

# 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="LinksListToSequenceConverterBase{TLink}" />
15     public class BalancedVariantConverter<TLink> : LinksListToSequenceConverterBase<TLink>
16     {
17         /// <summary>
18         /// <para>
19         /// Initializes a new <see cref="BalancedVariantConverter" /> instance.
20         /// </para>
21         /// <para></para>
22         /// </summary>
23         /// <param name="links">
24         /// <para>A links.</para>
25         /// <para></para>
26         /// </param>
27         [MethodImpl(MethodImplOptions.AggressiveInlining)]
28         public BalancedVariantConverter(ILinks<TLink> 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         /// <para></para>
39         /// </param>
40         /// <returns>
41         /// <para>The link</para>
42         /// <para></para>
43         /// </returns>
44         [MethodImpl(MethodImplOptions.AggressiveInlining)]
45         public override TLink Convert(ICollection<TLink> sequence)
46         {
47             var length = sequence.Count;
48             if (length < 1)
49             {
50                 return default;
51             }
52             if (length == 1)
53             {
54                 return sequence[0];
55             }
56             // Make copy of next layer
57             if (length > 2)
58             {
59                 // TODO: Try to use stackalloc (which at the moment is not working with
60                 // ↪ generics) but will be possible with Sigil
61                 var halvedSequence = new TLink[(length / 2) + (length % 2)];
62                 HalveSequence(halvedSequence, sequence, length);
63                 sequence = halvedSequence;
64                 length = halvedSequence.Length;
65             }
66             // Keep creating layer after layer
67             while (length > 2)
68             {
69                 HalveSequence(sequence, sequence, length);
70                 length = (length / 2) + (length % 2);
71             }
72             return _links.GetOrCreate(sequence[0], sequence[1]);
73         }
74         [MethodImpl(MethodImplOptions.AggressiveInlining)]
75         private void HalveSequence(ICollection<TLink> destination, ICollection<TLink> source, int length)
```

```

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
16     ///     Links на этапе сжатия.
17     ///     А именно будет создаваться временный список пар необходимых для выполнения сжатия, в
18     ///     таком случае тип значения элемента массива может быть любым, как char так и ulong.
19     ///     Как только список/словарь пар был выявлен можно разом выполнить создание всех этих
20     ///     пар, а так же разом выполнить замену.
21     /// </remarks>
22     public class CompressingConverter<TLink> : LinksListToSequenceConverterBase<TLink>
23     {
24         private static readonly LinksConstants<TLink> _constants =
25             Default<LinksConstants<TLink>>.Instance;
26         private static readonly EqualityComparer<TLink> _equalityComparer =
27             EqualityComparer<TLink>.Default;
28         private static readonly Comparer<TLink> _comparer = Comparer<TLink>.Default;
29         private static readonly TLink _zero = default;
30         private static readonly TLink _one = Arithmetic.Increment(_zero);
31         private readonly IConverter<IList<TLink>, TLink> _baseConverter;
32         private readonly LinkFrequenciesCache<TLink> _doubletFrequenciesCache;
33         private readonly TLink _minFrequencyToCompress;
34         private readonly bool _doInitialFrequenciesIncrement;
35         private Doublet<TLink> _maxDoublet;
36         private LinkFrequency<TLink> _maxDoubletData;
37         private struct HalfDoublet
38         {
39             /// <summary>
40             /// <para>
41             /// The element.
42             /// </para>
43             /// <para></para>
44             /// </summary>
45             public TLink Element;
46             /// <summary>
47             /// <para>
48             /// The doublet data.
49             /// </para>
50             /// <para></para>
51             /// </summary>
52             public LinkFrequency<TLink> DoubletData;
53
54             /// <summary>
55             /// <para>
56             /// Initializes a new <see cref="HalfDoublet"/> instance.
57             /// </para>
58             /// <para></para>
59             /// </summary>
60             /// <param name="element">
61             /// <para>A element.</para>
62             /// <para></para>
63             /// </param>
64             /// <param name="doubletData">
65             /// <para>A doublet data.</para>
66             /// <para></para>
67             /// </param>

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62     /// </param>
63     [MethodImpl(MethodImplOptions.AggressiveInlining)]
64     public HalfDoublet(TLink element, LinkFrequency<TLink> 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<TLink> links, IConverter<IList<TLink>, TLink>
103        ↪ baseConverter, LinkFrequenciesCache<TLink> doubletFrequenciesCache)
104        : this(links, baseConverter, doubletFrequenciesCache, _one, true) { }
105
106    /// <summary>
107    /// <para>
108    /// Initializes a new <see cref="CompressingConverter"/> instance.
109    /// </para>
110    /// <para></para>
111    /// </summary>
112    /// <param name="links">
113    /// <para>A links.</para>
114    /// <para></para>
115    /// </param>
116    /// <param name="baseConverter">
117    /// <para>A base converter.</para>
118    /// <para></para>
119    /// </param>
120    /// <param name="doubletFrequenciesCache">
121    /// <para>A doublet frequencies cache.</para>
122    /// <para></para>
123    /// </param>
124    /// <param name="doInitialFrequenciesIncrement">
125    /// <para>A do initial frequencies increment.</para>
126    /// <para></para>
127    /// </param>
128    [MethodImpl(MethodImplOptions.AggressiveInlining)]
129    public CompressingConverter(ILinks<TLink> links, IConverter<IList<TLink>, TLink>
130        ↪ baseConverter, LinkFrequenciesCache<TLink> doubletFrequenciesCache, bool
131        ↪ doInitialFrequenciesIncrement)
132        : this(links, baseConverter, doubletFrequenciesCache, _one,
133            ↪ doInitialFrequenciesIncrement) { }
134
135    /// <summary>
136    /// <para>
137    /// Initializes a new <see cref="CompressingConverter"/> instance.
138    /// </para>
139    /// <para></para>

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```

136     /// </summary>
137     /// <param name="links">
138     /// <para>A links.</para>
139     /// <para></para>
140     /// </param>
141     /// <param name="baseConverter">
142     /// <para>A base converter.</para>
143     /// <para></para>
144     /// </param>
145     /// <param name="doubletFrequenciesCache">
146     /// <para>A doublet frequencies cache.</para>
147     /// <para></para>
148     /// </param>
149     /// <param name="minFrequencyToCompress">
150     /// <para>A min frequency to compress.</para>
151     /// <para></para>
152     /// </param>
153     /// <param name="doInitialFrequenciesIncrement">
154     /// <para>A do initial frequencies increment.</para>
155     /// <para></para>
156     /// </param>
157     [MethodImpl(MethodImplOptions.AggressiveInlining)]
158     public CompressingConverter(ILinks<TLink> links, IConverter<IList<TLink>, TLink>
        ↪ baseConverter, LinkFrequenciesCache<TLink> doubletFrequenciesCache, TLink
        ↪ minFrequencyToCompress, bool doInitialFrequenciesIncrement)
        : base(links)
159     {
160         _baseConverter = baseConverter;
161         _doubletFrequenciesCache = doubletFrequenciesCache;
162         if (_comparer.Compare(minFrequencyToCompress, _one) < 0)
163         {
164             minFrequencyToCompress = _one;
165         }
166         _minFrequencyToCompress = minFrequencyToCompress;
167         _doInitialFrequenciesIncrement = doInitialFrequenciesIncrement;
168         ResetMaxDoublet();
169     }
170 }
171
172     /// <summary>
173     /// <para>
174     /// Converts the source.
175     /// </para>
176     /// <para></para>
177     /// </summary>
178     /// <param name="source">
179     /// <para>The source.</para>
180     /// <para></para>
181     /// </param>
182     /// <returns>
183     /// <para>The link</para>
184     /// <para></para>
185     /// </returns>
186     [MethodImpl(MethodImplOptions.AggressiveInlining)]
187     public override TLink Convert(IList<TLink> source) =>
        ↪ _baseConverter.Convert(Compress(source));
188     [MethodImpl(MethodImplOptions.AggressiveInlining)]
189     private IList<TLink> Compress(IList<TLink> sequence)
190     {
191         if (sequence.IsNullOrEmpty())
192         {
193             return null;
194         }
195         if (sequence.Count == 1)
196         {
197             return sequence;
198         }
199         if (sequence.Count == 2)
200         {
201             return new[] { _links.GetOrCreate(sequence[0], sequence[1]) };
202         }
203         // TODO: arraypool with min size (to improve cache locality) or stackallow with Sigil
204         var copy = new HalfDoublet[sequence.Count];
205         Doublet<TLink> doublet = default;
206         for (var i = 1; i < sequence.Count; i++)
207         {
208             doublet = new Doublet<TLink>(sequence[i - 1], sequence[i]);
209             LinkFrequency<TLink> 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<TLink>();
230 if (_comparer.Compare(_maxDoubletData.Frequency, default) > 0)
231 {
232     var newLength = ReplaceDoublets(copy);
233     sequence = new TLink[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(maxDoubletReplacementLink,
278                         ↪ next);
279                 }
280                 copy[w++].Element = maxDoubletReplacementLink;
281                 r++;
282                 newLength--;
283             }
284             else
285             {
286                 copy[w++] = copy[r];
287             }
288         }
289     }
290 }

```

```

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<TLink>();
296     _maxDoubletData = new LinkFrequency<TLink>();
297 }
298 [MethodImpl(MethodImplOptions.AggressiveInlining)]
299 private void UpdateMaxDoublet(HalfDoublet[] copy, int length)
300 {
301     Doublet<TLink> doublet = default;
302     for (var i = 1; i < length; i++)
303     {
304         doublet = new Doublet<TLink>(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<TLink> doublet, LinkFrequency<TLink> data)
310 {
311     var frequency = data.Frequency;
312     var maxFrequency = _maxDoubletData.Frequency;
313     //if (frequency > _minFrequencyToCompress && (maxFrequency < frequency ||
314     ↪ (maxFrequency == frequency && doublet.Source + doublet.Target < /* gives better
315     ↪ compression string data (and gives collisions quickly) */ _maxDoublet.Source +
316     ↪ _maxDoublet.Target)))
317     if (_comparer.Compare(frequency, _minFrequencyToCompress) > 0 &&
318     ↪ (_comparer.Compare(maxFrequency, frequency) < 0 ||
319     ↪ (_equalityComparer.Equals(maxFrequency, frequency) &&
320     ↪ _comparer.Compare(Arithmetic.Add(doublet.Source, doublet.Target),
321     ↪ Arithmetic.Add(_maxDoublet.Source, _maxDoublet.Target)) > 0))) /* gives
322     ↪ better stability and better compression on sequent data and even on random
323     ↪ numbers data (but gives collisions anyway) */
324     {
325         _maxDoublet = doublet;
326         _maxDoubletData = data;
327     }
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{TLink}"/>
16     /// <seealso cref="IConverter{IList{TLink}, TLink}"/>
17     public abstract class LinksListToSequenceConverterBase<TLink> : LinksOperatorBase<TLink>,
18     ↪ IConverter<IList<TLink>, TLink>
19     {
20         /// <summary>
21         /// <para>
22         /// Initializes a new <see cref="LinksListToSequenceConverterBase"/> instance.
23         /// </para>
24         /// <para></para>
25         /// </summary>
26         /// <param name="links">

```

```

26     /// <para>A links.</para>
27     /// <para></para>
28     /// </param>
29     [MethodImpl(MethodImplOptions.AggressiveInlining)]
30     protected LinksListToSequenceConverterBase(ILinks<TLink> 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 TLink Convert(ICollection<TLink> 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{TLink}" />
19     public class OptimalVariantConverter<TLink> : LinksListToSequenceConverterBase<TLink>
20     {
21         private static readonly EqualityComparer<TLink> _equalityComparer =
22             ↳ EqualityComparer<TLink>.Default;
23         private static readonly Comparer<TLink> _comparer = Comparer<TLink>.Default;
24         private readonly IConverter<ICollection<TLink>> _sequenceToItsLocalElementLevelsConverter;
25
26         /// <summary>
27         /// <para>
28         /// Initializes a new <see cref="OptimalVariantConverter" /> 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="sequenceToItsLocalElementLevelsConverter">
37         /// <para>A sequence to its local element levels converter.</para>
38         /// <para></para>
39         /// </param>
40         [MethodImpl(MethodImplOptions.AggressiveInlining)]
41         public OptimalVariantConverter(ILinks<TLink> links, IConverter<ICollection<TLink>>
42             ↳ sequenceToItsLocalElementLevelsConverter) : base(links)
43         {
44             => _sequenceToItsLocalElementLevelsConverter =
45                 ↳ sequenceToItsLocalElementLevelsConverter;
46
47         /// <summary>
48         /// <para>
49         /// Initializes a new <see cref="OptimalVariantConverter" /> instance.
50         /// </para>
51         /// <para></para>
52         /// </summary>
53         /// <param name="links">
54         /// <para>A links.</para>

```

```

51     /// <para></para>
52     /// </param>
53     /// <param name="linkFrequenciesCache">
54     /// <para>A link frequencies cache.</para>
55     /// <para></para>
56     /// </param>
57     [MethodImpl(MethodImplOptions.AggressiveInlining)]
58     public OptimalVariantConverter(ILinks<TLink> links, LinkFrequenciesCache<TLink>
59         ↪ linkFrequenciesCache)
60         : this(links, new SequenceToItsLocalElementLevelsConverter<TLink>(links, new Frequen
61             ↪ ciesCacheBasedLinkToItsFrequencyNumberConverter<TLink>(linkFrequenciesCache))) {
62             ↪ }
63
64     /// <summary>
65     /// <para>
66     /// Initializes a new <see cref="OptimalVariantConverter"/> instance.
67     /// </para>
68     /// <para></para>
69     /// </summary>
70     /// <param name="links">
71     /// <para>A links.</para>
72     /// <para></para>
73     /// </param>
74     [MethodImpl(MethodImplOptions.AggressiveInlining)]
75     public OptimalVariantConverter(ILinks<TLink> links)
76         : this(links, new LinkFrequenciesCache<TLink>(links, new
77             ↪ TotalSequenceSymbolFrequencyCounter<TLink>(links))) { }
78
79     /// <summary>
80     /// <para>
81     /// Converts the sequence.
82     /// </para>
83     /// <para></para>
84     /// </summary>
85     /// <param name="sequence">
86     /// <para>The sequence.</para>
87     /// <para></para>
88     /// </param>
89     /// <returns>
90     /// <para>The link</para>
91     /// <para></para>
92     /// </returns>
93     [MethodImpl(MethodImplOptions.AggressiveInlining)]
94     public override TLink Convert(ICollection<TLink> sequence)
95     {
96         var length = sequence.Count;
97         if (length == 1)
98         {
99             return sequence[0];
100         }
101         if (length == 2)
102         {
103             return _links.GetOrCreate(sequence[0], sequence[1]);
104         }
105         sequence = sequence.ToArray();
106         var levels = _sequenceToItsLocalElementLevelsConverter.Convert(sequence);
107         while (length > 2)
108         {
109             var levelRepeat = 1;
110             var currentLevel = levels[0];
111             var previousLevel = levels[0];
112             var skipOnce = false;
113             var w = 0;
114             for (var i = 1; i < length; i++)
115             {
116                 if (_equalityComparer.Equals(currentLevel, levels[i]))
117                 {
118                     levelRepeat++;
119                     skipOnce = false;
120                     if (levelRepeat == 2)
121                     {
122                         sequence[w] = _links.GetOrCreate(sequence[i - 1], sequence[i]);
123                         var newLevel = i >= length - 1 ?
124                             GetPreviousLowerThanCurrentOrCurrent(previousLevel,
125                                 ↪ currentLevel) :
126                             i < 2 ?
127                                 GetNextLowerThanCurrentOrCurrent(currentLevel, levels[i + 1]) :

```



```

123         GetGreatestNeighbourLowerThanCurrentOrCurrent(previousLevel,
124             ↪ currentLevel, levels[i + 1]);
125         levels[w] = newLevel;
126         previousLevel = currentLevel;
127         w++;
128         levelRepeat = 0;
129         skipOnce = true;
130     }
131     else if (i == length - 1)
132     {
133         sequence[w] = sequence[i];
134         levels[w] = levels[i];
135         w++;
136     }
137     else
138     {
139         currentLevel = levels[i];
140         levelRepeat = 1;
141         if (skipOnce)
142         {
143             skipOnce = false;
144         }
145         else
146         {
147             sequence[w] = sequence[i - 1];
148             levels[w] = levels[i - 1];
149             previousLevel = levels[w];
150             w++;
151         }
152         if (i == length - 1)
153         {
154             sequence[w] = sequence[i];
155             levels[w] = levels[i];
156             w++;
157         }
158     }
159     }
160     length = w;
161 }
162 return _links.GetOrCreate(sequence[0], sequence[1]);
163 }
164 [MethodImpl(MethodImplOptions.AggressiveInlining)]
165 private static TLink GetGreatestNeighbourLowerThanCurrentOrCurrent(TLink previous, TLink
166     ↪ current, TLink next)
167 {
168     return _comparer.Compare(previous, next) > 0
169         ? _comparer.Compare(previous, current) < 0 ? previous : current
170         : _comparer.Compare(next, current) < 0 ? next : current;
171 }
172 [MethodImpl(MethodImplOptions.AggressiveInlining)]
173 private static TLink GetNextLowerThanCurrentOrCurrent(TLink current, TLink next) =>
174     ↪ _comparer.Compare(next, current) < 0 ? next : current;
175 [MethodImpl(MethodImplOptions.AggressiveInlining)]
176 private static TLink GetPreviousLowerThanCurrentOrCurrent(TLink previous, TLink current)
177     ↪ => _comparer.Compare(previous, current) < 0 ? previous : current;
178 }
179 }

```

## 1.5 ./csharp/Platform.Data.Doublets.Sequences/Converters/SequenceToItsLocalElementLevelsConverter.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{TLink}" />
16     /// <seealso cref="IConverter{IList{TLink}}" />
17     public class SequenceToItsLocalElementLevelsConverter<TLink> : LinksOperatorBase<TLink>,
18         ↪ IConverter<IList<TLink>>
19     {

```

```

19 private static readonly Comparer<TLink> _comparer = Comparer<TLink>.Default;
20 private readonly IConverter<Doublet<TLink>, TLink> _linkToItsFrequencyToNumberConveter;
21
22 /// <summary>
23 /// <para>
24 /// Initializes a new <see cref="SequenceToItsLocalElementLevelsConverter"/> 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="linkToItsFrequencyToNumberConveter">
33 /// <para>A link to its frequency to number conveter.</para>
34 /// <para></para>
35 /// </param>
36 [MethodImpl(MethodImplOptions.AggressiveInlining)]
37 public SequenceToItsLocalElementLevelsConverter(ILinks<TLink> links,
    ↪ IConverter<Doublet<TLink>, TLink> linkToItsFrequencyToNumberConveter) : base(links)
    ↪ => _linkToItsFrequencyToNumberConveter = linkToItsFrequencyToNumberConveter;
38
39 /// <summary>
40 /// <para>
41 /// Converts the sequence.
42 /// </para>
43 /// <para></para>
44 /// </summary>
45 /// <param name="sequence">
46 /// <para>The sequence.</para>
47 /// <para></para>
48 /// </param>
49 /// <returns>
50 /// <para>The levels.</para>
51 /// <para></para>
52 /// </returns>
53 [MethodImpl(MethodImplOptions.AggressiveInlining)]
54 public IList<TLink> Convert(IList<TLink> sequence)
55 {
56     var levels = new TLink[sequence.Count];
57     levels[0] = GetFrequencyNumber(sequence[0], sequence[1]);
58     for (var i = 1; i < sequence.Count - 1; i++)
59     {
60         var previous = GetFrequencyNumber(sequence[i - 1], sequence[i]);
61         var next = GetFrequencyNumber(sequence[i], sequence[i + 1]);
62         levels[i] = _comparer.Compare(previous, next) > 0 ? previous : next;
63     }
64     levels[levels.Length - 1] = GetFrequencyNumber(sequence[sequence.Count - 2],
    ↪ sequence[sequence.Count - 1]);
65     return levels;
66 }
67
68 /// <summary>
69 /// <para>
70 /// Gets the frequency number using the specified source.
71 /// </para>
72 /// <para></para>
73 /// </summary>
74 /// <param name="source">
75 /// <para>The source.</para>
76 /// <para></para>
77 /// </param>
78 /// <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 TLink GetFrequencyNumber(TLink source, TLink target) =>
    ↪ _linkToItsFrequencyToNumberConveter.Convert(new Doublet<TLink>(source, 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{TLink}" />
15    /// <seealso cref="ICriterionMatcher{TLink}" />
16    public class DefaultSequenceElementCriterionMatcher<TLink> : LinksOperatorBase<TLink>,
17    ↪ ICriterionMatcher<TLink>
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<TLink> links) : base(links) { }
31
32        /// <summary>
33        /// <para>
34        /// Determines whether this instance is matched.
35        /// </para>
36        /// <para></para>
37        /// </summary>
38        /// <param name="argument">
39        /// <para>The argument.</para>
40        /// <para></para>
41        /// </param>
42        /// <returns>
43        /// <para>The bool</para>
44        /// <para></para>
45        /// </returns>
46        [MethodImpl(MethodImplOptions.AggressiveInlining)]
47        public bool IsMatched(TLink argument) => _links.IsPartialPoint(argument);
48    }
49 }
```

## 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{TLink}" />
16    public class MarkedSequenceCriterionMatcher<TLink> : ICriterionMatcher<TLink>
17    {
18        private static readonly EqualityComparer<TLink> _equalityComparer =
19        ↪ EqualityComparer<TLink>.Default;
20        private readonly ILinks<TLink> _links;
21        private readonly TLink _sequenceMarkerLink;
22
23        /// <summary>
24        /// <para>
25        /// Initializes a new <see cref="MarkedSequenceCriterionMatcher" /> instance.
26        /// </para>
27        /// <para></para>
28    }
```

```

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<TLink> links, TLink sequenceMarkerLink)
38     {
39         _links = links;
40         _sequenceMarkerLink = sequenceMarkerLink;
41     }
42
43     /// <summary>
44     /// <para>
45     /// Determines whether this instance is matched.
46     /// </para>
47     /// <para></para>
48     /// </summary>
49     /// <param name="sequenceCandidate">
50     /// <para>The sequence candidate.</para>
51     /// <para></para>
52     /// </param>
53     /// <returns>
54     /// <para>The bool</para>
55     /// <para></para>
56     /// </returns>
57     [MethodImpl(MethodImplOptions.AggressiveInlining)]
58     public bool IsMatched(TLink sequenceCandidate)
59     => _equalityComparer.Equals(_links.GetSource(sequenceCandidate), _sequenceMarkerLink)
60     || !_equalityComparer.Equals(_links.SearchOrDefault(_sequenceMarkerLink,
61         ↪ sequenceCandidate), _links.Constants.Null);
62 }

```

## 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{TLink}">
18     /// <seealso cref="ISequenceAppender{TLink}">
19     public class DefaultSequenceAppender<TLink> : LinksOperatorBase<TLink>,
20         ↪ ISequenceAppender<TLink>
21     {
22         private static readonly EqualityComparer<TLink> _equalityComparer =
23         ↪ EqualityComparer<TLink>.Default;
24         private readonly IStack<TLink> _stack;
25         private readonly ISequenceHeightProvider<TLink> _heightProvider;
26
27         /// <summary>
28         /// <para>
29         /// Initializes a new <see cref="DefaultSequenceAppender" /> 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="stack">
38         /// <para>A stack.</para>
39         /// <para></para>
40         /// </param>

```

```

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

```

## 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>

```



```

37     private readonly IListEqualityComparer<TLink> _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 =
46         ↪ Default<IListEqualityComparer<TLink>>.Instance;
47
48     /// <summary>
49     /// <para>
50     /// Determines whether this instance equals.
51     /// </para>
52     /// <para></para>
53     /// </summary>
54     /// <param name="left">
55     /// <para>The left.</para>
56     /// <para></para>
57     /// </param>
58     /// <param name="right">
59     /// <para>The right.</para>
60     /// <para></para>
61     /// </param>
62     /// <returns>
63     /// <para>The bool</para>
64     /// <para></para>
65     /// </returns>
66     [MethodImpl(MethodImplOptions.AggressiveInlining)]
67     public bool Equals(KeyValuePair<IList<TLink>, IList<TLink>> left,
68         ↪ KeyValuePair<IList<TLink>, IList<TLink>> right) =>
69         ↪ _listComparer.Equals(left.Key, right.Key) && _listComparer.Equals(left.Value,
70         ↪ right.Value);
71
72     /// <summary>
73     /// <para>
74     /// Gets the hash code using the specified pair.
75     /// </para>
76     /// <para></para>
77     /// </summary>
78     /// <param name="pair">
79     /// <para>The pair.</para>
80     /// <para></para>
81     /// </param>
82     /// <returns>
83     /// <para>The int</para>
84     /// <para></para>
85     /// </returns>
86     [MethodImpl(MethodImplOptions.AggressiveInlining)]
87     public int GetHashCode(KeyValuePair<IList<TLink>, IList<TLink>> pair) =>
88         ↪ (_listComparer.GetHashCode(pair.Key),
89         ↪ _listComparer.GetHashCode(pair.Value)).GetHashCode();
89 }
90 private class ItemComparer : IComparer<KeyValuePair<IList<TLink>, IList<TLink>>>
91 {
92     private readonly IListComparer<TLink> _listComparer;
93
94     /// <summary>
95     /// <para>
96     /// Initializes a new <see cref="ItemComparer"/> instance.
97     /// </para>
98     /// <para></para>
99     /// </summary>
100     [MethodImpl(MethodImplOptions.AggressiveInlining)]
101     public ItemComparer() => _listComparer = Default<IListComparer<TLink>>.Instance;
102
103     /// <summary>
104     /// <para>
105     /// Compares the left.
106     /// </para>
107     /// <para></para>
108     /// </summary>
109     /// <param name="left">
110     /// <para>The left.</para>
111     /// <para></para>
112     /// </param>
113     /// <param name="right">

```

```

109     /// <para>The right.</para>
110     /// <para></para>
111     /// </param>
112     /// <returns>
113     /// <para>The intermediate result.</para>
114     /// <para></para>
115     /// </returns>
116     [MethodImpl(MethodImplOptions.AggressiveInlining)]
117     public int Compare(KeyValuePair<IList<TLink>, IList<TLink>> left,
118         ↪ KeyValuePair<IList<TLink>, IList<TLink>> right)
119     {
120         var intermediateResult = _listComparer.Compare(left.Key, right.Key);
121         if (intermediateResult == 0)
122         {
123             intermediateResult = _listComparer.Compare(left.Value, right.Value);
124         }
125         return intermediateResult;
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     /// <para></para>
137     /// </param>
138     /// <param name="sequences">
139     /// <para>A sequences.</para>
140     /// <para></para>
141     /// </param>
142     [MethodImpl(MethodImplOptions.AggressiveInlining)]
143     public DuplicateSegmentsProvider(ILinks<TLink> links, ILinks<TLink> sequences)
144         : base(minimumStringSegmentLength: 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<TLink>, IList<TLink>>> Get()
162     {
163         _groups = new HashSet<KeyValuePair<IList<TLink>,
164             ↪ IList<TLink>>>(Default<ItemEqualityComparer>.Instance);
165         var links = _links;
166         var count = links.Count();
167         _visited = new BitString(_addressToInt64Converter.Convert(count) + 1L);
168         links.Each(link =>
169         {
170             var linkIndex = links.GetIndex(link);
171             var linkBitIndex = _addressToInt64Converter.Convert(linkIndex);
172             var constants = links.Constants;
173             if (!_visited.Get(linkBitIndex))
174             {
175                 var sequenceElements = new List<TLink>();
176                 var filler = new ListFiller<TLink, TLink>(sequenceElements, constants.Break);
177                 _sequences.Each(filler.AddSkipFirstAndReturnConstant, new
178                     ↪ LinkAddress<TLink>(linkIndex));
179                 if (sequenceElements.Count > 2)
180                 {
181                     WalkAll(sequenceElements);
182                 }
183             }
184             return constants.Continue;
185         });
186     }

```



```

184         var resultList = _groups.ToList();
185         var comparer = Default<ItemComparer>.Instance;
186         resultList.Sort(comparer);
187     #if DEBUG
188         foreach (var item in resultList)
189         {
190             PrintDuplicates(item);
191         }
192     #endif
193     return resultList;
194 }
195
196 /// <summary>
197 /// <para>
198 /// Creates the segment using the specified elements.
199 /// </para>
200 /// <para></para>
201 /// </summary>
202 /// <param name="elements">
203 /// <para>The elements.</para>
204 /// <para></para>
205 /// </param>
206 /// <param name="offset">
207 /// <para>The offset.</para>
208 /// <para></para>
209 /// </param>
210 /// <param name="length">
211 /// <para>The length.</para>
212 /// <para></para>
213 /// </param>
214 /// <returns>
215 /// <para>A segment of t link</para>
216 /// <para></para>
217 /// </returns>
218 [MethodImpl(MethodImplOptions.AggressiveInlining)]
219 protected override Segment<TLink> CreateSegment(IList<TLink> elements, int offset, int
    ↪ length) => new Segment<TLink>(elements, offset, length);
220
221 /// <summary>
222 /// <para>
223 /// Ons the duplicate found using the specified segment.
224 /// </para>
225 /// <para></para>
226 /// </summary>
227 /// <param name="segment">
228 /// <para>The segment.</para>
229 /// <para></para>
230 /// </param>
231 [MethodImpl(MethodImplOptions.AggressiveInlining)]
232 protected override void OnDuplicateFound(Segment<TLink> segment)
233 {
234     var duplicates = CollectDuplicatesForSegment(segment);
235     if (duplicates.Count > 1)
236     {
237         _groups.Add(new KeyValuePair<IList<TLink>, IList<TLink>>(segment.ToArray(),
    ↪ duplicates));
238     }
239 }
240 [MethodImpl(MethodImplOptions.AggressiveInlining)]
241 private List<TLink> CollectDuplicatesForSegment(Segment<TLink> segment)
242 {
243     var duplicates = new List<TLink>();
244     var readAsElement = new HashSet<TLink>();
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<TLink>();
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
                ↪ ashSet<ulong>)(object)readAsElement,
                ↪ (IList<ulong>)segment);
267         foreach (var partiallyMatchedSequence in partiallyMatched)
268         {
269             var sequenceIndex =
                ↪ _uInt64ToAddressConverter.Convert(partiallyMatchedSequence);
270             duplicates.Add(sequenceIndex);
271         }
272     }
273     duplicates.Sort();
274     return duplicates;
275 }
276 [MethodImpl(MethodImplOptions.AggressiveInlining)]
277 private void PrintDuplicates(KeyValuePair<IList<TLink>, IList<TLink>> duplicatesItem)
278 {
279     if (!(_links is ILinks<ulong> ulongLinks))
280     {
281         return;
282     }
283     var duplicatesKey = duplicatesItem.Key;
284     var keyString = UnicodeMap.FromLinksToString((IList<ulong>)duplicatesKey);
285     Console.WriteLine($"> {keyString} ({string.Join(", ", duplicatesKey)}");
286     var duplicatesList = duplicatesItem.Value;
287     for (int i = 0; i < duplicatesList.Count; i++)
288     {
289         var sequenceIndex = _addressToUInt64Converter.Convert(duplicatesList[i]);
290         var formattedSequenceStructure = ulongLinks.FormatStructure(sequenceIndex, x =>
                ↪ Point<ulong>.IsPartialPoint(x), (sb, link) => _ =
                ↪ UnicodeMap.IsCharLink(link.Index) ?
                ↪ sb.Append(UnicodeMap.FromLinkToChar(link.Index)) : sb.Append(link.Index));
291         Console.WriteLine(formattedSequenceStructure);
292         var sequenceString = UnicodeMap.FromSequenceLinkToString(sequenceIndex,
                ↪ ulongLinks);
293         Console.WriteLine(sequenceString);
294     }
295     Console.WriteLine();
296 }
297 }
298 }

```

## 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
        ↪ between them).
13     /// TODO: Extract interface to implement frequencies storage inside Links storage
14     /// </remarks>
15     public class LinkFrequenciesCache<TLink> : LinksOperatorBase<TLink>
16     {
17         private static readonly EqualityComparer<TLink> _equalityComparer =
            ↪ EqualityComparer<TLink>.Default;
18         private static readonly Comparer<TLink> _comparer = Comparer<TLink>.Default;
19         private static readonly TLink _zero = default;
20         private static readonly TLink _one = Arithmetic.Increment(_zero);
21         private readonly Dictionary<Doublet<TLink>, LinkFrequency<TLink>> _doubletsCache;
22         private readonly ICounter<TLink, TLink> _frequencyCounter;
23
24         /// <summary>
25         /// <para>
26         /// Initializes a new <see cref="LinkFrequenciesCache"/> instance.
27         /// </para>
28         /// <para></para>
29         /// </summary>

```

```

30    /// <param name="links">
31    /// <para>A links.</para>
32    /// </para>
33    /// </param>
34    /// <param name="frequencyCounter">
35    /// <para>A frequency counter.</para>
36    /// </para>
37    /// </param>
38    [MethodImpl(MethodImplOptions.AggressiveInlining)]
39    public LinkFrequenciesCache(ILinks<TLink> links, ICounter<TLink, TLink> frequencyCounter)
40        : base(links)
41    {
42        _doubletsCache = new Dictionary<Doublet<TLink>, LinkFrequency<TLink>>(4096,
43            ↪ DoubletComparer<TLink>.Default);
44        _frequencyCounter = frequencyCounter;
45    }
46    /// <summary>
47    /// <para>
48    /// Gets the frequency using the specified source.
49    /// </para>
50    /// </summary>
51    /// <param name="source">
52    /// <para>The source.</para>
53    /// </param>
54    /// <param name="target">
55    /// <para>The target.</para>
56    /// </param>
57    /// <returns>
58    /// <para>A link frequency of t link</para>
59    /// </returns>
60    [MethodImpl(MethodImplOptions.AggressiveInlining)]
61    public LinkFrequency<TLink> GetFrequency(TLink source, TLink target)
62    {
63        var doublet = new Doublet<TLink>(source, target);
64        return GetFrequency(ref doublet);
65    }
66    /// <summary>
67    /// <para>
68    /// Gets the frequency using the specified doublet.
69    /// </para>
70    /// </summary>
71    /// <param name="doublet">
72    /// <para>The doublet.</para>
73    /// </param>
74    /// <returns>
75    /// <para>The data.</para>
76    /// </returns>
77    [MethodImpl(MethodImplOptions.AggressiveInlining)]
78    public LinkFrequency<TLink> GetFrequency(ref Doublet<TLink> doublet)
79    {
80        _doubletsCache.TryGetValue(doublet, out LinkFrequency<TLink> data);
81        return data;
82    }
83    /// <summary>
84    /// <para>
85    /// Increments the frequencies using the specified sequence.
86    /// </para>
87    /// </summary>
88    /// <param name="sequence">
89    /// <para>The sequence.</para>
90    /// </param>
91    [MethodImpl(MethodImplOptions.AggressiveInlining)]
92    public void IncrementFrequencies(IList<TLink> sequence)
93    {
94        for (var i = 1; i < sequence.Count; i++)
95        {

```

```

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<TLink> IncrementFrequency(TLink source, TLink target)
131 {
132     var doublet = new Doublet<TLink>(source, target);
133     return IncrementFrequency(ref doublet);
134 }
135
136 /// <summary>
137 /// <para>
138 /// Prints the frequencies using the specified sequence.
139 /// </para>
140 /// <para></para>
141 /// </summary>
142 /// <param name="sequence">
143 /// <para>The sequence.</para>
144 /// <para></para>
145 /// </param>
146 [MethodImpl(MethodImplOptions.AggressiveInlining)]
147 public void PrintFrequencies(ICollection<TLink> sequence)
148 {
149     for (var i = 1; i < sequence.Count; i++)
150     {
151         PrintFrequency(sequence[i - 1], sequence[i]);
152     }
153 }
154
155 /// <summary>
156 /// <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(TLink source, TLink 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<TLink> IncrementFrequency(ref Doublet<TLink> doublet)
192     {
193         if (_doubletsCache.TryGetValue(doublet, out LinkFrequency<TLink> data))
194         {
195             data.IncrementFrequency();
196         }
197         else
198         {
199             var link = _links.SearchOrDefault(doublet.Source, doublet.Target);
200             data = new LinkFrequency<TLink>(_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     /// <summary>
211     /// <para>
212     /// Validates the frequencies.
213     /// </para>
214     /// <para></para>
215     /// </summary>
216     /// <exception cref="InvalidOperationException">
217     /// <para>Frequencies validation failed.</para>
218     /// <para></para>
219     /// </exception>
220     [MethodImpl(MethodImplOptions.AggressiveInlining)]
221     public void ValidateFrequencies()
222     {
223         foreach (var entry in _doubletsCache)
224         {
225             var value = entry.Value;
226             var linkIndex = value.Link;
227             if (!_equalityComparer.Equals(linkIndex, default))
228             {
229                 var frequency = value.Frequency;
230                 var count = _frequencyCounter.Count(linkIndex);
231                 // TODO: Why `frequency` always greater than `count` by 1?
232                 if (((_comparer.Compare(frequency, count) > 0) &&
233                     ↪ (_comparer.Compare(Arithmetic.Subtract(frequency, count), _one) > 0))
234                     || ((_comparer.Compare(count, frequency) > 0) &&
235                     ↪ (_comparer.Compare(Arithmetic.Subtract(count, frequency), _one) > 0)))
236                 {
237                     throw new InvalidOperationException("Frequencies validation failed.");
238                 }
239             }
240             //else
241             //{
242                 if (value.Frequency > 0)
243                 {
244                     var frequency = value.Frequency;
245                     linkIndex = _createLink(entry.Key.Source, entry.Key.Target);
246                     var count = _countLinkFrequency(linkIndex);
247                     if ((frequency > count && frequency - count > 1) || (count > frequency
248                     ↪ && count - frequency > 1))
249                     {
250                         throw new InvalidOperationException("Frequencies validation
251                         ↪ failed.");
252                     }
253                 }
254             }
255         }
256     }
257 }

```

## 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<TLink>
15    {
16        /// <summary>
17        /// <para>
18        /// Gets or sets the frequency value.
19        /// </para>
20        /// <para></para>
21        /// </summary>
22        public TLink Frequency { get; set; }
23        /// <summary>
24        /// <para>
25        /// Gets or sets the link value.
26        /// </para>
27        /// <para></para>
28        /// </summary>
29        public TLink 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(TLink frequency, TLink 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<TLink>.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<TLink>.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{TLink}, TLink}" />
15     public class FrequenciesCacheBasedLinkToItsFrequencyNumberConverter<TLink> :
16     ↪ IConverter<Doublet<TLink>, TLink>
17     {
18         private readonly LinkFrequenciesCache<TLink> _cache;
19
20         /// <summary>
21         /// <para>
22         /// Initializes a new <see
23         ↪ cref="FrequenciesCacheBasedLinkToItsFrequencyNumberConverter" /> instance.
24         /// </para>
25         /// <para></para>
26         /// </summary>
27         /// <param name="cache">
28         /// <para>A cache.</para>
29         /// <para></para>
30         /// </param>
31         [MethodImpl(MethodImplOptions.AggressiveInlining)]
32         public
33         ↪ FrequenciesCacheBasedLinkToItsFrequencyNumberConverter(LinkFrequenciesCache<TLink>
34         ↪ cache) => _cache = cache;
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 link</para>
48         /// <para></para>
49         /// </returns>
50         [MethodImpl(MethodImplOptions.AggressiveInlining)]
51         public TLink Convert(Doublet<TLink> source) => _cache.GetFrequency(ref source).Frequency;
52     }
53 }

```

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

```

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{TLink}"/>
15  public class MarkedSequenceSymbolFrequencyOneOffCounter<TLink> :
    ↳ SequenceSymbolFrequencyOneOffCounter<TLink>
16  {
17      private readonly ICriterionMatcher<TLink> _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<TLink> links,
    ↳ ICriterionMatcher<TLink> markedSequenceMatcher, TLink sequenceLink, TLink symbol)
    : base(links, sequenceLink, symbol)
    => _markedSequenceMatcher = markedSequenceMatcher;
43
44      /// <summary>
45      /// <para>
46      /// Counts this instance.
47      /// </para>
48      /// <para></para>
49      /// </summary>
50      /// <returns>
51      /// <para>The link</para>
52      /// <para></para>
53      /// </returns>
54      [MethodImpl(MethodImplOptions.AggressiveInlining)]
55      public override TLink Count()
56      {
57          if (!_markedSequenceMatcher.IsMatched(_sequenceLink))
58          {
59              return default;
60          }
61          return base.Count();
62      }
63  }
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{TLink}"/>
18     public class SequenceSymbolFrequencyOneOffCounter<TLink> : ICounter<TLink>

```



```

19 {
20     private static readonly EqualityComparer<TLink> _equalityComparer =
21         ↳ EqualityComparer<TLink>.Default;
22     private static readonly Comparer<TLink> _comparer = Comparer<TLink>.Default;
23
24     /// <summary>
25     /// <para>
26     /// The links.
27     /// </para>
28     /// </summary>
29     protected readonly ILinks<TLink> _links;
30     /// <summary>
31     /// <para>
32     /// The sequence link.
33     /// </para>
34     /// </summary>
35     protected readonly TLink _sequenceLink;
36     /// <summary>
37     /// <para>
38     /// The symbol.
39     /// </para>
40     /// </summary>
41     protected readonly TLink _symbol;
42     /// <summary>
43     /// <para>
44     /// The total.
45     /// </para>
46     /// </summary>
47     protected TLink _total;
48
49     /// <summary>
50     /// <para>
51     /// Initializes a new <see cref="SequenceSymbolFrequencyOneOffCounter"/> instance.
52     /// </para>
53     /// </summary>
54     /// <param name="links">
55     /// <para>A links.</para>
56     /// </param>
57     /// <param name="sequenceLink">
58     /// <para>A sequence link.</para>
59     /// </param>
60     /// <param name="symbol">
61     /// <para>A symbol.</para>
62     /// </param>
63     [MethodImpl(MethodImplOptions.AggressiveInlining)]
64     public SequenceSymbolFrequencyOneOffCounter(ILinks<TLink> links, TLink sequenceLink,
65         ↳ TLink symbol)
66     {
67         _links = links;
68         _sequenceLink = sequenceLink;
69         _symbol = symbol;
70         _total = default;
71     }
72
73     /// <summary>
74     /// <para>
75     /// Counts this instance.
76     /// </para>
77     /// </summary>
78     /// <returns>
79     /// <para>The total.</para>
80     /// </returns>
81     [MethodImpl(MethodImplOptions.AggressiveInlining)]
82     public virtual TLink Count()
83     {
84         if (_comparer.Compare(_total, default) > 0)
85         {
86             return _total;
87         }
88     }
89
90
91
92
93
94
95

```

```

96         StopableSequenceWalker.WalkRight(_sequenceLink, _links.GetSource, _links.GetTarget,
97         ↪ IsElement, VisitElement);
98         return _total;
99     }
100     [MethodImpl(MethodImplOptions.AggressiveInlining)]
101     private bool IsElement(TLink x) => _equalityComparer.Equals(x, _symbol) ||
102     ↪ _links.IsPartialPoint(x); // TODO: Use SequenceElementCriteriaMatcher instead of
103     ↪ IsPartialPoint
104     [MethodImpl(MethodImplOptions.AggressiveInlining)]
105     private bool VisitElement(TLink element)
106     {
107         if (_equalityComparer.Equals(element, _symbol))
108         {
109             _total = Arithmetic.Increment(_total);
110         }
111         return true;
112     }
113 }

```

## 1.16 ./csharp/Platform.Data.Doublets.Sequences/Frequencies/Counters/TotalMarkedSequenceSymbolFrequencyC

```

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{TLink, TLink}"/>
15     public class TotalMarkedSequenceSymbolFrequencyCounter<TLink> : ICounter<TLink, TLink>
16     {
17         private readonly ILinks<TLink> _links;
18         private readonly ICriterionMatcher<TLink> _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<TLink> links,
36         ↪ ICriterionMatcher<TLink> markedSequenceMatcher)
37         {
38             _links = links;
39             _markedSequenceMatcher = markedSequenceMatcher;
40         }
41
42         /// <summary>
43         /// <para>
44         /// Counts the argument.
45         /// </para>
46         /// <para></para>
47         /// </summary>
48         /// <param name="argument">
49         /// <para>The argument.</para>
50         /// <para></para>
51         /// </param>
52         /// <returns>
53         /// <para>The link</para>
54         /// <para></para>
55         /// </returns>
56         [MethodImpl(MethodImplOptions.AggressiveInlining)]

```

```

56         public TLink Count(TLink argument) => new
           ↳ TotalMarkedSequenceSymbolFrequencyOneOffCounter<TLink>(_links,
           ↳ _markedSequenceMatcher, argument).Count();
57     }
58 }

```

### 1.17 ./csharp/Platform.Data.Doublets.Sequences/Frequencies/Counters/TotalMarkedSequenceSymbolFrequencyCounter.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.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{TLink}" />
16     public class TotalMarkedSequenceSymbolFrequencyOneOffCounter<TLink> :
           ↳ TotalSequenceSymbolFrequencyOneOffCounter<TLink>
17     {
18         private readonly ICriterionMatcher<TLink> _markedSequenceMatcher;
19
20         /// <summary>
21         /// <para>
22         /// Initializes a new <see cref="TotalMarkedSequenceSymbolFrequencyOneOffCounter" />
           ↳ 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         /// <param name="symbol">
35         /// <para>A symbol.</para>
36         /// <para></para>
37         /// </param>
38         [MethodImpl(MethodImplOptions.AggressiveInlining)]
39         public TotalMarkedSequenceSymbolFrequencyOneOffCounter(ILinks<TLink> links,
           ↳ ICriterionMatcher<TLink> markedSequenceMatcher, TLink symbol)
40             : base(links, symbol)
41             => _markedSequenceMatcher = markedSequenceMatcher;
42
43         /// <summary>
44         /// <para>
45         /// Counts the sequence symbol frequency using the specified link.
46         /// </para>
47         /// <para></para>
48         /// </summary>
49         /// <param name="link">
50         /// <para>The link.</para>
51         /// <para></para>
52         /// </param>
53         [MethodImpl(MethodImplOptions.AggressiveInlining)]
54         protected override void CountSequenceSymbolFrequency(TLink link)
55         {
56             var symbolFrequencyCounter = new
           ↳ MarkedSequenceSymbolFrequencyOneOffCounter<TLink>(_links,
           ↳ _markedSequenceMatcher, link, _symbol);
57             _total = Arithmetic.Add(_total, symbolFrequencyCounter.Count());
58         }
59     }
60 }

```

### 1.18 ./csharp/Platform.Data.Doublets.Sequences/Frequencies/Counters/TotalSequenceSymbolFrequencyCounter.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 sequence symbol frequency counter.
11    /// </para>
12    /// <para></para>
13    /// </summary>
14    /// <seealso cref="ICounter{TLink, TLink}"/>
15    public class TotalSequenceSymbolFrequencyCounter<TLink> : ICounter<TLink, TLink>
16    {
17        private readonly ILinks<TLink> _links;
18
19        /// <summary>
20        /// <para>
21        /// Initializes a new <see cref="TotalSequenceSymbolFrequencyCounter"/> 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 TotalSequenceSymbolFrequencyCounter(ILinks<TLink> links) => _links = links;
31
32        /// <summary>
33        /// <para>
34        /// Counts the symbol.
35        /// </para>
36        /// <para></para>
37        /// </summary>
38        /// <param name="symbol">
39        /// <para>The symbol.</para>
40        /// <para></para>
41        /// </param>
42        /// <returns>
43        /// <para>The link</para>
44        /// <para></para>
45        /// </returns>
46        [MethodImpl(MethodImplOptions.AggressiveInlining)]
47        public TLink Count(TLink symbol) => new
48        {
49            ↪ TotalSequenceSymbolFrequencyOneOffCounter<TLink>(_links, symbol).Count();
50        }
51    }
52 }

```

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

```

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{TLink}"/>
17    public class TotalSequenceSymbolFrequencyOneOffCounter<TLink> : ICounter<TLink>
18    {
19        private static readonly EqualityComparer<TLink> _equalityComparer =
20        {
21            ↪ EqualityComparer<TLink>.Default;
22        };
23        private static readonly Comparer<TLink> _comparer = Comparer<TLink>.Default;
24
25        /// <summary>
26        /// <para>
27        /// The links.
28        /// </para>
29        /// <para></para>
30        /// </summary>
31        protected readonly ILinks<TLink> _links;
32
33        /// <summary>
34        /// <para>

```

```

31     /// The symbol.
32     /// </para>
33     /// <para></para>
34     /// </summary>
35     protected readonly TLink _symbol;
36     /// <summary>
37     /// <para>
38     /// The visits.
39     /// </para>
40     /// <para></para>
41     /// </summary>
42     protected readonly HashSet<TLink> _visits;
43     /// <summary>
44     /// <para>
45     /// The total.
46     /// </para>
47     /// <para></para>
48     /// </summary>
49     protected TLink _total;
50
51     /// <summary>
52     /// <para>
53     /// Initializes a new <see cref="TotalSequenceSymbolFrequencyOneOffCounter"/> instance.
54     /// </para>
55     /// <para></para>
56     /// </summary>
57     /// <param name="links">
58     /// <para>A links.</para>
59     /// <para></para>
60     /// </param>
61     /// <param name="symbol">
62     /// <para>A symbol.</para>
63     /// <para></para>
64     /// </param>
65     [MethodImpl(MethodImplOptions.AggressiveInlining)]
66     public TotalSequenceSymbolFrequencyOneOffCounter(ILinks<TLink> links, TLink symbol)
67     {
68         _links = links;
69         _symbol = symbol;
70         _visits = new HashSet<TLink>();
71         _total = default;
72     }
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 TLink 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(TLink 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(TLink link)
120     {
121         var symbolFrequencyCounter = new SequenceSymbolFrequencyOneOffCounter<TLink>(_links,
122             ↪ link, _symbol);
123         _total = Arithmetic.Add(_total, symbolFrequencyCounter.Count());
124     }
125     [MethodImpl(MethodImplOptions.AggressiveInlining)]
126     private TLink EachElementHandler(IList<TLink> 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{TLink}" />
17     public class CachedSequenceHeightProvider<TLink> : ISequenceHeightProvider<TLink>
18     {
19         private static readonly EqualityComparer<TLink> _equalityComparer =
20             ↪ EqualityComparer<TLink>.Default;
21         private readonly TLink _heightPropertyMarker;
22         private readonly ISequenceHeightProvider<TLink> _baseHeightProvider;
23         private readonly IConverter<TLink> _addressToUnaryNumberConverter;
24         private readonly IConverter<TLink> _unaryNumberToAddressConverter;
25         private readonly IProperties<TLink, TLink, TLink> _propertyOperator;
26
27         /// <summary>
28         /// <para>
29         /// Initializes a new <see cref="CachedSequenceHeightProvider" /> instance.
30         /// </para>
31         /// <para></para>
32         /// </summary>
33         /// <param name="baseHeightProvider">
34         /// <para>A base height provider.</para>
35         /// <para></para>
36         /// </param>
37         /// <param name="addressToUnaryNumberConverter">
38         /// <para>A address to unary number converter.</para>
39         /// <para></para>
40         /// </param>
41         /// <param name="unaryNumberToAddressConverter">
42         /// <para>A unary number to address converter.</para>
43         /// <para></para>
44         /// </param>
45         /// <param name="heightPropertyMarker">
46         /// <para>A height property marker.</para>
47         /// <para></para>
48         /// </param>
49         /// <param name="propertyOperator">

```

```

49     /// <para>A property operator.</para>
50     /// <para></para>
51     /// </param>
52     [MethodImpl(MethodImplOptions.AggressiveInlining)]
53     public CachedSequenceHeightProvider(
54         ISequenceHeightProvider<TLink> baseHeightProvider,
55         IConverter<TLink> addressToUnaryNumberConverter,
56         IConverter<TLink> unaryNumberToAddressConverter,
57         TLink heightPropertyMarker,
58         IProperties<TLink, TLink, TLink> propertyOperator)
59     {
60         _heightPropertyMarker = heightPropertyMarker;
61         _baseHeightProvider = baseHeightProvider;
62         _addressToUnaryNumberConverter = addressToUnaryNumberConverter;
63         _unaryNumberToAddressConverter = unaryNumberToAddressConverter;
64         _propertyOperator = propertyOperator;
65     }
66
67     /// <summary>
68     /// <para>
69     /// Gets 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>
78     /// <para>The height.</para>
79     /// <para></para>
80     /// </returns>
81     [MethodImpl(MethodImplOptions.AggressiveInlining)]
82     public TLink Get(TLink sequence)
83     {
84         TLink height;
85         var heightValue = _propertyOperator.GetValue(sequence, _heightPropertyMarker);
86         if (_equalityComparer.Equals(heightValue, default))
87         {
88             height = _baseHeightProvider.Get(sequence);
89             heightValue = _addressToUnaryNumberConverter.Convert(height);
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{TLink}"/>
16     /// <seealso cref="ISequenceHeightProvider{TLink}"/>
17     public class DefaultSequenceRightHeightProvider<TLink> : LinksOperatorBase<TLink>,
18         ↪ ISequenceHeightProvider<TLink>
19     {
20         private readonly ICriterionMatcher<TLink> _elementMatcher;
21
22         /// <summary>
23         /// <para>
24         /// Initializes a new <see cref="DefaultSequenceRightHeightProvider"/> instance.
25         /// <para></para>
26         /// </summary>

```

```

27     /// <param name="links">
28     /// <para>A links.</para>
29     /// <para></para>
30     /// </param>
31     /// <param name="elementMatcher">
32     /// <para>A element matcher.</para>
33     /// <para></para>
34     /// </param>
35     [MethodImpl(MethodImplOptions.AggressiveInlining)]
36     public DefaultSequenceRightHeightProvider(ILinks<TLink> links, ICriterionMatcher<TLink>
        ↪ elementMatcher) : base(links) => _elementMatcher = elementMatcher;
37
38     /// <summary>
39     /// <para>
40     /// Gets the sequence.
41     /// </para>
42     /// <para></para>
43     /// </summary>
44     /// <param name="sequence">
45     /// <para>The sequence.</para>
46     /// <para></para>
47     /// </param>
48     /// <returns>
49     /// <para>The height.</para>
50     /// <para></para>
51     /// </returns>
52     [MethodImpl(MethodImplOptions.AggressiveInlining)]
53     public TLink Get(TLink sequence)
54     {
55         var height = default(TLink);
56         var pairOrElement = sequence;
57         while (!_elementMatcher.IsMatched(pairOrElement))
58         {
59             pairOrElement = _links.GetTarget(pairOrElement);
60             height = Arithmetic.Increment(height);
61         }
62         return height;
63     }
64 }
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{TLink, TLink}"/>
14    public interface ISequenceHeightProvider<TLink> : IProvider<TLink, TLink>
15    {
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{TLink}"/>
16    /// <seealso cref="IIncrementer{TLink}"/>
17    public class FrequencyIncrementer<TLink> : LinksOperatorBase<TLink>, IIncrementer<TLink>

```



```

18 {
19     private static readonly EqualityComparer<TLink> _equalityComparer =
20         ↪ EqualityComparer<TLink>.Default;
21     private readonly TLink _frequencyMarker;
22     private readonly TLink _unaryOne;
23     private readonly IIncrementer<TLink> _unaryNumberIncrementer;
24
25     /// <summary>
26     /// <para>
27     /// Initializes a new <see cref="FrequencyIncrementer"/> instance.
28     /// </para>
29     /// </summary>
30     /// <param name="links">
31     /// <para>A links.</para>
32     /// </param>
33     /// <param name="frequencyMarker">
34     /// <para>A frequency marker.</para>
35     /// </param>
36     /// <param name="unaryOne">
37     /// <para>A unary one.</para>
38     /// </param>
39     /// <param name="unaryNumberIncrementer">
40     /// <para>A unary number incrementer.</para>
41     /// </param>
42     [MethodImpl(MethodImplOptions.AggressiveInlining)]
43     public FrequencyIncrementer(ILinks<TLink> links, TLink frequencyMarker, TLink unaryOne,
44         ↪ IIncrementer<TLink> unaryNumberIncrementer)
45         : base(links)
46     {
47         _frequencyMarker = frequencyMarker;
48         _unaryOne = unaryOne;
49         _unaryNumberIncrementer = unaryNumberIncrementer;
50     }
51
52     /// <summary>
53     /// <para>
54     /// Increments the frequency.
55     /// </para>
56     /// </summary>
57     /// <param name="frequency">
58     /// <para>The frequency.</para>
59     /// </param>
60     /// <returns>
61     /// <para>The link</para>
62     /// </returns>
63     [MethodImpl(MethodImplOptions.AggressiveInlining)]
64     public TLink Increment(TLink frequency)
65     {
66         var links = _links;
67         if (_equalityComparer.Equals(frequency, default))
68         {
69             return links.GetOrCreate(_unaryOne, _frequencyMarker);
70         }
71         var incrementedSource =
72             ↪ _unaryNumberIncrementer.Increment(links.GetSource(frequency));
73         return links.GetOrCreate(incrementedSource, _frequencyMarker);
74     }
75 }
76
77 }
78
79 }
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{TLink}" />
16  /// <seealso cref="IIncrementer{TLink}" />
17  public class UnaryNumberIncrementer<TLink> : LinksOperatorBase<TLink>, IIncrementer<TLink>
18  {
19      private static readonly EqualityComparer<TLink> _equalityComparer =
20          ↪ EqualityComparer<TLink>.Default;
21      private readonly TLink _unaryOne;
22
23      /// <summary>
24      /// <para>
25      /// Initializes a new <see cref="UnaryNumberIncrementer" /> instance.
26      /// </para>
27      /// <para></para>
28      /// </summary>
29      /// <param name="links">
30      /// <para>A links.</para>
31      /// </param>
32      /// <param name="unaryOne">
33      /// <para>A unary one.</para>
34      /// <para></para>
35      /// </param>
36      [MethodImpl(MethodImplOptions.AggressiveInlining)]
37      public UnaryNumberIncrementer(ILinks<TLink> links, TLink unaryOne) : base(links) =>
38          ↪ _unaryOne = unaryOne;
39
40      /// <summary>
41      /// <para>
42      /// Increments the unary number.
43      /// </para>
44      /// <para></para>
45      /// </summary>
46      /// <param name="unaryNumber">
47      /// <para>The unary number.</para>
48      /// <para></para>
49      /// </param>
50      /// <returns>
51      /// <para>The link</para>
52      /// <para></para>
53      /// </returns>
54      [MethodImpl(MethodImplOptions.AggressiveInlining)]
55      public TLink Increment(TLink unaryNumber)
56      {
57          var links = _links;
58          if (_equalityComparer.Equals(unaryNumber, _unaryOne))
59          {
60              return links.GetOrCreate(_unaryOne, _unaryOne);
61          }
62          var source = links.GetSource(unaryNumber);
63          var target = links.GetTarget(unaryNumber);
64          if (_equalityComparer.Equals(source, target))
65          {
66              return links.GetOrCreate(unaryNumber, _unaryOne);
67          }
68          else
69          {
70              return links.GetOrCreate(source, Increment(target));
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{TLink}" />
16  public class CachedFrequencyIncrementingSequenceIndex<TLink> : ISequenceIndex<TLink>
17  {
18      private static readonly EqualityComparer<TLink> _equalityComparer =
19          ↳ EqualityComparer<TLink>.Default;
20      private readonly LinkFrequenciesCache<TLink> _cache;
21
22      /// <summary>
23      /// <para>
24      /// Initializes a new <see cref="CachedFrequencyIncrementingSequenceIndex" /> instance.
25      /// </para>
26      /// <para></para>
27      /// </summary>
28      /// <param name="cache">
29      /// <para>A cache.</para>
30      /// <para></para>
31      /// </param>
32      [MethodImpl(MethodImplOptions.AggressiveInlining)]
33      public CachedFrequencyIncrementingSequenceIndex(LinkFrequenciesCache<TLink> cache) =>
34          ↳ _cache = cache;
35
36      /// <summary>
37      /// <para>
38      /// Determines whether this instance add.
39      /// </para>
40      /// <para></para>
41      /// </summary>
42      /// <param name="sequence">
43      /// <para>The sequence.</para>
44      /// <para></para>
45      /// </param>
46      /// <returns>
47      /// <para>The indexed.</para>
48      /// <para></para>
49      /// </returns>
50      [MethodImpl(MethodImplOptions.AggressiveInlining)]
51      public bool Add(IList<TLink> sequence)
52      {
53          var indexed = true;
54          var i = sequence.Count;
55          while (--i >= 1 && (indexed = IsIndexedWithIncrement(sequence[i - 1], sequence[i])))
56              ↳ { }
57          for (; i >= 1; i--)
58          {
59              _cache.IncrementFrequency(sequence[i - 1], sequence[i]);
60          }
61          return indexed;
62      }
63      [MethodImpl(MethodImplOptions.AggressiveInlining)]
64      private bool IsIndexedWithIncrement(TLink source, TLink target)
65      {
66          var frequency = _cache.GetFrequency(source, target);
67          if (frequency == null)
68          {
69              return false;
70          }
71          var indexed = !_equalityComparer.Equals(frequency.Frequency, default);
72          if (indexed)
73          {
74              _cache.IncrementFrequency(source, target);
75          }
76          return indexed;
77      }
78
79      /// <summary>
80      /// <para>
81      /// Determines whether this instance might contain.
82      /// </para>
83      /// <para></para>
84      /// </summary>
85      /// <param name="sequence">
86      /// <para>The sequence.</para>
87      /// <para></para>
88      /// </param>
89      /// <returns>
90      /// <para>The indexed.</para>

```

```

88     /// <para></para>
89     /// </returns>
90     [MethodImpl(MethodImplOptions.AggressiveInlining)]
91     public bool MightContain(ICollection<TLink> 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(TLink source, TLink 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.Incremeters;
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{TLink}" />
17     /// <seealso cref="ISequenceIndex{TLink}" />
18     public class FrequencyIncrementingSequenceIndex<TLink> : SequenceIndex<TLink>,
19         ↳ ISequenceIndex<TLink>
20     {
21         private static readonly EqualityComparer<TLink> _equalityComparer =
22             ↳ EqualityComparer<TLink>.Default;
23         private readonly IProperty<TLink, TLink> _frequencyPropertyOperator;
24         private readonly IIncrementer<TLink> _frequencyIncrementer;
25
26         /// <summary>
27         /// <para>
28         /// Initializes a new <see cref="FrequencyIncrementingSequenceIndex" /> 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="frequencyPropertyOperator">
37         /// <para>A frequency property operator.</para>
38         /// <para></para>
39         /// </param>
40         /// <param name="frequencyIncrementer">
41         /// <para>A frequency incrementer.</para>
42         /// <para></para>
43         /// </param>
44         [MethodImpl(MethodImplOptions.AggressiveInlining)]
45         public FrequencyIncrementingSequenceIndex(ICollection<TLink> links, IProperty<TLink, TLink>
46             ↳ frequencyPropertyOperator, IIncrementer<TLink> frequencyIncrementer)
47             : base(links)
48         {
49             _frequencyPropertyOperator = frequencyPropertyOperator;
50             _frequencyIncrementer = frequencyIncrementer;
51         }
52
53         /// <summary>
54         /// <para>
55         /// 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<TLink> sequence)
66     {
67         var indexed = true;
68         var i = sequence.Count;
69         while (--i >= 1 && (indexed = IsIndexedWithIncrement(sequence[i - 1], sequence[i])))
70             ↳ { }
71         for (; i >= 1; i--)
72         {
73             Increment(_links.GetOrCreate(sequence[i - 1], sequence[i]));
74         }
75         return indexed;
76     }
77     [MethodImpl(MethodImplOptions.AggressiveInlining)]
78     private bool IsIndexedWithIncrement(TLink source, TLink target)
79     {
80         var link = _links.SearchOrCreate(source, target);
81         var indexed = !_equalityComparer.Equals(link, default);
82         if (indexed)
83         {
84             Increment(link);
85         }
86         return indexed;
87     }
88     [MethodImpl(MethodImplOptions.AggressiveInlining)]
89     private void Increment(TLink link)
90     {
91         var previousFrequency = _frequencyPropertyOperator.Get(link);
92         var frequency = _frequencyIncrementer.Increment(previousFrequency);
93         _frequencyPropertyOperator.Set(link, frequency);
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<TLink>
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<TLink> 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<TLink> 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{TLink}" />
15     /// <seealso cref="ISequenceIndex{TLink}" />
16     public class SequenceIndex<TLink> : LinksOperatorBase<TLink>, ISequenceIndex<TLink>
17     {
18         private static readonly EqualityComparer<TLink> _equalityComparer =
19             ↳ EqualityComparer<TLink>.Default;
20
21         /// <summary>
22         /// <para>
23         /// Initializes a new <see cref="SequenceIndex" /> instance.
24         /// </para>
25         /// <para></para>
26         /// </summary>
27         /// <param name="links">
28         /// <para>A links.</para>
29         /// <para></para>
30         /// </param>
31         [MethodImpl(MethodImplOptions.AggressiveInlining)]
32         public SequenceIndex(ICollection<TLink> links) : base(links) { }
33
34         /// <summary>
35         /// <para>
36         /// Determines whether this instance add.
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 indexed.</para>
46         /// <para></para>
47         /// </returns>
48         [MethodImpl(MethodImplOptions.AggressiveInlining)]
49         public virtual bool Add(ICollection<TLink> sequence)
50         {
51             var indexed = true;
52             var i = sequence.Count;
53             while (--i >= 0 && (indexed =
54                 ↳ !_equalityComparer.Equals(_links.SearchOrCreate(sequence[i - 1], sequence[i]),
55                 ↳ default))) { }
56             for (; i >= 0; i--)
57             {
58                 _links.GetOrCreate(sequence[i - 1], sequence[i]);
59             }
60             return indexed;
61         }
62
63         /// <summary>
64         /// <para>
65         /// Determines whether this instance might contain.
66         /// </para>
67         /// <para></para>
68         /// </summary>
69         /// <param name="sequence">

```

```

67     /// <para>The sequence.</para>
68     /// <para></para>
69     /// </param>
70     /// <returns>
71     /// <para>The indexed.</para>
72     /// <para></para>
73     /// </returns>
74     [MethodImpl(MethodImplOptions.AggressiveInlining)]
75     public virtual bool MightContain(IList<TLink> sequence)
76     {
77         var indexed = true;
78         var i = sequence.Count;
79         while (--i >= 1 && (indexed =
            ↪ !_equalityComparer.Equals(_links.SearchOrDefault(sequence[i - 1], sequence[i]),
            ↪ default))) { }
80         return indexed;
81     }
82 }
83 }

```

## 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{TLink}" />
15     public class SynchronizedSequenceIndex<TLink> : ISequenceIndex<TLink>
16     {
17         private static readonly EqualityComparer<TLink> _equalityComparer =
            ↪ EqualityComparer<TLink>.Default;
18         private readonly ISynchronizedLinks<TLink> _links;
19
20         /// <summary>
21         /// <para>
22         /// Initializes a new <see cref="SynchronizedSequenceIndex" /> instance.
23         /// </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 SynchronizedSequenceIndex(ISynchronizedLinks<TLink> links) => _links = 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 bool Add(IList<TLink> sequence)
49         {
50             var indexed = true;
51             var i = sequence.Count;
52             var links = _links.Unsync;
53             _links.SyncRoot.ExecuteReadOperation(() =>
54             {
55                 while (--i >= 1 && (indexed =
                    ↪ !_equalityComparer.Equals(links.SearchOrDefault(sequence[i - 1],
                    ↪ sequence[i]), default))) { }

```

```

56     });
57     if (!indexed)
58     {
59         _links.SyncRoot.ExecuteWriteOperation(() =>
60         {
61             for (; i >= 1; i--)
62             {
63                 links.GetOrCreate(sequence[i - 1], sequence[i]);
64             }
65         });
66     }
67     return indexed;
68 }
69
70 /// <summary>
71 /// <para>
72 /// Determines whether this instance might contain.
73 /// </para>
74 /// <para></para>
75 /// </summary>
76 /// <param name="sequence">
77 /// <para>The sequence.</para>
78 /// <para></para>
79 /// </param>
80 /// <returns>
81 /// <para>The bool</para>
82 /// <para></para>
83 /// </returns>
84 [MethodImpl(MethodImplOptions.AggressiveInlining)]
85 public bool MightContain(ICollection<TLink> sequence)
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{TLink}" />
15    public class Unindex<TLink> : ISequenceIndex<TLink>
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<TLink> 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(IList<TLink> 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{TLink}"/>
18     /// <seealso cref="IConverter{decimal, TLink}"/>
19     public class DecimalToRationalConverter<TLink> : LinksDecoratorBase<TLink>,
20     ↪ IConverter<decimal, TLink>
21     where TLink: struct
22     {
23         /// <summary>
24         /// <para>
25         /// The big integer to raw number sequence converter.
26         /// </para>
27         /// <para></para>
28         /// </summary>
29         public readonly BigIntegerToRawNumberSequenceConverter<TLink>
30         ↪ BigIntegerToRawNumberSequenceConverter;
31
32         /// <summary>
33         /// <para>
34         /// Initializes a new <see cref="DecimalToRationalConverter"/> 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="bigIntegerToRawNumberSequenceConverter">
43         /// <para>A big integer to raw number sequence converter.</para>
44         /// <para></para>
45         /// </param>
46         public DecimalToRationalConverter(ILinks<TLink> links,
47         ↪ BigIntegerToRawNumberSequenceConverter<TLink>
48         ↪ bigIntegerToRawNumberSequenceConverter) : base(links)
49         {
50             BigIntegerToRawNumberSequenceConverter = bigIntegerToRawNumberSequenceConverter;
51         }
52
53         /// <summary>
54         /// <para>
55         /// Converts the decimal.
56         /// </para>
57         /// <para></para>
58         /// </summary>
59         /// <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 TLink 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{TLink}" />
16     /// <seealso cref="IConverter{TLink, decimal}" />
17     public class RationalToDecimalConverter<TLink> : LinksDecoratorBase<TLink>,
18     ↪ IConverter<TLink, decimal>
19     where TLink: struct
20     {
21         /// <summary>
22         /// <para>
23         /// The raw number sequence to big integer converter.
24         /// </para>
25         /// <para></para>
26         /// </summary>
27         public readonly RawNumberSequenceToBigIntegerConverter<TLink>
28         ↪ RawNumberSequenceToBigIntegerConverter;
29
30         /// <summary>
31         /// <para>
32         /// Initializes a new <see cref="RationalToDecimalConverter" /> 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="rawNumberSequenceToBigIntegerConverter">
41         /// <para>A raw number sequence to big integer converter.</para>
42         /// <para></para>
43         /// </param>

```

```

42     public RationalToDecimalConverter(ILinks<TLink> links,
    ↪     RawNumberSequenceToBigIntegerConverter<TLink>
    ↪     rawNumberSequenceToBigIntegerConverter) : base(links)
43     {
44         RawNumberSequenceToBigIntegerConverter = rawNumberSequenceToBigIntegerConverter;
45     }
46
47     /// <summary>
48     /// <para>
49     /// Converts the rational number.
50     /// </para>
51     /// <para></para>
52     /// </summary>
53     /// <param name="rationalNumber">
54     /// <para>The rational number.</para>
55     /// <para></para>
56     /// </param>
57     /// <returns>
58     /// <para>The decimal</para>
59     /// <para></para>
60     /// </returns>
61     public decimal Convert(TLink rationalNumber)
62     {
63         var numerator = (decimal)RawNumberSequenceToBigIntegerConverter.Convert(_links.GetSo
    ↪         ↪     urce(rationalNumber));
64         var denominator = (decimal)RawNumberSequenceToBigIntegerConverter.Convert(_links.Get
    ↪         ↪     Target(rationalNumber));
65         return numerator / denominator;
66     }
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{TLink}">
21     /// <seealso cref="IConverter{BigInteger, TLink}">
22     public class BigIntegerToRawNumberSequenceConverter<TLink> : LinksDecoratorBase<TLink>,
    ↪     IConverter<BigInteger, TLink>
    ↪     where TLink : struct
23     {
24         /// <summary>
25         /// <para>
26         /// The max value.
27         /// </para>
28         /// <para></para>
29         /// </summary>
30         public static readonly TLink MaximumValue = NumericType<TLink>.MaxValue;
31         /// <summary>
32         /// <para>
33         /// The maximum value.
34         /// </para>
35         /// <para></para>
36         /// </summary>
37         public static readonly TLink BitMask = Bit.ShiftRight(MaximumValue, 1);
38         /// <summary>
39         /// <para>
40         /// The address to number converter.
41         /// </para>
42         /// <para></para>
43         /// </summary>
44         public readonly IConverter<TLink> AddressToNumberConverter;
45     }

```

```

46     /// <summary>
47     /// <para>
48     /// The list to sequence converter.
49     /// </para>
50     /// <para></para>
51     /// </summary>
52     public readonly IConverter<IList<TLink>, TLink> ListToSequenceConverter;
53     /// <summary>
54     /// <para>
55     /// The negative number marker.
56     /// </para>
57     /// <para></para>
58     /// </summary>
59     public readonly TLink NegativeNumberMarker;
60
61     /// <summary>
62     /// <para>
63     /// Initializes a new <see cref="BigIntegerToRawNumberSequenceConverter"/> instance.
64     /// </para>
65     /// <para></para>
66     /// </summary>
67     /// <param name="links">
68     /// <para>A links.</para>
69     /// <para></para>
70     /// </param>
71     /// <param name="addressToNumberConverter">
72     /// <para>A address to number converter.</para>
73     /// <para></para>
74     /// </param>
75     /// <param name="listToSequenceConverter">
76     /// <para>A list to sequence converter.</para>
77     /// <para></para>
78     /// </param>
79     /// <param name="negativeNumberMarker">
80     /// <para>A negative number marker.</para>
81     /// <para></para>
82     /// </param>
83     public BigIntegerToRawNumberSequenceConverter(IList<TLink> links, IConverter<TLink>
        → addressToNumberConverter, IConverter<IList<TLink>,TLink> listToSequenceConverter,
        → TLink negativeNumberMarker) : base(links)
84     {
85         AddressToNumberConverter = addressToNumberConverter;
86         ListToSequenceConverter = listToSequenceConverter;
87         NegativeNumberMarker = negativeNumberMarker;
88     }
89     private List<TLink> GetRawNumberParts(BigInteger bigInteger)
90     {
91         List<TLink> rawNumbers = new();
92         BigInteger currentBigInt = bigInteger;
93         do
94         {
95             var bigIntBytes = currentBigInt.ToByteArray();
96             var bigIntWithBitMask = Bit.And(bigIntBytes.ToStructure<TLink>(), BitMask);
97             var rawNumber = AddressToNumberConverter.Convert(bigIntWithBitMask);
98             rawNumbers.Add(rawNumber);
99             currentBigInt >>= (NumericType<TLink>.BitsSize - 1);
100         }
101         while (currentBigInt > 0);
102         return rawNumbers;
103     }
104
105     /// <summary>
106     /// <para>
107     /// Converts the big integer.
108     /// </para>
109     /// <para></para>
110     /// </summary>
111     /// <param name="bigInteger">
112     /// <para>The big integer.</para>
113     /// <para></para>
114     /// </param>
115     /// <returns>
116     /// <para>The link</para>
117     /// <para></para>
118     /// </returns>
119     public TLink Convert(BigInteger bigInteger)
120     {
121         var sign = bigInteger.Sign;

```

```

122         var number = GetRawNumberParts(sign == -1 ? BigInteger.Negate(bigInteger) :
            ↪ bigInteger);
123         var numberSequence = ListToSequenceConverter.Convert(number);
124         return sign == -1 ? _links.GetOrCreate(NegativeNumberMarker, numberSequence) :
            ↪ numberSequence;
125     }
126 }
127 }

```

### 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, _bitsPerRowNumber), Convert(element));
75         }
76         return result;
77     }
78 }
79 }
80 }

```

### 1.35 ./csharp/Platform.Data.Doublets.Sequences/Numbers/Row/NumberToLongRawNumberSequenceConverter.cs

```

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.Row
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> :
        ↪ LinksDecoratorBase<TTarget>, IConverter<TSource, TTarget>
21     {
22         private static readonly Comparer<TSource> _comparer = Comparer<TSource>.Default;
23         private static readonly TSource _maximumValue = NumericType<TSource>.MaxValue;
24         private static readonly int _bitsPerRowNumber = NumericType<TTarget>.BitsSize - 1;
25         private static readonly TSource _bitMask = Bit.ShiftRight(_maximumValue,
        ↪ NumericType<TTarget>.BitsSize + 1);
26         private static readonly TSource _maximumConvertibleAddress = CheckedConverter<TTarget,
        ↪ TSource>.Default.Convert(Arithmetic.Decrement(Hybrid<TTarget>.ExternalZero));
27         private static readonly UncheckedConverter<TSource, TTarget> _sourceToTargetConverter =
        ↪ UncheckedConverter<TSource, TTarget>.Default;
28         private readonly IConverter<TTarget> _addressToNumberConverter;
29
30         /// <summary>
31         /// <para>
32         /// Initializes a new <see cref="NumberToLongRawNumberSequenceConverter"/> 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="addressToNumberConverter">
41         /// <para>A address to number converter.</para>
42         /// <para></para>
43         /// </param>
44         [MethodImpl(MethodImplOptions.AggressiveInlining)]
45         public NumberToLongRawNumberSequenceConverter(ILinks<TTarget> links, IConverter<TTarget>
        ↪ addressToNumberConverter) : base(links) => _addressToNumberConverter =
        ↪ addressToNumberConverter;
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 target</para>
59     /// <para></para>
60     /// </returns>
61     [MethodImpl(MethodImplOptions.AggressiveInlining)]
62     public TTarget Convert(TSource source)
63     {
64         if (_comparer.Compare(source, _maximumConvertibleAddress) > 0)
65         {
66             var numberPart = Bit.And(source, _bitMask);
67             var convertedNumber = _addressToNumberConverter.Convert(_sourceToTargetConverter.
                ↪ Convert(numberPart));
68             return Links.GetOrCreate(convertedNumber, Convert(Bit.ShiftRight(source,
                ↪ _bitsPerRawNumber)));
69         }
70         else
71         {
72             return
                ↪ _addressToNumberConverter.Convert(_sourceToTargetConverter.Convert(source));
73         }
74     }
75 }
76 }

```

### 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{TLink}"/>
22     /// <seealso cref="IConverter{TLink, BigInteger}"/>
23     public class RawNumberSequenceToBigIntegerConverter<TLink> : LinksDecoratorBase<TLink>,
        ↪ IConverter<TLink, BigInteger>
24     {
25         where TLink : struct
26     {
27         /// <summary>
28         /// <para>
29         /// The default.
30         /// </para>
31         /// <para></para>
32         /// </summary>
33         public readonly EqualityComparer<TLink> EqualityComparer =
            ↪ EqualityComparer<TLink>.Default;
34         /// <summary>
35         /// <para>
36         /// The number to address converter.
37         /// </para>
38         /// <para></para>
39         /// </summary>
40         public readonly IConverter<TLink, TLink> NumberToAddressConverter;
41         /// <summary>
42         /// <para>
43         /// The left sequence walker.
44         /// </para>
45         /// <para></para>
46         /// </summary>
47         public readonly LeftSequenceWalker<TLink> LeftSequenceWalker;
48         /// <summary>
49         /// <para>

```

```

49     /// The negative number marker.
50     /// </para>
51     /// <para></para>
52     /// </summary>
53     public readonly TLink NegativeNumberMarker;
54
55     /// <summary>
56     /// <para>
57     /// Initializes a new <see cref="RawNumberSequenceToBigIntegerConverter"/> instance.
58     /// </para>
59     /// <para></para>
60     /// </summary>
61     /// <param name="links">
62     /// <para>A links.</para>
63     /// <para></para>
64     /// </param>
65     /// <param name="numberToAddressConverter">
66     /// <para>A number to address converter.</para>
67     /// <para></para>
68     /// </param>
69     /// <param name="negativeNumberMarker">
70     /// <para>A negative number marker.</para>
71     /// <para></para>
72     /// </param>
73     public RawNumberSequenceToBigIntegerConverter(ILinks<TLink> links, IConverter<TLink,
74     ↪ TLink> numberToAddressConverter, TLink negativeNumberMarker) : base(links)
75     {
76         NumberToAddressConverter = numberToAddressConverter;
77         LeftSequenceWalker = new(links, new DefaultStack<TLink>());
78         NegativeNumberMarker = negativeNumberMarker;
79     }
80
81     /// <summary>
82     /// <para>
83     /// Converts the big integer.
84     /// </para>
85     /// <para></para>
86     /// </summary>
87     /// <param name="bigInteger">
88     /// <para>The big integer.</para>
89     /// <para></para>
90     /// </param>
91     /// <exception cref="Exception">
92     /// <para>Raw number sequence cannot be empty.</para>
93     /// <para></para>
94     /// </exception>
95     /// <returns>
96     /// <para>The big integer</para>
97     /// <para></para>
98     /// </returns>
99     public BigInteger Convert(TLink bigInteger)
100     {
101         var sign = 1;
102         var bigIntegerSequence = bigInteger;
103         if (EqualityComparer.Equals(_links.GetSource(bigIntegerSequence),
104         ↪ NegativeNumberMarker))
105         {
106             sign = -1;
107             bigIntegerSequence = _links.GetTarget(bigInteger);
108         }
109         using var enumerator = LeftSequenceWalker.Walk(bigIntegerSequence).GetEnumerator();
110         if (!enumerator.MoveNext())
111         {
112             throw new Exception("Raw number sequence cannot be empty.");
113         }
114         var nextPart = NumberToAddressConverter.Convert(enumerator.Current);
115         BigInteger currentBigInt = new(nextPart.ToBytes());
116         while (enumerator.MoveNext())
117         {
118             currentBigInt <= (NumericType<TLink>.BitsSize - 1);
119             nextPart = NumberToAddressConverter.Convert(enumerator.Current);
120             currentBigInt |= new BigInteger(nextPart.ToBytes());
121         }
122         return sign == -1 ? BigInteger.Negate(currentBigInt) : currentBigInt;
123     }
124 }

```



## 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{TLink}" />
18     /// <seealso cref="IConverter{TLink}" />
19     public class AddressToUnaryNumberConverter<TLink> : LinksOperatorBase<TLink>,
20         ↳ IConverter<TLink>
21     {
22         private static readonly EqualityComparer<TLink> _equalityComparer =
23             ↳ EqualityComparer<TLink>.Default;
24         private static readonly TLink _zero = default;
25         private static readonly TLink _one = Arithmetic.Increment(_zero);
26         private readonly IConverter<int, TLink> _powerOf2ToUnaryNumberConverter;
27
28         /// <summary>
29         /// <para>
30         /// Initializes a new <see cref="AddressToUnaryNumberConverter" /> 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="powerOf2ToUnaryNumberConverter">
39         /// <para>A power of 2 to unary number converter.</para>
40         /// <para></para>
41         /// </param>
42         [MethodImpl(MethodImplOptions.AggressiveInlining)]
43         public AddressToUnaryNumberConverter(ILinks<TLink> links, IConverter<int, TLink>
44             ↳ powerOf2ToUnaryNumberConverter) : base(links) => _powerOf2ToUnaryNumberConverter =
45             ↳ powerOf2ToUnaryNumberConverter;
46
47         /// <summary>
48         /// <para>
49         /// Converts the number.
50         /// </para>
51         /// <para></para>
52         /// </summary>
53         /// <param name="number">
54         /// <para>The number.</para>
55         /// <para></para>
56         /// </param>
57         /// <returns>
58         /// <para>The target.</para>
59         /// <para></para>
60         /// </returns>
61         [MethodImpl(MethodImplOptions.AggressiveInlining)]
62         public TLink Convert(TLink number)
63         {
64             var links = _links;
65             var nullConstant = links.Constants.Null;
66             var target = nullConstant;
67             for (var i = 0; !_equalityComparer.Equals(number, _zero) && i <
68                 ↳ NumericType<TLink>.BitsSize; i++)
69             {
70                 if (_equalityComparer.Equals(Bit.And(number, _one), _one))
71                 {
72                     target = _equalityComparer.Equals(target, nullConstant)
73                         ? _powerOf2ToUnaryNumberConverter.Convert(i)
74                         : links.GetOrCreate(_powerOf2ToUnaryNumberConverter.Convert(i), target);
75                 }
76                 number = Bit.ShiftRight(number, 1);
77             }
78             return target;
79         }
80     }
81 }

```

```

74     }
75 }
76 }

```

### 1.38 ./csharp/Platform.Data.Doublets.Sequences/Numbers/Unary/LinkToItsFrequencyNumberConveter.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 conveter.
14     /// </para>
15     /// <para></para>
16     /// </summary>
17     /// <seealso cref="LinksOperatorBase{TLink}" />
18     /// <seealso cref="IConverter{Doublet{TLink}, TLink}" />
19     public class LinkToItsFrequencyNumberConveter<TLink> : LinksOperatorBase<TLink>,
20     ↪ IConverter<Doublet<TLink>, TLink>
21     {
22         private static readonly EqualityComparer<TLink> _equalityComparer =
23         ↪ EqualityComparer<TLink>.Default;
24         private readonly IProperty<TLink, TLink> _frequencyPropertyOperator;
25         private readonly IConverter<TLink> _unaryNumberToAddressConverter;
26
27         /// <summary>
28         /// <para>
29         /// Initializes a new <see cref="LinkToItsFrequencyNumberConveter" /> 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="frequencyPropertyOperator">
38         /// <para>A frequency property operator.</para>
39         /// <para></para>
40         /// </param>
41         /// <param name="unaryNumberToAddressConverter">
42         /// <para>A unary number to address converter.</para>
43         /// <para></para>
44         /// </param>
45         [MethodImpl(MethodImplOptions.AggressiveInlining)]
46         public LinkToItsFrequencyNumberConveter(
47             ILinks<TLink> links,
48             IProperty<TLink, TLink> frequencyPropertyOperator,
49             IConverter<TLink> unaryNumberToAddressConverter)
50             : base(links)
51         {
52             _frequencyPropertyOperator = frequencyPropertyOperator;
53             _unaryNumberToAddressConverter = unaryNumberToAddressConverter;
54         }
55
56         /// <summary>
57         /// <para>
58         /// Converts the doublet.
59         /// </para>
60         /// <para></para>
61         /// </summary>
62         /// <param name="doublet">
63         /// <para>The doublet.</para>
64         /// <para></para>
65         /// </param>
66         /// <exception cref="ArgumentException">
67         /// <para>Link ({doublet}) not found. </para>
68         /// <para></para>
69         /// </exception>
70         /// <returns>
71         /// <para>The link</para>
72         /// <para></para>
73         /// </returns>
74         [MethodImpl(MethodImplOptions.AggressiveInlining)]

```

```

73 public TLink Convert(Doublet<TLink> 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{TLink}" />
18     /// <seealso cref="IConverter{int, TLink}" />
19     public class PowerOf2ToUnaryNumberConverter<TLink> : LinksOperatorBase<TLink>,
20         ↳ IConverter<int, TLink>
21     {
22         private static readonly EqualityComparer<TLink> _equalityComparer =
23             ↳ EqualityComparer<TLink>.Default;
24         private readonly TLink[] _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         /// </param>
35         /// <param name="one">
36         /// <para>A one.</para>
37         /// </param>
38         [MethodImpl(MethodImplOptions.AggressiveInlining)]
39         public PowerOf2ToUnaryNumberConverter(ILinks<TLink> links, TLink one) : base(links)
40         {
41             _unaryNumberPowersOf2 = new TLink[64];
42             _unaryNumberPowersOf2[0] = one;
43         }
44
45         /// <summary>
46         /// <para>
47         /// Converts the power.
48         /// </para>
49         /// <para></para>
50         /// </summary>
51         /// <param name="power">
52         /// <para>The power.</para>
53         /// </param>
54         /// <returns>
55         /// <para>The power of.</para>
56         /// </returns>
57     }

```

```

58     /// </returns>
59     [MethodImpl(MethodImplOptions.AggressiveInlining)]
60     public TLink Convert(int power)
61     {
62         Ensure.Always.ArgumentInRange(power, new Range<int>(0, _unaryNumberPowersOf2.Length
        ↪ - 1), nameof(power));
63         if (!_equalityComparer.Equals(_unaryNumberPowersOf2[power], default))
64         {
65             return _unaryNumberPowersOf2[power];
66         }
67         var previousPowerOf2 = Convert(power - 1);
68         var powerOf2 = _links.GetOrCreate(previousPowerOf2, previousPowerOf2);
69         _unaryNumberPowersOf2[power] = powerOf2;
70         return powerOf2;
71     }
72 }
73 }

```

#### 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{TLink}" />
17     /// <seealso cref="IConverter{TLink}" />
18     public class UnaryNumberToAddressAddOperationConverter<TLink> : LinksOperatorBase<TLink>,
        ↪ IConverter<TLink>
19     {
20         private static readonly EqualityComparer<TLink> _equalityComparer =
        ↪ EqualityComparer<TLink>.Default;
21         private static readonly UncheckedConverter<TLink, ulong> _addressToUInt64Converter =
        ↪ UncheckedConverter<TLink, ulong>.Default;
22         private static readonly UncheckedConverter<ulong, TLink> _uInt64ToAddressConverter =
        ↪ UncheckedConverter<ulong, TLink>.Default;
23         private static readonly TLink _zero = default;
24         private static readonly TLink _one = Arithmetic.Increment(_zero);
25         private readonly Dictionary<TLink, TLink> _unaryToUInt64;
26         private readonly TLink _unaryOne;
27
28         /// <summary>
29         /// <para>
30         /// Initializes a new <see cref="UnaryNumberToAddressAddOperationConverter" /> 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="unaryOne">
39         /// <para>A unary one.</para>
40         /// <para></para>
41         /// </param>
42         [MethodImpl(MethodImplOptions.AggressiveInlining)]
43         public UnaryNumberToAddressAddOperationConverter(ILinks<TLink> links, TLink unaryOne)
44             : base(links)
45         {
46             _unaryOne = unaryOne;
47             _unaryToUInt64 = CreateUnaryToUInt64Dictionary(links, unaryOne);
48         }
49
50         /// <summary>
51         /// <para>
52         /// Converts the unary number.
53         /// </para>
54         /// <para></para>
55         /// </summary>
56         /// <param name="unaryNumber">

```

```

57     /// <para>The unary number.</para>
58     /// <para></para>
59     /// </param>
60     /// <returns>
61     /// <para>The link</para>
62     /// <para></para>
63     /// </returns>
64     [MethodImpl(MethodImplOptions.AggressiveInlining)]
65     public TLink Convert(TLink unaryNumber)
66     {
67         if (_equalityComparer.Equals(unaryNumber, default))
68         {
69             return default;
70         }
71         if (_equalityComparer.Equals(unaryNumber, _unaryOne))
72         {
73             return _one;
74         }
75         var links = _links;
76         var source = links.GetSource(unaryNumber);
77         var target = links.GetTarget(unaryNumber);
78         if (_equalityComparer.Equals(source, target))
79         {
80             return _unaryToUInt64[unaryNumber];
81         }
82         else
83         {
84             var result = _unaryToUInt64[source];
85             TLink lastValue;
86             while (!_unaryToUInt64.TryGetValue(target, out lastValue))
87             {
88                 source = links.GetSource(target);
89                 result = Arithmetic<TLink>.Add(result, _unaryToUInt64[source]);
90                 target = links.GetTarget(target);
91             }
92             result = Arithmetic<TLink>.Add(result, lastValue);
93             return result;
94         }
95     }
96     [MethodImpl(MethodImplOptions.AggressiveInlining)]
97     private static Dictionary<TLink, TLink> CreateUnaryToUInt64Dictionary(ILinks<TLink>
98     ↪ links, TLink unaryOne)
99     {
100         var unaryToUInt64 = new Dictionary<TLink, TLink>
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 TLink Double(TLink number) =>
116     ↪ _uInt64ToAddressConverter.Convert(_addressToUInt64Converter.Convert(number) * 2UL);

```

#### 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{TLink}" />
18  /// <seealso cref="IConverter{TLink}" />
19  public class UnaryNumberToAddressOrOperationConverter<TLink> : LinksOperatorBase<TLink>,
    ⇨ IConverter<TLink>
20  {
21      private static readonly EqualityComparer<TLink> _equalityComparer =
    ⇨ EqualityComparer<TLink>.Default;
22      private static readonly TLink _zero = default;
23      private static readonly TLink _one = Arithmetic.Increment(_zero);
24      private readonly IDictionary<TLink, int> _unaryNumberPowerOf2Indicies;
25
26      /// <summary>
27      /// <para>
28      /// Initializes a new <see cref="UnaryNumberToAddressOrOperationConverter" /> instance.
29      /// </para>
30      /// </summary>
31      /// <param name="links">
32      /// <para>A links.</para>
33      /// </param>
34      /// <param name="powerOf2ToUnaryNumberConverter">
35      /// <para>A power of to unary number converter.</para>
36      /// </param>
37      [MethodImpl(MethodImplOptions.AggressiveInlining)]
38      public UnaryNumberToAddressOrOperationConverter(ILinks<TLink> links, IConverter<int,
    ⇨ TLink> powerOf2ToUnaryNumberConverter) : base(links) => _unaryNumberPowerOf2Indicies
    ⇨ = CreateUnaryNumberPowerOf2IndiciesDictionary(powerOf2ToUnaryNumberConverter);
39
40      /// <summary>
41      /// <para>
42      /// Converts the source number.
43      /// </para>
44      /// </summary>
45      /// <param name="sourceNumber">
46      /// <para>The source number.</para>
47      /// </param>
48      /// <returns>
49      /// <para>The target.</para>
50      /// </returns>
51      [MethodImpl(MethodImplOptions.AggressiveInlining)]
52      public TLink Convert(TLink sourceNumber)
53      {
54          var links = _links;
55          var nullConstant = links.Constants.Null;
56          var source = sourceNumber;
57          var target = nullConstant;
58          if (!_equalityComparer.Equals(source, nullConstant))
59          {
60              while (true)
61              {
62                  if (_unaryNumberPowerOf2Indicies.TryGetValue(source, out int powerOf2Index))
63                  {
64                      SetBit(ref target, powerOf2Index);
65                      break;
66                  }
67                  else
68                  {
69                      powerOf2Index = _unaryNumberPowerOf2Indicies[links.GetSource(source)];
70                      SetBit(ref target, powerOf2Index);
71                      source = links.GetTarget(source);
72                  }
73              }
74          }
75          return target;
76      }
77
78      [MethodImpl(MethodImplOptions.AggressiveInlining)]
79      private static Dictionary<TLink, int>
    ⇨ CreateUnaryNumberPowerOf2IndiciesDictionary(IConverter<int, TLink>
    ⇨ powerOf2ToUnaryNumberConverter)
80      {
81          var unaryNumberPowerOf2Indicies = new Dictionary<TLink, int>();
82          for (int i = 0; i < NumericType<TLink>.BitsSize; i++)

```

```

88         {
89             unaryNumberPowerOf2Indicies.Add(powerOf2ToUnaryNumberConverter.Convert(i), i);
90         }
91         return unaryNumberPowerOf2Indicies;
92     }
93     [MethodImpl(MethodImplOptions.AggressiveInlining)]
94     private static void SetBit(ref TLink target, int powerOf2Index) => target =
95         ↪ Bit.Or(target, Bit.ShiftLeft(_one, powerOf2Index));
96 }

```

## 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     return variants;
82 }
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></param>
93 /// </param>
94 /// <returns>
95 /// <para>A list of ulong</para>
96 /// </para></returns>
97
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
117 [MethodImpl(MethodImplOptions.AggressiveInlining)]
118 private List<ulong> CreateAllVariants1Core(ulong[] sequence, List<ulong> results)
119 {
120     if (sequence.Length == 2)
121     {
122         var link = Links.Unsync.GetOrCreate(sequence[0], sequence[1]);
123         if (link == Constants.Null)
124         {
125             throw new NotImplementedException("Creation cancellation is not
126                 ↳ implemented.");
127         }
128         results.Add(link);
129         return results;
130     }
131     var innerSequenceLength = sequence.Length - 1;
132     var innerSequence = new ulong[innerSequenceLength];
133     for (var li = 0; li < innerSequenceLength; li++)
134     {
135         var link = Links.Unsync.GetOrCreate(sequence[li], sequence[li + 1]);
136         if (link == Constants.Null)
137         {
138             throw new NotImplementedException("Creation cancellation is not
139                 ↳ implemented.");
140         }
141         for (var isi = 0; isi < li; isi++)
142         {
143             innerSequence[isi] = sequence[isi];
144         }
145     }

```



```

142         innerSequence[li] = link;
143         for (var isi = li + 1; isi < innerSequenceLength; isi++)
144         {
145             innerSequence[isi] = sequence[isi + 1];
146         }
147         CreateAllVariants1Core(innerSequence, results);
148     }
149     return results;
150 }
151
152 #endregion
153
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     }
300 }

```

```

297     }
298     else
299     {
300         Links.Each(Constants.Any, Constants.Any, handler);
301     }
302 }
303 else if (sequence.Length == 2)
304 {
305     //_links.Each(sequence[0], sequence[1], handler);
306     //  o_|      x_o ...
307     // x_|      |__|
308     Links.Each(sequence[1], Constants.Any, doublet =>
309     {
310         var match = Links.SearchOrDefault(sequence[0], doublet);
311         if (match != Constants.Null)
312         {
313             handler(new LinkAddress<LinkIndex>(match));
314         }
315         return true;
316     });
317     // |_x      ... x_o
318     // |_o      |__|
319     Links.Each(Constants.Any, sequence[0], doublet =>
320     {
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 // TODO: Test
375 [MethodImpl(MethodImplOptions.AggressiveInlining)]
376 private void PartialStepLeft(Action<IList<LinkIndex>> handler, ulong left, ulong right)
377 {
378     Links.Unsync.Each(right, Constants.Any, doublet =>
379     {
380         StepLeft(handler, left, doublet);
381         if (right != doublet)
382         {
383             PartialStepLeft(handler, left, doublet);
384         }
385         return true;
386     });
387 }
388 [MethodImpl(MethodImplOptions.AggressiveInlining)]
389 private void StepLeft(Action<IList<LinkIndex>> handler, ulong left, ulong right)
390 {
391     Links.Unsync.Each(Constants.Any, right, leftStep =>
392     {
393         TryStepLeftUp(handler, left, leftStep);
394         return true;
395     });
396 }
397 [MethodImpl(MethodImplOptions.AggressiveInlining)]
398 private void TryStepLeftUp(Action<IList<LinkIndex>> handler, ulong left, ulong stepFrom)
399 {
400     var upStep = stepFrom;
401     var firstTarget = Links.Unsync.GetSource(upStep);
402     while (firstTarget != left && firstTarget != upStep)
403     {
404         upStep = firstTarget;
405         firstTarget = Links.Unsync.GetTarget(upStep);
406     }
407     if (firstTarget == left)
408     {
409         handler(new LinkAddress<LinkIndex>(stepFrom));
410     }
411 }
412 [MethodImpl(MethodImplOptions.AggressiveInlining)]
413 private bool StartsWith(ulong sequence, ulong link)
414 {
415     var upStep = sequence;
416     var firstSource = Links.Unsync.GetSource(upStep);
417     while (firstSource != link && firstSource != upStep)
418     {
419         upStep = firstSource;
420         firstSource = Links.Unsync.GetSource(upStep);
421     }
422     return firstSource == link;
423 }
424 [MethodImpl(MethodImplOptions.AggressiveInlining)]
425 private bool EndsWith(ulong sequence, ulong link)
426 {
427     var upStep = sequence;
428     var lastTarget = Links.Unsync.GetTarget(upStep);
429     while (lastTarget != link && lastTarget != upStep)
430     {
431         upStep = lastTarget;
432         lastTarget = Links.Unsync.GetTarget(upStep);
433     }
434     return lastTarget == link;
435 }
436
437 /// <summary>
438 /// <para>
439 /// Gets the all matching sequences 0 using the specified sequence.
440 /// </para>
441 /// <para></para>
442 /// </summary>
443 /// <param name="sequence">
444 /// <para>The sequence.</para>
445 /// <para></para>
446 /// </param>
447 /// <returns>
448 /// <para>A list of ulong</para>
449 /// <para></para>
450 /// </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>

```

```

527 /// <param name="sequence">
528 /// <para>The sequence.</para>
529 /// <para></para>
530 /// </param>
531 /// <returns>
532 /// <para>A hash set of ulong</para>
533 /// <para></para>
534 /// </returns>
535 [MethodImpl(MethodImplOptions.AggressiveInlining)]
536 public HashSet<ulong> GetAllMatchingSequences1(params ulong[] sequence)
537 {
538     return _sync.ExecuteReadOperation(() =>
539     {
540         var results = new HashSet<ulong>();
541         if (sequence.Length > 0)
542         {
543             Links.EnsureLinkExists(sequence);
544             var firstElement = sequence[0];
545             if (sequence.Length == 1)
546             {
547                 results.Add(firstElement);
548                 return results;
549             }
550             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
580 /// <summary>
581 /// <para>
582 /// The max sequence format size.
583 /// </para>
584 /// </summary>
585 public const int MaxSequenceFormatSize = 200;
586
587 /// <summary>
588 /// <para>
589 /// Formats the sequence using the specified sequence link.
590 /// </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     /// </summary>
613     /// <param name="sequenceLink">
614     /// <para>The sequence link.</para>
615     /// </param>
616     /// <param name="elementToString">
617     /// <para>The element to string.</para>
618     /// </param>
619     /// <param name="insertComma">
620     /// <para>The insert comma.</para>
621     /// </param>
622     /// <param name="knownElements">
623     /// <para>The known elements.</para>
624     /// </param>
625     /// </returns>
626     /// <para>The string</para>
627     /// </returns>
628     [MethodImpl(MethodImplOptions.AggressiveInlining)]
629     public string FormatSequence(LinkIndex sequenceLink, Action<StringBuilder, LinkIndex>
630     ↪ elementToString, bool insertComma, params LinkIndex[] knownElements) =>
631     ↪ Links.SyncRoot.ExecuteReadOperation(() => FormatSequence(Links.Unsync, sequenceLink,
632     ↪ elementToString, insertComma, knownElements));
633     [MethodImpl(MethodImplOptions.AggressiveInlining)]
634     private string FormatSequence(ILinks<LinkIndex> links, LinkIndex sequenceLink,
635     ↪ Action<StringBuilder, LinkIndex> elementToString, bool insertComma, params
636     ↪ 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 => //
646             ↪ entered.AddAndReturnVoid, x => { }, entered.DoNotContains
647             {
648                 if (insertComma && sb.Length > 1)
649                 {
650                     sb.Append(',');
651                 }
652                 //if (entered.Contains(element))
653                 //{
654                 //    sb.Append('{');
655                 //    elementToString(sb, element);
656                 //    sb.Append('}');
657                 //}
658                 //else
659                 elementToString(sb, element);
660                 if (sb.Length < MaxSequenceFormatSize)
661                 {
662                     return true;
663                 }
664                 sb.Append(insertComma ? ", ..." : "...");
665                 return false;
666             });
667         }
668         sb.Append('}');
669         return sb.ToString();
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     /// <summary>
692     /// <para>
693     /// Safes the format sequence using the specified sequence link.
694     /// </para>
695     /// <para></para>
696     /// </summary>
697     /// <param name="sequenceLink">
698     /// <para>The sequence link.</para>
699     /// <para></para>
700     /// </param>
701     /// <param name="elementToString">
702     /// <para>The element to string.</para>
703     /// <para></para>
704     /// </param>
705     /// <param name="insertComma">
706     /// <para>The insert comma.</para>
707     /// <para></para>
708     /// </param>
709     /// <param name="knownElements">
710     /// <para>The known elements.</para>
711     /// <para></para>
712     /// </param>
713     /// <returns>
714     /// <para>The string</para>
715     /// <para></para>
716     /// </returns>
717     [MethodImpl(MethodImplOptions.AggressiveInlining)]
718     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                 }
744             }
745         }
746         sb.Append('}');
747     }

```



```

742         else
743         {
744             elementToString(sb, element);
745         }
746         if (sb.Length < MaxSequenceFormatSize)
747         {
748             return true;
749         }
750         sb.Append(insertComma ? ", ..." : "...");
751         return false;
752     });
753 }
754 sb.Append('}');
755 return sb.ToString();
756 }
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                 );
820             }
821             if (filterPosition == (sequence.Length - 1))

```

```

818         {
819             filteredResults.Add(result);
820         }
821     }
822     return filteredResults;
823 }
824 return new List<ulong>();
825 });
826 }
827
828 /// <summary>
829 /// <para>
830 /// Gets the all partially matching sequences 1 using the specified sequence.
831 /// </para>
832 /// <para></para>
833 /// </summary>
834 /// <param name="sequence">
835 /// <para>The sequence.</para>
836 /// <para></para>
837 /// </param>
838 /// <returns>
839 /// <para>A hash set of ulong</para>
840 /// <para></para>
841 /// </returns>
842 [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++)

```

```

895         {
896             if (!AllUsagesCore1(sequence[i], results, matcher.HandlePartialMatched))
897             {
898                 return false;
899             }
900         }
901         return true;
902     }
903     return true;
904 });
905 }
906
907 //public HashSet<ulong> GetAllPartiallyMatchingSequences3(params ulong[] sequence)
908 //{
909 //    return Sync.ExecuteReadOperation(() =>
910 //    {
911 //        if (sequence.Length > 0)
912 //        {
913 //            _links.EnsureEachLinkIsAnyOrExists(sequence);
914 //
915 //            var firstResults = new HashSet<ulong>();
916 //            var lastResults = new HashSet<ulong>();
917 //
918 //            var first = sequence.First(x => x != LinksConstants.Any);
919 //            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);

```

```

1047 //     var last = sequence.Length - 1;
1048 //     for (var i = 0; i < last; i++)
1049 //     {
1050 //         PartialStepRight(matcher.PartialMatch, sequence[i], sequence[i + 1]);
1051 //     }
1052 //     return results;
1053 // }
1054
1055 /// <summary>
1056 /// <para>
1057 /// Gets the all partially matching sequences using the specified sequence.
1058 /// </para>
1059 /// <para></para>
1060 /// </summary>
1061 /// <param name="sequence">
1062 /// <para>The sequence.</para>
1063 /// <para></para>
1064 /// </param>
1065 /// <returns>
1066 /// <para>A list of ulong</para>
1067 /// <para></para>
1068 /// </returns>
1069 [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)

```

```

1121         matches.Add(results);
1122     }
1123     }
1124     if (matches.Count == 2)
1125     {
1126         var merged = new List();
1127         for (var j = 0; j < matches[0].Count; j++)
1128             for (var k = 0; k < matches[1].Count; k++)
1129                 CloseInnerConnections(merged.Add, matches[0][j],
1130                     matches[1][k]);
1131         if (merged.Count > 0)
1132             matches = new List<List>> { merged };
1133         else
1134             return new List();
1135     }
1136     if (matches.Count > 0)
1137     {
1138         var usages = new HashSet();
1139         for (int i = 0; i < sequence.Length; i++)
1140         {
1141             AllUsagesCore(sequence[i], usages);
1142         }
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();
1149     AllUsagesCore(sequence[0], firstLinkUsages);
1150     firstLinkUsages.Add(sequence[0]);
1151     //var previousMatchings = firstLinkUsages.ToList(); //new List() {
1152     //    sequence[0] }; // or all sequences, containing this element?
1153     //return GetAllPartiallyMatchingSequencesCore(sequence, firstLinkUsages,
1154     //    1).ToList();
1155     var results = new HashSet();
1156     foreach (var match in GetAllPartiallyMatchingSequencesCore(sequence,
1157         firstLinkUsages, 1))
1158     {
1159         AllUsagesCore(match, results);
1160     }
1161     return results.ToList();
1162 }
1163 }
1164 }
1165 }
1166 }
1167 }
1168 }
1169 }
1170 }
1171 }
1172 }
1173 }
1174 }
1175 }
1176 }
1177 }
1178 }
1179 }
1180 }
1181 }
1182 }
1183 }
1184 }
1185 }
1186 }
1187 }
1188 }
1189 }
1190 }
1191 }
1192 }

```

```

1193     }
1194
1195     /// <summary>
1196     /// <para>
1197     /// Alls the bottom usages using the specified link.
1198     /// </para>
1199     /// <para></para>
1200     /// </summary>
1201     /// <param name="link">
1202     /// <para>The link.</para>
1203     /// <para></para>
1204     /// </param>
1205     /// <returns>
1206     /// <para>A hash set of ulong</para>
1207     /// <para></para>
1208     /// </returns>
1209     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1210     public HashSet<ulong> AllBottomUsages(ulong link)
1211     {
1212         return _sync.ExecuteReadOperation(() =>
1213         {
1214             var visits = new HashSet<ulong>();
1215             var usages = new HashSet<ulong>();
1216             AllBottomUsagesCore(link, visits, usages);
1217             return usages;
1218         });
1219     }
1220     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1221     private void AllBottomUsagesCore(ulong link, HashSet<ulong> visits, HashSet<ulong>
1222     ↪ usages)
1223     {
1224         bool handler(ulong doublet)
1225         {
1226             if (visits.Add(doublet))
1227             {
1228                 AllBottomUsagesCore(doublet, visits, usages);
1229             }
1230             return true;
1231         }
1232         if (Links.Unsync.Count(Constants.Any, link) == 0)
1233         {
1234             usages.Add(link);
1235         }
1236         else
1237         {
1238             Links.Unsync.Each(link, Constants.Any, handler);
1239             Links.Unsync.Each(Constants.Any, link, handler);
1240         }
1241     }
1242
1243     /// <summary>
1244     /// <para>
1245     /// Calculates the total symbol frequency core using the specified symbol.
1246     /// </para>
1247     /// <para></para>
1248     /// </summary>
1249     /// <param name="symbol">
1250     /// <para>The symbol.</para>
1251     /// <para></para>
1252     /// </param>
1253     /// <returns>
1254     /// <para>The ulong</para>
1255     /// <para></para>
1256     /// </returns>
1257     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1258     public ulong CalculateTotalSymbolFrequencyCore(ulong symbol)
1259     {
1260         if (Options.UseSequenceMarker)
1261         {
1262             var counter = new TotalMarkedSequenceSymbolFrequencyOneOffCounter<ulong>(Links,
1263             ↪ Options.MarkedSequenceMatcher, symbol);
1264             return counter.Count();
1265         }
1266         else
1267         {
1268             var counter = new TotalSequenceSymbolFrequencyOneOffCounter<ulong>(Links,
1269             ↪ symbol);
1270             return counter.Count();

```

```

1268     }
1269 }
1270 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1271 private bool AllUsagesCore1(ulong link, HashSet<ulong> usages, Func<IList<LinkIndex>,
1272     ↳ LinkIndex> outerHandler)
1273 {
1274     bool handler(ulong doublet)
1275     {
1276         if (usages.Add(doublet))
1277         {
1278             if (outerHandler(new LinkAddress<LinkIndex>(doublet)) != Constants.Continue)
1279             {
1280                 return false;
1281             }
1282             if (!AllUsagesCore1(doublet, usages, outerHandler))
1283             {
1284                 return false;
1285             }
1286         }
1287         return true;
1288     }
1289     return Links.Unsync.Each(link, Constants.Any, handler)
1290         && Links.Unsync.Each(Constants.Any, link, handler);
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,
    ↪ CalculateCore);
1359 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1360 private bool CalculateCore(ulong link)
1361 {
1362     if (_totals[link] == 0)
1363     {
1364         var total = 1UL;
1365         _totals[link] = total;
1366         var visitedChildren = new HashSet<ulong>();
1367         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,
    ↪ CalculateCore);
1416     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1417     private bool IsElement(ulong link)
1418     {
1419         // _linksInSequence.Contains(link) ||
1420         return _links.Unsync.GetTarget(link) == link || _links.Unsync.GetSource(link) ==
    ↪ link;

```

```

1421     }
1422     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1423     private bool CalculateCore(ulong link)
1424     {
1425         // TODO: Проработать защиту от заикливания
1426         // Основано на SequenceWalker.WalkLeft
1427         Func<ulong, ulong> getSource = _links.Unsync.GetSource;
1428         Func<ulong, ulong> getTarget = _links.Unsync.GetTarget;
1429         Func<ulong, bool> isElement = IsElement;
1430         void visitLeaf(ulong parent)
1431         {
1432             if (link != parent)
1433             {
1434                 _totals[parent]++;
1435             }
1436         }
1437         void visitNode(ulong parent)
1438         {
1439             if (link != parent)
1440             {
1441                 _totals[parent]++;
1442             }
1443         }
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             _totals[link]++;
1482             return true;
1483         }
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(ICollection<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 ICollection<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(ICollection<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>
        ↪ intersectWith, HashSet<ulong> usages)
1668     {
1669         _links = links;
1670         _intersectWith = intersectWith;
1671         _usages = usages;
1672         _enter = new HashSet<ulong>(); // защита от зацикливания
1673     }
1674
1675     /// <summary>
1676     /// <para>
1677     /// Determines whether this instance collect.
1678     /// </para>
1679     /// <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)]

```

```

private HashSet<ulong> GetAllPartiallyMatchingSequencesCore(ulong[] sequence,
    ↳ HashSet<ulong> previousMatchings, long startAt)
{
    if (startAt >= sequence.Length) // ?
    {
        return previousMatchings;
    }
    var secondLinkUsages = new HashSet<ulong>();
    AllUsagesCore(sequence[startAt], secondLinkUsages);
    secondLinkUsages.Add(sequence[startAt]);
    var matchings = new HashSet<ulong>();
    var filler = new SetFiller<LinkIndex, LinkIndex>(matchings, Constants.Continue);
    //for (var i = 0; i < previousMatchings.Count; i++)
    foreach (var secondLinkUsage in secondLinkUsages)
    {
        foreach (var previousMatching in previousMatchings)
        {
            //AllCloseConnections(matchings.AddAndReturnVoid, previousMatching,
            ↳ secondLinkUsage);
            StepRight(filler.AddFirstAndReturnConstant, previousMatching,
            ↳ secondLinkUsage);
            TryStepRightUp(filler.AddFirstAndReturnConstant, secondLinkUsage,
            ↳ previousMatching);
            //PartialStepRight(matchings.AddAndReturnVoid, secondLinkUsage,
            ↳ sequence[startAt]); // почему-то эта ошибочная запись приводит к
            ↳ желаемым результатам.
            PartialStepRight(filler.AddFirstAndReturnConstant, previousMatching,
            ↳ secondLinkUsage);
        }
    }
    if (matchings.Count == 0)
    {
        return matchings;
    }
    return GetAllPartiallyMatchingSequencesCore(sequence, matchings, startAt + 1); // ??
}
[MethodImpl(MethodImplOptions.AggressiveInlining)]
private static void EnsureEachLinkIsAnyOrZeroOrManyOrExists(SynchronizedLinks<ulong>
    ↳ links, params ulong[] sequence)
{
    if (sequence == null)
    {
        return;
    }
    for (var i = 0; i < sequence.Length; i++)
    {
        if (sequence[i] != links.Constants.Any && sequence[i] != ZeroOrMany &&
            ↳ !links.Exists(sequence[i]))
        {
            throw new ArgumentLinkDoesNotExistsException<ulong>(sequence[i],
            ↳ $"patternSequence[{i}]");
        }
    }
}

// Pattern Matching -> Key To Triggers
/// <summary>
/// <para>
/// Matches the pattern using the specified pattern sequence.
/// </para>
/// <para></para>
/// </summary>
/// <param name="patternSequence">
/// <para>The pattern sequence.</para>
/// <para></para>
/// </param>
/// <returns>
/// <para>A hash set of ulong</para>
/// <para></para>
/// </returns>
[MethodImpl(MethodImplOptions.AggressiveInlining)]
public HashSet<ulong> MatchPattern(params ulong[] patternSequence)
{
    return _sync.ExecuteReadOperation(() =>
    {
        patternSequence = Simplify(patternSequence);
        if (patternSequence.Length > 0)

```

```

1799     {
1800         EnsureEachLinkIsAnyOrZeroOrManyOrExists(Links, patternSequence);
1801         var uniqueSequenceElements = new HashSet<ulong>();
1802         for (var i = 0; i < patternSequence.Length; i++)
1803         {
1804             if (patternSequence[i] != Constants.Any && patternSequence[i] !=
1805                 ↳ ZeroOrMany)
1806             {
1807                 uniqueSequenceElements.Add(patternSequence[i]);
1808             }
1809             var results = new HashSet<ulong>();
1810             foreach (var uniqueSequenceElement in uniqueSequenceElements)
1811             {
1812                 AllUsagesCore(uniqueSequenceElement, results);
1813             }
1814             var filteredResults = new HashSet<ulong>();
1815             var matcher = new PatternMatcher(this, patternSequence, filteredResults);
1816             matcher.AddAllPatternMatchedToResults(results);
1817             return filteredResults;
1818         }
1819         return new HashSet<ulong>();
1820     });
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
1826 ↳ несколько раз в последовательности)
1827 /// <summary>
1828 /// <para>
1829 /// Gets the all connections using the specified links to connect.
1830 /// </para>
1831 /// </summary>
1832 /// <param name="linksToConnect">
1833 /// <para>The links to connect.</para>
1834 /// </param>
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 /// </param>
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             return results.GetSetUInt64Indices();
1974         });
1975     }
1976 [MethodImpl(MethodImplOptions.AggressiveInlining)]
1977 private static ulong[] Simplify(ulong[] sequence)
1978 {
1979     // Считаем новый размер последовательности
1980     long newLength = 0;
1981     var zeroOrManyStepped = false;
1982     for (var i = 0; i < sequence.Length; i++)
1983     {
1984         if (sequence[i] == ZeroOrMany)
1985         {
1986             if (zeroOrManyStepped)
1987             {
1988                 continue;
1989             }
1990             zeroOrManyStepped = true;
1991         }
1992         else
1993         {
1994             //if (zeroOrManyStepped) Is it efficient?
1995             zeroOrManyStepped = false;
1996         }
1997         newLength++;
1998     }
1999     // Строим новую последовательность
2000     zeroOrManyStepped = false;
2001     var newSequence = new ulong[newLength];
2002     long j = 0;
2003     for (var i = 0; i < sequence.Length; i++)
2004     {
2005         //var current = zeroOrManyStepped;
2006         //zeroOrManyStepped = patternSequence[i] == zeroOrMany;
2007         //if (current && zeroOrManyStepped)
2008         //    continue;
2009         //var newZeroOrManyStepped = patternSequence[i] == zeroOrMany;
2010         //if (zeroOrManyStepped && newZeroOrManyStepped)
2011         //    continue;
2012         //zeroOrManyStepped = newZeroOrManyStepped;
2013         if (sequence[i] == ZeroOrMany)
2014         {
2015             if (zeroOrManyStepped)
2016             {
2017                 continue;
2018             }
2019             zeroOrManyStepped = true;
2020         }
2021         else
2022         {
2023             //if (zeroOrManyStepped) Is it efficient?
2024             zeroOrManyStepped = false;
2025         }
2026         newSequence[j++] = sequence[i];
2027     }
2028     return newSequence;
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,
            ↪ ZeroOrMany, ZeroOrMany, 4, ZeroOrMany, ZeroOrMany, ZeroOrMany };
2040         var simplifiedSequence = Simplify(sequence);
2041     }
2042
2043     /// <summary>
2044     /// <para>
2045     /// Gets the similar sequences.
2046     /// </para>
2047     /// <para></para>
2048     /// </summary>
2049     /// <returns>
2050     /// <para>A list of ulong</para>
2051     /// <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
            ↪ поддерживаются.");
2099         }
2100         var leftBound = 0;
2101         var rightBound = links.Length - 1;
2102         var left = links[leftBound++];
2103         var right = links[rightBound--];
2104         var results = new List<ulong>();
2105         CollectMatchingSequences(left, leftBound, links, right, rightBound, ref results);

```

```

2106         return results;
2107     }
2108     [MethodImpl(MethodImplOptions.AggressiveInlining)]
2109     private void CollectMatchingSequences(ulong leftLink, int leftBound, ulong[]
2110     ↪ middleLinks, ulong rightLink, int rightBound, ref List<ulong> results)
2111     {
2112         var leftLinkTotalReferers = Links.Unsync.Count(leftLink);
2113         var rightLinkTotalReferers = Links.Unsync.Count(rightLink);
2114         if (leftLinkTotalReferers <= rightLinkTotalReferers)
2115         {
2116             var nextLeftLink = middleLinks[leftBound];
2117             var elements = GetRightElements(leftLink, nextLeftLink);
2118             if (leftBound <= rightBound)
2119             {
2120                 for (var i = elements.Length - 1; i >= 0; i--)
2121                 {
2122                     var element = elements[i];
2123                     if (element != 0)
2124                     {
2125                         CollectMatchingSequences(element, leftBound + 1, middleLinks,
2126                         ↪ rightLink, rightBound, ref results);
2127                     }
2128                 }
2129             }
2130             else
2131             {
2132                 for (var i = elements.Length - 1; i >= 0; i--)
2133                 {
2134                     var element = elements[i];
2135                     if (element != 0)
2136                     {
2137                         results.Add(element);
2138                     }
2139                 }
2140             }
2141         }
2142         else
2143         {
2144             var nextRightLink = middleLinks[rightBound];
2145             var elements = GetLeftElements(rightLink, nextRightLink);
2146             if (leftBound <= rightBound)
2147             {
2148                 for (var i = elements.Length - 1; i >= 0; i--)
2149                 {
2150                     var element = elements[i];
2151                     if (element != 0)
2152                     {
2153                         CollectMatchingSequences(leftLink, leftBound, middleLinks,
2154                         ↪ elements[i], rightBound - 1, ref results);
2155                     }
2156                 }
2157             }
2158             else
2159             {
2160                 for (var i = elements.Length - 1; i >= 0; i--)
2161                 {
2162                     var element = elements[i];
2163                     if (element != 0)
2164                     {
2165                         results.Add(element);
2166                     }
2167                 }
2168             }
2169         }
2170     }
2171 }
2172
2173 /// <summary>
2174 /// <para>
2175 /// Gets the right elements using the specified start link.
2176 /// </para>
2177 /// <para></para>
2178 /// </summary>
2179 /// <param name="startLink">
2180 /// <para>The start link.</para>
2181 /// <para></para>
2182 /// </param>
2183 /// <param name="rightLink">
2184 /// <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                 {

```

```

2258         return false;
2259     }
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             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,
2472     ↪ HashSet<LinkIndex> results)
2473     : base(sequences.Links.Unsync, new DefaultStack<ulong>())
2474 {
2475     _sequences = sequences;
2476     _patternSequence = patternSequence;
2477     _linksInSequence = new HashSet<LinkIndex>(patternSequence.Where(x => x !=
2478     ↪ _sequences.Constants.Any && x != ZeroOrMany));
2479     _results = results;
2480     _pattern = CreateDetailedPattern();
2481 }
2482
2483 /// <summary>
2484 /// <para>
2485 /// Determines whether this instance is element.
2486 /// </para>
2487 /// <para></para>
2488 /// </summary>
2489 /// <param name="link">
2490 /// <para>The link.</para>
2491 /// <para></para>
2492 /// </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     /// <summary>
2499     /// <para>
2500     /// Determines whether this instance pattern match.
2501     /// </para>
2502     /// <para></para>
2503     /// </summary>
2504     /// <param name="sequenceToMatch">
2505     /// <para>The sequence to match.</para>
2506     /// <para></para>
2507     /// </param>
2508     /// <returns>
2509     /// <para>The bool</para>
2510     /// <para></para>
2511     /// </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     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 //}

```

```

2647 //private void GetNextPatternElement(out LinkIndex element, out long mininumGap, out
2648 ↪ long maximumGap)
2649 //{
2650 //    mininumGap = 0;
2651 //    maximumGap = 0;
2652 //    element = 0;
2653 //    for (; _patternPosition < _patternSequence.Length; _patternPosition++)
2654 //    {
2655 //        if (_patternSequence[_patternPosition] == Doublets.Links.Null)
2656 //            mininumGap++;
2657 //        else if (_patternSequence[_patternPosition] == ZeroOrMany)
2658 //            maximumGap = long.MaxValue;
2659 //        else
2660 //            break;
2661 //    }
2662
2663 //    if (maximumGap < mininumGap)
2664 //        maximumGap = mininumGap;
2665 //}
2666 [MethodImpl(MethodImplOptions.AggressiveInlining)]
2667 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     }
2726 }

```

```

2724         else
2725         {
2726             _sequencePosition++;
2727         }
2728     }
2729     return true;
2730     //if (_patternSequence[_patternPosition] != element)
2731     //    return false;
2732     //else
2733     //{
2734         //    _sequencePosition++;
2735         //    _patternPosition++;
2736         //    return true;
2737     //}
2738     //if (_filterPosition == _patternSequence.Length)
2739     //{
2740         //    _filterPosition = -2; // Длиннее чем нужно
2741         //    return false;
2742     //}
2743     //if (element != _patternSequence[_filterPosition])
2744     //{
2745         //    _filterPosition = -1;
2746         //    return false; // Начинается иначе
2747     //}
2748     //if (_filterPosition == (_patternSequence.Length - 1))
2749     //    return false;
2750     //if (_filterPosition >= 0)
2751     //{
2752         //    if (element == _patternSequence[_filterPosition + 1])
2753         //        _filterPosition++;
2754         //    else
2755         //        return false;
2756     //}
2757     //if (_filterPosition < 0)
2758     //{
2759         //    if (element == _patternSequence[0])
2760         //        _filterPosition = 0;
2761     //}
2762 }
2763
2764 /// <summary>
2765 /// <para>
2766 /// Adds the all pattern matched to results using the specified sequences to match.
2767 /// </para>
2768 /// <para></para>
2769 /// </summary>
2770 /// <param name="sequencesToMatch">
2771 /// <para>The sequences to match.</para>
2772 /// </param>
2773 [MethodImpl(MethodImplOptions.AggressiveInlining)]
2774 public void AddAllPatternMatchedToResults(IEnumerable<ulong> sequencesToMatch)
2775 {
2776     foreach (var sequenceToMatch in sequencesToMatch)
2777     {
2778         if (PatternMatch(sequenceToMatch))
2779         {
2780             _results.Add(sequenceToMatch);
2781         }
2782     }
2783 }
2784 }
2785 }
2786 }
2787 }
2788 #endregion
2789 }
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,
32     /// то находятся любые структуры связей, которые содержат эти элементы именно в таком
33     /// ↪ порядке.
34     ///
35     /// Рост последовательности слева и справа.
36     /// Поиск со звёздочкой.
37     /// URL, PURL - реестр используемых во вне ссылок на ресурсы,
38     /// так же проблема может быть решена при реализации дистанционных триггеров.
39     /// Нужны ли уникальные указатели вообще?
40     /// Что если обращение к информации будет происходить через содержимое всегда?
41     ///
42     /// Писать тесты.
43     ///
44     /// Можно убрать зависимость от конкретной реализации Links,
45     /// на зависимость от абстрактного элемента, который может быть представлен несколькими
46     /// ↪ способами.
47     ///
48     /// Можно ли как-то сделать один общий интерфейс
49     ///
50     /// Блокчейн и/или гит для распределённой записи транзакций.
51     ///
52     /// </remarks>
53     public partial class Sequences : ILinks<LinkIndex> // IList<string>, IList<LinkIndex[]>
54     ↪ (после завершения реализации Sequences)
55     {
56         /// <summary>Возвращает значение LinkIndex, обозначающее любое количество
57         ↪ связей.</summary>
58         public const LinkIndex ZeroOrMany = LinkIndex.MaxValue;
59
60         /// <summary>
61         /// <para>
62         /// Gets the options value.
63         /// </para>
64         /// <para></para>
65         /// </summary>
66         public SequencesOptions<LinkIndex> Options { get; }
67
68         /// <summary>
69         /// <para>
70         /// Gets the links value.
71         /// </para>
72         /// <para></para>
73         /// </summary>
74         public SynchronizedLinks<LinkIndex> Links { get; }
75         private readonly ISynchronization _sync;
76
77         /// <summary>
78         /// <para>
79         /// Gets the constants value.
80         /// </para>
81         /// <para></para>
82         /// </summary>
83         public LinksConstants<LinkIndex> Constants { get; }
84
85         /// <summary>
86         /// <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(ICollection<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 /// <para></para>
257 /// </param>
258 /// <returns>
259 /// <para>The link index</para>
260 /// <para></para>
261 /// </returns>
262 [MethodImpl(MethodImplOptions.AggressiveInlining)]
263 public LinkIndex Create(IList<LinkIndex> restrictions)
264 {
265     return _sync.ExecuteWriteOperation(() =>
266     {
267         if (restrictions.IsNullOrEmpty())
268         {
269             return Constants.Null;
270         }
271         Links.EnsureInnerReferenceExists(restrictions, nameof(restrictions));
272         return CreateCore(restrictions);
273     });
274 }
275 [MethodImpl(MethodImplOptions.AggressiveInlining)]
276 private LinkIndex CreateCore(IList<LinkIndex> restrictions)
277 {
278     LinkIndex[] sequence = restrictions.SkipFirst();
279     if (Options.UseIndex)
280     {
281         Options.Index.Add(sequence);
282     }
283     var sequenceRoot = default(LinkIndex);
284     if (Options.EnforceSingleSequenceVersionOnWriteBasedOnExisting)
285     {
286         var matches = Each(restrictions);
287         if (matches.Count > 0)
288         {
289             sequenceRoot = matches[0];
290         }
291     }
292     else if (Options.EnforceSingleSequenceVersionOnWriteBasedOnNew)
293     {
294         return CompactCore(sequence);
295     }
296     if (sequenceRoot == default)
297     {
298         sequenceRoot = Options.LinksToSequenceConverter.Convert(sequence);
299     }
300     if (Options.UseSequenceMarker)
301     {
302         return Links.Unsync.GetOrCreate(Options.SequenceMarkerLink, sequenceRoot);
303     }
304     return sequenceRoot; // Возвращаем корень последовательности (т.е. сами элементы)
305 }
306 #endregion
307 #region Each
308
309 /// <summary>
310
311
312

```

```

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(IList<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                     {

```



```

387         link = sequenceLinkValues[Constants.TargetPart];
388     }
389 }
390 var sequence = Options.Walker.Walk(link).ToArray().ShiftRight();
391 sequence[0] = link;
392 return handler(sequence);
393 }
394 else if (restrictions.Count == 2)
395 {
396     throw new NotImplementedException();
397 }
398 else if (restrictions.Count == 3)
399 {
400     return Links.Unsync.Each(handler, restrictions);
401 }
402 else
403 {
404     var sequence = restrictions.SkipFirst();
405     if (Options.UseIndex && !Options.Index.MightContain(sequence))
406     {
407         return Constants.Break;
408     }
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 &&
547         ↪ !sequence.EqualTo(newSequence))
548     {
549         bestVariant = CompactCore(newSequence);
550     }
551     else
552     {
553         bestVariant = CreateCore(newSequence);
554     }
555     // TODO: Check all options only ones before loop execution
556     // Возможно нужно две версии Each, возвращающий фактические последовательности и с
557     ↪ маркером,
558     // или возможно даже возвращать и тот и тот вариант. С другой стороны все варианты
559     ↪ можно получить имея только фактические последовательности.
560     foreach (var variant in Each(sequence))
561     {
562         if (variant != bestVariant)
563         {
564             UpdateOneCore(variant, bestVariant);
565         }
566     }
567     return bestVariant;
568 }
569 [MethodImpl(MethodImplOptions.AggressiveInlining)]
570 private void UpdateOneCore(LinkIndex sequence, LinkIndex newSequence)
571 {
572     if (Options.UseGarbageCollection)
573     {
574         var sequenceElements = GetSequenceElements(sequence);
575         var sequenceElementsContents = new Link<ulong>(Links.GetLink(sequenceElements));
576         var sequenceLink = GetSequenceByElements(sequenceElements);
577         var newSequenceElements = GetSequenceElements(newSequence);
578         var newSequenceLink = GetSequenceByElements(newSequenceElements);
579         if (Options.UseCascadeUpdate || CountUsages(sequence) == 0)
580         {
581             if (sequenceLink != Constants.Null)
582             {
583                 Links.Unsync.MergeAndDelete(sequenceLink, newSequenceLink);
584             }
585             Links.Unsync.MergeAndDelete(sequenceElements, newSequenceElements);
586         }
587         ClearGarbage(sequenceElementsContents.Source);
588         ClearGarbage(sequenceElementsContents.Target);
589     }
590     else
591     {
592         if (Options.UseSequenceMarker)
593         {
594             var sequenceElements = GetSequenceElements(sequence);
595             var sequenceLink = GetSequenceByElements(sequenceElements);
596             var newSequenceElements = GetSequenceElements(newSequence);
597             var newSequenceLink = GetSequenceByElements(newSequenceElements);
598             if (Options.UseCascadeUpdate || CountUsages(sequence) == 0)
599             {
600                 if (sequenceLink != Constants.Null)
601                 {
602                     Links.Unsync.MergeAndDelete(sequenceLink, newSequenceLink);
603                 }
604                 Links.Unsync.MergeAndDelete(sequenceElements, newSequenceElements);
605             }
606         }
607     }

```

```

603     }
604     else
605     {
606         if (Options.UseCascadeUpdate || CountUsages(sequence) == 0)
607         {
608             Links.Unsync.MergeAndDelete(sequence, newSequence);
609         }
610     }
611 }
612 }
613
614 #endregion
615
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 }

```

```

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 /// <para></para>

```

```

758     /// </summary>
759     /// <param name="handler">
760     /// <para>The handler.</para>
761     /// <para></para>
762     /// </param>
763     /// <param name="sequence">
764     /// <para>The sequence.</para>
765     /// <para></para>
766     /// </param>
767     /// <returns>
768     /// <para>The bool</para>
769     /// <para></para>
770     /// </returns>
771     [MethodImpl(MethodImplOptions.AggressiveInlining)]
772     public bool EachPart(Func<LinkIndex, bool> handler, LinkIndex sequence)
773     {
774         return _sync.ExecuteReadOperation(() =>
775         {
776             var links = Links.Unsync;
777             foreach (var part in Options.Walker.Walk(sequence))
778             {
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         {

```

```

835     _sequences = sequences;
836     _patternSequence = patternSequence;
837     _linksInSequence = new HashSet<LinkIndex>(patternSequence.Where(x => x !=
    ↳ _links.Constants.Any && x != ZeroOrMany));
838     _results = results;
839     _stopableHandler = stopableHandler;
840     _readAsElements = readAsElements;
841 }
842
843 /// <summary>
844 /// <para>
845 /// Determines whether this instance is element.
846 /// </para>
847 /// <para></para>
848 /// </summary>
849 /// <param name="link">
850 /// <para>The link.</para>
851 /// <para></para>
852 /// </param>
853 /// <returns>
854 /// <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(ICollection<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(ICollection<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(ICollection<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;

```



```

988     }
989     }
990     return _filterPosition == _patternSequence.Count - 1;
991 }
992 [MethodImpl(MethodImplOptions.AggressiveInlining)]
993 private bool PartialMatchCore(LinkIndex element)
994 {
995     if (_filterPosition == (_patternSequence.Count - 1))
996     {
997         return false; // Нашлось
998     }
999     if (_filterPosition >= 0)
1000     {
1001         if (element == _patternSequence[_filterPosition + 1])
1002         {
1003             _filterPosition++;
1004         }
1005         else
1006         {
1007             _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     /// <para></para>
1096     /// </param>
1097     [MethodImpl(MethodImplOptions.AggressiveInlining)]
1098     public void AddAllPartialMatchedToResultsAndReadAsElements(IEnumerable<LinkIndex>
1099     ↪ sequencesToMatch)
1100     {
1101         foreach (var sequenceToMatch in sequencesToMatch)
1102         {
1103             if (PartialMatch(sequenceToMatch))
1104             {
1105                 _readAsElements.Add(sequenceToMatch);
1106                 _results.Add(sequenceToMatch);
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="TLink">
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 TLink Create<TLink>(this ILinks<TLink> sequences, IList<TLink[]>
    ↪ groupedSequence)
41     {
42         var finalSequence = new TLink[groupedSequence.Count];
43         for (var i = 0; i < finalSequence.Length; i++)
44         {
45             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="TLink">
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<TLink> ToList<TLink>(this ILinks<TLink> sequences, TLink sequence)
75     {
76         var list = new List<TLink>();
77         var filler = new ListFiller<TLink, TLink>(list, sequences.Constants.Break);
78         sequences.Each(filler.AddSkipFirstAndReturnConstant, new
    ↪ LinkAddress<TLink>(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<TLink> // TODO: To use type parameter <TLink> the
    ↳ ILinks<TLink> must contain GetConstants function.
25  {
26      private static readonly EqualityComparer<TLink> _equalityComparer =
    ↳ EqualityComparer<TLink>.Default;
27
28      /// <summary>
29      /// <para>
30      /// Gets or sets the sequence marker link value.
31      /// </para>
32      /// <para></para>
33      /// </summary>
34      public TLink 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<TLink> 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<TLink>, TLink> 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<TLink> 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<TLink> 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<TLink> 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
                ↪ link.");
260             }
261         }
262     }
263     if (MarkedSequenceMatcher == null)
264     {
265         MarkedSequenceMatcher = new MarkedSequenceCriterionMatcher<TLink>(links,
                ↪ SequenceMarkerLink);
266     }
267 }
268 var balancedVariantConverter = new BalancedVariantConverter<TLink>(links);
269 if (UseCompression)
270 {
271     if (LinksToSequenceConverter == null)
272     {
273         ICounter<TLink, TLink> totalSequenceSymbolFrequencyCounter;
274         if (UseSequenceMarker)
275         {
276             totalSequenceSymbolFrequencyCounter = new
                ↪ TotalMarkedSequenceSymbolFrequencyCounter<TLink>(links,
                ↪ MarkedSequenceMatcher);
277         }
278         else
279         {
280             totalSequenceSymbolFrequencyCounter = new
                ↪ TotalSequenceSymbolFrequencyCounter<TLink>(links);
281         }
282         var doubletFrequenciesCache = new LinkFrequenciesCache<TLink>(links,
                ↪ totalSequenceSymbolFrequencyCounter);
283         var compressingConverter = new CompressingConverter<TLink>(links,
                ↪ balancedVariantConverter, doubletFrequenciesCache);
284         LinksToSequenceConverter = compressingConverter;
285     }
286 }
287 else
288 {
289     if (LinksToSequenceConverter == null)
290     {
291         LinksToSequenceConverter = balancedVariantConverter;
292     }
293 }
294 if (UseIndex && Index == null)
295 {
296     Index = new SequenceIndex<TLink>(links);
297 }
298 if (Walker == null)
299 {
300     Walker = new RightSequenceWalker<TLink>(links, new DefaultStack<TLink>());
301 }
302 }
303
304 /// <summary>
305 /// <para>
306 /// Validates the options.
307 /// </para>
308 /// <para></para>
309 /// </summary>
310 /// <exception cref="NotSupportedException">
311 /// <para>To use garbage collection UseSequenceMarker option must be on.</para>
312 /// <para></para>
313 /// </exception>
314 [MethodImpl(MethodImplOptions.AggressiveInlining)]
315 public void ValidateOptions()
316 {
317     if (UseGarbageCollection && !UseSequenceMarker)
318     {
319         throw new NotSupportedException("To use garbage collection UseSequenceMarker
                ↪ option must be on.");
320     }
321 }
322 }
323 }

```

## 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, TLink}" />
16     public class DateTimeToLongRawNumberSequenceConverter<TLink> : IConverter<DateTime, TLink>
17     {
18         private readonly IConverter<long, TLink> _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, TLink>
32             ↪ int64ToLongRawNumberConverter) => _int64ToLongRawNumberConverter =
33             ↪ int64ToLongRawNumberConverter;
34
35         /// <summary>
36         /// <para>
37         /// Converts the source.
38         /// </para>
39         /// <para></para>
40         /// </summary>
41         /// <param name="source">
42         /// <para>The source.</para>
43         /// <para></para>
44         /// </param>
45         /// <returns>
46         /// <para>The link</para>
47         /// <para></para>
48         /// </returns>
49         [MethodImpl(MethodImplOptions.AggressiveInlining)]
50         public TLink Convert(DateTime source) =>
51             ↪ _int64ToLongRawNumberConverter.Convert(source.ToFileTimeUtc());
52     }
53 }

```

## 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{TLink, DateTime}" />
16     public class LongRawNumberSequenceToDateTimeConverter<TLink> : IConverter<TLink, DateTime>
17     {
18         private readonly IConverter<TLink, 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<TLink, 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(TLink source) =>
        ↪ DateTime.FromFileTimeUtc(_longRawNumberConverterToInt64.Convert(source));
49 }
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{TLink}"/>
15  /// <seealso cref="IConverter{char, TLink}"/>
16  public class CharToUnicodeSymbolConverter<TLink> : LinksOperatorBase<TLink>,
    ↪ IConverter<char, TLink>
17  {
18      private static readonly UncheckedConverter<char, TLink> _charToAddressConverter =
    ↪ UncheckedConverter<char, TLink>.Default;
19      private readonly IConverter<TLink> _addressToNumberConverter;
20      private readonly TLink _unicodeSymbolMarker;
21
22      /// <summary>
23      /// <para>
24      /// Initializes a new <see cref="CharToUnicodeSymbolConverter"/> 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="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<TLink> links, IConverter<TLink>
    ↪ addressToNumberConverter, TLink unicodeSymbolMarker) : base(links)
42      {
43          _addressToNumberConverter = addressToNumberConverter;
44          _unicodeSymbolMarker = unicodeSymbolMarker;
45      }
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 TLink Convert(char source)
63      {
64          var unaryNumber =
    ↪ _addressToNumberConverter.Convert(_charToAddressConverter.Convert(source));
65          return _links.GetOrCreate(unaryNumber, _unicodeSymbolMarker);
66      }
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{TLink}"/>
17     /// <seealso cref="IConverter{string, TLink}"/>

```

```

18 public class StringToUnicodeSequenceConverter<TLink> : LinksOperatorBase<TLink>,
    ↳ IConverter<string, TLink>
19 {
20     private readonly IConverter<string, IList<TLink>> _stringToUnicodeSymbolListConverter;
21     private readonly IConverter<IList<TLink>, TLink> _unicodeSymbolListToSequenceConverter;
22
23     /// <summary>
24     /// <para>
25     /// Initializes a new <see cref="StringToUnicodeSequenceConverter"/> instance.
26     /// </para>
27     /// <para></para>
28     /// </summary>
29     /// <param name="links">
30     /// <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<TLink> links, IConverter<string,
    ↳ IList<TLink>> stringToUnicodeSymbolListConverter, IConverter<IList<TLink>, TLink>
    ↳ 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<TLink> links, IConverter<string,
    ↳ IList<TLink>> stringToUnicodeSymbolListConverter, ISequenceIndex<TLink> index,
    ↳ IConverter<IList<TLink>, TLink> listToSequenceLinkConverter, TLink
    ↳ unicodeSequenceMarker)
76     : this(links, stringToUnicodeSymbolListConverter, new
    ↳ UnicodeSymbolsListToUnicodeSequenceConverter<TLink>(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>
91     /// </param>
92     /// <param name="index">
93     /// <para>A index.</para>
94     /// </para>
95     /// </param>
96     /// <param name="listToSequenceLinkConverter">
97     /// <para>A list to sequence link converter.</para>
98     /// </para>
99     /// </param>
100    /// <param name="unicodeSequenceMarker">
101    /// <para>A unicode sequence marker.</para>
102    /// </para>
103    /// </param>
104    [MethodImpl(MethodImplOptions.AggressiveInlining)]
105    public StringToUnicodeSequenceConverter(ILinks<TLink> links, IConverter<char, TLink>
        ↪ charToUnicodeSymbolConverter, ISequenceIndex<TLink> index, IConverter<IList<TLink>,
        ↪ TLink> listToSequenceLinkConverter, TLink unicodeSequenceMarker)
106        : this(links, new
            ↪ StringToUnicodeSymbolsListConverter<TLink>(charToUnicodeSymbolConverter), index,
            ↪ listToSequenceLinkConverter, unicodeSequenceMarker) { }

107
108    /// <summary>
109    /// <para>
110    /// Initializes a new <see cref="StringToUnicodeSequenceConverter"/> instance.
111    /// </para>
112    /// </para>
113    /// </summary>
114    /// <param name="links">
115    /// <para>A links.</para>
116    /// </para>
117    /// </param>
118    /// <param name="charToUnicodeSymbolConverter">
119    /// <para>A char to unicode symbol converter.</para>
120    /// </para>
121    /// </param>
122    /// <param name="listToSequenceLinkConverter">
123    /// <para>A list to sequence link converter.</para>
124    /// </para>
125    /// </param>
126    /// <param name="unicodeSequenceMarker">
127    /// <para>A unicode sequence marker.</para>
128    /// </para>
129    /// </param>
130    [MethodImpl(MethodImplOptions.AggressiveInlining)]
131    public StringToUnicodeSequenceConverter(ILinks<TLink> links, IConverter<char, TLink>
        ↪ charToUnicodeSymbolConverter, IConverter<IList<TLink>, TLink>
        ↪ listToSequenceLinkConverter, TLink unicodeSequenceMarker)
132        : this(links, charToUnicodeSymbolConverter, new Unindex<TLink>(),
            ↪ listToSequenceLinkConverter, unicodeSequenceMarker) { }

133
134    /// <summary>
135    /// <para>
136    /// Initializes a new <see cref="StringToUnicodeSequenceConverter"/> instance.
137    /// </para>
138    /// </para>
139    /// </summary>
140    /// <param name="links">
141    /// <para>A links.</para>
142    /// </para>
143    /// </param>
144    /// <param name="stringToUnicodeSymbolListConverter">
145    /// <para>A string to unicode symbol list converter.</para>
146    /// </para>
147    /// </param>
148    /// <param name="listToSequenceLinkConverter">
149    /// <para>A list to sequence link converter.</para>
150    /// </para>
151    /// </param>
152    /// <param name="unicodeSequenceMarker">
153    /// <para>A unicode sequence marker.</para>
154    /// </para>
155    /// </param>
156    [MethodImpl(MethodImplOptions.AggressiveInlining)]

```

```

157     public StringToUnicodeSequenceConverter(ILinks<TLink> links, IConverter<string,
    ↪     IList<TLink>> stringToUnicodeSymbolListConverter, IConverter<IList<TLink>, TLink>
    ↪     listToSequenceLinkConverter, TLink unicodeSequenceMarker)
158         : this(links, stringToUnicodeSymbolListConverter, new Unindex<TLink>(),
    ↪         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 TLink 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{TLink}}"/>
16     public class StringToUnicodeSymbolsListConverter<TLink> : IConverter<string, IList<TLink>>
17     {
18         private readonly IConverter<char, TLink> _charToUnicodeSymbolConverter;
19
20         /// <summary>
21         /// <para>
22         /// Initializes a new <see cref="StringToUnicodeSymbolsListConverter"/> instance.
23         /// </para>
24         /// <para></para>
25         /// </summary>
26         /// <param name="charToUnicodeSymbolConverter">
27         /// <para>A char to unicode symbol converter.</para>
28         /// <para></para>
29         /// </param>
30         [MethodImpl(MethodImplOptions.AggressiveInlining)]
31         public StringToUnicodeSymbolsListConverter(IConverter<char, TLink>
    ↪         charToUnicodeSymbolConverter) => _charToUnicodeSymbolConverter =
    ↪         charToUnicodeSymbolConverter;
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 elements.</para>
45         /// <para></para>
46         /// </returns>

```

```

47     [MethodImpl(MethodImplOptions.AggressiveInlining)]
48     public IList<TLink> Convert(string source)
49     {
50         var elements = new TLink[source.Length];
51         for (var i = 0; i < elements.Length; i++)
52         {
53             elements[i] = _charToUnicodeSymbolConverter.Convert(source[i]);
54         }
55         return elements;
56     }
57 }
58 }

```

## 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.

```

```

142    /// </para>
143    /// <para></para>
144    /// </summary>
145    /// <param name="link">
146    /// <para>The link.</para>
147    /// <para></para>
148    /// </param>
149    /// <returns>
150    /// <para>The char</para>
151    /// <para></para>
152    /// </returns>
153    [MethodImpl(MethodImplOptions.AggressiveInlining)]
154    public static char FromLinkToChar(ulong link) => (char)(link - 1);
155
156    /// <summary>
157    /// <para>
158    /// Determines whether is char link.
159    /// </para>
160    /// <para></para>
161    /// </summary>
162    /// <param name="link">
163    /// <para>The link.</para>
164    /// <para></para>
165    /// </param>
166    /// <returns>
167    /// <para>The bool</para>
168    /// <para></para>
169    /// </returns>
170    [MethodImpl(MethodImplOptions.AggressiveInlining)]
171    public static bool IsCharLink(ulong link) => link <= MapSize;
172
173    /// <summary>
174    /// <para>
175    /// Creates the links to string using the specified links list.
176    /// </para>
177    /// <para></para>
178    /// </summary>
179    /// <param name="linksList">
180    /// <para>The links list.</para>
181    /// <para></para>
182    /// </param>
183    /// <returns>
184    /// <para>The string</para>
185    /// <para></para>
186    /// </returns>
187    [MethodImpl(MethodImplOptions.AggressiveInlining)]
188    public static string FromLinksToString(IList<ulong> linksList)
189    {
190        var sb = new StringBuilder();
191        for (int i = 0; i < linksList.Count; i++)
192        {
193            sb.Append(FromLinkToChar(linksList[i]));
194        }
195        return sb.ToString();
196    }
197
198    /// <summary>
199    /// <para>
200    /// Creates the sequence link to string using the specified link.
201    /// </para>
202    /// <para></para>
203    /// </summary>
204    /// <param name="link">
205    /// <para>The link.</para>
206    /// <para></para>
207    /// </param>
208    /// <param name="links">
209    /// <para>The links.</para>
210    /// <para></para>
211    /// </param>
212    /// <returns>
213    /// <para>The string</para>
214    /// <para></para>
215    /// </returns>
216    [MethodImpl(MethodImplOptions.AggressiveInlining)]
217    public static string FromSequenceLinkToString(ulong link, ILinks<ulong> links)
218    {
219        var sb = new StringBuilder();

```



```

220     if (links.Exists(link))
221     {
222         StopableSequenceWalker.WalkRight(link, links.GetSource, links.GetTarget,
223             x => x <= MapSize || links.GetSource(x) == x || links.GetTarget(x) == x,
224             element =>
225             {
226                 sb.Append(FromLinkToChar(element));
227                 return true;
228             }
229         return sb.ToString();
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,
248         ↪ chars.Length);
249
250     /// <summary>
251     /// <para>
252     /// Creates the chars to link array using the specified chars.
253     /// </para>
254     /// <para></para>
255     /// </summary>
256     /// <param name="chars">
257     /// <para>The chars.</para>
258     /// <para></para>
259     /// </param>
260     /// <param name="count">
261     /// <para>The count.</para>
262     /// <para></para>
263     /// </param>
264     /// <returns>
265     /// <para>The links sequence.</para>
266     /// <para></para>
267     /// </returns>
268     [MethodImpl(MethodImplOptions.AggressiveInlining)]
269     public static ulong[] FromCharsToLinkArray(char[] chars, int count)
270     {
271         // char array to ulong array
272         var linksSequence = new ulong[count];
273         for (var i = 0; i < count; i++)
274         {
275             linksSequence[i] = FromCharToLink(chars[i]);
276         }
277         return linksSequence;
278     }
279
280     /// <summary>
281     /// <para>
282     /// Creates the string to link array using the specified sequence.
283     /// </para>
284     /// <para></para>
285     /// </summary>
286     /// <param name="sequence">
287     /// <para>The sequence.</para>
288     /// <para></para>
289     /// </param>
290     /// <returns>
291     /// <para>The links sequence.</para>
292     /// <para></para>
293     /// </returns>
294     [MethodImpl(MethodImplOptions.AggressiveInlining)]
295     public static ulong[] FromStringToLinkArray(string sequence)

```

```

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
349 /// <summary>
350 /// <para>
351 /// Creates the link array to link array groups using the specified array.
352 /// </para>
353 /// <para></para>
354 /// </summary>
355 /// <param name="array">
356 /// <para>The array.</para>
357 /// <para></para>
358 /// </param>
359 /// <returns>
360 /// <para>The result.</para>
361 /// <para></para>
362 /// </returns>
363 [MethodImpl(MethodImplOptions.AggressiveInlining)]
364 public static List<ulong[]> FromLinkArrayToLinkArrayGroups(ulong[] array)
365 {
366     var result = new List<ulong[]>();
367     var offset = 0;
368     while (offset < array.Length)
369     {
370         var relativeLength = 1;
371         if (array[offset] <= LastCharLink)
372         {
373             var currentCategory =
374                 CharUnicodeInfo.GetUnicodeCategory(FromLinkToChar(array[offset]));

```

```

373         var absoluteLength = offset + relativeLength;
374         while (absoluteLength < array.Length &&
375             array[absoluteLength] <= LastCharLink &&
376             currentCategory == CharUnicodeInfo.GetUnicodeCategory(FromLinkToChar(
377                 ↪ array[absoluteLength])))
378         {
379             relativeLength++;
380             absoluteLength++;
381         }
382     else
383     {
384         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{TLink}" />
19     /// <seealso cref="IConverter{TLink, string}" />
20     public class UnicodeSequenceToStringConverter<TLink> : LinksOperatorBase<TLink>,
21         ↪ IConverter<TLink, string>
22     {
23         private readonly ICriterionMatcher<TLink> _unicodeSequenceCriterionMatcher;
24         private readonly ISequenceWalker<TLink> _sequenceWalker;
25         private readonly IConverter<TLink, 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">

```

```

45     /// <para>A unicode symbol to char converter.</para>
46     /// <para></para>
47     /// </param>
48     [MethodImpl(MethodImplOptions.AggressiveInlining)]
49     public UnicodeSequenceToStringConverter(ILinks<TLink> links, ICriterionMatcher<TLink>
        ↳ unicodeSequenceCriterionMatcher, ISequenceWalker<TLink> sequenceWalker,
        ↳ IConverter<TLink, char> unicodeSymbolToCharConverter) : base(links)
50     {
51         _unicodeSequenceCriterionMatcher = unicodeSequenceCriterionMatcher;
52         _sequenceWalker = sequenceWalker;
53         _unicodeSymbolToCharConverter = unicodeSymbolToCharConverter;
54     }
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(TLink 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{TLink}">
17     /// <seealso cref="IConverter{TLink, char}">
18     public class UnicodeSymbolToCharConverter<TLink> : LinksOperatorBase<TLink>,
        ↳ IConverter<TLink, char>
19     {
20         private static readonly UncheckedConverter<TLink, char> _addressToCharConverter =
            ↳ UncheckedConverter<TLink, char>.Default;
21         private readonly IConverter<TLink> _numberToAddressConverter;
22         private readonly ICriterionMatcher<TLink> _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<TLink> links, IConverter<TLink>
        ↳ numberToAddressConverter, ICriterionMatcher<TLink> 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(TLink 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{TLink}"/>
17     /// <seealso cref="IConverter{IList{TLink}, TLink}"/>
18     public class UnicodeSymbolsListToUnicodeSequenceConverter<TLink> : LinksOperatorBase<TLink>,
        ↳ IConverter<IList<TLink>, TLink>
19     {
20         private readonly ISequenceIndex<TLink> _index;

```

```

21 private readonly IConverter<IList<TLink>, TLink> _listToSequenceLinkConverter;
22 private readonly TLink _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<TLink> links,
    ↳ ISequenceIndex<TLink> index, IConverter<IList<TLink>, TLink>
    ↳ listToSequenceLinkConverter, TLink unicodeSequenceMarker) : base(links)
48 {
49     _index = index;
50     _listToSequenceLinkConverter = listToSequenceLinkConverter;
51     _unicodeSequenceMarker = unicodeSequenceMarker;
52 }
53
54 /// <summary>
55 /// <para>
56 /// Initializes a new <see cref="UnicodeSymbolsListToUnicodeSequenceConverter"/>
    ↳ instance.
57 /// </para>
58 /// <para></para>
59 /// </summary>
60 /// <param name="links">
61 /// <para>A links.</para>
62 /// <para></para>
63 /// </param>
64 /// <param name="listToSequenceLinkConverter">
65 /// <para>A list to sequence link converter.</para>
66 /// <para></para>
67 /// </param>
68 /// <param name="unicodeSequenceMarker">
69 /// <para>A unicode sequence marker.</para>
70 /// <para></para>
71 /// </param>
72 [MethodImpl(MethodImplOptions.AggressiveInlining)]
73 public UnicodeSymbolsListToUnicodeSequenceConverter(ILinks<TLink> links,
    ↳ IConverter<IList<TLink>, TLink> listToSequenceLinkConverter, TLink
    ↳ unicodeSequenceMarker)
74 : this(links, new Unindex<TLink>(), listToSequenceLinkConverter,
    ↳ unicodeSequenceMarker) { }
75
76 /// <summary>
77 /// <para>
78 /// Converts the list.
79 /// </para>
80 /// <para></para>
81 /// </summary>
82 /// <param name="list">
83 /// <para>The list.</para>
84 /// <para></para>
85 /// </param>
86 /// <returns>
87 /// <para>The link</para>
88 /// <para></para>
89 /// </returns>
90 [MethodImpl(MethodImplOptions.AggressiveInlining)]
91 public TLink Convert(IList<TLink> list)

```

```

92     {
93         _index.Add(list);
94         var sequence = _listToSequenceLinkConverter.Convert(list);
95         return _links.GetOrCreate(sequence, _unicodeSequenceMarker);
96     }
97 }
98 }

```

#### 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<TLink>
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<TLink> Walk(TLink 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{TLink}">
17     public class LeftSequenceWalker<TLink> : SequenceWalkerBase<TLink>
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<TLink> links, IStack<TLink> stack, Func<TLink, bool>
        ↪ isElement) : base(links, stack, isElement) { }
39
40     /// <summary>
41     /// <para>
42     ///     Initializes a new <see cref="LeftSequenceWalker"/> 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 LeftSequenceWalker(ILinks<TLink> links, IStack<TLink> stack) : base(links, stack,
        ↪ links.IsPartialPoint) { }
56
57     /// <summary>
58     /// <para>
59     ///     Gets the next element after pop using the specified element.
60     /// </para>
61     /// <para></para>
62     /// </summary>
63     /// <param name="element">
64     /// <para>The element.</para>
65     /// <para></para>
66     /// </param>
67     /// <returns>
68     /// <para>The link</para>
69     /// <para></para>
70     /// </returns>
71     [MethodImpl(MethodImplOptions.AggressiveInlining)]
72     protected override TLink GetNextElementAfterPop(TLink element) =>
        ↪ _links.GetSource(element);
73
74     /// <summary>
75     /// <para>
76     ///     Gets the next element after push using the specified element.
77     /// </para>
78     /// <para></para>
79     /// </summary>
80     /// <param name="element">
81     /// <para>The element.</para>
82     /// <para></para>
83     /// </param>
84     /// <returns>
85     /// <para>The link</para>
86     /// <para></para>
87     /// </returns>
88     [MethodImpl(MethodImplOptions.AggressiveInlining)]
89     protected override TLink GetNextElementAfterPush(TLink element) =>
        ↪ _links.GetTarget(element);
90
91     /// <summary>
92     /// <para>
93     ///     Walks the contents using the specified element.
94     /// </para>
95     /// <para></para>
96     /// </summary>
97     /// <param name="element">
98     /// <para>The element.</para>
99     /// <para></para>
100    /// </param>
101    /// <returns>
102    /// <para>An enumerable of t link</para>
103    /// <para></para>
104    /// </returns>
105    [MethodImpl(MethodImplOptions.AggressiveInlining)]
106    protected override IEnumerable<TLink> WalkContents(TLink element)
107    {
108        var links = _links;

```



```

109     var parts = links.GetLink(element);
110     var start = links.Constants.SourcePart;
111     for (var i = parts.Count - 1; i >= start; i--)
112     {
113         var part = parts[i];
114         if (IsElement(part))
115         {
116             yield return part;
117         }
118     }
119 }
120 }
121 }

```

## 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{TLink}">
21     /// <seealso cref="ISequenceWalker{TLink}">
22     public class LeveledSequenceWalker<TLink> : LinksOperatorBase<TLink>, ISequenceWalker<TLink>
23     {
24         private static readonly EqualityComparer<TLink> _equalityComparer =
25             EqualityComparer<TLink>.Default;
26         private readonly Func<TLink, bool> _isElement;
27
28         /// <summary>
29         /// <para>
30         /// Initializes a new <see cref="LeveledSequenceWalker"> 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="isElement">
39         /// <para>A is element.</para>
40         /// <para></para>
41         /// </param>
42         [MethodImpl(MethodImplOptions.AggressiveInlining)]
43         public LeveledSequenceWalker(ILinks<TLink> links, Func<TLink, bool> isElement) :
44             base(links) => _isElement = isElement;
45
46         /// <summary>
47         /// <para>
48         /// Initializes a new <see cref="LeveledSequenceWalker"> instance.
49         /// </para>
50         /// <para></para>
51         /// </summary>
52         /// <param name="links">
53         /// <para>A links.</para>
54         /// <para></para>
55         /// </param>
56         [MethodImpl(MethodImplOptions.AggressiveInlining)]
57         public LeveledSequenceWalker(ILinks<TLink> links) : base(links) => _isElement =
58             links.IsPartialPoint;
59
60         /// <summary>
61         /// <para>
62         /// Walks the sequence.
63         /// </para>
64         /// <para></para>

```

```

62     /// </summary>
63     /// <param name="sequence">
64     /// <para>The sequence.</para>
65     /// <para></para>
66     /// </param>
67     /// <returns>
68     /// <para>An enumerable of t link</para>
69     /// <para></para>
70     /// </returns>
71     [MethodImpl(MethodImplOptions.AggressiveInlining)]
72     public IEnumerable<TLink> Walk(TLink sequence) => ToArray(sequence);
73
74     /// <summary>
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 TLink[] ToArray(TLink sequence)
90     {
91         var length = 1;
92         var array = new TLink[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 TLink[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 TLink[] CopyFilledElements(TLink[] array, int filledElementsCount)
155 {
156     var finalArray = new TLink[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(TLink[] 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{TLink}" />
17     public class RightSequenceWalker<TLink> : SequenceWalkerBase<TLink>
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<TLink> links, IStack<TLink> stack, Func<TLink, 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<TLink> links, IStack<TLink> stack) : base(links,
    ↪ stack, links.IsPartialPoint) { }
56
57    /// <summary>
58    /// <para>
59    /// Gets the next element after pop using the specified element.
60    /// </para>
61    /// <para></para>
62    /// </summary>
63    /// <param name="element">
64    /// <para>The element.</para>
65    /// <para></para>
66    /// </param>
67    /// <returns>
68    /// <para>The link</para>
69    /// <para></para>
70    /// </returns>
71    [MethodImpl(MethodImplOptions.AggressiveInlining)]
72    protected override TLink GetNextElementAfterPop(TLink element) =>
    ↪ _links.GetTarget(element);
73
74    /// <summary>
75    /// <para>
76    /// Gets the next element after push using the specified element.
77    /// </para>
78    /// <para></para>
79    /// </summary>
80    /// <param name="element">
81    /// <para>The element.</para>
82    /// <para></para>
83    /// </param>
84    /// <returns>
85    /// <para>The link</para>
86    /// <para></para>
87    /// </returns>
88    [MethodImpl(MethodImplOptions.AggressiveInlining)]
89    protected override TLink GetNextElementAfterPush(TLink element) =>
    ↪ _links.GetSource(element);
90
91    /// <summary>
92    /// <para>
93    /// Walks the contents using the specified element.
94    /// </para>
95    /// <para></para>
96    /// </summary>
97    /// <param name="element">
98    /// <para>The element.</para>
99    /// <para></para>
100    /// </param>
101    /// <returns>
102    /// <para>An enumerable of t link</para>
103    /// <para></para>
104    /// </returns>
105    [MethodImpl(MethodImplOptions.AggressiveInlining)]
106    protected override IEnumerable<TLink> WalkContents(TLink element)
107    {

```

```

108         var parts = _links.GetLink(element);
109         for (var i = _links.Constants.SourcePart; i < parts.Count; i++)
110         {
111             var part = parts[i];
112             if (IsElement(part))
113             {
114                 yield return part;
115             }
116         }
117     }
118 }
119 }

```

## 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{TLink}" />
17     /// <seealso cref="ISequenceWalker{TLink}" />
18     public abstract class SequenceWalkerBase<TLink> : LinksOperatorBase<TLink>,
19     ↪ ISequenceWalker<TLink>
20     {
21         private readonly IStack<TLink> _stack;
22         private readonly Func<TLink, 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         /// <para></para>
33         /// </param>
34         /// <param name="stack">
35         /// <para>A stack.</para>
36         /// <para></para>
37         /// </param>
38         /// <param name="isElement">
39         /// <para>A is element.</para>
40         /// <para></para>
41         /// </param>
42         [MethodImpl(MethodImplOptions.AggressiveInlining)]
43         protected SequenceWalkerBase(ILinks<TLink> links, IStack<TLink> stack, Func<TLink, bool>
44         ↪ isElement) : base(links)
45         {
46             _stack = stack;
47             _isElement = isElement;
48         }
49
50         /// <summary>
51         /// <para>
52         /// Initializes a new <see cref="SequenceWalkerBase" /> instance.
53         /// </para>
54         /// <para></para>
55         /// </summary>
56         /// <param name="links">
57         /// <para>A links.</para>
58         /// <para></para>
59         /// </param>
60         /// <param name="stack">
61         /// <para>A stack.</para>
62         /// <para></para>
63         /// </param>
64         [MethodImpl(MethodImplOptions.AggressiveInlining)]

```

```

63     protected SequenceWalkerBase(ILinks<TLink> links, IStack<TLink> stack) : this(links,
64         ↪ stack, links.IsPartialPoint) { }
65
66     /// <summary>
67     /// <para>
68     /// Walks the sequence.
69     /// </para>
70     /// <para></para>
71     /// </summary>
72     /// <param name="sequence">
73     /// <para>The sequence.</para>
74     /// <para></para>
75     /// </param>
76     /// <returns>
77     /// <para>An enumerable of t link</para>
78     /// <para></para>
79     /// </returns>
80     [MethodImpl(MethodImplOptions.AggressiveInlining)]
81     public IEnumerable<TLink> Walk(TLink sequence)
82     {
83         _stack.Clear();
84         var element = sequence;
85         if (IsElement(element))
86         {
87             yield return element;
88         }
89         else
90         {
91             while (true)
92             {
93                 if (IsElement(element))
94                 {
95                     if (_stack.IsEmpty)
96                     {
97                         break;
98                     }
99                     element = _stack.Pop();
100                     foreach (var output in WalkContents(element))
101                     {
102                         yield return output;
103                     }
104                     element = GetNextElementAfterPop(element);
105                 }
106                 else
107                 {
108                     _stack.Push(element);
109                     element = GetNextElementAfterPush(element);
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(TLink 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 TLink GetNextElementAfterPop(TLink 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 TLink GetNextElementAfterPush(TLink 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<TLink> WalkContents(TLink 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 TLink = System.UInt64;
11
12 namespace Platform.Data.Doublets.Sequences.Tests
13 {
14     public class BigIntegerConvertersTests
15     {
16         public ILinks<TLink> CreateLinks() => CreateLinks<TLink>(new IO.TemporaryFile());
17
18         public ILinks<TLink> CreateLinks<TLink>(string dataDbFilename)
19         {
20             var linksConstants = new LinksConstants<TLink>(enableExternalReferencesSupport:
21                 ↪ true);
22             return new UnitedMemoryLinks<TLink>(new
23                 ↪ FileMappedResizableDirectMemory(dataDbFilename),
24                 ↪ UnitedMemoryLinks<TLink>.DefaultLinksSizeStep, linksConstants,
25                 ↪ IndexTreeType.Default);
26         }
27
28         [Fact]
29         public void DecimalMaxValueTest()
30         {
31             var links = CreateLinks();
32             BigInteger bigInteger = new(decimal.MaxValue);
33             TLink negativeNumberMarker = links.Create();
34             AddressToRawNumberConverter<TLink> addressToRawNumberConverter = new();

```

```

31     RawNumberToAddressConverter<TLink> numberToAddressConverter = new();
32     BalancedVariantConverter<TLink> listToSequenceConverter = new(links);
33     BigIntegerToRawNumberSequenceConverter<TLink> bigIntegerToRawNumberSequenceConverter
    ↪ = new(links, addressToRawNumberConverter, listToSequenceConverter,
    ↪ negativeNumberMarker);
34     RawNumberSequenceToBigIntegerConverter<TLink> rawNumberSequenceToBigIntegerConverter
    ↪ = new(links, numberToAddressConverter, negativeNumberMarker);
35     var bigIntSequence = bigIntegerToRawNumberSequenceConverter.Convert(bigInteger);
36     var bigIntFromSequence =
    ↪ rawNumberSequenceToBigIntegerConverter.Convert(bigIntSequence);
37     Assert.Equal(bigInteger, bigIntFromSequence);
38 }
39
40 [Fact]
41 public void DecimalMinValueTest()
42 {
43     var links = CreateLinks();
44     BigInteger bigInteger = new(decimal.MinValue);
45     TLink negativeNumberMarker = links.Create();
46     AddressToRawNumberConverter<TLink> addressToRawNumberConverter = new();
47     RawNumberToAddressConverter<TLink> numberToAddressConverter = new();
48     BalancedVariantConverter<TLink> listToSequenceConverter = new(links);
49     BigIntegerToRawNumberSequenceConverter<TLink> bigIntegerToRawNumberSequenceConverter
    ↪ = new(links, addressToRawNumberConverter, listToSequenceConverter,
    ↪ negativeNumberMarker);
50     RawNumberSequenceToBigIntegerConverter<TLink> rawNumberSequenceToBigIntegerConverter
    ↪ = new(links, numberToAddressConverter, negativeNumberMarker);
51     var bigIntSequence = bigIntegerToRawNumberSequenceConverter.Convert(bigInteger);
52     var bigIntFromSequence =
    ↪ rawNumberSequenceToBigIntegerConverter.Convert(bigIntSequence);
53     Assert.Equal(bigInteger, bigIntFromSequence);
54 }
55
56 [Fact]
57 public void ZeroValueTest()
58 {
59     var links = CreateLinks();
60     BigInteger bigInteger = new(0);
61     TLink negativeNumberMarker = links.Create();
62     AddressToRawNumberConverter<TLink> addressToRawNumberConverter = new();
63     RawNumberToAddressConverter<TLink> numberToAddressConverter = new();
64     BalancedVariantConverter<TLink> listToSequenceConverter = new(links);
65     BigIntegerToRawNumberSequenceConverter<TLink> bigIntegerToRawNumberSequenceConverter
    ↪ = new(links, addressToRawNumberConverter, listToSequenceConverter,
    ↪ negativeNumberMarker);
66     RawNumberSequenceToBigIntegerConverter<TLink> rawNumberSequenceToBigIntegerConverter
    ↪ = new(links, numberToAddressConverter, negativeNumberMarker);
67     var bigIntSequence = bigIntegerToRawNumberSequenceConverter.Convert(bigInteger);
68     var bigIntFromSequence =
    ↪ rawNumberSequenceToBigIntegerConverter.Convert(bigIntSequence);
69     Assert.Equal(bigInteger, bigIntFromSequence);
70 }
71
72 [Fact]
73 public void OneValueTest()
74 {
75     var links = CreateLinks();
76     BigInteger bigInteger = new(1);
77     TLink negativeNumberMarker = links.Create();
78     AddressToRawNumberConverter<TLink> addressToRawNumberConverter = new();
79     RawNumberToAddressConverter<TLink> numberToAddressConverter = new();
80     BalancedVariantConverter<TLink> listToSequenceConverter = new(links);
81     BigIntegerToRawNumberSequenceConverter<TLink> bigIntegerToRawNumberSequenceConverter
    ↪ = new(links, addressToRawNumberConverter, listToSequenceConverter,
    ↪ negativeNumberMarker);
82     RawNumberSequenceToBigIntegerConverter<TLink> rawNumberSequenceToBigIntegerConverter
    ↪ = new(links, numberToAddressConverter, negativeNumberMarker);
83     var bigIntSequence = bigIntegerToRawNumberSequenceConverter.Convert(bigInteger);
84     var bigIntFromSequence =
    ↪ rawNumberSequenceToBigIntegerConverter.Convert(bigIntSequence);
85     Assert.Equal(bigInteger, bigIntFromSequence);
86 }
87 }
88 }

```

## 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 TLink = 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<TLink> CreateLinks() => CreateLinks<TLink>(new IO.TemporaryFile());
26
27         public static ILinks<TLink> CreateLinks<TLink>(string dataDBFilename)
28         {
29             var linksConstants = new LinksConstants<TLink>(enableExternalReferencesSupport:
30                 ↪ true);
31             return new UnitedMemoryLinks<TLink>(new
32                 ↪ FileMappedResizableDirectMemory(dataDBFilename),
33                 ↪ UnitedMemoryLinks<TLink>.DefaultLinksSizeStep, linksConstants,
34                 ↪ IndexTreeType.Default);
35         }
36
37         public class ValueCriterionMatcher<TLink> : ICriterionMatcher<TLink>
38         {
39             public readonly ILinks<TLink> Links;
40             public readonly TLink Marker;
41             public ValueCriterionMatcher(ILinks<TLink> links, TLink marker)
42             {
43                 Links = links;
44                 Marker = marker;
45             }
46
47             public bool IsMatched(TLink link) =>
48                 ↪ EqualityComparer<TLink>.Default.Equals(Links.GetSource(link), Marker);
49         }
50
51         [Fact]
52         public void AppendArrayBug()
53         {
54             ILinks<TLink> links = CreateLinks();
55             TLink 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<TLink> valueCriterionMatcher = new(links, meaningRoot);
63             DefaultSequenceRightHeightProvider<ulong> defaultSequenceRightHeightProvider =
64                 ↪ new(links, valueCriterionMatcher);
65             DefaultSequenceAppender<TLink> 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 }

```

#### 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,
28         ⇒ consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore
29         ⇒ magna aliqua.
30 Facilisi nullam vehicula ipsum a arcu cursus vitae congue mauris.
31 Et malesuada fames ac turpis egestas sed.
32 Eget velit aliquet sagittis id consectetur purus.
33 Dignissim cras tincidunt lobortis feugiat vivamus.
34 Vitae aliquet nec ullamcorper sit.
35 Lectus quam id leo in vitae.
36 Tortor dignissim convallis aenean et tortor at risus viverra adipiscing.
37 Sed risus ultricies tristique nulla aliquet enim tortor at auctor.
38 Integer eget aliquet nibh praesent tristique.
39 Vitae congue eu consequat ac felis donec et odio.
40 Tristique et egestas quis ipsum suspendisse.
41 Suspendisse potenti nullam ac tortor vitae purus faucibus ornare.
42 Nulla facilisi etiam dignissim diam quis enim lobortis scelerisque.
43 Imperdiet proin fermentum leo vel orci.
44 In ante metus dictum at tempor commodo.
45 Nisi lacus sed viverra tellus in.
46 Quam vulputate dignissim suspendisse in.
47 Elit scelerisque mauris pellentesque pulvinar pellentesque habitant morbi tristique senectus.
48 Gravida cum sociis natoque penatibus et magnis dis parturient.
49 Risus quis varius quam quisque id diam.
50 Congue nisi vitae suscipit tellus mauris a diam maecenas.
51 Eget nunc scelerisque viverra mauris in aliquam sem fringilla.
52 Pharetra vel turpis nunc eget lorem dolor sed viverra.
53 Mattis pellentesque id nibh tortor id aliquet.
54 Purus non enim praesent elementum facilisis leo vel.
55 Etiam sit amet nisl purus in mollis nunc sed.
56 Tortor at auctor urna nunc id cursus metus aliquam.
57 Volutpat odio facilisis mauris sit amet.
58 Turpis egestas pretium aenean pharetra magna ac placerat.
59 Fermentum dui faucibus in ornare quam viverra orci sagittis eu.
60 Porttitor leo a diam sollicitudin tempor id eu.
61 Volutpat sed cras ornare arcu dui.
62 Ut aliquam purus sit amet luctus venenatis lectus magna.
63 Aliquet risus feugiat in ante metus dictum at.
64 Mattis nunc sed blandit libero.
65 Elit pellentesque habitant morbi tristique senectus et netus.
66 Nibh sit amet commodo nulla facilisi nullam vehicula ipsum a.
67 Enim sit amet venenatis urna cursus eget nunc scelerisque viverra.
68 Amet venenatis urna cursus eget nunc scelerisque viverra mauris in.
69 Diam donec adipiscing tristique risus nec feugiat.
70 Pulvinar mattis nunc sed blandit libero volutpat.
71 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
78 [Fact]
79 public static void LinksBasedFrequencyStoredOptimalVariantSequenceTest()
80 {
81     using (var scope = new TempLinksTestScope(useSequences: false))
82     {
83         var links = scope.Links;
84         var constants = links.Constants;
85
86         links.UseUnicode();
87
88         var sequence = UnicodeMap.FromStringToLinkArray(_sequenceExample);
89
90         var meaningRoot = links.CreatePoint();
91         var unaryOne = links.CreateAndUpdate(meaningRoot, constants.Itself);
92         var frequencyMarker = links.CreateAndUpdate(meaningRoot, constants.Itself);
93         var frequencyPropertyMarker = links.CreateAndUpdate(meaningRoot,
94             ↪ constants.Itself);
95
96         var unaryNumberToAddressConverter = new
97             ↪ UnaryNumberToAddressAddOperationConverter<ulong>(links, unaryOne);
98         var unaryNumberIncrementer = new UnaryNumberIncrementer<ulong>(links, unaryOne);
99         var frequencyIncrementer = new FrequencyIncrementer<ulong>(links,
100             ↪ frequencyMarker, unaryOne, unaryNumberIncrementer);
101         var frequencyPropertyOperator = new PropertyOperator<ulong>(links,
102             ↪ frequencyPropertyMarker, frequencyMarker);
103         var index = new FrequencyIncrementingSequenceIndex<ulong>(links,
104             ↪ frequencyPropertyOperator, frequencyIncrementer);
105         var linkToItsFrequencyNumberConverter = new
106             ↪ LinkToItsFrequencyNumberConverter<ulong>(links, frequencyPropertyOperator,
107             ↪ unaryNumberToAddressConverter);
108         var sequenceToItsLocalElementLevelsConverter = new
109             ↪ SequenceToItsLocalElementLevelsConverter<ulong>(links,
110             ↪ linkToItsFrequencyNumberConverter);
111         var optimalVariantConverter = new OptimalVariantConverter<ulong>(links,
112             ↪ sequenceToItsLocalElementLevelsConverter);
113
114         var sequences = new Sequences(links, new SequencesOptions<ulong>() { Walker =
115             ↪ new LeveledSequenceWalker<ulong>(links) });
116
117         ExecuteTest(sequences, sequence, sequenceToItsLocalElementLevelsConverter,
118             ↪ index, optimalVariantConverter);
119     }
120 }
121
122 [Fact]
123 public static void DictionaryBasedFrequencyStoredOptimalVariantSequenceTest()
124 {
125     using (var scope = new TempLinksTestScope(useSequences: false))
126     {
127         var links = scope.Links;
128
129         links.UseUnicode();
130
131         var sequence = UnicodeMap.FromStringToLinkArray(_sequenceExample);
132
133         var totalSequenceSymbolFrequencyCounter = new
134             ↪ TotalSequenceSymbolFrequencyCounter<ulong>(links);
135
136         var linkFrequenciesCache = new LinkFrequenciesCache<ulong>(links,
137             ↪ totalSequenceSymbolFrequencyCounter);
138
139         var index = new
140             ↪ CachedFrequencyIncrementingSequenceIndex<ulong>(linkFrequenciesCache);
141         var linkToItsFrequencyNumberConverter = new FrequenciesCacheBasedLinkToItsFrequencyNumberConverter<ulong>(linkFrequenciesCache);
142
143         var sequenceToItsLocalElementLevelsConverter = new
144             ↪ SequenceToItsLocalElementLevelsConverter<ulong>(links,
145             ↪ linkToItsFrequencyNumberConverter);
146         var optimalVariantConverter = new OptimalVariantConverter<ulong>(links,
147             ↪ sequenceToItsLocalElementLevelsConverter);
148     }
149 }

```

```

130
131     var sequences = new Sequences(links, new SequencesOptions<ulong>() { Walker =
    ↳ new LevelSequenceWalker<ulong>(links) });
132
133     ExecuteTest(sequences, sequence, sequenceToItsLocalElementLevelsConverter,
    ↳ index, optimalVariantConverter);
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 =>
190             ↪ addressToNumberConverter.Convert(y)).ToArray()).ToArray();
191         for (int i = 0; i < arrays.Length; i++)
192         {
193             unicodeSequences.Create(arrays[i].ShiftRight());
194         }
195
196         var linksCountAfterCreation = links.Count();
197
198         // get list of sequences links
199         // for each sequence link
200         //     create new sequence version
201         //     if new sequence is not the same as sequence link
202         //         delete sequence link
203         //         collect garbadge
204         unicodeSequences.CompactAll();
205
206         var linksCountAfterCompactification = links.Count();
207
208         Assert.True(linksCountAfterCompactification < linksCountAfterCreation);
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 TLink = System.UInt64;
10
11 namespace Platform.Data.Doublets.Sequences.Tests
12 {
13     public class RationalNumbersTests
14     {
15         public ILinks<TLink> CreateLinks() => CreateLinks<TLink>(new IO.TemporaryFile());
16
17         public ILinks<TLink> CreateLinks<TLink>(string dataDbFilename)
18         {
19             var linksConstants = new LinksConstants<TLink>(enableExternalReferencesSupport:
20                 ↪ true);
21             return new UnitedMemoryLinks<TLink>(new
22                 ↪ FileMappedResizableDirectMemory(dataDbFilename),
23                 ↪ UnitedMemoryLinks<TLink>.DefaultLinksSizeStep, linksConstants,
24                 ↪ IndexTreeType.Default);
25         }
26
27         [Fact]
28         public void DecimalMinValueTest()
29         {
30             const decimal @decimal = decimal.MinValue;
31             var links = CreateLinks();
32             TLink negativeNumberMarker = links.Create();
33             AddressToRawNumberConverter<TLink> addressToRawNumberConverter = new();
34             RawNumberToAddressConverter<TLink> numberToAddressConverter = new();
35             BalancedVariantConverter<TLink> balancedVariantConverter = new(links);
36             BigIntegerToRawNumberSequenceConverter<TLink> bigIntegerToRawNumberSequenceConverter
37                 ↪ = new(links, addressToRawNumberConverter, balancedVariantConverter,
38                 ↪ negativeNumberMarker);
39             RawNumberSequenceToBigIntegerConverter<TLink> rawNumberSequenceToBigIntegerConverter
40                 ↪ = new(links, numberToAddressConverter, negativeNumberMarker);
41             DecimalToRationalConverter<TLink> decimalToRationalConverter = new(links,
42                 ↪ bigIntegerToRawNumberSequenceConverter);
43             RationalToDecimalConverter<TLink> rationalToDecimalConverter = new(links,
44                 ↪ rawNumberSequenceToBigIntegerConverter);
45             var rationalNumber = decimalToRationalConverter.Convert(@decimal);
46             var decimalFromRational = rationalToDecimalConverter.Convert(rationalNumber);
47             Assert.Equal(@decimal, decimalFromRational);
48         }
49
50         [Fact]
51         public void DecimalMaxValueTest()
52         {
53             const decimal @decimal = decimal.MaxValue;

```

```

45     var links = CreateLinks();
46     TLink negativeNumberMarker = links.Create();
47     AddressToRawNumberConverter<TLink> addressToRawNumberConverter = new();
48     RawNumberToAddressConverter<TLink> numberToAddressConverter = new();
49     BalancedVariantConverter<TLink> balancedVariantConverter = new(links);
50     BigIntegerToRawNumberSequenceConverter<TLink> bigIntegerToRawNumberSequenceConverter
    ↪ = new(links, addressToRawNumberConverter, balancedVariantConverter,
    ↪ negativeNumberMarker);
51     RawNumberSequenceToBigIntegerConverter<TLink> rawNumberSequenceToBigIntegerConverter
    ↪ = new(links, numberToAddressConverter, negativeNumberMarker);
52     DecimalToRationalConverter<TLink> decimalToRationalConverter = new(links,
    ↪ bigIntegerToRawNumberSequenceConverter);
53     RationalToDecimalConverter<TLink> 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     TLink negativeNumberMarker = links.Create();
65     AddressToRawNumberConverter<TLink> addressToRawNumberConverter = new();
66     RawNumberToAddressConverter<TLink> numberToAddressConverter = new();
67     BalancedVariantConverter<TLink> balancedVariantConverter = new(links);
68     BigIntegerToRawNumberSequenceConverter<TLink> bigIntegerToRawNumberSequenceConverter
    ↪ = new(links, addressToRawNumberConverter, balancedVariantConverter,
    ↪ negativeNumberMarker);
69     RawNumberSequenceToBigIntegerConverter<TLink> rawNumberSequenceToBigIntegerConverter
    ↪ = new(links, numberToAddressConverter, negativeNumberMarker);
70     DecimalToRationalConverter<TLink> decimalToRationalConverter = new(links,
    ↪ bigIntegerToRawNumberSequenceConverter);
71     RationalToDecimalConverter<TLink> 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     TLink negativeNumberMarker = links.Create();
83     AddressToRawNumberConverter<TLink> addressToRawNumberConverter = new();
84     RawNumberToAddressConverter<TLink> numberToAddressConverter = new();
85     BalancedVariantConverter<TLink> balancedVariantConverter = new(links);
86     BigIntegerToRawNumberSequenceConverter<TLink> bigIntegerToRawNumberSequenceConverter
    ↪ = new(links, addressToRawNumberConverter, balancedVariantConverter,
    ↪ negativeNumberMarker);
87     RawNumberSequenceToBigIntegerConverter<TLink> rawNumberSequenceToBigIntegerConverter
    ↪ = new(links, numberToAddressConverter, negativeNumberMarker);
88     DecimalToRationalConverter<TLink> decimalToRationalConverter = new(links,
    ↪ bigIntegerToRawNumberSequenceConverter);
89     RationalToDecimalConverter<TLink> 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    TLink negativeNumberMarker = links.Create();
101    AddressToRawNumberConverter<TLink> addressToRawNumberConverter = new();
102    RawNumberToAddressConverter<TLink> numberToAddressConverter = new();
103    BalancedVariantConverter<TLink> balancedVariantConverter = new(links);
104    BigIntegerToRawNumberSequenceConverter<TLink> bigIntegerToRawNumberSequenceConverter
    ↪ = new(links, addressToRawNumberConverter, balancedVariantConverter,
    ↪ negativeNumberMarker);

```

```

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

```

## 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

```

```

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

```



```

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 //         TODO: Из числа в bool значения o.UseSequenceMarker = ((value & 1) != 0)
82 //             o.
83 //
84 //         var sequences = new Sequences(links);
85 //
86 //         var sw1 = Stopwatch.StartNew();
87 //         var results1 = sequences.CreateAllVariants1(sequence); sw1.Stop();
88 //
89 //         var sw2 = Stopwatch.StartNew();
90 //         var results2 = sequences.CreateAllVariants2(sequence); sw2.Stop();
91 //
92 //         Assert.True(results1.Count > results2.Length);
93 //         Assert.True(sw1.Elapsed > sw2.Elapsed);
94 //
95 //         for (var i = 0; i < sequenceLength; i++)
96 //             links.Delete(sequence[i]);
97 //     }
98 //
99 //     File.Delete(tempFilename);
100 // }
101
102 [Fact]
103 public static void AllVariantsSearchTest()
104 {
105     const long sequenceLength = 8;
106
107     using (var scope = new TempLinksTestScope(useSequences: true))
108     {
109         var links = scope.Links;
110         var sequences = scope.Sequences;
111
112         var sequence = new ulong[sequenceLength];
113         for (var i = 0; i < sequenceLength; i++)
114         {
115             sequence[i] = links.Create();
116         }
117
118         var createResults = sequences.CreateAllVariants2(sequence).Distinct().ToArray();
119
120         // for (int i = 0; i < createResults.Length; i++)
121         //     sequences.Create(createResults[i]);
122
123         var sw0 = Stopwatch.StartNew();
124         var searchResults0 = sequences.GetAllMatchingSequences0(sequence); sw0.Stop();
125
126         var sw1 = Stopwatch.StartNew();
127         var searchResults1 = sequences.GetAllMatchingSequences1(sequence); sw1.Stop();
128
129         var sw2 = Stopwatch.StartNew();
130         var searchResults2 = sequences.Each1(sequence); sw2.Stop();
131
132         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     Array.Copy(sequence, 1, partialSequence, 0, (int)sequenceLength - 2);
226
227     var sw1 = Stopwatch.StartNew();
228     var searchResults1 =
229     ↪ sequences.GetAllPartiallyMatchingSequences0(partialSequence); sw1.Stop();
230
231     var sw2 = Stopwatch.StartNew();
232     var searchResults2 =
233     ↪ sequences.GetAllPartiallyMatchingSequences1(partialSequence); sw2.Stop();
234
235     //var sw3 = Stopwatch.StartNew();
236     //var searchResults3 =
237     ↪ sequences.GetAllPartiallyMatchingSequences2(partialSequence); sw3.Stop();
238
239     var sw4 = Stopwatch.StartNew();
240     var searchResults4 =
241     ↪ sequences.GetAllPartiallyMatchingSequences3(partialSequence); sw4.Stop();
242
243     //Global.Trash = searchResults3;
244
245     //var searchResults1Strings = searchResults1.Select(x => x + ": " +
246     ↪ sequences.FormatSequence(x)).ToList();
247     //Global.Trash = searchResults1Strings;
248
249     var intersection1 = createResults.Intersect(searchResults1).ToList();
250     Assert.True(intersection1.Count == createResults.Length);
251
252     var intersection2 = createResults.Intersect(searchResults2).ToList();
253     Assert.True(intersection2.Count == createResults.Length);
254
255     var intersection4 = createResults.Intersect(searchResults4).ToList();
256     Assert.True(intersection4.Count == createResults.Length);
257
258     for (var i = 0; i < sequenceLength; i++)
259     {
260         links.Delete(sequence[i]);
261     }
262 }
263
264 [Fact]
265 public static void BalancedPartialVariantsSearchTest()
266 {
267     const long sequenceLength = 200;
268
269     using (var scope = new TempLinksTestScope(useSequences: true))
270     {
271         var links = scope.Links;
272         var sequences = scope.Sequences;
273
274         var sequence = new ulong[sequenceLength];
275         for (var i = 0; i < sequenceLength; i++)
276         {
277             sequence[i] = links.Create();
278         }
279
280         var balancedVariantConverter = new BalancedVariantConverter<ulong>(links);
281         var balancedVariant = balancedVariantConverter.Convert(sequence);
282
283         var partialSequence = new ulong[sequenceLength - 2];
284         Array.Copy(sequence, 1, partialSequence, 0, (int)sequenceLength - 2);
285
286         var sw1 = Stopwatch.StartNew();
287         var searchResults1 =
288         ↪ sequences.GetAllPartiallyMatchingSequences0(partialSequence); sw1.Stop();

```

```

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

```

```

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?

```

382 [![чёрное пространство, белое
383 ↪ пространство](https://raw.githubusercontent.com/Konard/LinksPlatform/master/doc/Intro/1.png
384 ↪ ""чёрное пространство, белое пространство"")] (https://raw.githubusercontent.com/Konard/Links
385 ↪ Platform/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?

```

386 [![чёрное пространство, чёрная
387 ↪ точка](https://raw.githubusercontent.com/Konard/LinksPlatform/master/doc/Intro/2.png
388 ↪ ""чёрное пространство, чёрная
389 ↪ 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?

```

390 [![белая точка, чёрная
391 ↪ точка](https://raw.githubusercontent.com/Konard/LinksPlatform/master/doc/Intro/3.png ""белая
392 ↪ точка, чёрная
393 ↪ 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?

```

394 [![две белые точки, чёрная вертикальная
395 ↪ линия](https://raw.githubusercontent.com/Konard/LinksPlatform/master/doc/Intro/4.png ""две
396 ↪ белые точки, чёрная вертикальная
397 ↪ 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?

```

398 [![белая вертикальная линия, чёрный
399 ↪ круг](https://raw.githubusercontent.com/Konard/LinksPlatform/master/doc/Intro/5.png ""белая
400 ↪ вертикальная линия, чёрный
401 ↪ 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?

```

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

```

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?

```

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");
    private static readonly string _exampleLoremIpsumText =
432         @"Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor
433         ↪   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;
519
520         var constants = Default<LinksConstants<ulong>>.Instance;
521
522         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,
    ↳ constants.Itself);
515
516 //var unaryNumberToAddressConverter = new
    ↳ UnaryNumberToAddressAddOperationConverter<ulong>(links, unaryOne);
517 //var unaryNumberIncrementer = new UnaryNumberIncrementer<ulong>(links,
    ↳ unaryOne);
518 //var frequencyIncrementer = new FrequencyIncrementer<ulong>(links,
    ↳ frequencyMarker, unaryOne, unaryNumberIncrementer);
519 //var frequencyPropertyOperator = new FrequencyPropertyOperator<ulong>(links,
    ↳ frequencyPropertyMarker, frequencyMarker);
520 //var linkFrequencyIncrementer = new LinkFrequencyIncrementer<ulong>(links,
    ↳ frequencyPropertyOperator, frequencyIncrementer);
521 //var linkToItsFrequencyNumberConverter = new
    ↳ LinkToItsFrequencyNumberConveter<ulong>(links, frequencyPropertyOperator,
    ↳ unaryNumberToAddressConverter);
522
523 var linkFrequenciesCache3 = new LinkFrequenciesCache<ulong>(scope3.Links.Unsync,
    ↳ totalSequenceSymbolFrequencyCounter);
524
525 var linkToItsFrequencyNumberConverter = new FrequenciesCacheBasedLinkToItsFreque
    ↳ ncyNumberConverter<ulong>(linkFrequenciesCache3);
526
527 var sequenceToItsLocalElementLevelsConverter = new
    ↳ SequenceToItsLocalElementLevelsConverter<ulong>(scope3.Links.Unsync,
    ↳ linkToItsFrequencyNumberConverter);
528 var optimalVariantConverter = new
    ↳ OptimalVariantConverter<ulong>(scope3.Links.Unsync,
    ↳ sequenceToItsLocalElementLevelsConverter);
529
530 var compressed1 = new ulong[arrays.Length];
531 var compressed2 = new ulong[arrays.Length];
532 var compressed3 = new ulong[arrays.Length];
533
534 var START = 0;
535 var END = arrays.Length;
536
537 //for (int i = START; i < END; i++)
538 //    linkFrequenciesCache1.IncrementFrequencies(arrays[i]);
539
540 var initialCount1 = scope2.Links.Unsync.Count();
541
542 var sw1 = Stopwatch.StartNew();
543
544 for (int i = START; i < END; i++)
545 {
546     linkFrequenciesCache1.IncrementFrequencies(arrays[i]);
547     compressed1[i] = compressor1.Convert(arrays[i]);
548 }
549
550 var elapsed1 = sw1.Elapsed;
551
552 var balancedVariantConverter2 = new
    ↳ BalancedVariantConverter<ulong>(scope2.Links.Unsync);
553
554 var initialCount2 = scope2.Links.Unsync.Count();
555
556 var sw2 = Stopwatch.StartNew();
557
558 for (int i = START; i < END; i++)
559 {
560     compressed2[i] = balancedVariantConverter2.Convert(arrays[i]);
561 }
562
563 var elapsed2 = sw2.Elapsed;
564
565 for (int i = START; i < END; i++)
566 {
567     linkFrequenciesCache3.IncrementFrequencies(arrays[i]);
568 }
569
570 var initialCount3 = scope3.Links.Unsync.Count();
571
572 var sw3 = Stopwatch.StartNew();
573
574 for (int i = START; i < END; i++)

```



```

575 {
576     //linkFrequenciesCache3.IncrementFrequencies(arrays[i]);
577     compressed3[i] = optimalVariantConverter.Convert(arrays[i]);
578 }
579
580 var elapsed3 = sw3.Elapsed;
581
582 Console.WriteLine($"Compressor: {elapsed1}, Balanced variant: {elapsed2},
    ↳ Optimal variant: {elapsed3}");
583
584 // Assert.True(elapsed1 > elapsed2);
585
586 // Checks
587 for (int i = START; i < END; i++)
588 {
589     var sequence1 = compressed1[i];
590     var sequence2 = compressed2[i];
591     var sequence3 = compressed3[i];
592
593     var decompress1 = UnicodeMap.FromSequenceLinkToString(sequence1,
    ↳ scope1.Links.Unsync);
594
595     var decompress2 = UnicodeMap.FromSequenceLinkToString(sequence2,
    ↳ scope2.Links.Unsync);
596
597     var decompress3 = UnicodeMap.FromSequenceLinkToString(sequence3,
    ↳ scope3.Links.Unsync);
598
599     var structure1 = scope1.Links.Unsync.FormatStructure(sequence1, link =>
    ↳ link.IsPartialPoint());
600     var structure2 = scope2.Links.Unsync.FormatStructure(sequence2, link =>
    ↳ link.IsPartialPoint());
601     var structure3 = scope3.Links.Unsync.FormatStructure(sequence3, link =>
    ↳ link.IsPartialPoint());
602
603     //if (sequence1 != Constants.Null && sequence2 != Constants.Null &&
    ↳ arrays[i].Length > 3)
604     //    Assert.False(structure1 == structure2);
605     //if (sequence3 != Constants.Null && sequence2 != Constants.Null &&
    ↳ arrays[i].Length > 3)
606     //    Assert.False(structure3 == structure2);
607
608     Assert.True(strings[i] == decompress1 && decompress1 == decompress2);
609     Assert.True(strings[i] == decompress3 && decompress3 == decompress2);
610 }
611
612 Assert.True((int)(scope1.Links.Unsync.Count() - initialCount1) <
    ↳ totalCharacters);
613 Assert.True((int)(scope2.Links.Unsync.Count() - initialCount2) <
    ↳ totalCharacters);
614 Assert.True((int)(scope3.Links.Unsync.Count() - initialCount3) <
    ↳ totalCharacters);
615
616 Console.WriteLine($"{{(double)(scope1.Links.Unsync.Count() - initialCount1) /
    ↳ totalCharacters}} | {{(double)(scope2.Links.Unsync.Count() - initialCount2) /
    ↳ totalCharacters}} | {{(double)(scope3.Links.Unsync.Count() - initialCount3) /
    ↳ totalCharacters}}");
617
618 Assert.True(scope1.Links.Unsync.Count() - initialCount1 <
    ↳ scope2.Links.Unsync.Count() - initialCount2);
619 Assert.True(scope3.Links.Unsync.Count() - initialCount3 <
    ↳ scope2.Links.Unsync.Count() - initialCount2);
620
621 var duplicateProvider1 = new
    ↳ DuplicateSegmentsProvider<ulong>(scope1.Links.Unsync, scope1.Sequences);
622 var duplicateProvider2 = new
    ↳ DuplicateSegmentsProvider<ulong>(scope2.Links.Unsync, scope2.Sequences);
623 var duplicateProvider3 = new
    ↳ DuplicateSegmentsProvider<ulong>(scope3.Links.Unsync, scope3.Sequences);
624
625 var duplicateCounter1 = new DuplicateSegmentsCounter<ulong>(duplicateProvider1);
626 var duplicateCounter2 = new DuplicateSegmentsCounter<ulong>(duplicateProvider2);
627 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 }))
667     using (var scope2 = new TempLinksTestScope(useSequences: true))
668     {
669         scope1.Links.UseUnicode();
670         scope2.Links.UseUnicode();
671
672         //var compressor1 = new Compressor(scope1.Links.Unsync, scope1.Sequences);
673         var compressor1 = scope1.Sequences;
674         var compressor2 = scope2.Sequences;
675
676         var compressed1 = new ulong[arrays.Length];
677         var compressed2 = new ulong[arrays.Length];
678
679         var sw1 = Stopwatch.StartNew();
680
681         var START = 0;
682         var END = arrays.Length;
683
684         // Collisions proved (cannot be solved by max doublet comparison, no stable rule)
685         // Stability issue starts at 10001 or 11000
686         //for (int i = START; i < END; i++)
687         //{
688             var first = compressor1.Compress(arrays[i]);
689             var second = compressor1.Compress(arrays[i]);
690
691             if (first == second)
692                 compressed1[i] = first;
693             else
694             {
695                 // TODO: Find a solution for this case
696             }
697         //}
698
699         for (int i = START; i < END; i++)
700         {
701             var first = compressor1.Create(arrays[i].ShiftRight());
702             var second = compressor1.Create(arrays[i].ShiftRight());
703
704             if (first == second)
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
778 [Fact]
779 public static void RandomNumbersCompressionQualityTest()
780 {
781     const ulong N = 500;
782
783     //const ulong minNumbers = 10000;
784     //const ulong maxNumbers = 20000;
785
786     //var strings = new List<string>();
787
788     //for (ulong i = 0; i < N; i++)

```

```

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

```

```

853         Debug.WriteLine($"{((double)(scope1.Links.Count() - UnicodeMap.MapSize) /
854             ↳ totalCharacters} | {(double)(scope2.Links.Count() - UnicodeMap.MapSize) /
855             ↳ totalCharacters}");
856
857         // Can be worse than balanced variant
858         //Assert.True(scope1.Links.Count() <= scope2.Links.Count());
859
860         //compressor1.ValidateFrequencies();
861     }
862 }
863
864 [Fact]
865 public static void AllTreeBreakDownAtSequencesCreationBugTest()
866 {
867     // Made out of AllPossibleConnectionsTest test.
868
869     //const long sequenceLength = 5; //100% bug
870     const long sequenceLength = 4; //100% bug
871     //const long sequenceLength = 3; //100% _no_bug (ok)
872
873     using (var scope = new TempLinksTestScope(useSequences: true))
874     {
875         var links = scope.Links;
876         var sequences = scope.Sequences;
877
878         var sequence = new ulong[sequenceLength];
879         for (var i = 0; i < sequenceLength; i++)
880         {
881             sequence[i] = links.Create();
882         }
883
884         var createResults = sequences.CreateAllVariants2(sequence);
885         Global.Trash = createResults;
886
887         for (var i = 0; i < sequenceLength; i++)
888         {
889             links.Delete(sequence[i]);
890         }
891     }
892 }
893
894 [Fact]
895 public static void AllPossibleConnectionsTest()
896 {
897     const long sequenceLength = 5;
898
899     using (var scope = new TempLinksTestScope(useSequences: true))
900     {
901         var links = scope.Links;
902         var sequences = scope.Sequences;
903
904         var sequence = new ulong[sequenceLength];
905         for (var i = 0; i < sequenceLength; i++)
906         {
907             sequence[i] = links.Create();
908         }
909
910         var createResults = sequences.CreateAllVariants2(sequence);
911         var reverseResults = sequences.CreateAllVariants2(sequence.Reverse().ToArray());
912
913         for (var i = 0; i < 1; i++)
914         {
915             var sw1 = Stopwatch.StartNew();
916             var searchResults1 = sequences.GetAllConnections(sequence); sw1.Stop();
917
918             var sw2 = Stopwatch.StartNew();
919             var searchResults2 = sequences.GetAllConnections1(sequence); sw2.Stop();
920
921             var sw3 = Stopwatch.StartNew();
922             var searchResults3 = sequences.GetAllConnections2(sequence); sw3.Stop();
923
924             var sw4 = Stopwatch.StartNew();
925             var searchResults4 = sequences.GetAllConnections3(sequence); sw4.Stop();
926
927             Global.Trash = searchResults3;
928             Global.Trash = searchResults4; //-V3008
929
930             var intersection1 = createResults.Intersect(searchResults1).ToList();
931             Assert.True(intersection1.Count == createResults.Length);
932         }
933     }
934 }

```

```

931         var intersection2 = reverseResults.Intersect(searchResults1).ToList();
932         Assert.True(intersection2.Count == reverseResults.Length);
933
934         var intersection0 = searchResults1.Intersect(searchResults2).ToList();
935         Assert.True(intersection0.Count == searchResults2.Count);
936
937         var intersection3 = searchResults2.Intersect(searchResults3).ToList();
938         Assert.True(intersection3.Count == searchResults3.Count);
939
940         var intersection4 = searchResults3.Intersect(searchResults4).ToList();
941         Assert.True(intersection4.Count == searchResults4.Count);
942     }
943
944     for (var i = 0; i < sequenceLength; i++)
945     {
946         links.Delete(sequence[i]);
947     }
948 }
949
950 }
951
952 [Fact(Skip = "Correct implementation is pending")]
953 public static void CalculateAllUsagesTest()
954 {
955     const long sequenceLength = 3;
956
957     using (var scope = new TempLinksTestScope(useSequences: true))
958     {
959         var links = scope.Links;
960         var sequences = scope.Sequences;
961
962         var sequence = new ulong[sequenceLength];
963         for (var i = 0; i < sequenceLength; i++)
964         {
965             sequence[i] = links.Create();
966         }
967
968         var createResults = sequences.CreateAllVariants2(sequence);
969
970         //var reverseResults =
971         ↪ sequences.CreateAllVariants2(sequence.Reverse().ToArray());
972
973         for (var i = 0; i < 1; i++)
974         {
975             var linksTotalUsages1 = new ulong[links.Count() + 1];
976
977             sequences.CalculateAllUsages(linksTotalUsages1);
978
979             var linksTotalUsages2 = new ulong[links.Count() + 1];
980
981             sequences.CalculateAllUsages2(linksTotalUsages2);
982
983             var intersection1 = linksTotalUsages1.Intersect(linksTotalUsages2).ToList();
984             Assert.True(intersection1.Count == linksTotalUsages2.Length);
985         }
986
987         for (var i = 0; i < sequenceLength; i++)
988         {
989             links.Delete(sequence[i]);
990         }
991     }
992 }
993
994 }

```

## 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
107     links.Update(linkAddress2, linkAddress1, h108E);

```



```

108     var link2 = new Link<T>(links.GetLink(linkAddress2));
109
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<TLink>(this ILinks<TLink>
    ↪ links, int maximumOperationsPerCycle)
158 {
159     var comparer = Comparer<TLink>.Default;
160     var addressToUInt64Converter = CheckedConverter<TLink, ulong>.Default;
161     var uint64ToAddressConverter = CheckedConverter<ulong, TLink>.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                 TLink source = uint64ToAddressConverter.Convert(random.NextUInt64(linksA_
    ↪ ddressRange));
175                 TLink target = uint64ToAddressConverter.Convert(random.NextUInt64(linksA_
    ↪ ddressRange));
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     }

```

```

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         TLink 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
43         [Fact]
44         public static void CascadeUpdateTest()
45         {
46             var itself = _constants.Itself;
47             using (var scope = new TempLinksTestScope(useLog: true))
48             {
49                 var links = scope.Links;
50
51                 var l1 = links.Create();
52                 var l2 = links.Create();
53
54                 l2 = links.Update(l2, l2, l1, l2);
55
56                 links.CreateAndUpdate(l2, itself);
57                 links.CreateAndUpdate(l2, itself);
58             }
59         }
60     }
61 }

```

```

56         l2 = links.Update(l2, l1);
57
58         links.Delete(l2);
59
60         Global.Trash = links.Count();
61
62         links.Unsync.DisposeIfPossible(); // Close links to access log
63
64         Global.Trash = FileHelpers.ReadAll<UInt64LinksTransactionsLayer.Transition>(scope
65             ↪ 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
85             ↪ e.TempTransactionLogFilename);
86     }
87 }
88
89 [Fact]
90 public static void TransactionAutoRevertedTest()
91 {
92     // Auto Reverted (Because no commit at transaction)
93     using (var scope = new TempLinksTestScope(useLog: true))
94     {
95         var links = scope.Links;
96         var transactionsLayer = (UInt64LinksTransactionsLayer)scope.MemoryAdapter;
97         using (var transaction = transactionsLayer.BeginTransaction())
98         {
99             var l1 = links.Create();
100             var l2 = links.Create();
101
102             links.Update(l2, l2, l1, l2);
103         }
104
105         Assert.Equal(0UL, links.Count());
106
107         links.Unsync.DisposeIfPossible();
108
109         var transitions = FileHelpers.ReadAll<UInt64LinksTransactionsLayer.Transition>(s
110             ↪ cope.TempTransactionLogFilename);
111         Assert.Single(transitions);
112     }
113 }
114
115 [Fact]
116 public static void TransactionUserCodeErrorNoDataSavedTest()
117 {
118     // User Code Error (Autoreverted), no data saved
119     var itself = _constants.Itself;
120
121     TempLinksTestScope lastScope = null;
122     try
123     {
124         using (var scope = lastScope = new TempLinksTestScope(deleteFiles: false,
125             ↪ useLog: true))
126         {
127             var links = scope.Links;
128             var transactionsLayer = (UInt64LinksTransactionsLayer)((LinksDisposableDecor
129                 ↪ atorBase<ulong>)links.Unsync).Links;
130             using (var transaction = transactionsLayer.BeginTransaction())
131             {
132                 var l1 = links.CreateAndUpdate(itself, itself);
133                 var l2 = links.CreateAndUpdate(itself, itself);

```

```

130         l2 = links.Update(l2, l2, l1, l2);
131
132         links.CreateAndUpdate(l2, itself);
133         links.CreateAndUpdate(l2, itself);
134
135         //Global.Trash = FileHelpers.ReadAll<UInt64LinksTransactionsLayer.Transi_
136         ↪ tion>(scope.TempTransactionLogFilename);
137
138         l2 = links.Update(l2, l1);
139
140         links.Delete(l2);
141
142         ExceptionThrower();
143
144         transaction.Commit();
145     }
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();
206             }
207         }
208     }
209 }

```

```

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))
    using (var links = new UInt64Links(memoryAdapter))
    {
286         Global.Trash = links.Count();
287     }
288 }
289
290 catch (NotSupportedException ex)
291 {
292     Assert.True(ex.Message == "Database is damaged, autorecovery is not supported
    ↳ yet.");
293 }
294
295 Global.Trash = FileHelpers.ReadAll<UInt64LinksTransactionsLayer.Transition>(tempTran
    ↳ sactionLogFilename);
296
297 File.Delete(tempDatabaseFilename);
298 File.Delete(tempTransactionLogFilename);
299
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))
    using (var links = new UInt64Links(memoryAdapter))
    {
318             l1 = links.CreateAndUpdate(itself, itself);
319             l2 = links.CreateAndUpdate(itself, itself);
320
321             l2 = links.Update(l2, l2, l1, l2);
322
323             links.CreateAndUpdate(l2, itself);
324             links.CreateAndUpdate(l2, itself);
325         }
326
327         Global.Trash = FileHelpers.ReadAll<UInt64LinksTransactionsLayer.Transition>(temp
    ↳ TransactionLogFilename);
328
329         using (var memory = new UInt64UnitedMemoryLinks(tempDatabaseFilename))
330         using (var memoryAdapter = new UInt64LinksTransactionsLayer(memory,
    ↳ tempTransactionLogFilename))
    using (var links = new UInt64Links(memoryAdapter))
    {
331             using (var transaction = memoryAdapter.BeginTransaction())
332             {
333                 l2 = links.Update(l2, l1);
334                 links.Delete(l2);
335                 ExceptionThrower();
336                 transaction.Commit();
337             }
338
339             Global.Trash = links.Count();
340         }
341     }
342     catch
343     {
344
345
346
347
348
349
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.GetByKey(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
432         return;
433
434         try
435         {
436             //ThreadPool.SetMaxThreads(2, 2);
437
438             // Запускаем все тесты дважды, чтобы первоначальная инициализация не повлияла на
↪ результат // Также это дополнительно помогает в отладке
439             // Увеличивает вероятность попадания информации в кэши
440             for (var i = 0; i < 10; i++)
441             {
442                 //0 - 10 ГБ
443                 //Каждые 100 МБ срез цифр
444
445                 //links.TestGetSourceFunction();
446                 //links.TestGetSourceFunctionInParallel();
447                 //links.TestGetTargetFunction();
448                 //links.TestGetTargetFunctionInParallel();
449                 links.Create64BillionLinks();
450
451                 links.TestRandomSearchFixed();
452                 //links.Create64BillionLinksInParallel();
453                 links.TestEachFunction();
454                 //links.TestForeach();
455                 //links.TestParallelForeach();
456             }
457
458             links.TestDeletionOfAllLinks();
459
460         }
461         catch (Exception ex)
462         {
463             ex.WriteToConsole();
464         }
465     }*/
466 }*/
467
468 /*
469 public static void TestLinksInSteps()
470 {
471     const long gibibyte = 1024 * 1024 * 1024;
472     const long mebibyte = 1024 * 1024;
473
474     var totalLinksToCreate = gibibyte /
↪ Platform.Links.Data.Core.Doublets.Links.LinkSizeInBytes;
475     var linksStep = 102 * mebibyte /
↪ Platform.Links.Data.Core.Doublets.Links.LinkSizeInBytes;
476
477     var creationMeasurements = new List<TimeSpan>();
478     var searchMeasurements = new List<TimeSpan>();
479     var deletionMeasurements = new List<TimeSpan>();
480
481     GetBaseRandomLoopOverhead(linksStep);
482     GetBaseRandomLoopOverhead(linksStep);
483
484     var stepLoopOverhead = GetBaseRandomLoopOverhead(linksStep);
485
486     ConsoleHelpers.Debug("Step loop overhead: {0}.", stepLoopOverhead);
487
488     var loops = totalLinksToCreate / linksStep;
489
490     for (int i = 0; i < loops; i++)
491     {
492         creationMeasurements.Add(Measure(() => links.RunRandomCreations(linksStep)));
493         searchMeasurements.Add(Measure(() => links.RunRandomSearches(linksStep)));
494
495         Console.WriteLine("\rC + S {0}/{1}", i + 1, loops);
496     }
497
498     ConsoleHelpers.Debug();

```



```

499         for (int i = 0; i < loops; i++)
500         {
501             deletionMeasurements.Add(Measure(() => links.RunRandomDeletions(linksStep)));
502
503             Console.WriteLine("\rD {0}/{1}", i + 1, loops);
504         }
505
506         ConsoleHelpers.Debug();
507
508         ConsoleHelpers.Debug("C S D");
509
510         for (int i = 0; i < loops; i++)
511         {
512             ConsoleHelpers.Debug("{0} {1} {2}", creationMeasurements[i],
513 ↪ 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,
521 ↪ searchMeasurements[i] - stepLoopOverhead, deletionMeasurements[i] - stepLoopOverhead);
522         }
523
524         ConsoleHelpers.Debug("All tests done. Total links left in database: {0}.",
525 ↪ links.Total);
526     }
527
528     private static void CreatePoints(this Platform.Links.Data.Core.Doublets.Links links, long
529 ↪ amountToCreate)
530     {
531         for (long i = 0; i < amountToCreate; i++)
532             links.Create(0, 0);
533     }
534
535     private static TimeSpan GetBaseRandomLoopOverhead(long loops)
536     {
537         return Measure(() =>
538         {
539             ulong maxValue = RandomHelpers.DefaultFactory.NextUInt64();
540             ulong result = 0;
541             for (long i = 0; i < loops; i++)
542             {
543                 var source = RandomHelpers.DefaultFactory.NextUInt64(maxValue);
544                 var target = RandomHelpers.DefaultFactory.NextUInt64(maxValue);
545
546                 result += maxValue + source + target;
547             }
548             Global.Trash = result;
549         });
550     }
551
552     /*
553     [Fact(Skip = "performance test")]
554     public static void GetSourceTest()
555     {
556         using (var scope = new TempLinksTestScope())
557         {
558             var links = scope.Links;
559             ConsoleHelpers.Debug("Testing GetSource function with {0} Iterations.",
560 ↪ Iterations);
561
562             ulong counter = 0;
563
564             //var firstLink = links.First();
565             // Создаём одну связь, из которой будет производить считывание
566             var firstLink = links.Create();
567
568             var sw = Stopwatch.StartNew();
569
570             // Тестируем саму функцию
571             for (ulong i = 0; i < Iterations; i++)
572             {
573                 counter += links.GetSource(firstLink);
574             }
575
576             var elapsedTime = sw.Elapsed;

```

```

573     var iterationsPerSecond = Iterations / elapsedTime.TotalSeconds;
574
575     // Удаляем связь, из которой производилось считывание
576     links.Delete(firstLink);
577
578     ConsoleHelpers.Debug(
579         "{0} Iterations of GetSource function done in {1} ({2} Iterations per
580         ↳ second), counter result: {3}",
581         Iterations, elapsedTime, (long)iterationsPerSecond, counter);
582     }
583 }
584
585 [Fact(Skip = "performance test")]
586 public static void GetSourceInParallel()
587 {
588     using (var scope = new TempLinksTestScope())
589     {
590         var links = scope.Links;
591         ConsoleHelpers.Debug("Testing GetSource function with {0} Iterations in
592         ↳ parallel.", Iterations);
593
594         long counter = 0;
595
596         //var firstLink = links.First();
597         var firstLink = links.Create();
598
599         var sw = Stopwatch.StartNew();
600
601         // Тестируем саму функцию
602         Parallel.For(0, Iterations, x =>
603         {
604             Interlocked.Add(ref counter, (long)links.GetSource(firstLink));
605             //Interlocked.Increment(ref counter);
606         });
607
608         var elapsedTime = sw.Elapsed;
609
610         var iterationsPerSecond = Iterations / elapsedTime.TotalSeconds;
611
612         links.Delete(firstLink);
613
614         ConsoleHelpers.Debug(
615             "{0} Iterations of GetSource function done in {1} ({2} Iterations per
616             ↳ second), counter result: {3}",
617             Iterations, elapsedTime, (long)iterationsPerSecond, counter);
618     }
619 }
620
621 [Fact(Skip = "performance test")]
622 public static void TestGetTarget()
623 {
624     using (var scope = new TempLinksTestScope())
625     {
626         var links = scope.Links;
627         ConsoleHelpers.Debug("Testing GetTarget function with {0} Iterations.",
628         ↳ Iterations);
629
630         ulong counter = 0;
631
632         //var firstLink = links.First();
633         var firstLink = links.Create();
634
635         var sw = Stopwatch.StartNew();
636
637         for (ulong i = 0; i < Iterations; i++)
638         {
639             counter += links.GetTarget(firstLink);
640         }
641
642         var elapsedTime = sw.Elapsed;
643
644         var iterationsPerSecond = Iterations / elapsedTime.TotalSeconds;
645
646         links.Delete(firstLink);
647
648         ConsoleHelpers.Debug(
649             "{0} Iterations of GetTarget function done in {1} ({2} Iterations per
650             ↳ 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}",
680             Iterations, elapsedTime, (long)iterationsPerSecond, counter);
681     }
682 }
683
684 // TODO: Заполнить базу данных перед тестом
685 /*
686 [Fact]
687 public void TestRandomSearchFixed()
688 {
689     var tempFilename = Path.GetTempFileName();
690
691     using (var links = new Platform.Links.Data.Core.Doublets.Links(tempFilename,
        ↪ DefaultLinksSizeStep))
692     {
693         long iterations = 64 * 1024 * 1024 /
        ↪ Platform.Links.Data.Core.Doublets.Links.LinkSizeInBytes;
694
695         ulong counter = 0;
696         var maxLink = links.Total;
697
698         ConsoleHelpers.Debug("Testing Random Search with {0} Iterations.", iterations);
699
700         var sw = Stopwatch.StartNew();
701
702         for (var i = iterations; i > 0; i--)
703         {
704             var source =
        ↪ RandomHelpers.DefaultFactory.NextUInt64(LinksConstants.MinPossibleIndex, maxLink);
705             var target =
        ↪ RandomHelpers.DefaultFactory.NextUInt64(LinksConstants.MinPossibleIndex, maxLink);
706
707             counter += links.Search(source, target);
708         }
709
710         var elapsedTime = sw.Elapsed;
711
712         var iterationsPerSecond = iterations / elapsedTime.TotalSeconds;
713
714         ConsoleHelpers.Debug("{0} Iterations of Random Search done in {1} ({2}
        ↪ Iterations per second), c: {3}", iterations, elapsedTime, (long)iterationsPerSecond,
        ↪ counter);
715     }
716
717     File.Delete(tempFilename);

```

```
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         var maxLink = links.Count();
```

```
727         var iterations = links.Count();
```

```
728         ConsoleHelpers.Debug("Testing Random Search with {0} Iterations.",  
729                               ↪ links.Count());
```

```
730         var sw = Stopwatch.StartNew();
```

```
731         for (var i = iterations; i > 0; i--)
```

```
732         {
```

```
733             var linksAddressRange = new
```

```
734                 ↪ Range<ulong>(_constants.InternalReferencesRange.Minimum, maxLink);
```

```
735             var source = RandomHelpers.Default.NextUInt64(linksAddressRange);
```

```
736             var target = RandomHelpers.Default.NextUInt64(linksAddressRange);
```

```
737             counter += links.SearchOrDefault(source, target);
```

```
738         }
```

```
739         var elapsedTime = sw.Elapsed;
```

```
740         var iterationsPerSecond = iterations / elapsedTime.TotalSeconds;
```

```
741         ConsoleHelpers.Debug("{0} Iterations of Random Search done in {1} ({2}  
742                               ↪ Iterations per second), c: {3}",  
743                               iterations, elapsedTime, (long)iterationsPerSecond, counter);
```

```
744     }
```

```
745 }
```

```
746 [Fact(Skip = "useless: 0(0), was dependent on creation tests")]
```

```
747 public static void TestEach()
```

```
748 {
```

```
749     using (var scope = new TempLinksTestScope())
```

```
750     {
```

```
751         var links = scope.Links;
```

```
752         var counter = new Counter<IList<ulong>, ulong>(links.Constants.Continue);
```

```
753         ConsoleHelpers.Debug("Testing Each function.");
```

```
754         var sw = Stopwatch.StartNew();
```

```
755         links.Each(counter.IncrementAndReturnTrue);
```

```
756         var elapsedTime = sw.Elapsed;
```

```
757         var linksPerSecond = counter.Count / elapsedTime.TotalSeconds;
```

```
758         ConsoleHelpers.Debug("{0} Iterations of Each's handler function done in {1} ({2}  
759                               ↪ links per second)",  
760                               counter, elapsedTime, (long)linksPerSecond);
```

```
761     }
```

```
762 }
```

```
763 /*
```

```
764 [Fact]
```

```
765 public static void TestForeach()
```

```
766 {
```

```
767     var tempFilename = Path.GetTempFileName();
```

```
768     using (var links = new Platform.Links.Data.Core.Doublets.Links(tempFilename,  
769                               ↪ DefaultLinksSizeStep))
```

```
770     {
```

```
771         ulong counter = 0;
```

```
772         ConsoleHelpers.Debug("Testing foreach through links.");
```

```
773         var sw = Stopwatch.StartNew();
```

```
774 }
```

```
775 /*
```

```

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);
866     }
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: O(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 TLink = System.UInt64;
9
10 namespace Platform.Data.Doublets.Sequences.Tests
11 {
12     public class UInt64LinksExtensionsTests
13     {
14         public static ILinks<TLink> CreateLinks() => CreateLinks<TLink>(new
15             ↪ Platform.IO.TemporaryFile());
16
17         public static ILinks<TLink> CreateLinks<TLink>(string dataDBFilename)
18         {
19             var linksConstants = new LinksConstants<TLink>(enableExternalReferencesSupport:
20                 ↪ true);
21             return new UnitedMemoryLinks<TLink>(new
22                 ↪ FileMappedResizableDirectMemory(dataDBFilename),
23                 ↪ UnitedMemoryLinks<TLink>.DefaultLinksSizeStep, linksConstants,
24                 ↪ IndexTreeType.Default);
25         }
26     }
27 }

```

```

21 [Fact]
22 public void FormatStructureWithExternalReferenceTest()
23 {
24     ILinks<TLink> links = CreateLinks();
25     TLink 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<TLink> 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
80                 var itself = links.Constants.Itself;
81
82                 var meaningRoot = links.CreatePoint();
83                 var unaryOne = links.CreateAndUpdate(meaningRoot, itself);
84                 var unicodeSymbolMarker = links.CreateAndUpdate(meaningRoot, itself);
85                 var unicodeSequenceMarker = links.CreateAndUpdate(meaningRoot, itself);
86                 var frequencyMarker = links.CreateAndUpdate(meaningRoot, itself);
87                 var frequencyPropertyMarker = links.CreateAndUpdate(meaningRoot, itself);
88             }
89         }
90     }
91 }

```



```

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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