represents the total marked sequence symbol frequency one off counter.
12     /// </para>
13     /// <para></para>
14     /// </summary>
15     /// <seealso cref="TotalSequenceSymbolFrequencyOneOffCounter{TLinkAddress}"/>
16     public class TotalMarkedSequenceSymbolFrequencyOneOffCounter<TLinkAddress> :
17     ↪ TotalSequenceSymbolFrequencyOneOffCounter<TLinkAddress>
18     {
19         private readonly ICriterionMatcher<TLinkAddress> _markedSequenceMatcher;
20
21         /// <summary>
22         /// <para>
23         /// Initializes a new <see cref="TotalMarkedSequenceSymbolFrequencyOneOffCounter"/>
24         ↪ instance.
25         /// </para>
26         /// <para></para>
27         /// </summary>
28         /// <param name="links">
29         /// <para>A links.</para>
30         /// <para></para>
31         /// </param>
32         /// <param name="markedSequenceMatcher">
33         /// <para>A marked sequence matcher.</para>
34         /// <para></para>
35         /// </param>
36         /// <param name="symbol">
37         /// <para>A symbol.</para>
38         /// <para></para>
39         /// </param>

```

```

37     /// </param>
38     [MethodImpl(MethodImplOptions.AggressiveInlining)]
39     public TotalMarkedSequenceSymbolFrequencyOneOffCounter(ILinks<TLinkAddress> links,
40         ↪ ICriterionMatcher<TLinkAddress> markedSequenceMatcher, TLinkAddress symbol)
41         : base(links, symbol)
42         => _markedSequenceMatcher = markedSequenceMatcher;
43
44     /// <summary>
45     /// <para>
46     /// Counts the sequence symbol frequency using the specified link.
47     /// </para>
48     /// </summary>
49     /// <param name="link">
50     /// <para>The link.</para>
51     /// </param>
52     [MethodImpl(MethodImplOptions.AggressiveInlining)]
53     protected override void CountSequenceSymbolFrequency(TLinkAddress link)
54     {
55         var symbolFrequencyCounter = new
56         ↪ MarkedSequenceSymbolFrequencyOneOffCounter<TLinkAddress>(_links,
57         ↪ _markedSequenceMatcher, link, _symbol);
58         _total = Arithmetic.Add(_total, symbolFrequencyCounter.Count());
59     }
60 }

```

## 1.18 ./csharp/Platform.Data.Doublets.Sequences/Frequencies/Counters/TotalSequenceSymbolFrequencyCounter.

```

1 using System.Runtime.CompilerServices;
2 using Platform.Interfaces;
3
4 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
5
6 namespace Platform.Data.Doublets.Sequences.Frequencies.Counters
7 {
8     /// <summary>
9     /// <para>
10    /// Represents the total sequence symbol frequency counter.
11    /// </para>
12    /// </summary>
13    /// <seealso cref="ICounter{TLinkAddress, TLinkAddress}"/>
14    public class TotalSequenceSymbolFrequencyCounter<TLinkAddress> : ICounter<TLinkAddress,
15        ↪ TLinkAddress>
16    {
17        private readonly ILinks<TLinkAddress> _links;
18
19        /// <summary>
20        /// <para>
21        /// Initializes a new <see cref="TotalSequenceSymbolFrequencyCounter"/> instance.
22        /// </para>
23        /// </summary>
24        /// <param name="links">
25        /// <para>A links.</para>
26        /// </param>
27        [MethodImpl(MethodImplOptions.AggressiveInlining)]
28        public TotalSequenceSymbolFrequencyCounter(ILinks<TLinkAddress> links) => _links = links;
29
30        /// <summary>
31        /// <para>
32        /// Counts the symbol.
33        /// </para>
34        /// </summary>
35        /// <param name="symbol">
36        /// <para>The symbol.</para>
37        /// </param>
38        /// <returns>
39        /// <para>The link</para>
40        /// </returns>
41        [MethodImpl(MethodImplOptions.AggressiveInlining)]
42        public TLinkAddress Count(TLinkAddress symbol) => new
43        ↪ TotalSequenceSymbolFrequencyOneOffCounter<TLinkAddress>(_links, symbol).Count();
44    }
45 }

```

```
48     }
49 }
```

## 1.19 ./csharp/Platform.Data.Doublets.Sequences/Frequencies/Counters/TotalSequenceSymbolFrequencyOneOffCounter

```
1  using System.Collections.Generic;
2  using System.Runtime.CompilerServices;
3  using Platform.Interfaces;
4  using Platform.Numbers;
5
6  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
7
8  namespace Platform.Data.Doublets.Sequences.Frequencies.Counters
9  {
10     /// <summary>
11     /// <para>
12     /// Represents the total sequence symbol frequency one off counter.
13     /// </para>
14     /// <para></para>
15     /// </summary>
16     /// <seealso cref="ICounter{TLinkAddress}"/>
17     public class TotalSequenceSymbolFrequencyOneOffCounter<TLinkAddress> : ICounter<TLinkAddress>
18     {
19         private static readonly EqualityComparer<TLinkAddress> _equalityComparer =
20             ↪ EqualityComparer<TLinkAddress>.Default;
21         private static readonly Comparer<TLinkAddress> _comparer =
22             ↪ Comparer<TLinkAddress>.Default;
23
24         /// <summary>
25         /// <para>
26         /// The links.
27         /// </para>
28         /// <para></para>
29         /// </summary>
30         protected readonly ILinks<TLinkAddress> _links;
31         /// <summary>
32         /// <para>
33         /// The symbol.
34         /// </para>
35         /// <para></para>
36         /// </summary>
37         protected readonly TLinkAddress _symbol;
38         /// <summary>
39         /// <para>
40         /// The visits.
41         /// </para>
42         /// <para></para>
43         /// </summary>
44         protected readonly HashSet<TLinkAddress> _visits;
45         /// <summary>
46         /// <para>
47         /// The total.
48         /// </para>
49         /// <para></para>
50         /// </summary>
51         protected TLinkAddress _total;
52
53         /// <summary>
54         /// <para>
55         /// Initializes a new <see cref="TotalSequenceSymbolFrequencyOneOffCounter"/> instance.
56         /// </para>
57         /// <para></para>
58         /// </summary>
59         /// <param name="links">
60         /// <para>A links.</para>
61         /// <para></para>
62         /// </param>
63         /// <param name="symbol">
64         /// <para>A symbol.</para>
65         /// <para></para>
66         /// </param>
67         [MethodImpl(MethodImplOptions.AggressiveInlining)]
68         public TotalSequenceSymbolFrequencyOneOffCounter(ILinks<TLinkAddress> links,
69             ↪ TLinkAddress symbol)
70         {
71             _links = links;
72             _symbol = symbol;
73             _visits = new HashSet<TLinkAddress>();
74             _total = default;
75         }
76     }
77 }
```

```

73
74     /// <summary>
75     /// <para>
76     /// Counts this instance.
77     /// </para>
78     /// <para></para>
79     /// </summary>
80     /// <returns>
81     /// <para>The total.</para>
82     /// <para></para>
83     /// </returns>
84     [MethodImpl(MethodImplOptions.AggressiveInlining)]
85     public TLinkAddress Count()
86     {
87         if (_comparer.Compare(_total, default) > 0 || _visits.Count > 0)
88         {
89             return _total;
90         }
91         CountCore(_symbol);
92         return _total;
93     }
94     [MethodImpl(MethodImplOptions.AggressiveInlining)]
95     private void CountCore(TLinkAddress link)
96     {
97         var any = _links.Constants.Any;
98         if (_equalityComparer.Equals(_links.Count(any, link), default))
99         {
100             CountSequenceSymbolFrequency(link);
101         }
102         else
103         {
104             _links.Each(EachElementHandler, any, link);
105         }
106     }
107
108     /// <summary>
109     /// <para>
110     /// Counts the sequence symbol frequency using the specified link.
111     /// </para>
112     /// <para></para>
113     /// </summary>
114     /// <param name="link">
115     /// <para>The link.</para>
116     /// <para></para>
117     /// </param>
118     [MethodImpl(MethodImplOptions.AggressiveInlining)]
119     protected virtual void CountSequenceSymbolFrequency(TLinkAddress link)
120     {
121         var symbolFrequencyCounter = new
122             ↪ SequenceSymbolFrequencyOneOffCounter<TLinkAddress>(_links, link, _symbol);
123         _total = Arithmetic.Add(_total, symbolFrequencyCounter.Count());
124     }
125     [MethodImpl(MethodImplOptions.AggressiveInlining)]
126     private TLinkAddress EachElementHandler(ICollection<TLinkAddress>? doublet)
127     {
128         var constants = _links.Constants;
129         var doubletIndex = doublet[constants.IndexPart];
130         if (_visits.Add(doubletIndex))
131         {
132             CountCore(doubletIndex);
133         }
134         return constants.Continue;
135     }
136 }

```

## 1.20 ./csharp/Platform.Data.Doublets.Sequences/HeightProviders/CachedSequenceHeightProvider.cs

```

1 using System.Collections.Generic;
2 using System.Runtime.CompilerServices;
3 using Platform.Interfaces;
4 using Platform.Converters;
5
6 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
7
8 namespace Platform.Data.Doublets.Sequences.HeightProviders
9 {
10     /// <summary>
11     /// <para>
12     /// Represents the cached sequence height provider.

```

```

13  /// </para>
14  /// <para></para>
15  /// </summary>
16  /// <seealso cref="ISequenceHeightProvider{TLinkAddress}"/>
17  public class CachedSequenceHeightProvider<TLinkAddress> :
18  ↪ ISequenceHeightProvider<TLinkAddress>
19  {
20      private static readonly EqualityComparer<TLinkAddress> _equalityComparer =
21      ↪ EqualityComparer<TLinkAddress>.Default;
22      private readonly TLinkAddress _heightPropertyMarker;
23      private readonly ISequenceHeightProvider<TLinkAddress> _baseHeightProvider;
24      private readonly IConverter<TLinkAddress> _addressToUnaryNumberConverter;
25      private readonly IConverter<TLinkAddress> _unaryNumberToAddressConverter;
26      private readonly IProperties<TLinkAddress, TLinkAddress, TLinkAddress> _propertyOperator;
27
28      /// <summary>
29      /// <para>
30      /// Initializes a new <see cref="CachedSequenceHeightProvider"/> instance.
31      /// </para>
32      /// <para></para>
33      /// </summary>
34      /// <param name="baseHeightProvider">
35      /// <para>A base height provider.</para>
36      /// <para></para>
37      /// </param>
38      /// <param name="addressToUnaryNumberConverter">
39      /// <para>A address to unary number converter.</para>
40      /// <para></para>
41      /// </param>
42      /// <param name="unaryNumberToAddressConverter">
43      /// <para>A unary number to address converter.</para>
44      /// <para></para>
45      /// </param>
46      /// <param name="heightPropertyMarker">
47      /// <para>A height property marker.</para>
48      /// <para></para>
49      /// </param>
50      /// <param name="propertyOperator">
51      /// <para>A property operator.</para>
52      /// <para></para>
53      /// </param>
54      [MethodImpl(MethodImplOptions.AggressiveInlining)]
55      public CachedSequenceHeightProvider(
56          ISequenceHeightProvider<TLinkAddress> baseHeightProvider,
57          IConverter<TLinkAddress> addressToUnaryNumberConverter,
58          IConverter<TLinkAddress> unaryNumberToAddressConverter,
59          TLinkAddress heightPropertyMarker,
60          IProperties<TLinkAddress, TLinkAddress, TLinkAddress> propertyOperator)
61      {
62          _heightPropertyMarker = heightPropertyMarker;
63          _baseHeightProvider = baseHeightProvider;
64          _addressToUnaryNumberConverter = addressToUnaryNumberConverter;
65          _unaryNumberToAddressConverter = unaryNumberToAddressConverter;
66          _propertyOperator = propertyOperator;
67      }
68
69      /// <summary>
70      /// <para>
71      /// Gets the sequence.
72      /// </para>
73      /// <para></para>
74      /// </summary>
75      /// <param name="sequence">
76      /// <para>The sequence.</para>
77      /// <para></para>
78      /// </param>
79      /// <returns>
80      /// <para>The height.</para>
81      /// <para></para>
82      /// </returns>
83      [MethodImpl(MethodImplOptions.AggressiveInlining)]
84      public TLinkAddress Get(TLinkAddress sequence)
85      {
86          TLinkAddress height;
87          var heightValue = _propertyOperator.GetValue(sequence, _heightPropertyMarker);
88          if (_equalityComparer.Equals(heightValue, default))
89          {
90              height = _baseHeightProvider.Get(sequence);
91              heightValue = _addressToUnaryNumberConverter.Convert(height);
92          }
93      }
94  }

```

```

90         _propertyOperator.SetValue(sequence, _heightPropertyMarker, heightValue);
91     }
92     else
93     {
94         height = _unaryNumberToAddressConverter.Convert(heightValue);
95     }
96     return height;
97 }
98 }
99 }

```

## 1.21 ./csharp/Platform.Data.Doublets.Sequences/HeightProviders/DefaultSequenceRightHeightProvider.cs

```

1  using System.Runtime.CompilerServices;
2  using Platform.Interfaces;
3  using Platform.Numbers;
4
5  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
6
7  namespace Platform.Data.Doublets.Sequences.HeightProviders
8  {
9      /// <summary>
10     /// <para>
11     /// Represents the default sequence right height provider.
12     /// </para>
13     /// <para></para>
14     /// </summary>
15     /// <seealso cref="LinksOperatorBase{TLinkAddress}"/>
16     /// <seealso cref="ISequenceHeightProvider{TLinkAddress}"/>
17     public class DefaultSequenceRightHeightProvider<TLinkAddress> :
18         ↳ LinksOperatorBase<TLinkAddress>, ISequenceHeightProvider<TLinkAddress>
19     {
20         private readonly ICriterionMatcher<TLinkAddress> _elementMatcher;
21
22         /// <summary>
23         /// <para>
24         /// Initializes a new <see cref="DefaultSequenceRightHeightProvider"/> instance.
25         /// </para>
26         /// <para></para>
27         /// </summary>
28         /// <param name="links">
29         /// <para>A links.</para>
30         /// <para></para>
31         /// </param>
32         /// <param name="elementMatcher">
33         /// <para>A element matcher.</para>
34         /// <para></para>
35         /// </param>
36         [MethodImpl(MethodImplOptions.AggressiveInlining)]
37         public DefaultSequenceRightHeightProvider(ILinks<TLinkAddress> links,
38             ↳ ICriterionMatcher<TLinkAddress> elementMatcher) : base(links) => _elementMatcher =
39             ↳ elementMatcher;
40
41         /// <summary>
42         /// <para>
43         /// Gets the sequence.
44         /// </para>
45         /// <para></para>
46         /// </summary>
47         /// <param name="sequence">
48         /// <para>The sequence.</para>
49         /// <para></para>
50         /// </param>
51         /// <returns>
52         /// <para>The height.</para>
53         /// <para></para>
54         /// </returns>
55         [MethodImpl(MethodImplOptions.AggressiveInlining)]
56         public TLinkAddress Get(TLinkAddress sequence)
57         {
58             var height = default(TLinkAddress);
59             var pairOrElement = sequence;
60             while (!_elementMatcher.IsMatched(pairOrElement))
61             {
62                 pairOrElement = _links.GetTarget(pairOrElement);
63                 height = Arithmetic.Increment(height);
64             }
65             return height;
66         }
67     }
68 }

```



```
65 }
```

## 1.22 ./csharp/Platform.Data.Doublets.Sequences/HeightProviders/ISequenceHeightProvider.cs

```
1 using Platform.Interfaces;
2
3 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
4
5 namespace Platform.Data.Doublets.Sequences.HeightProviders
6 {
7     /// <summary>
8     /// <para>
9     /// Defines the sequence height provider.
10    /// </para>
11    /// <para></para>
12    /// </summary>
13    /// <seealso cref="IProvider{TLinkAddress, TLinkAddress}"/>
14    public interface ISequenceHeightProvider<TLinkAddress> : IProvider<TLinkAddress,
15        ↪ TLinkAddress>
16    {
17    }
```

## 1.23 ./csharp/Platform.Data.Doublets.Sequences/Incrementers/FrequencyIncrementer.cs

```
1 using System.Collections.Generic;
2 using System.Runtime.CompilerServices;
3 using Platform.Incrementers;
4
5 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
6
7 namespace Platform.Data.Doublets.Incrementers
8 {
9     /// <summary>
10    /// <para>
11    /// Represents the frequency incrementer.
12    /// </para>
13    /// <para></para>
14    /// </summary>
15    /// <seealso cref="LinksOperatorBase{TLinkAddress}"/>
16    /// <seealso cref="IIncrementer{TLinkAddress}"/>
17    public class FrequencyIncrementer<TLinkAddress> : LinksOperatorBase<TLinkAddress>,
18        ↪ IIncrementer<TLinkAddress>
19    {
20        private static readonly EqualityComparer<TLinkAddress> _equalityComparer =
21            ↪ EqualityComparer<TLinkAddress>.Default;
22        private readonly TLinkAddress _frequencyMarker;
23        private readonly TLinkAddress _unaryOne;
24        private readonly IIncrementer<TLinkAddress> _unaryNumberIncrementer;
25
26        /// <summary>
27        /// <para>
28        /// Initializes a new <see cref="FrequencyIncrementer"/> instance.
29        /// </para>
30        /// <para></para>
31        /// </summary>
32        /// <param name="links">
33        /// <para>A links.</para>
34        /// <para></para>
35        /// </param>
36        /// <param name="frequencyMarker">
37        /// <para>A frequency marker.</para>
38        /// <para></para>
39        /// </param>
40        /// <param name="unaryOne">
41        /// <para>A unary one.</para>
42        /// <para></para>
43        /// </param>
44        /// <param name="unaryNumberIncrementer">
45        /// <para>A unary number incrementer.</para>
46        /// <para></para>
47        /// </param>
48        [MethodImpl(MethodImplOptions.AggressiveInlining)]
49        public FrequencyIncrementer(ILinks<TLinkAddress> links, TLinkAddress frequencyMarker,
50            ↪ TLinkAddress unaryOne, IIncrementer<TLinkAddress> unaryNumberIncrementer)
51            : base(links)
52        {
53            _frequencyMarker = frequencyMarker;
54            _unaryOne = unaryOne;
55            _unaryNumberIncrementer = unaryNumberIncrementer;
56        }
57    }
```

```

54
55     /// <summary>
56     /// <para>
57     /// Increments the frequency.
58     /// </para>
59     /// <para></para>
60     /// </summary>
61     /// <param name="frequency">
62     /// <para>The frequency.</para>
63     /// <para></para>
64     /// </param>
65     /// <returns>
66     /// <para>The link</para>
67     /// <para></para>
68     /// </returns>
69     [MethodImpl(MethodImplOptions.AggressiveInlining)]
70     public TLinkAddress Increment(TLinkAddress frequency)
71     {
72         var links = _links;
73         if (_equalityComparer.Equals(frequency, default))
74         {
75             return links.GetOrCreate(_unaryOne, _frequencyMarker);
76         }
77         var incrementedSource =
78             ↪ _unaryNumberIncrementer.Increment(links.GetSource(frequency));
79         return links.GetOrCreate(incrementedSource, _frequencyMarker);
80     }
81 }

```

#### 1.24 ./csharp/Platform.Data.Doublets.Sequences/Incrementers/UnaryNumberIncrementer.cs

```

1  using System.Collections.Generic;
2  using System.Runtime.CompilerServices;
3  using Platform.Incrementers;
4
5  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
6
7  namespace Platform.Data.Doublets.Incrementers
8  {
9      /// <summary>
10     /// <para>
11     /// Represents the unary number incrementer.
12     /// </para>
13     /// <para></para>
14     /// </summary>
15     /// <seealso cref="LinksOperatorBase{TLinkAddress}"/>
16     /// <seealso cref="IIncrementer{TLinkAddress}"/>
17     public class UnaryNumberIncrementer<TLinkAddress> : LinksOperatorBase<TLinkAddress>,
18         ↪ IIncrementer<TLinkAddress>
19     {
20         private static readonly EqualityComparer<TLinkAddress> _equalityComparer =
21             ↪ EqualityComparer<TLinkAddress>.Default;
22         private readonly TLinkAddress _unaryOne;
23
24         /// <summary>
25         /// <para>
26         /// Initializes a new <see cref="UnaryNumberIncrementer"/> instance.
27         /// </para>
28         /// <para></para>
29         /// </summary>
30         /// <param name="links">
31         /// <para>A links.</para>
32         /// <para></para>
33         /// </param>
34         /// <param name="unaryOne">
35         /// <para>A unary one.</para>
36         /// <para></para>
37         /// </param>
38         [MethodImpl(MethodImplOptions.AggressiveInlining)]
39         public UnaryNumberIncrementer(ILinks<TLinkAddress> links, TLinkAddress unaryOne) :
40             ↪ base(links) => _unaryOne = unaryOne;
41
42         /// <summary>
43         /// <para>
44         /// Increments the unary number.
45         /// </para>
46         /// <para></para>
47         /// </summary>
48         /// <param name="unaryNumber">

```

```

46     /// <para>The unary number.</para>
47     /// <para></para>
48     /// </param>
49     /// <returns>
50     /// <para>The link</para>
51     /// <para></para>
52     /// </returns>
53     [MethodImpl(MethodImplOptions.AggressiveInlining)]
54     public TLinkAddress Increment(TLinkAddress unaryNumber)
55     {
56         var links = _links;
57         if (_equalityComparer.Equals(unaryNumber, _unaryOne))
58         {
59             return links.GetOrCreate(_unaryOne, _unaryOne);
60         }
61         var source = links.GetSource(unaryNumber);
62         var target = links.GetTarget(unaryNumber);
63         if (_equalityComparer.Equals(source, target))
64         {
65             return links.GetOrCreate(unaryNumber, _unaryOne);
66         }
67         else
68         {
69             return links.GetOrCreate(source, Increment(target));
70         }
71     }
72 }
73 }

```

## 1.25 ./csharp/Platform.Data.Doublets.Sequences/Indexes/CachedFrequencyIncrementingSequenceIndex.cs

```

1  using System.Collections.Generic;
2  using System.Runtime.CompilerServices;
3  using Platform.Data.Doublets.Sequences.Frequencies.Cache;
4
5  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
6
7  namespace Platform.Data.Doublets.Sequences.Indexes
8  {
9      /// <summary>
10     /// <para>
11     /// Represents the cached frequency incrementing sequence index.
12     /// </para>
13     /// <para></para>
14     /// </summary>
15     /// <seealso cref="ISequenceIndex{TLinkAddress}"/>
16     public class CachedFrequencyIncrementingSequenceIndex<TLinkAddress> :
17         ↳ ISequenceIndex<TLinkAddress>
18     {
19         private static readonly EqualityComparer<TLinkAddress> _equalityComparer =
20             ↳ EqualityComparer<TLinkAddress>.Default;
21         private readonly LinkFrequenciesCache<TLinkAddress> _cache;
22
23         /// <summary>
24         /// <para>
25         /// Initializes a new <see cref="CachedFrequencyIncrementingSequenceIndex"/> instance.
26         /// </para>
27         /// <para></para>
28         /// </summary>
29         /// <param name="cache">
30         /// <para>A cache.</para>
31         /// <para></para>
32         /// </param>
33         [MethodImpl(MethodImplOptions.AggressiveInlining)]
34         public CachedFrequencyIncrementingSequenceIndex(LinkFrequenciesCache<TLinkAddress>
35             ↳ cache) => _cache = cache;
36
37         /// <summary>
38         /// <para>
39         /// Determines whether this instance add.
40         /// </para>
41         /// <para></para>
42         /// </summary>
43         /// <param name="sequence">
44         /// <para>The sequence.</para>
45         /// <para></para>
46         /// </param>
47         /// <returns>
48         /// <para>The indexed.</para>
49         /// <para></para>

```

```

47     /// </returns>
48     [MethodImpl(MethodImplOptions.AggressiveInlining)]
49     public bool Add(ICollection<TLinkAddress>? sequence)
50     {
51         var indexed = true;
52         var i = sequence.Count;
53         while (--i >= 1 && (indexed = IsIndexedWithIncrement(sequence[i - 1], sequence[i])))
54             { }
55         for (; i >= 1; i--)
56         {
57             _cache.IncrementFrequency(sequence[i - 1], sequence[i]);
58         }
59         return indexed;
60     }
61     [MethodImpl(MethodImplOptions.AggressiveInlining)]
62     private bool IsIndexedWithIncrement(TLinkAddress source, TLinkAddress target)
63     {
64         var frequency = _cache.GetFrequency(source, target);
65         if (frequency == null)
66         {
67             return false;
68         }
69         var indexed = !_equalityComparer.Equals(frequency.Frequency, default);
70         if (indexed)
71         {
72             _cache.IncrementFrequency(source, target);
73         }
74         return indexed;
75     }
76     /// <summary>
77     /// <para>
78     /// Determines whether this instance might contain.
79     /// </para>
80     /// <para></para>
81     /// </summary>
82     /// <param name="sequence">
83     /// <para>The sequence.</para>
84     /// <para></para>
85     /// </param>
86     /// <returns>
87     /// <para>The indexed.</para>
88     /// <para></para>
89     /// </returns>
90     [MethodImpl(MethodImplOptions.AggressiveInlining)]
91     public bool MightContain(ICollection<TLinkAddress>? sequence)
92     {
93         var indexed = true;
94         var i = sequence.Count;
95         while (--i >= 1 && (indexed = IsIndexed(sequence[i - 1], sequence[i]))) { }
96         return indexed;
97     }
98     [MethodImpl(MethodImplOptions.AggressiveInlining)]
99     private bool IsIndexed(TLinkAddress source, TLinkAddress target)
100     {
101         var frequency = _cache.GetFrequency(source, target);
102         if (frequency == null)
103         {
104             return false;
105         }
106         return !_equalityComparer.Equals(frequency.Frequency, default);
107     }
108 }
109 }

```

## 1.26 ./csharp/Platform.Data.Doublets.Sequences/Indexes/FrequencyIncrementingSequenceIndex.cs

```

1  using System.Collections.Generic;
2  using System.Runtime.CompilerServices;
3  using Platform.Interfaces;
4  using Platform.Incrementers;
5
6  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
7
8  namespace Platform.Data.Doublets.Sequences.Indexes
9  {
10     /// <summary>
11     /// <para>
12     /// Represents the frequency incrementing sequence index.
13     /// </para>

```

```

14  /// <para></para>
15  /// </summary>
16  /// <seealso cref="SequenceIndex{TLinkAddress}"/>
17  /// <seealso cref="ISequenceIndex{TLinkAddress}"/>
18  public class FrequencyIncrementingSequenceIndex<TLinkAddress> : SequenceIndex<TLinkAddress>,
    ↪ ISequenceIndex<TLinkAddress>
19  {
20      private static readonly EqualityComparer<TLinkAddress> _equalityComparer =
    ↪ EqualityComparer<TLinkAddress>.Default;
21      private readonly IProperty<TLinkAddress, TLinkAddress> _frequencyPropertyOperator;
22      private readonly IIncrementer<TLinkAddress> _frequencyIncrementer;
23
24      /// <summary>
25      /// <para>
26      /// Initializes a new <see cref="FrequencyIncrementingSequenceIndex"/> instance.
27      /// </para>
28      /// <para></para>
29      /// </summary>
30      /// <param name="links">
31      /// <para>A links.</para>
32      /// <para></para>
33      /// </param>
34      /// <param name="frequencyPropertyOperator">
35      /// <para>A frequency property operator.</para>
36      /// <para></para>
37      /// </param>
38      /// <param name="frequencyIncrementer">
39      /// <para>A frequency incrementer.</para>
40      /// <para></para>
41      /// </param>
42      [MethodImpl(MethodImplOptions.AggressiveInlining)]
43      public FrequencyIncrementingSequenceIndex(ILinks<TLinkAddress> links,
    ↪ IProperty<TLinkAddress, TLinkAddress> frequencyPropertyOperator,
    ↪ IIncrementer<TLinkAddress> frequencyIncrementer)
44          : base(links)
45      {
46          _frequencyPropertyOperator = frequencyPropertyOperator;
47          _frequencyIncrementer = frequencyIncrementer;
48      }
49
50      /// <summary>
51      /// <para>
52      /// Determines whether this instance add.
53      /// </para>
54      /// <para></para>
55      /// </summary>
56      /// <param name="sequence">
57      /// <para>The sequence.</para>
58      /// <para></para>
59      /// </param>
60      /// <returns>
61      /// <para>The indexed.</para>
62      /// <para></para>
63      /// </returns>
64      [MethodImpl(MethodImplOptions.AggressiveInlining)]
65      public override bool Add(ICollection<TLinkAddress>? sequence)
66      {
67          var indexed = true;
68          var i = sequence.Count;
69          while (--i >= 1 && (indexed = IsIndexedWithIncrement(sequence[i - 1], sequence[i])))
    ↪ { }
70          for (; i >= 1; i--)
71          {
72              Increment(_links.GetOrCreate(sequence[i - 1], sequence[i]));
73          }
74          return indexed;
75      }
76      [MethodImpl(MethodImplOptions.AggressiveInlining)]
77      private bool IsIndexedWithIncrement(TLinkAddress source, TLinkAddress target)
78      {
79          var link = _links.SearchOrDefault(source, target);
80          var indexed = !_equalityComparer.Equals(link, default);
81          if (indexed)
82          {
83              Increment(link);
84          }
85          return indexed;
86      }

```

```

87     [MethodImpl(MethodImplOptions.AggressiveInlining)]
88     private void Increment(TLinkAddress link)
89     {
90         var previousFrequency = _frequencyPropertyOperator.Get(link);
91         var frequency = _frequencyIncrementer.Increment(previousFrequency);
92         _frequencyPropertyOperator.Set(link, frequency);
93     }
94 }
95 }

```

## 1.27 ./csharp/Platform.Data.Doublets.Sequences/Indexes/ISequenceIndex.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.Data.Doublets.Sequences.Indexes
7  {
8      /// <summary>
9      /// <para>
10     /// Defines the sequence index.
11     /// </para>
12     /// <para></para>
13     /// </summary>
14     public interface ISequenceIndex<TLinkAddress>
15     {
16         /// <summary>
17         /// Индексирует последовательность глобально, и возвращает значение,
18         /// определяющие была ли запрошенная последовательность проиндексирована ранее.
19         /// </summary>
20         /// <param name="sequence">Последовательность для индексации.</param>
21         [MethodImpl(MethodImplOptions.AggressiveInlining)]
22         bool Add(ICollection<TLinkAddress>? sequence);
23
24         /// <summary>
25         /// <para>
26         /// Determines whether this instance might contain.
27         /// </para>
28         /// <para></para>
29         /// </summary>
30         /// <param name="sequence">
31         /// <para>The sequence.</para>
32         /// <para></para>
33         /// </param>
34         /// <returns>
35         /// <para>The bool</para>
36         /// <para></para>
37         /// </returns>
38         [MethodImpl(MethodImplOptions.AggressiveInlining)]
39         bool MightContain(ICollection<TLinkAddress>? sequence);
40     }
41 }

```

## 1.28 ./csharp/Platform.Data.Doublets.Sequences/Indexes/SequenceIndex.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.Data.Doublets.Sequences.Indexes
7  {
8      /// <summary>
9      /// <para>
10     /// Represents the sequence index.
11     /// </para>
12     /// <para></para>
13     /// </summary>
14     /// <seealso cref="LinksOperatorBase{TLinkAddress}">
15     /// <seealso cref="ISequenceIndex{TLinkAddress}">
16     public class SequenceIndex<TLinkAddress> : LinksOperatorBase<TLinkAddress>,
17         ↳ ISequenceIndex<TLinkAddress>
18     {
19         private static readonly EqualityComparer<TLinkAddress> _equalityComparer =
20         ↳ EqualityComparer<TLinkAddress>.Default;
21
22         /// <summary>
23         /// <para>
24         /// Initializes a new <see cref="SequenceIndex"/> instance.
25         /// </para>

```

```

24     /// <para></para>
25     /// </summary>
26     /// <param name="links">
27     /// <para>A links.</para>
28     /// <para></para>
29     /// </param>
30     [MethodImpl(MethodImplOptions.AggressiveInlining)]
31     public SequenceIndex(ILinks<TLinkAddress> links) : base(links) { }
32
33     /// <summary>
34     /// <para>
35     /// Determines whether this instance add.
36     /// </para>
37     /// <para></para>
38     /// </summary>
39     /// <param name="sequence">
40     /// <para>The sequence.</para>
41     /// <para></para>
42     /// </param>
43     /// <returns>
44     /// <para>The indexed.</para>
45     /// <para></para>
46     /// </returns>
47     [MethodImpl(MethodImplOptions.AggressiveInlining)]
48     public virtual bool Add(IList<TLinkAddress>? sequence)
49     {
50         var indexed = true;
51         var i = sequence.Count;
52         while (--i >= 1 && (indexed =
53             ↪ !_equalityComparer.Equals(_links.SearchOrDefault(sequence[i - 1], sequence[i]),
54             ↪ default))) { }
55         for (; i >= 1; i--)
56         {
57             _links.GetOrCreate(sequence[i - 1], sequence[i]);
58         }
59         return indexed;
60     }
61
62     /// <summary>
63     /// <para>
64     /// Determines whether this instance might contain.
65     /// </para>
66     /// <para></para>
67     /// </summary>
68     /// <param name="sequence">
69     /// <para>The sequence.</para>
70     /// <para></para>
71     /// </param>
72     /// <returns>
73     /// <para>The indexed.</para>
74     /// <para></para>
75     /// </returns>
76     [MethodImpl(MethodImplOptions.AggressiveInlining)]
77     public virtual bool MightContain(IList<TLinkAddress>? sequence)
78     {
79         var indexed = true;
80         var i = sequence.Count;
81         while (--i >= 1 && (indexed =
82             ↪ !_equalityComparer.Equals(_links.SearchOrDefault(sequence[i - 1], sequence[i]),
83             ↪ default))) { }
84         return indexed;
85     }
86 }

```

## 1.29 ./csharp/Platform.Data.Doublets.Sequences/Indexes/SynchronizedSequenceIndex.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.Data.Doublets.Sequences.Indexes
7 {
8     /// <summary>
9     /// <para>
10     /// Represents the synchronized sequence index.
11     /// </para>
12     /// <para></para>

```

```

13  /// </summary>
14  /// <seealso cref="ISequenceIndex{TLinkAddress}"/>
15  public class SynchronizedSequenceIndex<TLinkAddress> : ISequenceIndex<TLinkAddress>
16  {
17      private static readonly EqualityComparer<TLinkAddress> _equalityComparer =
18          EqualityComparer<TLinkAddress>.Default;
19      private readonly ISynchronizedLinks<TLinkAddress> _links;
20
21      /// <summary>
22      /// <para>
23      /// Initializes a new <see cref="SynchronizedSequenceIndex"/> instance.
24      /// </para>
25      /// </summary>
26      /// <param name="links">
27      /// <para>A links.</para>
28      /// </param>
29      [MethodImpl(MethodImplOptions.AggressiveInlining)]
30      public SynchronizedSequenceIndex(ISynchronizedLinks<TLinkAddress> links) => _links =
31          links;
32
33      /// <summary>
34      /// <para>
35      /// Determines whether this instance add.
36      /// </para>
37      /// </summary>
38      /// <param name="sequence">
39      /// <para>The sequence.</para>
40      /// </param>
41      /// <returns>
42      /// <para>The indexed.</para>
43      /// </returns>
44      [MethodImpl(MethodImplOptions.AggressiveInlining)]
45      public bool Add(IList<TLinkAddress>? sequence)
46      {
47          var indexed = true;
48          var i = sequence.Count;
49          var links = _links.Unsync;
50          _links.SyncRoot.ExecuteReadOperation(() =>
51          {
52              while (--i >= 1 && (indexed =
53                  !_equalityComparer.Equals(links.SearchOrDefault(sequence[i - 1],
54                      sequence[i]), default))) { }
55          });
56          if (!indexed)
57          {
58              _links.SyncRoot.ExecuteWriteOperation(() =>
59              {
60                  for (; i >= 1; i--)
61                  {
62                      links.GetOrCreate(sequence[i - 1], sequence[i]);
63                  }
64              });
65          }
66          return indexed;
67      }
68  }
69
70  /// <summary>
71  /// <para>
72  /// Determines whether this instance might contain.
73  /// </para>
74  /// </summary>
75  /// <param name="sequence">
76  /// <para>The sequence.</para>
77  /// </param>
78  /// <returns>
79  /// <para>The bool</para>
80  /// </returns>
81  [MethodImpl(MethodImplOptions.AggressiveInlining)]
82  public bool MightContain(IList<TLinkAddress>? sequence)
83  {
84  }
85
86

```



```

87     var links = _links.Unsync;
88     return _links.SyncRoot.ExecuteReadOperation(() =>
89     {
90         var indexed = true;
91         var i = sequence.Count;
92         while (--i >= 1 && (indexed =
93             ↪ !_equalityComparer.Equals(links.SearchOrDefault(sequence[i - 1],
94             ↪ sequence[i]), default))) { }
95         return indexed;
96     });
97 }

```

### 1.30 ./csharp/Platform.Data.Doublets.Sequences/Indexes/Unindex.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.Data.Doublets.Sequences.Indexes
7  {
8      /// <summary>
9      /// <para>
10     /// Represents the unindex.
11     /// </para>
12     /// <para></para>
13     /// </summary>
14     /// <seealso cref="ISequenceIndex{TLinkAddress}"/>
15     public class Unindex<TLinkAddress> : ISequenceIndex<TLinkAddress>
16     {
17         /// <summary>
18         /// <para>
19         /// Determines whether this instance add.
20         /// </para>
21         /// <para></para>
22         /// </summary>
23         /// <param name="sequence">
24         /// <para>The sequence.</para>
25         /// <para></para>
26         /// </param>
27         /// <returns>
28         /// <para>The bool</para>
29         /// <para></para>
30         /// </returns>
31         [MethodImpl(MethodImplOptions.AggressiveInlining)]
32         public virtual bool Add(ICollection<TLinkAddress>? sequence) => false;
33
34         /// <summary>
35         /// <para>
36         /// Determines whether this instance might contain.
37         /// </para>
38         /// <para></para>
39         /// </summary>
40         /// <param name="sequence">
41         /// <para>The sequence.</para>
42         /// <para></para>
43         /// </param>
44         /// <returns>
45         /// <para>The bool</para>
46         /// <para></para>
47         /// </returns>
48         [MethodImpl(MethodImplOptions.AggressiveInlining)]
49         public virtual bool MightContain(ICollection<TLinkAddress>? sequence) => true;
50     }
51 }

```

### 1.31 ./csharp/Platform.Data.Doublets.Sequences/Numbers/Rational/DecimalToRationalConverter.cs

```

1  using System.Numerics;
2  using Platform.Converters;
3  using Platform.Data.Doublets.Decorators;
4  using System.Globalization;
5  using Platform.Data.Doublets.Numbers.Raw;
6
7  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
8
9  namespace Platform.Data.Doublets.Numbers.Rational
10 {
11     /// <summary>

```

```

12  /// <para>
13  /// Represents the decimal to rational converter.
14  /// </para>
15  /// <para></para>
16  /// </summary>
17  /// <seealso cref="LinksDecoratorBase{TLinkAddress}"/>
18  /// <seealso cref="IConverter{decimal, TLinkAddress}"/>
19  public class DecimalToRationalConverter<TLinkAddress> : LinksDecoratorBase<TLinkAddress>,
    ↳ IConverter<decimal, TLinkAddress>
20  where TLinkAddress: struct
21  {
22      /// <summary>
23      /// <para>
24      /// The big integer to raw number sequence converter.
25      /// </para>
26      /// <para></para>
27      /// </summary>
28      public readonly BigIntegerToRawNumberSequenceConverter<TLinkAddress>
    ↳ BigIntegerToRawNumberSequenceConverter;
29
30      /// <summary>
31      /// <para>
32      /// Initializes a new <see cref="DecimalToRationalConverter"/> instance.
33      /// </para>
34      /// <para></para>
35      /// </summary>
36      /// <param name="links">
37      /// <para>A links.</para>
38      /// <para></para>
39      /// </param>
40      /// <param name="bigIntegerToRawNumberSequenceConverter">
41      /// <para>A big integer to raw number sequence converter.</para>
42      /// <para></para>
43      /// </param>
44      public DecimalToRationalConverter(ILinks<TLinkAddress> links,
    ↳ BigIntegerToRawNumberSequenceConverter<TLinkAddress>
    ↳ bigIntegerToRawNumberSequenceConverter) : base(links)
45      {
46          BigIntegerToRawNumberSequenceConverter = bigIntegerToRawNumberSequenceConverter;
47      }
48
49      /// <summary>
50      /// <para>
51      /// Converts the decimal.
52      /// </para>
53      /// <para></para>
54      /// </summary>
55      /// <param name="@decimal">
56      /// <para>The decimal.</para>
57      /// <para></para>
58      /// </param>
59      /// <returns>
60      /// <para>The link</para>
61      /// <para></para>
62      /// </returns>
63      public TLinkAddress Convert(decimal @decimal)
64      {
65          var decimalAsString = @decimal.ToString(CultureInfo.InvariantCulture);
66          var dotPosition = decimalAsString.IndexOf('.');
67          var decimalWithoutDots = decimalAsString;
68          int digitsAfterDot = 0;
69          if (dotPosition != -1)
70          {
71              decimalWithoutDots = decimalWithoutDots.Remove(dotPosition, 1);
72              digitsAfterDot = decimalAsString.Length - 1 - dotPosition;
73          }
74          BigInteger denominator = new(System.Math.Pow(10, digitsAfterDot));
75          BigInteger numerator = BigInteger.Parse(decimalWithoutDots);
76          BigInteger greatestCommonDivisor;
77          do
78          {
79              greatestCommonDivisor = BigInteger.GreatestCommonDivisor(numerator, denominator);
80              numerator /= greatestCommonDivisor;
81              denominator /= greatestCommonDivisor;
82          }
83          while (greatestCommonDivisor > 1);
84          var numeratorLink = BigIntegerToRawNumberSequenceConverter.Convert(numerator);
85          var denominatorLink = BigIntegerToRawNumberSequenceConverter.Convert(denominator);

```

```

86         return _links.GetOrCreate(numeratorLink, denominatorLink);
87     }
88 }
89 }

```

### 1.32 ./csharp/Platform.Data.Doublets.Sequences/Numbers/Rational/RationalToDecimalConverter.cs

```

1  using Platform.Converters;
2  using Platform.Data.Doublets.Decorators;
3  using Platform.Data.Doublets.Numbers.Raw;
4
5  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
6
7  namespace Platform.Data.Doublets.Numbers.Rational
8  {
9      /// <summary>
10     /// <para>
11     /// Represents the rational to decimal converter.
12     /// </para>
13     /// <para></para>
14     /// </summary>
15     /// <seealso cref="LinksDecoratorBase{TLinkAddress}"/>
16     /// <seealso cref="IConverter{TLinkAddress, decimal}"/>
17     public class RationalToDecimalConverter<TLinkAddress> : LinksDecoratorBase<TLinkAddress>,
18         ↪ IConverter<TLinkAddress, decimal>
19     {
20         where TLinkAddress: struct
21         {
22             /// <summary>
23             /// <para>
24             /// The raw number sequence to big integer converter.
25             /// </para>
26             /// <para></para>
27             /// </summary>
28             public readonly RawNumberSequenceToBigIntegerConverter<TLinkAddress>
29                 ↪ RawNumberSequenceToBigIntegerConverter;
30
31             /// <summary>
32             /// <para>
33             /// Initializes a new <see cref="RationalToDecimalConverter"/> instance.
34             /// </para>
35             /// <para></para>
36             /// </summary>
37             /// <param name="links">
38             /// <para>A links.</para>
39             /// <para></para>
40             /// </param>
41             /// <param name="rawNumberSequenceToBigIntegerConverter">
42             /// <para>A raw number sequence to big integer converter.</para>
43             /// <para></para>
44             /// </param>
45             public RationalToDecimalConverter(ILinks<TLinkAddress> links,
46                 ↪ RawNumberSequenceToBigIntegerConverter<TLinkAddress>
47                 ↪ rawNumberSequenceToBigIntegerConverter) : base(links)
48             {
49                 RawNumberSequenceToBigIntegerConverter = rawNumberSequenceToBigIntegerConverter;
50             }
51
52             /// <summary>
53             /// <para>
54             /// Converts the rational number.
55             /// </para>
56             /// <para></para>
57             /// </summary>
58             /// <param name="rationalNumber">
59             /// <para>The rational number.</para>
60             /// <para></para>
61             /// </param>
62             /// <returns>
63             /// <para>The decimal</para>
64             /// <para></para>
65             /// </returns>
66             public decimal Convert(TLinkAddress rationalNumber)
67             {
68                 var numerator = (decimal)RawNumberSequenceToBigIntegerConverter.Convert(_links.GetSo
69                 ↪ urce(rationalNumber));
70                 var denominator = (decimal)RawNumberSequenceToBigIntegerConverter.Convert(_links.Get
71                 ↪ Target(rationalNumber));
72                 return numerator / denominator;
73             }
74         }
75     }
76 }

```

```
67     }
68 }
```

### 1.33 ./csharp/Platform.Data.Doublets.Sequences/Numbers/Raw/BigIntegerToRawNumberSequenceConverter.cs

```
1 using System.Collections.Generic;
2 using System.Numerics;
3 using System.Runtime.InteropServices;
4 using Platform.Converters;
5 using Platform.Data.Doublets.Decorators;
6 using Platform.Numbers;
7 using Platform.Reflection;
8 using Platform.Unsafe;
9
10 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
11
12 namespace Platform.Data.Doublets.Numbers.Raw
13 {
14     /// <summary>
15     /// <para>
16     /// Represents the big integer to raw number sequence converter.
17     /// </para>
18     /// <para></para>
19     /// </summary>
20     /// <seealso cref="LinksDecoratorBase{TLinkAddress}"/>
21     /// <seealso cref="IConverter{BigInteger, TLinkAddress}"/>
22     public class BigIntegerToRawNumberSequenceConverter<TLinkAddress> :
23         ↳ LinksDecoratorBase<TLinkAddress>, IConverter<BigInteger, TLinkAddress>
24     where TLinkAddress : struct
25     {
26         /// <summary>
27         /// <para>
28         /// The max value.
29         /// </para>
30         /// <para></para>
31         /// </summary>
32         public static readonly TLinkAddress MaximumValue = NumericType<TLinkAddress>.MaxValue;
33         /// <summary>
34         /// <para>
35         /// The maximum value.
36         /// </para>
37         /// <para></para>
38         /// </summary>
39         public static readonly TLinkAddress BitMask = Bit.ShiftRight(MaximumValue, 1);
40         /// <summary>
41         /// <para>
42         /// The address to number converter.
43         /// </para>
44         /// <para></para>
45         /// </summary>
46         public readonly IConverter<TLinkAddress> AddressToNumberConverter;
47         /// <summary>
48         /// <para>
49         /// The list to sequence converter.
50         /// </para>
51         /// <para></para>
52         /// </summary>
53         public readonly IConverter<IList<TLinkAddress>?, TLinkAddress> ListToSequenceConverter;
54         /// <summary>
55         /// <para>
56         /// The negative number marker.
57         /// </para>
58         /// <para></para>
59         /// </summary>
60         public readonly TLinkAddress NegativeNumberMarker;
61
62         /// <summary>
63         /// <para>
64         /// Initializes a new <see cref="BigIntegerToRawNumberSequenceConverter"/> instance.
65         /// </para>
66         /// <para></para>
67         /// </summary>
68         /// <param name="links">
69         /// <para>A links.</para>
70         /// <para></para>
71         /// </param>
72         /// <param name="addressToNumberConverter">
73         /// <para>A address to number converter.</para>
74         /// <para></para>
75         /// </param>
```

```

75     /// <param name="listToSequenceConverter">
76     /// <para>A list to sequence converter.</para>
77     /// </para>
78     /// </param>
79     /// <param name="negativeNumberMarker">
80     /// <para>A negative number marker.</para>
81     /// </para>
82     /// </param>
83     public BigIntegerToRawNumberSequenceConverter(ILinks<TLinkAddress> links,
84         ↪ IConverter<TLinkAddress> addressToNumberConverter,
85         ↪ IConverter<IList<TLinkAddress>?, TLinkAddress> listToSequenceConverter, TLinkAddress
86         ↪ negativeNumberMarker) : base(links)
87     {
88         AddressToNumberConverter = addressToNumberConverter;
89         ListToSequenceConverter = listToSequenceConverter;
90         NegativeNumberMarker = negativeNumberMarker;
91     }
92     private List<TLinkAddress> GetRawNumberParts(BigInteger bigInteger)
93     {
94         List<TLinkAddress> rawNumbers = new();
95         BigInteger currentBigInt = bigInteger;
96         do
97         {
98             var bigIntBytes = currentBigInt.ToByteArray();
99             var bigIntWithBitMask = Bit.And(bigIntBytes.ToStructure<TLinkAddress>(),
100                 ↪ BitMask);
101             var rawNumber = AddressToNumberConverter.Convert(bigIntWithBitMask);
102             rawNumbers.Add(rawNumber);
103             currentBigInt >>= (NumericType<TLinkAddress>.BitsSize - 1);
104         }
105         while (currentBigInt > 0);
106         return rawNumbers;
107     }
108     /// <summary>
109     /// <para>
110     /// Converts the big integer.
111     /// </para>
112     /// <para></para>
113     /// </summary>
114     /// <param name="bigInteger">
115     /// <para>The big integer.</para>
116     /// <para></para>
117     /// </param>
118     /// <returns>
119     /// <para>The link</para>
120     /// <para></para>
121     /// </returns>
122     public TLinkAddress Convert(BigInteger bigInteger)
123     {
124         var sign = bigInteger.Sign;
125         var number = GetRawNumberParts(sign == -1 ? BigInteger.Negate(bigInteger) :
126             ↪ bigInteger);
127         var numberSequence = ListToSequenceConverter.Convert(number);
128         return sign == -1 ? _links.GetOrCreate(NegativeNumberMarker, numberSequence) :
129             ↪ numberSequence;
130     }
131 }
132 }

```

### 1.34 ./csharp/Platform.Data.Doublets.Sequences/Numbers/Raw/LongRawNumberSequenceToNumberConverter.c

```

1  using System.Runtime.CompilerServices;
2  using Platform.Collections.Stacks;
3  using Platform.Converters;
4  using Platform.Numbers;
5  using Platform.Reflection;
6  using Platform.Data.Doublets.Decorators;
7  using Platform.Data.Doublets.Sequences.Walkers;
8
9  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
10
11 namespace Platform.Data.Doublets.Numbers.Raw
12 {
13     /// <summary>
14     /// <para>
15     /// Represents the long raw number sequence to number converter.
16     /// </para>
17     /// <para></para>
18     /// </summary>

```

```

19  /// <seealso cref="LinksDecoratorBase{TSource}"/>
20  /// <seealso cref="IConverter{TSource, TTarget}"/>
21  public class LongRawNumberSequenceToNumberConverter<TSource, TTarget> :
    ↳ LinksDecoratorBase<TSource>, IConverter<TSource, TTarget>
22  {
23      private static readonly int _bitsPerRawNumber = NumericType<TSource>.BitsSize - 1;
24      private static readonly UncheckedConverter<TSource, TTarget> _sourceToTargetConverter =
    ↳ UncheckedConverter<TSource, TTarget>.Default;
25      private readonly IConverter<TSource> _numberToAddressConverter;
26
27      /// <summary>
28      /// <para>
29      /// Initializes a new <see cref="LongRawNumberSequenceToNumberConverter"/> instance.
30      /// </para>
31      /// <para></para>
32      /// </summary>
33      /// <param name="links">
34      /// <para>A links.</para>
35      /// <para></para>
36      /// </param>
37      /// <param name="numberToAddressConverter">
38      /// <para>A number to address converter.</para>
39      /// <para></para>
40      /// </param>
41      [MethodImpl(MethodImplOptions.AggressiveInlining)]
42      public LongRawNumberSequenceToNumberConverter(ILinks<TSource> links, IConverter<TSource>
    ↳ numberToAddressConverter) : base(links) => _numberToAddressConverter =
    ↳ numberToAddressConverter;
43
44      /// <summary>
45      /// <para>
46      /// Converts the source.
47      /// </para>
48      /// <para></para>
49      /// </summary>
50      /// <param name="source">
51      /// <para>The source.</para>
52      /// <para></para>
53      /// </param>
54      /// <returns>
55      /// <para>The target</para>
56      /// <para></para>
57      /// </returns>
58      [MethodImpl(MethodImplOptions.AggressiveInlining)]
59      public TTarget Convert(TSource source)
60      {
61          var constants = Links.Constants;
62          var externalReferencesRange = constants.ExternalReferencesRange;
63          if (externalReferencesRange.HasValue &&
    ↳ externalReferencesRange.Value.Contains(source))
64          {
65              return
    ↳ _sourceToTargetConverter.Convert(_numberToAddressConverter.Convert(source));
66          }
67          else
68          {
69              var pair = Links.GetLink(source);
70              var walker = new LeftSequenceWalker<TSource>(Links, new DefaultStack<TSource>(),
    ↳ (link) => externalReferencesRange.HasValue &&
    ↳ externalReferencesRange.Value.Contains(link));
71              TTarget result = default;
72              foreach (var element in walker.Walk(source))
73              {
74                  result = Bit.Or(Bit.ShiftLeft(result, _bitsPerRawNumber), Convert(element));
75              }
76              return result;
77          }
78      }
79  }
80  }

```

### 1.35 ./csharp/Platform.Data.Doublets.Sequences/Numbers/Raw/NumberToLongRawNumberSequenceConverter.c

```

1  using System.Collections.Generic;
2  using System.Runtime.CompilerServices;
3  using Platform.Converters;
4  using Platform.Numbers;
5  using Platform.Reflection;
6  using Platform.Data.Doublets.Decorators;
7

```

```

8 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
9
10 namespace Platform.Data.Doublets.Numbers.Raw
11 {
12     /// <summary>
13     /// <para>
14     /// Represents the number to long raw number sequence converter.
15     /// </para>
16     /// <para></para>
17     /// </summary>
18     /// <seealso cref="LinksDecoratorBase{TTarget}"/>
19     /// <seealso cref="IConverter{TSource, TTarget}"/>
20     public class NumberToLongRawNumberSequenceConverter<TSource, TTarget> :
21         ↳ LinksDecoratorBase<TTarget>, IConverter<TSource, TTarget>
22     {
23         private static readonly Comparer<TSource> _comparer = Comparer<TSource>.Default;
24         private static readonly TSource _maximumValue = NumericType<TSource>.MaxValue;
25         private static readonly int _bitsPerRawNumber = NumericType<TTarget>.BitsSize - 1;
26         private static readonly TSource _bitMask = Bit.ShiftRight(_maximumValue,
27             ↳ NumericType<TTarget>.BitsSize + 1);
28         private static readonly TSource _maximumConvertibleAddress = CheckedConverter<TTarget,
29             ↳ TSource>.Default.Convert(Arithmetic.Decrement(Hybrid<TTarget>.ExternalZero));
30         private static readonly UncheckedConverter<TSource, TTarget> _sourceToTargetConverter =
31             ↳ UncheckedConverter<TSource, TTarget>.Default;
32         private readonly IConverter<TTarget> _addressToNumberConverter;
33
34         /// <summary>
35         /// <para>
36         /// Initializes a new <see cref="NumberToLongRawNumberSequenceConverter"/> instance.
37         /// </para>
38         /// <para></para>
39         /// </summary>
40         /// <param name="links">
41         /// <para>A links.</para>
42         /// <para></para>
43         /// </param>
44         /// <param name="addressToNumberConverter">
45         /// <para>A address to number converter.</para>
46         /// <para></para>
47         /// </param>
48         [MethodImpl(MethodImplOptions.AggressiveInlining)]
49         public NumberToLongRawNumberSequenceConverter(ILinks<TTarget> links, IConverter<TTarget>
50             ↳ addressToNumberConverter) : base(links) => _addressToNumberConverter =
51             ↳ addressToNumberConverter;
52
53         /// <summary>
54         /// <para>
55         /// Converts the source.
56         /// </para>
57         /// <para></para>
58         /// </summary>
59         /// <param name="source">
60         /// <para>The source.</para>
61         /// <para></para>
62         /// </param>
63         /// <returns>
64         /// <para>The target</para>
65         /// <para></para>
66         /// </returns>
67         [MethodImpl(MethodImplOptions.AggressiveInlining)]
68         public TTarget Convert(TSource source)
69         {
70             if (_comparer.Compare(source, _maximumConvertibleAddress) > 0)
71             {
72                 var numberPart = Bit.And(source, _bitMask);
73                 var convertedNumber = _addressToNumberConverter.Convert(_sourceToTargetConverter
74                     ↳ .Convert(numberPart));
75                 return Links.GetOrCreate(convertedNumber, Convert(Bit.ShiftRight(source,
76                     ↳ _bitsPerRawNumber)));
77             }
78             else
79             {
80                 return
81                     ↳ _addressToNumberConverter.Convert(_sourceToTargetConverter.Convert(source));
82             }
83         }
84     }
85 }

```

## 1.36 ./csharp/Platform.Data.Doublets.Sequences/Numbers/Raw/RawNumberSequenceToBigIntegerConverter.cs

```

1  using System;
2  using System.Collections.Generic;
3  using System.Numerics;
4  using Platform.Collections.Stacks;
5  using Platform.Converters;
6  using Platform.Data.Doublets.Decorators;
7  using Platform.Data.Doublets.Sequences.Walkers;
8  using Platform.Reflection;
9  using Platform.Unsafe;
10
11 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
12
13 namespace Platform.Data.Doublets.Numbers.Raw
14 {
15     /// <summary>
16     /// <para>
17     /// Represents the raw number sequence to big integer converter.
18     /// </para>
19     /// <para></para>
20     /// </summary>
21     /// <seealso cref="LinksDecoratorBase{TLinkAddress}"/>
22     /// <seealso cref="IConverter{TLinkAddress, BigInteger}"/>
23     public class RawNumberSequenceToBigIntegerConverter<TLinkAddress> :
24         ↳ LinksDecoratorBase<TLinkAddress>, IConverter<TLinkAddress, BigInteger>
25     {
26         where TLinkAddress : struct
27     {
28         /// <summary>
29         /// <para>
30         /// The default.
31         /// </para>
32         /// <para></para>
33         /// </summary>
34         public readonly EqualityComparer<TLinkAddress> EqualityComparer =
35             ↳ EqualityComparer<TLinkAddress>.Default;
36         /// <summary>
37         /// <para>
38         /// The number to address converter.
39         /// </para>
40         /// <para></para>
41         /// </summary>
42         public readonly IConverter<TLinkAddress, TLinkAddress> NumberToAddressConverter;
43         /// <summary>
44         /// <para>
45         /// The left sequence walker.
46         /// </para>
47         /// <para></para>
48         /// </summary>
49         public readonly LeftSequenceWalker<TLinkAddress> LeftSequenceWalker;
50         /// <summary>
51         /// <para>
52         /// The negative number marker.
53         /// </para>
54         /// <para></para>
55         /// </summary>
56         public readonly TLinkAddress NegativeNumberMarker;
57         /// <summary>
58         /// <para>
59         /// Initializes a new <see cref="RawNumberSequenceToBigIntegerConverter"/> instance.
60         /// </para>
61         /// <para></para>
62         /// </summary>
63         /// <param name="links">
64         /// <para>A links.</para>
65         /// <para></para>
66         /// </param>
67         /// <param name="numberToAddressConverter">
68         /// <para>A number to address converter.</para>
69         /// <para></para>
70         /// </param>
71         /// <param name="negativeNumberMarker">
72         /// <para>A negative number marker.</para>
73         /// <para></para>
74         /// </param>
75         public RawNumberSequenceToBigIntegerConverter(ILinks<TLinkAddress> links,
76             ↳ IConverter<TLinkAddress, TLinkAddress> numberToAddressConverter, TLinkAddress
77             ↳ negativeNumberMarker) : base(links)
78     {

```



```

75     NumberToAddressConverter = numberToAddressConverter;
76     LeftSequenceWalker = new(links, new DefaultStack<TLinkAddress>());
77     NegativeNumberMarker = negativeNumberMarker;
78 }
79
80 /// <summary>
81 /// <para>
82 /// Converts the big integer.
83 /// </para>
84 /// <para></para>
85 /// </summary>
86 /// <param name="bigInteger">
87 /// <para>The big integer.</para>
88 /// <para></para>
89 /// </param>
90 /// <exception cref="Exception">
91 /// <para>Raw number sequence cannot be empty.</para>
92 /// <para></para>
93 /// </exception>
94 /// <returns>
95 /// <para>The big integer</para>
96 /// <para></para>
97 /// </returns>
98 public BigInteger Convert(TLinkAddress bigInteger)
99 {
100     var sign = 1;
101     var bigIntegerSequence = bigInteger;
102     if (EqualityComparer.Equals(_links.GetSource(bigIntegerSequence),
103         ↪ NegativeNumberMarker))
104     {
105         sign = -1;
106         bigIntegerSequence = _links.GetTarget(bigInteger);
107     }
108     using var enumerator = LeftSequenceWalker.Walk(bigIntegerSequence).GetEnumerator();
109     if (!enumerator.MoveNext())
110     {
111         throw new Exception("Raw number sequence cannot be empty.");
112     }
113     var nextPart = NumberToAddressConverter.Convert(enumerator.Current);
114     BigInteger currentBigInt = new(nextPart.ToBytes());
115     while (enumerator.MoveNext())
116     {
117         currentBigInt <= (NumericType<TLinkAddress>.BitsSize - 1);
118         nextPart = NumberToAddressConverter.Convert(enumerator.Current);
119         currentBigInt |= new BigInteger(nextPart.ToBytes());
120     }
121     return sign == -1 ? BigInteger.Negate(currentBigInt) : currentBigInt;
122 }
123 }

```

### 1.37 ./csharp/Platform.Data.Doublets.Sequences/Numbers/Unary/AddressToUnaryNumberConverter.cs

```

1  using System.Collections.Generic;
2  using Platform.Reflection;
3  using Platform.Converters;
4  using Platform.Numbers;
5  using System.Runtime.CompilerServices;
6
7  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
8
9  namespace Platform.Data.Doublets.Numbers.Unary
10 {
11     /// <summary>
12     /// <para>
13     /// Represents the address to unary number converter.
14     /// </para>
15     /// <para></para>
16     /// </summary>
17     /// <seealso cref="LinksOperatorBase{TLinkAddress}"/>
18     /// <seealso cref="IConverter{TLinkAddress}"/>
19     public class AddressToUnaryNumberConverter<TLinkAddress> : LinksOperatorBase<TLinkAddress>,
20         ↪ IConverter<TLinkAddress>
21     {
22         private static readonly EqualityComparer<TLinkAddress> _equalityComparer =
23             ↪ EqualityComparer<TLinkAddress>.Default;
24         private static readonly TLinkAddress _zero = default;
25         private static readonly TLinkAddress _one = Arithmetic.Increment(_zero);
26         private readonly IConverter<int, TLinkAddress> _powerOf2ToUnaryNumberConverter;

```

```

26     /// <summary>
27     /// <para>
28     /// Initializes a new <see cref="AddressToUnaryNumberConverter"/> instance.
29     /// </para>
30     /// <para></para>
31     /// </summary>
32     /// <param name="links">
33     /// <para>A links.</para>
34     /// <para></para>
35     /// </param>
36     /// <param name="powerOf2ToUnaryNumberConverter">
37     /// <para>A power of 2 to unary number converter.</para>
38     /// <para></para>
39     /// </param>
40     [MethodImpl(MethodImplOptions.AggressiveInlining)]
41     public AddressToUnaryNumberConverter(ILinks<TLinkAddress> links, IConverter<int,
42     ↪ TLinkAddress> powerOf2ToUnaryNumberConverter) : base(links) =>
43     ↪ _powerOf2ToUnaryNumberConverter = powerOf2ToUnaryNumberConverter;
44
45     /// <summary>
46     /// <para>
47     /// Converts the number.
48     /// </para>
49     /// <para></para>
50     /// </summary>
51     /// <param name="number">
52     /// <para>The number.</para>
53     /// <para></para>
54     /// </param>
55     /// <returns>
56     /// <para>The target.</para>
57     /// <para></para>
58     /// </returns>
59     [MethodImpl(MethodImplOptions.AggressiveInlining)]
60     public TLinkAddress Convert(TLinkAddress number)
61     {
62         var links = _links;
63         var nullConstant = links.Constants.Null;
64         var target = nullConstant;
65         for (var i = 0; !_equalityComparer.Equals(number, _zero) && i <
66         ↪ NumericType<TLinkAddress>.BitsSize; i++)
67         {
68             if (_equalityComparer.Equals(Bit.And(number, _one), _one))
69             {
70                 target = _equalityComparer.Equals(target, nullConstant)
71                 ? _powerOf2ToUnaryNumberConverter.Convert(i)
72                 : links.GetOrCreate(_powerOf2ToUnaryNumberConverter.Convert(i), target);
73             }
74             number = Bit.ShiftRight(number, 1);
75         }
76         return target;
77     }
78 }

```

### 1.38 ./csharp/Platform.Data.Doublets.Sequences/Numbers/Unary/LinkToItsFrequencyNumberConverter.cs

```

1  using System;
2  using System.Collections.Generic;
3  using Platform.Interfaces;
4  using Platform.Converters;
5  using System.Runtime.CompilerServices;
6
7  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
8
9  namespace Platform.Data.Doublets.Numbers.Unary
10 {
11     /// <summary>
12     /// <para>
13     /// Represents the link to its frequency number converter.
14     /// </para>
15     /// <para></para>
16     /// </summary>
17     /// <seealso cref="LinksOperatorBase{TLinkAddress}"/>
18     /// <seealso cref="IConverter{Doublet{TLinkAddress}, TLinkAddress}"/>
19     public class LinkToItsFrequencyNumberConverter<TLinkAddress> :
20     ↪ LinksOperatorBase<TLinkAddress>, IConverter<Doublet<TLinkAddress>, TLinkAddress>
21     {
22         private static readonly EqualityComparer<TLinkAddress> _equalityComparer =
23         ↪ EqualityComparer<TLinkAddress>.Default;
24     }
25 }

```

```

22     private readonly IProperty<TLinkAddress, TLinkAddress> _frequencyPropertyOperator;
23     private readonly IConverter<TLinkAddress> _unaryNumberToAddressConverter;
24
25     /// <summary>
26     /// <para>
27     /// Initializes a new <see cref="LinkToItsFrequencyNumberConveter"/> instance.
28     /// </para>
29     /// <para></para>
30     /// </summary>
31     /// <param name="links">
32     /// <para>A links.</para>
33     /// <para></para>
34     /// </param>
35     /// <param name="frequencyPropertyOperator">
36     /// <para>A frequency property operator.</para>
37     /// <para></para>
38     /// </param>
39     /// <param name="unaryNumberToAddressConverter">
40     /// <para>A unary number to address converter.</para>
41     /// <para></para>
42     /// </param>
43     [MethodImpl(MethodImplOptions.AggressiveInlining)]
44     public LinkToItsFrequencyNumberConveter(
45         ILinks<TLinkAddress> links,
46         IProperty<TLinkAddress, TLinkAddress> frequencyPropertyOperator,
47         IConverter<TLinkAddress> unaryNumberToAddressConverter)
48         : base(links)
49     {
50         _frequencyPropertyOperator = frequencyPropertyOperator;
51         _unaryNumberToAddressConverter = unaryNumberToAddressConverter;
52     }
53
54     /// <summary>
55     /// <para>
56     /// Converts the doublet.
57     /// </para>
58     /// <para></para>
59     /// </summary>
60     /// <param name="doublet">
61     /// <para>The doublet.</para>
62     /// <para></para>
63     /// </param>
64     /// <exception cref="ArgumentException">
65     /// <para>Link ({doublet}) not found. </para>
66     /// <para></para>
67     /// </exception>
68     /// <returns>
69     /// <para>The link</para>
70     /// <para></para>
71     /// </returns>
72     [MethodImpl(MethodImplOptions.AggressiveInlining)]
73     public TLinkAddress Convert(Doublet<TLinkAddress> doublet)
74     {
75         var links = _links;
76         var link = links.SearchOrDefault(doublet.Source, doublet.Target);
77         if (_equalityComparer.Equals(link, default))
78         {
79             throw new ArgumentException($"Link ({doublet}) not found.", nameof(doublet));
80         }
81         var frequency = _frequencyPropertyOperator.Get(link);
82         if (_equalityComparer.Equals(frequency, default))
83         {
84             return default;
85         }
86         var frequencyNumber = links.GetSource(frequency);
87         return _unaryNumberToAddressConverter.Convert(frequencyNumber);
88     }
89 }
90 }

```

### 1.39 ./csharp/Platform.Data.Doublets.Sequences/Numbers/Unary/PowerOf2ToUnaryNumberConverter.cs

```

1 using System.Collections.Generic;
2 using Platform.Exceptions;
3 using Platform.Ranges;
4 using Platform.Converters;
5 using System.Runtime.CompilerServices;
6
7 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
8

```

```

9 namespace Platform.Data.Doublets.Numbers.Unary
10 {
11     /// <summary>
12     /// <para>
13     /// Represents the power of to unary number converter.
14     /// </para>
15     /// <para></para>
16     /// </summary>
17     /// <seealso cref="LinksOperatorBase{TLinkAddress}"/>
18     /// <seealso cref="IConverter{int, TLinkAddress}"/>
19     public class PowerOf2ToUnaryNumberConverter<TLinkAddress> : LinksOperatorBase<TLinkAddress>,
20     ↪ IConverter<int, TLinkAddress>
21     {
22         private static readonly EqualityComparer<TLinkAddress> _equalityComparer =
23         ↪ EqualityComparer<TLinkAddress>.Default;
24         private readonly TLinkAddress[] _unaryNumberPowersOf2;
25
26         /// <summary>
27         /// <para>
28         /// Initializes a new <see cref="PowerOf2ToUnaryNumberConverter"/> instance.
29         /// </para>
30         /// <para></para>
31         /// </summary>
32         /// <param name="links">
33         /// <para>A links.</para>
34         /// <para></para>
35         /// </param>
36         /// <param name="one">
37         /// <para>A one.</para>
38         /// <para></para>
39         /// </param>
40         [MethodImpl(MethodImplOptions.AggressiveInlining)]
41         public PowerOf2ToUnaryNumberConverter(ILinks<TLinkAddress> links, TLinkAddress one) :
42         ↪ base(links)
43         {
44             _unaryNumberPowersOf2 = new TLinkAddress[64];
45             _unaryNumberPowersOf2[0] = one;
46         }
47
48         /// <summary>
49         /// <para>
50         /// Converts the power.
51         /// </para>
52         /// <para></para>
53         /// </summary>
54         /// <param name="power">
55         /// <para>The power.</para>
56         /// <para></para>
57         /// </param>
58         /// <returns>
59         /// <para>The power of.</para>
60         /// <para></para>
61         /// </returns>
62         [MethodImpl(MethodImplOptions.AggressiveInlining)]
63         public TLinkAddress Convert(int power)
64         {
65             Ensure.Always.ArgumentInRange(power, new Range<int>(0, _unaryNumberPowersOf2.Length
66             ↪ - 1), nameof(power));
67             if (!_equalityComparer.Equals(_unaryNumberPowersOf2[power], default))
68             {
69                 return _unaryNumberPowersOf2[power];
70             }
71             var previousPowerOf2 = Convert(power - 1);
72             var powerOf2 = _links.GetOrCreate(previousPowerOf2, previousPowerOf2);
73             _unaryNumberPowersOf2[power] = powerOf2;
74             return powerOf2;
75         }
76     }
77 }

```

#### 1.40 ./csharp/Platform.Data.Doublets.Sequences/Numbers/Unary/UnaryNumberToAddressAddOperationConverter

```

1 using System.Collections.Generic;
2 using System.Runtime.CompilerServices;
3 using Platform.Converters;
4 using Platform.Numbers;
5
6 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
7

```

```

8 namespace Platform.Data.Doublets.Numbers.Unary
9 {
10     /// <summary>
11     /// <para>
12     /// Represents the unary number to address add operation converter.
13     /// </para>
14     /// <para></para>
15     /// </summary>
16     /// <seealso cref="LinksOperatorBase{TLinkAddress}"/>
17     /// <seealso cref="IConverter{TLinkAddress}"/>
18     public class UnaryNumberToAddressAddOperationConverter<TLinkAddress> :
19         ↳ LinksOperatorBase<TLinkAddress>, IConverter<TLinkAddress>
20     {
21         private static readonly EqualityComparer<TLinkAddress> _equalityComparer =
22             ↳ EqualityComparer<TLinkAddress>.Default;
23         private static readonly UncheckedConverter<TLinkAddress, ulong>
24             ↳ _addressToUInt64Converter = UncheckedConverter<TLinkAddress, ulong>.Default;
25         private static readonly UncheckedConverter<ulong, TLinkAddress>
26             ↳ _uInt64ToAddressConverter = UncheckedConverter<ulong, TLinkAddress>.Default;
27         private static readonly TLinkAddress _zero = default;
28         private static readonly TLinkAddress _one = Arithmetic.Increment(_zero);
29         private readonly Dictionary<TLinkAddress, TLinkAddress> _unaryToUInt64;
30         private readonly TLinkAddress _unaryOne;
31
32         /// <summary>
33         /// <para>
34         /// Initializes a new <see cref="UnaryNumberToAddressAddOperationConverter"/> instance.
35         /// </para>
36         /// <para></para>
37         /// </summary>
38         /// <param name="links">
39         /// <para>A links.</para>
40         /// <para></para>
41         /// </param>
42         /// <param name="unaryOne">
43         /// <para>A unary one.</para>
44         /// <para></para>
45         /// </param>
46         [MethodImpl(MethodImplOptions.AggressiveInlining)]
47         public UnaryNumberToAddressAddOperationConverter(ILinks<TLinkAddress> links,
48             ↳ TLinkAddress unaryOne)
49             : base(links)
50         {
51             _unaryOne = unaryOne;
52             _unaryToUInt64 = CreateUnaryToUInt64Dictionary(links, unaryOne);
53         }
54
55         /// <summary>
56         /// <para>
57         /// Converts the unary number.
58         /// </para>
59         /// <para></para>
60         /// </summary>
61         /// <param name="unaryNumber">
62         /// <para>The unary number.</para>
63         /// <para></para>
64         /// </param>
65         /// <returns>
66         /// <para>The link</para>
67         /// <para></para>
68         /// </returns>
69         [MethodImpl(MethodImplOptions.AggressiveInlining)]
70         public TLinkAddress Convert(TLinkAddress unaryNumber)
71         {
72             if (_equalityComparer.Equals(unaryNumber, default))
73             {
74                 return default;
75             }
76             if (_equalityComparer.Equals(unaryNumber, _unaryOne))
77             {
78                 return _one;
79             }
80             var links = _links;
81             var source = links.GetSource(unaryNumber);
82             var target = links.GetTarget(unaryNumber);
83             if (_equalityComparer.Equals(source, target))
84             {
85                 return _unaryToUInt64[unaryNumber];
86             }
87         }
88     }
89 }

```

```

82     else
83     {
84         var result = _unaryToUInt64[source];
85         TLinkAddress lastValue;
86         while (!_unaryToUInt64.TryGetValue(target, out lastValue))
87         {
88             source = links.GetSource(target);
89             result = Arithmetic<TLinkAddress>.Add(result, _unaryToUInt64[source]);
90             target = links.GetTarget(target);
91         }
92         result = Arithmetic<TLinkAddress>.Add(result, lastValue);
93         return result;
94     }
95 }
96 [MethodImpl(MethodImplOptions.AggressiveInlining)]
97 private static Dictionary<TLinkAddress, TLinkAddress>
98 ↪ CreateUnaryToUInt64Dictionary(ILinks<TLinkAddress> links, TLinkAddress unaryOne)
99 {
100     var unaryToUInt64 = new Dictionary<TLinkAddress, TLinkAddress>
101     {
102         { unaryOne, _one }
103     };
104     var unary = unaryOne;
105     var number = _one;
106     for (var i = 1; i < 64; i++)
107     {
108         unary = links.GetOrCreate(unary, unary);
109         number = Double(number);
110         unaryToUInt64.Add(unary, number);
111     }
112     return unaryToUInt64;
113 }
114 [MethodImpl(MethodImplOptions.AggressiveInlining)]
115 private static TLinkAddress Double(TLinkAddress number) =>
116 ↪ _uInt64ToAddressConverter.Convert(_addressToUInt64Converter.Convert(number) * 2UL);
117 }

```

## 1.41 ./csharp/Platform.Data.Doublets.Sequences/Numbers/Unary/UnaryNumberToAddressOrOperationConverter

```

1 using System.Collections.Generic;
2 using System.Runtime.CompilerServices;
3 using Platform.Reflection;
4 using Platform.Converters;
5 using Platform.Numbers;
6
7 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
8
9 namespace Platform.Data.Doublets.Numbers.Unary
10 {
11     /// <summary>
12     /// <para>
13     /// Represents the unary number to address or operation converter.
14     /// </para>
15     /// <para></para>
16     /// </summary>
17     /// <seealso cref="LinksOperatorBase{TLinkAddress}"/>
18     /// <seealso cref="IConverter{TLinkAddress}"/>
19     public class UnaryNumberToAddressOrOperationConverter<TLinkAddress> :
20     ↪ LinksOperatorBase<TLinkAddress>, IConverter<TLinkAddress>
21     {
22         private static readonly EqualityComparer<TLinkAddress> _equalityComparer =
23         ↪ EqualityComparer<TLinkAddress>.Default;
24         private static readonly TLinkAddress _zero = default;
25         private static readonly TLinkAddress _one = Arithmetic.Increment(_zero);
26         private static readonly IDictionary<TLinkAddress, int> _unaryNumberPowerOf2Indicies;
27
28         /// <summary>
29         /// <para>
30         /// Initializes a new <see cref="UnaryNumberToAddressOrOperationConverter"/> instance.
31         /// </para>
32         /// <para></para>
33         /// </summary>
34         /// <param name="links">
35         /// <para>A links.</para>
36         /// </param>
37         /// <param name="powerOf2ToUnaryNumberConverter">
38         /// <para>A power of 2 to unary number converter.</para>
39         /// </param>

```

```

39     /// </param>
40     [MethodImpl(MethodImplOptions.AggressiveInlining)]
41     public UnaryNumberToAddressOrOperationConverter(ILinks<TLinkAddress> links,
42     ↪ IConverter<int, TLinkAddress> powerOf2ToUnaryNumberConverter) : base(links) =>
43     ↪ _unaryNumberPowerOf2Indicies =
44     ↪ CreateUnaryNumberPowerOf2IndiciesDictionary(powerOf2ToUnaryNumberConverter);
45
46     /// <summary>
47     /// <para>
48     /// Converts the source number.
49     /// </para>
50     /// <para></para>
51     /// </summary>
52     /// <param name="sourceNumber">
53     /// <para>The source number.</para>
54     /// <para></para>
55     /// </param>
56     /// <returns>
57     /// <para>The target.</para>
58     /// <para></para>
59     /// </returns>
60     [MethodImpl(MethodImplOptions.AggressiveInlining)]
61     public TLinkAddress Convert(TLinkAddress sourceNumber)
62     {
63         var links = _links;
64         var nullConstant = links.Constants.Null;
65         var source = sourceNumber;
66         var target = nullConstant;
67         if (!_equalityComparer.Equals(source, nullConstant))
68         {
69             while (true)
70             {
71                 if (_unaryNumberPowerOf2Indicies.TryGetValue(source, out int powerOf2Index))
72                 {
73                     SetBit(ref target, powerOf2Index);
74                     break;
75                 }
76                 else
77                 {
78                     powerOf2Index = _unaryNumberPowerOf2Indicies[links.GetSource(source)];
79                     SetBit(ref target, powerOf2Index);
80                     source = links.GetTarget(source);
81                 }
82             }
83             return target;
84         }
85     }
86     [MethodImpl(MethodImplOptions.AggressiveInlining)]
87     private static Dictionary<TLinkAddress, int>
88     ↪ CreateUnaryNumberPowerOf2IndiciesDictionary(IConverter<int, TLinkAddress>
89     ↪ powerOf2ToUnaryNumberConverter)
90     {
91         var unaryNumberPowerOf2Indicies = new Dictionary<TLinkAddress, int>();
92         for (int i = 0; i < NumericType<TLinkAddress>.BitsSize; i++)
93         {
94             unaryNumberPowerOf2Indicies.Add(powerOf2ToUnaryNumberConverter.Convert(i), i);
95         }
96         return unaryNumberPowerOf2Indicies;
97     }
98     [MethodImpl(MethodImplOptions.AggressiveInlining)]
99     private static void SetBit(ref TLinkAddress target, int powerOf2Index) => target =
100     ↪ Bit.Or(target, Bit.ShiftLeft(_one, powerOf2Index));
101 }

```

## 1.42 ./csharp/Platform.Data.Doublets.Sequences/Sequences.Experiments.cs

```

1  using System;
2  using System.Collections.Generic;
3  using System.Runtime.CompilerServices;
4  using System.Linq;
5  using System.Text;
6  using Platform.Collections;
7  using Platform.Collections.Sets;
8  using Platform.Collections.Stacks;
9  using Platform.Data.Exceptions;
10 using Platform.Data.Sequences;
11 using Platform.Data.Doublets.Sequences.Frequencies.Counters;
12 using Platform.Data.Doublets.Sequences.Walkers;
13 using LinkIndex = System.UInt64;

```

```

14 using Stack = System.Collections.Generic.Stack<ulong>;
15
16 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
17
18 namespace Platform.Data.Doublets.Sequences
19 {
20     /// <summary>
21     /// <para>
22     /// Represents the sequences.
23     /// </para>
24     /// <para></para>
25     /// </summary>
26     partial class Sequences
27     {
28         #region Create All Variants (Not Practical)
29
30         /// <remarks>
31         /// Number of links that is needed to generate all variants for
32         /// sequence of length N corresponds to https://oeis.org/A014143/list sequence.
33         /// </remarks>
34         [MethodImpl(MethodImplOptions.AggressiveInlining)]
35         public ulong[] CreateAllVariants2(ulong[] sequence)
36         {
37             return _sync.ExecuteWriteOperation(() =>
38             {
39                 if (sequence.IsNullOrEmpty())
40                 {
41                     return Array.Empty<ulong>();
42                 }
43                 Links.EnsureLinkExists(sequence);
44                 if (sequence.Length == 1)
45                 {
46                     return sequence;
47                 }
48                 return CreateAllVariants2Core(sequence, 0, (ulong)sequence.Length - 1);
49             });
50         }
51         [MethodImpl(MethodImplOptions.AggressiveInlining)]
52         private ulong[] CreateAllVariants2Core(ulong[] sequence, ulong startAt, ulong stopAt)
53         {
54             if ((stopAt - startAt) == 0)
55             {
56                 return new[] { sequence[startAt] };
57             }
58             if ((stopAt - startAt) == 1)
59             {
60                 return new[] { Links.Unsync.GetOrCreate(sequence[startAt], sequence[stopAt]) };
61             }
62             var variants = new ulong[Platform.Numbers.Math.Catalan(stopAt - startAt)];
63             var last = 0;
64             for (var splitter = startAt; splitter < stopAt; splitter++)
65             {
66                 var left = CreateAllVariants2Core(sequence, startAt, splitter);
67                 var right = CreateAllVariants2Core(sequence, splitter + 1, stopAt);
68                 for (var i = 0; i < left.Length; i++)
69                 {
70                     for (var j = 0; j < right.Length; j++)
71                     {
72                         var variant = Links.Unsync.GetOrCreate(left[i], right[j]);
73                         if (variant == Constants.Null)
74                         {
75                             throw new NotImplementedException("Creation cancellation is not
76                                 ↳ implemented.");
77                         }
78                         variants[last++] = variant;
79                     }
80                 }
81             }
82             return variants;
83         }
84         /// <summary>
85         /// <para>
86         /// Creates the all variants 1 using the specified sequence.
87         /// </para>
88         /// <para></para>
89         /// </summary>
90         /// <param name="sequence">

```



```

91  /// <para>The sequence.</para>
92  /// <para></para>
93  /// </param>
94  /// <returns>
95  /// <para>A list of ulong</para>
96  /// <para></para>
97  /// </returns>
98  [MethodImpl(MethodImplOptions.AggressiveInlining)]
99  public List<ulong> CreateAllVariants1(params ulong[] sequence)
100  {
101      return _sync.ExecuteWriteOperation(() =>
102      {
103          if (sequence.IsNullOrEmpty())
104          {
105              return new List<ulong>();
106          }
107          Links.Unsync.EnsureLinkExists(sequence);
108          if (sequence.Length == 1)
109          {
110              return new List<ulong> { sequence[0] };
111          }
112          var results = new
113              ↪ List<ulong>((int)Platform.Numbers.Math.Catalan((ulong)sequence.Length));
114          return CreateAllVariants1Core(sequence, results);
115      });
116  [MethodImpl(MethodImplOptions.AggressiveInlining)]
117  private List<ulong> CreateAllVariants1Core(ulong[] sequence, List<ulong> results)
118  {
119      if (sequence.Length == 2)
120      {
121          var link = Links.Unsync.GetOrCreate(sequence[0], sequence[1]);
122          if (link == Constants.Null)
123          {
124              throw new NotImplementedException("Creation cancellation is not
125              ↪ implemented.");
126          }
127          results.Add(link);
128          return results;
129      }
130      var innerSequenceLength = sequence.Length - 1;
131      var innerSequence = new ulong[innerSequenceLength];
132      for (var li = 0; li < innerSequenceLength; li++)
133      {
134          var link = Links.Unsync.GetOrCreate(sequence[li], sequence[li + 1]);
135          if (link == Constants.Null)
136          {
137              throw new NotImplementedException("Creation cancellation is not
138              ↪ implemented.");
139          }
140          for (var isi = 0; isi < li; isi++)
141          {
142              innerSequence[isi] = sequence[isi];
143          }
144          innerSequence[li] = link;
145          for (var isi = li + 1; isi < innerSequenceLength; isi++)
146          {
147              innerSequence[isi] = sequence[isi + 1];
148          }
149          CreateAllVariants1Core(innerSequence, results);
150      }
151      return results;
152  }
153  #endregion
154  /// <summary>
155  /// <para>
156  /// Eaches the 1 using the specified sequence.
157  /// </para>
158  /// <para></para>
159  /// </summary>
160  /// <param name="sequence">
161  /// <para>The sequence.</para>
162  /// <para></para>
163  /// </param>
164  /// <returns>
165  /// <para>The visited links.</para>

```

```

166 /// <para></para>
167 /// </returns>
168 [MethodImpl(MethodImplOptions.AggressiveInlining)]
169 public HashSet<ulong> Each1(params ulong[] sequence)
170 {
171     var visitedLinks = new HashSet<ulong>(); // Заменить на bitstring
172     Each1(link =>
173     {
174         if (!visitedLinks.Contains(link))
175         {
176             visitedLinks.Add(link); // изучить почему случаются повторы
177         }
178         return true;
179     }, sequence);
180     return visitedLinks;
181 }
182 [MethodImpl(MethodImplOptions.AggressiveInlining)]
183 private void Each1(Func<ulong, bool> handler, params ulong[] sequence)
184 {
185     if (sequence.Length == 2)
186     {
187         Links.Unsync.Each(sequence[0], sequence[1], handler);
188     }
189     else
190     {
191         var innerSequenceLength = sequence.Length - 1;
192         for (var li = 0; li < innerSequenceLength; li++)
193         {
194             var left = sequence[li];
195             var right = sequence[li + 1];
196             if (left == 0 && right == 0)
197             {
198                 continue;
199             }
200             var linkIndex = li;
201             ulong[] innerSequence = null;
202             Links.Unsync.Each(doublet =>
203             {
204                 if (innerSequence == null)
205                 {
206                     innerSequence = new ulong[innerSequenceLength];
207                     for (var isi = 0; isi < linkIndex; isi++)
208                     {
209                         innerSequence[isi] = sequence[isi];
210                     }
211                     for (var isi = linkIndex + 1; isi < innerSequenceLength; isi++)
212                     {
213                         innerSequence[isi] = sequence[isi + 1];
214                     }
215                 }
216                 innerSequence[linkIndex] = doublet[Constants.IndexPart];
217                 Each1(handler, innerSequence);
218                 return Constants.Continue;
219             }, Constants.Any, left, right);
220         }
221     }
222 }
223
224 /// <summary>
225 /// <para>
226 /// Eaches the part using the specified sequence.
227 /// </para>
228 /// <para></para>
229 /// </summary>
230 /// <param name="sequence">
231 /// <para>The sequence.</para>
232 /// <para></para>
233 /// </param>
234 /// </returns>
235 /// <para>The visited links.</para>
236 /// <para></para>
237 /// </returns>
238 [MethodImpl(MethodImplOptions.AggressiveInlining)]
239 public HashSet<ulong> EachPart(params ulong[] sequence)
240 {
241     var visitedLinks = new HashSet<ulong>(); // Заменить на bitstring
242     EachPartCore(link =>
243     {

```

```

244     var linkIndex = link[Constants.IndexPart];
245     if (!visitedLinks.Contains(linkIndex))
246     {
247         visitedLinks.Add(linkIndex); // изучить почему случаются повторы
248     }
249     return Constants.Continue;
250 }, sequence);
251 return visitedLinks;
252 }
253
254 /// <summary>
255 /// <para>
256 /// Eaches the part using the specified handler.
257 /// </para>
258 /// <para></para>
259 /// </summary>
260 /// <param name="handler">
261 /// <para>The handler.</para>
262 /// <para></para>
263 /// </param>
264 /// <param name="sequence">
265 /// <para>The sequence.</para>
266 /// <para></para>
267 /// </param>
268 [MethodImpl(MethodImplOptions.AggressiveInlining)]
269 public void EachPart(Func<IList<LinkIndex>, LinkIndex> handler, params ulong[] sequence)
270 {
271     var visitedLinks = new HashSet<ulong>(); // Заменить на bitstring
272     EachPartCore(link =>
273     {
274         var linkIndex = link[Constants.IndexPart];
275         if (!visitedLinks.Contains(linkIndex))
276         {
277             visitedLinks.Add(linkIndex); // изучить почему случаются повторы
278             return handler(new LinkAddress<LinkIndex>(linkIndex));
279         }
280         return Constants.Continue;
281     }, sequence);
282 }
283 [MethodImpl(MethodImplOptions.AggressiveInlining)]
284 private void EachPartCore(Func<IList<LinkIndex>, LinkIndex> handler, params ulong[]
285 ↪ sequence)
286 {
287     if (sequence.IsNullOrEmpty())
288     {
289         return;
290     }
291     Links.EnsureLinkIsAnyOrExists(sequence);
292     if (sequence.Length == 1)
293     {
294         var link = sequence[0];
295         if (link > 0)
296         {
297             handler(new LinkAddress<LinkIndex>(link));
298         }
299         else
300         {
301             Links.Each(Constants.Any, Constants.Any, handler);
302         }
303     }
304     else if (sequence.Length == 2)
305     {
306         //_links.Each(sequence[0], sequence[1], handler);
307         // o_|      x_o ...
308         // x_|      |___|
309         Links.Each(sequence[1], Constants.Any, doublet =>
310         {
311             var match = Links.SearchOrDefault(sequence[0], doublet);
312             if (match != Constants.Null)
313             {
314                 handler(new LinkAddress<LinkIndex>(match));
315             }
316             return true;
317         });
318         // |_x      ... x_o
319         // |_o      |___|
320         Links.Each(Constants.Any, sequence[0], doublet =>
321         {

```

```

321         var match = Links.SearchOrDefault(doublet, sequence[1]);
322         if (match != 0)
323         {
324             handler(new LinkAddress<LinkIndex>(match));
325         }
326         return true;
327     });
328     //      . _ x o _ .
329     //      | _ _ _ |
330     PartialStepRight(x => handler(x), sequence[0], sequence[1]);
331 }
332 else
333 {
334     throw new NotImplementedException();
335 }
336 }
337 [MethodImpl(MethodImplOptions.AggressiveInlining)]
338 private void PartialStepRight(Action<IList<LinkIndex>> handler, ulong left, ulong right)
339 {
340     Links.Unsync.Each(Constants.Any, left, doublet =>
341     {
342         StepRight(handler, doublet, right);
343         if (left != doublet)
344         {
345             PartialStepRight(handler, doublet, right);
346         }
347         return true;
348     });
349 }
350 [MethodImpl(MethodImplOptions.AggressiveInlining)]
351 private void StepRight(Action<IList<LinkIndex>> handler, ulong left, ulong right)
352 {
353     Links.Unsync.Each(left, Constants.Any, rightStep =>
354     {
355         TryStepRightUp(handler, right, rightStep);
356         return true;
357     });
358 }
359 [MethodImpl(MethodImplOptions.AggressiveInlining)]
360 private void TryStepRightUp(Action<IList<LinkIndex>> handler, ulong right, ulong
↪ stepFrom)
361 {
362     var upStep = stepFrom;
363     var firstSource = Links.Unsync.GetTarget(upStep);
364     while (firstSource != right && firstSource != upStep)
365     {
366         upStep = firstSource;
367         firstSource = Links.Unsync.GetSource(upStep);
368     }
369     if (firstSource == right)
370     {
371         handler(new LinkAddress<LinkIndex>(stepFrom));
372     }
373 }
374
375 // TODO: Test
376 [MethodImpl(MethodImplOptions.AggressiveInlining)]
377 private void PartialStepLeft(Action<IList<LinkIndex>> handler, ulong left, ulong right)
378 {
379     Links.Unsync.Each(right, Constants.Any, doublet =>
380     {
381         StepLeft(handler, left, doublet);
382         if (right != doublet)
383         {
384             PartialStepLeft(handler, left, doublet);
385         }
386         return true;
387     });
388 }
389 [MethodImpl(MethodImplOptions.AggressiveInlining)]
390 private void StepLeft(Action<IList<LinkIndex>> handler, ulong left, ulong right)
391 {
392     Links.Unsync.Each(Constants.Any, right, leftStep =>
393     {
394         TryStepLeftUp(handler, left, leftStep);
395         return true;
396     });
397 }

```

```

398 [MethodImpl(MethodImplOptions.AggressiveInlining)]
399 private void TryStepLeftUp(Action<IList<LinkIndex>> handler, ulong left, ulong stepFrom)
400 {
401     var upStep = stepFrom;
402     var firstTarget = Links.Unsync.GetSource(upStep);
403     while (firstTarget != left && firstTarget != upStep)
404     {
405         upStep = firstTarget;
406         firstTarget = Links.Unsync.GetTarget(upStep);
407     }
408     if (firstTarget == left)
409     {
410         handler(new LinkAddress<LinkIndex>(stepFrom));
411     }
412 }
413 [MethodImpl(MethodImplOptions.AggressiveInlining)]
414 private bool StartsWith(ulong sequence, ulong link)
415 {
416     var upStep = sequence;
417     var firstSource = Links.Unsync.GetSource(upStep);
418     while (firstSource != link && firstSource != upStep)
419     {
420         upStep = firstSource;
421         firstSource = Links.Unsync.GetSource(upStep);
422     }
423     return firstSource == link;
424 }
425 [MethodImpl(MethodImplOptions.AggressiveInlining)]
426 private bool EndsWith(ulong sequence, ulong link)
427 {
428     var upStep = sequence;
429     var lastTarget = Links.Unsync.GetTarget(upStep);
430     while (lastTarget != link && lastTarget != upStep)
431     {
432         upStep = lastTarget;
433         lastTarget = Links.Unsync.GetTarget(upStep);
434     }
435     return lastTarget == link;
436 }
437
438 /// <summary>
439 /// <para>
440 /// Gets the all matching sequences 0 using the specified sequence.
441 /// </para>
442 /// <para></para>
443 /// </summary>
444 /// <param name="sequence">
445 /// <para>The sequence.</para>
446 /// <para></para>
447 /// </param>
448 /// <returns>
449 /// <para>A list of ulong</para>
450 /// <para></para>
451 /// </returns>
452 [MethodImpl(MethodImplOptions.AggressiveInlining)]
453 public List<ulong> GetAllMatchingSequences0(params ulong[] sequence)
454 {
455     return _sync.ExecuteReadOperation(() =>
456     {
457         var results = new List<ulong>();
458         if (sequence.Length > 0)
459         {
460             Links.EnsureLinkExists(sequence);
461             var firstElement = sequence[0];
462             if (sequence.Length == 1)
463             {
464                 results.Add(firstElement);
465                 return results;
466             }
467             if (sequence.Length == 2)
468             {
469                 var doublet = Links.SearchOrDefault(firstElement, sequence[1]);
470                 if (doublet != Constants.Null)
471                 {
472                     results.Add(doublet);
473                 }
474                 return results;
475             }

```

```

476     var linksInSequence = new HashSet<ulong>(sequence);
477     void handler(IList<LinkIndex> result)
478     {
479         var resultIndex = result[Links.Constants.IndexPart];
480         var filterPosition = 0;
481         StopableSequenceWalker.WalkRight(resultIndex, Links.Unsync.GetSource,
482             ↪ Links.Unsync.GetTarget,
483             ↪ x => linksInSequence.Contains(x) || Links.Unsync.GetTarget(x) == x,
484             ↪ x =>
485             {
486                 if (filterPosition == sequence.Length)
487                 {
488                     filterPosition = -2; // Длиннее чем нужно
489                     return false;
490                 }
491                 if (x != sequence[filterPosition])
492                 {
493                     filterPosition = -1;
494                     return false; // Начинается иначе
495                 }
496                 filterPosition++;
497                 return true;
498             });
499         if (filterPosition == sequence.Length)
500         {
501             results.Add(resultIndex);
502         }
503     }
504     if (sequence.Length >= 2)
505     {
506         StepRight(handler, sequence[0], sequence[1]);
507     }
508     var last = sequence.Length - 2;
509     for (var i = 1; i < last; i++)
510     {
511         PartialStepRight(handler, sequence[i], sequence[i + 1]);
512     }
513     if (sequence.Length >= 3)
514     {
515         StepLeft(handler, sequence[sequence.Length - 2],
516             ↪ sequence[sequence.Length - 1]);
517     }
518     }
519     return results;
520 }
521 }
522
523 /// <summary>
524 /// <para>
525 /// Gets the all matching sequences 1 using the specified sequence.
526 /// </para>
527 /// <para></para>
528 /// </summary>
529 /// <param name="sequence">
530 /// <para>The sequence.</para>
531 /// <para></para>
532 /// </param>
533 /// <returns>
534 /// <para>A hash set of ulong</para>
535 /// <para></para>
536 /// </returns>
537 [MethodImpl(MethodImplOptions.AggressiveInlining)]
538 public HashSet<ulong> GetAllMatchingSequences1(params ulong[] sequence)
539 {
540     return _sync.ExecuteReadOperation(() =>
541     {
542         var results = new HashSet<ulong>();
543         if (sequence.Length > 0)
544         {
545             Links.EnsureLinkExists(sequence);
546             var firstElement = sequence[0];
547             if (sequence.Length == 1)
548             {
549                 results.Add(firstElement);
550                 return results;
551             }
552             if (sequence.Length == 2)

```

```

551         {
552             var doublet = Links.SearchOrDefault(firstElement, sequence[1]);
553             if (doublet != Constants.Null)
554             {
555                 results.Add(doublet);
556             }
557             return results;
558         }
559         var matcher = new Matcher(this, sequence, results, null);
560         if (sequence.Length >= 2)
561         {
562             StepRight(matcher.AddFullMatchedToResults, sequence[0], sequence[1]);
563         }
564         var last = sequence.Length - 2;
565         for (var i = 1; i < last; i++)
566         {
567             PartialStepRight(matcher.AddFullMatchedToResults, sequence[i],
568                 ↪ sequence[i + 1]);
569         }
570         if (sequence.Length >= 3)
571         {
572             StepLeft(matcher.AddFullMatchedToResults, sequence[sequence.Length - 2],
573                 ↪ sequence[sequence.Length - 1]);
574         }
575         return results;
576     });
577 }
578
579 /// <summary>
580 /// <para>
581 /// The max sequence format size.
582 /// </para>
583 /// </summary>
584 public const int MaxSequenceFormatSize = 200;
585
586 /// <summary>
587 /// <para>
588 /// Formats the sequence using the specified sequence link.
589 /// </para>
590 /// <para></para>
591 /// </summary>
592 /// <param name="sequenceLink">
593 /// <para>The sequence link.</para>
594 /// <para></para>
595 /// </param>
596 /// <param name="knownElements">
597 /// <para>The known elements.</para>
598 /// <para></para>
599 /// </param>
600 /// <returns>
601 /// <para>The string</para>
602 /// <para></para>
603 /// </returns>
604 [MethodImpl(MethodImplOptions.AggressiveInlining)]
605 public string FormatSequence(LinkIndex sequenceLink, params LinkIndex[] knownElements)
606     ↪ => FormatSequence(sequenceLink, (sb, x) => sb.Append(x), true, knownElements);
607
608 /// <summary>
609 /// <para>
610 /// Formats the sequence using the specified sequence link.
611 /// </para>
612 /// <para></para>
613 /// </summary>
614 /// <param name="sequenceLink">
615 /// <para>The sequence link.</para>
616 /// <para></para>
617 /// </param>
618 /// <param name="elementToString">
619 /// <para>The element to string.</para>
620 /// <para></para>
621 /// </param>
622 /// <param name="insertComma">
623 /// <para>The insert comma.</para>
624 /// <para></para>
625 /// </param>
626 /// <param name="knownElements">

```

```

626 /// <para>The known elements.</para>
627 /// <para></para>
628 /// </param>
629 /// <returns>
630 /// <para>The string</para>
631 /// <para></para>
632 /// </returns>
633 [MethodImpl(MethodImplOptions.AggressiveInlining)]
634 public string FormatSequence(LinkIndex sequenceLink, Action<StringBuilder, LinkIndex>
    ↳ elementToString, bool insertComma, params LinkIndex[] knownElements) =>
    ↳ Links.SyncRoot.ExecuteReadOperation(() => FormatSequence(Links.Unsync, sequenceLink,
    ↳ elementToString, insertComma, knownElements));
635 [MethodImpl(MethodImplOptions.AggressiveInlining)]
636 private string FormatSequence(ILinks<LinkIndex> links, LinkIndex sequenceLink,
    ↳ Action<StringBuilder, LinkIndex> elementToString, bool insertComma, params
    ↳ LinkIndex[] knownElements)
637 {
638     var linksInSequence = new HashSet<ulong>(knownElements);
639     //var entered = new HashSet<ulong>();
640     var sb = new StringBuilder();
641     sb.Append('{');
642     if (links.Exists(sequenceLink))
643     {
644         StopableSequenceWalker.WalkRight(sequenceLink, links.GetSource, links.GetTarget,
645             x => linksInSequence.Contains(x) || links.IsPartialPoint(x), element => //
        ↳ entered.AddAndReturnVoid, x => { }, entered.DoNotContains
646         {
647             if (insertComma && sb.Length > 1)
648             {
649                 sb.Append(',');
650             }
651             //if (entered.Contains(element))
652             //{
653             //    sb.Append('{');
654             //    elementToString(sb, element);
655             //    sb.Append('}');
656             //}
657             //else
658             elementToString(sb, element);
659             if (sb.Length < MaxSequenceFormatSize)
660             {
661                 return true;
662             }
663             sb.Append(insertComma ? ", ..." : "...");
664             return false;
665         });
666     }
667     sb.Append('}');
668     return sb.ToString();
669 }
670
671 /// <summary>
672 /// <para>
673 /// Safes the format sequence using the specified sequence link.
674 /// </para>
675 /// <para></para>
676 /// </summary>
677 /// <param name="sequenceLink">
678 /// <para>The sequence link.</para>
679 /// <para></para>
680 /// </param>
681 /// <param name="knownElements">
682 /// <para>The known elements.</para>
683 /// <para></para>
684 /// </param>
685 /// <returns>
686 /// <para>The string</para>
687 /// <para></para>
688 /// </returns>
689 [MethodImpl(MethodImplOptions.AggressiveInlining)]
690 public string SafeFormatSequence(LinkIndex sequenceLink, params LinkIndex[]
    ↳ knownElements) => SafeFormatSequence(sequenceLink, (sb, x) => sb.Append(x), true,
    ↳ knownElements);
691
692 /// <summary>
693 /// <para>
694 /// Safes the format sequence using the specified sequence link.

```



```

695     /// </para>
696     /// <para></para>
697     /// </summary>
698     /// <param name="sequenceLink">
699     /// <para>The sequence link.</para>
700     /// <para></para>
701     /// </param>
702     /// <param name="elementToString">
703     /// <para>The element to string.</para>
704     /// <para></para>
705     /// </param>
706     /// <param name="insertComma">
707     /// <para>The insert comma.</para>
708     /// <para></para>
709     /// </param>
710     /// <param name="knownElements">
711     /// <para>The known elements.</para>
712     /// <para></para>
713     /// </param>
714     /// <returns>
715     /// <para>The string</para>
716     /// <para></para>
717     /// </returns>
718     [MethodImpl(MethodImplOptions.AggressiveInlining)]
719     public string SafeFormatSequence(LinkIndex sequenceLink, Action<StringBuilder,
        ↳ LinkIndex> elementToString, bool insertComma, params LinkIndex[] knownElements) =>
        ↳ Links.SyncRoot.ExecuteReadOperation(() => SafeFormatSequence(Links.Unsync,
        ↳ sequenceLink, elementToString, insertComma, knownElements));
720     [MethodImpl(MethodImplOptions.AggressiveInlining)]
721     private string SafeFormatSequence(ILinks<LinkIndex> links, LinkIndex sequenceLink,
        ↳ Action<StringBuilder, LinkIndex> elementToString, bool insertComma, params
        ↳ LinkIndex[] knownElements)
722     {
723         var linksInSequence = new HashSet<ulong>(knownElements);
724         var entered = new HashSet<ulong>();
725         var sb = new StringBuilder();
726         sb.Append('{');
727         if (links.Exists(sequenceLink))
728         {
729             StopableSequenceWalker.WalkRight(sequenceLink, links.GetSource, links.GetTarget,
730                 x => linksInSequence.Contains(x) || links.IsFullPoint(x),
731                 ↳ entered.AddAndReturnVoid, x => { }, entered.DoNotContains, element =>
732                 {
733                     if (insertComma && sb.Length > 1)
734                     {
735                         sb.Append(',');
736                     }
737                     if (entered.Contains(element))
738                     {
739                         sb.Append('{');
740                         elementToString(sb, element);
741                         sb.Append('}');
742                     }
743                     else
744                     {
745                         elementToString(sb, element);
746                     }
747                     if (sb.Length < MaxSequenceFormatSize)
748                     {
749                         return true;
750                     }
751                     sb.Append(insertComma ? ", ..." : "...");
752                     return false;
753                 }
754             });
755         sb.Append('}');
756         return sb.ToString();
757     }
758     /// <summary>
759     /// <para>
760     /// Gets the all partially matching sequences 0 using the specified sequence.
761     /// </para>
762     /// <para></para>
763     /// </summary>
764     /// <param name="sequence">
765     /// <para>The sequence.</para>
766     /// <para></para>

```

```

767 /// </param>
768 /// <returns>
769 /// <para>A list of ulong</para>
770 /// <para></para>
771 /// </returns>
772 [MethodImpl(MethodImplOptions.AggressiveInlining)]
773 public List<ulong> GetAllPartiallyMatchingSequences0(params ulong[] sequence)
774 {
775     return _sync.ExecuteReadOperation(() =>
776     {
777         if (sequence.Length > 0)
778         {
779             Links.EnsureLinkExists(sequence);
780             var results = new HashSet<ulong>();
781             for (var i = 0; i < sequence.Length; i++)
782             {
783                 AllUsagesCore(sequence[i], results);
784             }
785             var filteredResults = new List<ulong>();
786             var linksInSequence = new HashSet<ulong>(sequence);
787             foreach (var result in results)
788             {
789                 var filterPosition = -1;
790                 StopableSequenceWalker.WalkRight(result, Links.Unsync.GetSource,
791                 ↪ Links.Unsync.GetTarget,
792                 ↪ x => linksInSequence.Contains(x) || Links.Unsync.GetTarget(x) == x,
793                 ↪ x =>
794                 {
795                     if (filterPosition == (sequence.Length - 1))
796                     {
797                         return false;
798                     }
799                     if (filterPosition >= 0)
800                     {
801                         if (x == sequence[filterPosition + 1])
802                         {
803                             filterPosition++;
804                         }
805                         else
806                         {
807                             return false;
808                         }
809                     }
810                     if (filterPosition < 0)
811                     {
812                         if (x == sequence[0])
813                         {
814                             filterPosition = 0;
815                         }
816                     }
817                     return true;
818                 });
819                 if (filterPosition == (sequence.Length - 1))
820                 {
821                     filteredResults.Add(result);
822                 }
823             }
824             return filteredResults;
825         }
826         return new List<ulong>();
827     });
828 }
829
830 /// <summary>
831 /// <para>
832 /// Gets the all partially matching sequences 1 using the specified sequence.
833 /// </para>
834 /// <para></para>
835 /// </summary>
836 /// <param name="sequence">
837 /// <para>The sequence.</para>
838 /// <para></para>
839 /// </param>
840 /// <returns>
841 /// <para>A hash set of ulong</para>
842 /// <para></para>
843 /// </returns>
844 [MethodImpl(MethodImplOptions.AggressiveInlining)]

```

```

843 public HashSet<ulong> GetAllPartiallyMatchingSequences1(params ulong[] sequence)
844 {
845     return _sync.ExecuteReadOperation(() =>
846     {
847         if (sequence.Length > 0)
848         {
849             Links.EnsureLinkExists(sequence);
850             var results = new HashSet<ulong>();
851             for (var i = 0; i < sequence.Length; i++)
852             {
853                 AllUsagesCore(sequence[i], results);
854             }
855             var filteredResults = new HashSet<ulong>();
856             var matcher = new Matcher(this, sequence, filteredResults, null);
857             matcher.AddAllPartialMatchedToResults(results);
858             return filteredResults;
859         }
860         return new HashSet<ulong>();
861     });
862 }
863
864 /// <summary>
865 /// <para>
866 /// Determines whether this instance get all partially matching sequences 2.
867 /// </para>
868 /// <para></para>
869 /// </summary>
870 /// <param name="handler">
871 /// <para>The handler.</para>
872 /// <para></para>
873 /// </param>
874 /// <param name="sequence">
875 /// <para>The sequence.</para>
876 /// <para></para>
877 /// </param>
878 /// <returns>
879 /// <para>The bool</para>
880 /// <para></para>
881 /// </returns>
882 [MethodImpl(MethodImplOptions.AggressiveInlining)]
883 public bool GetAllPartiallyMatchingSequences2(Func<IList<LinkIndex>, LinkIndex> handler,
884 ↪ params ulong[] sequence)
885 {
886     return _sync.ExecuteReadOperation(() =>
887     {
888         if (sequence.Length > 0)
889         {
890             Links.EnsureLinkExists(sequence);
891
892             var results = new HashSet<ulong>();
893             var filteredResults = new HashSet<ulong>();
894             var matcher = new Matcher(this, sequence, filteredResults, handler);
895             for (var i = 0; i < sequence.Length; i++)
896             {
897                 if (!AllUsagesCore1(sequence[i], results, matcher.HandlePartialMatched))
898                 {
899                     return false;
900                 }
901             }
902             return true;
903         }
904         return true;
905     });
906 }
907
908 ///public HashSet<ulong> GetAllPartiallyMatchingSequences3(params ulong[] sequence)
909 ///{
910 ///    return Sync.ExecuteReadOperation(() =>
911 ///    {
912 ///        if (sequence.Length > 0)
913 ///        {
914 ///            _links.EnsureEachLinkIsAnyOrExists(sequence);
915
916 ///            var firstResults = new HashSet<ulong>();
917 ///            var lastResults = new HashSet<ulong>();
918
919 ///            var first = sequence.First(x => x != LinksConstants.Any);
920 ///            var last = sequence.Last(x => x != LinksConstants.Any);

```

```

920
921 //         AllUsagesCore(first, firstResults);
922 //         AllUsagesCore(last, lastResults);
923
924 //         firstResults.IntersectWith(lastResults);
925
926 //         //for (var i = 0; i < sequence.Length; i++)
927 //         //     AllUsagesCore(sequence[i], results);
928
929 //         var filteredResults = new HashSet<ulong>();
930 //         var matcher = new Matcher(this, sequence, filteredResults, null);
931 //         matcher.AddAllPartialMatchedToResults(firstResults);
932 //         return filteredResults;
933 //     }
934
935 //     return new HashSet<ulong>();
936 // });
937 //}
938
939 /// <summary>
940 /// <para>
941 /// Gets the all partially matching sequences 3 using the specified sequence.
942 /// </para>
943 /// <para></para>
944 /// </summary>
945 /// <param name="sequence">
946 /// <para>The sequence.</para>
947 /// <para></para>
948 /// </param>
949 /// <returns>
950 /// <para>A hash set of ulong</para>
951 /// <para></para>
952 /// </returns>
953 [MethodImpl(MethodImplOptions.AggressiveInlining)]
954 public HashSet<ulong> GetAllPartiallyMatchingSequences3(params ulong[] sequence)
955 {
956     return _sync.ExecuteReadOperation(() =>
957     {
958         if (sequence.Length > 0)
959         {
960             ILinksExtensions.EnsureLinkIsAnyOrExists(Links, sequence);
961             var firstResults = new HashSet<ulong>();
962             var lastResults = new HashSet<ulong>();
963             var first = sequence.First(x => x != Constants.Any);
964             var last = sequence.Last(x => x != Constants.Any);
965             AllUsagesCore(first, firstResults);
966             AllUsagesCore(last, lastResults);
967             firstResults.IntersectWith(lastResults);
968             //for (var i = 0; i < sequence.Length; i++)
969             //     AllUsagesCore(sequence[i], results);
970             var filteredResults = new HashSet<ulong>();
971             var matcher = new Matcher(this, sequence, filteredResults, null);
972             matcher.AddAllPartialMatchedToResults(firstResults);
973             return filteredResults;
974         }
975         return new HashSet<ulong>();
976     });
977 }
978
979 /// <summary>
980 /// <para>
981 /// Gets the all partially matching sequences 4 using the specified read as elements.
982 /// </para>
983 /// <para></para>
984 /// </summary>
985 /// <param name="readAsElements">
986 /// <para>The read as elements.</para>
987 /// <para></para>
988 /// </param>
989 /// <param name="sequence">
990 /// <para>The sequence.</para>
991 /// <para></para>
992 /// </param>
993 /// <returns>
994 /// <para>A hash set of ulong</para>
995 /// <para></para>
996 /// </returns>
997 [MethodImpl(MethodImplOptions.AggressiveInlining)]

```

```

998 public HashSet<ulong> GetAllPartiallyMatchingSequences4(HashSet<ulong> readAsElements,
999     ↳ IList<ulong> sequence)
1000 {
1001     return _sync.ExecuteReadOperation(() =>
1002     {
1003         if (sequence.Count > 0)
1004         {
1005             Links.EnsureLinkExists(sequence);
1006             var results = new HashSet<LinkIndex>();
1007             //var nextResults = new HashSet<ulong>();
1008             //for (var i = 0; i < sequence.Length; i++)
1009             //{
1010                 // AllUsagesCore(sequence[i], nextResults);
1011                 // if (results.IsNullOrEmpty())
1012                 // {
1013                     results = nextResults;
1014                     nextResults = new HashSet<ulong>();
1015                 // }
1016                 // else
1017                 // {
1018                     results.IntersectWith(nextResults);
1019                     nextResults.Clear();
1020                 // }
1021             //}
1022             var collector1 = new AllUsagesCollector1(Links.Unsync, results);
1023             collector1.Collect(Links.Unsync.GetLink(sequence[0]));
1024             var next = new HashSet<ulong>();
1025             for (var i = 1; i < sequence.Count; i++)
1026             {
1027                 var collector = new AllUsagesCollector1(Links.Unsync, next);
1028                 collector.Collect(Links.Unsync.GetLink(sequence[i]));
1029
1030                 results.IntersectWith(next);
1031                 next.Clear();
1032             }
1033             var filteredResults = new HashSet<ulong>();
1034             var matcher = new Matcher(this, sequence, filteredResults, null,
1035                 ↳ readAsElements);
1036             matcher.AddAllPartialMatchedToResultsAndReadAsElements(results.OrderBy(x =>
1037                 ↳ x)); // OrderBy is a Hack
1038             return filteredResults;
1039         }
1040         return new HashSet<ulong>();
1041     });
1042 }
1043
1044 // Does not work
1045 //public HashSet<ulong> GetAllPartiallyMatchingSequences5(HashSet<ulong> readAsElements,
1046 //    ↳ params ulong[] sequence)
1047 //{
1048 //    var visited = new HashSet<ulong>();
1049 //    var results = new HashSet<ulong>();
1050 //    var matcher = new Matcher(this, sequence, visited, x => { results.Add(x); return
1051 //        ↳ true; }, readAsElements);
1052 //    var last = sequence.Length - 1;
1053 //    for (var i = 0; i < last; i++)
1054 //    {
1055 //        PartialStepRight(matcher.PartialMatch, sequence[i], sequence[i + 1]);
1056 //    }
1057 //    return results;
1058 //}
1059
1060 /// <summary>
1061 /// <para>
1062 /// Gets the all partially matching sequences using the specified sequence.
1063 /// </para>
1064 /// <para></para>
1065 /// </summary>
1066 /// <param name="sequence">
1067 /// <para>The sequence.</para>
1068 /// <para></para>
1069 /// </param>
1070 /// <returns>
1071 /// <para>A list of ulong</para>
1072 /// <para></para>
1073 /// </returns>
1074 [MethodImpl(MethodImplOptions.AggressiveInlining)]

```

```

1070 public List<ulong> GetAllPartiallyMatchingSequences(params ulong[] sequence)
1071 {
1072     return _sync.ExecuteReadOperation(() =>
1073     {
1074         if (sequence.Length > 0)
1075         {
1076             Links.EnsureLinkExists(sequence);
1077             //var firstElement = sequence[0];
1078             //if (sequence.Length == 1)
1079             //{
1080                 //    //results.Add(firstElement);
1081                 //    return results;
1082             //}
1083             //if (sequence.Length == 2)
1084             //{
1085                 //    //var doublet = _links.SearchCore(firstElement, sequence[1]);
1086                 //    //if (doublet != Doublets.Links.Null)
1087                 //    //    results.Add(doublet);
1088                 //    return results;
1089             //}
1090             //var lastElement = sequence[sequence.Length - 1];
1091             //Func<ulong, bool> handler = x =>
1092             //{
1093                 //    if (StartsWith(x, firstElement) && EndsWith(x, lastElement))
1094                 //        results.Add(x);
1095                 //    return true;
1096             //};
1097             //if (sequence.Length >= 2)
1098             //    StepRight(handler, sequence[0], sequence[1]);
1099             //var last = sequence.Length - 2;
1100             //for (var i = 1; i < last; i++)
1101             //    PartialStepRight(handler, sequence[i], sequence[i + 1]);
1102             //if (sequence.Length >= 3)
1103             //    StepLeft(handler, sequence[sequence.Length - 2],
1104                 //        sequence[sequence.Length - 1]);
1105             //if (sequence.Length == 1)
1106             //    throw new NotImplementedException(); // all sequences, containing
1107             //    this element?
1108             //if (sequence.Length == 2)
1109             //{
1110                 //    var results = new List<ulong>();
1111                 //    PartialStepRight(results.Add, sequence[0], sequence[1]);
1112                 //    return results;
1113             //}
1114             //var matches = new List<List<ulong>>();
1115             //var last = sequence.Length - 1;
1116             //for (var i = 0; i < last; i++)
1117             //{
1118                 //    var results = new List<ulong>();
1119                 //    //StepRight(results.Add, sequence[i], sequence[i + 1]);
1120                 //    PartialStepRight(results.Add, sequence[i], sequence[i + 1]);
1121                 //    if (results.Count > 0)
1122                 //        matches.Add(results);
1123                 //    else
1124                 //        return results;
1125                 //    if (matches.Count == 2)
1126                 //    {
1127                     //        var merged = new List<ulong>();
1128                     //        for (var j = 0; j < matches[0].Count; j++)
1129                     //            for (var k = 0; k < matches[1].Count; k++)
1130                     //                CloseInnerConnections(merged.Add, matches[0][j],
1131                         //                    matches[1][k]);
1132                     //        if (merged.Count > 0)
1133                     //            matches = new List<List<ulong>> { merged };
1134                     //        else
1135                     //            return new List<ulong>();
1136                 //    }
1137             //}
1138             //if (matches.Count > 0)
1139             //{
1140                 //    var usages = new HashSet<ulong>();
1141                 //    for (int i = 0; i < sequence.Length; i++)
1142                 //    {
1143                     //        AllUsagesCore(sequence[i], usages);
1144                 //    }

```

```

1143         //for (int i = 0; i < matches[0].Count; i++)
1144         //    AllUsagesCore(matches[0][i], usages);
1145         //usages.UnionWith(matches[0]);
1146         return usages.ToList();
1147     }
1148     var firstLinkUsages = new HashSet<ulong>();
1149     AllUsagesCore(sequence[0], firstLinkUsages);
1150     firstLinkUsages.Add(sequence[0]);
1151     //var previousMatchings = firstLinkUsages.ToList(); //new List<ulong>() {
1152     //    sequence[0] }; // or all sequences, containing this element?
1153     //return GetAllPartiallyMatchingSequencesCore(sequence, firstLinkUsages,
1154     //    1).ToList();
1155     var results = new HashSet<ulong>();
1156     foreach (var match in GetAllPartiallyMatchingSequencesCore(sequence,
1157         firstLinkUsages, 1))
1158     {
1159         AllUsagesCore(match, results);
1160     }
1161     return results.ToList();
1162 }
1163 return new List<ulong>();
1164 });
1165 }
1166
1167 /// <remarks>
1168 /// TODO: Может потребоваться ограничение на уровень глубины рекурсии
1169 /// </remarks>
1170 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1171 public HashSet<ulong> AllUsages(ulong link)
1172 {
1173     return _sync.ExecuteReadOperation(() =>
1174     {
1175         var usages = new HashSet<ulong>();
1176         AllUsagesCore(link, usages);
1177         return usages;
1178     });
1179 }
1180
1181 // При сборе всех использований (последовательностей) можно сохранять обратный путь к
1182 // той связи с которой начинался поиск (STTTSSSTT),
1183 // причём достаточно одного бита для хранения перехода влево или вправо
1184 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1185 private void AllUsagesCore(ulong link, HashSet<ulong> usages)
1186 {
1187     bool handler(ulong doublet)
1188     {
1189         if (usages.Add(doublet))
1190         {
1191             AllUsagesCore(doublet, usages);
1192         }
1193         return true;
1194     }
1195     Links.Unsync.Each(link, Constants.Any, handler);
1196     Links.Unsync.Each(Constants.Any, link, handler);
1197 }
1198
1199 /// <summary>
1200 /// <para>
1201 /// Alls the bottom usages using the specified link.
1202 /// </para>
1203 /// <para></para>
1204 /// </summary>
1205 /// <param name="link">
1206 /// <para>The link.</para>
1207 /// <para></para>
1208 /// </param>
1209 /// <returns>
1210 /// <para>A hash set of ulong</para>
1211 /// <para></para>
1212 /// </returns>
1213 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1214 public HashSet<ulong> AllBottomUsages(ulong link)
1215 {
1216     return _sync.ExecuteReadOperation(() =>
1217     {
1218         var visits = new HashSet<ulong>();
1219         var usages = new HashSet<ulong>();
1220         AllBottomUsagesCore(link, visits, usages);
1221     });
1222 }

```

```

1217         return usages;
1218     });
1219 }
1220 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1221 private void AllBottomUsagesCore(ulong link, HashSet<ulong> visits, HashSet<ulong>
    ↳ usages)
1222 {
1223     bool handler(ulong doublet)
1224     {
1225         if (visits.Add(doublet))
1226         {
1227             AllBottomUsagesCore(doublet, visits, usages);
1228         }
1229         return true;
1230     }
1231     if (Links.Unsync.Count(Constants.Any, link) == 0)
1232     {
1233         usages.Add(link);
1234     }
1235     else
1236     {
1237         Links.Unsync.Each(link, Constants.Any, handler);
1238         Links.Unsync.Each(Constants.Any, link, handler);
1239     }
1240 }
1241
1242 /// <summary>
1243 /// <para>
1244 /// Calculates the total symbol frequency core using the specified symbol.
1245 /// </para>
1246 /// <para></para>
1247 /// </summary>
1248 /// <param name="symbol">
1249 /// <para>The symbol.</para>
1250 /// <para></para>
1251 /// </param>
1252 /// <returns>
1253 /// <para>The ulong</para>
1254 /// <para></para>
1255 /// </returns>
1256 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1257 public ulong CalculateTotalSymbolFrequencyCore(ulong symbol)
1258 {
1259     if (Options.UseSequenceMarker)
1260     {
1261         var counter = new TotalMarkedSequenceSymbolFrequencyOneOffCounter<ulong>(Links,
            ↳ Options.MarkedSequenceMatcher, symbol);
1262         return counter.Count();
1263     }
1264     else
1265     {
1266         var counter = new TotalSequenceSymbolFrequencyOneOffCounter<ulong>(Links,
            ↳ symbol);
1267         return counter.Count();
1268     }
1269 }
1270 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1271 private bool AllUsagesCore1(ulong link, HashSet<ulong> usages, Func<IList<LinkIndex>,
    ↳ LinkIndex> outerHandler)
1272 {
1273     bool handler(ulong doublet)
1274     {
1275         if (usages.Add(doublet))
1276         {
1277             if (outerHandler(new LinkAddress<LinkIndex>(doublet)) != Constants.Continue)
1278             {
1279                 return false;
1280             }
1281             if (!AllUsagesCore1(doublet, usages, outerHandler))
1282             {
1283                 return false;
1284             }
1285         }
1286         return true;
1287     }
1288     return Links.Unsync.Each(link, Constants.Any, handler)
        && Links.Unsync.Each(Constants.Any, link, handler);
1289 }
1290

```



```

1291
1292     /// <summary>
1293     /// <para>
1294     /// Calculates the all usages using the specified totals.
1295     /// </para>
1296     /// <para></para>
1297     /// </summary>
1298     /// <param name="totals">
1299     /// <para>The totals.</para>
1300     /// <para></para>
1301     /// </param>
1302     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1303     public void CalculateAllUsages(ulong[] totals)
1304     {
1305         var calculator = new AllUsagesCalculator(Links, totals);
1306         calculator.Calculate();
1307     }
1308
1309     /// <summary>
1310     /// <para>
1311     /// Calculates the all usages 2 using the specified totals.
1312     /// </para>
1313     /// <para></para>
1314     /// </summary>
1315     /// <param name="totals">
1316     /// <para>The totals.</para>
1317     /// <para></para>
1318     /// </param>
1319     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1320     public void CalculateAllUsages2(ulong[] totals)
1321     {
1322         var calculator = new AllUsagesCalculator2(Links, totals);
1323         calculator.Calculate();
1324     }
1325     private class AllUsagesCalculator
1326     {
1327         private readonly SynchronizedLinks<ulong> _links;
1328         private readonly ulong[] _totals;
1329
1330         /// <summary>
1331         /// <para>
1332         /// Initializes a new <see cref="AllUsagesCalculator"/> instance.
1333         /// </para>
1334         /// <para></para>
1335         /// </summary>
1336         /// <param name="links">
1337         /// <para>A links.</para>
1338         /// <para></para>
1339         /// </param>
1340         /// <param name="totals">
1341         /// <para>A totals.</para>
1342         /// <para></para>
1343         /// </param>
1344         [MethodImpl(MethodImplOptions.AggressiveInlining)]
1345         public AllUsagesCalculator(SynchronizedLinks<ulong> links, ulong[] totals)
1346         {
1347             _links = links;
1348             _totals = totals;
1349         }
1350
1351         /// <summary>
1352         /// <para>
1353         /// Calculates this instance.
1354         /// </para>
1355         /// <para></para>
1356         /// </summary>
1357         [MethodImpl(MethodImplOptions.AggressiveInlining)]
1358         public void Calculate() => _links.Each(_links.Constants.Any, _links.Constants.Any,
1359             ↪ CalculateCore);
1360         [MethodImpl(MethodImplOptions.AggressiveInlining)]
1361         private bool CalculateCore(ulong link)
1362         {
1363             if (_totals[link] == 0)
1364             {
1365                 var total = 1UL;
1366                 _totals[link] = total;
1367                 var visitedChildren = new HashSet<ulong>();
1368                 bool linkCalculator(ulong child)

```

```

1368         {
1369             if (link != child && visitedChildren.Add(child))
1370             {
1371                 total += _totals[child] == 0 ? 1 : _totals[child];
1372             }
1373             return true;
1374         }
1375         _links.Unsync.Each(link, _links.Constants.Any, linkCalculator);
1376         _links.Unsync.Each(_links.Constants.Any, link, linkCalculator);
1377         _totals[link] = total;
1378     }
1379     return true;
1380 }
1381 }
1382 private class AllUsagesCalculator2
1383 {
1384     private readonly SynchronizedLinks<ulong> _links;
1385     private readonly ulong[] _totals;
1386
1387     /// <summary>
1388     /// <para>
1389     /// Initializes a new <see cref="AllUsagesCalculator2"/> instance.
1390     /// </para>
1391     /// <para></para>
1392     /// </summary>
1393     /// <param name="links">
1394     /// <para>A links.</para>
1395     /// <para></para>
1396     /// </param>
1397     /// <param name="totals">
1398     /// <para>A totals.</para>
1399     /// <para></para>
1400     /// </param>
1401     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1402     public AllUsagesCalculator2(SynchronizedLinks<ulong> links, ulong[] totals)
1403     {
1404         _links = links;
1405         _totals = totals;
1406     }
1407
1408     /// <summary>
1409     /// <para>
1410     /// Calculates this instance.
1411     /// </para>
1412     /// <para></para>
1413     /// </summary>
1414     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1415     public void Calculate() => _links.Each(_links.Constants.Any, _links.Constants.Any,
1416         ↪ CalculateCore);
1417     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1418     private bool IsElement(ulong link)
1419     {
1420         // _linksInSequence.Contains(link) ||
1421         return _links.Unsync.GetTarget(link) == link || _links.Unsync.GetSource(link) ==
1422             ↪ link;
1423     }
1424     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1425     private bool CalculateCore(ulong link)
1426     {
1427         // TODO: Проработать защиту от заикливания
1428         // Основано на SequenceWalker.WalkLeft
1429         Func<ulong, ulong> getSource = _links.Unsync.GetSource;
1430         Func<ulong, ulong> getTarget = _links.Unsync.GetTarget;
1431         Func<ulong, bool> isElement = IsElement;
1432         void visitLeaf(ulong parent)
1433         {
1434             if (link != parent)
1435             {
1436                 _totals[parent]++;
1437             }
1438         }
1439         void visitNode(ulong parent)
1440         {
1441             if (link != parent)
1442             {
1443                 _totals[parent]++;
1444             }
1445         }
1446     }
1447 }

```

```

1444     var stack = new Stack();
1445     var element = link;
1446     if (isElement(element))
1447     {
1448         visitLeaf(element);
1449     }
1450     else
1451     {
1452         while (true)
1453         {
1454             if (isElement(element))
1455             {
1456                 if (stack.Count == 0)
1457                 {
1458                     break;
1459                 }
1460                 element = stack.Pop();
1461                 var source = getSource(element);
1462                 var target = getTarget(element);
1463                 // Обработка элемента
1464                 if (isElement(target))
1465                 {
1466                     visitLeaf(target);
1467                 }
1468                 if (isElement(source))
1469                 {
1470                     visitLeaf(source);
1471                 }
1472                 element = source;
1473             }
1474             else
1475             {
1476                 stack.Push(element);
1477                 visitNode(element);
1478                 element = getTarget(element);
1479             }
1480         }
1481     }
1482     _totals[link]++;
1483     return true;
1484 }
1485 }
1486 private class AllUsagesCollector
1487 {
1488     private readonly ILinks<ulong> _links;
1489     private readonly HashSet<ulong> _usages;
1490
1491     /// <summary>
1492     /// <para>
1493     /// Initializes a new <see cref="AllUsagesCollector"/> instance.
1494     /// </para>
1495     /// <para></para>
1496     /// </summary>
1497     /// <param name="links">
1498     /// <para>A links.</para>
1499     /// <para></para>
1500     /// </param>
1501     /// <param name="usages">
1502     /// <para>A usages.</para>
1503     /// <para></para>
1504     /// </param>
1505     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1506     public AllUsagesCollector(ILinks<ulong> links, HashSet<ulong> usages)
1507     {
1508         _links = links;
1509         _usages = usages;
1510     }
1511
1512     /// <summary>
1513     /// <para>
1514     /// Determines whether this instance collect.
1515     /// </para>
1516     /// <para></para>
1517     /// </summary>
1518     /// <param name="link">
1519     /// <para>The link.</para>
1520     /// <para></para>
1521     /// </param>
1522     /// <returns>

```

```

1523     /// <para>The bool</para>
1524     /// <para></para>
1525     /// </returns>
1526     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1527     public bool Collect(ulong link)
1528     {
1529         if (_usages.Add(link))
1530         {
1531             _links.Each(link, _links.Constants.Any, Collect);
1532             _links.Each(_links.Constants.Any, link, Collect);
1533         }
1534         return true;
1535     }
1536 }
1537 private class AllUsagesCollector1
1538 {
1539     private readonly ILinks<ulong> _links;
1540     private readonly HashSet<ulong> _usages;
1541     private readonly ulong _continue;
1542
1543     /// <summary>
1544     /// <para>
1545     /// Initializes a new <see cref="AllUsagesCollector1"/> instance.
1546     /// </para>
1547     /// <para></para>
1548     /// </summary>
1549     /// <param name="links">
1550     /// <para>A links.</para>
1551     /// <para></para>
1552     /// </param>
1553     /// <param name="usages">
1554     /// <para>A usages.</para>
1555     /// <para></para>
1556     /// </param>
1557     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1558     public AllUsagesCollector1(ILinks<ulong> links, HashSet<ulong> usages)
1559     {
1560         _links = links;
1561         _usages = usages;
1562         _continue = _links.Constants.Continue;
1563     }
1564
1565     /// <summary>
1566     /// <para>
1567     /// Collects the link.
1568     /// </para>
1569     /// <para></para>
1570     /// </summary>
1571     /// <param name="link">
1572     /// <para>The link.</para>
1573     /// <para></para>
1574     /// </param>
1575     /// <returns>
1576     /// <para>The continue.</para>
1577     /// <para></para>
1578     /// </returns>
1579     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1580     public ulong Collect(ILink<ulong> link)
1581     {
1582         var linkIndex = _links.GetIndex(link);
1583         if (_usages.Add(linkIndex))
1584         {
1585             _links.Each(Collect, _links.Constants.Any, linkIndex);
1586         }
1587         return _continue;
1588     }
1589 }
1590 private class AllUsagesCollector2
1591 {
1592     private readonly ILinks<ulong> _links;
1593     private readonly BitString _usages;
1594
1595     /// <summary>
1596     /// <para>
1597     /// Initializes a new <see cref="AllUsagesCollector2"/> instance.
1598     /// </para>
1599     /// <para></para>
1600     /// </summary>
1601     /// <param name="links">

```

```

1602     /// <para>A links.</para>
1603     /// <para></para>
1604     /// </param>
1605     /// <param name="usages">
1606     /// <para>A usages.</para>
1607     /// <para></para>
1608     /// </param>
1609     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1610     public AllUsagesCollector2(ILinks<ulong> links, BitString usages)
1611     {
1612         _links = links;
1613         _usages = usages;
1614     }
1615
1616     /// <summary>
1617     /// <para>
1618     /// Determines whether this instance collect.
1619     /// </para>
1620     /// <para></para>
1621     /// </summary>
1622     /// <param name="link">
1623     /// <para>The link.</para>
1624     /// <para></para>
1625     /// </param>
1626     /// <returns>
1627     /// <para>The bool</para>
1628     /// <para></para>
1629     /// </returns>
1630     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1631     public bool Collect(ulong link)
1632     {
1633         if (_usages.Add((long)link))
1634         {
1635             _links.Each(link, _links.Constants.Any, Collect);
1636             _links.Each(_links.Constants.Any, link, Collect);
1637         }
1638         return true;
1639     }
1640 }
1641 private class AllUsagesIntersectingCollector
1642 {
1643     private readonly SynchronizedLinks<ulong> _links;
1644     private readonly HashSet<ulong> _intersectWith;
1645     private readonly HashSet<ulong> _usages;
1646     private readonly HashSet<ulong> _enter;
1647
1648     /// <summary>
1649     /// <para>
1650     /// Initializes a new <see cref="AllUsagesIntersectingCollector"/> instance.
1651     /// </para>
1652     /// <para></para>
1653     /// </summary>
1654     /// <param name="links">
1655     /// <para>A links.</para>
1656     /// <para></para>
1657     /// </param>
1658     /// <param name="intersectWith">
1659     /// <para>A intersect with.</para>
1660     /// <para></para>
1661     /// </param>
1662     /// <param name="usages">
1663     /// <para>A usages.</para>
1664     /// <para></para>
1665     /// </param>
1666     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1667     public AllUsagesIntersectingCollector(SynchronizedLinks<ulong> links, HashSet<ulong>
1668     ↪ intersectWith, HashSet<ulong> usages)
1669     {
1670         _links = links;
1671         _intersectWith = intersectWith;
1672         _usages = usages;
1673         _enter = new HashSet<ulong>(); // защита от зацикливания
1674     }
1675
1676     /// <summary>
1677     /// <para>
1678     /// Determines whether this instance collect.
1679     /// </para>
1680     /// <para></para>

```

```

1680     /// </summary>
1681     /// <param name="link">
1682     /// <para>The link.</para>
1683     /// <para></para>
1684     /// </param>
1685     /// <returns>
1686     /// <para>The bool</para>
1687     /// <para></para>
1688     /// </returns>
1689     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1690     public bool Collect(ulong link)
1691     {
1692         if (_enter.Add(link))
1693         {
1694             if (_intersectWith.Contains(link))
1695             {
1696                 _usages.Add(link);
1697             }
1698             _links.Unsync.Each(link, _links.Constants.Any, Collect);
1699             _links.Unsync.Each(_links.Constants.Any, link, Collect);
1700         }
1701         return true;
1702     }
1703 }
1704 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1705 private void CloseInnerConnections(Action<IList<LinkIndex>> handler, ulong left, ulong
↪ right)
1706 {
1707     TryStepLeftUp(handler, left, right);
1708     TryStepRightUp(handler, right, left);
1709 }
1710 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1711 private void AllCloseConnections(Action<IList<LinkIndex>> handler, ulong left, ulong
↪ right)
1712 {
1713     // Direct
1714     if (left == right)
1715     {
1716         handler(new LinkAddress<LinkIndex>(left));
1717     }
1718     var doublet = Links.Unsync.SearchOrDefault(left, right);
1719     if (doublet != Constants.Null)
1720     {
1721         handler(new LinkAddress<LinkIndex>(doublet));
1722     }
1723     // Inner
1724     CloseInnerConnections(handler, left, right);
1725     // Outer
1726     StepLeft(handler, left, right);
1727     StepRight(handler, left, right);
1728     PartialStepRight(handler, left, right);
1729     PartialStepLeft(handler, left, right);
1730 }
1731 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1732 private HashSet<ulong> GetAllPartiallyMatchingSequencesCore(ulong[] sequence,
↪ HashSet<ulong> previousMatchings, long startAt)
1733 {
1734     if (startAt >= sequence.Length) // ?
1735     {
1736         return previousMatchings;
1737     }
1738     var secondLinkUsages = new HashSet<ulong>();
1739     AllUsagesCore(sequence[startAt], secondLinkUsages);
1740     secondLinkUsages.Add(sequence[startAt]);
1741     var matchings = new HashSet<ulong>();
1742     var filler = new SetFiller<LinkIndex, LinkIndex>(matchings, Constants.Continue);
1743     //for (var i = 0; i < previousMatchings.Count; i++)
1744     foreach (var secondLinkUsage in secondLinkUsages)
1745     {
1746         foreach (var previousMatching in previousMatchings)
1747         {
1748             //AllCloseConnections(matchings.AddAndReturnVoid, previousMatching,
↪ secondLinkUsage);
1749             StepRight(filler.AddFirstAndReturnConstant, previousMatching,
↪ secondLinkUsage);
1750             TryStepRightUp(filler.AddFirstAndReturnConstant, secondLinkUsage,
↪ previousMatching);

```

```

1751         //PartialStepRight(matchings.AddAndReturnVoid, secondLinkUsage,
1752         ↪ sequence[startAt]); // почему-то эта ошибочная запись приводит к
1753         ↪ желаемым результатам.
1754     PartialStepRight(filler.AddFirstAndReturnConstant, previousMatching,
1755     ↪ secondLinkUsage);
1756 }
1757 }
1758 if (matchings.Count == 0)
1759 {
1760     return matchings;
1761 }
1762 return GetAllPartiallyMatchingSequencesCore(sequence, matchings, startAt + 1); // ??
1763 }
1764 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1765 private static void EnsureEachLinkIsAnyOrZeroOrManyOrExists(SynchronizedLinks<ulong>
1766 ↪ links, params ulong[] sequence)
1767 {
1768     if (sequence == null)
1769     {
1770         return;
1771     }
1772     for (var i = 0; i < sequence.Length; i++)
1773     {
1774         if (sequence[i] != links.Constants.Any && sequence[i] != ZeroOrMany &&
1775         ↪ !links.Exists(sequence[i]))
1776         {
1777             throw new ArgumentLinkDoesNotExistsException<ulong>(sequence[i],
1778             ↪ $"patternSequence[{i}]");
1779         }
1780     }
1781 }
1782 }
1783 }
1784 // Pattern Matching -> Key To Triggers
1785 /// <summary>
1786 /// <para>
1787 /// Matches the pattern using the specified pattern sequence.
1788 /// </para>
1789 /// <para></para>
1790 /// </summary>
1791 /// <param name="patternSequence">
1792 /// <para>The pattern sequence.</para>
1793 /// <para></para>
1794 /// </param>
1795 /// <returns>
1796 /// <para>A hash set of ulong</para>
1797 /// <para></para>
1798 /// </returns>
1799 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1800 public HashSet<ulong> MatchPattern(params ulong[] patternSequence)
1801 {
1802     return _sync.ExecuteReadOperation(() =>
1803     {
1804         patternSequence = Simplify(patternSequence);
1805         if (patternSequence.Length > 0)
1806         {
1807             EnsureEachLinkIsAnyOrZeroOrManyOrExists(links, patternSequence);
1808             var uniqueSequenceElements = new HashSet<ulong>();
1809             for (var i = 0; i < patternSequence.Length; i++)
1810             {
1811                 if (patternSequence[i] != Constants.Any && patternSequence[i] !=
1812                 ↪ ZeroOrMany)
1813                 {
1814                     uniqueSequenceElements.Add(patternSequence[i]);
1815                 }
1816             }
1817             var results = new HashSet<ulong>();
1818             foreach (var uniqueSequenceElement in uniqueSequenceElements)
1819             {
1820                 AllUsagesCore(uniqueSequenceElement, results);
1821             }
1822             var filteredResults = new HashSet<ulong>();
1823             var matcher = new PatternMatcher(this, patternSequence, filteredResults);
1824             matcher.AddAllPatternMatchedToResults(results);
1825             return filteredResults;
1826         }
1827         return new HashSet<ulong>();
1828     });
1829 }

```

```

1821 }
1822
1823 // Найти все возможные связи между указанным списком связей.
1824 // Находит связи между всеми указанными связями в любом порядке.
1825 // TODO: решить что делать с повторами (когда одни и те же элементы встречаются
    ↳ несколько раз в последовательности)
1826 /// <summary>
1827 /// <para>
1828 /// Gets the all connections using the specified links to connect.
1829 /// </para>
1830 /// <para></para>
1831 /// </summary>
1832 /// <param name="linksToConnect">
1833 /// <para>The links to connect.</para>
1834 /// <para></para>
1835 /// </param>
1836 /// <returns>
1837 /// <para>A hash set of ulong</para>
1838 /// <para></para>
1839 /// </returns>
1840 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1841 public HashSet<ulong> GetAllConnections(params ulong[] linksToConnect)
1842 {
1843     return _sync.ExecuteReadOperation(() =>
1844     {
1845         var results = new HashSet<ulong>();
1846         if (linksToConnect.Length > 0)
1847         {
1848             Links.EnsureLinkExists(linksToConnect);
1849             AllUsagesCore(linksToConnect[0], results);
1850             for (var i = 1; i < linksToConnect.Length; i++)
1851             {
1852                 var next = new HashSet<ulong>();
1853                 AllUsagesCore(linksToConnect[i], next);
1854                 results.IntersectWith(next);
1855             }
1856         }
1857         return results;
1858     });
1859 }
1860
1861 /// <summary>
1862 /// <para>
1863 /// Gets the all connections 1 using the specified links to connect.
1864 /// </para>
1865 /// <para></para>
1866 /// </summary>
1867 /// <param name="linksToConnect">
1868 /// <para>The links to connect.</para>
1869 /// <para></para>
1870 /// </param>
1871 /// <returns>
1872 /// <para>A hash set of ulong</para>
1873 /// <para></para>
1874 /// </returns>
1875 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1876 public HashSet<ulong> GetAllConnections1(params ulong[] linksToConnect)
1877 {
1878     return _sync.ExecuteReadOperation(() =>
1879     {
1880         var results = new HashSet<ulong>();
1881         if (linksToConnect.Length > 0)
1882         {
1883             Links.EnsureLinkExists(linksToConnect);
1884             var collector1 = new AllUsagesCollector(Links.Unsync, results);
1885             collector1.Collect(linksToConnect[0]);
1886             var next = new HashSet<ulong>();
1887             for (var i = 1; i < linksToConnect.Length; i++)
1888             {
1889                 var collector = new AllUsagesCollector(Links.Unsync, next);
1890                 collector.Collect(linksToConnect[i]);
1891                 results.IntersectWith(next);
1892                 next.Clear();
1893             }
1894         }
1895         return results;
1896     });
1897 }

```



```

1898
1899 /// <summary>
1900 /// <para>
1901 /// Gets the all connections 2 using the specified links to connect.
1902 /// </para>
1903 /// <para></para>
1904 /// </summary>
1905 /// <param name="linksToConnect">
1906 /// <para>The links to connect.</para>
1907 /// <para></para>
1908 /// </param>
1909 /// <returns>
1910 /// <para>A hash set of ulong</para>
1911 /// <para></para>
1912 /// </returns>
1913 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1914 public HashSet<ulong> GetAllConnections2(params ulong[] linksToConnect)
1915 {
1916     return _sync.ExecuteReadOperation(() =>
1917     {
1918         var results = new HashSet<ulong>();
1919         if (linksToConnect.Length > 0)
1920         {
1921             Links.EnsureLinkExists(linksToConnect);
1922             var collector1 = new AllUsagesCollector(Links, results);
1923             collector1.Collect(linksToConnect[0]);
1924             //AllUsagesCore(linksToConnect[0], results);
1925             for (var i = 1; i < linksToConnect.Length; i++)
1926             {
1927                 var next = new HashSet<ulong>();
1928                 var collector = new AllUsagesIntersectingCollector(Links, results, next);
1929                 collector.Collect(linksToConnect[i]);
1930                 //AllUsagesCore(linksToConnect[i], next);
1931                 //results.IntersectWith(next);
1932                 results = next;
1933             }
1934         }
1935         return results;
1936     });
1937 }
1938
1939 /// <summary>
1940 /// <para>
1941 /// Gets the all connections 3 using the specified links to connect.
1942 /// </para>
1943 /// <para></para>
1944 /// </summary>
1945 /// <param name="linksToConnect">
1946 /// <para>The links to connect.</para>
1947 /// <para></para>
1948 /// </param>
1949 /// <returns>
1950 /// <para>A list of ulong</para>
1951 /// <para></para>
1952 /// </returns>
1953 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1954 public List<ulong> GetAllConnections3(params ulong[] linksToConnect)
1955 {
1956     return _sync.ExecuteReadOperation(() =>
1957     {
1958         var results = new BitString((long)Links.Unsync.Count() + 1); // new
1959         ↪ BitArray((int)_links.Total + 1);
1960         if (linksToConnect.Length > 0)
1961         {
1962             Links.EnsureLinkExists(linksToConnect);
1963             var collector1 = new AllUsagesCollector2(Links.Unsync, results);
1964             collector1.Collect(linksToConnect[0]);
1965             for (var i = 1; i < linksToConnect.Length; i++)
1966             {
1967                 var next = new BitString((long)Links.Unsync.Count() + 1); //new
1968                 ↪ BitArray((int)_links.Total + 1);
1969                 var collector = new AllUsagesCollector2(Links.Unsync, next);
1970                 collector.Collect(linksToConnect[i]);
1971                 results = results.And(next);
1972             }
1973         }
1974         return results.GetSetUInt64Indices();
1975     });

```

```

1974 }
1975 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1976 private static ulong[] Simplify(ulong[] sequence)
1977 {
1978     // Считаем новый размер последовательности
1979     long newLength = 0;
1980     var zeroOrManyStepped = false;
1981     for (var i = 0; i < sequence.Length; i++)
1982     {
1983         if (sequence[i] == ZeroOrMany)
1984         {
1985             if (zeroOrManyStepped)
1986             {
1987                 continue;
1988             }
1989             zeroOrManyStepped = true;
1990         }
1991         else
1992         {
1993             //if (zeroOrManyStepped) Is it efficient?
1994             zeroOrManyStepped = false;
1995         }
1996         newLength++;
1997     }
1998     // Строим новую последовательность
1999     zeroOrManyStepped = false;
2000     var newSequence = new ulong[newLength];
2001     long j = 0;
2002     for (var i = 0; i < sequence.Length; i++)
2003     {
2004         //var current = zeroOrManyStepped;
2005         //zeroOrManyStepped = patternSequence[i] == zeroOrMany;
2006         //if (current && zeroOrManyStepped)
2007         //    continue;
2008         //var newZeroOrManyStepped = patternSequence[i] == zeroOrMany;
2009         //if (zeroOrManyStepped && newZeroOrManyStepped)
2010         //    continue;
2011         //zeroOrManyStepped = newZeroOrManyStepped;
2012         if (sequence[i] == ZeroOrMany)
2013         {
2014             if (zeroOrManyStepped)
2015             {
2016                 continue;
2017             }
2018             zeroOrManyStepped = true;
2019         }
2020         else
2021         {
2022             //if (zeroOrManyStepped) Is it efficient?
2023             zeroOrManyStepped = false;
2024         }
2025         newSequence[j++] = sequence[i];
2026     }
2027     return newSequence;
2028 }
2029
2030 /// <summary>
2031 /// <para>
2032 /// Tests the simplify.
2033 /// </para>
2034 /// <para></para>
2035 /// </summary>
2036 [MethodImpl(MethodImplOptions.AggressiveInlining)]
2037 public static void TestSimplify()
2038 {
2039     var sequence = new ulong[] { ZeroOrMany, ZeroOrMany, 2, 3, 4, ZeroOrMany,
2040     ↪ ZeroOrMany, ZeroOrMany, 4, ZeroOrMany, ZeroOrMany, ZeroOrMany };
2041     var simplifiedSequence = Simplify(sequence);
2042 }
2043
2044 /// <summary>
2045 /// <para>
2046 /// Gets the similar sequences.
2047 /// </para>
2048 /// <para></para>
2049 /// </summary>
2050 /// <returns>
2051 /// <para>A list of ulong</para>
2052 /// <para></para>

```

```

2052     /// </returns>
2053     [MethodImpl(MethodImplOptions.AggressiveInlining)]
2054     public List<ulong> GetSimilarSequences() => new List<ulong>();
2055
2056     /// <summary>
2057     /// <para>
2058     /// Predictions this instance.
2059     /// </para>
2060     /// <para></para>
2061     /// </summary>
2062     [MethodImpl(MethodImplOptions.AggressiveInlining)]
2063     public void Prediction()
2064     {
2065         //_links
2066         //sequences
2067     }
2068
2069     #region From Triplets
2070
2071     //public static void DeleteSequence(Link sequence)
2072     //{
2073     //}
2074
2075     /// <summary>
2076     /// <para>
2077     /// Collects the matching sequences using the specified links.
2078     /// </para>
2079     /// <para></para>
2080     /// </summary>
2081     /// <param name="links">
2082     /// <para>The links.</para>
2083     /// <para></para>
2084     /// </param>
2085     /// <exception cref="InvalidOperationException">
2086     /// <para>Подпоследовательности с одним элементом не поддерживаются.</para>
2087     /// <para></para>
2088     /// </exception>
2089     /// <returns>
2090     /// <para>The results.</para>
2091     /// <para></para>
2092     /// </returns>
2093     [MethodImpl(MethodImplOptions.AggressiveInlining)]
2094     public List<ulong> CollectMatchingSequences(ulong[] links)
2095     {
2096         if (links.Length == 1)
2097         {
2098             throw new InvalidOperationException("Подпоследовательности с одним элементом не
2099                 ↳ поддерживаются.");
2100         }
2101         var leftBound = 0;
2102         var rightBound = links.Length - 1;
2103         var left = links[leftBound++];
2104         var right = links[rightBound--];
2105         var results = new List<ulong>();
2106         CollectMatchingSequences(left, leftBound, links, right, rightBound, ref results);
2107         return results;
2108     }
2109     [MethodImpl(MethodImplOptions.AggressiveInlining)]
2110     private void CollectMatchingSequences(ulong leftLink, int leftBound, ulong[]
2111         ↳ middleLinks, ulong rightLink, int rightBound, ref List<ulong> results)
2112     {
2113         var leftLinkTotalReferers = Links.Unsync.Count(leftLink);
2114         var rightLinkTotalReferers = Links.Unsync.Count(rightLink);
2115         if (leftLinkTotalReferers <= rightLinkTotalReferers)
2116         {
2117             var nextLeftLink = middleLinks[leftBound];
2118             var elements = GetRightElements(leftLink, nextLeftLink);
2119             if (leftBound <= rightBound)
2120             {
2121                 for (var i = elements.Length - 1; i >= 0; i--)
2122                 {
2123                     var element = elements[i];
2124                     if (element != 0)
2125                     {
2126                         CollectMatchingSequences(element, leftBound + 1, middleLinks,
2127                             ↳ rightLink, rightBound, ref results);
2128                     }
2129                 }
2130             }
2131         }
2132     }

```

```

2127     }
2128     else
2129     {
2130         for (var i = elements.Length - 1; i >= 0; i--)
2131         {
2132             var element = elements[i];
2133             if (element != 0)
2134             {
2135                 results.Add(element);
2136             }
2137         }
2138     }
2139 }
2140 else
2141 {
2142     var nextRightLink = middleLinks[rightBound];
2143     var elements = GetLeftElements(rightLink, nextRightLink);
2144     if (leftBound <= rightBound)
2145     {
2146         for (var i = elements.Length - 1; i >= 0; i--)
2147         {
2148             var element = elements[i];
2149             if (element != 0)
2150             {
2151                 CollectMatchingSequences(leftLink, leftBound, middleLinks,
2152                                         ↪ elements[i], rightBound - 1, ref results);
2153             }
2154         }
2155     }
2156     else
2157     {
2158         for (var i = elements.Length - 1; i >= 0; i--)
2159         {
2160             var element = elements[i];
2161             if (element != 0)
2162             {
2163                 results.Add(element);
2164             }
2165         }
2166     }
2167 }
2168
2169 /// <summary>
2170 /// <para>
2171 /// Gets the right elements using the specified start link.
2172 /// </para>
2173 /// <para></para>
2174 /// </summary>
2175 /// <param name="startLink">
2176 /// <para>The start link.</para>
2177 /// <para></para>
2178 /// </param>
2179 /// <param name="rightLink">
2180 /// <para>The right link.</para>
2181 /// <para></para>
2182 /// </param>
2183 /// <returns>
2184 /// <para>The result.</para>
2185 /// <para></para>
2186 /// </returns>
2187 [MethodImpl(MethodImplOptions.AggressiveInlining)]
2188 public ulong[] GetRightElements(ulong startLink, ulong rightLink)
2189 {
2190     var result = new ulong[5];
2191     TryStepRight(startLink, rightLink, result, 0);
2192     Links.Each(Constants.Any, startLink, couple =>
2193     {
2194         if (couple != startLink)
2195         {
2196             if (TryStepRight(couple, rightLink, result, 2))
2197             {
2198                 return false;
2199             }
2200         }
2201         return true;
2202     });
2203     if (Links.GetTarget(Links.GetTarget(startLink)) == rightLink)

```

```

2204     {
2205         result[4] = startLink;
2206     }
2207     return result;
2208 }
2209
2210 /// <summary>
2211 /// <para>
2212 /// Determines whether this instance try step right.
2213 /// </para>
2214 /// <para></para>
2215 /// </summary>
2216 /// <param name="startLink">
2217 /// <para>The start link.</para>
2218 /// <para></para>
2219 /// </param>
2220 /// <param name="rightLink">
2221 /// <para>The right link.</para>
2222 /// <para></para>
2223 /// </param>
2224 /// <param name="result">
2225 /// <para>The result.</para>
2226 /// <para></para>
2227 /// </param>
2228 /// <param name="offset">
2229 /// <para>The offset.</para>
2230 /// <para></para>
2231 /// </param>
2232 /// <returns>
2233 /// <para>The bool</para>
2234 /// <para></para>
2235 /// </returns>
2236 [MethodImpl(MethodImplOptions.AggressiveInlining)]
2237 public bool TryStepRight(ulong startLink, ulong rightLink, ulong[] result, int offset)
2238 {
2239     var added = 0;
2240     Links.Each(startLink, Constants.Any, couple =>
2241     {
2242         if (couple != startLink)
2243         {
2244             var coupleTarget = Links.GetTarget(couple);
2245             if (coupleTarget == rightLink)
2246             {
2247                 result[offset] = couple;
2248                 if (++added == 2)
2249                 {
2250                     return false;
2251                 }
2252             }
2253             else if (Links.GetSource(coupleTarget) == rightLink) // coupleTarget.Linker
2254             ↪ == Net.And &&
2255             {
2256                 result[offset + 1] = couple;
2257                 if (++added == 2)
2258                 {
2259                     return false;
2260                 }
2261             }
2262             return true;
2263         });
2264     return added > 0;
2265 }
2266
2267 /// <summary>
2268 /// <para>
2269 /// Gets the left elements using the specified start link.
2270 /// </para>
2271 /// <para></para>
2272 /// </summary>
2273 /// <param name="startLink">
2274 /// <para>The start link.</para>
2275 /// <para></para>
2276 /// </param>
2277 /// <param name="leftLink">
2278 /// <para>The left link.</para>
2279 /// <para></para>
2280 /// </param>

```

```

2281 /// <returns>
2282 /// <para>The result.</para>
2283 /// <para></para>
2284 /// </returns>
2285 [MethodImpl(MethodImplOptions.AggressiveInlining)]
2286 public ulong[] GetLeftElements(ulong startLink, ulong leftLink)
2287 {
2288     var result = new ulong[5];
2289     TryStepLeft(startLink, leftLink, result, 0);
2290     Links.Each(startLink, Constants.Any, couple =>
2291     {
2292         if (couple != startLink)
2293         {
2294             if (TryStepLeft(couple, leftLink, result, 2))
2295             {
2296                 return false;
2297             }
2298         }
2299         return true;
2300     });
2301     if (Links.GetSource(Links.GetSource(leftLink)) == startLink)
2302     {
2303         result[4] = leftLink;
2304     }
2305     return result;
2306 }
2307
2308 /// <summary>
2309 /// <para>
2310 /// Determines whether this instance try step left.
2311 /// </para>
2312 /// <para></para>
2313 /// </summary>
2314 /// <param name="startLink">
2315 /// <para>The start link.</para>
2316 /// <para></para>
2317 /// </param>
2318 /// <param name="leftLink">
2319 /// <para>The left link.</para>
2320 /// <para></para>
2321 /// </param>
2322 /// <param name="result">
2323 /// <para>The result.</para>
2324 /// <para></para>
2325 /// </param>
2326 /// <param name="offset">
2327 /// <para>The offset.</para>
2328 /// <para></para>
2329 /// </param>
2330 /// <returns>
2331 /// <para>The bool</para>
2332 /// <para></para>
2333 /// </returns>
2334 [MethodImpl(MethodImplOptions.AggressiveInlining)]
2335 public bool TryStepLeft(ulong startLink, ulong leftLink, ulong[] result, int offset)
2336 {
2337     var added = 0;
2338     Links.Each(Constants.Any, startLink, couple =>
2339     {
2340         if (couple != startLink)
2341         {
2342             var coupleSource = Links.GetSource(couple);
2343             if (coupleSource == leftLink)
2344             {
2345                 result[offset] = couple;
2346                 if (++added == 2)
2347                 {
2348                     return false;
2349                 }
2350             }
2351             else if (Links.GetTarget(coupleSource) == leftLink) // coupleSource.Linker
2352             ⇐ == Net.And &&
2353             {
2354                 result[offset + 1] = couple;
2355                 if (++added == 2)
2356                 {
2357                     return false;
2358                 }
2359             }
2360         }
2361     });

```

```

2358         }
2359     }
2360     return true;
2361 });
2362 return added > 0;
2363 }
2364
2365 #endregion
2366
2367 #region Walkers
2368
2369 /// <summary>
2370 /// <para>
2371 /// Represents the pattern matcher.
2372 /// </para>
2373 /// <para></para>
2374 /// </summary>
2375 /// <seealso cref="RightSequenceWalker{ulong}" />
2376 public class PatternMatcher : RightSequenceWalker<ulong>
2377 {
2378     private readonly Sequences _sequences;
2379     private readonly ulong[] _patternSequence;
2380     private readonly HashSet<LinkIndex> _linksInSequence;
2381     private readonly HashSet<LinkIndex> _results;
2382
2383     #region Pattern Match
2384
2385     /// <summary>
2386     /// <para>
2387     /// The pattern block type enum.
2388     /// </para>
2389     /// <para></para>
2390     /// </summary>
2391     enum PatternBlockType
2392     {
2393         /// <summary>
2394         /// <para>
2395         /// The undefined pattern block type.
2396         /// </para>
2397         /// <para></para>
2398         /// </summary>
2399         Undefined,
2400         /// <summary>
2401         /// <para>
2402         /// The gap pattern block type.
2403         /// </para>
2404         /// <para></para>
2405         /// </summary>
2406         Gap,
2407         /// <summary>
2408         /// <para>
2409         /// The elements pattern block type.
2410         /// </para>
2411         /// <para></para>
2412         /// </summary>
2413         Elements
2414     }
2415
2416     /// <summary>
2417     /// <para>
2418     /// The pattern block.
2419     /// </para>
2420     /// <para></para>
2421     /// </summary>
2422     struct PatternBlock
2423     {
2424         /// <summary>
2425         /// <para>
2426         /// The type.
2427         /// </para>
2428         /// <para></para>
2429         /// </summary>
2430         public PatternBlockType Type;
2431         /// <summary>
2432         /// <para>
2433         /// The start.
2434         /// </para>
2435         /// <para></para>
2436         /// </summary>

```

```

2437     public long Start;
2438     /// <summary>
2439     /// <para>
2440     /// The stop.
2441     /// </para>
2442     /// <para></para>
2443     /// </summary>
2444     public long Stop;
2445 }
2446 private readonly List<PatternBlock> _pattern;
2447 private int _patternPosition;
2448 private long _sequencePosition;
2449
2450 #endregion
2451
2452 /// <summary>
2453 /// <para>
2454 /// Initializes a new <see cref="PatternMatcher"/> instance.
2455 /// </para>
2456 /// <para></para>
2457 /// </summary>
2458 /// <param name="sequences">
2459 /// <para>A sequences.</para>
2460 /// <para></para>
2461 /// </param>
2462 /// <param name="patternSequence">
2463 /// <para>A pattern sequence.</para>
2464 /// <para></para>
2465 /// </param>
2466 /// <param name="results">
2467 /// <para>A results.</para>
2468 /// <para></para>
2469 /// </param>
2470 [MethodImpl(MethodImplOptions.AggressiveInlining)]
2471 public PatternMatcher(Sequences sequences, LinkIndex[] patternSequence,
    ↳ HashSet<LinkIndex> results)
    : base(sequences.Links.Unsync, new DefaultStack<ulong>())
2472 {
2473     _sequences = sequences;
2474     _patternSequence = patternSequence;
2475     _linksInSequence = new HashSet<LinkIndex>(patternSequence.Where(x => x !=
    ↳ _sequences.Constants.Any && x != ZeroOrMany));
2476     _results = results;
2477     _pattern = CreateDetailedPattern();
2478 }
2479
2480
2481 /// <summary>
2482 /// <para>
2483 /// Determines whether this instance is element.
2484 /// </para>
2485 /// <para></para>
2486 /// </summary>
2487 /// <param name="link">
2488 /// <para>The link.</para>
2489 /// <para></para>
2490 /// </param>
2491 /// <returns>
2492 /// <para>The bool</para>
2493 /// <para></para>
2494 /// </returns>
2495 [MethodImpl(MethodImplOptions.AggressiveInlining)]
2496 protected override bool IsElement(ulong link) => _linksInSequence.Contains(link) ||
    ↳ base.IsElement(link);
2497
2498
2499 /// <summary>
2500 /// <para>
2501 /// Determines whether this instance pattern match.
2502 /// </para>
2503 /// <para></para>
2504 /// </summary>
2505 /// <param name="sequenceToMatch">
2506 /// <para>The sequence to match.</para>
2507 /// <para></para>
2508 /// </param>
2509 /// <returns>
2510 /// <para>The bool</para>
2511 /// <para></para>
2512 /// </returns>

```



```

2512 [MethodImpl(MethodImplOptions.AggressiveInlining)]
2513 public bool PatternMatch(LinkIndex sequenceToMatch)
2514 {
2515     _patternPosition = 0;
2516     _sequencePosition = 0;
2517     foreach (var part in Walk(sequenceToMatch))
2518     {
2519         if (!PatternMatchCore(part))
2520         {
2521             break;
2522         }
2523     }
2524     return _patternPosition == _pattern.Count || (_patternPosition == _pattern.Count
        ↳ - 1 && _pattern[_patternPosition].Start == 0);
2525 }
2526 [MethodImpl(MethodImplOptions.AggressiveInlining)]
2527 private List<PatternBlock> CreateDetailedPattern()
2528 {
2529     var pattern = new List<PatternBlock>();
2530     var patternBlock = new PatternBlock();
2531     for (var i = 0; i < _patternSequence.Length; i++)
2532     {
2533         if (patternBlock.Type == PatternBlockType.Undefined)
2534         {
2535             if (_patternSequence[i] == _sequences.Constants.Any)
2536             {
2537                 patternBlock.Type = PatternBlockType.Gap;
2538                 patternBlock.Start = 1;
2539                 patternBlock.Stop = 1;
2540             }
2541             else if (_patternSequence[i] == ZeroOrMany)
2542             {
2543                 patternBlock.Type = PatternBlockType.Gap;
2544                 patternBlock.Start = 0;
2545                 patternBlock.Stop = long.MaxValue;
2546             }
2547             else
2548             {
2549                 patternBlock.Type = PatternBlockType.Elements;
2550                 patternBlock.Start = i;
2551                 patternBlock.Stop = i;
2552             }
2553         }
2554         else if (patternBlock.Type == PatternBlockType.Elements)
2555         {
2556             if (_patternSequence[i] == _sequences.Constants.Any)
2557             {
2558                 pattern.Add(patternBlock);
2559                 patternBlock = new PatternBlock
2560                 {
2561                     Type = PatternBlockType.Gap,
2562                     Start = 1,
2563                     Stop = 1
2564                 };
2565             }
2566             else if (_patternSequence[i] == ZeroOrMany)
2567             {
2568                 pattern.Add(patternBlock);
2569                 patternBlock = new PatternBlock
2570                 {
2571                     Type = PatternBlockType.Gap,
2572                     Start = 0,
2573                     Stop = long.MaxValue
2574                 };
2575             }
2576             else
2577             {
2578                 patternBlock.Stop = i;
2579             }
2580         }
2581         else // patternBlock.Type == PatternBlockType.Gap
2582         {
2583             if (_patternSequence[i] == _sequences.Constants.Any)
2584             {
2585                 patternBlock.Start++;
2586                 if (patternBlock.Stop < patternBlock.Start)
2587                 {
2588                     patternBlock.Stop = patternBlock.Start;
2589                 }
2590             }
2591         }
2592     }

```

```

2591         else if (_patternSequence[i] == ZeroOrMany)
2592         {
2593             patternBlock.Stop = long.MaxValue;
2594         }
2595         else
2596         {
2597             pattern.Add(patternBlock);
2598             patternBlock = new PatternBlock
2599             {
2600                 Type = PatternBlockType.Elements,
2601                 Start = i,
2602                 Stop = i
2603             };
2604         }
2605     }
2606 }
2607 if (patternBlock.Type != PatternBlockType.Undefined)
2608 {
2609     pattern.Add(patternBlock);
2610 }
2611 return pattern;
2612 }
2613
2614 // match: search for regexp anywhere in text
2615 //int match(char* regexp, char* text)
2616 //{
2617 //    do
2618 //    {
2619 //        } while (*text++ != '\0');
2620 //    return 0;
2621 //}
2622
2623 // matchhere: search for regexp at beginning of text
2624 //int matchhere(char* regexp, char* text)
2625 //{
2626 //    if (regexp[0] == '\0')
2627 //        return 1;
2628 //    if (regexp[1] == '*')
2629 //        return matchstar(regexp[0], regexp + 2, text);
2630 //    if (regexp[0] == '$' && regexp[1] == '\0')
2631 //        return *text == '\0';
2632 //    if (*text != '\0' && (regexp[0] == '.' || regexp[0] == *text))
2633 //        return matchhere(regexp + 1, text + 1);
2634 //    return 0;
2635 //}
2636
2637 // matchstar: search for c*regexp at beginning of text
2638 //int matchstar(int c, char* regexp, char* text)
2639 //{
2640 //    do
2641 //    {
2642 //        /* a * matches zero or more instances */
2643 //        if (matchhere(regexp, text))
2644 //            return 1;
2645 //    } while (*text != '\0' && (*text++ == c || c == '.'));
2646 //    return 0;
2647 //}
2648
2649 //private void GetNextPatternElement(out LinkIndex element, out long mininumGap, out
2650 //    ↪ long maximumGap)
2651 //{
2652 //    mininumGap = 0;
2653 //    maximumGap = 0;
2654 //    element = 0;
2655 //    for (; _patternPosition < _patternSequence.Length; _patternPosition++)
2656 //    {
2657 //        if (_patternSequence[_patternPosition] == Doublets.Links.Null)
2658 //            mininumGap++;
2659 //        else if (_patternSequence[_patternPosition] == ZeroOrMany)
2660 //            maximumGap = long.MaxValue;
2661 //        else
2662 //            break;
2663 //    }
2664
2665 //    if (maximumGap < mininumGap)
2666 //        maximumGap = mininumGap;
2667 //}
2668 [MethodImpl(MethodImplOptions.AggressiveInlining)]
2669 private bool PatternMatchCore(LinkIndex element)

```

```

2668 {
2669     if (_patternPosition >= _pattern.Count)
2670     {
2671         _patternPosition = -2;
2672         return false;
2673     }
2674     var currentPatternBlock = _pattern[_patternPosition];
2675     if (currentPatternBlock.Type == PatternBlockType.Gap)
2676     {
2677         //var currentMatchingBlockLength = (_sequencePosition -
2678         ↪ _lastMatchedBlockPosition);
2679         if (_sequencePosition < currentPatternBlock.Start)
2680         {
2681             _sequencePosition++;
2682             return true; // Двигаемся дальше
2683         }
2684         // Это последний блок
2685         if (_pattern.Count == _patternPosition + 1)
2686         {
2687             _patternPosition++;
2688             _sequencePosition = 0;
2689             return false; // Полное соответствие
2690         }
2691         else
2692         {
2693             if (_sequencePosition > currentPatternBlock.Stop)
2694             {
2695                 return false; // Соответствие невозможно
2696             }
2697             var nextPatternBlock = _pattern[_patternPosition + 1];
2698             if (_patternSequence[nextPatternBlock.Start] == element)
2699             {
2700                 if (nextPatternBlock.Start < nextPatternBlock.Stop)
2701                 {
2702                     _patternPosition++;
2703                     _sequencePosition = 1;
2704                 }
2705                 else
2706                 {
2707                     _patternPosition += 2;
2708                     _sequencePosition = 0;
2709                 }
2710             }
2711         }
2712     }
2713     else // currentPatternBlock.Type == PatternBlockType.Elements
2714     {
2715         var patternElementPosition = currentPatternBlock.Start + _sequencePosition;
2716         if (_patternSequence[patternElementPosition] != element)
2717         {
2718             return false; // Соответствие невозможно
2719         }
2720         if (patternElementPosition == currentPatternBlock.Stop)
2721         {
2722             _patternPosition++;
2723             _sequencePosition = 0;
2724         }
2725         else
2726         {
2727             _sequencePosition++;
2728         }
2729     }
2730     return true;
2731     //if (_patternSequence[_patternPosition] != element)
2732     //    return false;
2733     //else
2734     //{
2735     //    _sequencePosition++;
2736     //    _patternPosition++;
2737     //    return true;
2738     //}
2739     //if (_filterPosition == _patternSequence.Length)
2740     //{
2741     //    _filterPosition = -2; // Длиннее чем нужно
2742     //    return false;
2743     //}
2744     //if (element != _patternSequence[_filterPosition])
2745     //{

```

```

2746         // _filterPosition = -1;
2747         // return false; // Начинается иначе
2748     //}
2749     //_filterPosition++;
2750     //if (_filterPosition == (_patternSequence.Length - 1))
2751     //    return false;
2752     //if (_filterPosition >= 0)
2753     //{
2754         // if (element == _patternSequence[_filterPosition + 1])
2755         //     _filterPosition++;
2756         // else
2757         //     return false;
2758     //}
2759     //if (_filterPosition < 0)
2760     //{
2761         // if (element == _patternSequence[0])
2762         //     _filterPosition = 0;
2763     //}
2764 }
2765
2766 /// <summary>
2767 /// <para>
2768 /// Adds the all pattern matched to results using the specified sequences to match.
2769 /// </para>
2770 /// <para></para>
2771 /// </summary>
2772 /// <param name="sequencesToMatch">
2773 /// <para>The sequences to match.</para>
2774 /// </param>
2775 [MethodImpl(MethodImplOptions.AggressiveInlining)]
2776 public void AddAllPatternMatchedToResults(IEnumerable<ulong> sequencesToMatch)
2777 {
2778     foreach (var sequenceToMatch in sequencesToMatch)
2779     {
2780         if (PatternMatch(sequenceToMatch))
2781         {
2782             _results.Add(sequenceToMatch);
2783         }
2784     }
2785 }
2786 }
2787 }
2788
2789 #endregion
2790 }
2791 }

```

#### 1.43 ./csharp/Platform.Data.Doublets.Sequences/Sequences.cs

```

1  using System;
2  using System.Collections.Generic;
3  using System.Linq;
4  using System.Runtime.CompilerServices;
5  using Platform.Collections;
6  using Platform.Collections.Lists;
7  using Platform.Collections.Stacks;
8  using Platform.Threading.Synchronization;
9  using Platform.Data.Doublets.Sequences.Walkers;
10 using LinkIndex = System.UInt64;
11
12 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
13
14 namespace Platform.Data.Doublets.Sequences
15 {
16     /// <summary>
17     /// Представляет коллекцию последовательностей связей.
18     /// </summary>
19     /// <remarks>
20     /// Обязательно реализовать атомарность каждого публичного метода.
21     ///
22     /// TODO:
23     ///
24     /// !!! Повышение вероятности повторного использования групп (подпоследовательностей),
25     /// через естественную группировку по unicode типам, все whitespace вместе, все символы
26     /// ↪ вместе, все числа вместе и т.п.
27     /// + использовать ровно сбалансированный вариант, чтобы уменьшать вложенность (глубину
28     /// ↪ графа)
29     ///
30     /// х*у - найти все связи между, в последовательностях любой формы, если не стоит
31     /// ↪ ограничитель на то, что является последовательностью, а что нет,

```

```

29  /// то находятся любые структуры связей, которые содержат эти элементы именно в таком
    ↳ порядке.
30  ///
31  /// Рост последовательности слева и справа.
32  /// Поиск со звёздочкой.
33  /// URL, PURL - реестр используемых во вне ссылок на ресурсы,
34  /// так же проблема может быть решена при реализации дистанционных триггеров.
35  /// Нужны ли уникальные указатели вообще?
36  /// Что если обращение к информации будет происходить через содержимое всегда?
37  ///
38  /// Писать тесты.
39  ///
40  ///
41  /// Можно убрать зависимость от конкретной реализации Links,
42  /// на зависимость от абстрактного элемента, который может быть представлен несколькими
    ↳ способами.
43  ///
44  /// Можно ли как-то сделать один общий интерфейс
45  ///
46  ///
47  /// Блокчейн и/или гит для распределённой записи транзакций.
48  ///
49  /// </remarks>
50  public partial class Sequences : ILinks<LinkIndex> // IList<string>, IList<LinkIndex[]>
    ↳ (после завершения реализации Sequences)
51  {
52      /// <summary>Возвращает значение LinkIndex, обозначающее любое количество
        ↳ связей.</summary>
53      public const LinkIndex ZeroOrMany = LinkIndex.MaxValue;
54
55      /// <summary>
56      /// <para>
57      /// Gets the options value.
58      /// </para>
59      /// <para></para>
60      /// </summary>
61      public SequencesOptions<LinkIndex> Options { get; }
62      /// <summary>
63      /// <para>
64      /// Gets the links value.
65      /// </para>
66      /// <para></para>
67      /// </summary>
68      public SynchronizedLinks<LinkIndex> Links { get; }
69      private readonly ISynchronization _sync;
70
71      /// <summary>
72      /// <para>
73      /// Gets the constants value.
74      /// </para>
75      /// <para></para>
76      /// </summary>
77      public LinksConstants<LinkIndex> Constants { get; }
78
79      /// <summary>
80      /// <para>
81      /// Initializes a new <see cref="Sequences"/> instance.
82      /// </para>
83      /// <para></para>
84      /// </summary>
85      /// <param name="links">
86      /// <para>A links.</para>
87      /// <para></para>
88      /// </param>
89      /// <param name="options">
90      /// <para>A options.</para>
91      /// <para></para>
92      /// </param>
93      [MethodImpl(MethodImplOptions.AggressiveInlining)]
94      public Sequences(SynchronizedLinks<LinkIndex> links, SequencesOptions<LinkIndex> options)
95      {
96          Links = links;
97          _sync = links.SyncRoot;
98          Options = options;
99          Options.ValidateOptions();
100          Options.InitOptions(Links);
101          Constants = links.Constants;
102      }

```

```

103
104 /// <summary>
105 /// <para>
106 /// Initializes a new <see cref="Sequences"/> instance.
107 /// </para>
108 /// <para></para>
109 /// </summary>
110 /// <param name="links">
111 /// <para>A links.</para>
112 /// <para></para>
113 /// </param>
114 [MethodImpl(MethodImplOptions.AggressiveInlining)]
115 public Sequences(SynchronizedLinks<LinkIndex> links) : this(links, new
    ↳ SequencesOptions<LinkIndex>()) { }
116
117 /// <summary>
118 /// <para>
119 /// Determines whether this instance is sequence.
120 /// </para>
121 /// <para></para>
122 /// </summary>
123 /// <param name="sequence">
124 /// <para>The sequence.</para>
125 /// <para></para>
126 /// </param>
127 /// <returns>
128 /// <para>The bool</para>
129 /// <para></para>
130 /// </returns>
131 [MethodImpl(MethodImplOptions.AggressiveInlining)]
132 public bool IsSequence(LinkIndex sequence)
133 {
134     return _sync.ExecuteReadOperation(() =>
135     {
136         if (Options.UseSequenceMarker)
137         {
138             return Options.MarkedSequenceMatcher.IsMatched(sequence);
139         }
140         return !Links.Unsync.IsPartialPoint(sequence);
141     });
142 }
143 [MethodImpl(MethodImplOptions.AggressiveInlining)]
144 private LinkIndex GetSequenceByElements(LinkIndex sequence)
145 {
146     if (Options.UseSequenceMarker)
147     {
148         return Links.SearchOrDefault(Options.SequenceMarkerLink, sequence);
149     }
150     return sequence;
151 }
152 [MethodImpl(MethodImplOptions.AggressiveInlining)]
153 private LinkIndex GetSequenceElements(LinkIndex sequence)
154 {
155     if (Options.UseSequenceMarker)
156     {
157         var linkContents = new Link<ulong>(Links.GetLink(sequence));
158         if (linkContents.Source == Options.SequenceMarkerLink)
159         {
160             return linkContents.Target;
161         }
162         if (linkContents.Target == Options.SequenceMarkerLink)
163         {
164             return linkContents.Source;
165         }
166     }
167     return sequence;
168 }
169
170 #region Count
171
172 /// <summary>
173 /// <para>
174 /// Counts the restrictions.
175 /// </para>
176 /// <para></para>
177 /// </summary>
178 /// <param name="restrictions">
179 /// <para>The restrictions.</para>

```

```

180    /// <para></para>
181    /// </param>
182    /// <exception cref="NotImplementedException">
183    /// <para></para>
184    /// <para></para>
185    /// </exception>
186    /// <returns>
187    /// <para>The link index</para>
188    /// <para></para>
189    /// </returns>
190    [MethodImpl(MethodImplOptions.AggressiveInlining)]
191    public LinkIndex Count(IList<LinkIndex> restrictions)
192    {
193        if (restrictions.IsNullOrEmpty())
194        {
195            return Links.Count(Constants.Any, Options.SequenceMarkerLink, Constants.Any);
196        }
197        if (restrictions.Count == 1) // Первая связь это адрес
198        {
199            var sequenceIndex = restrictions[0];
200            if (sequenceIndex == Constants.Null)
201            {
202                return 0;
203            }
204            if (sequenceIndex == Constants.Any)
205            {
206                return Count(null);
207            }
208            if (Options.UseSequenceMarker)
209            {
210                return Links.Count(Constants.Any, Options.SequenceMarkerLink, sequenceIndex);
211            }
212            return Links.Exists(sequenceIndex) ? 1UL : 0;
213        }
214        throw new NotImplementedException();
215    }
216    [MethodImpl(MethodImplOptions.AggressiveInlining)]
217    private LinkIndex CountUsages(params LinkIndex[] restrictions)
218    {
219        if (restrictions.Length == 0)
220        {
221            return 0;
222        }
223        if (restrictions.Length == 1) // Первая связь это адрес
224        {
225            if (restrictions[0] == Constants.Null)
226            {
227                return 0;
228            }
229            var any = Constants.Any;
230            if (Options.UseSequenceMarker)
231            {
232                var elementsLink = GetSequenceElements(restrictions[0]);
233                var sequenceLink = GetSequenceByElements(elementsLink);
234                if (sequenceLink != Constants.Null)
235                {
236                    return Links.Count(any, sequenceLink) + Links.Count(any, elementsLink) -
237                        ↪ 1;
238                }
239                return Links.Count(any, elementsLink);
240            }
241            return Links.Count(any, restrictions[0]);
242        }
243        throw new NotImplementedException();
244    }
245    #endregion
246    #region Create
247
248    /// <summary>
249    /// <para>
250    /// Creates the restrictions.
251    /// </para>
252    /// <para></para>
253    /// </summary>
254    /// <param name="restrictions">
255    /// <para>The restrictions.</para>
256
```

```

257 /// <para></para>
258 /// </param>
259 /// <returns>
260 /// <para>The link index</para>
261 /// <para></para>
262 /// </returns>
263 [MethodImpl(MethodImplOptions.AggressiveInlining)]
264 public LinkIndex Create(ICollection<LinkIndex> restrictions)
265 {
266     return _sync.ExecuteWriteOperation(() =>
267     {
268         if (restrictions.IsNullOrEmpty())
269         {
270             return Constants.Null;
271         }
272         Links.EnsureInnerReferenceExists(restrictions, nameof(restrictions));
273         return CreateCore(restrictions);
274     });
275 }
276 [MethodImpl(MethodImplOptions.AggressiveInlining)]
277 private LinkIndex CreateCore(ICollection<LinkIndex> restrictions)
278 {
279     LinkIndex[] sequence = restrictions.SkipFirst();
280     if (Options.UseIndex)
281     {
282         Options.Index.Add(sequence);
283     }
284     var sequenceRoot = default(LinkIndex);
285     if (Options.EnforceSingleSequenceVersionOnWriteBasedOnExisting)
286     {
287         var matches = Each(restrictions);
288         if (matches.Count > 0)
289         {
290             sequenceRoot = matches[0];
291         }
292     }
293     else if (Options.EnforceSingleSequenceVersionOnWriteBasedOnNew)
294     {
295         return CompactCore(sequence);
296     }
297     if (sequenceRoot == default)
298     {
299         sequenceRoot = Options.LinksToSequenceConverter.Convert(sequence);
300     }
301     if (Options.UseSequenceMarker)
302     {
303         return Links.Unsync.GetOrCreate(Options.SequenceMarkerLink, sequenceRoot);
304     }
305     return sequenceRoot; // Возвращаем корень последовательности (т.е. сами элементы)
306 }
307
308 #endregion
309
310 #region Each
311
312 /// <summary>
313 /// <para>
314 /// Eaches the sequence.
315 /// </para>
316 /// <para></para>
317 /// </summary>
318 /// <param name="sequence">
319 /// <para>The sequence.</para>
320 /// <para></para>
321 /// </param>
322 /// <returns>
323 /// <para>The results.</para>
324 /// <para></para>
325 /// </returns>
326 [MethodImpl(MethodImplOptions.AggressiveInlining)]
327 public List<LinkIndex> Each(ICollection<LinkIndex> sequence)
328 {
329     var results = new List<LinkIndex>();
330     var filler = new ListFiller<LinkIndex, LinkIndex>(results, Constants.Continue);
331     Each(filler.AddFirstAndReturnConstant, sequence);
332     return results;
333 }
334

```



```

335     /// <summary>
336     /// <para>
337     /// Eaches the handler.
338     /// </para>
339     /// <para></para>
340     /// </summary>
341     /// <param name="handler">
342     /// <para>The handler.</para>
343     /// <para></para>
344     /// </param>
345     /// <param name="restrictions">
346     /// <para>The restrictions.</para>
347     /// <para></para>
348     /// </param>
349     /// <exception cref="NotImplementedException">
350     /// <para></para>
351     /// <para></para>
352     /// </exception>
353     /// <returns>
354     /// <para>The link index</para>
355     /// <para></para>
356     /// </returns>
357     [MethodImpl(MethodImplOptions.AggressiveInlining)]
358     public LinkIndex Each(Func<IList<LinkIndex>, LinkIndex> handler, IList<LinkIndex>
359     ↪ restrictions)
360     {
361         return _sync.ExecuteReadOperation(() =>
362         {
363             if (restrictions.IsNullOrEmpty())
364             {
365                 return Constants.Continue;
366             }
367             Links.EnsureInnerReferenceExists(restrictions, nameof(restrictions));
368             if (restrictions.Count == 1)
369             {
370                 var link = restrictions[0];
371                 var any = Constants.Any;
372                 if (link == any)
373                 {
374                     if (Options.UseSequenceMarker)
375                     {
376                         return Links.Unsync.Each(handler, new Link<LinkIndex>(any,
377                         ↪ Options.SequenceMarkerLink, any));
378                     }
379                     else
380                     {
381                         return Links.Unsync.Each(handler, new Link<LinkIndex>(any, any,
382                         ↪ any));
383                     }
384                 }
385                 if (Options.UseSequenceMarker)
386                 {
387                     var sequenceLinkValues = Links.Unsync.GetLink(link);
388                     if (sequenceLinkValues[Constants.SourcePart] ==
389                     ↪ Options.SequenceMarkerLink)
390                     {
391                         link = sequenceLinkValues[Constants.TargetPart];
392                     }
393                     var sequence = Options.Walker.Walk(link).ToArray().ShiftRight();
394                     sequence[0] = link;
395                     return handler(sequence);
396                 }
397             }
398             else if (restrictions.Count == 2)
399             {
400                 throw new NotImplementedException();
401             }
402             else if (restrictions.Count == 3)
403             {
404                 return Links.Unsync.Each(handler, restrictions);
405             }
406             else
407             {
408                 var sequence = restrictions.SkipFirst();
409                 if (Options.UseIndex && !Options.Index.MightContain(sequence))
410                 {
411                     return Constants.Break;
412                 }
413             }
414         });
415     }

```

```

409         return EachCore(handler, sequence);
410     }
411 });
412 }
413 [MethodImpl(MethodImplOptions.AggressiveInlining)]
414 private LinkIndex EachCore(Func<IList<LinkIndex>, LinkIndex> handler, IList<LinkIndex>
    ↪ values)
415 {
416     var matcher = new Matcher(this, values, new HashSet<LinkIndex>(), handler);
417     // TODO: Find out why matcher.HandleFullMatched executed twice for the same sequence
    ↪ Id.
418     Func<IList<LinkIndex>, LinkIndex> innerHandler = Options.UseSequenceMarker ?
    ↪ (Func<IList<LinkIndex>, LinkIndex>)matcher.HandleFullMatchedSequence :
    ↪ matcher.HandleFullMatched;
419     //if (sequence.Length >= 2)
420     if (StepRight(innerHandler, values[0], values[1]) != Constants.Continue)
421     {
422         return Constants.Break;
423     }
424     var last = values.Count - 2;
425     for (var i = 1; i < last; i++)
426     {
427         if (PartialStepRight(innerHandler, values[i], values[i + 1]) !=
    ↪ Constants.Continue)
428         {
429             return Constants.Break;
430         }
431     }
432     if (values.Count >= 3)
433     {
434         if (StepLeft(innerHandler, values[values.Count - 2], values[values.Count - 1])
    ↪ != Constants.Continue)
435         {
436             return Constants.Break;
437         }
438     }
439     return Constants.Continue;
440 }
441 [MethodImpl(MethodImplOptions.AggressiveInlining)]
442 private LinkIndex PartialStepRight(Func<IList<LinkIndex>, LinkIndex> handler, LinkIndex
    ↪ left, LinkIndex right)
443 {
444     return Links.Unsync.Each(doublet =>
445     {
446         var doubletIndex = doublet[Constants.IndexPart];
447         if (StepRight(handler, doubletIndex, right) != Constants.Continue)
448         {
449             return Constants.Break;
450         }
451         if (left != doubletIndex)
452         {
453             return PartialStepRight(handler, doubletIndex, right);
454         }
455         return Constants.Continue;
456     }, new Link<LinkIndex>(Constants.Any, Constants.Any, left));
457 }
458 [MethodImpl(MethodImplOptions.AggressiveInlining)]
459 private LinkIndex StepRight(Func<IList<LinkIndex>, LinkIndex> handler, LinkIndex left,
    ↪ LinkIndex right) => Links.Unsync.Each(rightStep => TryStepRightUp(handler, right,
    ↪ rightStep[Constants.IndexPart]), new Link<LinkIndex>(Constants.Any, left,
    ↪ Constants.Any));
460 [MethodImpl(MethodImplOptions.AggressiveInlining)]
461 private LinkIndex TryStepRightUp(Func<IList<LinkIndex>, LinkIndex> handler, LinkIndex
    ↪ right, LinkIndex stepFrom)
462 {
463     var upStep = stepFrom;
464     var firstSource = Links.Unsync.GetTarget(upStep);
465     while (firstSource != right && firstSource != upStep)
466     {
467         upStep = firstSource;
468         firstSource = Links.Unsync.GetSource(upStep);
469     }
470     if (firstSource == right)
471     {
472         return handler(new LinkAddress<LinkIndex>(stepFrom));
473     }
474     return Constants.Continue;
475 }

```

```

476 [MethodImpl(MethodImplOptions.AggressiveInlining)]
477 private LinkIndex StepLeft(Func<IList<LinkIndex>, LinkIndex> handler, LinkIndex left,
    ↳ LinkIndex right) => Links.Unsync.Each(leftStep => TryStepLeftUp(handler, left,
    ↳ leftStep[Constants.IndexPart]), new Link<LinkIndex>(Constants.Any, Constants.Any,
    ↳ right));
478 [MethodImpl(MethodImplOptions.AggressiveInlining)]
479 private LinkIndex TryStepLeftUp(Func<IList<LinkIndex>, LinkIndex> handler, LinkIndex
    ↳ left, LinkIndex stepFrom)
480 {
481     var upStep = stepFrom;
482     var firstTarget = Links.Unsync.GetSource(upStep);
483     while (firstTarget != left && firstTarget != upStep)
484     {
485         upStep = firstTarget;
486         firstTarget = Links.Unsync.GetTarget(upStep);
487     }
488     if (firstTarget == left)
489     {
490         return handler(new LinkAddress<LinkIndex>(stepFrom));
491     }
492     return Constants.Continue;
493 }
494
495 #endregion
496
497 #region Update
498
499 /// <summary>
500 /// <para>
501 /// Updates the restrictions.
502 /// </para>
503 /// <para></para>
504 /// </summary>
505 /// <param name="restrictions">
506 /// <para>The restrictions.</para>
507 /// <para></para>
508 /// </param>
509 /// <param name="substitution">
510 /// <para>The substitution.</para>
511 /// <para></para>
512 /// </param>
513 /// <returns>
514 /// <para>The link index</para>
515 /// <para></para>
516 /// </returns>
517 [MethodImpl(MethodImplOptions.AggressiveInlining)]
518 public LinkIndex Update(IList<LinkIndex> restrictions, IList<LinkIndex> substitution)
519 {
520     var sequence = restrictions.SkipFirst();
521     var newSequence = substitution.SkipFirst();
522     if (sequence.IsNullOrEmpty() && newSequence.IsNullOrEmpty())
523     {
524         return Constants.Null;
525     }
526     if (sequence.IsNullOrEmpty())
527     {
528         return Create(substitution);
529     }
530     if (newSequence.IsNullOrEmpty())
531     {
532         Delete(restrictions);
533         return Constants.Null;
534     }
535     return _sync.ExecuteWriteOperation((Func<ulong>)(() =>
536     {
537         ILinksExtensions.EnsureLinkIsAnyOrExists<ulong>(Links, (IList<ulong>)sequence);
538         Links.EnsureLinkExists(newSequence);
539         return UpdateCore(sequence, newSequence);
540     })));
541 }
542 [MethodImpl(MethodImplOptions.AggressiveInlining)]
543 private LinkIndex UpdateCore(IList<LinkIndex> sequence, IList<LinkIndex> newSequence)
544 {
545     LinkIndex bestVariant;
546     if (Options.EnforceSingleSequenceVersionOnWriteBasedOnNew &&
    ↳ !sequence.EqualTo(newSequence))
547     {
548         bestVariant = CompactCore(newSequence);

```

```

549     }
550     else
551     {
552         bestVariant = CreateCore(newSequence);
553     }
554     // TODO: Check all options only ones before loop execution
555     // Возможно нужно две версии Each, возвращающий фактические последовательности и с
556     // ↪ маркером,
557     // или возможно даже возвращать и тот и тот вариант. С другой стороны все варианты
558     // ↪ можно получить имея только фактические последовательности.
559     foreach (var variant in Each(sequence))
560     {
561         if (variant != bestVariant)
562         {
563             UpdateOneCore(variant, bestVariant);
564         }
565     }
566     return bestVariant;
567 }
568 [MethodImpl(MethodImplOptions.AggressiveInlining)]
569 private void UpdateOneCore(LinkIndex sequence, LinkIndex newSequence)
570 {
571     if (Options.UseGarbageCollection)
572     {
573         var sequenceElements = GetSequenceElements(sequence);
574         var sequenceElementsContents = new Link<ulong>(Links.GetLink(sequenceElements));
575         var sequenceLink = GetSequenceByElements(sequenceElements);
576         var newSequenceElements = GetSequenceElements(newSequence);
577         var newSequenceLink = GetSequenceByElements(newSequenceElements);
578         if (Options.UseCascadeUpdate || CountUsages(sequence) == 0)
579         {
580             if (sequenceLink != Constants.Null)
581             {
582                 Links.Unsync.MergeAndDelete(sequenceLink, newSequenceLink);
583             }
584             Links.Unsync.MergeAndDelete(sequenceElements, newSequenceElements);
585         }
586         ClearGarbage(sequenceElementsContents.Source);
587         ClearGarbage(sequenceElementsContents.Target);
588     }
589     else
590     {
591         if (Options.UseSequenceMarker)
592         {
593             var sequenceElements = GetSequenceElements(sequence);
594             var sequenceLink = GetSequenceByElements(sequenceElements);
595             var newSequenceElements = GetSequenceElements(newSequence);
596             var newSequenceLink = GetSequenceByElements(newSequenceElements);
597             if (Options.UseCascadeUpdate || CountUsages(sequence) == 0)
598             {
599                 if (sequenceLink != Constants.Null)
600                 {
601                     Links.Unsync.MergeAndDelete(sequenceLink, newSequenceLink);
602                 }
603                 Links.Unsync.MergeAndDelete(sequenceElements, newSequenceElements);
604             }
605         }
606         else
607         {
608             if (Options.UseCascadeUpdate || CountUsages(sequence) == 0)
609             {
610                 Links.Unsync.MergeAndDelete(sequence, newSequence);
611             }
612         }
613     }
614 }
615 #endregion
616 #region Delete
617
618 /// <summary>
619 /// <para>
620 /// Deletes the restrictions.
621 /// </para>
622 /// <para></para>
623 /// </summary>
624 /// <param name="restrictions">

```

```

625 /// <para>The restrictions.</para>
626 /// <para></para>
627 /// </param>
628 [MethodImpl(MethodImplOptions.AggressiveInlining)]
629 public void Delete(ICollection<LinkIndex> restrictions)
630 {
631     _sync.ExecuteWriteOperation(() =>
632     {
633         var sequence = restrictions.SkipFirst();
634         // TODO: Check all options only ones before loop execution
635         foreach (var linkToDelete in Each(sequence))
636         {
637             DeleteOneCore(linkToDelete);
638         }
639     });
640 }
641 [MethodImpl(MethodImplOptions.AggressiveInlining)]
642 private void DeleteOneCore(LinkIndex link)
643 {
644     if (Options.UseGarbageCollection)
645     {
646         var sequenceElements = GetSequenceElements(link);
647         var sequenceElementsContents = new Link<ulong>(Links.GetLink(sequenceElements));
648         var sequenceLink = GetSequenceByElements(sequenceElements);
649         if (Options.UseCascadeDelete || CountUsages(link) == 0)
650         {
651             if (sequenceLink != Constants.Null)
652             {
653                 Links.Unsync.Delete(sequenceLink);
654             }
655             Links.Unsync.Delete(link);
656         }
657         ClearGarbage(sequenceElementsContents.Source);
658         ClearGarbage(sequenceElementsContents.Target);
659     }
660     else
661     {
662         if (Options.UseSequenceMarker)
663         {
664             var sequenceElements = GetSequenceElements(link);
665             var sequenceLink = GetSequenceByElements(sequenceElements);
666             if (Options.UseCascadeDelete || CountUsages(link) == 0)
667             {
668                 if (sequenceLink != Constants.Null)
669                 {
670                     Links.Unsync.Delete(sequenceLink);
671                 }
672                 Links.Unsync.Delete(link);
673             }
674         }
675         else
676         {
677             if (Options.UseCascadeDelete || CountUsages(link) == 0)
678             {
679                 Links.Unsync.Delete(link);
680             }
681         }
682     }
683 }
684
685 #endregion
686
687 #region Compactification
688
689 /// <summary>
690 /// <para>
691 /// Compacts the all.
692 /// </para>
693 /// <para></para>
694 /// </summary>
695 [MethodImpl(MethodImplOptions.AggressiveInlining)]
696 public void CompactAll()
697 {
698     _sync.ExecuteWriteOperation(() =>
699     {
700         var sequences = Each((LinkAddress<LinkIndex>)Constants.Any);
701         for (int i = 0; i < sequences.Count; i++)
702         {

```

```

703         var sequence = this.ToList(sequences[i]);
704         Compact(sequence.ShiftRight());
705     }
706 });
707 }
708
709 /// <remarks>
710 /// bestVariant можно выбирать по максимальному числу использований,
711 /// но балансированный позволяет гарантировать уникальность (если есть возможность,
712 /// гарантировать его использование в других местах).
713 ///
714 /// Получается этот метод должен игнорировать Options.EnforceSingleSequenceVersionOnWrite
715 /// </remarks>
716 [MethodImpl(MethodImplOptions.AggressiveInlining)]
717 public LinkIndex Compact(ICollection<LinkIndex> sequence)
718 {
719     return _sync.ExecuteWriteOperation(() =>
720     {
721         if (sequence.IsNullOrEmpty())
722         {
723             return Constants.Null;
724         }
725         Links.EnsureInnerReferenceExists(sequence, nameof(sequence));
726         return CompactCore(sequence);
727     });
728 }
729 [MethodImpl(MethodImplOptions.AggressiveInlining)]
730 private LinkIndex CompactCore(ICollection<LinkIndex> sequence) => UpdateCore(sequence,
731     ↪ sequence);
732
733 #endregion
734
735 #region Garbage Collection
736 [MethodImpl(MethodImplOptions.AggressiveInlining)]
737 private bool IsGarbage(LinkIndex link) => link != Options.SequenceMarkerLink &&
738     ↪ !Links.Unsync.IsPartialPoint(link) && Links.Count(Constants.Any, link) == 0;
739 [MethodImpl(MethodImplOptions.AggressiveInlining)]
740 private void ClearGarbage(LinkIndex link)
741 {
742     if (IsGarbage(link))
743     {
744         var contents = new Link<ulong>(Links.GetLink(link));
745         Links.Unsync.Delete(link);
746         ClearGarbage(contents.Source);
747         ClearGarbage(contents.Target);
748     }
749 }
750
751 #endregion
752
753 #region Walkers
754
755 /// <summary>
756 /// <para>
757 /// Determines whether this instance each part.
758 /// </para>
759 /// </summary>
760 /// <param name="handler">
761 /// <para>The handler.</para>
762 /// </param>
763 /// <param name="sequence">
764 /// <para>The sequence.</para>
765 /// </param>
766 /// <returns>
767 /// <para>The bool</para>
768 /// </returns>
769 [MethodImpl(MethodImplOptions.AggressiveInlining)]
770 public bool EachPart(Func<LinkIndex, bool> handler, LinkIndex sequence)
771 {
772     return _sync.ExecuteReadOperation(() =>
773     {
774         var links = Links.Unsync;
775         foreach (var part in Options.Walker.Walk(sequence))
776         {

```

```

779         if (!handler(part))
780         {
781             return false;
782         }
783     }
784     return true;
785 });
786 }
787
788 /// <summary>
789 /// <para>
790 /// Represents the matcher.
791 /// </para>
792 /// <para></para>
793 /// </summary>
794 /// <seealso cref="RightSequenceWalker{LinkIndex}"/>
795 public class Matcher : RightSequenceWalker<LinkIndex>
796 {
797     private readonly Sequences _sequences;
798     private readonly IList<LinkIndex> _patternSequence;
799     private readonly HashSet<LinkIndex> _linksInSequence;
800     private readonly HashSet<LinkIndex> _results;
801     private readonly Func<IList<LinkIndex>, LinkIndex> _stopableHandler;
802     private readonly HashSet<LinkIndex> _readAsElements;
803     private int _filterPosition;
804
805     /// <summary>
806     /// <para>
807     /// Initializes a new <see cref="Matcher"/> instance.
808     /// </para>
809     /// <para></para>
810     /// </summary>
811     /// <param name="sequences">
812     /// <para>A sequences.</para>
813     /// <para></para>
814     /// </param>
815     /// <param name="patternSequence">
816     /// <para>A pattern sequence.</para>
817     /// <para></para>
818     /// </param>
819     /// <param name="results">
820     /// <para>A results.</para>
821     /// <para></para>
822     /// </param>
823     /// <param name="stopableHandler">
824     /// <para>A stopable handler.</para>
825     /// <para></para>
826     /// </param>
827     /// <param name="readAsElements">
828     /// <para>A read as elements.</para>
829     /// <para></para>
830     /// </param>
831     [MethodImpl(MethodImplOptions.AggressiveInlining)]
832     public Matcher(Sequences sequences, IList<LinkIndex> patternSequence,
833         ↳ HashSet<LinkIndex> results, Func<IList<LinkIndex>, LinkIndex> stopableHandler,
834         ↳ HashSet<LinkIndex> readAsElements = null)
835         : base(sequences.Links.Unsync, new DefaultStack<LinkIndex>())
836     {
837         _sequences = sequences;
838         _patternSequence = patternSequence;
839         _linksInSequence = new HashSet<LinkIndex>(patternSequence.Where(x => x !=
840             ↳ _links.Constants.Any && x != ZeroOrMany));
841         _results = results;
842         _stopableHandler = stopableHandler;
843         _readAsElements = readAsElements;
844     }
845
846     /// <summary>
847     /// <para>
848     /// Determines whether this instance is element.
849     /// </para>
850     /// <para></para>
851     /// </summary>
852     /// <param name="link">
853     /// <para>The link.</para>
854     /// <para></para>
855     /// </param>
856     /// <returns>
857     /// <para>The bool</para>

```

```

855     /// <para></para>
856     /// </returns>
857     [MethodImpl(MethodImplOptions.AggressiveInlining)]
858     protected override bool IsElement(LinkIndex link) => base.IsElement(link) ||
        ↳ (_readAsElements != null && _readAsElements.Contains(link)) ||
        ↳ _linksInSequence.Contains(link);

859
860     /// <summary>
861     /// <para>
862     /// Determines whether this instance full match.
863     /// </para>
864     /// <para></para>
865     /// </summary>
866     /// <param name="sequenceToMatch">
867     /// <para>The sequence to match.</para>
868     /// <para></para>
869     /// </param>
870     /// <returns>
871     /// <para>The bool</para>
872     /// <para></para>
873     /// </returns>
874     [MethodImpl(MethodImplOptions.AggressiveInlining)]
875     public bool FullMatch(LinkIndex sequenceToMatch)
876     {
877         _filterPosition = 0;
878         foreach (var part in Walk(sequenceToMatch))
879         {
880             if (!FullMatchCore(part))
881             {
882                 break;
883             }
884         }
885         return _filterPosition == _patternSequence.Count;
886     }
887     [MethodImpl(MethodImplOptions.AggressiveInlining)]
888     private bool FullMatchCore(LinkIndex element)
889     {
890         if (_filterPosition == _patternSequence.Count)
891         {
892             _filterPosition = -2; // Длиннее чем нужно
893             return false;
894         }
895         if (_patternSequence[_filterPosition] != _links.Constants.Any
896             && element != _patternSequence[_filterPosition])
897         {
898             _filterPosition = -1;
899             return false; // Начинается/Продолжается иначе
900         }
901         _filterPosition++;
902         return true;
903     }
904
905     /// <summary>
906     /// <para>
907     /// Adds the full matched to results using the specified restrictions.
908     /// </para>
909     /// <para></para>
910     /// </summary>
911     /// <param name="restrictions">
912     /// <para>The restrictions.</para>
913     /// <para></para>
914     /// </param>
915     [MethodImpl(MethodImplOptions.AggressiveInlining)]
916     public void AddFullMatchedToResults(IList<LinkIndex> restrictions)
917     {
918         var sequenceToMatch = restrictions[_links.Constants.IndexPart];
919         if (FullMatch(sequenceToMatch))
920         {
921             _results.Add(sequenceToMatch);
922         }
923     }
924
925     /// <summary>
926     /// <para>
927     /// Handles the full matched using the specified restrictions.
928     /// </para>
929     /// <para></para>
930     /// </summary>

```



```

931    /// <param name="restrictions">
932    /// <para>The restrictions.</para>
933    /// <para></para>
934    /// </param>
935    /// <returns>
936    /// <para>The link index</para>
937    /// <para></para>
938    /// </returns>
939    [MethodImpl(MethodImplOptions.AggressiveInlining)]
940    public LinkIndex HandleFullMatched(IList<LinkIndex> restrictions)
941    {
942        var sequenceToMatch = restrictions[_links.Constants.IndexPart];
943        if (FullMatch(sequenceToMatch) && _results.Add(sequenceToMatch))
944        {
945            return _stopableHandler(new LinkAddress<LinkIndex>(sequenceToMatch));
946        }
947        return _links.Constants.Continue;
948    }
949
950    /// <summary>
951    /// <para>
952    /// Handles the full matched sequence using the specified restrictions.
953    /// </para>
954    /// <para></para>
955    /// </summary>
956    /// <param name="restrictions">
957    /// <para>The restrictions.</para>
958    /// <para></para>
959    /// </param>
960    /// <returns>
961    /// <para>The link index</para>
962    /// <para></para>
963    /// </returns>
964    [MethodImpl(MethodImplOptions.AggressiveInlining)]
965    public LinkIndex HandleFullMatchedSequence(IList<LinkIndex> restrictions)
966    {
967        var sequenceToMatch = restrictions[_links.Constants.IndexPart];
968        var sequence = _sequences.GetSequenceByElements(sequenceToMatch);
969        if (sequence != _links.Constants.Null && FullMatch(sequenceToMatch) &&
970            ↪ _results.Add(sequenceToMatch))
971        {
972            return _stopableHandler(new LinkAddress<LinkIndex>(sequence));
973        }
974        return _links.Constants.Continue;
975    }
976
977    /// <remarks>
978    /// TODO: Add support for LinksConstants.Any
979    /// </remarks>
980    [MethodImpl(MethodImplOptions.AggressiveInlining)]
981    public bool PartialMatch(LinkIndex sequenceToMatch)
982    {
983        _filterPosition = -1;
984        foreach (var part in Walk(sequenceToMatch))
985        {
986            if (!PartialMatchCore(part))
987            {
988                break;
989            }
990        }
991        return _filterPosition == _patternSequence.Count - 1;
992    }
993    [MethodImpl(MethodImplOptions.AggressiveInlining)]
994    private bool PartialMatchCore(LinkIndex element)
995    {
996        if (_filterPosition == (_patternSequence.Count - 1))
997        {
998            return false; // Нашлось
999        }
1000        if (_filterPosition >= 0)
1001        {
1002            if (element == _patternSequence[_filterPosition + 1])
1003            {
1004                _filterPosition++;
1005            }
1006            else
1007            {
1008                _filterPosition = -1;

```

```

1008     }
1009 }
1010 if (_filterPosition < 0)
1011 {
1012     if (element == _patternSequence[0])
1013     {
1014         _filterPosition = 0;
1015     }
1016 }
1017 return true; // Ищем дальше
1018 }
1019
1020 /// <summary>
1021 /// <para>
1022 /// Adds the partial matched to results using the specified sequence to match.
1023 /// </para>
1024 /// <para></para>
1025 /// </summary>
1026 /// <param name="sequenceToMatch">
1027 /// <para>The sequence to match.</para>
1028 /// <para></para>
1029 /// </param>
1030 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1031 public void AddPartialMatchedToResults(LinkIndex sequenceToMatch)
1032 {
1033     if (PartialMatch(sequenceToMatch))
1034     {
1035         _results.Add(sequenceToMatch);
1036     }
1037 }
1038
1039 /// <summary>
1040 /// <para>
1041 /// Handles the partial matched using the specified restrictions.
1042 /// </para>
1043 /// <para></para>
1044 /// </summary>
1045 /// <param name="restrictions">
1046 /// <para>The restrictions.</para>
1047 /// <para></para>
1048 /// </param>
1049 /// <returns>
1050 /// <para>The link index</para>
1051 /// <para></para>
1052 /// </returns>
1053 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1054 public LinkIndex HandlePartialMatched(ICollection<LinkIndex> restrictions)
1055 {
1056     var sequenceToMatch = restrictions[_links.Constants.IndexPart];
1057     if (PartialMatch(sequenceToMatch))
1058     {
1059         return _stopableHandler(new LinkAddress<LinkIndex>(sequenceToMatch));
1060     }
1061     return _links.Constants.Continue;
1062 }
1063
1064 /// <summary>
1065 /// <para>
1066 /// Adds the all partial matched to results using the specified sequences to match.
1067 /// </para>
1068 /// <para></para>
1069 /// </summary>
1070 /// <param name="sequencesToMatch">
1071 /// <para>The sequences to match.</para>
1072 /// <para></para>
1073 /// </param>
1074 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1075 public void AddAllPartialMatchedToResults(IEnumerable<LinkIndex> sequencesToMatch)
1076 {
1077     foreach (var sequenceToMatch in sequencesToMatch)
1078     {
1079         if (PartialMatch(sequenceToMatch))
1080         {
1081             _results.Add(sequenceToMatch);
1082         }
1083     }
1084 }
1085

```

```

1086     /// <summary>
1087     /// <para>
1088     /// Adds the all partial matched to results and read as elements using the specified
1089     ↪ sequences to match.
1090     /// </para>
1091     /// <para></para>
1092     /// </summary>
1093     /// <param name="sequencesToMatch">
1094     /// <para>The sequences to match.</para>
1095     /// </param>
1096     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1097     public void AddAllPartialMatchedToResultsAndReadAsElements(IEnumerable<LinkIndex>
1098     ↪ sequencesToMatch)
1099     {
1100         foreach (var sequenceToMatch in sequencesToMatch)
1101         {
1102             if (PartialMatch(sequenceToMatch))
1103             {
1104                 _readAsElements.Add(sequenceToMatch);
1105                 _results.Add(sequenceToMatch);
1106             }
1107         }
1108     }
1109 }
1110 #endregion
1111 }
1112 }

```

#### 1.44 ./csharp/Platform.Data.Doublets.Sequences/SequencesExtensions.cs

```

1  using System.Collections.Generic;
2  using System.Runtime.CompilerServices;
3  using Platform.Collections.Lists;
4
5  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
6
7  namespace Platform.Data.Doublets.Sequences
8  {
9      /// <summary>
10     /// <para>
11     /// Represents the sequences extensions.
12     /// </para>
13     /// <para></para>
14     /// </summary>
15     public static class SequencesExtensions
16     {
17         /// <summary>
18         /// <para>
19         /// Creates the sequences.
20         /// </para>
21         /// <para></para>
22         /// </summary>
23         /// <typeparam name="TLinkAddress">
24         /// <para>The link.</para>
25         /// <para></para>
26         /// </typeparam>
27         /// <param name="sequences">
28         /// <para>The sequences.</para>
29         /// <para></para>
30         /// </param>
31         /// <param name="groupedSequence">
32         /// <para>The grouped sequence.</para>
33         /// <para></para>
34         /// </param>
35         /// <returns>
36         /// <para>The link</para>
37         /// <para></para>
38         /// </returns>
39         [MethodImpl(MethodImplOptions.AggressiveInlining)]
40         public static TLinkAddress Create<TLinkAddress>(this ILinks<TLinkAddress> sequences,
41         ↪ IList<TLinkAddress[]> groupedSequence)
42         {
43             var finalSequence = new TLinkAddress[groupedSequence.Count];
44             for (var i = 0; i < finalSequence.Length; i++)
45             {
46                 var part = groupedSequence[i];

```

```

46         finalSequence[i] = part.Length == 1 ? part[0] :
           ↪ sequences.Create(part.ShiftRight());
47     }
48     return sequences.Create(finalSequence.ShiftRight());
49 }
50
51 /// <summary>
52 /// <para>
53 /// Returns the list using the specified sequences.
54 /// </para>
55 /// <para></para>
56 /// </summary>
57 /// <typeparam name="TLinkAddress">
58 /// <para>The link.</para>
59 /// <para></para>
60 /// </typeparam>
61 /// <param name="sequences">
62 /// <para>The sequences.</para>
63 /// <para></para>
64 /// </param>
65 /// <param name="sequence">
66 /// <para>The sequence.</para>
67 /// <para></para>
68 /// </param>
69 /// <returns>
70 /// <para>The list.</para>
71 /// <para></para>
72 /// </returns>
73 [MethodImpl(MethodImplOptions.AggressiveInlining)]
74 public static IList<TLinkAddress>? ToList<TLinkAddress>(this ILinks<TLinkAddress>
   ↪ sequences, TLinkAddress sequence)
75 {
76     var list = new List<TLinkAddress>();
77     var filler = new ListFiller<TLinkAddress, TLinkAddress>(list,
   ↪ sequences.Constants.Break);
78     sequences.Each(filler.AddSkipFirstAndReturnConstant, new
   ↪ LinkAddress<TLinkAddress>(sequence));
79     return list;
80 }
81 }
82 }

```

#### 1.45 ./csharp/Platform.Data.Doublets.Sequences/SequencesOptions.cs

```

1  using System;
2  using System.Collections.Generic;
3  using Platform.Interfaces;
4  using Platform.Collections.Stacks;
5  using Platform.Converters;
6  using Platform.Data.Doublets.Sequences.Frequencies.Cache;
7  using Platform.Data.Doublets.Sequences.Frequencies.Counters;
8  using Platform.Data.Doublets.Sequences.Converters;
9  using Platform.Data.Doublets.Sequences.Walkers;
10 using Platform.Data.Doublets.Sequences.Indexes;
11 using Platform.Data.Doublets.Sequences.CriterionMatchers;
12 using System.Runtime.CompilerServices;
13
14 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
15
16 namespace Platform.Data.Doublets.Sequences
17 {
18     /// <summary>
19     /// <para>
20     /// Represents the sequences options.
21     /// </para>
22     /// <para></para>
23     /// </summary>
24     public class SequencesOptions<TLinkAddress> // TODO: To use type parameter <TLinkAddress>
   ↪ the ILinks<TLinkAddress> must contain GetConstants function.
25     {
26         private static readonly EqualityComparer<TLinkAddress> _equalityComparer =
   ↪ EqualityComparer<TLinkAddress>.Default;
27
28         /// <summary>
29         /// <para>
30         /// Gets or sets the sequence marker link value.
31         /// </para>
32         /// <para></para>
33         /// </summary>
34         public TLinkAddress SequenceMarkerLink

```

```

35 {
36     [MethodImpl(MethodImplOptions.AggressiveInlining)]
37     get;
38     [MethodImpl(MethodImplOptions.AggressiveInlining)]
39     set;
40 }
41
42 /// <summary>
43 /// <para>
44 /// Gets or sets the use cascade update value.
45 /// </para>
46 /// <para></para>
47 /// </summary>
48 public bool UseCascadeUpdate
49 {
50     [MethodImpl(MethodImplOptions.AggressiveInlining)]
51     get;
52     [MethodImpl(MethodImplOptions.AggressiveInlining)]
53     set;
54 }
55
56 /// <summary>
57 /// <para>
58 /// Gets or sets the use cascade delete value.
59 /// </para>
60 /// <para></para>
61 /// </summary>
62 public bool UseCascadeDelete
63 {
64     [MethodImpl(MethodImplOptions.AggressiveInlining)]
65     get;
66     [MethodImpl(MethodImplOptions.AggressiveInlining)]
67     set;
68 }
69
70 /// <summary>
71 /// <para>
72 /// Gets or sets the use index value.
73 /// </para>
74 /// <para></para>
75 /// </summary>
76 public bool UseIndex
77 {
78     [MethodImpl(MethodImplOptions.AggressiveInlining)]
79     get;
80     [MethodImpl(MethodImplOptions.AggressiveInlining)]
81     set;
82 } // TODO: Update Index on sequence update/delete.
83
84 /// <summary>
85 /// <para>
86 /// Gets or sets the use sequence marker value.
87 /// </para>
88 /// <para></para>
89 /// </summary>
90 public bool UseSequenceMarker
91 {
92     [MethodImpl(MethodImplOptions.AggressiveInlining)]
93     get;
94     [MethodImpl(MethodImplOptions.AggressiveInlining)]
95     set;
96 }
97
98 /// <summary>
99 /// <para>
100 /// Gets or sets the use compression value.
101 /// </para>
102 /// <para></para>
103 /// </summary>
104 public bool UseCompression
105 {
106     [MethodImpl(MethodImplOptions.AggressiveInlining)]
107     get;
108     [MethodImpl(MethodImplOptions.AggressiveInlining)]
109     set;
110 }
111
112 /// <summary>
113 /// <para>
114 /// Gets or sets the use garbage collection value.

```

```

115 /// </para>
116 /// <para></para>
117 /// </summary>
118 public bool UseGarbageCollection
119 {
120     [MethodImpl(MethodImplOptions.AggressiveInlining)]
121     get;
122     [MethodImpl(MethodImplOptions.AggressiveInlining)]
123     set;
124 }
125
126 /// <summary>
127 /// <para>
128 /// Gets or sets the enforce single sequence version on write based on existing value.
129 /// </para>
130 /// <para></para>
131 /// </summary>
132 public bool EnforceSingleSequenceVersionOnWriteBasedOnExisting
133 {
134     [MethodImpl(MethodImplOptions.AggressiveInlining)]
135     get;
136     [MethodImpl(MethodImplOptions.AggressiveInlining)]
137     set;
138 }
139
140 /// <summary>
141 /// <para>
142 /// Gets or sets the enforce single sequence version on write based on new value.
143 /// </para>
144 /// <para></para>
145 /// </summary>
146 public bool EnforceSingleSequenceVersionOnWriteBasedOnNew
147 {
148     [MethodImpl(MethodImplOptions.AggressiveInlining)]
149     get;
150     [MethodImpl(MethodImplOptions.AggressiveInlining)]
151     set;
152 }
153
154 /// <summary>
155 /// <para>
156 /// Gets or sets the marked sequence matcher value.
157 /// </para>
158 /// <para></para>
159 /// </summary>
160 public MarkedSequenceCriterionMatcher<TLinkAddress> MarkedSequenceMatcher
161 {
162     [MethodImpl(MethodImplOptions.AggressiveInlining)]
163     get;
164     [MethodImpl(MethodImplOptions.AggressiveInlining)]
165     set;
166 }
167
168 /// <summary>
169 /// <para>
170 /// Gets or sets the links to sequence converter value.
171 /// </para>
172 /// <para></para>
173 /// </summary>
174 public IConverter<IList<TLinkAddress>?, TLinkAddress> LinksToSequenceConverter
175 {
176     [MethodImpl(MethodImplOptions.AggressiveInlining)]
177     get;
178     [MethodImpl(MethodImplOptions.AggressiveInlining)]
179     set;
180 }
181
182 /// <summary>
183 /// <para>
184 /// Gets or sets the index value.
185 /// </para>
186 /// <para></para>
187 /// </summary>
188 public ISequenceIndex<TLinkAddress> Index
189 {
190     [MethodImpl(MethodImplOptions.AggressiveInlining)]
191     get;
192     [MethodImpl(MethodImplOptions.AggressiveInlining)]
193     set;
194 }

```

```

195
196     /// <summary>
197     /// <para>
198     /// Gets or sets the walker value.
199     /// </para>
200     /// <para></para>
201     /// </summary>
202     public ISequenceWalker<TLinkAddress> Walker
203     {
204         [MethodImpl(MethodImplOptions.AggressiveInlining)]
205         get;
206         [MethodImpl(MethodImplOptions.AggressiveInlining)]
207         set;
208     }
209
210     /// <summary>
211     /// <para>
212     /// Gets or sets the read full sequence value.
213     /// </para>
214     /// <para></para>
215     /// </summary>
216     public bool ReadFullSequence
217     {
218         [MethodImpl(MethodImplOptions.AggressiveInlining)]
219         get;
220         [MethodImpl(MethodImplOptions.AggressiveInlining)]
221         set;
222     }
223
224     // TODO: Реализовать компактификацию при чтении
225     //public bool EnforceSingleSequenceVersionOnRead { get; set; }
226     //public bool UseRequestMarker { get; set; }
227     //public bool StoreRequestResults { get; set; }
228
229     /// <summary>
230     /// <para>
231     /// Inits the options using the specified links.
232     /// </para>
233     /// <para></para>
234     /// </summary>
235     /// <param name="links">
236     /// <para>The links.</para>
237     /// <para></para>
238     /// </param>
239     /// <exception cref="InvalidOperationException">
240     /// <para>Cannot recreate sequence marker link.</para>
241     /// <para></para>
242     /// </exception>
243     [MethodImpl(MethodImplOptions.AggressiveInlining)]
244     public void InitOptions(ISynchronizedLinks<TLinkAddress> links)
245     {
246         if (UseSequenceMarker)
247         {
248             if (_equalityComparer.Equals(SequenceMarkerLink, links.Constants.Null))
249             {
250                 SequenceMarkerLink = links.CreatePoint();
251             }
252             else
253             {
254                 if (!links.Exists(SequenceMarkerLink))
255                 {
256                     var link = links.CreatePoint();
257                     if (!_equalityComparer.Equals(link, SequenceMarkerLink))
258                     {
259                         throw new InvalidOperationException("Cannot recreate sequence marker
260                             ↪ link.");
261                     }
262                 }
263             }
264             if (MarkedSequenceMatcher == null)
265             {
266                 MarkedSequenceMatcher = new
267                     ↪ MarkedSequenceCriterionMatcher<TLinkAddress>(links, SequenceMarkerLink);
268             }
269             var balancedVariantConverter = new BalancedVariantConverter<TLinkAddress>(links);
270             if (UseCompression)
271             {

```

```

271         if (LinksToSequenceConverter == null)
272         {
273             ICounter<TLinkAddress, TLinkAddress> totalSequenceSymbolFrequencyCounter;
274             if (UseSequenceMarker)
275             {
276                 totalSequenceSymbolFrequencyCounter = new
277                     ↪ TotalMarkedSequenceSymbolFrequencyCounter<TLinkAddress>(links,
278                     ↪ MarkedSequenceMatcher);
279             }
280             else
281             {
282                 totalSequenceSymbolFrequencyCounter = new
283                     ↪ TotalSequenceSymbolFrequencyCounter<TLinkAddress>(links);
284             }
285             var doubletFrequenciesCache = new LinkFrequenciesCache<TLinkAddress>(links,
286                 ↪ totalSequenceSymbolFrequencyCounter);
287             var compressingConverter = new CompressingConverter<TLinkAddress>(links,
288                 ↪ balancedVariantConverter, doubletFrequenciesCache);
289             LinksToSequenceConverter = compressingConverter;
290         }
291         else
292         {
293             if (LinksToSequenceConverter == null)
294             {
295                 LinksToSequenceConverter = balancedVariantConverter;
296             }
297             if (UseIndex && Index == null)
298             {
299                 Index = new SequenceIndex<TLinkAddress>(links);
300             }
301             if (Walker == null)
302             {
303                 Walker = new RightSequenceWalker<TLinkAddress>(links, new
304                     ↪ DefaultStack<TLinkAddress>());
305             }
306         }
307     }
308
309     /// <summary>
310     /// <para>
311     /// Validates the options.
312     /// </para>
313     /// <para></para>
314     /// </summary>
315     /// <exception cref="NotSupportedException">
316     /// <para>To use garbage collection UseSequenceMarker option must be on.</para>
317     /// <para></para>
318     /// </exception>
319     [MethodImpl(MethodImplOptions.AggressiveInlining)]
320     public void ValidateOptions()
321     {
322         if (UseGarbageCollection && !UseSequenceMarker)
323         {
324             throw new NotSupportedException("To use garbage collection UseSequenceMarker
325                 ↪ option must be on.");
326         }
327     }
328 }

```

#### 1.46 ./csharp/Platform.Data.Doublets.Sequences/Time/DateTimeToLongRawNumberSequenceConverter.cs

```

1  using System;
2  using System.Runtime.CompilerServices;
3  using Platform.Converters;
4
5  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
6
7  namespace Platform.Data.Doublets.Time
8  {
9      /// <summary>
10     /// <para>
11     /// Represents the date time to long raw number sequence converter.
12     /// </para>
13     /// <para></para>
14     /// </summary>
15     /// <seealso cref="IConverter{DateTime, TLinkAddress}"/>
16     public class DateTimeToLongRawNumberSequenceConverter<TLinkAddress> : IConverter<DateTime,
17         ↪ TLinkAddress>

```



```

17 {
18     private readonly IConverter<long, TLinkAddress> _int64ToLongRawNumberConverter;
19
20     /// <summary>
21     /// <para>
22     /// Initializes a new <see cref="DateTimeToLongRawNumberSequenceConverter"/> instance.
23     /// </para>
24     /// <para></para>
25     /// </summary>
26     /// <param name="int64ToLongRawNumberConverter">
27     /// <para>A int 64 to long raw number converter.</para>
28     /// <para></para>
29     /// </param>
30     [MethodImpl(MethodImplOptions.AggressiveInlining)]
31     public DateTimeToLongRawNumberSequenceConverter(IConverter<long, TLinkAddress>
        ↪ int64ToLongRawNumberConverter) => _int64ToLongRawNumberConverter =
        ↪ int64ToLongRawNumberConverter;
32
33     /// <summary>
34     /// <para>
35     /// Converts the source.
36     /// </para>
37     /// <para></para>
38     /// </summary>
39     /// <param name="source">
40     /// <para>The source.</para>
41     /// <para></para>
42     /// </param>
43     /// <returns>
44     /// <para>The link</para>
45     /// <para></para>
46     /// </returns>
47     [MethodImpl(MethodImplOptions.AggressiveInlining)]
48     public TLinkAddress Convert(DateTime source) =>
        ↪ _int64ToLongRawNumberConverter.Convert(source.ToFileTimeUtc());
49 }
50 }

```

#### 1.47 ./csharp/Platform.Data.Doublets.Sequences/Time/LongRawNumberSequenceToDateTimeConverter.cs

```

1 using System;
2 using System.Runtime.CompilerServices;
3 using Platform.Converters;
4
5 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
6
7 namespace Platform.Data.Doublets.Time
8 {
9     /// <summary>
10    /// <para>
11    /// Represents the long raw number sequence to date time converter.
12    /// </para>
13    /// <para></para>
14    /// </summary>
15    /// <seealso cref="IConverter{TLinkAddress, DateTime}"/>
16    public class LongRawNumberSequenceToDateTimeConverter<TLinkAddress> :
        ↪ IConverter<TLinkAddress, DateTime>
17    {
18        private readonly IConverter<TLinkAddress, long> _longRawNumberConverterToInt64;
19
20        /// <summary>
21        /// <para>
22        /// Initializes a new <see cref="LongRawNumberSequenceToDateTimeConverter"/> instance.
23        /// </para>
24        /// <para></para>
25        /// </summary>
26        /// <param name="longRawNumberConverterToInt64">
27        /// <para>A long raw number converter to int 64.</para>
28        /// <para></para>
29        /// </param>
30        [MethodImpl(MethodImplOptions.AggressiveInlining)]
31        public LongRawNumberSequenceToDateTimeConverter(IConverter<TLinkAddress, long>
            ↪ longRawNumberConverterToInt64) => _longRawNumberConverterToInt64 =
            ↪ longRawNumberConverterToInt64;
32
33        /// <summary>
34        /// <para>
35        /// Converts the source.
36        /// </para>
37        /// <para></para>

```

```

38     /// </summary>
39     /// <param name="source">
40     /// <para>The source.</para>
41     /// <para></para>
42     /// </param>
43     /// <returns>
44     /// <para>The date time</para>
45     /// <para></para>
46     /// </returns>
47     [MethodImpl(MethodImplOptions.AggressiveInlining)]
48     public DateTime Convert(TLinkAddress source) =>
49         ↪ DateTime.FromFileTimeUtc(_longRawNumberConverterToInt64.Convert(source));
50 }

```

#### 1.48 ./csharp/Platform.Data.Doublets.Sequences/UInt64LinksExtensions.cs

```

1  using System;
2  using System.Text;
3  using System.Collections.Generic;
4  using System.Runtime.CompilerServices;
5  using Platform.Singletons;
6  using Platform.Data.Doublets.Unicode;
7
8  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
9
10 namespace Platform.Data.Doublets
11 {
12     /// <summary>
13     /// <para>
14     /// Represents the int 64 links extensions.
15     /// </para>
16     /// <para></para>
17     /// </summary>
18     public static class UInt64LinksExtensions
19     {
20         /// <summary>
21         /// <para>
22         /// Uses the unicode using the specified links.
23         /// </para>
24         /// <para></para>
25         /// </summary>
26         /// <param name="links">
27         /// <para>The links.</para>
28         /// <para></para>
29         /// </param>
30         [MethodImpl(MethodImplOptions.AggressiveInlining)]
31         public static void UseUnicode(this ILinks<ulong> links) => UnicodeMap.InitNew(links);
32     }
33 }

```

#### 1.49 ./csharp/Platform.Data.Doublets.Sequences/Unicode/CharToUnicodeSymbolConverter.cs

```

1  using System.Runtime.CompilerServices;
2  using Platform.Converters;
3
4  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
5
6  namespace Platform.Data.Doublets.Unicode
7  {
8     /// <summary>
9     /// <para>
10     /// Represents the char to unicode symbol converter.
11     /// </para>
12     /// <para></para>
13     /// </summary>
14     /// <seealso cref="LinksOperatorBase{TLinkAddress}"/>
15     /// <seealso cref="IConverter{char, TLinkAddress}"/>
16     public class CharToUnicodeSymbolConverter<TLinkAddress> : LinksOperatorBase<TLinkAddress>,
17         ↪ IConverter<char, TLinkAddress>
18     {
19         private static readonly UncheckedConverter<char, TLinkAddress> _charToAddressConverter =
20             ↪ UncheckedConverter<char, TLinkAddress>.Default;
21         private readonly IConverter<TLinkAddress> _addressToNumberConverter;
22         private readonly TLinkAddress _unicodeSymbolMarker;
23
24         /// <summary>
25         /// <para>
26         /// Initializes a new <see cref="CharToUnicodeSymbolConverter"/> instance.
27         /// </para>
28         /// <para></para>

```

```

27     /// </summary>
28     /// <param name="links">
29     /// <para>A links.</para>
30     /// <para></para>
31     /// </param>
32     /// <param name="addressToNumberConverter">
33     /// <para>A address to number converter.</para>
34     /// <para></para>
35     /// </param>
36     /// <param name="unicodeSymbolMarker">
37     /// <para>A unicode symbol marker.</para>
38     /// <para></para>
39     /// </param>
40     [MethodImpl(MethodImplOptions.AggressiveInlining)]
41     public CharToUnicodeSymbolConverter(ILinks<TLinkAddress> links, IConverter<TLinkAddress>
42     ↪ addressToNumberConverter, TLinkAddress unicodeSymbolMarker) : base(links)
43     {
44         _addressToNumberConverter = addressToNumberConverter;
45         _unicodeSymbolMarker = unicodeSymbolMarker;
46     }
47     /// <summary>
48     /// <para>
49     /// Converts the source.
50     /// </para>
51     /// <para></para>
52     /// </summary>
53     /// <param name="source">
54     /// <para>The source.</para>
55     /// <para></para>
56     /// </param>
57     /// <returns>
58     /// <para>The link</para>
59     /// <para></para>
60     /// </returns>
61     [MethodImpl(MethodImplOptions.AggressiveInlining)]
62     public TLinkAddress Convert(char source)
63     {
64         var unaryNumber =
65         ↪ _addressToNumberConverter.Convert(_charToAddressConverter.Convert(source));
66         return _links.GetOrCreate(unaryNumber, _unicodeSymbolMarker);
67     }
68 }

```

## 1.50 ./csharp/Platform.Data.Doublets.Sequences/Unicode/StringToUnicodeSequenceConverter.cs

```

1 using System.Collections.Generic;
2 using System.Runtime.CompilerServices;
3 using Platform.Converters;
4 using Platform.Data.Doublets.Sequences.Indexes;
5
6 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
7
8 namespace Platform.Data.Doublets.Unicode
9 {
10     /// <summary>
11     /// <para>
12     /// Represents the string to unicode sequence converter.
13     /// </para>
14     /// <para></para>
15     /// </summary>
16     /// <seealso cref="LinksOperatorBase{TLinkAddress}"/>
17     /// <seealso cref="IConverter{string, TLinkAddress}"/>
18     public class StringToUnicodeSequenceConverter<TLinkAddress> :
19     ↪ LinksOperatorBase<TLinkAddress>, IConverter<string, TLinkAddress>
20     {
21         private readonly IConverter<string, IList<TLinkAddress>?>
22         ↪ _stringToUnicodeSymbolListConverter;
23         private readonly IConverter<IList<TLinkAddress>?, TLinkAddress>
24         ↪ _unicodeSymbolListToSequenceConverter;
25
26         /// <summary>
27         /// <para>
28         /// Initializes a new <see cref="StringToUnicodeSequenceConverter"/> instance.
29         /// </para>
30         /// </summary>
31         /// <param name="links">
32         /// <para>A links.</para>

```

```

31     /// <para></para>
32     /// </param>
33     /// <param name="stringToUnicodeSymbolListConverter">
34     /// <para>A string to unicode symbol list converter.</para>
35     /// <para></para>
36     /// </param>
37     /// <param name="unicodeSymbolListToSequenceConverter">
38     /// <para>A unicode symbol list to sequence converter.</para>
39     /// <para></para>
40     /// </param>
41     [MethodImpl(MethodImplOptions.AggressiveInlining)]
42     public StringToUnicodeSequenceConverter(ILinks<TLinkAddress> links, IConverter<string,
    ↪     IList<TLinkAddress>?> stringToUnicodeSymbolListConverter,
    ↪     IConverter<IList<TLinkAddress>?, TLinkAddress> unicodeSymbolListToSequenceConverter)
    ↪     : base(links)
43     {
44         _stringToUnicodeSymbolListConverter = stringToUnicodeSymbolListConverter;
45         _unicodeSymbolListToSequenceConverter = unicodeSymbolListToSequenceConverter;
46     }
47
48     /// <summary>
49     /// <para>
50     /// Initializes a new <see cref="StringToUnicodeSequenceConverter"/> instance.
51     /// </para>
52     /// <para></para>
53     /// </summary>
54     /// <param name="links">
55     /// <para>A links.</para>
56     /// <para></para>
57     /// </param>
58     /// <param name="stringToUnicodeSymbolListConverter">
59     /// <para>A string to unicode symbol list converter.</para>
60     /// <para></para>
61     /// </param>
62     /// <param name="index">
63     /// <para>A index.</para>
64     /// <para></para>
65     /// </param>
66     /// <param name="listToSequenceLinkConverter">
67     /// <para>A list to sequence link converter.</para>
68     /// <para></para>
69     /// </param>
70     /// <param name="unicodeSequenceMarker">
71     /// <para>A unicode sequence marker.</para>
72     /// <para></para>
73     /// </param>
74     [MethodImpl(MethodImplOptions.AggressiveInlining)]
75     public StringToUnicodeSequenceConverter(ILinks<TLinkAddress> links, IConverter<string,
    ↪     IList<TLinkAddress>?> stringToUnicodeSymbolListConverter,
    ↪     ISequenceIndex<TLinkAddress> index, IConverter<IList<TLinkAddress>?, TLinkAddress>
    ↪     listToSequenceLinkConverter, TLinkAddress unicodeSequenceMarker)
76     : this(links, stringToUnicodeSymbolListConverter, new
    ↪     UnicodeSymbolsListToUnicodeSequenceConverter<TLinkAddress>(links, index,
    ↪     listToSequenceLinkConverter, unicodeSequenceMarker)) { }
77
78     /// <summary>
79     /// <para>
80     /// Initializes a new <see cref="StringToUnicodeSequenceConverter"/> instance.
81     /// </para>
82     /// <para></para>
83     /// </summary>
84     /// <param name="links">
85     /// <para>A links.</para>
86     /// <para></para>
87     /// </param>
88     /// <param name="charToUnicodeSymbolConverter">
89     /// <para>A char to unicode symbol converter.</para>
90     /// <para></para>
91     /// </param>
92     /// <param name="index">
93     /// <para>A index.</para>
94     /// <para></para>
95     /// </param>
96     /// <param name="listToSequenceLinkConverter">
97     /// <para>A list to sequence link converter.</para>
98     /// <para></para>
99     /// </param>
100    /// <param name="unicodeSequenceMarker">

```

```

101  /// <para>A unicode sequence marker.</para>
102  /// <para></para>
103  /// </param>
104  [MethodImpl(MethodImplOptions.AggressiveInlining)]
105  public StringToUnicodeSequenceConverter(ILinks<TLinkAddress> links, IConverter<char,
    ↳ TLinkAddress> charToUnicodeSymbolConverter, ISequenceIndex<TLinkAddress> index,
    ↳ IConverter<IList<TLinkAddress>?, TLinkAddress> listToSequenceLinkConverter,
    ↳ TLinkAddress unicodeSequenceMarker)
106      : this(links, new
    ↳ StringToUnicodeSymbolsListConverter<TLinkAddress>(charToUnicodeSymbolConverter),
    ↳ index, listToSequenceLinkConverter, unicodeSequenceMarker) { }
107
108  /// <summary>
109  /// <para>
110  /// Initializes a new <see cref="StringToUnicodeSequenceConverter"/> instance.
111  /// </para>
112  /// <para></para>
113  /// </summary>
114  /// <param name="links">
115  /// <para>A links.</para>
116  /// <para></para>
117  /// </param>
118  /// <param name="charToUnicodeSymbolConverter">
119  /// <para>A char to unicode symbol converter.</para>
120  /// <para></para>
121  /// </param>
122  /// <param name="listToSequenceLinkConverter">
123  /// <para>A list to sequence link converter.</para>
124  /// <para></para>
125  /// </param>
126  /// <param name="unicodeSequenceMarker">
127  /// <para>A unicode sequence marker.</para>
128  /// <para></para>
129  /// </param>
130  [MethodImpl(MethodImplOptions.AggressiveInlining)]
131  public StringToUnicodeSequenceConverter(ILinks<TLinkAddress> links, IConverter<char,
    ↳ TLinkAddress> charToUnicodeSymbolConverter, IConverter<IList<TLinkAddress>?,
    ↳ TLinkAddress> listToSequenceLinkConverter, TLinkAddress unicodeSequenceMarker)
132      : this(links, charToUnicodeSymbolConverter, new Unindex<TLinkAddress>(),
    ↳ listToSequenceLinkConverter, unicodeSequenceMarker) { }
133
134  /// <summary>
135  /// <para>
136  /// Initializes a new <see cref="StringToUnicodeSequenceConverter"/> instance.
137  /// </para>
138  /// <para></para>
139  /// </summary>
140  /// <param name="links">
141  /// <para>A links.</para>
142  /// <para></para>
143  /// </param>
144  /// <param name="stringToUnicodeSymbolListConverter">
145  /// <para>A string to unicode symbol list converter.</para>
146  /// <para></para>
147  /// </param>
148  /// <param name="listToSequenceLinkConverter">
149  /// <para>A list to sequence link converter.</para>
150  /// <para></para>
151  /// </param>
152  /// <param name="unicodeSequenceMarker">
153  /// <para>A unicode sequence marker.</para>
154  /// <para></para>
155  /// </param>
156  [MethodImpl(MethodImplOptions.AggressiveInlining)]
157  public StringToUnicodeSequenceConverter(ILinks<TLinkAddress> links, IConverter<string,
    ↳ IList<TLinkAddress>?> stringToUnicodeSymbolListConverter,
    ↳ IConverter<IList<TLinkAddress>?, TLinkAddress> listToSequenceLinkConverter,
    ↳ TLinkAddress unicodeSequenceMarker)
158      : this(links, stringToUnicodeSymbolListConverter, new Unindex<TLinkAddress>(),
    ↳ listToSequenceLinkConverter, unicodeSequenceMarker) { }
159
160  /// <summary>
161  /// <para>
162  /// Converts the source.
163  /// </para>
164  /// <para></para>
165  /// </summary>

```

```

166     /// <param name="source">
167     /// <para>The source.</para>
168     /// <para></para>
169     /// </param>
170     /// <returns>
171     /// <para>The link</para>
172     /// <para></para>
173     /// </returns>
174     [MethodImpl(MethodImplOptions.AggressiveInlining)]
175     public TLinkAddress Convert(string source)
176     {
177         var elements = _stringToUnicodeSymbolListConverter.Convert(source);
178         return _unicodeSymbolListToSequenceConverter.Convert(elements);
179     }
180 }
181 }

```

1.51 `./csharp/Platform.Data.Doublets.Sequences/Unicode/StringToUnicodeSymbolsListConverter.cs`

```

1  using System.Collections.Generic;
2  using System.Runtime.CompilerServices;
3  using Platform.Converters;
4
5  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
6
7  namespace Platform.Data.Doublets.Unicode
8  {
9      /// <summary>
10     /// <para>
11     /// Represents the string to unicode symbols list converter.
12     /// </para>
13     /// <para></para>
14     /// </summary>
15     /// <seealso cref="IConverter{string, IList{TLinkAddress}}"/>
16     public class StringToUnicodeSymbolsListConverter<TLinkAddress> : IConverter<string,
17     ↪     IList<TLinkAddress>?>
18     {
19         private readonly IConverter<char, TLinkAddress> _charToUnicodeSymbolConverter;
20
21         /// <summary>
22         /// <para>
23         /// Initializes a new <see cref="StringToUnicodeSymbolsListConverter"/> instance.
24         /// </para>
25         /// <para></para>
26         /// </summary>
27         /// <param name="charToUnicodeSymbolConverter">
28         /// <para>A char to unicode symbol converter.</para>
29         /// <para></para>
30         /// </param>
31         [MethodImpl(MethodImplOptions.AggressiveInlining)]
32         public StringToUnicodeSymbolsListConverter(IConverter<char, TLinkAddress>
33         ↪     charToUnicodeSymbolConverter) => _charToUnicodeSymbolConverter =
34         ↪     charToUnicodeSymbolConverter;
35
36         /// <summary>
37         /// <para>
38         /// Converts the source.
39         /// </para>
40         /// <para></para>
41         /// </summary>
42         /// <param name="source">
43         /// <para>The source.</para>
44         /// <para></para>
45         /// </param>
46         /// <returns>
47         /// <para>The elements.</para>
48         /// <para></para>
49         /// </returns>
50         [MethodImpl(MethodImplOptions.AggressiveInlining)]
51         public IList<TLinkAddress>? Convert(string source)
52         {
53             var elements = new TLinkAddress[source.Length];
54             for (var i = 0; i < elements.Length; i++)
55             {
56                 elements[i] = _charToUnicodeSymbolConverter.Convert(source[i]);
57             }
58             return elements;
59         }
60     }
61 }

```

## 1.52 ./csharp/Platform.Data.Doublets.Sequences/Unicode/UnicodeMap.cs

```

1  using System;
2  using System.Collections.Generic;
3  using System.Globalization;
4  using System.Runtime.CompilerServices;
5  using System.Text;
6  using Platform.Data.Sequences;
7
8  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
9
10 namespace Platform.Data.Doublets.Unicode
11 {
12     /// <summary>
13     /// <para>
14     /// Represents the unicode map.
15     /// </para>
16     /// <para></para>
17     /// </summary>
18     public class UnicodeMap
19     {
20         /// <summary>
21         /// <para>
22         /// The first char link.
23         /// </para>
24         /// <para></para>
25         /// </summary>
26         public static readonly ulong FirstCharLink = 1;
27         /// <summary>
28         /// <para>
29         /// The max value.
30         /// </para>
31         /// <para></para>
32         /// </summary>
33         public static readonly ulong LastCharLink = FirstCharLink + char.MaxValue;
34         /// <summary>
35         /// <para>
36         /// The max value.
37         /// </para>
38         /// <para></para>
39         /// </summary>
40         public static readonly ulong MapSize = 1 + char.MaxValue;
41         private readonly ILinks<ulong> _links;
42         private bool _initialized;
43
44         /// <summary>
45         /// <para>
46         /// Initializes a new <see cref="UnicodeMap"/> instance.
47         /// </para>
48         /// <para></para>
49         /// </summary>
50         /// <param name="links">
51         /// <para>A links.</para>
52         /// <para></para>
53         /// </param>
54         [MethodImpl(MethodImplOptions.AggressiveInlining)]
55         public UnicodeMap(ILinks<ulong> links) => _links = links;
56
57         /// <summary>
58         /// <para>
59         /// Inits the new using the specified links.
60         /// </para>
61         /// <para></para>
62         /// </summary>
63         /// <param name="links">
64         /// <para>The links.</para>
65         /// <para></para>
66         /// </param>
67         /// <returns>
68         /// <para>The map.</para>
69         /// <para></para>
70         /// </returns>
71         [MethodImpl(MethodImplOptions.AggressiveInlining)]
72         public static UnicodeMap InitNew(ILinks<ulong> links)
73         {
74             var map = new UnicodeMap(links);
75             map.Init();
76             return map;
77         }
78     }

```

```

79     /// <summary>
80     /// <para>
81     /// Inits this instance.
82     /// </para>
83     /// <para></para>
84     /// </summary>
85     /// <exception cref="InvalidOperationException">
86     /// <para>Unable to initialize UTF 16 table.</para>
87     /// <para></para>
88     /// </exception>
89     [MethodImpl(MethodImplOptions.AggressiveInlining)]
90     public void Init()
91     {
92         if (!_initialized)
93         {
94             return;
95         }
96         _initialized = true;
97         var firstLink = _links.CreatePoint();
98         if (firstLink != FirstCharLink)
99         {
100             _links.Delete(firstLink);
101         }
102         else
103         {
104             for (var i = FirstCharLink + 1; i <= LastCharLink; i++)
105             {
106                 // From NIL to It (NIL -> Character) transformation meaning, (or infinite
107                 // ↪ amount of NIL characters before actual Character)
108                 var createdLink = _links.CreatePoint();
109                 _links.Update(createdLink, firstLink, createdLink);
110                 if (createdLink != i)
111                 {
112                     throw new InvalidOperationException("Unable to initialize UTF 16
113                     ↪ table.");
114                 }
115             }
116         }
117
118         // 0 - null link
119         // 1 - nil character (0 character)
120         // ...
121         // 65536 (0(1) + 65535 = 65536 possible values)
122
123     /// <summary>
124     /// <para>
125     /// Creates the char to link using the specified character.
126     /// </para>
127     /// <para></para>
128     /// </summary>
129     /// <param name="character">
130     /// <para>The character.</para>
131     /// <para></para>
132     /// </param>
133     /// <returns>
134     /// <para>The ulong</para>
135     /// <para></para>
136     /// </returns>
137     [MethodImpl(MethodImplOptions.AggressiveInlining)]
138     public static ulong FromCharToLink(char character) => (ulong)character + 1;
139
140     /// <summary>
141     /// <para>
142     /// Creates the link to char using the specified link.
143     /// </para>
144     /// <para></para>
145     /// </summary>
146     /// <param name="link">
147     /// <para>The link.</para>
148     /// <para></para>
149     /// </param>
150     /// <returns>
151     /// <para>The char</para>
152     /// <para></para>
153     /// </returns>
154     [MethodImpl(MethodImplOptions.AggressiveInlining)]
155     public static char FromLinkToChar(ulong link) => (char)(link - 1);

```



```

155     /// <summary>
156     /// <para>
157     /// Determines whether is char link.
158     /// </para>
159     /// </summary>
160     /// <param name="link">
161     /// <para>The link.</para>
162     /// </param>
163     /// <returns>
164     /// <para>The bool</para>
165     /// </returns>
166     [MethodImpl(MethodImplOptions.AggressiveInlining)]
167     public static bool IsCharLink(ulong link) => link <= MapSize;
168
169     /// <summary>
170     /// <para>
171     /// Creates the links to string using the specified links list.
172     /// </para>
173     /// </summary>
174     /// <param name="linksList">
175     /// <para>The links list.</para>
176     /// </param>
177     /// <returns>
178     /// <para>The string</para>
179     /// </returns>
180     [MethodImpl(MethodImplOptions.AggressiveInlining)]
181     public static string FromLinksToString(IList<ulong> linksList)
182     {
183         var sb = new StringBuilder();
184         for (int i = 0; i < linksList.Count; i++)
185         {
186             sb.Append(FromLinkToChar(linksList[i]));
187         }
188         return sb.ToString();
189     }
190
191     /// <summary>
192     /// <para>
193     /// Creates the sequence link to string using the specified link.
194     /// </para>
195     /// </summary>
196     /// <param name="link">
197     /// <para>The link.</para>
198     /// </param>
199     /// <param name="links">
200     /// <para>The links.</para>
201     /// </param>
202     /// <returns>
203     /// <para>The string</para>
204     /// </returns>
205     [MethodImpl(MethodImplOptions.AggressiveInlining)]
206     public static string FromSequenceLinkToString(ulong link, ILinks<ulong> links)
207     {
208         var sb = new StringBuilder();
209         if (links.Exists(link))
210         {
211             StopableSequenceWalker.WalkRight(link, links.GetSource, links.GetTarget,
212                 x => x <= MapSize || links.GetSource(x) == x || links.GetTarget(x) == x,
213                 element =>
214                 {
215                     sb.Append(FromLinkToChar(element));
216                     return true;
217                 }
218             );
219         }
220         return sb.ToString();
221     }
222
223     }
224
225     }
226
227     }
228
229     }
230
231     }

```

```

232     /// <summary>
233     /// <para>
234     /// Creates the chars to link array using the specified chars.
235     /// </para>
236     /// <para></para>
237     /// </summary>
238     /// <param name="chars">
239     /// <para>The chars.</para>
240     /// <para></para>
241     /// </param>
242     /// <returns>
243     /// <para>The ulong array</para>
244     /// <para></para>
245     /// </returns>
246     [MethodImpl(MethodImplOptions.AggressiveInlining)]
247     public static ulong[] FromCharsToLinkArray(char[] chars) => FromCharsToLinkArray(chars,
        ↪ chars.Length);
248
249     /// <summary>
250     /// <para>
251     /// Creates the chars to link array using the specified chars.
252     /// </para>
253     /// <para></para>
254     /// </summary>
255     /// <param name="chars">
256     /// <para>The chars.</para>
257     /// <para></para>
258     /// </param>
259     /// <param name="count">
260     /// <para>The count.</para>
261     /// <para></para>
262     /// </param>
263     /// <returns>
264     /// <para>The links sequence.</para>
265     /// <para></para>
266     /// </returns>
267     [MethodImpl(MethodImplOptions.AggressiveInlining)]
268     public static ulong[] FromCharsToLinkArray(char[] chars, int count)
269     {
270         // char array to ulong array
271         var linksSequence = new ulong[count];
272         for (var i = 0; i < count; i++)
273         {
274             linksSequence[i] = FromCharToLink(chars[i]);
275         }
276         return linksSequence;
277     }
278
279     /// <summary>
280     /// <para>
281     /// Creates the string to link array using the specified sequence.
282     /// </para>
283     /// <para></para>
284     /// </summary>
285     /// <param name="sequence">
286     /// <para>The sequence.</para>
287     /// <para></para>
288     /// </param>
289     /// <returns>
290     /// <para>The links sequence.</para>
291     /// <para></para>
292     /// </returns>
293     [MethodImpl(MethodImplOptions.AggressiveInlining)]
294     public static ulong[] FromStringToLinkArray(string sequence)
295     {
296         // char array to ulong array
297         var linksSequence = new ulong[sequence.Length];
298         for (var i = 0; i < sequence.Length; i++)
299         {
300             linksSequence[i] = FromCharToLink(sequence[i]);
301         }
302         return linksSequence;
303     }
304
305     /// <summary>
306     /// <para>
307     /// Creates the string to link array groups using the specified sequence.
308     /// </para>

```

```

309    /// <para></para>
310    /// </summary>
311    /// <param name="sequence">
312    /// <para>The sequence.</para>
313    /// <para></para>
314    /// </param>
315    /// <returns>
316    /// <para>The result.</para>
317    /// <para></para>
318    /// </returns>
319    [MethodImpl(MethodImplOptions.AggressiveInlining)]
320    public static List<ulong[]> FromStringToLinkArrayGroups(string sequence)
321    {
322        var result = new List<ulong[]>();
323        var offset = 0;
324        while (offset < sequence.Length)
325        {
326            var currentCategory = CharUnicodeInfo.GetUnicodeCategory(sequence[offset]);
327            var relativeLength = 1;
328            var absoluteLength = offset + relativeLength;
329            while (absoluteLength < sequence.Length &&
330                currentCategory ==
331                ↪ CharUnicodeInfo.GetUnicodeCategory(sequence[absoluteLength]))
332            {
333                relativeLength++;
334                absoluteLength++;
335            }
336            // char array to ulong array
337            var innerSequence = new ulong[relativeLength];
338            var maxLength = offset + relativeLength;
339            for (var i = offset; i < maxLength; i++)
340            {
341                innerSequence[i - offset] = FromCharToLink(sequence[i]);
342            }
343            result.Add(innerSequence);
344            offset += relativeLength;
345        }
346        return result;
347    }
348    /// <summary>
349    /// <para>
350    /// Creates the link array to link array groups using the specified array.
351    /// </para>
352    /// <para></para>
353    /// </summary>
354    /// <param name="array">
355    /// <para>The array.</para>
356    /// <para></para>
357    /// </param>
358    /// <returns>
359    /// <para>The result.</para>
360    /// <para></para>
361    /// </returns>
362    [MethodImpl(MethodImplOptions.AggressiveInlining)]
363    public static List<ulong[]> FromLinkArrayToLinkArrayGroups(ulong[] array)
364    {
365        var result = new List<ulong[]>();
366        var offset = 0;
367        while (offset < array.Length)
368        {
369            var relativeLength = 1;
370            if (array[offset] <= LastCharLink)
371            {
372                var currentCategory =
373                ↪ CharUnicodeInfo.GetUnicodeCategory(FromLinkToChar(array[offset]));
374                var absoluteLength = offset + relativeLength;
375                while (absoluteLength < array.Length &&
376                    array[absoluteLength] <= LastCharLink &&
377                    currentCategory == CharUnicodeInfo.GetUnicodeCategory(FromLinkToChar(
378                    ↪ array[absoluteLength])))
379                {
380                    relativeLength++;
381                    absoluteLength++;
382                }
383            }
384            else
385            {
386                var absoluteLength = offset + relativeLength;

```

```

385         while (absoluteLength < array.Length && array[absoluteLength] > LastCharLink)
386         {
387             relativeLength++;
388             absoluteLength++;
389         }
390     }
391     // copy array
392     var innerSequence = new ulong[relativeLength];
393     var maxLength = offset + relativeLength;
394     for (var i = offset; i < maxLength; i++)
395     {
396         innerSequence[i - offset] = array[i];
397     }
398     result.Add(innerSequence);
399     offset += relativeLength;
400 }
401 return result;
402 }
403 }
404 }

```

## 1.53 ./csharp/Platform.Data.Doublets.Sequences/Unicode/UnicodeSequenceToStringConverter.cs

```

1  using System;
2  using System.Runtime.CompilerServices;
3  using Platform.Interfaces;
4  using Platform.Converters;
5  using Platform.Data.Doublets.Sequences.Walkers;
6  using System.Text;
7
8  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
9
10 namespace Platform.Data.Doublets.Unicode
11 {
12     /// <summary>
13     /// <para>
14     /// Represents the unicode sequence to string converter.
15     /// </para>
16     /// <para></para>
17     /// </summary>
18     /// <seealso cref="LinksOperatorBase{TLinkAddress}"/>
19     /// <seealso cref="IConverter{TLinkAddress, string}"/>
20     public class UnicodeSequenceToStringConverter<TLinkAddress> :
21         ↳ LinksOperatorBase<TLinkAddress>, IConverter<TLinkAddress, string>
22     {
23         private readonly ICriterionMatcher<TLinkAddress> _unicodeSequenceCriterionMatcher;
24         private readonly ISequenceWalker<TLinkAddress> _sequenceWalker;
25         private readonly IConverter<TLinkAddress, char> _unicodeSymbolToCharConverter;
26
27         /// <summary>
28         /// <para>
29         /// Initializes a new <see cref="UnicodeSequenceToStringConverter"/> instance.
30         /// </para>
31         /// <para></para>
32         /// </summary>
33         /// <param name="links">
34         /// <para>A links.</para>
35         /// <para></para>
36         /// </param>
37         /// <param name="unicodeSequenceCriterionMatcher">
38         /// <para>A unicode sequence criterion matcher.</para>
39         /// <para></para>
40         /// </param>
41         /// <param name="sequenceWalker">
42         /// <para>A sequence walker.</para>
43         /// <para></para>
44         /// </param>
45         /// <param name="unicodeSymbolToCharConverter">
46         /// <para>A unicode symbol to char converter.</para>
47         /// <para></para>
48         /// </param>
49         [MethodImpl(MethodImplOptions.AggressiveInlining)]
50         public UnicodeSequenceToStringConverter(ILinks<TLinkAddress> links,
51         ↳ ICriterionMatcher<TLinkAddress> unicodeSequenceCriterionMatcher,
52         ↳ ISequenceWalker<TLinkAddress> sequenceWalker, IConverter<TLinkAddress, char>
53         ↳ unicodeSymbolToCharConverter) : base(links)
54     {
55         _unicodeSequenceCriterionMatcher = unicodeSequenceCriterionMatcher;
56         _sequenceWalker = sequenceWalker;
57         _unicodeSymbolToCharConverter = unicodeSymbolToCharConverter;
58     }
59 }

```

```

55
56     /// <summary>
57     /// <para>
58     /// Converts the source.
59     /// </para>
60     /// <para></para>
61     /// </summary>
62     /// <param name="source">
63     /// <para>The source.</para>
64     /// <para></para>
65     /// </param>
66     /// <exception cref="ArgumentOutOfRangeException">
67     /// <para>Specified link is not a unicode sequence.</para>
68     /// <para></para>
69     /// </exception>
70     /// <returns>
71     /// <para>The string</para>
72     /// <para></para>
73     /// </returns>
74     [MethodImpl(MethodImplOptions.AggressiveInlining)]
75     public string Convert(TLinkAddress source)
76     {
77         if (!_unicodeSequenceCriterionMatcher.IsMatched(source))
78         {
79             throw new ArgumentOutOfRangeException(nameof(source), source, "Specified link is
            ↳ not a unicode sequence.");
80         }
81         var sequence = _links.GetSource(source);
82         var sb = new StringBuilder();
83         foreach(var character in _sequenceWalker.Walk(sequence))
84         {
85             sb.Append(_unicodeSymbolToCharConverter.Convert(character));
86         }
87         return sb.ToString();
88     }
89 }
90 }

```

#### 1.54 ./csharp/Platform.Data.Doublets.Sequences/Unicode/UnicodeSymbolToCharConverter.cs

```

1  using System;
2  using System.Runtime.CompilerServices;
3  using Platform.Interfaces;
4  using Platform.Converters;
5
6  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
7
8  namespace Platform.Data.Doublets.Unicode
9  {
10     /// <summary>
11     /// <para>
12     /// Represents the unicode symbol to char converter.
13     /// </para>
14     /// <para></para>
15     /// </summary>
16     /// <seealso cref="LinksOperatorBase{TLinkAddress}"/>
17     /// <seealso cref="IConverter{TLinkAddress, char}"/>
18     public class UnicodeSymbolToCharConverter<TLinkAddress> : LinksOperatorBase<TLinkAddress>,
        ↳ IConverter<TLinkAddress, char>
19     {
20         private static readonly UncheckedConverter<TLinkAddress, char> _addressToCharConverter =
            ↳ UncheckedConverter<TLinkAddress, char>.Default;
21         private readonly IConverter<TLinkAddress> _numberToAddressConverter;
22         private readonly ICriterionMatcher<TLinkAddress> _unicodeSymbolCriterionMatcher;
23
24         /// <summary>
25         /// <para>
26         /// Initializes a new <see cref="UnicodeSymbolToCharConverter"/> instance.
27         /// </para>
28         /// <para></para>
29         /// </summary>
30         /// <param name="links">
31         /// <para>A links.</para>
32         /// <para></para>
33         /// </param>
34         /// <param name="numberToAddressConverter">
35         /// <para>A number to address converter.</para>
36         /// <para></para>
37         /// </param>
38         /// <param name="unicodeSymbolCriterionMatcher">

```

```

39     /// <para>A unicode symbol criterion matcher.</para>
40     /// <para></para>
41     /// </param>
42     [MethodImpl(MethodImplOptions.AggressiveInlining)]
43     public UnicodeSymbolToCharConverter(ILinks<TLinkAddress> links, IConverter<TLinkAddress>
        ↳ numberToAddressConverter, ICriterionMatcher<TLinkAddress>
        ↳ unicodeSymbolCriterionMatcher) : base(links)
44     {
45         _numberToAddressConverter = numberToAddressConverter;
46         _unicodeSymbolCriterionMatcher = unicodeSymbolCriterionMatcher;
47     }
48
49     /// <summary>
50     /// <para>
51     /// Converts the source.
52     /// </para>
53     /// <para></para>
54     /// </summary>
55     /// <param name="source">
56     /// <para>The source.</para>
57     /// <para></para>
58     /// </param>
59     /// <exception cref="ArgumentOutOfRangeException">
60     /// <para>Specified link is not a unicode symbol.</para>
61     /// <para></para>
62     /// </exception>
63     /// <returns>
64     /// <para>The char</para>
65     /// <para></para>
66     /// </returns>
67     [MethodImpl(MethodImplOptions.AggressiveInlining)]
68     public char Convert(TLinkAddress source)
69     {
70         if (!_unicodeSymbolCriterionMatcher.IsMatched(source))
71         {
72             throw new ArgumentOutOfRangeException(nameof(source), source, "Specified link is
        ↳ not a unicode symbol.");
73         }
74         return _addressToCharConverter.Convert(_numberToAddressConverter.Convert(_links.GetS
        ↳ ource(source)));
75     }
76 }
77 }

```

## 1.55 ./csharp/Platform.Data.Doublets.Sequences/Unicode/UnicodeSymbolsListToUnicodeSequenceConverter.cs

```

1 using System.Collections.Generic;
2 using System.Runtime.CompilerServices;
3 using Platform.Converters;
4 using Platform.Data.Doublets.Sequences.Indexes;
5
6 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
7
8 namespace Platform.Data.Doublets.Unicode
9 {
10     /// <summary>
11     /// <para>
12     /// Represents the unicode symbols list to unicode sequence converter.
13     /// </para>
14     /// <para></para>
15     /// </summary>
16     /// <seealso cref="LinksOperatorBase{TLinkAddress}"/>
17     /// <seealso cref="IConverter{IList{TLinkAddress}, TLinkAddress}"/>
18     public class UnicodeSymbolsListToUnicodeSequenceConverter<TLinkAddress> :
        ↳ LinksOperatorBase<TLinkAddress>, IConverter<IList<TLinkAddress>?, TLinkAddress>
19     {
20         private readonly ISequenceIndex<TLinkAddress> _index;
21         private readonly IConverter<IList<TLinkAddress>?, TLinkAddress>
        ↳ _listToSequenceLinkConverter;
22         private readonly TLinkAddress _unicodeSequenceMarker;
23
24         /// <summary>
25         /// <para>
26         /// Initializes a new <see cref="UnicodeSymbolsListToUnicodeSequenceConverter"/>
        ↳ instance.
27         /// </para>
28         /// <para></para>
29         /// </summary>
30         /// <param name="links">
31         /// <para>A links.</para>

```

```

32     /// <para></para>
33     /// </param>
34     /// <param name="index">
35     /// <para>A index.</para>
36     /// <para></para>
37     /// </param>
38     /// <param name="listToSequenceLinkConverter">
39     /// <para>A list to sequence link converter.</para>
40     /// <para></para>
41     /// </param>
42     /// <param name="unicodeSequenceMarker">
43     /// <para>A unicode sequence marker.</para>
44     /// <para></para>
45     /// </param>
46     [MethodImpl(MethodImplOptions.AggressiveInlining)]
47     public UnicodeSymbolsListToUnicodeSequenceConverter(ILinks<TLinkAddress> links,
48         ↪ ISequenceIndex<TLinkAddress> index, IConverter<IList<TLinkAddress>?, TLinkAddress>
49         ↪ listToSequenceLinkConverter, TLinkAddress unicodeSequenceMarker) : base(links)
50     {
51         _index = index;
52         _listToSequenceLinkConverter = listToSequenceLinkConverter;
53         _unicodeSequenceMarker = unicodeSequenceMarker;
54     }
55
56     /// <summary>
57     /// <para>
58     /// Initializes a new <see cref="UnicodeSymbolsListToUnicodeSequenceConverter"/>
59     ↪ instance.
60     /// </para>
61     /// <para></para>
62     /// </summary>
63     /// <param name="links">
64     /// <para>A links.</para>
65     /// <para></para>
66     /// </param>
67     /// <param name="listToSequenceLinkConverter">
68     /// <para>A list to sequence link converter.</para>
69     /// <para></para>
70     /// </param>
71     /// <param name="unicodeSequenceMarker">
72     /// <para>A unicode sequence marker.</para>
73     /// <para></para>
74     /// </param>
75     [MethodImpl(MethodImplOptions.AggressiveInlining)]
76     public UnicodeSymbolsListToUnicodeSequenceConverter(ILinks<TLinkAddress> links,
77         ↪ IConverter<IList<TLinkAddress>?, TLinkAddress> listToSequenceLinkConverter,
78         ↪ TLinkAddress unicodeSequenceMarker)
79         : this(links, new Unindex<TLinkAddress>(), listToSequenceLinkConverter,
80             ↪ unicodeSequenceMarker) { }
81
82     /// <summary>
83     /// <para>
84     /// Converts the list.
85     /// </para>
86     /// <para></para>
87     /// </summary>
88     /// <param name="list">
89     /// <para>The list.</para>
90     /// <para></para>
91     /// </param>
92     /// <returns>
93     /// <para>The link</para>
94     /// <para></para>
95     /// </returns>
96     [MethodImpl(MethodImplOptions.AggressiveInlining)]
97     public TLinkAddress Convert(IList<TLinkAddress>? list)
98     {
99         _index.Add(list);
100         var sequence = _listToSequenceLinkConverter.Convert(list);
101         return _links.GetOrCreate(sequence, _unicodeSequenceMarker);
102     }
103 }

```

## 1.56 ./csharp/Platform.Data.Doublets.Sequences/Walkers/ISequenceWalker.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.Data.Doublets.Sequences.Walkers
7 {
8     /// <summary>
9     /// <para>
10    /// Defines the sequence walker.
11    /// </para>
12    /// <para></para>
13    /// </summary>
14    public interface ISequenceWalker<TLinkAddress>
15    {
16        /// <summary>
17        /// <para>
18        /// Walks the sequence.
19        /// </para>
20        /// <para></para>
21        /// </summary>
22        /// <param name="sequence">
23        /// <para>The sequence.</para>
24        /// <para></para>
25        /// </param>
26        /// <returns>
27        /// <para>An enumerable of t link</para>
28        /// <para></para>
29        /// </returns>
30        [MethodImpl(MethodImplOptions.AggressiveInlining)]
31        IEnumerable<TLinkAddress> Walk(TLinkAddress sequence);
32    }
33 }

```

#### 1.57 ./csharp/Platform.Data.Doublets.Sequences/Walkers/LeftSequenceWalker.cs

```

1 using System;
2 using System.Collections.Generic;
3 using System.Runtime.CompilerServices;
4 using Platform.Collections.Stacks;
5
6 #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
7
8 namespace Platform.Data.Doublets.Sequences.Walkers
9 {
10    /// <summary>
11    /// <para>
12    /// Represents the left sequence walker.
13    /// </para>
14    /// <para></para>
15    /// </summary>
16    /// <seealso cref="SequenceWalkerBase{TLinkAddress}"/>
17    public class LeftSequenceWalker<TLinkAddress> : SequenceWalkerBase<TLinkAddress>
18    {
19        /// <summary>
20        /// <para>
21        /// Initializes a new <see cref="LeftSequenceWalker"/> instance.
22        /// </para>
23        /// <para></para>
24        /// </summary>
25        /// <param name="links">
26        /// <para>A links.</para>
27        /// <para></para>
28        /// </param>
29        /// <param name="stack">
30        /// <para>A stack.</para>
31        /// <para></para>
32        /// </param>
33        /// <param name="isElement">
34        /// <para>A is element.</para>
35        /// <para></para>
36        /// </param>
37        [MethodImpl(MethodImplOptions.AggressiveInlining)]
38        public LeftSequenceWalker(ILinks<TLinkAddress> links, IStack<TLinkAddress> stack,
39            ↪ Func<TLinkAddress, bool> isElement) : base(links, stack, isElement) { }
40
41        /// <summary>
42        /// <para>
43        /// Initializes a new <see cref="LeftSequenceWalker"/> instance.
44        /// </para>
45        /// <para></para>
46        /// </summary>
47        /// <param name="links">

```



```

47     /// <para>A links.</para>
48     /// <para></para>
49     /// </param>
50     /// <param name="stack">
51     /// <para>A stack.</para>
52     /// <para></para>
53     /// </param>
54     [MethodImpl(MethodImplOptions.AggressiveInlining)]
55     public LeftSequenceWalker(ILinks<TLinkAddress> links, IStack<TLinkAddress> stack) :
56         ↪ base(links, stack, links.IsPartialPoint) { }
57
58     /// <summary>
59     /// <para>
60     /// Gets the next element after pop using the specified element.
61     /// </para>
62     /// <para></para>
63     /// </summary>
64     /// <param name="element">
65     /// <para>The element.</para>
66     /// <para></para>
67     /// </param>
68     /// <returns>
69     /// <para>The link</para>
70     /// <para></para>
71     /// </returns>
72     [MethodImpl(MethodImplOptions.AggressiveInlining)]
73     protected override TLinkAddress GetNextElementAfterPop(TLinkAddress element) =>
74         ↪ _links.GetSource(element);
75
76     /// <summary>
77     /// <para>
78     /// Gets the next element after push using the specified element.
79     /// </para>
80     /// <para></para>
81     /// </summary>
82     /// <param name="element">
83     /// <para>The element.</para>
84     /// <para></para>
85     /// </param>
86     /// <returns>
87     /// <para>The link</para>
88     /// <para></para>
89     /// </returns>
90     [MethodImpl(MethodImplOptions.AggressiveInlining)]
91     protected override TLinkAddress GetNextElementAfterPush(TLinkAddress element) =>
92         ↪ _links.GetTarget(element);
93
94     /// <summary>
95     /// <para>
96     /// Walks the contents using the specified element.
97     /// </para>
98     /// <para></para>
99     /// </summary>
100    /// <param name="element">
101    /// <para>The element.</para>
102    /// <para></para>
103    /// </param>
104    /// <returns>
105    /// <para>An enumerable of t link</para>
106    /// <para></para>
107    /// </returns>
108    [MethodImpl(MethodImplOptions.AggressiveInlining)]
109    protected override IEnumerable<TLinkAddress> WalkContents(TLinkAddress element)
110    {
111        var links = _links;
112        var parts = links.GetLink(element);
113        var start = links.Constants.SourcePart;
114        for (var i = parts.Count - 1; i >= start; i--)
115        {
116            var part = parts[i];
117            if (IsElement(part))
118            {
119                yield return part;
120            }
121        }
122    }
123 }

```

## 1.58 ./csharp/Platform.Data.Doublets.Sequences/Walkers/LeveledSequenceWalker.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 // #define USEARRAYPOOL
8 #if USEARRAYPOOL
9 using Platform.Collections;
10 #endif
11
12 namespace Platform.Data.Doublets.Sequences.Walkers
13 {
14     /// <summary>
15     /// <para>
16     /// Represents the leveled sequence walker.
17     /// </para>
18     /// <para></para>
19     /// </summary>
20     /// <seealso cref="LinksOperatorBase{TLinkAddress}"/>
21     /// <seealso cref="ISequenceWalker{TLinkAddress}"/>
22     public class LeveledSequenceWalker<TLinkAddress> : LinksOperatorBase<TLinkAddress>,
23     ↪ ISequenceWalker<TLinkAddress>
24     {
25         private static readonly EqualityComparer<TLinkAddress> _equalityComparer =
26         ↪ EqualityComparer<TLinkAddress>.Default;
27         private readonly Func<TLinkAddress, bool> _isElement;
28
29         /// <summary>
30         /// <para>
31         /// Initializes a new <see cref="LeveledSequenceWalker"/> instance.
32         /// </para>
33         /// <para></para>
34         /// </summary>
35         /// <param name="links">
36         /// <para>A links.</para>
37         /// </param>
38         /// <param name="isElement">
39         /// <para>A is element.</para>
40         /// </param>
41         [MethodImpl(MethodImplOptions.AggressiveInlining)]
42         public LeveledSequenceWalker(ILinks<TLinkAddress> links, Func<TLinkAddress, bool>
43         ↪ isElement) : base(links) => _isElement = isElement;
44
45         /// <summary>
46         /// <para>
47         /// Initializes a new <see cref="LeveledSequenceWalker"/> instance.
48         /// </para>
49         /// <para></para>
50         /// </summary>
51         /// <param name="links">
52         /// <para>A links.</para>
53         /// </param>
54         [MethodImpl(MethodImplOptions.AggressiveInlining)]
55         public LeveledSequenceWalker(ILinks<TLinkAddress> links) : base(links) => _isElement =
56         ↪ _links.IsPartialPoint;
57
58         /// <summary>
59         /// <para>
60         /// Walks the sequence.
61         /// </para>
62         /// <para></para>
63         /// </summary>
64         /// <param name="sequence">
65         /// <para>The sequence.</para>
66         /// </param>
67         /// <returns>
68         /// <para>An enumerable of t link</para>
69         /// </returns>
70         [MethodImpl(MethodImplOptions.AggressiveInlining)]
71         public IEnumerable<TLinkAddress> Walk(TLinkAddress sequence) => ToArray(sequence);
72
73         /// <summary>
74

```

```

75     /// <para>
76     /// Returns the array using the specified sequence.
77     /// </para>
78     /// <para></para>
79     /// </summary>
80     /// <param name="sequence">
81     /// <para>The sequence.</para>
82     /// <para></para>
83     /// </param>
84     /// <returns>
85     /// <para>The link array</para>
86     /// <para></para>
87     /// </returns>
88     [MethodImpl(MethodImplOptions.AggressiveInlining)]
89     public TLinkAddress[] ToArray(TLinkAddress sequence)
90     {
91         var length = 1;
92         var array = new TLinkAddress[length];
93         array[0] = sequence;
94         if (_isElement(sequence))
95         {
96             return array;
97         }
98         bool hasElements;
99         do
100         {
101             length *= 2;
102             #if USEARRAYPOOL
103                 var nextArray = ArrayPool.Allocate<ulong>(length);
104             #else
105                 var nextArray = new TLinkAddress[length];
106             #endif
107             hasElements = false;
108             for (var i = 0; i < array.Length; i++)
109             {
110                 var candidate = array[i];
111                 if (_equalityComparer.Equals(array[i], default))
112                 {
113                     continue;
114                 }
115                 var doubletOffset = i * 2;
116                 if (_isElement(candidate))
117                 {
118                     nextArray[doubletOffset] = candidate;
119                 }
120                 else
121                 {
122                     var links = _links;
123                     var link = links.GetLink(candidate);
124                     var linkSource = links.GetSource(link);
125                     var linkTarget = links.GetTarget(link);
126                     nextArray[doubletOffset] = linkSource;
127                     nextArray[doubletOffset + 1] = linkTarget;
128                     if (!hasElements)
129                     {
130                         hasElements = !(_isElement(linkSource) && _isElement(linkTarget));
131                     }
132                 }
133             }
134             #if USEARRAYPOOL
135                 if (array.Length > 1)
136                 {
137                     ArrayPool.Free(array);
138                 }
139             #endif
140             array = nextArray;
141         }
142         while (hasElements);
143         var filledElementsCount = CountFilledElements(array);
144         if (filledElementsCount == array.Length)
145         {
146             return array;
147         }
148         else
149         {
150             return CopyFilledElements(array, filledElementsCount);
151         }
152     }
153     [MethodImpl(MethodImplOptions.AggressiveInlining)]

```

```

154     private static TLinkAddress[] CopyFilledElements(TLinkAddress[] array, int
        ↪ filledElementsCount)
155     {
156         var finalArray = new TLinkAddress[filledElementsCount];
157         for (int i = 0, j = 0; i < array.Length; i++)
158         {
159             if (!_equalityComparer.Equals(array[i], default))
160             {
161                 finalArray[j] = array[i];
162                 j++;
163             }
164         }
165         #if USEARRAYPOOL
166             ArrayPool.Free(array);
167         #endif
168         return finalArray;
169     }
170     [MethodImpl(MethodImplOptions.AggressiveInlining)]
171     private static int CountFilledElements(TLinkAddress[] array)
172     {
173         var count = 0;
174         for (var i = 0; i < array.Length; i++)
175         {
176             if (!_equalityComparer.Equals(array[i], default))
177             {
178                 count++;
179             }
180         }
181         return count;
182     }
183 }
184 }

```

### 1.59 ./csharp/Platform.Data.Doublets.Sequences/Walkers/RightSequenceWalker.cs

```

1  using System;
2  using System.Collections.Generic;
3  using System.Runtime.CompilerServices;
4  using Platform.Collections.Stacks;
5
6  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
7
8  namespace Platform.Data.Doublets.Sequences.Walkers
9  {
10     /// <summary>
11     /// <para>
12     /// Represents the right sequence walker.
13     /// </para>
14     /// <para></para>
15     /// </summary>
16     /// <seealso cref="SequenceWalkerBase{TLinkAddress}"/>
17     public class RightSequenceWalker<TLinkAddress> : SequenceWalkerBase<TLinkAddress>
18     {
19         /// <summary>
20         /// <para>
21         /// Initializes a new <see cref="RightSequenceWalker"/> instance.
22         /// </para>
23         /// <para></para>
24         /// </summary>
25         /// <param name="links">
26         /// <para>A links.</para>
27         /// <para></para>
28         /// </param>
29         /// <param name="stack">
30         /// <para>A stack.</para>
31         /// <para></para>
32         /// </param>
33         /// <param name="isElement">
34         /// <para>A is element.</para>
35         /// <para></para>
36         /// </param>
37         [MethodImpl(MethodImplOptions.AggressiveInlining)]
38         public RightSequenceWalker(ILinks<TLinkAddress> links, IStack<TLinkAddress> stack,
            ↪ Func<TLinkAddress, bool> isElement) : base(links, stack, isElement) { }
39
40         /// <summary>
41         /// <para>
42         /// Initializes a new <see cref="RightSequenceWalker"/> instance.
43         /// </para>
44         /// <para></para>

```

```

45     /// </summary>
46     /// <param name="links">
47     /// <para>A links.</para>
48     /// <para></para>
49     /// </param>
50     /// <param name="stack">
51     /// <para>A stack.</para>
52     /// <para></para>
53     /// </param>
54     [MethodImpl(MethodImplOptions.AggressiveInlining)]
55     public RightSequenceWalker(ILinks<TLinkAddress> links, IStack<TLinkAddress> stack) :
56         ↪ base(links, stack, links.IsPartialPoint) { }
57
58     /// <summary>
59     /// <para>
60     /// Gets the next element after pop using the specified element.
61     /// </para>
62     /// <para></para>
63     /// </summary>
64     /// <param name="element">
65     /// <para>The element.</para>
66     /// <para></para>
67     /// </param>
68     /// <returns>
69     /// <para>The link</para>
70     /// <para></para>
71     /// </returns>
72     [MethodImpl(MethodImplOptions.AggressiveInlining)]
73     protected override TLinkAddress GetNextElementAfterPop(TLinkAddress element) =>
74         ↪ _links.GetTarget(element);
75
76     /// <summary>
77     /// <para>
78     /// Gets the next element after push using the specified element.
79     /// </para>
80     /// <para></para>
81     /// </summary>
82     /// <param name="element">
83     /// <para>The element.</para>
84     /// <para></para>
85     /// </param>
86     /// <returns>
87     /// <para>The link</para>
88     /// <para></para>
89     /// </returns>
90     [MethodImpl(MethodImplOptions.AggressiveInlining)]
91     protected override TLinkAddress GetNextElementAfterPush(TLinkAddress element) =>
92         ↪ _links.GetSource(element);
93
94     /// <summary>
95     /// <para>
96     /// Walks the contents using the specified element.
97     /// </para>
98     /// <para></para>
99     /// </summary>
100    /// <param name="element">
101    /// <para>The element.</para>
102    /// <para></para>
103    /// </param>
104    /// <returns>
105    /// <para>An enumerable of t link</para>
106    /// <para></para>
107    /// </returns>
108    [MethodImpl(MethodImplOptions.AggressiveInlining)]
109    protected override IEnumerable<TLinkAddress> WalkContents(TLinkAddress element)
110    {
111        var parts = _links.GetLink(element);
112        for (var i = _links.Constants.SourcePart; i < parts.Count; i++)
113        {
114            var part = parts[i];
115            if (IsElement(part))
116            {
117                yield return part;
118            }
119        }
120    }
121 }

```

## 1.60 ./csharp/Platform.Data.Doublets.Sequences/Walkers/SequenceWalkerBase.cs

```

1  using System;
2  using System.Collections.Generic;
3  using System.Runtime.CompilerServices;
4  using Platform.Collections.Stacks;
5
6  #pragma warning disable CS1591 // Missing XML comment for publicly visible type or member
7
8  namespace Platform.Data.Doublets.Sequences.Walkers
9  {
10     /// <summary>
11     /// <para>
12     /// Represents the sequence walker base.
13     /// </para>
14     /// <para></para>
15     /// </summary>
16     /// <seealso cref="LinksOperatorBase{TLinkAddress}"/>
17     /// <seealso cref="ISequenceWalker{TLinkAddress}"/>
18     public abstract class SequenceWalkerBase<TLinkAddress> : LinksOperatorBase<TLinkAddress>,
19         ↳ ISequenceWalker<TLinkAddress>
20     {
21         private readonly IStack<TLinkAddress> _stack;
22         private readonly Func<TLinkAddress, bool> _isElement;
23
24         /// <summary>
25         /// <para>
26         /// Initializes a new <see cref="SequenceWalkerBase"/> instance.
27         /// </para>
28         /// <para></para>
29         /// </summary>
30         /// <param name="links">
31         /// <para>A links.</para>
32         /// </param>
33         /// <param name="stack">
34         /// <para>A stack.</para>
35         /// <para></para>
36         /// </param>
37         /// <param name="isElement">
38         /// <para>A is element.</para>
39         /// <para></para>
40         /// </param>
41         [MethodImpl(MethodImplOptions.AggressiveInlining)]
42         protected SequenceWalkerBase(ILinks<TLinkAddress> links, IStack<TLinkAddress> stack,
43             ↳ Func<TLinkAddress, bool> isElement) : base(links)
44         {
45             _stack = stack;
46             _isElement = isElement;
47         }
48
49         /// <summary>
50         /// <para>
51         /// Initializes a new <see cref="SequenceWalkerBase"/> instance.
52         /// </para>
53         /// <para></para>
54         /// </summary>
55         /// <param name="links">
56         /// <para>A links.</para>
57         /// <para></para>
58         /// </param>
59         /// <param name="stack">
60         /// <para>A stack.</para>
61         /// <para></para>
62         /// </param>
63         [MethodImpl(MethodImplOptions.AggressiveInlining)]
64         protected SequenceWalkerBase(ILinks<TLinkAddress> links, IStack<TLinkAddress> stack) :
65             ↳ this(links, stack, links.IsPartialPoint) { }
66
67         /// <summary>
68         /// <para>
69         /// Walks the sequence.
70         /// </para>
71         /// <para></para>
72         /// </summary>
73         /// <param name="sequence">
74         /// <para>The sequence.</para>
75         /// <para></para>
76         /// </param>
77         /// </returns>

```

```

76  /// <para>An enumerable of t link</para>
77  /// <para></para>
78  /// </returns>
79  [MethodImpl(MethodImplOptions.AggressiveInlining)]
80  public IEnumerable<TLinkAddress> Walk(TLinkAddress sequence)
81  {
82      _stack.Clear();
83      var element = sequence;
84      if (IsElement(element))
85      {
86          yield return element;
87      }
88      else
89      {
90          while (true)
91          {
92              if (IsElement(element))
93              {
94                  if (_stack.IsEmpty)
95                  {
96                      break;
97                  }
98                  element = _stack.Pop();
99                  foreach (var output in WalkContents(element))
100                  {
101                      yield return output;
102                  }
103                  element = GetNextElementAfterPop(element);
104              }
105              else
106              {
107                  _stack.Push(element);
108                  element = GetNextElementAfterPush(element);
109              }
110          }
111      }
112  }
113
114  /// <summary>
115  /// <para>
116  /// Determines whether this instance is element.
117  /// </para>
118  /// <para></para>
119  /// </summary>
120  /// <param name="elementLink">
121  /// <para>The element link.</para>
122  /// <para></para>
123  /// </param>
124  /// <returns>
125  /// <para>The bool</para>
126  /// <para></para>
127  /// </returns>
128  [MethodImpl(MethodImplOptions.AggressiveInlining)]
129  protected virtual bool IsElement(TLinkAddress elementLink) => _isElement(elementLink);
130
131  /// <summary>
132  /// <para>
133  /// Gets the next element after pop using the specified element.
134  /// </para>
135  /// <para></para>
136  /// </summary>
137  /// <param name="element">
138  /// <para>The element.</para>
139  /// <para></para>
140  /// </param>
141  /// <returns>
142  /// <para>The link</para>
143  /// <para></para>
144  /// </returns>
145  [MethodImpl(MethodImplOptions.AggressiveInlining)]
146  protected abstract TLinkAddress GetNextElementAfterPop(TLinkAddress element);
147
148  /// <summary>
149  /// <para>
150  /// Gets the next element after push using the specified element.
151  /// </para>
152  /// <para></para>
153  /// </summary>

```

```

154     /// <param name="element">
155     /// <para>The element.</para>
156     /// <para></para>
157     /// </param>
158     /// <returns>
159     /// <para>The link</para>
160     /// <para></para>
161     /// </returns>
162     [MethodImpl(MethodImplOptions.AggressiveInlining)]
163     protected abstract TLinkAddress GetNextElementAfterPush(TLinkAddress element);
164
165     /// <summary>
166     /// <para>
167     /// Walks the contents using the specified element.
168     /// </para>
169     /// <para></para>
170     /// </summary>
171     /// <param name="element">
172     /// <para>The element.</para>
173     /// <para></para>
174     /// </param>
175     /// <returns>
176     /// <para>An enumerable of t link</para>
177     /// <para></para>
178     /// </returns>
179     [MethodImpl(MethodImplOptions.AggressiveInlining)]
180     protected abstract IEnumerable<TLinkAddress> WalkContents(TLinkAddress element);
181 }
182 }

```

## 1.61 ./csharp/Platform.Data.Doublets.Sequences.Tests/BigIntegerConvertersTests.cs

```

1  using System.Collections.Generic;
2  using System.Numerics;
3  using Platform.Data.Doublets.Memory;
4  using Platform.Data.Doublets.Memory.United.Generic;
5  using Platform.Data.Doublets.Numbers.Raw;
6  using Platform.Data.Doublets.Sequences.Converters;
7  using Platform.Data.Numbers.Raw;
8  using Platform.Memory;
9  using Xunit;
10 using TLinkAddress = System.UInt64;
11
12 namespace Platform.Data.Doublets.Sequences.Tests
13 {
14     public class BigIntegerConvertersTests
15     {
16         public ILinks<TLinkAddress> CreateLinks() => CreateLinks<TLinkAddress>(new
17             ↪ IO.TemporaryFile());
18
19         public ILinks<TLinkAddress> CreateLinks<TLinkAddress>(string dataDbFilename)
20         {
21             var linksConstants = new
22                 ↪ LinksConstants<TLinkAddress>(enableExternalReferencesSupport: true);
23             return new
24                 ↪ UnitedMemoryLinks<TLinkAddress>(new
25                     ↪ FileMappedResizableDirectMemory(dataDbFilename),
26                     ↪ UnitedMemoryLinks<TLinkAddress>.DefaultLinksSizeStep, linksConstants,
27                     ↪ IndexTreeType.Default);
28         }
29
30         [Fact]
31         public void DecimalMaxValueTest()
32         {
33             var links = CreateLinks();
34             BigInteger bigInteger = new(decimal.MaxValue);
35             TLinkAddress negativeNumberMarker = links.Create();
36             AddressToRawNumberConverter<TLinkAddress> addressToRawNumberConverter = new();
37             RawNumberToAddressConverter<TLinkAddress> numberToAddressConverter = new();
38             BalancedVariantConverter<TLinkAddress> listToSequenceConverter = new(links);
39             BigIntegerToRawNumberSequenceConverter<TLinkAddress>
40                 ↪ bigIntegerToRawNumberSequenceConverter = new(links, addressToRawNumberConverter,
41                 ↪ listToSequenceConverter, negativeNumberMarker);
42             RawNumberSequenceToBigIntegerConverter<TLinkAddress>
43                 ↪ rawNumberSequenceToBigIntegerConverter = new(links, numberToAddressConverter,
44                 ↪ negativeNumberMarker);
45             var bigIntSequence = bigIntegerToRawNumberSequenceConverter.Convert(bigInteger);
46             var bigIntFromSequence =
47                 ↪ rawNumberSequenceToBigIntegerConverter.Convert(bigIntSequence);
48             Assert.Equal(bigInteger, bigIntFromSequence);
49         }
50     }
51 }

```



```

39
40 [Fact]
41 public void DecimalMinValueTest()
42 {
43     var links = CreateLinks();
44     BigInteger bigInteger = new(decimal.MinValue);
45     TLinkAddress negativeNumberMarker = links.Create();
46     AddressToRawNumberConverter<TLinkAddress> addressToRawNumberConverter = new();
47     RawNumberToAddressConverter<TLinkAddress> numberToAddressConverter = new();
48     BalancedVariantConverter<TLinkAddress> listToSequenceConverter = new(links);
49     BigIntegerToRawNumberSequenceConverter<TLinkAddress>
50     ↪ bigIntegerToRawNumberSequenceConverter = new(links, addressToRawNumberConverter,
51     ↪ listToSequenceConverter, negativeNumberMarker);
52     RawNumberSequenceToBigIntegerConverter<TLinkAddress>
53     ↪ rawNumberSequenceToBigIntegerConverter = new(links, numberToAddressConverter,
54     ↪ negativeNumberMarker);
55     var bigIntSequence = bigIntegerToRawNumberSequenceConverter.Convert(bigInteger);
56     var bigIntFromSequence =
57     ↪ rawNumberSequenceToBigIntegerConverter.Convert(bigIntSequence);
58     Assert.Equal(bigInteger, bigIntFromSequence);
59 }
60
61 [Fact]
62 public void ZeroValueTest()
63 {
64     var links = CreateLinks();
65     BigInteger bigInteger = new(0);
66     TLinkAddress negativeNumberMarker = links.Create();
67     AddressToRawNumberConverter<TLinkAddress> addressToRawNumberConverter = new();
68     RawNumberToAddressConverter<TLinkAddress> numberToAddressConverter = new();
69     BalancedVariantConverter<TLinkAddress> listToSequenceConverter = new(links);
70     BigIntegerToRawNumberSequenceConverter<TLinkAddress>
71     ↪ bigIntegerToRawNumberSequenceConverter = new(links, addressToRawNumberConverter,
72     ↪ listToSequenceConverter, negativeNumberMarker);
73     RawNumberSequenceToBigIntegerConverter<TLinkAddress>
74     ↪ rawNumberSequenceToBigIntegerConverter = new(links, numberToAddressConverter,
75     ↪ negativeNumberMarker);
76     var bigIntSequence = bigIntegerToRawNumberSequenceConverter.Convert(bigInteger);
77     var bigIntFromSequence =
78     ↪ rawNumberSequenceToBigIntegerConverter.Convert(bigIntSequence);
79     Assert.Equal(bigInteger, bigIntFromSequence);
80 }
81
82 [Fact]
83 public void OneValueTest()
84 {
85     var links = CreateLinks();
86     BigInteger bigInteger = new(1);
87     TLinkAddress negativeNumberMarker = links.Create();
88     AddressToRawNumberConverter<TLinkAddress> addressToRawNumberConverter = new();
89     RawNumberToAddressConverter<TLinkAddress> numberToAddressConverter = new();
90     BalancedVariantConverter<TLinkAddress> listToSequenceConverter = new(links);
91     BigIntegerToRawNumberSequenceConverter<TLinkAddress>
92     ↪ bigIntegerToRawNumberSequenceConverter = new(links, addressToRawNumberConverter,
93     ↪ listToSequenceConverter, negativeNumberMarker);
94     RawNumberSequenceToBigIntegerConverter<TLinkAddress>
95     ↪ rawNumberSequenceToBigIntegerConverter = new(links, numberToAddressConverter,
96     ↪ negativeNumberMarker);
97     var bigIntSequence = bigIntegerToRawNumberSequenceConverter.Convert(bigInteger);
98     var bigIntFromSequence =
99     ↪ rawNumberSequenceToBigIntegerConverter.Convert(bigIntSequence);
100     Assert.Equal(bigInteger, bigIntFromSequence);
101 }
102 }
103 }

```

## 1.62 ./csharp/Platform.Data.Doublets.Sequences.Tests/DefaultSequenceAppenderTests.cs

```

1 using System.Collections.Generic;
2 using Platform.Collections.Stacks;
3 using Platform.Data.Doublets.Memory;
4 using Platform.Data.Doublets.Memory.United.Generic;
5 using Platform.Data.Doublets.Sequences;
6 using Platform.Data.Doublets.Sequences.HeightProviders;
7 using Platform.Data.Numbers.Raw;
8 using Platform.Interfaces;
9 using Platform.Memory;
10 using Platform.Numbers;
11 using Xunit;

```

```

12 using Xunit.Abstractions;
13 using TLinkAddress = System.UInt64;
14
15 namespace Platform.Data.Doublets.Sequences.Tests
16 {
17     public class DefaultSequenceAppenderTests
18     {
19         private readonly ITestOutputHelper _output;
20
21         public DefaultSequenceAppenderTests(ITestOutputHelper output)
22         {
23             _output = output;
24         }
25         public static ILinks<TLinkAddress> CreateLinks() => CreateLinks<TLinkAddress>(new
            ↳ IO.TemporaryFile());
26
27         public static ILinks<TLinkAddress> CreateLinks<TLinkAddress>(string dataDBFilename)
28         {
29             var linksConstants = new
30                 ↳ LinksConstants<TLinkAddress>(enableExternalReferencesSupport: true);
31             return new UnitedMemoryLinks<TLinkAddress>(new
32                 ↳ FileMappedResizableDirectMemory(dataDBFilename),
33                 ↳ UnitedMemoryLinks<TLinkAddress>.DefaultLinksSizeStep, linksConstants,
34                 ↳ IndexTreeType.Default);
35         }
36
37         public class ValueCriterionMatcher<TLinkAddress> : ICriterionMatcher<TLinkAddress>
38         {
39             public readonly ILinks<TLinkAddress> Links;
40             public readonly TLinkAddress Marker;
41             public ValueCriterionMatcher(ILinks<TLinkAddress> links, TLinkAddress marker)
42             {
43                 Links = links;
44                 Marker = marker;
45             }
46
47             public bool IsMatched(TLinkAddress link) =>
48                 ↳ EqualityComparer<TLinkAddress>.Default.Equals(Links.GetSource(link), Marker);
49         }
50
51         [Fact]
52         public void AppendArrayBug()
53         {
54             ILinks<TLinkAddress> links = CreateLinks();
55             TLinkAddress zero = default;
56             var markerIndex = Arithmetic.Increment(zero);
57             var meaningRoot = links.GetOrCreate(markerIndex, markerIndex);
58             var sequence = links.Create();
59             sequence = links.Update(sequence, meaningRoot, sequence);
60             var appendant = links.Create();
61             appendant = links.Update(appendant, meaningRoot, appendant);
62             ValueCriterionMatcher<TLinkAddress> valueCriterionMatcher = new(links, meaningRoot);
63             DefaultSequenceRightHeightProvider<ulong> defaultSequenceRightHeightProvider =
64                 ↳ new(links, valueCriterionMatcher);
65             DefaultSequenceAppender<TLinkAddress> defaultSequenceAppender = new(links, new
66                 ↳ DefaultStack<ulong>(), defaultSequenceRightHeightProvider);
67             var newArray = defaultSequenceAppender.Append(sequence, appendant);
68             var output = links.FormatStructure(newArray, link => link.IsFullPoint(), true);
69             Assert.Equal("(4:(2:1 2) (3:1 3))", output);
70         }
71     }
72 }

```

### 1.63 ./csharp/Platform.Data.Doublets.Sequences.Tests/ILinksExtensionsTests.cs

```

1 using Xunit;
2
3 namespace Platform.Data.Doublets.Sequences.Tests
4 {
5     public class ILinksExtensionsTests
6     {
7         [Fact]
8         public void FormatTest()
9         {
10             using (var scope = new TempLinksTestScope())
11             {
12                 var links = scope.Links;
13                 var link = links.Create();
14                 var linkString = links.Format(link);
15                 Assert.Equal("(1: 1 1)", linkString);
16             }
17         }
18     }
19 }

```

```

16     }
17 }
18 }
19 }

```

#### 1.64 ./csharp/Platform.Data.Doublets.Sequences.Tests/OptimalVariantSequenceTests.cs

```

1  using System;
2  using System.Linq;
3  using Xunit;
4  using Platform.Collections.Stacks;
5  using Platform.Collections.Arrays;
6  using Platform.Memory;
7  using Platform.Data.Numbers.Raw;
8  using Platform.Data.Doublets.Sequences;
9  using Platform.Data.Doublets.Sequences.Frequencies.Cache;
10 using Platform.Data.Doublets.Sequences.Frequencies.Counters;
11 using Platform.Data.Doublets.Sequences.Converters;
12 using Platform.Data.Doublets.PropertyOperators;
13 using Platform.Data.Doublets.Incrementers;
14 using Platform.Data.Doublets.Sequences.Walkers;
15 using Platform.Data.Doublets.Sequences.Indexes;
16 using Platform.Data.Doublets.Unicode;
17 using Platform.Data.Doublets.Numbers.Unary;
18 using Platform.Data.Doublets.Decorators;
19 using Platform.Data.Doublets.Memory.United.Specific;
20 using Platform.Data.Doublets.Memory;
21
22 namespace Platform.Data.Doublets.Sequences.Tests
23 {
24     public static class OptimalVariantSequenceTests
25     {
26         private static readonly string _sequenceExample = "зеленела зелёная зелень";
27         private static readonly string _loremIpsumExample = @"Lorem ipsum dolor sit amet,
                ↳ consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore
                ↳ magna aliqua.
28 Facilisi nullam vehicula ipsum a arcu cursus vitae congue mauris.
29 Et malesuada fames ac turpis egestas sed.
30 Eget velit aliquet sagittis id consectetur purus.
31 Dignissim cras tincidunt lobortis feugiat vivamus.
32 Vitae aliquet nec ullamcorper sit.
33 Lectus quam id leo in vitae.
34 Tortor dignissim convallis aenean et tortor at risus viverra adipiscing.
35 Sed risus ultricies tristique nulla aliquet enim tortor at auctor.
36 Integer eget aliquet nibh praesent tristique.
37 Vitae congue eu consequat ac felis donec et odio.
38 Tristique et egestas quis ipsum suspendisse.
39 Suspendisse potenti nullam ac tortor vitae purus faucibus ornare.
40 Nulla facilisi etiam dignissim diam quis enim lobortis scelerisque.
41 Imperdiet proin fermentum leo vel orci.
42 In ante metus dictum at tempor commodo.
43 Nisi lacus sed viverra tellus in.
44 Quam vulputate dignissim suspendisse in.
45 Elit scelerisque mauris pellentesque pulvinar pellentesque habitant morbi tristique senectus.
46 Gravida cum sociis natoque penatibus et magnis dis parturient.
47 Risus quis varius quam quisque id diam.
48 Congue nisi vitae suscipit tellus mauris a diam maecenas.
49 Eget nunc scelerisque viverra mauris in aliquam sem fringilla.
50 Pharetra vel turpis nunc eget lorem dolor sed viverra.
51 Mattis pellentesque id nibh tortor id aliquet.
52 Purus non enim praesent elementum facilisis leo vel.
53 Etiam sit amet nisl purus in mollis nunc sed.
54 Tortor at auctor urna nunc id cursus metus aliquam.
55 Volutpat odio facilisis mauris sit amet.
56 Turpis egestas pretium aenean pharetra magna ac placerat.
57 Fermentum dui faucibus in ornare quam viverra orci sagittis eu.
58 Porttitor leo a diam sollicitudin tempor id eu.
59 Volutpat sed cras ornare arcu dui.
60 Ut aliquam purus sit amet luctus venenatis lectus magna.
61 Aliquet risus feugiat in ante metus dictum at.
62 Mattis nunc sed blandit libero.
63 Elit pellentesque habitant morbi tristique senectus et netus.
64 Nibh sit amet commodo nulla facilisi nullam vehicula ipsum a.
65 Enim sit amet venenatis urna cursus eget nunc scelerisque viverra.
66 Amet venenatis urna cursus eget nunc scelerisque viverra mauris in.
67 Diam donec adipiscing tristique risus nec feugiat.
68 Pulvinar mattis nunc sed blandit libero volutpat.
69 Cras fermentum odio eu feugiat pretium nibh ipsum.
70 In nulla posuere sollicitudin aliquam ultrices sagittis orci a.
71 Mauris pellentesque pulvinar pellentesque habitant morbi tristique senectus et.
72 A iaculis at erat pellentesque.
73 Morbi blandit cursus risus at ultrices mi tempus imperdiet nulla.
74 Eget lorem dolor sed viverra ipsum nunc.
75 Leo a diam sollicitudin tempor id eu.
76 Interdum consectetur libero id faucibus nisl tincidunt eget nullam non.";

```

```

77 [Fact]
78 public static void LinksBasedFrequencyStoredOptimalVariantSequenceTest()
79 {
80     using (var scope = new TempLinksTestScope(useSequences: false))
81     {
82         var links = scope.Links;
83         var constants = links.Constants;
84
85         links.UseUnicode();
86
87         var sequence = UnicodeMap.FromStringToLinkArray(_sequenceExample);
88
89         var meaningRoot = links.CreatePoint();
90         var unaryOne = links.CreateAndUpdate(meaningRoot, constants.Itself);
91         var frequencyMarker = links.CreateAndUpdate(meaningRoot, constants.Itself);
92         var frequencyPropertyMarker = links.CreateAndUpdate(meaningRoot,
93             ↪ constants.Itself);
94
95         var unaryNumberToAddressConverter = new
96             ↪ UnaryNumberToAddressAddOperationConverter<ulong>(links, unaryOne);
97         var unaryNumberIncrementer = new UnaryNumberIncrementer<ulong>(links, unaryOne);
98         var frequencyIncrementer = new FrequencyIncrementer<ulong>(links,
99             ↪ frequencyMarker, unaryOne, unaryNumberIncrementer);
100         var frequencyPropertyOperator = new PropertyOperator<ulong>(links,
101             ↪ frequencyPropertyMarker, frequencyMarker);
102         var index = new FrequencyIncrementingSequenceIndex<ulong>(links,
103             ↪ frequencyPropertyOperator, frequencyIncrementer);
104         var linkToItsFrequencyNumberConverter = new
105             ↪ LinkToItsFrequencyNumberConverter<ulong>(links, frequencyPropertyOperator,
106             ↪ unaryNumberToAddressConverter);
107         var sequenceToItsLocalElementLevelsConverter = new
108             ↪ SequenceToItsLocalElementLevelsConverter<ulong>(links,
109             ↪ linkToItsFrequencyNumberConverter);
110         var optimalVariantConverter = new OptimalVariantConverter<ulong>(links,
111             ↪ sequenceToItsLocalElementLevelsConverter);
112
113         var sequences = new Sequences(links, new SequencesOptions<ulong>() { Walker =
114             ↪ new LeveledSequenceWalker<ulong>(links) });
115
116         ExecuteTest(sequences, sequence, sequenceToItsLocalElementLevelsConverter,
117             ↪ index, optimalVariantConverter);
118     }
119 }
120
121 [Fact]
122 public static void DictionaryBasedFrequencyStoredOptimalVariantSequenceTest()
123 {
124     using (var scope = new TempLinksTestScope(useSequences: false))
125     {
126         var links = scope.Links;
127
128         links.UseUnicode();
129
130         var sequence = UnicodeMap.FromStringToLinkArray(_sequenceExample);
131
132         var totalSequenceSymbolFrequencyCounter = new
133             ↪ TotalSequenceSymbolFrequencyCounter<ulong>(links);
134
135         var linkFrequenciesCache = new LinkFrequenciesCache<ulong>(links,
136             ↪ totalSequenceSymbolFrequencyCounter);
137
138         var index = new
139             ↪ CachedFrequencyIncrementingSequenceIndex<ulong>(linkFrequenciesCache);
140         var linkToItsFrequencyNumberConverter = new FrequenciesCacheBasedLinkToItsFrequencyNumberConverter<ulong>(linkFrequenciesCache);
141
142         var sequenceToItsLocalElementLevelsConverter = new
143             ↪ SequenceToItsLocalElementLevelsConverter<ulong>(links,
144             ↪ linkToItsFrequencyNumberConverter);
145         var optimalVariantConverter = new OptimalVariantConverter<ulong>(links,
146             ↪ sequenceToItsLocalElementLevelsConverter);
147
148         var sequences = new Sequences(links, new SequencesOptions<ulong>() { Walker =
149             ↪ new LeveledSequenceWalker<ulong>(links) });
150
151         ExecuteTest(sequences, sequence, sequenceToItsLocalElementLevelsConverter,
152             ↪ index, optimalVariantConverter);
153     }
154 }

```

```

134     }
135 }
136 private static void ExecuteTest(Sequences sequences, ulong[] sequence,
    ↪ SequenceToItsLocalElementLevelsConverter<ulong>
    ↪ sequenceToItsLocalElementLevelsConverter, ISequenceIndex<ulong> index,
    ↪ OptimalVariantConverter<ulong> optimalVariantConverter)
137 {
138     index.Add(sequence);
139
140     var optimalVariant = optimalVariantConverter.Convert(sequence);
141
142     var readSequence1 = sequences.ToList(optimalVariant);
143
144     Assert.True(sequence.SequenceEqual(readSequence1));
145 }
146
147 [Fact]
148 public static void SavedSequencesOptimizationTest()
149 {
150     LinksConstants<ulong> constants = new LinksConstants<ulong>((1, long.MaxValue),
    ↪ (long.MaxValue + 1UL, ulong.MaxValue));
151
152     using (var memory = new HeapResizableDirectMemory())
153     using (var disposableLinks = new UInt64UnitedMemoryLinks(memory,
    ↪ UInt64UnitedMemoryLinks.DefaultLinksSizeStep, constants, IndexTreeType.Default))
154     {
155         var links = new UInt64Links(disposableLinks);
156
157         var root = links.CreatePoint();
158
159         //var numberToAddressConverter = new RawNumberToAddressConverter<ulong>();
160         var addressToNumberConverter = new AddressToRawNumberConverter<ulong>();
161
162         var unicodeSymbolMarker = links.GetOrCreate(root,
    ↪ addressToNumberConverter.Convert(1));
163         var unicodeSequenceMarker = links.GetOrCreate(root,
    ↪ addressToNumberConverter.Convert(2));
164
165         var totalSequenceSymbolFrequencyCounter = new
    ↪ TotalSequenceSymbolFrequencyCounter<ulong>(links);
166         var linkFrequenciesCache = new LinkFrequenciesCache<ulong>(links,
    ↪ totalSequenceSymbolFrequencyCounter);
167         var index = new
    ↪ CachedFrequencyIncrementingSequenceIndex<ulong>(linkFrequenciesCache);
168         var linkToItsFrequencyNumberConverter = new FrequenciesCacheBasedLinkToItsFreque
    ↪ ncyNumberConverter<ulong>(linkFrequenciesCache);
169         var sequenceToItsLocalElementLevelsConverter = new
    ↪ SequenceToItsLocalElementLevelsConverter<ulong>(links,
    ↪ linkToItsFrequencyNumberConverter);
170         var optimalVariantConverter = new OptimalVariantConverter<ulong>(links,
    ↪ sequenceToItsLocalElementLevelsConverter);
171
172         var walker = new RightSequenceWalker<ulong>(links, new DefaultStack<ulong>(),
    ↪ (link) => constants.IsExternalReference(link) || links.IsPartialPoint(link));
173
174         var unicodeSequencesOptions = new SequencesOptions<ulong>()
175         {
176             UseSequenceMarker = true,
177             SequenceMarkerLink = unicodeSequenceMarker,
178             UseIndex = true,
179             Index = index,
180             LinksToSequenceConverter = optimalVariantConverter,
181             Walker = walker,
182             UseGarbageCollection = true
183         };
184
185         var unicodeSequences = new Sequences(new SynchronizedLinks<ulong>(links),
    ↪ unicodeSequencesOptions);
186
187         // Create some sequences
188         var strings = _loremIpsumExample.Split(new[] { '\n', '\r' },
    ↪ StringSplitOptions.RemoveEmptyEntries);
189         var arrays = strings.Select(x => x.Select(y =>
    ↪ addressToNumberConverter.Convert(y)).ToArray()).ToArray();
190         for (int i = 0; i < arrays.Length; i++)
191         {
192             unicodeSequences.Create(arrays[i].ShiftRight());
193         }

```

```

194
195         var linksCountAfterCreation = links.Count();
196
197         // get list of sequences links
198         // for each sequence link
199         //     create new sequence version
200         //     if new sequence is not the same as sequence link
201         //         delete sequence link
202         //         collect garbadge
203         unicodeSequences.CompactAll();
204
205         var linksCountAfterCompactification = links.Count();
206
207         Assert.True(linksCountAfterCompactification < linksCountAfterCreation);
208     }
209 }
210 }
211 }

```

## 1.65 ./csharp/Platform.Data.Doublets.Sequences.Tests/RationalNumbersTests.cs

```

1  using Platform.Data.Doublets.Memory;
2  using Platform.Data.Doublets.Memory.United.Generic;
3  using Platform.Data.Doublets.Numbers.Rational;
4  using Platform.Data.Doublets.Numbers.Raw;
5  using Platform.Data.Doublets.Sequences.Converters;
6  using Platform.Data.Numbers.Raw;
7  using Platform.Memory;
8  using Xunit;
9  using TLinkAddress = System.UInt64;
10
11 namespace Platform.Data.Doublets.Sequences.Tests
12 {
13     public class RationalNumbersTests
14     {
15         public ILinks<TLinkAddress> CreateLinks() => CreateLinks<TLinkAddress>(new
            ↳ IO.TemporaryFile());
16
17         public ILinks<TLinkAddress> CreateLinks<TLinkAddress>(string dataDbFilename)
18         {
19             var linksConstants = new
                ↳ LinksConstants<TLinkAddress>(enableExternalReferencesSupport: true);
20             return new UnitedMemoryLinks<TLinkAddress>(new
                ↳ FileMappedResizableDirectMemory(dataDbFilename),
                ↳ UnitedMemoryLinks<TLinkAddress>.DefaultLinksSizeStep, linksConstants,
                ↳ IndexTreeType.Default);
21         }
22
23         [Fact]
24         public void DecimalMinValueTest()
25         {
26             const decimal @decimal = decimal.MinValue;
27             var links = CreateLinks();
28             TLinkAddress negativeNumberMarker = links.Create();
29             AddressToRawNumberConverter<TLinkAddress> addressToRawNumberConverter = new();
30             RawNumberToAddressConverter<TLinkAddress> numberToAddressConverter = new();
31             BalancedVariantConverter<TLinkAddress> balancedVariantConverter = new(links);
32             BigIntegerToRawNumberSequenceConverter<TLinkAddress>
                ↳ bigIntegerToRawNumberSequenceConverter = new(links, addressToRawNumberConverter,
                ↳ balancedVariantConverter, negativeNumberMarker);
33             RawNumberSequenceToBigIntegerConverter<TLinkAddress>
                ↳ rawNumberSequenceToBigIntegerConverter = new(links, numberToAddressConverter,
                ↳ negativeNumberMarker);
34             DecimalToRationalConverter<TLinkAddress> decimalToRationalConverter = new(links,
                ↳ bigIntegerToRawNumberSequenceConverter);
35             RationalToDecimalConverter<TLinkAddress> rationalToDecimalConverter = new(links,
                ↳ rawNumberSequenceToBigIntegerConverter);
36             var rationalNumber = decimalToRationalConverter.Convert(@decimal);
37             var decimalFromRational = rationalToDecimalConverter.Convert(rationalNumber);
38             Assert.Equal(@decimal, decimalFromRational);
39         }
40
41         [Fact]
42         public void DecimalMaxValueTest()
43         {
44             const decimal @decimal = decimal.MaxValue;
45             var links = CreateLinks();
46             TLinkAddress negativeNumberMarker = links.Create();
47             AddressToRawNumberConverter<TLinkAddress> addressToRawNumberConverter = new();
48             RawNumberToAddressConverter<TLinkAddress> numberToAddressConverter = new();

```

```

49     BalancedVariantConverter<TLinkAddress> balancedVariantConverter = new(links);
50     BigIntegerToRawNumberSequenceConverter<TLinkAddress>
    ↪     bigIntegerToRawNumberSequenceConverter = new(links, addressToRawNumberConverter,
    ↪     balancedVariantConverter, negativeNumberMarker);
51     RawNumberSequenceToBigIntegerConverter<TLinkAddress>
    ↪     rawNumberSequenceToBigIntegerConverter = new(links, numberToAddressConverter,
    ↪     negativeNumberMarker);
52     DecimalToRationalConverter<TLinkAddress> decimalToRationalConverter = new(links,
    ↪     bigIntegerToRawNumberSequenceConverter);
53     RationalToDecimalConverter<TLinkAddress> rationalToDecimalConverter = new(links,
    ↪     rawNumberSequenceToBigIntegerConverter);
54     var rationalNumber = decimalToRationalConverter.Convert(@decimal);
55     var decimalFromRational = rationalToDecimalConverter.Convert(rationalNumber);
56     Assert.Equal(@decimal, decimalFromRational);
57 }
58
59 [Fact]
60 public void DecimalPositiveHalfTest()
61 {
62     const decimal @decimal = 0.5M;
63     var links = CreateLinks();
64     TLinkAddress negativeNumberMarker = links.Create();
65     AddressToRawNumberConverter<TLinkAddress> addressToRawNumberConverter = new();
66     RawNumberToAddressConverter<TLinkAddress> numberToAddressConverter = new();
67     BalancedVariantConverter<TLinkAddress> balancedVariantConverter = new(links);
68     BigIntegerToRawNumberSequenceConverter<TLinkAddress>
    ↪     bigIntegerToRawNumberSequenceConverter = new(links, addressToRawNumberConverter,
    ↪     balancedVariantConverter, negativeNumberMarker);
69     RawNumberSequenceToBigIntegerConverter<TLinkAddress>
    ↪     rawNumberSequenceToBigIntegerConverter = new(links, numberToAddressConverter,
    ↪     negativeNumberMarker);
70     DecimalToRationalConverter<TLinkAddress> decimalToRationalConverter = new(links,
    ↪     bigIntegerToRawNumberSequenceConverter);
71     RationalToDecimalConverter<TLinkAddress> rationalToDecimalConverter = new(links,
    ↪     rawNumberSequenceToBigIntegerConverter);
72     var rationalNumber = decimalToRationalConverter.Convert(@decimal);
73     var decimalFromRational = rationalToDecimalConverter.Convert(rationalNumber);
74     Assert.Equal(@decimal, decimalFromRational);
75 }
76
77 [Fact]
78 public void DecimalNegativeHalfTest()
79 {
80     const decimal @decimal = -0.5M;
81     var links = CreateLinks();
82     TLinkAddress negativeNumberMarker = links.Create();
83     AddressToRawNumberConverter<TLinkAddress> addressToRawNumberConverter = new();
84     RawNumberToAddressConverter<TLinkAddress> numberToAddressConverter = new();
85     BalancedVariantConverter<TLinkAddress> balancedVariantConverter = new(links);
86     BigIntegerToRawNumberSequenceConverter<TLinkAddress>
    ↪     bigIntegerToRawNumberSequenceConverter = new(links, addressToRawNumberConverter,
    ↪     balancedVariantConverter, negativeNumberMarker);
87     RawNumberSequenceToBigIntegerConverter<TLinkAddress>
    ↪     rawNumberSequenceToBigIntegerConverter = new(links, numberToAddressConverter,
    ↪     negativeNumberMarker);
88     DecimalToRationalConverter<TLinkAddress> decimalToRationalConverter = new(links,
    ↪     bigIntegerToRawNumberSequenceConverter);
89     RationalToDecimalConverter<TLinkAddress> rationalToDecimalConverter = new(links,
    ↪     rawNumberSequenceToBigIntegerConverter);
90     var rationalNumber = decimalToRationalConverter.Convert(@decimal);
91     var decimalFromRational = rationalToDecimalConverter.Convert(rationalNumber);
92     Assert.Equal(@decimal, decimalFromRational);
93 }
94
95 [Fact]
96 public void DecimalOneTest()
97 {
98     const decimal @decimal = 1;
99     var links = CreateLinks();
100     TLinkAddress negativeNumberMarker = links.Create();
101     AddressToRawNumberConverter<TLinkAddress> addressToRawNumberConverter = new();
102     RawNumberToAddressConverter<TLinkAddress> numberToAddressConverter = new();
103     BalancedVariantConverter<TLinkAddress> balancedVariantConverter = new(links);
104     BigIntegerToRawNumberSequenceConverter<TLinkAddress>
    ↪     bigIntegerToRawNumberSequenceConverter = new(links, addressToRawNumberConverter,
    ↪     balancedVariantConverter, negativeNumberMarker);

```

```

105     RawNumberSequenceToBigIntegerConverter<TLinkAddress>
106     ↪ rawNumberSequenceToBigIntegerConverter = new(links, numberToAddressConverter,
107     ↪ negativeNumberMarker);
108     DecimalToRationalConverter<TLinkAddress> decimalToRationalConverter = new(links,
109     ↪ bigIntegerToRawNumberSequenceConverter);
110     RationalToDecimalConverter<TLinkAddress> rationalToDecimalConverter = new(links,
111     ↪ rawNumberSequenceToBigIntegerConverter);
112     var rationalNumber = decimalToRationalConverter.Convert(@decimal);
113     var decimalFromRational = rationalToDecimalConverter.Convert(rationalNumber);
114     Assert.Equal(@decimal, decimalFromRational);
115 }
116
117 [Fact]
118 public void DecimalMinusOneTest()
119 {
120     const decimal @decimal = -1;
121     var links = CreateLinks();
122     TLinkAddress negativeNumberMarker = links.Create();
123     AddressToRawNumberConverter<TLinkAddress> addressToRawNumberConverter = new();
124     RawNumberToAddressConverter<TLinkAddress> numberToAddressConverter = new();
125     BalancedVariantConverter<TLinkAddress> balancedVariantConverter = new(links);
126     BigIntegerToRawNumberSequenceConverter<TLinkAddress>
127     ↪ bigIntegerToRawNumberSequenceConverter = new(links, addressToRawNumberConverter,
128     ↪ balancedVariantConverter, negativeNumberMarker);
129     RawNumberSequenceToBigIntegerConverter<TLinkAddress>
130     ↪ rawNumberSequenceToBigIntegerConverter = new(links, numberToAddressConverter,
131     ↪ negativeNumberMarker);
132     DecimalToRationalConverter<TLinkAddress> decimalToRationalConverter = new(links,
133     ↪ bigIntegerToRawNumberSequenceConverter);
134     RationalToDecimalConverter<TLinkAddress> rationalToDecimalConverter = new(links,
135     ↪ rawNumberSequenceToBigIntegerConverter);
136     var rationalNumber = decimalToRationalConverter.Convert(@decimal);
137     var decimalFromRational = rationalToDecimalConverter.Convert(rationalNumber);
138     Assert.Equal(@decimal, decimalFromRational);
139 }
140 }
141 }

```

## 1.66 ./csharp/Platform.Data.Doublets.Sequences.Tests/ReadSequenceTests.cs

```

1 using System;
2 using System.Collections.Generic;
3 using System.Diagnostics;
4 using System.Linq;
5 using Xunit;
6 using Platform.Data.Sequences;
7 using Platform.Data.Doublets.Sequences.Converters;
8 using Platform.Data.Doublets.Sequences.Walkers;
9 using Platform.Data.Doublets.Sequences;
10
11 namespace Platform.Data.Doublets.Sequences.Tests
12 {
13     public static class ReadSequenceTests
14     {
15         [Fact]
16         public static void ReadSequenceTest()
17         {
18             const long sequenceLength = 2000;
19
20             using (var scope = new TempLinksTestScope(useSequences: false))
21             {
22                 var links = scope.Links;
23                 var sequences = new Sequences(links, new SequencesOptions<ulong> { Walker = new
24                 ↪ LeveledSequenceWalker<ulong>(links) });
25
26                 var sequence = new ulong[sequenceLength];
27                 for (var i = 0; i < sequenceLength; i++)
28                 {
29                     sequence[i] = links.Create();
30                 }
31
32                 var balancedVariantConverter = new BalancedVariantConverter<ulong>(links);
33
34                 var sw1 = Stopwatch.StartNew();
35                 var balancedVariant = balancedVariantConverter.Convert(sequence); sw1.Stop();
36
37                 var sw2 = Stopwatch.StartNew();
38                 var readSequence1 = sequences.ToList(balancedVariant); sw2.Stop();
39
40                 var sw3 = Stopwatch.StartNew();

```



```

40         var readSequence2 = new List<ulong>();
41         SequenceWalker.WalkRight(balancedVariant,
42                                 links.GetSource,
43                                 links.GetTarget,
44                                 links.IsPartialPoint,
45                                 readSequence2.Add);
46
47         sw3.Stop();
48
49         Assert.True(sequence.SequenceEqual(readSequence1));
50
51         Assert.True(sequence.SequenceEqual(readSequence2));
52
53         // Assert.True(sw2.Elapsed < sw3.Elapsed);
54
55         Console.WriteLine($"Stack-based walker: {sw3.Elapsed}, Level-based reader:
56         ↳ {sw2.Elapsed}");
57
58         for (var i = 0; i < sequenceLength; i++)
59         {
60             links.Delete(sequence[i]);
61         }
62     }
63 }

```

## 1.67 ./csharp/Platform.Data.Doublets.Sequences.Tests/SequencesTests.cs

```

1  using System;
2  using System.Collections.Generic;
3  using System.Diagnostics;
4  using System.Linq;
5  using Xunit;
6  using Platform.Collections;
7  using Platform.Collections.Arrays;
8  using Platform.Random;
9  using Platform.IO;
10 using Platform.Singletons;
11 using Platform.Data.Doublets.Sequences;
12 using Platform.Data.Doublets.Sequences.Frequencies.Cache;
13 using Platform.Data.Doublets.Sequences.Frequencies.Counters;
14 using Platform.Data.Doublets.Sequences.Converters;
15 using Platform.Data.Doublets.Unicode;
16
17 namespace Platform.Data.Doublets.Sequences.Tests
18 {
19     public static class SequencesTests
20     {
21         private static readonly LinksConstants<ulong> _constants =
22             ↳ Default<LinksConstants<ulong>>.Instance;
23
24         static SequencesTests()
25         {
26             // Trigger static constructor to not mess with performance measurements
27             ↳ = BitString.GetBitMaskFromIndex(1);
28         }
29
30         [Fact]
31         public static void CreateAllVariantsTest()
32         {
33             const long sequenceLength = 8;
34
35             using (var scope = new TempLinksTestScope(useSequences: true))
36             {
37                 var links = scope.Links;
38                 var sequences = scope.Sequences;
39
40                 var sequence = new ulong[sequenceLength];
41                 for (var i = 0; i < sequenceLength; i++)
42                 {
43                     sequence[i] = links.Create();
44                 }
45
46                 var sw1 = Stopwatch.StartNew();
47                 var results1 = sequences.CreateAllVariants1(sequence); sw1.Stop();
48
49                 var sw2 = Stopwatch.StartNew();
50                 var results2 = sequences.CreateAllVariants2(sequence); sw2.Stop();
51
52                 Assert.True(results1.Count > results2.Length);
53                 Assert.True(sw1.Elapsed > sw2.Elapsed);

```

```

54         for (var i = 0; i < sequenceLength; i++)
55         {
56             links.Delete(sequence[i]);
57         }
58
59         Assert.True(links.Count() == 0);
60     }
61 }
62
63 //[Fact]
64 //public void CUDTest()
65 //{
66 //    var tempFilename = Path.GetTempFileName();
67 //
68 //    const long sequenceLength = 8;
69 //
70 //    const ulong itself = LinksConstants.Itself;
71 //
72 //    using (var memoryAdapter = new ResizableDirectMemoryLinks(tempFilename,
73 //        ↪ DefaultLinksSizeStep))
74 //    using (var links = new Links(memoryAdapter))
75 //    {
76 //        var sequence = new ulong[sequenceLength];
77 //        for (var i = 0; i < sequenceLength; i++)
78 //            sequence[i] = links.Create(itself, itself);
79 //
80 //        SequencesOptions o = new SequencesOptions();
81 //
82 //        // TODO: Из числа в bool значения o.UseSequenceMarker = ((value & 1) != 0)
83 //        o.
84 //
85 //        var sequences = new Sequences(links);
86 //
87 //        var sw1 = Stopwatch.StartNew();
88 //        var results1 = sequences.CreateAllVariants1(sequence); sw1.Stop();
89 //
90 //        var sw2 = Stopwatch.StartNew();
91 //        var results2 = sequences.CreateAllVariants2(sequence); sw2.Stop();
92 //
93 //        Assert.True(results1.Count > results2.Length);
94 //        Assert.True(sw1.Elapsed > sw2.Elapsed);
95 //
96 //        for (var i = 0; i < sequenceLength; i++)
97 //            links.Delete(sequence[i]);
98 //    }
99 //
100 //    File.Delete(tempFilename);
101 //}
102
103 [Fact]
104 public static void AllVariantsSearchTest()
105 {
106     const long sequenceLength = 8;
107
108     using (var scope = new TempLinksTestScope(useSequences: true))
109     {
110         var links = scope.Links;
111         var sequences = scope.Sequences;
112
113         var sequence = new ulong[sequenceLength];
114         for (var i = 0; i < sequenceLength; i++)
115         {
116             sequence[i] = links.Create();
117         }
118
119         var createResults = sequences.CreateAllVariants2(sequence).Distinct().ToArray();
120
121         //for (int i = 0; i < createResults.Length; i++)
122         //    sequences.Create(createResults[i]);
123
124         var sw0 = Stopwatch.StartNew();
125         var searchResults0 = sequences.GetAllMatchingSequences0(sequence); sw0.Stop();
126
127         var sw1 = Stopwatch.StartNew();
128         var searchResults1 = sequences.GetAllMatchingSequences1(sequence); sw1.Stop();
129
130         var sw2 = Stopwatch.StartNew();
131         var searchResults2 = sequences.Each1(sequence); sw2.Stop();
132
133         var sw3 = Stopwatch.StartNew();

```

```

133     var searchResults3 = sequences.Each(sequence.ShiftRight()); sw3.Stop();
134
135     var intersection0 = createResults.Intersect(searchResults0).ToList();
136     Assert.True(intersection0.Count == searchResults0.Count);
137     Assert.True(intersection0.Count == createResults.Length);
138
139     var intersection1 = createResults.Intersect(searchResults1).ToList();
140     Assert.True(intersection1.Count == searchResults1.Count);
141     Assert.True(intersection1.Count == createResults.Length);
142
143     var intersection2 = createResults.Intersect(searchResults2).ToList();
144     Assert.True(intersection2.Count == searchResults2.Count);
145     Assert.True(intersection2.Count == createResults.Length);
146
147     var intersection3 = createResults.Intersect(searchResults3).ToList();
148     Assert.True(intersection3.Count == searchResults3.Count);
149     Assert.True(intersection3.Count == createResults.Length);
150
151     for (var i = 0; i < sequenceLength; i++)
152     {
153         links.Delete(sequence[i]);
154     }
155 }
156
157 [Fact]
158 public static void BalancedVariantSearchTest()
159 {
160     const long sequenceLength = 200;
161
162     using (var scope = new TempLinksTestScope(useSequences: true))
163     {
164         var links = scope.Links;
165         var sequences = scope.Sequences;
166
167         var sequence = new ulong[sequenceLength];
168         for (var i = 0; i < sequenceLength; i++)
169         {
170             sequence[i] = links.Create();
171         }
172
173         var balancedVariantConverter = new BalancedVariantConverter<ulong>(links);
174
175         var sw1 = Stopwatch.StartNew();
176         var balancedVariant = balancedVariantConverter.Convert(sequence); sw1.Stop();
177
178         var sw2 = Stopwatch.StartNew();
179         var searchResults2 = sequences.GetAllMatchingSequences0(sequence); sw2.Stop();
180
181         var sw3 = Stopwatch.StartNew();
182         var searchResults3 = sequences.GetAllMatchingSequences1(sequence); sw3.Stop();
183
184         // На количестве в 200 элементов это будет занимать вечность
185         //var sw4 = Stopwatch.StartNew();
186         //var searchResults4 = sequences.Each(sequence); sw4.Stop();
187
188         Assert.True(searchResults2.Count == 1 && balancedVariant == searchResults2[0]);
189
190         Assert.True(searchResults3.Count == 1 && balancedVariant ==
191             ↪ searchResults3.First());
192
193         //Assert.True(sw1.Elapsed < sw2.Elapsed);
194
195         for (var i = 0; i < sequenceLength; i++)
196         {
197             links.Delete(sequence[i]);
198         }
199     }
200 }
201
202 [Fact]
203 public static void AllPartialVariantsSearchTest()
204 {
205     const long sequenceLength = 8;
206
207     using (var scope = new TempLinksTestScope(useSequences: true))
208     {
209         var links = scope.Links;
210         var sequences = scope.Sequences;
211

```

```

212     var sequence = new ulong[sequenceLength];
213     for (var i = 0; i < sequenceLength; i++)
214     {
215         sequence[i] = links.Create();
216     }
217
218     var createResults = sequences.CreateAllVariants2(sequence);
219
220     //var createResultsStrings = createResults.Select(x => x + ": " +
221     ↪ sequences.FormatSequence(x)).ToList();
222     //Global.Trash = createResultsStrings;
223
224     var partialSequence = new ulong[sequenceLength - 2];
225
226     Array.Copy(sequence, 1, partialSequence, 0, (int)sequenceLength - 2);
227
228     var sw1 = Stopwatch.StartNew();
229     var searchResults1 =
230     ↪ sequences.GetAllPartiallyMatchingSequences0(partialSequence); sw1.Stop();
231
232     var sw2 = Stopwatch.StartNew();
233     var searchResults2 =
234     ↪ sequences.GetAllPartiallyMatchingSequences1(partialSequence); sw2.Stop();
235
236     //var sw3 = Stopwatch.StartNew();
237     //var searchResults3 =
238     ↪ sequences.GetAllPartiallyMatchingSequences2(partialSequence); sw3.Stop();
239
240     var sw4 = Stopwatch.StartNew();
241     var searchResults4 =
242     ↪ sequences.GetAllPartiallyMatchingSequences3(partialSequence); sw4.Stop();
243
244     //Global.Trash = searchResults3;
245
246     //var searchResults1Strings = searchResults1.Select(x => x + ": " +
247     ↪ sequences.FormatSequence(x)).ToList();
248     //Global.Trash = searchResults1Strings;
249
250     var intersection1 = createResults.Intersect(searchResults1).ToList();
251     Assert.True(intersection1.Count == createResults.Length);
252
253     var intersection2 = createResults.Intersect(searchResults2).ToList();
254     Assert.True(intersection2.Count == createResults.Length);
255
256     var intersection4 = createResults.Intersect(searchResults4).ToList();
257     Assert.True(intersection4.Count == createResults.Length);
258
259     for (var i = 0; i < sequenceLength; i++)
260     {
261         links.Delete(sequence[i]);
262     }
263 }
264
265 [Fact]
266 public static void BalancedPartialVariantsSearchTest()
267 {
268     const long sequenceLength = 200;
269
270     using (var scope = new TempLinksTestScope(useSequences: true))
271     {
272         var links = scope.Links;
273         var sequences = scope.Sequences;
274
275         var sequence = new ulong[sequenceLength];
276         for (var i = 0; i < sequenceLength; i++)
277         {
278             sequence[i] = links.Create();
279         }
280
281         var balancedVariantConverter = new BalancedVariantConverter<ulong>(links);
282
283         var balancedVariant = balancedVariantConverter.Convert(sequence);
284
285         var partialSequence = new ulong[sequenceLength - 2];
286
287         Array.Copy(sequence, 1, partialSequence, 0, (int)sequenceLength - 2);
288
289         var sw1 = Stopwatch.StartNew();

```

```

285     var searchResults1 =
286         ↪ sequences.GetAllPartiallyMatchingSequences0(partialSequence); sw1.Stop();
287
288     var sw2 = Stopwatch.StartNew();
289     var searchResults2 =
290         ↪ sequences.GetAllPartiallyMatchingSequences1(partialSequence); sw2.Stop();
291
292     Assert.True(searchResults1.Count == 1 && balancedVariant == searchResults1[0]);
293
294     Assert.True(searchResults2.Count == 1 && balancedVariant ==
295         ↪ searchResults2.First());
296
297     for (var i = 0; i < sequenceLength; i++)
298     {
299         links.Delete(sequence[i]);
300     }
301 }
302
303 [Fact(Skip = "Correct implementation is pending")]
304 public static void PatternMatchTest()
305 {
306     var zeroOrMany = Sequences.ZeroOrMany;
307
308     using (var scope = new TempLinksTestScope(useSequences: true))
309     {
310         var links = scope.Links;
311         var sequences = scope.Sequences;
312
313         var e1 = links.Create();
314         var e2 = links.Create();
315
316         var sequence = new[]
317         {
318             e1, e2, e1, e2 // mama / papa
319         };
320
321         var balancedVariantConverter = new BalancedVariantConverter<ulong>(links);
322
323         var balancedVariant = balancedVariantConverter.Convert(sequence);
324
325         // 1: [1]
326         // 2: [2]
327         // 3: [1,2]
328         // 4: [1,2,1,2]
329
330         var doublet = links.GetSource(balancedVariant);
331
332         var matchedSequences1 = sequences.MatchPattern(e2, e1, zeroOrMany);
333
334         Assert.True(matchedSequences1.Count == 0);
335
336         var matchedSequences2 = sequences.MatchPattern(zeroOrMany, e2, e1);
337
338         Assert.True(matchedSequences2.Count == 0);
339
340         var matchedSequences3 = sequences.MatchPattern(e1, zeroOrMany, e1);
341
342         Assert.True(matchedSequences3.Count == 0);
343
344         var matchedSequences4 = sequences.MatchPattern(e1, zeroOrMany, e2);
345
346         Assert.Contains(doublet, matchedSequences4);
347         Assert.Contains(balancedVariant, matchedSequences4);
348
349         for (var i = 0; i < sequence.Length; i++)
350         {
351             links.Delete(sequence[i]);
352         }
353     }
354 }
355
356 [Fact]
357 public static void IndexTest()
358 {
359     using (var scope = new TempLinksTestScope(new SequencesOptions<ulong> { UseIndex =
360         ↪ true }, useSequences: true))
361     {
362         var links = scope.Links;
363         var sequences = scope.Sequences;

```

```

361     var index = sequences.Options.Index;
362
363     var e1 = links.Create();
364     var e2 = links.Create();
365
366     var sequence = new[]
367     {
368         e1, e2, e1, e2 // mama / papa
369     };
370
371     Assert.False(index.MightContain(sequence));
372
373     index.Add(sequence);
374
375     Assert.True(index.MightContain(sequence));
376 }
377
378 private static readonly string _exampleText =
379     @"([english
    ↪     version](https://github.com/Konard/LinksPlatform/wiki/About-the-beginning))

```

Обозначение пустоты, какое оно? Темнота ли это? Там где отсутствие света, отсутствие фотонов  
 ↪ (носителей света)? Или это то, что полностью отражает свет? Пустой белый лист бумаги? Там  
 ↪ где есть место для нового начала? Разве пустота это не характеристика пространства?  
 ↪ Пространство это то, что можно чем-то наполнить?

![чёрное пространство, белое  
 ↪ пространство](https://raw.githubusercontent.com/Konard/LinksPlatform/master/doc/Intro/1.png  
 ↪ "чёрное пространство, белое пространство")](https://raw.githubusercontent.com/Konard/LinksPlatform/master/doc/Intro/1.png)

Что может быть минимальным рисунком, образом, графикой? Может быть это точка? Это ли простейшая  
 ↪ форма? Но есть ли у точки размер? Цвет? Масса? Координаты? Время существования?

![чёрное пространство, чёрная  
 ↪ точка](https://raw.githubusercontent.com/Konard/LinksPlatform/master/doc/Intro/2.png  
 ↪ "чёрное пространство, чёрная  
 ↪ точка")](https://raw.githubusercontent.com/Konard/LinksPlatform/master/doc/Intro/2.png)

А что если повторить? Сделать копию? Создать дубликат? Из одного сделать два? Может это быть  
 ↪ так? Инверсия? Отражение? Сумма?

![белая точка, чёрная  
 ↪ точка](https://raw.githubusercontent.com/Konard/LinksPlatform/master/doc/Intro/3.png "белая  
 ↪ точка, чёрная  
 ↪ точка")](https://raw.githubusercontent.com/Konard/LinksPlatform/master/doc/Intro/3.png)

А что если мы вообразим движение? Нужно ли время? Каким самым коротким будет путь? Что будет  
 ↪ если этот путь зафиксировать? Запомнить след? Как две точки становятся линией? Чертой?  
 ↪ Гранью? Разделителем? Единицей?

![две белые точки, чёрная вертикальная  
 ↪ линия](https://raw.githubusercontent.com/Konard/LinksPlatform/master/doc/Intro/4.png "две  
 ↪ белые точки, чёрная вертикальная  
 ↪ линия")](https://raw.githubusercontent.com/Konard/LinksPlatform/master/doc/Intro/4.png)

Можно ли замкнуть движение? Может ли это быть кругом? Можно ли замкнуть время? Или остаётся  
 ↪ только спираль? Но что если замкнуть предел? Создать ограничение, разделение? Получится  
 ↪ замкнутая область? Полностью отделённая от всего остального? Но что это всё остальное? Что  
 ↪ можно делить? В каком направлении? Ничего или всё? Пустота или полнота? Начало или конец?  
 ↪ Или может быть это единица и ноль? Дуальность? Противоположность? А что будет с кругом если  
 ↪ у него нет размера? Будет ли круг точкой? Точка состоящая из точек?

![белая вертикальная линия, чёрный  
 ↪ круг](https://raw.githubusercontent.com/Konard/LinksPlatform/master/doc/Intro/5.png "белая  
 ↪ вертикальная линия, чёрный  
 ↪ круг")](https://raw.githubusercontent.com/Konard/LinksPlatform/master/doc/Intro/5.png)

Как ещё можно использовать грань, черту, линию? А что если она может что-то соединять, может  
 ↪ тогда её нужно повернуть? Почему то, что перпендикулярно вертикальному горизонтально?  
 ↪ Горизонт? Инвертирует ли это смысл? Что такое смысл? Из чего состоит смысл? Существует ли  
 ↪ элементарная единица смысла?

![белый круг, чёрная горизонтальная  
 ↪ линия](https://raw.githubusercontent.com/Konard/LinksPlatform/master/doc/Intro/6.png "белый  
 ↪ круг, чёрная горизонтальная  
 ↪ линия")](https://raw.githubusercontent.com/Konard/LinksPlatform/master/doc/Intro/6.png)

```

405 Соединять, допустим, а какой смысл в этом есть ещё? Что если помимо смысла ""соединить,
    ↳ связать"", есть ещё и смысл направления ""от начала к концу""? От предка к потомку? От
    ↳ родителя к ребёнку? От общего к частному?
406
407 [![белая горизонтальная линия, чёрная горизонтальная
    ↳ стрелка](https://raw.githubusercontent.com/Konard/LinksPlatform/master/doc/Intro/7.png
    ↳ ""белая горизонтальная линия, чёрная горизонтальная
    ↳ стрелка"")] (https://raw.githubusercontent.com/Konard/LinksPlatform/master/doc/Intro/7.png)
408
409 Шаг назад. Возьмём опять отделённую область, которая лишь та же замкнутая линия, что ещё она
    ↳ может представлять собой? Объект? Но в чём его суть? Разве не в том, что у него есть
    ↳ граница, разделяющая внутреннее и внешнее? Допустим связь, стрелка, линия соединяет два
    ↳ объекта, как бы это выглядело?
410
411 [![белая связь, чёрная направленная
    ↳ связь](https://raw.githubusercontent.com/Konard/LinksPlatform/master/doc/Intro/8.png ""белая
    ↳ связь, чёрная направленная
    ↳ связь"")] (https://raw.githubusercontent.com/Konard/LinksPlatform/master/doc/Intro/8.png)
412
413 Допустим у нас есть смысл ""связать"" и смысл ""направления"", много ли это нам даёт? Много ли
    ↳ вариантов интерпретации? А что если уточнить, каким именно образом выполнена связь? Что если
    ↳ можно задать ей чёткий, конкретный смысл? Что это будет? Тип? Глагол? Связка? Действие?
    ↳ Трансформация? Переход из состояния в состояние? Или всё это и есть объект, суть которого в
    ↳ его конечном состоянии, если конечно конец определён направлением?
414
415 [![белая обычная и направленная связи, чёрная типизированная
    ↳ связь](https://raw.githubusercontent.com/Konard/LinksPlatform/master/doc/Intro/9.png ""белая
    ↳ обычная и направленная связи, чёрная типизированная
    ↳ связь"")] (https://raw.githubusercontent.com/Konard/LinksPlatform/master/doc/Intro/9.png)
416
417 А что если всё это время, мы смотрели на суть как бы снаружи? Можно ли взглянуть на это изнутри?
    ↳ Что будет внутри объектов? Объекты ли это? Или это связи? Может ли эта структура описать
    ↳ сама себя? Но что тогда получится, разве это не рекурсия? Может это фрактал?
418
419 [![белая обычная и направленная связи с рекурсивной внутренней структурой, чёрная типизированная
    ↳ связь с рекурсивной внутренней
    ↳ структурой](https://raw.githubusercontent.com/Konard/LinksPlatform/master/doc/Intro/10.png
    ↳ ""белая обычная и направленная связи с рекурсивной внутренней структурой, чёрная
    ↳ типизированная связь с рекурсивной внутренней структурой"")] (https://raw.githubusercontent.com/Konard/LinksPlatform/master/doc/Intro/10.png)
420
421 На один уровень внутрь (вниз)? Или на один уровень во вне (вверх)? Или это можно назвать шагом
    ↳ рекурсии или фрактала?
422
423 [![белая обычная и направленная связи с двойной рекурсивной внутренней структурой, чёрная
    ↳ типизированная связь с двойной рекурсивной внутренней
    ↳ структурой](https://raw.githubusercontent.com/Konard/LinksPlatform/master/doc/Intro/11.png
    ↳ ""белая обычная и направленная связи с двойной рекурсивной внутренней структурой, чёрная
    ↳ типизированная связь с двойной рекурсивной внутренней структурой"")] (https://raw.githubusercontent.com/Konard/LinksPlatform/master/doc/Intro/11.png)
424
425 Последовательность? Массив? Список? Множество? Объект? Таблица? Элементы? Цвета? Символы? Буквы?
    ↳ Слово? Цифры? Число? Алфавит? Дерево? Сеть? Граф? Гиперграф?
426
427 [![белая обычная и направленная связи со структурой из 8 цветных элементов последовательности,
    ↳ чёрная типизированная связь со структурой из 8 цветных элементов последовательности](https://
    ↳ raw.githubusercontent.com/Konard/LinksPlatform/master/doc/Intro/12.png ""белая обычная и
    ↳ направленная связи со структурой из 8 цветных элементов последовательности, чёрная
    ↳ типизированная связь со структурой из 8 цветных элементов последовательности"")] (https://raw
    ↳ .githubusercontent.com/Konard/LinksPlatform/master/doc/Intro/12.png)
428
429 ...
430
431 [![анимация](https://raw.githubusercontent.com/Konard/LinksPlatform/master/doc/Intro/intro-animat
    ↳ ion-500.gif
    ↳ ""анимация"")] (https://raw.githubusercontent.com/Konard/LinksPlatform/master/doc/Intro/intro
    ↳ -animation-500.gif)";
432     private static readonly string _exampleLoremIpsumText =
433         @"Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor
            ↳ incididunt ut labore et dolore magna aliqua.
434 Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo
            ↳ consequat.";
435
436 [Fact]
437 public static void CompressionTest()
438 {
439     using (var scope = new TempLinksTestScope(useSequences: true))
440     {
441         var links = scope.Links;

```

```

442     var sequences = scope.Sequences;
443
444     var e1 = links.Create();
445     var e2 = links.Create();
446
447     var sequence = new[]
448     {
449         e1, e2, e1, e2 // mama / papa / template [(m/p), a] { [1] [2] [1] [2] }
450     };
451
452     var balancedVariantConverter = new BalancedVariantConverter<ulong>(links.Unsync);
453     var totalSequenceSymbolFrequencyCounter = new
454         ↳ TotalSequenceSymbolFrequencyCounter<ulong>(links.Unsync);
455     var doubletFrequenciesCache = new LinkFrequenciesCache<ulong>(links.Unsync,
456         ↳ totalSequenceSymbolFrequencyCounter);
457     var compressingConverter = new CompressingConverter<ulong>(links.Unsync,
458         ↳ balancedVariantConverter, doubletFrequenciesCache);
459
460     var compressedVariant = compressingConverter.Convert(sequence);
461
462     // 1: [1]          (1->1) point
463     // 2: [2]          (2->2) point
464     // 3: [1,2]        (1->2) doublet
465     // 4: [1,2,1,2]    (3->3) doublet
466
467     Assert.True(links.GetSource(links.GetSource(compressedVariant)) == sequence[0]);
468     Assert.True(links.GetTarget(links.GetSource(compressedVariant)) == sequence[1]);
469     Assert.True(links.GetSource(links.GetTarget(compressedVariant)) == sequence[2]);
470     Assert.True(links.GetTarget(links.GetTarget(compressedVariant)) == sequence[3]);
471
472     var source = _constants.SourcePart;
473     var target = _constants.TargetPart;
474
475     Assert.True(links.GetByKeys(compressedVariant, source, source) == sequence[0]);
476     Assert.True(links.GetByKeys(compressedVariant, source, target) == sequence[1]);
477     Assert.True(links.GetByKeys(compressedVariant, target, source) == sequence[2]);
478     Assert.True(links.GetByKeys(compressedVariant, target, target) == sequence[3]);
479
480     // 4 - length of sequence
481     Assert.True(links.GetSquareMatrixSequenceElementByIndex(compressedVariant, 4, 0)
482         ↳ == sequence[0]);
483     Assert.True(links.GetSquareMatrixSequenceElementByIndex(compressedVariant, 4, 1)
484         ↳ == sequence[1]);
485     Assert.True(links.GetSquareMatrixSequenceElementByIndex(compressedVariant, 4, 2)
486         ↳ == sequence[2]);
487     Assert.True(links.GetSquareMatrixSequenceElementByIndex(compressedVariant, 4, 3)
488         ↳ == sequence[3]);
489 }
490
491 [Fact]
492 public static void CompressionEfficiencyTest()
493 {
494     var strings = _exampleLoremIpsumText.Split(new[] { '\n', '\r' },
495         ↳ StringSplitOptions.RemoveEmptyEntries);
496     var arrays = strings.Select(UnicodeMap.FromStringToLinkArray).ToArray();
497     var totalCharacters = arrays.Select(x => x.Length).Sum();
498
499     using (var scope1 = new TempLinksTestScope(useSequences: true))
500     using (var scope2 = new TempLinksTestScope(useSequences: true))
501     using (var scope3 = new TempLinksTestScope(useSequences: true))
502     {
503         scope1.Links.Unsync.UseUnicode();
504         scope2.Links.Unsync.UseUnicode();
505         scope3.Links.Unsync.UseUnicode();
506
507         var balancedVariantConverter1 = new
508             ↳ BalancedVariantConverter<ulong>(scope1.Links.Unsync);
509         var totalSequenceSymbolFrequencyCounter = new
510             ↳ TotalSequenceSymbolFrequencyCounter<ulong>(scope1.Links.Unsync);
511         var linkFrequenciesCache1 = new LinkFrequenciesCache<ulong>(scope1.Links.Unsync,
512             ↳ totalSequenceSymbolFrequencyCounter);
513         var compressor1 = new CompressingConverter<ulong>(scope1.Links.Unsync,
514             ↳ balancedVariantConverter1, linkFrequenciesCache1,
515             ↳ doInitialFrequenciesIncrement: false);
516
517         //var compressor2 = scope2.Sequences;
518         var compressor3 = scope3.Sequences;

```



```

507
508     var constants = Default<LinksConstants<ulong>>.Instance;
509
510     var sequences = compressor3;
511     //var meaningRoot = links.CreatePoint();
512     //var unaryOne = links.CreateAndUpdate(meaningRoot, constants.Itself);
513     //var frequencyMarker = links.CreateAndUpdate(meaningRoot, constants.Itself);
514     //var frequencyPropertyMarker = links.CreateAndUpdate(meaningRoot,
515         ↪ constants.Itself);
516
517     //var unaryNumberToAddressConverter = new
518         ↪ UnaryNumberToAddressAddOperationConverter<ulong>(links, unaryOne);
519     //var unaryNumberIncrementer = new UnaryNumberIncrementer<ulong>(links,
520         ↪ unaryOne);
521     //var frequencyIncrementer = new FrequencyIncrementer<ulong>(links,
522         ↪ frequencyMarker, unaryOne, unaryNumberIncrementer);
523     //var frequencyPropertyOperator = new FrequencyPropertyOperator<ulong>(links,
524         ↪ frequencyPropertyMarker, frequencyMarker);
525     //var linkFrequencyIncrementer = new LinkFrequencyIncrementer<ulong>(links,
526         ↪ frequencyPropertyOperator, frequencyIncrementer);
527     //var linkToItsFrequencyNumberConverter = new
528         ↪ LinkToItsFrequencyNumberConveter<ulong>(links, frequencyPropertyOperator,
529         ↪ unaryNumberToAddressConverter);
530
531     var linkFrequenciesCache3 = new LinkFrequenciesCache<ulong>(scope3.Links.Unsync,
532         ↪ totalSequenceSymbolFrequencyCounter);
533
534     var linkToItsFrequencyNumberConverter = new FrequenciesCacheBasedLinkToItsFreque_
535         ↪ ncyNumberConverter<ulong>(linkFrequenciesCache3);
536
537     var sequenceToItsLocalElementLevelsConverter = new
538         ↪ SequenceToItsLocalElementLevelsConverter<ulong>(scope3.Links.Unsync,
539         ↪ linkToItsFrequencyNumberConverter);
540     var optimalVariantConverter = new
541         ↪ OptimalVariantConverter<ulong>(scope3.Links.Unsync,
542         ↪ sequenceToItsLocalElementLevelsConverter);
543
544     var compressed1 = new ulong[arrays.Length];
545     var compressed2 = new ulong[arrays.Length];
546     var compressed3 = new ulong[arrays.Length];
547
548     var START = 0;
549     var END = arrays.Length;
550
551     //for (int i = START; i < END; i++)
552     //    linkFrequenciesCache1.IncrementFrequencies(arrays[i]);
553
554     var initialCount1 = scope2.Links.Unsync.Count();
555
556     var sw1 = Stopwatch.StartNew();
557
558     for (int i = START; i < END; i++)
559     {
560         linkFrequenciesCache1.IncrementFrequencies(arrays[i]);
561         compressed1[i] = compressor1.Convert(arrays[i]);
562     }
563
564     var elapsed1 = sw1.Elapsed;
565
566     var balancedVariantConverter2 = new
567         ↪ BalancedVariantConverter<ulong>(scope2.Links.Unsync);
568
569     var initialCount2 = scope2.Links.Unsync.Count();
570
571     var sw2 = Stopwatch.StartNew();
572
573     for (int i = START; i < END; i++)
574     {
575         compressed2[i] = balancedVariantConverter2.Convert(arrays[i]);
576     }
577
578     var elapsed2 = sw2.Elapsed;
579
580     for (int i = START; i < END; i++)
581     {
582         linkFrequenciesCache3.IncrementFrequencies(arrays[i]);
583     }
584
585     var initialCount3 = scope3.Links.Unsync.Count();

```

```

571     var sw3 = Stopwatch.StartNew();
572
573     for (int i = START; i < END; i++)
574     {
575         //linkFrequenciesCache3.IncrementFrequencies(arrays[i]);
576         compressed3[i] = optimalVariantConverter.Convert(arrays[i]);
577     }
578
579     var elapsed3 = sw3.Elapsed;
580
581     Console.WriteLine($"Compressor: {elapsed1}, Balanced variant: {elapsed2},
582         ↳ Optimal variant: {elapsed3}");
583
584     // Assert.True(elapsed1 > elapsed2);
585
586     // Checks
587     for (int i = START; i < END; i++)
588     {
589         var sequence1 = compressed1[i];
590         var sequence2 = compressed2[i];
591         var sequence3 = compressed3[i];
592
593         var decompress1 = UnicodeMap.FromSequenceLinkToString(sequence1,
594             ↳ scope1.Links.Unsync);
595
596         var decompress2 = UnicodeMap.FromSequenceLinkToString(sequence2,
597             ↳ scope2.Links.Unsync);
598
599         var decompress3 = UnicodeMap.FromSequenceLinkToString(sequence3,
600             ↳ scope3.Links.Unsync);
601
602         var structure1 = scope1.Links.Unsync.FormatStructure(sequence1, link =>
603             ↳ link.IsPartialPoint());
604         var structure2 = scope2.Links.Unsync.FormatStructure(sequence2, link =>
605             ↳ link.IsPartialPoint());
606         var structure3 = scope3.Links.Unsync.FormatStructure(sequence3, link =>
607             ↳ link.IsPartialPoint());
608
609         //if (sequence1 != Constants.Null && sequence2 != Constants.Null &&
610             ↳ arrays[i].Length > 3)
611             // Assert.False(structure1 == structure2);
612         //if (sequence3 != Constants.Null && sequence2 != Constants.Null &&
613             ↳ arrays[i].Length > 3)
614             // Assert.False(structure3 == structure2);
615
616         Assert.True(strings[i] == decompress1 && decompress1 == decompress2);
617         Assert.True(strings[i] == decompress3 && decompress3 == decompress2);
618     }
619
620     Assert.True((int)(scope1.Links.Unsync.Count() - initialCount1) <
621         ↳ totalCharacters);
622     Assert.True((int)(scope2.Links.Unsync.Count() - initialCount2) <
623         ↳ totalCharacters);
624     Assert.True((int)(scope3.Links.Unsync.Count() - initialCount3) <
625         ↳ totalCharacters);
626
627     Console.WriteLine($"{{(double)(scope1.Links.Unsync.Count() - initialCount1) /
628         ↳ totalCharacters}} | {{(double)(scope2.Links.Unsync.Count() - initialCount2) /
629         ↳ totalCharacters}} | {{(double)(scope3.Links.Unsync.Count() - initialCount3) /
630         ↳ totalCharacters}}");
631
632     Assert.True(scope1.Links.Unsync.Count() - initialCount1 <
633         ↳ scope2.Links.Unsync.Count() - initialCount2);
634     Assert.True(scope3.Links.Unsync.Count() - initialCount3 <
635         ↳ scope2.Links.Unsync.Count() - initialCount2);
636
637     var duplicateProvider1 = new
638         ↳ DuplicateSegmentsProvider<ulong>(scope1.Links.Unsync, scope1.Sequences);
639     var duplicateProvider2 = new
640         ↳ DuplicateSegmentsProvider<ulong>(scope2.Links.Unsync, scope2.Sequences);
641     var duplicateProvider3 = new
642         ↳ DuplicateSegmentsProvider<ulong>(scope3.Links.Unsync, scope3.Sequences);
643
644     var duplicateCounter1 = new DuplicateSegmentsCounter<ulong>(duplicateProvider1);
645     var duplicateCounter2 = new DuplicateSegmentsCounter<ulong>(duplicateProvider2);
646     var duplicateCounter3 = new DuplicateSegmentsCounter<ulong>(duplicateProvider3);

```

```

628
629     var duplicates1 = duplicateCounter1.Count();
630
631     ConsoleHelpers.Debug("-----");
632
633     var duplicates2 = duplicateCounter2.Count();
634
635     ConsoleHelpers.Debug("-----");
636
637     var duplicates3 = duplicateCounter3.Count();
638
639     Console.WriteLine($"{duplicates1} | {duplicates2} | {duplicates3}");
640
641     linkFrequenciesCache1.ValidateFrequencies();
642     linkFrequenciesCache3.ValidateFrequencies();
643 }
644 }
645
646 [Fact]
647 public static void CompressionStabilityTest()
648 {
649     // TODO: Fix bug (do a separate test)
650     //const ulong minNumbers = 0;
651     //const ulong maxNumbers = 1000;
652
653     const ulong minNumbers = 10000;
654     const ulong maxNumbers = 12500;
655
656     var strings = new List<string>();
657
658     for (ulong i = minNumbers; i < maxNumbers; i++)
659     {
660         strings.Add(i.ToString());
661     }
662
663     var arrays = strings.Select(UnicodeMap.FromStringToLinkArray).ToArray();
664     var totalCharacters = arrays.Select(x => x.Length).Sum();
665
666     using (var scope1 = new TempLinksTestScope(useSequences: true, sequencesOptions: new
        ↪ SequencesOptions<ulong> { UseCompression = true,
        ↪ EnforceSingleSequenceVersionOnWriteBasedOnExisting = true }))
        using (var scope2 = new TempLinksTestScope(useSequences: true))
        {
667             scope1.Links.UseUnicode();
668             scope2.Links.UseUnicode();
669
670             //var compressor1 = new Compressor(scope1.Links.Unsync, scope1.Sequences);
671             var compressor1 = scope1.Sequences;
672             var compressor2 = scope2.Sequences;
673
674             var compressed1 = new ulong[arrays.Length];
675             var compressed2 = new ulong[arrays.Length];
676
677             var sw1 = Stopwatch.StartNew();
678
679             var START = 0;
680             var END = arrays.Length;
681
682             // Collisions proved (cannot be solved by max doublet comparison, no stable rule)
683             // Stability issue starts at 10001 or 11000
684             //for (int i = START; i < END; i++)
685             //{
686                 // var first = compressor1.Compress(arrays[i]);
687                 // var second = compressor1.Compress(arrays[i]);
688
689                 // if (first == second)
690                 //     compressed1[i] = first;
691                 // else
692                 // {
693                     // // TODO: Find a solution for this case
694                     // }
695                 // }
696             //}
697
698             for (int i = START; i < END; i++)
699             {
700                 var first = compressor1.Create(arrays[i].ShiftRight());
701                 var second = compressor1.Create(arrays[i].ShiftRight());
702
703                 if (first == second)
704                 {
705

```

```

706         compressed1[i] = first;
707     }
708     else
709     {
710         // TODO: Find a solution for this case
711     }
712 }
713
714 var elapsed1 = sw1.Elapsed;
715
716 var balancedVariantConverter = new BalancedVariantConverter<ulong>(scope2.Links);
717
718 var sw2 = Stopwatch.StartNew();
719
720 for (int i = START; i < END; i++)
721 {
722     var first = balancedVariantConverter.Convert(arrays[i]);
723     var second = balancedVariantConverter.Convert(arrays[i]);
724
725     if (first == second)
726     {
727         compressed2[i] = first;
728     }
729 }
730
731 var elapsed2 = sw2.Elapsed;
732
733 Debug.WriteLine($"Compressor: {elapsed1}, Balanced sequence creator:
734     ↳ {elapsed2}");
735
736 Assert.True(elapsed1 > elapsed2);
737
738 // Checks
739 for (int i = START; i < END; i++)
740 {
741     var sequence1 = compressed1[i];
742     var sequence2 = compressed2[i];
743
744     if (sequence1 != _constants.Null && sequence2 != _constants.Null)
745     {
746         var decompress1 = UnicodeMap.FromSequenceLinkToString(sequence1,
747             ↳ scope1.Links);
748
749         var decompress2 = UnicodeMap.FromSequenceLinkToString(sequence2,
750             ↳ scope2.Links);
751
752         //var structure1 = scope1.Links.FormatStructure(sequence1, link =>
753             ↳ link.IsPartialPoint());
754         //var structure2 = scope2.Links.FormatStructure(sequence2, link =>
755             ↳ link.IsPartialPoint());
756
757         //if (sequence1 != Constants.Null && sequence2 != Constants.Null &&
758             ↳ arrays[i].Length > 3)
759             // Assert.False(structure1 == structure2);
760
761         Assert.True(strings[i] == decompress1 && decompress1 == decompress2);
762     }
763 }
764
765 Assert.True((int)(scope1.Links.Count() - UnicodeMap.MapSize) < totalCharacters);
766 Assert.True((int)(scope2.Links.Count() - UnicodeMap.MapSize) < totalCharacters);
767
768 Debug.WriteLine($"{{(double)(scope1.Links.Count() - UnicodeMap.MapSize) /
769     ↳ totalCharacters}} | {{(double)(scope2.Links.Count() - UnicodeMap.MapSize) /
770     ↳ totalCharacters}}");
771
772 Assert.True(scope1.Links.Count() <= scope2.Links.Count());
773
774 //compressor1.ValidateFrequencies();
775 }
776
777 [Fact]
778 public static void RandomNumbersCompressionQualityTest()
779 {
780     const ulong N = 500;
781
782     //const ulong minNumbers = 10000;
783     //const ulong maxNumbers = 20000;

```

```

777 //var strings = new List<string>();
778
779 //for (ulong i = 0; i < N; i++)
780 //    strings.Add(RandomHelpers.DefaultFactory.NextUInt64(minNumbers,
781 //        ↪ maxNumbers).ToString());
782
783 var strings = new List<string>();
784
785 for (ulong i = 0; i < N; i++)
786 {
787     strings.Add(RandomHelpers.Default.NextUInt64().ToString());
788 }
789
790 strings = strings.Distinct().ToList();
791
792 var arrays = strings.Select(UnicodeMap.FromStringToLinkArray).ToArray();
793 var totalCharacters = arrays.Select(x => x.Length).Sum();
794
795 using (var scope1 = new TempLinksTestScope(useSequences: true, sequencesOptions: new
796     ↪ SequencesOptions<ulong> { UseCompression = true,
797     ↪ EnforceSingleSequenceVersionOnWriteBasedOnExisting = true }))
798 using (var scope2 = new TempLinksTestScope(useSequences: true))
799 {
800     scope1.Links.UseUnicode();
801     scope2.Links.UseUnicode();
802
803     var compressor1 = scope1.Sequences;
804     var compressor2 = scope2.Sequences;
805
806     var compressed1 = new ulong[arrays.Length];
807     var compressed2 = new ulong[arrays.Length];
808
809     var sw1 = Stopwatch.StartNew();
810
811     var START = 0;
812     var END = arrays.Length;
813
814     for (int i = START; i < END; i++)
815     {
816         compressed1[i] = compressor1.Create(arrays[i].ShiftRight());
817     }
818
819     var elapsed1 = sw1.Elapsed;
820
821     var balancedVariantConverter = new BalancedVariantConverter<ulong>(scope2.Links);
822
823     var sw2 = Stopwatch.StartNew();
824
825     for (int i = START; i < END; i++)
826     {
827         compressed2[i] = balancedVariantConverter.Convert(arrays[i]);
828     }
829
830     var elapsed2 = sw2.Elapsed;
831
832     Debug.WriteLine($"Compressor: {elapsed1}, Balanced sequence creator:
833     ↪ {elapsed2}");
834
835     Assert.True(elapsed1 > elapsed2);
836
837     // Checks
838     for (int i = START; i < END; i++)
839     {
840         var sequence1 = compressed1[i];
841         var sequence2 = compressed2[i];
842
843         if (sequence1 != _constants.Null && sequence2 != _constants.Null)
844         {
845             var decompress1 = UnicodeMap.FromSequenceLinkToString(sequence1,
846                 ↪ scope1.Links);
847
848             var decompress2 = UnicodeMap.FromSequenceLinkToString(sequence2,
849                 ↪ scope2.Links);
850
851             Assert.True(strings[i] == decompress1 && decompress1 == decompress2);
852         }
853     }
854
855     Assert.True((int)(scope1.Links.Count() - UnicodeMap.MapSize) < totalCharacters);

```

```

851     Assert.True((int)(scope2.Links.Count() - UnicodeMap.MapSize) < totalCharacters);
852
853     Debug.WriteLine($"{{(double)(scope1.Links.Count() - UnicodeMap.MapSize) /
      ↳ totalCharacters}} | {{(double)(scope2.Links.Count() - UnicodeMap.MapSize) /
      ↳ totalCharacters}}");
854
855     // Can be worse than balanced variant
856     //Assert.True(scope1.Links.Count() <= scope2.Links.Count());
857
858     //compressor1.ValidateFrequencies();
859 }
860 }
861
862 [Fact]
863 public static void AllTreeBreakDownAtSequencesCreationBugTest()
864 {
865     // Made out of AllPossibleConnectionsTest test.
866
867     //const long sequenceLength = 5; //100% bug
868     const long sequenceLength = 4; //100% bug
869     //const long sequenceLength = 3; //100% _no_bug (ok)
870
871     using (var scope = new TempLinksTestScope(useSequences: true))
872     {
873         var links = scope.Links;
874         var sequences = scope.Sequences;
875
876         var sequence = new ulong[sequenceLength];
877         for (var i = 0; i < sequenceLength; i++)
878         {
879             sequence[i] = links.Create();
880         }
881
882         var createResults = sequences.CreateAllVariants2(sequence);
883
884         Global.Trash = createResults;
885
886         for (var i = 0; i < sequenceLength; i++)
887         {
888             links.Delete(sequence[i]);
889         }
890     }
891 }
892
893 [Fact]
894 public static void AllPossibleConnectionsTest()
895 {
896     const long sequenceLength = 5;
897
898     using (var scope = new TempLinksTestScope(useSequences: true))
899     {
900         var links = scope.Links;
901         var sequences = scope.Sequences;
902
903         var sequence = new ulong[sequenceLength];
904         for (var i = 0; i < sequenceLength; i++)
905         {
906             sequence[i] = links.Create();
907         }
908
909         var createResults = sequences.CreateAllVariants2(sequence);
910         var reverseResults = sequences.CreateAllVariants2(sequence.Reverse().ToArray());
911
912         for (var i = 0; i < 1; i++)
913         {
914             var sw1 = Stopwatch.StartNew();
915             var searchResults1 = sequences.GetAllConnections(sequence); sw1.Stop();
916
917             var sw2 = Stopwatch.StartNew();
918             var searchResults2 = sequences.GetAllConnections1(sequence); sw2.Stop();
919
920             var sw3 = Stopwatch.StartNew();
921             var searchResults3 = sequences.GetAllConnections2(sequence); sw3.Stop();
922
923             var sw4 = Stopwatch.StartNew();
924             var searchResults4 = sequences.GetAllConnections3(sequence); sw4.Stop();
925
926             Global.Trash = searchResults3;
927             Global.Trash = searchResults4; //-V3008
928

```

```

929         var intersection1 = createResults.Intersect(searchResults1).ToList();
930         Assert.True(intersection1.Count == createResults.Length);
931
932         var intersection2 = reverseResults.Intersect(searchResults1).ToList();
933         Assert.True(intersection2.Count == reverseResults.Length);
934
935         var intersection0 = searchResults1.Intersect(searchResults2).ToList();
936         Assert.True(intersection0.Count == searchResults2.Count);
937
938         var intersection3 = searchResults2.Intersect(searchResults3).ToList();
939         Assert.True(intersection3.Count == searchResults3.Count);
940
941         var intersection4 = searchResults3.Intersect(searchResults4).ToList();
942         Assert.True(intersection4.Count == searchResults4.Count);
943     }
944
945     for (var i = 0; i < sequenceLength; i++)
946     {
947         links.Delete(sequence[i]);
948     }
949 }
950
951 [Fact(Skip = "Correct implementation is pending")]
952 public static void CalculateAllUsagesTest()
953 {
954     const long sequenceLength = 3;
955
956     using (var scope = new TempLinksTestScope(useSequences: true))
957     {
958         var links = scope.Links;
959         var sequences = scope.Sequences;
960
961         var sequence = new ulong[sequenceLength];
962         for (var i = 0; i < sequenceLength; i++)
963         {
964             sequence[i] = links.Create();
965         }
966
967         var createResults = sequences.CreateAllVariants2(sequence);
968
969         //var reverseResults =
970         ↪ sequences.CreateAllVariants2(sequence.Reverse().ToArray());
971
972         for (var i = 0; i < 1; i++)
973         {
974             var linksTotalUsages1 = new ulong[links.Count() + 1];
975
976             sequences.CalculateAllUsages(linksTotalUsages1);
977
978             var linksTotalUsages2 = new ulong[links.Count() + 1];
979
980             sequences.CalculateAllUsages2(linksTotalUsages2);
981
982             var intersection1 = linksTotalUsages1.Intersect(linksTotalUsages2).ToList();
983             Assert.True(intersection1.Count == linksTotalUsages2.Length);
984         }
985
986         for (var i = 0; i < sequenceLength; i++)
987         {
988             links.Delete(sequence[i]);
989         }
990     }
991 }
992
993 }

```

## 1.68 ./csharp/Platform.Data.Doublets.Sequences.Tests/TempLinksTestScope.cs

```

1  using System.IO;
2  using Platform.Disposables;
3  using Platform.Data.Doublets.Sequences;
4  using Platform.Data.Doublets.Decorators;
5  using Platform.Data.Doublets.Memory.United.Specific;
6  using Platform.Data.Doublets.Memory.Split.Specific;
7  using Platform.Memory;
8
9  namespace Platform.Data.Doublets.Sequences.Tests
10 {
11     public class TempLinksTestScope : DisposableBase
12     {

```

```

13     public ILinks<ulong> MemoryAdapter { get; }
14     public SynchronizedLinks<ulong> Links { get; }
15     public Sequences Sequences { get; }
16     public string TempFilename { get; }
17     public string TempTransactionLogFilename { get; }
18     private readonly bool _deleteFiles;
19
20     public TempLinksTestScope(bool deleteFiles = true, bool useSequences = false, bool
        ↪ useLog = false) : this(new SequencesOptions<ulong>(), deleteFiles, useSequences,
        ↪ useLog) { }
21
22     public TempLinksTestScope(SequencesOptions<ulong> sequencesOptions, bool deleteFiles =
        ↪ true, bool useSequences = false, bool useLog = false)
23     {
24         _deleteFiles = deleteFiles;
25         TempFilename = Path.GetTempFileName();
26         TempTransactionLogFilename = Path.GetTempFileName();
27         //var coreMemoryAdapter = new UInt64UnitedMemoryLinks(TempFilename);
28         var coreMemoryAdapter = new UInt64SplitMemoryLinks(new
        ↪ FileMappedResizableDirectMemory(TempFilename), new
        ↪ FileMappedResizableDirectMemory(Path.ChangeExtension(TempFilename, "indexes")),
        ↪ UInt64SplitMemoryLinks.DefaultLinksSizeStep, new LinksConstants<ulong>(),
        ↪ Memory.IndexTreeType.Default, useLinkedList: true);
29         MemoryAdapter = useLog ? (ILinks<ulong>)new
        ↪ UInt64LinksTransactionsLayer(coreMemoryAdapter, TempTransactionLogFilename) :
        ↪ coreMemoryAdapter;
30         Links = new SynchronizedLinks<ulong>(new UInt64Links(MemoryAdapter));
31         if (useSequences)
32         {
33             Sequences = new Sequences(Links, sequencesOptions);
34         }
35     }
36
37     protected override void Dispose(bool manual, bool wasDisposed)
38     {
39         if (!wasDisposed)
40         {
41             Links.Unsync.DisposeIfPossible();
42             if (_deleteFiles)
43             {
44                 DeleteFiles();
45             }
46         }
47     }
48
49     public void DeleteFiles()
50     {
51         File.Delete(TempFilename);
52         File.Delete(TempTransactionLogFilename);
53     }
54 }
55 }

```

## 1.69 ./csharp/Platform.Data.Doublets.Sequences.Tests/TestExtensions.cs

```

1  using System.Collections.Generic;
2  using Xunit;
3  using Platform.Ranges;
4  using Platform.Numbers;
5  using Platform.Random;
6  using Platform.Setters;
7  using Platform.Converters;
8
9  namespace Platform.Data.Doublets.Sequences.Tests
10 {
11     public static class TestExtensions
12     {
13         public static void TestCRUDOperations<T>(this ILinks<T> links)
14         {
15             var constants = links.Constants;
16
17             var equalityComparer = EqualityComparer<T>.Default;
18
19             var zero = default(T);
20             var one = Arithmetic.Increment(zero);
21
22             // Create Link
23             Assert.True(equalityComparer.Equals(links.Count(), zero));
24
25             var setter = new Setter<T>(constants.Null);

```



```

26     links.Each(constants.Any, constants.Any, setter.SetAndReturnTrue);
27
28     Assert.True(equalityComparer.Equals(setter.Result, constants.Null));
29
30     var linkAddress = links.Create();
31
32     var link = new Link<T>(links.GetLink(linkAddress));
33
34     Assert.True(link.Count == 3);
35     Assert.True(equalityComparer.Equals(link.Index, linkAddress));
36     Assert.True(equalityComparer.Equals(link.Source, constants.Null));
37     Assert.True(equalityComparer.Equals(link.Target, constants.Null));
38
39     Assert.True(equalityComparer.Equals(links.Count(), one));
40
41     // Get first link
42     setter = new Setter<T>(constants.Null);
43     links.Each(constants.Any, constants.Any, setter.SetAndReturnFalse);
44
45     Assert.True(equalityComparer.Equals(setter.Result, linkAddress));
46
47     // Update link to reference itself
48     links.Update(linkAddress, linkAddress, linkAddress);
49
50     link = new Link<T>(links.GetLink(linkAddress));
51
52     Assert.True(equalityComparer.Equals(link.Source, linkAddress));
53     Assert.True(equalityComparer.Equals(link.Target, linkAddress));
54
55     // Update link to reference null (prepare for delete)
56     var updated = links.Update(linkAddress, constants.Null, constants.Null);
57
58     Assert.True(equalityComparer.Equals(updated, linkAddress));
59
60     link = new Link<T>(links.GetLink(linkAddress));
61
62     Assert.True(equalityComparer.Equals(link.Source, constants.Null));
63     Assert.True(equalityComparer.Equals(link.Target, constants.Null));
64
65     // Delete link
66     links.Delete(linkAddress);
67
68     Assert.True(equalityComparer.Equals(links.Count(), zero));
69
70     setter = new Setter<T>(constants.Null);
71     links.Each(constants.Any, constants.Any, setter.SetAndReturnTrue);
72
73     Assert.True(equalityComparer.Equals(setter.Result, constants.Null));
74 }
75
76 public static void TestRawNumbersCRUDOperations<T>(this ILinks<T> links)
77 {
78     // Constants
79     var constants = links.Constants;
80     var equalityComparer = EqualityComparer<T>.Default;
81
82     var zero = default(T);
83     var one = Arithmetic.Increment(zero);
84     var two = Arithmetic.Increment(one);
85
86     var h106E = new Hybrid<T>(106L, isExternal: true);
87     var h107E = new Hybrid<T>(-char.ConvertFromUtf32(107)[0]);
88     var h108E = new Hybrid<T>(-108L);
89
90     Assert.Equal(106L, h106E.AbsoluteValue);
91     Assert.Equal(107L, h107E.AbsoluteValue);
92     Assert.Equal(108L, h108E.AbsoluteValue);
93
94     // Create Link (External -> External)
95     var linkAddress1 = links.Create();
96
97     links.Update(linkAddress1, h106E, h108E);
98
99     var link1 = new Link<T>(links.GetLink(linkAddress1));
100
101     Assert.True(equalityComparer.Equals(link1.Source, h106E));
102     Assert.True(equalityComparer.Equals(link1.Target, h108E));
103
104     // Create Link (Internal -> External)
105     var linkAddress2 = links.Create();

```

```

106     links.Update(linkAddress2, linkAddress1, h108E);
107
108
109     var link2 = new Link<T>(links.GetLink(linkAddress2));
110
111     Assert.True(equalityComparer.Equals(link2.Source, linkAddress1));
112     Assert.True(equalityComparer.Equals(link2.Target, h108E));
113
114     // Create Link (Internal -> Internal)
115     var linkAddress3 = links.Create();
116
117     links.Update(linkAddress3, linkAddress1, linkAddress2);
118
119     var link3 = new Link<T>(links.GetLink(linkAddress3));
120
121     Assert.True(equalityComparer.Equals(link3.Source, linkAddress1));
122     Assert.True(equalityComparer.Equals(link3.Target, linkAddress2));
123
124     // Search for created link
125     var setter1 = new Setter<T>(constants.Null);
126     links.Each(h106E, h108E, setter1.SetAndReturnFalse);
127
128     Assert.True(equalityComparer.Equals(setter1.Result, linkAddress1));
129
130     // Search for nonexistent link
131     var setter2 = new Setter<T>(constants.Null);
132     links.Each(h106E, h107E, setter2.SetAndReturnFalse);
133
134     Assert.True(equalityComparer.Equals(setter2.Result, constants.Null));
135
136     // Update link to reference null (prepare for delete)
137     var updated = links.Update(linkAddress3, constants.Null, constants.Null);
138
139     Assert.True(equalityComparer.Equals(updated, linkAddress3));
140
141     link3 = new Link<T>(links.GetLink(linkAddress3));
142
143     Assert.True(equalityComparer.Equals(link3.Source, constants.Null));
144     Assert.True(equalityComparer.Equals(link3.Target, constants.Null));
145
146     // Delete link
147     links.Delete(linkAddress3);
148
149     Assert.True(equalityComparer.Equals(links.Count(), two));
150
151     var setter3 = new Setter<T>(constants.Null);
152     links.Each(constants.Any, constants.Any, setter3.SetAndReturnTrue);
153
154     Assert.True(equalityComparer.Equals(setter3.Result, linkAddress2));
155 }
156
157 public static void TestMultipleRandomCreationsAndDeletions<TLinkAddress>(this
    ↳ ILinks<TLinkAddress> links, int maximumOperationsPerCycle)
158 {
159     var comparer = Comparer<TLinkAddress>.Default;
160     var addressToUInt64Converter = CheckedConverter<TLinkAddress, ulong>.Default;
161     var uint64ToAddressConverter = CheckedConverter<ulong, TLinkAddress>.Default;
162     for (var N = 1; N < maximumOperationsPerCycle; N++)
163     {
164         var random = new System.Random(N);
165         var created = 0UL;
166         var deleted = 0UL;
167         for (var i = 0; i < N; i++)
168         {
169             var linksCount = addressToUInt64Converter.Convert(links.Count());
170             var createPoint = random.NextBoolean();
171             if (linksCount >= 2 && createPoint)
172             {
173                 var linksAddressRange = new Range<ulong>(1, linksCount);
174                 TLinkAddress source = uint64ToAddressConverter.Convert(random.NextUInt64
    ↳ (linksAddressRange));
175                 TLinkAddress target = uint64ToAddressConverter.Convert(random.NextUInt64
    ↳ (linksAddressRange));
176                 // -V3086
177                 var resultLink = links.GetOrCreate(source, target);
178                 if (comparer.Compare(resultLink,
    ↳ uint64ToAddressConverter.Convert(linksCount)) > 0)
179                 {
180                     created++;
181                 }
182             }
183         }
184     }
185 }

```

```

180         }
181     }
182     else
183     {
184         links.Create();
185         created++;
186     }
187 }
188 Assert.True(created == addressToUInt64Converter.Convert(links.Count()));
189 for (var i = 0; i < N; i++)
190 {
191     TLinkAddress link = uInt64ToAddressConverter.Convert((ulong)i + 1UL);
192     if (links.Exists(link))
193     {
194         links.Delete(link);
195         deleted++;
196     }
197 }
198 Assert.True(addressToUInt64Converter.Convert(links.Count()) == 0L);
199 }
200 }
201 }
202 }

```

## 1.70 ./csharp/Platform.Data.Doublets.Sequences.Tests/UInt64LinksTests.cs

```

1  using System;
2  using System.Collections.Generic;
3  using System.Diagnostics;
4  using System.IO;
5  using System.Text;
6  using System.Threading;
7  using System.Threading.Tasks;
8  using Xunit;
9  using Platform.Disposables;
10 using Platform.Ranges;
11 using Platform.Random;
12 using Platform.Timestamps;
13 using Platform.Reflection;
14 using Platform.Singletons;
15 using Platform.Scopes;
16 using Platform.Counters;
17 using Platform.Diagnostics;
18 using Platform.IO;
19 using Platform.Memory;
20 using Platform.Data.Doublets.Decorators;
21 using Platform.Data.Doublets.Memory.United.Specific;
22
23 namespace Platform.Data.Doublets.Sequences.Tests
24 {
25     public static class UInt64LinksTests
26     {
27         private static readonly LinksConstants<ulong> _constants =
28             ↪ Default<LinksConstants<ulong>>.Instance;
29         private const long Iterations = 10 * 1024;
30
31         #region Concept
32
33         [Fact]
34         public static void MultipleCreateAndDeleteTest()
35         {
36             using (var scope = new Scope<Types<HeapResizableDirectMemory,
37                 ↪ UInt64UnitedMemoryLinks>>())
38             {
39                 new UInt64Links(scope.Use<ILinks<ulong>>()).TestMultipleRandomCreationsAndDeletions(100);
40             }
41
42             [Fact]
43             public static void CascadeUpdateTest()
44             {
45                 var itself = _constants.Itself;
46                 using (var scope = new TempLinksTestScope(useLog: true))
47                 {
48                     var links = scope.Links;
49
50                     var l1 = links.Create();
51                     var l2 = links.Create();
52
53                     l2 = links.Update(l2, l2, l1, l2);
54                 }
55             }
56         }
57     }
58 }

```

```

54         links.CreateAndUpdate(l2, itself);
55         links.CreateAndUpdate(l2, itself);
56
57         l2 = links.Update(l2, l1);
58
59         links.Delete(l2);
60
61         Global.Trash = links.Count();
62
63         links.Unsync.DisposeIfPossible(); // Close links to access log
64
65         Global.Trash = FileHelpers.ReadAll<UInt64LinksTransactionsLayer.Transition>(scope
        ↪ e.TempTransactionLogFilename);
66     }
67 }
68
69 [Fact]
70 public static void BasicTransactionLogTest()
71 {
72     using (var scope = new TempLinksTestScope(useLog: true))
73     {
74         var links = scope.Links;
75         var l1 = links.Create();
76         var l2 = links.Create();
77
78         Global.Trash = links.Update(l2, l2, l1, l2);
79
80         links.Delete(l1);
81
82         links.Unsync.DisposeIfPossible(); // Close links to access log
83
84         Global.Trash = FileHelpers.ReadAll<UInt64LinksTransactionsLayer.Transition>(scope
        ↪ e.TempTransactionLogFilename);
85     }
86 }
87
88 [Fact]
89 public static void TransactionAutoRevertedTest()
90 {
91     // Auto Reverted (Because no commit at transaction)
92     using (var scope = new TempLinksTestScope(useLog: true))
93     {
94         var links = scope.Links;
95         var transactionsLayer = (UInt64LinksTransactionsLayer)scope.MemoryAdapter;
96         using (var transaction = transactionsLayer.BeginTransaction())
97         {
98             var l1 = links.Create();
99             var l2 = links.Create();
100
101             links.Update(l2, l2, l1, l2);
102         }
103
104         Assert.Equal(OUL, links.Count());
105
106         links.Unsync.DisposeIfPossible();
107
108         var transitions = FileHelpers.ReadAll<UInt64LinksTransactionsLayer.Transition>(s
        ↪ cope.TempTransactionLogFilename);
109         Assert.Single(transitions);
110     }
111 }
112
113 [Fact]
114 public static void TransactionUserCodeErrorNoDataSavedTest()
115 {
116     // User Code Error (Autoreverted), no data saved
117     var itself = _constants.Itself;
118
119     TempLinksTestScope lastScope = null;
120     try
121     {
122         using (var scope = lastScope = new TempLinksTestScope(deleteFiles: false,
        ↪ useLog: true))
123         {
124             var links = scope.Links;
125             var transactionsLayer = (UInt64LinksTransactionsLayer)((LinksDisposableDecor
        ↪ atorBase<ulong>)links.Unsync).Links;
126             using (var transaction = transactionsLayer.BeginTransaction())
127             {

```

```

128         var l1 = links.CreateAndUpdate(itself, itself);
129         var l2 = links.CreateAndUpdate(itself, itself);
130
131         l2 = links.Update(l2, l2, l1, l2);
132
133         links.CreateAndUpdate(l2, itself);
134         links.CreateAndUpdate(l2, itself);
135
136         //Global.Trash = FileHelpers.ReadAll<UInt64LinksTransactionsLayer.Transi_
137         ↪ tion>(scope.TempTransactionLogFilename);
138
139         l2 = links.Update(l2, l1);
140
141         links.Delete(l2);
142
143         ExceptionThrower();
144
145         transaction.Commit();
146     }
147     Global.Trash = links.Count();
148 }
149 }
150 catch
151 {
152     Assert.False(lastScope == null);
153
154     var transitions = FileHelpers.ReadAll<UInt64LinksTransactionsLayer.Transition>(l_
155     ↪ astScope.TempTransactionLogFilename);
156
157     Assert.True(transitions.Length == 1 && transitions[0].Before.IsNull() &&
158     ↪ transitions[0].After.IsNull());
159
160     lastScope.DeleteFiles();
161 }
162 }
163 [Fact]
164 public static void TransactionUserCodeErrorSomeDataSavedTest()
165 {
166     // User Code Error (Autoreverted), some data saved
167     var itself = _constants.Itself;
168
169     TempLinksTestScope lastScope = null;
170     try
171     {
172         ulong l1;
173         ulong l2;
174
175         using (var scope = new TempLinksTestScope(useLog: true))
176         {
177             var links = scope.Links;
178             l1 = links.CreateAndUpdate(itself, itself);
179             l2 = links.CreateAndUpdate(itself, itself);
180
181             l2 = links.Update(l2, l2, l1, l2);
182
183             links.CreateAndUpdate(l2, itself);
184             links.CreateAndUpdate(l2, itself);
185
186             links.Unsync.DisposeIfPossible();
187
188             Global.Trash = FileHelpers.ReadAll<UInt64LinksTransactionsLayer.Transition>(
189             ↪ scope.TempTransactionLogFilename);
190         }
191
192         using (var scope = lastScope = new TempLinksTestScope(deleteFiles: false,
193         ↪ useLog: true))
194         {
195             var links = scope.Links;
196             var transactionsLayer = (UInt64LinksTransactionsLayer)links.Unsync;
197             using (var transaction = transactionsLayer.BeginTransaction())
198             {
199                 l2 = links.Update(l2, l1);
200
201                 links.Delete(l2);
202
203                 ExceptionThrower();
204
205                 transaction.Commit();

```

```

203     }
204
205     Global.Trash = links.Count();
206 }
207 }
208 catch
209 {
210     Assert.False(lastScope == null);
211
212     Global.Trash = FileHelpers.ReadAll<UInt64LinksTransactionsLayer.Transition>(last
        ↪ Scope.TempTransactionLogFilename);
213
214     lastScope.DeleteFiles();
215 }
216 }
217
218 [Fact]
219 public static void TransactionCommit()
220 {
221     var itself = _constants.Itself;
222
223     var tempDatabaseFilename = Path.GetTempFileName();
224     var tempTransactionLogFilename = Path.GetTempFileName();
225
226     // Commit
227     using (var memoryAdapter = new UInt64LinksTransactionsLayer(new
        ↪ UInt64UnitedMemoryLinks(tempDatabaseFilename), tempTransactionLogFilename))
228     using (var links = new UInt64Links(memoryAdapter))
229     {
230         using (var transaction = memoryAdapter.BeginTransaction())
231         {
232             var l1 = links.CreateAndUpdate(itself, itself);
233             var l2 = links.CreateAndUpdate(itself, itself);
234
235             Global.Trash = links.Update(l2, l2, l1, l2);
236
237             links.Delete(l1);
238
239             transaction.Commit();
240         }
241
242         Global.Trash = links.Count();
243     }
244
245     Global.Trash = FileHelpers.ReadAll<UInt64LinksTransactionsLayer.Transition>(tempTran
        ↪ sactionLogFilename);
246 }
247
248 [Fact]
249 public static void TransactionDamage()
250 {
251     var itself = _constants.Itself;
252
253     var tempDatabaseFilename = Path.GetTempFileName();
254     var tempTransactionLogFilename = Path.GetTempFileName();
255
256     // Commit
257     using (var memoryAdapter = new UInt64LinksTransactionsLayer(new
        ↪ UInt64UnitedMemoryLinks(tempDatabaseFilename), tempTransactionLogFilename))
258     using (var links = new UInt64Links(memoryAdapter))
259     {
260         using (var transaction = memoryAdapter.BeginTransaction())
261         {
262             var l1 = links.CreateAndUpdate(itself, itself);
263             var l2 = links.CreateAndUpdate(itself, itself);
264
265             Global.Trash = links.Update(l2, l2, l1, l2);
266
267             links.Delete(l1);
268
269             transaction.Commit();
270         }
271
272         Global.Trash = links.Count();
273     }
274
275     Global.Trash = FileHelpers.ReadAll<UInt64LinksTransactionsLayer.Transition>(tempTran
        ↪ sactionLogFilename);
276

```

```

277 // Damage database
278
279 FileHelpers.WriteFirst(tempTransactionLogFilename, new
    ↳ UInt64LinksTransactionsLayer.Transition(new UniqueTimestampFactory(), 555));
280
281 // Try load damaged database
282 try
283 {
284     // TODO: Fix
285     using (var memoryAdapter = new UInt64LinksTransactionsLayer(new
        ↳ UInt64UnitedMemoryLinks(tempDatabaseFilename), tempTransactionLogFilename))
286     using (var links = new UInt64Links(memoryAdapter))
287     {
288         Global.Trash = links.Count();
289     }
290 }
291 catch (NotSupportedException ex)
292 {
293     Assert.True(ex.Message == "Database is damaged, autorecovery is not supported
        ↳ yet.");
294 }
295
296 Global.Trash = FileHelpers.ReadAll<UInt64LinksTransactionsLayer.Transition>(tempTran_
    ↳ sactionLogFilename);
297
298 File.Delete(tempDatabaseFilename);
299 File.Delete(tempTransactionLogFilename);
300 }
301
302 [Fact]
303 public static void Bug1Test()
304 {
305     var tempDatabaseFilename = Path.GetTempFileName();
306     var tempTransactionLogFilename = Path.GetTempFileName();
307
308     var itself = _constants.Itself;
309
310     // User Code Error (Autoreverted), some data saved
311     try
312     {
313         ulong l1;
314         ulong l2;
315
316         using (var memory = new UInt64UnitedMemoryLinks(tempDatabaseFilename))
317         using (var memoryAdapter = new UInt64LinksTransactionsLayer(memory,
            ↳ tempTransactionLogFilename))
318         using (var links = new UInt64Links(memoryAdapter))
319         {
320             l1 = links.CreateAndUpdate(itself, itself);
321             l2 = links.CreateAndUpdate(itself, itself);
322
323             l2 = links.Update(l2, l2, l1, l2);
324
325             links.CreateAndUpdate(l2, itself);
326             links.CreateAndUpdate(l2, itself);
327         }
328
329         Global.Trash = FileHelpers.ReadAll<UInt64LinksTransactionsLayer.Transition>(temp_
            ↳ TransactionLogFilename);
330
331         using (var memory = new UInt64UnitedMemoryLinks(tempDatabaseFilename))
332         using (var memoryAdapter = new UInt64LinksTransactionsLayer(memory,
            ↳ tempTransactionLogFilename))
333         using (var links = new UInt64Links(memoryAdapter))
334         {
335             using (var transaction = memoryAdapter.BeginTransaction())
336             {
337                 l2 = links.Update(l2, l1);
338
339                 links.Delete(l2);
340
341                 ExceptionThrower();
342
343                 transaction.Commit();
344             }
345
346             Global.Trash = links.Count();
347         }
348     }

```

```

349     catch
350     {
351         Global.Trash = FileHelpers.ReadAll<UInt64LinksTransactionsLayer.Transition>(temp ↵
            ↵ TransactionLogFilename);
352     }
353
354     File.Delete(tempDatabaseFilename);
355     File.Delete(tempTransactionLogFilename);
356 }
357 private static void ExceptionThrower() => throw new InvalidOperationException();
358
359 [Fact]
360 public static void PathsTest()
361 {
362     var source = _constants.SourcePart;
363     var target = _constants.TargetPart;
364
365     using (var scope = new TempLinksTestScope())
366     {
367         var links = scope.Links;
368         var l1 = links.CreatePoint();
369         var l2 = links.CreatePoint();
370
371         var r1 = links.GetByKeys(l1, source, target, source);
372         var r2 = links.CheckPathExistence(l2, l2, l2, l2);
373     }
374 }
375
376 [Fact]
377 public static void RecursiveStringFormattingTest()
378 {
379     using (var scope = new TempLinksTestScope(useSequences: true))
380     {
381         var links = scope.Links;
382         var sequences = scope.Sequences; // TODO: Auto use sequences on Sequences getter.
383
384         var a = links.CreatePoint();
385         var b = links.CreatePoint();
386         var c = links.CreatePoint();
387
388         var ab = links.GetOrCreate(a, b);
389         var cb = links.GetOrCreate(c, b);
390         var ac = links.GetOrCreate(a, c);
391
392         a = links.Update(a, c, b);
393         b = links.Update(b, a, c);
394         c = links.Update(c, a, b);
395
396         Debug.WriteLine(links.FormatStructure(ab, link => link.IsFullPoint(), true));
397         Debug.WriteLine(links.FormatStructure(cb, link => link.IsFullPoint(), true));
398         Debug.WriteLine(links.FormatStructure(ac, link => link.IsFullPoint(), true));
399
400         Assert.True(links.FormatStructure(cb, link => link.IsFullPoint(), true) ==
            ↵ "(5:(4:5 (6:5 4)) 6)");
401         Assert.True(links.FormatStructure(ac, link => link.IsFullPoint(), true) ==
            ↵ "(6:(5:(4:5 6) 6) 4)");
402         Assert.True(links.FormatStructure(ab, link => link.IsFullPoint(), true) ==
            ↵ "(4:(5:4 (6:5 4)) 6)");
403
404         // TODO: Think how to build balanced syntax tree while formatting structure (eg.
            ↵ "(4:(5:4 6) (6:5 4))" instead of "(4:(5:4 (6:5 4)) 6)"
405
406         Assert.True(sequences.SafeFormatSequence(cb, DefaultFormatter, false) ==
            ↵ "{{5}{5}{4}{6}}");
407         Assert.True(sequences.SafeFormatSequence(ac, DefaultFormatter, false) ==
            ↵ "{{5}{6}{6}{4}}");
408         Assert.True(sequences.SafeFormatSequence(ab, DefaultFormatter, false) ==
            ↵ "{{4}{5}{4}{6}}");
409     }
410 }
411 private static void DefaultFormatter(StringBuilder sb, ulong link)
412 {
413     sb.Append(link.ToString());
414 }
415
416 #endregion
417
418 #region Performance
419

```



```

420     /*
421     public static void RunAllPerformanceTests()
422     {
423         try
424         {
425             links.TestLinksInSteps();
426         }
427         catch (Exception ex)
428         {
429             ex.WriteToConsole();
430         }
431         return;
432     }
433     try
434     {
435         //ThreadPool.SetMaxThreads(2, 2);
436
437         // Запускаем все тесты дважды, чтобы первоначальная инициализация не повлияла на
438         ↪ результат
439         // Также это дополнительно помогает в отладке
440         // Увеличивает вероятность попадания информации в кэши
441         for (var i = 0; i < 10; i++)
442         {
443             //0 - 10 ГБ
444             //Каждые 100 МБ срез цифр
445
446             //links.TestGetSourceFunction();
447             //links.TestGetSourceFunctionInParallel();
448             //links.TestGetTargetFunction();
449             //links.TestGetTargetFunctionInParallel();
450             links.Create64BillionLinks();
451
452             links.TestRandomSearchFixed();
453             //links.Create64BillionLinksInParallel();
454             links.TestEachFunction();
455             //links.TestForeach();
456             //links.TestParallelForeach();
457         }
458
459         links.TestDeletionOfAllLinks();
460     }
461     catch (Exception ex)
462     {
463         ex.WriteToConsole();
464     }
465 }*/
466
467     /*
468     public static void TestLinksInSteps()
469     {
470         const long gibibyte = 1024 * 1024 * 1024;
471         const long mebibyte = 1024 * 1024;
472
473         var totalLinksToCreate = gibibyte /
474         ↪ Platform.Links.Data.Core.Doublets.Links.LinkSizeInBytes;
475         var linksStep = 102 * mebibyte /
476         ↪ Platform.Links.Data.Core.Doublets.Links.LinkSizeInBytes;
477
478         var creationMeasurements = new List<TimeSpan>();
479         var searchMeasurements = new List<TimeSpan>();
480         var deletionMeasurements = new List<TimeSpan>();
481
482         GetBaseRandomLoopOverhead(linksStep);
483         GetBaseRandomLoopOverhead(linksStep);
484
485         var stepLoopOverhead = GetBaseRandomLoopOverhead(linksStep);
486
487         ConsoleHelpers.Debug("Step loop overhead: {0}.", stepLoopOverhead);
488
489         var loops = totalLinksToCreate / linksStep;
490
491         for (int i = 0; i < loops; i++)
492         {
493             creationMeasurements.Add(Measure(() => links.RunRandomCreations(linksStep)));
494             searchMeasurements.Add(Measure(() => links.RunRandomSearches(linksStep)));
495
496             Console.WriteLine("\rC + S {0}/{1}", i + 1, loops);

```

```

496     }
497
498     ConsoleHelpers.Debug();
499
500     for (int i = 0; i < loops; i++)
501     {
502         deletionMeasurements.Add(Measure(() => links.RunRandomDeletions(linksStep)));
503
504         Console.Write("\rD {0}/{1}", i + 1, loops);
505     }
506
507     ConsoleHelpers.Debug();
508
509     ConsoleHelpers.Debug("C S D");
510
511     for (int i = 0; i < loops; i++)
512     {
513         ConsoleHelpers.Debug("{0} {1} {2}", creationMeasurements[i],
↵ searchMeasurements[i], deletionMeasurements[i]);
514     }
515
516     ConsoleHelpers.Debug("C S D (no overhead)");
517
518     for (int i = 0; i < loops; i++)
519     {
520         ConsoleHelpers.Debug("{0} {1} {2}", creationMeasurements[i] - stepLoopOverhead,
↵ searchMeasurements[i] - stepLoopOverhead, deletionMeasurements[i] - stepLoopOverhead);
521     }
522
523     ConsoleHelpers.Debug("All tests done. Total links left in database: {0}.",
↵ links.Total);
524 }
525
526 private static void CreatePoints(this Platform.Links.Data.Core.Doublets.Links links, long
↵ amountToCreate)
527 {
528     for (long i = 0; i < amountToCreate; i++)
529         links.Create(0, 0);
530 }
531
532 private static TimeSpan GetBaseRandomLoopOverhead(long loops)
533 {
534     return Measure(() =>
535     {
536         ulong maxValue = RandomHelpers.DefaultFactory.NextUInt64();
537         ulong result = 0;
538         for (long i = 0; i < loops; i++)
539         {
540             var source = RandomHelpers.DefaultFactory.NextUInt64(maxValue);
541             var target = RandomHelpers.DefaultFactory.NextUInt64(maxValue);
542
543             result += maxValue + source + target;
544         }
545         Global.Trash = result;
546     });
547 }
548 */
549
550 [Fact(Skip = "performance test")]
551 public static void GetSourceTest()
552 {
553     using (var scope = new TempLinksTestScope())
554     {
555         var links = scope.Links;
556         ConsoleHelpers.Debug("Testing GetSource function with {0} Iterations.",
↵ Iterations);
557
558         ulong counter = 0;
559
560         //var firstLink = links.First();
561         // Создаём одну связь, из которой будет производить считывание
562         var firstLink = links.Create();
563
564         var sw = Stopwatch.StartNew();
565
566         // Тестируем саму функцию
567         for (ulong i = 0; i < Iterations; i++)
568         {
569             counter += links.GetSource(firstLink);

```

```

570     }
571
572     var elapsedTime = sw.Elapsed;
573
574     var iterationsPerSecond = Iterations / elapsedTime.TotalSeconds;
575
576     // Удаляем связь, из которой производилось считывание
577     links.Delete(firstLink);
578
579     ConsoleHelpers.Debug(
580         "{0} Iterations of GetSource function done in {1} ({2} Iterations per
        ↳ second), counter result: {3}",
        Iterations, elapsedTime, (long)iterationsPerSecond, counter);
581     }
582 }
583
584 [Fact(Skip = "performance test")]
585 public static void GetSourceInParallel()
586 {
587     using (var scope = new TempLinksTestScope())
588     {
589         var links = scope.Links;
590         ConsoleHelpers.Debug("Testing GetSource function with {0} Iterations in
        ↳ parallel.", Iterations);
591
592         long counter = 0;
593
594         //var firstLink = links.First();
595         var firstLink = links.Create();
596
597         var sw = Stopwatch.StartNew();
598
599         // Тестируем саму функцию
600         Parallel.For(0, Iterations, x =>
601         {
602             Interlocked.Add(ref counter, (long)links.GetSource(firstLink));
603             //Interlocked.Increment(ref counter);
604         });
605
606         var elapsedTime = sw.Elapsed;
607
608         var iterationsPerSecond = Iterations / elapsedTime.TotalSeconds;
609
610         links.Delete(firstLink);
611
612         ConsoleHelpers.Debug(
613             "{0} Iterations of GetSource function done in {1} ({2} Iterations per
            ↳ second), counter result: {3}",
            Iterations, elapsedTime, (long)iterationsPerSecond, counter);
614     }
615 }
616
617 [Fact(Skip = "performance test")]
618 public static void TestGetTarget()
619 {
620     using (var scope = new TempLinksTestScope())
621     {
622         var links = scope.Links;
623         ConsoleHelpers.Debug("Testing GetTarget function with {0} Iterations.",
        ↳ Iterations);
624
625         ulong counter = 0;
626
627         //var firstLink = links.First();
628         var firstLink = links.Create();
629
630         var sw = Stopwatch.StartNew();
631
632         for (ulong i = 0; i < Iterations; i++)
633         {
634             counter += links.GetTarget(firstLink);
635         }
636
637         var elapsedTime = sw.Elapsed;
638
639         var iterationsPerSecond = Iterations / elapsedTime.TotalSeconds;
640
641         links.Delete(firstLink);
642
643         ConsoleHelpers.Debug(
644
645

```

```

646         "{0} Iterations of GetTarget function done in {1} ({2} Iterations per
        ↳ second), counter result: {3}",
647         Iterations, elapsedTime, (long)iterationsPerSecond, counter);
648     }
649 }
650
651 [Fact(Skip = "performance test")]
652 public static void TestGetTargetInParallel()
653 {
654     using (var scope = new TempLinksTestScope())
655     {
656         var links = scope.Links;
657         ConsoleHelpers.Debug("Testing GetTarget function with {0} Iterations in
        ↳ parallel.", Iterations);
658
659         long counter = 0;
660
661         //var firstLink = links.First();
662         var firstLink = links.Create();
663
664         var sw = Stopwatch.StartNew();
665
666         Parallel.For(0, Iterations, x =>
667         {
668             Interlocked.Add(ref counter, (long)links.GetTarget(firstLink));
669             //Interlocked.Increment(ref counter);
670         });
671
672         var elapsedTime = sw.Elapsed;
673
674         var iterationsPerSecond = Iterations / elapsedTime.TotalSeconds;
675
676         links.Delete(firstLink);
677
678         ConsoleHelpers.Debug(
679             "{0} Iterations of GetTarget function done in {1} ({2} Iterations per
            ↳ second), counter result: {3}",
            Iterations, elapsedTime, (long)iterationsPerSecond, counter);
680     }
681 }
682
683 // TODO: Заполнить базу данных перед тестом
684 /*
685 [Fact]
686 public void TestRandomSearchFixed()
687 {
688     var tempFilename = Path.GetTempFileName();
689
690     using (var links = new Platform.Links.Data.Core.Doublets.Links(tempFilename,
691     ↳ DefaultLinksSizeStep))
692     {
693         long iterations = 64 * 1024 * 1024 /
694     ↳ Platform.Links.Data.Core.Doublets.Links.LinkSizeInBytes;
695
696         ulong counter = 0;
697         var maxLink = links.Total;
698
699         ConsoleHelpers.Debug("Testing Random Search with {0} Iterations.", iterations);
700
701         var sw = Stopwatch.StartNew();
702
703         for (var i = iterations; i > 0; i--)
704         {
705             var source =
706     ↳ RandomHelpers.DefaultFactory.NextUInt64(LinksConstants.MinPossibleIndex, maxLink);
707             var target =
708     ↳ RandomHelpers.DefaultFactory.NextUInt64(LinksConstants.MinPossibleIndex, maxLink);
709
710             counter += links.Search(source, target);
711         }
712
713         var elapsedTime = sw.Elapsed;
714
715         var iterationsPerSecond = iterations / elapsedTime.TotalSeconds;
716
717         ConsoleHelpers.Debug("{0} Iterations of Random Search done in {1} ({2}
            ↳ Iterations per second), c: {3}", iterations, elapsedTime, (long)iterationsPerSecond,
            ↳ counter);
718     }
719 }
720 */

```

```

716     File.Delete(tempFilename);
717 }*/
718
719 [Fact(Skip = "useless: 0(0), was dependent on creation tests")]
720 public static void TestRandomSearchAll()
721 {
722     using (var scope = new TempLinksTestScope())
723     {
724         var links = scope.Links;
725         ulong counter = 0;
726
727         var maxLink = links.Count();
728
729         var iterations = links.Count();
730
731         ConsoleHelpers.Debug("Testing Random Search with {0} Iterations.",
732             ↪ links.Count());
733
734         var sw = Stopwatch.StartNew();
735
736         for (var i = iterations; i > 0; i--)
737         {
738             var linksAddressRange = new
739                 ↪ Range<ulong>(_constants.InternalReferencesRange.Minimum, maxLink);
740
741             var source = RandomHelpers.Default.NextUInt64(linksAddressRange);
742             var target = RandomHelpers.Default.NextUInt64(linksAddressRange);
743
744             counter += links.SearchOrDefault(source, target);
745         }
746
747         var elapsedTime = sw.Elapsed;
748
749         var iterationsPerSecond = iterations / elapsedTime.TotalSeconds;
750
751         ConsoleHelpers.Debug("{0} Iterations of Random Search done in {1} ({2}
752             ↪ Iterations per second), c: {3}",
753             iterations, elapsedTime, (long)iterationsPerSecond, counter);
754     }
755 }
756
757 [Fact(Skip = "useless: 0(0), was dependent on creation tests")]
758 public static void TestEach()
759 {
760     using (var scope = new TempLinksTestScope())
761     {
762         var links = scope.Links;
763
764         var counter = new Counter<IList<ulong>, ulong>(links.Constants.Continue);
765
766         ConsoleHelpers.Debug("Testing Each function.");
767
768         var sw = Stopwatch.StartNew();
769
770         links.Each(counter.IncrementAndReturnTrue);
771
772         var elapsedTime = sw.Elapsed;
773
774         var linksPerSecond = counter.Count / elapsedTime.TotalSeconds;
775
776         ConsoleHelpers.Debug("{0} Iterations of Each's handler function done in {1} ({2}
777             ↪ links per second)",
778             counter, elapsedTime, (long)linksPerSecond);
779     }
780 }
781
782 /*
783 [Fact]
784 public static void TestForeach()
785 {
786     var tempFilename = Path.GetTempFileName();
787
788     using (var links = new Platform.Links.Data.Core.Doublets.Links(tempFilename,
789         ↪ DefaultLinksSizeStep))
790     {
791         ulong counter = 0;
792
793         ConsoleHelpers.Debug("Testing foreach through links.");
794     }
795 }

```

```

791         var sw = Stopwatch.StartNew();
792
793         //foreach (var link in links)
794         //{
795             counter++;
796         //}
797
798         var elapsedTime = sw.Elapsed;
799
800         var linksPerSecond = (double)counter / elapsedTime.TotalSeconds;
801
802         ConsoleHelpers.Debug("{0} Iterations of Foreach's handler block done in {1} ({2}
↪ links per second)", counter, elapsedTime, (long)linksPerSecond);
803     }
804
805     File.Delete(tempFilename);
806 }
807 */
808
809 /*
810 [Fact]
811 public static void TestParallelForeach()
812 {
813     var tempFilename = Path.GetTempFileName();
814
815     using (var links = new Platform.Links.Data.Core.Doublets.Links(tempFilename,
↪ DefaultLinksSizeStep))
816     {
817         long counter = 0;
818
819         ConsoleHelpers.Debug("Testing parallel foreach through links.");
820
821         var sw = Stopwatch.StartNew();
822
823         //Parallel.ForEach((IEnumerable<ulong>)links, x =>
824         //{
825             // Interlocked.Increment(ref counter);
826         //});
827
828         var elapsedTime = sw.Elapsed;
829
830         var linksPerSecond = (double)counter / elapsedTime.TotalSeconds;
831
832         ConsoleHelpers.Debug("{0} Iterations of Parallel Foreach's handler block done in
↪ {1} ({2} links per second)", counter, elapsedTime, (long)linksPerSecond);
833     }
834
835     File.Delete(tempFilename);
836 }
837 */
838
839 [Fact(Skip = "performance test")]
840 public static void Create64BillionLinks()
841 {
842     using (var scope = new TempLinksTestScope())
843     {
844         var links = scope.Links;
845         var linksBeforeTest = links.Count();
846
847         long linksToCreate = 64 * 1024 * 1024 / UInt64UnitedMemoryLinks.LinkSizeInBytes;
848
849         ConsoleHelpers.Debug("Creating {0} links.", linksToCreate);
850
851         var elapsedTime = Performance.Measure(() =>
852         {
853             for (long i = 0; i < linksToCreate; i++)
854             {
855                 links.Create();
856             }
857         });
858
859         var linksCreated = links.Count() - linksBeforeTest;
860         var linksPerSecond = linksCreated / elapsedTime.TotalSeconds;
861
862         ConsoleHelpers.Debug("Current links count: {0}.", links.Count());
863
864         ConsoleHelpers.Debug("{0} links created in {1} ({2} links per second)",
↪ linksCreated, elapsedTime,
865             (long)linksPerSecond);

```

```

867     }
868 }
869
870 [Fact(Skip = "performance test")]
871 public static void Create64BillionLinksInParallel()
872 {
873     using (var scope = new TempLinksTestScope())
874     {
875         var links = scope.Links;
876         var linksBeforeTest = links.Count();
877
878         var sw = Stopwatch.StartNew();
879
880         long linksToCreate = 64 * 1024 * 1024 / UInt64UnitedMemoryLinks.LinkSizeInBytes;
881
882         ConsoleHelpers.Debug("Creating {0} links in parallel.", linksToCreate);
883
884         Parallel.For(0, linksToCreate, x => links.Create());
885
886         var elapsedTime = sw.Elapsed;
887
888         var linksCreated = links.Count() - linksBeforeTest;
889         var linksPerSecond = linksCreated / elapsedTime.TotalSeconds;
890
891         ConsoleHelpers.Debug("{0} links created in {1} ({2} links per second)",
892             ↪ linksCreated, elapsedTime,
893             (long)linksPerSecond);
894     }
895 }
896
897 [Fact(Skip = "useless: 0(0), was dependent on creation tests")]
898 public static void TestDeletionOfAllLinks()
899 {
900     using (var scope = new TempLinksTestScope())
901     {
902         var links = scope.Links;
903         var linksBeforeTest = links.Count();
904
905         ConsoleHelpers.Debug("Deleting all links");
906
907         var elapsedTime = Performance.Measure(links.DeleteAll);
908
909         var linksDeleted = linksBeforeTest - links.Count();
910         var linksPerSecond = linksDeleted / elapsedTime.TotalSeconds;
911
912         ConsoleHelpers.Debug("{0} links deleted in {1} ({2} links per second)",
913             ↪ linksDeleted, elapsedTime,
914             (long)linksPerSecond);
915     }
916 }
917
918 #endregion
919 }
920 }

```

## 1.71 ./csharp/Platform.Data.Doublets.Sequences.Tests/UInt64LinksExtensionsTests.cs

```

1  using Platform.Data.Doublets.Memory;
2  using Platform.Data.Doublets.Memory.United.Generic;
3  using Platform.Data.Numbers.Raw;
4  using Platform.Memory;
5  using Platform.Numbers;
6  using Xunit;
7  using Xunit.Abstractions;
8  using TLinkAddress = System.UInt64;
9
10 namespace Platform.Data.Doublets.Sequences.Tests
11 {
12     public class UInt64LinksExtensionsTests
13     {
14         public static ILinks<TLinkAddress> CreateLinks() => CreateLinks<TLinkAddress>(new
15             ↪ Platform.IO.TemporaryFile());
16
17         public static ILinks<TLinkAddress> CreateLinks<TLinkAddress>(string dataDBFilename)
18         {
19             var linksConstants = new
20                 ↪ LinksConstants<TLinkAddress>(enableExternalReferencesSupport: true);
21             return new UnitedMemoryLinks<TLinkAddress>(new
22                 ↪ FileMappedResizableDirectMemory(dataDBFilename),
23                 ↪ UnitedMemoryLinks<TLinkAddress>.DefaultLinksSizeStep, linksConstants,
24                 ↪ IndexTreeType.Default);
25         }
26     }
27 }

```

```

20     }
21     [Fact]
22     public void FormatStructureWithExternalReferenceTest()
23     {
24         ILinks<TLinkAddress> links = CreateLinks();
25         TLinkAddress zero = default;
26         var one = Arithmetic.Increment(zero);
27         var markerIndex = one;
28         var meaningRoot = links.GetOrCreate(markerIndex, markerIndex);
29         var numberMarker = links.GetOrCreate(meaningRoot, Arithmetic.Increment(ref
            ↪ markerIndex));
30         AddressToRawNumberConverter<TLinkAddress> addressToNumberConverter = new();
31         var numberAddress = addressToNumberConverter.Convert(1);
32         var numberLink = links.GetOrCreate(numberMarker, numberAddress);
33         var linkNotation = links.FormatStructure(numberLink, link => link.IsFullPoint(),
            ↪ true);
34         Assert.Equal("(3:(2:1 2) 18446744073709551615)", linkNotation);
35     }
36 }
37 }

```

## 1.72 ./csharp/Platform.Data.Doublets.Sequences.Tests/UnaryNumberConvertersTests.cs

```

1  using Xunit;
2  using Platform.Random;
3  using Platform.Data.Doublets.Numbers.Unary;
4
5  namespace Platform.Data.Doublets.Sequences.Tests
6  {
7      public static class UnaryNumberConvertersTests
8      {
9          [Fact]
10         public static void ConvertersTest()
11         {
12             using (var scope = new TempLinksTestScope())
13             {
14                 const int N = 10;
15                 var links = scope.Links;
16                 var meaningRoot = links.CreatePoint();
17                 var one = links.CreateAndUpdate(meaningRoot, links.Constants.Itself);
18                 var powerOf2ToUnaryNumberConverter = new
19                     ↪ PowerOf2ToUnaryNumberConverter<ulong>(links, one);
20                 var toUnaryNumberConverter = new AddressToUnaryNumberConverter<ulong>(links,
21                     ↪ powerOf2ToUnaryNumberConverter);
22                 var random = new System.Random(0);
23                 ulong[] numbers = new ulong[N];
24                 ulong[] unaryNumbers = new ulong[N];
25                 for (int i = 0; i < N; i++)
26                 {
27                     numbers[i] = random.NextUInt64();
28                     unaryNumbers[i] = toUnaryNumberConverter.Convert(numbers[i]);
29                 }
30                 var fromUnaryNumberConverterUsingOrOperation = new
31                     ↪ UnaryNumberToAddressOrOperationConverter<ulong>(links,
32                     ↪ powerOf2ToUnaryNumberConverter);
33                 var fromUnaryNumberConverterUsingAddOperation = new
34                     ↪ UnaryNumberToAddressAddOperationConverter<ulong>(links, one);
35                 for (int i = 0; i < N; i++)
36                 {
37                     Assert.Equal(numbers[i],
38                         ↪ fromUnaryNumberConverterUsingOrOperation.Convert(unaryNumbers[i]));
39                     Assert.Equal(numbers[i],
40                         ↪ fromUnaryNumberConverterUsingAddOperation.Convert(unaryNumbers[i]));
41                 }
42             }
43         }
44     }
45 }

```

## 1.73 ./csharp/Platform.Data.Doublets.Sequences.Tests/UnicodeConvertersTests.cs

```

1  using Xunit;
2  using Platform.Converters;
3  using Platform.Memory;
4  using Platform.Reflection;
5  using Platform.Scopes;
6  using Platform.Data.Numbers.Raw;
7  using Platform.Data.Doublets.Incrementers;
8  using Platform.Data.Doublets.Numbers.Unary;
9  using Platform.Data.Doublets.PropertyOperators;

```



```

10 using Platform.Data.Doublets.Sequences.Converters;
11 using Platform.Data.Doublets.Sequences.Indexes;
12 using Platform.Data.Doublets.Sequences.Walkers;
13 using Platform.Data.Doublets.Unicode;
14 using Platform.Data.Doublets.Memory.United.Generic;
15 using Platform.Data.Doublets.CriterionMatchers;
16
17 namespace Platform.Data.Doublets.Sequences.Tests
18 {
19     public static class UnicodeConvertersTests
20     {
21         [Fact]
22         public static void CharAndUnaryNumberUnicodeSymbolConvertersTest()
23         {
24             using (var scope = new TempLinksTestScope())
25             {
26                 var links = scope.Links;
27                 var meaningRoot = links.CreatePoint();
28                 var one = links.CreateAndUpdate(meaningRoot, links.Constants.Itself);
29                 var powerOf2ToUnaryNumberConverter = new
30                     ↪ PowerOf2ToUnaryNumberConverter<ulong>(links, one);
31                 var addressToUnaryNumberConverter = new
32                     ↪ AddressToUnaryNumberConverter<ulong>(links, powerOf2ToUnaryNumberConverter);
33                 var unaryNumberToAddressConverter = new
34                     ↪ UnaryNumberToAddressOrOperationConverter<ulong>(links,
35                     ↪ powerOf2ToUnaryNumberConverter);
36                 TestCharAndUnicodeSymbolConverters(links, meaningRoot,
37                     ↪ addressToUnaryNumberConverter, unaryNumberToAddressConverter);
38             }
39         }
40
41         [Fact]
42         public static void CharAndRawNumberUnicodeSymbolConvertersTest()
43         {
44             using (var scope = new Scope<Types<HeapResizableDirectMemory,
45                 ↪ UnitedMemoryLinks<ulong>>>())
46             {
47                 var links = scope.Use<ILinks<ulong>>>();
48                 var meaningRoot = links.CreatePoint();
49                 var addressToRawNumberConverter = new AddressToRawNumberConverter<ulong>();
50                 var rawNumberToAddressConverter = new RawNumberToAddressConverter<ulong>();
51                 TestCharAndUnicodeSymbolConverters(links, meaningRoot,
52                     ↪ addressToRawNumberConverter, rawNumberToAddressConverter);
53             }
54         }
55
56         private static void TestCharAndUnicodeSymbolConverters(ILinks<ulong> links, ulong
57             ↪ meaningRoot, IConverter<ulong> addressToNumberConverter, IConverter<ulong>
58             ↪ numberToAddressConverter)
59         {
60             var unicodeSymbolMarker = links.CreateAndUpdate(meaningRoot, links.Constants.Itself);
61             var charToUnicodeSymbolConverter = new CharToUnicodeSymbolConverter<ulong>(links,
62                 ↪ addressToNumberConverter, unicodeSymbolMarker);
63             var originalCharacter = 'H';
64             var characterLink = charToUnicodeSymbolConverter.Convert(originalCharacter);
65             var unicodeSymbolCriterionMatcher = new TargetMatcher<ulong>(links,
66                 ↪ unicodeSymbolMarker);
67             var unicodeSymbolToCharConverter = new UnicodeSymbolToCharConverter<ulong>(links,
68                 ↪ numberToAddressConverter, unicodeSymbolCriterionMatcher);
69             var resultingCharacter = unicodeSymbolToCharConverter.Convert(characterLink);
70             Assert.Equal(originalCharacter, resultingCharacter);
71         }
72
73         [Fact]
74         public static void StringAndUnicodeSequenceConvertersTest()
75         {
76             using (var scope = new TempLinksTestScope())
77             {
78                 var links = scope.Links;
79                 var itself = links.Constants.Itself;
80
81                 var meaningRoot = links.CreatePoint();
82                 var unaryOne = links.CreateAndUpdate(meaningRoot, itself);
83                 var unicodeSymbolMarker = links.CreateAndUpdate(meaningRoot, itself);
84                 var unicodeSequenceMarker = links.CreateAndUpdate(meaningRoot, itself);
85                 var frequencyMarker = links.CreateAndUpdate(meaningRoot, itself);
86                 var frequencyPropertyMarker = links.CreateAndUpdate(meaningRoot, itself);
87             }
88         }
89     }
90 }

```

```

76     var powerOf2ToUnaryNumberConverter = new
77         ↪ PowerOf2ToUnaryNumberConverter<ulong>(links, unaryOne);
78     var addressToUnaryNumberConverter = new
79         ↪ AddressToUnaryNumberConverter<ulong>(links, powerOf2ToUnaryNumberConverter);
80     var charToUnicodeSymbolConverter = new
81         ↪ CharToUnicodeSymbolConverter<ulong>(links, addressToUnaryNumberConverter,
82         ↪ unicodeSymbolMarker);
83
84     var unaryNumberToAddressConverter = new
85         ↪ UnaryNumberToAddressOrOperationConverter<ulong>(links,
86         ↪ powerOf2ToUnaryNumberConverter);
87     var unaryNumberIncrementer = new UnaryNumberIncrementer<ulong>(links, unaryOne);
88     var frequencyIncrementer = new FrequencyIncrementer<ulong>(links,
89         ↪ frequencyMarker, unaryOne, unaryNumberIncrementer);
90     var frequencyPropertyOperator = new PropertyOperator<ulong>(links,
91         ↪ frequencyPropertyMarker, frequencyMarker);
92     var index = new FrequencyIncrementingSequenceIndex<ulong>(links,
93         ↪ frequencyPropertyOperator, frequencyIncrementer);
94     var linkToItsFrequencyNumberConverter = new
95         ↪ LinkToItsFrequencyNumberConverter<ulong>(links, frequencyPropertyOperator,
96         ↪ unaryNumberToAddressConverter);
97     var sequenceToItsLocalElementLevelsConverter = new
98         ↪ SequenceToItsLocalElementLevelsConverter<ulong>(links,
99         ↪ linkToItsFrequencyNumberConverter);
100    var optimalVariantConverter = new OptimalVariantConverter<ulong>(links,
101        ↪ sequenceToItsLocalElementLevelsConverter);
102
103    var stringToUnicodeSequenceConverter = new
104        ↪ StringToUnicodeSequenceConverter<ulong>(links, charToUnicodeSymbolConverter,
105        ↪ index, optimalVariantConverter, unicodeSequenceMarker);
106
107    var originalString = "Hello";
108
109    var unicodeSequenceLink =
110        ↪ stringToUnicodeSequenceConverter.Convert(originalString);
111
112    var unicodeSymbolCriterionMatcher = new TargetMatcher<ulong>(links,
113        ↪ unicodeSymbolMarker);
114    var unicodeSymbolToCharConverter = new
115        ↪ UnicodeSymbolToCharConverter<ulong>(links, unaryNumberToAddressConverter,
116        ↪ unicodeSymbolCriterionMatcher);
117
118    var unicodeSequenceCriterionMatcher = new TargetMatcher<ulong>(links,
119        ↪ unicodeSequenceMarker);
120
121    var sequenceWalker = new LeveledSequenceWalker<ulong>(links,
122        ↪ unicodeSymbolCriterionMatcher.IsMatched);
123
124    var unicodeSequenceToStringConverter = new
125        ↪ UnicodeSequenceToStringConverter<ulong>(links,
126        ↪ unicodeSequenceCriterionMatcher, sequenceWalker,
127        ↪ unicodeSymbolToCharConverter);
128
129    var resultingString =
130        ↪ unicodeSequenceToStringConverter.Convert(unicodeSequenceLink);
131
132    Assert.Equal(originalString, resultingString);
133
134    }
135
136    }
137
138    }

```

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